Operating Your

FOCUS™ Ellipsometer System

Part No. A15424
5/01/97

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DISCLAIMER

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Revision History

This page provides a revision history for this manual.

Pages Affected	Revision	Change	Date	Reason
All			5/01/97	Original release covering FE III, IV, VII, SMIF, and D Series.

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About This Guide

Introduction

This guide describes how to set up and use the FOCUS Ellipsometer (FE) System for performing wafer thickness measurements and analyses, and is made up of the following sections:

About This Guide

Describes the purpose, structure, and intended audience of this guide.

Chapter 1: System Overview

Describes the hardware and software components of the FE System.

Chapter 2: Operator Interface

Describes how to run a measurement process on a cassette of wafers and retrieve the data. Includes high level information on queued loading and wafer mapping.

Chapter 3: Developing Film Applications

Describes how to develop filmstack models and how to test the filmstacks for use in wafer measurements. Sample applications using the FE System in the Fab are also provided.

Chapter 4: Creating Recipes

Describes how to create wafer recipes and the organization of wafer recipes. Includes information on monitor recipes and product recipes (using pattern recognition).

Chapter 5: Wafer Mapping and Data Reporting

Describes how to generate contour (2D) and topographical (3D) wafer maps as well as etch rate and difference wafer maps. Also describes how to retrieve wafer measurement data and how to import/export data between two or more FE Systems.

Appendix A: Starting and Stopping the System

Describes how to start up and shut down the FE System under normal and emergency conditions, and how to recover from an emergency shut down.

Appendix B: System Configuration

Describes how to configure the FE System to require the use of operator logins and passwords and how to add login names and passwords to the system. Also includes some high level information on setting up a SECS-II/GEM interface and how to perform database backup, restore, and maintenance procedures.

Appendix C: Default Recipes and Filmstacks

Provides a listing and a description of the default recipes, filmstacks, and measurement controls that are provided with the FE System by Rudolph Technologies.

Appendix D: Menu Maps Quick Reference

Provides menu maps for each of the programs that make up the FOCUS software package.

Appendix E: Theory of Operation

Provides an introduction to the basic theory behind FOCUS ellipsometry.

Appendix F: Error Messages/Getting Help

Provides a listing of error messages, possible causes, and troubleshooting steps including how to contact Rudolph Technologies for additional information and support.

Glossary

Provides definitions of commonly used terms.

Intended Audience

This guide is mainly intended for those people who are responsible for setting up wafers and cassettes for measuring and testing (Process Engineers), as well as those responsible for performing the actual wafer measurements (Operators).

Related Manuals

Other relevant Rudolph publications include:

- FOCUS Ellipsometer Facility Requirements Manual (Part Number A14376). Describes considerations that need to be addressed prior to shipment and installation of the FE System.
- FOCUS Ellipsometer SECS-II/GEM Interface Specifications (Part Number A11646). Describes the SECS-II/GEM interface.
- Additional documentation as provided by Rudolph Technologies.

Usage Conventions

The following table shows some of the conventions used in this guide.

Usage Example	Meaning
FOCUS Setup window	Window names and areas of a dialog box appear in initial capitals followed by the word “window” or “area”.
Bold	Bold text identifies menu selections, window buttons, and other text that may require particular attention.

Notes provide important or explanatory information that stands out from the rest of the text. Notes are presented in the following manner:

NOTE

This is an example of a note.

Cautions indicate the presence of a hazard that will or can cause property damage (such as equipment damage, loss of software/data, or service interruption) if the hazard is not avoided. Cautions are presented in the following manner:

CAUTION

This is an example of a caution.

Warnings indicate the presence of a hazard that will or can cause personal injury if the hazard is not avoided. Warnings are presented in the following manner:

WARNING

This is an example of a warning.

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System Overview

Chapter 1

Introduction

The purpose of this chapter is to provide descriptions of the main hardware and software components that make up the FOCUS Ellipsometer System. The information in this section applies to the FOCUS Ellipsometer (FE) III, IV, and VII systems, and includes the following topics:

- Descriptions of the main hardware components of the FE System.
- Descriptions of the programs that make up the software package that is part of the FE System, including:
  - Focus Operator Queued Loading
  - Focus Interactive
  - Focus Recipe Creator
  - Focus Mapping
  - Focus Browser
  - Focus Setup

This section is intended to be a high level overview of the FE System. Detailed operating instructions and theory of operation are provided in later chapters.

FOCUS Hardware

The FOCUS Ellipsometer uses simultaneous multiple angle of incidence ellipsometry, as described in Appendix E, "Theory of Operation". The FE System is used in the characterization of transparent films in semi-conductor applications. The major modules for the FE System include:

1. **Measurement Console** — Provides the means to accurately measure film thickness on the FE System.

2. **Wafer Handler Console** — Used to transport wafers through the FE System.

3. **Optional Monitor Console** — Provides a platform for the FE System monitor and some additional storage space.

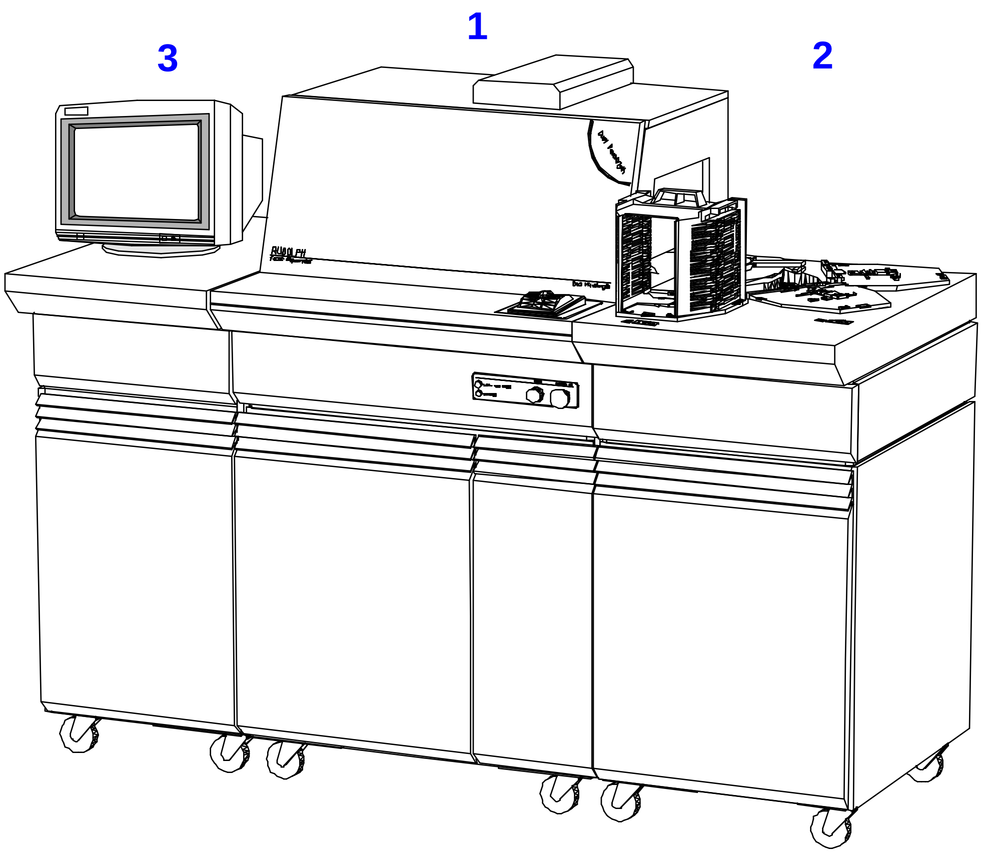


Figure 1-1. The FE System

Measurement Console

The Measurement Console contains the following components:

- Measurement system (including vacuum control, stage, lifters, optical components, and so on).
- Control electronics
- Computer System (including keyboard and trackball pointing device).

Measurement System

The measurement system, located behind the optics door on top of the measurement console, includes all of the hardware that actually performs the film measurements.

Once a wafer is loaded onto the stage, it is detected and held in place by the vacuum control system. The stage moves the wafer along the x and y axes to position the desired measurement location under the laser spot. Once properly positioned, the optical components perform the measurements as programmed by the Engineer.

The FE System may be configured with either one laser (single wavelength) or two lasers (dual wavelength).

Control Electronics

The control electronics, located behind the left door panel on the bottom of the measurement console, includes all of the electronic control modules (including rectifiers, transformers, and motion control circuitry) that powers the FE System and contains the logic and drivers for all motion of the robot, stage, and vacuum chuck.

Computer System

The computer system, located behind the right door panel on the bottom of the measurement console, is an IBM-compatible PC running OS/2. The computer system is used to set up measurements and calculate the data results. A VGA monitor (with live video overlay) and a trackball pointing device are also part of the computer system.

Wafer Handler Console

The Wafer Handler Console provides a storage area and contains the following components:

- Wafer handler robot arm
- Cassette plates
- Printer (optional)
- External flat/notch finder (FE IV only)

Robot Arm

The robot arm is used to transport wafers between a cassette and the stage in the Measurement Console. Single arm and dual arm robots are available.

Cassette Plates

The cassette plates hold the wafer cassettes and contain sensors which are used to automatically determine the size of the wafer cassette that has been placed upon the plate.

The FE System can be configured with either two or three cassette plates.

FE System Printer

A compartment located behind the door panel on the Wafer Handler Console provides for additional storage space for the FE System and may also contain the optional printer for the system.

The printer allows you to generate hard copy of wafer maps and reports that may be created when measurements are performed.

External Flat/ Notch Finder

The external flat/notch finder, available only on FE IV systems, performs centering and flat/notch orientation on a wafer prior to the wafer being loaded onto the stage.

The external flat/notch finder takes up the space normally used by cassette plate 3, therefore the FE IV system has only two cassette plates.

Monitor Console

The optional Monitor Console is typically used to provide a mounting surface for the computer monitor and for working counter space. The interior of the console can be used for the storage of cassettes, tools, books and other materials used with the FE System.

Optional Equipment

This section describes the following FE System options that can be purchased from Rudolph Technologies:

- Dual wavelength
- SMIF unit
- Queued loading
- GEM compliant SECS-II
- Pattern Recognition (vision system)
- Printer
- Floor mounting
- Signal Tower

Dual Wavelength

Dual wavelength uses a second laser to provide additional measurement capability.

SMIF Unit

The Standard Mechanical Interface (SMIF) unit provides a Class I mini clean environment for the containment of cassettes on the FE System.

Queued Loading

Queued loading improves throughput, productivity, and tool availability by allowing data review, cassette removal, cassette setup and recipe setup to occur while the system is measuring another wafer. In addition, the first wafer from the next cassette may be pre-aligned while the last wafer of the first cassette is being measured.

GEM-compliant SECS II

The GEM-compliant SECS II option uses software and a standard 25-pin connector to allow PC to remote mainframe communications.

Pattern Recognition (Vision System)

The Pattern Recognition (or vision) system allows automatic alignment for small site measurement.

Printer

An optional color printer may be connected to the FE System for printing out wafer mapping information and measurement data reports.

Unit Mounting

There are two types of unit mounting:

1. Earthquake Security Hardware

   In those areas where the equipment should be secured against seismic movement, an optional earthquake kit is available to fasten the FE System to the floor. This optional earthquake security hardware can be ordered from Rudolph Technologies, Inc.

2. Hard Feet

   Levelers that screw into the bottom of the unit to lift and level the unit.

Signal Tower

The signal tower option is an audible alarm and array of colored lights which provide an easy indication of the status of the FE System. What each light in the signal tower indicates is programmable through the Focus Setup program.

FE System Safety Features

All FE System models provide the following safety mechanisms:

- **Laser Safety.** The FOCUS Ellipsometer System meets or exceeds all the requirements of Federal Regulation 21CFR1040.00 for a Class I laser product. No special measures are required to protect the operator from laser radiation under normal operating conditions. For special safety modifications required to comply with International safety standards, please provide Rudolph Technologies with a detailed description of any specific safety requirements. Special safety modification requirements should be communicated to Rudolph Technologies prior to placing your final order and must be accepted by Rudolph Technologies. Laser warning labels (shown below) are affixed at several locations on the FE System:

Figure 1-2. Laser Safety Label

- **Motion and Laser Interlocks.** There are several interlocks built into the FE System to ensure laser safety. If the plexi door is opened on the front of the unit, the measurement lasers are automatically shuttered and the alignment laser is automatically de-energized.

- **Safety Clutch.** A safety clutch is built into the FE System robot to ensure that the following torque limits are not exceeded in each axis of movement.

Table 1-1. Safety Clutch Stall Forces

Axis	Stall Force
Rotational	0.23 kgf (0.5 lb) torque limited
Vertical (down only)	0.91 kgf (2 lbs) clutched
Horizontal	0.23 kgf (0.5 lb) clutched

- **Emergency Motion Off.** An Emergency Motion Off (EMO) switch provides emergency stopping of all unit motion except air flow. Refer to Appendix A, "Starting and Stopping the System" for additional information.

FOCUS Software

The FE software is pre-installed by Rudolph Technologies and is ready to use when you first start the FE System. The software interface consists of the OS/2 operating system and the following FE applications:

- Focus Operator Queued Loading
- Focus Interactive
- Focus Recipe Creator
- Focus Mapping
- Focus Browser
- Focus Setup
- Focus SECS-II (optional)

The Focus Ellipsometer folder on the OS/2 desktop is displayed in Figure 1-3. The programs available, and the icons displayed in the folder may vary depending on your system configuration and software version.

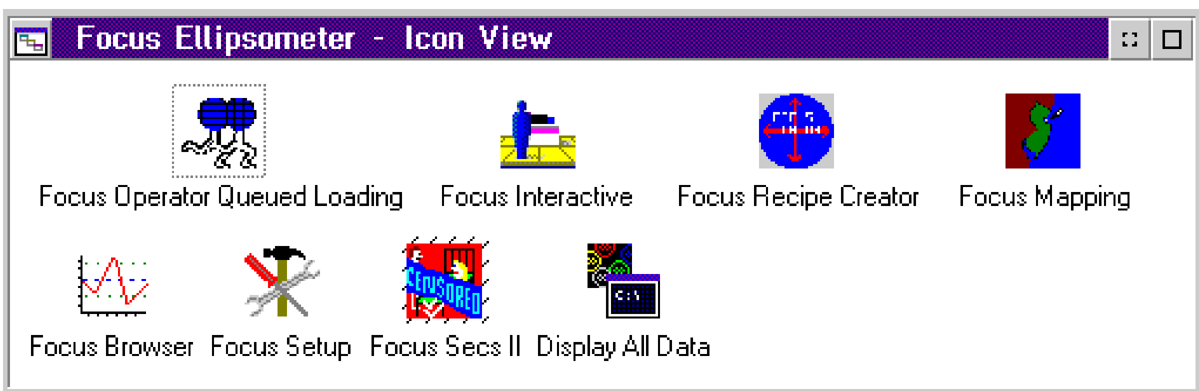


Figure 1-3. Focus Ellipsometer Folder (OS/2 Desktop)

Focus Operator Queued Loading

The Focus Operator Queued Loading program is used by the Operator to make measurements on production wafers using recipes created by the Engineer. After placing a cassette of wafers to be measured on a cassette plate, the Operator can select the desired measurement process to measure the cassette of wafers, review system status, and start wafer measurements.

The operation of the FE System can range from completely automatic to operator-interactive. When a fully automatic recipe is being run, the FE System does not require any attention from the Operator after measurements begin. In the interactive mode, the Operator may be required to specify wafer transfers and select/position measurement sites on the wafers. In both modes, the Operator program continually updates and displays measurement conditions and results by means of a status screen. A measurement summary is automatically displayed at the end of a run for viewing, validation and printing, if desired.

Detailed instructions for using the Focus Operator Queued Loading program are provided in Chapter 2, “Operator Interface”.

Focus Interactive

The Focus Interactive program is used by the Engineer to interactively develop and test-run a filmstack. Different filmstack models can be created and tested until the best combination is found to characterize a given structure on a wafer. In this manner, new materials and concepts can be thoroughly tested and validated before use.

Detailed instructions for using the Focus Interactive program are provided in Chapter 3, “Developing Film Applications”.

Focus Recipe Creator

The Recipe Creator program is used by the Engineer to create wafer recipes which are incorporated into process steps. A “building block” approach is possible, where recipe components (templates) can be created and stored for later assembly into complete recipes, or data can be entered to create complete individual recipes.

After the necessary recipes have been created and stored by the Engineer, the Operator can call up the desired process step in the Focus Operator program and perform the wafer measurements.

Detailed instructions for using the Focus Recipe Creator program are provided in Chapter 4, “Creating Recipes”.

Focus Mapping

The Focus Mapping program permits the contents of the wafer information database, which stores mapping files created during wafer measurements, to be displayed as contour (2D) or topographic (3D) maps.

Detailed instructions for using the Focus Mapping program are provided in Chapter 5, “Wafer Mapping and Data Reporting”.

Focus Browser

The Focus Browser permits stored measurement data to be viewed and organized as desired. The Focus Browser can be used to perform statistical analyses and database queries and generate output in the form of suitable reports, charts and graphs.

Detailed instructions for using the Focus Browser program are provided in Chapter 5, “Wafer Mapping and Data Reporting”.

Focus Setup

The Focus Setup program is typically used by Rudolph support personnel to change the FOCUS Ellipsometer software configuration, including all the default parameters and settings for the various FE programs. The Focus Setup program also provides for the creation of FE System login names, data file backup, data file restore, and database maintenance functions.

Instructions for using the Focus Setup program are provided in Appendix B, “System Configuration”.

Focus SECS-II

Using the optional SECS-II/GEM protocol makes it possible for the FE System to communicate with a host computer. The SECS-II program provides a programmable interface where the SECS-II controls, communications and host monitor controls can be specified. Complete host control of the FE System is possible using SECS-II.

When the FE System is powered up, the SECS-II program begins to execute in the background, allowing the Operator to run another program in the foreground simultaneously. The program provides a control panel that allows the Operator to configure a number of SECS-I and SECS-II interface characteristics and parameters.

For instructions on configuring and using the SECS-II/GEM interface, refer to the Rudolph Technologies document “FOCUS Ellipsometer SECS-II/GEM Interface Specifications” (manual part number A11646).

NOTE:

Communications will be limited unless the Focus Operator program is running.

Operator Interface

Chapter 2

Introduction

The purpose of this chapter is to provide information to both the Operator and the Engineer on how to run a cassette of wafers and retrieve data. The information in this section pertains to the FOCUS Ellipsometer (FE) III, IV, and VII systems, and includes the following topics:

- How to log in and log out of the operator interface.
- How to select program names and start a process run.
- Operator views including all operator windows, Wafer View, Cassette View, and Data View.
- How to retrieve, review and/or print data in the following formats:
  - Text data
  - Contour maps
  - 3D maps
- Advanced operator features to include:
  - Setting up queued loading
  - Commonly deferred values
  - How to abort and skip wafers
  - SECS-II/GEM controls
- Commonly encountered error messages.

The tasks described in this chapter are performed with the use of the Focus Operator Queued Loading program. This is the program that runs the process steps created by the Recipe Creator and, if your FE System is so equipped and configured, allows the "queuing" of additional cassette wafers while a current cassette is running. Queuing allows for uninterrupted measurements, thus increasing overall system throughput.

Starting Focus Operator and Logging In

To start the Focus Operator Queued Loading program, perform the following procedure:

1. Position the trackball pointer over the Focus Operator Queued Loading icon, located in the Focus Ellipsometer folder, and double click the left trackball button.

   A Focus Ellipsometer Operator Interface splash screen is displayed briefly followed by one of the screens shown below.

   If your FE System has been configured in such a way as to **require** Operators to log in to the system, a screen such as the one shown in Figure 2-1 is displayed. Continue the procedure with Step 2.

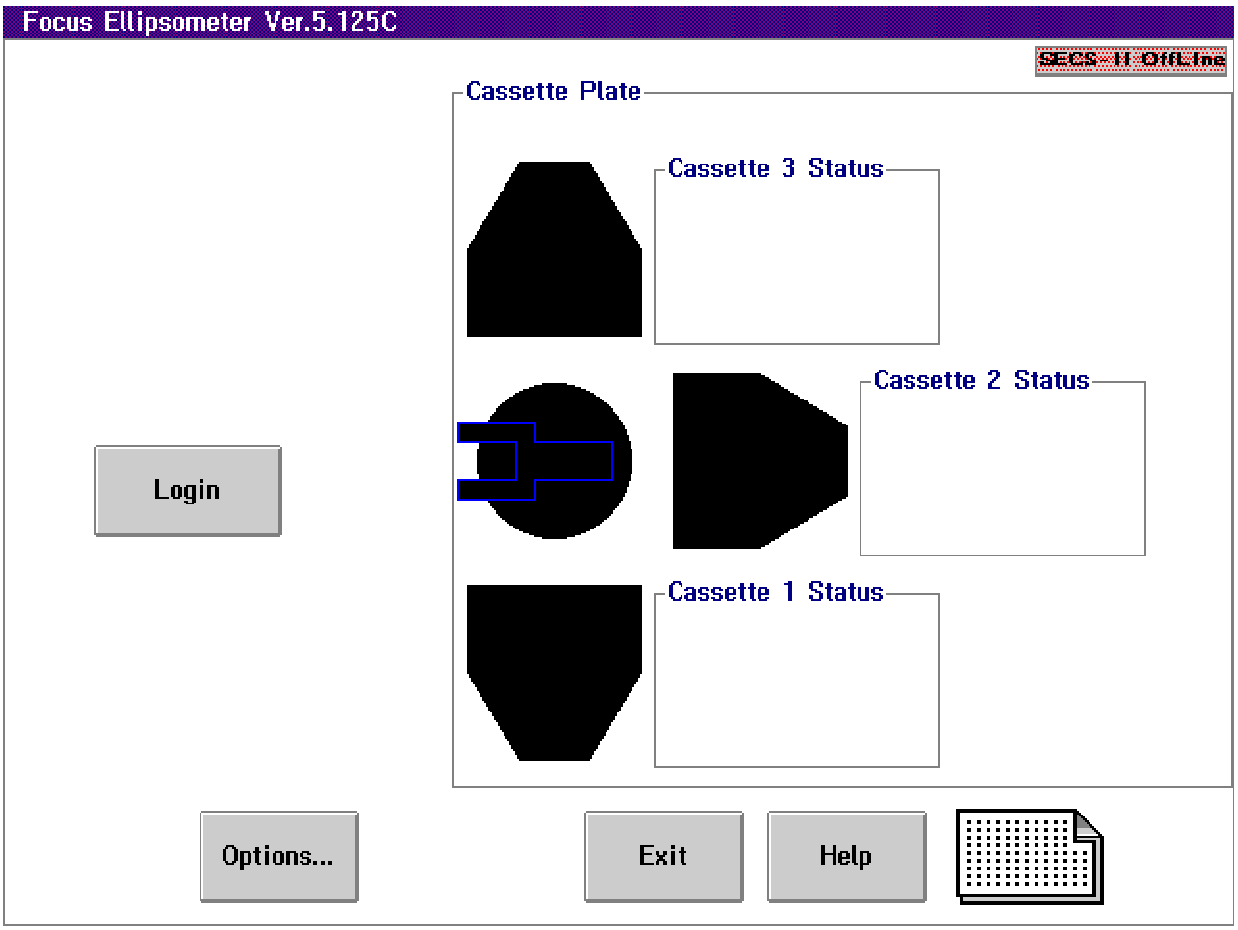


Figure 2-1. Focus Operator Login Screen

If your FE System **does not require** Operators to log in, a screen such as the one shown in Figure 2-2 is displayed. You are now ready to select the desired process specification and start the run. See "Using Focus Operator" on page 2–16 for more information.

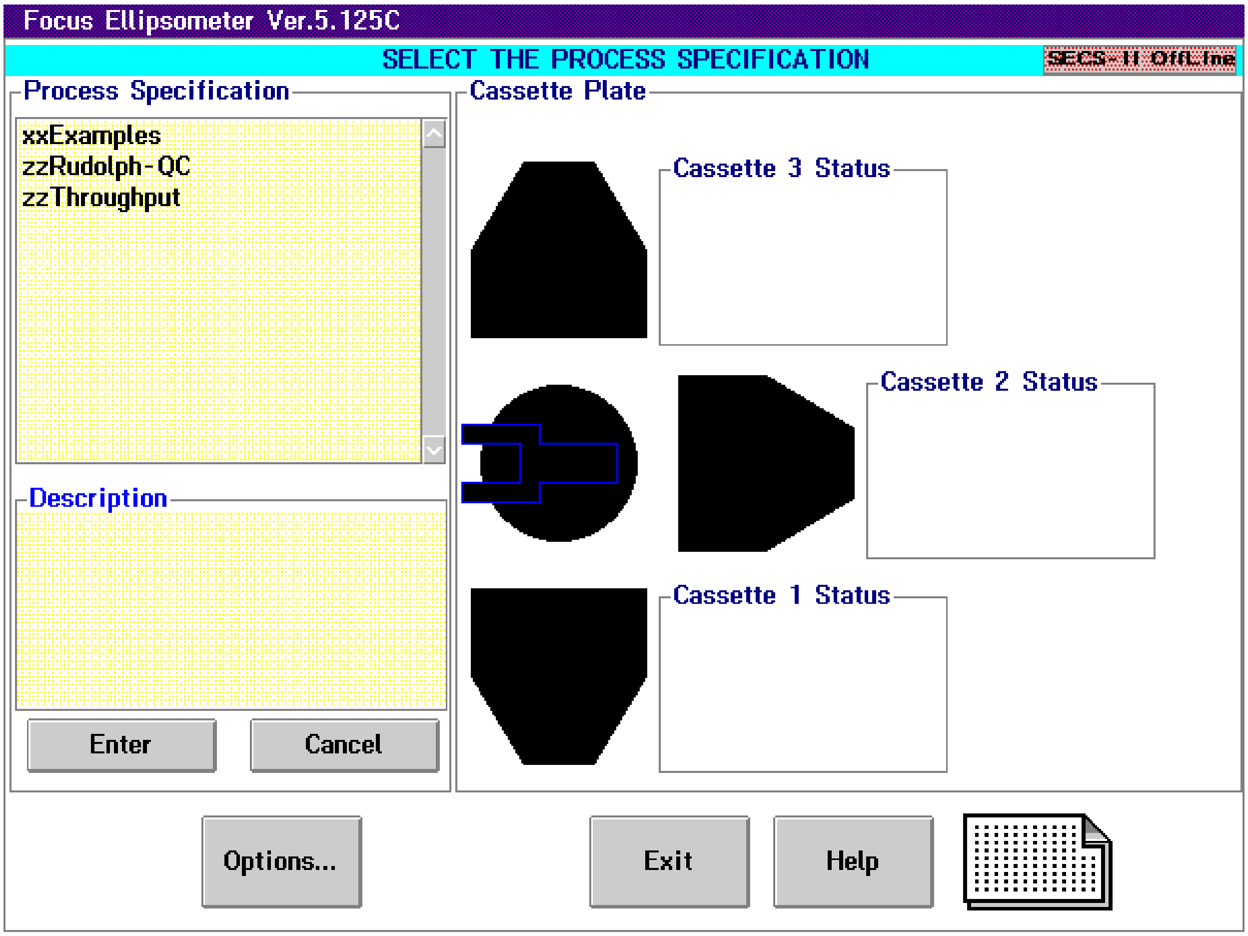


Figure 2-2. Focus Operator Queued Loading Selection Screen

2. With the Login screen displayed as shown in Figure 2-1, position the trackball cursor over the **Login** button on the screen and click the left trackball button one time.

   A list of the login names that are available on your system is displayed as shown in Figure 2-3.

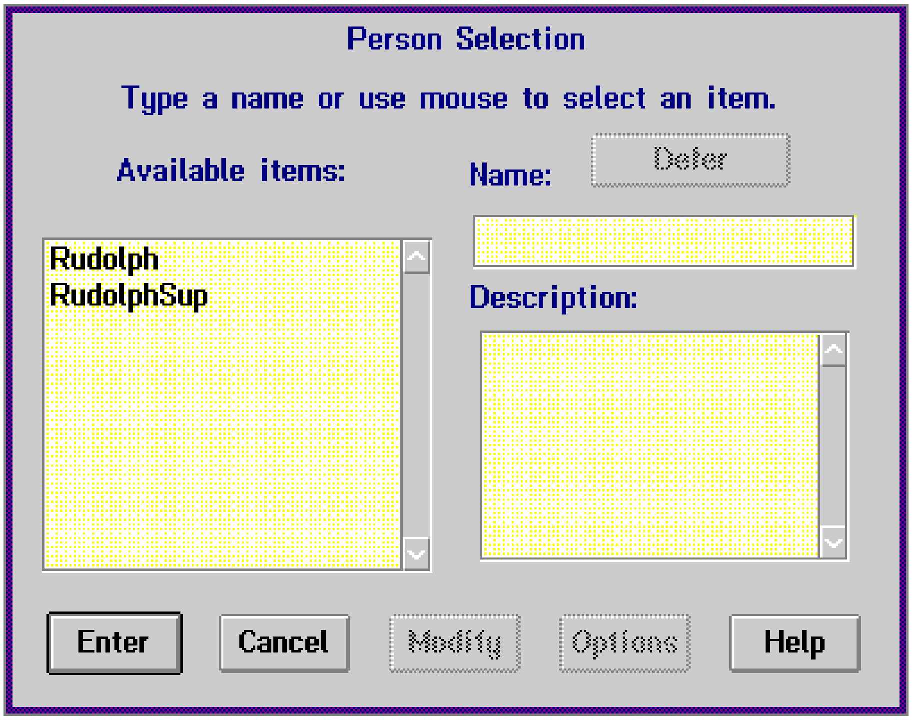


Figure 2-3. Focus Operator User Login Selection

3. Select a login name by clicking the left trackball button on the desired name and then clicking on **Enter**, or by double clicking the left trackball button on the name.

   The Focus Operator Password Entry dialog box is displayed as shown in Figure 2-4.

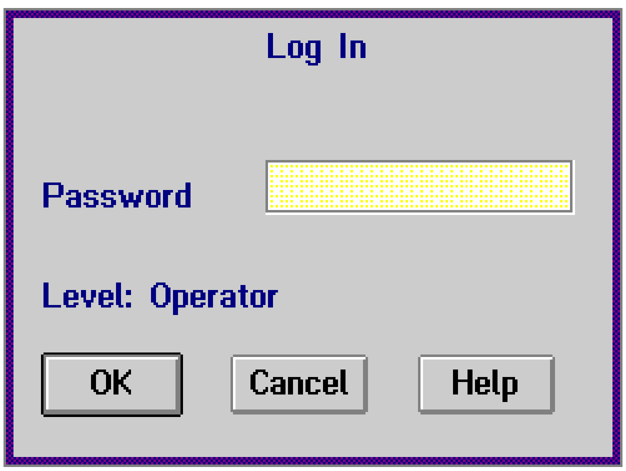


Figure 2-4. Focus Operator Password Entry

4. Enter your password and press **Enter**, or click on **OK**.

NOTE

For security reasons, asterisks (*) will be displayed as you enter your password.

The Focus Operator Queued Loading program screen is displayed as shown in Figure 2-2.

Focus Operator Windows

The Focus Operator program consists of three main views or windows. These are the Cassette View, Wafer View, and Data View windows.

The following sections provide descriptions of the parts that make up each of the windows.

Cassette View

When the Focus Operator software is first started, the Cassette View window is displayed. The appearance of the Cassette View window will vary depending on the system setup and the task that is currently running.

Figure 2-5 shows the Cassette View window as it first appears if the FE System is configured to require Operator login. Descriptions of the various parts of the screen follow the figure.

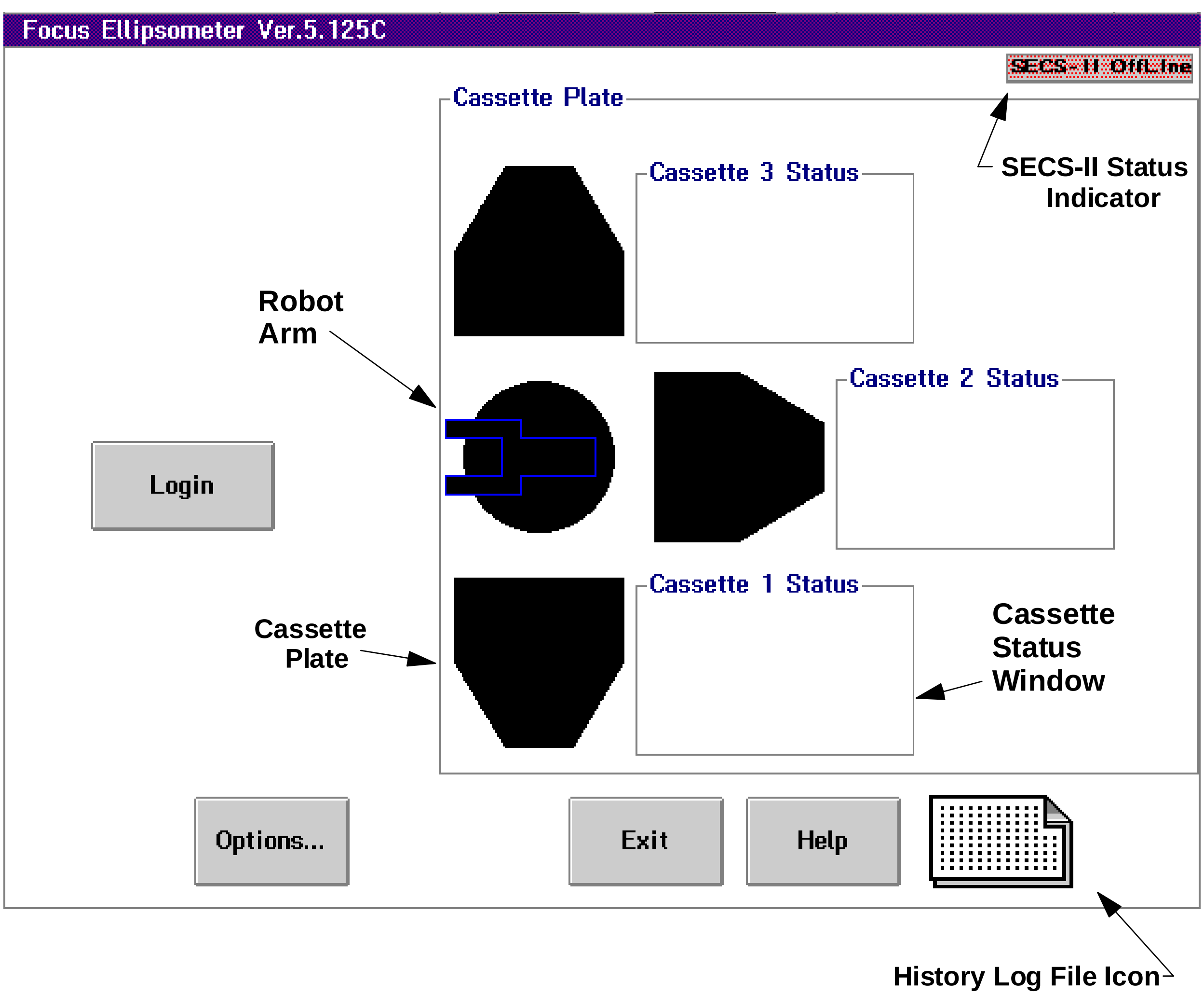


Figure 2-5. Cassette View Login Screen

- **SECS-II Status Indicator** — Indicates the current status, either Off-line or On-line, of the SECS-II communications interface.
- **Cassette Plates** — Represent the cassette plates on the FE System. The number of cassette plates shown on the screen will depend upon your system configuration.

  The appearance of the cassette plate will change to display a message to reflect the status of the FE System as follows:

  - **Ready** when a process run has been selected and is ready to be started. Clicking on the cassette plate when it indicates Ready will offer you the option of clearing the program.
  - **Running** when the program is being executed. Clicking on the cassette plate when it indicates Running will display the Wafer View and Data View windows.
  - **PRESS FOR DATA** when the program has been completed. Clicking on PRESS FOR DATA will display the measurement data for the process just run.
- **Cassette Plate Status Windows** — Provides information on the process that is assigned to that cassette plate. Information includes the process specification and step, the priority level of the process, and the Operator running the process. Figure 2-8 shows an example of the Cassette Plate Status window.
- **Robot Arm** — A graphic representation of the FE System robot arm. When the FE System is idle, the robot arm points to the left, when a process is running, the robot arm points to the cassette plate on which the process is running.
- **History Log File Icon** — Provides access to the stored history logs. The number of logs in the history file depends on your system setup. Clicking on this icon allows you to select an individual logfile from a previously run measurement session. Refer to “Accessing Previously Run Data (History Log)” on page 2–32 for information.
- **Login Button** — Allows the Operator to login and run processes. This button is only displayed if the FE System is configured to require system Operators to log in. Refer to “Starting Focus Operator and Logging In” on page 2–2 for information.
- **Options... Button** — Provides access to FE System options. The options available through this button will depend on your system setup. Examples of options available include: SECS-II status, setting local or remote control, communications and equipment state, and mapping.
- **Exit Button** — Exits the Focus Operator program. Depending on your system setup, a username and password may be required to exit.

Figure 2-6 shows the Cassette View window during process specification selection. Items unique to this window are described below.

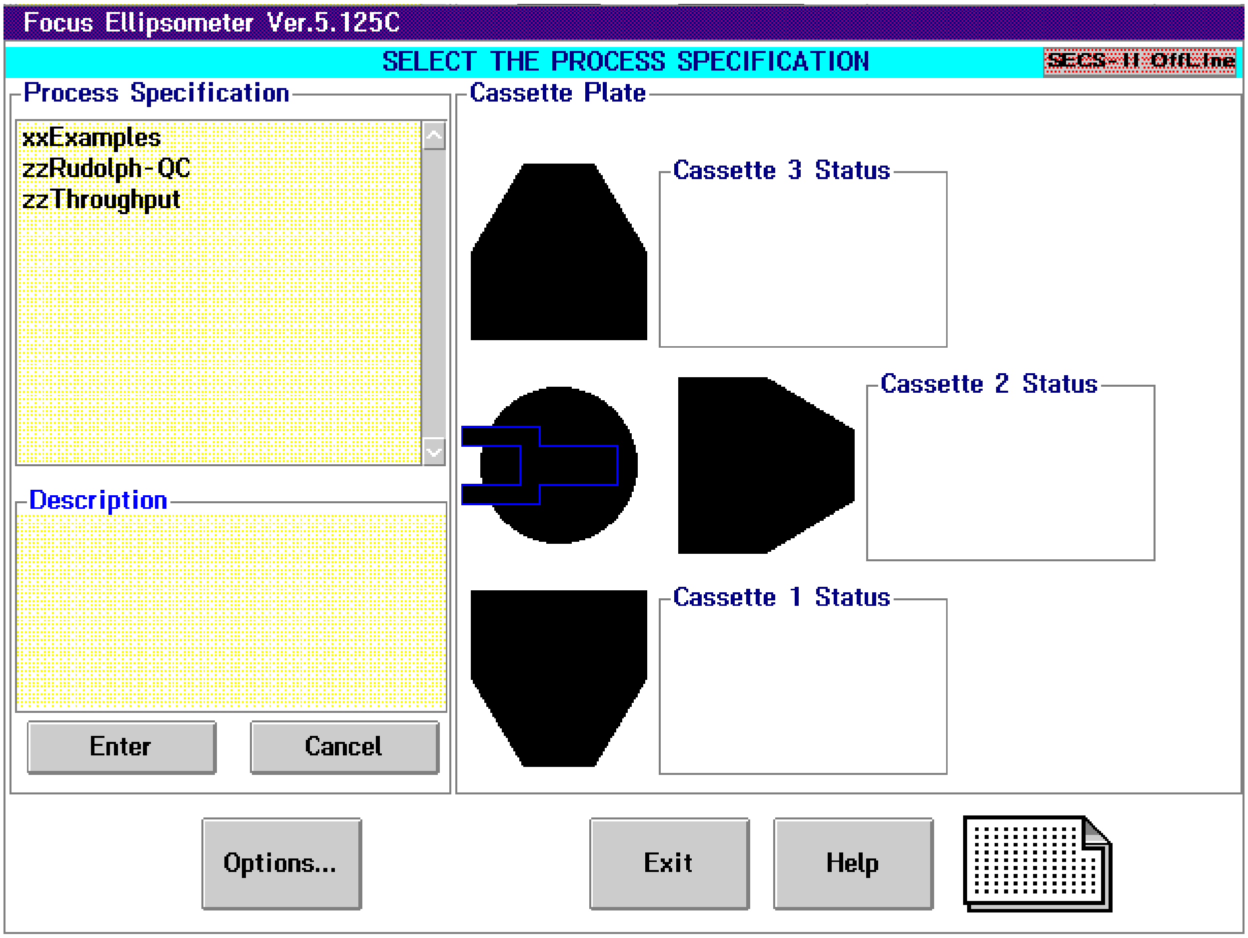


Figure 2-6. Cassette View Process Specification Screen

- **Process Specification Selection Area** — Provides a list of the process specifications available to the Operator for selection. Click once to highlight a process specification, click twice to select that process specification.
- **Description Area** — Provides a brief description (if one has been provided) of the highlighted process specification.
- **Enter Button** — Selects the highlighted process specification.
- **Cancel Button** — Cancels the process specification selection. Clicking on this button will either return you to the Cassette View Login screen (if Operator log in is required), or will clear the highlighted process specification and allow you to select a different process specification (if no Operator log in is required).

Figure 2-7 shows the Cassette View window during process step selection. Items unique to this window are described below.

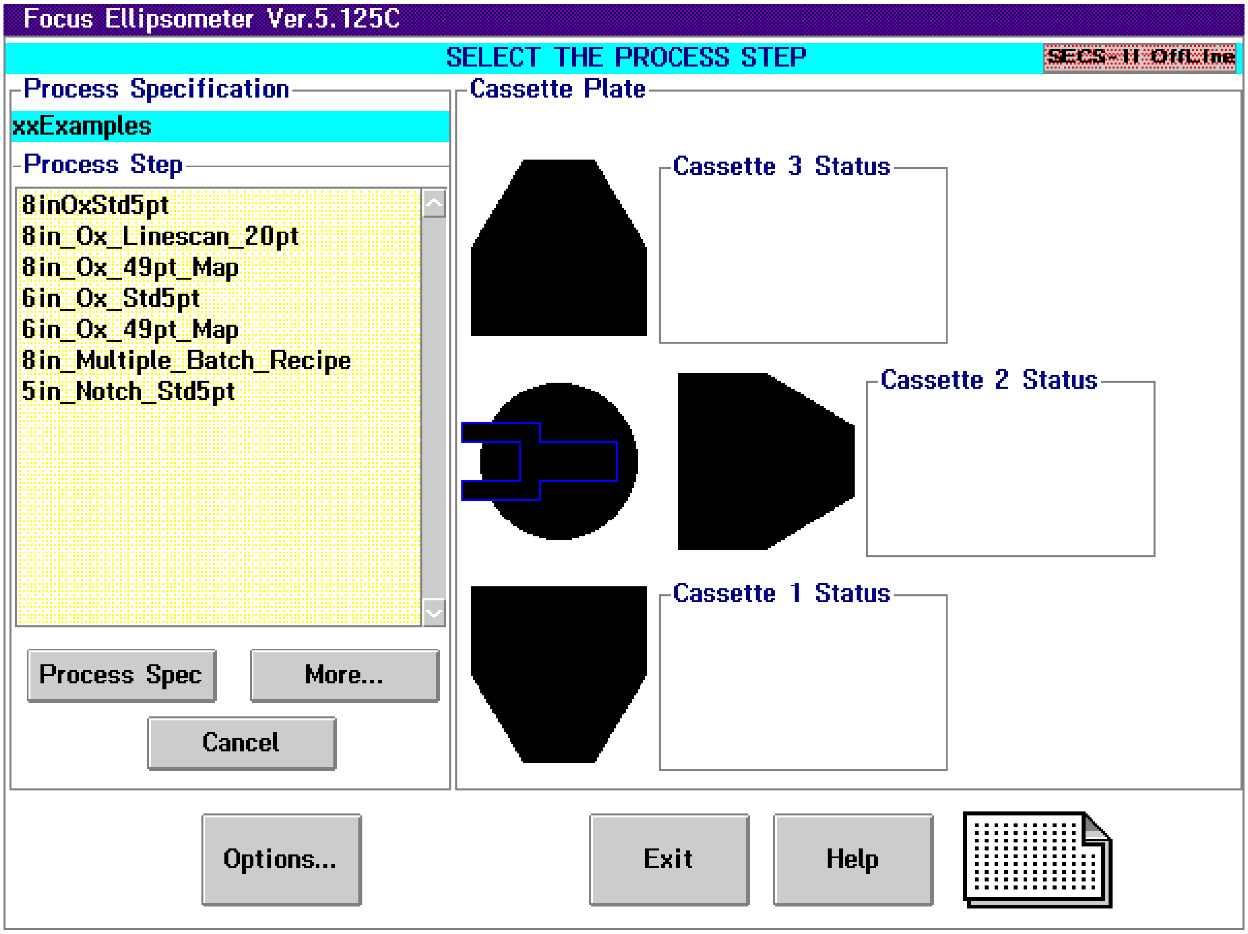


Figure 2-7. Cassette View Process Step Screen

- **Process Specification** — Displays the currently selected process specification.
- **Process Step Selection Area** — Provides a list of the process steps available to the Operator for selection. Click once to highlight a process step then click on the desired cassette plate, or click twice on a process step to assign the process to the default cassette plate.
- **Process Spec Button** — Re-displays the list of process specifications available so that you may select a different one.
- **More... Button** — Clicking on this button provides you with more information on the components that make up the selected process step (such as, process step name, and transfer, recipe, and control information).

Figure 2-8 shows the Cassette View window when the process is ready to run on the selected cassette plate. Items unique to this window are described below.

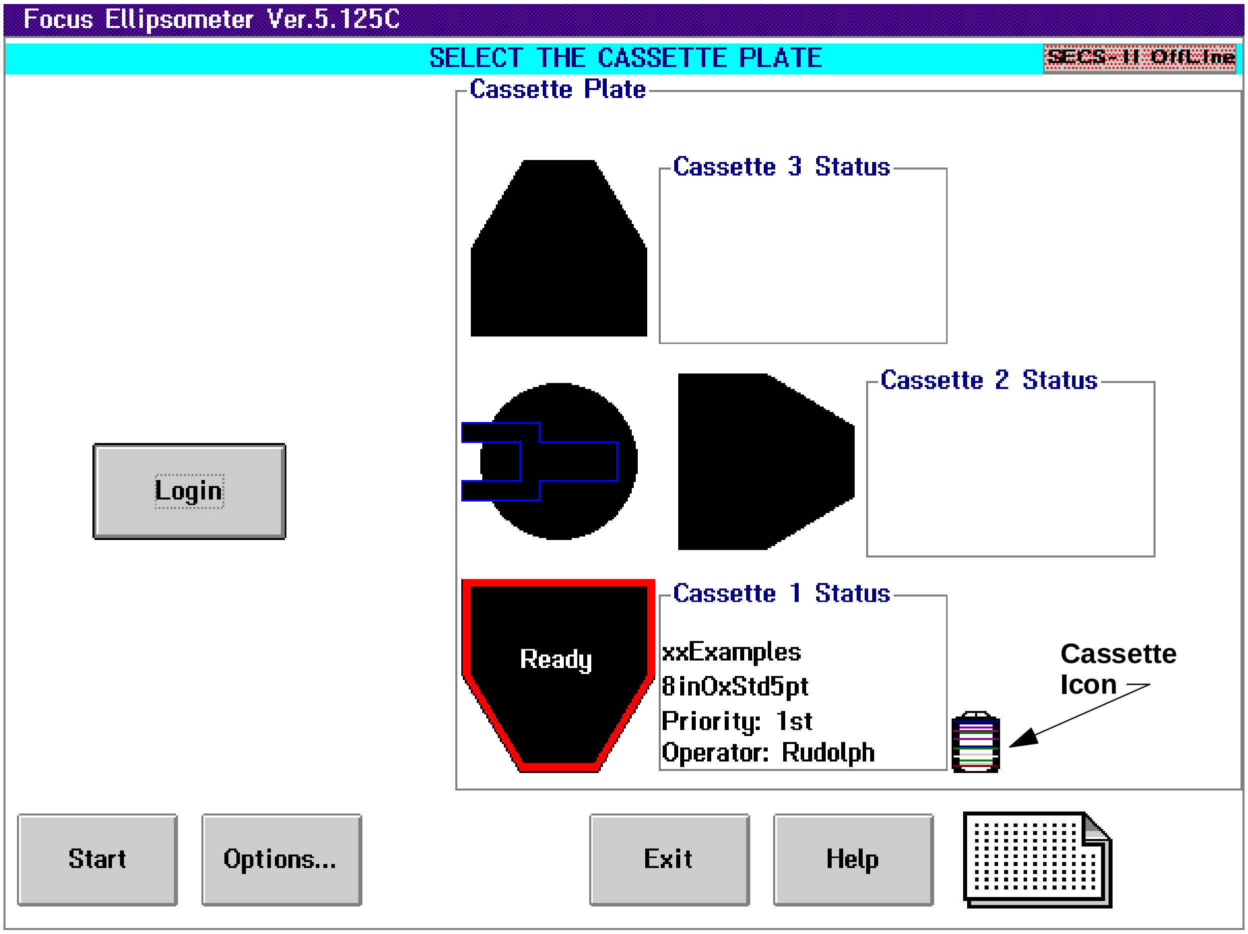


Figure 2-8. Cassette View Process Ready Screen

- **Cassette Plate Showing Ready** — Indicates a process run has been programmed and is ready to be started. Clicking on the cassette plate now offers the option of clearing the program.
- **Cassette Icon** — The cassette icon appears when the process is ready to be run on the selected cassette plate. Clicking on the icon allows the Operator to change the slots in the cassette that are selected for measurement. Depending on the system setup, entering an Operator login name and password may be required.
- **Start Button** — Starts the programmed process and causes the Wafer View window to be displayed (as shown in Figure 2-10).

Figure 2-9 shows the Cassette View window when the process is running on the selected cassette plate. Items unique to this window are described below.

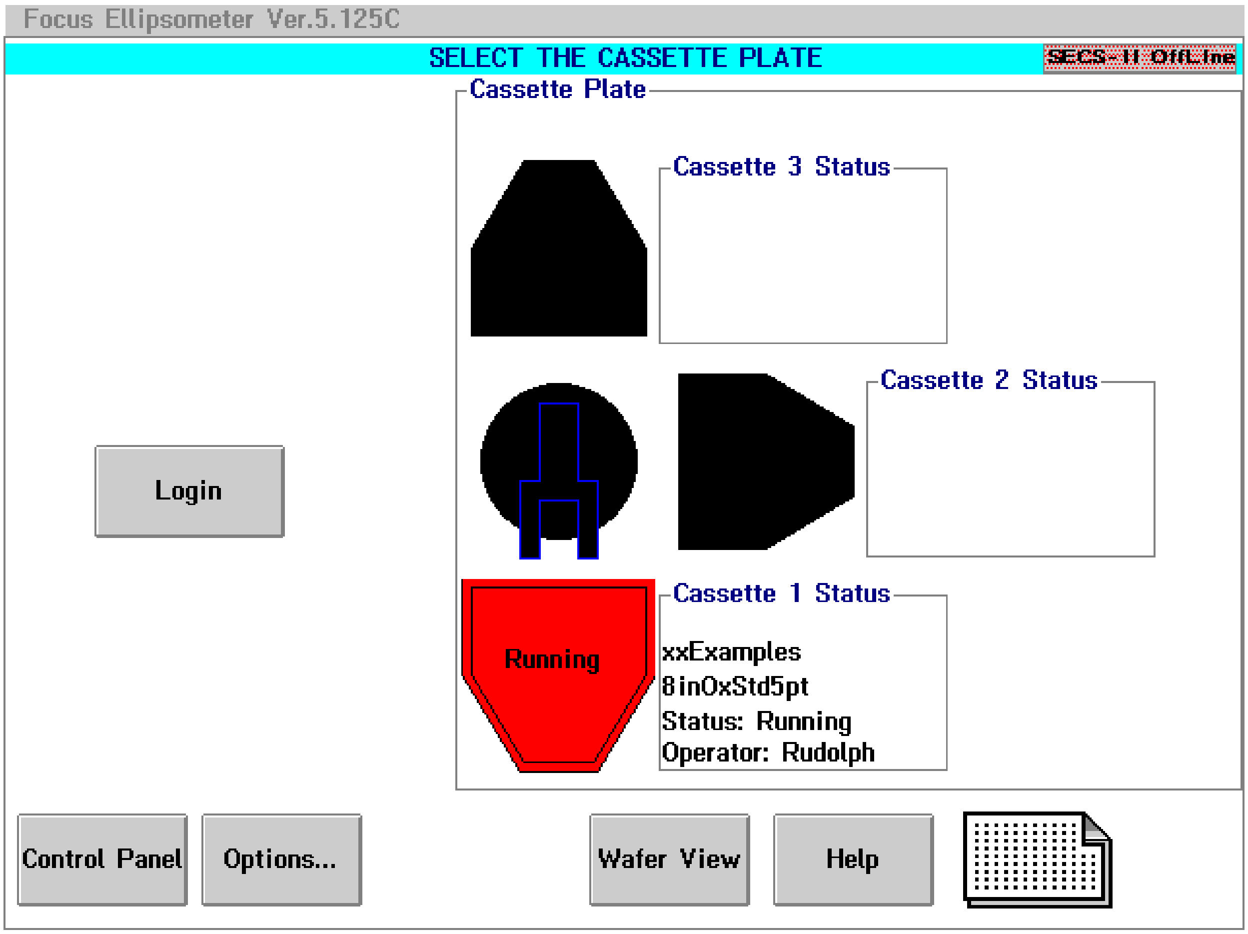


Figure 2-9. Cassette View Process Running Screen

- **Cassette Plate Showing Running** — Indicates a process run has been started and measurements are being taken. Clicking on the cassette plate now will display the Wafer View and Data View windows.
- **Control Panel Button** — Displays the Wafer View window and the FE System Control Panel. With the control panel, the Operator may abort the entire measurement process run, skip the wafer currently being measured, or select a different view to be displayed (video, data, or cassette). The measurement process is paused while the control panel is displayed.
- **Wafer View Button** — Displays the Wafer View window. An example of a Wafer View window is shown in Figure 2-10.

Wafer View

When a measurement process specification and process step have been selected and assigned to a cassette plate and the run is started, the Wafer View window is displayed. When all measurements in the run have been completed, the Wafer View window is automatically closed and you are returned to the Cassette View window.

Figure 2-10 shows an example of the Focus Operator Wafer View window. Descriptions of the various parts of the screen follow the figure.

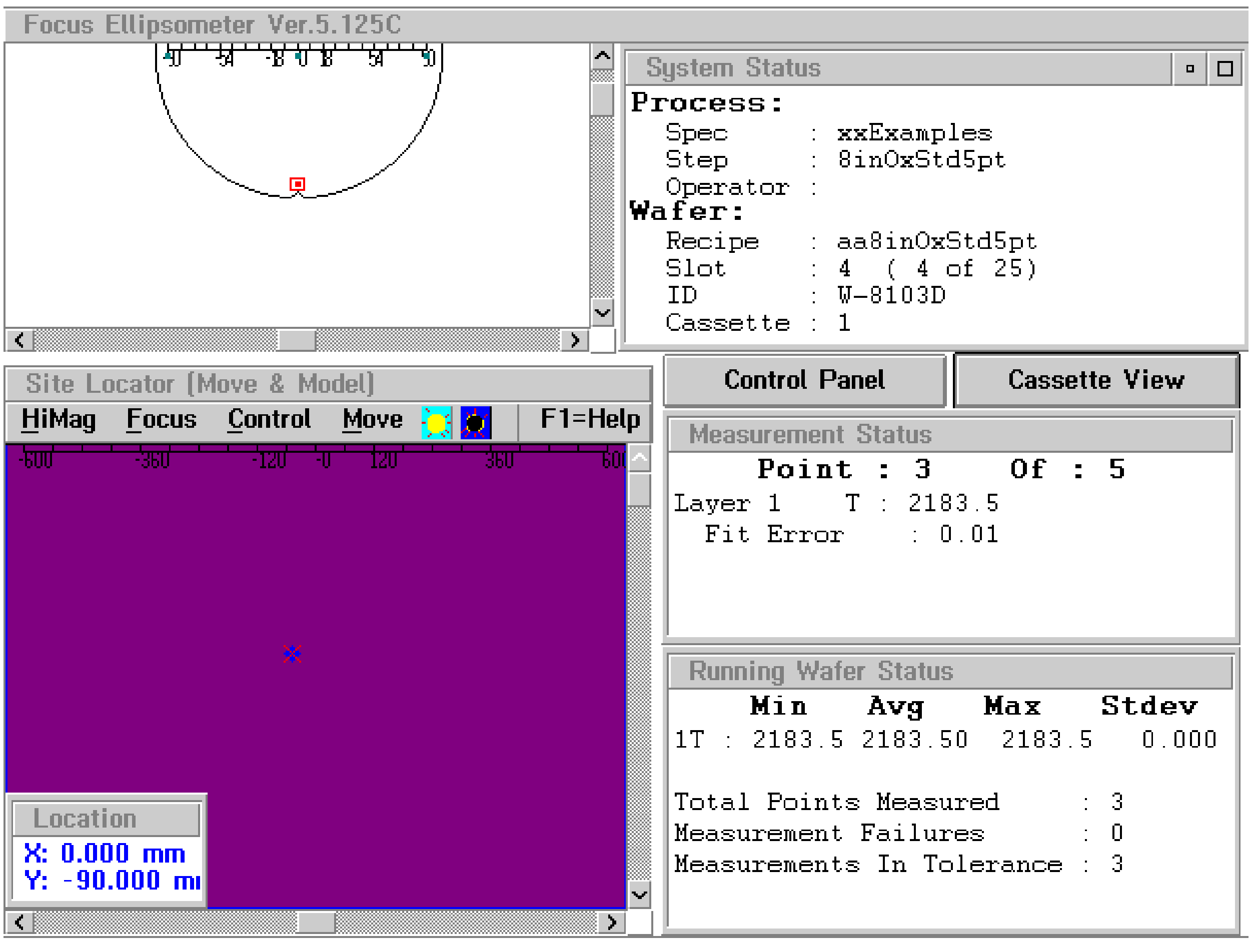


Figure 2-10. Wafer View Window

- **Wafer View** — Located in the upper lefthand corner, this window provides a graphical representation of the wafer currently loaded on the stage and undergoing the measurement process. The red spot located in the square box indicates the current measurement location on the wafer. The other spots visible on the wafer indicate locations on the wafer that have been or will be measured.

- **Site Locator** — Shows a live video image of the location being measured on the wafer. The small blue spot in the window indicates where the laser is focused on the wafer. The Site Locator window offers the following menu items:
  - **HiMag/LoMag** — Indicates whether the live video image is in High Magnification or Low Magnification mode. Clicking on this menu item toggles between the two modes. The field of view in the Site Locator window in HiMag is .54mm x .72mm (FE VII) or .9mm x 1.2mm (FE III and IV). The field of view in LoMag is 5.4mm x 7.2mm (FE VII) or 7mm x 9mm (FE III and IV).
  - **Focus** — Clicking on this menu item will focus the laser spot to a point. When measurements are performed, focus is automatically performed.
  - **Control** — Clicking on this menu item displays the Control menu. This menu consists of the following items:

    Mag — Consists of the following items: **Wafer View** displays the wafer view in the site locator window, **Low Mag** causes the microscope to switch to low magnification mode, **High Mag** causes the microscope to switch to high magnification mode. The Low Mag and High Mag items are functionally the same as the HiMag/LoMag items on the menu bar.

    Zoom — Consists of the following items: **One Quarter** reduces the Site Locator window to one quarter size, **One Half** displays the Site Locator window at half size (default), **One X** displays the Site Locator window on the full screen.

    Live Off/Live On — Toggles between turning the live video view on and off in the Site Locator window.

    Laser Off/Laser On — Toggles the laser on and off. The laser must be on in order to make measurements.

    Illumination — Allows you to set the illumination intensity of the microscope lamp.
  - **Move** — The items in this menu are used to move around on the wafer and do not apply to the Focus Operator program.
  - **Light/Dark Icons** — Located to the right of the **Move** menu, clicking on these icons allow you to change the illumination intensity of the microscope lamp.
- **Location** — Shows the X and Y coordinates for the location that is currently being measured on the wafer.

- **System Status** — Provides information associated with the process including the process specification and step being run, and the wafer recipe, slot, ID and cassette information.
- **Measurement Status** — Displays the measurement data and fit error for each location on the wafer as it is measured.
- **Running Wafer Status** — Provides a running status of all of the measurements that have been taken on the wafer currently on the stage. Status includes: minimum, maximum, average, and standard deviation of the measurements taken, as well as the number of points measured and the number of measurements in and out of tolerance. This window is updated after each measurement is taken on the wafer.
- **Control Panel Button** — Displays the FE System Control Panel. With the control panel, the Operator may abort the entire measurement process run, skip the wafer currently being measured, or select a different view to be displayed (video, data, or cassette). The measurement process is paused while the control panel is displayed.
- **Cassette View Button** — Displays the Cassette View window. An example of a Cassette View window is shown in Figure 2-9.

Data View

When a measurement process is running, the Data View window may be displayed (in addition to the Wafer View window) by clicking on **Control Panel** in the Wafer View window, selecting **Data View**, then clicking on **Enter**.

Figure 2-11 shows an example of the Focus Operator Data View window. Descriptions of the various parts of the screen follow the figure.

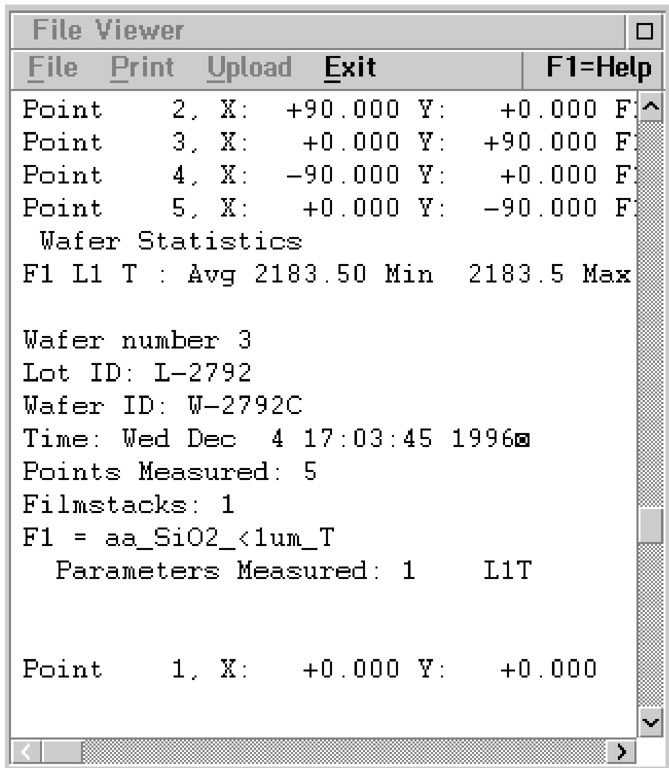


Figure 2-11. Data View Window

The Data View window displays the measurement data for each point on each wafer as it is taken. When all measurements in the run have been completed, the Data View window is automatically closed and you are returned to the Cassette View window.

- **File Menu** — This menu is not active while measurements are being taken.
- **Print Menu** — This menu is not active while measurements are being taken.
- **Upload Menu** — This menu is not active while measurements are being taken.
- **Exit Menu** — Exits the Data View window and returns you to the Wafer View window.

Using Focus Operator

The FE System can measure both patterned and unpatterned wafers.

From the operating point of view, pattern recognition (vision) recipes are not different from non-pattern recognition recipes. The Operator selects the process specification, selects the process step, and presses **Start** at the confirmation screen. The Focus Operator can then perform the normal wafer load, wafer centering and flat/notch routines.

After the wafer is centered and the flat/notch is found, the vision system registers the wafer by searching for the two registration points previously trained. Once the sites are found, the system proceeds to each stepper group to measure the selected sites.

The display is slightly different during operation. The site locator window displays a simulated map of the chip and measurement sites on the wafer. In the live video window, vision measurement sites are represented by squares. Non-vision sites are represented by an “X”. When the system moves to a site, the box will be drawn at the location where the site was predicted to be (by the numbers). Once the vision system corrects the position, the blue diamond will separate from the box showing the difference between the predicted location (box) and the measurement location (blue diamond).

This process and the various windows that make up the Focus Operator program will be discussed in more detail in the sections that follow.

Figure 2-12 shows the Focus Operator Queued Loading screen after the Operator has logged in and prior to the selection of any process specifications.

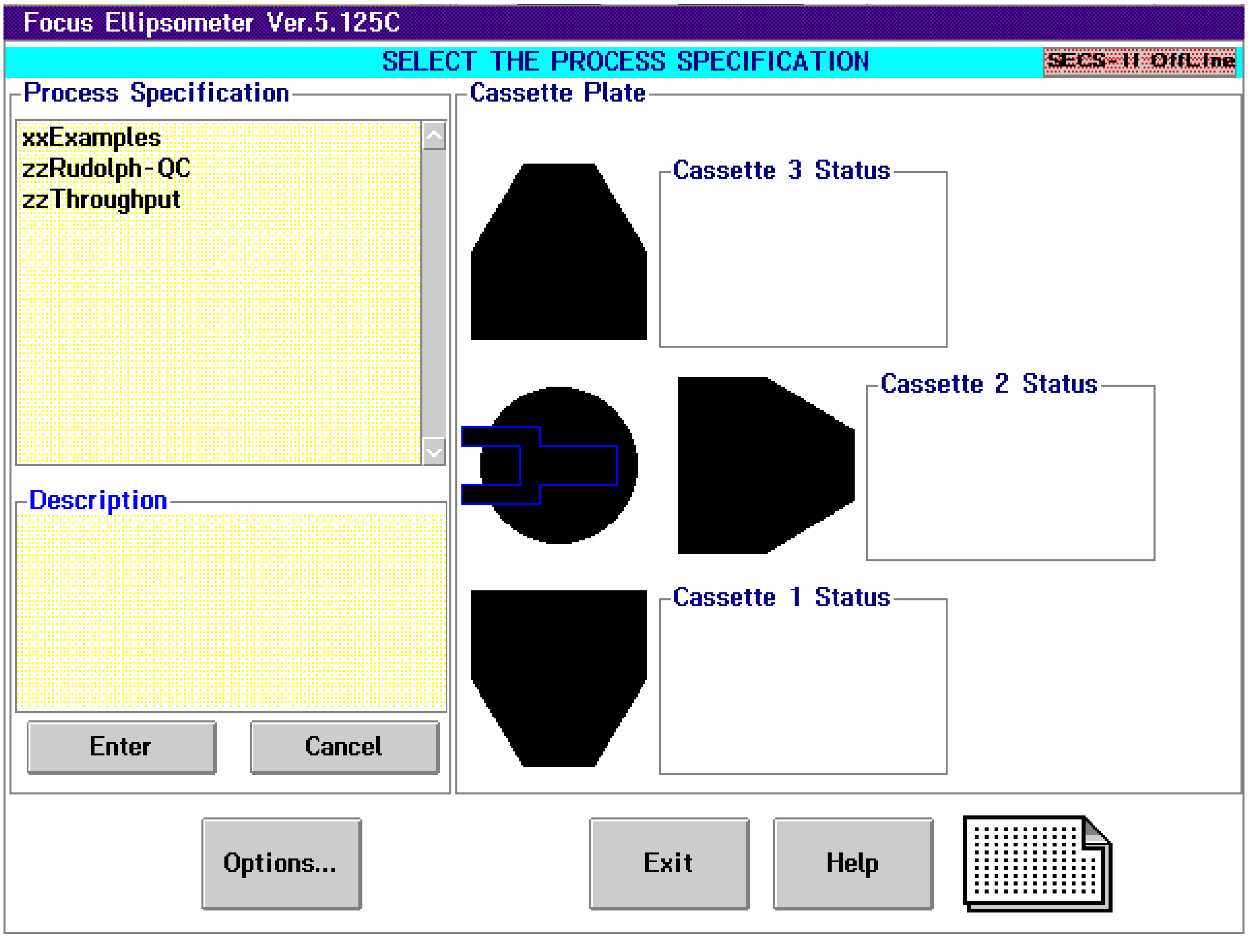


Figure 2-12. Focus Operator Queued Loading Screen

Setting Up a Process Run

1. Place the cassette(s) that contain the wafer(s) to be measured on the desired cassette plate(s) on the FE System.

2. Select a **Process Specification** from the window list either by double clicking on the desired name, or by single clicking on the name and then clicking the **Enter** button.

   A Process Step window will be displayed (as shown below) with a list of the process steps defined for that process specification.

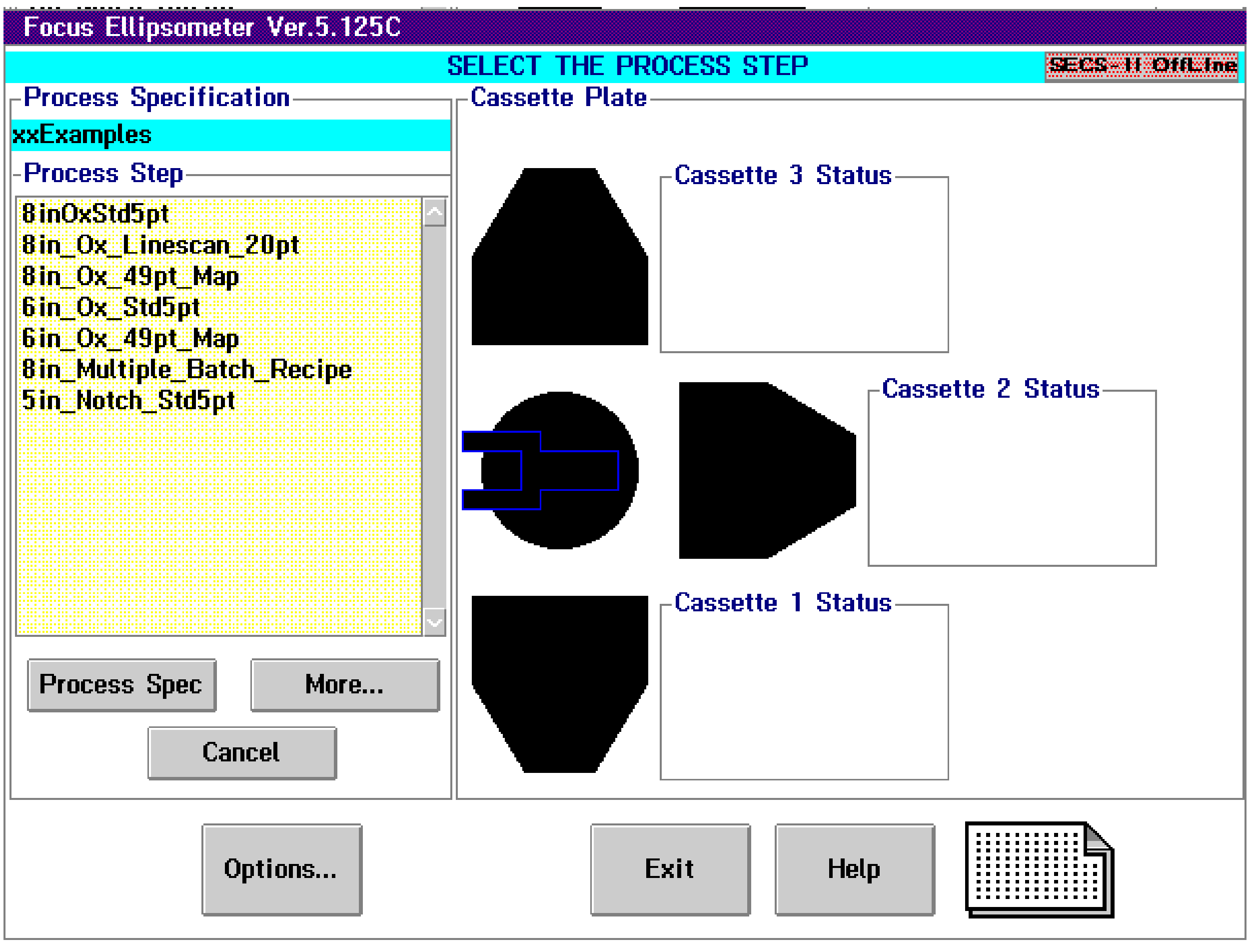


Figure 2-13. Focus Operator Showing Process Step Window

3. Select a **Process Step** from the window list by clicking on the name of the desired Process Step then clicking on the appropriate cassette plate. You may also click on **Process Spec** to return to the Process Specification window to select a different name.

NOTE

Double clicking on a Process Step will cause the system to assign it to the default cassette plate as determined by your system configuration.

If process run parameters **were not deferred**, the selected cassette plate will say **Ready** and a cassette icon will appear to the right of the selected cassette plate. Continue with “Start the Process Run” on page 2–21.

If process run parameters **were deferred**, the Operator will have to input the appropriate parameters. Continue with the next step to enter deferred values.

4. If process run parameters were deferred, the operator must now enter the appropriate parameters (such as transfer specification or map name). A window will be displayed for each of the deferred parameters.

Once all of the deferred process run parameters have been specified, the selected cassette plate will say **Ready** and a cassette icon will appear beside the selected cassette plate. In addition, the selected process specification and process step, the priority of the run, and the Operator name appear in the Cassette Status window beside the selected cassette plate. See Figure 2-14 for a sample screen.

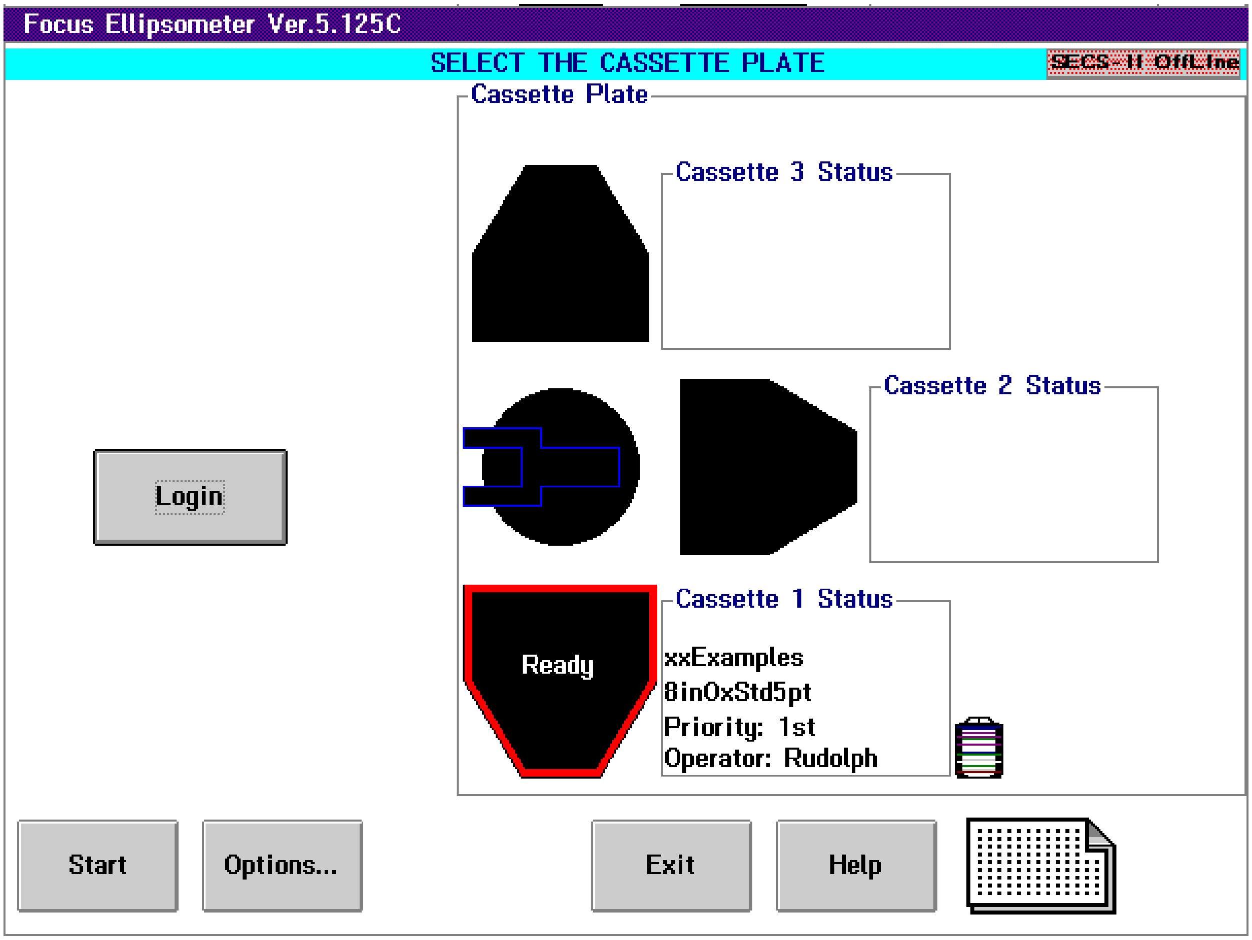


Figure 2-14. Focus Operator Ready to Start Run

NOTE

You may change the selected wafer slots at this time by clicking on the cassette icon located to the right of the cassette plate status window. A Transfer Specification window will be displayed in which you may select some or all of the slots to be measured.

Cancel the Process Run

Once the selected cassette plate says **Ready** and the **Start** button appears, you may cancel out of the process run by clicking one time on the cassette plate.

A confirmation box will appear asking if you wish to clear the process program on the selected cassette plate. Click on **Yes** to clear the program, **No** to return to the Focus Operator screen and continue with the program. Return to Step 1 of "Setting Up a Process Run" on page 2–18 to define a new process to run.

Start the Process Run

When the cassette plate says **Ready** and the **Start** button appears (as shown in Figure 2-14) click on **Start**.

Typically, the Wafer View window is now displayed as shown in Figure 2-15. However, your FE System may have been configured to display either the Cassette View or Data View window.

For a detailed description of the Wafer View, Cassette View, and Data View windows, and of the information that is provided by these windows, refer to “Focus Operator Windows” on page 2–6.

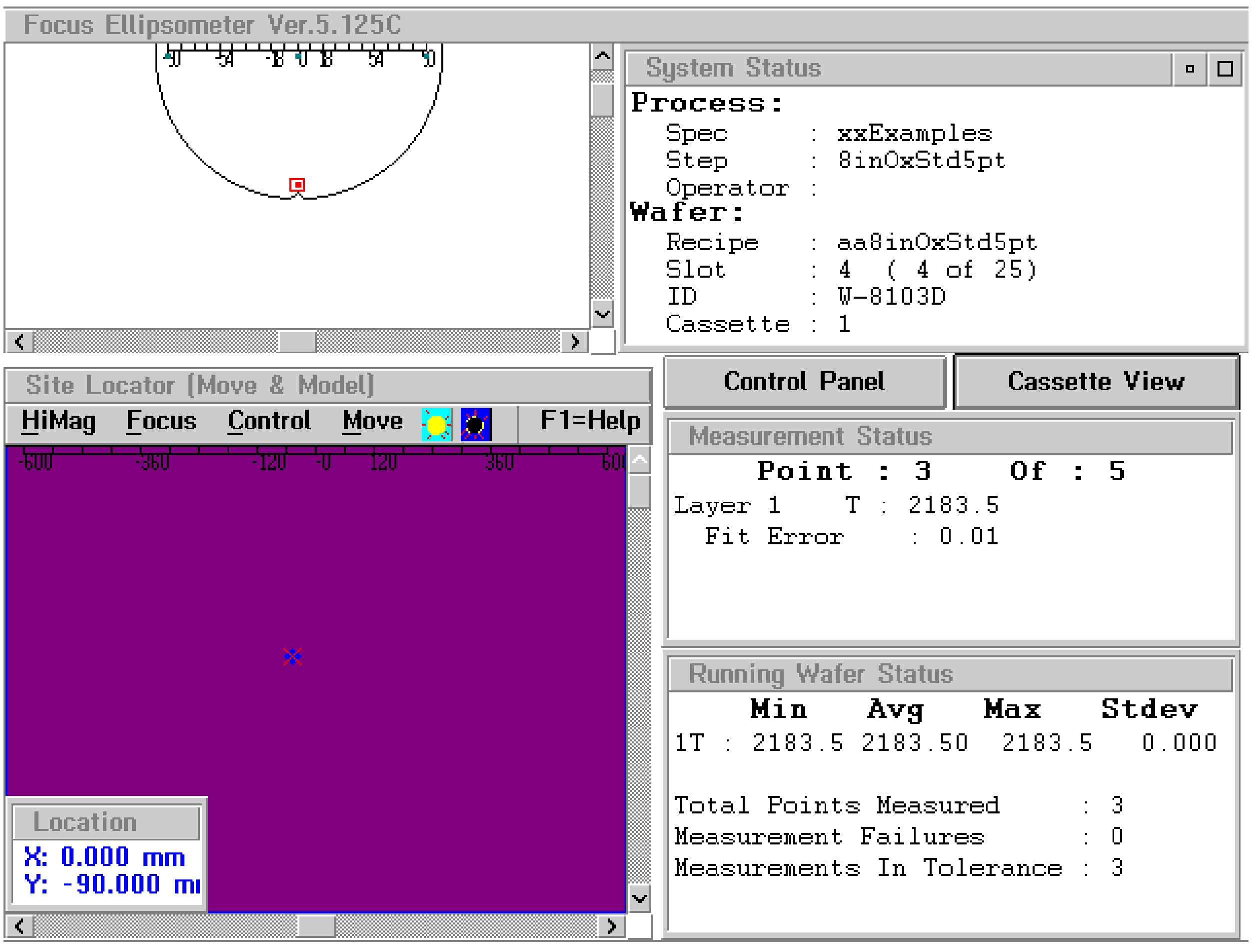


Figure 2-15. Wafer View Window

When the process run has started, from the Wafer View window you will be able to observe the FE System register and center the selected wafer, and then perform the specified measurements as defined by the process specification and steps selected previously.

Upon completion of the process run, the run data is available for retrieval and a screen as shown in Figure 2-16 is displayed.

Process Run Completion

When the process run has completed, the Focus Operator Cassette View window is redisplayed and the cassette plate on which the process was run turns into an icon that says **PRESS FOR DATA**.

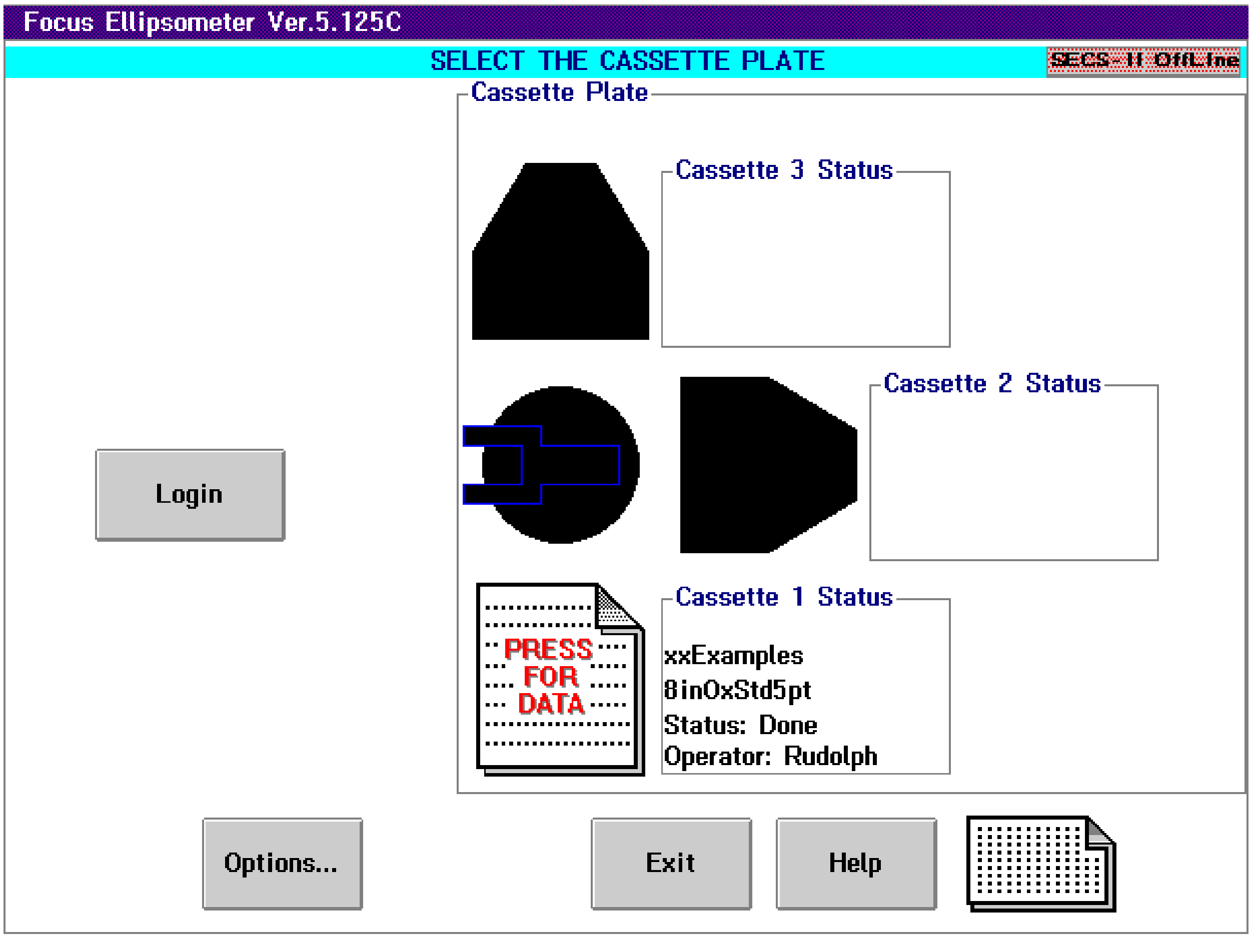


Figure 2-16. Process Run Complete — Press for Data

Click on **PRESS FOR DATA** to view the report from the process run that has just completed. The report data, in text format, is then displayed on the screen.

This report may be printed and/or saved to a file where it may then be imported into a text viewer or spreadsheet.

For more information on data retrieval and report files, refer to "Retrieving Run Data" on page 2–30.

Skipping a Wafer Measurement

While the process is running, it is possible to skip the wafer currently being measured by performing the following:

1. From the Wafer View window (Figure 2-15) click on **Control Panel**.

   The Focus Ellipsometer Control Panel window is displayed as shown in the figure below.

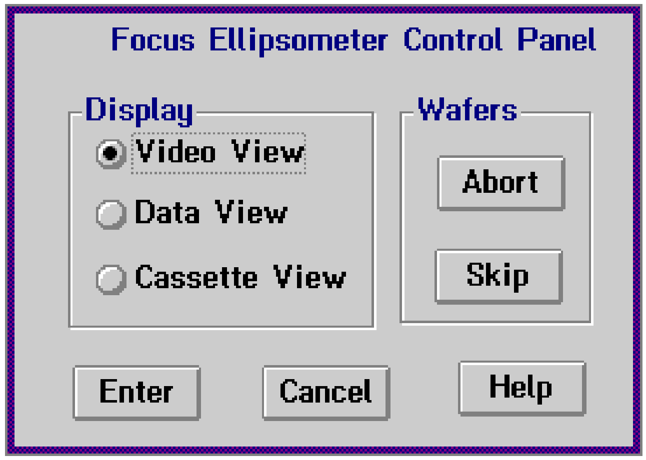


Figure 2-17. Focus Ellipsometer Control Panel Window

2. Click on **Skip** in the **Wafers** section of the Control Panel.

   A message is displayed asking if you wish to skip this wafer.

3. Perform **one** of the following:

   - **To continue the measurements on this wafer**, click on **Cancel**.

     You are returned to the Wafer View window and the measurements continue as programmed.

   - **To skip the measurements on this wafer**, click on **OK**.

     The measurements being performed on the current wafer are terminated and the next wafer (if any) is loaded into the FE System for measurement. If there are additional wafers to be measured after the wafer that was skipped, you are returned to the Wafer View window. If there are no additional wafers to be measured, you are returned to the Focus Operator window and the cassette plate on which the program was running will display **PRESS FOR DATA**.

Aborting a Measurement Session

While the process is running, it is possible to abort the entire session by performing the following:

1. From the Wafer View window (Figure 2-15) click on **Control Panel**.

   The Focus Ellipsometer Control Panel window is displayed as shown in the figure below.

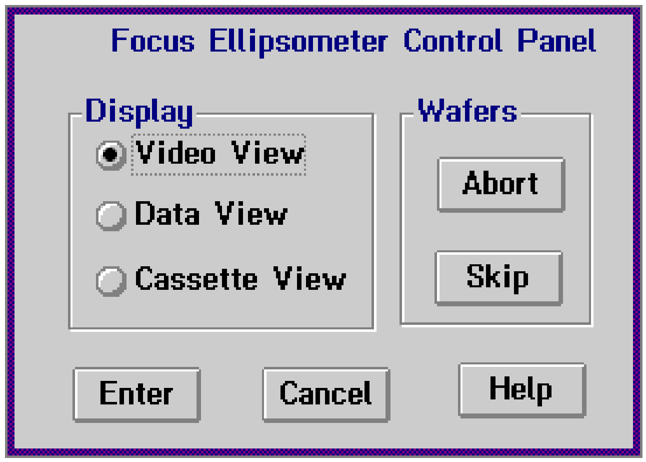


Figure 2-18. Focus Ellipsometer Control Panel Window

2. Click on **Abort** in the **Wafers** section of the Control Panel.

   A message is displayed asking if you wish to abort this process.

3. Perform **one** of the following:

   - **To continue the measurements**, click on **Cancel**.

     You are returned to the Wafer View window and the measurements continue as programmed.

   - **To abort the process**, click on **OK**.

     The remainder of the measurement program is terminated and you are returned to Focus Operator window. The cassette plate on which the program was running will display **PRESS FOR DATA**.

Setting Up Queued Loading

If the queued loading option has been enabled on your FE System, the Focus Operator program allows "queuing" of one or two additional cassette(s) of wafers (depending upon the configuration of your FE System) while a current cassette is running. This allows uninterrupted measurements, thus increasing overall system throughput.

Cassettes may be queued either prior to starting the first process run or while a process is already running.

Queuing Multiple Cassettes Prior to Starting the Run

To queue up multiple cassettes prior to starting the first run, use the following procedure:

1. Set up the process run for the first cassette following the instructions provided in "Setting Up a Process Run" on page 2–18 of this manual but DO NOT press **Start** after the cassette plate indicates **Ready**.

2. Set up the process run for the second and/or third cassette also by following the instructions provided in "Setting Up a Process Run" on page 2–18 of this manual.

3. Once each of the cassettes have been set up, the Focus Operator Cassette View window shows which cassette plates are ready and the run information for each cassette. Figure 2-19 shows an example of the Cassette View screen with two cassettes queued and ready to run their programs.

NOTE

The Priority: number in the cassette status window indicates the order in which the cassettes will be processed.

4. Press **Start** to begin wafer measurements.

   The Wafer View window is displayed as shown in Figure 2-15.

5. Once the run has completed on all cassettes, the data is available for review. Proceed to "Queued Run Completion" on page 2–29.

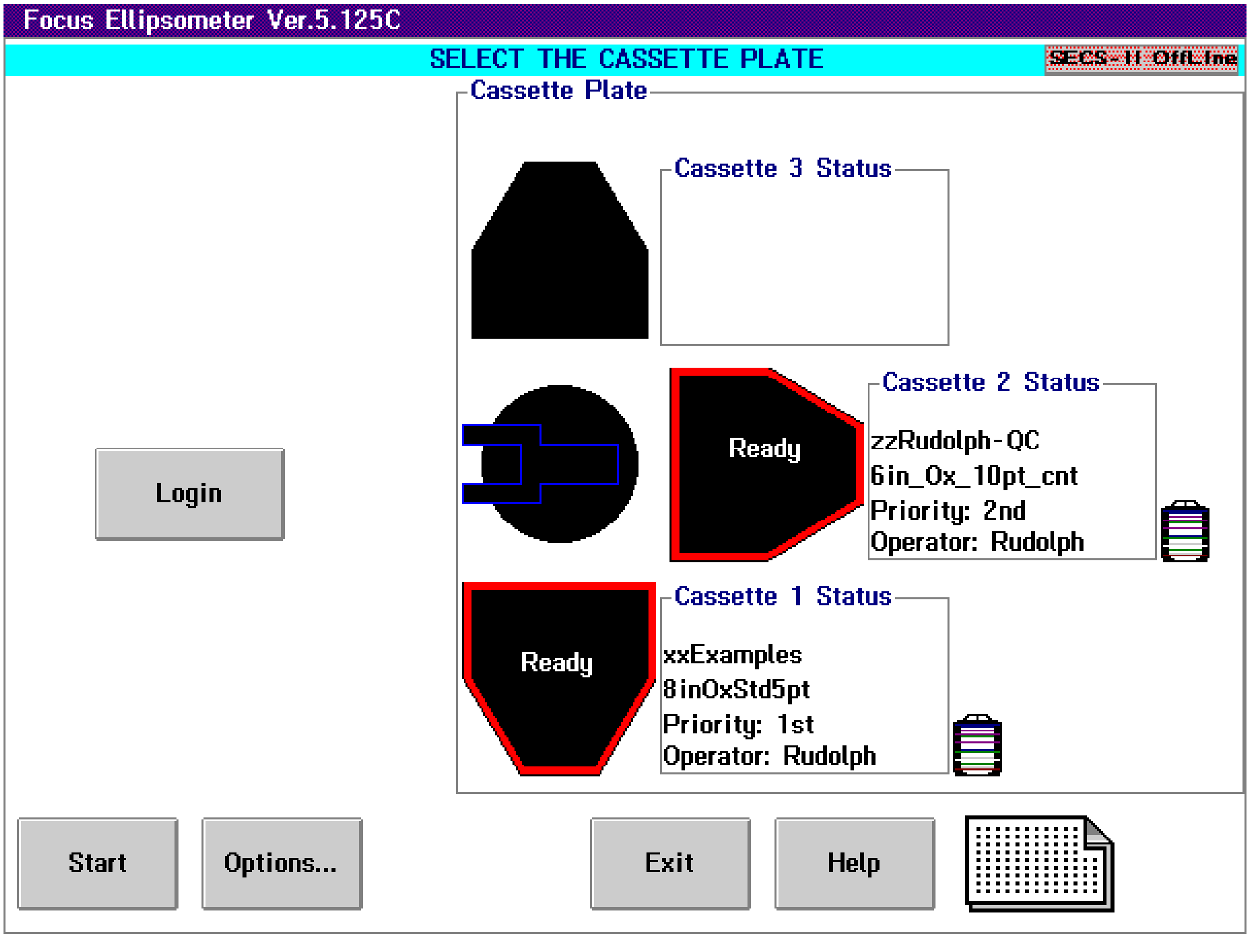


Figure 2-19. Focus Operator — Two Cassettes Queued to Run

Queuing Another Cassette While a Run is in Progress

To queue up another cassette while a program is running on the first cassette, perform the following:

1. In the Wafer View window click on the **Cassette View** button.

   The Focus Operator Cassette View window is displayed as shown in Figure 2-20.

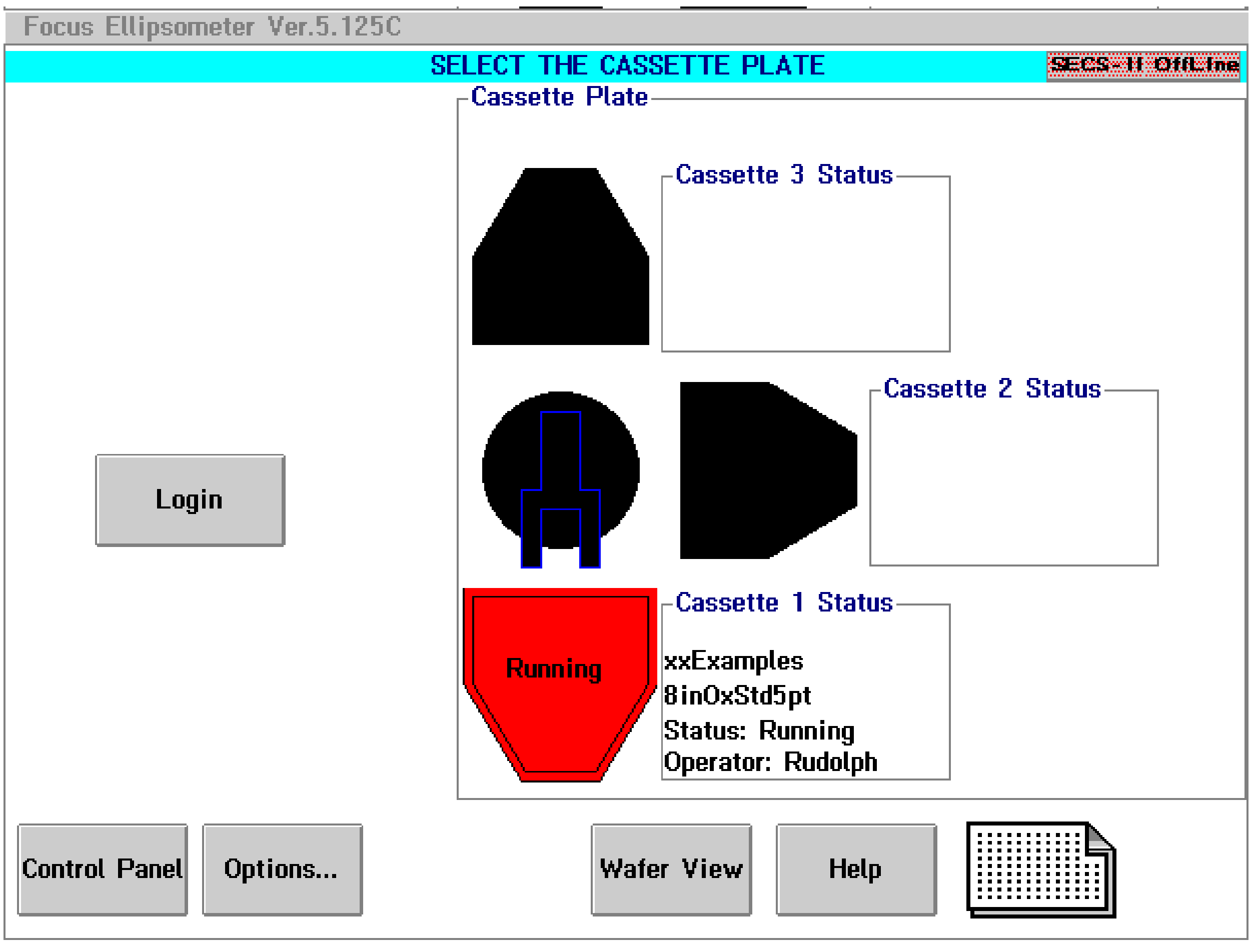


Figure 2-20. Focus Operator — One Cassette Running, None Queued

2. If Focus Operator Login is required, log in using the procedure in “Starting Focus Operator and Logging In” on page 2–2. If Operator Login is not required, continue with the next step.

3. Set up the process run for the second and/or third cassette by following the instructions provided in “Setting Up a Process Run” on page 2–18 of this manual.

   The Focus Operator Cassette View window will now display the information for the cassette that is currently running, as well as the cassette that is queued (as shown in Figure 2-21).

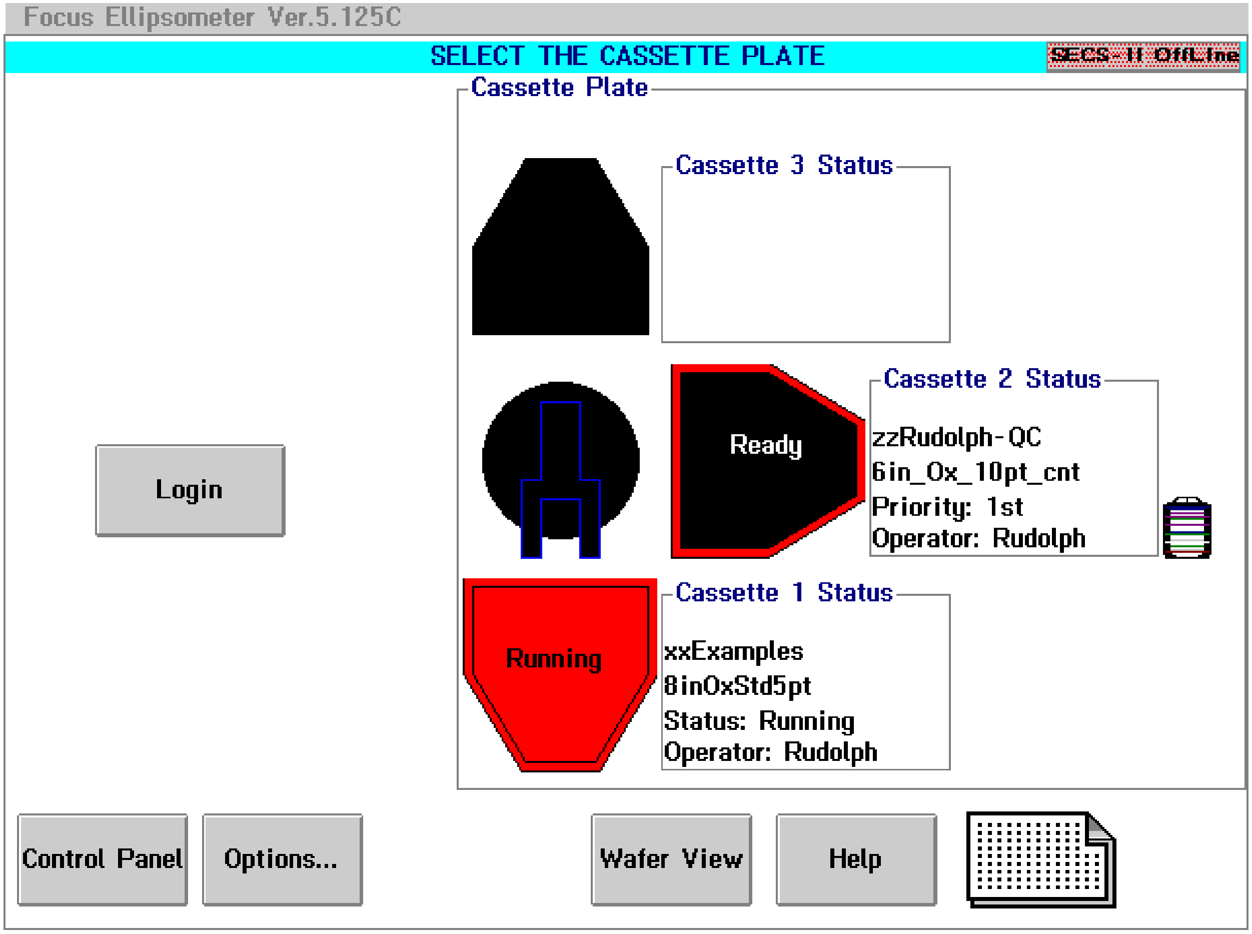


Figure 2-21. Focus Operator — One Cassette Running, One Queued

4. You may either remain in the Cassette View window or return to the Wafer View window by clicking on the **Wafer View** button.

5. Once the run has completed on all cassettes, the data is available for review. Proceed to "Queued Run Completion" on page 2–29.

Queued Run Completion

When the process runs have completed, the Focus Operator Cassette View window is redisplayed and the cassette plates on which the processes were run turn into an icon that says **PRESS FOR DATA**.

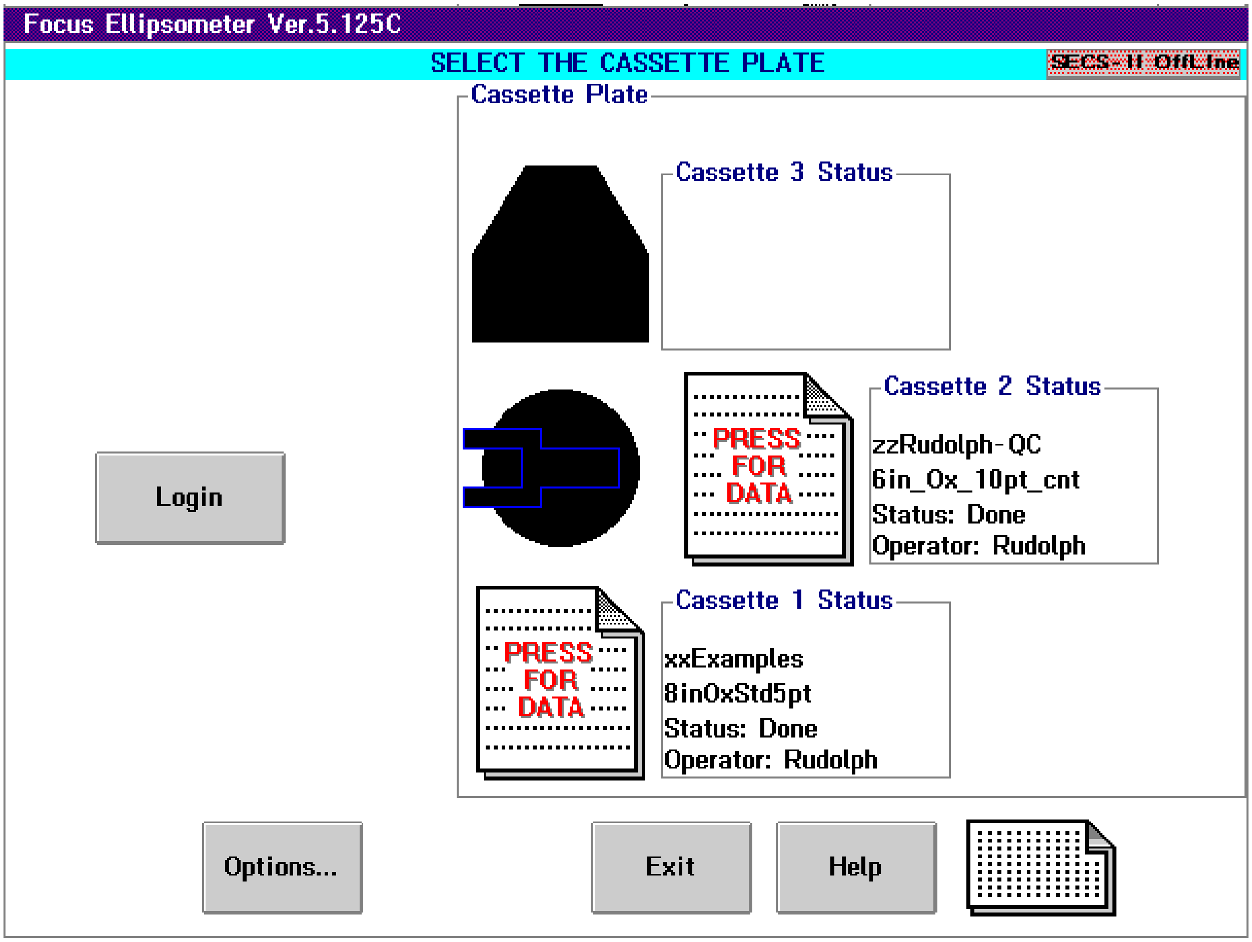


Figure 2-22. All Runs Complete — Press for Data

Click on **PRESS FOR DATA** on one of the cassette plates to view the report from the process run that has just completed. The report data, in text format, is then displayed on the screen.

This report may be printed and/or saved to a file where it may then be imported into a text viewer or spreadsheet.

Click on **PRESS FOR DATA** on the other cassette plates as required to view the report for the process that has just completed on that cassette.

For more information on data retrieval and report files, refer to “Retrieving Run Data” on page 2–30.

Retrieving Run Data

After each process run, a data file (or report) is generated by the FE System for that run. The data in the report is available for viewing on-line either immediately after the completion of the run, or from the history log file. The reports may then be saved as a text file and/or printed directly to the printer connected to the FE System.

Figure 2-23 illustrates the two icons on the Focus Operator Cassette View window that may be used for data retrieval:

- The “PRESS FOR DATA” Icon — Used to view the data associated with the measurements just completed on that cassette plate.
- The History Log File Icon — Used to call up a history log which lists the reports available for viewing on the system.

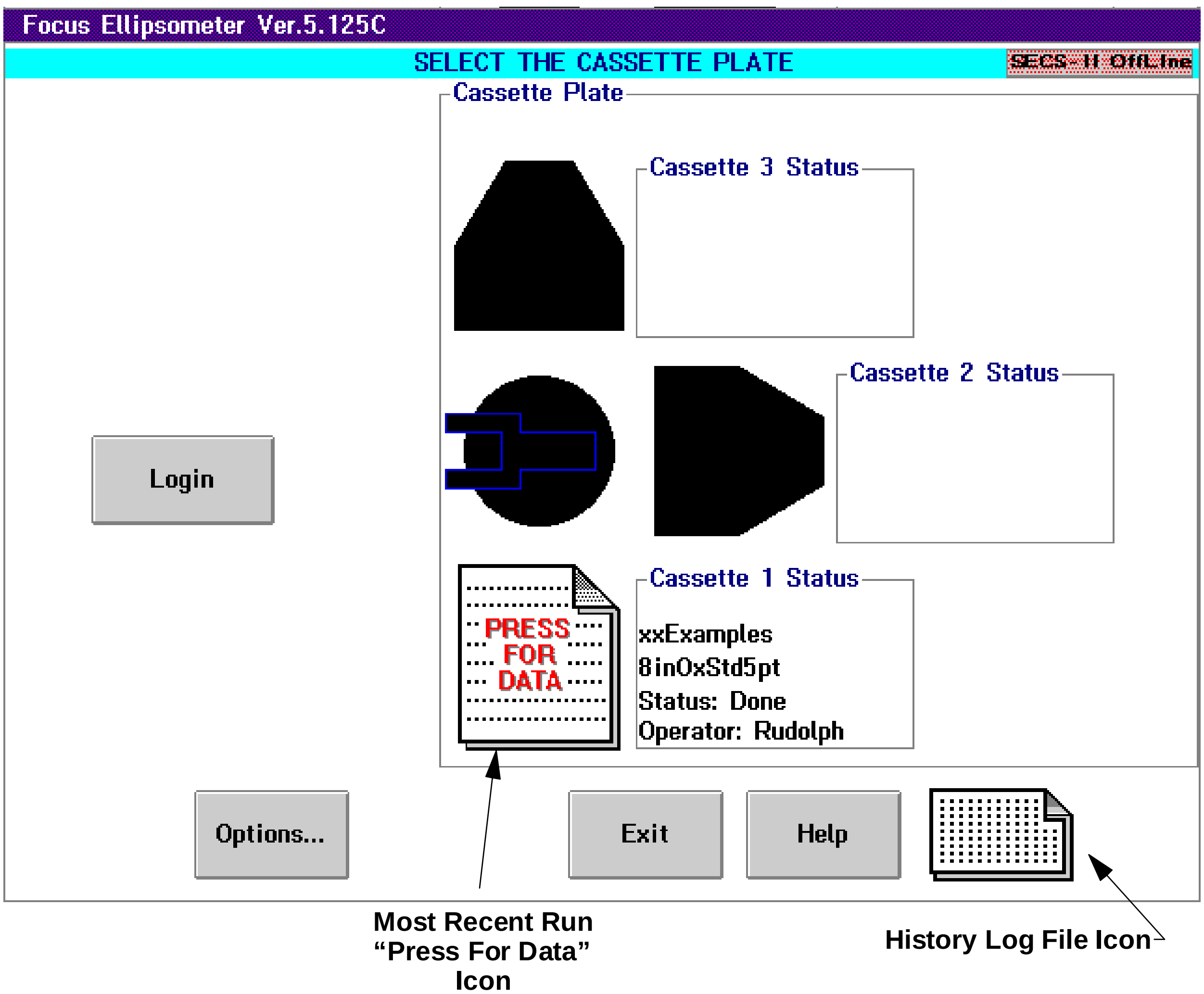
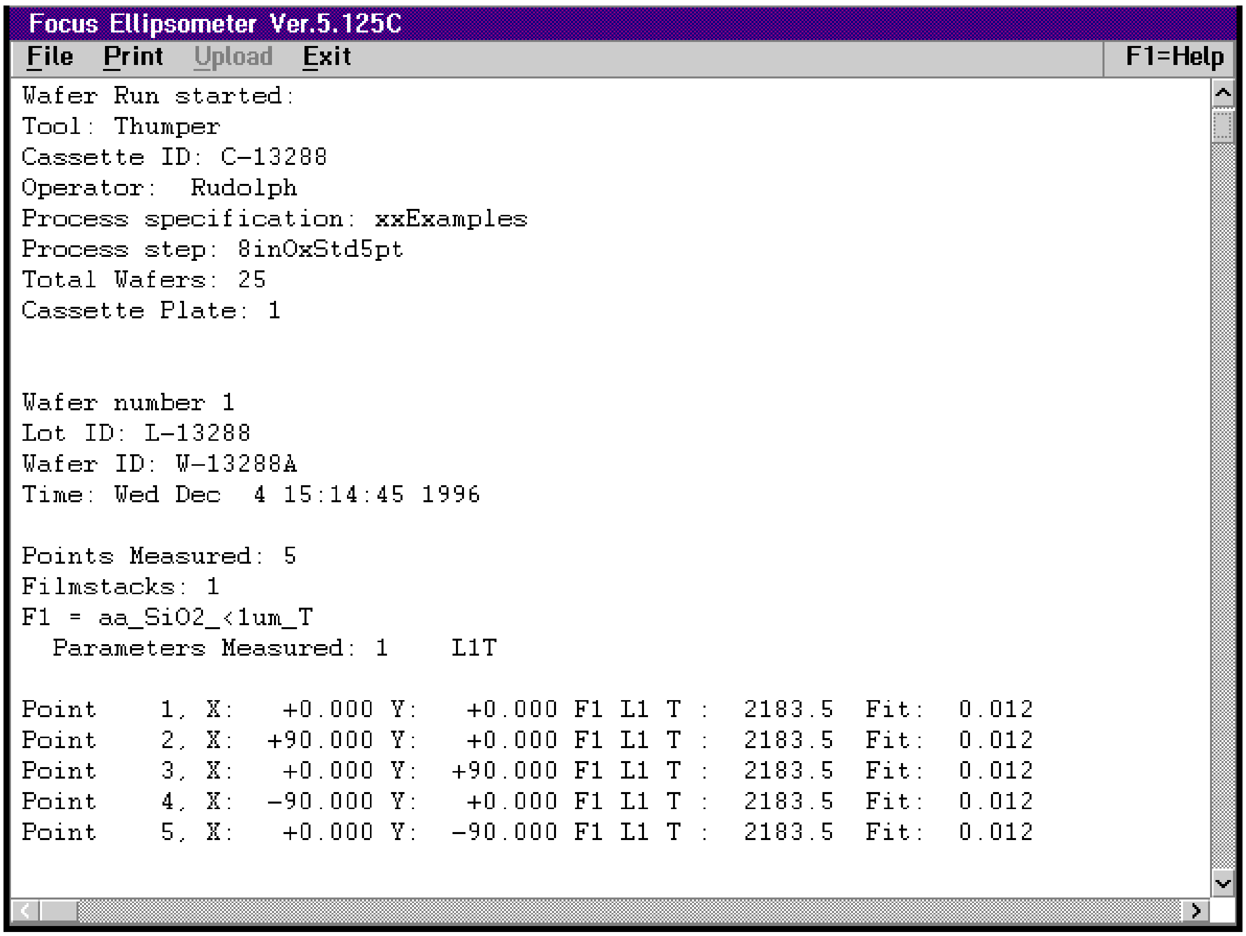


Figure 2-23. Cassette View Window Data Retrieval

Accessing Current Run Data

Upon completion of the measurements programmed for a process, the **PRESS FOR DATA** icon appears over the cassette plate on which the process was run, as shown in Figure 2-23.

Clicking on the **PRESS FOR DATA** icon will display a report consisting of the data associated with the measurements just completed. A sample of a report is shown in Figure 2-24 below. The data that makes up the report is explained in greater detail in “Sample Report Data” on page 2–34.




```
Wafer Run started:
Tool: Thumper
Cassette ID: C-13288
Operator:  Rudolph
Process specification: xxExamples
Process step: 8inOxStd5pt
Total Wafers: 25
Cassette Plate: 1


Wafer number 1
Lot ID: L-13288
Wafer ID: W-13288A
Time: Wed Dec  4 15:14:45 1996

Points Measured: 5
Filmstacks: 1
F1 = aa_SiO2_<1um_T
  Parameters Measured: 1    L1T

Point    1, X:   +0.000 Y:   +0.000 F1 L1 T :  2183.5  Fit:  0.012
Point    2, X:  +90.000 Y:   +0.000 F1 L1 T :  2183.5  Fit:  0.012
Point    3, X:   +0.000 Y:  +90.000 F1 L1 T :  2183.5  Fit:  0.012
Point    4, X:  -90.000 Y:   +0.000 F1 L1 T :  2183.5  Fit:  0.012
Point    5, X:   +0.000 Y:  -90.000 F1 L1 T :  2183.5  Fit:  0.012
```

Figure 2-24. Sample Report File (Partial)

When you have finished viewing the report on-line, you may:

- Save the data in the report to a text file by clicking on the **File** menu, then clicking on **Save As**. Enter the desired destination path and filename in the dialog box that is displayed and click on **Enter**.

  The data is saved in the specified file and may be imported into a text editor or spreadsheet.

- Print the report to the printer that is connected to the FE System by clicking on the **Print** menu item. Ensure that the printer is connected, is turned on, and is on-line.

- Upload the data to a host by clicking on the **Upload** menu item. The SECS-II interface must be on-line.

- Quit the report viewer by clicking on the **Exit** menu item. This exits the report viewer, however the data contained in the report still resides on the FE System in the history log file.

  Quitting the report viewer returns you to the Focus Operator Cassette View window.

Accessing Previously Run Data (History Log)

The FE System maintains a history log of previously run data. The number of reports that will be saved in the history log is determined by your system setup. Typically, the default is 10.

CAUTION

If the FE System history log file already contains the maximum number of reports and another measurement run is performed, the new report is saved in the history log file and the oldest report in the history log file is removed.

To access the history log file:

1. Click on the **History Log File** icon (as shown in Figure 2-23).

   The History Log File Selection window is displayed as shown in the figure below. This selection window shows all of the reports currently saved in the history log, the date and time the measurement run was completed, the Operator who ran the process, as well as the process specification and step used to perform the measurements.

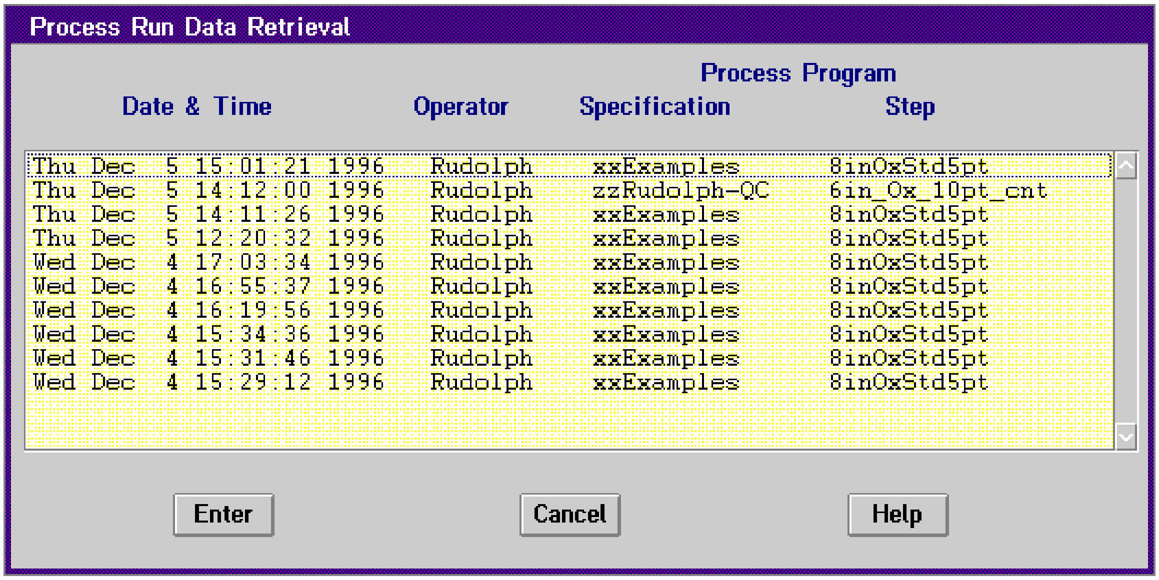


Figure 2-25. History Log File Selection

2. Click on the desired report and then click on **Enter**, or double click on the report.

   The selected report is displayed similar to the sample report shown in Figure 2-24. The data that makes up the report is explained in greater detail in “Sample Report Data” on page 2–34.

Once the report is displayed on the screen, you may:

- **Save the data in the report to a text file** by clicking on the **File** menu, then clicking on **Save As**. Enter the desired destination path and filename in the dialog box that is displayed and click on **Enter**.

  The data is saved in the specified file and may be imported into a text editor or spreadsheet.

- **Print the report to the printer** that is connected to the FE System by clicking on the **Print** menu item. Ensure that the printer is connected, is turned on, and is on-line.

- **Upload the data to a host** by clicking on the **Upload** menu item. The SECS-II interface must be on-line.

- **Quit the report viewer** by clicking on the **Exit** menu item. This exits the report viewer, however the data contained in the report still resides on the FE System in the history log file.

  Quitting the report viewer returns you to the Focus Operator Cassette View window.

Sample Report Data

This section provides a brief description of the information that makes up a report file.

Figure 2-26 provides a sample of a basic report file.

```
1   Wafer Run started:
    Tool: Focus
    Cassette ID: C-13288
    Operator:  Rudolph
    Process specification: xxExamples
    Process step: 8inOxStd5pt
    Total Wafers: 25
    Cassette Plate: 1

2   Wafer number 1
    Lot ID: L-13288
    Wafer ID: W-13288A
    Time: Wed Dec  4 15:14:45 1996

3   Points Measured: 5
    Filmstacks: 1
    F1 = aa_SiO2_<1um_T
      Parameters Measured: 1    L1T

4   Point   1, X:   +0.000 Y:   +0.000 F1 L1 T :  2183.5  Fit:  0.012
    Point   2, X:  +90.000 Y:   +0.000 F1 L1 T :  2183.5  Fit:  0.012
    Point   3, X:   +0.000 Y:  +90.000 F1 L1 T :  2183.5  Fit:  0.012
    Point   4, X:  -90.000 Y:   +0.000 F1 L1 T :  2183.5  Fit:  0.012
    Point   5, X:   +0.000 Y:  -90.000 F1 L1 T :  2183.5  Fit:  0.012

5   Wafer Statistics
    F1 L1 T : Avg 2183.50 Min  2183.5 Max  2183.5 Std. Dev   0.000

6   Wafer number 2
    Lot ID: L-13288
    Wafer ID: W-13288B
    Time: Wed Dec  4 15:14:47 1996

          .
          .
          .

    End Of Report
```

Figure 2-26. Sample Report File

1. Provides information associated with the process. Information includes: the cassette ID, the Operator that performed the measurements, the process specification and step used for the measurements, the total number of wafers that were measured, and the cassette plate used.

2. Provides information specific to the particular wafer being measured. Information includes: the wafer slot number, the lot ID and wafer ID of the wafer, and the date and time the measurement of this wafer was performed.

3. Provides information on the measurement parameters for the wafer. Information includes: the number of points measured, the filmstack used, and which parameters were measured. In the example shown in Figure 2-26, the **aa_SiO2_<1um_T** filmstack was used to measure layer 1 thickness of the oxide at five points across the wafer.

4. Provides information on each individual measurement point on the wafer. Information includes: the X and Y coordinate of the point on the wafer, the filmstack used, the parameters that were measured at the point, and the measurement information and fit error for each point on the wafer.

5. Provides overall wafer statistics including: the average, minimum, and maximum measurements for the wafer as well as the standard deviation of the measurements. Warnings may also be displayed here if any (or all) of the data is out of tolerance.

6. Provides information as stated above for each additional wafer in the run (if applicable).

Creating a Wafer Map

The FE System has the capability of creating contour and topographical (3D) maps of a wafer. In addition, etch rate and difference maps may also be created.

Each of the wafer maps may be displayed in black and white, greyscale, or color.

To create and view a new wafer map, perform the following:

1. Setup the wafer cassette and select a process specification and process step, and select the wafer slot(s) (if the slot numbers were deferred) using the instructions provided in "Setting Up a Process Run" on page 2–18.

NOTE

Select a process step that is configured to generate map data (such as, 8in_Ox_49pt_Map).

If the wafer map name was deferred, the Wafer Map Name window is displayed as shown in the figure below.

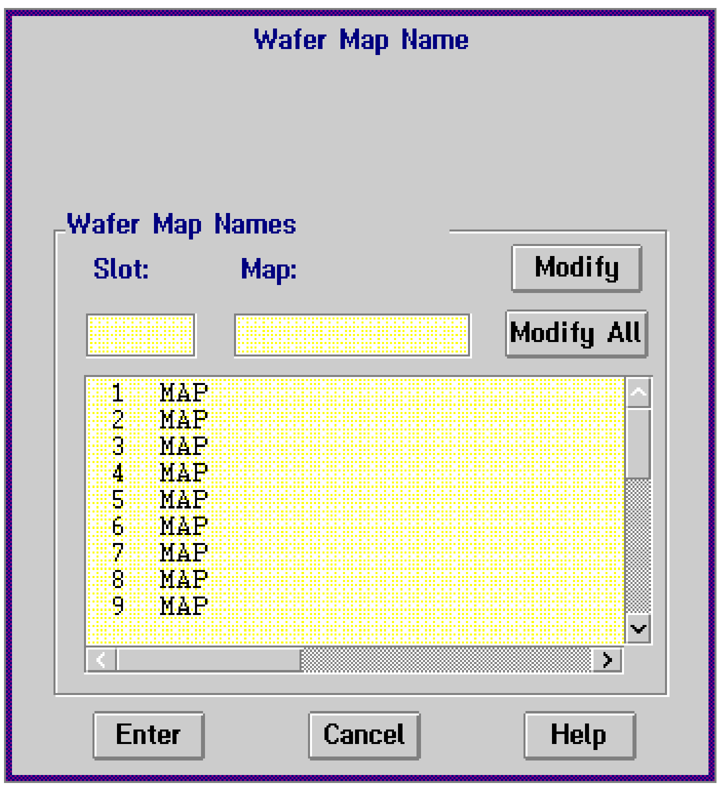


Figure 2-27. Wafer Map Name Window

2. Double click on a map name, or click once on the desired name and click on **Modify**.

   The selected slot and map appear in the **Slot:** and **Map:** fields.

3. Enter a new map name by typing over the information in the **Map:** and/or **Slot:** fields

CAUTION

If you do not enter a new map name, the system will use the default map name (such as, map.1 for a map of the wafer in slot 1). If a file with the specified name already exists, it will be overwritten.

4. Click on **Modify** to change just the one map name or click on **Modify All** to change the name of all of the wafer maps to same name with the slot number as the file suffix.

   The new map name(s) appear in the Wafer Map Name window.

5. If you are specifying individual names for each wafer map (that is, clicking on **Modify** after entering the map name), repeat Steps 3 and 4 for each of the wafer maps until all map names have been entered.

6. Once all of the map names have been modified, click **Enter**.

   The Cassette View window is displayed and the selected cassette plate says **Ready**.

7. Click **Start** to begin measuring the wafer(s) and creating the wafer maps.

   The Wafer View window is displayed and the measurements are performed on the selected wafers. Once all of the measurements are complete, the Cassette View window is displayed and the cassette plate on which the program was run will indicate **PRESS FOR DATA**.

8. Click on **PRESS FOR DATA** to view the measurement data. Print and/or save the information as desired using the instructions found in “Retrieving Run Data” on page 2–30.

9. Click on **Exit** to close the report viewer window.

   The Cassette View window is displayed.

10. Follow the procedure in “Accessing Wafer Mapping” on page 2–38 to view the newly created wafer map.

Accessing Wafer Mapping

To view a wafer map, perform the following:

1. Click on the **Options** button in the Cassette View window.

   The Options window is displayed as shown in Figure 2-28.

NOTE

The appearance of the Options window will vary depending upon the configuration of your FE System.

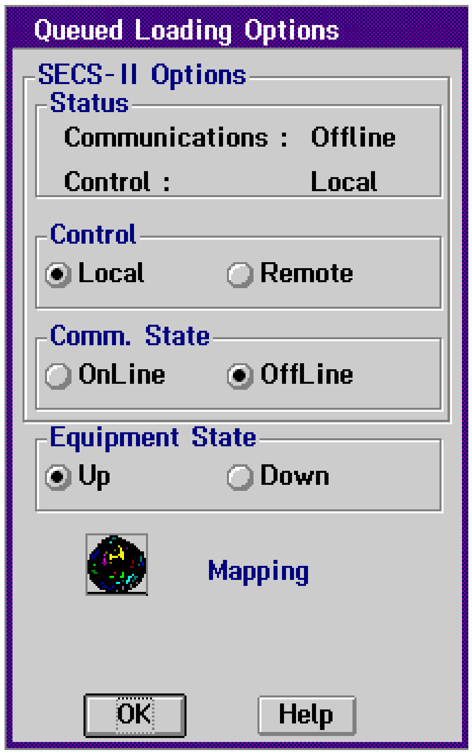


Figure 2-28. Queued Loading Options Window

2. Click on the icon that appears beside **Mapping**.

   The Mapping software is started and a Map File Selection window is displayed as shown in Figure 5-3 on page 5–6 of this guide. For information on viewing wafer maps and using the wafer mapping software, refer to Chapter 5, “Wafer Mapping and Data Reporting”.

Logging Out and Exiting Focus Operator

To log out and exit the Focus Operator Queued Loading program, perform the following procedure:

1. On the Focus Operator Interface screen, click on **Exit**.

   If Login Exit **has not been** enabled on your FE System, the Focus Operator Queued Loading program will exit and you will be returned to the OS/2 desktop.

   If Login Exit **has been** enabled on your FE System, a list of the names that are available on your system is displayed as shown in Figure 2-3.

2. Select a name by clicking the left trackball button on the desired name and then clicking on **Enter**, or by double clicking the left trackball button on the name.

   NOTE

   The name selected must have Engineer or Supervisor level privileges. Users with Operator level privileges may not exit the Focus Operator Queued Loading program.

   The Focus Operator Password Entry dialog box is displayed as shown in Figure 2-4.

3. Enter the password and press **Enter**, or click on **OK**.

   NOTE

   For security reasons, asterisks (*) will be displayed as you enter your password.

   The Focus Operator Queued Loading program will exit and you will be returned to the OS/2 desktop.

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Developing Film Applications

Chapter 3

Introduction

The purpose of this chapter is to provide information on how to develop and test filmstack models for use in wafer measurements. Basic theory and algorithms are also provided. The information in this section pertains to the FOCUS Ellipsometer (FE) III, IV, and VII systems, and includes the following topics:

- Describe the basics of the film application development cycle, to include:
  - The elements that make up a filmstack
  - Rudolph supplied filmstacks
  - Film parameter computation
- How to log in, use, and exit the Focus Interactive program.
- Describe the components that make up the Focus Interactive program.
- How to develop filmstacks, to include:
  - Creating and testing new filmstacks
  - Copying and editing existing filmstacks
  - Testing filmstacks and performing sample wafer measurements
- How to log measurements
- How to E-mail data and measurement fax printouts to Rudolph Applications Support.
- Sample applications by Fab Area using the FE System, including: Diffusion, Etch, CVD, and CMP applications.

The tasks described in this chapter are performed with the use of the Focus Interactive program. This is the program that allows the Process Engineer to develop and test filmstack models that are used in the creation of wafer recipes and process specifications run by the Operator.

Introduction to Film Application Development

The FOCUS System provides a simple and straight forward method for application development. Standard materials can be easily arranged into layers to produce filmstacks. Parameters such as thickness (**T**), refractive index (**N**), and extinction coefficient (**K**) can be calculated for these layers.

NOTE

These parameters, as well as the theory behind focus ellipsometry, are explained in greater detail in Appendix E, "Theory of Operation".

The application development cycle begins with some knowledge of the film being measured. The Engineer creates a filmstack to represent the films on the wafer. The filmstack can be used to make test measurements of a real wafer and gauge the ellipsometer's capability for the particular application. Once a film application is verified, a recipe can be created and run to complete the application.

Figure 3-1 shows a basic block diagram of the filmstack development and testing process for the measuring of film layers.

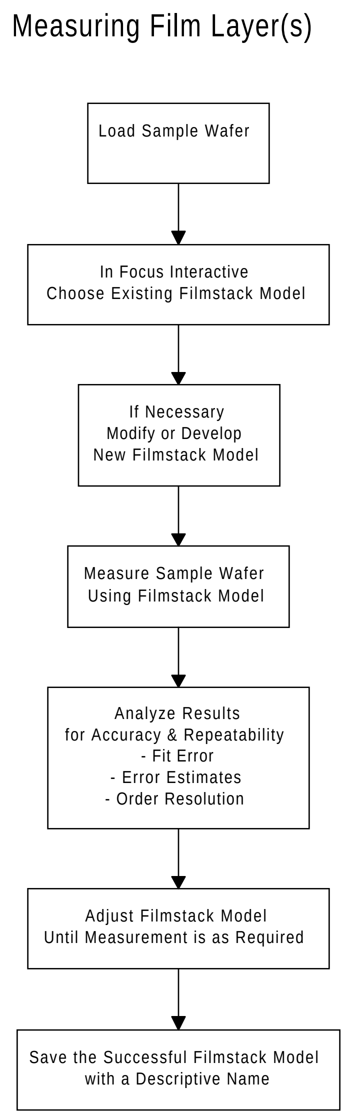

Figure 3-1. Measuring Film Layers Flow Diagram

Unlike traditional single angle of incidence ellipsometers, the FE System measures at multiple angles of incidence simultaneously. The parameters actually measured by ellipsometry are called the ellipsometric angles Δ and Ψ (Delta and Psi). Mathematical relations of these angles to thickness, refractive index and the extinction coefficient are brought together by construction of a filmstack model. The model acts as a representation of the physical filmstack that is to be measured.

Using the Focus Interactive program, a filmstack model is constructed layer by layer, just as a wafer's actual filmstack is constructed layer by layer. The layers act as the building blocks of the completed filmstack.

Filmstacks are the interface between the user and the computation routine (algorithm). The parameters that describe a wafer are contained in the filmstacks. The descriptive parameters, and the film parameters to be calculated can be changed when the filmstack creation window is open.

When creating a new application, the filmstack is made first, then tested by measuring the wafer to which the filmstack applies. The first measurement should reveal whether or not the desired results can be obtained. It may be necessary to adjust some variables before the desired results are obtained.

After the results of the first measurement have been analyzed, the filmstack is revised to improve the expected results, and the wafer is measured again. This loop continues until no further improvement can be achieved (or the required results are obtained), then the filmstack is saved.

The Focus Interactive program is used by Process Engineers to set up and test filmstacks to determine the best model to use for a given measurement point. The Rudolph supplied filmstacks provide a comprehensive library of filmstack models that can be used directly with little or no changes. However, new filmstacks may be easily created by the Engineer to suit a particular application. The procedures provided in this chapter will aid you in creating and modifying filmstacks, though you may wish to contact Rudolph Applications Support for additional assistance.

Starting Focus Interactive and Logging In

To start the Focus Interactive program, perform the following procedure:

1. Position the trackball pointer over the Focus Interactive icon, located in the Focus Ellipsometer folder, and double click the left trackball button.

   If your FE System **does not require** a Login for the Focus Interactive program, the Focus Interactive main window is displayed as shown in Figure 3-2.

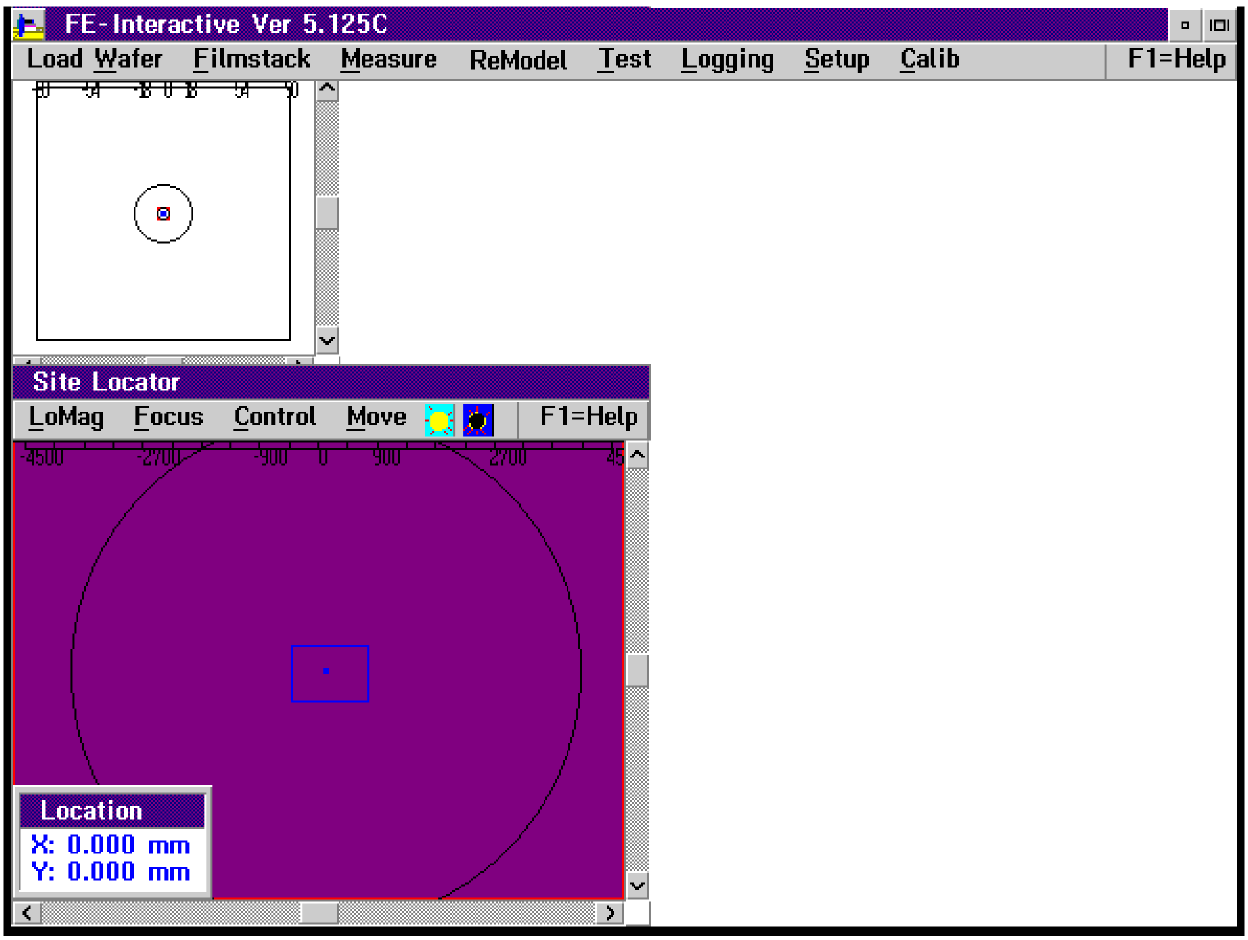

Figure 3-2. Focus Interactive Main Window

If your FE System is configured to **require** a Login for the Focus Interactive program, a list of the login names that are available on your system is displayed as shown in Figure 3-3. Continue the procedure with Step 2.

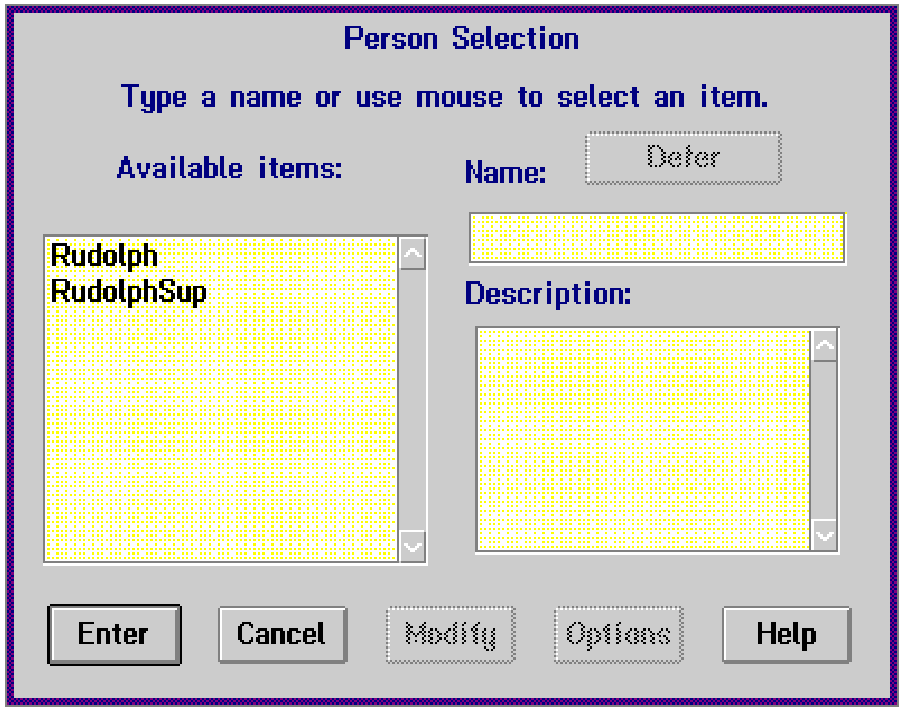

Figure 3-3. Focus Interactive User Login Selection

2. Select a login name by clicking the left trackball button on the desired name and then clicking on **Enter**, or by double clicking the left trackball button on the name.

NOTE

If you click on the Cancel button, or if the login name selected does not have a high enough privilege level, the Focus Interactive program will exit and you are returned to the OS/2 desktop view.

The Password Entry dialog box is displayed as shown in Figure 3-4.

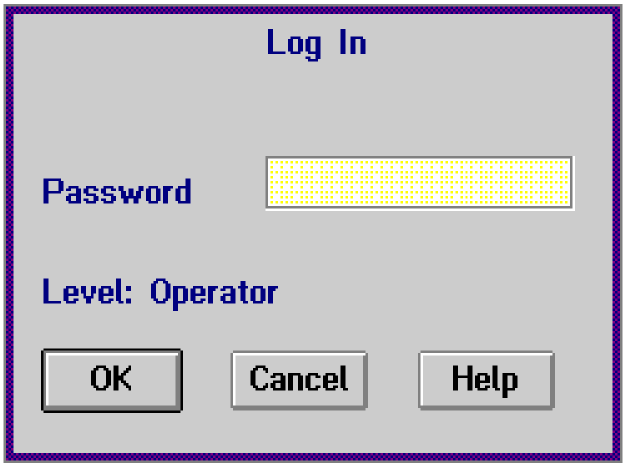

Figure 3-4. Focus Interactive Password Entry

3. Enter your password and press **Enter**, or click on **OK**.

NOTE

For security reasons, asterisks (*) will be displayed as you enter your password.

The Focus Interactive main window is displayed as shown in Figure 3-2.

Focus Interactive Main Window

The Focus Interactive main window is divided into the following areas: the Wafer View, Site Locator (including the Location information window), Filmstack, and Calculated Parameters area.

These areas are described in the sections that follow.

NOTE

Only the Wafer View and Site Locator areas are available when Focus Interactive first starts up. The Filmstack Model and Calculated Parameters areas are available as filmstacks are being created and measurements are being taken.

Wafer View Area

The Wafer View area provides a graphical representation of the wafer. It may be used to move around on the wafer by using the scroll bars or by double clicking the right trackball button directly on a spot on the wafer.

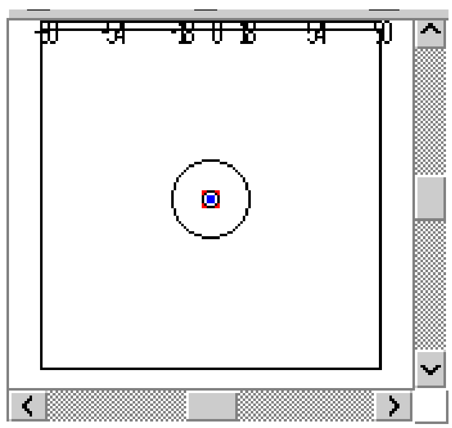

Figure 3-5. Focus Interactive Wafer View Element

Site Locator Area

Also called the Live Video window, this window shows a live video image of the wafer surface as it appears in the FE System. It may also be used to move around on the wafer by using the scroll bars or by double clicking the right trackball button directly on a spot on the wafer. The small blue spot in the window indicates where the laser is focused on the wafer.

The Location information in the Site Locator area shows the X and Y coordinates for the location on which the laser is currently focused.

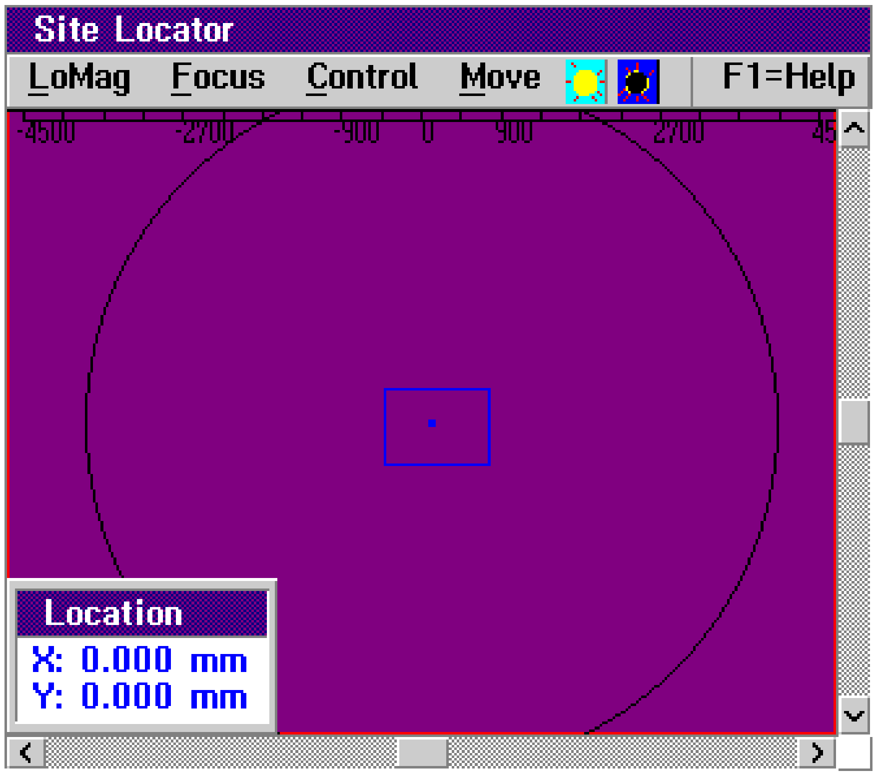

Figure 3-6. Focus Interactive Site Locator Element

Site Locator Menu

The Site Locator area also consists of the following menu selections:

- **HiMag/LoMag** — Indicates whether the live video image is in High Magnification or Low Magnification mode. Clicking on this menu item toggles between the two modes. The field of view in the Site Locator window in HiMag is .54mm x .72mm (FE VII) or .9mm x 1.2mm (FE III and IV). The field of view in LoMag is 5.4mm x 7.2mm (FE VII) or 7mm x 9mm (FE III and IV).

- **Focus** — Clicking on this menu item will focus the laser spot to a point. When measurements are performed, focus is automatically performed.

- **Control** — Clicking on this menu item displays the Control menu. This menu consists of the following items:
  - **Mag —** Consists of the following items: **Wafer View** displays the wafer view in the site locator window, **Low Mag** causes the microscope to switch to low magnification mode, **High Mag** causes the microscope to switch to high magnification mode. The Low Mag and High Mag items are functionally the same as the HiMag/LoMag items on the menu bar.
  - **Zoom** — Consists of the following items: **One Quarter** reduces the Site Locator window to one quarter size, **One Half** displays the Site Locator window at half size (default), **One X** displays the Site Locator window on the full screen.
  - **Live Off/Live On** — Toggles between turning the live video view on and off in the Site Locator window.
  - **Laser Off/Laser On** — Toggles the laser on and off. The laser must be on in order to make measurements.
  - **Illumination** — Allows you to set the illumination intensity of the microscope lamp.
- **Move** — The items in this menu provide alternate methods for moving the wafer so that the laser spot is positioned over the desired location. The following options are available:
  - **Keyboard** — Prompts you to enter the X and Y coordinates of the desired location on the wafer. Make the appropriate entry and click on **Enter** to move to the selected spot.
  - **Center** — Moves the wafer so that the laser is located over the center of the wafer.
  - **Left** — Moves the wafer so that the laser is located at the left outer edge of the wafer.
  - **Right** — Moves the wafer so that the laser is located at the right outer edge of the wafer.
  - **Top** — Moves the wafer so that the laser is located at the top outer edge of the wafer.
  - **Bottom** — Moves the wafer so that the laser is located at the bottom outer edge of the wafer.
- **Light/Dark Icons** — Located to the right of the **Move** menu, clicking on these icons allow you to change the illumination intensity of the microscope lamp.

Filmstack Model Area

Displays a graphical representation of the wafer's film layers, including the material composition, thickness, and the parameters that are to be calculated.

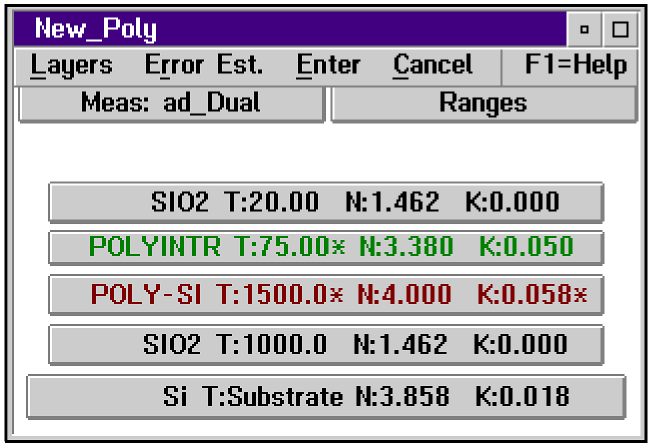

Figure 3-7. Focus Interactive Filmstack Model Element

The following conventions pertain to the Filmstack Model window:

Table 3-1. Filmstack Model Window Conventions

Indicator	Meaning
Asterisk (*)	Shown next to a parameter in a filmstack, indicates that parameter is being calculated.
@ symbol in a red highlighted layer	An order search is being performed on that layer. Order search is a method of obtaining absolute thickness with no order ambiguity. Classic single-wavelength, or single angle, ellipsometry is unable to resolve order due to the cyclical behavior of the ellipsometric parameters. The FOCUS multiple angle and multiple wavelength technique reduces (improves) order ambiguity. For more information, see "Order Searching and Order Resolution" on page 3–34.
Green highlighted, slightly smaller layer	This layer has been selected to be an interlayer. For more information on interlayers, see "About Interlayers" on page 3–64.

Filmstack Menu

The Filmstack area also consists of the following menu selections:

- **Layers** — Allows you to add and/or delete layers to the current filmstack using the menu items below:
  - **Add Layer** — Adds layers to the filmstack currently displayed. You will be prompted to select a material as well as the parameters to be calculated and measurement ranges for that material. Layers are added to the top of the filmstack.
  - **Delete Top** — Deletes the top layer of the current filmstack. You will be prompted to confirm this action.
- **Error Est** — Turns error estimate function on or off as selected from the menu. Error estimates are an approximation of the accuracy of the computed film parameters.
- **Enter** — Saves any modifications made to the filmstack.
- **Cancel** — Cancels the filmstack currently displayed. Clicking on this menu item causes the Filmstack window to be closed.
- **Meas:** — Allows you to select the measurement control to be used for the filmstack.
- **Ranges** — Allows you to set the maximum fit error allowed and the action the FE System will perform if a measurement is out of range. Options include: warn and continue, warn and pause, reject, and switch to a different filmstack.
- **Filmstack Layer** — The buttons in the main Filmstack window that represent each layer of the filmstack. Clicking on a Filmstack layer button allows you to specify the material for the layer, the parameters to be calculated, and specify ranges for those calculations.

Calculated Parameters Area

The Calculated Parameters area provides information pertaining to the measurement taken to test a filmstack. This information includes: the layer and parameter that was measured (layer 1 thickness in the example below), the value of the measurement, and the fit error.

This allows you to assess the validity of the filmstack for your application.

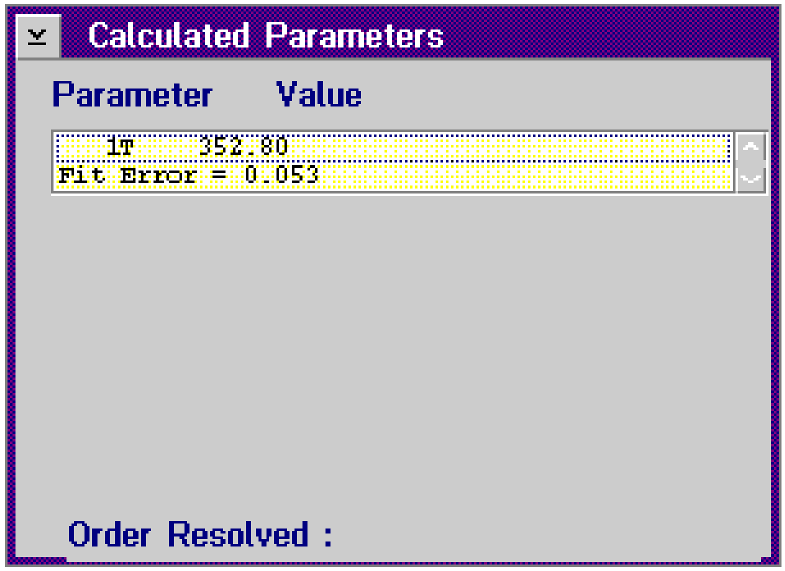

Figure 3-8. Focus Interactive Calculated Parameters Element

Focus Interactive Main Menu

The following menu items are available in the Focus Interactive Main window:

- **Load Wafer** — Used to load and unload a test wafer either manually or automatically using the FE robot.
  - **Manual Load** — The stage moves forward and the system prompts you to place a wafer on the stage.

NOTE

After manually loading the wafer you must close the door on the optics hood.

  - **Cassette Load** — Enables the loading of a wafer from a cassette. Select the cassette and slot number for the wafer to be loaded.

- **UnLoad** — Removes the wafer from the stage in the same manner in which it was loaded.
- **Wafer Setup** — Allows you to set the wafer load specifications such as wafer size, load action (flat or notch), whether to center the wafer, centering tolerance (this should not be changed), and wafer orientation.

NOTE

You can center a wafer without finding the wafer flat/notch. However, the reverse is not possible.

- **Register** — This function is not available.
- **SMIF Arm** — Enables the loading and unloading of a wafer from a cassette by SMIF Arm 1 or 2.
- **SMIF Indexer** — Enables the loading and unloading of a wafer from a cassette by SMIF Indexer 1 or 2.

• **Filmstack** — Allows you to select an existing measurement filmstack or create a new one.

NOTE

Filmstacks with an "aa" (single wavelength - 633 nm) or "ad" (dual wavelength - 633 nm/780 nm) prefix are Rudolph supplied default filmstacks and should not be modified or deleted. If a modification is necessary, make a copy as described in "Modifying an Existing Filmstack" on page 3–22. A list of the Rudolph supplied filmstacks is provided in Appendix C, "Default Recipes and Filmstacks".

• **Measure** — Used to perform a single test measurement using the filmstack model you have selected or developed.

• **ReModel** — Used when remodeling the changes made to a filmstack model (such as changing the material, adding or deleting layers, switching from dual to single wavelength, and so on) prior to performing another measurement. Allows the user to quickly model a solution based on the Delta/Psi data obtained from the last measurement that was performed.

NOTE

ReModel may only be used in cases where the measurement control and the measurement site is not changed.

- **Test** — Used as directed by Rudolph personnel to troubleshoot measurement problems and perform diagnostic tests. Only those functions relevant to applications are shown below. Other menu options are used by Rudolph service personnel.
  - **Short Term** — Used for making repeated static measurements at one particular site. The minimum, maximum, and standard deviation for all parameters calculated are displayed during and after the measurement is completed. A graphical representation is also an option upon completion of the measurement.
  - **Long Term** — Simulates a load/unload measurement. The wafer is driven to its edge and an automatic tilt and height are performed. The wafer is then returned to its measurement position where a tilt and height alignment is performed again. A measurement is then made and the above procedure is repeated.
  - **Measurement** — Allows a view of intensity, delta, and psi values versus pixels for the given measurement.
  - **Just Measure** — A measurement is made without an alignment or auto-intensity setting.
  - **Measure vs Model** — Displays the comparison between the modeled delta/psi curves (blue lines) and the measured delta and psi curves (green lines) versus the angle of incidence.
  - **Measure vs Predicted** — Displays the comparison between the measured delta/psi curves and the delta/psi curves generated based on the given thickness and optical constraints before any iteration.
  - **Reduced Measure** — The original delta/psi pairs are reduced/averaged down to fewer pairs and similar results are obtained as in the Measurement command above. A typical reduced measure consists of ten pairs.
- **Logging** — Used to start and stop saving calculations and measurement data to a log file. Also allows you to save or load the delta/psi values measured for a given measurement. This is used to simulate modeling at a remote location (such as a desktop computer). This file will have a **.log** extension.
  - **Start** — Starts saving measurement data to the specified log file.

NOTE

The file name MUST be eight characters or less and use the extension ".log".

- **Stop** — Stops saving measurement data to the log file.
- **Load Measurement** — Used to recall the delta/psi values for a previously saved single wavelength measurement. Once loaded, a filmstack model may be used and modified to calculate parameters based on these measurement values.
- **Save Measurement** — Saves the delta/psi values for the single wavelength measurement just taken to a specified filename.

NOTE

The filename MUST be eight characters or less and use the extension ".log".

- **Load Multi-Wavelength** — Used to recall the delta/psi values for a previously saved dual wavelength measurement. Once loaded, a filmstack model may be used and modified to calculate parameters based on these measurement values.
- **Save Multi-Wavelength** — Saves the delta/psi values for the dual wavelength measurement just taken to a specified filename.

NOTE

The filename MUST be eight characters or less and use the extension ".log".

- **Measurement Fax Printout** — Prints the filmstack information and delta/psi values obtained from the last measurement made. This can be used to fax the information to Rudolph Technologies where the measurement may be simulated for troubleshooting purposes.

• **Setup** — Used by Rudolph service personnel only.

• **Calib** — Used by Rudolph service personnel to calibrate the FE System.

Filmstack Development

A filmstack is a model, constructed layer by layer, designed to represent the actual films deposited on a wafer. The filmstack can be used to make test measurements of a real wafer and gauge the ellipsometers capability for the particular application. Once a film application is verified and saved, it can later be recalled using the Focus Recipe Creator program and incorporated into a recipe.

The filmstack development cycle includes the following steps:

1. Load the test wafer.
2. Develop the filmstack.
3. Perform a sample measurement.
4. Unload the test wafer.

Use the following procedure to develop a filmstack for your application:

NOTE

In many instances, the Rudolph supplied filmstacks will be sufficient for your application. However, it may be necessary to modify an existing filmstack or create a new filmstack. A list of the Rudolph supplied filmstacks is provided in Appendix C, "Default Recipes and Filmstacks".

CAUTION

Modifying any existing filmstack will affect every recipe that uses that filmstack.

Load a Test Wafer

A sample or test wafer is used to ensure that the filmstack model and recipe that you are developing will work on similar production wafers.

Use the following procedure to load wafers to the stage, either manually or from a cassette, define the wafer size, loading action, wafer orientation and wafer registration:

1. In the Focus Interactive main menu, click on **Load Wafer**.

   The Load Wafer menu is displayed.

2. Determine the method you wish to use to load the wafer and perform **one** of the following:

   - **To load the test wafer from cassette:** Click on **Cassette Load** in the Load Wafer menu.

     The Wafer Load/Unload window is displayed as shown in Figure 3-9.

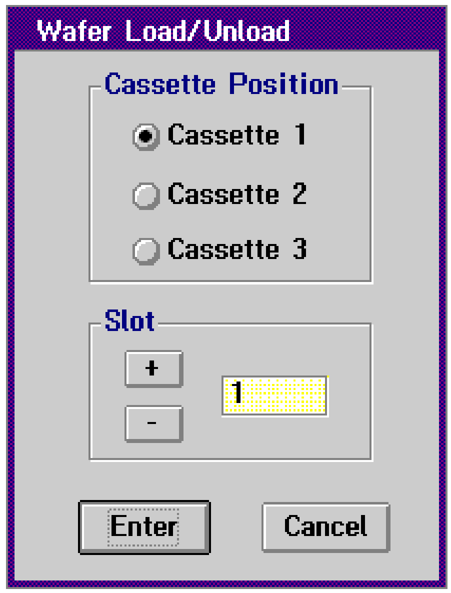

Figure 3-9. Wafer Load/Unload Window

     Select the cassette and slot from which to load the wafer and click on **Enter**. The Wafer Specification window is displayed as shown in Figure 3-10.

   - **To manually load the test wafer:** Click on **Manual Load** in the Load Wafer menu.

     A window is displayed prompting you to load a new wafer. Place a wafer on the stage, center it manually, and click on **OK**.

     The Wafer Specification window is displayed as shown in Figure 3-10.

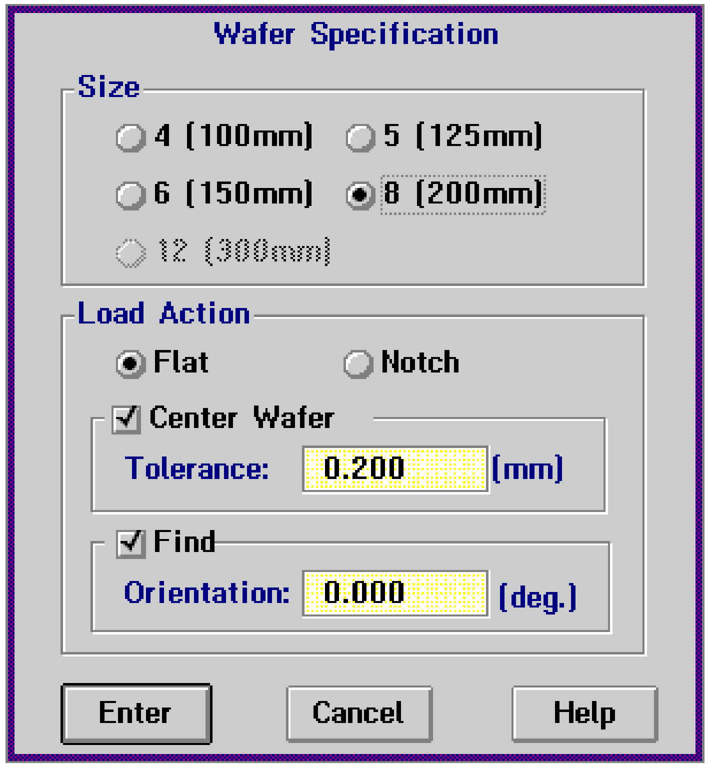

Figure 3-10. Wafer Specification Window

3. Select the information that applies to the test wafer (wafer size, flat/notch information, centering, and wafer orientation) then click on the **Enter** button.

NOTE

When loading a wafer from a cassette, the FE System has a sensor that automatically detects the wafer size. Wafer size must always be specified when manually loading a wafer.

NOTE

Do not change the default Centering Tolerance unless instructed by Rudolph support personnel. "Center Wafer" must be selected in order to find a specified orientation. Entering positive increasing values for wafer orientation rotates the wafer by degrees in a counterclockwise direction.

The wafer is loaded and wafer centering and orientation is performed (if selected). The Site Locator window now shows a live video image of the wafer, and the Wafer View window is also updated.

Choosing a Filmstack Model

This section describes how to choose a filmstack model that will later be incorporated into a wafer recipe used for measuring production wafers.

There are three general procedures that can be used to choose a filmstack:

- Select an existing filmstack that fits your application.
- Copy an existing filmstack and modify it to create a new filmstack.
- Create an entirely new filmstack.

NOTE

A list of the Rudolph supplied filmstacks is provided in Appendix C, "Default Recipes and Filmstacks".

Selecting an Existing Filmstack

This procedure selects an existing filmstack for your application.

1. In the Focus Interactive main menu, click on **Filmstack**.

   The Filmstack Selection window is displayed as shown Figure 3-11.

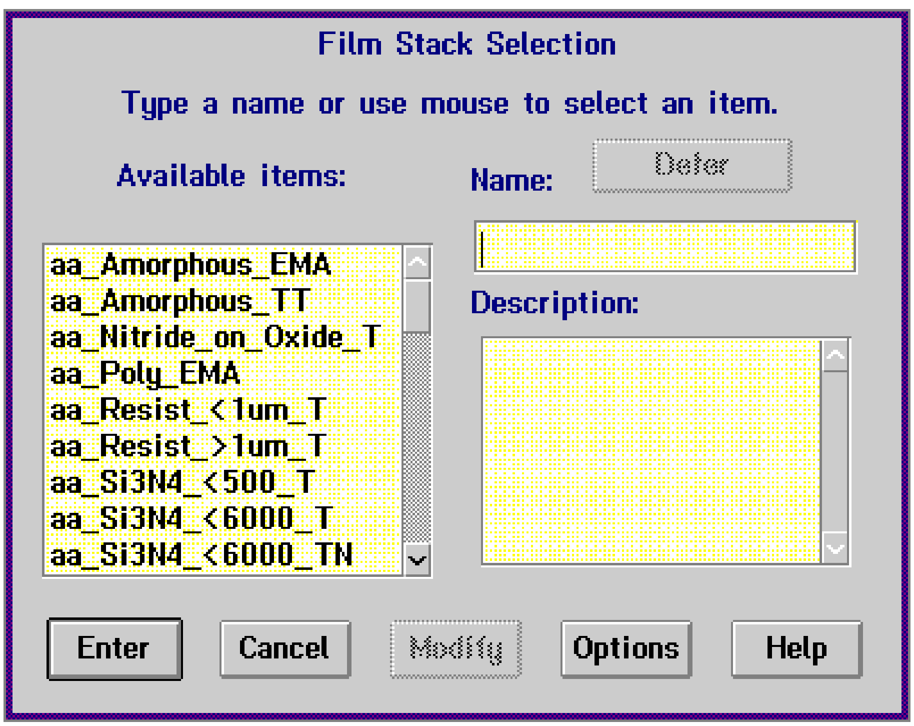

Figure 3-11. Filmstack Selection Window

NOTE

For Rudolph supplied filmstacks, an “aa” prefix indicates a single wavelength (633 nm) measurement. An “ad” prefix indicates a dual wavelength (633 nm and 780 nm) measurement.

2. Single click on the desired filmstack name to highlight it.

   A description of the selected filmstack appears in the **Description** area of the Filmstack Selection window.

3. Review the filmstack description to verify that it is appropriate for your application. When you have highlighted the appropriate filmstack name, click the **Enter** button.

   The Filmstack Model window is displayed as shown in Figure 3-12.

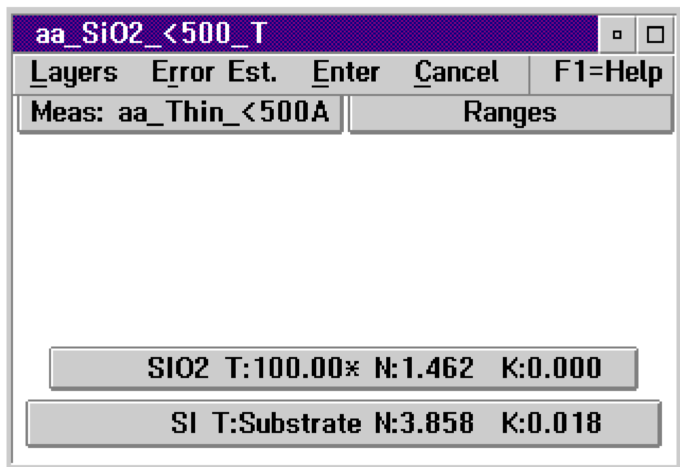

Figure 3-12. Filmstack Model Window

4. Perform **one** of the following:

   - **If this filmstack is satisfactory and no modifications are required**, test measurements may now be performed using the procedure provided in “Testing the Filmstack Model” on page 3–31.

NOTE

If you wish to log the test measurements, logging must be turned on before measurements begin. Refer to “Logging Measurements” on page 3–28 for information on activating the logging feature.

   - **If you wish to modify the selected filmstack**, proceed to “Modifying an Existing Filmstack” on page 3–22.

Modifying an Existing Filmstack

The FE System software database contains many Rudolph supplied filmstack models covering a wide range of possible applications. For special applications, these Rudolph supplied filmstacks can be copied and the new copy modified as follows:

- Select the substrate material for the filmstack.
- Add or delete layers of material that make up the filmstack.
- Choose the parameters (Thickness, N, or K) that will be calculated or fixed as constants.
- Select the type of measurement (for example: single/dual wavelength, rough film mode, Ψ exclusion, and tilt options).
- Create new materials with new optical constants.
- Define a range for the calculated parameters.

CAUTION

Modifying any existing filmstack will affect every recipe that uses that filmstack. It is recommended that you only modify copies of existing filmstacks.

Use the following procedure to modify an existing filmstack model:

1. In the Focus Interactive main menu, click on **Filmstack**.

   The Film Stack Selection window is displayed as shown Figure 3-13.

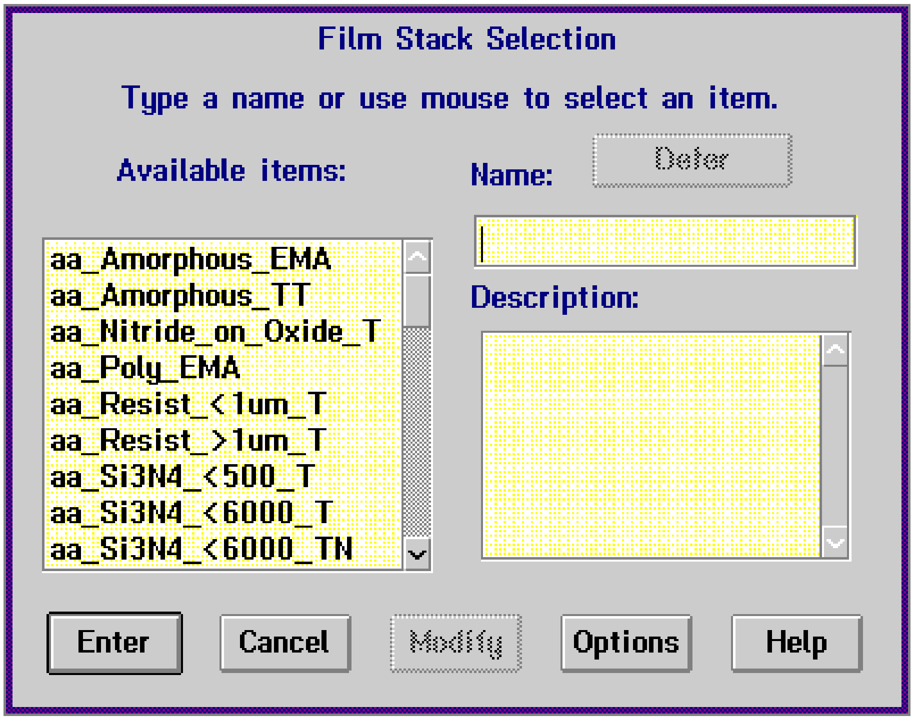

Figure 3-13. Filmstack Selection Window

NOTE

For Rudolph supplied filmstacks, an "aa" prefix indicates a single wavelength (633 nm) measurement. An "ad" prefix indicates a dual wavelength (633 nm and 780 nm) measurement.

2. Single click on the desired filmstack name to highlight it.

   A description of the selected filmstack appears in the **Description** area of the Filmstack Selection window.

3. Review the filmstack description to verify that it is best suited to your application. When you have highlighted the appropriate filmstack name, click the **Options** button.

   The Options Result window is displayed as shown in Figure 3-14.

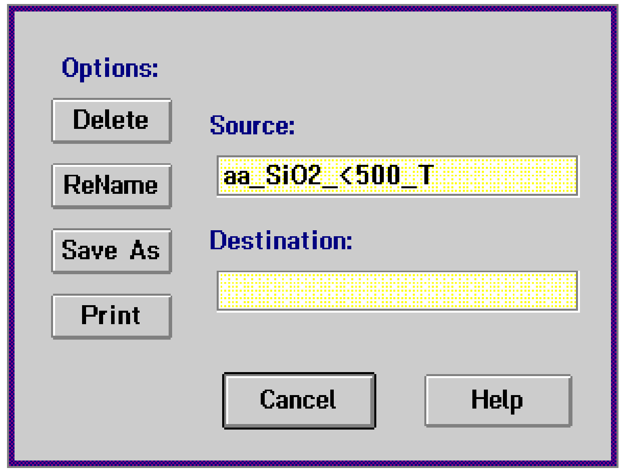

Figure 3-14. Options Result Window

4. Enter a new name in the **Destination** field for the filmstack to be modified and click on the **Save As** button.

NOTE

The name of the filmstack should identify the purpose of the filmstack model (for example: aa_SiO2_<500_T indicates that the model is used for measuring thickness of a SiO2 layer that is less than 500 Å).

You are returned to the Filmstack Selection window with the new filmstack name displayed in the **Name** field.

5. Click on **Enter** in the Filmstack Selection window.

A Filmstack Model window is displayed.

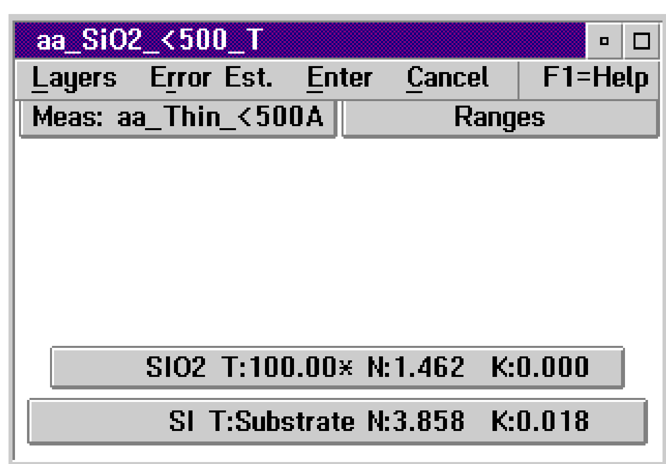

Figure 3-15. Filmstack Model Window

6. Add, delete, and/or modify filmstack layers as follows:

    - **To change the substrate:** Use the procedure provided in “Changing the Filmstack Substrate” on page 3–38.
    - **To add a layer:** Use the procedure provided in “Adding Film Layers” on page 3–41.
    - **To delete a layer:** Use the procedure provided in “Deleting Film Layers” on page 3–49.
    - **To modify a layer:** Use the procedure provided in “Modifying Film Layers” on page 3–50.

7. Select a Measurement Control for the filmstack using the procedure provided in “Selecting Measurement Controls” on page 3–54.

8. Set Range Specifications for the filmstack using the procedure provided in “Setting Range Specifications” on page 3–55.

9. Once the filmstack is satisfactory for your application, click on **Enter** in the Filmstack Model window to save this filmstack.

    A window is displayed informing you that the changes have been saved. Click on **OK**.

10. Test measurements may now be performed using the procedure in “Testing the Filmstack Model” on page 3–31.

NOTE

If you wish to log the test measurements, logging must be turned on before measurements begin. Refer to “Logging Measurements” on page 3–28 for information on activating the logging feature.

Creating a New Filmstack

The FE System allows for the creation of entirely new filmstack models to suit your particular application. The new filmstack is built layer by layer on the default substrate. The default substrate is typically silicon (Si).

Use the following procedure to create a new filmstack model:

1. In the Focus Interactive main menu, click on **Filmstack**.

   The Film Stack Selection window is displayed as shown Figure 3-16.

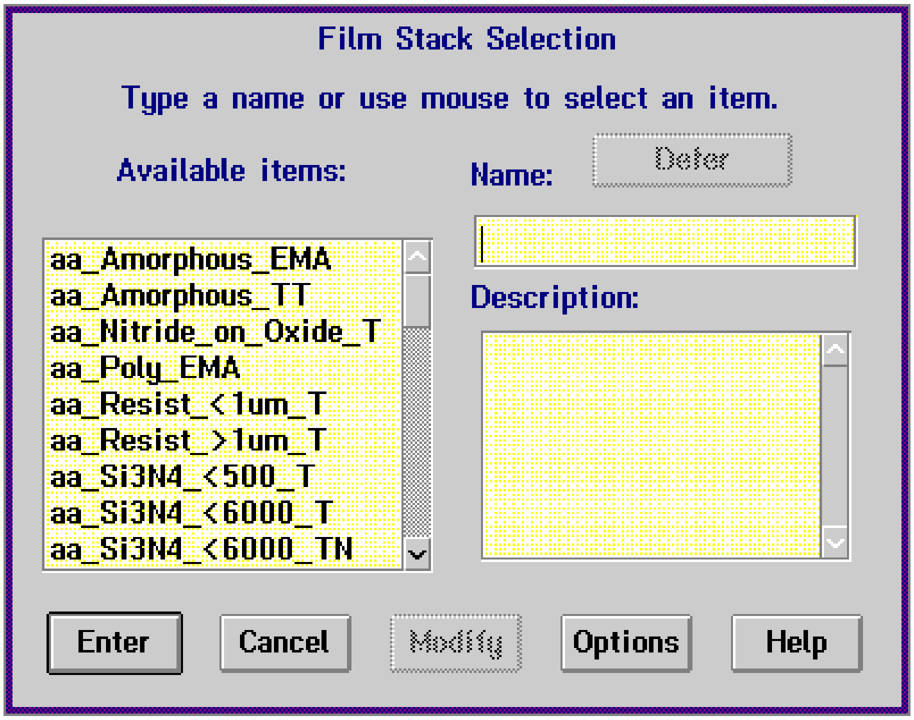

Figure 3-16. Filmstack Selection Window

2. Enter a name for the new filmstack in the **Name** field and click on the **Enter** button.

NOTE

The name of the filmstack should identify the purpose of the filmstack model (for example: aa_SiO2_<500_T indicates that the model is used for measuring thickness of a SiO2 layer that is less than 500 Å).

A Filmstack Model window is displayed as shown in Figure 3-17. At this point the filmstack consists only of the default substrate upon which the filmstack will be constructed.

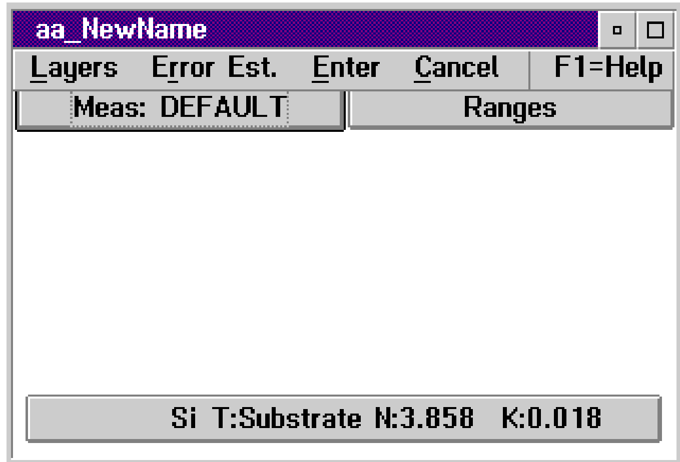

Figure 3-17. Filmstack Model Window - Substrate Only

3. If desired, change the filmstack substrate using the procedure provided in "Changing the Filmstack Substrate" on page 3–38.

4. Add filmstack layers using the procedure provided in "Adding Film Layers" on page 3–41.

5. Select a Measurement Control for the filmstack using the procedure provided in "Selecting Measurement Controls" on page 3–54.

6. Set Range Specifications for the filmstack using the procedure provided in "Setting Range Specifications" on page 3–55.

7. Once the filmstack is satisfactory for your application, click on **Enter** in the Filmstack Model window to save this filmstack.

   A window is displayed informing you that the changes have been saved. Click on **OK**.

8. Test measurements may now be performed using the procedure in "Testing the Filmstack Model" on page 3–31.

NOTE

If you wish to log the test measurements, logging must be turned on before measurements begin. Refer to "Logging Measurements" on page 3–28 for information on activating the logging feature.

Logging Measurements

After the filmstack has been developed, you may wish to save measurement data to a log file. Use the procedures below to start and stop data logging.

NOTE

Logging must be activated before measurements begin and will continue until deactivated.

Start Logging

To start logging measurement data, perform the following:

1. In the Focus Interactive main menu, click on **Logging**.

   The Logging menu is displayed.

2. Click on **Start** in the Logging menu.

   A Log File Report Selection window is displayed as shown in Figure 3-18. If any log files already exist they will be displayed in the Available Items field.

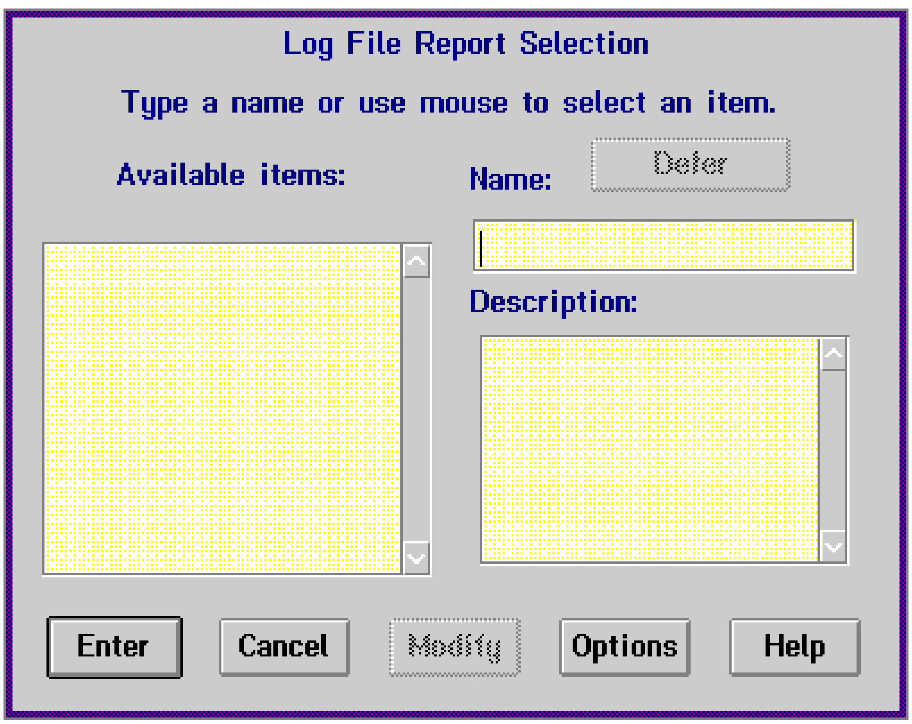

Figure 3-18. Log File Report Selection Window

3. Enter the desired log file name in the **Name** field (eight characters or less with an extension of **.log**) and click on **Enter**.

CAUTION

Entering the name of a log file that already exists will cause that log file to be overwritten and any data that was in the log is lost.

A Logging Measurement Data window is displayed as shown in Figure 3-19.

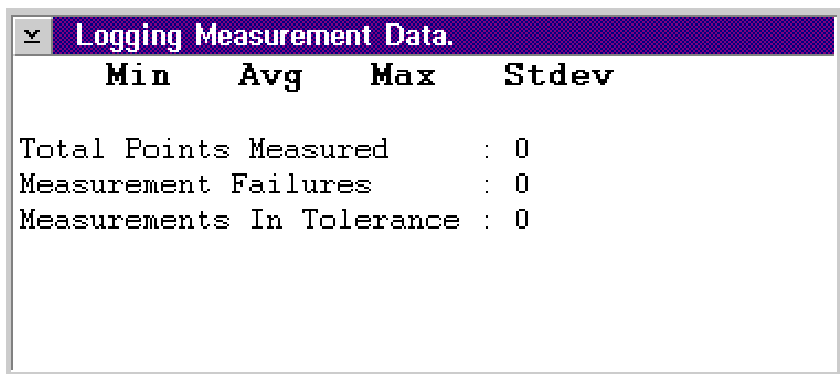

Figure 3-19. Logging Measurement Data Window

4. Perform the desired measurements using the procedures given in "Testing the Filmstack Model" on page 3–31.

   The Logging Measurement Data window is updated with the results of each measurement performed.

5. Stop data logging once all measurement data has been collected.

Stop Logging

To stop logging measurement data, perform the following:

1. In the Focus Interactive main menu, click on **Logging**.

   The Logging menu is displayed.

2. Click on **Stop** in the Logging menu.

   A window is displayed informing you that logging has been completed. The number of points that have been measured is also reported and you are given the opportunity to view a graphical output of the measurement data.

3. Perform **one** of the following:

   - **If you wish to view the graphical output:**

     - Click on the **Yes** button.

       A Graphics window similar to the one shown in Figure 3-20 is displayed.

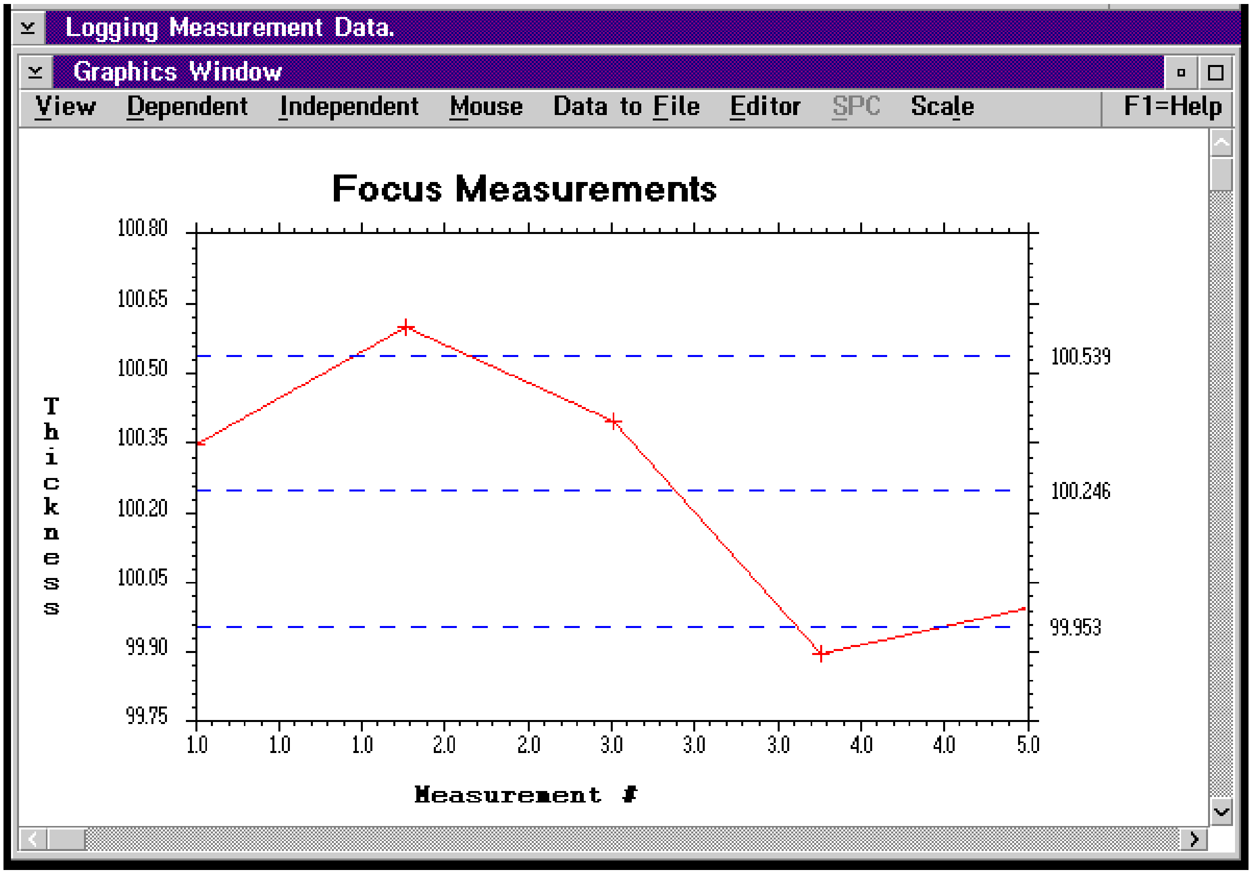

Figure 3-20. Logging Measurement Data Graphics Window

- When you have finished viewing the measurement data, click on the icon in the upper left corner beside the Graphics Window title then click on **Close** from the menu that is displayed.

  The Graphics window is closed and the Logging Measurement Data window is displayed.

- Click on the icon in the upper left corner beside the Logging Measurement Data title then click on **Close** from the menu that is displayed.

  The Logging Measurement Data window is closed and the Focus Interactive main window is displayed. Data logging is now stopped.

- **If you do not wish to view the graphical output:**
  - Click on the **No** button.

    The Logging Measurement Data window is closed and the Focus Interactive main window is displayed. Data logging is now stopped.

Testing the Filmstack Model

Once the filmstack has been developed, it may be tested by making sample measurements of the wafer. By default, the FE System will perform a single measurement at the center of the wafer. For higher confidence in the test results, and to determine how robust the filmstack is, you may perform test measurements on multiple locations.

To test the filmstack model, perform the following:

1. Ensure that a wafer is loaded as described in “Load a Test Wafer” on page 3–17.

2. Ensure the Filmstack Model window is displayed and shows the filmstack that you selected using the procedures described in “Choosing a Filmstack Model” on page 3–20.

3. **(Optional)** If you want to save the measurement data, activate logging as described in “Logging Measurements” on page 3–28.

NOTE

Logging must be activated before measurements begin and will continue until deactivated.

4. To measure a location other than the center of the wafer (default measurement site), select the desired measurement site by positioning the trackball pointer over the desired location in either the Wafer View or Site Locator window and double clicking the right trackball button.

   The stage moves the wafer so that the laser is positioned over the desired location.

5. In the Focus Interactive main menu, click on **Measure**.

   The FE System begins measuring the test site and performs the calculations for the measurement. The title bar of the Site Locator window indicates the FE System progress with the following messages:

   Focusing
   Setting intensity
   Measuring wafer
   Modeling data

When data modeling is complete, the data is displayed in a Calculated Parameters window, as shown in Figure 3-21. This window displays the parameter that was measured, the measured value of that parameter, and the fit error of the measurement. Refer to "Analyzing Test Results" on page 3–33 for details on how to use this information.

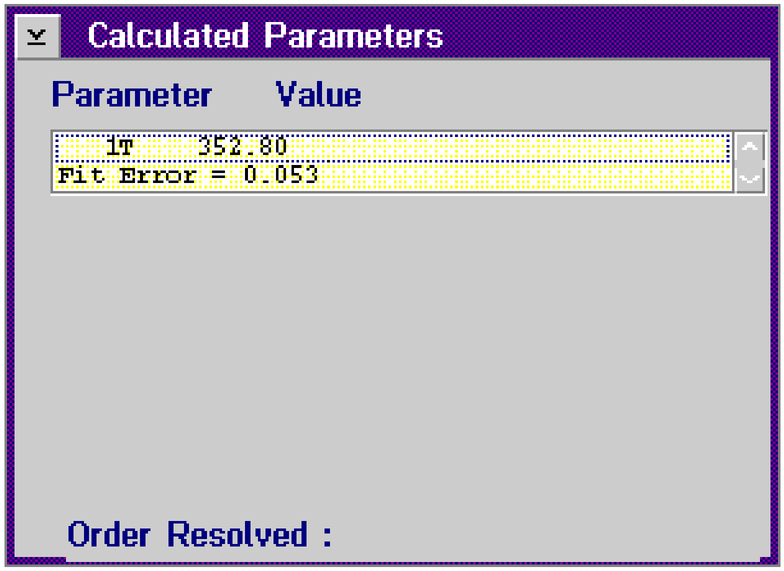

Figure 3-21. Calculated Parameters Window

6. To test other measurement sites, repeat Step 4 and Step 5 above until all sites have been measured.
7. If measurement logging was started, stop measurement logging as described in "Logging Measurements" on page 3–28.
8. Once all measurements have been taken, and the filmstack is determined to be satisfactory for your application, you may unload the wafer as described in "Unloading the Wafer" on page 3–37.

Analyzing Test Results

The FE System provides three indicators to help you determine the accuracy and repeatability for using a filmstack model on your application:

- Fit error
- Error estimates
- Order resolution

The degree of correlation between the model and the actual physical filmstack is interpreted by the fit error, which is based on a $\chi 2$ fit between the measured and modeled ellipsometric angles. Error estimates may also be used to qualitatively determine the accuracy of the measured parameters.

Fit Error

After a measurement is made, the calculated parameters and the fit error are returned. When performing calculations, the FE software searches for the solution with the lowest fit error. The fit error is a measure of how well the measured data fits the theoretical Delta (Δ) and Psi (Ψ) data of the film model. The statistical quantity “Chi squared” ($\chi 2$) is used to measure fit error.

A fit error ≤ 1 is expected from a single wavelength measurement of a dielectric film and means that the measured and modeled data agree to within the accuracy of the measurement.

Usually, the measured Delta (Δ) and Psi (Ψ) data are correct to within the accuracy of the measurement.

Therefore, a large fit error means there is a problem with the filmstack model (one or more of the assumed parameter values is incorrect). You must change the filmstack parameters and re-test the filmstack model.

Fit error can also be used to detect a measurement related problem. For example, if the laser spot is hitting the edge of a measurement site on a product wafer, the fit error will be much larger than when the laser spot is well centered on the site.

Figure 3-22 illustrates the mathematical definition of fit error.

$$\text{Fit Error} = \chi^2 = \frac{1}{N}\frac{\sum_{i=1}^{n}[\Delta(i)^{Measured} - \Delta(i)^{Modeled}]^2}{\sigma_\Delta^2} + \frac{1}{N}\frac{\sum_{i=1}^{n}[\psi(i)^{Measured} - \psi(i)^{Modeled}]^2}{\sigma_\psi^2}$$

where

σ_Δ = Estimated error in measured Δ

σ_ψ = Estimated error in measured ψ

Figure 3-22. Fit Error Equation

Error Estimates

Error estimates provide an assessment of the accuracy of the computed film parameters. As a general rule, the error estimates should be approximately 1% of the measured value. Thinner films (<100Å) may have higher error estimates. Usually, as more parameters are calculated, the error of each parameter is increased, while the fit error is decreased. Fewer calculations provide better accuracy.

Order Searching and Order Resolution

Because of the cyclic nature of the interference of light when measuring thin films, the Δ/ψ pair obtained from a given measurement is not unique. These values are periodic with the thickness of the film. Every material has an associated order thickness, or “Cycle Thickness.” Cycle Thickness (Tc) is a function of refractive index, wavelength of light and angle of incidence. Figure 3-23 expresses the mathematical definition of this relationship.

$$T_c = \frac{\lambda}{2\sqrt{n^2 - \sin^2\theta}}$$

Figure 3-23. Cycle Thickness Function

NOTE

Refer to Appendix E, “Theory of Operation” for more information.

With other variables remaining constant, Δ/ψ values will be the same for any multiple of Tc. For example, at a wavelength of 632.8 nm, AOI of 70 and an RI of 1.462, the Tc is 2825Å. Measurement of this material (SiO2 in this case) indicates a thickness of 6000Å as well as 6000Å $\pm$ *m*Tc where *m* =1,2,3.... . All have the same Δ/ψ pair.

To determine which thickness associated with a given multiple of Tc is the correct solution, order searching "searches" different orders and returns the answer that has the lowest fit error, which approximates the "real" answers for the parameters calculated.

With **Standard Order Search** (using single wavelength), the region searched varies with the application but is typically ± 5 orders. This option is most appropriate for low refractive index films, such as SiO2 and Si3N4.

At times, however, especially for Poly single wavelength measurements, the fit error between different orders are very close. In this case, a **Restricted Order Search** is needed. Because Restricted Order Search limits the search area, a better foreknowledge of the correct thickness of the material is needed. The spec thickness must be within the specified range of search. Refer to Table E-1 on page E–20 for more information.

If the FE software cannot resolve order using the following algorithms, a message will appear stating that there is order ambiguity.

Order Resolution by Fit Error

The best three answers (by fit error) are generated and a calculation is performed to determine whether the order is resolved.

If the next best fit is ≥1.5 times the best fit, and the next best fit error is greater than 2.0, the order is resolved. If the next best fit is ≥1.5 times the best fit, and the next best fit error is less than 2.0, then order is not resolved.

This is mathematically expressed as follows:

Let:

x = Best Fit
y = Next Best Fit

For $1.5x < y$

If $y > 2.0$: order is resolved

If $y < 2.0$: order is not resolved

For $1.5x > y$: order is not resolved

Order Resolution by Index Matching

If order is not resolved by fit error, and index or refraction (N) or absorption (K) are being computed, then the algorithm resorts to “index matching”. Index matching chooses the solution whose measured index values are within specified tolerances so that order can be resolved. If order cannot be resolved, the solution whose thickness is closest to the starting value will be returned.

Specified index values can be modified by using “Set Search Tolerance” in the Layer View window (Figure 3-27).

Remodeling a Modified Filmstack

Once a measurement is completed, if you are not satisfied with the results of the measurement, you may want to modify the filmstack model and recalculate the measurement. To modify the filmstack model, you may change the parameters selected for calculation, choose a different material, add or delete a layer, or switch from dual to single wavelength.

By using the ReModel option, the filmstack model can be quickly recalculated without making another measurement.

NOTE

If the measurement control or the measurement site have been changed, ReModel cannot be used.

To recalculate measurements with a changed filmstack, use the following procedure:

1. Make the required changes to the filmstack model using the procedures describe in “Choosing a Filmstack Model” on page 3–20.
2. Once the filmstack has been modified and saved, in the Focus Interactive main menu, click on **ReModel**.

   The ReModel menu item is highlighted.
3. In the Focus Interactive main menu, click on **Measure**.

   The filmstack model is recalculated based on the changes made in Step 1 of this procedure. The ellipsometric data obtained from the previous measurement are used in the re-calculation.

Unloading the Wafer

When you have completed measurements on the wafer, use the following procedure to unload the wafer:

1. In the Focus Interactive main menu, click on **Load Wafer**.

   The Load Wafer menu is displayed.

2. Click on **Unload** in the Load Wafer menu.

   The FE System unloads the wafer in the same manner it was loaded:

   - **If the wafer was loaded using Cassette Load:** the robot returns the wafer to the cassette and slot from which it was initially taken.

   - **If the wafer was loaded using Manual Load:** the stage moves forward and prompts for the wafer to be manually removed.

A filmstack model has now been created and can be incorporated into a wafer recipe as described in Chapter 4, “Creating Recipes”

Creating and Modifying Filmstacks

The following procedures should be used to change the filmstack substrate, add, delete, or modify filmstack layers, select filmstack measurement controls, and to set range specifications.

Changing the Filmstack Substrate

To change the substrate in the filmstack model, you must have already selected, copied, or created a filmstack using the procedures in "Modifying an Existing Filmstack" on page 3–22 or "Creating a New Filmstack" on page 3–26 respectively.

1. In the Filmstack Model window, click on the substrate layer.

   A Substrate View window is displayed that contains the information for the substrate material. In the examples below the Substrate View window in Figure 3-24 shows a single wavelength measurement, the Substrate View window in Figure 3-25 shows a dual wavelength measurement. The window displayed will depend on the type of filmstack being modified.

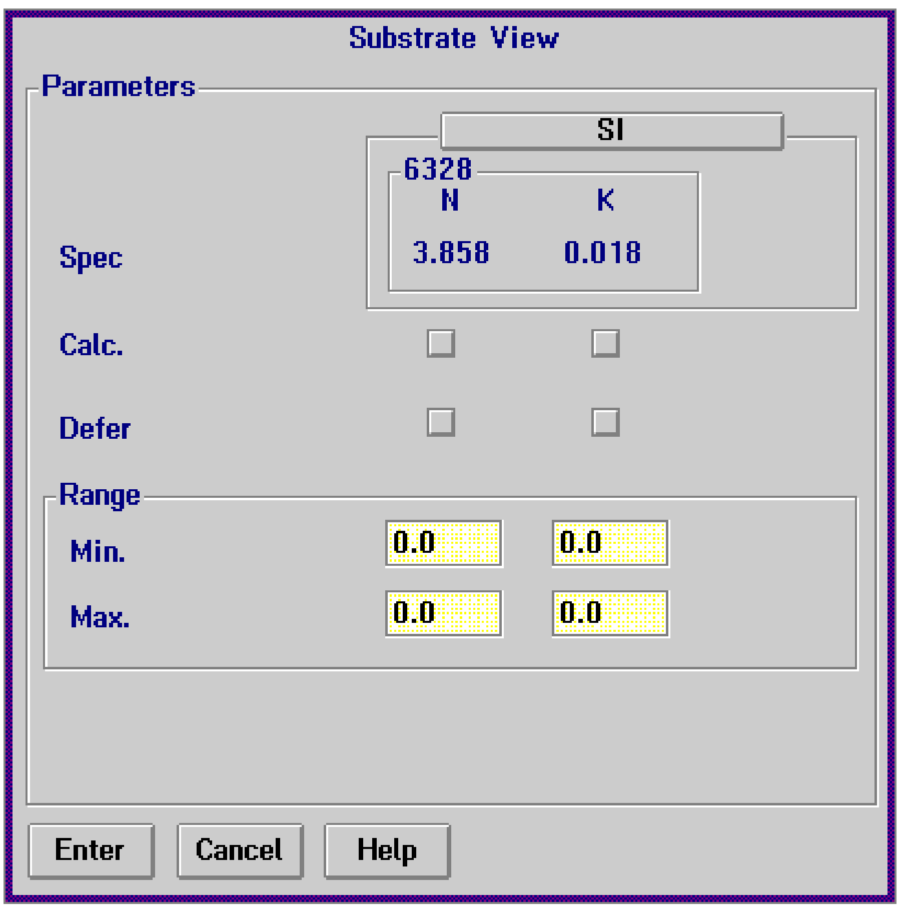

Figure 3-24. Substrate View Window - Single Wavelength

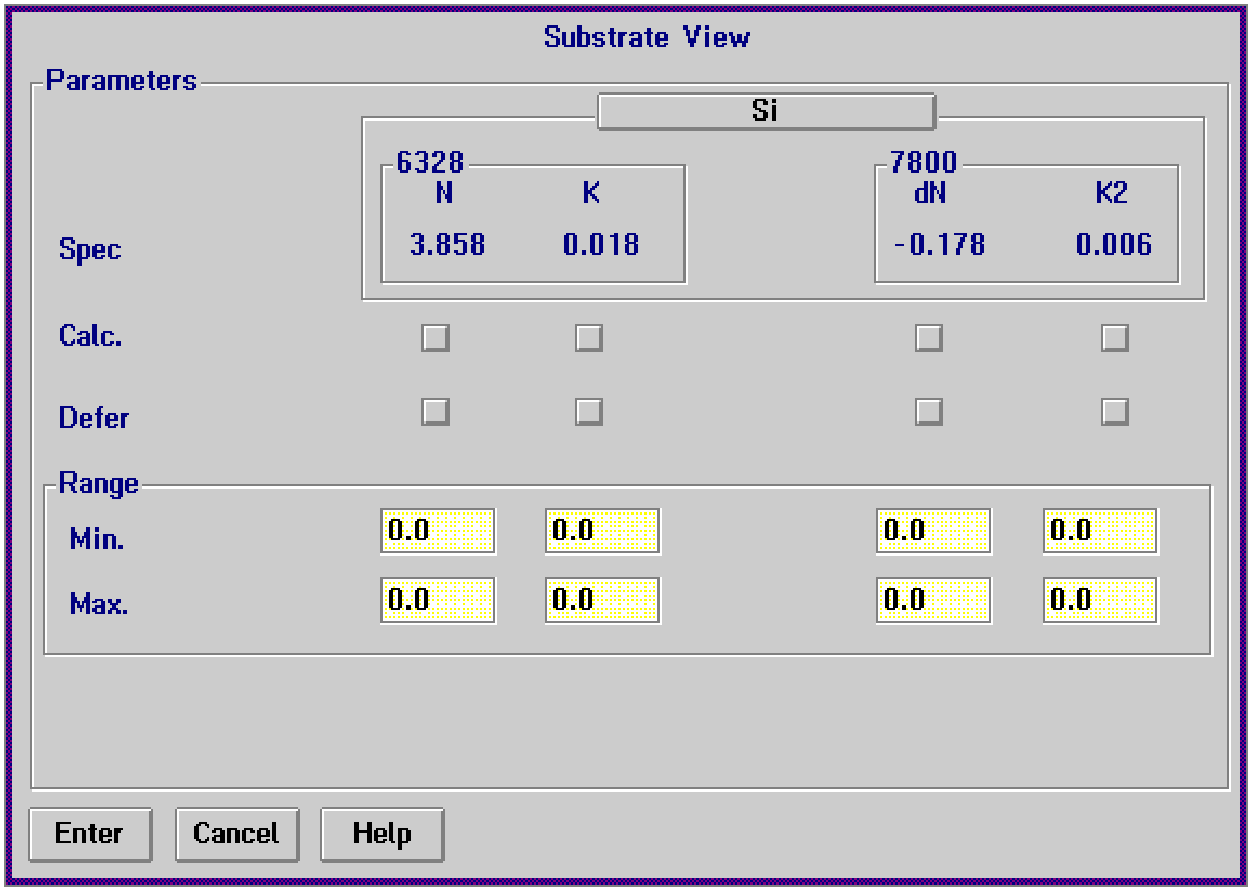

Figure 3-25. Substrate View Window - Dual Wavelength

2. Enter the values for the substrate in the Substrate View window using the information below as a guide.

   - **Substrate Material** — Click on the button with name of the material that makes up the substrate to display the Material Selection window as shown in Figure 3-26. Select the desired material from the list by clicking once on the item then clicking **Enter**, or by double clicking on the item. The name of the selected material is displayed in the Substrate Material button in the Substrate View window and the specs for **N**, **K**, **dN**, and/or **K2** (as applicable) are updated.

NOTE

You may also enter the name of a new material to be used as the filmstack substrate by using the procedure in "Creating New Materials" on page 3–46.

- **Spec**
  - **N** — Displays the **N** value (index of refraction) based on the selected material.
  - **K** — Displays the **K** value (absorption coefficient) based on the selected material.
  - **dN** — Only displayed for dual wavelength measurements. Displays the **dN** value (difference in refractive index between the two wavelengths) based on the selected material.
  - **K2** — Only displayed for dual wavelength measurements. Displays the **K2** value (absorption coefficient for the second wavelength) based on the selected material.
- **Calc.** — Specify the parameters that should be calculated during the measurement.
- **Defer** — Specify the parameter measurements that will be deferred to the Operator.
- **Range** — Enter the range tolerance for the calculated parameters. Entering 0 in both fields effectively disables range tolerance checking. If values other than 0 are entered and the calculation is outside of the specified range, the FE System will take the action that is selected using the Range button in the Filmstack Model window. See “Setting Range Specifications” on page 3–55 for more information.

NOTE

The out of range action only applies to the Focus Operator Queued Loading program.

  - **Min.** — Specify the minimum range value.
  - **Max.** — Specify the maximum range value.

3. When all entries have been made for the substrate, click the **Enter** button in the Substrate View window.

   You are returned to the Filmstack Model window with the substrate modifications displayed in the filmstack model.

4. Make other modifications to the filmstack model as desired.

Adding Film Layers

To add a layer to the filmstack model, you must have already selected a filmstack to modify or specified the name for a new filmstack using the procedures in “Modifying an Existing Filmstack” on page 3–22 or “Creating a New Filmstack” on page 3–26 respectively.

NOTE

Layers are added to the top of the filmstack model.

1. In the Filmstack Model window, click on **Layers** then click on **Add Layer** when the Layers menu is displayed.

   The Material Selection window is displayed as shown in Figure 3-26.

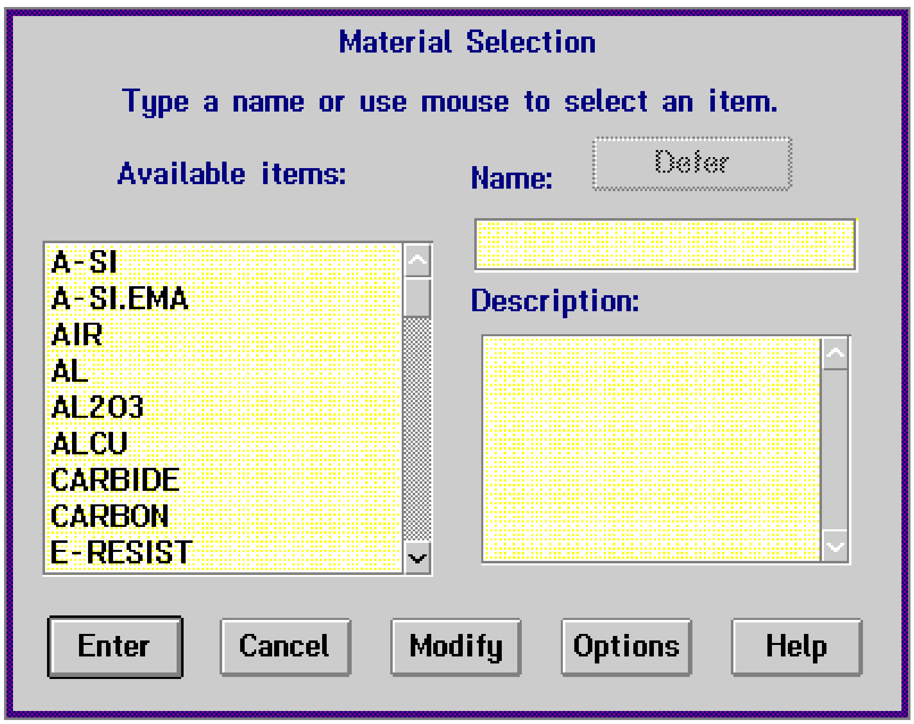

Figure 3-26. Material Selection Window

2. Select the material for the new layer from the list by clicking once on the item then clicking **Enter**, or by double clicking on the item.

   A Layer View window is displayed as shown in Figure 3-27 and Figure 3-28. The Layer View window in Figure 3-27 shows a single wavelength measurement, the Layer View window in Figure 3-28 shows a dual wavelength measurement. The window displayed will depend upon the type of filmstack being built.

NOTE

You may also enter the name of a new material to be used in the filmstack by using the procedure in **"Creating New Materials" on page 3–46****.**

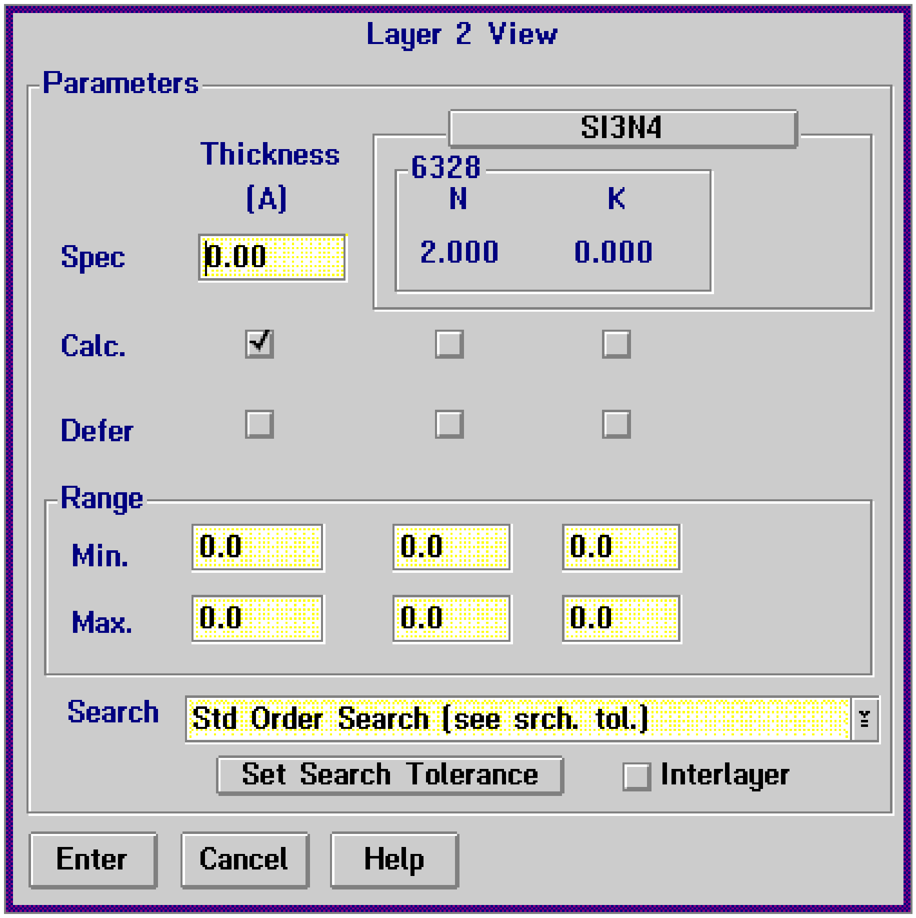

Figure 3-27. Layer View Window - Single Wavelength

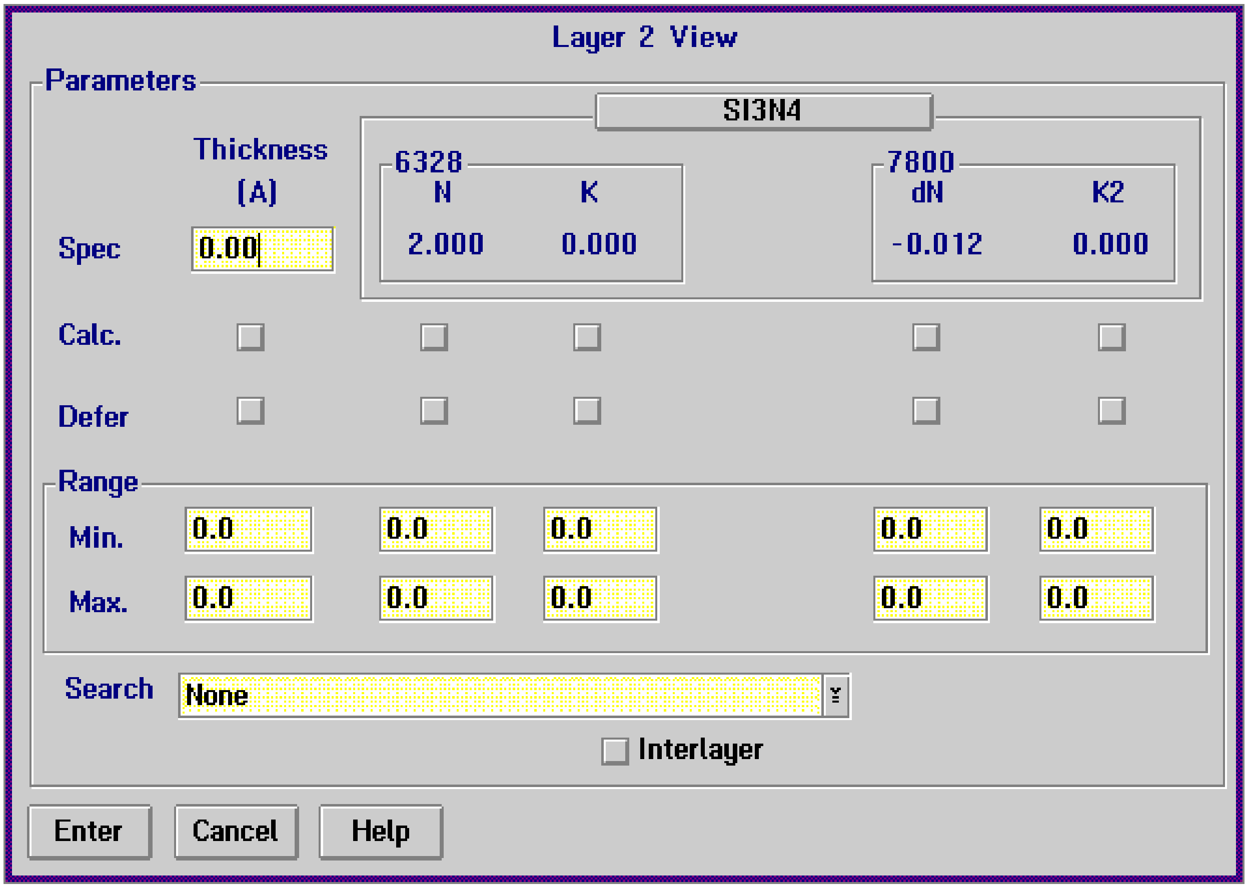

Figure 3-28. Layer View Window - Dual Wavelength

3. Enter the values for the selected material in the Layer View window using the information below as a guide.

   - **Spec**

     - **Thickness** — Enter the approximate thickness (in Angstroms) for the layer.
     - **N** — Displays the **N** value (index of refraction) for the layer based on the selected material.
     - **K** — Displays the **K** value (absorption coefficient) for the layer based on the selected material.
     - **dN** — Only displayed for dual wavelength measurements. Displays the **dN** value (difference in refractive index between the two wavelengths) for the layer based on the selected material.
     - **K2** — Only displayed for dual wavelength measurements. Displays the **K2** value (absorption coefficient for the second wavelength) for the layer based on the selected material.

- **Calc.** — Specify the parameters that should be calculated during the measurement.
- **Defer** — Specify the parameter measurements that will be deferred to the Operator.
- **Range** — Enter the range tolerance for the calculated parameters. Entering 0 in both fields effectively disables range tolerance checking. If values other than 0 are entered and the calculation is outside of the specified range, the FE System will take the action that is selected using the Range button in the Filmstack Model window. See "Setting Range Specifications" on page 3–55 for more information.

NOTE

The out of range action only applies to the Focus Operator Queued Loading program.

  - **Min.** — Specify the minimum range value.
  - **Max.** — Specify the maximum range value.

- **Search** — Select the search type by clicking on the down arrow button to the right of the Search field. Refer to "Order Searching and Order Resolution" on page 3–34 for more information.
  - **None** — The FE System will find the closest local minima of fit error.
  - **Restricted Search** — Perform order search over a restricted thickness range. Refer to Table E-1 on page E–20 for more information.
  - **Std Order Search** — When using single wavelength, the region searched varies with the application but is typically ± 5 orders.
- **Set Search Tolerance** — Only displayed when Restricted Search or Std Order Search types are selected. Sets tolerances on acceptable values of computed optical constants (N, K, dN, and K2). The checkboxes for **N**, **K**, **dN**, and/or **K2** must be selected for the entered tolerances to apply. Click on the Set Search Tolerance button to display the Search Tolerance window as shown in Figure 3-29. Enter the desired values and click on **Enter**.

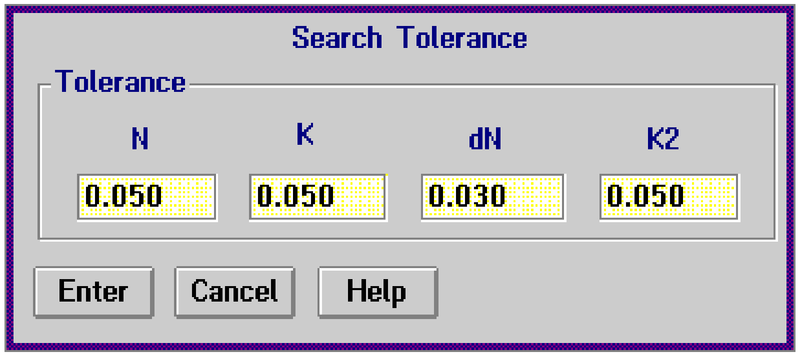

Figure 3-29. Search Tolerance Window

- **Interlayer** — Click on this box to indicate that this layer is an "interlayer". This causes the thickness of this layer to be added to the underlying layer. This feature is useful when a single film is represented as a composite of two layers (such as, poly-silicon). Refer to "About Interlayers" on page 3–64 for more information.

4. When all entries have been made for this layer, click the **Enter** button in the Layer View window (Figure 3-28).

   You are returned to the Filmstack Model window (Figure 3-12) with the new layer displayed as the top layer of the filmstack model.

5. Perform **one** of the following:

   - **To add another layer**, repeat Steps 1 through 4 of this procedure.

   - **To delete the top layer**, proceed to "Deleting Film Layers" on page 3–49.

   - **To modify an existing layer**, proceed to "Modifying Film Layers" on page 3–50.

6. When all filmstack layers have been added, return to Step 6 in "Modifying an Existing Filmstack" on page 3–22, or Step 5 in "Creating a New Filmstack" on page 3–26 as appropriate.

Creating New Materials

The FE System contains an extensive database of film materials. However, you may create new materials to suit your application by using the procedure in this section.

NOTE

This procedure assumes that you are either creating a new filmstack model or are modifying a filmstack model and the Material Selection window (Figure 3-26) is currently displayed.

1. With the Material Selection window displayed, enter a name for the new material in the Name field (such as **Poly15%**) and click on the **Enter** button.

   A window is displayed asking if this is an EMA (Effective Medium Approximation) composite material.

2. Perform **one** of the following:

   - If you **are creating** an EMA composite material, proceed to “Creating EMA Composite Materials” on page 3–47.
   - If you **are not creating** an EMA composite material, proceed to “Creating Non-EMA Composite Materials” below.

Creating Non-EMA Composite Materials

1. In the window asking if this is an EMA composite material, click on **No**.

   A Material window is displayed that allows you to enter the N, K, dN, and K2 values for the newly created material.

2. Enter the **N**, **K**, **dN**, and **K2** values for the material and click on the **Enter** button.

   The Material Selection window is displayed with the newly created material highlighted.

3. Click on the **Enter** button in the Material Selection window.

   The Layer View window appears with the optical constants for the material.

4. In the Layer View window, enter the desired information for the material using the procedure given in “Modifying Film Layers” on page 3–50.

Creating EMA Composite Materials

1. In the window asking if this is an EMA composite material, click on **Yes**.

   The EMA Material window appears with the material name specified as shown in Figure 3-30.

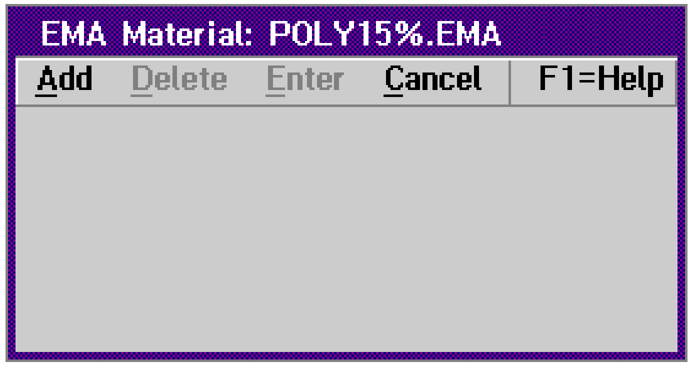

Figure 3-30. EMA Material Window

2. In the EMA Material window, click on **Add**.

   A Constituent window is displayed as shown in Figure 3-31.

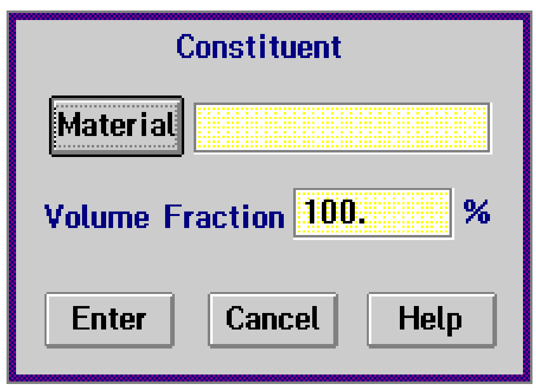

Figure 3-31. EMA Material Constituent Window

3. In the Constituent window, click on the **Material** button and select the first component of the composite material from the Material Selection window.

   The selected material is displayed in the Constituent window.

4. In the Constituent window, enter the percentage of the EMA material that is made up of this constituent in the Volume Fraction field, then click on the **Enter** button.

   The EMA Material window is displayed with the selected component as shown in Figure 3-32.

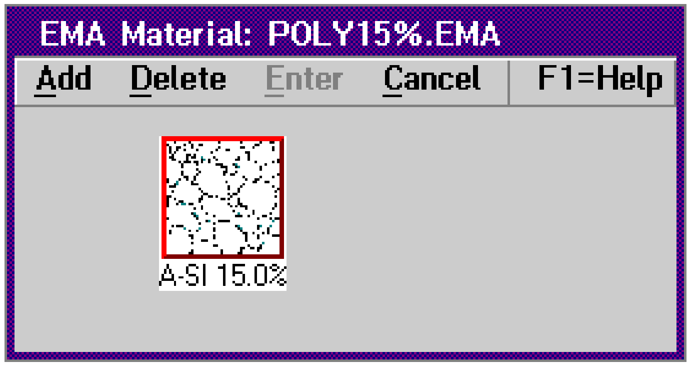

Figure 3-32. EMA Material Window - First Component

5. Add the second component of the EMA composite material by repeating Step 2 through Step 4 above.

   Each time a component is selected, the EMA Material window is redisplayed showing the components selected. Figure 3-33 below shows an example of an EMA composite material made up of the components A-SI and SI.

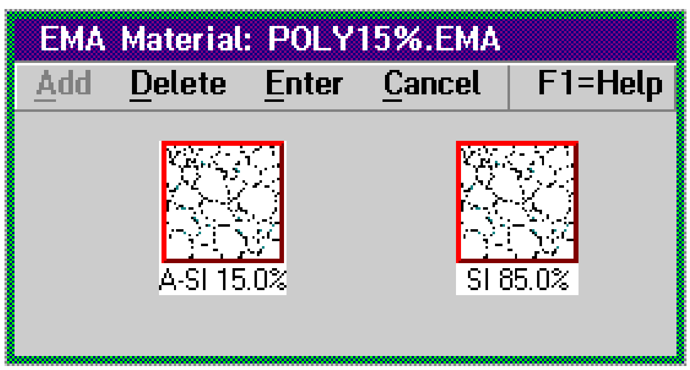

Figure 3-33. EMA Material Window - Two Components

6. When the components have been selected, in the EMA Material window menu, click on **Enter**.

   The Material Selection window is displayed with the newly created material highlighted.

7. Click on the **Enter** button in the Material Selection window.

   The Layer View window appears with the optical constants for the newly created EMA composite material.

8. In the Layer View window, enter the desired information for the material (such as spec thickness, ranges, and the parameters to be calculated) using the procedure given in “Modifying Film Layers” on page 3–50.

Deleting Film Layers

To delete the top layer of the filmstack model, you must have already selected or copied a previously defined filmstack using the procedures in “Modifying an Existing Filmstack” on page 3–22.

1. In the Filmstack Model window, click on **Layers** then click on **Delete Top** when the Layers menu is displayed.

   A window is displayed asking you to confirm that you wish to delete the top layer of the filmstack model.

2. Perform **one** of the following:

   - **If you do not wish to delete the top layer of the filmstack model**, click on **Cancel**.

     You are returned to the Filmstack Model window.

   - **If you do wish to delete the top layer of the filmstack model**, click on **OK**.

     You are returned to the Filmstack Model window and the top layer is removed from the filmstack.

3. Repeat this procedure if you wish to delete another layer from the filmstack model.

4. When you have deleted the desired layer(s), return to Step 6 in “Modifying an Existing Filmstack” on page 3–22.

Modifying Film Layers

To modify an existing layer in the filmstack model, you must have already selected, copied, or created a filmstack using the procedures in "Modifying an Existing Filmstack" on page 3–22 or "Creating a New Filmstack" on page 3–26 respectively.

1. In the Filmstack Model window, click on the layer that you wish to modify.

   A Layer View window is displayed that contains the information for the selected layer. In the examples below the Layer View window in Figure 3-34 shows a single wavelength measurement, the Layer View window in Figure 3-35 shows a dual wavelength measurement. The window displayed will depend upon the type of filmstack being modified.

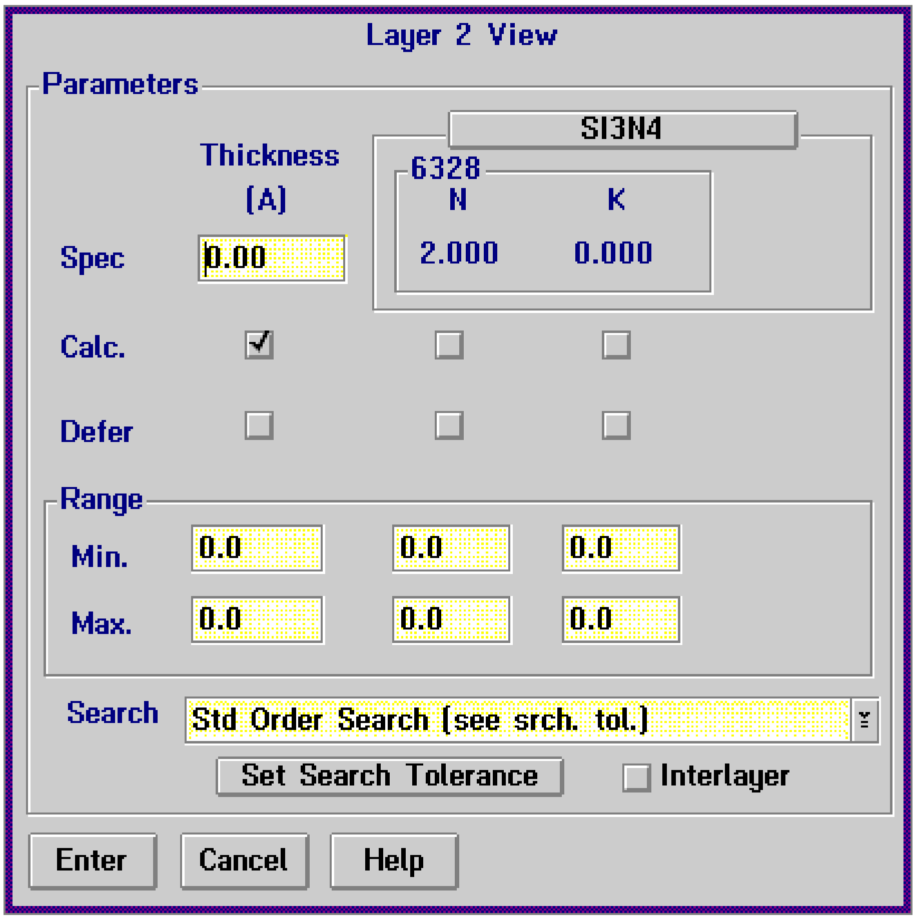

Figure 3-34. Layer View Window - Single Wavelength

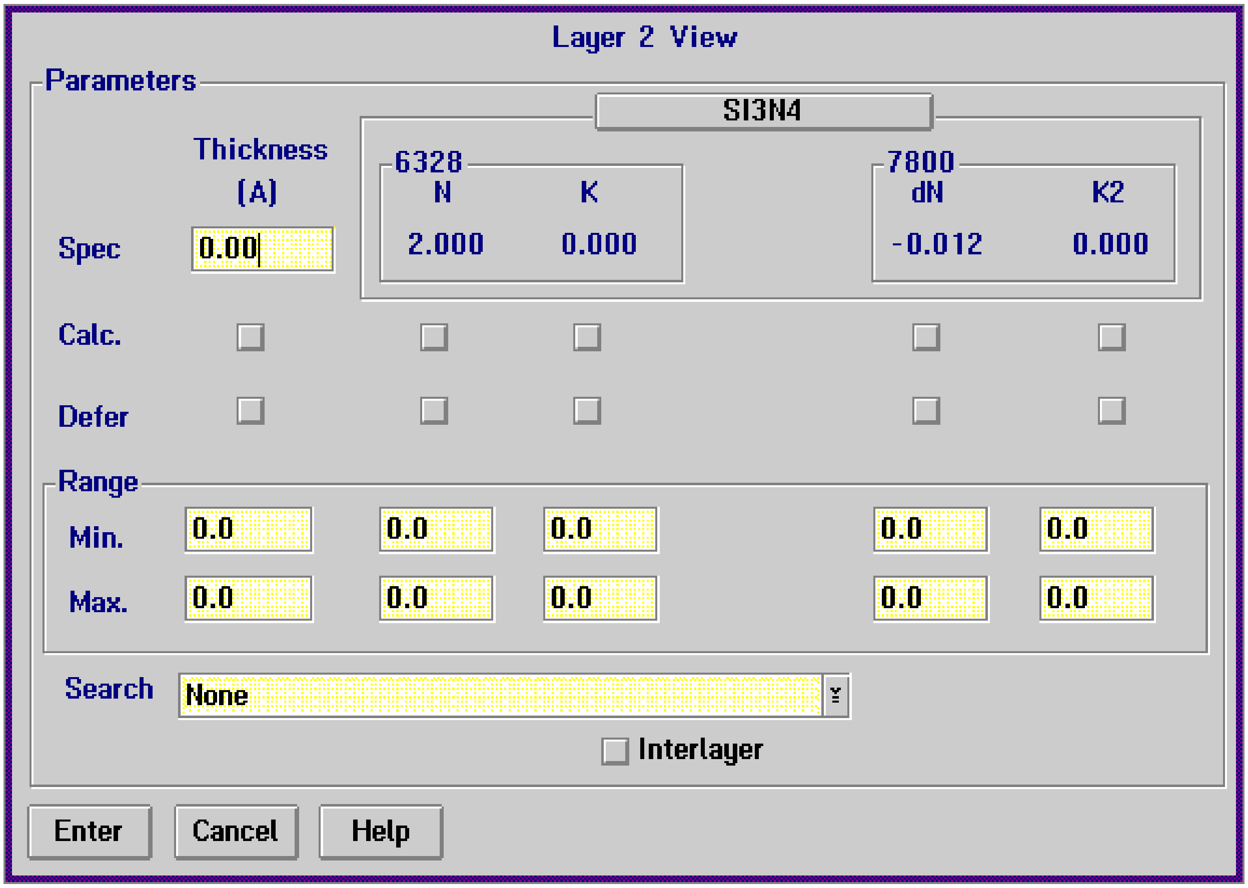

Figure 3-35. Layer View Window - Dual Wavelength

2. Enter the values for the selected layer in the Layer View window using the information below as a guide.

   - **Layer Material** — Click on the button with name of the material that makes up the layer to display the Material Selection window as shown in Figure 3-26. Select the desired material from the list by clicking once on the item then clicking **Enter**, or by double clicking on the item. The name of the selected material is displayed in the Layer Material button in the Layer View window and the specs for **N**, **K**, **dN**, and/or **K2** (as applicable) are updated.

NOTE

You may also enter the name of a new material to be used in the filmstack by using the procedure in "Creating New Materials" on page 3–46.

   - **Spec**

     - **Thickness** — Enter the approximate thickness (in Angstroms) for the layer.

- **N** — Displays the **N** value (index of refraction) for the layer based on the selected material.
- **K** — Displays the **K** value (absorption coefficient) for the layer based on the selected material.
- **dN** — Only displayed for dual wavelength measurements. Displays the **dN** value (difference in refractive index between the two wavelengths) for the layer based on the selected material.
- **K2** — Only displayed for dual wavelength measurements. Displays the **K2** value (absorption coefficient for the second wavelength) for the layer based on the selected material.

• **Calc.** — Specify the parameters that should be calculated during the measurement.

• **Defer** — Specify the parameter measurements that will be deferred to the Operator.

• **Range** — Enter the range tolerance for the calculated parameters. Entering 0 in both fields effectively disables range tolerance checking. If values other than 0 are entered and the calculation is outside of the specified range, the FE System will take the action that is selected using the Range button in the Filmstack Model window. See “Setting Range Specifications” on page 3–55 for more information.

NOTE

The out of range action only applies to the Focus Operator Queued Loading program.

- **Min.** — Specify the minimum range value.
- **Max.** — Specify the maximum range value.

• **Search** — Select the search type by clicking on the down arrow button to the right of the Search field. Refer to “Order Searching and Order Resolution” on page 3–34 for more information.

- **None** — The FE System will find the closest local minima of fit error.
- **Restricted Search** — Perform order search over a restricted thickness range. Refer to Table E-1 on page E–20 for more information.
- **Std Order Search** — When using single wavelength, the region searched varies with the application but is typically ± 5 orders.

- **Set Search Tolerance** — Only displayed when Restricted Search or Std Order Search types are selected. Sets tolerances on acceptable values of computed optical constants (N, K, dN, and K2). The checkboxes for **N**, **K**, **dN**, and/or **K2** must be selected for the entered tolerances to apply. Click on the Set Search Tolerance button to display the Search Tolerance window as shown in Figure 3-36. Enter the desired values and click on **Enter**.

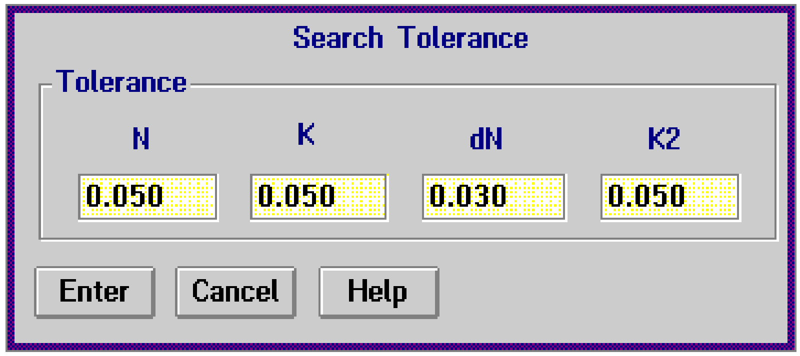

Figure 3-36. Search Tolerance Window

- **Interlayer** — Click on this box to indicate that this layer is an "interlayer". This causes the thickness of this layer to be added to the underlying layer. This feature is useful when a single film is represented as a composite of two layers (such as, poly-silicon). Refer to "About Interlayers" on page 3–64 for more information.

3. When all entries have been made for this layer, click the **Enter** button in the Layer View window (Figure 3-35).

   You are returned to the Filmstack Model window with the layer modifications displayed in the filmstack model.

4. Repeat this procedure if you wish to modify another layer from the filmstack model.

5. When all modifications to the filmstack model layers have been completed, return to Step 6 in "Modifying an Existing Filmstack" on page 3–22.

Selecting Measurement Controls

To select a measurement control for the filmstack model, you must have already selected, copied, or created a filmstack using the procedures in "Modifying an Existing Filmstack" on page 3–22 or "Creating a New Filmstack" on page 3–26 respectively.

1. In the Filmstack Model window, click on the **Meas:** button.

   A Measurement Selection window is displayed as shown in Figure 3-37.

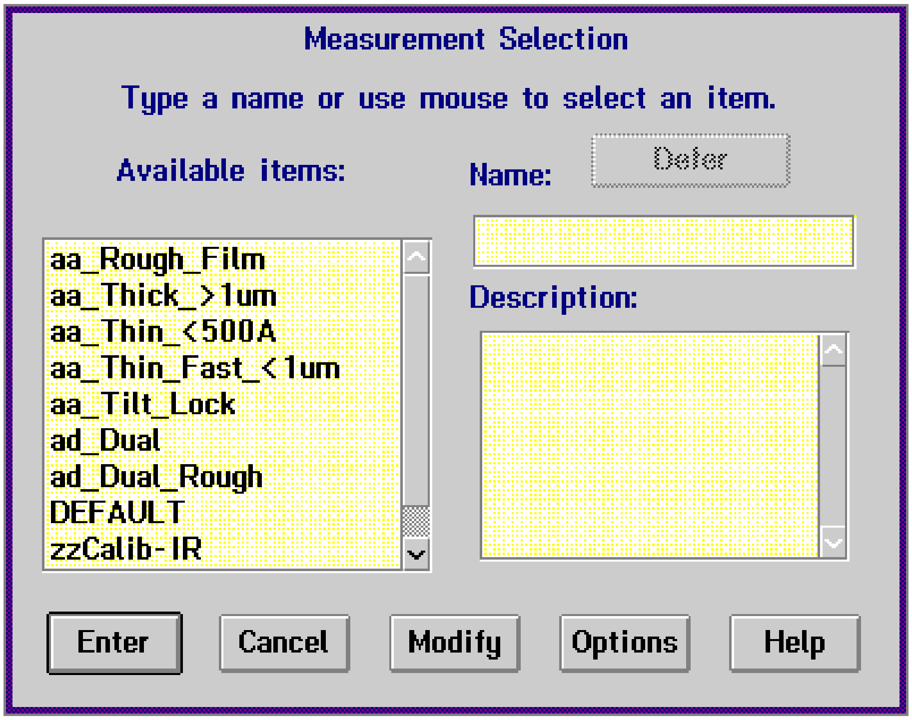

Figure 3-37. Measurement Selection Window

2. Select a measurement control for the layer from the list by clicking once on the item then clicking **Enter**, or by double clicking on the item. Select **DEFAULT** to use the standard measurement mode (equivalent to thin mode).

   You are returned to the Filmstack Model window. The selected measurement control is displayed in the **Meas:** button.

NOTE

A list of the Rudolph supplied measurement controls is provided in Appendix C, "Default Recipes and Filmstacks".

3. Return to Step 8 in "Modifying an Existing Filmstack" on page 3–22, or Step 6 in "Creating a New Filmstack" on page 3–26 as appropriate.

Setting Range Specifications

To set the maximum fit error for the filmstack and the action that the FE System will take when a measurement is out of range, you must have already selected, copied, or created a filmstack using the procedures in "Modifying an Existing Filmstack" on page 3–22 or "Creating a New Filmstack" on page 3–26 respectively.

1. In the Filmstack Model window, click on the **Ranges** button.

   The Range Specifications window is displayed as shown in Figure 3-38.

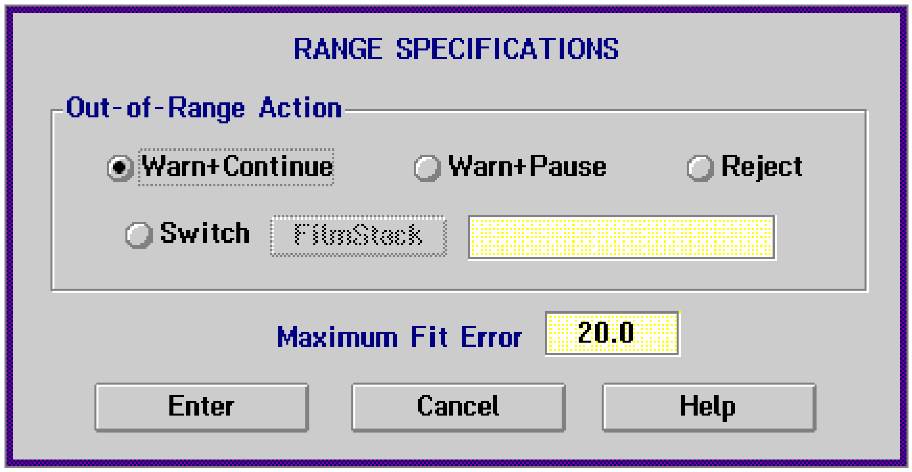

Figure 3-38. Range Specifications Window

2. Enter the desired maximum fit error and select the out-of-range action to be taken when a measurement exceeds the maximum fit error.

3. If you selected **Switch** for the out-of-range action in the previous step, click on the **Filmstack** button and select a filmstack from the Filmstack Selection window. The FE System will automatically switch to this filmstack and perform the test measurement again if the initial measurement exceeds the maximum allowed fit error.

4. When you have completed the range specifications for the filmstack, click on the **Enter** button in the Range Specifications window.

   You are returned to the Filmstack Model window.

5. When the desired measurement control has been selected, return to Step 9 in "Modifying an Existing Filmstack" on page 3–22, or Step 7 in "Creating a New Filmstack" on page 3–26 as appropriate.

Faxing Data to Rudolph Technologies

In the event that you encounter difficulties developing your filmstack model, or if you need assistance in modeling a wafer, measurement data may be faxed to the Rudolph Applications Support group. This will allow the simulation of your filmstack modeling at the Rudolph Technologies facilities.

By using the procedure below, a measurement fax printout will be generated that consists of the filmstack information and the delta/psi values that were obtained from the last measurement that was made.

1. Ensure that a wafer is loaded as described in “Load a Test Wafer” on page 3–17.

2. Ensure the Filmstack Model window is displayed and shows the filmstack that you selected using the procedures described in “Choosing a Filmstack Model” on page 3–20.

3. In the Focus Interactive main menu, click on **Measure**.

   The FE System begins measuring the test site and performs the calculations for the measurement.

4. Once the measurement calculations have been completed, in the Focus Interactive main menu, click on **Logging**.

   The Logging menu is displayed.

5. Click on **Measurement Fax Printout** in the Logging menu.

   A window is displayed instructing you to enter **lpt1** to send the data to the printer.

6. Click on **OK**.

   A Measured Data Selection window is displayed as shown in Figure 3-39.

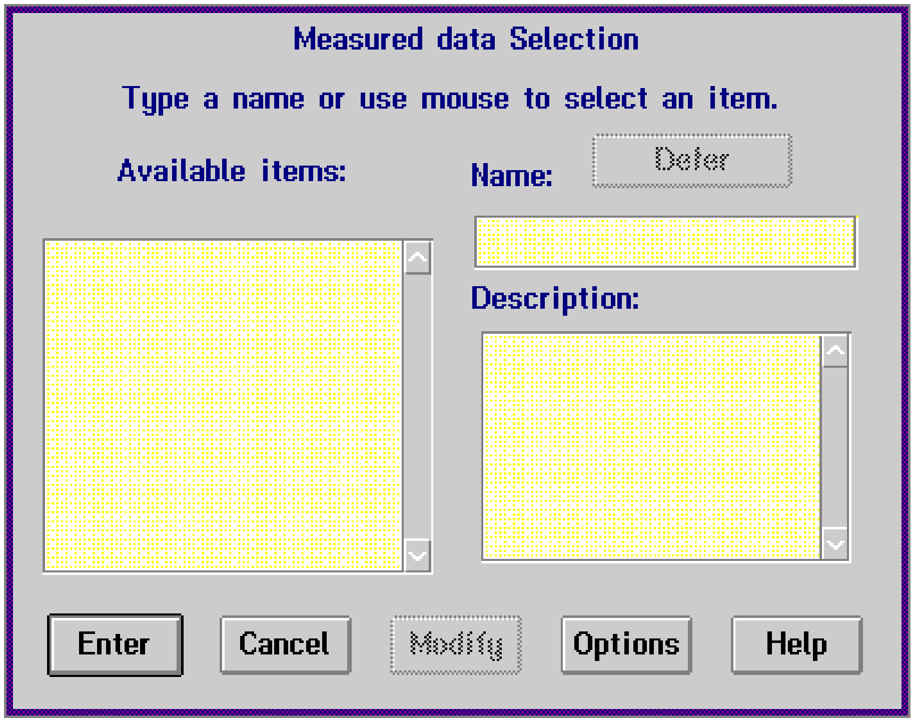

Figure 3-39. Measured Data Selection Window

7. Enter **lpt1** in the Name field and click on the **Enter** button.

   The filmstack and measurement data is output to the printer that is connected to the FE System.

8. Fill in the appropriate information in the **From:** section of the printout and fax the report to the Rudolph Applications Support group at the number provided on the printout.

   An example of a measurement printout is shown in Figure 3-40.

```
***                 Rudolph Application Fax           ***


To:      Rudolph Applications Support
         Rudolph Technologies
         1 Rudolph Road
         Flanders, NJ 07876  USA
         Fax: (201)-691-5480


From:

         Name:

         Company:

         Phone

         Fax

         Comments:


Filmstack:
   Film Stack: aa_SiO2_<1um_T

       SIO2       T:    1000*  N:1.462  K:0.000   @
       SI         T:Substrate N:3.858  K:0.018

       Error Est:      Off
       Measure Control: aa_Thin_Fast_<1um
       Range Specs -
          Fit Error:  20.000000
          OoR Action: Warn & Continue


Delta, Psi Values

10 1.015388 0.690903 0.000000
67.166321 247.212799 22.871733 0.000000
64.543564 226.229584 21.411255 0.000000
61.872223 204.838364 22.492907 0.000000
59.164879 187.313660 24.389507 0.000000
56.434097 177.728882 26.584040 0.000000
53.692459 168.399933 29.413336 0.000000
50.952538 163.569702 30.001020 0.000000
48.226902 162.007446 33.419010 0.000000
45.528130 158.352844 34.339687 0.000000
42.868790 158.581650 36.561695 0.000000
```

Figure 3-40. Measurement Data Fax Printout

Exiting Focus Interactive

To exit the Focus Interactive program, perform the following procedure:

1. On the Focus Interactive screen, perform **one** of the following:

   - Double click the left trackball button on the icon located in the upper left-hand corner of the screen (beside the Focus Interactive program name).

   - Single click the left trackball button on the icon located in the upper left-hand corner of the screen (beside the Focus Interactive program name). Select **Close** from the menu that is displayed.

   The Focus Interactive program will exit and you will be returned to the OS/2 desktop.

Applications by Fab Area

The following system applications and Fab areas are covered in the sections that follow. Examples of common applications, or “application notes” are provided.

NOTE

The application examples provided in this section are intended as a teaching tool so that Engineers can learn the fundamentals of creating filmstacks. All applications can vary greatly, therefore please contact the Rudolph Applications Support Group nearest to you for help with your particular application.

Table 3-2. Typical Applications by Fab Area

Fab Areas:	Diffusion	CVD	Etch	CMP	Lithography
System Applications:	Thin and Thick Oxide	Thick Oxide	Oxide Etch to Clear	TEOS on Metal	Photo Resist
	Thin and Thick Nitride	Amorphous Si		BPSG on Metal	
	Poly Variations	TiN/Si		PMD on Silicide	
	Poly-Si using EMA				

Diffusion Applications

This section provides examples of the system applications within the Diffusion area of the Fab. These include standard filmstacks such as Thin Oxide, Thick Oxide, Thin Nitride, and Thick Nitride, as well as custom filmstacks including Poly Variations, and Poly-Si using EMA.

NOTE

The application examples provided in this section are intended as a teaching tool so that Engineers can learn the fundamentals of creating filmstacks. All applications can vary greatly, therefore please contact the Rudolph Applications Support Group nearest to you for help with your particular application.

Diffusion Application: Oxides/Nitrides

Introduction

The formation of silicon dioxide ($SiO2$) on a silicon substrate (oxidation) is a popular process in the diffusion area of the Fab. Some functions of thermally-grown oxide films are:

- Masking against ion implantation and diffusion
- Passivation of the silicon surface
- Isolation of individual devices

Silicon nitride ($Si3N4$) plays an important role in the diffusion area of the Fab. It acts as a diffusion barrier, and is useful as a mask for the selective oxidation of exposed silicon.

The following example will describe the procedure for developing and testing a filmstack for measuring the thickness of a single layer of SiO2 or Si3N4 on a silicon substrate.

Procedure

1. In the Focus Interactive main menu, click on **Filmstack**.

   The Filmstack Selection window is displayed.

2. Click the left trackball button once on the Rudolph-supplied filmstack that is designed to measure the thickness of an oxide or nitride film on silicon. The name of these filmstacks are **aa_SiO2_XXX_T** and **aa_Si3N4_XXX_T** respectively where **XXX** is an estimation of the thickness of the oxide or nitride layer (such as **<500** or **>1um**). The prefix “aa” indicates this filmstack uses a single wavelength measurement control.

3. Review the filmstack description to verify that it is appropriate for your application, and click the **Enter** button in the Filmstack Selection window.

   A Filmstack Model window is displayed. The example Filmstack Model window below shows the thin oxide filmstack model. The filmstack model windows for other oxide or nitride models are similar.

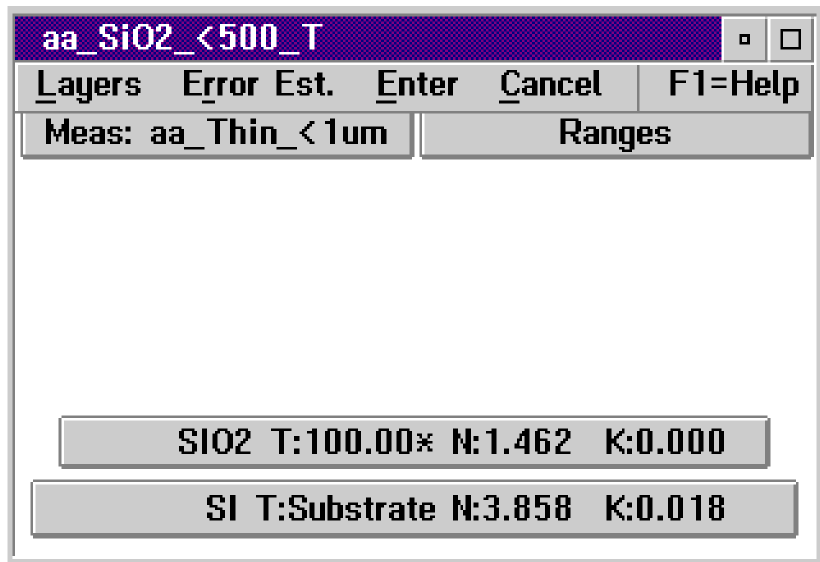

Figure 3-41. Rudolph-supplied Thin Oxide Filmstack

   The filmstack will show a SiO2 or Si3N4 layer on a SI substrate. The SiO2/Si3N4 layer has fixed optical constants (**N** and **K** values) and shows the filmstack model's spec thickness (100Å in this example). The asterisk (*) indicates a calculated parameter. It is recommended that the optical constants not be calculated for this application. Although the target thickness of the actual film layer may not be what is indicated in the filmstack model, the system will determine the correct thickness without any modification of this value.

4. Once the filmstack has been reviewed and is determined to be appropriate for the wafer, in the Focus Interactive main menu, click on **Measure**.

   The FE System performs the measurement and calculations on this wafer. When the data modeling is complete, the data is displayed in the Calculated Parameters window, as shown in Figure 3-42.

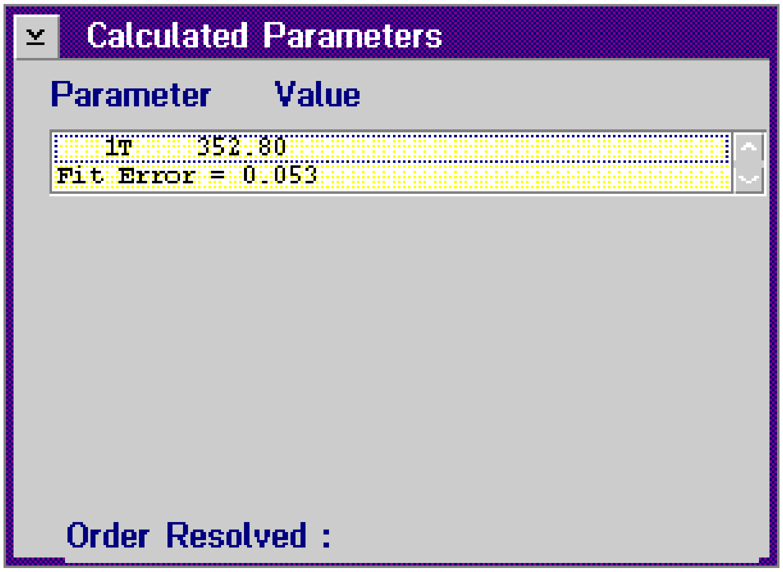

Figure 3-42. Sample Calculated Parameters

Analyzing the Results

The expected fit error should be in the range of 0 to 0.5 for thin film dielectrics, and 0 to 1 for thick film dielectrics.

NOTE

Fit error may vary when measuring the same wafer on a different FE System.

As shown in the calculated parameters window, the fit error for the measured thickness of the oxide/nitride layer, 1T, falls within the acceptable range. Therefore, the filmstack chosen for this application can be reliably used for production measurements in a Wafer Recipe.

Summary

The FE System database includes various Rudolph-supplied filmstacks for measuring oxide or nitride on silicon, each with different thicknesses and calculated parameters. Once the appropriate Rudolph-supplied filmstack has been determined, you should not have to modify it in any way to produce accurate and repeatable results.

Diffusion Application: Poly Variations

Introduction

Polycrystalline silicon (Poly-Si) films are generally used as gate electrodes and interconnections in MOS circuits. Optimum resistivity for these products can be achieved by the doping of polycrystalline films in the diffusion area of the Fab. In most cases, an SiO2 layer is grown before the Poly-Si is deposited, for purposes of electrical isolation. The FE System can be used to measure multi-layer filmstacks and multi-parameters for optical characterization of Poly-Si.

The following example will show the procedure for optimizing the filmstack required for measuring Poly-Si thickness of a wafer with 1500Å of Poly-Si deposited on 1000Å thermally grown SiO2. The interlayer feature for improved modeling is explained below and the EMA feature for optical characterization will be explained later in this section.

About Interlayers

Interlayers serve to reduce fit errors and improve order resolution. Some applications model better with one or more interlayers. Poly films often require these interlayers.

Although the thickness of interlayers is effectively subtracted from the modeled poly thickness and provides a more accurate representation of poly films, you may be more accustomed to receiving only one thickness for the combined poly/interlayer thickness. A typical poly filmstack is shown below:

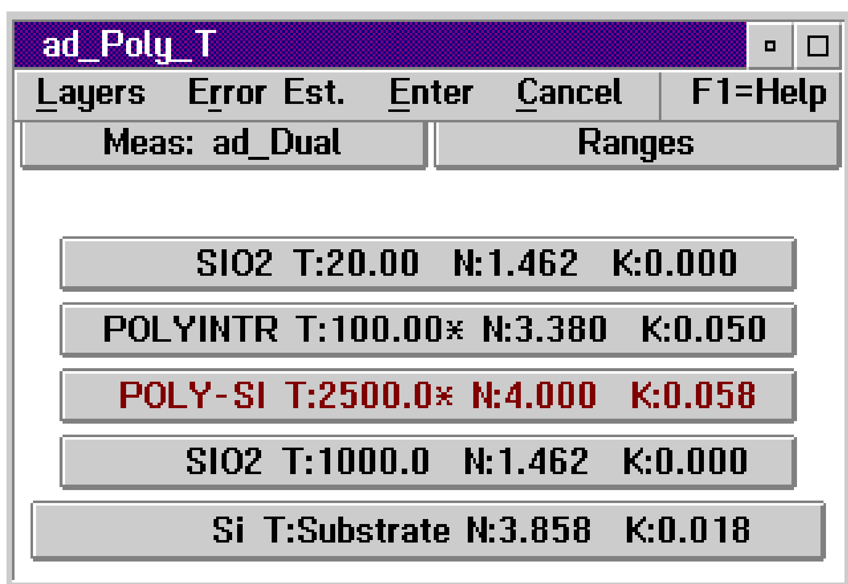

Figure 3-43. Poly Filmstack without an Interlayer

In this filmstack, the **POLYINTR** layer represents the partially oxidized roughness layer (interface between the poly and SiO2). The SiO2 layer represents the completely oxidized top layer. The resultant poly thickness will show 75Å less than a non-interlayer model.

In cases where the POLYINTR layer must be calculated, two separate thickness values must be manually summed to get the total poly thickness. The goal of interlayer modeling is to provide for interlayers and automatically add back the thickness values.

Each layer in a filmstack can be an interlayer. The interlayer is activated by checking the **Interlayer** check box on the Layer View window, as shown below:

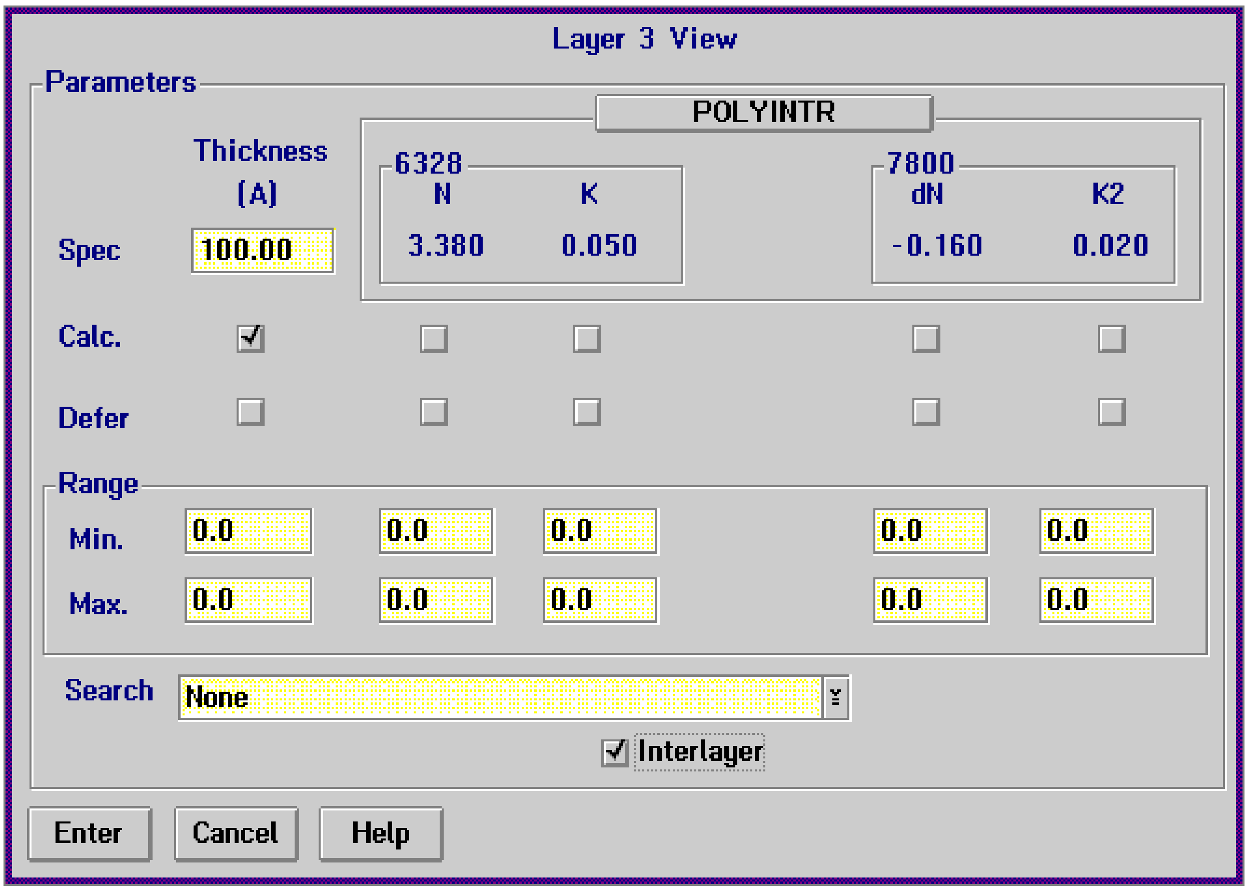

Figure 3-44. Specifying an Interlayer (Layer View Window)

When interlayer is checked, the layer displays on the Filmstack window slightly smaller and with green text.

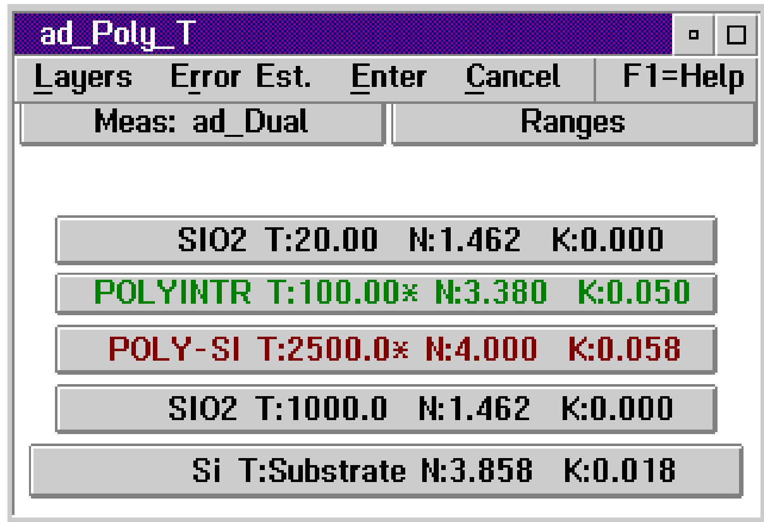

Figure 3-45. Poly Filmstack with an Interlayer

With an interlayer in the filmstack model, the POLYINTR layer thickness will be automatically added back into the POLY.EMA layer thickness.

The rules for the interlayer calculations are outlined below:

- Any number of adjacent interlayers will be summed into the first non-interlayer below.
- Interlayers with calculated thickness values will also be summed. The calculated thickness (of the interlayer) will not be displayed individually.
- Multiple sets of interlayers are allowed. For example, the filmstack: INTERLAYER/FILM/INTERLAYER/FILM/SUBSTRATE is allowed provided that the two film layers have calculated thickness values.
- Calculated refractive index values are not summed or removed by interlayers.
- The summation is a simple addition, there is no index weighting.

Although these rules allow some flexibility, very few applications will use more than one interlayer.

Procedure

1. In the Focus Interactive main menu, click on **Filmstack**.

   The Filmstack Selection window is displayed.

2. Select the Rudolph-supplied filmstack designed to measure the thickness of a Poly-Si film on a 1000Å SiO2 film on silicon substrate. The name of this filmstack is **ad_Poly_T**. The prefix “ad” indicates a dual wavelength measurement control.

NOTE

Dual wavelength is recommended for Poly-Si measurements to enhance order resolution.

3. Review the Description to verify that this filmstack is appropriate for this application, and click the **Enter** button.

   A Filmstack Model window is displayed as shown below.

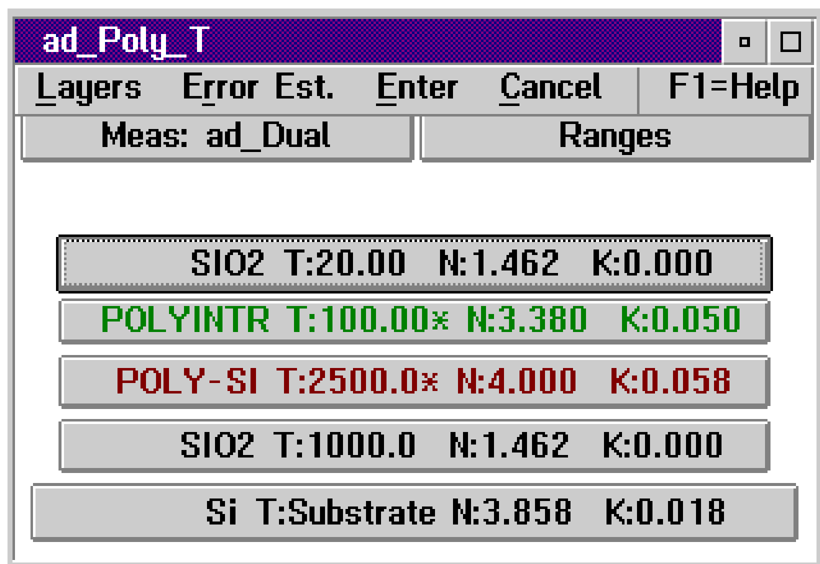

Figure 3-46. A Diffusion Poly Filmstack

This filmstack model has an initial oxide layer with a fixed value of 1000Å. Better knowledge of the bottom oxide thickness will provide more accurate results for the calculated parameters.

The POLY-SI layer shows a spec thickness of 2500Å with optical constants initially set at fixed values. The thickness of the Poly-Si layer is being calculated with a Restricted Search applied.

NOTE

A Restricted Order Search is recommended for all Poly-Si and A-Si applications.

The remaining top layers include an interlayer with calculated thickness and a native oxide layer for improved modeling.

Your Poly-Si application may have a different bottom oxide or Poly-Si thickness, or different Poly-Si optical constants. If your application differs, copy the Rudolph-supplied filmstack to a different name using **Save As**, and proceed with any necessary modifications.

4. Once the filmstack has been reviewed and is determined to be appropriate for the wafer, in the Focus Interactive main menu, click on **Measure**.

   The FE System performs the measurement and calculations on this wafer. When the data modeling is complete, the data is displayed in the Calculated Parameters window, as shown in Figure 3-47.

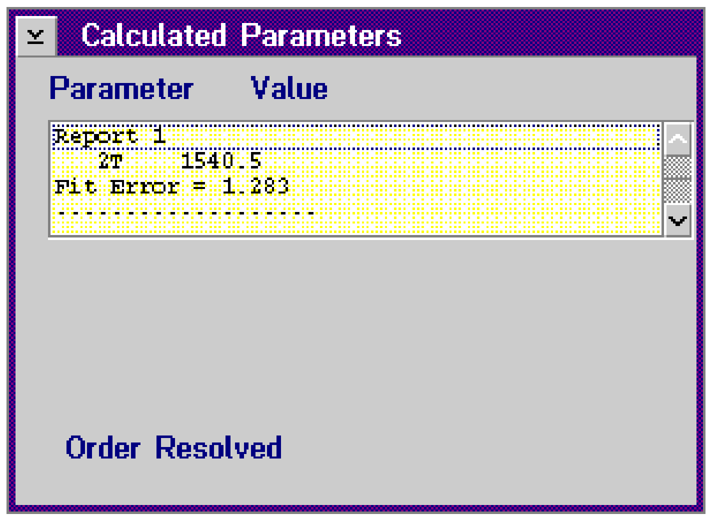

Figure 3-47. Calculated Parameters Window

Analyzing the Results

The fit error for this application can range from 0 to 10, depending on the quality of the film. Higher fit errors may be expected for Poly-Si films with disordered crystal structures. The fit error shown above falls within the acceptable range, and the calculated thickness is close to the target value. If needed, the fit error may be improved by calculating the absorption coefficient (**K**) of the Poly-Si layer. An incorrect fixed value of K may introduce inaccuracies in the calculated thickness of the Poly-Si.

If you need to re-calculate, use the following procedure:

1. Click on the **POLY-SI** layer to open the Layer View window.

2. In the Layer View window, check the **Calc.** box for **K** and click on the **Enter** button.

3. In the Focus Interactive main menu, click on **ReModel**, then click on **Measure**.

   The FE System performs a recalculation without making another measurement. The results of the modified filmstack are shown in the Calculated Parameters window shown in Figure 3-48.

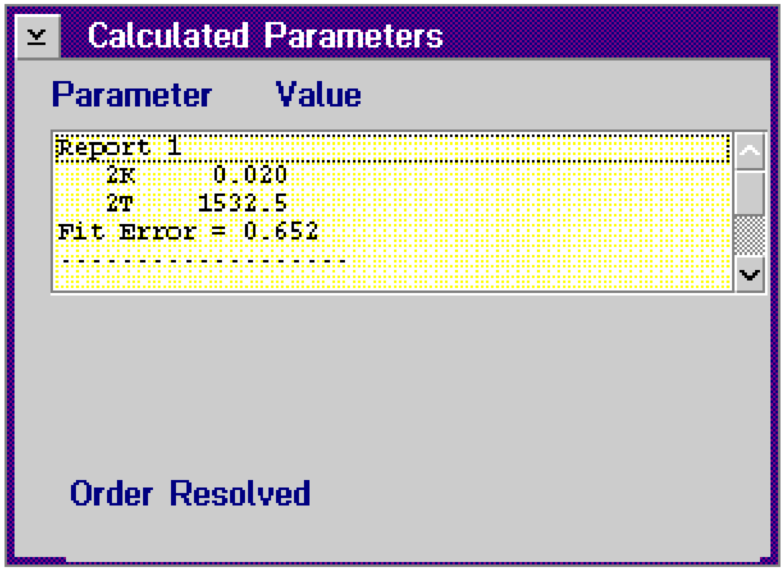

Figure 3-48. Calculated Parameters (Improved Fit Error)

The fit error has decreased, and is approximately one half the value of the fit error using the original filmstack. This indicates that by modifying the filmstack to calculate the Poly-Si thickness and K, the results have been improved.

Summary

The FE system provides the capability to calculate multiple parameters in a multi-layer filmstack of Poly-Si on oxide using dual wavelength, multiple angle of incidence ellipsometry. The typical filmstack for measuring Poly-Si in the thickness range of 500-1500Å includes an interlayer, a native oxide layer, and calculating the absorption (**K**).

Diffusion Application: Poly-Si Using EMA

Introduction

Deposition and doping conditions can vary the optical properties. Therefore, you might produce inaccurate results if you calculate a Poly-Si thickness while assuming values for the optical constants N (refractive index) and K (absorption coefficient). EMA (Effective Medium Approximation) provides the added capability of characterizing the optical constants, N and K, of the Poly-Si.

The following simplified assumption is the basis for using EMA modeling:

POLY-SI = X%(A-SI) + Y%(SI)

The N and K values of the Poly-Si layer are determined by calculating the volume fraction (Vf) of the A-Si content. With EMA, the N and K of the material is assumed to be in proportion to the N and K of the composite materials. If a Poly-Si film is 80% crystalline silicon and 20% A-Si, the N and K should be 80% like silicon and 20% like A-Si.

Use EMA to characterize the optical constants of the Poly-Si, and create a new material according to the calculated Vf of A-Si. Although the rules for using EMA are application dependent, this feature works best with a minimum Poly-Si thickness of 1500Å and a bottom oxide of at least 500Å.

NOTE

It is not recommended that EMA be used in day to day production unless the composition of the Poly-Si throughout each cassette of wafers varies too widely to accurately assume the optical constants.

The following example will show the procedure for using EMA and creating a new material for measuring Poly-Si thickness of a wafer with 5000Å of Poly-Si deposited on 1000Å thermally grown SiO2.

Procedure

1. In the Focus Interactive main menu, click on **Filmstack**.

   The Filmstack Selection window is displayed.

2. A pre-loaded filmstack does not exist using EMA to measure Poly-Si. Therefore, highlight the filmstack **ad_Poly_T** and click on the **Options** button. Copy this filmstack to a new name by typing the new name in the Destination field and click on the **Save As** button. Click **Enter** in the Filmstack Selection window to view the newly created filmstack model.

3. Change the POLY-SI layer to POLY.EMA by clicking on the **POLY-SI** layer in the Filmstack Model window.

   The Layer View window is displayed.

4. Click on the **POLY-SI** material in the Layer View window.

   The Material Selection window is displayed.

5. Select the material **POLY.EMA** in the Material Selection window and click on the **Enter** button.

6. In the Layer View window, enter a spec thickness of **5000Å** in the field, and check the **Calc.** box for Thickness and volume fraction (**Vf**). The Layer View window is shown below.

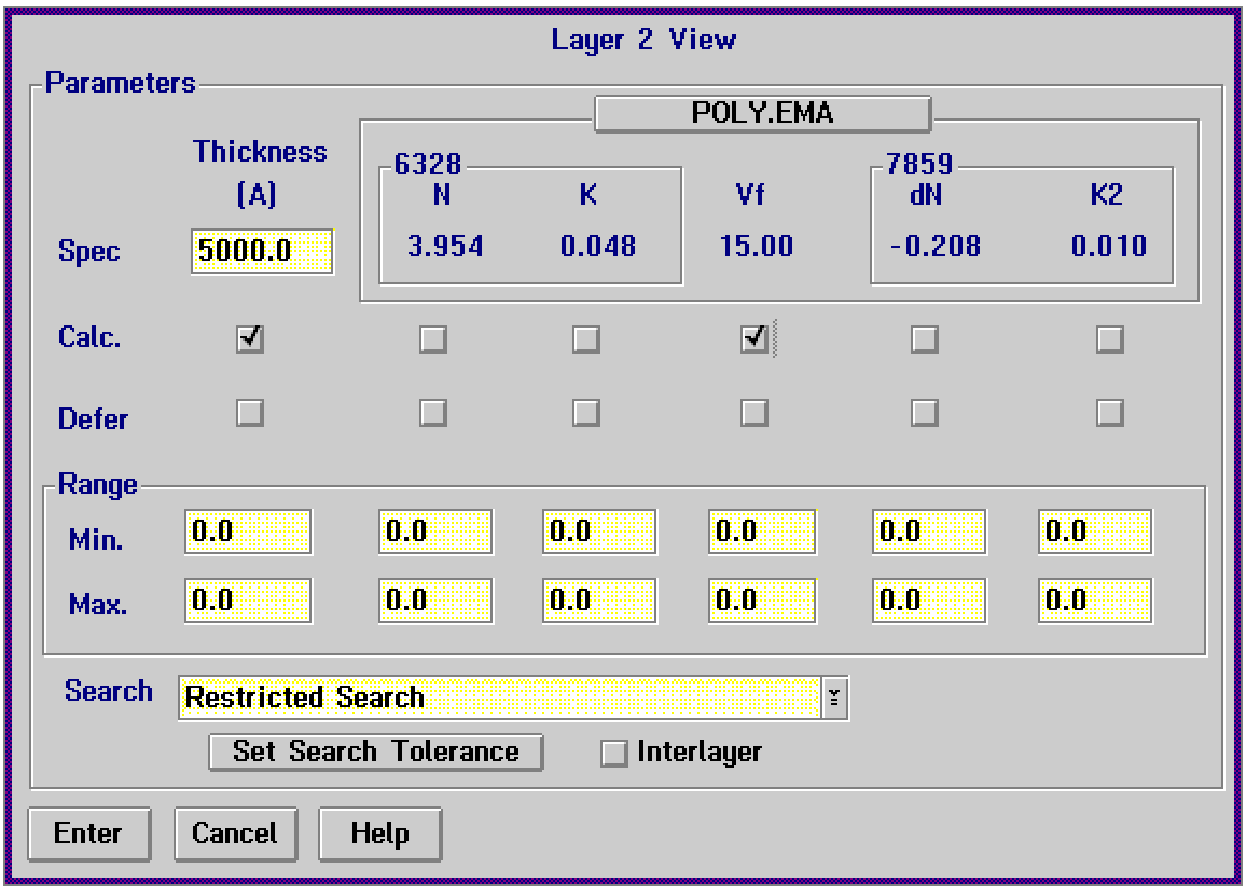

Figure 3-49. Layer View Window - Adding a POLY.EMA Layer

7. Click **Enter** in the Layer View window.

   A Filmstack Model window is displayed as shown in Figure 3-50.

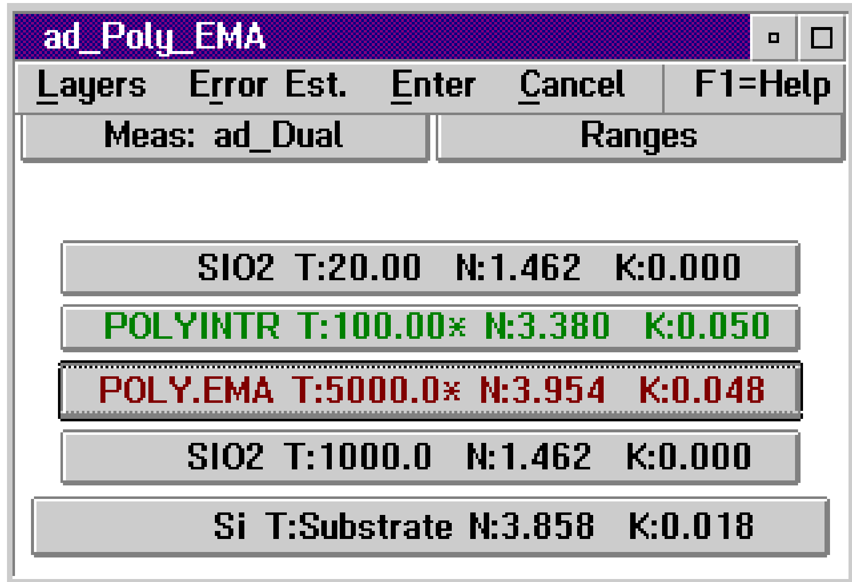

Figure 3-50. Revised Filmstack with POLY.EMA Layer

The new filmstack is identical to the **ad_Poly_T** filmstack with the exception of the POLY.EMA layer. The thickness of the Poly-Si layer is being calculated with a Restricted Search applied.

NOTE

A Restricted Order Search is recommended for all Poly-Si and A-Si applications.

The remaining top layers include an interlayer with calculated thickness and a native oxide layer for improved modeling.

8. Once the filmstack has been reviewed and is determined to be appropriate for the wafer, in the Focus Interactive main menu, click on **Measure**.

   The FE System performs the measurement and calculations on this wafer. When the data modeling is complete, the data is displayed in the Calculated Parameters window, as shown in Figure 3-51.

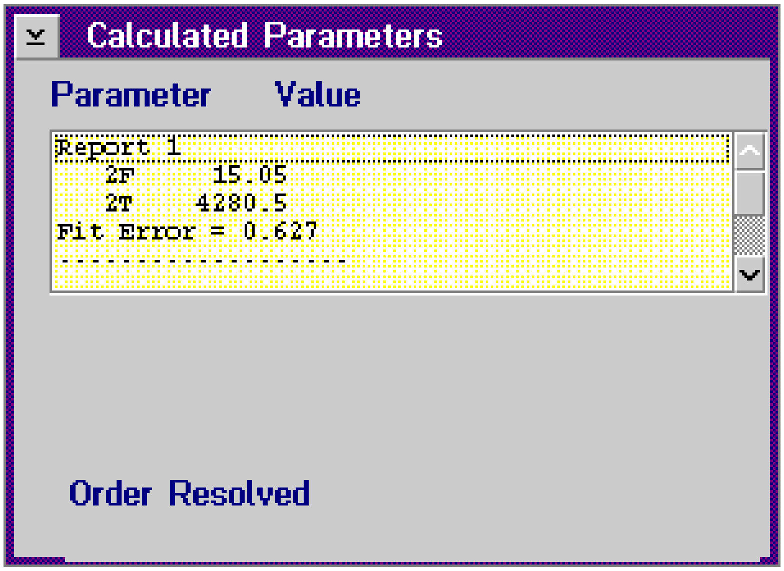

Figure 3-51. Calculated Parameters Using POLY.EMA

The fit error for this application can range from 0 to 10, depending on the quality of the film. Higher fit errors may be expected for Poly-Si films with disordered crystal structures. The fit error shown above is acceptable, and the calculated thickness close to the target value.

9. Create a new material associated with the calculated composition of the Poly-Si for production measurements of Poly-Si thickness. Click on the **POLY.EMA** layer in the Filmstack Model window.

   The Layer View window is displayed.

10. Click on the **POLY.EMA** material in the Layer View window.

    The Material Selection window is displayed.

11. Enter a name for the new material in the Name field (in this example enter **Poly15%**) in the Material Selection window and click on the **Enter** button.

    A window is displayed asking if this is an EMA composite material.

12. Click **Yes** to create an EMA material that is created by combining the two component materials, A-Si and Si.

    The EMA Material window appears with the material name specified.

13. In the EMA Material window, click on **Add**.

    A Constituent window is displayed.

14. In the Constituent window, click on the **Material** button and select the first component of the composite material (in this example, **A-Si**) from the Material Selection window.

    The selected material is displayed in the Constituent window.

15. In the Constituent window, enter **15** in the Volume Fraction field to specify that the Poly-Si is composed of 15% A-Si, then click on the **Enter** button.

    The EMA Material window is displayed with the A-Si component shown.

16. In the EMA Material window, click on **Add** and select the second component for the composite material by clicking on the **Material** button in the Constituent window and selecting **SI** from the material list.

    The Constituent window is displayed with the selected material shown. The FE System automatically determines that the composition is made up of 85% of the second component and displays **85** in the Volume Fraction field.

17. In the Constituent window, click on the **Enter** button.

    The EMA Material window is displayed as shown in Figure 3-52.

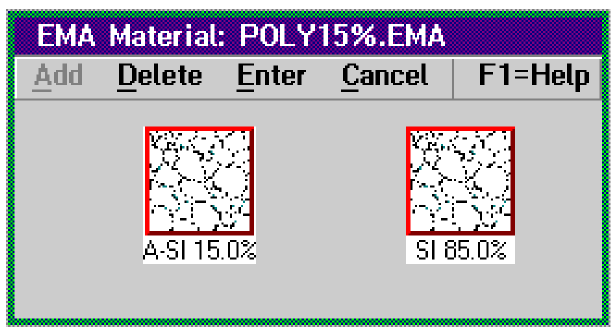

Figure 3-52. Final Composition: EMA Material Window

18. In the EMA Material window menu, click on **Enter**.

    The Material Selection window is displayed with the newly created material highlighted.

19. Click on the **Enter** button in the Material Selection window.

    The Layer View window appears (as shown in Figure 3-53) with the new optical constants for a 15% A-Si and 85% Si polycrystalline material.

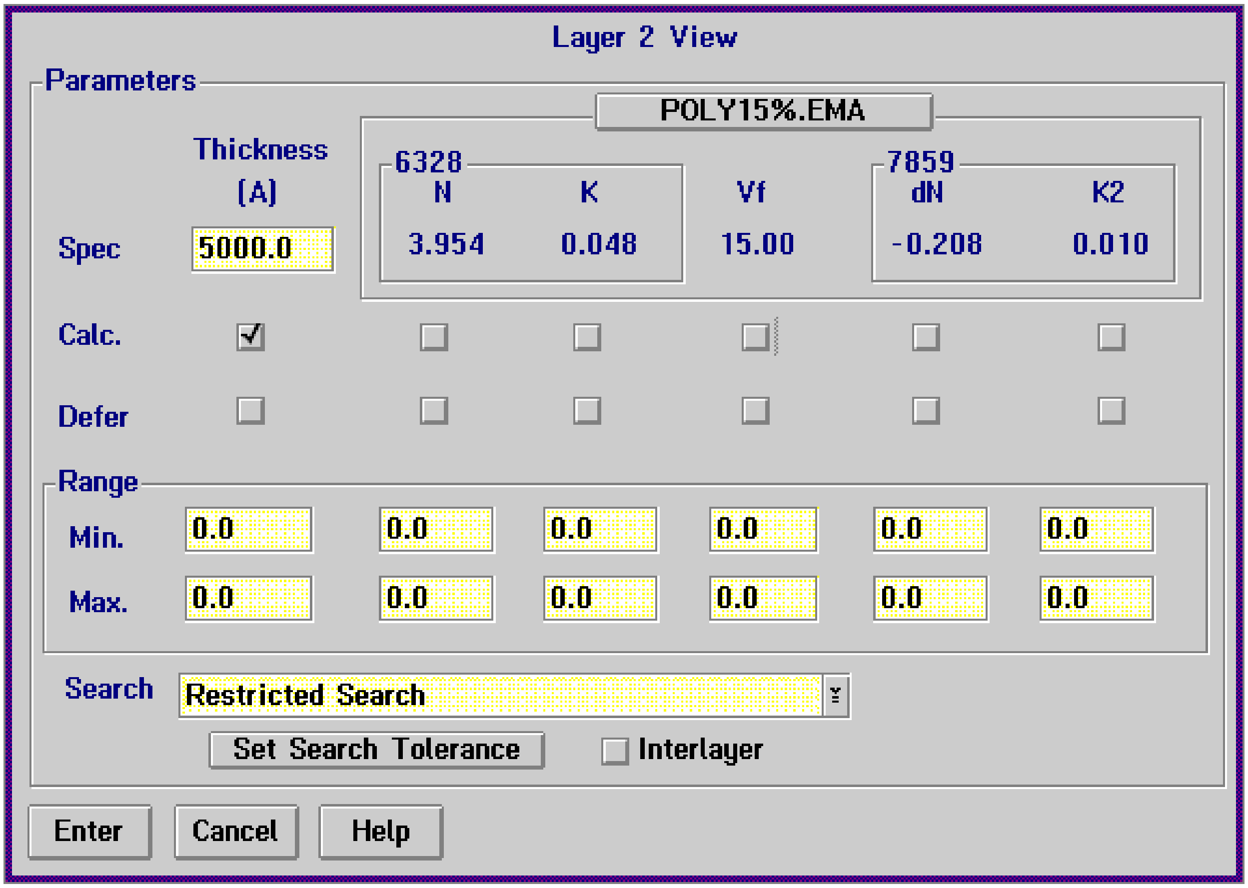

Figure 3-53. EMA Layer View with New Constants

20. In the Layer View window, click on the **Calc.** box for **Vf** to calculate thickness only, then click on the **Enter** button.

    The Filmstack Model window is displayed with the updated information.

21. Once the filmstack has been reviewed and is determined to be appropriate for the wafer, in the Focus Interactive main menu, click on **Measure**.

    The FE System performs the measurement and calculations on this wafer. When the data modeling is complete, the data is displayed in the Calculated Parameters window, as shown in Figure 3-54.

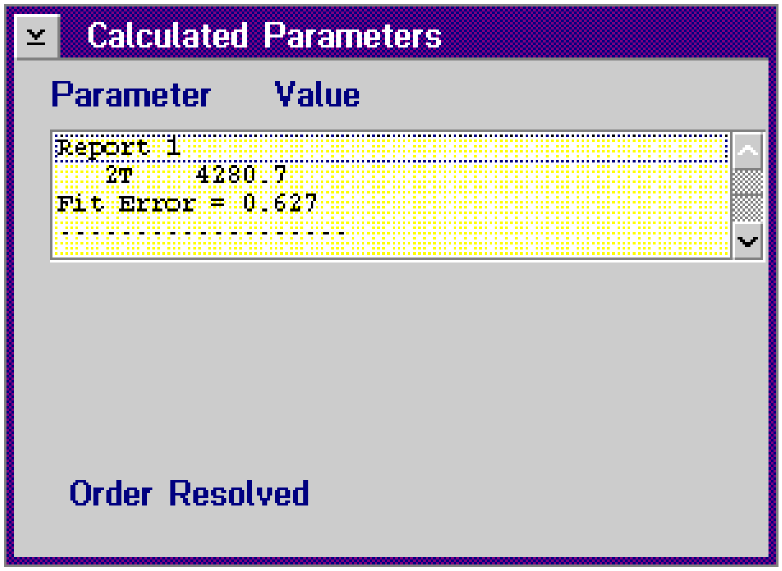

Figure 3-54. Final Calculated Parameters for Poly EMA

Analyzing the Results

The fit error is the same as when calculating Vf and thickness simultaneously, but the filmstack will be more reliable for production measurement purposes.

Summary

The dual wavelength, multi-angle technique provided by the FE System allows for multi-layer, multi-parameter capabilities for measuring Poly-Si using the EMA modeling feature. Use EMA to characterize the optical constants of the Poly-Si, and create a new material according to the calculated Vf of A-Si. It is not recommended that EMA be used in day to day production unless the composition of the Poly-Si throughout each cassette of wafers varies too widely to accurately assume the optical constants.

CVD (Deposition) Applications

This section provides examples of Thick Oxide, Amorphous Si, and TiN/Si applications within the CVD area of the Fab.

NOTE

The application examples provided in this section are intended as a teaching tool so that Engineers can learn the fundamentals of creating filmstacks. All applications can vary greatly, therefore please contact the Rudolph Applications Support Group nearest to you for help with your particular application.

CVD Application: Thick Oxide, T&N Measurements

Introduction

This example will describe setting up a filmstack model for wafers with a thick oxide layer on top of silicon. This is a simple film structure which shows the FE System's ability to calculate both thickness and refractive index simultaneously. This procedure applies for filmstacks in the range of 1000Å to 10000Å.

Procedure

1. In the Focus Interactive main menu, click on **Filmstack**.

   The Filmstack Selection window is displayed.

2. In this example the wafer to be measured was manufactured to a target thickness of 3000Å. To determine the thickness and refractive index of the wafer. Select the filmstack labeled, **aa_SiO2_>1um_TN**.

   The Filmstack Model window is displayed as shown in Figure 3-55.

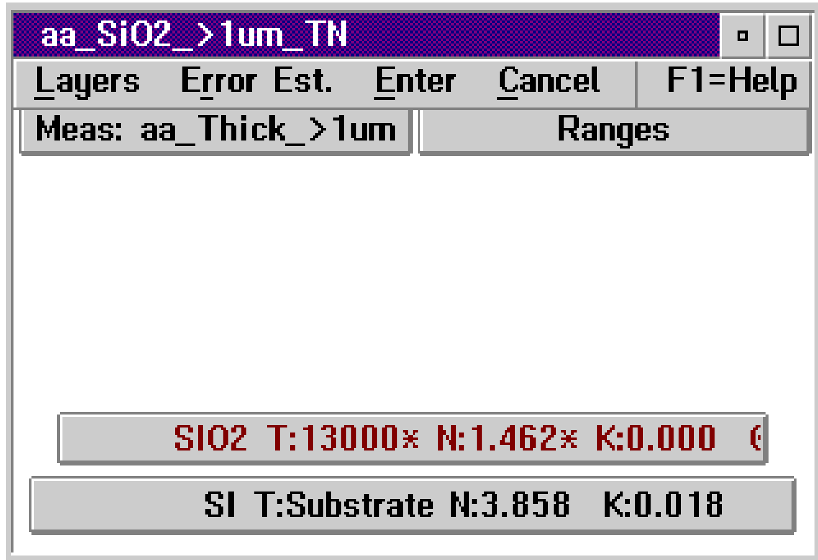

Figure 3-55. Thick Oxide Filmstack

There is no need to change the initial thickness values because a standard order search is selected for the oxide thickness so it will be well within the range of thicknesses for this application.

3. Once the filmstack has been reviewed and is determined to be appropriate for the wafer, in the Focus Interactive main menu, click on **Measure**.

   The FE System performs the measurement and calculations on this wafer. When the data modeling is complete, the data is displayed in the Calculated Parameters window, as shown in Figure 3-56.

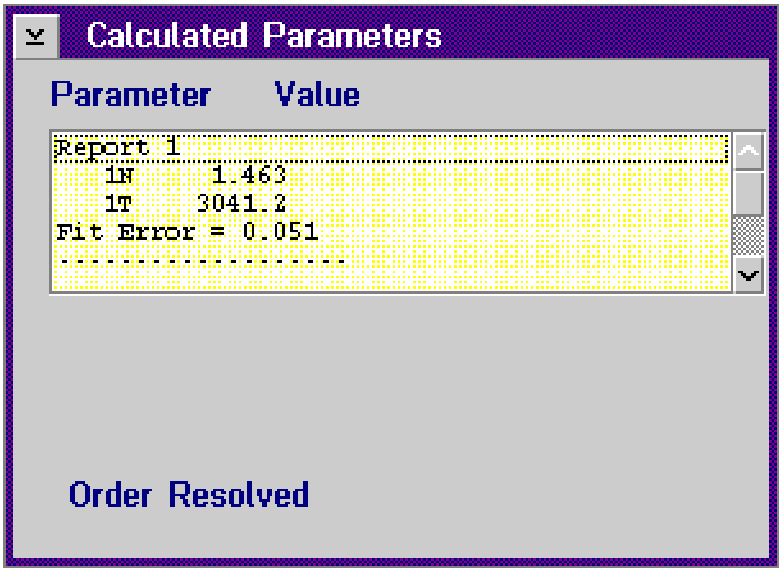

Figure 3-56. Calculated Parameters Window

Analyzing the Results

As expected, the refractive index of SiO2 should be very close to 1.462. In addition, there is a low fit error. These indicate reliable measurement results and that the filmstack model is acceptable for this application.

Summary

Ellipsometry allows the metrologist to simultaneously calculate thickness and refractive index. The FOCUS Ellipsometer's multiple angle of incidence technology allows the correct thickness order to be determined.

CVD Application: Amorphous Si

Introduction

This example will describe setting up a filmstack model for wafers with an amorphous silicon (A-Si) on an oxide layer. This is not a simple film structure; however, it is one often encountered in CVD.

All A-Si wafers have a native oxide layer present on the surface. This layer is often considered negligible, but results have shown that by adding a native oxide layer to the filmstack more stable measurement results can be obtained.

Procedure

1. In the Focus Interactive main menu, click on **Filmstack**.

   The Filmstack Selection window is displayed.

2. To develop this application, copy the A-Si filmstack to a new name and modify the copy. Highlight the filmstack **ad_Amorphous_TT** and click on the **Options** button. Copy this filmstack to a new name by typing the new name (in this example **150_A-Si/1000_SiO2**) in the Destination field and click on the **Save As** button. Click **Enter** in the Filmstack Selection window to view the newly created filmstack model.

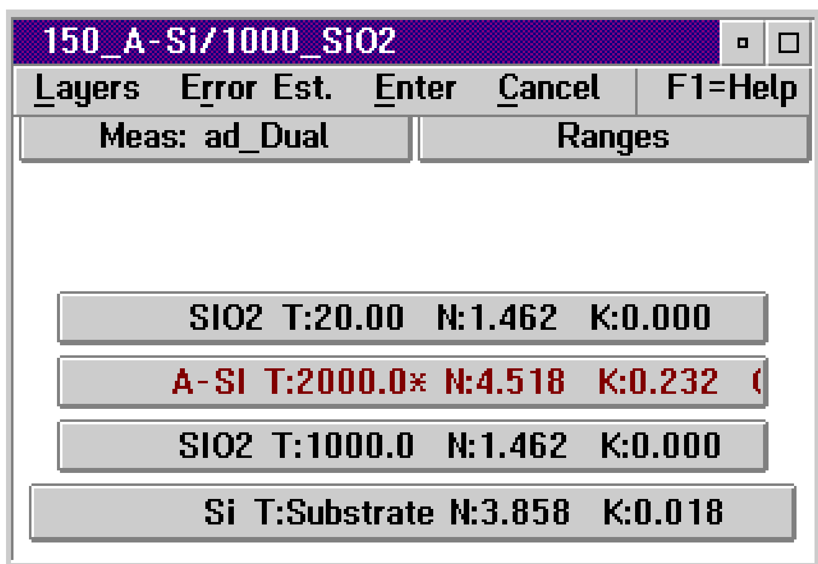

Figure 3-57. Amorphous Si Filmstack - Original

3. Modify the filmstack according to your specific application by clicking the **A-Si** layer in the Filmstack Model window.

   The Layer View window is displayed.

4. In the box under **Thickness**, type in your thickness value and click **Enter**. If necessary repeat this step for the bottom oxide layer.

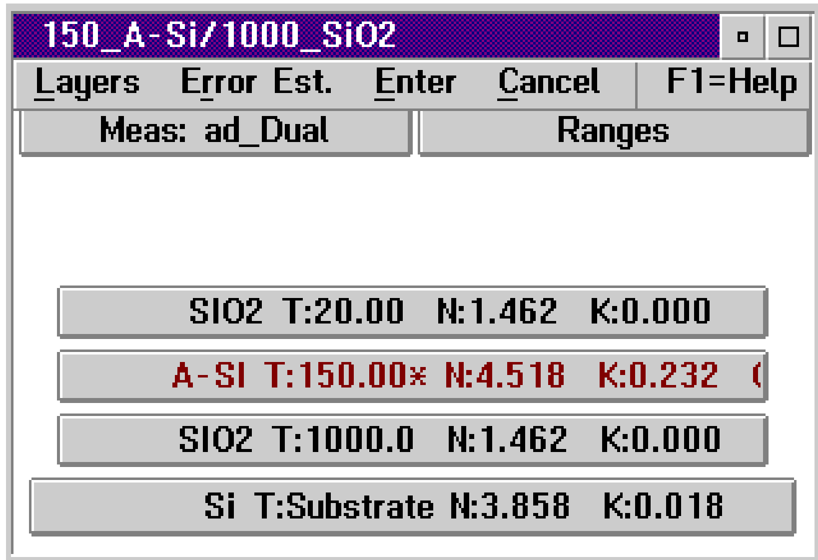

Figure 3-58. Amorphous Si Filmstack - Modified

5. In the Filmstack Model window, click **Enter** to save your filmstack.

6. Once the filmstack has been reviewed and is determined to be appropriate for the wafer, in the Focus Interactive main menu, click on **Measure**.

   The FE System performs the measurement and calculations on this wafer. When the data modeling is complete, the data is displayed in the Calculated Parameters window, as shown in Figure 3-59.

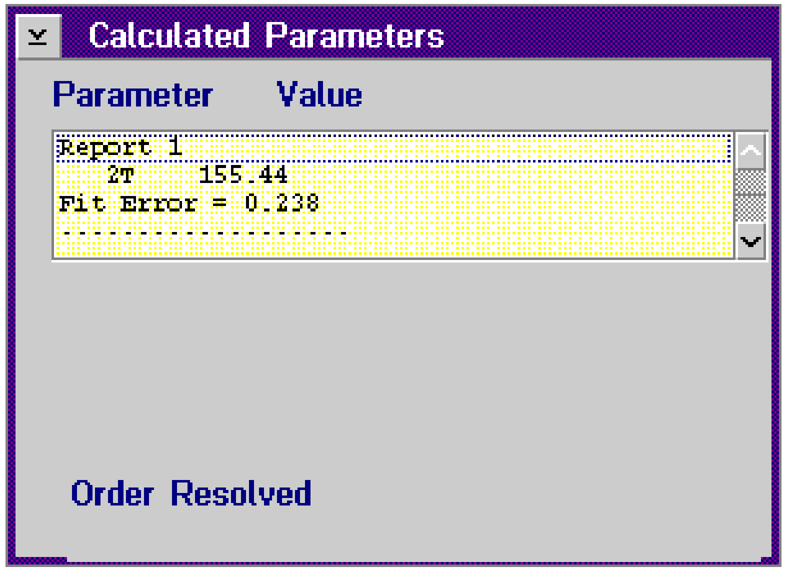

Figure 3-59. A-Si Calculated Parameters

Analyzing the Results

The thickness returned in the report is very good. As the A-Si layer's thickness increases, the fit error may increase, however, less than one is usually acceptable. If the fit error is poor, one should question either the accuracy of the assumed thickness on the bottom layer or the optical constants of the amorphous silicon. For thicker amorphous silicon layers, it might also be necessary to iterate on the extinction coefficient, K, if there is difficulty resolving order.

Summary

The FOCUS Ellipsometer has the ability to accurately model and measure materials with multiple layers.

CVD Application: TiN/Si

Introduction

This example will describe setting up a filmstack model for wafers with a non opaque Titanium Nitride layer on silicon (TiN/Si). The thickness value of a TiN layer can be determined for thicknesses less than about 500Å, depending on how absorbent the material is to light.

Procedure

NOTE

For this example, you must create a new filmstack.

1. In the Focus Interactive main menu, click on **Filmstack**.

   The Filmstack Selection window is displayed.

2. Enter an appropriate name for the filmstack in the Name field (such as **250_TiN/Si**) and click on the **Enter** button.

   The Filmstack Model window is displayed as shown in Figure 3-60.

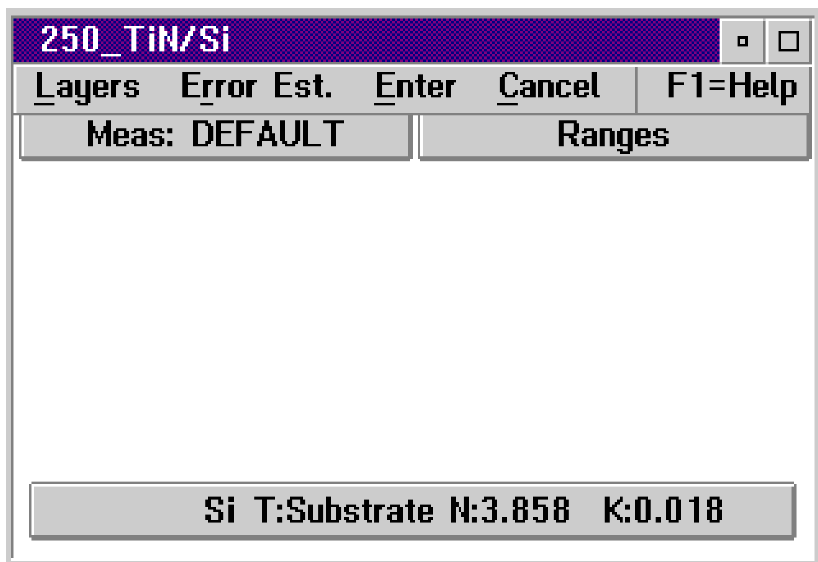

Figure 3-60. New TiN/Si Filmstack

3. In the Filmstack Model window menu, click on **Layers** then select **Add Layer** when the Layers menu is displayed.

   The Material Selection window is displayed.

4. Select **TiN** from the list of available items by single clicking the left trackball button on the item name and clicking on **Enter**, or by double clicking on the name.

   The Layer View window is displayed.

5. Enter the desired Thickness Spec (for this example, enter **250**) and click the **Calc.** checkbox under Thickness. When you have completed entering the specifications, click the **Enter** button in the Layer View window.

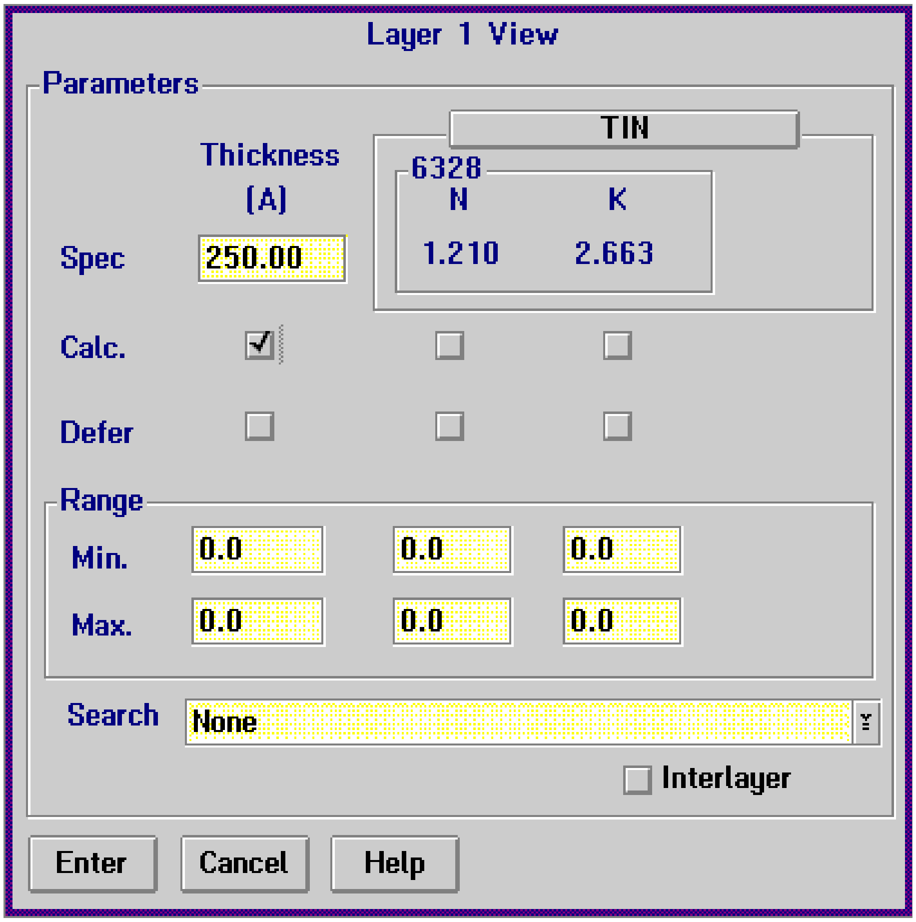

Figure 3-61. TiN Film Layer

6. In the Filmstack Model window, click on **Meas: DEFAULT**.

   The Measurement Selection window is displayed.

7. Select **ad_Dual** from the list of available items and click on the **Enter** button.

The Filmstack Model window is displayed with the newly created film-stack as shown in Figure 3-62.

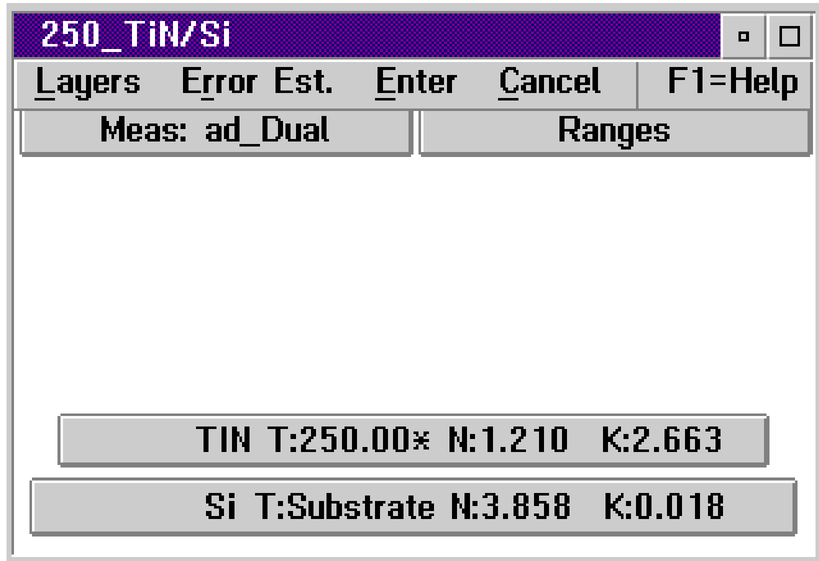

Figure 3-62. Completed TiN/Si Filmstack Model

8. In the Filmstack Model window menu, click **Enter**.

   The filmstack model is saved in the database.

9. Once the filmstack has been reviewed and is determined to be appropriate for the wafer, in the Focus Interactive main menu, click on **Measure**.

   The FE System performs the measurement and calculations on this wafer. When the data modeling is complete, the data is displayed in the Calculated Parameters window.

Analyzing the Results

TiN optical constants are very dependent on deposition conditions. The Rudolph starting values for N and K might vary considerably from your application requirements. If this is the case, we recommend that the N and K values be calculated.

Summary

The FE System is capable of measuring thin layers of metal on substrate with exceptional accuracy.

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Etch Applications

This section provides an example of Oxide Etch to Clear applications within the Etch area of the Fab.

NOTE

The application examples provided in this section are intended as a teaching tool so that Engineers can learn the fundamentals of creating filmstacks. All applications can vary greatly, therefore please contact the Rudolph Applications Support Group nearest to you for help with your particular application.

Etch Application: Oxide Etch to Clear

Introduction

Presently, few nondestructive metrology production tools are capable of accurately detecting a successful etch, specifically the complete removal of a transparent oxide film on silicon substrate. Any remaining oxide can adversely effect subsequent process steps by inhibiting interfacial reactions of films deposited on the substrate, or by causing high contact resistance.

When over etch occurs substrate damage causes the SiO2/Si model to erroneously report the presence of oxide. Hence, this application requires calculation of a more sensitive parameter in the film model to reliably detect oxide etch to clear. Simultaneous calculation of both thickness (T) and absorption (K) of the oxide reliably indicates both the complete removal of the oxide and the over etch condition by a dramatic change in K.

The following example will describe the procedure for developing and testing a filmstack for detecting both the over etch and under etch conditions.

Procedure

1. In the Focus Interactive main menu, click on **Filmstack**.

   The Filmstack Selection window is displayed.

2. Enter the name for the new filmstack (in this example, **Oxide_Clear**) and click on the **Enter** button.

   The Filmstack Model window is displayed with the default substrate material, SI.

3. In the Filmstack Model window menu, click on **Layers**, then click on **Add layer** when the Layers menu is displayed.

   The Material Selection window is displayed.

4. Select **SiO2** from the material selection window.

   The Layer View window is displayed.

5. Type in the target value in the **Thickness** field (in this example, **100**) and click on the **Calc.** checkboxes for both Thickness and K (absorption). Click on the **Enter** button when you have completed the selections.

   The Filmstack Model window is displayed with the new material.

6. In the Filmstack Model window, click on the **Meas: DEFAULT** button.

   The Measurement Selection window is displayed.

7. Select a single wavelength measurement control for a very thin film, **aa_Thin<500A**.

   The Filmstack Model window is displayed as shown in Figure 3-63.

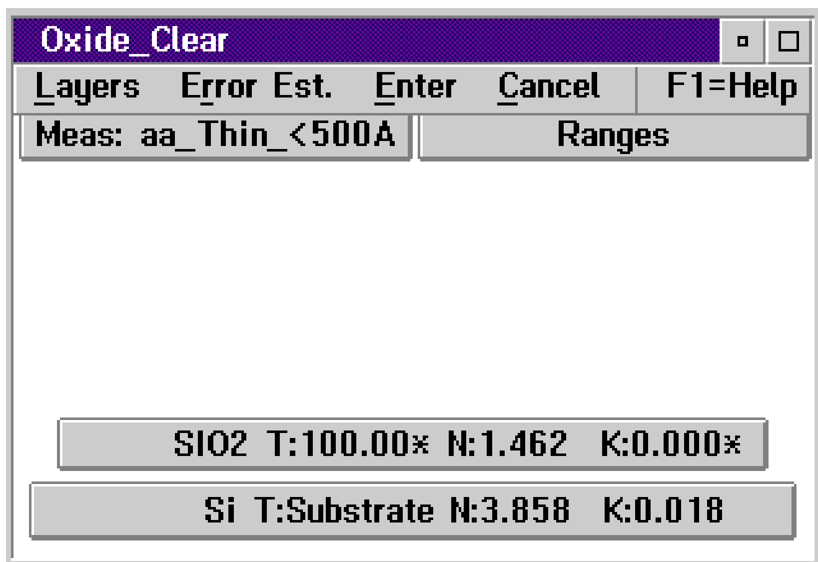

Figure 3-63. Oxide Etch to Clear Filmstack

8. In the Filmstack Model window menu, click on **Enter** to save the new filmstack in the database.

9. Once the filmstack has been reviewed and is determined to be appropriate for the wafer, in the Focus Interactive main menu, click on **Measure**.

   The FE System performs the measurement and calculations on this wafer. When the data modeling is complete, the data is displayed in the Calculated Parameters window.

The following results show five point measurements of an under etched and over etched wafer using both the simple thickness only filmstack and the etch to clear filmstack developed using the procedure above.

Table 3-3. Under Etched Wafer of Oxide on Silicon

Point #	T Only	T	K
1	145.24	145.59	0.002
2	137.13	136.53	0.001
3	74.88	74.13	0.007
4	148.19	148.14	0.002
5	169.22	169.64	0.007

Table 3-4. Over Etched Wafer of Oxide on Silicon

Point #	T Only	T	K
1	39.62	0.0	0.86
2	40.18	0.0	0.83
3	31.71	0.0	0.85
4	35.87	0.0	0.91
5	43.22	0.0	0.84

Analyzing the Results

The data in Table 3-3 is a five point measurement of an under etched wafer of oxide on silicon. Notice that when simultaneously calculating T and K there is no significant difference in thickness when comparing with the T only measurement.

Table 3-4 shows data from a five point measurement of an over etched wafer. The standard SiO_2/Si only film model shows the presence of about 40Å of oxide in spite of the fact that the wafer has been over etched. The proposed film model which calculates both T and K indicates a dramatic change in K due to the damaged silicon induced by over etch. Notice the difference in K in Table 3-4 as compared with K in Table 3-3 of the under etched wafer. The magnitude of the change in K between the two conditions allows the FOCUS Ellipsometer to accurately detect the complete removal of the oxide layer without incorrectly reporting the presence of oxide when over etch occurs.

Software features provided with the FOCUS Ellipsometer allow for a film model which indicates to the user a complete and successful etch while displaying the true oxide thickness if the wafer is under etched.

Summary

The FOCUS Ellipsometer provides the required multi-parameter capability using a simple film model for detecting complete removal of the oxide film. With the ability to switch the film model, the user can reliably detect with great sensitivity both the under etch and etch to clear conditions.

CMP Applications

This section provides examples of Teos on Metal, BPSG on Metal, and PMD on Silicide applications within the CMP area of the Fab.

NOTE

The application examples provided in this section are intended as a teaching tool so that Engineers can learn the fundamentals of creating filmstacks. All applications can vary greatly, therefore please contact the Rudolph Applications Support Group nearest to you for help with your particular application.

CMP Application: Teos on Metal

Introduction

This example will describe how to measure the thickness of a Teos layer on metal. In this case the AlCu is optically opaque and is considered to be a substrate. The TiN layer can be either transparent or opaque. The TiN and AlCu will be considered to be one effective metal substrate having pseudo optical constants Ns and Ks.

It is well understood that the underlying metal layers can vary in thickness and composition. Other measurement techniques can suffer from order skipping problems in the ILD (Inter-Layer Dielectric – a layer placed between metal films that acts as an insulating layer) thickness. This is due to variations in the metal's pseudo optical constants, and techniques other than ellipsometry cannot compute the metal optical constants. With FOCUS Ellipsometry, a user can measure the thickness of the ILD layer, and the substrate optical constants Ns and Ks simultaneously. The Ns and Ks parameters account for the process variations in the metal layers and will stabilize the ILD thickness, thus avoiding order skipping.

NOTE

The procedure that follows is also applicable to the measurement of BPSG on metal in that the thickness of the BPSG layer and the N and K values of the substrate are all calculated.

Procedure

1. In the Focus Interactive main menu, click on **Filmstack**.

   The Filmstack Selection window is displayed.

2. From the list of filmstacks, highlight **ad_CMP-Ox/Metal-T-Ns-Ks** then click on the **Options** button. Copy this filmstack to a new name by typing the new name in the Destination field and click on the **Save As** button. Click on the **Enter** button in the Filmstack Selection window to view the newly created filmstack model.

3. Click on the **TEOS** layer in the Filmstack Model window to modify the thickness of the Teos layer.

NOTE

This filmstack has a capture range of about ± 11,000Å around the target thickness.

   The Layer View window is displayed.

4. In the Layer View window, enter the spec thickness of the Teos layer and click on the **Enter** button.

   The Filmstack Model window is displayed as shown in Figure 3-64.

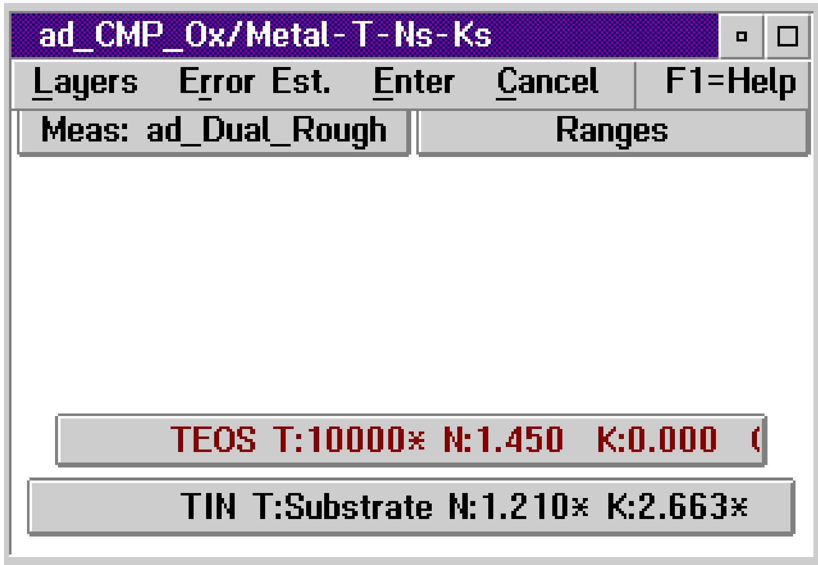

Figure 3-64. Teos Filmstack

In this example the substrate is the TiN layer. This represents the combined TiN/AlCu substrate. For other applications the substrate can be changed to other materials such as Ti, W-Si, or TiS2. All these materials are present in the material library.

To optimize this filmstack, it is recommended that you have a sample with only the metal substrate and no ILD on top. This allows you to measure the optical constants of the substrate, then create a material with those values. To change substrates, click on the **TiN** layer in the Filmstack Model window, then click the **TiN** button in the Layer View window. Select the new material for the substrate from the list.

5. When the filmstack is complete, in the Filmstack Model window menu, click on **Enter** to save the new filmstack in the database.

6. Once the filmstack has been reviewed and is determined to be appropriate for the wafer, in the Focus Interactive main menu, click on **Measure**.

   The FE System performs the measurement and calculations on this wafer. When the data modeling is complete, the data is displayed in the Calculated Parameters window as shown in Figure 3-65.

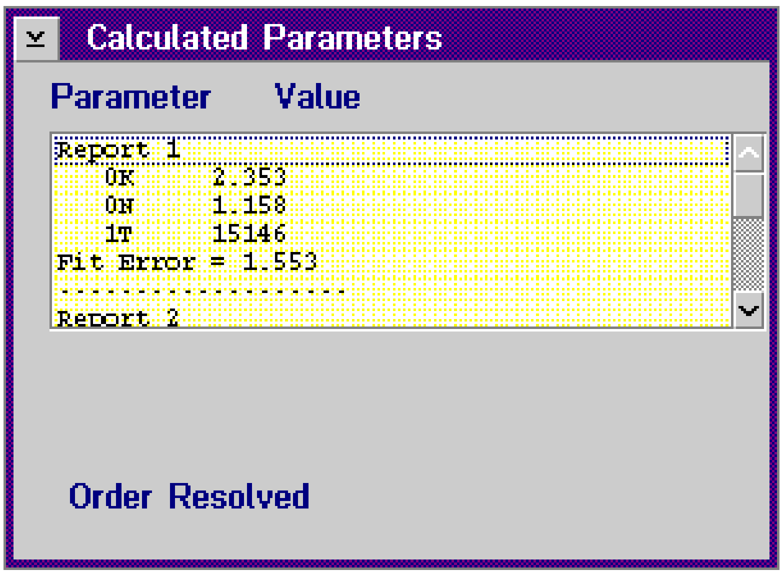

Figure 3-65. Teos Calculated Parameters

Analyzing the Results

The thickness returned in this report is very good. Typically the fit error should be less than 1 for Oxide measurements on Silicon. This sample however is on metal and the fit error can range between 0-10. This is due to the roughness and variation of the metal substrate.

Summary

To measure ILD layers, you must compute the thickness of the ILD along with the pseudo-optical constants of the metal substrate. The Ns and Ks parameters yield stable thickness measurements that will not order skip. Only with ellipsometry can you measure optical constants.

CMP Application: BPSG on Metal

Introduction

For information pertaining to the measurement of a BPSG layer on metal, refer to “CMP Application: Teos on Metal” on page 3–91.

Lithography Applications

This section provides an example of a Photo Resist application within the Lithography area of the Fab.

NOTE

The application examples provided in this section are intended as a teaching tool so that Engineers can learn the fundamentals of creating filmstacks. All applications can vary greatly, therefore please contact the Rudolph Applications Support Group nearest to you for help with your particular application.

Lithography Application: Photo Resist

Introduction

This example will describe setting up a filmstack model for wafers with a Resist on silicon. Resist is a straightforward application well suited for measurement by the FOCUS Ellipsometer.

Procedure

1. In the Focus Interactive main menu, click on **Filmstack**.

   The Filmstack Selection window is displayed.

2. Select the filmstack that is most appropriate for your application (such as **aa_Resist_<1um_T**, and **aa_Resist_>1um_T**). The thickness of the Resist will determine which filmstack should be chosen. In this example the sample wafer has approximately 11000Å of Resist, therefore the **aa_Resist_>1um_T** is applicable.

   The Filmstack Model window is displayed as shown in Figure 3-66.

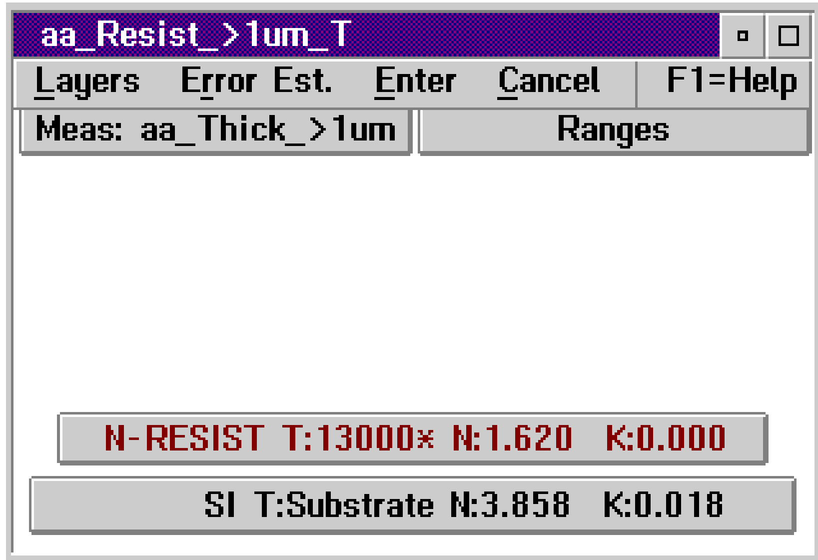

Figure 3-66. Photo Resist Filmstack

3. There is no need to modify this filmstack any further, therefore once the filmstack has been reviewed and is determined to be appropriate for the wafer, in the Focus Interactive main menu, click on **Measure**.

   The FE System performs the measurement and calculations on this wafer. When the data modeling is complete, the data is displayed in the Calculated Parameters window, as shown in Figure 3-67.

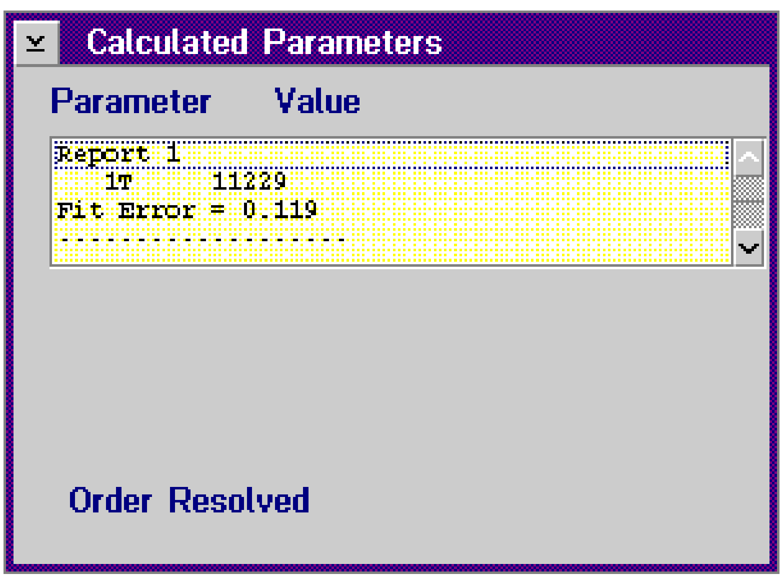

Figure 3-67. Photo Resist Calculated Parameters

Analyzing the Results

As expected, the thickness returned in the Calculated Parameters window was close to 11000Å. Notice that the Fit Error is low and that the correct thickness order was found.

Summary

The FE System easily calculates the thickness and, if desired, the refractive index of photoresists on oxide. Choose from one of three wide thickness ranges for accurate measurements.

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Creating Recipes

Chapter 4

Introduction

The purpose of this chapter is to provide the Engineers and Supervisors who are responsible for setting up measurement processes, with the procedures necessary to create wafer recipes. The information in this section pertains to the FOCUS Ellipsometer (FE) III, IV, and VII systems, and includes the following topics:

- Describe the basics of recipe creation, the components that make up a wafer recipe, and how to organize recipes into processes and process steps.
- How to log in, use, and exit the Focus Recipe Creator.
- Describe the components of the Focus Recipe Creator.
- How to create wafer recipes for monitor (bare) and product (patterned) wafers to include:
  - Wafer information
  - Filmstacks
  - Measurement patterns
  - Wafer reports
- How to customize monitor wafer recipes.
- How to customize product wafer recipes to include:
  - Pattern recognition
  - Deskew
  - Site-by-site pattern recognition
- How to create wafer mapping recipes.
- Vision system modes and thresholds.
- Vision system diagnostics.

The tasks described in this chapter are performed with the use of the Focus Recipe Creator program. This is the program that allows the Process Engineer to perform such tasks as; create process specifications and recipes, and train and automate recognition of patterns on wafers.

NOTE

The Focus Recipe Creator program is also used to set up Operator information that is used for system login requirements. For information regarding setting up system login requirements, refer to Appendix B, "System Configuration".

Figure 4-1 shows a basic block diagram of the recipe creation process for both monitor and product wafers.

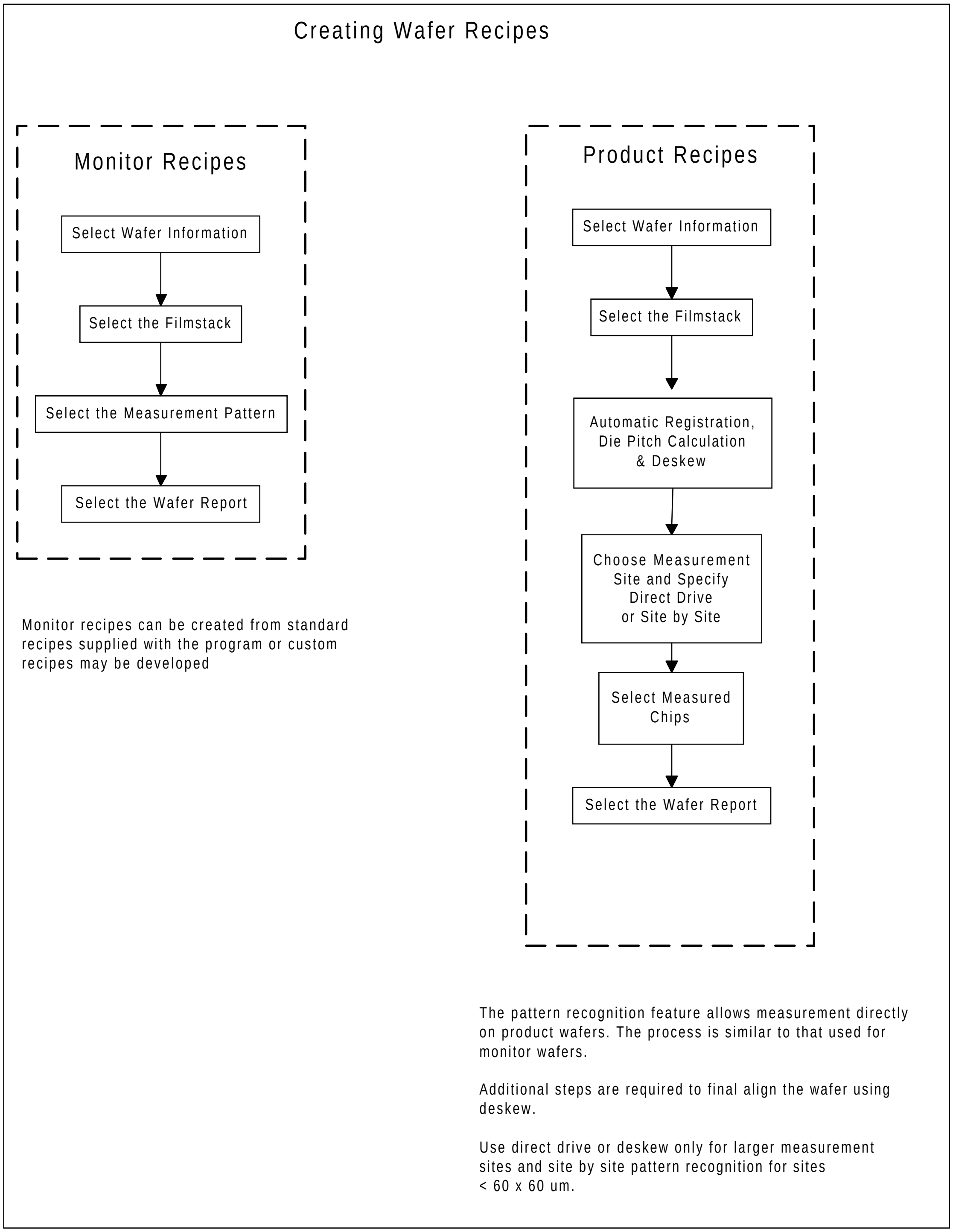

Figure 4-1. Creating Wafer Recipes Flow Diagram

Wafer Recipes

A Process Engineer will use the Focus Recipe Creator to develop a measurement process using the filmstack created using the Focus Interactive program (see Chapter 3, "Developing Film Applications" for information). This measurement process will later be accessed by an Operator using the Focus Operator Queued Loading program (see Chapter 2, "Operator Interface" for information).

Wafer recipes consist of a number of elements or "templates". The FE System has several standard templates already programmed to simplify the recipe creation process. However, these templates may be customized or entirely new recipes may be created to suit the needs of the application.

CAUTION

Modifying any existing template will affect every recipe that uses that template.

Recipes are combined with transfer and control instructions to form process steps which in turn are grouped to form process specifications. This organization is designed to match the process used at a semiconductor Fab.

Process Specifications and Process Steps

There may be several steps in the **process specification**, each step involves measurements done on a wafer film layer after a production process. Each **process step** contains one or more recipes. This relationship is shown in the figure below:

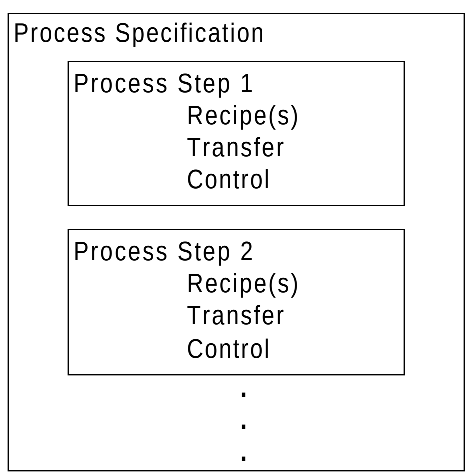

Figure 4-2. Recipe to Process Specification Relationship

Starting Recipe Creator and Logging In

To start the Focus Recipe Creator program, perform the following procedure:

1. Position the trackball pointer over the Focus Recipe Creator icon, located in the Focus Ellipsometer folder, and double click the left trackball button.

   The Focus Recipe Creator main window is displayed as shown in Figure 4-3.

   If your FE System **does not require** a Login for the Recipe Creator, you are now ready to begin the recipe creation process.

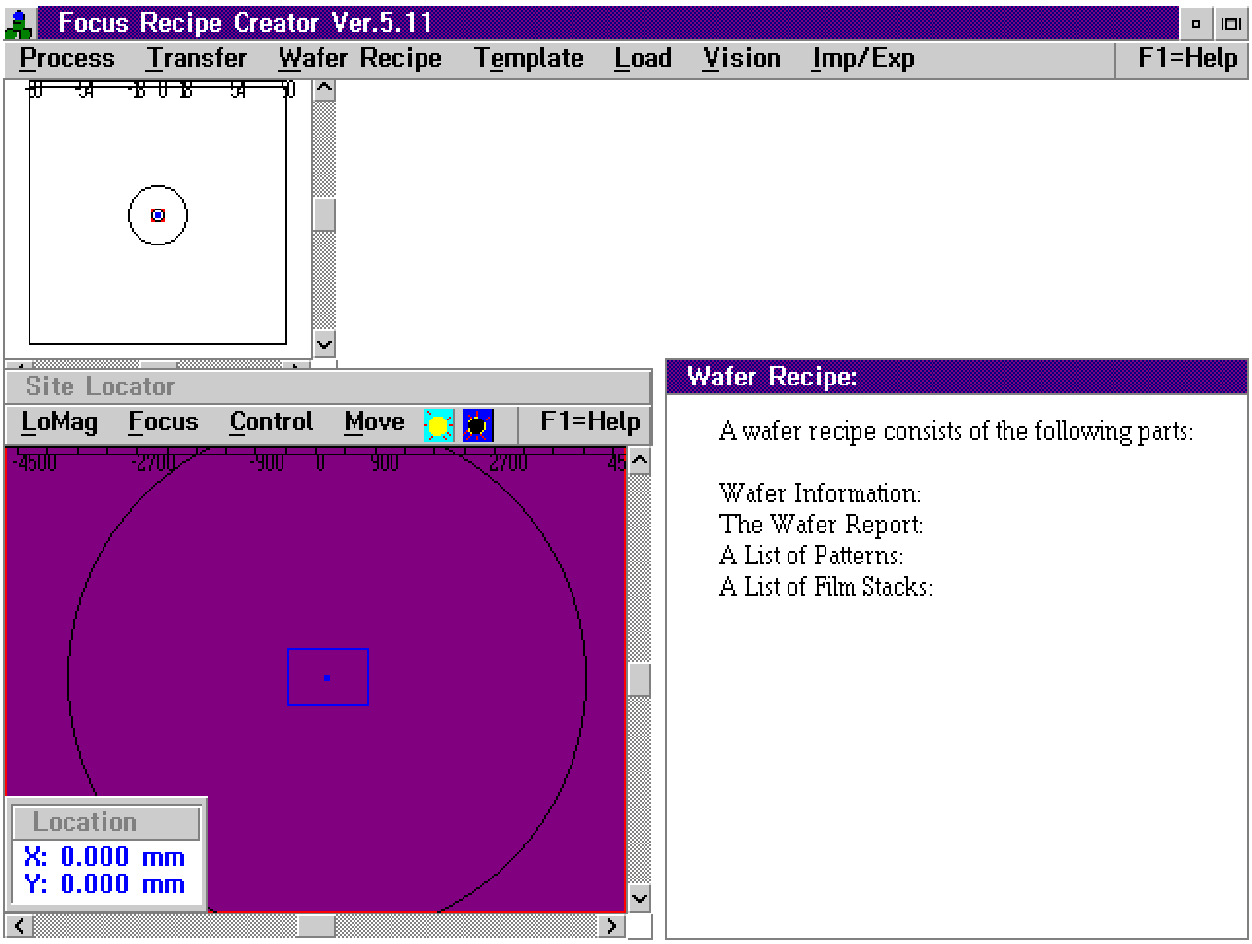

Figure 4-3. Recipe Creator Main Window

If your FE System has been configured in such a way as to **require** a login to the Recipe Creator, a list of the login names that are available on your system is also displayed as shown in Figure 4-4. Continue the procedure with Step 2.

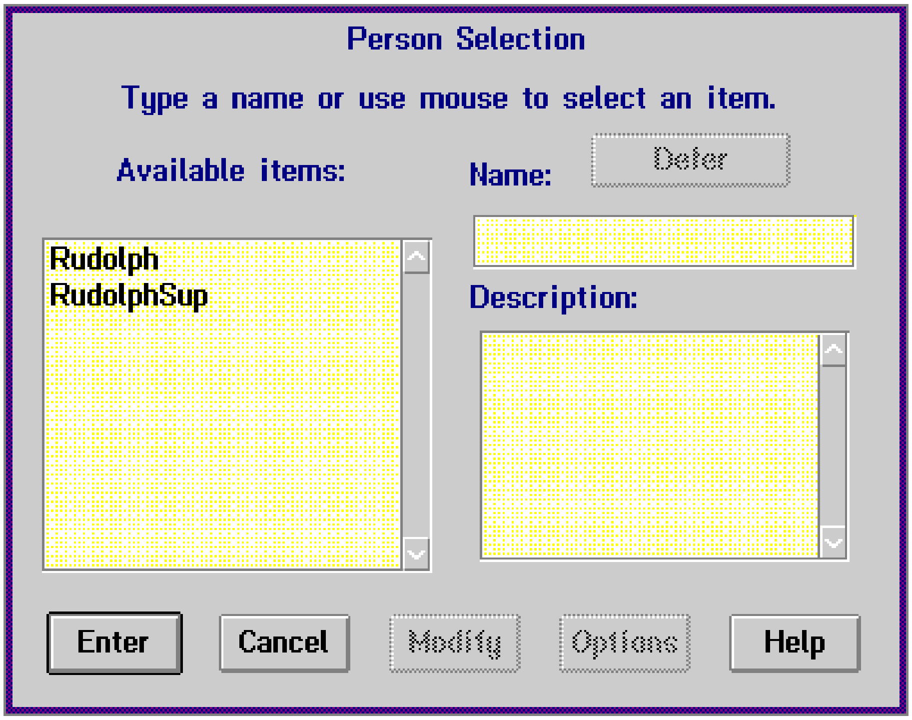

Figure 4-4. Recipe Creator User Login Selection

2. Select a login name by clicking the left trackball button on the desired name and then clicking on **Enter**, or by double clicking the left trackball button on the name.

NOTE

If you click on the Cancel button, or if the login name selected does not have a high enough privilege level, the Recipe Creator will exit and you are returned to the OS/2 desktop view.

The Password Entry dialog box is displayed as shown in Figure 4-5.

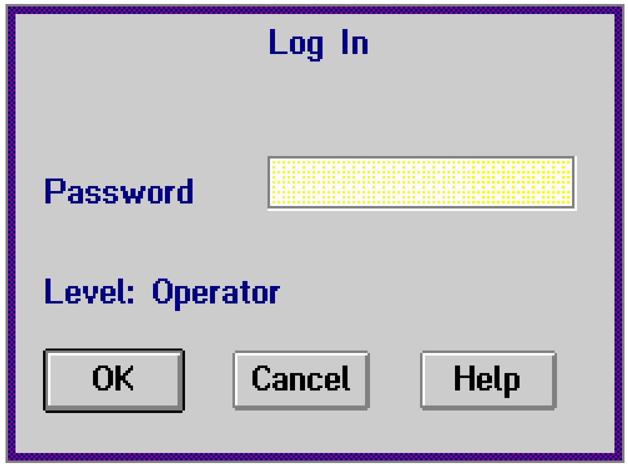

Figure 4-5. Focus Operator Password Entry

3. Enter your password and press **Enter**, or click on **OK**.

NOTE

For security reasons, asterisks (*) will be displayed as you enter your password.

The Focus Recipe Creator main window is displayed as shown in Figure 4-3.

Recipe Creator Main Window

The Recipe Creator Main window is divided into three areas: the Wafer View, Site Locator (including the Location information window), and Wafer Recipe area.

These areas are described in the sections that follow.

Wafer View Area

The Wafer View area provides a graphical representation of the wafer. It may be used to move around on the wafer by using the scroll bars or by double clicking the right trackball button directly on a spot on the wafer.

This window also indicates all the specified measurement sites and, during measurement, the site currently being measured.

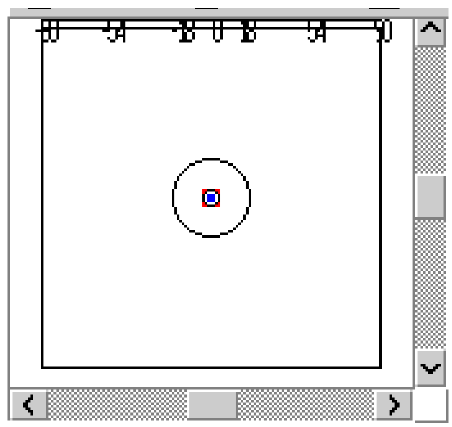

Figure 4-6. Recipe Creator Wafer View Element

Wafer Recipe Area

Displays information about the wafer recipe (including wafer information, wafer report information, the measurement pattern to be used, and the filmstack to be used for the wafer) that is currently being programmed. This information is updated as the recipe is built.

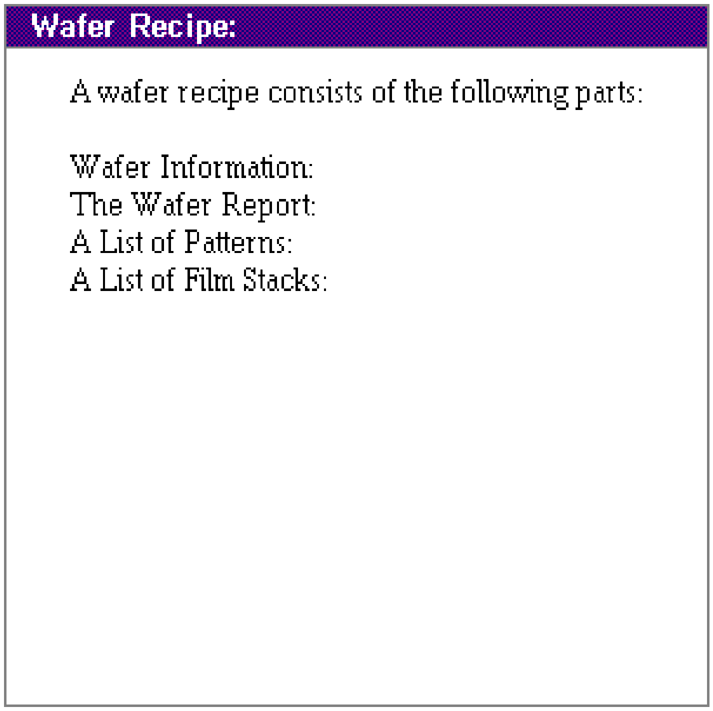

Figure 4-7. Recipe Creator Wafer Recipe Element

Site Locator Area

Also called the Live Video window, this window shows a live video image of the wafer surface as it appears in the FE System. The small blue spot in the window indicates where the laser is focused on the wafer.

The Location information in the Site Locator area shows the X and Y coordinates for the location on which the laser is currently focused.

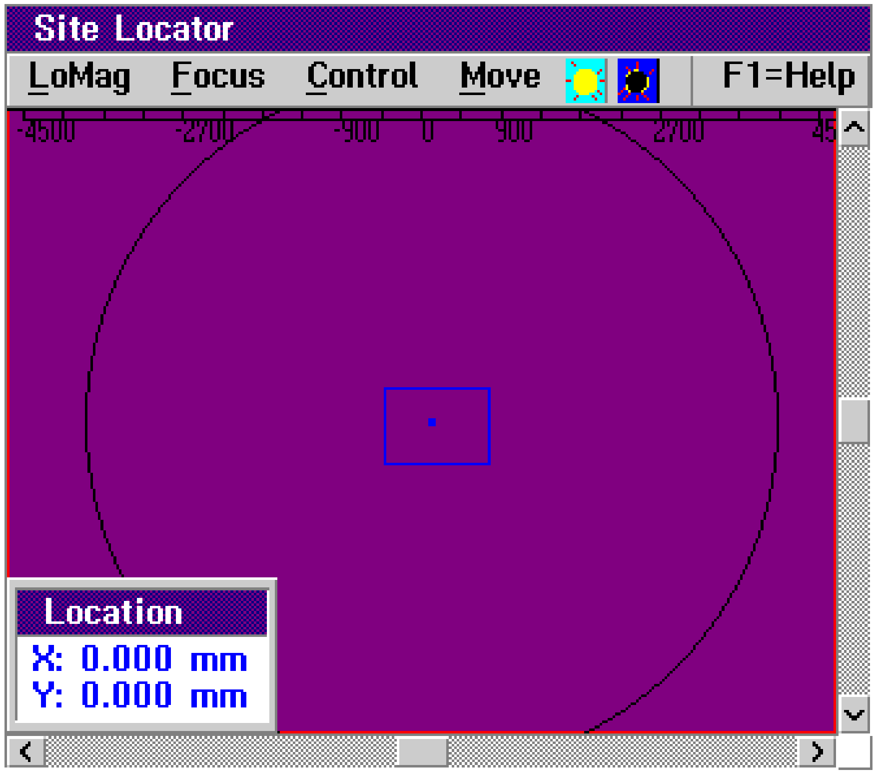

Figure 4-8. Recipe Creator Site Locator Element

Site Locator Menu

The Site Locator area also consists of the following menu selections:

- **HiMag/LoMag** — Indicates whether the live video image is in High Magnification or Low Magnification mode. Clicking on this menu item toggles between the two modes. The field of view in the Site Locator window in HiMag is .54mm x .72mm (FE VII) or .9mm x 1.2mm (FE III and IV). The field of view in LoMag is 5.4mm x 7.2mm (FE VII) or 7mm x 9mm (FE III and IV).

- **Focus** — Clicking on this menu item will focus the laser spot to a point. When measurements are performed, focus is automatically performed.

- **Control** — Clicking on this menu item displays the Control menu. This menu consists of the following items:
  - **Mag —** Consists of the following items: **Wafer View** displays the wafer view in the site locator window, **Low Mag** causes the microscope to switch to low magnification mode, **High Mag** causes the microscope to switch to high magnification mode. The Low Mag and High Mag items are functionally the same as the HiMag/LoMag items on the menu bar.
  - **Zoom** — Consists of the following items: **One Quarter** reduces the Site Locator window to one quarter size, **One Half** displays the Site Locator window at half size (default), **One X** displays the Site Locator window on the full screen.
  - **Live Off/Live On** — Toggles between turning the live video view on and off in the Site Locator window.
  - **Laser Off/Laser On** — Toggles the laser on and off. The laser must be on in order to make measurements.
  - **Illumination** — Allows you to set the illumination intensity of the microscope lamp.
- **Move** — The items in this menu provide alternate methods for moving the wafer so that the laser spot is positioned over the desired location. The following options are available:
  - **Keyboard** — Prompts you to enter the X and Y coordinates of the desired location on the wafer. Make the appropriate entry and click on **Enter** to move to the selected spot.
  - **Center** — Moves the wafer so that the laser is located over the center of the wafer.
  - **Left** — Moves the wafer so that the laser is located at the left outer edge of the wafer.
  - **Right** — Moves the wafer so that the laser is located at the right outer edge of the wafer.
  - **Top** — Moves the wafer so that the laser is located at the top outer edge of the wafer.
  - **Bottom** — Moves the wafer so that the laser is located at the bottom outer edge of the wafer.
- **Light/Dark Icons** — Located to the right of the **Move** menu, clicking on these icons allow you to change the illumination intensity of the microscope lamp.

Recipe Creator Main Menu

The following menu items are available in the Recipe Creator Main window:

- **Process** — Named by the Engineer, a process specification includes multiple process steps which can be added to or deleted from a list of Steps (maximum of 25). Each process step includes a Transfer, Recipe, and Control which identify the wafer(s) to be measured, the recipes to be used, and how the data will be stored.

  If a cassette includes wafers with different recipes, the Engineer may use the **Details** option to modify the wafer program, choose the correct recipe, and assign it to the wafer slot number. The Recipe line will display **{Varies}**, indicating different recipes within the process step.

- **Transfer** — A Transfer identifies which cassette and slot the wafer of interest will be taken from and returned to. If the filmstack being used rejects wafers that exceed the specified fit error tolerance or thickness range, the cassette to which these wafers are rejected is selected here.

  There are Transfer files supplied with the Focus software which have significant meaning. For example: **aaX1-1S1,12,25** indicates cassette 1 as the source and destination of the wafers in slots 1, 12, and 25; **aaX1-1S1-5Reject2** indicates cassette 1 as the source and destination of the wafers in slots 1 through 5, sending the rejected wafers to cassette 2. The **DEFER** Transfer allows the Operator to specify which cassette and slot holds the wafer of interest.

- **Wafer Recipe** — Used to create a recipe indicating the wafer information, filmstack, wafer type (monitor or patterned), measurement pattern or sites, and type of data report. You must complete each item of the Wafer Recipe menu in sequence, finally saving the recipe and using it in a process specification.

  - **Name** — The Engineer assigns a specific Recipe name of significant meaning.

  - **Wafer Information** — Defines the parameters of a wafer relating to size, finding a flat or notch, centering, and orientation. A selection is normally made from the database list.

  - **Filmstack** — Selects a particular filmstack that will be used to model the wafer(s) being measured. The Filmstack may have been previously created by the Engineer or one supplied with the Focus software.

- **Registration** — Differentiates between monitor and patterned wafers.

  None — Use for monitor wafers only. Continue to the **Unpatterned Wafer** option.

  Manual — Use for patterned wafers when registration sites will be manually selected by the operator.

  Automatic — Use for patterned wafers when registration sites will be automatically identified using pattern recognition.

  Reteach — Use to retrain pattern recognition sites used for registration.

- **Unpatterned Wafer** — Allows the Engineer to choose a measurement routine for a monitor wafer. A selection may be made from the database list, or created by entering coordinates, dragging lines, or forming shapes such as a circle. See “Creating a Monitor Wafer Recipe” on page 4–22 for more information.

- **Patterned Wafer** — After the stepper group registration is completed, one chip is trained as an example for the system to recognize as being the model chip for the entire wafer. Next, the measurement sites within that die are chosen, with three options for finding the site when running a test:

  Pattern Recognition — performs a site by site search and measurement.

  Defer Location — moves to the measurement site and allows the Operator to do any necessary fine tuning and initiate a measurement.

  Direct Drive — If neither Pattern Recognition nor Defer Location are selected, the stage direct drives to the measurement site and a measurement is taken. Direct driving to a measurement site increases throughput. Pattern Recognition and Defer Location are reserved for smaller measurement sites, but require more time.

  If there is more than one measurement site with different film materials, the appropriate filmstack may be chosen for each individual site. Individual chips, or all chips, may be selected for measurement. See “Creating a Patterned Wafer Recipe (Cognex System)” on page 4–26 for more information.

- **Report** — Used to select how the data will be presented and where it will be stored.

- **Save** — Saves the current Recipe to the database.

- **Cancel** — Cancels the current Recipe being created. If changes were being made to a previously created Recipe, the corrections will not be saved.

• **Template** — Used to create or change the following FE database files. Changes will appear in any recipes that use these files.

  - **Wafer Information** — Defines the parameters of a wafer relating to size, finding a flat or notch, centering, and orientation. A selection is normally made from the database list.

  - **Film Stack** — Allows the Engineer to create, choose, or modify a filmstack. Refer to Chapter 3, "Developing Film Applications" for information.

  - **Measure Control** — Allows the Engineer to create, choose, or modify a measurement control (laser type, angle range, whether to use Psi Exclusion or Psi Reference, rough film measurement controls, and so on). Refer to Chapter 3, "Developing Film Applications" for information.

  - **Equipment** — Fab delineated equipment identifier used for SECS-II communications. Refer to Rudolph Technologies document number A11646 entitled "FOCUS Ellipsometer SECS-II/GEM Interface Specifications" for information.

  - **Report** — Allows the Engineer to create, choose, or modify the style and data to be included in a wafer report. Refer to Chapter 5, "Wafer Mapping and Data Reporting" for information.

  - **Material** — Allows the Engineer to create, choose, or modify the materials in the database that can be used in filmstacks. Refer to Chapter 3, "Developing Film Applications" for information.

  - **Recipe Control** — Allows the Engineer to defer Transfers, Wafer Recipes, Map Names, and Wafer IDs until run time where they may be specified by the Operator. The Engineer may also indicate how many days the data from a certain recipe will remain in the database, as well as how many times a recipe will repeat.

NOTE

The number of times a recipe will repeat can also be set in the Focus Setup program.

  - **Operator** — Sets up login names and passwords for Operator, Engineer, and Supervisor security levels. Also allows the setting of quick buttons. Refer to Appendix B, "System Configuration" for information.

- **Load** — Used to load and unload a test wafer either manually or automatically using the FE robot.
  - **Manual Load** — The stage moves forward and the system prompts you to place a wafer on the stage.
  - **Cassette Load** — Enables loading a wafer from a cassette. Select the cassette and slot number for the wafer to be measured.
  - **Unload Wafer** — Removes the wafer from the stage in the same manner in which it was loaded.
  - **SMIF Arm** — Enables the loading and unloading of a wafer from a cassette by SMIF Arm 1 or 2.
  - **SMIF Indexer** — Enables the loading and unloading of a wafer from a cassette by SMIF Indexer 1 or 2.
- **Vision** — Used to set up the FE vision system for automatic pattern recognition. Select **Setup** to identify the parameters necessary to create a Patterned Wafer recipe. These parameters are preset and normally do not need to be changed. However, if you need to make modifications to the vision system setup parameters, contact Rudolph Technologies.

  The **Restricted Search** feature allows the vision system to overcome the problem of distinguishing between similar small die sizes in Low Mag and repeating test structures in Hi Mag. This search limits the size of the area searched by the vision system to a smaller region around the trained site. By searching a smaller area, the vision system will not see the repeating patterns that are outside the Restricted Search window.

  The **Training Mode** option allows the Engineer to choose between **Auto**, which sets the default pattern window to 200 X 200 pixels, and **Manual**, where the pattern window may be modified by dragging out a box to cut out certain troublesome features.

NOTE

The Manual Training Mode must be disabled after site training.

- **Imp/Exp** — Used to transfer recipes (import and export) between FE Systems using a specially formatted floppy disk. Information that can be imported or exported includes a Process Specification, Wafer Recipe, Filmstack, or Person. Refer to "Importing and Exporting Data" on page 5–37 for information.

Creating a Wafer Recipe

An FE wafer recipe specifies the composition and instructions for measuring a wafer.

To create a recipe, the Process Engineer must complete each step of the Wafer Recipe menu as described below, ultimately saving the recipe and using it in a process.

Many of the initial steps taken to create a wafer recipe are common to both monitor (bare) and product (patterned) wafers. The information presented in this section is applicable to both monitor and product wafers.

It is often convenient to use templates to create the elements of the recipe in advance.

CAUTION

Modifying any existing template will affect every recipe that uses that template.

Use the following procedure to create a new wafer recipe. For information on how to select and modify existing wafer recipes, refer to “Modifying a Wafer Recipe” on page 4–43.

Recipe Selection

1. In the Recipe Creator main menu, click on **Wafer Recipe**.

   The Wafer Recipe menu is displayed.

2. Click on **Name** in the Wafer Recipe menu.

   The Wafer Recipe Selection window is displayed as shown in Figure 4-9.

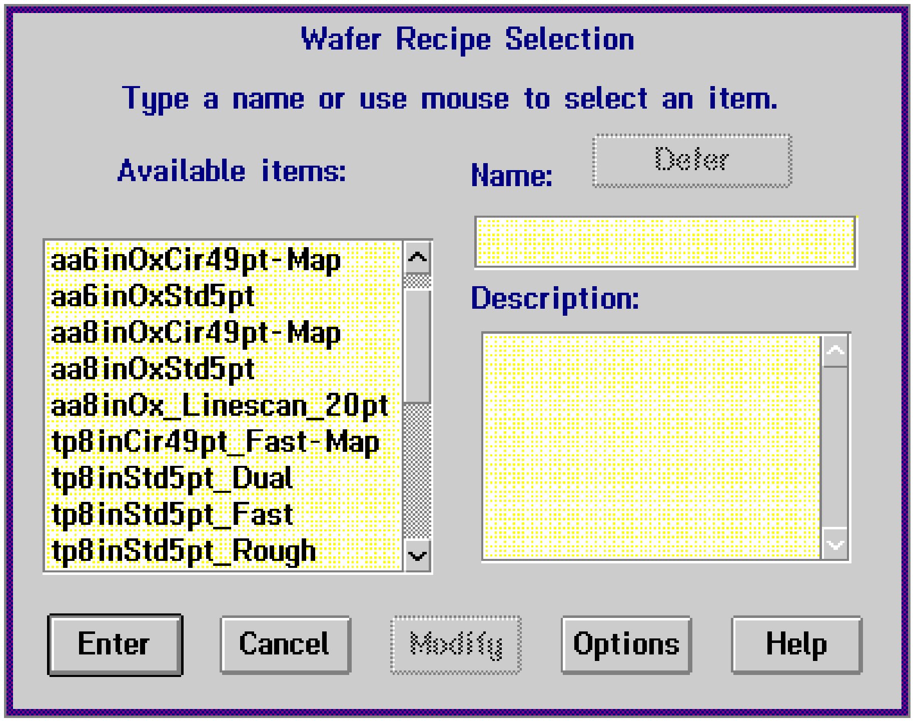

Figure 4-9. Wafer Recipe Selection Window

3. Create a new wafer recipe by typing the desired name in the **Name** field and a description (if desired) in the **Description** field. Click on **Enter** when you have completed the entry.

   The pertinent wafer recipe information (if any) is displayed in the Wafer Recipe area of the Recipe Creator.

Wafer Information

1. In the Recipe Creator main menu, click on **Wafer Recipe**.

   The Wafer Recipe menu is displayed.

2. Click on **Wafer Information** in the Wafer Recipe menu.

   The Wafer Selection window is displayed as shown in Figure 4-10. This window is used to specify wafer parameters such as size, wafer flat or notch, centering, and orientation.

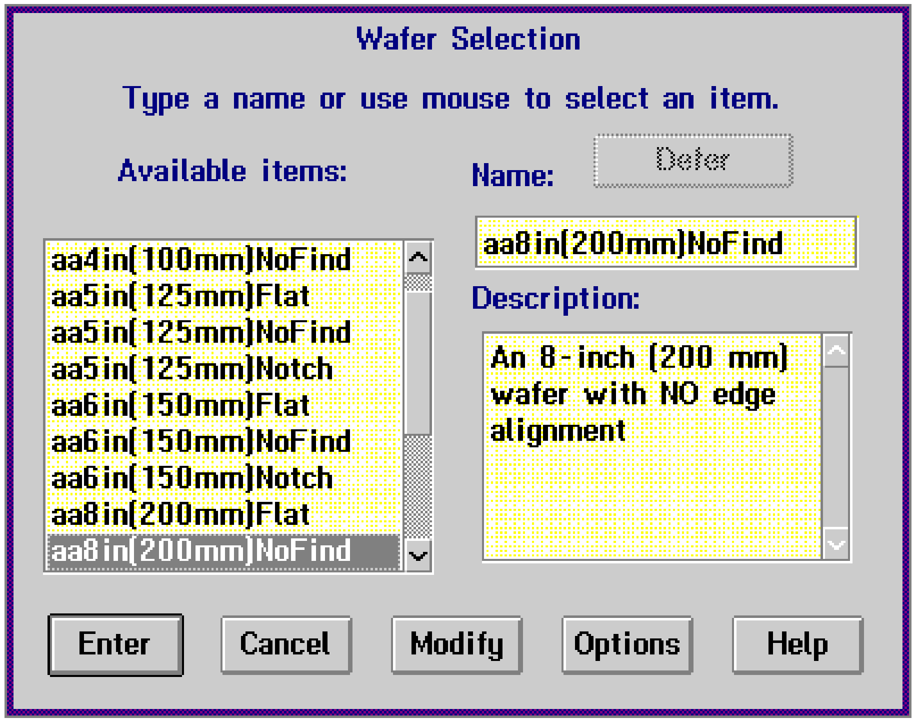

Figure 4-10. Wafer Selection Window

3. Select the item that matches the information for the wafer to be measured by clicking once on the item then clicking **Enter**, or by double clicking on the item. You may also click on **DEFAULT** to select the default wafer parameters based on the previously selected wafer recipe.

   You may also modify an existing Wafer Selection entry by clicking once on the entry name, then clicking on **Modify**. A Wafer Specification window is displayed as shown in Figure 4-11. Specify the wafer size, flat/notch information, and orientation as desired and click on **Enter**.

CAUTION

Modifying any existing wafer information template will affect every recipe that uses that template.

NOTE

The minimum recommended setting for Centering Tolerance is 0.2mm.

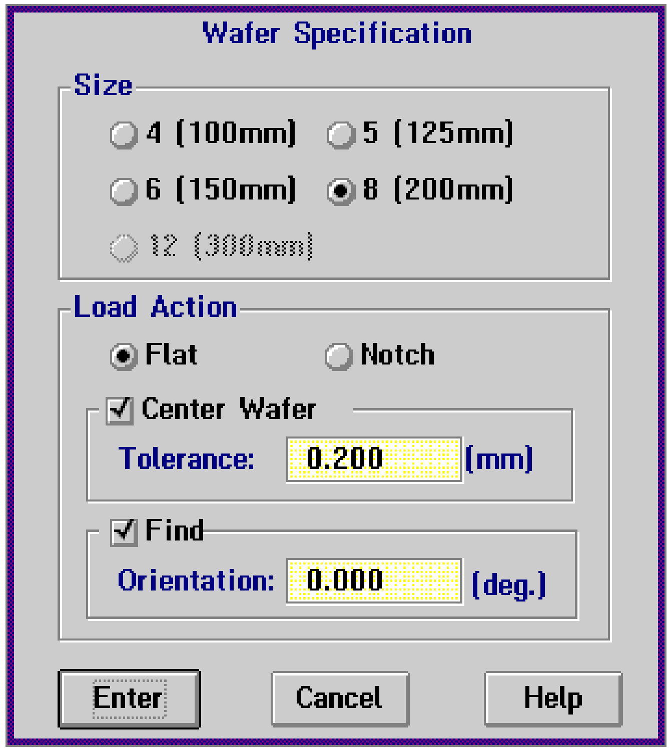

Figure 4-11. Wafer Specification Window

The Wafer Information is displayed in the Wafer Recipe area of the Recipe Creator.

Film Stack Specification

1. In the Recipe Creator main menu, click on **Wafer Recipe**.

   The Wafer Recipe menu is displayed.

2. Click on **Film Stack** in the Wafer Recipe menu.

   The Film Stack Selection window is displayed as shown in Figure 4-12. This window is used to specify filmstack parameters such as layer composition, and parameters to be measured.

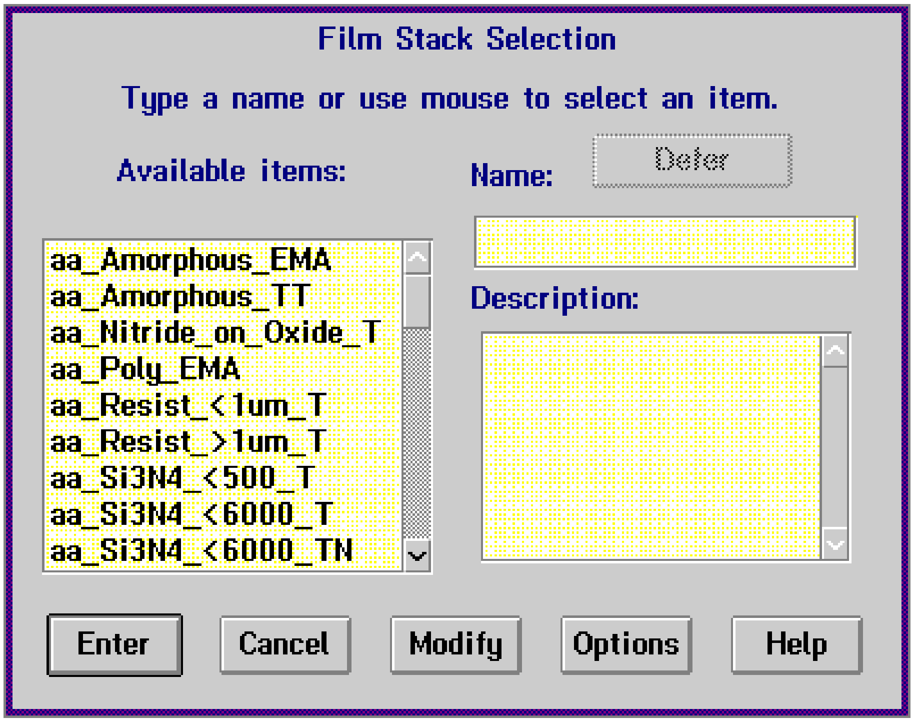

Figure 4-12. Film Stack Selection Window

3. Select the desired filmstack from the list by clicking once on the item then clicking **Enter**, or by double clicking on the item. You may also click on **DEFAULT** to select the default filmstack specification.

   You may also modify an existing filmstack entry by clicking once on the entry name, then clicking on **Modify**. A Filmstack Model window is displayed in which you may make changes to the layer and measured parameters as desired. For information on how to use this window, refer to Chapter 3, "Developing Film Applications".

CAUTION

Modifying any existing filmstack will affect every recipe that uses that filmstack.

When the desired filmstack has been selected, the filmstack information is displayed in the Wafer Recipe area of the Recipe Creator.

Wafer Registration

1. In the Recipe Creator main menu, click on **Wafer Recipe**.

   The Wafer Recipe menu is displayed.

2. Click on **Registration** in the Wafer Recipe menu.

   The Registration sub-menu is displayed. See “Recipe Creator Main Menu” on page 4–12 for descriptions of the menu items.

3. Select one of the options from the Registration sub-menu based on the type of wafer to be measured (either monitor wafer or patterned wafer). Perform one of the following:

   - **For an unpatterned wafer:** Select **None** and proceed to “Creating a Monitor Wafer Recipe” on page 4–22 to continue the procedure for creating the recipe.

   - **For a patterned wafer:** Proceed to “Creating a Patterned Wafer Recipe (Cognex System)” on page 4–26 to continue the procedure for creating the recipe.

Creating a Monitor Wafer Recipe

After completing the steps in “Creating a Wafer Recipe” on page 4–16, and selecting **None** from the Registration sub-menu under the Wafer Recipe menu, select a measurement pattern and report style using the information in the sections that follow.

Measurement Pattern Selection

1. In the Recipe Creator main menu, click on **Wafer Recipe**.

   The Wafer Recipe menu is displayed.

2. Click on **Unpatterned Wafer** in the Wafer Recipe menu.

   The Pattern Selection window is displayed as shown in Figure 4-13.

NOTE

If you wish to create a wafer mapping recipe, refer to the procedure given in “Creating a Wafer Mapping Recipe” on page 4–45.

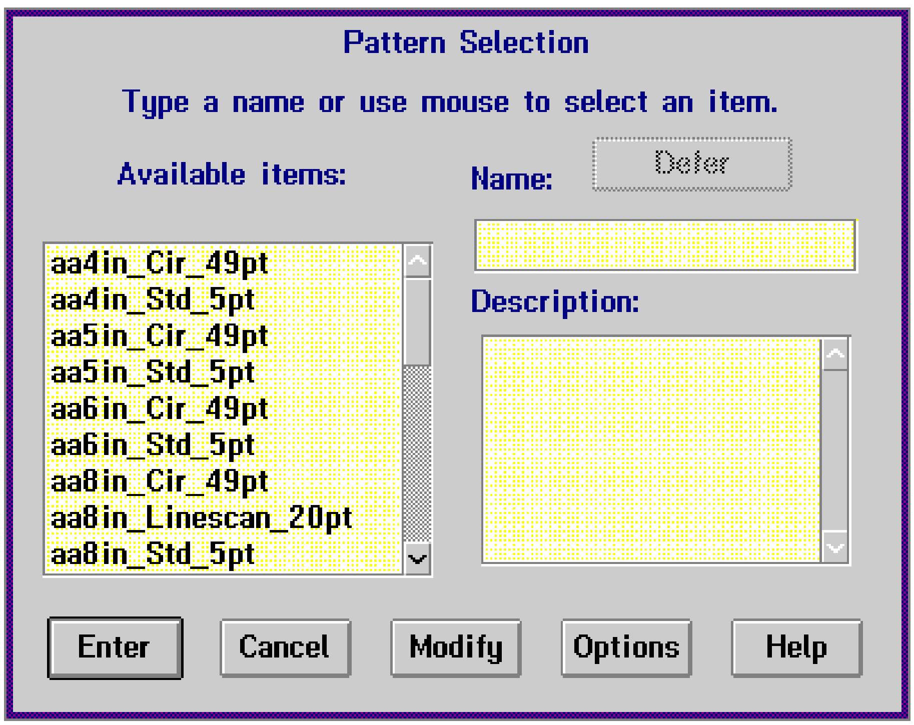

Figure 4-13. Pattern Selection Window

3. Perform **one** of the following:

   - **Select an existing measurement pattern:** click once on a pattern in the Available Items window then click **Enter**, or double click on the desired pattern name.

   - **Modify an existing measurement pattern:** click once on a pattern name in the Available Items window then click on **Modify**. The Site Pattern window is displayed as shown in Figure 4-29.

CAUTION

Modifying any existing measurement pattern will affect every recipe that uses that measurement pattern.

For information on modifying measurement patterns, see “Creating and Modifying Measurement Patterns” on page 4–46.

When you have completed modifying the measurement pattern, the pattern information is displayed in the Wafer Recipe area of the Recipe Creator.

NOTE

Do not modify the Rudolph supplied patterns. To make modifications to the Rudolph supplied patterns, they should first be copied to a new file using the “Options” button then modify the newly created file.

   - **Create a new measurement pattern:** type the desired name in the **Name** field, and a description (if desired) in the **Description** field. Click on **Enter** and the Site Pattern window is displayed as shown in Figure 4-29 on page 4–46.

For information on creating a new measurement pattern, see “Creating and Modifying Measurement Patterns” on page 4–46.

When you have completed modifying the measurement pattern, the pattern information is displayed in the Wafer Recipe area of the Recipe Creator.

Wafer Report Selection

1. In the Recipe Creator main menu, click on **Wafer Recipe**.

   The Wafer Recipe menu is displayed.

2. Click on **Report** in the Wafer Recipe menu.

   The Report Selection window is displayed as shown in Figure 4-14.

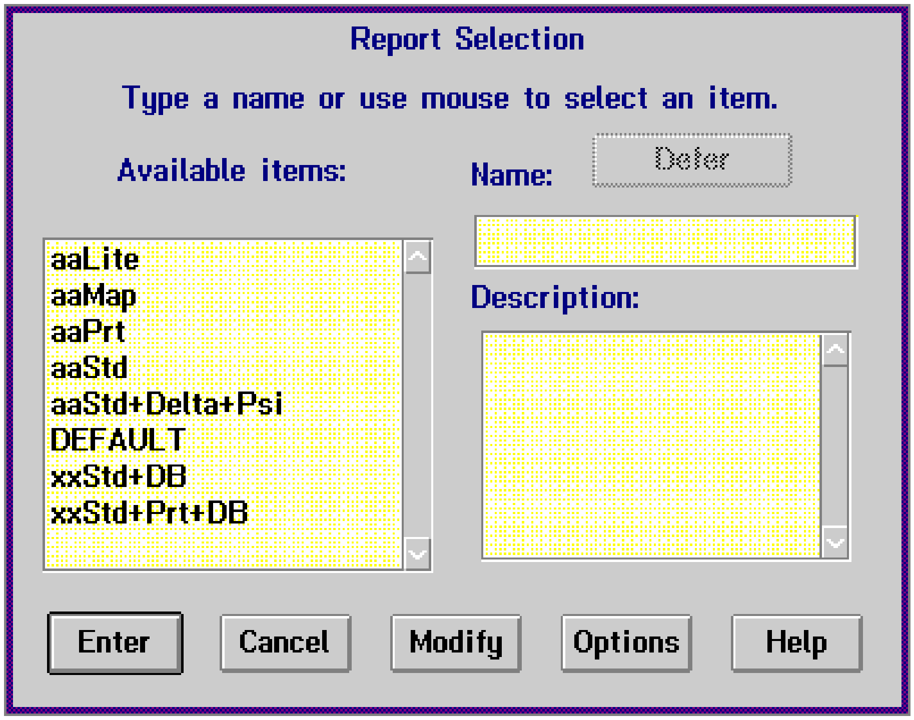

Figure 4-14. Report Selection Window

3. Perform **one** of the following:

   - **Select an existing report:** click once on a report name in the Available Items window then click **Enter**, or double click on the desired report name. Select **DEFAULT** to use the default report parameters.

   - **Modify an existing report:** click once on a report name in the Available Items window then click on **Modify**. The Wafer Report window is displayed in which you may specify the data source, where the data will be saved and/or displayed, how the data is saved and/or displayed, and what data will be included in the report.

     CAUTION

     Modifying any existing report template will affect every recipe that uses that template.

     For information on modifying wafer reports, refer to "Creating a Wafer Mapping Recipe" on page 4–45 and "Wafer Reports" on page 4–61.

     When you have completed modifying the wafer report, the report name is displayed in the Wafer Recipe area of the Recipe Creator.

     NOTE

     Do not modify the Rudolph supplied reports. To make modifications to the Rudolph supplied reports, they should first be copied to a new file using the "Options" button then modify the newly created file.

   - **Create a new report:** type the desired name in the **Name** field, and a description (if desired) in the **Description** field. Click on **Enter** and the Wafer Report window is displayed in which you may specify the data source, where the data will be saved and/or displayed, how the data is saved and/or displayed, and what data will be included in the report.

     For information on modifying wafer reports, refer to "Creating a Wafer Mapping Recipe" on page 4–45 and "Wafer Reports" on page 4–61.

     When you have completed creating the new report, the report name is displayed in the Wafer Recipe area of the Recipe Creator.

Saving the Recipe

Once all of the recipe selections have been made, save the current recipe in the database by performing the following:

1. In the Recipe Creator main menu, click on **Wafer Recipe**.

   The Wafer Recipe menu is displayed.

2. Click on **Save** in the Wafer Recipe menu. You may also click on **Cancel** in the Wafer Recipe menu at any time while creating the recipe to cancel the current wafer recipe and start over.

   The monitor wafer recipe has now been created. Before the wafer recipe can be run by the Operator, the recipe (together with transfer and control information) must be inserted into a process step under a process specification.

3. Proceed to “Transfer Control” on page 4–64.

Creating a Patterned Wafer Recipe (Cognex System)

After completing the steps in “Creating a Wafer Recipe” on page 4–16, and selecting **Automatic** from the Registration sub-menu under the Wafer Recipe menu, you must now train the FE System to automatically recognize (register) the patterns on the wafer using one of three methods (direct drive, site-by-site, and deferred), and select the measured chips.

Automatic Registration Using Pattern Recognition

1. In the Recipe Creator main menu, click on **Wafer Recipe**.

   The Wafer Recipe menu is displayed.

2. Click on **Registration** in the Wafer Recipe menu, then click on **Automatic** when the Registration sub-menu is displayed.

   A window is displayed asking if you wish to load a wafer.

3. Click on **Yes** to load a wafer.

   The Wafer Load/Unload window is displayed as shown in Figure 4-15.

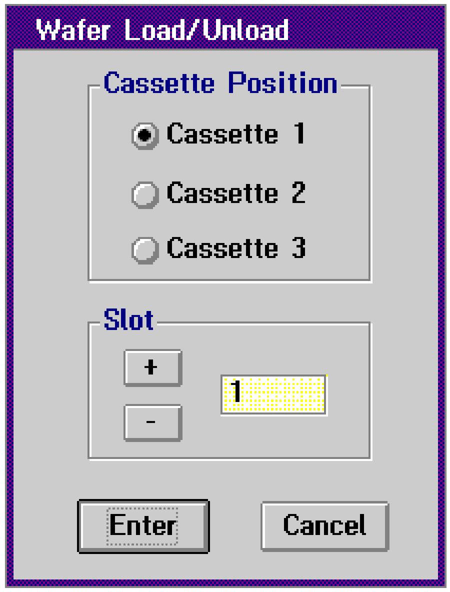

Figure 4-15. Wafer Load/Unload Window

4. Select the cassette and slot from which to load the wafer and click on **Enter**.

   The selected wafer is loaded onto the stage and the Site Locator window now shows a live video image of the wafer. An Automatic Registration window is displayed instructing you to input the die pitch and click on the **Train** button to determine chip spacing parameters.

NOTE

Depending on the software version of the Recipe Creator and the type of imaging system hardware, the Site Locator window will display the video image in either half or full screen mode.

5. Click on **OK** in the Automatic Registration window that is displayed once the wafer is loaded on the stage.

   The Wafer Layout window is displayed as shown in Figure 4-16.

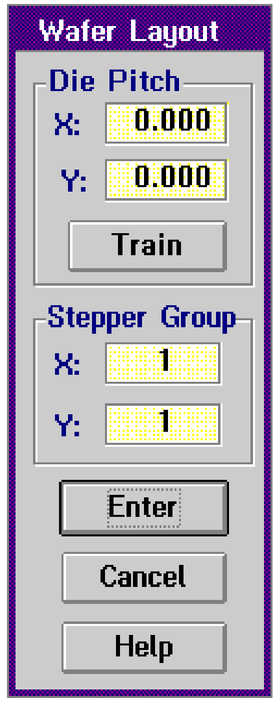

Figure 4-16. Wafer Layout Window

6. If the Die Pitch (the size of the stepper groups) is known, enter the value in millimeters in the Die Pitch boxes. If the Die Pitch is not known, leave the default values and proceed with the next step.

7. Click on the **Train** button in the Wafer Layout window to begin the stepper group training.

   A Die Pitch Training window is displayed instructing you to move to the lower left-hand corner of a die in the Site Locator window.

8. Click on **OK** in the Die Pitch Training window.

   A boxed area with a blue diamond is displayed on the live video image in the Site Locator window indicating the location on the wafer that the laser spot is focused.

   You must now select the lower left hand corner of three dies as illustrated in Figure 4-17. The three dies should be located near the center of the wafer.

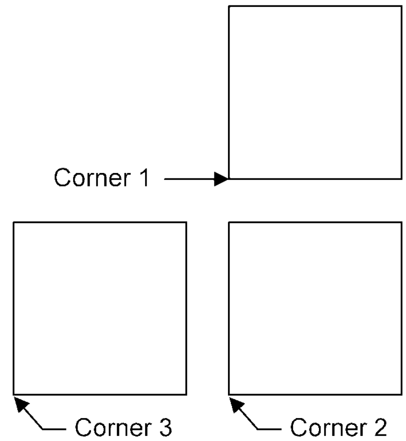

Figure 4-17. Die Corner Training Locations

9. In **LoMag**, drive the laser spot to the lower left-hand corner of the first die (corner 1), switch to **HiMag** and refine the positioning to the precise lower left corner of the first die. Positioning the wafer under the laser spot (blue diamond) may be done by moving the trackball pointer to the desired location in the live video image of the Site Locator window, and double clicking the right trackball button.

NOTE

It may not be easy to determine just what the corner of the die looks like. The die corner can be set up on any repeating feature in the pattern. It does not necessarily have to be the true lower left corner of a die if it will be easier to perform pattern recognition on another feature.

10. Once the laser spot has been positioned over the lower left corner of the first die, click on the **Corner 1** button.

    A window is displayed instructing you to choose the lower left-hand corner of the next die DOWN.

11. Switch to **LoMag**, then drive the wafer so that the laser spot (blue diamond) is positioned over the lower left-hand corner of the die directly below the first die (corner 2), switch to **HiMag** and refine the positioning. If the correct die pitch was chosen, the stage will automatically drive to the approximate position of the second corner, then you may refine the position.

NOTE

Ensure that all of the same types of features are visible in the Site Locator window for the second die as were present for the first die.

12. Once the laser spot has been positioned over the lower left corner of the second die, click on the **Corner 2** button.

    A window is displayed instructing you to choose the lower left-hand corner of the next die to the LEFT.

13. Switch to **LoMag**, then drive the wafer so that the laser spot (blue diamond) is positioned over the lower left-hand corner of the die directly to the left of the second die (corner 3), switch to **HiMag** and refine the positioning. If the correct die pitch was chosen, the stage will automatically drive to the approximate position of the third corner, then you may refine the position.

NOTE

Ensure that all of the same types of features are visible in the Site Locator window for the third die as were present for the first and second dies.

14. Once the laser spot has been positioned over the lower left corner of the third die, click on the **Corner 3** button.

    The Wafer Layout window is redisplayed with the rough X and Y values for the Die Pitch.

15. Click on the **Enter** button in the Wafer Layout window.

    The pattern recognition system will now automatically complete the registration. The system will adjust the lightbulb illumination, select the best color channel for the wafer, and train and test the registration points.

NOTE

For FE III and FE IV systems, training will be performed in HiMag and LoMag mode. For FE VII systems, training will be performed in HiMag only.

A Site Pattern Selection window is displayed instructing you to drag a box over the teach site. The teach site is the three corners just specified. Click on **OK**.

16. Position the trackball pointer over the corner of the image you want to train, click down and hold the left trackball button and simultaneously move the trackball to drag a rectangular box over the desired area. When the box is the correct size, release the left trackball button.

NOTE

If you released the left trackball button in error, or if you wish to redraw the teach site box, you may redo this step and redraw the box again.

The outline of the box will appear on the screen. Click on the **OK** button in the lower right corner of the Site Locator window.

NOTE

It is important that the selected teach site box not be too small. As a suggestion, try to make the box approximately the size of the Site Locator screen that is located in the upper left corner of the live video image.

Ensure that you include several distinguishing features within the teach site box. The Cognex pattern recognition system will more easily recognize differences between large shapes rather than small lines. Letters are usually unique, however they may be difficult to see. Examples of good shapes to train on are shown in the figure below.

Figure 4-18. Examples of Shapes for Pattern Training

17. Click on **OK** in the Site Pattern box.

The system will now move through the teach site area to memorize the patterns within the teach site. Once the system has completed this step, a Vision System Setup window will be displayed as shown in Figure 4-19.

The Vision System Setup window gives you a graphic representation of how well the system could teach that site (the higher the score, the better). This indicates the likelihood of the system being able to recognize that pattern on the wafer.

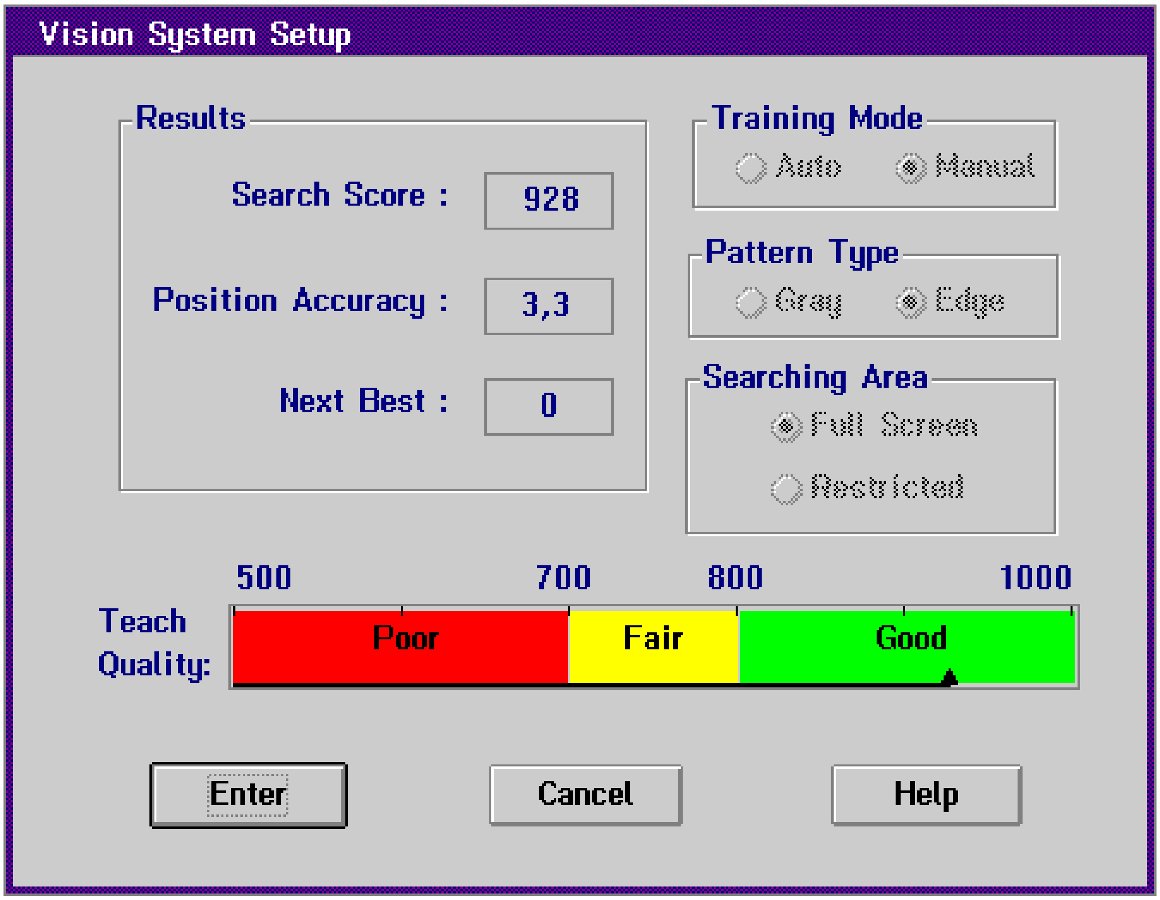

Figure 4-19. Vision System Setup Window

18. Perform **one** of the following:

- **If you wish to reteach the system:** Click on the **Cancel** button in the Vision System Setup window. You will then be allowed to drag a box for the new teach site as explained in Step 16 of this procedure.
- **If the score for the teach site is acceptable:** Click on the **Enter** button in the Vision System Setup window.

Once you have accepted the score for the teach site and clicked on **Enter**, the system will refine the die pitch using the pattern taught in the previous steps. At each site, depending on the version of the software, a window may be displayed asking if the site shown is a good refine site.

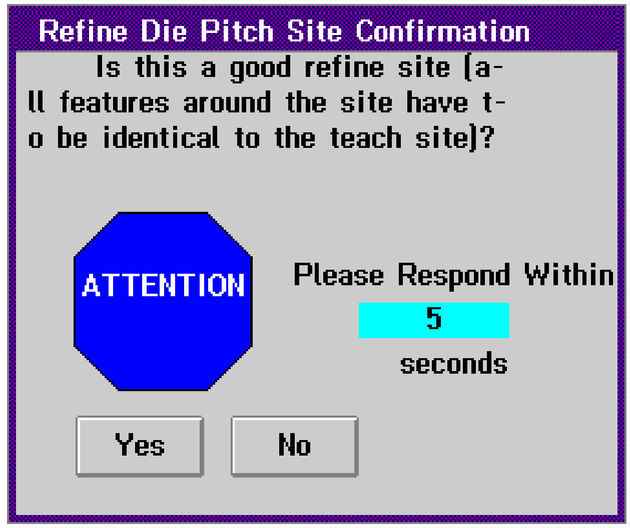

Figure 4-20. Refine Die Pitch Site Confirmation Window

19. If prompted to confirm the refine site, perform **one** of the following:

    - **If the refine site displayed closely matches the teach site:** click on **Yes**.

      The system moves to the next refine site and you are once again prompted to confirm if this is a valid refine site.

    - **If the refine site displayed does not closely match the teach site:** click on **No**.

      The system moves to a new refine site and you are once again prompted to confirm if this is a good refine site.

    Once the system has found the refine sites on the wafer, a window is displayed showing the refined die pitch information.

20. Click on the **OK** button in the Automatic Die Pitch Refine window.

    The system will now deskew the wafer to ensure that it is centered on the stage and the pattern is aligned correctly. The number of sites checked will depend on the version of the software. At each location a window is displayed asking you to verify that this is a valid registration site.

21. Each time you are prompted to verify the registration site, perform **one** of the following:

    - **If this is not a valid registration site:** click on **No**.

      The system moves to another site and you are asked to verify if this is a valid registration site.

    - **If this is a valid registration site:** click on **Yes**.

      The system moves to the another deskew site. A window is displayed asking you to verify that this is a valid registration site.

      Once all of the registration sites have been verified, a window is displayed informing you that wafer registration is now complete.

22. Click on the **OK** button.

    The Pattern Recognition System sets up a grid outlining the dies, and Automatic Registration is complete. A window is displayed asking you to select **Train Patterns** from the Patterned Wafer sub-menu of the Wafer Recipe menu.

23. Click on the **OK** button.

    You are returned to the Recipe Creator Main window.

You may now train the measurement patterns for the wafer.

Pattern Training

The steps provided in this section will allow you to identify the measurement sites within a die on the wafer. The trained measurement pattern may then be duplicated onto other selected dies. Modifications may be made to trained measurement patterns using the procedure in “Changing Measurement Sites in a Registered Pattern” on page 4–58.

To train the measurement patterns, perform the following:

1. In the Recipe Creator main menu, click on **Wafer Recipe**.

   The Wafer Recipe menu is displayed.

2. Click on **Patterned Wafer** in the Wafer Recipe menu, then click on **Train Patterns** when the Patterned Wafer sub-menu is displayed.

   A window is displayed instructing you to press one of the die button(s) in the stepper group pattern window to train a die pattern.

3. Click on **OK** in the Stepper Group window.

   A Stepper Group Pattern Training window (Figure 4-21), and the Site Locator window showing a grid simulating the chip spacing on the wafer (Figure 4-22) are displayed.

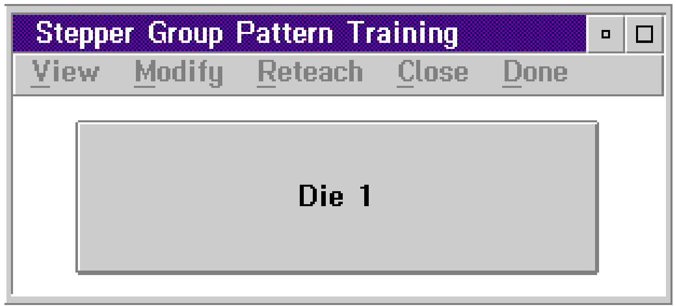

Figure 4-21. Stepper Group Pattern Training Window

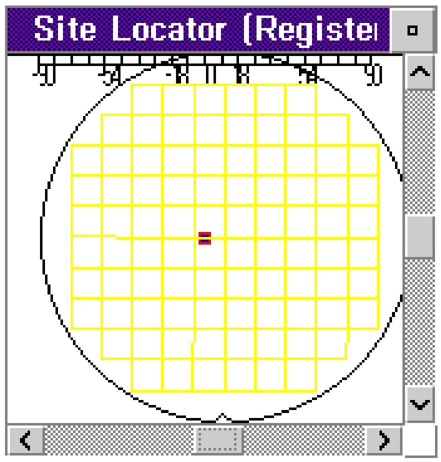

Figure 4-22. Site Locator Wafer View Window

4. In the Site Locator Wafer View window located in the upper left-hand portion of the screen, move to the stepper group that will be used as a model to train the measurement sites by positioning the trackball pointer over the desired stepper group and double clicking the right trackball button.

   The stage moves the wafer to the selected stepper group.

5. Click on the **Die 1** button in the Stepper Group Pattern Training window.

   The stage moves and the laser spot is positioned over the bottom left corner of the selected stepper group in the Site Locator Live Video window and the selected stepper group in the Site Locator Wafer View window is highlighted. The Site Pattern Window is displayed as shown in Figure 4-23.

Figure 4-23. Site Pattern Window - Patterned Wafers

6. Click the **Point** button in the Site Pattern window.

   A window is displayed instructing you to move a measurement site to the laser spot and click the **Enter** button in the lower right corner of the Site Locator window. Click on **OK**.

NOTE

Remember to stay within the active die while training the points to measure. The region of the die is marked by lines drawn in the lower Site Locator window and is highlighted in the upper right Site Locator window. Training is not allowed in other stepper groups.

7. Move to the desired measurement site within the previously selected stepper group by positioning the trackball pointer over the desired site and double clicking the right trackball button. Use HiMag and/or LoMag as necessary to move to the desired site.

   The stage moves the wafer so that the laser spot is positioned over the selected location.

8. Click the **Enter** button in the lower right corner of the Site Locator window.

   The Point Selection window is displayed as shown in Figure 4-24. A default filmstack is displayed in the Filmstack field.

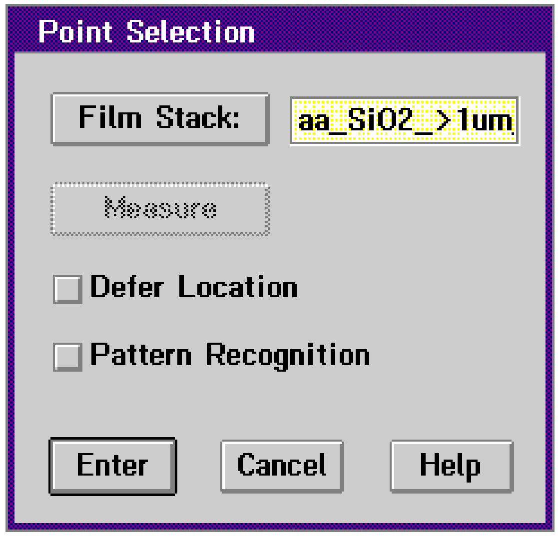

Figure 4-24. Point Selection Window

9. In the Point Selection window, you may:

   - Specify the desired filmstack for this point by clicking on the **Filmstack** button then selecting the desired filmstack from the selection list that is displayed.
   - Allow the Operator to fine tune the position of the measurement site at run time by clicking on the button beside **Defer Location**. This is particularly useful if you have a very small measurement site and should only be used if the FE System has no pattern recognition hardware, or when the pattern recognition hardware will not work and the direct drive alignment is not acceptable.
   - Perform site-by-site pattern recognition on this location by clicking on the button beside **Pattern Recognition**. This is particularly useful if you have a very small measurement site.

NOTE

Selecting neither Defer Location nor Pattern Recognition allows the system to directly drive to the measurement site. This relies on the original deskew for position accuracy. Individual sites are not checked. This mode has the fastest throughput.

10. Click on the **Enter** button in the Point Selection window.

    One of the following will occur:

    - **If you did not select Pattern Recognition**, you are returned to the Recipe Creator Main window with the Site Pattern window displayed. An “X” is displayed on the selected measurement location.

    - **If you selected Pattern Recognition**, the system goes through the same registration procedure used for training the registration sites. Drag a box over the teach site for the measurement location and click on **OK** in the Site Pattern window that is displayed. The Vision System Setup window is then displayed. Click on **Enter** to accept the teach site, **Cancel** to reject the teach site and select another.

      When the teach site has been selected, you are returned to the Recipe Creator Main window with the Site Pattern window displayed. A square box is displayed on the selected measurement location to indicate that pattern recognition will be used for this site.

11. Repeat Step 6 through Step 10 of this procedure to select additional measurement sites within this stepper group.

12. When all measurement sites have been selected, click on the **Enter** button in the Site Pattern window.

    A window is displayed indicating that training is completed and instructing you to select the **Select Measured Chips** item from the Patterned Wafer sub-menu of the Wafer Recipe menu.

13. Click on the **OK** button.

    You are returned to the Recipe Creator Main window.

You may now select the chips to be measured on the wafer. Once the pattern has been trained, it may be modified using the procedure provided in “Changing Measurement Sites in a Registered Pattern” on page 4–58.

Select Measured Chips

The steps provided in this section will allow you to identify the stepper groups on which to perform the previously defined measurement. The stepper groups will be measured in the order in which they are selected in this procedure.

To select the stepper groups to be measured and apply the measurement pattern, perform the following:

1. In the Recipe Creator main menu, click on **Wafer Recipe**.

   The Wafer Recipe menu is displayed.

2. Click on **Patterned Wafer** in the Wafer Recipe menu, then click on **Select Measured Chips** when the Patterned Wafer sub-menu is displayed.

   The Site Locator Live Video window is displayed in half screen, LoMag mode. A Stepper Group Map window is displayed as shown in Figure 4-25 and the Site Locator Wafer View window appears as shown in Figure 4-26.

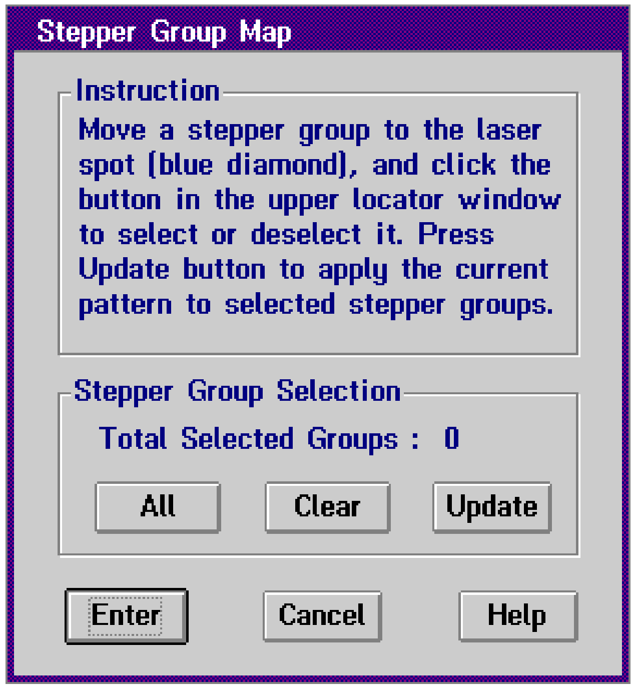

Figure 4-25. Stepper Group Map Window

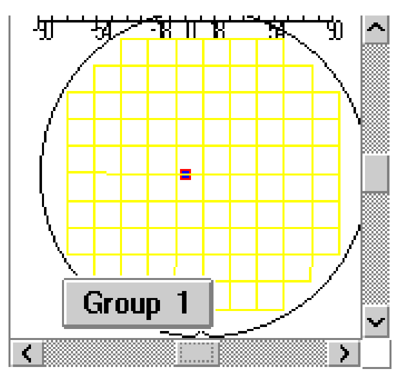

Figure 4-26. Site Locator Wafer View - Stepper Group Selection

3. Move a stepper group to the laser spot by positioning the trackball pointer over the desired stepper group in the Site Locator Wafer View window and double click the right trackball button.

   The wafer moves to the selected position and the blue diamond is now positioned over the selected stepper group.

NOTE

For stepper groups printed near the outer edge of the wafer, you may wish to verify that the desired stepper group is actually printed completely on the wafer by checking the die in the Site Locator Live Video window. Incomplete stepper groups may not contain all of the measurement sites trained in the example stepper group.

4. Click on the **Group #** button in the upper left Site Locator Wafer View window.

   The selected stepper group is now highlighted in the Site Locator window and the number in the **Group #** button increments by one. The Total Selected Groups field of the Stepper Group Map window displays the number of stepper groups that have currently been selected.

NOTE

You may select ALL of the stepper groups on this wafer by clicking on the "All" button in the Stepper Group Map window. All of the stepper groups are then highlighted and you are prompted to remove any selected stepper groups that are not wholly printed on the wafer.

5. Repeat Step 3 and Step 4 above for each desired stepper group.

NOTE

You may deselect a previously selected stepper group by moving the laser spot to that stepper group and clicking on the "Group #" button in the upper left Site Locator window. Alternatively, you may clear ALL of the selected stepper groups by clicking on the "Clear" button in the Stepper Group Map window.

6. Once all of the desired stepper groups have been selected, click on **Enter** in the Stepper Group Map window.

   You are returned to the Recipe Creator Main window. You may now select the wafer report to complete the recipe.

Wafer Report Selection

1. In the Recipe Creator main menu, click on **Wafer Recipe**.

   The Wafer Recipe menu is displayed.

2. Click on **Report** in the Wafer Recipe menu.

   The Report Selection window is displayed as shown in Figure 4-27.

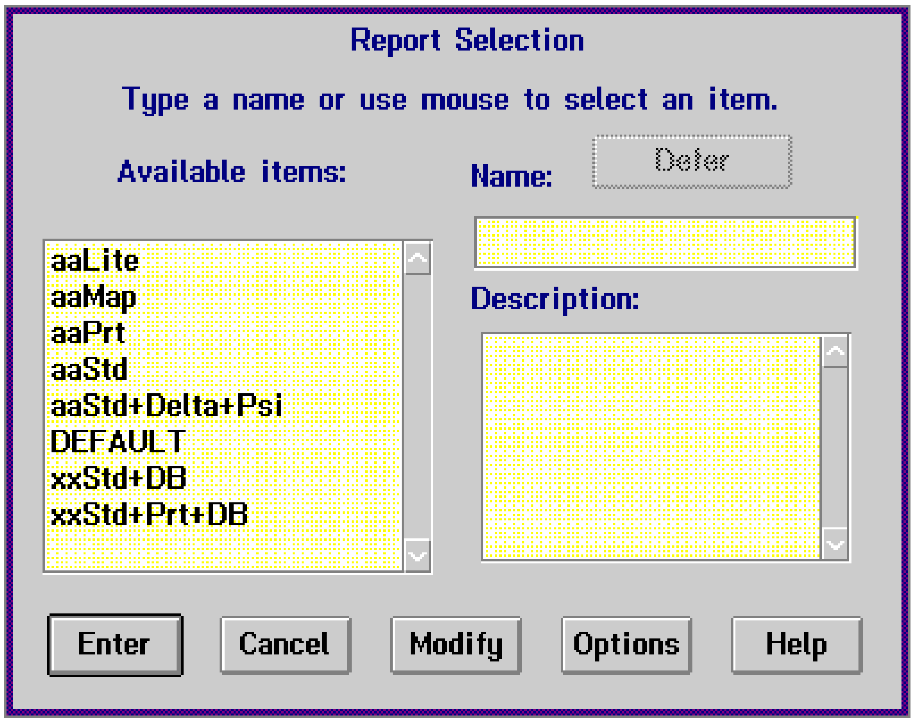

Figure 4-27. Report Selection Window

3. Perform **one** of the following:

   - **Select an existing report:** click once on a report name in the Available Items window then click **Enter**, or double click on the desired report name. Select **DEFAULT** to use the default report parameters.

   - **Modify an existing report:** click once on a report name in the Available Items window then click on **Modify**. The Wafer Report window is displayed in which you may specify the data source, where the data will be saved and/or displayed, how the data is saved and/or displayed, and what data will be included in the report.

     For information on modifying wafer reports, refer to "Creating a Wafer Mapping Recipe" on page 4–45 and "Wafer Reports" on page 4–61.

When you have completed modifying the wafer report, the report name is displayed in the Wafer Recipe area of the Recipe Creator.

CAUTION

Modifying any existing wafer report will affect every recipe that uses that report.

- **Create a new report:** type the desired name in the **Name** field, and a description (if desired) in the **Description** field. Click on **Enter** and the Wafer Report window is displayed in which you may specify the data source, where the data will be saved and/or displayed, how the data is saved and/or displayed, and what data will be included in the report.

  For information on modifying wafer reports, refer to "Creating a Wafer Mapping Recipe" on page 4–45 and "Wafer Reports" on page 4–61.

  When you have completed creating the new report, the report name is displayed in the Wafer Recipe area of the Recipe Creator.

Saving the Recipe

Once all of the recipe selections have been made, save the current recipe in the database by performing the following:

1. In the Recipe Creator main menu, click on **Wafer Recipe**.

   The Wafer Recipe menu is displayed.

2. Click on **Save** in the Wafer Recipe menu. You may also click on **Cancel** in the Wafer Recipe menu to cancel the current wafer recipe being created and start over.

CAUTION

If you click on "Cancel" the wafer recipe will not be saved.

The patterned wafer recipe has now been created. Before the wafer recipe can be run by the Operator, it must be placed into a process specification.

3. Proceed to "Transfer Control" on page 4–64.

Modifying a Wafer Recipe

To modify a recipe, the Process Engineer first selects the desired recipe. Once selected modifications may either be made to that recipe or to a copy of the selected recipe. The changes are then saved and the recipe may then be used in a process.

CAUTION

Modifying any existing recipe will affect every process specification that includes that recipe.

Use the following procedure to select and modify existing wafer recipes. For information on creating new wafer recipes, refer to "Creating a Wafer Recipe" on page 4–16.

Recipe Selection

1. In the Recipe Creator main menu, click on **Wafer Recipe**.

   The Wafer Recipe menu is displayed.

2. Click on **Name** in the Wafer Recipe menu.

   The Wafer Recipe Selection window is displayed as shown in Figure 4-28.

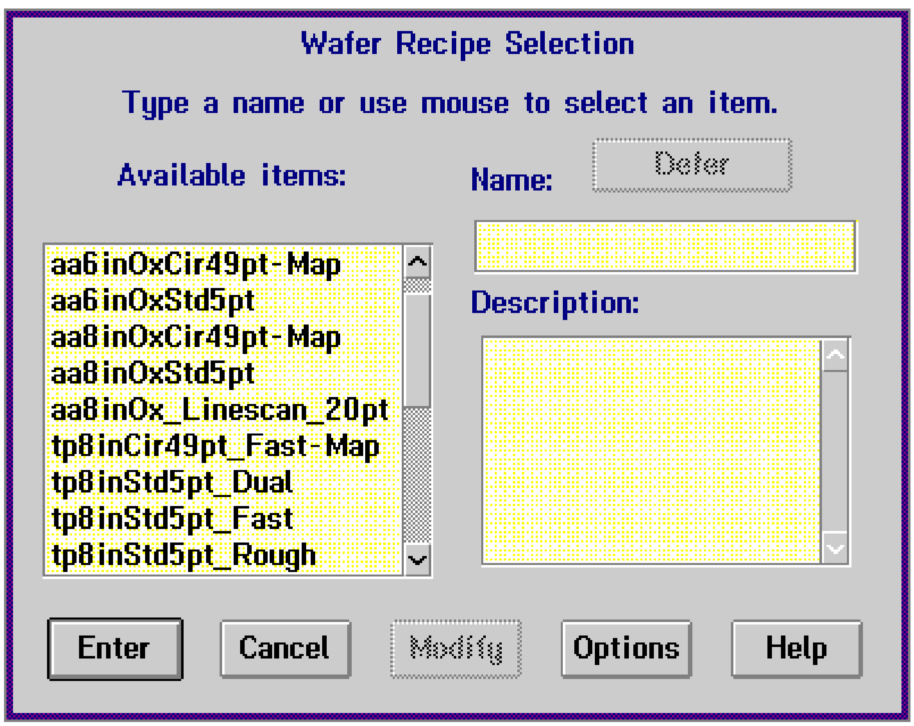

Figure 4-28. Wafer Recipe Selection Window

3. Perform **one** of the following:

   - **Modify an existing wafer recipe:** click once on a wafer recipe in the Available Items window then click **Enter**, or double click on the desired wafer recipe name.

   - **Modify a copy of an existing recipe:** click once on a wafer recipe name in the Available Items window then click on **Options**. Enter the new wafer recipe name in the **Destination** field, then click on **Save As**. Click on **Enter** when you have returned to the Wafer Recipe Selection window.

   The pertinent wafer recipe information (if any) is displayed in the Wafer Recipe area of the Recipe Creator.

4. Once the wafer recipe is selected and displayed in the Wafer Recipe area, perform any of the following:

   - **Modify the Wafer Information** in the wafer recipe using the procedure provided in "Wafer Information" on page 4–17.

   - **Modify the Filmstack** in the wafer recipe using the procedure provided in "Film Stack Specification" on page 4–19.

   - **Modify the Wafer Registration** information in the wafer recipe using the procedure provided in "Wafer Registration" on page 4–21.

   - **Modify a Monitor wafer recipe** using the procedure provided in "Creating a Monitor Wafer Recipe" on page 4–22.

   - **Modify a Patterned wafer recipe** using the procedure provided in "Creating a Patterned Wafer Recipe (Cognex System)" on page 4–26.

Creating a Wafer Mapping Recipe

This section provides information on how to create a wafer recipe that will generate a wafer map file. The map file may be viewed either using the Focus Mapping software (see Chapter 5, "Wafer Mapping and Data Reporting") or the Focus Operator Queued Loading software (see Chapter 2, "Operator Interface").

Any wafer recipe can be a wafer mapping recipe providing at least five points are measured. Perform the following to configure a wafer recipe to generate a wafer map file:

1. Perform the procedure provided in "Creating a Wafer Recipe" on page 4–16.

2. Perform the procedures provided in "Creating a Monitor Wafer Recipe" on page 4–22 and "Creating a Patterned Wafer Recipe (Cognex System)" on page 4–26 as appropriate up to the point of specifying a wafer report.

3. Perform **one** of the following:

   - **Select an existing report** by clicking once on the report name in the list of available items and then clicking on **Modify**.

   CAUTION

   Modifying any existing wafer report will affect every recipe that uses that report.

   - **Create a new report** by entering the desired name for the report in the **Name** field and a description for the report (if desired) in the **Description** field and click on **Enter**.

   The Wafer Report window is displayed as shown in Figure 4-37 on page 4–61.

4. Use the information provided in "Wafer Reports" on page 4–61 to configure the wafer report for this recipe.

   CAUTION

   The "Map" option must be selected in the Display portion of the Wafer Report window to generate a wafer map. If the Map option is not selected, a wafer map will not be generated.

5. In the Recipe Creator main menu, click on **Wafer Recipe** then click on **Save** when the Wafer Recipe menu is displayed.

   The wafer recipe has now been saved.

Creating and Modifying Measurement Patterns

The FE System allows the Process Engineer to create new wafer measurement patterns, or modify measurement patterns that already exist in the database, in the event that a default pattern does not meet the needs of the current application.

Once you have entered a new measurement pattern name, or selected a pattern for modification, as described in Step 3 of "Measurement Pattern Selection" on page 4–22, the Site Pattern window is displayed as shown in Figure 4-29.

NOTE

Creating and modifying measurement patterns can only be performed while creating or modifying a recipe.

Figure 4-29. Site Pattern Window

The following buttons are available from the Site Pattern window:

- **Draw Point** — Select individual points to be measured on the wafer by double clicking on the desired location in the Site Locator window.
- **Draw Coords** — Select the individual points to be measured on the wafer by entering the X and Y coordinates of each point.
- **Draw Shapes** — Select a measurement pattern, such as a circle or line. The pattern is then drawn in the Site Locator window and points along the selected pattern will be measured.
- **File Export** — Saves measurement pattern information to a specified path and filename so that the information may be used on another FE System.
- **File Import** — Loads measurement pattern information from a specified path and filename.
- **Erase Last** — Erases the last measurement point or pattern entered. Clicking repeatedly on this button will erase all points and patterns in the reverse order in which they were entered.
- **Enter** — Saves the measurement pattern information and returns you to the Recipe Creator main window.
- **Cancel** — Cancels measurement pattern selection and returns you to the Recipe Creator main window. Any changes made to the measurement pattern are lost.
- **Help** — Not available at this time.

Select the desired drawing method and design a measurement pattern. The following sections provide more information on each of the drawing methods.

Pattern Creation by Point

To create a wafer measurement pattern point by point, perform the following:

1. In the Site Locator window, change to Wafer View by selecting the **Control** menu. Click on **Mag** from the Control menu items and select **Wafer View** from the sub-menu that is displayed

   The Site Locator window is now in Wafer View mode.

2. Click on the **Point** button in the Site Pattern window.

   A window is displayed instructing you to double click on the desired measurement site in the Site Locator window. Click on **OK**.

3. Position the trackball pointer over the desired measurement location in the Site Locator window and double click the left trackball button.

   The Point Selection window is displayed as shown in Figure 4-30.

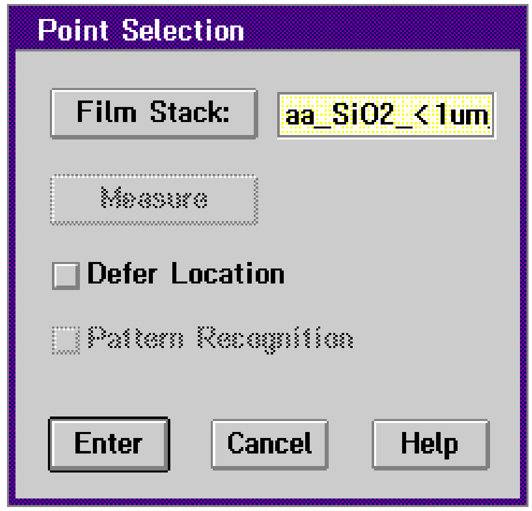

Figure 4-30. Measurement Point Selection Window

4. Make any changes to the filmstack selection for this measurement point by clicking on the **Film Stack** button. You may also opt to defer the measurement of this point to the Operator when the process is run.

5. Click on **Enter** to enter the information for this measurement point.

   The Wafer View window and the wafer view in the Site Locator window are updated to show the new measurement location and you are returned to the Site Pattern window.

   You may also click on **Cancel** to abort the selection of this point and return to the Site Pattern window.

6. Repeat Steps 2 through 5 of this procedure to select any additional measurement points.

7. When all measurement points have been selected, click on the **Enter** button in the Site Pattern window.

   You are returned to the Recipe Creator main window.

Pattern Creation by Coordinate

To create a wafer measurement pattern using point X and Y coordinates, perform the following:

1. In the Site Locator window, change to Wafer View by selecting the **Control** menu. Click on **Mag** from the Control menu items and select **Wafer View** from the sub-menu that is displayed.

   The Site Locator window is now in Wafer View mode.

2. Click on the **Coord** button in the Site Pattern window.

   The Coordinates Entry Pattern window is displayed as shown in Figure 4-31.

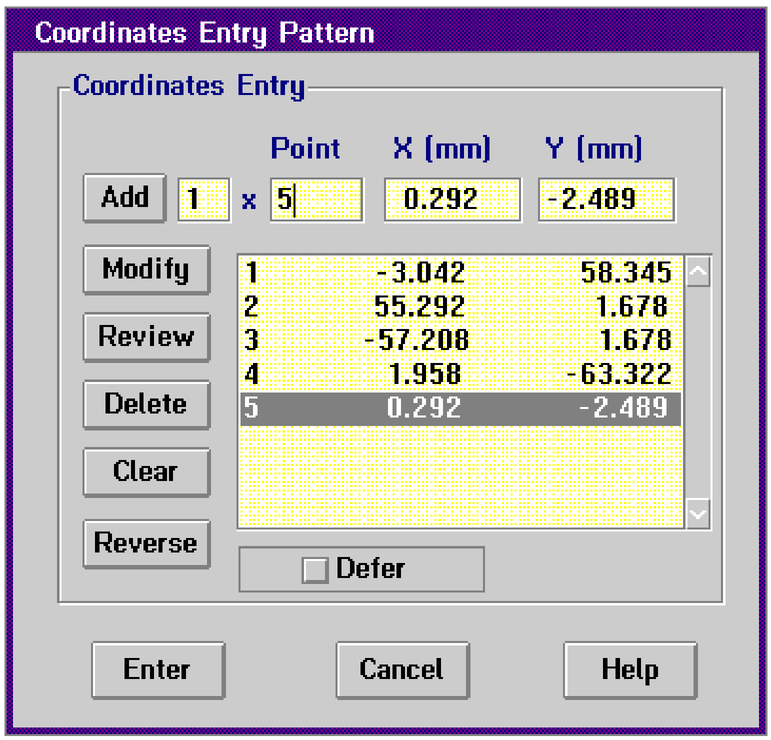

Figure 4-31. Coordinates Entry Pattern Window

NOTE

If any measurement points have been previously defined, they will be displayed in the Coordinates Entry Pattern window. If no points have been defined, this window will be blank.

3. You may **Add**, **Modify**, **Review**, and **Delete** individual measurement points by clicking on the appropriate button in the Coordinates Entry Pattern window. You may also **Clear** all points, **Reverse** the order in which the points will be measured, and defer the measurement of these points to the Operator when the process is run.

4. Click on **Enter** to enter the information for these measurement points.

   The Wafer View window and the wafer view in the Site Locator window show the new measurement locations and you are returned to the Site Pattern window.

   You may also click on **Cancel** to abort the selection of these points and return to the Site Pattern window.

5. When all measurement points have been entered, click on the **Enter** button in the Site Pattern window.

   You are returned to the Recipe Creator main window.

Pattern Creation by Shape

To create a wafer measurement pattern by drawing shapes on the wafer view, perform the following:

1. In the Site Locator window, change to Wafer View by selecting the **Control** menu. Click on **Mag** from the Control menu items and select **Wafer View** from the sub-menu that is displayed.

   The Site Locator window is now in Wafer View mode.

2. Click on the **Shapes** button in the Site Pattern window.

   The Shape Pattern window is displayed as shown in Figure 4-32.

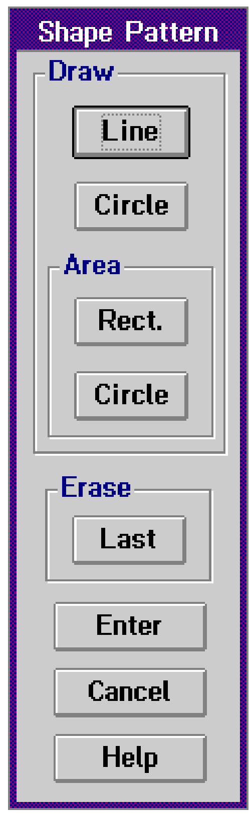

Figure 4-32. Shape Pattern Window

The following buttons are available from the Shape Pattern window:

- **Draw Line** — Selects points to be measured along a specified line drawn on the wafer view.
- **Draw Circle** — Selects points to be measured around the perimeter of a circle drawn on the wafer view.
- **Area Rect.** — Selects points to be measured in a selected rectangular area.
- **Area Circle** — Selects points to be measured in a selected circular area.
- **Erase Last** — Erases the last measurement shape pattern entered. Clicking repeatedly on this button will erase all patterns in the reverse order in which they were entered.
- **Enter** — Saves the measurement shape pattern information and returns you to the Site Pattern window.
- **Cancel** — Cancels measurement shape selection and returns you to the Site Pattern window. Any changes made to the measurement shape pattern are lost.
- **Help** — Not available at this time.

Line Patterns

To create a linear wafer measurement pattern, perform the following:

1. Click on the **Line** button in the Shape Pattern window.

   A window is displayed instructing you to drag a line in the Site Locator window. Click on **OK**.

2. Position the trackball pointer over the desired starting point for the line, press and hold the left trackball button and move the trackball pointer to the ending point for the line and release the left trackball button.

   The Linear Selection window is displayed as shown in Figure 4-33. This window provides information about the number of measurement points along the line.

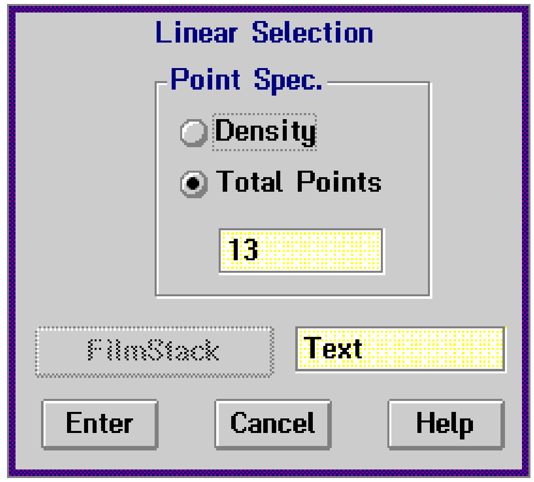

Figure 4-33. Linear Selection Window

3. Click on the **Enter** button to accept the displayed information, or you may enter another number in the **Total Points** field and then click on the **Enter** button.

   The shape measurement pattern is displayed on the wafer view and you are returned to the Shape Pattern window.

   You may also click on the **Cancel** button to reject this information. The point information is discarded and you are returned to the Shape Pattern window where you may make another selection.

4. Repeat Steps 1 through 3 of this procedure to draw additional linear patterns on the wafer as desired.

5. When all linear patterns have been completed, click on the **Enter** button in the Shape Pattern window.

   You are returned to the Site Pattern window.

6. Click on the **Enter** button in the Site Pattern window to save the measurement pattern information.

   You are returned to the Recipe Creator main window.

Circular Patterns

To create a circular wafer measurement pattern, perform the following:

1. Click on the **Circle** button in the Draw section of the Shape Pattern window.

   A window is displayed instructing you to drag the center and radius of the circle in the Site Locator window. Click on **OK**.

2. Position the trackball pointer over the desired center point of the circle, press and hold the left trackball button and move the trackball pointer the desired distance for the radius of the circle and release the left trackball button.

   The outline of a circle is displayed in the Site Locator window as you drag the trackball. When the left trackball button is released, the Linear Selection window is displayed as shown in Figure 4-34. This window provides information about the number of measurement points along the perimeter of the circle.

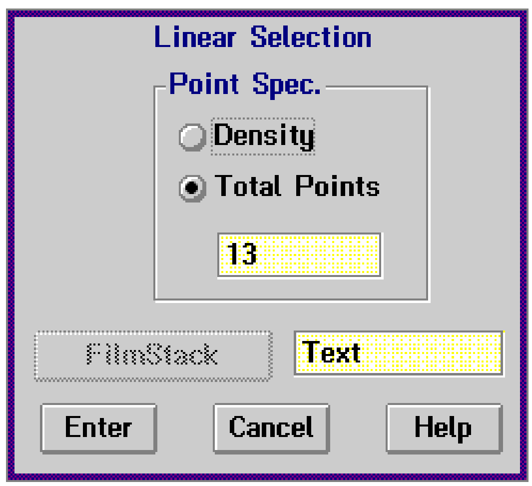

Figure 4-34. Linear Selection Window

3. Click on the **Enter** button to accept the displayed information, or you may enter another number in the **Total Points** field and then click on the **Enter** button.

   The shape measurement pattern is displayed on the wafer view and you are returned to the Shape Pattern window.

   You may also click on the **Cancel** button to reject this information. The point information is discarded and you are returned to the Shape Pattern window where you may make another selection.

4. Repeat Steps 1 through 3 of this procedure to draw additional circular patterns on the wafer as desired.

5. When all circular patterns have been completed, click on the **Enter** button in the Shape Pattern window.

   You are returned to the Site Pattern window.

6. Click on the **Enter** button in the Site Pattern window to save the measurement pattern information.

   You are returned to the Recipe Creator main window.

Rectangular Area Patterns

To create a rectangular area wafer measurement pattern, perform the following:

1. Click on the **Rect.** button in the Shape Pattern window.

   The Area Selection window is displayed as shown in Figure 4-35.

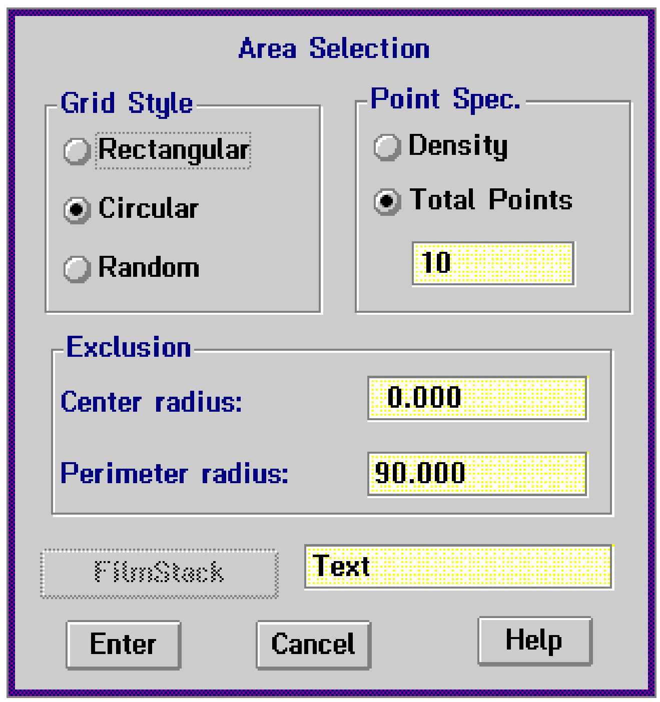

Figure 4-35. Area Selection Window

2. Enter the desired Grid Style and/or the number of measurement points and click on the **Enter** button, or just click on the **Enter** button to accept the default values.

   The area pattern is displayed on the wafer view and you are returned to the Shape Pattern window.

   You may also click on the **Cancel** button to reject this information. You are returned to the Shape Pattern window where you may make another selection.

3. Click on the **Enter** button in the Shape Pattern window when all shape patterns have been completed.

   You are returned to the Site Pattern window.

   You may also click on the **Cancel** button to reject this information. You are returned to the Site Pattern window where you may make another selection.

4. Click on the **Enter** button in the Site Pattern window to save the measurement pattern information.

   You are returned to the Recipe Creator main window.

Circular Area Patterns

To create a circular area wafer measurement pattern, perform the following:

1. Click on the **Circle** button in the Area section of the Shape Pattern window.

   The Circular Area window is displayed as shown in Figure 4-36.

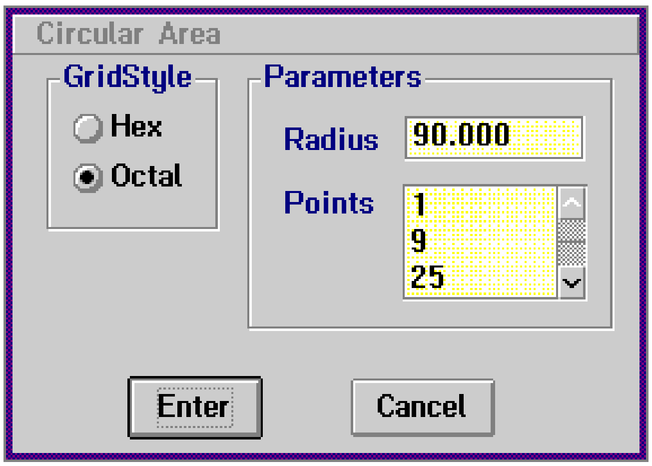

Figure 4-36. Circular Area Window

2. Enter the desired Grid Style and/or circle radius for the pattern. Click on the desired number of measurement points for the pattern and then click on the **Enter** button.

   The area pattern is displayed on the wafer view and you are returned to the Shape Pattern window.

   You may also click on the **Cancel** button to reject this information. You are returned to the Shape Pattern window where you may make another selection.

3. Click on the **Enter** button in the Shape Pattern window when all shape patterns have been completed.

   You are returned to the Site Pattern window.

   You may also click on the **Cancel** button to reject this information. You are returned to the Site Pattern window where you may make another selection.

4. Click on the **Enter** button in the Site Pattern window to save the measurement pattern information.

   You are returned to the Recipe Creator main window.

Changing Measurement Sites in a Registered Pattern

A Registered Pattern is one in which the stepper groups have already been trained.

To change a Registered Pattern, but keep the selected chips to be measured the same, use the following procedure:

1. In the Recipe Creator main menu, click on **Wafer Recipe**.

   The Wafer Recipe menu is displayed.

2. Click on **Name** in the Wafer Recipe menu.

   The Wafer Recipe Selection window is displayed as shown in Figure 4-9.

3. Select an existing patterned wafer recipe by clicking once on a wafer recipe in the Available Items window then clicking **Enter**, or by double clicking on the desired wafer recipe name.

   The pertinent wafer recipe information (if any) is displayed in the Wafer Recipe area of the Recipe Creator.

4. In the Recipe Creator main menu, click on **Wafer Recipe**.

   The Wafer Recipe menu is displayed.

5. Click on **Registration** in the Wafer Recipe menu, then click on **Automatic** when the Registration sub-menu is displayed.

   The wafer is loaded and the system automatically registers the wafer, sets up the stepper group grid, and displays the chips to be measured and the measurement sites. A window is displayed informing you when the registration is complete. Click on **OK**.

6. In the Recipe Creator main menu, click on **Wafer Recipe**.

   The Wafer Recipe menu is displayed.

7. Click on **Patterned Wafer** in the Wafer Recipe menu, then click on **Train Patterns** when the Registration sub-menu is displayed.

   A Stepper Group Pattern Training window (Figure 4-21), and the Site Locator window showing a grid simulating the chip spacing on the wafer (Figure 4-22) are displayed.

8. In the Site Locator Wafer View window located in the upper left-hand portion of the screen, move to the stepper group that you wish to modify by positioning the trackball pointer over the desired stepper group and double clicking the right trackball button.

   The wafer is moved to position the selected stepper group under the laser spot.

9. In the Stepper Group Pattern Training window menu, click on **Modify**, then click on **Stepper Group** when the Modify menu is displayed.

10. Click on the **Die 1** button in the Stepper Group Pattern Training window.

    The measurement sites that were previously chosen are highlighted and the Site Pattern Window is displayed as shown in Figure 4-23.

11. You may perform any of the following:

    - Click on **Last** under **Erase** in the Site Pattern window to clear any unwanted measurement sites.

    - Select **Point** in the Site Pattern window to add any new measurement sites. Use the instructions provided in Step 6 through Step 11 of the section entitled "Pattern Training" on page 4–34.

12. When you are finished erasing and adding sites, click on **Enter** in the Site Pattern window.

    You are returned to the Recipe Creator Main window.

13. In the Recipe Creator main menu, click on **Wafer Recipe**.

    The Wafer Recipe menu is displayed.

14. Click on **Patterned Wafer** in the Wafer Recipe menu, then click on **Select Measured Chips** when the Registration sub-menu is displayed.

    The Site Locator Live Video window is displayed in half screen, LoMag mode. A Stepper Group Map window is displayed as shown in Figure 4-25 and the Site Locator Wafer View window appears as shown in Figure 4-26.

15. Click on **Update** in the Stepper Group Map window so that the new measurement sites will appear in the selected chips to be measured.

    A window is displayed informing you when the selected stepper groups have been updated with the new measurement pattern. Click on **OK**.

16. Click on **Enter** in the Stepper Group Map window.

    You are returned to the Recipe Creator Main window.

17. In the Stepper Group Pattern Training window menu, click on **View**, then click on **Wafer Pattern** from the View menu.

    The Wafer View will show all of the updated measurement sites.

18. In the Stepper Group Pattern Training window menu, click on **Close**.

    The Stepper Group Pattern Training window is closed and you are returned to the Recipe Creator Main window.

19. In the Recipe Creator main menu, click on **Wafer Recipe**.

    The Wafer Recipe menu is displayed.

20. Click on **Save** in the Wafer Recipe menu. You may also click on **Cancel** in the Wafer Recipe menu to cancel the current wafer recipe being created and start over.

CAUTION

If you click on “Cancel” any information modified in the wafer recipe is lost.

The modifications to the measurement sites have now been completed. Before the wafer recipe can be run by the Operator, wafer transfer control must be specified and the process specification must be created.

Wafer Reports

Once you have entered a new measurement report name, or selected a report for modification, as described in Step 3 of "Wafer Report Selection" on page 4–24 for monitor wafers, or Step 3 of "Wafer Report Selection" on page 4–41 for patterned wafers, the Wafer Report window is displayed as shown in Figure 4-37.

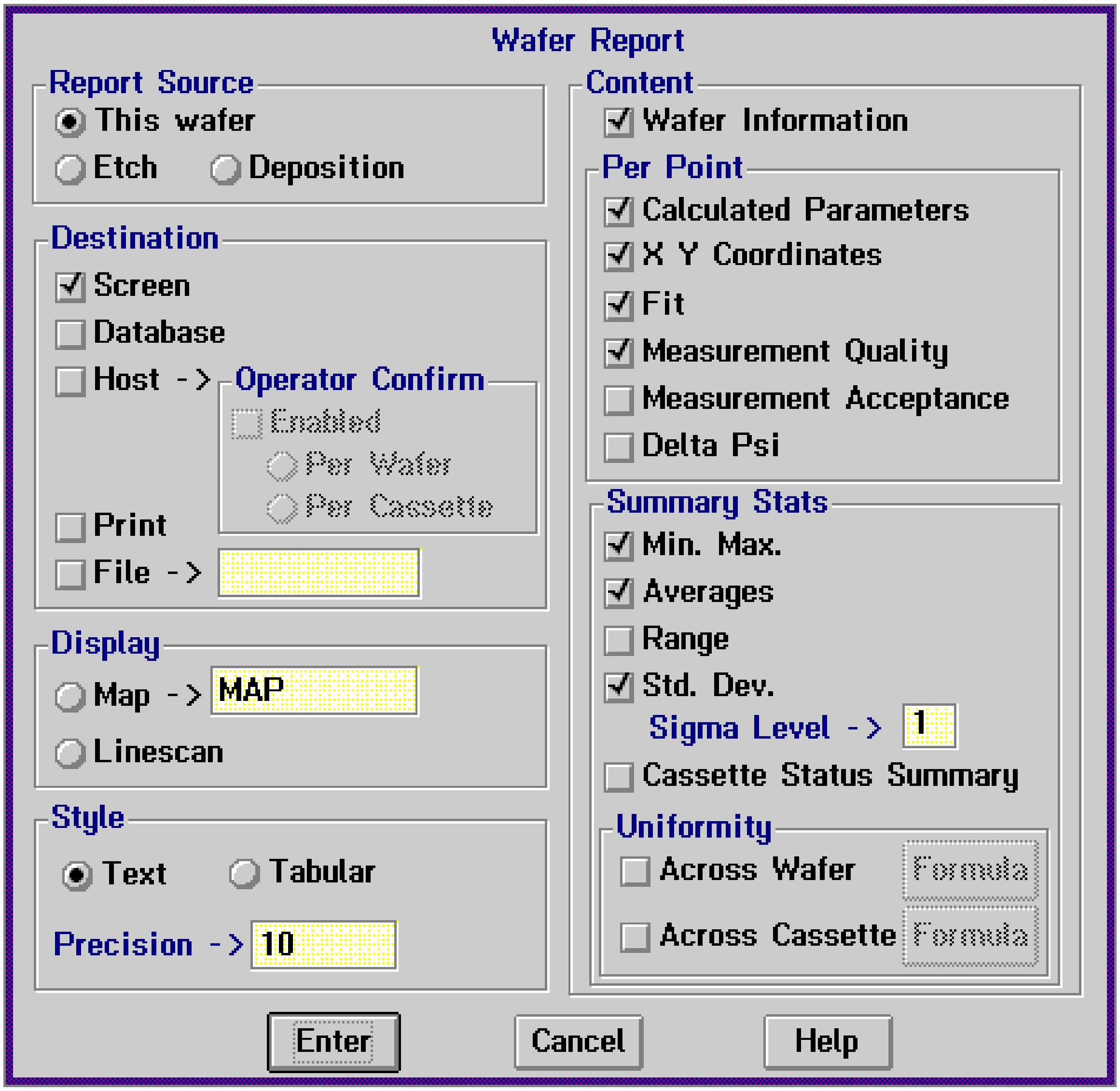

Figure 4-37. Wafer Report Window

This window is used to specify how the measurement data will be presented and where it will be stored.

The data may be saved to the database, a specified filename, or a map with a specified filename. The contents of the report, such as wafer information, per point information, and cassette summary statistics, may also be specified.

The Wafer Report window is made up of the following sections that allow you to customize the report format and destination.

- **Report Source** — This option is for future software use.
- **Destination** — Determines the measurement data output destination. Select from the following (more than one option may be selected):
  - **Screen** — Displays measurement data on the screen only.
  - **Database** — Saves measurement data to the database in a log file.

NOTE

The "Database" option must be selected in order to generate wafer measurement reports that can be used by the Focus Browser. Refer to **"Wafer Reports" on page 5–20 of Chapter 5, "Wafer Mapping and Data Reporting"** **for information.**

  - **Host** — Transfers measurement data to the host system (if SECS-II option is available). An option is also available to require Operator confirmation of the data transfer on a per wafer or per cassette basis.
  - **Print** — Automatically directs measurement data to the printer connected to the FE System.
  - **File** — This option is for future software use.
- **Display** — Generates wafer map or linescan files.
  - **Map** — Saves the wafer measurement data in the specified map file. Map files may then be displayed by the Focus Mapping software or the Focus Operator program.

NOTE

The "Map" option must be selected in order to generate wafer measurement maps that can be used by the Focus Mapping program. Refer to **"Wafer Mapping" on page 5–2 of Chapter 5, "Wafer Mapping and Data Reporting"** **for information.**

  - **Linescan** — This option is for future software use.

- **Style** — This option is for future software use.
- **Content** — This option is for future software use.
- **Per Point** — Includes the selected information for each measurement point in the report.
    - **Calculated Parameters** — The parameter(s) for each measurement point are displayed.
    - **X Y Coordinates** — The measurement position for each point on the wafer is displayed with 0,0 representing the center of the wafer.
    - **Fit** — The fit error of each measurement point is displayed.
    - **Measurement Quality** — This option is for future software use.
    - **Measurement Acceptance** — This option is for future software use.
    - **Delta Psi** — The delta/psi data for each measurement point is displayed.

NOTE

Selecting "Delta Psi" will dramatically increase the data to be stored and should be used only if delta/psi information is absolutely necessary.

- **Summary Stats** — Determines which statistics are to be displayed in the report.
    - **Min. Max.** — Displays minimum and maximum values across the wafer.
    - **Averages** — Displays the average of the cassette.
    - **Range** — Displays the maximum to minimum values across the cassette.
    - **Std Dev** — Displays standard deviation value across the cassette.
    - **Cassette Status Summary** — Displays the same values except across an entire run of wafers in a cassette.
- **Uniformity** — Allows you to input a uniformity formula either across a wafer or a cassette.

Transfer Control

Wafer transfer control allows the Process Engineer to specify the source and destination cassette(s) and or slot(s) for the wafer to be measured, as well as how the wafers will be transferred and the destination for rejected wafers. These options may also be deferred at this time allowing the Operator to make these decisions when the process is run using the Focus Operator Queues Loading program (see Chapter 2, “Operator Interface” for information).

Once you have created and saved a wafer recipe, specify transfer control by performing the following:

1. In the Recipe Creator main menu, click on **Transfer**.

   The Transfer Selection window is displayed as shown in Figure 4-38. The naming conventions of the transfer specifications shown indicate the source and destination cassettes, wafer slots, transfer style and where rejected wafers will be placed (each of these parameters are discussed in detail later in this procedure).

   The following examples illustrate the naming convention:

   - **xxX1-1S1,12,25**

     Indicates this transfer will take wafers from cassette 1 and return them to cassette 1 after measurement. Wafers in slots 1, 12, and 25 will be measured.

   - **xxX1-2S1-25**

     Indicates this transfer will take wafers from cassette 1 and return them to cassette 2 after measurement. Wafers in slots 1 through 25 will be measured.

   - **xxX1-1S1-5Reject2**

     Indicates this transfer will take wafers from cassette 1 and return them to cassette 1 after measurement. Wafers in slots 1 through 5 will be measured. Wafers that are rejected will be placed in cassette 2.

   - **xxX1-3S1-25_B2T**

     Indicates this transfer will take wafers from cassette 1 and return them to cassette 3 after measurement. Wafers in slots 1 through 25 will be measured. As the measurements are completed, the wafers are transferred between the two cassettes in a “bottom to top” manner. That is the wafer taken from cassette 1 slot 1 will be returned to cassette 3 slot 25 and so on.

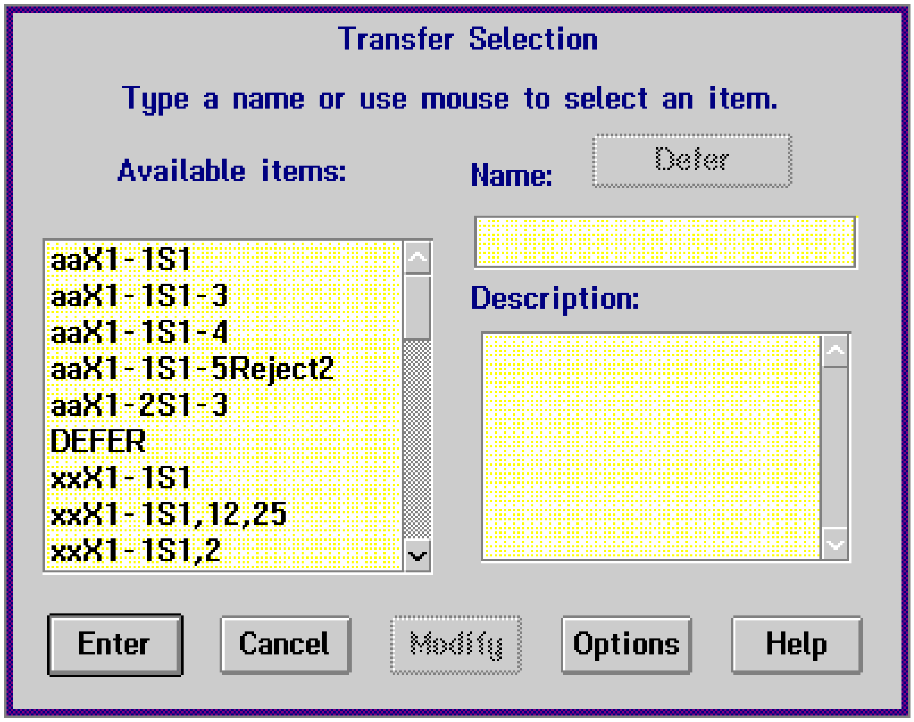

Figure 4-38. Transfer Selection Window

2. Perform **one** of the following:

   - **Select an existing transfer control item:** click once on a transfer name in the Available Items window then click **Enter**, or double click on the desired transfer name. Select **DEFER** to defer the transfer control to the Operator at run time.

   - **Modify an existing transfer control item:** click once on a transfer name in the Available Items window then click on **Options**. Enter the new transfer control name in the **Destination** field, then click on **Save As**. Click on **Enter** when you have returned to the Transfer Selection window.

CAUTION

Modifying an existing transfer control will affect all recipes that use that transfer control.

   - **Create a new transfer control item:** type the desired name in the **Name** field, and a description (if desired) in the **Description** field then click on **Enter**.

   The Transfer Specification window is displayed as shown in Figure 4-39.

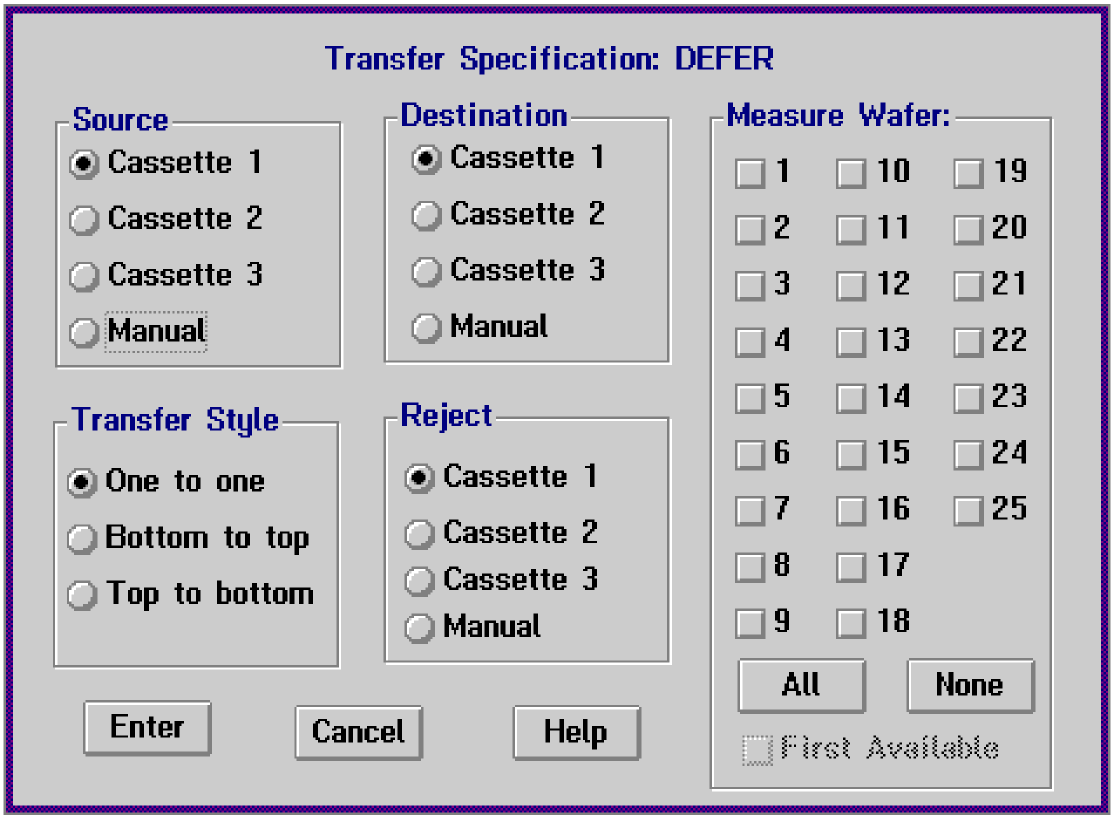

Figure 4-39. Transfer Specification Window

3. Perform **one** of the following:

   - **To accept the default values:** select the desired wafer slots then click on **Enter** in the Transfer Specification window.

   - **To modify the transfer specification:** make the selections using the information below then click on **Enter** in the Transfer Specification window:

     Source/Destination — Specifies the source cassette from which the wafer will be selected and the destination cassette to which the wafer will be returned after measurement. Selecting **Manual** defers these selections to the Operator.

     Measure Wafer — Specifies the cassette slot number(s) for the wafers to be measured. Leaving all slots blank defers this selection to the Operator. Select **All** to select all slots, **None** to deselect all slots.

Transfer Style — Specifies how the wafers will be transferred from one cassette to another. **One to one** takes a wafer from Slot 1 and after measurements are completed places the wafer in the destination cassette in Slot 1, **Bottom to top** takes a wafer from Slot 1 and returns it to Slot 25, and **Top to bottom** takes a wafer from Slot 25 and returns it to Slot 1.

CAUTION

Specifying "Bottom to top" or "Top to bottom" transfer style could result in damage to a wafer if there is already a wafer in the slot in which the FE system is attempting to transfer. To reduce the risk of damage to the wafer, it is recommended that only the "One to one" transfer style be used.

Reject — Specifies the destination cassette for wafers that are rejected due to measurements out of tolerance. Selecting **Manual** defers this selection to the Operator.

CAUTION

Ensure that the destination cassette is empty, otherwise damage could occur to the wafer.

The transfer control information is saved and you are returned to the Recipe Creator Main window. Before the wafer recipe can be run by the Operator, the process specification must be created.

4. Proceed to "Creating and Modifying a Process Specification" on page 4–68.

Creating and Modifying a Process Specification

The process specification consists of those steps (the wafer recipe(s), transfer, and control information) that have been previously defined by the Process Engineer in this chapter. The process specification is then run by the Operator and the actual wafer measurements are performed (see Chapter 2, "Operator Interface" for information).

Once you have created and saved a wafer recipe and specified the transfer control information, create a process specification by performing the following:

1. In the Recipe Creator main menu, click on **Process**.

   The Process Specification Selection window is displayed as shown in Figure 4-40. Using the Process Specification Selection window you may enter the name of the process. Typically this name will reflect the end product for this wafer, such as **80586_CHIP**.

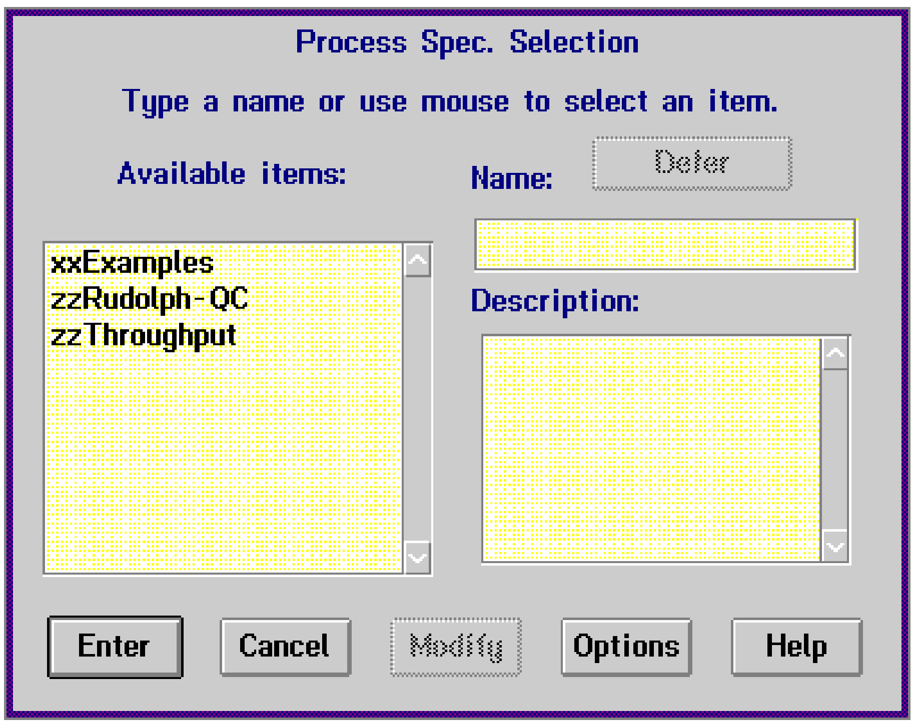

Figure 4-40. Process Specification Selection Window

2. Perform **one** of the following:

   - **Select an existing process specification:** click once on a name in the Available Items window then click **Enter**, or double click on the desired name.

   - **Modify an existing process specification:** click once on a name in the Available Items window then click on **Options**. Enter the new name in the **Destination** field, then click on **Save As**. Click on **Enter** when you have returned to the Process Specification Selection window.

   - **Create a new process specification:** type the desired name in the **Name** field, and a description (if desired) in the **Description** field, then click on **Enter**.

   The Process Specification window is displayed as shown in Figure 4-41. Using the Process Specification window you may create the individual steps that make up the final process specification. If process steps have already been created within the selected process specification, they will be displayed in the Process Steps area of the window. If no process steps have been defined, this area will be blank.

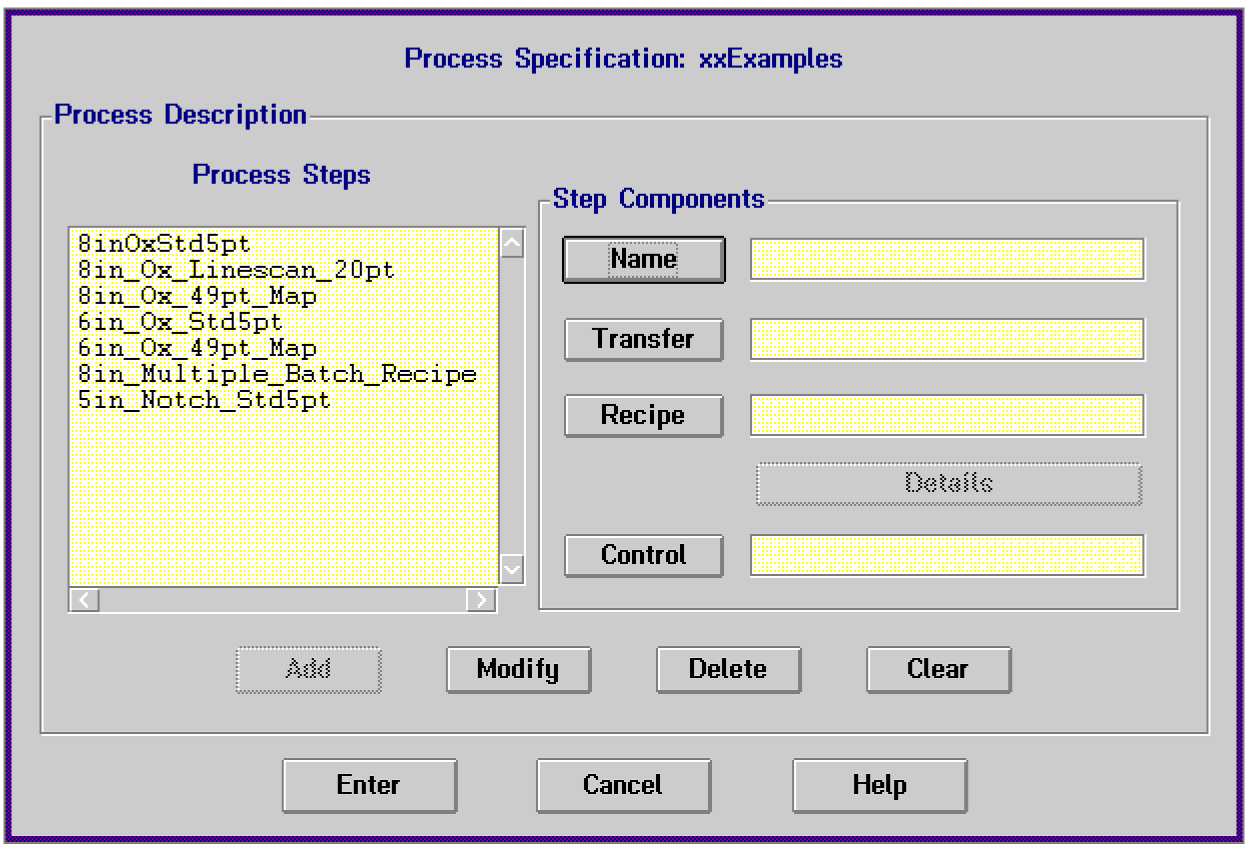

Figure 4-41. Process Specification Window

3. Perform **one** of the following:
   - **To modify an existing process step:** proceed to “Modifying a Process Step” on page 4–73.
   - **To create a new process step:** continue with the next step in this procedure.
4. Click the **Name** button on the Process Specification window. Enter the desired process step name and click on **Enter**. The process step name should be descriptive of the function of that step. For example, **8inOxStd5pt** would indicate that this step will perform a standard five point measurement on an eight inch oxide wafer.

   The name appears on the Name field of the Step Components.
5. Click the **Transfer** button on the Process Specification window.

   The Transfer Selection window appears as shown in Figure 4-38 on page 4–65.
6. Select **DEFER** to defer the transfer options to the Operator at run time, or you may select a transfer specification from the list or create or modify a transfer specification using the procedure given in “Transfer Control” on page 4–64. Click on **Enter** when you have selected the desired name.

   The selected name appears on the Transfer field of the Step Components in Figure 4-40.
7. Click the **Recipe** button on the Process Specification window.

   The Wafer Recipe Selection window appears as shown in Figure 4-9 on page 4–17.
8. Select a wafer recipe from the list or create or modify a wafer recipe using the procedure in “Creating a Wafer Recipe” on page 4–16. Click on **Enter** when you have selected the desired name.

   The selected name appears on the Recipe field of the Step Components in Figure 4-40.
9. Click the **Control** button on the Process Specification window.

   The Recipe Control Selection window appears as shown in Figure 4-42. Using the Recipe Control window you may choose to defer certain actions to the Operator at run time.

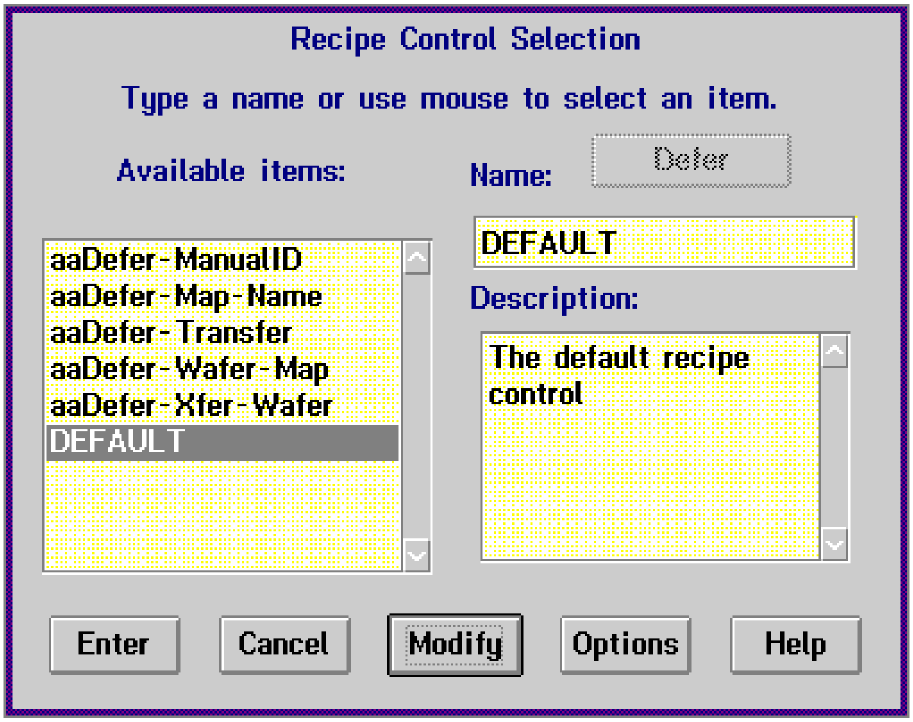

Figure 4-42. Recipe Control Selection Window

10. Perform **one** of the following:

- **Select a recipe control item:** click on the item name then click on **Enter**, or double click on the item name. Selecting **DEFAULT** will defer no options to the Operator.

- **Modify a recipe control item:** click on the item name and then click on **Modify**.

  The Recipe Control window is displayed as shown in Figure 4-43. Make the desired selections on the Recipe Control window.

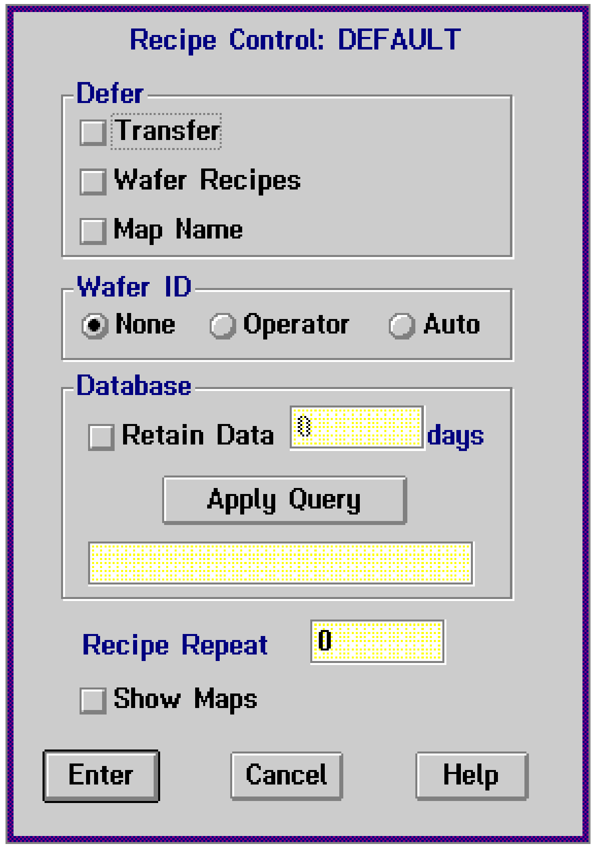

Figure 4-43. Recipe Control Window

The selection for Wafer ID in the Recipe Control window interacts with the **Generate IDs On/Off** setting that was configured by the Focus Setup software. Refer to Table 4-1 for information on this interaction.

Table 4-1: Wafer ID Generation

Generate ID[1]	Wafer ID[2]	Result
Off	None	No Wafer ID is generated.
On	Auto/None	Wafer IDs are automatically generated.
Off	Operator	The Operator manually enters Wafer IDs.
On	Operator	Wafer IDs are automatically generated and the Operator is given the option to accept the ID or enter a new ID.

1. As specified by the Focus Setup program.
2. As specified in the Recipe Control window.

Once all desired entries are made in the Recipe Control window, click on the **Enter** button then click on **Enter** again when you are returned to the Recipe Control Selection window.

The selected name appears on the Control field of the Step Components.

11. Click the **Add** button on the Process Specification window.

    The process step just created is displayed at the bottom of the list in the Process Steps area of the Process Specification window.

12. Click the **Enter** button on the Process Specification window.

    The process specification is saved and you are returned to the Recipe Creator Main window.

13. Repeat Step 1 through Step 12 of this procedure to add additional steps to the process specification.

When all process steps have been added to the process specification, the recipe creation process has been completed. The Operator may now run the process specification using the Focus Operator Queued Loading program to perform wafer measurements. Refer to Chapter 2, "Operator Interface" for information.

Modifying a Process Step

To modify a process step that has already been created and is part of a process specification, perform the following:

NOTE

This procedure assumes that the Recipe Creator Main window is displayed. If you were sent to this section by Step 3 in "Creating and Modifying a Process Specification" on page 4–68, you may begin this procedure at Step 3.

1. In the Recipe Creator main menu, click on **Process**.

   The Process Specification Selection window is displayed as shown in Figure 4-40.

2. Select the desired process specification by either clicking once on a name in the Available Items window then clicking **Enter**, or by double clicking on the desired name.

   The Process Specification window is displayed as shown in Figure 4-41 on page 4–69.

3. Click once on the process step you wish to modify.

   The components that make up the process step are displayed.

4. Click on the appropriate button in the Step Components area to make changes to the process step as desired.

   The new information is displayed.

NOTE

Selecting a new Transfer option will automatically clear the Recipe selection. You must reselect a wafer recipe to continue.

5. When all changes to the process step have been completed, click on the **Add** button in the Process Specification window.

   A window is displayed to inform you that the selected process step has been successfully modified. Click on **OK**.

6. Perform **one** of the following:

   - **To modify another process step:** select another process step to be modified and repeat Step 3 through Step 5 of this procedure.

   - **If all modifications are complete:** click on the **Enter** button.

     You are returned to the Recipe Creator Main window.

Exiting Recipe Creator

To exit the Focus Recipe Creator program, perform the following procedure:

1. On the Recipe Creator screen, perform **one** of the following:

   - Double click the left trackball button on the icon located in the upper left corner of the screen (beside the Focus Recipe Creator program name).
   - Single click the left trackball button on the icon located in the upper left corner of the screen (beside the Focus Recipe Creator program name). Select **Close** from the menu that is displayed.

   The Focus Recipe Creator program will exit and you will be returned to the OS/2 desktop.

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Wafer Mapping and Data Reporting

Chapter 5

Introduction

The purpose of this chapter is to provide information on how to utilize wafer mapping and data reporting functions to analyze wafer measurement information that is gathered when the Operator runs the process specifications created by the Engineer. The information in this section pertains to the FOCUS Ellipsometer (FE) III, IV, and VII systems, and includes the following topics:

- How to use the Focus Mapping software to access the following wafer map types:
  - Contour maps
  - Topographical maps
  - Difference maps
  - Etch Rate maps
- How to use the Focus Browser software to access tabular data reports.
- How to import and export between two or more FE Systems.

The tasks described in this chapter are performed with the use of the Focus Mapping and Focus Browser software (with the exception of importing and exporting data, which is performed using the Focus Recipe Creator software). Wafer mapping and report data is also available through the Focus Operator Queued Loading program. For information on how to access this information using the Focus Operator Queued Loading program, refer to Chapter 2, "Operator Interface".

It should be noted that certain steps must be performed using the Focus Recipe Creator and/or Focus Operator Queued Loading programs in order to create the wafer mapping and report data. Refer to the appropriate chapter in this guide for more information.

Wafer Mapping

The Focus Mapping program makes it possible to display wafer measurement data graphically. Any or all of the three optical parameters (**T**, **N**, and **K**) can be presented on the monitor in either topographical (3D) or contour (2D) form. In addition, etch maps (showing etch rate or difference information) may also be generated.

NOTE

Wafer mapping data may also be displayed using the Focus Operator Queued Loading program. Refer to **"Accessing Wafer Mapping" on page 2–38 of Chapter 2, "Operator Interface"** **for information.**

Using the mapping software, the map viewing perspective can be changed to obtain the best point of view of the film parameter variations. Up to one hundred maps can be displayed, with each map using up to fourteen colored strata to show parameter variations.

The following steps are taken to create a wafer map:

1. The **Map** box must be checked in the report section of the wafer recipe. Refer to "Creating a Wafer Mapping Recipe" on page 4–45 of Chapter 4, "Creating Recipes" for information.

2. The process specification and step containing the wafer mapping recipe are run by the Operator using the Focus Operator Queued Loading program. This will generate the map file. Refer to "Creating a Wafer Map" on page 2–36 of Chapter 2, "Operator Interface" for information.

Once the wafer map file is generated, the Focus Mapping program may be used to create a wafer map from the wafer map file and to view, scale, manipulate, and print the map.

Starting Focus Mapping

To start the Focus Mapping program, position the trackball pointer over the Focus Mapping icon, located in the Focus Ellipsometer folder, and double click the left trackball button.

The Focus Mapping main window is displayed as shown in Figure 5-1.

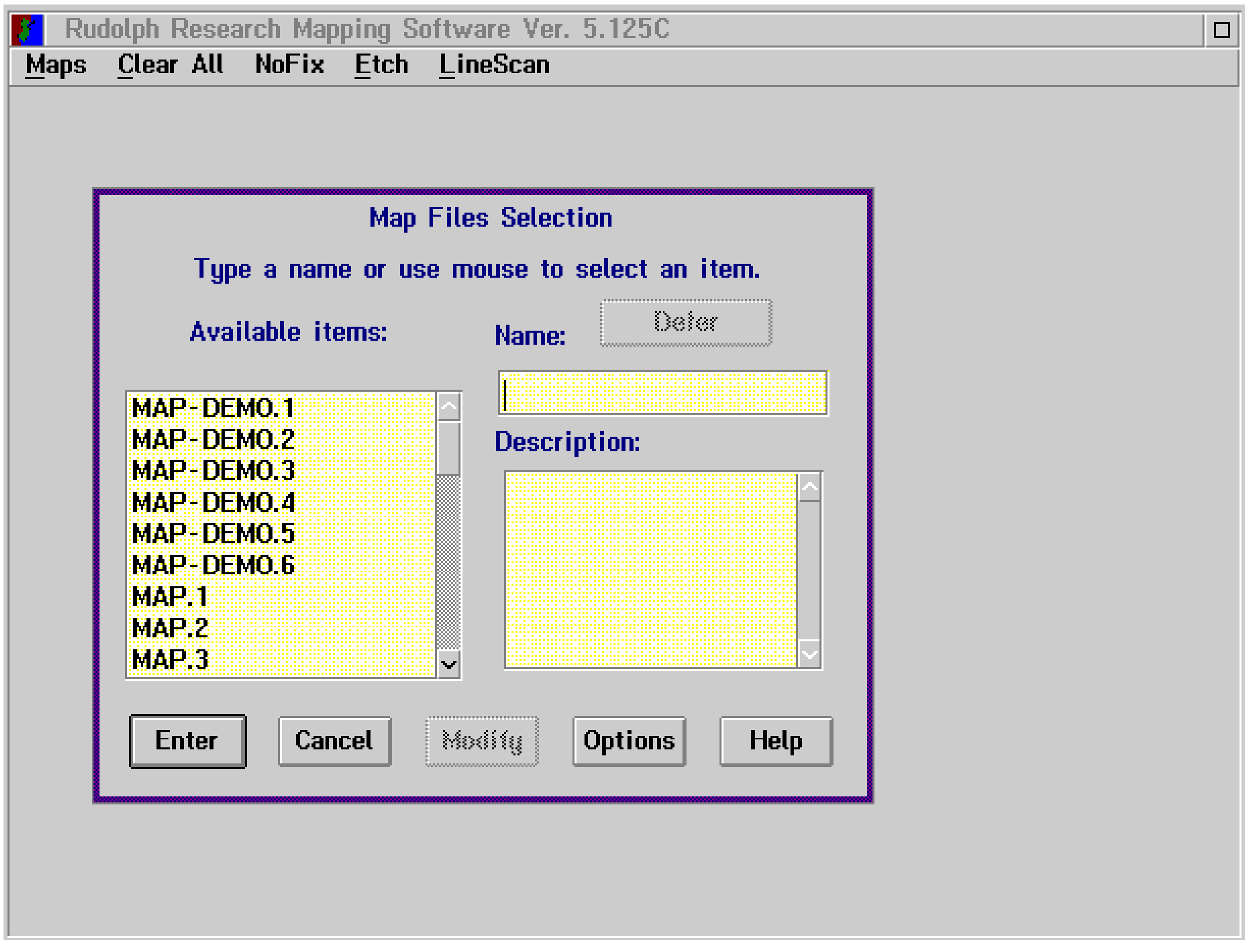

Figure 5-1. Focus Mapping Main Window

Focus Mapping Main Menu

The following menu items are available in the Focus Mapping Main window:

- **Maps** — Used to select the wafer map to be viewed. Clicking on the Maps menu item causes the Map Files Selection window to be displayed.
- **Clear All** — Used to close all open maps and clear the screen.

- **NoFix/Fix** — Toggle item, switches between NoFix and Fix mode. In **NoFix** mode (default) the minimum and maximum values in the wafer map file are automatically scaled on the vertical axis. In **Fix** mode, the minimum and maximum map values can be selected and fixed so that all subsequent maps will be displayed according to these values. When map scaling is fixed, the differences between maps can be directly compared.
- **Etch** — Used to create Difference and Etch Rate wafer maps.
  - **Difference Map** — Used to compare two wafer map files to generate a wafer difference map.
  - **Etch Rate Map** — Used to compare two wafer map files to generate a wafer etch rate map.
- **Linescan** — This item is reserved for future use.

Map Window

This window displays the generated wafer map file. Wafer maps may be viewed in Contour (2D) or Topographic (3D) mode, and each may be displayed in either color, greyscale, or black and white.

Figure 5-2 shows an example of a greyscale contour wafer map.

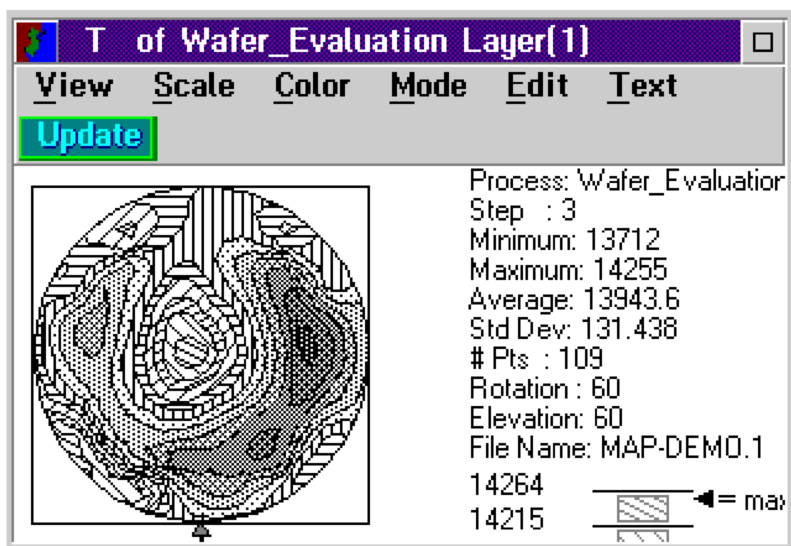

Figure 5-2. Example Wafer Map

Map Window Menu

The Wafer Map window also consists of the following menu selections:

- **View** — Used to alter the viewpoint from which the map is seen. Displays a View Control Window that allows you to modify the angle of elevation and rotation of the view. These modifications only apply to Topographic wafer maps.
  - **Elevation:** Enter the number of degrees (0-90°) that the top of the map should be turned toward the viewer.
  - **Rotation:** Enter the number of degrees (0-360°) that the front of the map should be rotated. Increasing the value rotates the view counterclockwise away from the viewer.
- **Scale** — Used to modify the vertical scale of the Topographic wafer map. Choosing smaller sigmas increases the vertical sensitivity of the map and the number of colors displayed. The average value of the data will always remain centered on the vertical scale. This mode automatically optimizes the display of single wafer maps.
- **Color** — Used to display the map in **Color**, **Grey**, or **Black & White** mode. Also allows you to determine whether the color divisions will be set automatically or in a user specified range.
- **Mode** — Selects the way in which the map will be displayed.
  - **Topograph** — Displays the map in simulated 3D with a rotation angle of 60° counter-clockwise and an elevation angle of 60°.
  - **Contour** — Displays the map in 2D with a rotation angle of 0° and an elevation angle of 90°.
  - **Spec Line** — Displays a line on the map denoting the average of the parameter being displayed. If **Draw Marker** is also selected, the markers are displayed as a "**+**" if points are higher than the spec line, and "**–**" if points are lower than the spec line.
  - **Draw Box** — Displays a wireframe box around the wafer map.
  - **Draw Contour** — In color or greyscale mode, lines are displayed between the divisions.
  - **Draw Grid** — Displays a black wire grid over the wafer map.
  - **Draw Marker** — Displays markers on each measurement point.
- **Edit** — Allows you to edit the data that makes up the wafer map.
- **Text** — Displays the wafer map data in text format.
- **Update** — When selected, the wafer map is automatically updated each time a display mode is selected.

Viewing Wafer Maps

Once a wafer mapping recipe has been created, incorporated into a process step, then run by the Operator using the procedures provided in Chapter 4, "Creating Recipes" and Chapter 2, "Operator Interface" respectively, the wafer map may be viewed.

To view the wafer maps, perform the following:

1. Perform **one** of the following:
   - **If the Map Files Selection window is displayed**, continue with the next step.
   - **If the Map Files Selection window is not displayed**, in the Focus Mapping main menu, click on **Maps**.

     The Map Files Selection window is displayed as shown in Figure 5-3.

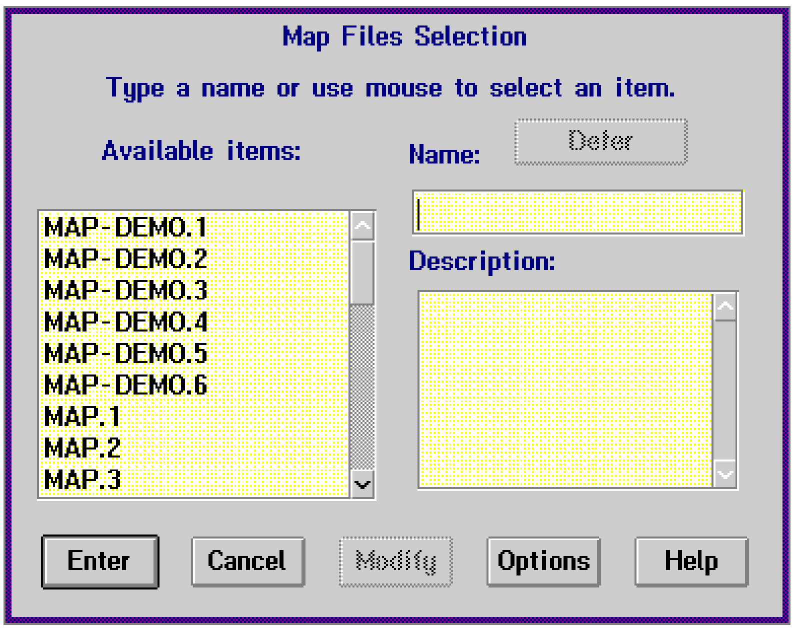

Figure 5-3. Map Files Selection Window

2. Select the wafer map you wish to view by clicking once on the desired map file name in the list of available items and then clicking on **Enter**, or double click on desired map file name.

   The selected map is displayed on the screen. The type of map that is displayed (contour or topographic) color mode (black and white, grey, or color) is determined by your FE System configuration.

Topographical Mapping

Topographical wafer mapping is a 3D representation of the wafer thickness as measured by the FE System.

Topographical wafer maps may be displayed in black and white, color, or greyscale, and the orientation of the wafer view can also be easily changed. You may also switch back and forth between topographical and contour maps for the wafer as desired.

Figure 5-4 shows an example of a black and white topographical wafer map. Note that the wafer statistics are also displayed with the map.

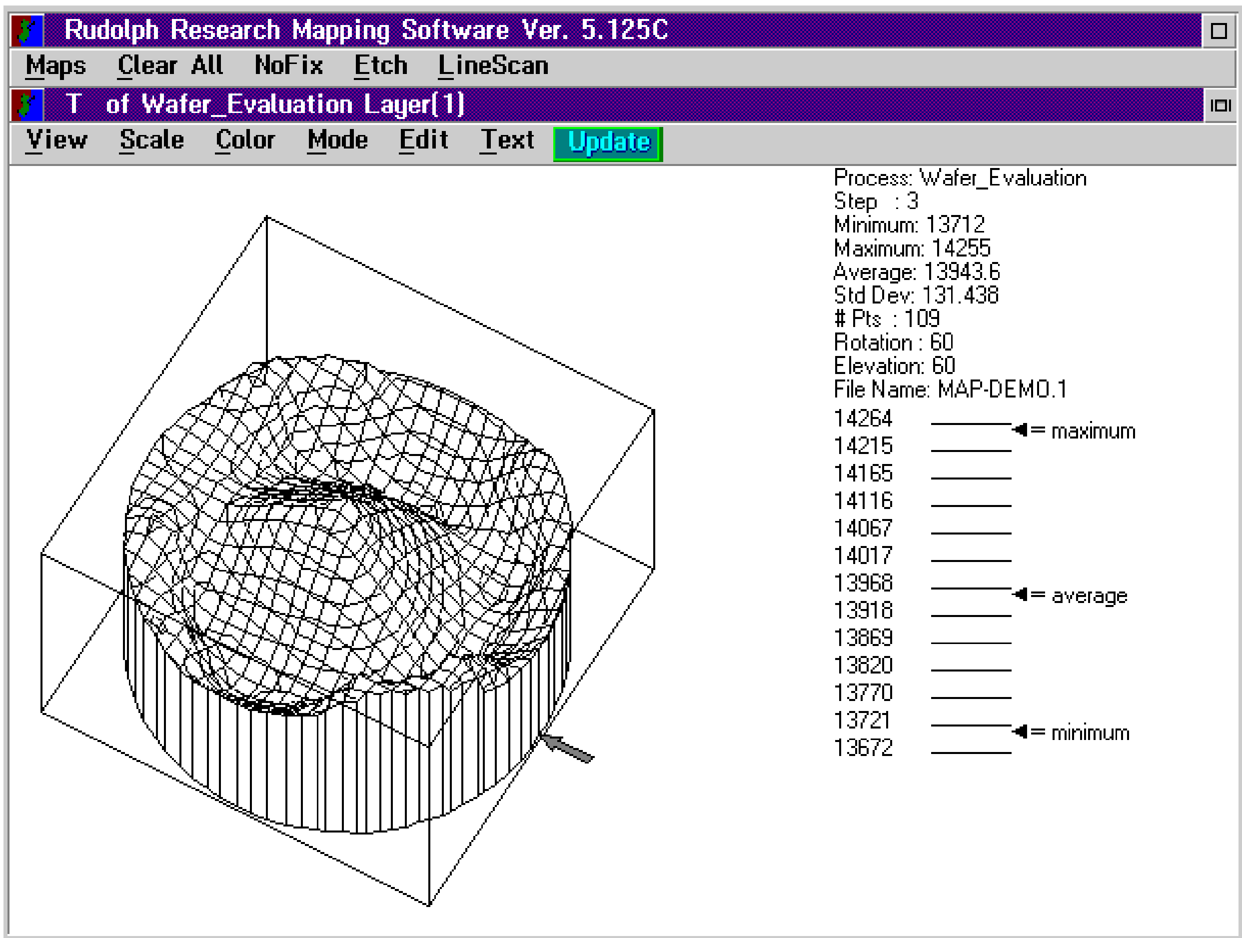

Figure 5-4. Topographical Wafer Map (Black and White)

NOTE

The arrow pointing to the wafer map indicates the location of the wafer flat or notch.

Contour Mapping

Contour wafer mapping is a 2D representation of the wafer thickness as measured by the FE System.

Contour wafer maps may be displayed in black and white, color, or grey-scale, and the orientation of the wafer view can also be easily changed. You may also switch back and forth between contour and topographical maps for the wafer as desired.

Figure 5-5 shows an example of a black and white contour wafer map. Note that the wafer statistics are also displayed with the map.

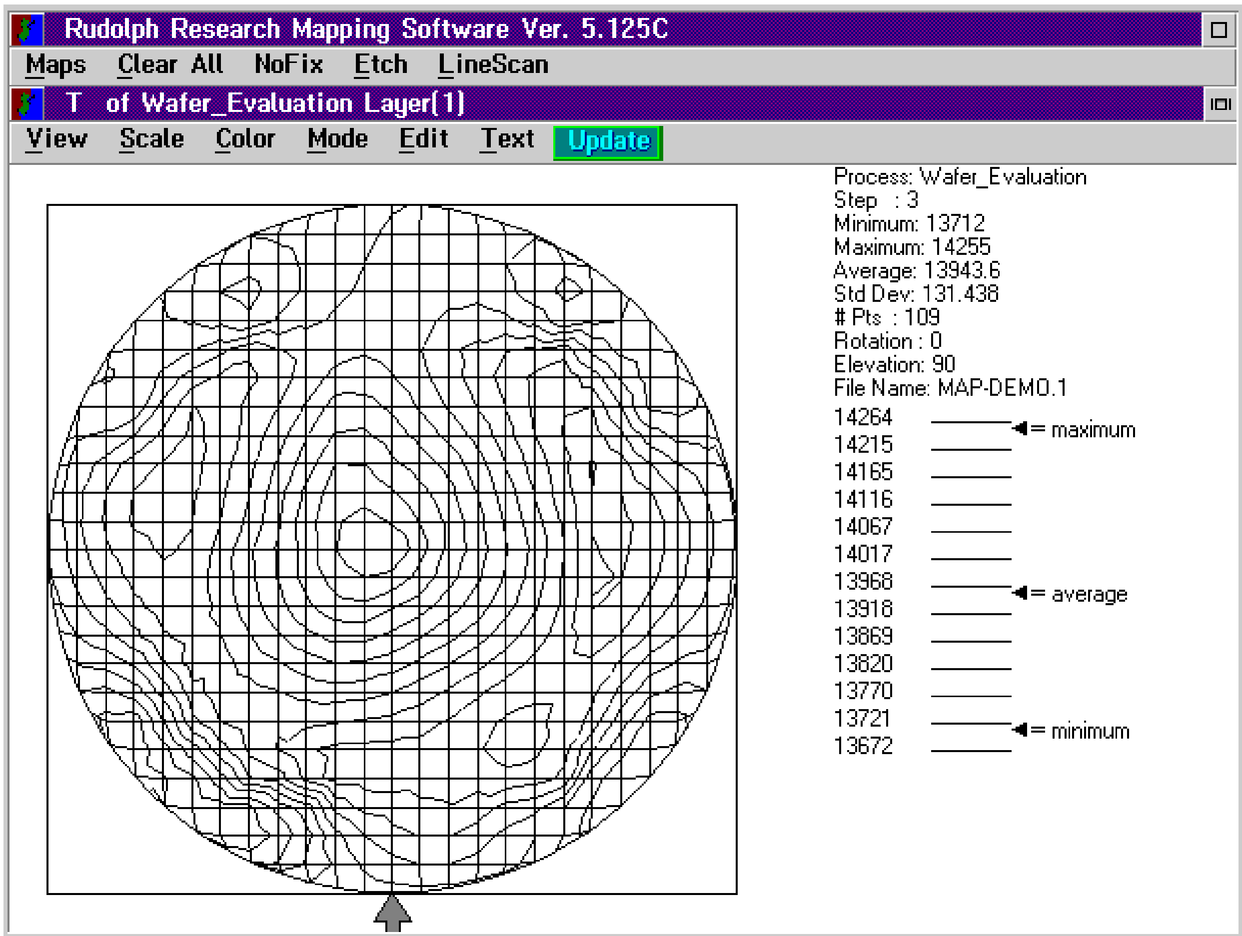

Figure 5-5. Contour Wafer Map (Black and White)

NOTE

The arrow pointing to the wafer map indicates the location of the wafer flat or notch.

Difference and Etch Rate Maps

The FE System's mapping software has the capability to create the following types of etch maps:

- **Difference Map** — Compares a wafer before and after undergoing an etch or CMP (Chemical Mechanical Polishing) process that removes material from the wafer. Difference maps show how much material was removed between measurements.
- **Etch Rate Map** — Created according to an equation that is developed for etch rate calculations. Etch rate maps give an indication of the uniformity of the etch process.

Creating a Difference Map

To create a difference map, you should first have created a map of the wafer both **before** and **after** the etch process. Once both maps have been created, enter the mapping software using the procedure in "Starting Focus Mapping" on page 5–3.

1. With the wafer mapping software running, perform **one** of the following:

   - **If the Map File Selection window is displayed**, click on the **Cancel** button in the Map File Selection window then continue with Step 2.
   - **If the Map File Selection window is not displayed**, continue with Step 2.

2. In the Focus Mapping main menu, click on **Etch**.

   The Etch menu is displayed.

3. Click on **Difference Map** in the Etch menu.

   A window is displayed instructing you to select two wafer maps. The formula used is **DISPLAYED MAP = WAFER1 – WAFER2**.

4. Click on **OK**.

   A window is displayed instructing you to select the first wafer map.

5. Click on **OK**.

   The Map File Selection window is displayed as shown in Figure 5-3 on page 5–6.

6. Click once on the desired map file name in the Map File Selection window then click on **Enter**, or double click on the desired map file name.

   A window is displayed instructing you to select the wafer map that will be subtracted from the first map.

7. Click on **OK**.

   The Map File Selection window is displayed.

8. Click once on the desired map file name in the Map File Selection window and then click on **Enter**, or double click on desired map file name.

   A window is displayed asking if you wish to see the map.

9. Perform **one** of the following:

   - Click on **No** and the resultant wafer difference information is displayed in text format. After viewing the information you may save the information to a specified destination path and filename, and/or print the information.

     Click on **Exit** when you have finished viewing the information.

   - Click on **Yes** and the wafer difference map is displayed on the screen along with a window asking if you wish to save the difference map.

     - Click on **No** and the difference map data is not saved. The map remains on the screen.

CAUTION

If you do not save the difference map, when you clear the map or exit the Mapping software, the newly created map is lost.

     - Click on **Yes** and a window is displayed in which you may enter the desired difference map name. Type the desired name for the difference map and click on the **Enter** button.

Creating an Etch Rate Map

To create an etch rate map, you should first have created a map of the wafer both **before** and **after** the etch process. Once both maps have been created, enter the mapping software using the procedure in "Starting Focus Mapping" on page 5–3.

1. With the wafer mapping software running, perform **one** of the following:

   - **If the Map File Selection window is displayed**, click on the **Cancel** button in the Map File Selection window then continue with Step 2.

   - **If the Map File Selection window is not displayed**, continue with Step 2.

2. In the Focus Mapping main menu, click on **Etch**.

   The Etch menu is displayed.

3. Click on **Etch Rate Map** in the Etch menu.

   A window is displayed as shown in Figure 5-6 that shows you the current etch rate calculation formula. This window also allows you to define a new etch rate calculation formula.

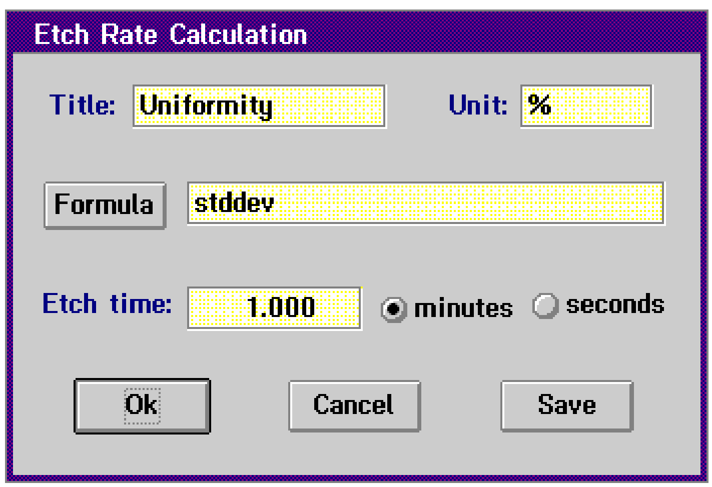

Figure 5-6. Etch Rate Calculation Window

4. Perform **one** of the following:

    - Click on **Ok** to accept the current etch rate calculation formula.

      A window is displayed instructing you to select two etch maps. Continue with Step 5.

    - Make the desired changes to the etch rate calculation information. Click on the **Formula** button to change the actual etch rate formula. Click on the **Ok** button in the Etch Rate Formula window when you have finished modifying the etch rate formula, then click on **Ok** in the Etch Rate Calculation window.

      A window is displayed instructing you to select two etch maps. Continue with Step 5.

5. Click on **OK**.

   A window is displayed instructing you to select the map before etch.

6. Click on **OK**.

   The Map File Selection window is displayed as shown in Figure 5-3 on page 5–6.

7. Click once on the desired map file name in the Map File Selection window and then click on **Enter**, or double click on desired map file name.

   A window is displayed instructing you to select the map after etch.

8. Click on **OK**.

   The Map File Selection window is displayed.

9. Click once on the desired map file name in the Map File Selection window and then click on **Enter**, or double click on desired map file name.

   A window is displayed asking if you wish to see the map.

10. Perform **one** of the following:

- Click on **No** and the resultant etch rate information is displayed in text format. After viewing, you may save the information to a specified destination path and filename, print the information, and/or upload the information to a host.

  Click on **Exit** when you have finished viewing the information.

- Click on **Yes** and the wafer etch rate map is displayed on the screen along with a window asking if you wish to save the map.

  - Click on **No** and the etch rate map data is not saved. The map remains on the screen.

CAUTION

If you do not save the etch rate map, when you clear the map or exit the Mapping software, the data is lost.

  - Click on **Yes** and a window is displayed in which you may enter the desired difference map name. Type the desired name for the etch rate map and click on the **Enter** button.

Updating Wafer Map Views

There are two ways in which to update the wafer map that is currently displayed on the screen. These methods are **Automatic** and **Manual** updating.

Automatic Updating

In Automatic update mode, the **Update** button on the menu bar is high-lighted. Any change made to the display, such as changing the color mode, map orientation, or switching between contour and topographical displays will cause the wafer map to be updated immediately. This method can be time consuming if several changes are to be made to the wafer map view. Automatic update is the system default.

Manual Updating

In Manual update mode, you may make several changes to the wafer map view and the changes will not take effect until the Operator manually updates the view. To enter Manual update mode, perform the following:

1. Click on the **Update** button in the menu bar so that the button is no longer highlighted.

2. Make other menu selections (such as changing the color mode, map orientation, switching between contour and topographical displays, or modifying other display modes) as desired using the procedures given in this chapter. Note that the wafer map view is not updated.

3. Click on the **Update** button in the menu bar. The button is now highlighted and the wafer map view is updated with the new display selections.

Switching Color Modes

To change the wafer map view to/from black and white, color, or grey-scale, perform the following:

1. Click on **Color** in the menu bar.

   The Color menu is displayed (with a checkmark beside the current color mode).

2. Click on the desired color mode (**Color**, **Grey**, or **Black + White**).

   The wafer map is displayed in the selected color mode.

Changing Wafer Orientation View

To change the orientation of the wafer map on the screen, perform the following:

1. Click on **View** in the menu bar.

   The View Control window is displayed as shown in the figure below.

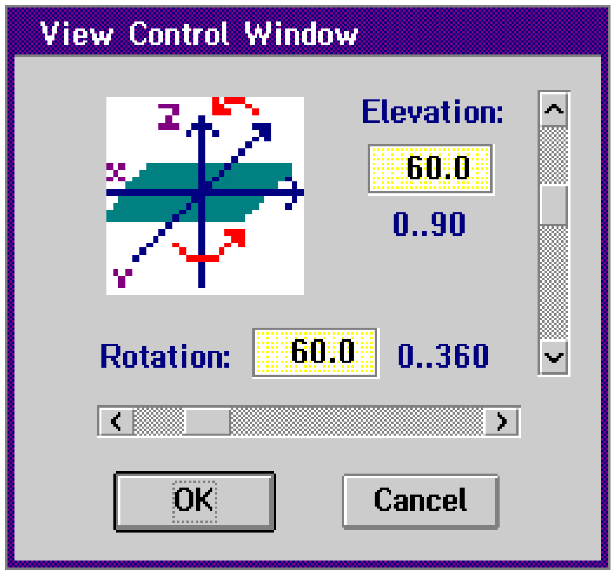

Figure 5-7. View Control Window

2. Click in the **Rotation:** and/or **Elevation:** fields and enter the desired values, or use the slider bars to display the desired rotation and elevation of the view.

NOTE

Elevation and Rotation values only apply to topographic wafer maps.

3. When the desired values are displayed, click on the **OK** button.

   The wafer map view is updated using the new rotation and/or elevation values.

Switching Between Topographic and Contour Mapping

To change the wafer map view between topographical and contour mapping, perform the following:

1. Click on **Mode** in the menu bar.

   The Mode menu is displayed (with a checkmark beside the current display mode).

2. Click on either **Topograph** or **Contour** in the Mode menu.

   A map of the selected type is displayed using the current wafer measurement information. See Figure 5-4 on page 5–7 and Figure 5-5 on page 5–8 for examples of topographical and contour wafer maps.

Clearing the Wafer Map View

When you have completed viewing the wafer maps, you may clear the screen by clicking on **Clear All** in the menu bar.

All currently displayed maps are closed. You may now exit the Mapping software (see “Exiting Wafer Mapping” on page 5–19), or select another wafer map to view (see “Opening a New or Additional Wafer Maps” on page 5–16).

Opening a New or Additional Wafer Maps

You may open a new wafer map to view after clearing the screen, or open an additional wafer map while the current map is still displayed by performing the following:

1. Click on **Maps** in the menu bar.

   The Map File Selection window is displayed as shown in Figure 5-3 on page 5–6.

2. Select a map name using the procedure given in “Viewing Wafer Maps” on page 5–6.

   The selected map is displayed on the screen.

Editing the Measured Data

Erroneous points, which may be caused by processing, debris, or edge effects on the wafer, may distort the appearance of a wafer map.

You may edit the measurement data for the displayed wafer map by performing the following:

1. With a wafer map displayed, click on **Edit** in the menu bar then click on **Data** from the Edit menu.

   The Editing Measured Data window is displayed as shown in the figure below.

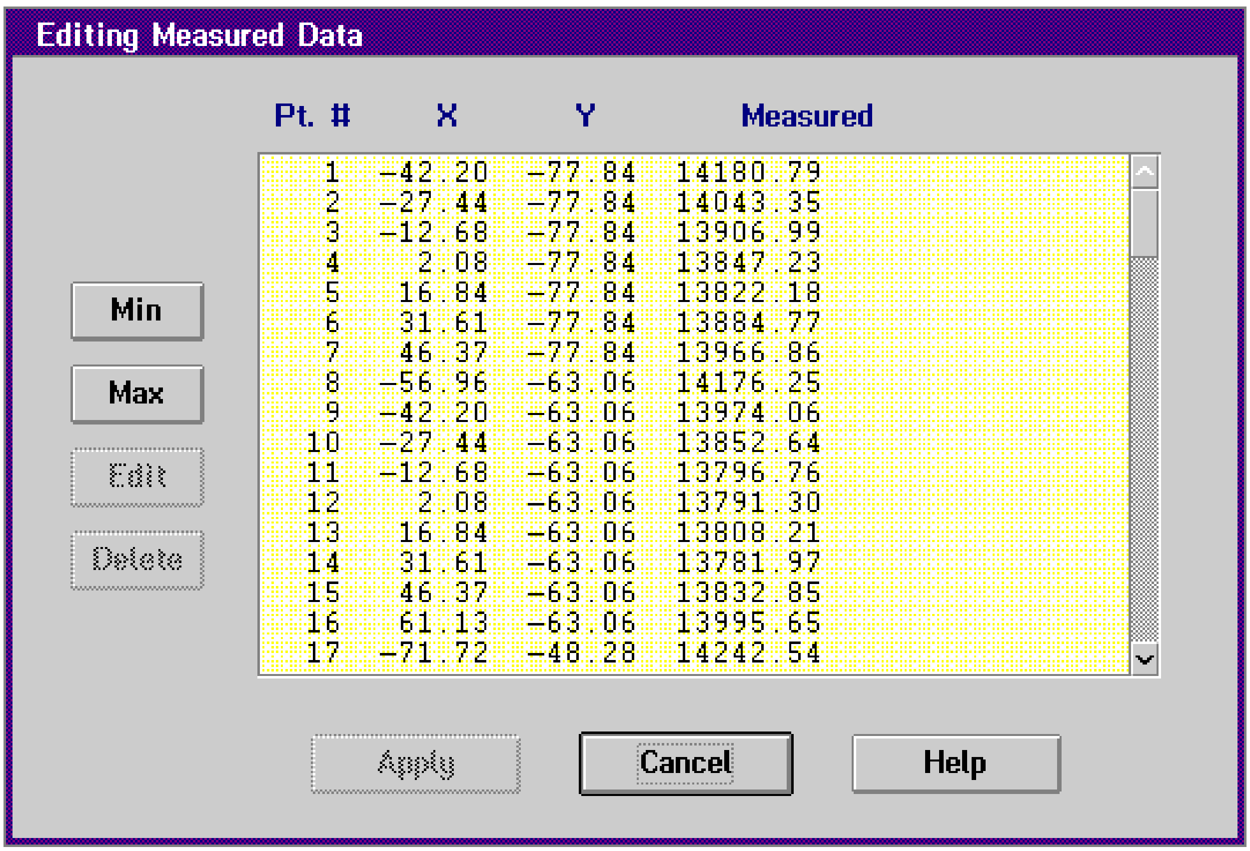

Figure 5-8. Editing Measured Data Window

NOTE

Clicking on the Cancel button at any time returns you to the Wafer Map View window.

2. Click on **Min** to automatically select the minimum measurement point, **Max** to automatically select the maximum measurement point, or click on the point you wish to edit.

   The selected point is highlighted.

3. Once the desired measurement point is selected, click on the **Edit** button to edit the data or **Delete** to delete the measurement point.

   If you select **Delete**, you are asked to confirm your action. Click on **Yes** to delete the point or **No** to return to the Editing Measured Data window.

   If you select **Edit**, a window is displayed in which you may enter the new measurement information for the selected point. Enter the new information and click on **Enter**.

4. When you have completed making changes to the measurement data, click on the **Apply** button.

   The wafer map is redisplayed using the new measurement information.

5. Click on **Edit** in the menu bar.

   The Edit menu is displayed.

6. Click on **Save** in the Edit menu to save the new measurement information.

CAUTION

If you do not save the new measurement information, when you clear the wafer map or exit the Mapping software, the changes you made will be lost.

Exiting Wafer Mapping

To exit the wafer mapping software, double click the icon in the upper-left corner of the screen, or single click the icon to display a menu. With the menu displayed, click on the **Close** menu item.

Any wafer maps currently displayed will be closed and the Mapping software will exit. You are returned to the OS/2 desktop.

Wafer Reports

The Focus Browser program makes it possible to view the wafer measurement data collected by the FE System. In order to view the data you must select the wafers that you wish to view and, within the selected set of wafers, the exact point(s), film layer(s), and film parameter(s) must be selected.

The process of “Browsing” the data consists of defining a query and displaying data. A query is the means used to collect the data. An example query might be: “Select all of the 16 MEG-DRAM Gate oxide wafers and display only the thickness of the first point on each wafer.” The data can be displayed as a graph, an SPC trend chart or text.

The following steps are taken to create a wafer report:

1. A wafer recipe must be created by the Engineer that sends the wafer measurement data to the database using the Focus Recipe Creator program. The wafer recipe is then incorporated into a process step. Refer to “Wafer Report Selection” on page 4–24 of Chapter 4, “Creating Recipes” for information.

2. The process specification and step containing the wafer recipe are run by the Operator using the Focus Operator Queued Loading program. This will generate the database report file. Refer to Chapter 2, “Operator Interface” for information.

Once the wafer database file is generated, the Focus Browser program may be used to query the database and display the measurement report data.

Starting Focus Browser

To start the Focus Browser program, position the trackball pointer over the Focus Browser icon, located in the Focus Ellipsometer folder, and double click the left trackball button.

The Focus Browser main window is displayed as shown in Figure 5-9.

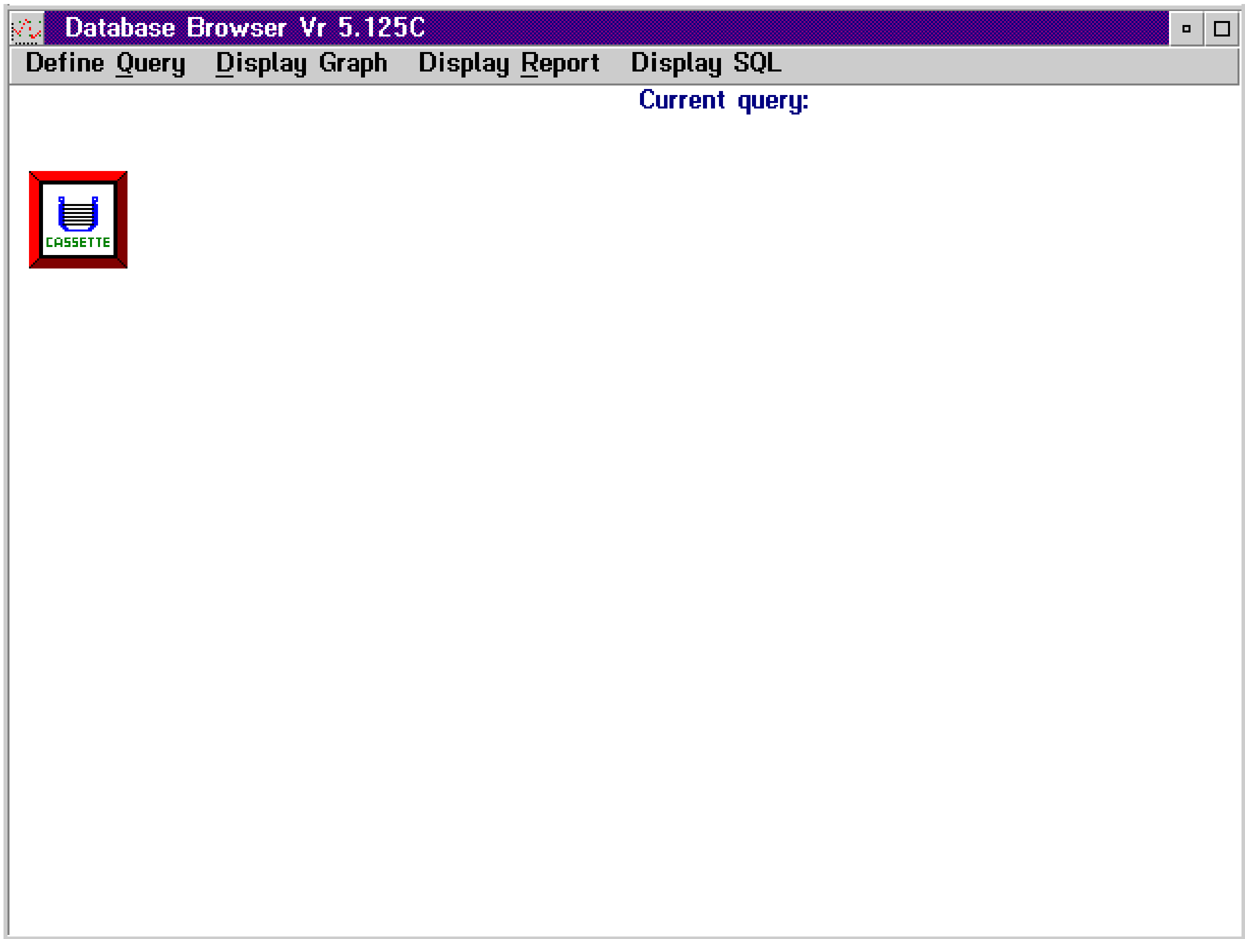

Figure 5-9. Focus Browser Main Window

Focus Browser Main Menu

The following menu items are available in the Focus Browser Main window:

- **Define Query** — Used to select a predefined database query or to define a new database query for retrieving the desired data from the FE System database.
- **Display Graph** — Displays the retrieved measurement data as a graph in “values vs. measurements” format.
- **Display Report** — Displays the retrieved measurement data as a Text Report, or Data Dump.
    - **Text Report** — Presents the data in the format similar to the reports generated by the Operator using the Focus Operator Queued Loading program, except that the points do not necessarily represent consecutive data.
    - **Data Dump** — Displays the data in columns separated by tabs to facilitate its use in a spreadsheet program.
- **Display SQL** — Provides information on the query currently selected (such as query name, process specification and step, recipe, and filmstack information).

Cassette Icon

The Cassette Icon, displayed in the Focus Browser main window, provides an easy method for reviewing data by cassette groups. Cassette groups are identified by cassette ID and measurement data. The most recently measured cassettes appear at the top of the list.

Browsing the Database

The following methods may be used to browse the database:

- Cassette Browsing
- Database Queries

NOTE

Prior to wafer measurement, it is essential that the database option be selected in the “report” template of the wafer recipe. Refer to “Wafer Report Selection” on page 4–24 of Chapter 4, “Creating Recipes” for information.

Cassette Browsing

The cassette mode makes it possible to view the measurement data in its “as measured” format. The data cannot be reorganized.

To start the cassette browsing mode, perform the following:

1. Click the left trackball button on the **Cassette Icon** located on the Focus Browser main window.

   A window is displayed with a list of the available cassette IDs as shown in Figure 5-10. The date and time during which the cassettes were measured is also given. The cassette IDs are listed in reverse time order, most recent cassette measured at the top of the list.

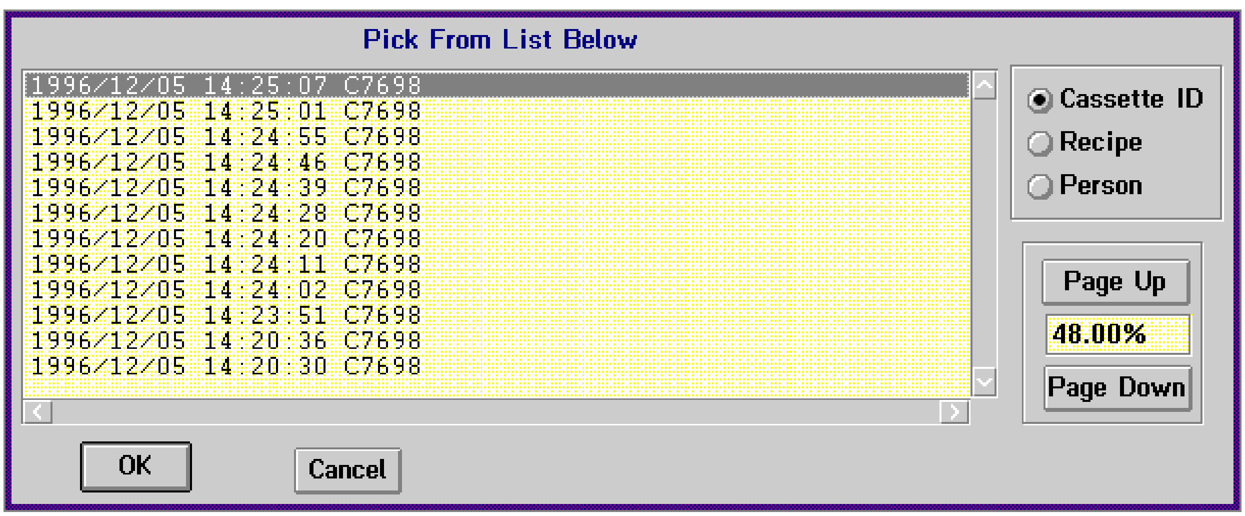

Figure 5-10. Cassette Selection List

2. Select a cassette by single clicking on the desired item from the list and clicking on the **OK** button or by double clicking on the desired item. Scroll the list up or down using the **Page Up** and **Page Down** buttons if necessary. The display may be changed to show the cassette ID, the recipe that was run on the cassette, or the Operator who ran the process step by clicking on the **Cassette ID**, **Recipe**, or **Person** button respectively.

   A measurement report is displayed as shown in Figure 5-11. The cassette entry will be shown in a format similar to those produced by Focus Operator Queued Loading program. One difference between the formats is that multiple parameters create duplicate lines (for example, two lines for point 1).

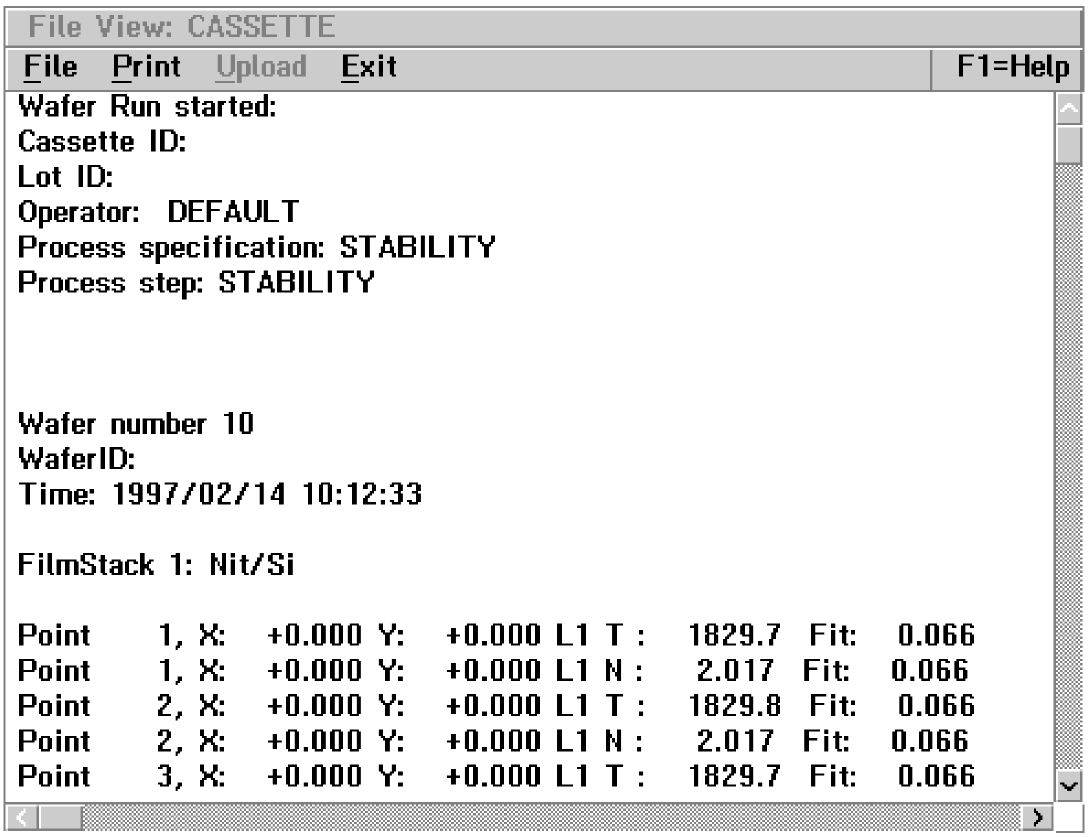

Figure 5-11. Cassette Measurement Report

3. When when the report is displayed, you may perform any of the following:

   - Save the data in the report to a text file by clicking on the **File** menu, then clicking on **Save As**. Enter the desired destination path and filename in the dialog box that is displayed and click on **Enter**.

     The data is saved in the specified file and may be imported into a text editor or into Microsoft Excel.

   - Print the report to the printer that is connected to the FE System by clicking on the **Print** menu item. Ensure that the printer is connected, is turned on, and is on-line.

   - Quit the report viewer by clicking on the **Exit** menu item. This exits the report viewer, however the data contained in the report still resides in the FE System database.

     Quitting the report viewer returns you to the Focus Browser window.

Database Queries

A query is a set of rules used to retrieve data from the database. You must indicate which wafers you wish to view and then decide which information from each wafer you wish to see.

To query the database, perform the following procedure:

1. From the Focus Browser main menu, click on **Query Database**.

   The Browser Query Selection window is displayed as shown in Figure 5-12. If there are any pre-defined queries, they will be displayed in the Available Items section.

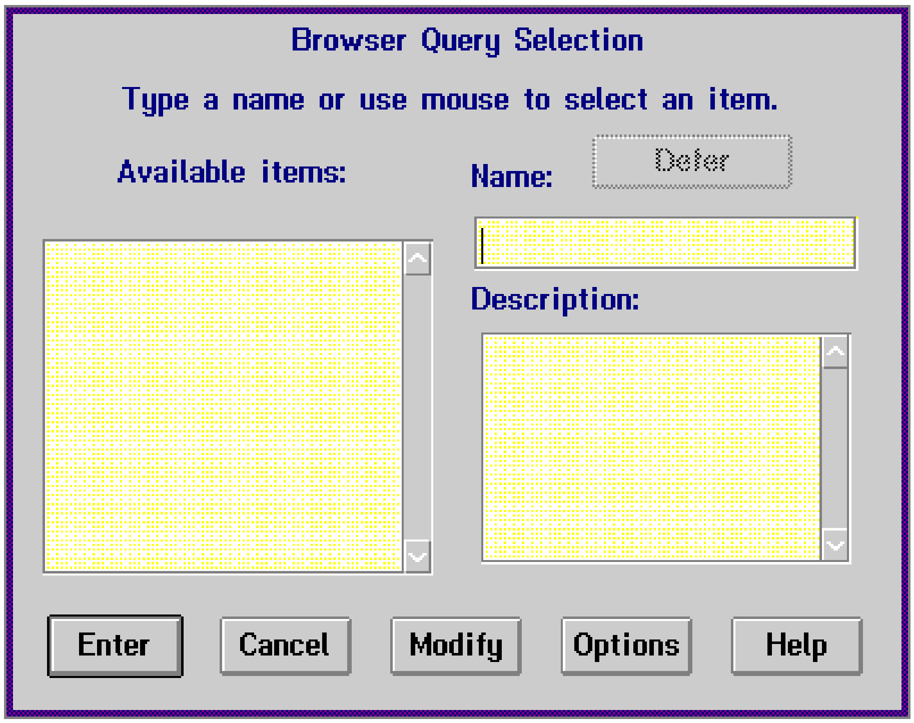

Figure 5-12. Browser Query Selection Window

2. Perform **one** of the following:

   - **Select an existing browser query:** click once on a query name in the Available Items window then click **Enter**, or double click on the desired query name.

     You are returned to the Focus Browser main window with the selected query name displayed as shown in Figure 5-14. Proceed to “Viewing Report Data” on page 5–30 to perform the desired query (graph, text, or text dump).

- **Modify an existing query:** click once on a query name in the Available Items window then click on **Modify**.

  The Query Definition Screen is displayed similar to the one shown in Figure 5-13.

NOTE

When modifying an existing query, the query parameters will be displayed in the Query Definition Screen.

- **Create a new query:** type the desired name in the **Name** field, type a description for the new query in the **Description** field, then click on the **Enter** button.

  The Query Definition Screen is displayed as shown in Figure 5-13.

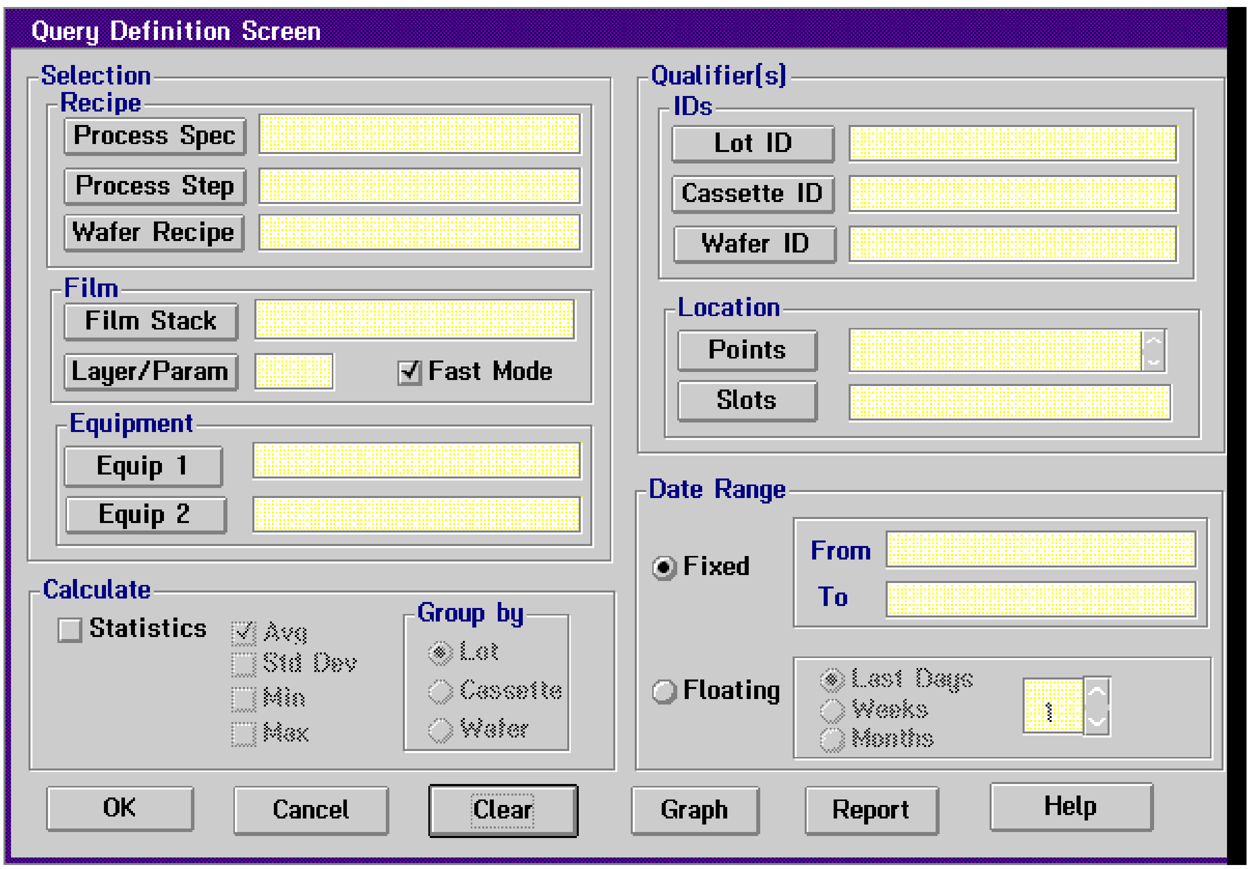

Figure 5-13. Query Definition Screen

The following information must be defined in the query:

- Process Specification
- Process Step
- Wafer Recipe
- FilmStack
- Layer
- Film Parameter
- Wafer Points
- Wafer Slot

This information is required to avoid mixing different types of information. For example, nitride film thicknesses cannot be compared to oxide film thicknesses. However, there are cases where it may be desirable to mix information. For example, the measurement points listed on the wafer can be taken from any wafer. In this case, it is permissible to mix the choices.

The items in the above list comprise all of the information required to extract one type of information from the database. The information itself can be separated into three categories:

- Recipe information
- Film information
- Position information

3. Perform **one** of the following:

   • **If you are defining a new query:** click on the **Process Spec** button on the Query Definition Screen.

   The system will automatically step you through the query definition process. Each time you are prompted, select the desired process spec, process step, wafer recipe, filmstack, layer, points, and wafer slot.

NOTE

If only one option is available for a given parameter, the system will automatically select that option and display it in the appropriate field.

- **If you are modifying an existing query:** click on the button of the parameter you wish to modify and select the new value for that parameter.

  The system automatically steps through the remainder of the query definition from that point. Each time you are prompted, select the desired option for the parameter displayed.

4. Make any optional selections for the query as desired. These selections include:

   - Whether to calculate statistics, which statistics to calculate, and how to group the calculations.
   - Selecting lot, cassette, and wafer IDs.
   - Specifying date ranges for the query.

5. Perform **one** of the following:

   - **To cancel the query definition:** click on the **Cancel** button.

     You are returned to the Focus Browser main window.

   - **To clear the Query Definition Screen:** click on the **Clear** button.

     The Query Definition Screen is cleared. Repeat this procedure from Step 3 above to create a new query.

   - **To save the query:** click on the **OK** button.

     The query is saved in the database and you are returned to the Focus Browser main window with the selected query name displayed as shown in Figure 5-14.

   - **To perform the query and display the data as a graph:** click on the **Graph** button.

     A Measurement Value Graph is displayed. Refer to "Displaying Data as a Graph" on page 5–31.

   - **To perform the query and display the data as a report:** click on the **Report** button.

     A text report is displayed. Refer to "Displaying Data in Text Format" on page 5–32.

Viewing Report Data

Data can be displayed as a graph, text report, or text dump (suitable for a spread-sheet program). In addition, the query statistics (query name, process specification and step, recipe name, and so on) can be displayed.

The current query, displayed in either in the Focus Browser main window (Figure 5-14) or in the Query Definition Screen, will be used to select the data for display.

Figure 5-14. Focus Browser with Query Selected

Displaying Data as a Graph

Once a query has been defined and selected, display the data retrieved by the query as a graph by performing the following:

1. Perform **one** of the following:

   - **From the Focus Browser window:** click on **Display Graph** from the main menu.

   - **From the Query Definition Screen:** click on the **Graph** button.

   A database query is performed and a Measurement Value Graph is displayed similar to the example shown in Figure 5-15.

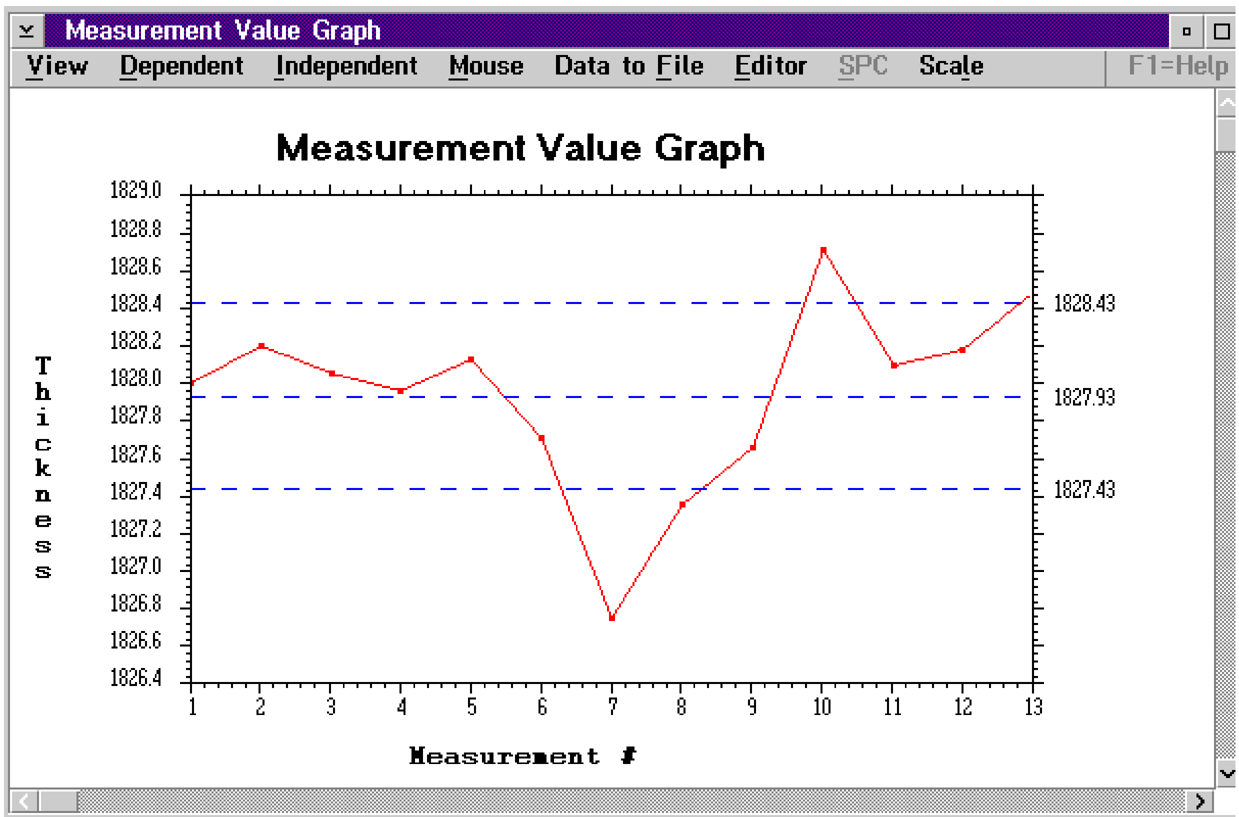

Figure 5-15. Sample Measurement Value Graph

2. When you have finished viewing the graph, exit the viewer by double clicking the icon in the upper left corner of the viewer window (to the left of the Measurement Value Graph name), or single click the icon to display a menu. With the menu displayed, click on the **Close** item.

   You are returned to the screen from which you opted to display the graph (the Focus Browser window or the Query Definition Screen).

Displaying Data in Text Format

The data retrieved by the selected query may be displayed in either text mode or data dump format.

Text Mode

The text display presents the data in the format similar to that generated by the Focus Operator Queued Loading program, except that the points do not necessarily represent consecutive data.

Once a query has been defined and selected, display the data retrieved by the query as a text report by performing the following:

1. Perform **one** of the following:

   - **From the Focus Browser window:** click on **Display Report** from the main menu, then click on **Text Report**.

   - **From the Query Definition Screen:** click on the **Report** button.

   A database query is performed and a text report is displayed similar to the example shown in Figure 5-16.

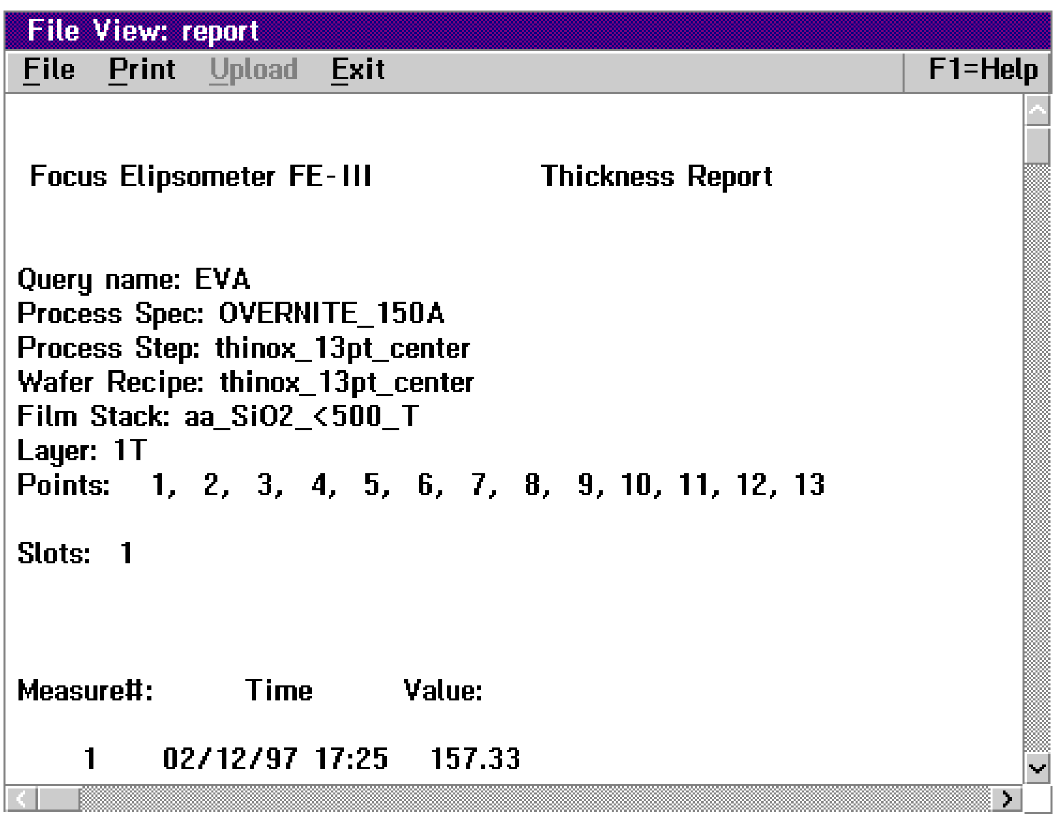

Figure 5-16. Sample Text Report

2. When you have finished viewing the report on-line, you may:

   - Save the data in the report to a text file by clicking on the **File** menu, then clicking on **Save As**. Enter the desired destination path and filename in the dialog box that is displayed and click on **Enter**.

     The data is saved in the specified file and may be imported into a text editor or into Microsoft Excel.

   - Print the report to the printer that is connected to the FE System by clicking on the **Print** menu item. Ensure that the printer is connected, is turned on, and is on-line.

   - Quit the report viewer by clicking on the **Exit** menu item. This exits the report viewer, however the data contained in the report still resides in the FE System database.

   You are returned to the screen from which you opted to display the report (either the Focus Browser main window or the Query Definition Screen).

Text Dump Mode

The text dump mode displays the data in columns separated by tabs to facilitate its use in a spreadsheet program.

Once a query has been defined and selected, display the data retrieved by the query as a data dump report by performing the following:

1. From the Focus Browser window, click on **Display Report** from the main menu, then click on **Data Dump**.

   A database query is performed and a text report is displayed (in data dump mode) similar to the example shown in Figure 5-17.

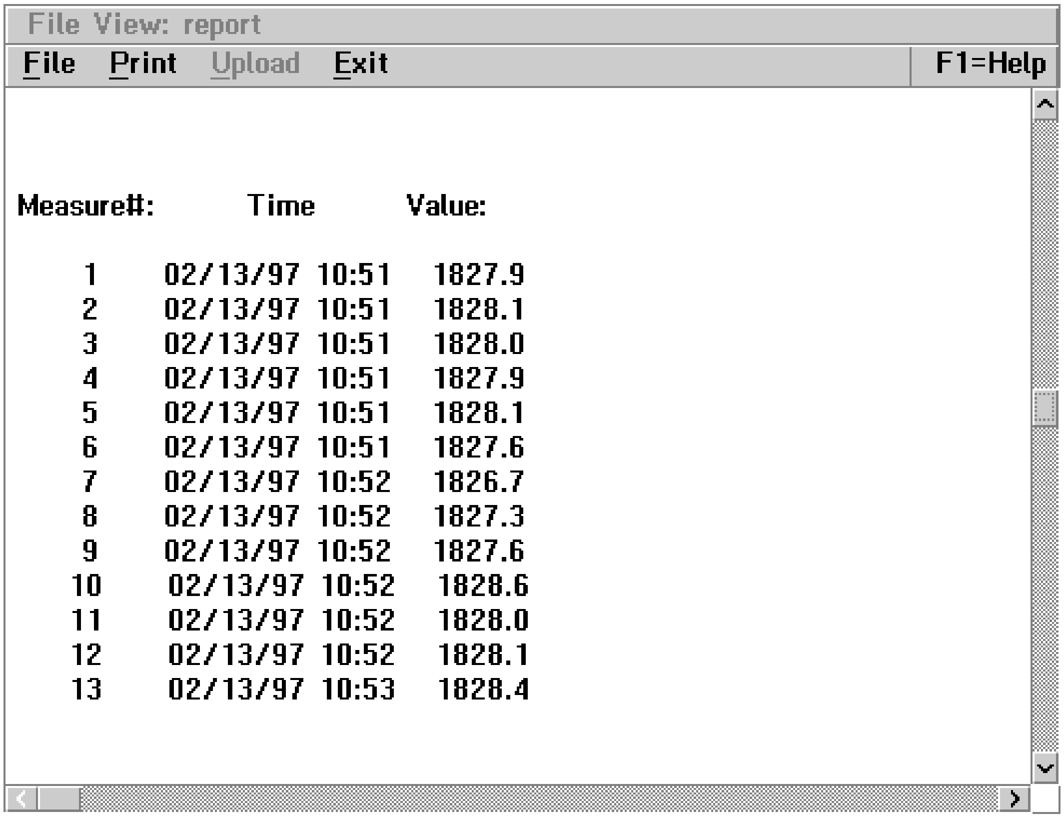

Figure 5-17. Sample Data Dump Report

2. When you have finished viewing the report on-line, you may:

   - Save the data in the report to a text file by clicking on the **File** menu, then clicking on **Save As**. Enter the desired destination path and filename in the dialog box that is displayed and click on **Enter**.

     The data is saved in the specified file and may be imported into a text editor or into Microsoft Excel.

   - Print the report to the printer that is connected to the FE System by clicking on the **Print** menu item. Ensure that the printer is connected, is turned on, and is on-line.

   - Quit the report viewer by clicking on the **Exit** menu item. This exits the report viewer, however the data contained in the report still resides in the FE System database.

   You are returned to the Focus Browser main window.

Query Statistics

To display the parameters that make up the current query, perform the following:

1. In the Focus Browser main menu, click on **Display SQL**.

   A Query Information window is displayed as shown in Figure 5-18.

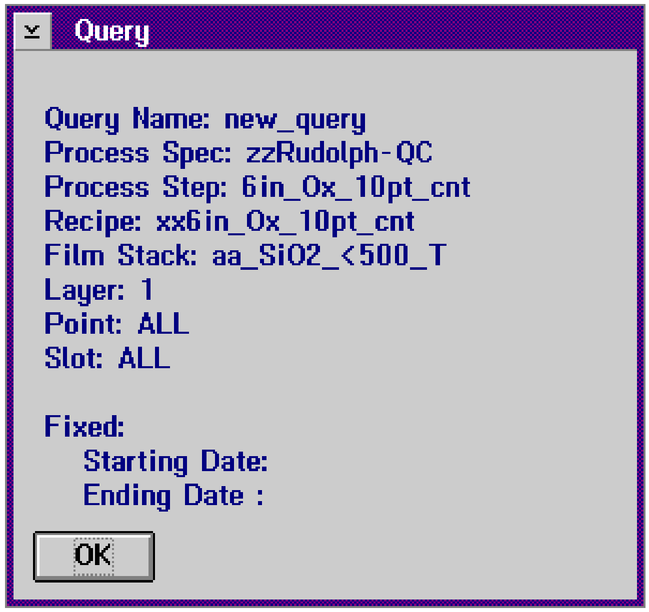

Figure 5-18. Query Information Window

2. When you have finished viewing the query information, click on the **OK** button.

   You are returned to the Focus Browser main window.

Exiting Focus Browser

To exit the Focus Browser software, double click the icon in the upper-left corner of the screen, or single click the icon to display a menu. With the menu displayed, click on the **Close** menu item.

Any reports currently displayed will be closed and the Focus Browser will exit. You are returned to the OS/2 desktop.

Importing and Exporting Data

The Import/Export function of the FE System allows the Engineer to export process specification, wafer recipe, filmstack, and/or person (login name) information from one FE System and import that data to another system's database. This process is performed through the Focus Recipe Creator program.

NOTE

The software versions on the two FE Systems must be identical. Patterned wafer recipes may only be imported and exported to/from FE-VII systems.

A media disk, or a blank, formatted floppy disk is required which must then be converted into a Media disk before data may be imported or exported.

CAUTION

If the media disk becomes full during the export process, the FE System database will be corrupted. To reduce the risk of corrupting the FE database, you should always use a new media disk and export one wafer recipe at a time. It is NOT recommended that you export by process spec.

Perform the following:

1. Start the Focus Recipe Creator program and log in using the procedures provided in "Starting Recipe Creator and Logging In" on page 4–5 of Chapter 4, "Creating Recipes".
2. In the Focus Recipe Creator main menu, click on **Imp/Exp**.

   A window is displayed instructing you to have an import/export media disk or a blank, formatted floppy disk inserted in disk drive A:\.
3. Perform **one** of the following:
   - **If you already have an import/export media disk:** insert the media disk in drive A:\. Continue the procedure with Step 5.
   - **If you do not have an import/export media disk:** insert a blank, formatted floppy in drive A:\. Proceed to "Creating an Import/Export Media Disk" on page 5–41.
4. With the media disk inserted in drive A:\, click on the **OK** button.

   The Recipe Import/Export window is displayed as shown in Figure 5-19.

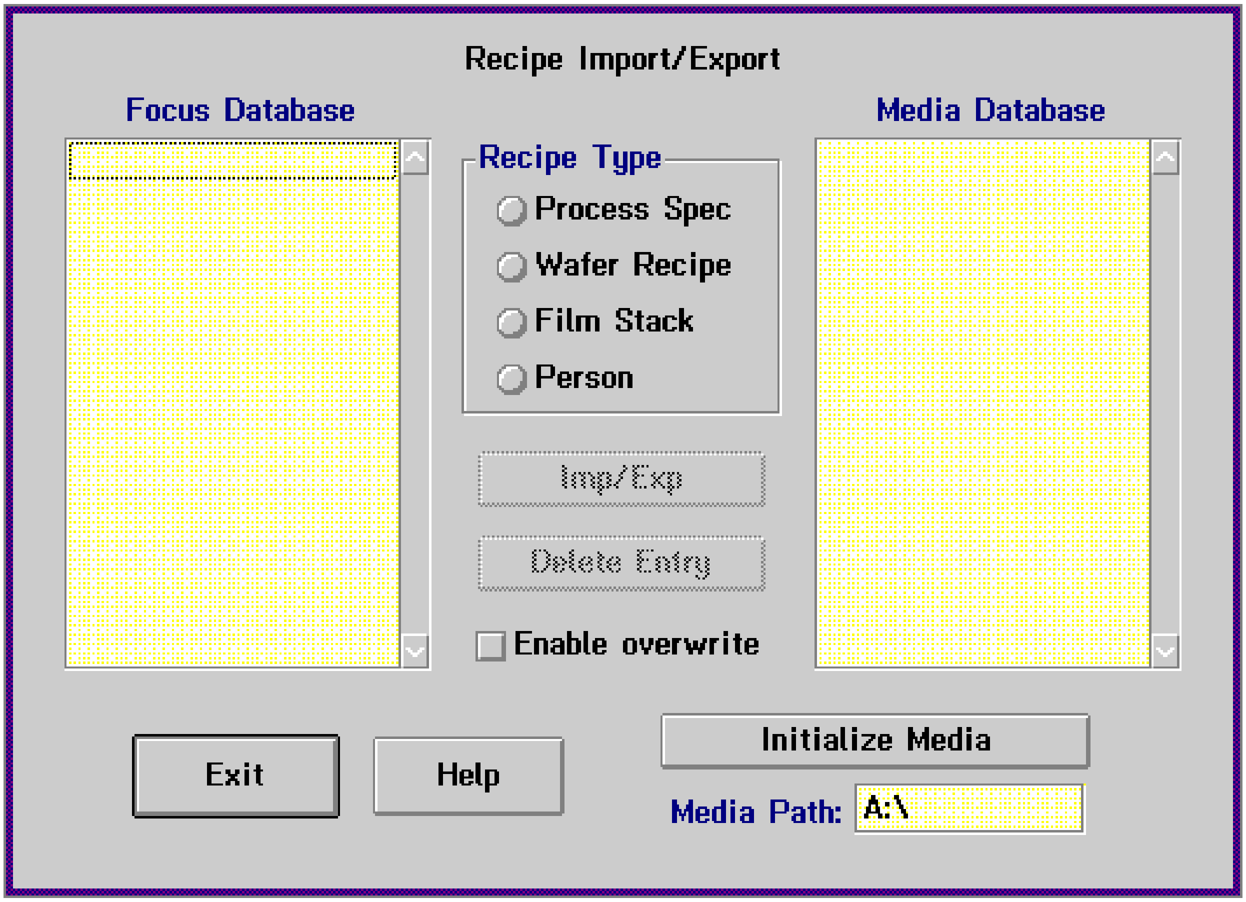

Figure 5-19. Recipe Import/Export Window

The Recipe Import/Export window is made up of the following:

- **Focus Database** — Displays all process spec, wafer recipe, filmstack, or person (login names) information currently in the Focus database. This includes default information and new entries that were created by the Engineer. The list that is displayed is dependent upon the Recipe Type that is selected.

- **Media Database** — Displays the process spec, wafer recipe, filmstack, or person (login names) information that is currently on the media disk.

- **Recipe Type**

  - **Process Spec** — Displays all process spec information that is in the Focus database and on the media disk in the Focus Database and Media Database lists.

  - **Wafer Recipe** — Displays all wafer recipe information that is in the Focus database and on the media disk in the Focus Database and Media Database lists.

- **Film Stack** — Displays all filmstack information that is in the Focus database and on the media disk in the Focus Database and Media Database lists.
- **Person** — Displays all login name information that is in the Focus database and on the media disk in the Focus Database and Media Database lists.

- **Imp/Exp Button** — Clicking this button after selecting an item, or items, from a list will cause the selected item(s) to either be exported from the Focus database to the media disk, or imported from the media disk to the Focus database. The label on this button will display **Import** or **Export** depending on which list the item(s) were selected. Selecting items from the Focus Database list will cause this button to display **Export**. Selecting items from the Media Database list will cause the button to display **Import** and arrows (“>>” or “<<“) in the Imp/Exp button will indicate the direction the files will move.
- **Delete Entry Button** — Clicking this button after selecting an item, or items, from a list will result in the selected item(s) being deleted from the database. You will be prompted to confirm the action before the item(s) are actually deleted.
- **Enable overwrite** — Selecting this option will allow the system to automatically overwrite any entries that already exist in the destination database. If this option is not selected and an item already exists in the destination database, you will be prompted to decide whether or not the item should be overwritten.
- **Initialize Media Button** — Clicking this button will cause the media disk to be erased. You will be prompted to confirm this action before the disk is actually erased.
- **Media Path** — Displays the path for the media disk.

5. Select the desired Recipe Type to be imported or exported by clicking on the **Process Spec**, **Wafer Recipe**, **Film Stack**, or **Person** button as appropriate.

CAUTION

If the media disk becomes full during the export process, the FE System database will be corrupted. To reduce the risk of corrupting the FE database, you should always use a new media disk and export one wafer recipe at a time. It is NOT recommended that you export by Process Spec.

The database information for both the Focus System and media disk is displayed.

6. Select the desired item(s) to import, export, or delete from the appropriate list by positioning the trackball pointer over the item and single clicking the left trackball button.

   The selected item(s) are highlighted and the Imp/Exp button will display either **Import** or **Export**.

7. You may optionally select **Enable overwrite** to automatically overwrite any files that already exist in the destination database.

8. Perform **one** of the following:

   - **To delete the selected item(s):** click on the **Delete** button.

     A window is displayed for each item you have selected for deletion asking you to confirm the action. Click on **Yes** to delete the item, click on **No** to leave the item in the database.

   - **To import the selected item(s) from the media disk to the Focus Database:** click on the **Import** button.

     The selected item(s) are copied from the media disk to the FE database. If **Enable overwrite** was not selected, you are prompted before items that already exist in the database are overwritten. Click on **Yes** to overwrite the file, **No** to keep the existing file.

   - **To export the selected item(s) from the Focus Database to the media disk:** click on the **Export** button.

     The selected item(s) are copied from the FE database to the media disk. If **Enable overwrite** was not selected, you are prompted before items that already exist on the media disk are overwritten. Click on **Yes** to overwrite the file, **No** to keep the existing file.

9. Repeat Step 5 through Step 8 above for each of the Recipe Types you wish to import or export.

10. When all of the desired information has been imported or exported, click on the **Exit** button.

    The message **Deregistering Export Media** is displayed.

CAUTION

DO NOT remove the media disk while the message "Deregistering Export Media" is being displayed. Removing the disk while the message is displayed will corrupt the FE System database.

11. After the Deregistering Export Media message is no longer displayed and the drive activity light has been off for at least 10 seconds, you may remove the media disk from the floppy drive.

Creating an Import/Export Media Disk

A media disk is a Focus database formatted disk which has all of the default database filmstacks, materials, recipes, and so on.

After inserting a blank, formatted floppy in disk drive A:\ as described in Step 3 of the procedure provided in "Importing and Exporting Data" on page 5–37, use the following procedure to create an import/export media disk.

1. Click on the **OK** button.

   The Recipe Import/Export window is displayed as shown in Figure 5-20.

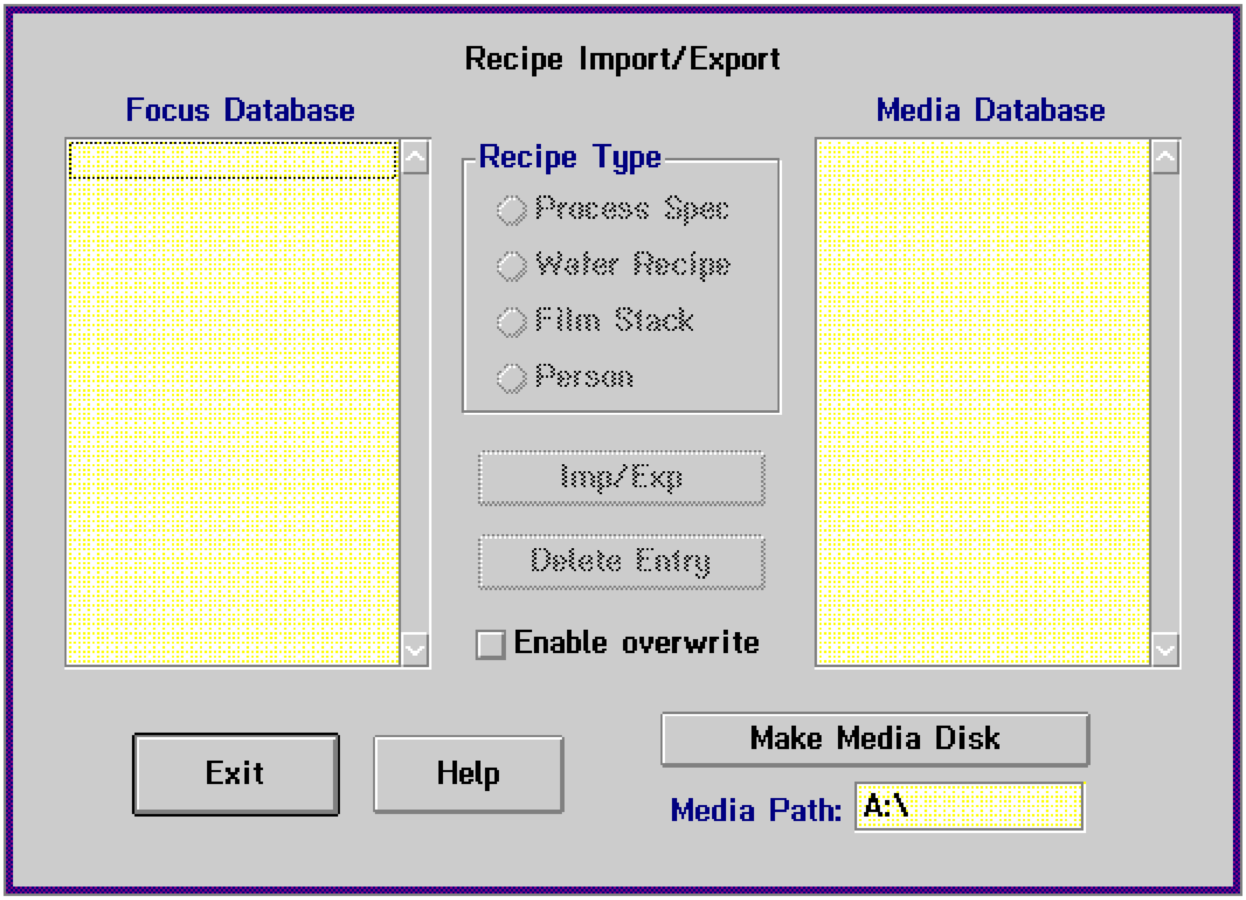

Figure 5-20. Recipe Import/Export Window - Make Media Disk

2. In the Recipe Import/Export window, click on the **Make Media Disk** button.

   A window is displayed asking you to confirm that a blank, formatted floppy disk is inserted in drive A:\.

NOTE

If you do not already have a blank, formatted floppy disk inserted in drive A:\, insert one at this time.

3. With a blank, formatted floppy in drive A:\, click on the **Yes** button.

   A window is displayed indicating that a Media Disk is being created. Once the process has completed, the Recipe Import/Export window is redisplayed as shown in Figure 5-19. Notice that the **Make Media Disk** button is now labeled **Initialize Media**.

NOTE

This step may take several minutes to complete as the system transfers all of the default database information to the floppy disk.

4. With the media disk now created, return to Step 5 of the procedure given in “Importing and Exporting Data” on page 5–37.

Appendix A

Starting and Stopping the System

Introduction

The purpose of this appendix is to provide the operator and the engineer with detailed instructions for starting and stopping the system. The information in this section pertains to the FOCUS Ellipsometer (FE) III, IV, and VII systems, and includes the following topics:

- How to perform a normal system startup.
- How to perform a normal system shutdown.
- How to initiate an emergency system shutdown.
- How to recover from an emergency system shutdown.

NOTE

The procedures in this guide assume that once the FE System is started after installation it will be left on. The shutdown procedures are provided for possible service requirements or emergency situations.

FE System Control Panel

All FE System models have a standard control panel (as shown in the figure below) which contains the following:

1. **Power On/Off switch** — Green switch used to turn the system on and off under normal operating conditions.

2. **Emergency Motion Off (EMO)** or **Emergency Power Off (EPO) switch** — Red switch for emergency use. This switch can be configured (to customer requirements) as an EMO switch, which stops all unit motion but maintains air flow and power to the unit, or as an EPO switch, which powers down the unit.

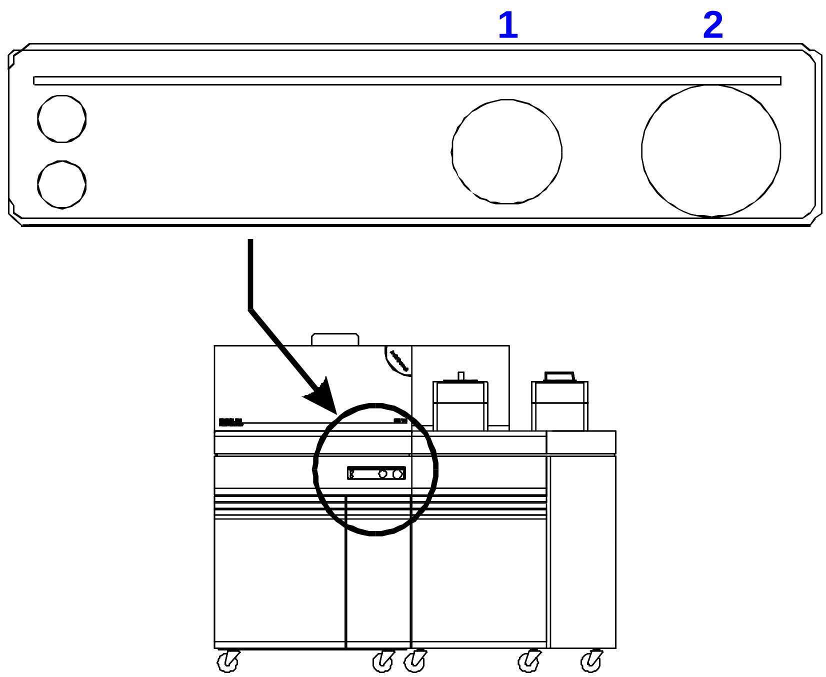

Figure A-1. Power On/Off Switches

Normal System Startup

To startup your FE System, ensure that power is applied to the system (that is, the power cord is plugged into the wall outlet, the main power breaker for that outlet is turned on, and the circuit breaker behind the large door on the measurement module is turned on) then press the green Power On/Off switch on the control panel.

NOTE

Turning off the circuit breaker behind the large door on the measurement module will remove all power from the FE System after the breaker. Figure A-2 shows the location of the circuit breaker.

The system software will boot up and the hardware will initialize automatically.

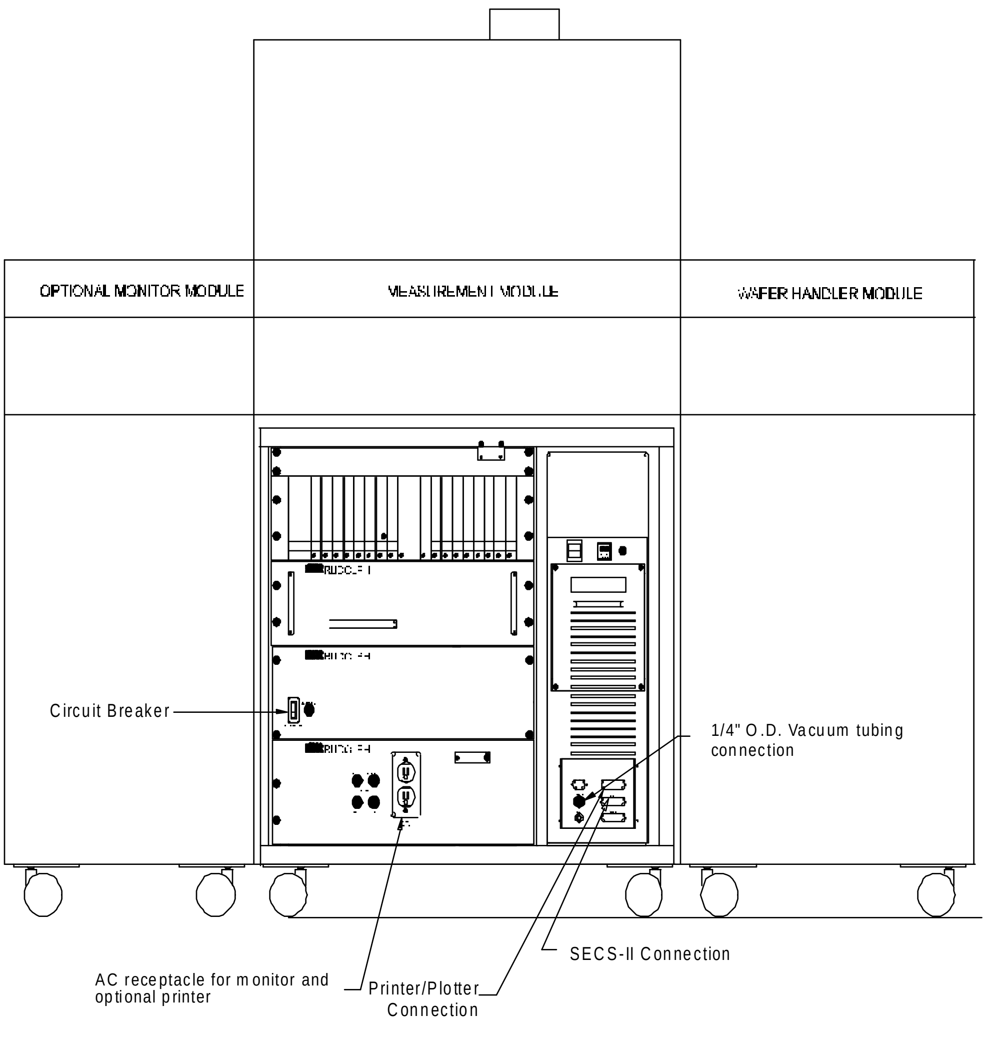

Figure A-2. FE System Utility Connections

Normal System Shutdown

To perform a normal FE System shutdown, use the following procedure:

1. Remove all wafers from the stage, external flat/notch finder, and the robot.
2. Exit the Focus program that is currently running (such as: Focus Operator, Focus Interactive, and so on).

   You are returned to the OS/2 desktop.

   NOTE

   Your FE System may have been configured to require an Engineer or Supervisor level login name and password to exit the Focus Operator program.

3. On the OS/2 desktop background, not in a window, click once with the RIGHT mouse button.

   A list of OS/2 system commands is displayed.

4. Click the LEFT mouse button on the **Shut down** command.

   The computer will go through its shutdown procedure and will display a message when the shutdown is complete and it is safe to turn off the system.

5. Press the green Power On/Off switch on the FE System control panel to turn off the system.

   The FE System is powered off.

   NOTE

   If the large door under the control panel is opened, there is a circuit breaker in the lower left hand corner that may also be switched off. Turning off this circuit breaker removes all power from the FE System after the breaker.

6. Once the FE System is powered off, and if desired, the power cord can be removed from the outlet or the main power breaker may be shut off.

Emergency System Shutdown

To perform an emergency FE System shutdown, press the red EMO/EPO switch on the FE System control panel.

The result of pressing the EMO/EPO switch will depend on whether the switch is configured as an Emergency Motion Off or Emergency Power Off switch.

Emergency Motion Off (EMO)

If the EMO/EPO switch is configured as an Emergency Motion Off switch, the following will occur when the switch is pressed:

1. The stage and robot will stop moving.
2. The compensator will shutdown.
3. The laser shutters will be activated and the tilt LED will turn off.
4. For an FE III or FE IV System, the last two LEDs on the rectifier board (the Positive Rotating Compensator and Positive Motor LEDs) will turn off.
5. For an FE VII System (with or without SMIF), the LEDs on the rectifier board corresponding to Positive Chuck Power, Positive Motor, and Positive Converter Input will turn off.
6. Air flow around the FE System is maintained.

Emergency Power Off (EPO)

If the EMO/EPO switch is configured as an Emergency Power Off switch, the FE System will turn off completely.

Recovering from an Emergency System Shutdown

Once the EMO/EPO switch has been pressed and the FE System is shutdown, perform the following:

1. Clear any wafers from the robot or external flat/notch finder.
2. Shutdown the software using the standard shutdown procedure given in "Normal System Shutdown" on page A–4.
3. Press the green Power On/Off switch on the control panel.

NOTE

The next step must be performed with the power off to ensure a proper recovery.

4. Reset the EMO/EPO switch.
5. Power the FE System on by pressing the green Power On/Off switch on the control panel.
6. Verify that the Positive Rotating Compensator and Positive Motor LEDs (FE III or FE IV) or Positive Chuck Power, Positive Motor, and Positive Converter Input LEDs (FE VII) are now on.

The FE System may now be used. If any wafers were left on the stage, robot, or flat/notch finder, the system will sense them and will ask where you wish to unload them.

System Configuration

Appendix B

Introduction

The purpose of this appendix is to provide information that will allow you to configure the FOCUS Ellipsometer system and customize the default parameters and settings for the programs that make up the FOCUS Ellipsometer software package. The information in this section pertains to the FOCUS Ellipsometer (FE) III, IV, and VII systems, and includes the following topics:

- How to start up, use, and exit the Focus Setup program.
- Describe the configuration options available through the Focus Setup program.
- How to create user login names and passwords and configure the FE System login requirements.
- How to configure the FE System to communicate with a host computer via SECS-II/GEM interface.
- How to perform database backup and restore procedures.

The tasks described in this appendix are performed with the use of the Focus Setup program. This is the program that allows the user to change the FOCUS Ellipsometer software configuration. The Focus Setup program also provides data file backup, data file restore, and database maintenance functions.

NOTE

Configuring user login and password information requires the use of the Focus Recipe Creator program in addition to the Focus Setup program.

Starting Focus Setup

To start the Focus Setup program, perform the following procedure:

1. Position the trackball pointer over the Focus Setup icon and double click the left trackball button.

   The Focus Setup main window is displayed as shown in Figure B-1.

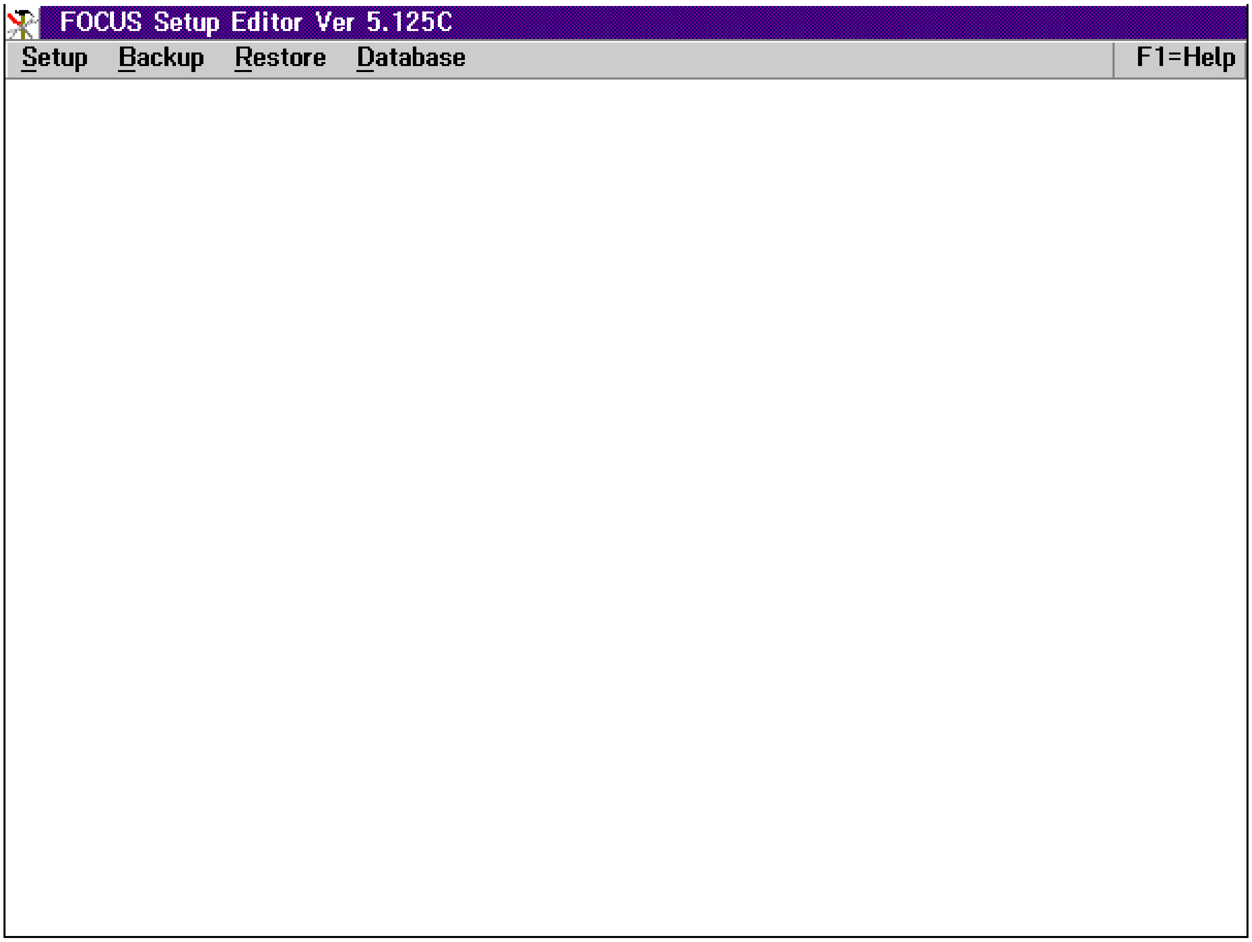

Figure B-1. Focus Setup Main Window

Focus Setup Main Menu

The following menu items are available in the Focus Setup Main window:

CAUTION

The FOCUS System is set up and configured by Rudolph Technologies personnel when the system is installed. It is recommended that these settings not be changed unless directed to do so by Rudolph Technical Support.

With the exception of configuring user login information, only brief descriptions of the options available are provided in this section. Contact Rudolph Technologies for more detailed configuration information.

NOTE

The Focus Setup menu selections will vary depending on your FE System hardware configuration and your software version. Some of the items shown in this section may not be displayed.

- **Setup** — Allows you to access and change any of the following parameters. These parameters include hardware configuration data and default settings for the Focus software.
  - **Model Number** — Specifies the model number, type of flatnotch finder, type of wafer handling robot, and whether a SMIF Indexer is present for the FE System.
  - **Login** — Sets the FE System login requirements for the Focus Operator Queued Loading, Focus Recipe Creator, and Focus Interactive programs.
  - **Simulation** — When enabled (indicated by a checkmark), the system recognizes that the hardware has been disabled. This allows you to load a logged measurement from the Focus Interactive program and experiment with filmstacks. No measurements can be made in Simulation mode.
  - **Initialization** — Sets the initialization frequency of the wafer handler. Initialization frequency may be set to every time a program (Focus Interactive, Focus Recipe Creator, or Focus Operator) is started, or only on power-up. With Smart Idle Initialization enabled, a window may be set to initialize the wafer handler at a specified time when the system has not been used for a specified period of time. Also indicates the last time the wafer handler was initialized.

- **Mapping** — Sets the system defaults for viewing wafer maps. Sigma level, grid dimensions, type of map (2D or 3D), color mode, and other display options may be specified.

- **Vision & Video** — Specifies the type of vision system installed and defines the vision and pattern recognition system related parameters.

- **Measurement** — Sets the FE System measurement defaults including: the default number of test repeats for repeatability testing, delay count, fit tolerance, compensator motor speed, default substrate and ambient layers, laser wavelengths, measurement units, and temperature compensation.

- **Wafer Handler** — Sets the wafer handler system defaults including: stage x and y movement, robot arm, and stage chuck settings. The **Pulses Per Second** numbers indicate the speed of the robot/stage movements. The **Ramping Time** numbers indicate the ramping time of robot/stage movements.

NOTE

Setting the wafer handler speed values too high may cause the stage/robot to stall.

- **Focus Operator** — Sets the default values for the Focus Operator program. Options include: enable or disable the queued loading feature, whether to generate cassette plate information and wafer IDs, transfer window type, date review and Operator lock on/off, the default view when Focus Operator is started up, and the items that will be available when the Operator clicks on the **Options** button.

- **Database** — Enables or disables the saving of wafer measurement data and specifies how long measurement data will remain in the database. Also specifies the media path, which defines the default path for the Recipe Creator import/export function.

- **Data Files** — Specifies the default filenames for the History log and the log that contains the data from the measurement that was last run. Also specifies the log file path, the number of logs that will be stored, the font style for the log viewer, and how the pattern recognition data will be grouped in the log.

- **Miscellaneous** — Sets the password required to access the Focus Test diagnostic program. If no entry is made, then no password is required. Also specifies the tool name (which identifies the instrument and is shown in the text when generating a data report), the number of wafer slots per cassette, wafer unload orientation, centering tolerances, illumination levels, and SMIF Arm/SMIF Indexer information.

- **Recipe Repeat** — Specifies the number of times the selected Wafer Recipe will be run by the Focus Operator program.
- **PM** — Sets the activation/deactivation method of preventative maintenance messages (by wafer count or time). Each of four possible warning messages may have its own specified warning message text. The Current State indicates the state of the message. **Time Activation** can be selected for a Start or a Repeat method. The Start method will activate the message at the time selected. The Repeat method will activated the message every X days. **Wafer Activation** can be selected for a Start or a Repeat method. The Start method will activate the message at the time X wafers have been measured. The Repeat method will activate the message after every X wafers are measured.
- **Parallel Solver** — Enables or disables a separate modeling process while the system moves and measures.
- **D-Series** — Sets the height and stage adjustments for the IR focal point.
- **Signal Tower** — Specifies whether a signal tower is present on the system and how the signal tower has been configured.
- **Throughput** — Used specifically for running throughput tests. Throughput optimizations and thread sleep times may also be specified.

• **Backup** — Allows you to perform FE System database backup procedures.

- **Recipe Database** — Backs up the Wafer Recipe database (this includes the optical characteristics of materials, N and K database), and the Vision System pattern database.
- **Log0** — Backs up the log0 history file.
- **Configuration Files** — Backs up the calibration files.
- **Map Files** — Backs up the wafer map files.
- **Wafer Database** — Backs up the wafer database.

- **Restore** — Allows you to restore the FE System database from backup.
  - **Recipe Database** — Restores the Wafer Recipe database and the Vision System pattern database.
  - **Configuration Files** — Restores the calibration files.
  - **Map Files** — Restores the wafer map files.
  - **Wafer Database** — Restores the wafer database.
- **Database** — Allows you to perform database maintenance tasks.
  - **Vision** — Deletes those image files that are left behind in the database when associated pattern recognition recipe was deleted.
  - **Database Compression** — Compresses the FE System database information.

Setting FE System Login Requirements

The FE System can be configured to require a user to enter a login name and password in order to access the following programs:

- Focus Operator Queued Loading
- Focus Interactive
- Focus Recipe Creator

For each of the three programs, you may specify whether a user must log in, if the user must enter a password, and the security level the user must possess in order to run the program. In addition, for the Focus Operator Queued Loading program, you may specify if the user must log in to view measurement data, and if the user must log out in order to exit the Focus Operator Queued Loading program.

Use the following procedure to specify the login requirements for each of the FE programs:

1. If it is not already running, start the Focus Setup program using the procedure given in “Starting Focus Setup” on page B–2.

   The Focus Setup main window is displayed.

2. From the Focus Setup main menu, click on **Setup** then click on **Login** when the Setup menu is displayed.

   The Focus Login window is displayed as shown in Figure B-2.

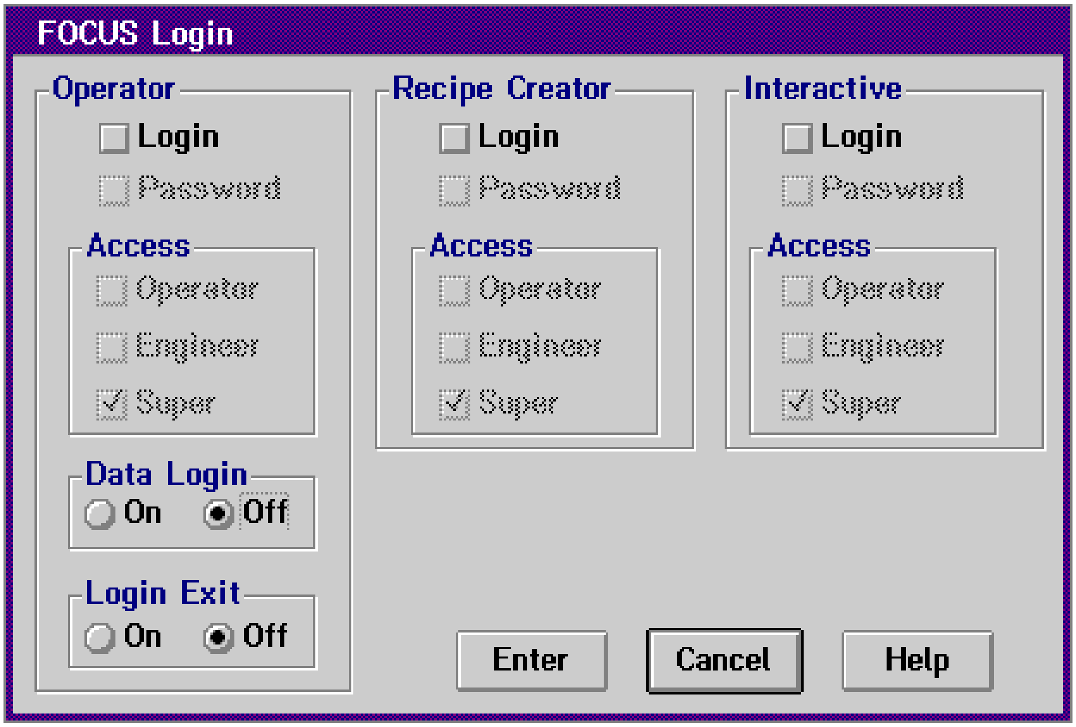

Figure B-2. Focus Login Window

3. Use the following information to set the login requirements for each of the FE System programs (Focus Operator, Recipe Creator, and Focus Interactive):

- **Login** — Click on the **Login** checkbox to require that a user enter a valid login name in order to access the program.
- **Password** — Click on the **Password** checkbox to require that a user enter a valid login name and password in order to access the program.
- **Access** — Specify the privilege level the user must have in order to access the program by clicking on the checkbox for either **Operator** or **Engineer**.

NOTE

A user with a higher privilege level than that which is specified will also be able to access the program. For example, clicking on the “Operator” checkbox for any of the programs will also select the “Engineer” access level. Users with “Super” privilege have access to all of the programs at all times.

4. **For Focus Operator only**, set the following as desired:

   - **Data Login** — Specify whether a login is required to access the data stored in the FE database. Click on the **On** or **Off** button as desired.

   - **Login Exit** — Specify whether a login is required to exit the Focus Operator program. Click on the **On** or **Off** button as desired. If this option is turned on, only a user with Engineer level access or higher may exit the Focus Operator program.

5. When you have completed entering the login requirements, click on the **Enter** button.

   The Focus Setup main window is displayed.

6. You may now exit the Focus Setup program by using the procedure provided in "Exiting Focus Setup" on page B–10.

7. If user records have not already been created for the FE System, proceed to "Setting Up User Logins and Passwords" on page B–11.

Exiting Focus Setup

To exit the Focus Setup program, perform the following procedure:

1. On the Focus Setup screen, perform **one** of the following:
   - Double click the left trackball button on the icon located in the upper left corner of the screen (beside the Focus Recipe Creator program name).
   - Single click the left trackball button on the icon located in the upper left corner of the screen (beside the Focus Recipe Creator program name). Select **Close** from the menu that is displayed.

   The Focus Setup program will exit and you will be returned to the OS/2 desktop.

Setting Up User Logins and Passwords

If the FE System is configured to require a user log in to access the FE Software, user records must be configured using the Focus Recipe Creator program.

A User Record consists of a login name, an optional password, the security level for the user, and optionally assigned "quick buttons" for the process specifications the user is allowed to run.

Creating New User Records

Use the following procedure to define a new user record:

1. Start the Focus Recipe Creator program using the procedures provided in Chapter 4, "Creating Recipes".

   The Focus Recipe Creator main window is displayed.

2. From the Focus Recipe Creator main menu, click on **Template** then click on **Operator** when the Template menu is displayed.

   The Person Selection window is displayed as shown in Figure B-3.

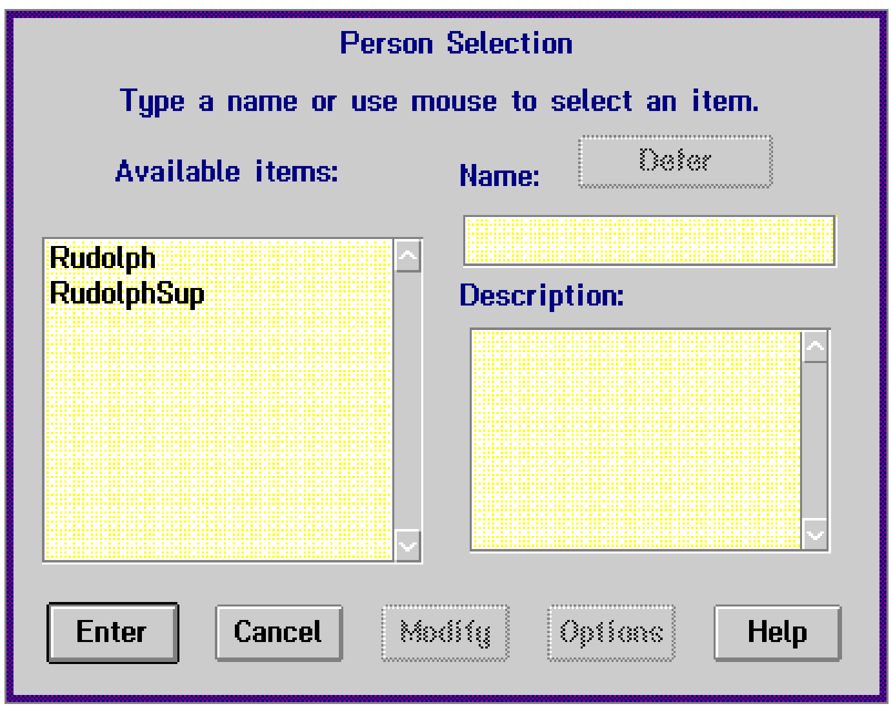

Figure B-3. Person Selection Window

3. Enter the new login name in the **Name:** field. If desired you may also enter a brief description of this login name in the **Description:** field. Click on the **Enter** button when you have completed the entries.

The Operator Information window is displayed as shown in Figure B-4.

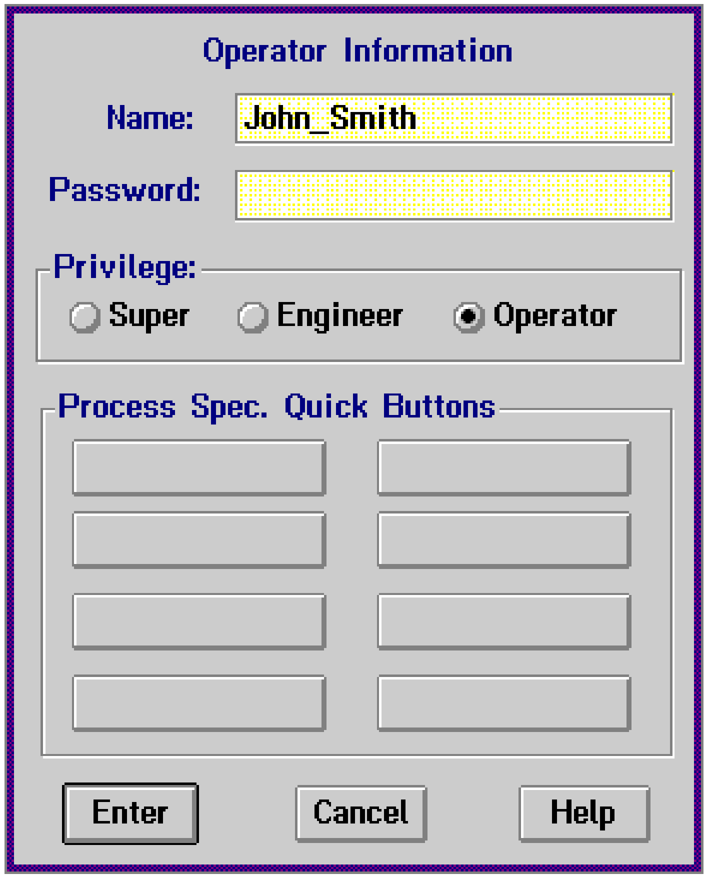

Figure B-4. Operator Information Window

4. Enter the desired password for this user in the **Password:** field.

NOTE

The password is optional and is not case sensitive.

5. Select the security level for this user by clicking the left trackball button on the desired privilege button. The security level will determine which programs the user is allowed to access (as determined by the Focus Setup program). Refer to “Setting FE System Login Requirements” on page B–7 for information.

NOTE

Assigning a security level of “Super” grants the user access to all programs.

6. Perform **one** of the following:

   - **If you wish to specify the process specs the user may access:** click on one of the **Process Spec. Quick Buttons**.

     Select the desired process specification from the Process Selection window by single clicking the left trackball button on the desired item then clicking the **Enter** button, or by double clicking the left trackball button on the item. You may clear a process specification from a Quick Button by selecting the ***** Clear Entry ***** item.

     Repeat this step for each Quick Button you wish to assign then proceed to the next step.

   - **If you do not wish to specify the process specs the user may access:** proceed to the next step.

7. In the Operator Information window, click on the **Enter** button.

   The Focus Recipe Creator main window is displayed.

8. If desired, repeat Step 2 through Step 7 of this procedure to add more login names.

9. When you have completed specifying login names, you may exit the Focus Recipe Creator using the procedures provided in Chapter 4, "Creating Recipes".

Renaming, Deleting, or Copying User Records

In addition to creating a new user record, you may rename an existing user record, delete user records from the database, or copy an existing user record to a new name by using the following procedure:

1. Start the Focus Recipe Creator program using the procedures provided in Chapter 4, “Creating Recipes”.

   The Focus Recipe Creator main window is displayed.

2. From the Focus Recipe Creator main menu, click on **Template** then click on **Operator** when the Template menu is displayed.

   The Person Selection window is displayed as shown in Figure B-5.

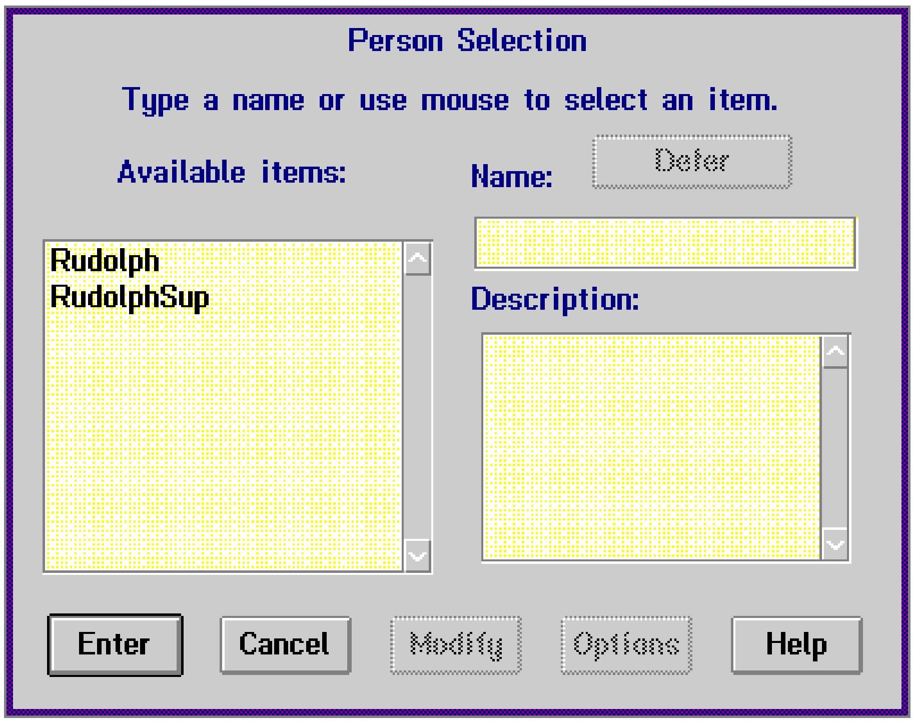

Figure B-5. Person Selection Window

3. Click the left trackball button once on the login name you wish to change, delete, or copy then click on the **Options** button.

   The Person Selection Options window is displayed as shown in Figure B-6.

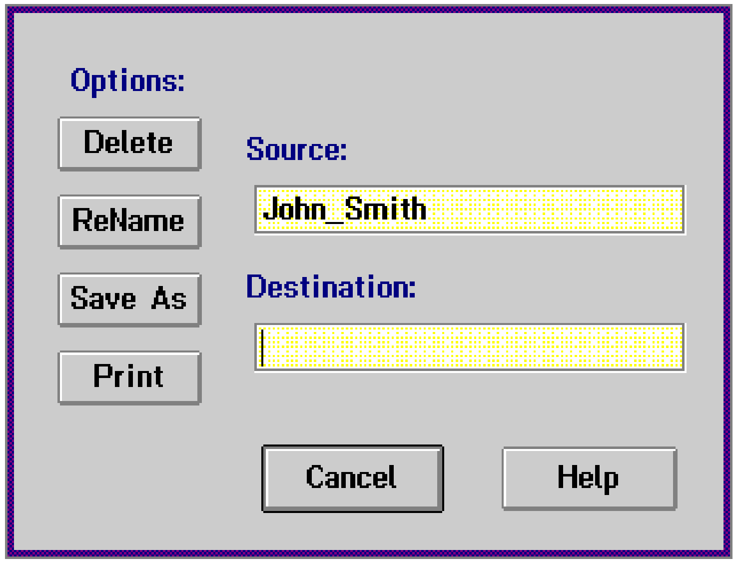

Figure B-6. Person Selection Options Window

4. Perform **one** of the following:

   - **To delete the login name and its database information:** click the **Delete** button.

     You will be prompted to confirm that the login name should be deleted. Click on the **Yes** button to delete the login name and return to the Person Selection window.

   - **To rename the login name:** enter the new name in the **Destination:** field and click the **ReName** button.

     The login name is changed and you are returned to the Person Selection window.

   - **To copy the login name and password to a new login name:** enter the new name in the **Destination:** field and click the **Save As** button.

     The login name and password are copied to the new name and you are returned to the Person Selection window.

   - **To print the login name and its database information:** click the **Print** button.

     The login name and its database information are printed and you are returned to the Person Selection window.

5. Repeat Step 3 and Step 4 for each login name you wish to delete, rename, copy, or print.

6. When you have completed all of the desired changes, in the Person Selection Window click the **Enter** button.

   The Focus Recipe Creator main window is displayed.

7. Exit the Focus Recipe Creator using the procedures provided in Chapter 4, "Creating Recipes".

Modifying User Records

Once a user record is created, you can change the user's password, security level, and/or process specification quick buttons by using the following procedure:

1. Start the Focus Recipe Creator program using the procedures provided in Chapter 4, "Creating Recipes".

   The Focus Recipe Creator main window is displayed.

2. From the Focus Recipe Creator main menu, click on **Template** then click on **Operator** when the Template menu is displayed.

   The Person Selection window is displayed as shown in Figure B-7.

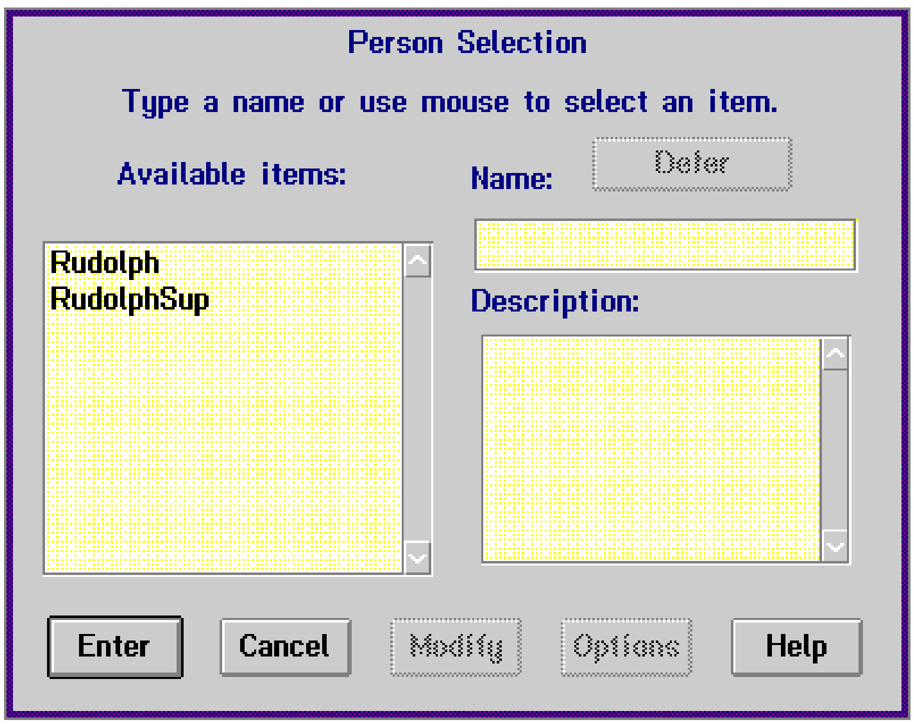

Figure B-7. Person Selection Window

3. Select the login name to modify by single clicking the left trackball button on the desired name then clicking the **Enter** button, or by double clicking the left trackball button on the name.

   The Operator Information window is displayed as shown in Figure B-8.

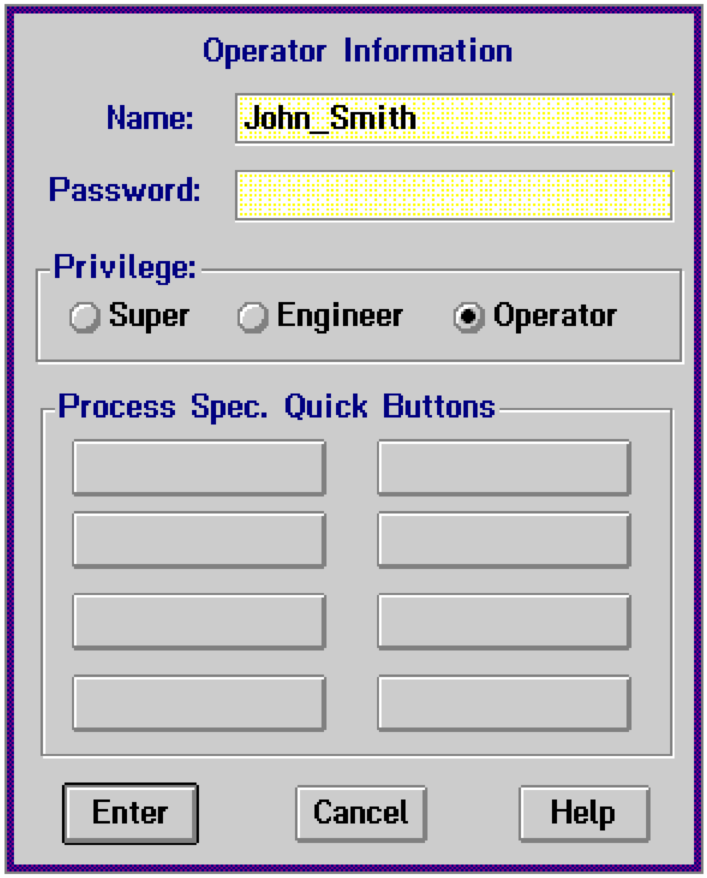

Figure B-8. Operator Information Window

4. Modify the user record as desired by changing the login password, privilege level, and/or clicking on a process specification quick button and selecting new (or clearing) quick button assignments.

NOTE

The password is optional and is not case sensitive.

NOTE

Assigning a security level of "Super" grants the user access to all FE System programs.

5. When all modifications have been completed, In the Operator Information window, click on the **Enter** button.

   The Focus Recipe Creator main window is displayed.

6. If desired, repeat Step 2 through Step 5 of this procedure to modify additional user records.

7. When you completed all modifications, you may exit the Focus Recipe Creator using the procedures provided in Chapter 4, “Creating Recipes”.

Database Operations

In order to protect against the possible loss of database information, the FE System provides the capability to back up and restore the following database information and files:

- Wafer recipe database (including the optical characteristics of materials, N and K database)
- Vision System pattern database
- The log0 history file
- Calibration files
- Wafer map files
- Wafer database

In addition to the database backup and restore operations, certain database maintenance tasks (such as database compression) may also be performed.

All of these database operations are performed with the use of the Focus Setup program.

Backing Up the FE Database

Use the following procedure to back up selected FE System files:

1. If it is not already running, start the Focus Setup program using the procedure given in "Starting Focus Setup" on page B–2.

   The Focus Setup main window is displayed.

2. From the Focus Setup main menu, click on **Backup**.

   The Backup menu is displayed.

3. Select the files to back up using the information below:

   - **Recipe Database** — Backs up the Wafer Recipe database (this includes the optical characteristics of materials, N and K database), and the Vision System pattern database.
   - **Log0** — Backs up the log0 history file.
   - **Configuration Files** — Backs up the calibration files.
   - **Map Files** — Backs up the wafer map files.
   - **Wafer Database** — Backs up the wafer database.

   A window is displayed asking if you wish to backup to drive A:\.

NOTE

The number of floppy disks required to backup the database will vary. However, it is recommended that you have at least 10 blank, formatted, floppy disks available for the backup.

4. Perform **one** of the following:

   - **To backup to a floppy disk in drive A:**, click on **Yes**.

     A window is displayed indicating that the database files are being compressed. When the compression has been completed a window is displayed indicating the number of floppy disks the backup will require. Continue with Step 5.

   - **To backup to a path other than drive A:**, click on **No**.

     A window is displayed in which you may enter the desired backup path. Enter the full path name of the desired backup directory (such as, E:\BACKUP\\) and click on **Enter**. A window is displayed indicating that the selected database files are being written to the backup path. Proceed to Step 7.

5. Click on **OK**.

   A window is displayed instructing you to insert a blank, formatted floppy disk in drive A:\\.

6. Insert a blank, formatted floppy disk in drive A:\ and click on **OK**.

   A window is displayed indicating that the selected database files are being written to the disk. You will be prompted to insert each additional floppy disk that is required to complete the backup.

7. When all files have been written to the selected backup path, a window will be displayed indicating that the backup is complete. Click on the **OK** button.

   One of the following will occur:

   - **If you selected any option from the Backup menu except Log0**, you are returned to the Focus Setup main window.
   - **If you selected Log0 from the Backup menu**, a window is displayed asking if you wish to delete the current Log0 file. Click on **Yes** to delete the Log0 file, click on **No** to leave the current Log0 file on the FE System. You are then returned to the Focus Setup main window.

Restoring the FE Database

Use the following procedure to backup selected FE System files:

1. If it is not already running, start the Focus Setup program using the procedure given in "Starting Focus Setup" on page B–2.

   The Focus Setup main window is displayed.

2. From the Focus Setup main menu, click on **Restore**.

   The Restore menu is displayed.

3. Select the files to restore using the information below:

   - **Recipe Database** — Backs up the Wafer Recipe database (this includes the optical characteristics of materials, N and K database), and the Vision System pattern database.
   - **Configuration Files** — Backs up the calibration files.
   - **Map Files** — Backs up the wafer map files.
   - **Wafer Database** — Backs up the wafer database.

   A window is displayed warning you that the existing files on the FE System will be overwritten.

4. Perform **one** of the following:

   - **To continue with the restore and overwrite the existing files**, click on **OK**.

     A window is displayed asking if you wish to restore from drive A:\. Continue with Step 5.

   - **To abort the restore**, click on **Cancel**.

     You are returned to the Focus Setup main window and the procedure is complete.

5. Perform **one** of the following:

   - **To restore from a floppy disk in drive A:**, click on **Yes**.

     A window is displayed in which you must enter the number of floppy disks that make up the backup set for the selected files. Continue with Step 6.

   - **To restore from a path other than drive A:**, click on **No**.

     A window is displayed in which you may enter the source path for the restore files. Enter the full path name of the desired directory (such as, E:\BACKUP\) and click on **Enter**. A window is displayed indicating that the files are being copied from the restore path. Proceed to Step 8.

6. Enter the number of floppy disks that make up the backup set and click on **Enter**.

   A window is displayed instructing you to insert the first disk in drive A:\.

7. Insert the first backup disk in drive A:\ and click on **OK**.

   A window is displayed indicating that the files are being copied from the floppy disk. You will be prompted to insert each additional floppy disk that is required to complete the restore.

8. When all files have been copied from the selected restore path, a window will be displayed indicating that the restore is complete. Click on the **OK** button.

   You are returned to the Focus Setup main window.

Database Maintenance

In addition to database backup and restore operations, general database maintenance may be performed with the Focus Setup program. These tasks include:

- Deleting the image files that are left behind in the database when associated pattern recognition recipes are deleted.
- Compressing the FE System database to save disk space.

Delete Vision System Files

Use the following procedure to delete the image files that are no longer associated with a current recipe:

1. If it is not already running, start the Focus Setup program using the procedure given in "Starting Focus Setup" on page B–2.

   The Focus Setup main window is displayed.

2. From the Focus Setup main menu, click on **Database** then click on **Vision** when the Database menu is displayed.

   The Vision Database Maintenance window is displayed as shown in Figure B-9. This window will show all of the image files in the database that are no longer associated with a recipe.

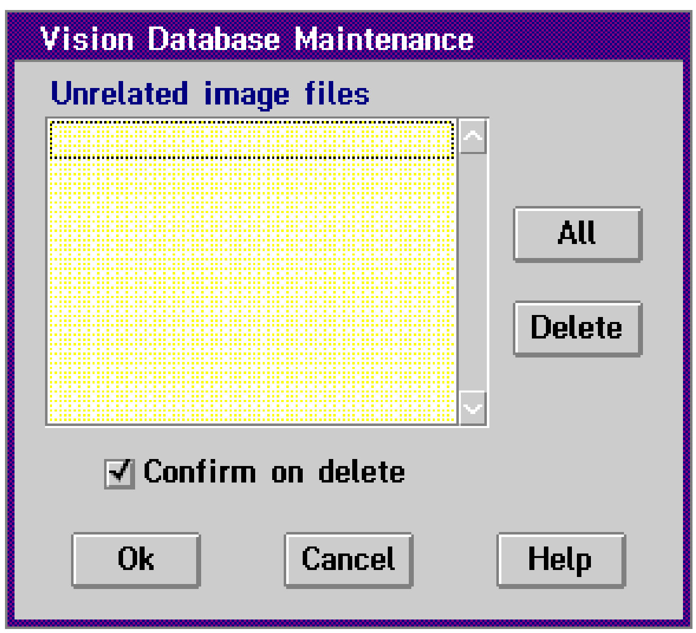

Figure B-9. Vision Database Maintenance Window

3. Select the image file(s) to be deleted by single clicking the left trackball button on the desired name(s) in the list, or click on the **ALL** button to select all of the image files shown.

4. Click on the **Delete** button to delete the selected image files from the database.

5. When the task has been completed, in the Vision Database Maintenance window, click on the **Ok** button.

   You are returned to the Focus Setup main window.

Database Compression

NOTE

Database compression should not be performed unless instructed to do so by Rudolph Support personnel.

Use the following procedure to compress the FE System database:

1. If it is not already running, start the Focus Setup program using the procedure given in “Starting Focus Setup” on page B–2.

   The Focus Setup main window is displayed.

2. From the Focus Setup main menu, click on **Database** then click on **Database Compression** when the Database menu is displayed.

   A window is displayed informing you that this process may take a long time to complete.

3. Perform **one** of the following:

   - **To abort the database compression**, click on **Cancel**.

     You are returned to the Focus Setup main window. This procedure is completed.

   - **To continue with the database compression**, click on **OK**.

     A window is displayed informing you that a temporary database is being created. The Database Compression window is displayed as shown in Figure B-10.

     This window provides information estimating how long the compression will take as well as the size of the database and the amount of free hard disk space both before and after the compression.

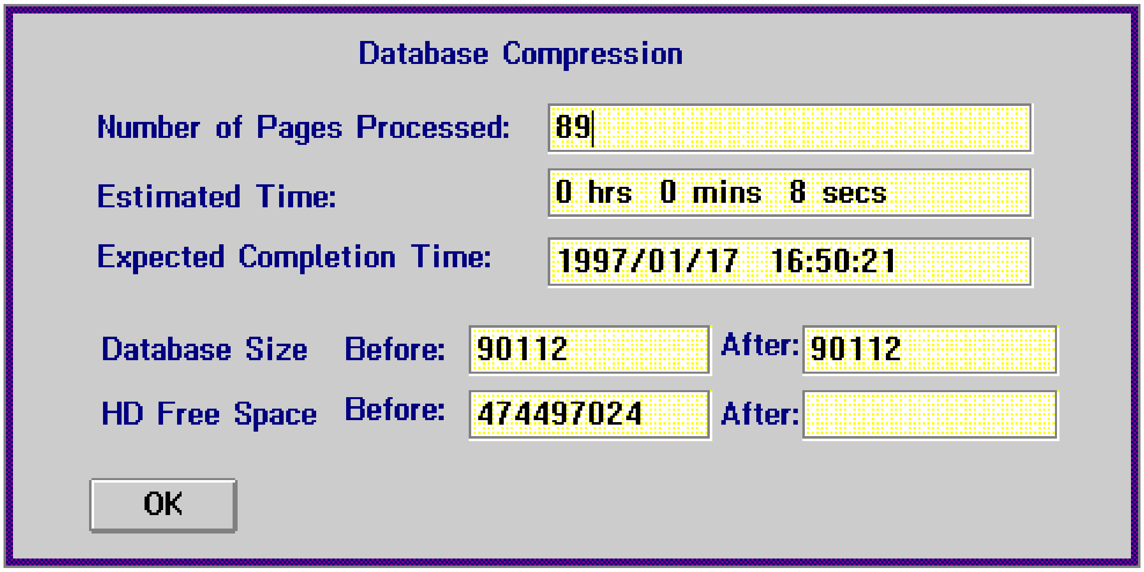

Figure B-10. Database Compression Window

NOTE

If the “HD Free Space” is less than the “Database Size” times 2, the FE System will abort the database compression.

4. Click on **OK** in the Database Compression window.

   A window is displayed informing you that the compression is being performed. When the compression is complete, you are returned to the Focus Setup main window.

Recommended Intervals for Database Backup and Maintenance

The following table provides the recommended intervals for database backup and maintenance procedures:

Table B-1. Recommended Intervals for Database Operations

Database File	Operation	Frequency
Recipe Database	Backup	User determined based on frequency of Recipe creation.
Log0 File	Backup and Delete	Quarterly
Configuration Files	Backup	On installation and after calibration.
Map Files	Backup	User determined based on size of Map file database.
Wafer Database	Backup Compression	User determined based on use of the database. Compression should only be performed when instructed to do so by Rudolph Support personnel.
Vision Files	Purge	Quarterly

SECS-II/GEM

The SECS-II/GEM program provides a programmable interface that allows the FE System to communicate with a host computer.

For detailed information on the SECS-II/GEM interface, refer to Rudolph Technologies document number A11646 entitled “FOCUS Ellipsometer SECS-II/GEM Interface Specifications”.

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Default Recipes and Filmstacks

Appendix C

Introduction

The purpose of this appendix is to provide a listing of the filmstacks, recipes, and measurement controls that are provided by Rudolph Technologies with your FE System. The information in this section applies to the FOCUS Ellipsometer (FE) III, IV, and VII systems.

These listings are provided in tabular form with a brief description of each column following the table.

NOTE

Rudolph supplied filmstacks, recipes, and measurement controls should not be modified or deleted. If changes must be made, make a copy of the desired filmstack, recipe, and/or measurement control to a new file and modify the copy.

Default Filmstacks

The following filmstacks are supplied by Rudolph Technologies and should not be modified or deleted. If necessary, create a copy of the film-stack to a new name and modify the copy.

A description of each column follows the table.

Table C-1. Rudolph Supplied Filmstacks

Filmstack	Laser	Description
150_A-Si/1000_SiO2	632.8/ 780	Computes thickness of the A-Si and bottom oxide layer. Edit spec thicknesses for your application.
aa_Amorphous_EMA	632.8	Uses EMA modeling to compute N, K, and T of an amorphous film. Edit oxide and A-Si spec thicknesses for your application.
aa_Amorphous_TT	632.8	Computes thickness of the A-Si and bottom oxide layer. Edit spec thicknesses for your application.
aa_Nitride_on_Oxide_T	632.8	Computes thickness of top nitride layer. Modify spec thicknesses for your application.
aa_Poly_EMA	632.8	Computes thickness of the Poly layer along with Vf which is used to compute N and K of the Poly. Edit spec thickness of the Poly layer for your application.
aa_Resist_<1um_T	632.8	Performs a standard order search to compute thickness of a Resist layer in the 0 to 12000Å range. Spec thickness set to 4000Å.
aa_Resist_>1um_T	632.8	Performs a standard order search to compute thickness of a Resist layer in the 8k to 3um range. Spec thickness set to 13000Å.
aa_Si3N4_<500_T	632.8	Computes thickness of a nitride layer in the 1 to 700Å range. Spec thickness set to 100Å.
aa_Si3N4_<6000_T	632.8	Performs a standard order search to compute thickness of a nitride layer in the 1 to 7000Å range. Spec thickness set to 500Å.
aa_Si3N4_<6000_TN	632.8	Performs a standard order search to compute thickness and N of a nitride layer in the 300 to 7000Å range. Spec thickness set to 500Å.
aa_Si3N4_>6000_T	632.8	Performs a standard order search to compute thickness of a nitride layer in the 5k to 15kÅ range. Spec thickness set to 9000Å.
aa_Si3N4_>6000_TN	632.8	Performs a standard order search to compute thickness and N of a nitride layer in the 5k to 15kÅ range. Spec thickness set to 9000Å.

Table C-1. Rudolph Supplied Filmstacks (Continued)

Filmstack	Laser	Description
aa_SiO2_<1um_T	632.8	Performs a standard order search to compute thickness of an oxide layer in the 1 to 10000Å range. Spec thickness set to 1000Å.
aa_SiO2_<1um_TN	632.8	Performs a standard order search to compute thickness and N of an oxide layer in the 400 to 10kÅ range. Spec thickness set to 1000Å.
aa_SiO2_<500_T	632.8	Computes thickness of an oxide layer in the 1 to 900Å range. Spec thickness set to 100Å.
aa_SiO2_>1um_T	632.8	Performs a standard order search to compute thickness of an oxide layer in the 8k to 25kÅ range. Spec thickness set to 13000Å.
aa_SiO2_>1um_TN	632.8	Performs a standard order search to compute thickness and N of an oxide layer in the 8k to 18kÅ range. Spec thickness set to 13000Å.
ad_Amorphous_TKK	632.8/ 780	Computes T, K, and K2 of the A-Si layer. Spec thickness range is +/-1600Å. Edit spec thicknesses for your application.
ad_Amorphous_TT	632.8/ 780	Computes thickness of the A-Si and bottom oxide layer. Edit spec thicknesses for your application.
ad_CMP-Ox/TiN/Al-TT	632.8/ 780	Measures thickness of the TEOS layer and the Tin layer simultaneously. Edit spec thicknesses for your application.
ad_CMP-Ox/Metal-T-Ns	632.8/ 780	Measures thickness of the TEOS layer along with the optical constants of the “substrate” underneath.
ad_Ox/Poly/Ox_TT	632.8/ 780	Computes thickness of the top oxide and poly layers. Modify all spec thicknesses for your application.
ad_Poly_EMA	632.8/ 780	Poly is represented as two layers (Poly-Si and Interface). After calculation, the thicknesses are added together. Spec thickness range is +/-1600Å. Edit spec thicknesses for your application.
ad_Poly_T	632.8/ 780	Poly is represented as two layers (Poly-Si and Interface). After calculation the thicknesses are added together. Spec thickness range is +/-1600Å. Edit spec thicknesses for your application.
ad_Resist_>2um_T	632.8/ 780	Performs a standard order search to compute thickness of an N-Resist layer. Spec thickness range is +/-8000Å.
ad_Si3N4_>1um_T	632.8/ 780	Performs a standard order search to compute thickness of a nitride layer. Spec thickness range is +/-7000Å.
ad_Si3N4_>1um_TN	632.8/ 780	Performs a standard order search to compute thickness and N of a nitride layer. Spec thickness range is +/-7000Å.
ad_SiO2>4um_T	632.8/ 780	Performs a standard order search to compute thickness of an oxide layer. Spec thickness range is +/-10600Å.

Table C-1. Rudolph Supplied Filmstacks (Continued)

Filmstack	Laser	Description
DEFAULT	632.8	Default filmstack specification. Performs a standard order search to compute thickness of an oxide layer. Spec thickness set to 1000Å. Edit spec thickness for your application.
tp_SiO2_<1um_T_Rough	632.8	Used as a throughput test for rough film. Performs a standard order search to compute thickness of an oxide layer in the 1 to 10000Å range. Spec thickness set to 1000Å.
zCal-100	632.8/ 780	Calibration filmstack for use with Rudolph's 100Å SiO2 check sample wafer.
zCal-1100	632.8/ 780	Calibration filmstack for use with Rudolph's 1100Å SiO2 check sample wafer.
zCal-1um	632.8/ 780	Calibration filmstack for use with Rudolph's 1000Å SiO2 check sample wafer.
zCal-2300	632.8/ 780	Calibration filmstack for use with Rudolph's 2300Å SiO2 check sample wafer.
zCal-400	632.8/ 780	Calibration filmstack for use with Rudolph's 400Å SiO2 check sample wafer.
zCal-950-Nit	632.8/ 780	Calibration filmstack for use with Rudolph's 950Å Si3N4 check sample wafer.

- **Filmstack** — The name of the Rudolph supplied filmstack.

NOTE

Do not modify the Rudolph supplied filmstacks. Make a copy of the desired filmstack and modify the copy if desired.

- **Laser** — Indicates the laser wavelength(s) used by each filmstack.
- **Description** — A brief description of each filmstack.

Default Recipes

The following wafer recipes are supplied by Rudolph Technologies and should not be modified or deleted. If necessary, create a copy of the recipe and modify the copy.

A description of each column follows the table.

Table C-2. Rudolph Supplied Wafer Recipes

Recipe	Description
aa6inOxCir49pt-Map	Used to measure 49 points of an SiO2 film on a 6" wafer in an octal circular pattern. A wafer map file is generated.
aa6inOxStd5pt	Used to measure 5 points in a standard pattern of an SiO2 film on a 6" wafer.
aa8inOxCir49pt-Map	Used to measure 49 points of an SiO2 film on an 8" wafer in an octal circular pattern. A wafer map file is generated.
aa8inOxStd5pt	Used to measure 5 points in a standard pattern of an SiO2 film on an 8" wafer.
aa8inOx_Linescan_20pt	Used to measure 20 points along a line to create a linescan graph of an SiO2 film on an 8" wafer.
tp8inCir49pt_Fast-Map	Throughput test recipe using an 8" wafer and a circular 49 point measurement pattern in a high speed measurement mode. A map file is generated.
tp8inStd5pt_Dual	Throughput test recipe using both IR and HeNe lasers to measure 5 points in a standard pattern on an 8" wafer.
tp8inStd5pt_Fast	Throughput test recipe using high speed mode to measure 5 points in a standard pattern on an 8" wafer.
tp8inStd5pt_Rough	Throughput test recipe applying rough film measurement techniques to measure 5 points in a standard pattern on an 8" wafer.
tp8inStd5pt_Slow	Throughput test recipe using high repeatability measurement mode to measure 5 points in a standard pattern on an 8" wafer.
tp8inStd9pt_Fast	Throughput test recipe using high speed mode to measure 9 points in a standard pattern on an 8" wafer.
tp8inStd9pt_Slow	Throughput test recipe using high repeatability measurement mode to measure 9 points in a standard pattern on an 8" wafer.
xx5in_Notch_Std5pt	Used to measure 5 points in a standard pattern of an SiO2 film on an 5" notched wafer.
xx5in_Ox_10pt_cnt	Used to measure 10 points in a center pattern of an SiO2 film on a 5" wafer.

Table C-2. Rudolph Supplied Wafer Recipes (Continued)

Recipe	Description
xx6in_2.7KPoly_10pt_cnt	Used to measure 10 points in a center pattern of a Poly layer with a thickness of 2.7kÅ on a 6" wafer.
xx6in_4KPoly_10pt_cnt	Used to measure 10 points in a center pattern of a Poly layer with a thickness of 4kÅ on a 6" wafer.
xx6in_550Poly_10pt_cnt	Used to measure 10 points in a center pattern of a Poly layer with a thickness of 550Å on a 6" wafer.
xx6in_Ox_10pt_cnt	Used to measure 10 points in a center pattern of an SiO2 film on a 6" wafer.
xx8in_Ox_5pt_Fast	Used to measure 5 points in a standard pattern of an SiO2 film on an 8" wafer using high speed mode.

- **Recipe** — The name of the Rudolph supplied recipe.

NOTE

Do not modify the Rudolph supplied recipes. Make a copy of the desired recipe and modify the copy if desired.

- **Description** — A brief description of each recipe.

Default Measurement Controls

The following measurement controls are supplied by Rudolph Technologies and should not be modified or deleted. If necessary, create a copy of the measurement control and modify the copy.

A description of each column follows the table.

Table C-3. Rudolph Supplied Measurement Controls

Measurement Control	Laser	Meas. Avg.	# of Angles	Angle Range	Psi Excl.	Tilt	Description
aa_Rough_Film	632.8	40	10	Full	Yes	Fast	Vibrates stage for improved performance on rough films. Can be used for Poly EMA, OPO, and films on metal.
aa_Thick_>1um	632.8	20	10	Full	Yes	Fast	Used for thick films from 5000Å to 4um. Can be used for thick Resists, Oxides, Nitrides and some Poly.
aa_Thin_<500A	632.8	40	10	Reduced	No	On	Used for thin films less than 500Å. High repeatability mode with slight decrease in throughput.
aa_Thin_Fast_<1um	632.8	20	10	Reduced	No	Fast	High throughput mode (auto-height and tilt at first measurement point, auto-height only for all other points). Recommended for films 500Å to 1um.
aa_Tilt_Lock	632.8	20	10	Reduced	No	Off	Tilt lockout mode for applications which exhibit weak tilt signal error message. Certain nitride thickness regions, Poly thickness regions, and samples with metal layers may exhibit this condition.
ad_Dual	632.8/ 780	10	10	Reduced	Yes	Fast	Standard dual wavelength measurement. Used for improved Poly and A-SI Order Resolution, extended thick film Order Resolution (nitride > 1um, Resist > 2um, Oxide > 4um), and better OPO measurement performance.
ad_Dual_Rough	632.8/ 780	20	10	Reduced	Yes	Fast	Dual wavelength measurement with improved performance on rough films. Can be used for Poly, OPO, A-SI, films on metals, and etch surfaces).
DEFAULT	632.8	40	10	Reduced	No	On	Standard measurement mode equivalent to Thin Mode. Used for thin film applications.
zzCalibrate	632.8/ 780	80	10	Reduced	No	On	Only used in Check Sample Calibration Filmstacks.

- **Measurement Control** — The name of the Rudolph supplied measurement control.

NOTE

Do not modify the Rudolph supplied measurement controls. Make a copy of the desired measurement control and modify the copy if desired.

- **Laser** — Indicates the laser wavelength(s) used by each measurement control.
- **Meas. Avg.** — The measurement averages used by each measurement control. One measurement average is taken for each revolution of the compensator. With an increased number of averages, the effects of noise are lessened and averaged out.
- **# of Angles** — Indicates the number of delta-psi pairs that will be used in the modeling of the filmstack.
- **Angle Range** — Indicates whether the measurement control uses Full or Reduced angle range. Full range covers 25° so 10 angles will be selected within a 25° range. Reduced range covers 15°. This determines how close or far apart each angle is from the other.
- **Psi Excl.** — Indicates whether the measurement control uses Psi Exclusion. This is normally used when modeling thick films or some Poly thickness regions. Any angles that produce Psi values that fall below 15° or higher than 55° will be eliminated from the modeling.
- **Tilt** — Indicates the tilt mode used by each measurement control. When the tilt is On, auto-tilt is performed at every measurement site. Fast tilt will perform auto-height and tilt at the first point, and auto-height only at all the other sites.
- **Description** — A brief description of each measurement control.

Menu Maps Quick Reference

Appendix D

Introduction

The purpose of this appendix is to provide menu maps for each of the programs that make up the FOCUS software package. The information in this section pertains to the FOCUS Ellipsometer (FE) III, IV, and VII systems, and includes the following:

- Menu maps for the Focus Interactive program including:
  - Main menu (Figure D-1 on page D–3)
  - Site Locator window menu (Figure D-2 on page D–4)
  - Filmstack Model window menu (Figure D-3 on page D–4)
  - EMA Material window menu (Figure D-4 on page D–4)
- Menu maps for the Focus Recipe Creator program including:
  - Main menu (Figure D-5 on page D–5)
  - Site Locator window menu (Figure D-6 on page D–6)
  - Stepper Group Pattern Training window menu (Figure D-7 on page D–6)
- Menu maps for the Focus Operator program including:
  - Site Locator window menu (Figure D-8 on page D–7)
  - File viewer window menu (Figure D-9 on page D–7)
- Menu maps for the Focus Browser program including:
  - Main menu (Figure D-10 on page D–8)
  - File viewer window menu (Figure D-11 on page D–8)
  - Graphics window menu (Figure D-12 on page D–9)

- Menu maps for the Focus Mapping program including:
  - Main menu (Figure D-13 on page D–10)
  - Wafer Map window menu (Figure D-14 on page D–10)
  - File viewer window menu (Figure D-15 on page D–11)
  - Graphics window menu (Figure D-16 on page D–11)
- Menu maps for the Focus Setup program including:
  - Main menu (Figure D-17 on page D–12)

Detailed descriptions for the selections from each of the menus are included in the chapter that pertains to that particular program.

Focus Interactive Menus

Figure D-1 through Figure D-4 show the menu maps for the Focus Interactive program. Descriptions of the menu items and instructions for using the Focus Interactive program are provided in Chapter 3, “Developing Film Applications”.

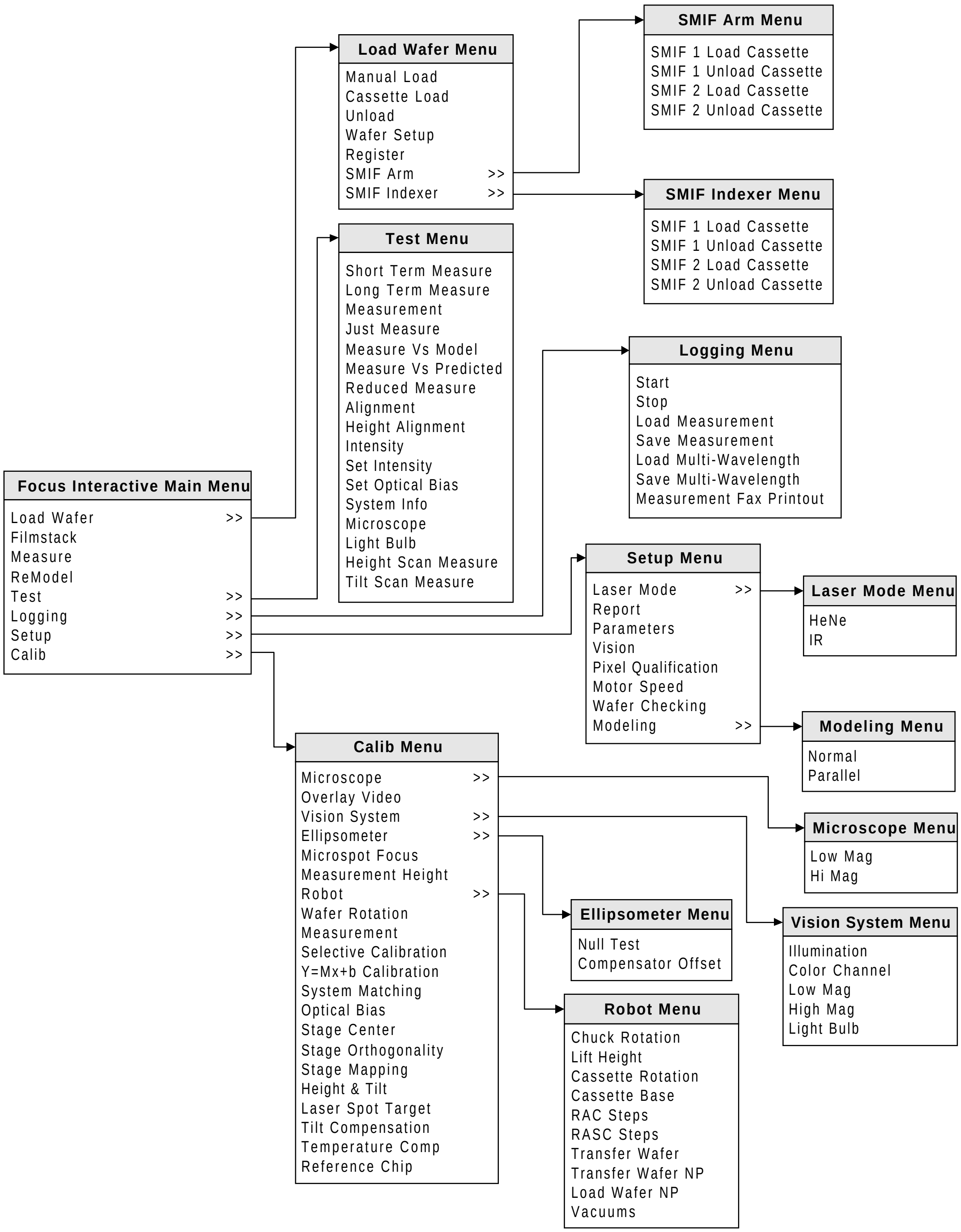


Figure D-1. Focus Interactive Program Main Menu

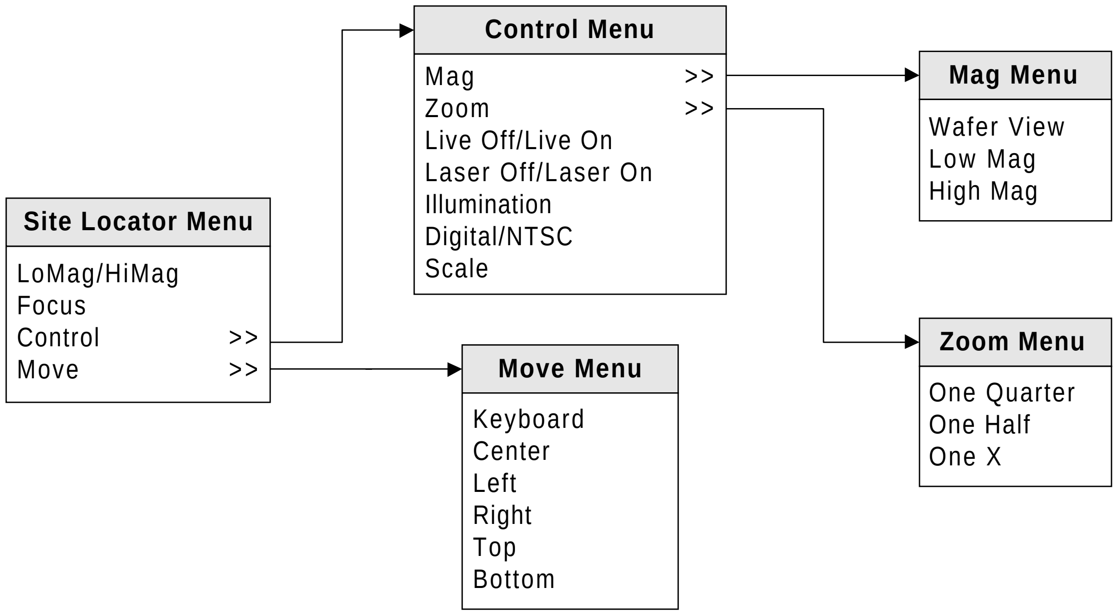


Figure D-2. Focus Interactive Site Locator Window Menu

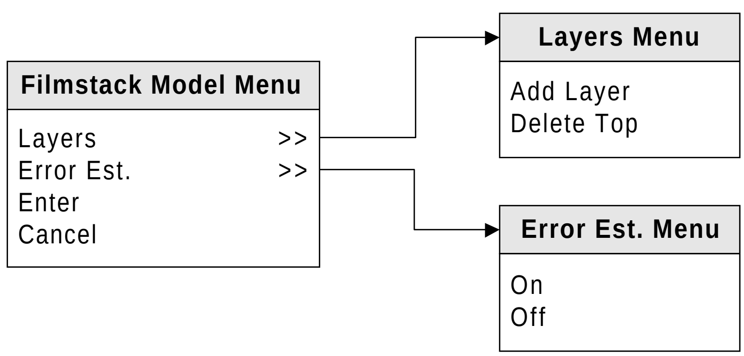


Figure D-3. Focus Interactive Filmstack Model Window Menu

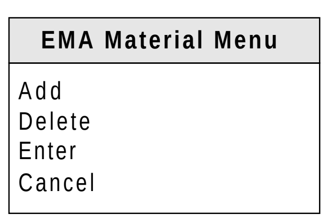


Figure D-4. Focus Interactive EMA Material Window Menu

Focus Recipe Creator Menus

Figure D-5 through Figure D-7 show the menu maps for the Focus Recipe Creator program. Descriptions of the menu items and instructions for using the Focus Recipe Creator program are provided in Chapter 4, "Creating Recipes".

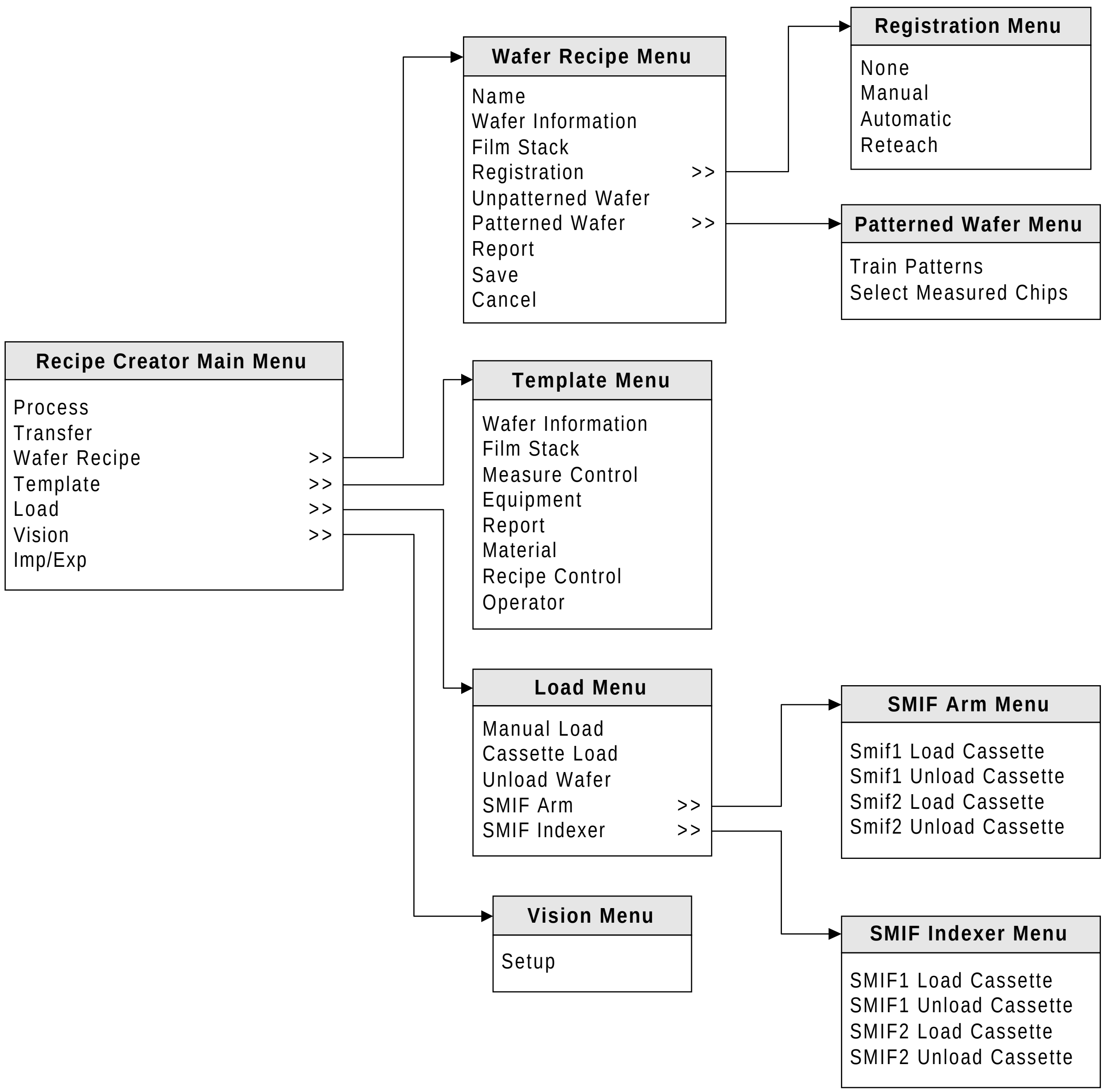


Figure D-5. Focus Recipe Creator Main Menu

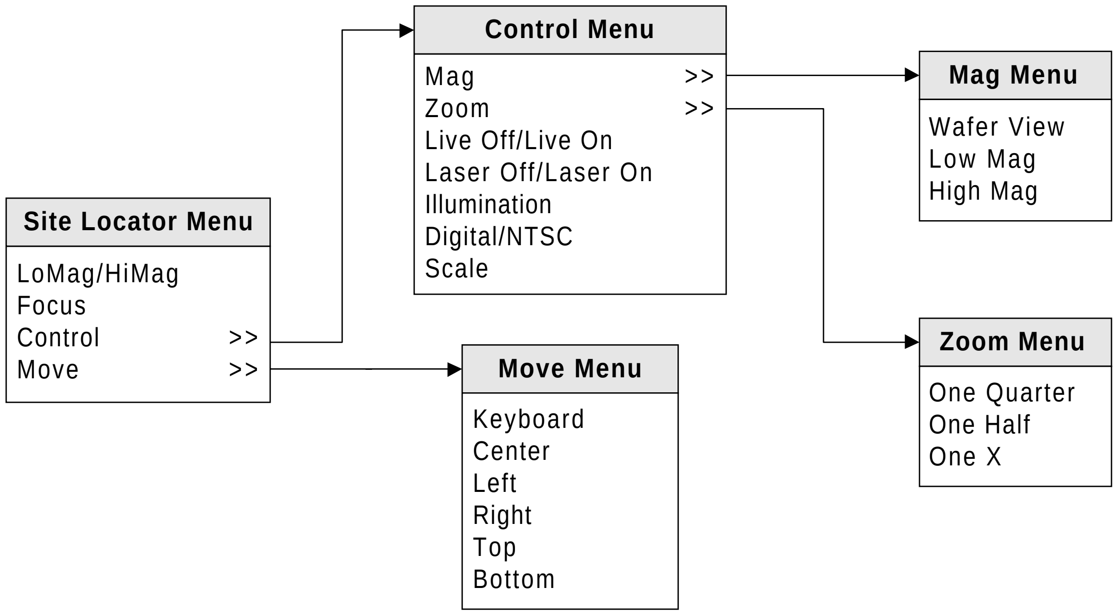


Figure D-6. Focus Recipe Creator Site Locator Window Menu

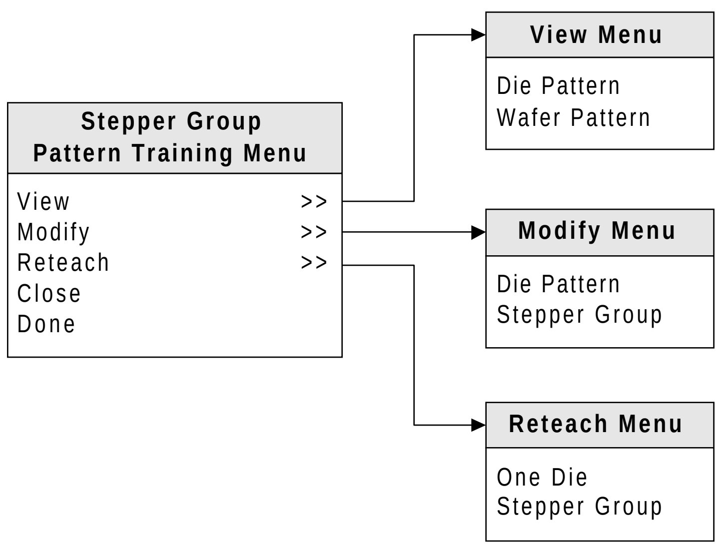


Figure D-7. Focus Recipe Creator Stepper Group Pattern Training Menu

Focus Operator Menus

Figure D-8 through Figure D-9 show the menu maps for the Focus Operator program. Descriptions of the menu items and instructions for using the Focus Operator program are provided in Chapter 2, "Operator Interface".

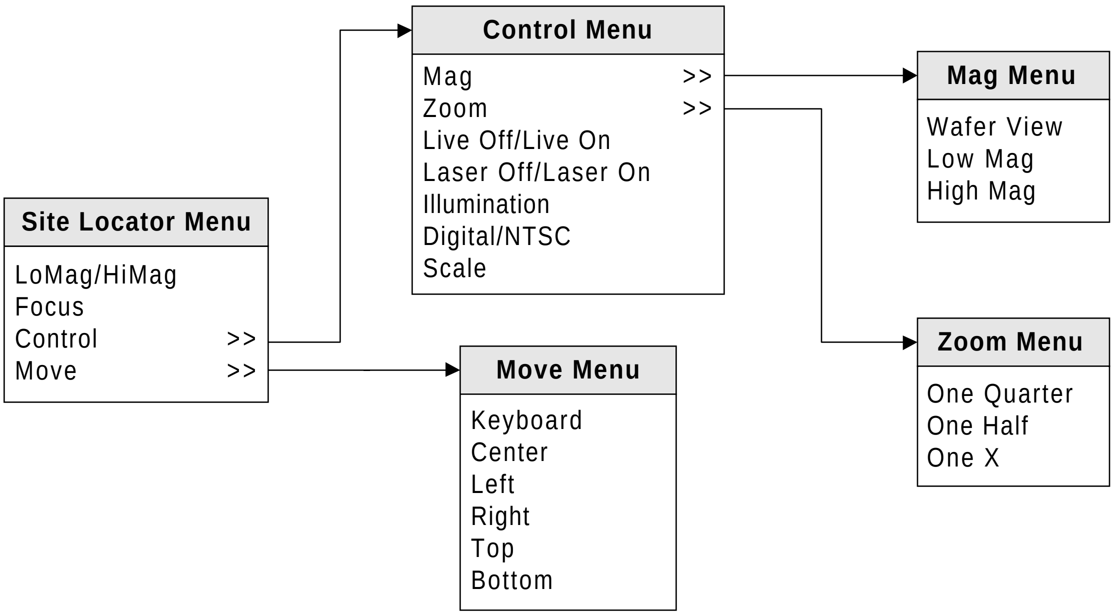


Figure D-8. Focus Operator Site Locator Window Menu

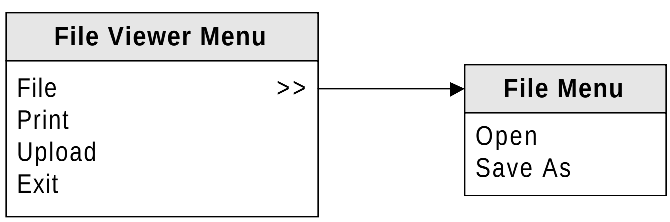


Figure D-9. Focus Operator File Viewer Menu

Focus Browser Menus

Figure D-10 through Figure D-12 show the menu maps for the Focus Browser program. Descriptions of the menu items and instructions for using the Focus Browser program are provided in Chapter 5, “Wafer Mapping and Data Reporting”.

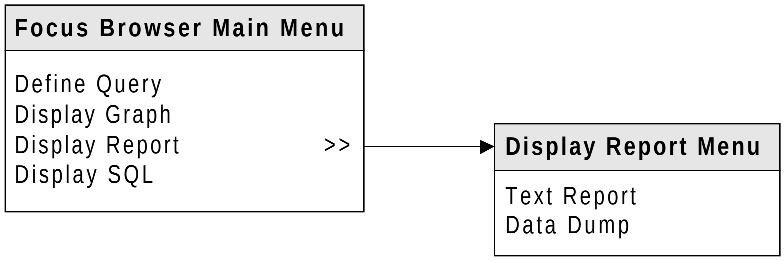


Figure D-10. Focus Browser Main Menu

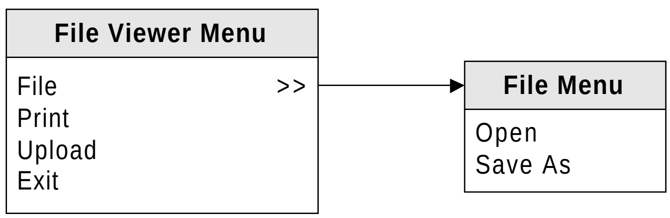


Figure D-11. Focus Browser File Viewer Menu

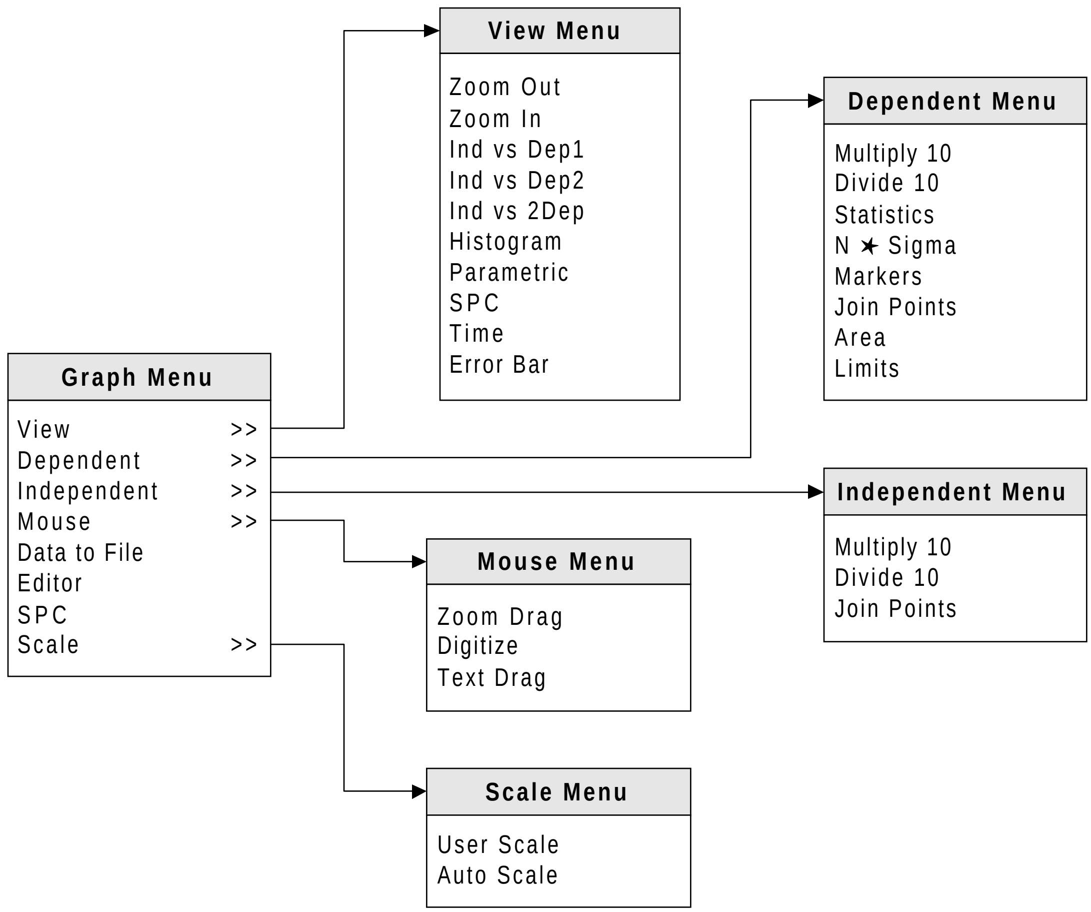


Figure D-12. Focus Browser Measurement Graph Menu

Focus Mapping Menus

Figure D-13 through Figure D-16 show the menu maps for the Focus Mapping program. Descriptions of the menu items and instructions for using the Focus Mapping program are provided in Chapter 5, "Wafer Mapping and Data Reporting".

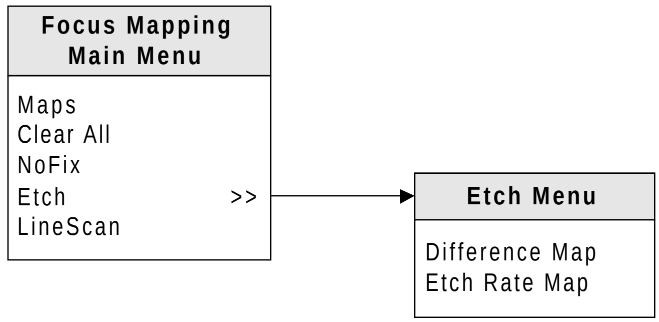


Figure D-13. Focus Mapping Main Menu

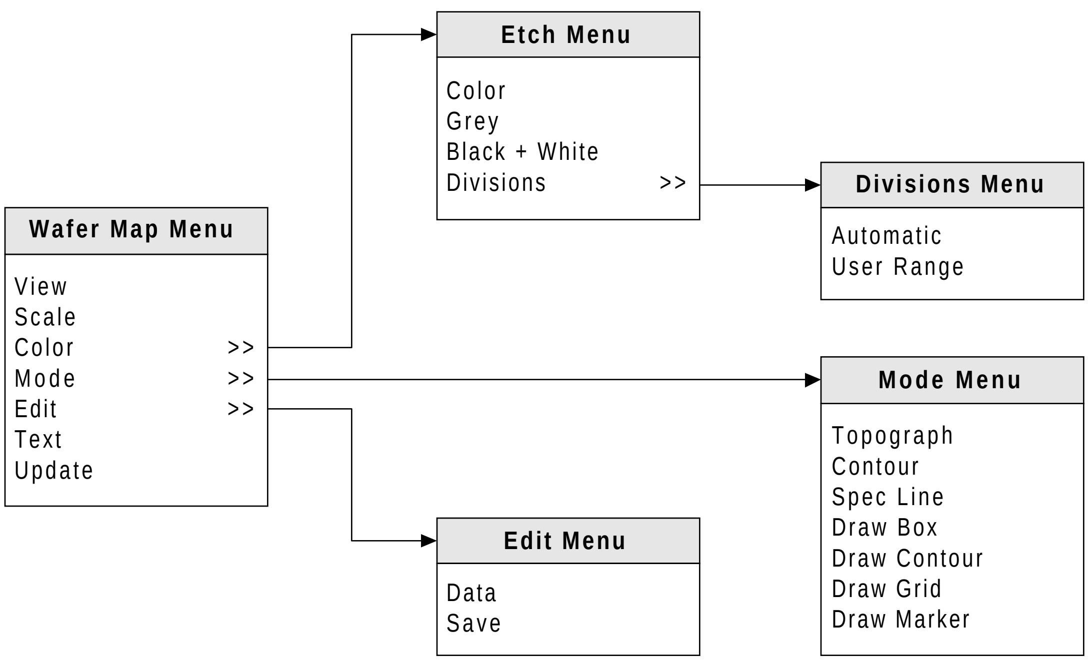


Figure D-14. Focus Mapping Wafer Map Window Menu

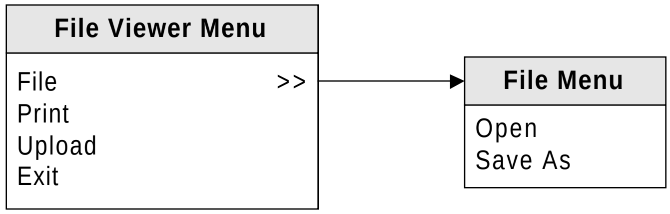


Figure D-15. Focus Mapping File Viewer Menu

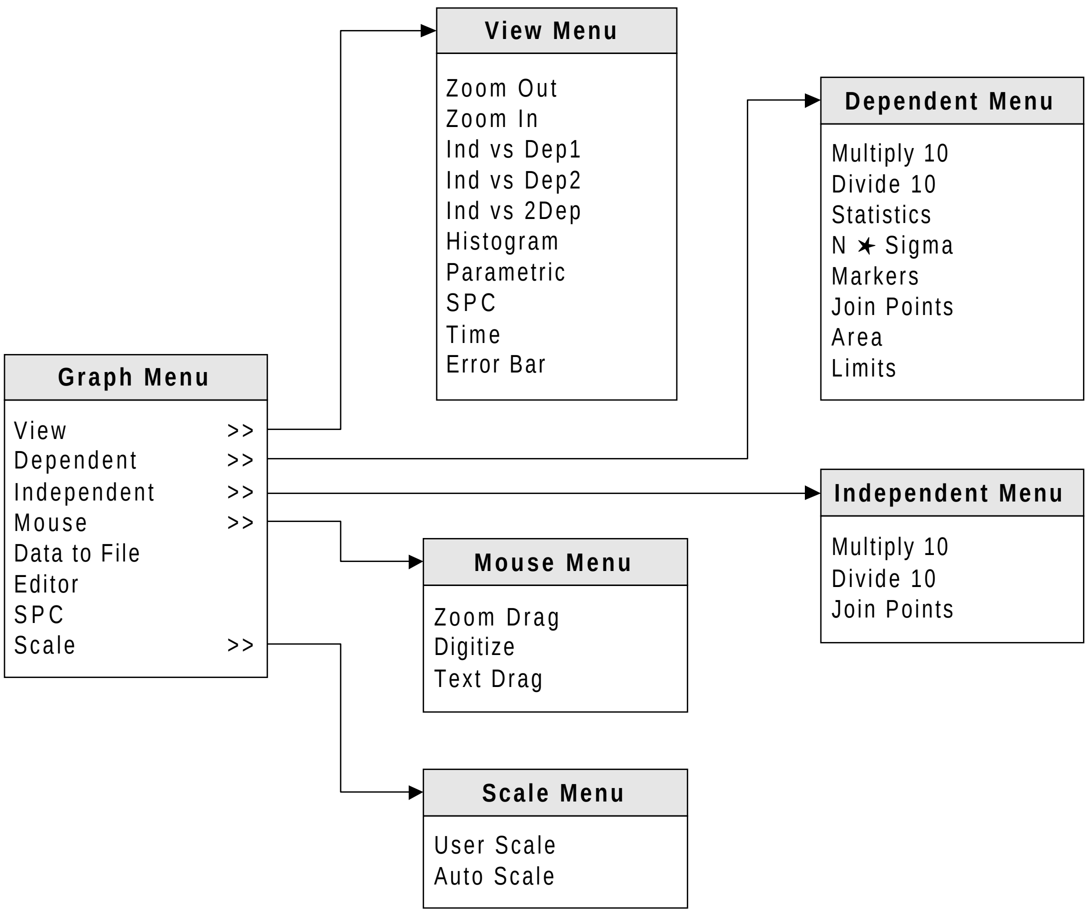


Figure D-16. Focus Mapping Graphics Menu

Focus Setup Menus

Figure D-17 shows the menu map for the Focus Setup program. Descriptions of the menu items and instructions for using the Focus Setup program are provided in Appendix B, "System Configuration".

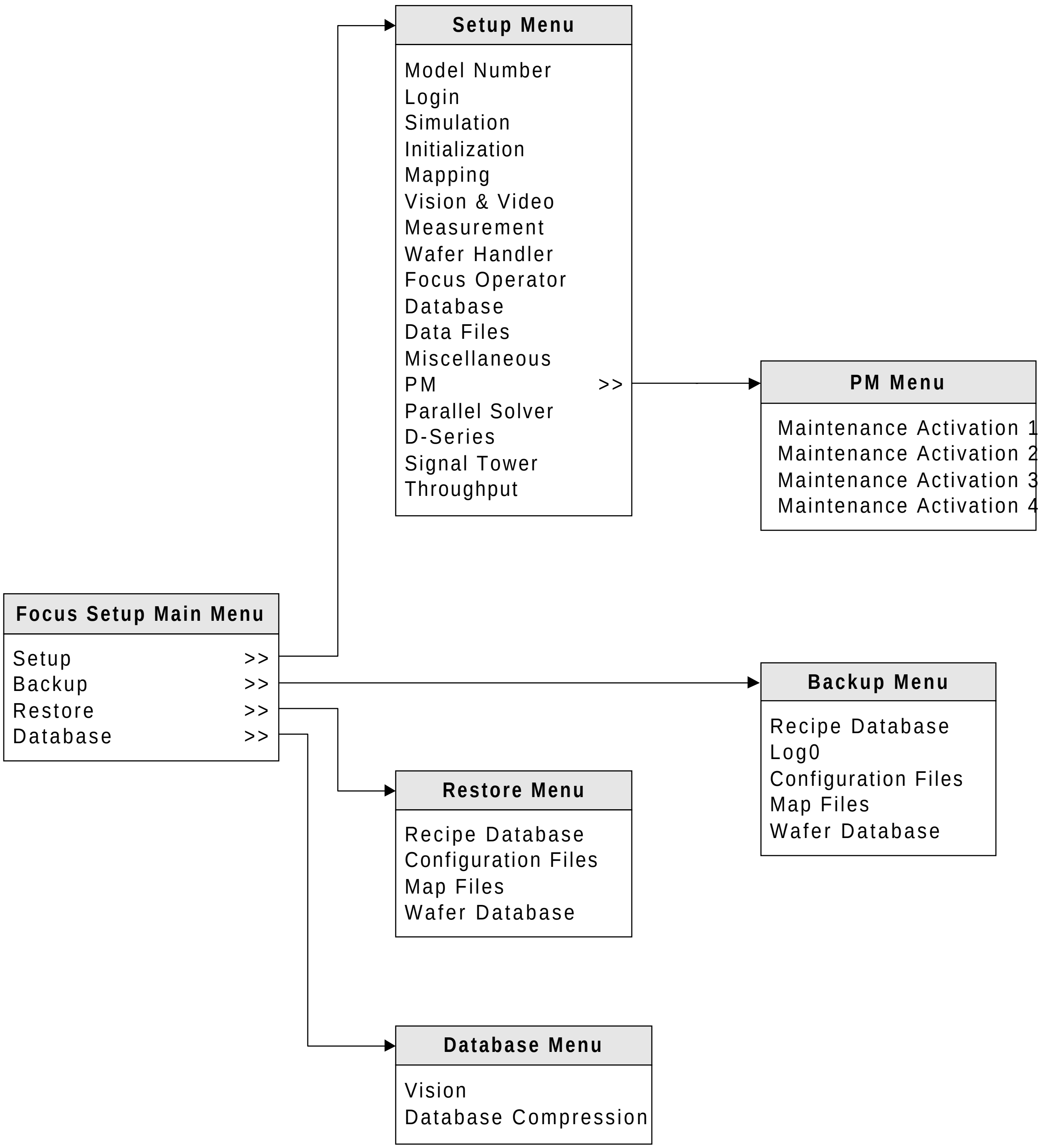


Figure D-17. Focus Setup Program Main Menu

Theory of Operation

Appendix E

Introduction

Ellipsometry is an optical technique used for the characterization of surfaces and thin films on surfaces. It is both non-contact and non-destructive.

Ellipsometers measure changes in the polarization state of light. When these polarization state changes are caused by reflection from a sample surface at non-normal incidence, it is possible to calculate certain optical properties of the surface, such as the index of refraction (**N**) and extinction coefficient (**K**). If thin films are present on the surface, it is also possible to determine the thickness (**T**) of these films.

In general, the equations which relate the polarization state change to the sample properties cannot be solved for the sample properties analytically. Consequently, the sample properties are determined through an extensive modeling process.

Interaction of Light with Material

The index of refraction (**N**) and extinction coefficient (**K**) are the constants that characterize the optical properties of a material.

Refractive index is defined by the equation **N=C/V**, which describes the ratio of the velocity of light in vacuum to the velocity of light when passing through another medium. $N \cong 1$ for light propagating through air and other gasses.

The extinction coefficient (**K**) describes how absorbing a material is. For dielectric materials such as glass and transparent films, little visible light is absorbed and $K \cong 0$. This is also the case for light in vacuum.

N and **K** are both a function of wavelength, but are constants at each wavelength of light used for ellipsometry measurements.

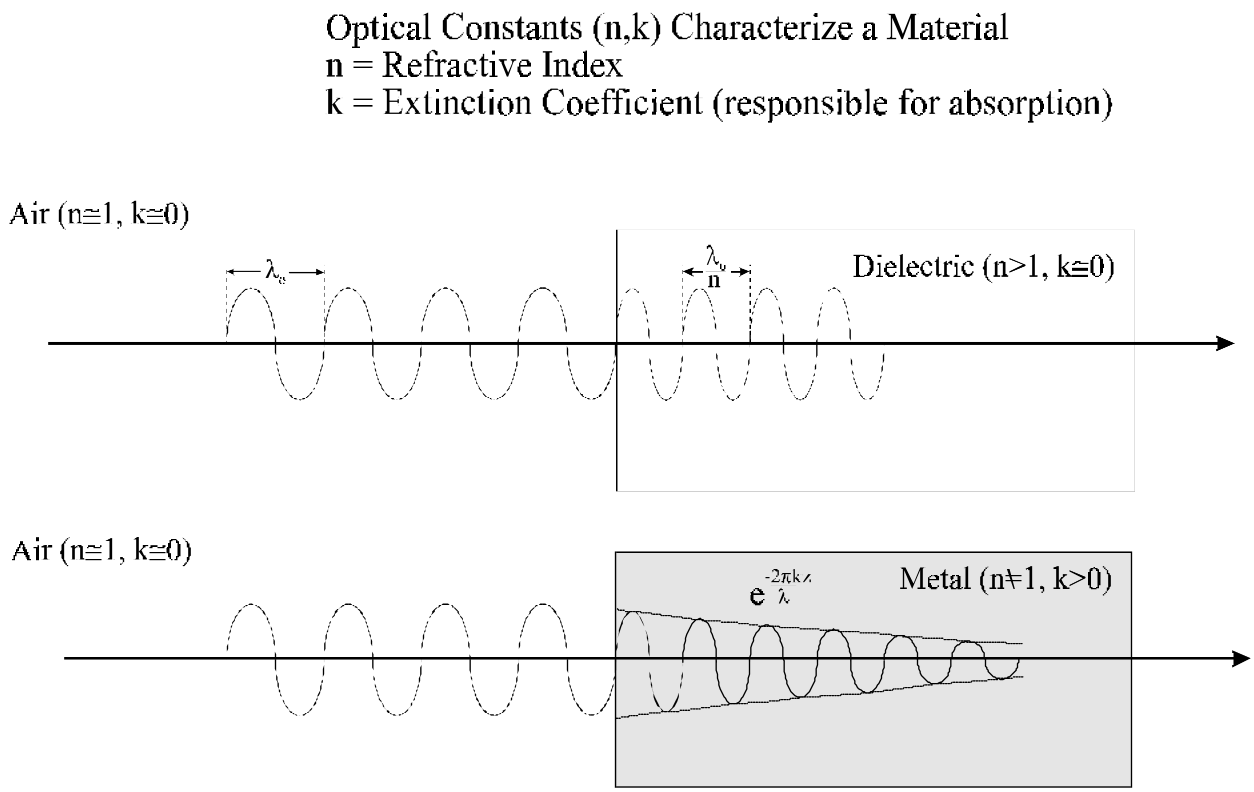


Figure E-1. Light Propagation in Materials

Polarized Light

The polarization state of light is described by the orientation of the electric fields of its components. The components that constitute the resultant electric field are represented as $\mathbf{E_x}$ and $\mathbf{E_y}$. Polarized light may be obtained by passing the light beam through polarizing optics or by causing the beam to be reflected under certain conditions.

Unpolarized light has components with electric fields oriented in all directions perpendicular to the direction of propagation.

Linear Polarization

Linearly or plane polarized light occurs when all of the photons in a light beam have the electric field oriented in one direction. If two linearly polarized light beams, one vertical and one horizontal, with the same frequency, amplitude, and phase are combined, the resultant electric field vector is also linearly polarized 45° from each of the original beams. If the amplitudes were not the same, the angle of polarization would be determined by the vector sum of the electric field vector.

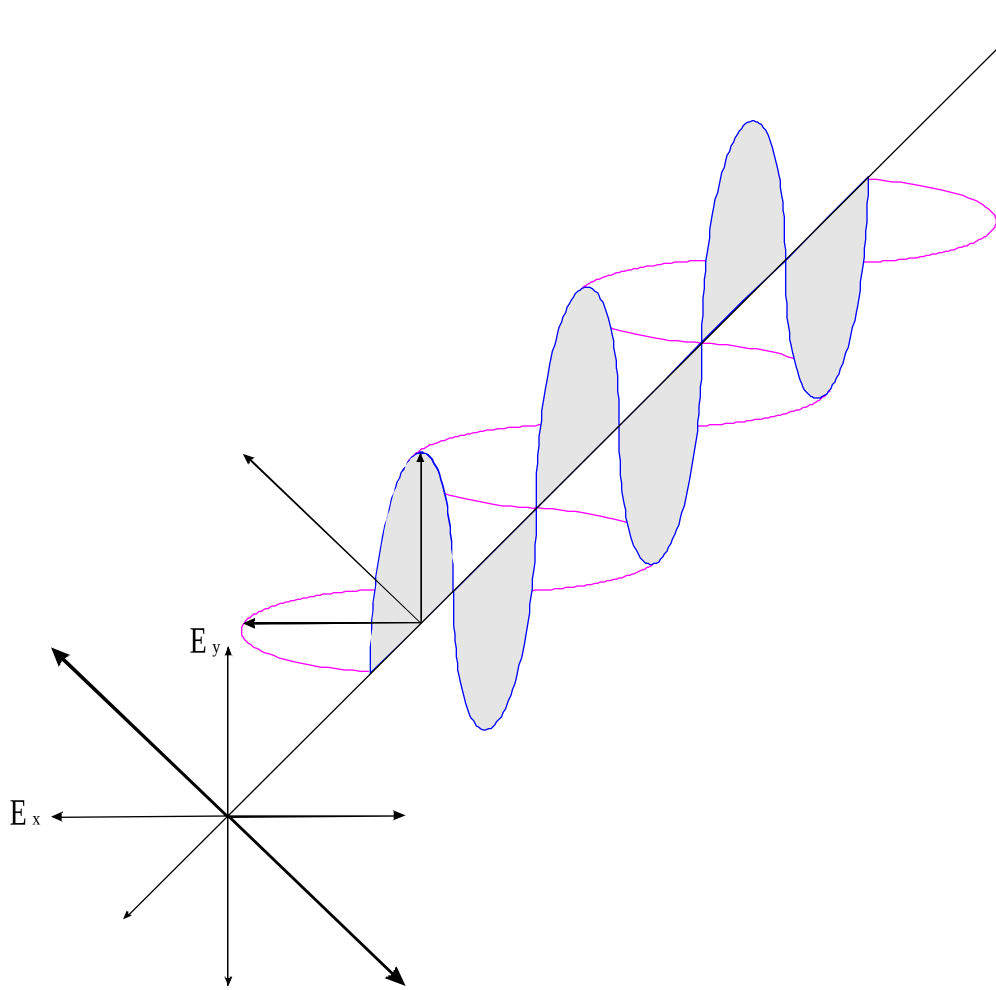


Figure E-2. Linear Polarization

Circular Polarization

Circularly polarized light results from the combination of two linearly polarized light beams whose electric field components are of equal magnitude and are 90° out of phase. Looking down the direction of propagation, the tip of the resultant electric field vector would appear to trace a circle.

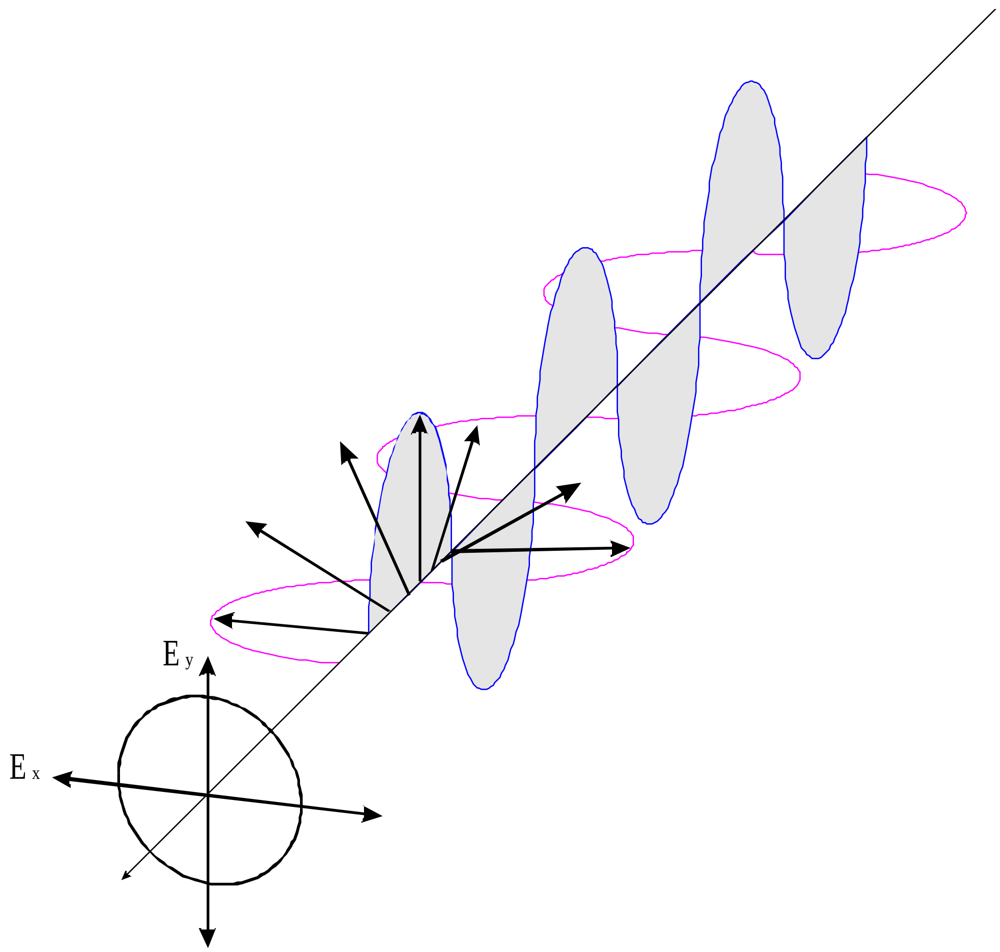


Figure E-3. Right-Circular Polarization

Elliptical Polarization

Elliptically polarized light, the most general form of polarized light, exhibits its electric field components with any phase difference and unequal magnitudes.

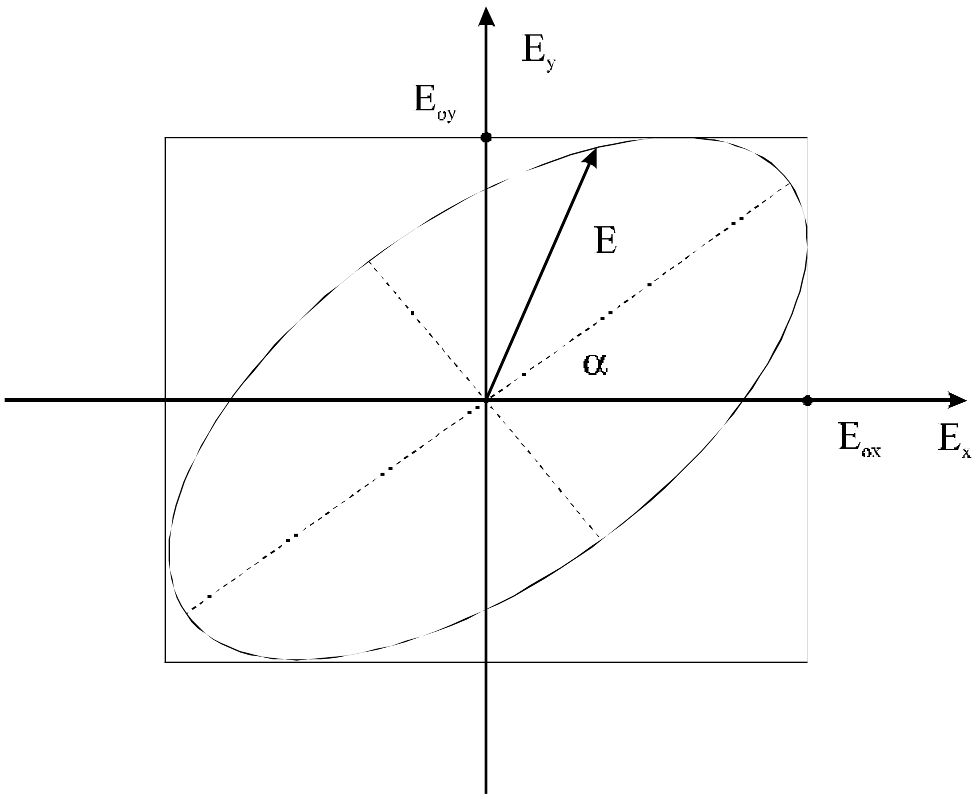


Figure E-4. Elliptical Polarization

Reflection of Light from a Surface

Ellipsometry involves the reflection of elliptically polarized light from a surface. In order to characterize the behavior of the reflected light, it is divided into two components, the **P** and **S** polarization states. The **P** component refers to the linearly polarized light parallel to the plane of incidence, and the **S** component describes the linearly polarized light perpendicular to the plane of incidence.

The Fresnel reflection coefficient **r** describes the reflection of the incident light at a bare surface. The Fresnel reflection coefficients of both the **S** and **P** states are defined as the ratio of the amplitude of the reflected wave to the amplitude of the incident wave of each polarization state. Similar equations exist for transmission, but are not used in reflection ellipsometry.

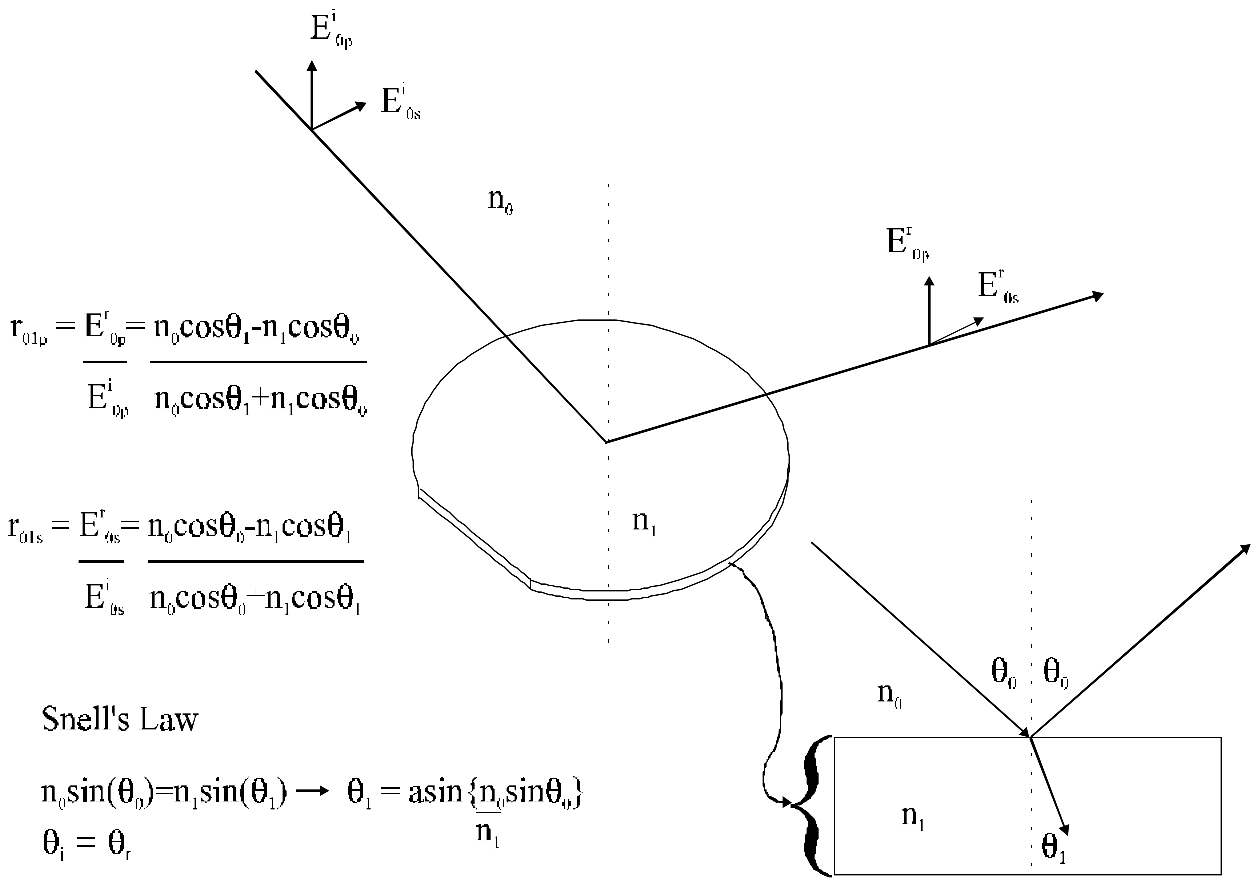


Figure E-5. Fresnel Equations

Most situations involve multiple refractive index boundaries, and the resultant light returning to the initial medium is composed of multiple reflections and transmissions. The total reflection coefficients $\mathbf{R_p}$ and $\mathbf{R_s}$ account for this, and are determined by the individual Fresnel reflection coefficients of each interface. $\mathbf{R_p}$ and $\mathbf{R_s}$ are defined as the ratios of the amplitudes of the resultant reflected waves to the amplitudes of the incident waves.

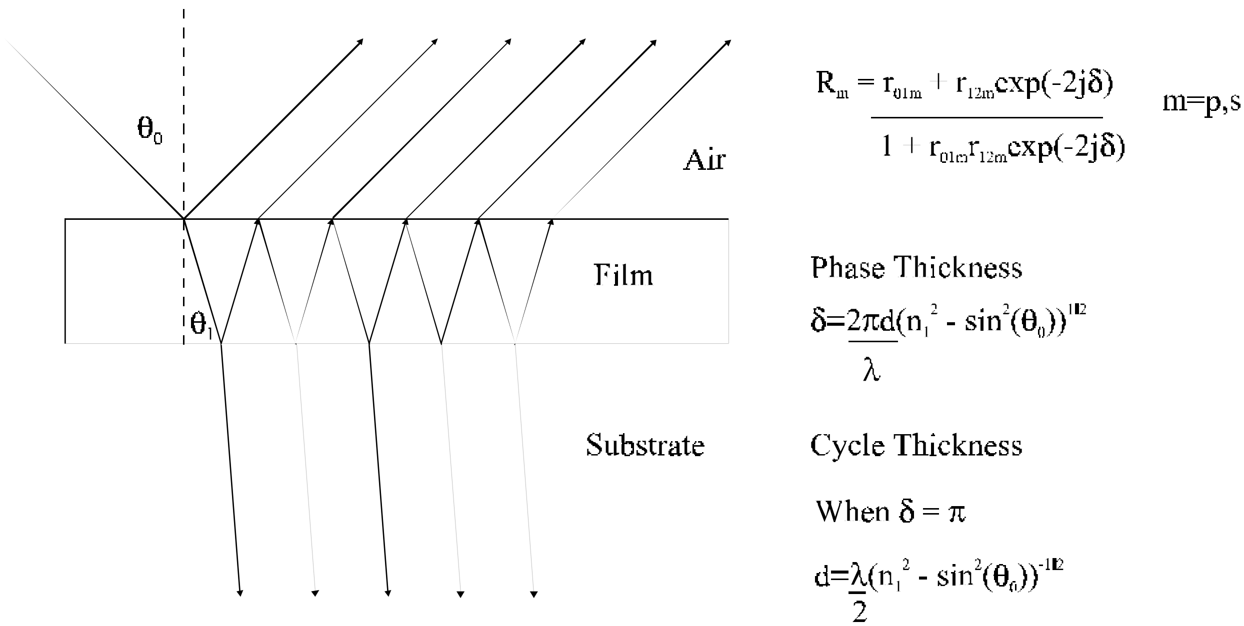


Figure E-6. Multi-Reflection Through Thin Dielectric

Ellipsometry Parameters Δ and Ψ

Δ (delta) is the change in phase difference between the **P** and **S** components of the incident light and the **P** and **S** components of the reflected light. Δ ranges from zero to 360°.

Ψ (psi) is the angle whose tangent is the ratio of the magnitudes of the total reflection coefficients $\mathbf{R_p}$ and $\mathbf{R_s}$. Ψ represents the change in amplitude upon reflection, and can be between zero and 90°.

The fundamental equation of ellipsometry is a relationship between Δ, Ψ, $\mathbf{R_p}$, and $\mathbf{R_s}$. From this equation, information about the sample in question, such as thickness and index of refraction, may be obtained.

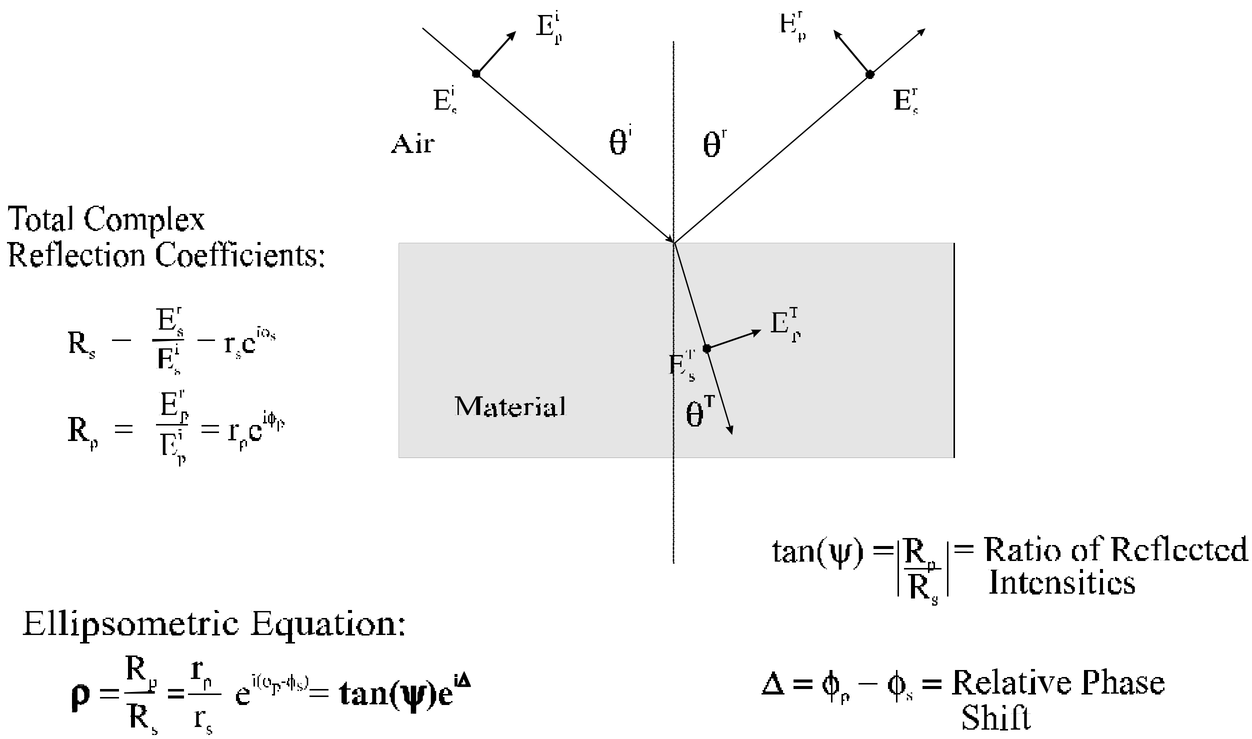


Figure E-7. Two Polarization States (S&P) for Light Reflected from a Surface

Δ / Ψ Trajectories and Cycle Thickness

Knowing **T**, **N**, and **K** of a film and **N** and **K** of a substrate, the expected Δ and Ψ values can be calculated for a fixed wavelength and angle of incidence. By varying **T**, different Δ and Ψ values are obtained, and can be plotted to form what is called a Δ/Ψ trajectory.

For dielectric films with K=0, the trajectory closes in on itself at a specific thickness called the cycle thickness ($\mathbf{T_c}$). Therefore, $\mathbf{T_c}$ denotes one full cycle around the closed trajectory. The trajectory retraces the same path for larger thicknesses, passing through multiples of $\mathbf{T_c}$.

It is possible to have the same Δ and Ψ pairs for different thicknesses which differ only by $\mathbf{T_c}$. This results in multiple orders of thickness and order ambiguity, which can be a problem if the approximate thickness is unknown.

A different set of possible thickness values can be obtained by changing the wavelength or the angle of incidence. Only one value should be the same on both lists, which would represent the correct thickness, and order would be resolved.

It can be seen that for materials with similar **N** values, it is difficult to differentiate between their trajectories near the cycle thickness. By measuring Δ and Ψ at multiple angles of incidence, **N** can be calculated more precisely.

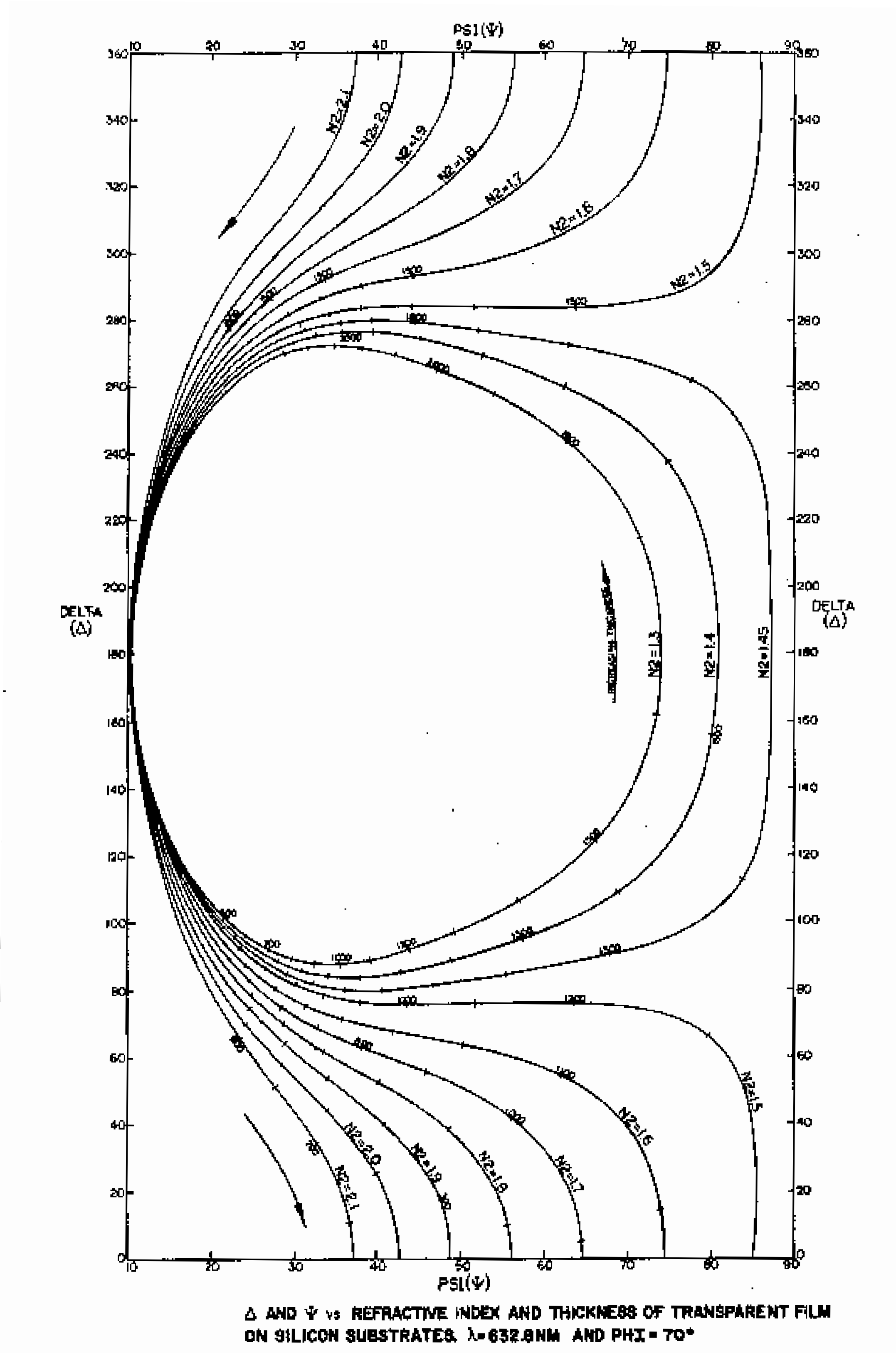


Figure E-8. Delta/Psi Plot

Instrumentation

The following sections discuss the equipment needed to perform the measurements of the film materials.

Required Components

In order to perform the calculations discussed in the previous sections, the equipment used to take the measurements must have the following components:

- Monochromatic (single wavelength) light source.
- Optics to convert unpolarized light to linearly polarized light.
- Optics to convert linearly polarized light to elliptically polarized light.
- Reflection from a sample.
- Optics and detector to determine the polarization of the reflected light.
- A computer to calculate the results according to an assumed model.

Ellipsometer Types

The two types of ellipsometers covered in this section are:

- Null ellipsometers
- Rotating Compensator Ellipsometers

Null Ellipsometers

The **Null Ellipsometer** is based on the principal that by fixing the compensator at 45°, the polarizer and analyzer are rotated until a null is found, or the light has been extinguished. Therefore, upon reflection, the ellipticity created by the compensator is canceled.

To achieve a null, some manual ellipsometers require the use of the eye to determine whether the light has been extinguished. Most advanced null ellipsometers use a detector or photomultiplier to detect the minimum intensity observed at the null for more precise measurements.

Δ and Ψ are related to the settings of the polarizer and analyzer, and can be easily calculated.

The Rudolph Technologies AutoEL Ellipsometer uses the classical null configuration.

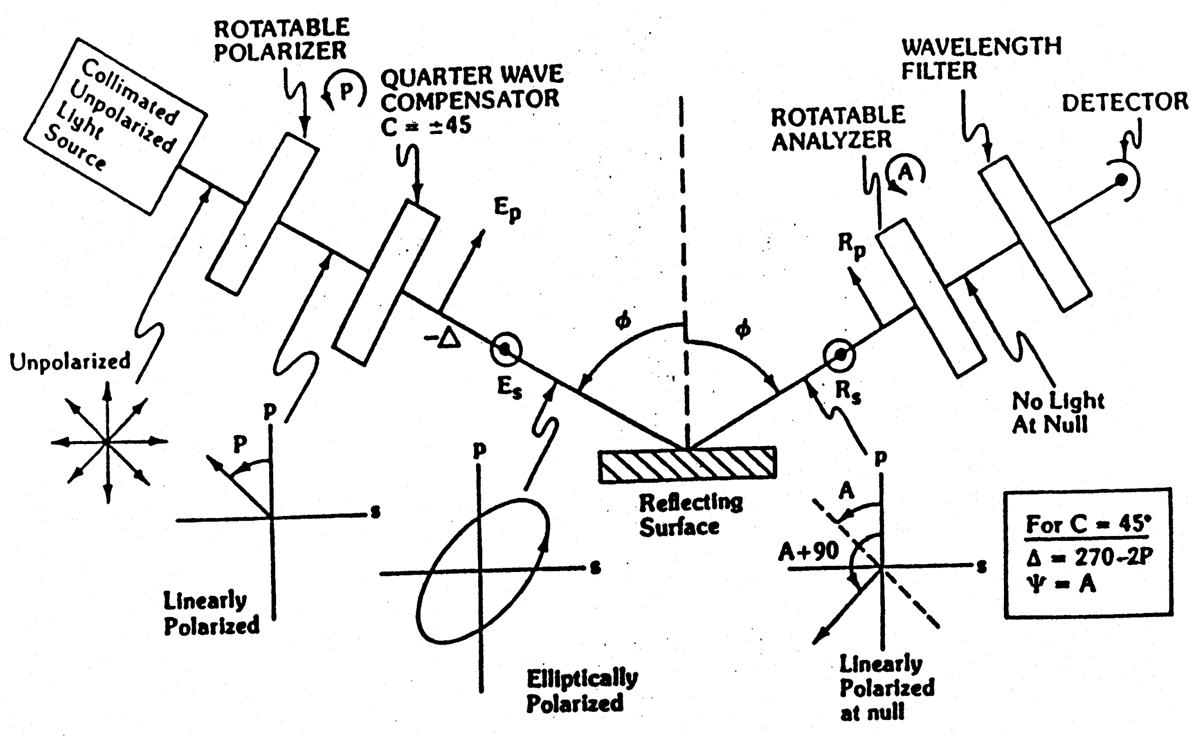


Figure E-9. Typical Null Ellipsometer Configuration

Rotating Compensator Ellipsometers

The Rudolph Technologies FOCUS Ellipsometer is based on the principal of a **rotating-compensator ellipsometer** (RCE).

The polarizer and analyzer are fixed producing a constant state of polarization at the detector, while the compensator is constantly rotating allowing for multiple intensities of the fixed polarization state. The intensity of the light emerging from the analyzer is measured, sampled, and digitally Fourier analyzed to determine Δ and Ψ.

The advantages of RCE are that it is fast, precise, has data processing flexibility, operates at high detected light levels, and eliminates the handedness ambiguity problem (the inability to distinguish between complementary polarization states).

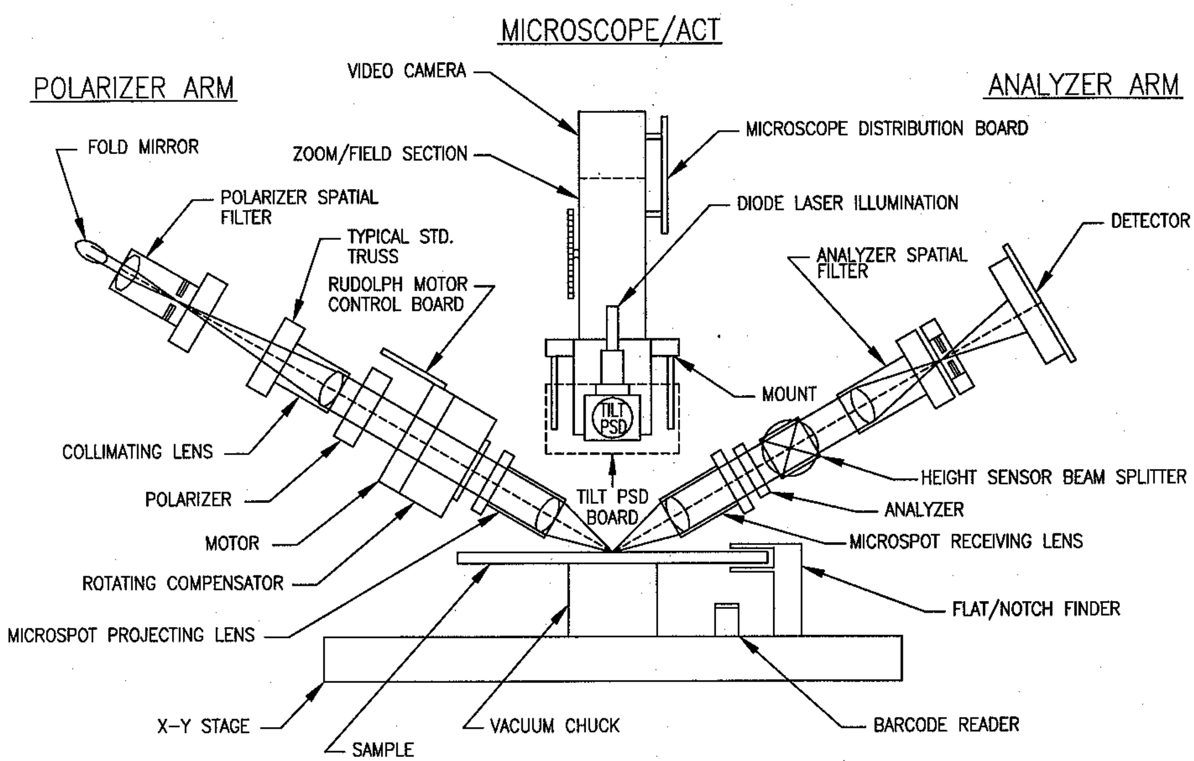


Figure E-10. Typical FOCUS Ellipsometer Configuration

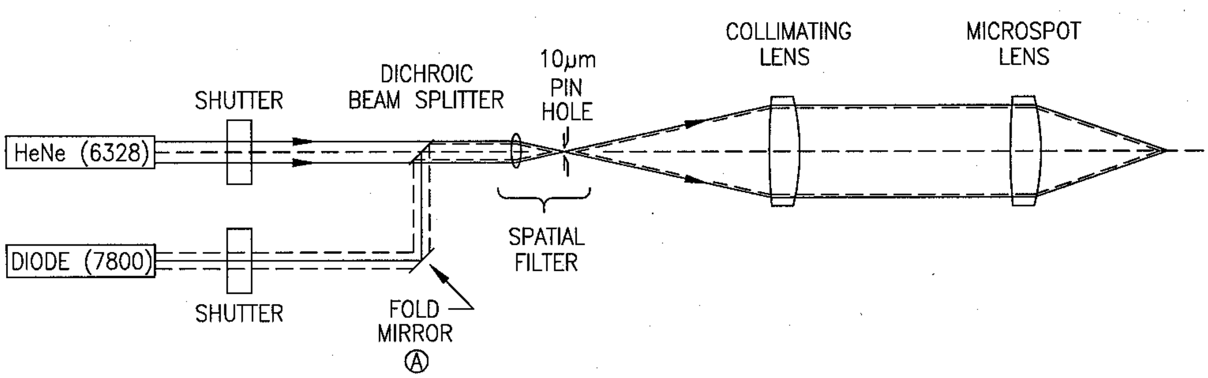


Figure E-11. Dual Wavelength FOCUS Ellipsometer (Optical Schematic)

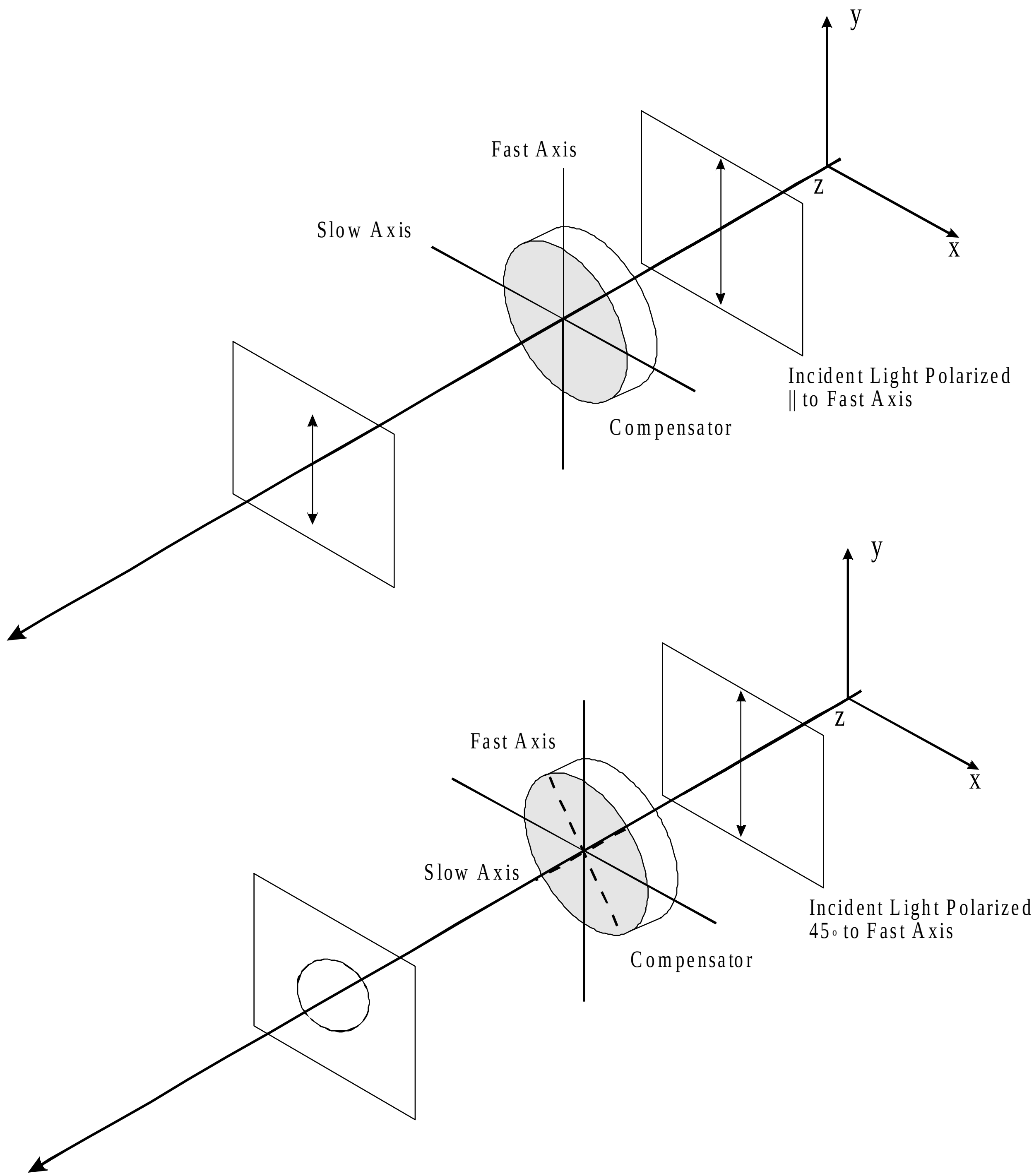


Figure E-12. Polarization Effects of Compensator Rotation

Focused Beam Technology

Focused Beam Technology implements a cone shaped beam of light which includes a range of angles with a minimum of 40°, maximum of 70°, and mean of 55°.

The detector has multiple pixels to account for the range of measurement angles. Reflections from the angles near the maximum and minimum (the outer edge of the microspot) may not produce acceptable results, and the corresponding pixels can be cut out.

The beam is focused to a spot size incident on the sample of 12 x 24 microns (FE III), or 5 x 10 microns (FE VII).

Focused Beam Technology uses multiple measurement angles, eliminating order ambiguity, and allowing for **T** and **N** measurements near cycle thickness ($\mathbf{T_c}$).

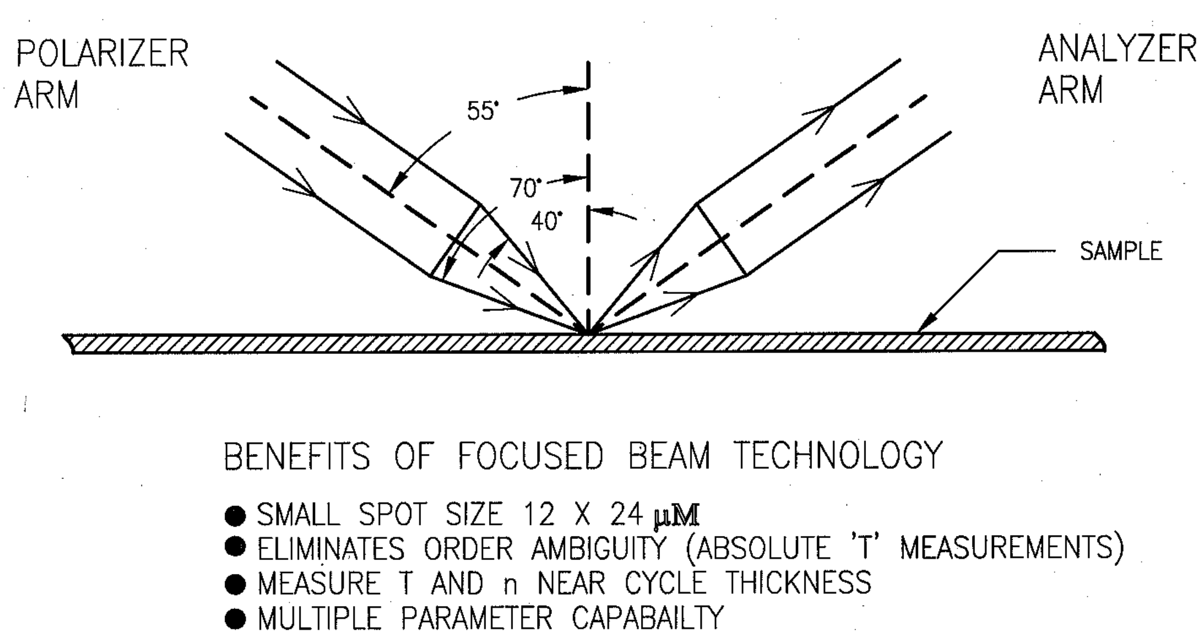


Figure E-13. Focused Beam Technology

Fit Error and Error Estimates

Fit error is a $\chi 2$ (Chi squared) statistical quantity that indicates how well the measured Δ and Ψ data fit the theoretical data of the film model.

A small fit error means that the measured and modeled data agree to within the accuracy of the measurement. A large fit error means that the measured data is incompatible with the theoretical data of the film model.

Usually, the measured Δ and Ψ data are correct to within the accuracy of the measurement. Therefore, large fit errors can be attributed to a problem with the theoretical data of the film model, such as incorrect **N**, **K**, or **T** of a fixed underlying layer.

Error estimates provide an estimate of the accuracy of the computed film parameters, and also indicate how repeatable the measured parameters will be. Measurement errors are not known exactly, and the error estimates are approximate values only.

Film Parameter Computation Algorithm

The Engineer first creates a filmstack to compare the measured data with the theoretical modeled data.

Upon making a measurement, the modeled Δ and Ψ values are compared with those that were measured.

The program searches for the best solution by finding that which has the lowest fit error. The program is constantly updating the film model by varying the calculated parameters until the measured and modeled data converge, and the lowest fit error is found.

If the solution found by the program is not acceptable (the fit error is too high), the user must then change the filmstack parameters.

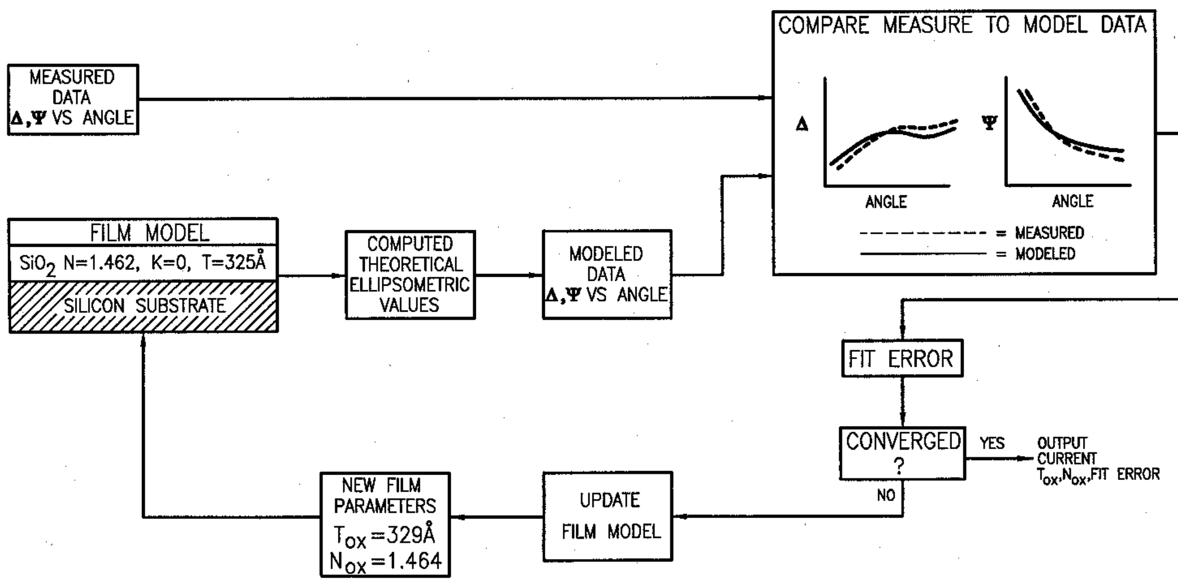


Figure E-14. Film Parameter Computation Algorithm (Single Wave)

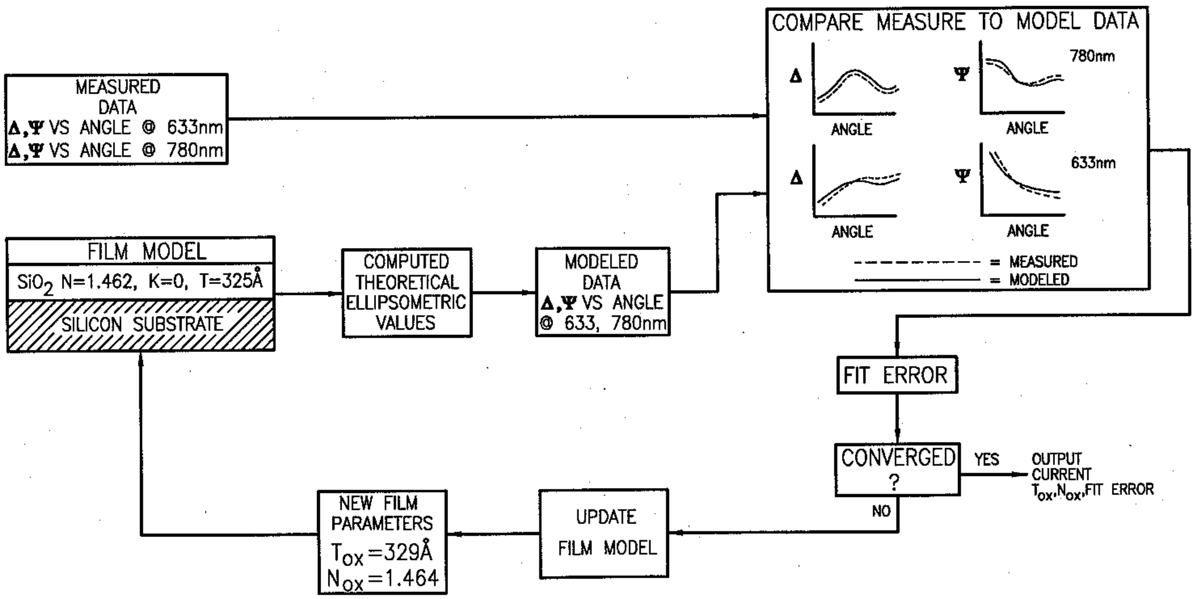


Figure E-15. Film Parameter Computation Algorithm (Dual Wave)

Order Search Algorithm

There are two types of order search modes offered by the FOCUS software to find the minimum fit error and to resolve order.

In **Standard Order Search** mode, using a single wavelength measurement, the region searched varies with the application but is typically ± 5 order cycles. This option is most appropriate for low refractive index films, such as SiO2 and Si3N4. When using a dual wavelength measurement, the program starts from the spec thickness entered by the user, and searches ± 4 order cycles.

In **Restricted Search** mode, using single wavelength measurement, the program starts from the spec thickness and searches ± 1/2 order cycles. When using a dual wavelength measurement, Restricted Search mode searches ± 2 order cycles from the spec thickness.

CYCLE THICKNESS:

$Tc = 0.5 \times \lambda \times [N^2 - \sin^2\theta]^{-1/2}$

N= Refractive Index θ = Angle of Incidence λ = Wavelength

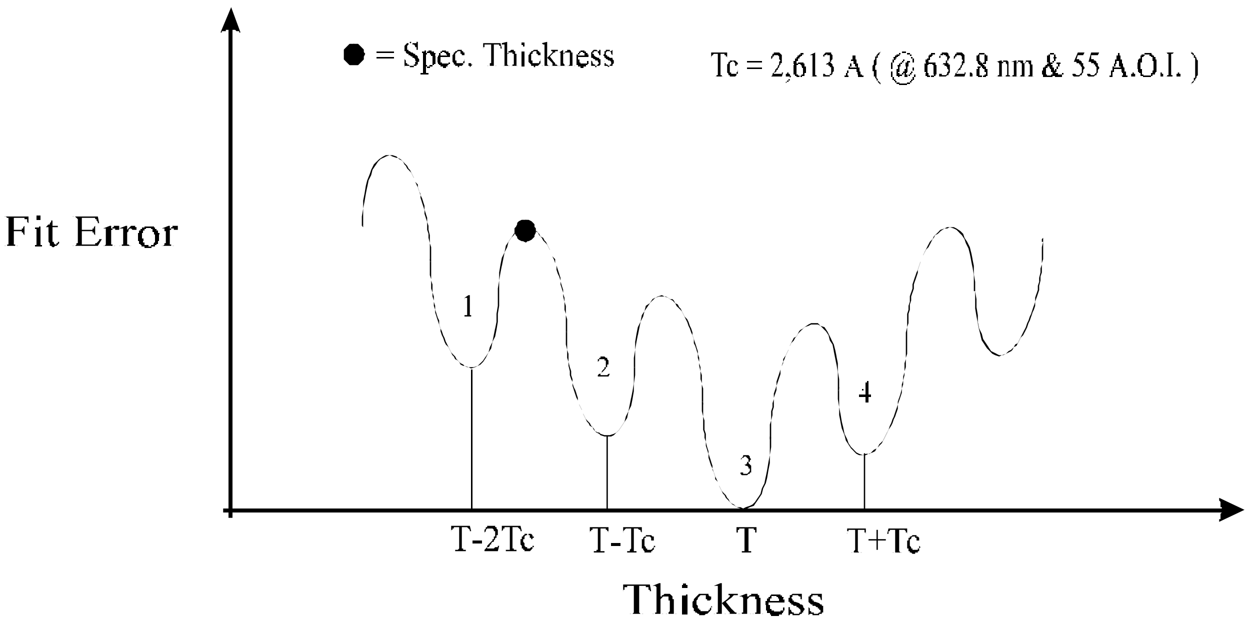
FILM	Tc at 40°, 633nm	Tc at 55°, 633nm	Tc at 70°, 633nm
SiO2	2410 A	2613 A	2825 A
Si3N4	1671 A	1734 A	1792 A
POLY	801 A	808 A	814 A
A-SI	707 A	712 A	716 A

FILM	Tc at 40°, 780nm	Tc at 55°, 780nm	Tc at 70°, 780nm
SiO2	2970 A	3221 A	3482 A
Si3N4	2059 A	2138 A	2209 A
POLY	988 A	996 A	1003 A
A-SI	872 A	877 A	882 A

EXAMPLE: 1300A Oxide at 633nm

FILM	40°, 633nm Δ_1,Ψ_1	55°, 633nm Δ_2,Ψ_2	70°, 633nm Δ_3,Ψ_3
Order 0	1300A	1300A	1300A
Order 1	3710A	3913A	4125A
Order 2	6120A	6526A	6950A

Figure E-16. Order Resolution Example



Solution	T	Fit Error
1	5,744 A	35.7
2	8,387 A	12.2
3	11,000 A	0.5
4	13,613 A	9.3

Figure E-17. Order Search Algorithm Example

Table E-1. Order Search Modes

Search Type	**Single λ (632.8 nm)**	**Dual λ (632.8 nm + 788 nm)**
Restricted Search	Spec thickness ± 1/2 order cycles.	Spec thickness ± 2 order cycles.
Standard Order Search	Spec thickness ± 5 order cycles for most applications.	Spec thickness ± 4 order cycles.

Error Messages/ Getting Help

Appendix F

Introduction

The purpose of this appendix is to provide the user with information necessary to perform simple troubleshooting and maintenance tasks. The information in this section applies to the FOCUS Ellipsometer (FE) III, IV, and VII systems.

NOTE

Component replacement, repairs, optical alignment and system calibration should not be attempted without first contacting Rudolph Technologies.

The topics covered in this appendix include:

- Possible problems that may be encountered with your FE System hardware.
- Software error messages and probable causes.
- How to contact Rudolph Technologies for assistance.

The troubleshooting tables that follow are not an all inclusive list of every possible trouble resolution and should be used for reference only. If using the procedures given in this section do not resolve the problem, contact Rudolph Technologies for assistance and/or support using the information provided at the end of this appendix.

WARNING

Potentially hazardous voltages may be present in the FE System. Failure to follow proper safety precautions may result in serious personal injury or death. Electrical problems should be referred to qualified electricians or Rudolph Technologies support personnel.

FE System Hardware Symptoms

Use the information in the following table to troubleshoot possible hardware problems with your FE System. Locate the applicable symptom in the left column of the table to determine probable causes and recommended actions to rectify the problem.

Table F-1. FE System Hardware Problem Symptoms

Symptoms	Probable Causes	Recommended Actions
FE System has no power. Low voltage power supply LEDs are off.	Emergency switch has been pushed in.	Turn Emergency Switch clockwise; cycle the ON/OFF switch to reboot the computer.
FE System has no power.	1. Line cord disconnected. 2. Outlet has no power. 3. Main circuit breaker tripped. 4. Miswired.	1. Connect line cord. 2. Notify an electrician. 3. Open door on the Measurement Console, cycle/reset the tripped breaker. 4. Call Rudolph Field Service.
Most FE functions not operational.	Aux. 7amp breaker is tripped (upper left).	Cycle/reset the tripped breaker.
No fans.	Aux. 7amp breaker is tripped (lower left).	Cycle/reset the tripped breaker.
Computer outlets have no power.	Aux. 7amp breaker is tripped (upper right).	Cycle/reset the tripped breaker.
No front panel illumination.	Aux 0.5amp breaker is tripped (lower right).	Cycle/reset the tripped breaker.
One or more DC voltage LEDs are out on the center panel.	1. Low voltage fuse blown. 2. Fresh fuse blows again. 3. Still no DC voltage. 4. Low voltage DC power supply defective. 5. Miswired.	1. Replace defective fuse on regulator board. 2. Repair short circuit. 3. Check AC input to regulator board. 4. Replace the regulator board. 5. Call Rudolph Field Service.
No vacuum.	1. Hose not connected to house supply line. 2. House vacuum out. 3. Electronics Control Unit problem.	1. Connect hose. 2. Call plant maintenance. 3. Call Rudolph Field Service.
Robot/stage is not operational.	1. No AC power to control unit. 2. Electronics Control Unit problem.	1. AC power relay not working. 2. Call Rudolph Field Service.

Software Error Messages

Use the information in the following table to troubleshoot possible software problems with your FE System. Locate the applicable error message in the left column of the table to determine probable causes and recommended actions to rectify the problem.

NOTE

The error listing provided here is not all inclusive. If you encounter an error that is not included in this section, contact the Rudolph Service Department for information.

Table F-2. FE System Software Error Messages

Err #	Error Message	Probable Causes	Recommended Actions
6	Alignment Matrix Not Calibrate: PC.	Align.dat file corrupted.	Contact Rudolph Technologies.
7	ALIGNMENT ERROR.	Unable to align optic head to wafer. - Dust on wafer. - Bad wafer. - Alignment matrix miscalibrated. - Height detector board failure. - Tilt detector board failure.	Check wafer for problems. Contact Rudolph Technologies.
10	ILLEGAL CASSETTE SPECIFIED: PC.	Incorrect wafer cassette identifier specified.	Enter correct cassette identifier.
11	ILLEGAL WAFER SPECIFIED: PC.	Incorrect wafer location specified.	Enter correct wafer location.
13	BARCODE READ ERROR.	Barcode at location incorrect, unreadable, or missing.	Supply correct barcode.
17	A communication timeout has occurred between the PC and the BASE control board.	Communication cable not connected. PC serial port failure. Base control board hangup.	Check cables (most likely). Replace serial port. Reset FOCUS.
18	A communication timeout has occurred between the PC and the OPTIC control board.	Communication cable not connected. PC serial port failure. Base control board hangup. Optic control board hangup.	Check cables (most likely). Replace serial port. Reset FOCUS.
21	ALIGN.DAT FILE MISSING.	Align.dat file missing.	Recover an archived file and recalibrate alignment matrices.
22	ILLEGAL OPTICAL BIAS LEVEL.	Invalid optical bias selected.	Enter a valid optical bias.

Table F-2. FE System Software Error Messages (Continued)

Err #	Error Message	Probable Causes	Recommended Actions
23	EEPROMB.DAT FILE MISSING.	EEPROMB.DAT file missing.	Create file and enter command “upload base” or “upload_b” in FOCTEST.
24	EEPROMO.DAT FILE MISSING.	EEPROMO.DAT file missing.	Create file and enter command “upload optic” or “upload_o” in FOCTEST.
25	WAFER REPOSITION ERROR: PC.	Unable to center the wafer.	Make sure flat/notch setting is correct. Recalibrate flat/notch finder.
26	INVALID PASSWORD.	Incorrect password was given.	Provide correct password or contact system administrator.
27	FOCUS.INI FILE MISSING.	FOCUS.INI file missing.	Restore backup copy.
28	Illegal Light Bulb Illumination. Valid Range (0-31)	Value entered that was outside the valid range.	Specify value that is within the specified range.
29	Base2 Control Board Not Installed.	Invalid FOCUS configuration.	Check FOCUS configured correctly in SETUP program.
30	A communication timeout has occurred between the PC and the BASE2 control board.	Communication cable not connected. Base2 control board hung up. PC serial port failure.	Check cables. Reboot FOCUS. Replace serial port.
31	EEPROMB2.DAT FILE MISSING.	EEPROMB2.DAT file missing.	Create file by entering command “upload base2” or “upload_base2” in FOCTEST.
34	A communication timeout has occurred between the PC and the SMIF2 ARM.	Communication cable not connected. SMIF arm not connected.	Check cables. Attach SMIF arm.
37	Extfn Not Installed.	External flat/notch finder not installed.	Check configuration of FOCUS.
38	EEPROMO.DAT File Is Corrupt.	Unknown.	Recreate file by typing “upload_o” in FOCTEST.
39	EEPROMB.DAT File Is Corrupt.	Unknown.	Recreate file by typing “upload_b” in FOCTEST.
40	EEPROMB2.DAT File Is Corrupt.	Unknown.	Recreate file by typing “upload_base2” in FOCTEST.
41	ALIGN.DAT File Is Corrupt.	Unknown.	Restore file from backup copy.

Table F-2. FE System Software Error Messages (Continued)

Err #	Error Message	Probable Causes	Recommended Actions
42	EEPROMIF.DAT file missing. Please run FOCTEST and upload eeprom values from interface control board.	First time installation.	Run FOCTEST and type “upload intf”.
43	EEPROMIF.DAT file is corrupt.	Unknown.	Recreate EEPROMIF.DAT file by typing “upload intf” in FOCTEST.
44	Interface Control Board Not Communicating with PC.	PC to Interface Control Board Cable not connected. Interface Control Board failure.	Check cables. Replace interface control board.
45	Wafer found on robot. Cannot initialize robot while wafer present. Please manually remove wafer from robot.	Wafer on robot arm when robot is initialized. On SMIF units, the robot cannot be initialized when wafer is on robot.	Manually remove wafer from robot.
106	Lifter 0 failed to home: TOP SENSOR Not Found.	Failure to home lifter 0.	Retry to initialize unit. Replace lifter 0.
107	Lifter 1 failed to home: TOP SENSOR Not Found.	Failure to home lifter 1.	Retry to initialize unit. Replace lifter 1
108	Lifter 2 failed to home: TOP SENSOR Not Found.	Failure to home lifter 2.	Retry to initialize unit. Replace lifter 2.
109	The base control board has been requested to move a lifter past its limits.	Failure to align optic head to wafer because lifter moved to limit.	Check wafer. Check alignment system and recalibrate it.
110	The wafer FLAT was not found.	Failure to find flat on wafer.	Check wafer has a flat.
111	The wafer NOTCH was not found.	Failure to find notch on wafer.	Check wafer has a notch.
112	The lifters are not homed.	Lifters not initialized.	Initialize unit.
113	A wafer has been found on the robot.	Wafer unexpectedly found on robot.	Remove wafer from robot by unloading it into a cassette.
114	No Wafer is loaded on the stage.	Wafer not found on stage when a wafer unload is attempted.	Check vacuum system. Check wafer is on stage.

Table F-2. FE System Software Error Messages (Continued)

Err #	Error Message	Probable Causes	Recommended Actions
115	Illegal Cassette Destination.	Attempt to unload wafer to invalid cassette plate.	Retry command.
116	The wafer transfer cannot be performed because the two cassette sizes do not match.	Cassette sizes are different.	Place identical cassette sizes for wafer transfer.
117	Cassette Size Error. Check that the cassette is seated properly and that you are using the same cassette size specified in the recipe.	Cassette not found.	Place cassette.
122	SOURCE VACUUM ERROR.	Vacuum error.	Check vacuum system. Re-initialize unit.
123	A communication timeout has occurred between the BASE control board and the WAFER HANDLING unit.	Failure to communicate with wafer handler unit.	Check cables. Re-initialize unit.
124	The Wafer was Not Found in the Cassette Slot.	Wafer not found in cassette slot.	Check wafer present. Check vacuum system.
126	BARCODE was not correctly read.	Cannot read barcode on wafer.	Check wafer. Check barcode reader.
127	STAGE VACUUM ERROR.	Stage vacuum sensor failure.	Replace stage vacuum sensor.
128	ROBOT VACUUM ERROR.	Robot vacuum sensor failure.	Replace robot vacuum sensor.
129	Wafer Centering Failure.	Cannot center wafer.	Recalibrate flatnotch finding system. Verify flat or notch selected correctly.
633	Vision Process unable to open semaphores.	Possible OS/2 or memory problems.	Exit from the program and reboot OS/2.
634	Vision Process unable to set semaphores.	Possible OS/2 or memory problems.	Exit from the program and reboot OS/2.
635	Vision Process unable to close semaphores.	Possible OS/2 or memory problems.	Exit from the program and reboot OS/2.

Table F-2. FE System Software Error Messages (Continued)

Err #	Error Message	Probable Causes	Recommended Actions
636	Vision Process unable to clear semaphores	Possible OS/2 or memory problems.	Exit from the program and reboot OS/2.
637	Vision Process unable to find calibration file.	hicalib.par or localib.par is missing from d:\focus\vision\setup.	Retrieve hicalib.par or localib.par from FOCUS vision install disk, then re-calibrate vision system.
638	Vision Process unable to find configuration file.	VSP.cnf is missing from d:\focus\vision\setup.	Retrieve vsp.cnf from FOCUS vision install disk.
639	Vision Process unable to find number generation file.	Filenum.str is missing from d:\focus\vision\setup.	Find out the largest pattern number in d:\focus\vision\pat, then edit filenum.str, enter the number and save it.
640	Vision Process received invalid magnification.	Possible wrong vismain.exe.	Consult Rudolph Service Department to obtain the correct vismain.exe.
641	Poor vision pattern teach quality.	Poor features or improper threshold setup.	Select different site or re-adjust thresholds.
642	Not enough successful alignments to calibrate.	Poor feature site or repeat pattern site.	Select another site.
643	Vision Calibration Figure Of Merit too high.	Bad calibration site.	Select another site and re-calibrate.
644	Vision Teach unable to find enough patterns to qualify for alignment.	Poor teach site or hardware sync problem.	Select another site or check the hardware.
645	Vision Teach unable to write patterns.	No space on hard disk.	Check the hard disk space on D:\ drive.
648	Vision Teach unable to read patterns.	Pattern is missing or hardware failure.	Check the pattern in d:\focus\vision\pat directory.
649	Vision Process unable to allocate.	OS/2 memory management problem.	Shutdown OS/2 and reboot.
650	Vision Search unable to find 2 patterns in site pattern file.	Color variation or pattern is outside FOV.	Contact Rudolph Service Department.
651	Vision Search unable to read patterns.	Pattern is missing.	Check the pattern in d:\focus\vision\pat directory.
652	Vision Search unable to find pattern alignment quality above threshold.	Color variation or pattern is outside FOV.	Contact Rudolph Service Department.

Table F-2. FE System Software Error Messages (Continued)

Err #	Error Message	Probable Causes	Recommended Actions
653	Vision Search coupling exceed Coupling Difference Threshold.	Possible repeat patterns or similar patterns in FOV.	Use restricted search.
656	Protect Device not installed in Imaging Technology Board.	EEPROM is missing on Imaging Tech Board.	Contact Rudolph Service Department.
657	Ill formed Vision System calibration matrix.	Incomplete localib.par or hicalib.par.	Check the files. Re-calibrate vision system if necessary.
658	Vision Process made call with parameter out of range.	Possible software bugs.	Contact Rudolph Service Department.
659	Vision Process unable to find any valid pattern.	Poor search image or pattern is outside FOV.	Contact Rudolph Service Department.
660	Vision Process unable to free shared data.	OS/2 API failure.	Shutdown OS/2 and reboot or consult with Rudolph Software Group.
661	Vision child process is not running, unable to register wafer.	Hardware security key is not installed.	Contact Rudolph Service Department to install the security key.
662	Vision Process unable to initialize vision board.	Communication failure between vision board and PC.	Re-plug in the board or replace the board.
663	Vision child process is unable to open pseudo serial port.	Communication failure between PC and Cognex board.	Check Cognex device driver is properly installed, board is properly plugged in and functions normally.
664	Vision child process is unable to close pseudo serial port.	Communication failure between PC and Cognex board.	Check Cognex device driver is properly installed, board is properly plugged in and functions normally.
665	Vision child process is unable to reset.	Communication failure between PC and Cognex board.	Check Cognex device driver is properly installed, board is properly plugged in and functions normally.
666	Vision child process is not in polling mode.	Cognex functions abnormally.	Check the board and run reset_vp.
675	Parent Vision Process unable to free shared data.	OS/2 API failure.	Shutdown OS/2 and reboot or consult with Rudolph Service Department.

Table F-2. FE System Software Error Messages (Continued)

Err #	Error Message	Probable Causes	Recommended Actions
677	Parent Vision Process unable to create semaphores.	OS/2 failure.	Contact Rudolph Service Department.
678	Parent Vision Process unable to set semaphores.	OS/2 failure.	Contact Rudolph Service Department.
679	Parent Vision Process unable to close semaphores.	OS/2 failure.	Contact Rudolph Service Department.
680	Parent Vision Process unable to clear semaphores.	OS/2 failure.	Contact Rudolph Service Department.
681	Call made to Child Vision Process after it ended.	Calls between FOCUS Apps and vismain are out of sync.	Exit the problem. Terminate vismain then restart.
682	Parent Vision Process unable to execute Child Vision Process.	The vismain could be still running.	Terminate vismain.

Contacting Rudolph Technologies

For additional information and support, contact Rudolph Technologies, Inc. directly or through an authorized representative in your area. Contact information is provided in the following table.

Item	Information
Phone Number	(201) 691-1300
Fax Number	(201) 691-5480
Address	One Rudolph Road PO Box 1000 Flanders, NJ 07836

NOTE

Before contacting Rudolph Technologies, please have ready the Serial Number of your FE System. This will help Rudolph Technologies personnel to expedite serving you.

Glossary

Analog to Digital Board (A/D)
That part of the detector system which changes the output of the detector from an analog to a digital form.

Analysis
The data reduction routines applied to the measurements.

Analyzer
A manually rotatable Glan-Taylor polarizer assembly.

Analyzer Arm
An assembly of all the components mounted on the analyzer arm plate. Used to “analyze” the polarization state of the light reflected from the sample.

Application
A film measurement requirement.

Barcode Reader
A device used to scan the identification code on the bottom of each wafer.

Batch
A numbered group of wafers.

Border
The boundary of a window. Clicking on the border and dragging it changes the size of the window.

Browser
A means for accessing database information.

Cassette
A container for transporting and storing wafers.

Cassette Storage
The lower portion of the right cabinet (Wafer Handler Console), which may be used to store wafer cassettes.

CCD Detector
A linear array charge coupled detector (CCD), used to detect the intensity modulated laser beam.

Chip and Die
Used interchangeably in this document. They refer to one integrated circuit on the wafer.

Collimated Diode Laser
Used to generate the probe beam required by the tilt control system.

Collimating Lens
Makes parallel the diverging rays of light emerging from the spatial filter.

Compensator
A mica quarter-wave plate.

Computer Bay
The lower right-hand side of the measurement console that contains the computer CPU and disk drives.

Database
Information stored in a structured, easily retrievable fashion. Consists of the measured data, calculated parameters, thickness, index of refraction and wafer data.

Delta (Δ)
The relative phase shift between the **S** and **P** polarizations after reflection from the sample.

Die
The region on a wafer that defines one integrated circuit (chip).

Dual Wavelength
Combined 633 nm HeNe laser and 780 nm diode laser measurement system.

Dynamic Repeatability
A test to determine the measurement variation of the instrument when measuring the same point on a wafer n times, and includes the variations introduced by the mechanical movements of the sample stage.

Electronics Bay
The lower left portion of the measurement console.

EMA
Effective Medium Approximation. Technique for generating the optical constants of a mixture from the optical constants of its constituent parts.

FE Recipe
See "Process Specification".

FE Process Specification
A collection of all the measurement process steps that are required for one kind of integrated circuit. The highest level FE recipe.

Filmstack (Film Stack)
A template used to represent the materials and parameters expected in the film structure of a particular site on a wafer. Filmstacks are required to model the measured data and produce calculated results such as **t, n** and **k**. For unpatterned wafers, one filmstack can be used to model all points on the wafer. For patterned wafers, a different filmstack may be used for each measurement location.

Flat / Notch Finder (Detector)
A sensing system used to determine centering and radial position of the wafer on the vacuum chuck.

Focus Interactive
Program used by the Process Engineer to interactively develop a filmstack.

Focus Operator
The Focus Operator Program contains wafer measurement recipes created by the Process Engineer. The Operator uses these recipes to make measurements on production wafers. The operation of the FE by the program can range from completely automatic to semi-automatic, depending on the purpose for which each recipe was written. The measurement results are automatically stored for use by the Process Engineer. Identification (name and password) of the Operator. Set-up of the FE for a measurement run. Measurement of one cassette load of wafers (from fully automatic to semi-automatic). Progress and intermediate results are displayed for monitoring purposes. Automatic storage of measurements and calculated results in the database. Results displayed at the end of the measurement run, and can be printed.

Focus Recipe Creator
Program used by the Process Engineer to specify FE information for measuring wafers. The Process Engineer can enter the following information into the recipe creator: Cassette contents, transfer path, measurement patterns, wafer physical information.

Focus Setup
Program used to configure and customize the FE. Sets system default values.

Generated data
Delta and psi calculated parameters and the results of any statistical operations.

Height Control System
Senses and adjusts the elevation of the optics head above the sample.

HeNe Laser
A red laser light source.

Icon
A pictogram that represents a program.

Iterated Parameters
Iterated (calculated) parameters include items that can be calculated from Δ and ψ. These parameters can include **n**, **k**, Thickness and Order.

Laser Shutter
A shutter used to mechanically block the laser beam.

Mapping
Program used to view wafer maps. Maps may be viewed as contour (2D) or topographic (3D). Creation of etch rate and difference maps is also possible.

Material
Physical composition of a film or substrate. There are two types of materials: homogenous materials (such as: SiO2), and EMA materials (such as: polysilicon) which are aggregates composed of two homogenous materials.

Maximize Button
A small "up" arrow in the upper right corner of a window used to expand a small window to full screen size.

Measurement Console
The main (center) console.

Measurement System
The electro-optical system composed of the optics head, the optics base, the stage, and the lifters.

Menu Bar
Directly beneath the title bar, the horizontal menu bar displays the items or commands that can be selected or activated in this window. “Grayed out” items can not be selected (for example; the “maximize” box will gray out if the window has already been maximized).

Microscope
Used to provide magnified views of the wafer on the video monitor.

Minimize Button
A small “down” arrow in the upper right corner of a window used to reduce the size of this window or to shrink this window to an icon. An “iconized” program continues to run in the background (for example; a compiler).

Monitor Console
The left console. Used to support the computer monitor and provide additional storage space.

Optics Head
All of the components mounted on top of the lifters.

Optics Hood
The cover on top of the measurement console.

Order Resolution
The ability of the FE to determine the thickness order.

Patterned Wafer
A wafer having integrated circuits, or precursor etched patterns, on its surface. Also a menu item used to “train” measurement locations (patterns) for the chips or stepper groups on a wafer.

Process Step
Each process step consists of a “step title”, a “transfer specification”, one or more “wafer recipes”, and a “control specification”.

Process Specification
A group of process steps.

Psi (ψ)
The arctangent of the ratio of the reflectances of the **P** and **S** polarizations.

Recipe
A set of instructions to describe the measurement of a wafer.

Registration
Menu item used for patterned wafers to accurately determine chip size and wafer position (deskew).

Repeatability
Statistical spread of repeated measurements.

Report
A template used to control the format of the measured data.

Sample
The object to be measured.

Scroll Bar
A vertical or horizontal control and indicator bar, usually located on the right side of a window. To scroll through the window's contents, click on the slider button (between the “up” and “down” arrows) and drag it to get to the desired item rapidly. The slider button can be used as a moving indicator to show where you are in a list. The small “up” and “down” arrows on the scroll bar can be clicked to move up or down one line per click, or held down for continuous scrolling.

Static Repeatability
A test to determine the measurement variation of the instrument when measuring the same point on a wafer “n” times, and does NOT include the variations introduced by the mechanical movements of the sample stage.

Stepper Group
The chips contained within one exposure of the stepper. Normally each stepper group on a wafer is identical although the chips within the stepper groups may not be.

Template
Consists of a data component, such as a filmstack, containing a unique data configuration.

Transfer
Menu item used to create the “Transfer Specifications” that identify the source and destination cassette locations, the cassette slots containing the wafers to be measured, and the wafer transfer style. The creation of transfer specifications is done in the “Transfer Selection” window.

Unpatterned Wafer
A template used to specify the measurement pattern for unpatterned wafers. Recipe made for monitor wafer applications.

Wafer Chuck
A chuck used to retain the wafer in place on the sample stage, and to rotate the wafer when required.

Wafer Handler Console
The right console. Contains the wafer handling robot.

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USER'S DOCUMENTATION FEEDBACK FORM

Rudolph Technologies, Inc. encourages you to mail or fax this Feedback Form, together with any comments or suggestions regarding this manual, to:

Rudolph Technologies, Inc.
Publications Group Leader
One Rudolph Road, P.O. Box 1000
Flanders, NJ 07836

Tel. (201) 691-1300
Fax. (201) 691-5480

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