M-2000®
Spectroscopic Ellipsometer

Hardware Manual
Auto Angle ESM-300 Base
CompleteEASE®

J.A. Woollam Co., Inc.

Ellipsometry Solutions℠

The following table summarizes your M-2000® system and any options or accessories included in your purchase.

M-2000___ S/N___________________

Spectral Range___________________

Source FLS XLS FQTH

Receiver Dual Single

Options:

- ☐ Rack Mount Table Included
- ☐ Manual Sample Translation Stage
  - ☐ 50mm by 50mm XY Mapping
  - ☐ 100mm by 100mm XY Mapping
- ☐ Automated Sample Translation Stage
  - ☐ 100mm by 100mm XY Mapping
  - ☐ 150mm by 150mm XY Mapping
  - ☐ 200mm R-θ or XY Mapping
  - ☐ 300mm R-θ or XY Mapping
- ☐ Focusing Optics (focused beam size ________)
- ☐ Camera
- ☐ Neutral Density Filter Wheel

Accessories:

- ☐ Sample Heater - Standard (see Heat Stage manual)
- ☐ Sample Heater - Instec (see Heat Stage manual)
- ☐ Simple Liquid Cell (see Liquid Cell manual)
- ☐ Small Volume Liquid Cell (see Liquid Cell manual)
- ☐ In Situ Attachments (see In Situ manual)
- ☐ QCM Cell Stage (see QCM Cell manual)
- ☐ Heated Liquid Cell (see Heated Liquid Cell manual)
- ☐ Transmission Stage (see Transmission Stage manual)
- ☐ Electrochemical Cell (see Electrochemical Cell manual)
- ☐ Custom Stage

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Thank you for purchasing a J.A. Woollam Co., Inc. Spectroscopic Ellipsometer (SE) system. We hope the information contained in this manual will help you develop a better understanding and appreciation for the M-2000® hardware.

The contents of this manual are subject to change without notice and do not constitute a commitment on the part of J.A. Woollam Co., Inc. Every effort has been made to ensure the accuracy of this document. However, due to ongoing product improvements and revisions, J.A. Woollam Co., Inc. cannot guarantee the accuracy of the printed material after the date of publication nor can it accept responsibility for errors or omissions. J.A. Woollam Co., Inc. will update and revise this document as needed.

Please read Chapter 1, which contains important safety information concerning the operation of this instrument.

Contents

1. Safety Tips

1.1. Message Boxes

There are three message boxes used in this manual. They are explained below:

> ***Warning:* This box is used to warn the user of a potential hazard to the user or persons in the area of the ellipsometer.**

> ***Caution:* This box is used to alert the user that an incorrect operation or procedure could cause damage to the equipment.**

> ***Note:* This box contains tips, hints, and useful information relating to the procedure in which it is located.**

1.2. General Safety Tips

Keep hands/fingers/body parts away from the instrument while making motor position changes.

Ensure all system controls and power cables are tied/tucked away/hidden/kept away/arranged such that persons walking around the instrument area will not snag or trip on any of the cables.

Turn the computer off when working within the electronic control box(es). Voltages from the computer are present within the box(es) even when the box power is off.

Replace bad fuses only with proper type and rated fuse.

Never look into a tip of an optical fiber.

Never look directly at an operating lamp, severe eye injury may result. Wear UV protective lenses, such as a welder's helmet, when working around operating lamps.

Permanent eye damage can result from looking directly into the beam. It is best to view the beam using a piece of paper or business card.

Before servicing the lamp housing, be sure to disconnect all cables. Make certain the lamp is at room temperature (turn lamp off for at least 20 minutes).

Compact arc lamps contain highly pressurized gas, and present an explosion hazard even when cold. Wear face protection, such as a full-face shield, gloves and a long sleeve shirt whenever handling lamps.

2. Hardware Description

2.1. System configurations

This manual covers the full line of M-2000® based spectroscopic ellipsometers mounted on the Auto-Angle ESM-300 base..

MODEL	**SPECTRAL RANGE**	**LAMP(S)**
M-2000D	193-1000 nm	32W Deuterium and 20W QTH
M-2000DI	193-1690 nm	32W Deuterium and 20W QTH
M-2000U	245-1000 nm	32W Deuterium and 20W QTH
M-2000UI	245-1690 nm	32W Deuterium and 20W QTH
M-2000V	370-1000 nm	50W QTH
M-2000VI	370-1690 nm	50W QTH
M-2000X-210	210-1000 nm	75W Xenon arc
M-2000XI-210	210-1690 nm	75W Xenon arc
M-2000X	245-1000 nm	75W Xenon arc
M-2000XI	245-1690 nm	75W Xenon arc

Table 2-1. Available M-2000® models.

2.2. System Components

The M-2000® spectroscopic ellipsometer system is based on advanced Diode Array Rotating Compensator Ellipsometer (DARCE™) technology from the J. A. Woollam Co. This technology provides consistently accurate ellipsometric data, independent of the sample characteristics.

Light Sources

The following are the light sources available for the M-2000® ellipsometers.

M-2000® XLS-200 D2 and QTH Light Source

Figure 2-1. M-2000® XLS-100 Light Source.

The M-2000D, DI, U and UI ellipsometers use the XLS-200 light source. The XLS-200 D2 and QTH Light Source houses the Deuterium and Quartz Tungsten Halogen lamps. The power for the lamp is supplied through highly regulated switching DC power supplies that are located in the M-2000® XLS light source. 24 Volts is provided to it from the M-2000® Detector and Lamp Power Supply Module. This unit also contains the beam collimation optics, a fixed polarizer, and a compensator located in a continuously rotating stepper motor.

30 watt D2 (Deuterium) Lamp

Figure 2-2. D2 Lamp.

The D2 (Dueterium) Lamp Supplies light from the UV to the visible region of the spectrum. This lamp is mounted just behind the shutter apeture.

20 watt QTH Lamp

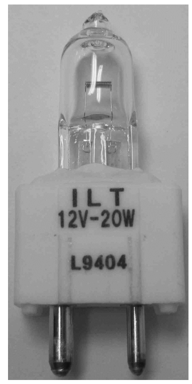


Figure 2-3. QTH Lamp.

The QTH (Quartz Tungsten Halogen) Lamp supplies light from the visible to the IR region of the spectrum. It is mounted just behind the D2 lamp aperture.

> ***Warning: The D2 and QTH lamps get extremely hot during operation. Always allow them to cool adequately before replacing them.***

FLS-350 75W Xe Light Source

Figure 2-4. M-2000® FLS-350 Light Source.

The M-2000X and XI ellipsometers use the FLS-350 Light Source. The FLS-350 Xe Light Source houses the 75 W Xe arc lamp and ignitor circuitry. The power for the lamp is supplied through a highly regulated DC power supply that is located in the M-2000® Detector and Lamp Power Supply Module. This unit also contains the beam collimation optics, a fixed polarizer, and a compensator located in a continuously rotating stepper motor.

75 watt Xenon Arc Lamp

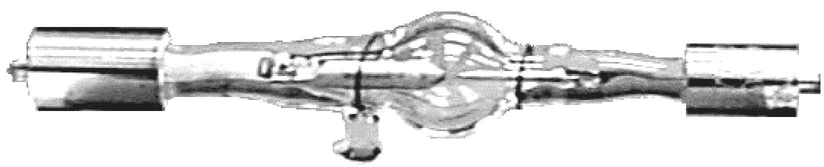


Figure 2-5. Typical Arc Lamp.

The Arc Lamp is a high pressure Xenon discharge point source lamp. It is filled with Xenon gas at above atmospheric pressure. The lamp is mounted in an inner enclosure within the M-2000® Light Source.

> ***Warning: Compact arc lamps contain highly pressurized gas, and present an explosion hazard <u>even when cold</u>. Wear face protection, such as a welder's helmet, whenever handling lamps.***

> ***Warning: The Xe arc lamp gets extremely hot during operation. Always allow it to cool adequately before replacing the lamp.***

Optional Neutral Density Filter and Filter Wheels

The system may include an optional ND filter wheel (auto or manual). The auto filter wheel is controlled by the software and can be set to auto select the intensity level by checking the auto box. This is used to select the optimum intensity level for the sample under measurement.

The intensity can also be set by the user to a specified value by un-checking the auto box and selecting the filter value from the drop down menu. This can be helpful during system alignment.

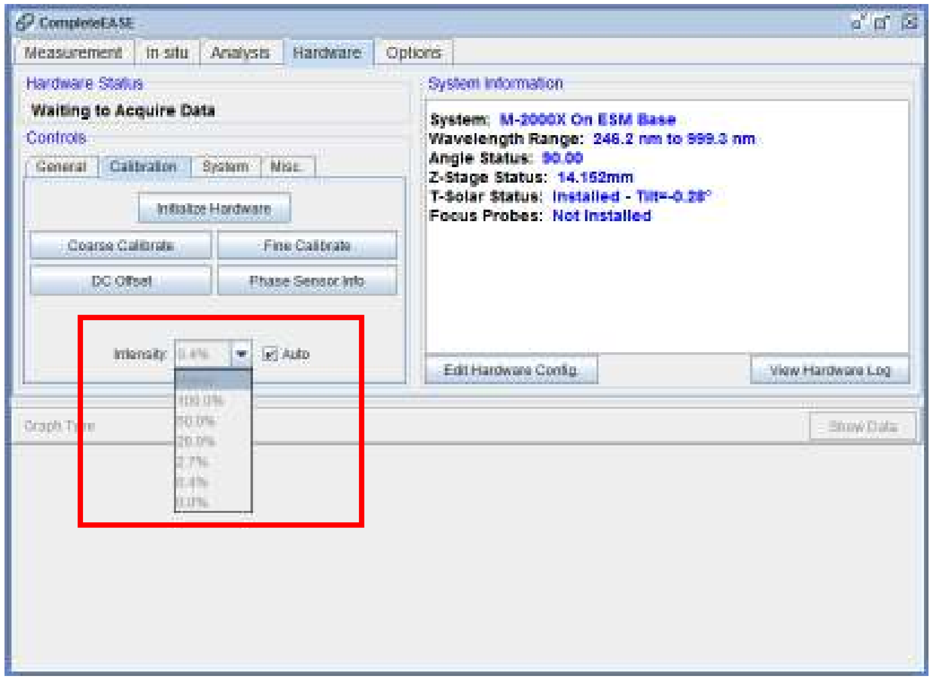


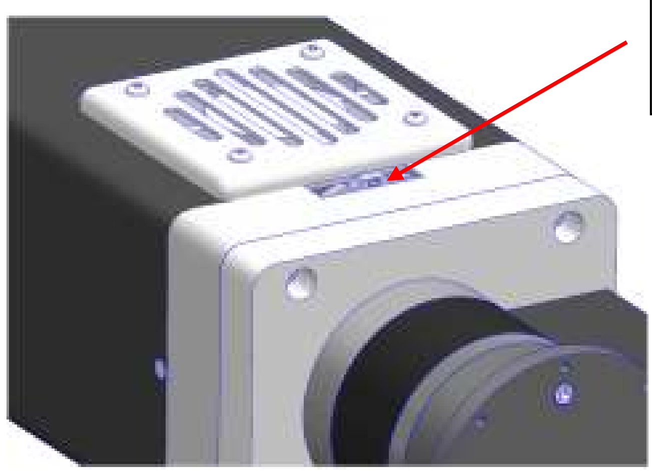
Figure 2-6. Auto Intensity selection option.

The manual filter wheel option has seven (8) detent positions:

0,1,2,3,4,5,6,7. These correspond to:

100%, 50%, 25%, 10%, 5%, 3%, .3% and a long pass filter at 530nm.

Rotate the wheel of the filter wheel to select the amount of light intensity needed for the sample under measurement.



Filter shown at the 100% light throughput position

Figure 2-7. Filter Wheel Option.

M-2000® 50W FQTH-100 Light Source

Figure 2-8. M-2000® FQTH-100 Light Source.

The M-2000V and VI ellipsometers use the FQTH-100 light source. The FQTH-100 Light Source houses the 50W Quartz Tungsten Halogen lamp. The power for the lamp is supplied through a highly regulated switching DC power supply that is located in the M-2000® Detector and Lamp Power Supply Module. This unit also contains the beam collimation optics, a fixed polarizer, and a compensator located in a continuously rotating stepper motor.

50 watt QTH Lamp

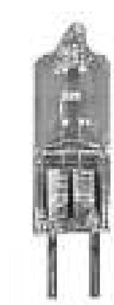


Figure 2-9. Typical QTH Lamp.

The QTH Lamp is a Quartz Tungsten Halogen Lamp. The lamp is mounted just behind the pinhole in the rear on the lamp housing.

***Warning:* The QTH lamp gets extremely hot during operation. Always allow it to cool adequately before replacing the lamp.**

Fiber Optic Cables

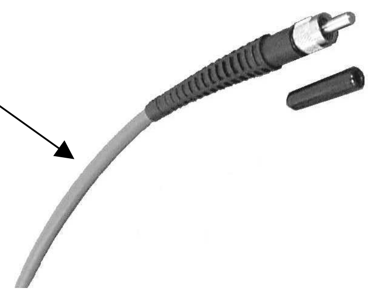


Figure 2-10. Optical Fiber.

The Fiber Optic Cable(s) is used to couple the beam from the Receiver Unit to the Detector(s) located in the M-2000® Detector and Lamp Power Supply Module. The Fiber Optic Cable(s) has a 200 micron core diameter (standard). The fiber(s) is terminated on each end with an SMA connector for easy insertion and removal.

One DUV-200 fiber optic cable is used in the M-2000D, U, and X systems. The M-2000V uses an IR-200 fiber since the spectrum is limited to 370nm. If the ellipsometer system is an M-2000DI, UI, XI or VI, an IR-200 fiber optic cable is also used for the second NIR Detector. The fiber(s) is normally 2 or 3 meters long, depending on application.

> ***Note:* When the fiber is first installed it needs to be oriented for Maximum light throughput. This is covered in the Maintenance Chapter**

> ***Caution:* Proper handling of the fiber is necessary to ensure long life. Never allow the fiber tip to contact any other surface (fingertip, tabletop, etc). Always cover the tips with protective rubber end caps while the fiber is not in use. The bend radius of the fiber should never be smaller than two inches. Never use a tool to tighten the fiber.**

Reciever Units

The following are the receiver units available for the M-2000® spectroscopic ellipsometers.

MQD Single Receiver Unit

Figure 2-11. MQD-Single Receiver Unit.

The MQD Single Receiver Unit is used on the M-2000D, U, X and V systems. It consists of a stepper motor driven rotational stage which houses a polarizer. There is also a four-quadrant detector used for alignment of the system. This receiver contains one beam folding mirror and one fiber coupling lens (UV).

MQD Dual Receiver Unit

Figure 2-12. MQD-Dual Receiver Unit.

The MQD Dual Receiver Unit is used on the M-2000DI, UI, XI and VI systems. It consists of a stepper motor driven rotational stage which houses a polarizer. There is also a four-quadrant detector used for alignment of the system. This receiver contains two beam folding mirrors and two fiber coupling lenses (UV & IR).

Detector and Lamp Power Supply Modules

The following are the Detector and Lamp Power Supply Modules available for the M-2000® spectroscopic ellipsometers.

M-2000D and DI Detector and Lamp Power Supply Modules

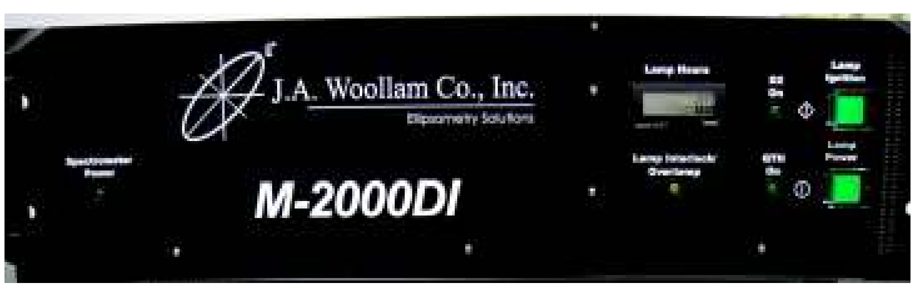


Figure 2-13. M-2000D/DI Detector and Lamp Power Supply Module.

The M-2000D and M-2000DI Detector and Lamp Power Supply Modules each contain a UV Spectrometer covering a wavelength range of 193-1000 nm. The M-2000DI also contains an IR spectrometer that covers a wavelength range of 1000-1690 nm. Both modules also house the Light Source power supply. The switching power supply provides a very stable Source of power for the D2 and QTH lamps.

M-2000U and UI Detector and Lamp Power Supply Modules

Figure 2-14. M-2000U/UI Detector and Lamp Power Supply Module.

The M-2000U and M-2000UI Detector and Lamp Power Supply Modules each contain a UV Spectrometer covering a wavelength range of 245-1000 nm. The M-2000UI also contains an IR Spectrometer that covers a wavelength range of 1000-1690 nm. Both modules also house the Light Source power supply. The switching power supply provides a very stable source of power for the D2 and QTH lamps.

M-2000X and XI Detector and Lamp Power Supply Modules

Figure 2-15. M-2000X/XI Detector and Lamp Power Supply Module.

The M-2000X and M-2000XI Detector and Lamp Power Supply Modules each contain a UV Spectrometer covering a wavelength range of 210, 245-1000 nm. The M-2000XI also contains an IR

Spectrometer that covers a wavelength range of 1000-1690 nm. Both modules also house the Light Source power supply. The switching power supply provides a very stable source of power for the arc lamp. The LED indicators on the front panel are green/blue status lights for the lamp control. Green is normal operation. Blue indicates that the lamp will not ignite for the reason stated above the respective LED.

M-2000V and VI Detector and Lamp Power Supply Modules

Figure 2-16. M-2000V/VI Detector and Lamp Power Supply Module.

The M-2000V and M-2000VI Detector and Lamp Power Supply Modules each contain a UV Spectrometer covering a wavelength range of 370-1000 nm. The M-2000VI also contains an IR Spectrometer that covers a wavelength range of 1000-1690 nm. Both modules also house the Light Source power supply. The switching power supply provides a very stable Source of power for the QTH lamp.

EC-400 Electronics Control Module

Figure 2-17. EC-400 Electronics Control Module.

The EC-400 Electronics Control Module contains a 486DX2 embedded computer. This computer is responsible for controlling the analog-to-digital (A/D) converter, the stepper motor drivers and communicating with the host computer via a network card.

During the Alignment, Calibration and Data Acquisition Procedures, signals from the Detector are sent to the embedded computer via the A/D. The software on the host computer analyzes this data and displays the results on the computer screen.

Computer

The computer operates the CompleteEASE® data acquisition and analysis software. The main function of this computer is to communicate with the remote computer located within the EC-400 electronic control module. It also analyzes all data acquired from the embedded computer and displays the results on the computer screen.

Surge Suppressor

The system is shipped with either a (110V) or two (220V) surge suppressors. These are provided to condition and filter the input AC power for the ellipsometer and to provide a central location for the system's AC power.

USB Camera (optional)

The system may be shipped with an optional high resolution USB color camera. This camera comes with a 1X-6.5X variable zoom lens, an additional 2X lens may also be included. The CompleteEASE® software allows the user to view and capture color images from the camera.

Auto Angle ESM-300 Base Unit

The M-2000® spectroscopic ellipsometer system on the auto-angle base comes in three sizes depending on the mapping stage (if present).

- A small auto-angle base is used for systems with no mapping or manual 50mm X-Y mapping.
- A medium auto-angle base is used for systems with 100mm, 150mm or 200mm X-Y mapping.
- A large auto-angle base is used for systems with 300mm X-Y mapping.

The auto-angle base may also come with an optional rack mount table.

The base is for Ex-Situ use only. It brings together the Sample Stage, Source Unit, and Receiver Unit. It is used for calibrating, sample mapping and taking data at various angles.

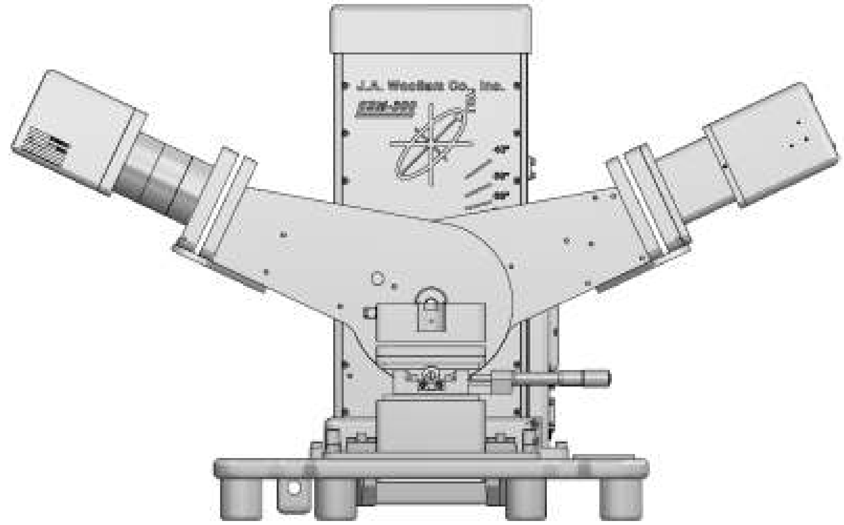


Figure 2-18. M-2000V Small Auto-Angle base with 50mm X-Y mapping.

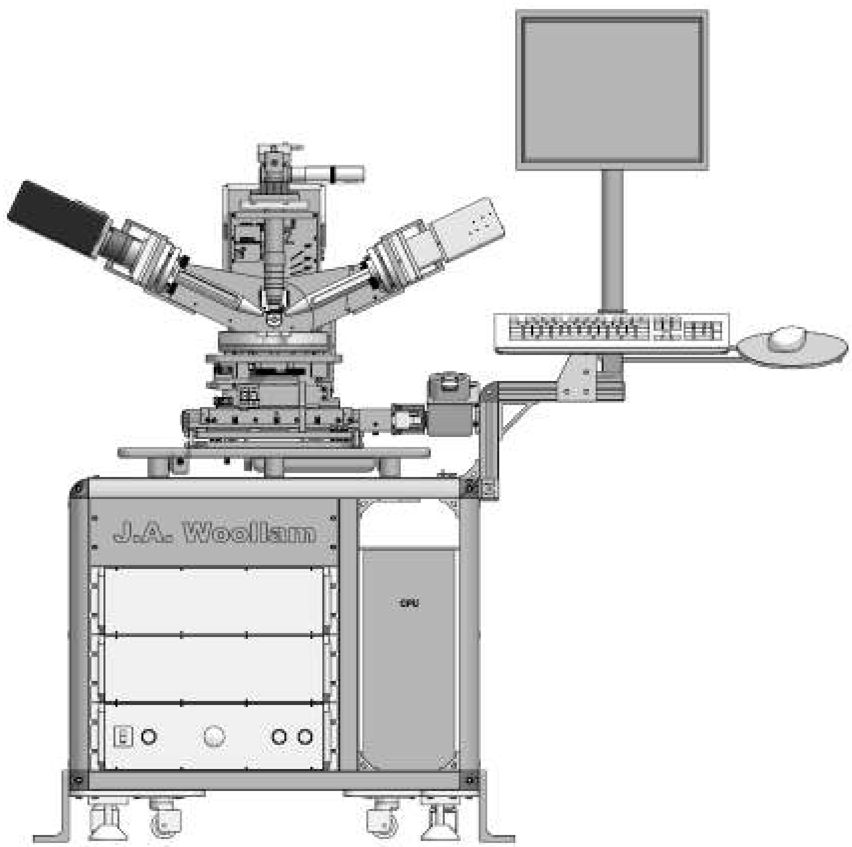


Figure 2-19. M-2000XI Medium Auto-Angle base on table with 200mm X-Y mapping, Auto Tilt Align, focusing, and camera.

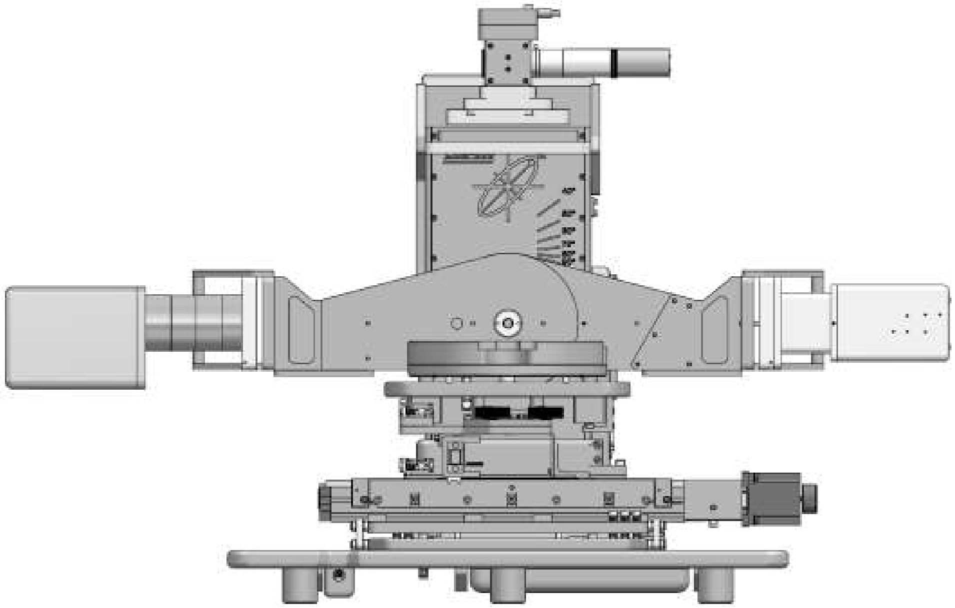


Figure 2-20. M-2000DI Large Auto-Angle base with Auto Tilt Align and 300mm X-Y mapping.

EPM-224 Emergency Power Off Module (Optional)

Figure 2-21. EPM-224 Emergency Power Off Module.

Systems supplied with the optional table receive an Emergency Power Off Module. This module allows the user to Power Off the entire system by pressing one button in an emergency situation. It also acts as a centralized location for the system's power. AC power is connected to the back of the EPM-224. The EPM-224 contains a 5Amp UL489 listed circuit breaker that has an AIC (Ampere Interrupting Capacity) rating of 10KA.

3. Installation

3.1. System Assembly without Table Option

Preliminary

A good sturdy table is required if the optional table is not included.

The table should be away from high traffic areas and near an electrical outlet.

Open all boxes and/or crates.

Carefully un-wrap all parts to ensure all components are present.

Base Assembly

1. Remove the base from the shipping container (DO NOT LIFT THE BASE USING THE ARMS) and set it on a table that can support at least 300 lbs.

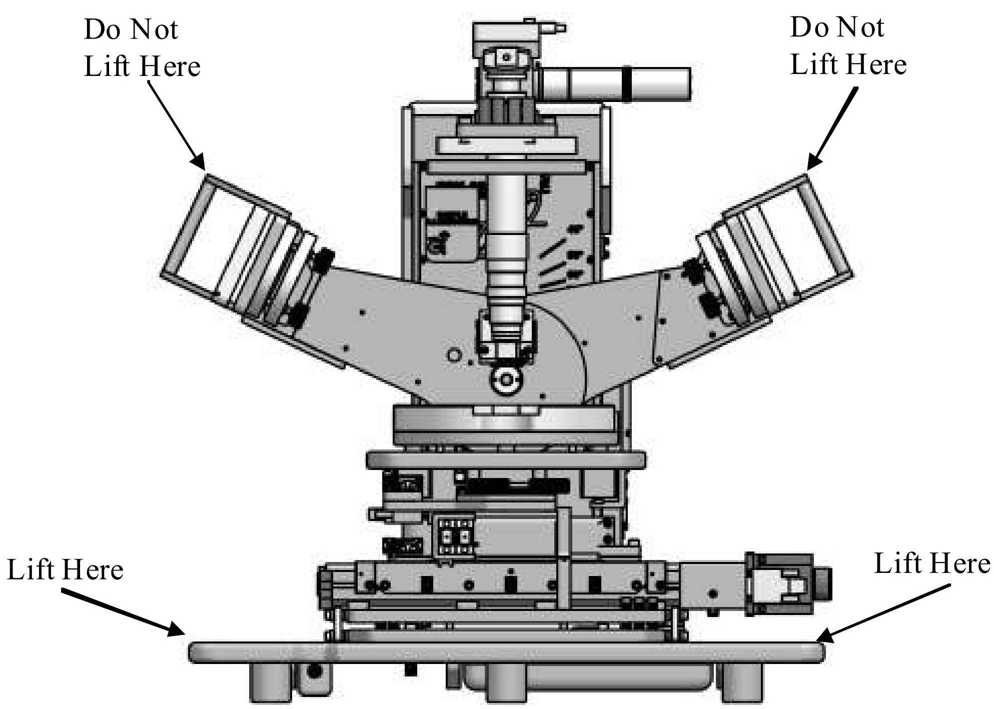


Figure 3-1. Lifting Locations.

2. Remove the angle of incidence locking screw located on the left side of the base using a 4mm metric Allen wrench.

Angle of incidence locking screw

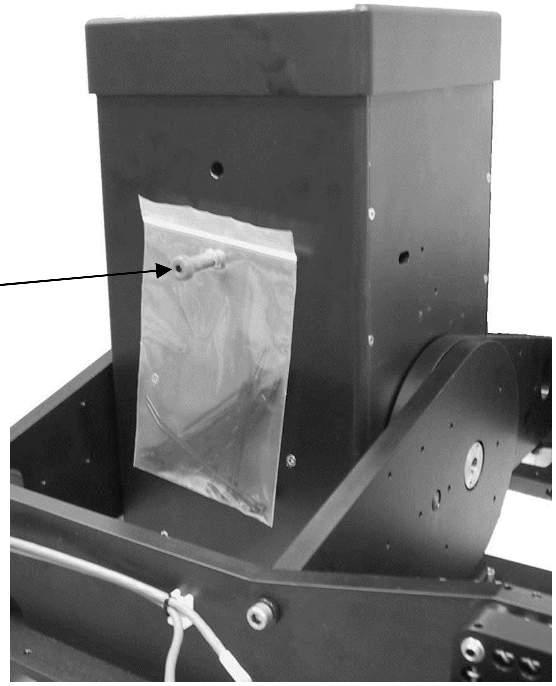


Figure 3-2. Angle of incidence locking screw.

3. Hold the arms at the center of the base to support the weight of the tower (lift slightly) and remove the Z-stage locking screw located on the right side of the base using a 4mm metric Allen wrench.

Support stage here

Z-stage locking screw

Support stage here

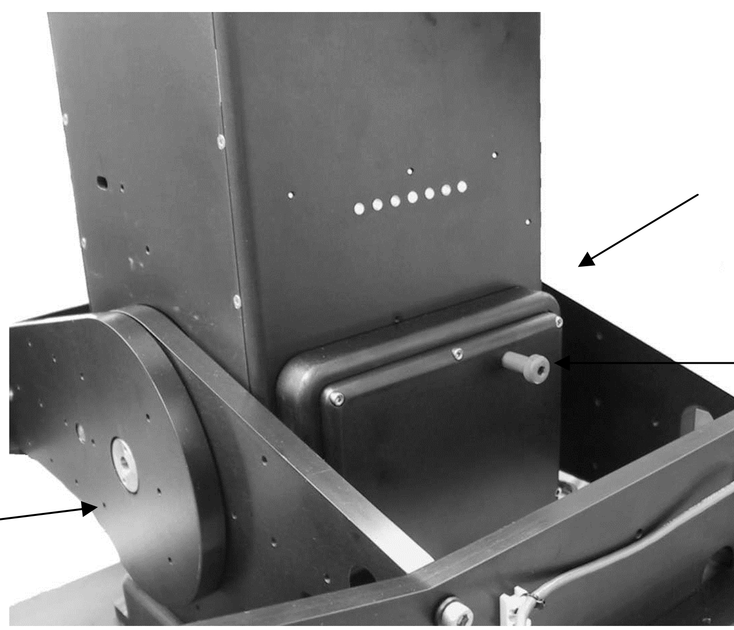


Figure 3-3. Z-stage locking screw.

4. For systems with automated sample translation, the translator shipping lock must be removed.
5. Unplug the vacuum quick disconnect on the left side of the sample chuck assembly.

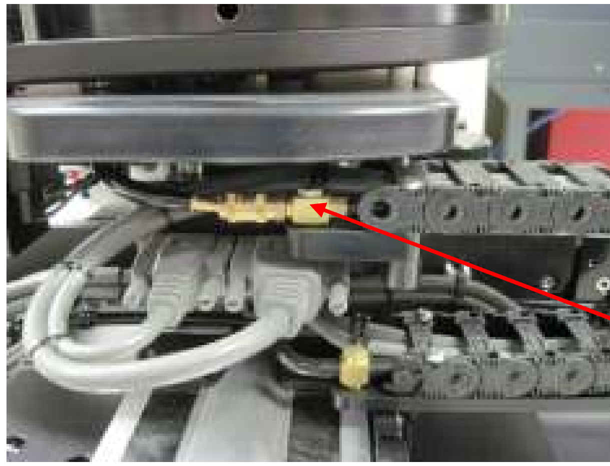


Figure 3-4. Vacuum disconnect.

6. Remove the sample chuck assembly by loosening the (4) black thumb screws. (2) are at the front of the sample stage and (2) are at the back of the sample stage.

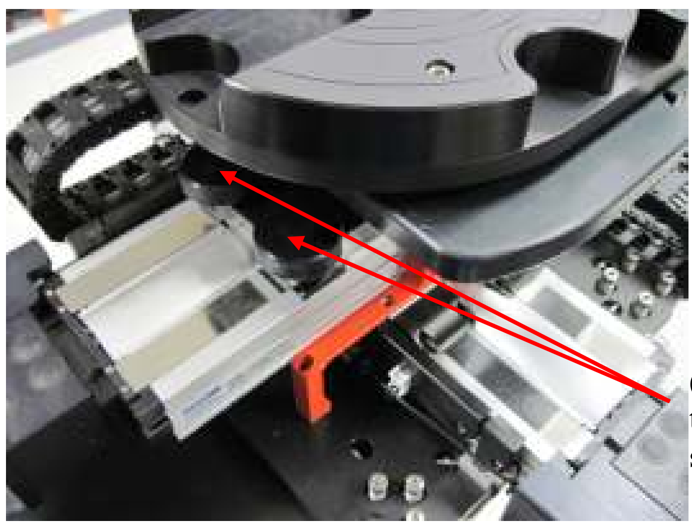


Figure 3-5. Sample stage thumb screws.

7. Lift the sample chuck off of the translator.
8. Remove the (6) SHC screws to remove the orange shipping lock. The top (4) using a 4mm metric Allen wrench, the front/back (2) using a 3mm metric Allen wrench.

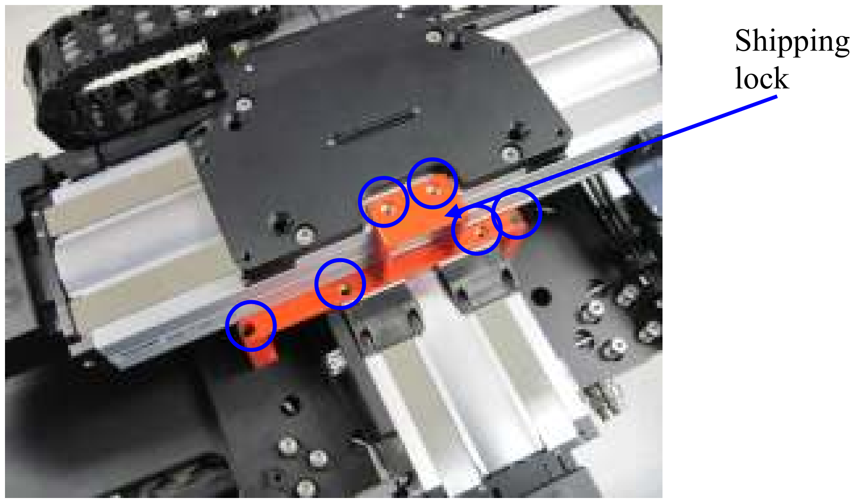


Figure 3-6. Removing the shipping lock.

9. Attach the source unit to the source tilt stage on the base using (4) M3 socket head screws with the connectors pointing to the rear of the base.

Figure 3-7. Source mounting (FQTH-100 light source shown).

10. Attach the receiver unit to the receiver tilt stage on the base using (2) M3 socket head screws with the connectors pointing to the rear of the base.

Figure 3-8. Receiver mounting (MQD-Single receiver unit shown).

AC Wiring

1. Ensure all components are turned off before attaching AC power cords.
2. Attach the computer and monitor AC power cords to the surge suppressor.
3. Attach AC power cords to the EC-400, and the M-2000 Module
4. Attach the other end of the AC power cords to the appropriately labeled jack on the surge suppressor(s).
5. Attach surge suppressor(s) to the AC power outlet and ensure it is switched on.

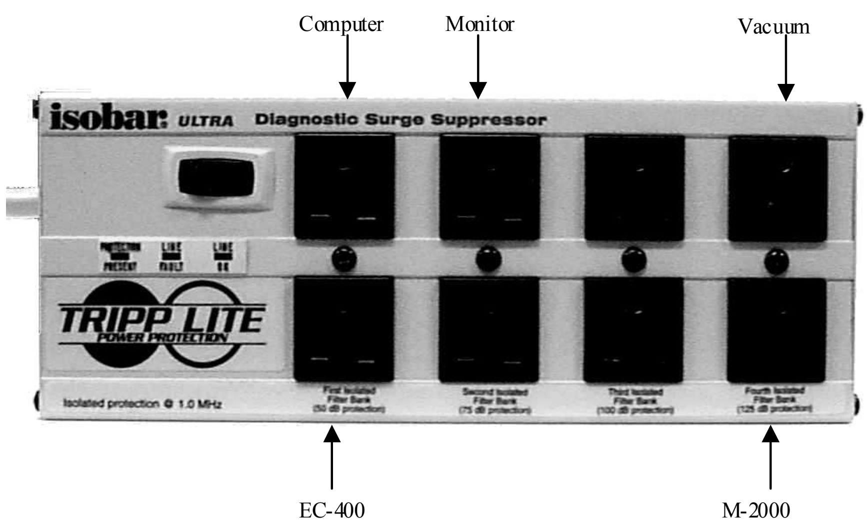


Figure 3-9. (110VAC) Configuration.

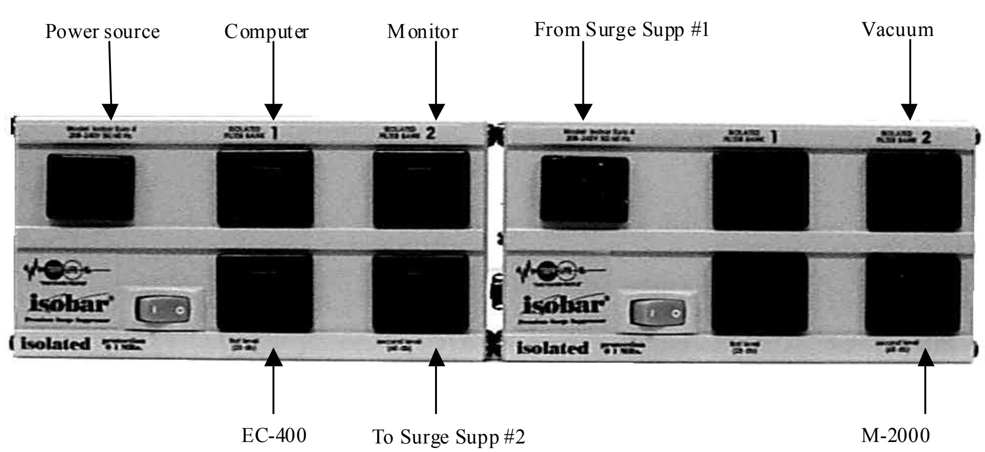


Figure 3-10. (220V AC) Configuration.

Cabling

Connect cables as directed in Table 3-1 and shown in Figure 3-11.

SYSTEM JACK LOCATION	CABLE PLUG LABEL	CABLE PLUG LABEL	SYSTEM JACK LOCATION
J1 (EC-400)	P1	P2	J2 (LIGHT SOURCE)
J3 (EC-400)	P3	P4	J4 (LIGHT SOURCE)
J5 (EC-400)	P5	P6	J6 (RECEIVER UNIT)
J7 (EC-400)	P7	P8	J8 (M-2000)
J9 (EC-400)	P9	P10	J10 (M-2000)
J11 (EC-400)	P11	P12	J12 (M-2000)
J13 (EC-400)	P13	P14	J14 (BASE OPTION)
J15 (EC-400)	P15	P16	J16 (BASE OPTION)
J17 (EC-400)	N/C	N/C	OPTIONAL AUX. PORT
J19 (EC-400)	P19	P20	J20 (BASE OPTION)
J21 (EC-400)	RJ-45	RJ-45	NETWORK CARD IN PC
J23 / J33 (M-2000)	P23 / P33	P24 / P34	J24 / J34 (LIGHT SOURCE)
J25 (M-2000)	P25	P26	J26 (RECEIVER UNIT)
J29 (EC-400)	P29	P30	J30 (SYSTEM OPTION)
J31 (EC-400)	P31	P32	J32 (SYSTEM OPTION)
J37 (EC-400)	P37	P38	J38 (SYSTEM OPTION)
UV (M-2000)	UV FIBER	UV FIBER	SMA UV (RECEIVER UNIT)
IR (M-2000)	IR FIBER	IR FIBER	SMA IR (RECEIVER UNIT)

Table 3-1. Cabling diagram.

Note:* *The IR fiber is only used on M-2000DI, UI, XI and VI systems.

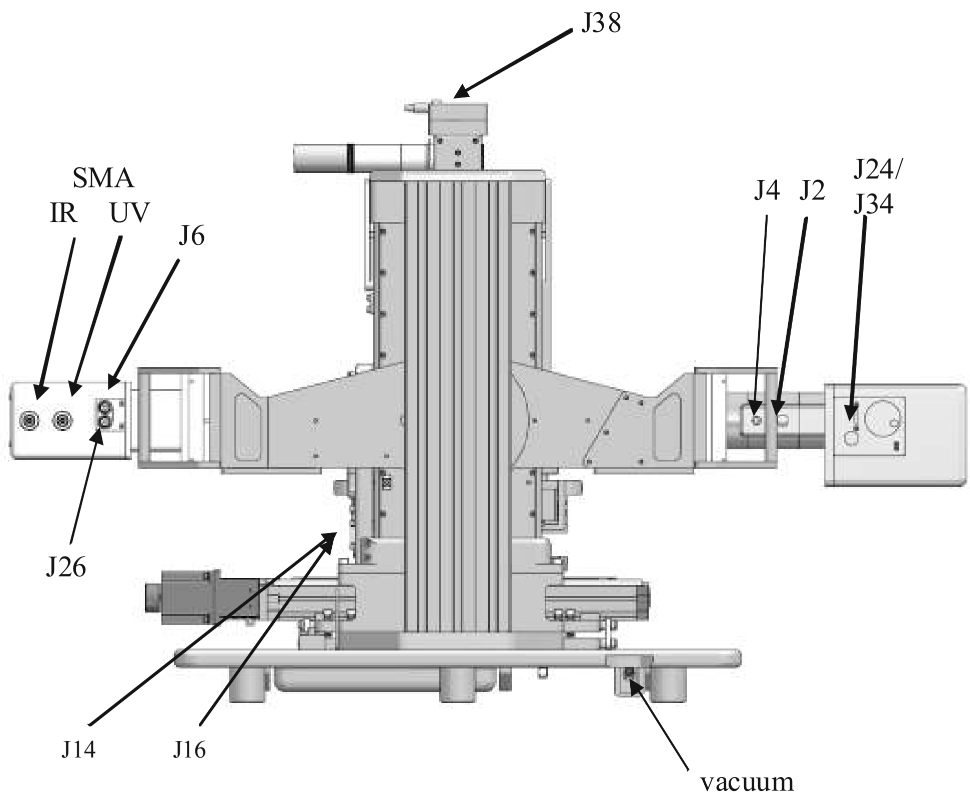


Figure 3-11. Connector locations.

Figure 3-12. EC-400, Rear View.

Figure 3-13. M-2000, Rear View.

Computer

1. Attach the monitor cable to the computer.
2. Attach keyboard to the computer.
3. Attach the mouse to the computer.

Lamp installation

The FLS-350 Xenon lamp housing requires the Xenon lamp to be removed during shipping. See Scheduled Maintenance chapter for instructions on installing and replacing the lamp(s).

3.2. System Assembly With Table Option

Preliminary

The system should be away from high traffic areas and near an AC power outlet.

The table should be placed such that there is at least 36 inches of clearance provided on all sides of the system.

Open all crates and boxes.

Carefully un-wrap all parts to ensure all components are present.

Base Assembly

1. Cut straps and remove the box around the ESM-300 base pallet. Remove the ratcheting straps holding the base to the pallet.
2. Cut straps and remove the box around the table pallet. Use the ramp provided to roll the table off the pallet and position it behind the ESM-300 base.
3. Use a forklift to lift the ESM-300 base onto the supplied table. The fork must be rated to lift 165 lbs. and meet the requirements detailed below.
4. Position the forklift properly under the ESM-300 base and set the parking brake on the forklift.
5. Lift the ESM-300 a few inches and pull the crate out from underneath the ESM-300. Do not put any part of your body under the ESM-300 or forklift.

6. Lift the ESM-300 to about 40" above floor and properly position the table under the ESM-300.
7. Lower the ESM-300 onto the table. Be sure that all persons are clear before lowering the ESM-300 base onto the table.
8. Roll the table and ESM-300 base away from the forklift.

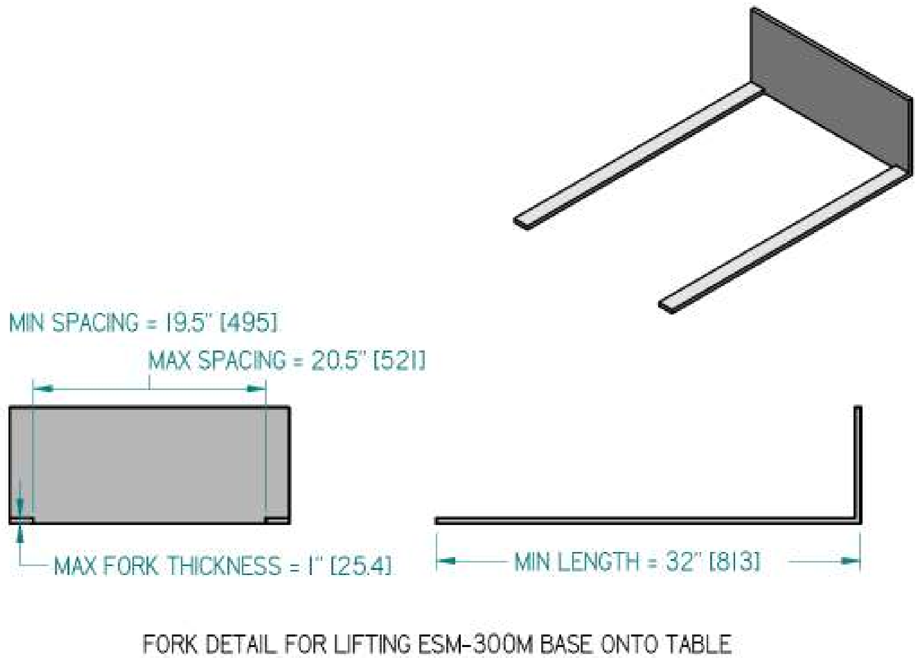


Figure 3-14. Forklift details for lifting the ESM-300 base.

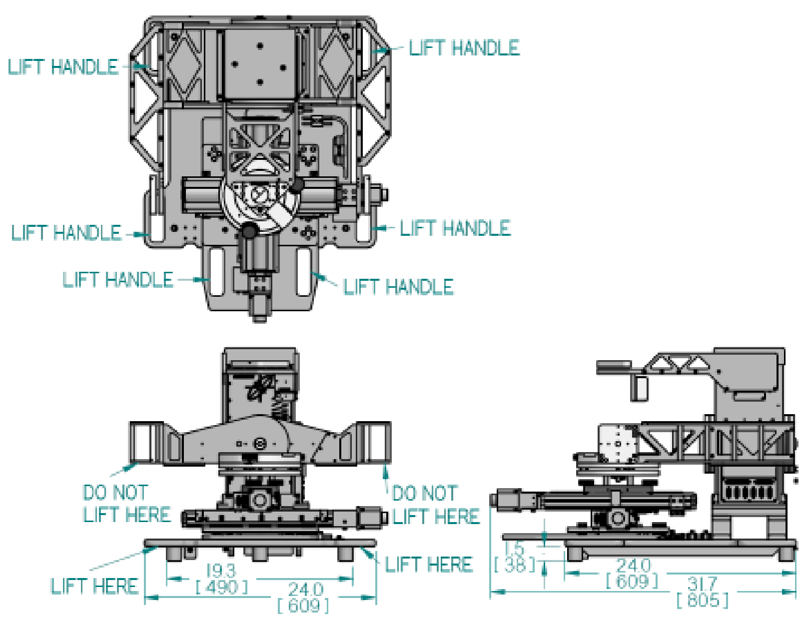


Figure 3-15. ESM-300 dimensions with respect to forklift placement.

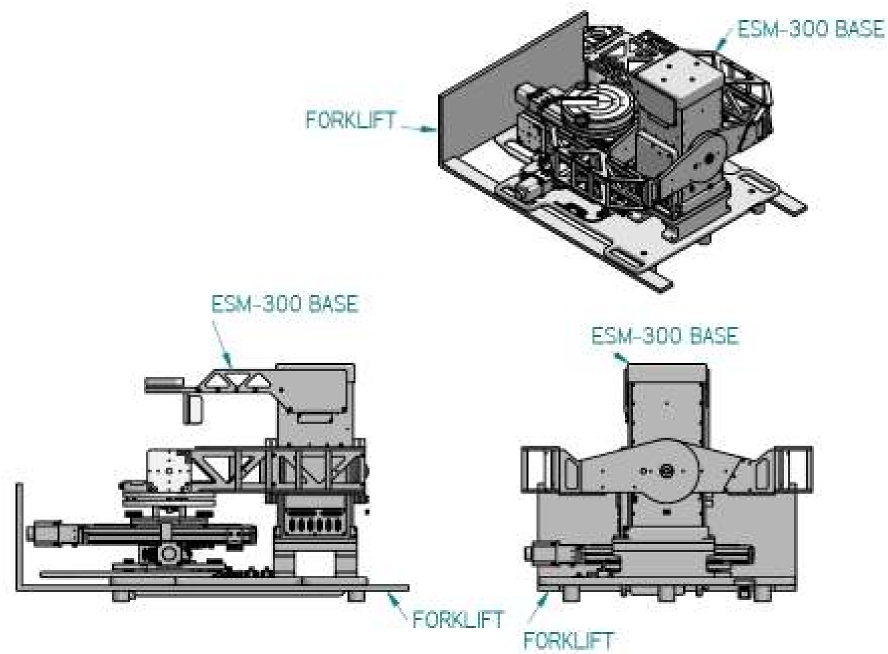


Figure 3-16. Forklift placement with respect to the ESM-300 base.

9. Secure the Ellipsometer system to the base unit using the (4) 5/16-18 BHC screws provided.

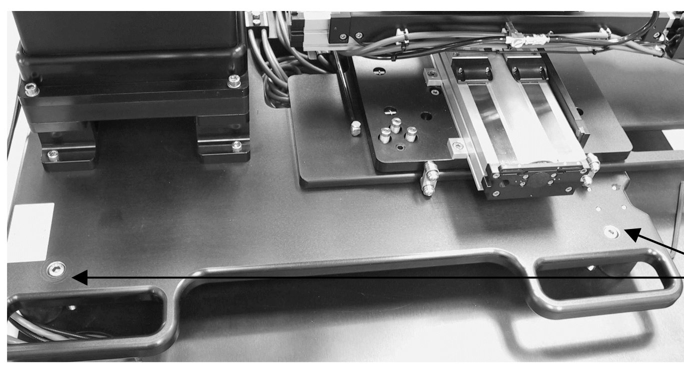


Figure 3-17. Mounting locations, left side.

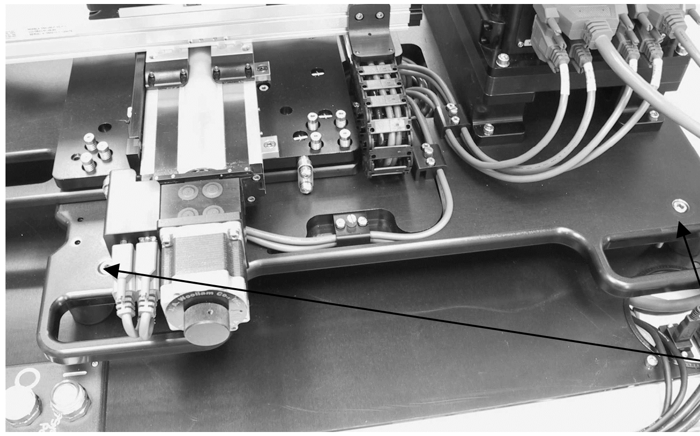


Figure 3-18. Mounting locations, right side.

10. Remove the angle of incidence locking screw located on the left side of the base using a 4mm metric Allen wrench.

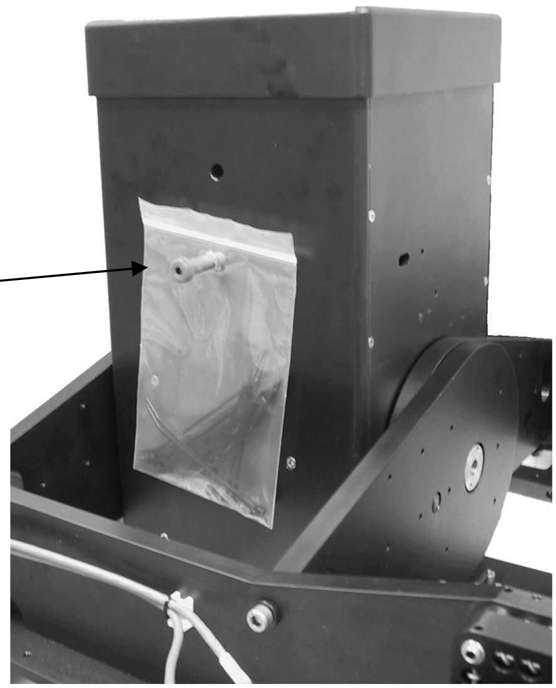


Figure 3-19. Angle of incidence locking screw.

11. Hold the arms at the center of the base to support the weight of the tower (lift slightly) and remove the Z-stage locking screw located on the right side of the base using a 4mm metric Allen wrench.

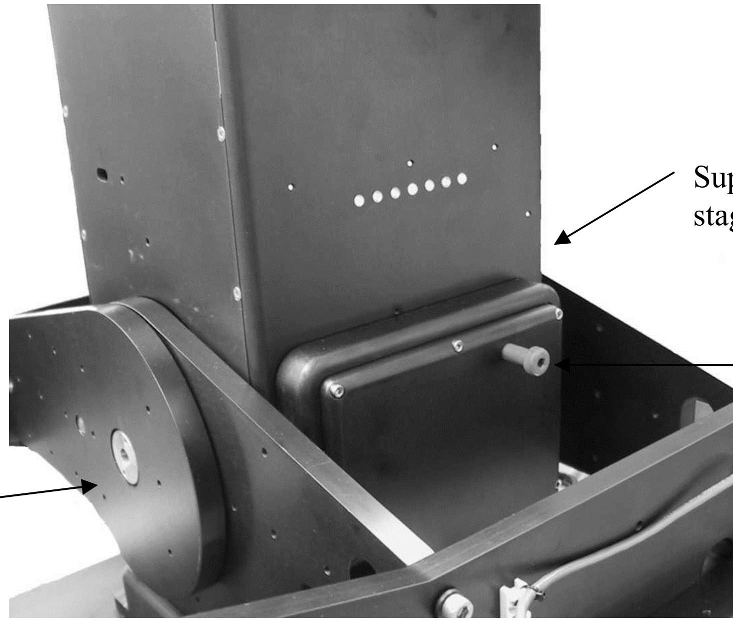


Figure 3-20. Z-stage locking screw.

12. For systems with automated sample translation the translator shipping lock must be removed.
13. Unplug the vacuum quick disconnect on the left side of the sample chuck assembly.

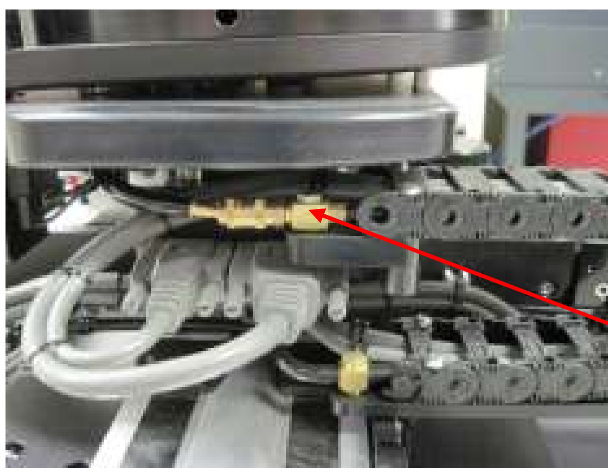


Figure 3-21. Vacuum disconnect.

14. Remove the sample chuck assembly by loosening the (4) black thumb screws. (2) are at the front of the sample stage and (2) are at the back of the sample stage.

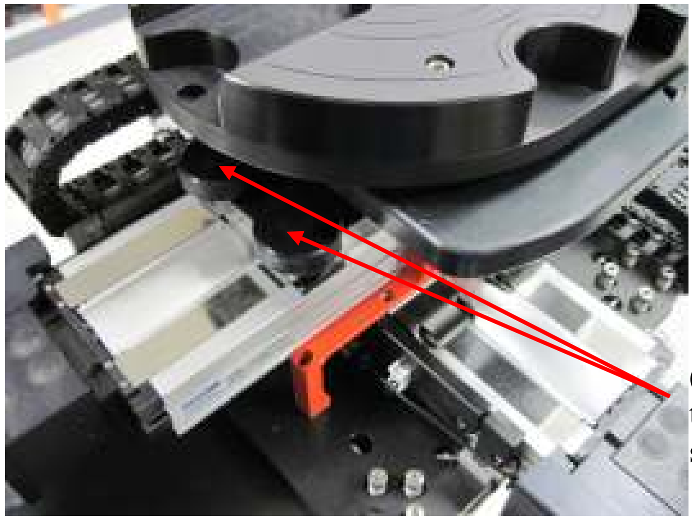


Figure 3-22. Sample stage thumb screws.

15. Lift the sample chuck off of the translator.
16. Remove the (6) SHC screws to remove the orange shipping lock. The top (4) using a 4mm metric Allen wrench, the front/back (2) using a 3mm metric Allen wrench.

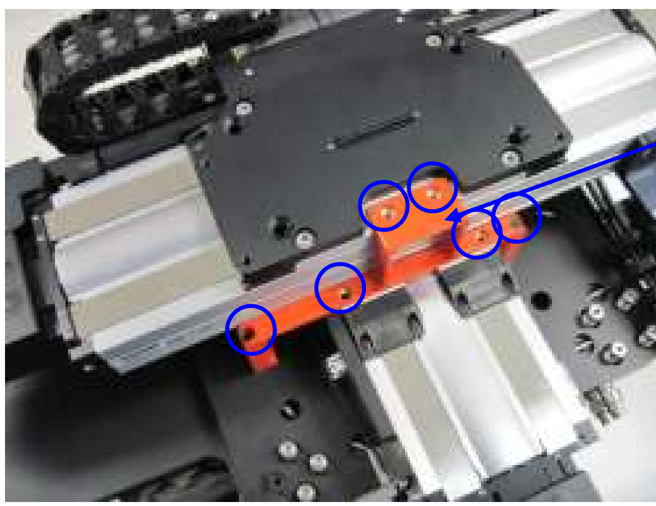


Figure 3-23. Removing the shipping lock.

17. Attach the source unit to the source tilt stage on the base using (4) M3 socket head screws with the connectors pointing to the rear of the base.

Source Tilt Stage

Figure 3-24. Source mounting (FQTH-100 light source shown).

18. Attach the receiver unit to the receiver tilt stage on the base using (2) M3 socket head screws with the connectors pointing to the rear of the base.

Receiver Tilt Stage

Figure 3-25. Receiver mounting (MQD-Single receiver unit shown).

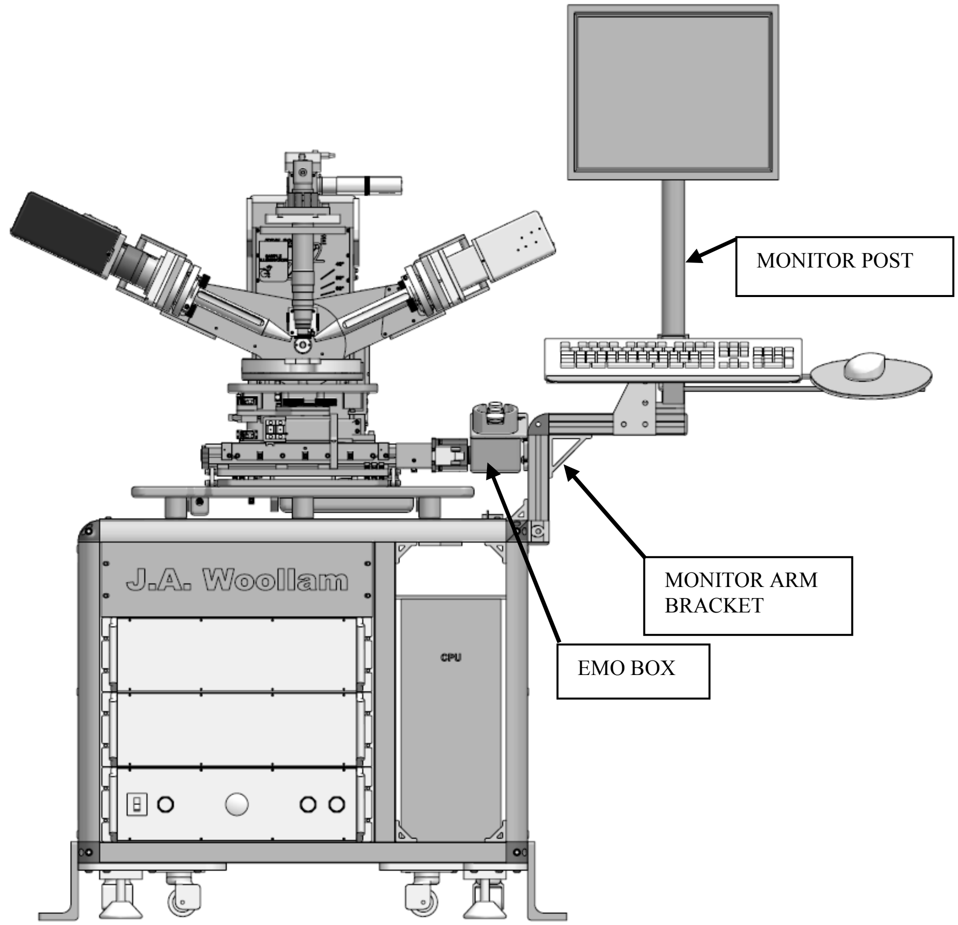


Figure 3-26. Assembled system (simulated).

19. Mount the monitor arm bracket to the table using (3) screws provided on the table.
20. Slide the keyboard, mouse, monitor post onto the arm bracket.
21. Route the monitor power, VGA, and USB hub cables through the cable ties on the arm bracket and plug into the appropriate location on the monitor.
22. Plug in the EMO Switch cable (DB-25) to the EMO box on the arm bracket.

AC Wiring

1. Ensure all components are turned off before attaching the AC power cord.
2. Attach a power cord from a mains power outlet protected by a 15 Amp breaker to the EPM-224. This power cord is not supplied and must have a IEC-320 C-13 plug on one end. The cord must be rated for at least 15A continuous.

IEC-320 C14 receptacle. Cord should have IEC-320 C13 plug and 15A continuous rating.

Figure 3-27. EPM-224 back panel.

SYSTEM JACK LOCATION	CABLE PLUG LABEL	CABLE PLUG LABEL	SYSTEM JACK LOCATION
COMPUTER	COMPUTER	STAGE1 AC1	STAGE 1 AC1 (EPM-224)
EC-400	EC-400	STAGE1 AC2	STAGE 1 AC2 (EPM-224)
M-2000	M-2000	STAGE2 AC3	STAGE 2 AC3 (EPM-224)
COMPUTER MONITOR	COMPUTER MONITOR	STAGE2 AC4	STAGE 2 AC4 (EPM-224)
VACUUM PUMP	VACUUM	STAGE3 AC5	STAGE 3 AC5 (EPM-224)
OPTIONS/ ACCESSORIES	OPTIONS/ ACCESSORIES	STAGE3 AC6	STAGE 3 AC6 (EPM-224)
OPTIONS/ ACCESSORIES	OPTIONS/ ACCESSORIES	STAGE4 AC7	STAGE 4 AC7 (EPM-224)
OPTIONS/ ACCESSORIES	OPTIONS/ ACCESSORIES	STAGE4 AC8	STAGE 4 AC8 (EPM-224)

Table 3-2. AC wiring diagram.

Cabling

Connect cables as directed in Table 3-3 and shown in Figure 3-28.

SYSTEM JACK LOCATION	CABLE PLUG LABEL	CABLE PLUG LABEL	SYSTEM JACK LOCATION
J1 (EC-400)	P1	P2	J2 (LIGHT SOURCE)
J3 (EC-400)	P3	P4	J4 (LIGHT SOURCE)
J5 (EC-400)	P5	P6	J6 (RECEIVER UNIT)
J7 (EC-400)	P7	P8	J8 (M-2000)
J9 (EC-400)	P9	P10	J10 (M-2000)
J11 (EC-400)	P11	P12	J12 (M-2000)
J13 (EC-400)	P13	P14	J14 (BASE OPTION)
J15 (EC-400)	P15	P16	J16 (BASE OPTION)
J17 (EC-400)	N/C	N/C	OPTIONAL AUX. PORT
J19 (EC-400)	P19	P20	J20 (BASE OPTION)
J21 (EC-400)	RJ-45	RJ-45	NETWORK CARD IN PC
J23 / J33 (M-2000)	P23 / P33	P24 / P34	J24 / J34 (LIGHT SOURCE)
J25 (M-2000)	P25	P26	J26 (RECEIVER UNIT)
J29 (EC-400)	P29	P30	J30 (SYSTEM OPTION)
J31 (EC-400)	P31	P32	J32 (SYSTEM OPTION)
J37 (EC-400)	P37	P38	J38 (SYSTEM OPTION)
UV (M-2000)	UV FIBER	UV FIBER	SMA UV (RECEIVER UNIT)
IR (M-2000)	IR FIBER	IR FIBER	SMA IR (RECEIVER UNIT)

Table 3-3. Cabling diagram.

Note:* *The IR fiber is only used on M-2000DI, UI, XI and VI systems.

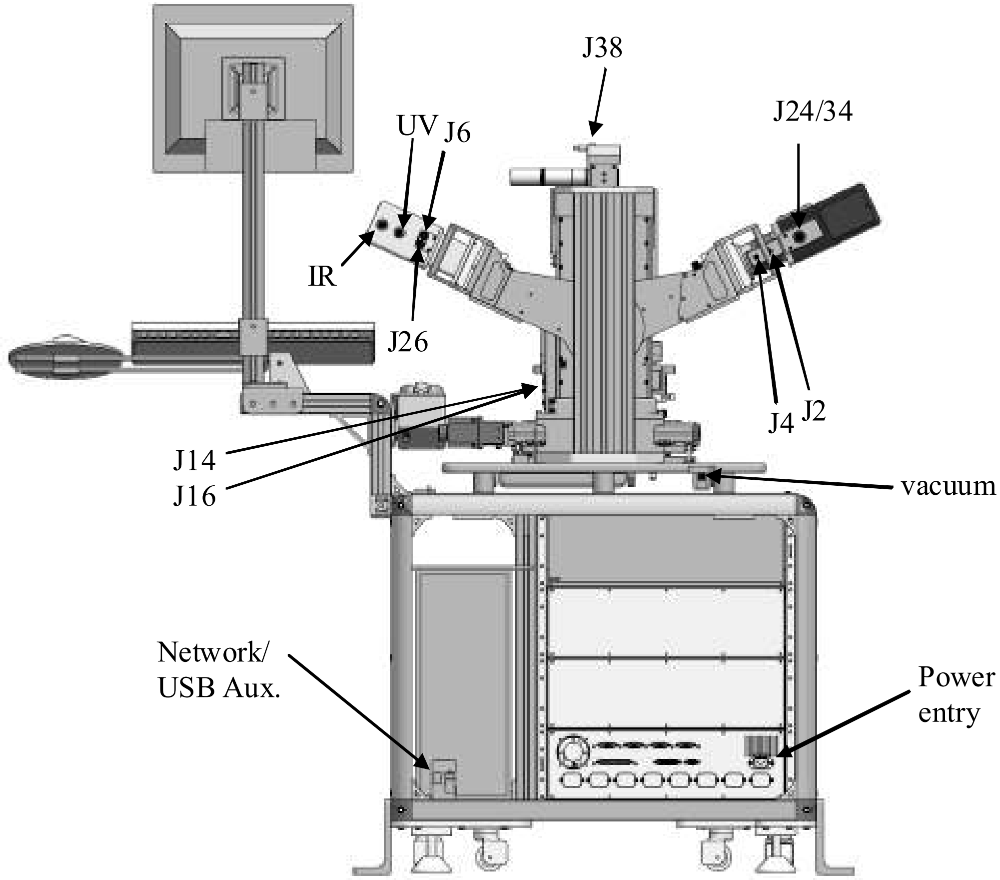


Figure 3-28. Connector locations.

Lamp installation

The FLS-350 Xenon lamp housing requires the Xenon lamp to be removed during shipping. See Scheduled Maintenance chapter for instructions on installing and replacing the lamp(s).

3.3. EC-400 Setup

The EC-400 has been configured at the factory and should not need to be changed. If components are repaired/replaced the instructions below may be necessary.

Configuring the EC-400

> ***Caution:* Incorrect setup of the EC-400 will prevent the system from operating. Only qualified personnel should change the TCP/IP address if it is necessary. Contact J.A. Woollam Co., Inc. if assistance is needed.**

1. With the power off press and hold the up and down arrows and turn the power on.
2. Release the buttons when the screen displays “Select Control Type:”

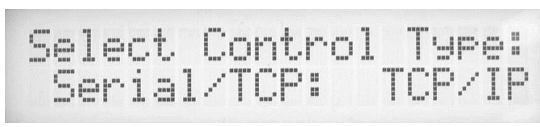


Figure 3-29. Selecting control type.

3. Press the up or down arrow key to select TCP/IP.
4. Press the right arrow key to enter.
5. Using the up or down arrow keys select the TCP/ IP address and use the right arrow key to enter.

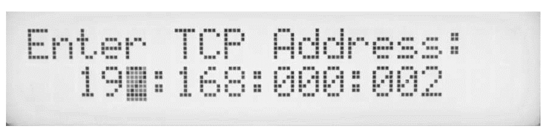


Figure 3-30. Entering TCP/IP address.

6. Now using the up or down arrow keys select the TCP/IP mask and use the right arrow key to enter.

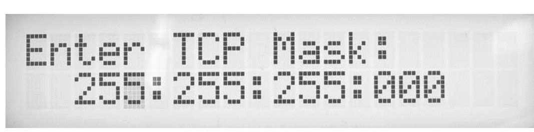


Figure 3-31. Entering TCP/IP Mask.

7. The display will now ask “Control Type: TCP/IP?” Use the down arrow key to select yes.

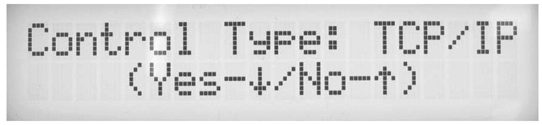


Figure 3-32. Verifying control type.

8. The display will now ask “TCP OK: xxx:xxx:xxx:xxx?” If it is correct use the down arrow key to select yes.

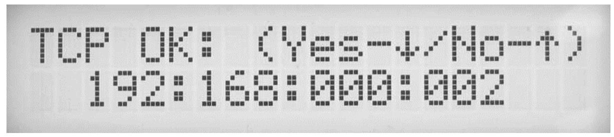


Figure 3-33. Verifying TCP/IP address.

9. The display will now ask “Mask OK: xxx:xxx:xxx:xxx?” If it is correct use the down arrow key to select yes.

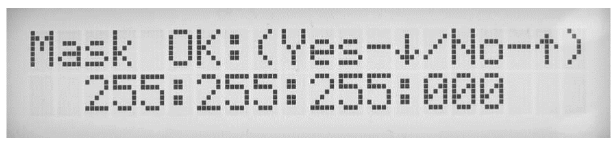


Figure 3-34. Verifying Mask address.

The EC-400 has now been setup for the TCP/IP address.

Note: ***The default TCP/IP address set at the factory is 192.168.000.002. The default Mask is 255.255.255.000.***

TCP/IP address in the Hardware.cnf file

1. Using Notepad, open the hardware.cnf file located in the C:\CompleteEASE\cnf directory.
2. The line under the [Hardware] section should say ‘Remote=TCP 192.168.0.2 300 0’
3. The first four numbers (192.168.0.2) need to be the same as the TCP/IP address on the EC-400.
4. If a change is made, save the file, and changes will be in effect the next time CompleteEASE® is started.

Note: ***The Hardware.cnf file TCP/IP address must match the EC-400 TCP/IP address.***

4. Preparing the System for Use

4.1. Power up Procedure

Turn on the components of the M-2000® system in the following order.

1. Turn on the lamp power supply button on the M-2000 module. Wait 3 seconds and press the ignition button (not applicable on M-2000V and VI systems.) Place a piece of paper in front of the Light Source unit to check that the lamp is on. If this intensity is weak, the lamp inside the lamp housing may need to be adjusted or replaced. This information can be found in Chapter 9 Scheduled Maintenance.
2. Turn on the EC-400.
3. Turn on the monitor and the computer (will turn on automatically with power on a rack mount table system).
4. Double click the CompleteEASE® program icon (or highlight the title bar under the CompleteEASE® program icon and press <enter>). A status message will appear on the screen showing the initialization progress
5. After the hardware is successfully initialized, the software will display "Waiting to Acquire Data" in the Hardware Status panel. If the hardware initialization is not successful, note the error messages that are displayed, and consult the troubleshooting section in this manual.

4.2. Conventions Used in this Manual

The following conventions are used to describe features in the CompleteEASE® software, in order to help the user navigate this manual.

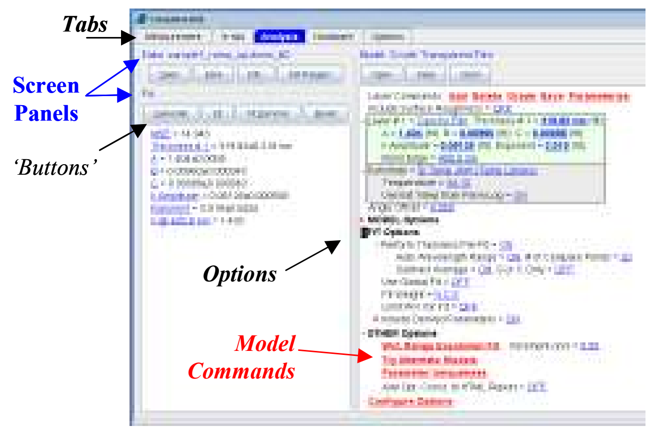


Figure 4-1. Software Conventions.

Tabs such as ***Measurement*** and ***In Situ*** will be written in bold italics.

Screen Panels such as **Data:**, **Fit:**, and **Model:** (in the ***Analysis*** Tab above) will be written in bold, blue text.

'Buttons' such as 'Open' and 'Save' (in the ***Analysis*** Tab above) will be designated with single quote marks.

Model Commands such as **Parameter Uniqueness**, which are found in the **Model:** panel will be written in bold, underlined, red letters.

+FIT, +MODEL and **+OTHER** Options found in the **Model:** panel will be written in bold black letters. The symbol preceding the text shows whether that section is collapsed (+) or expanded (-).

Mouse-selected menus are indicated with (🖱R) or (L🖱) for Right and Left mouse-buttons, respectively.

"Pipeline" descriptions of command selections: Command selection sequences will be described as a "pipeline" in this order: ***Tab***>**Panel**>'Button', (🖱R), etc. For example: the 'Open' button within the **Model:** panel under the ***Analysis*** tab is described as

Analysis>**Model:**>'Open'

A more extensive discussion of CompleteEASE® software features is available in the CompleteEASE® Data Analysis Manual, Section 1.3 "Software Overview".

4.3. File Organization & Manipulation

The CompleteEASE® software is installed on the hard-drive in a single directory. Within CompleteEASE® folder, there are several default subdirectories \DAT, \MAT, \MOD, \cnf and \jar. Users can also add there own directories.

A more extensive discussion of the CompleteEASE® file structure, as well methods to save and manipulate files, can be found in the CompleteEASE® Data Analysis Manual, section 1.3 "Software Overview," under "File Structure". The CompleteEASE® Data Analysis Manual can be viewed by selecting

***Options*>Miscellaneous>'Show Manual'**

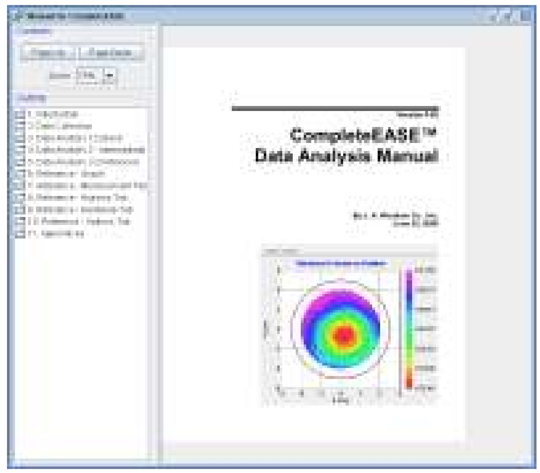
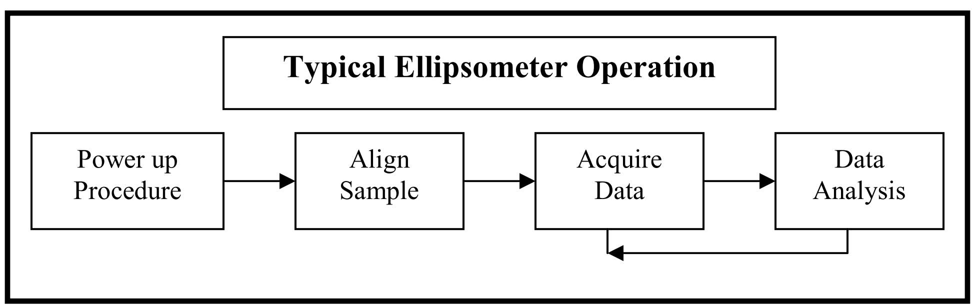


Figure 4-2. CompleteEASE® Data Analysis Manual.

4.4. Operation

The typical ellipsometric measurement involves the following steps:



The following definitions should be understood before operating the system:

System Alignment

System alignment is the adjustment of the Light source and Receiver components relative to the base of the M-2000® system. It is required when the system is first delivered, when first mounting the system onto a base or chamber, or whenever the integrity of the alignment is in question.

Alignment with filter wheel option

When performing the system alignment using a filter wheel, there are some factors to consider. Since the Straight-through position is included in the calibration, the signal needs to be optimized throughout the entire spectrum. If a higher density filter is selected, the DUV signal is lower with respect to the overall average signal. As seen below, if a lower density filter is selected and the iris(es) on the Receiver unit is closed down to avoid 'Overload', the DUV signal is optimized. This results in a much better calibration result at these lower wavelengths.

This procedure also applies to sample alignment for highly reflective samples (ex. Silicon wafer).

Examples of filter wheel positions vs. Signal Intensity:

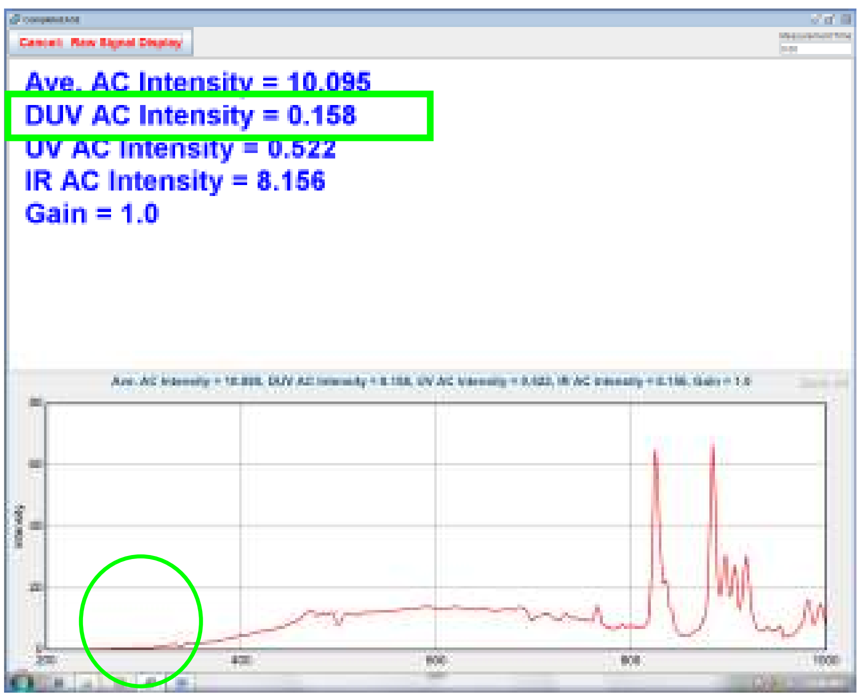


Figure 4-3. Filter 6 with iris open.

Figure 4-4. Filter 4 with iris closed to avoid Overloading the Spectrometer.

Figure 4-5. Overloaded Spectrometer.

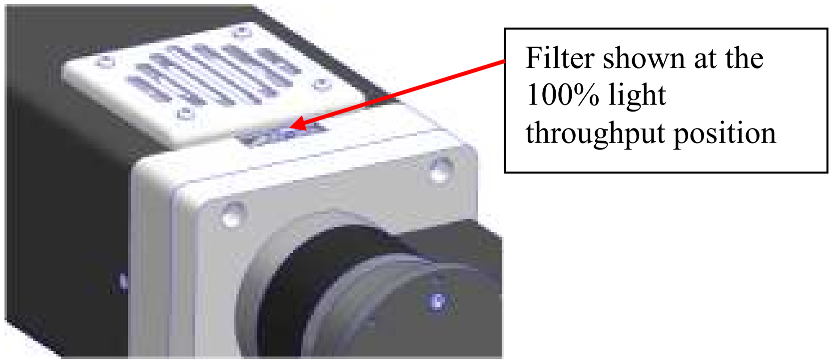


Figure 4-6. Filter Wheel Option.

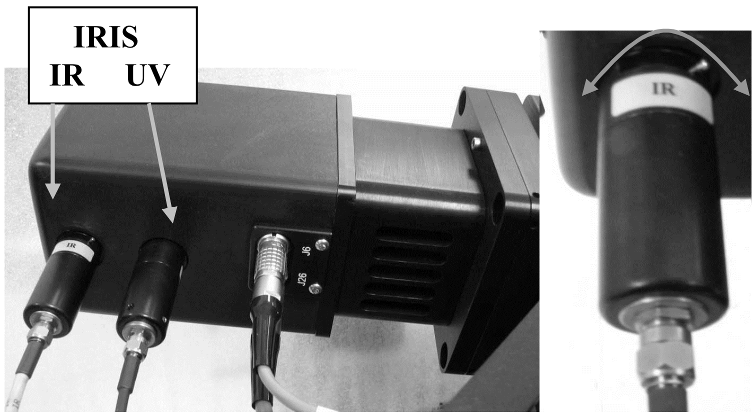


Figure 4-7. Receiver unit iris.

Sample Alignment

Sample alignment is required for each new sample to align the sample surface with respect to the ellipsometer.

System Check (Calibration)

A System Check must be performed every time the M-2000® hardware is re-mounted on the *ex situ* base or *in situ* chamber. This is required to determine the azimuthal angles of the polarizer, compensator, and analyzer optical elements with respect to the sample plane of incidence. This step also determines the in-plane and out-of-plane window effects when the system is mounted on a chamber with windows present. The system will automatically fit the data to the calibration wafer model. This confirms that the ellipsometer is working properly.

4.5. Alignment and Calibration Procedures

System Alignment (with Manual Tip/Tilt)

System alignment is the adjustment of the source and receiver components relative to the variable angle base of the M-2000® system. It is required when the system is first delivered, when first mounting the system onto a base or chamber, or whenever the integrity of the alignment is in question. Figure 4-8 shows the basic components of the M-2000® system, and this naming convention will be followed throughout these instructions.

In the straight-through position (angle = 90°), the white light beam should be centered on both the Receiver Unit aperture and the 4-quadrant alignment detector that is located inside the Receiver Unit. This alignment is easily tested, using the following instructions, which also describe correction to the alignment. All operations will be performed from within the ***Hardware*** tab of CompleteEASE®.

> ***Note:* A System Alignment should only be performed when the instrument is first delivered, after mounting the Light Source and Receiver components onto a base or chamber, or if the integrity of the alignment is in question.**

> ***Note:* Alignment of the Light Source and Receiver tilt stages on the base should only be adjusted when the base is in the straight through position.**

> ***Note:* If optional focusing optics are attached, please remove before continuing.**

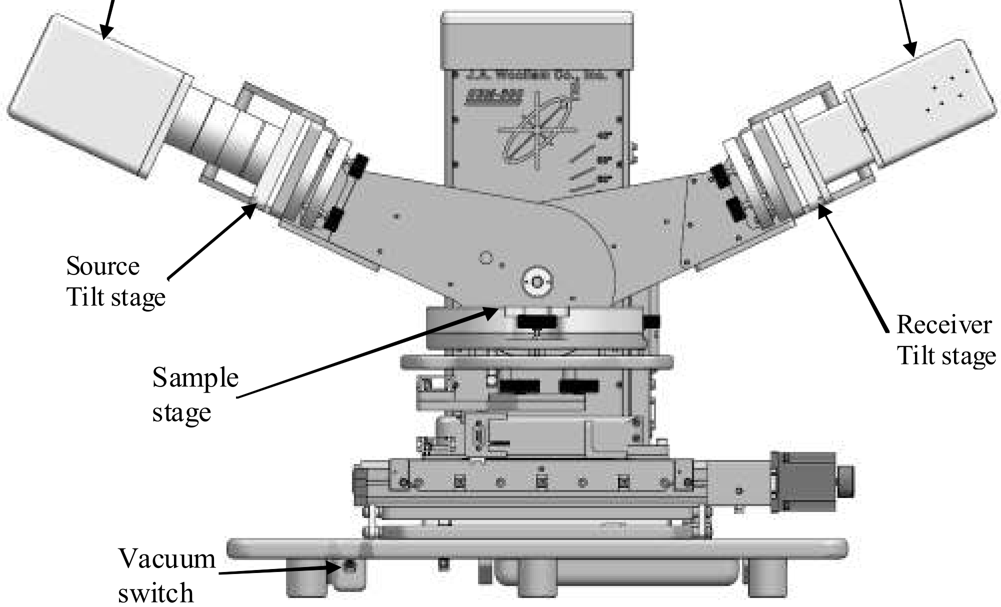


Figure 4-8. Nomenclature.

Source Unit Alignment

The lamp is housed inside the Source Unit, which is mounted to the system with tip-tilt adjustment (Source Tilt Stage) to manipulate the beam direction. The source beam alignment is verified in the straight-through position to ensure that it is aligned on the Receiver Unit aperture.

1. From System tab press the 'Angle' button. Choose an Angle of 90°. The base will move to the straight-through position.

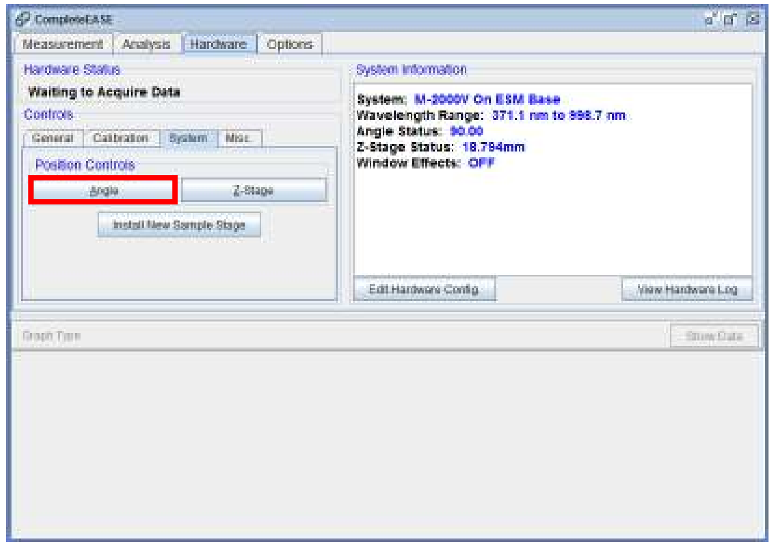


Figure 4-9. CompleteEase® hardware tab, Angle button.

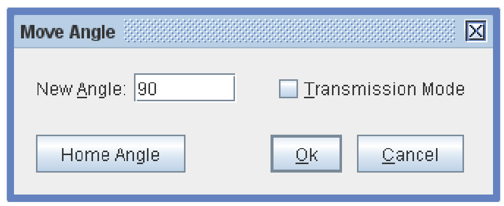


Figure 4-10. Move Angle dialog box.

2. From ***System*** tab press the 'Z-Stage' button. Choose 10mm. This raises the Source and Receiver optics above the Sample Stage, so the beam can be viewed traveling to the Receiver Unit. If in a well-lit room, it may be difficult to view the light beam. Reduce room lights for next step of operation.

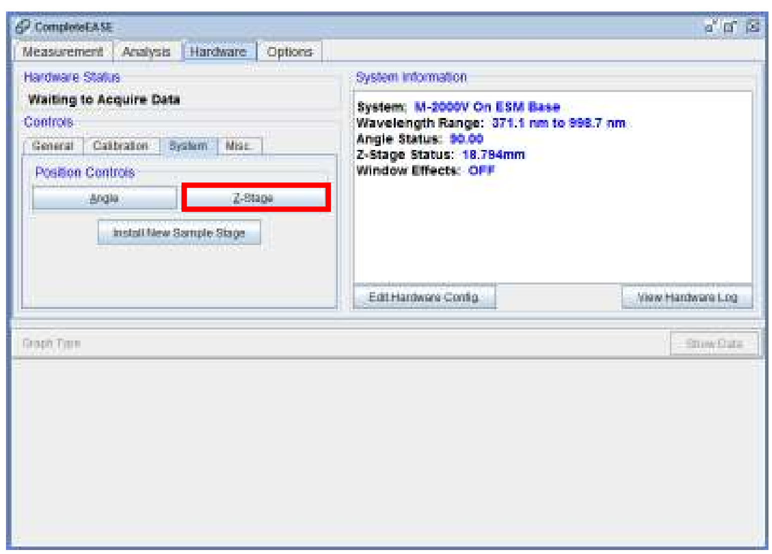


Figure 4-11. CompleteEase® hardware tab, Z-stage button.

3. Move your eye close to the source unit to view along the same path as the beam. This will allow you to see the beam entering the Receiver Unit aperture as shown below.
4. If the beam is not centered, center the probe beam on Receiver Unit aperture by adjusting the Source Unit tip-tilt stage using a 3.175mm (1/8”) English Allen wrench. When the beam is aligned, there should be a white halo around the black aperture (shown below). Misalignment results in a "crescent" halo that is larger on one side of the black aperture.

Figure 4-12. Centering Beam on Receiver Unit’s aperture.

Receiver Unit Alignment

After the Source Unit alignment has been verified, the light beam will be centered on the front aperture of the Receiver Unit. However, this does not ensure alignment throughout the Receiver Unit. The tip-tilt of the Receiver Unit controls the alignment of the beam as it travels through the Receiver Unit. To verify alignment, a 4-quadrant alignment detector has been placed inside the Receiver Unit. In this section, we will verify alignment and adjust the Receiver Unit to the measurement beam if not aligned.

1. From ***General*** Tab, press the 'Align Sample' button. You will be asked whether to perform a full sample alignment - select ‘No’.

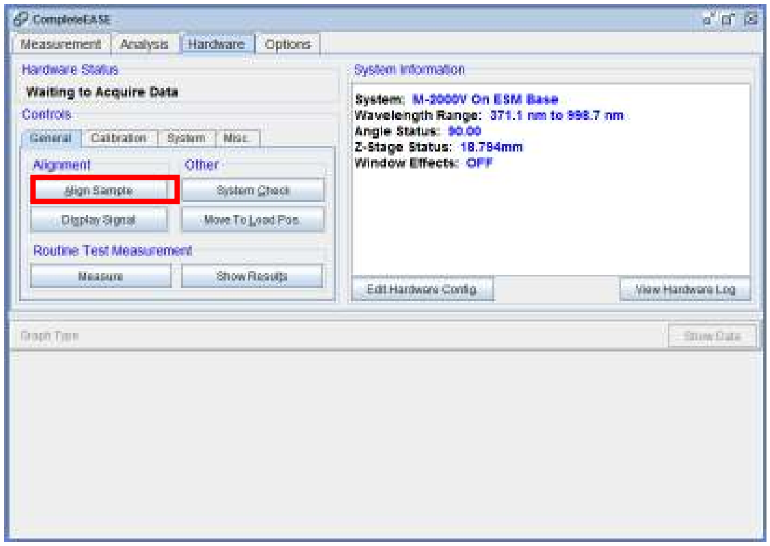


Figure 4-13. Align Sample button.

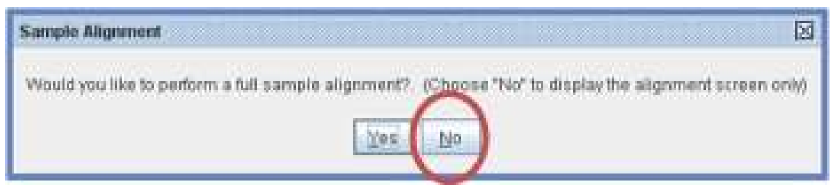


Figure 4-14. Sample Alignment dialog box.

> ***Note:* The following alignment screen is a generic screen shot. Refer to the system test report for your specific intensity values.**

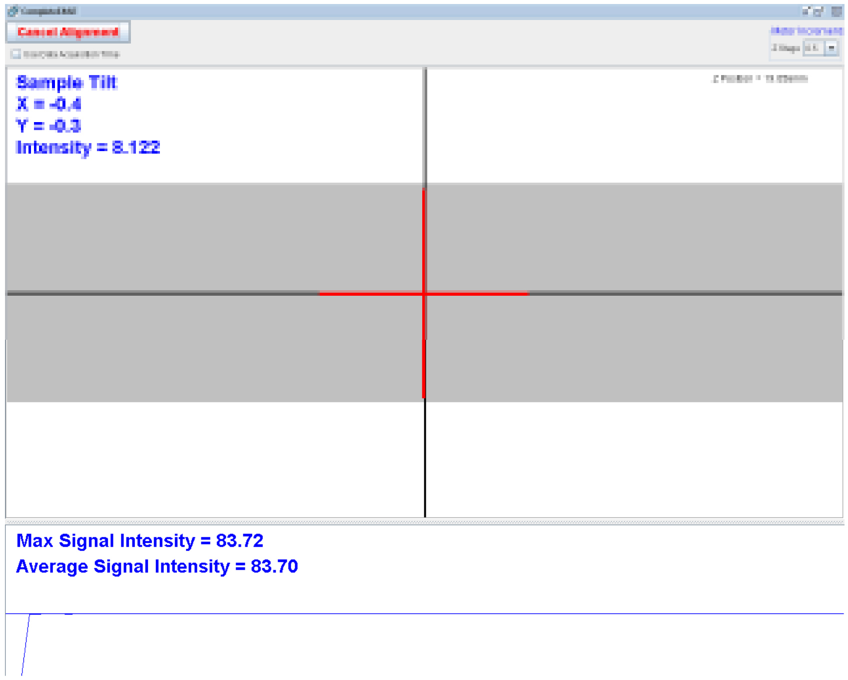


Figure 4-15. Alignment Screen.

2. The alignment screen shows gray areas to represent the intensity reaching each of the 4-quadrants of the detector, with a red cross hair to show the position of the light beam inside the Receiver Unit.

3. If the cross hair is not centered, adjust the Receiver Unit tip-tilt stage using a 3.175mm (1/8") English Allen wrench until the cross hair is centered on the alignment screen. Now, the beam should be aligned at both the front aperture and throughout the Receiver Unit. Revert back to the Source Unit alignment if the beam is no longer centered on the receiver aperture.

4. Press Escape or click 'Cancel Alignment' when finished.

Verify Signal

Inside the Receiver Unit, the light is directed into a fiber optic cable(s) which carries the light to the Spectrometer.

1. View the signal reaching the Spectrometer by selecting the 'Display Signal' button from the ***General*** Tab.

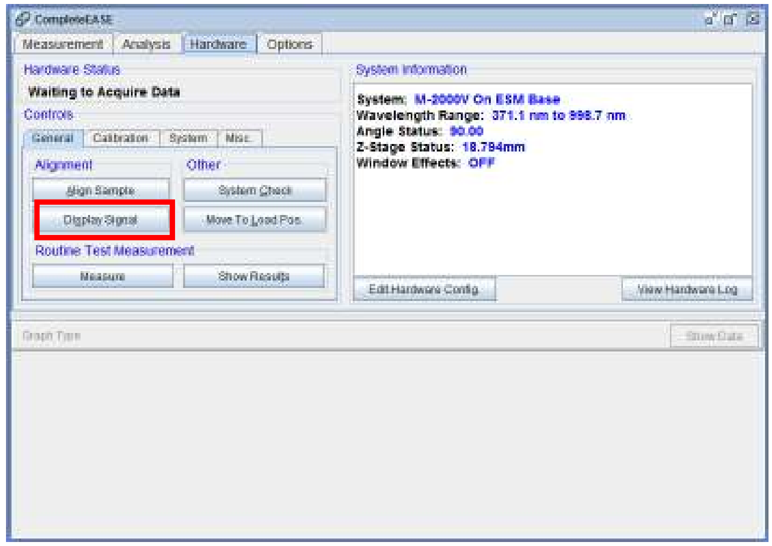


Figure 4-16. Display signal button.

2. This will display a plot of the magnitude of the signal from all detector channels, as shown below. The intensities below are typical for an M-2000® in the straight-through configuration. Check the value of the *Gain* displayed at the top of the signal intensity screen.

> ***Note:* The following signal screen is a generic screen shot. Refer to the system test report for your specific intensity values.**

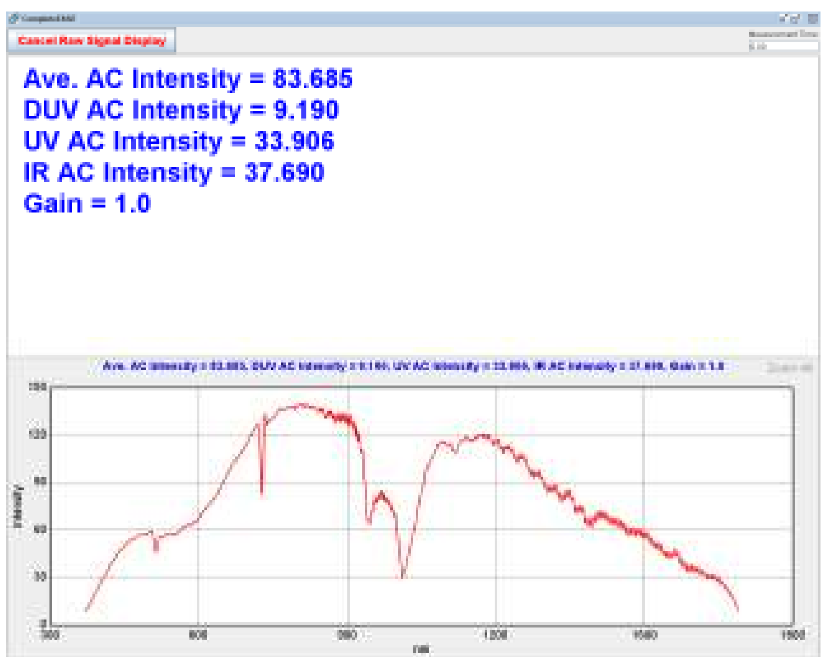


Figure 4-17. Raw Signal Display screen.

3. It is a good idea to check the value of the *Gain* displayed at the top of the signal intensity screen. In the straight-through position, the gain should be either 1 or 2. Otherwise, the system is not aligned properly or the lamp needs to be replaced/aligned. For your specific M-2000® intensity distribution of all channels please refer to the system test report. A hard copy is shipped with each system and a soft copy is included on the backup CD.

4. If part of the UV signal, optional IR, or both is "Overloading" as shown below, the iris(es) on the receiver unit may need to be closed down until the signal is no longer "Overloaded" as shown above. If the system is equipped with the ND filter wheel, this can be adjusted also to avoid the overload (see Optional Neutral Density Filter and Filter Wheels page 14).

***Note:* The following signal screen is a generic screen shot. Refer to the system test report for your specific intensity values.**

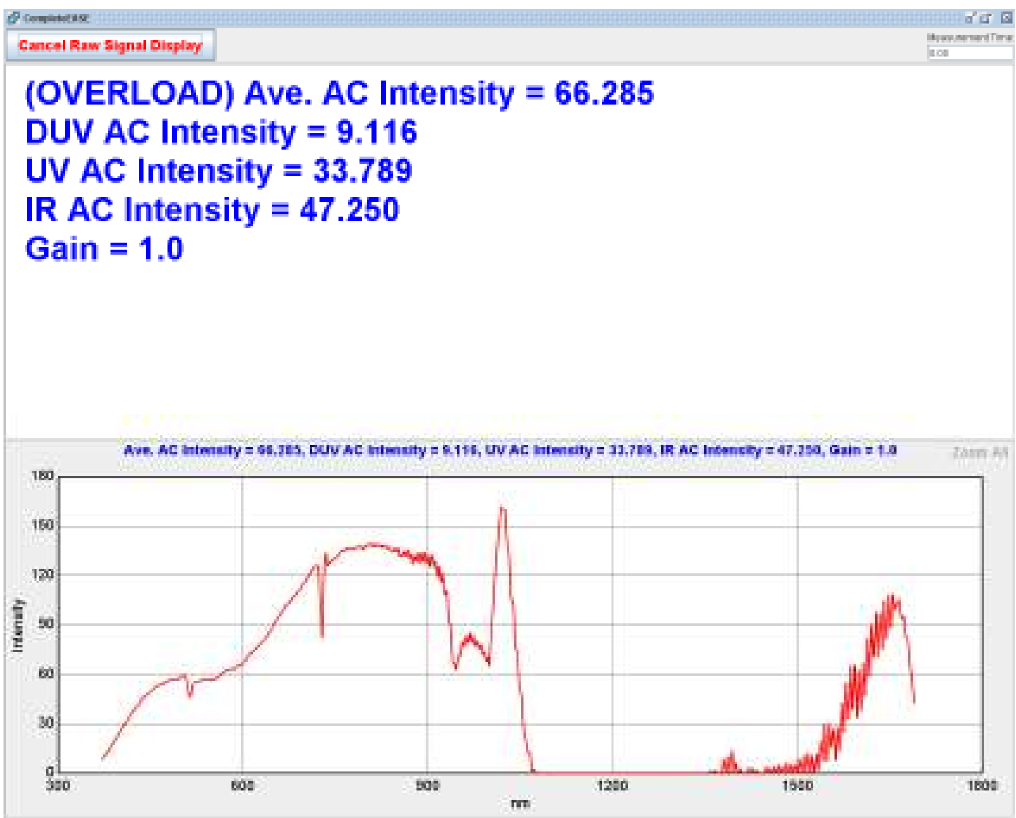


Figure 4-18. Optional IR spectrometer overloaded on M-2000® system.

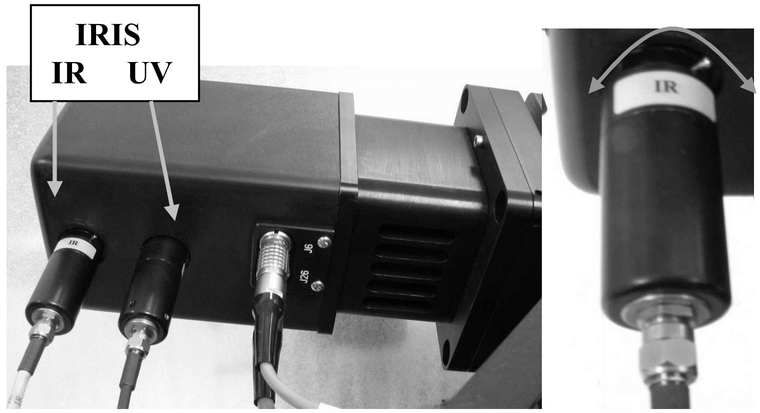


Figure 4-19. MQD Dual Receiver unit iris'.

5. Adjust the iris(es) by rotating the small silver lever around the fiber collimation tube. This will change the iris diameter affecting the amount of light available to enter the spectrometer through the fiber(s). Select Cancel Raw Signal Display (or Press ESC) to exit the screen.

System Alignment (with Automated Tip/Tilt)

> ***Note:* Automated Tip/Tilt alignment is an optional accessory that may or may not have been purchased with your system.**

System alignment is the adjustment of the source and receiver components relative to the variable angle base of the M-2000® system. It is required when the system is first delivered, when first mounting the system onto a base or chamber, or whenever the integrity of the alignment is in question. Figure 4-8 shows the basic components of the M-2000® system, and this naming convention will be followed throughout these instructions.

In the straight-through position (angle = 90°), the white light beam should be centered on both the Receiver Unit aperture and the 4-quadrant alignment detector that is located inside the Receiver Unit. This alignment is easily tested, using the following instructions, which also describe correction to the alignment. All operations will be performed from within the ***Hardware*** tab of CompleteEASE®.

> ***Note:* A System Alignment should only be performed when the instrument is first delivered, after mounting the Light Source and Receiver components onto a base or chamber, or if the integrity of the alignment is in question.**

> ***Note:* Alignment of the Light Source and Receiver tilt stages on the base should only be adjusted when the base is in the straight through position.**

> ***Note:* If optional focusing optics are attached, please remove before continuing.**

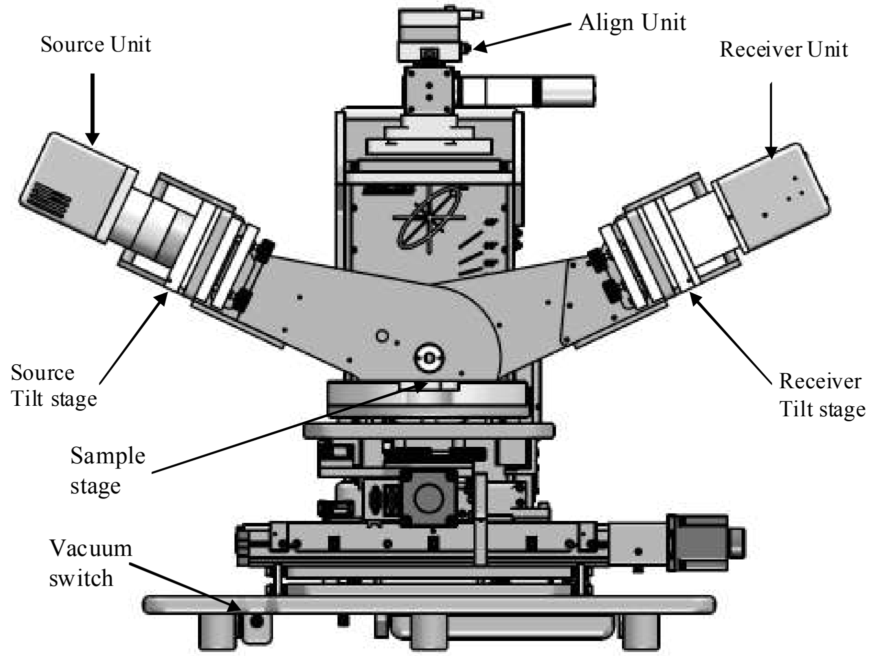


Figure 4-20. Nomenclature.

Source Unit Alignment

The lamp is housed inside the Source Unit, which is mounted to the system with tip-tilt adjustment (Source Tilt Stage) to manipulate the beam direction. The source beam alignment is verified in the straight-through position to ensure that it is aligned on the Receiver Unit aperture.

1. From System tab press the 'Angle' button. Choose an Angle of 90°. The base will move to the straight through position.

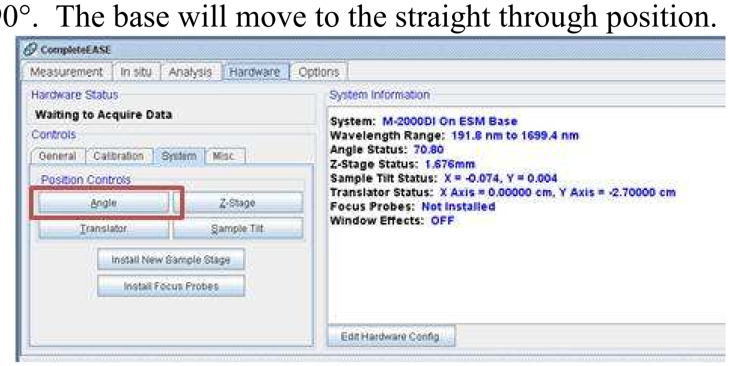


Figure 4-21. CompleteEase® hardware tab, Angle button.

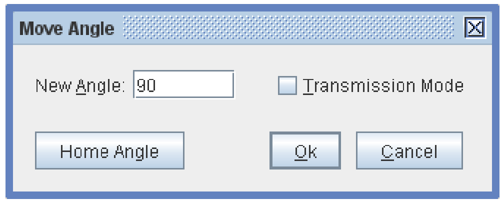


Figure 4-22. Move Angle dialog box.

2. From System tab press the 'Z-Stage' button. Choose 10mm. This raises the Source and Receiver optics above the Sample Stage, so the beam can be viewed traveling to the Receiver Unit. If in a well-lit room, it may be difficult to view the light beam. Reduce room lights for next step of operation.

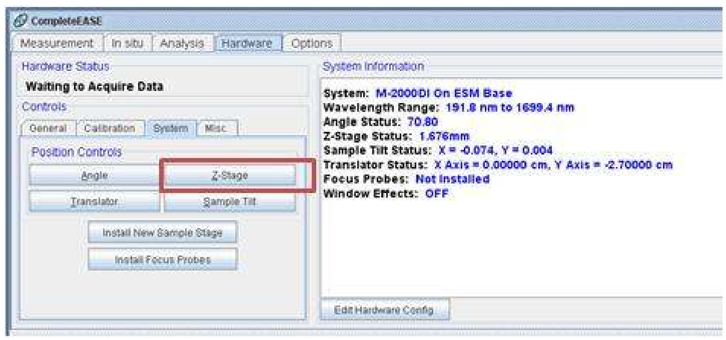


Figure 4-23. CompleteEase® hardware tab, Z-stage button.

3. Move your eye close to the source unit to view along the same path as the beam. This will allow you to see the beam entering the Receiver Unit aperture as shown below.

4. If the beam is not centered: Center the probe beam on Receiver Unit aperture by adjusting the Source Unit tip-tilt stage using a 3.175mm (1/8") English Allen wrench. When the beam is aligned, there should be a white halo around the black aperture (shown below). Misalignment results in a "crescent" halo that is larger on one side of the black aperture.

Figure 4-24. Centering Beam on Receiver Unit's aperture.

Receiver Unit Alignment

After the Source Unit alignment has been verified, the light beam will be centered on the front aperture of the Receiver Unit. However, this does not ensure alignment throughout the Receiver Unit. The tip-tilt of the Receiver Unit controls the alignment of the beam as it travels through the Receiver Unit. To verify alignment, a 4-quadrant alignment detector has been placed inside the Receiver Unit. In this section, we will verify alignment and adjust the Receiver Unit to the measurement beam if not aligned.

1. From General Tab, press the 'Align Sample' button. You will be asked whether to perform a full sample alignment - Press **NO**. There are two alignment detectors on this system. Change the Detector to "RECEIVER".

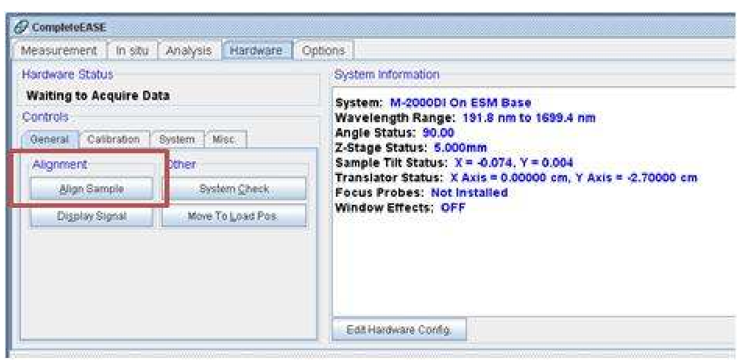


Figure 4-25. Align Sample button.

Figure 4-26. Sample Alignment dialog box.

***Note:* The following alignment screen is a generic screen shot. Refer to the system test report for your specific intensity values.**

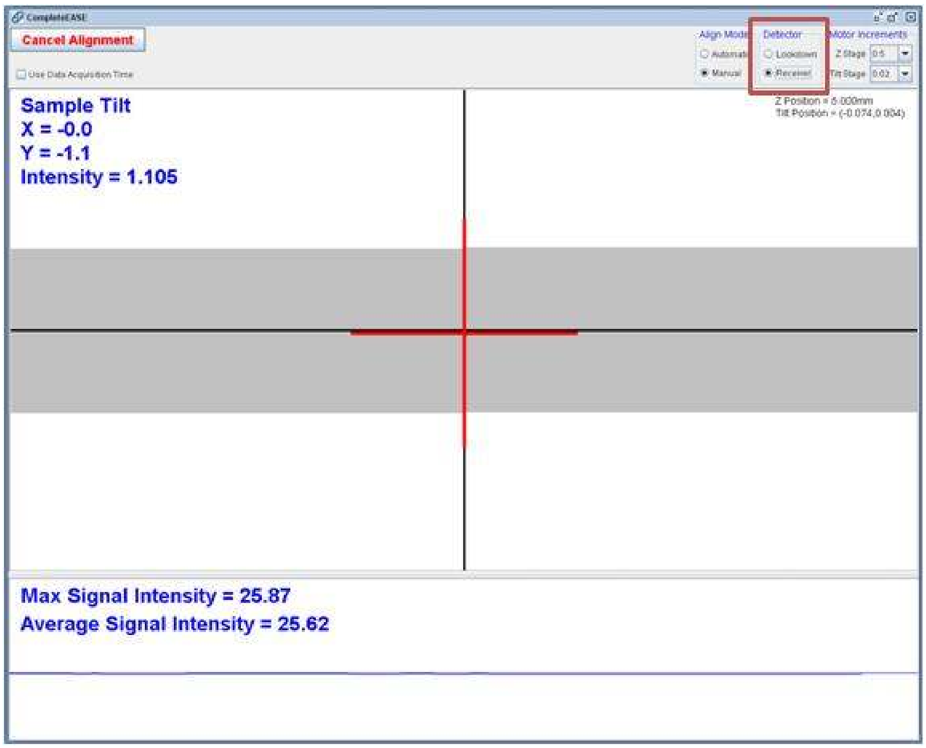


Figure 4-27. Alignment Screen.

2. The alignment screen shows gray areas to represent the intensity reaching each of the 4-quadrants of detector, with a red cross hair to show the position of the light beam inside the Receiver Unit.

3. If the cross hair is not centered, adjust the Receiver Unit tip-tilt adjustment using a 3.175mm (1/8”) English Allen wrench until the cross hair is centered on the alignment screen. Now, the beam should be aligned at both the front aperture and throughout the Receiver Unit. Revert back to the Source Unit alignment if the beam is no longer centered on the receiver aperture.

4. Press Escape or click Cancel Alignment when finished.

Verify Signal

Inside the Receiver Unit, the light is directed into a fiber optic cable(s) which carries the light to the Spectrometer.

6. View the signal reaching the Spectrometer by selecting the 'Display Signal' button from the ***General*** Tab.

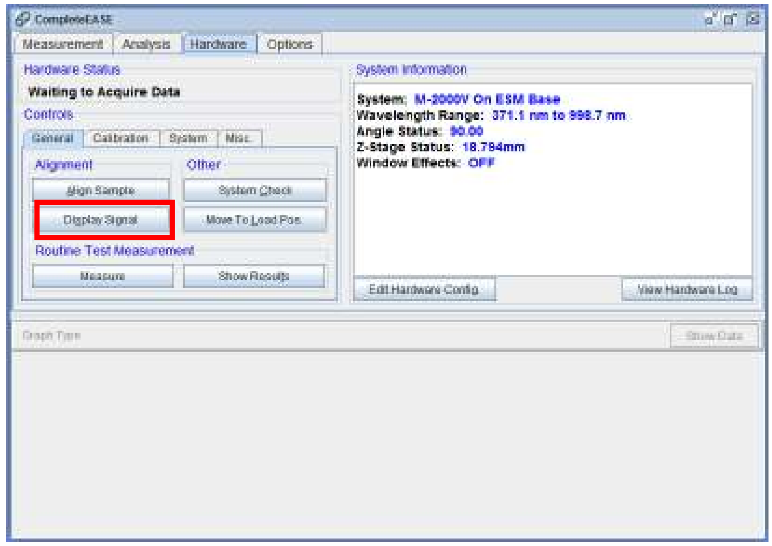


Figure 4-28. Display signal button.

7. This will display a plot of the magnitude of the signal from all detector channels, as shown below. The intensities below are typical for an M-2000® in the straight-through configuration. Check the value of the *Gain* displayed at the top of the signal intensity screen.

Note: The following signal screen is a generic screen shot. Refer to the system test report for your specific intensity values.

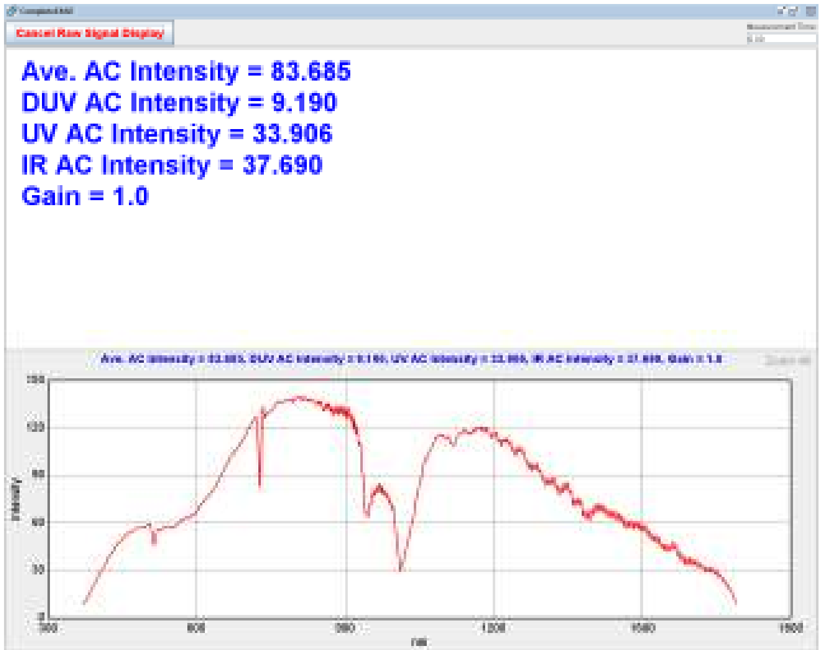


Figure 4-29. Raw Signal Display screen.

8. It is a good idea to check the value of the *Gain* displayed at the top of the signal intensity screen. In the straight-through position, the gain should be either 1 or 2. Otherwise, the system is not aligned properly or the lamp needs to be replaced/aligned. For your specific M-2000® intensity distribution of all channels please refer to the system test report. A hard copy is shipped with each system and a soft copy is included on the backup CD.

9. If part of the UV signal, optional IR, or both is "Overloading" as shown below, the iris(es) on the receiver unit may need to be closed down until the signal is no longer "Overloaded" as shown above. If the system is equipped with the ND filter wheel, this can be adjusted also to avoid the overload (see Optional Neutral Density Filter and Filter Wheels page 14).

> ***Note:* The following signal screen is a generic screen shot. Refer to the system test report for your specific intensity values.**

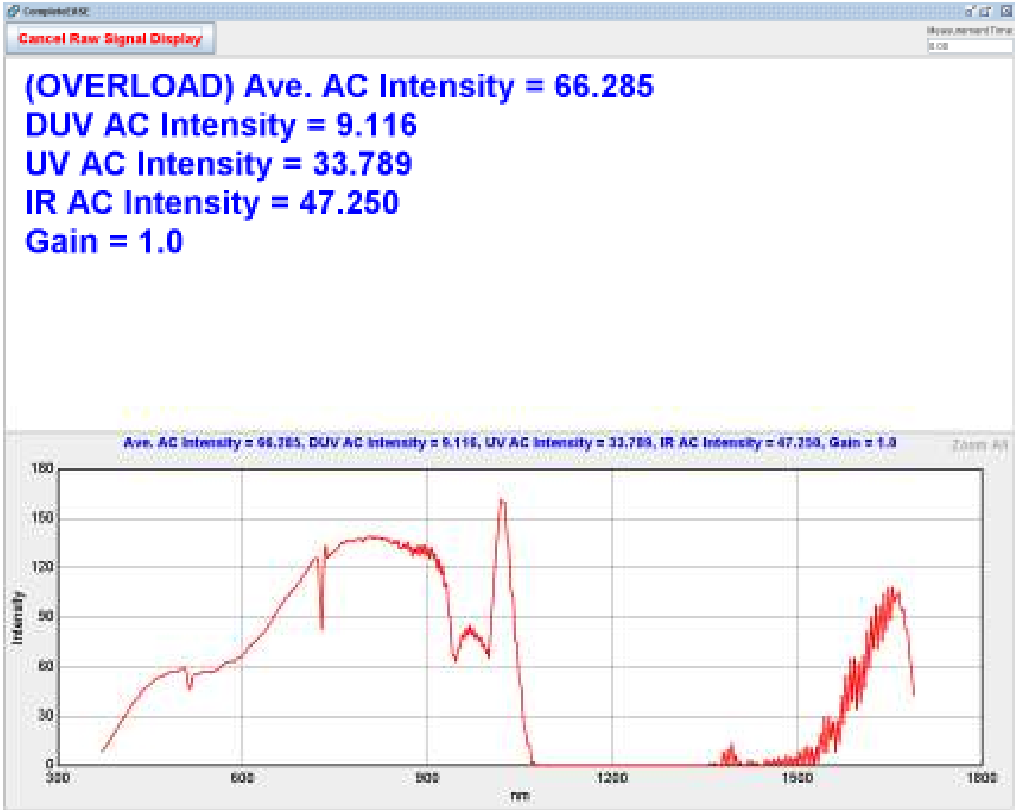


Figure 4-30. Optional IR spectrometer overloaded on M-2000® system.

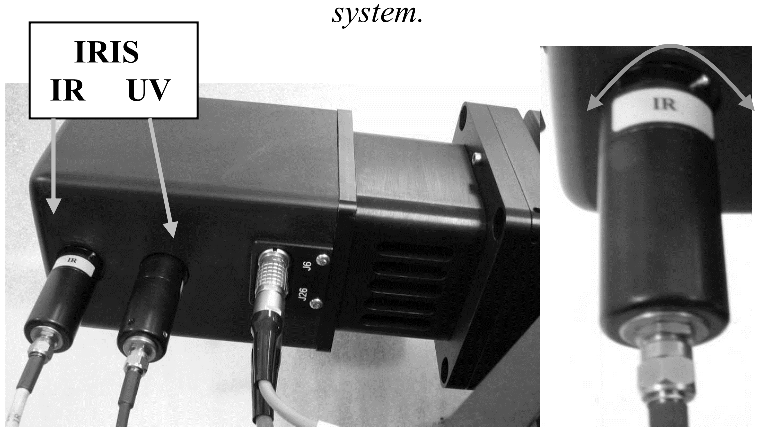


Figure 4-31. MQD Dual Receiver unit irises.

10. Adjust the iris(es) by rotating the small silver lever around the fiber collimation tube. This will change the iris diameter affecting the amount of light available to enter the spectrometer through the fiber(s). Select Cancel Raw Signal Display (or Press ESC) to exit the screen.

Sample Stage Alignment

Thus far, we have aligned the Source and Receiver Units to the Angular Base. Next, we need to align the Sample Stage to the Measurement Beam. Once we have the sample stage aligned to the system, we will align the Look-Down Detector to the sample stage to allow for automated sample alignment for future samples.

> ***Note:* This procedure should only be performed when the system is first installed, if the beam alignment has been adjusted or if the Look-Down detector alignment is under question.**

Aligning Sample Stage to Measurement Beam

1. Remove any custom mounts or samples and mount the 25nm Oxide on Silicon Calibration Wafer directly to the sample stage. Make sure to switch on the vacuum to hold wafer in place.
2. From the ***Hardware***>System Tab, choose 'Z-Stage' button and move to 0.5mm as a starting position for the thickness of the Calibration Wafer.
3. From ***Hardware***>System Tab, choose 'Angle' button and move to 65°.

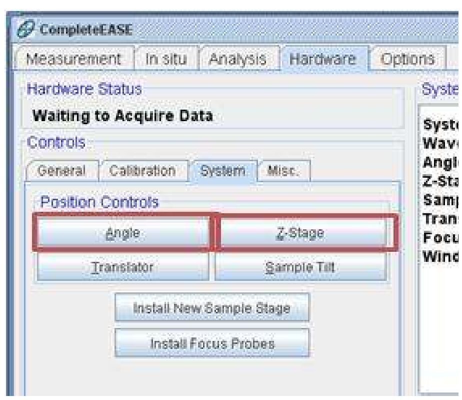


Figure 4-32. CompleteEase® Hardware, System Tab.

4. From ***Hardware***> General Tab, press the 'Align Sample' button. You will be asked whether to perform a full sample alignment - Press NO. There are two alignment detectors on this system. Change the Detector to "RECEIVER".

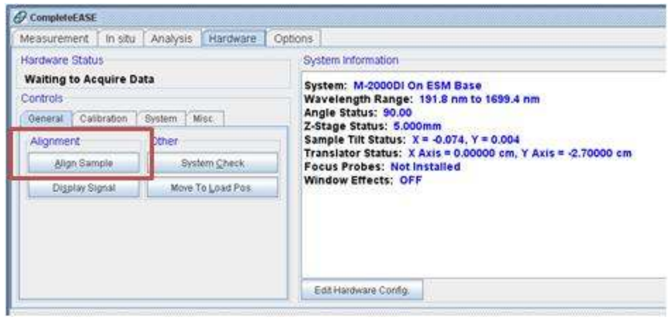


Figure 4-33. Align sample button.

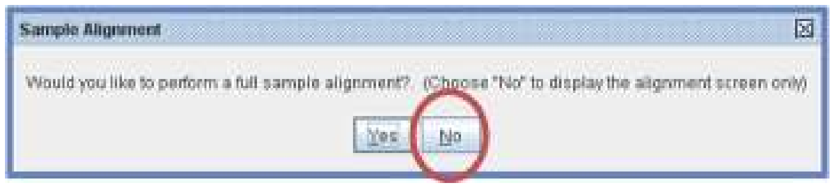


Figure 4-34. Sample Alignment dialog box.

***Note:* The following alignment screen is a generic screen shot. Refer to the system test report for your specific intensity values.**

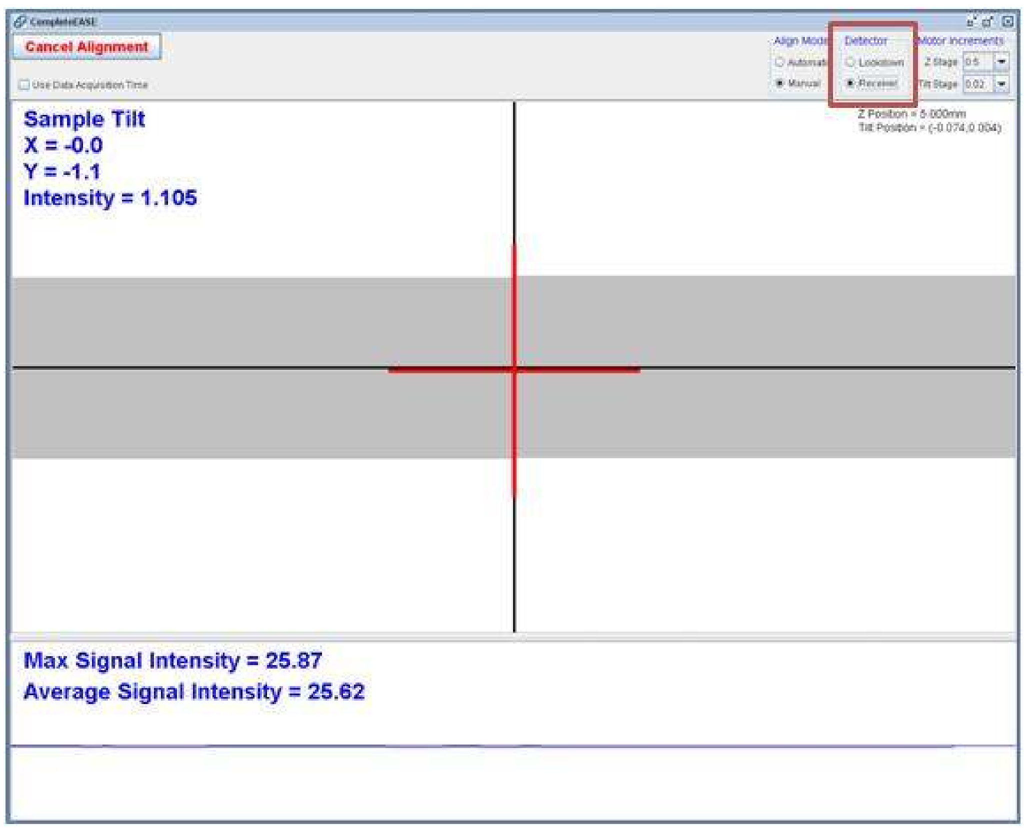


Figure 4-35. Alignment Screen.

5. The cross hair will not likely be aligned. We will adjust the sample stage to align the cross hair, effectively matching the Sample Stage to the System Alignment.
6. Align the sample Tip/Tilt by pressing the Up/Down/Left/Right Arrow keys on keyboard. Tip and tilt the sample stage until the cross hair is centered on the screen. You will have to adjust the Tilt Stage Motor Increment to reduce the steps to get "fine" adjustment of the motors.

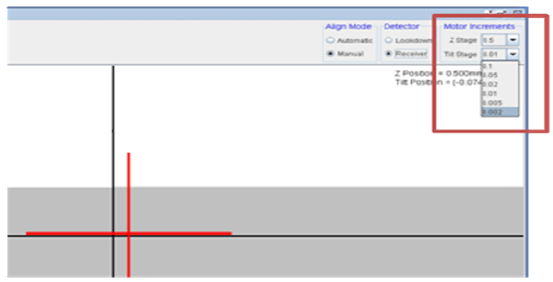


Figure 4-36. Adjusting Tilt stage motor increment.

7. Align the sample Height. Maximize "Average Signal Intensity" shown across the bottom of the Alignment Screen by adjusting Z-height with PageUp/PageDown keys. Change Z-Stage increment to smaller value to fine tune.

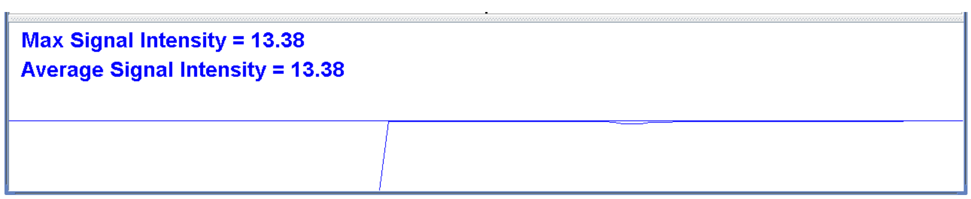


Figure 4-37. Adjusting for Maximum Signal Intensity.

> ***Note:* Iterate between the "Tip-Tilt" and "Z" alignments until both are optimized at the same time. When both are optimized simultaneously, the sample stage is aligned to the Measurement Beam.**

Look-Down Detector (Align Unit) Alignment

After the Sample Stage has been aligned to the measurement beam (previous section), the Align Unit "Look-Down Detector" can be aligned to the same sample before it is moved.

> ***Note:* It is very important that the sample remains in its aligned condition from the previous section until after this step is completed. If the sample is removed or the Sample Stage is adjusted, please repeat previous section before proceeding.**

The Alignment Screen should still be open from the previous section. If not, repeat step 4 in *Aligning Sample Stage to Measurement Beam* to open the Alignment Screen again. With the sample well aligned on the Receiver Detector, we will now switch to the Look-Down detector.

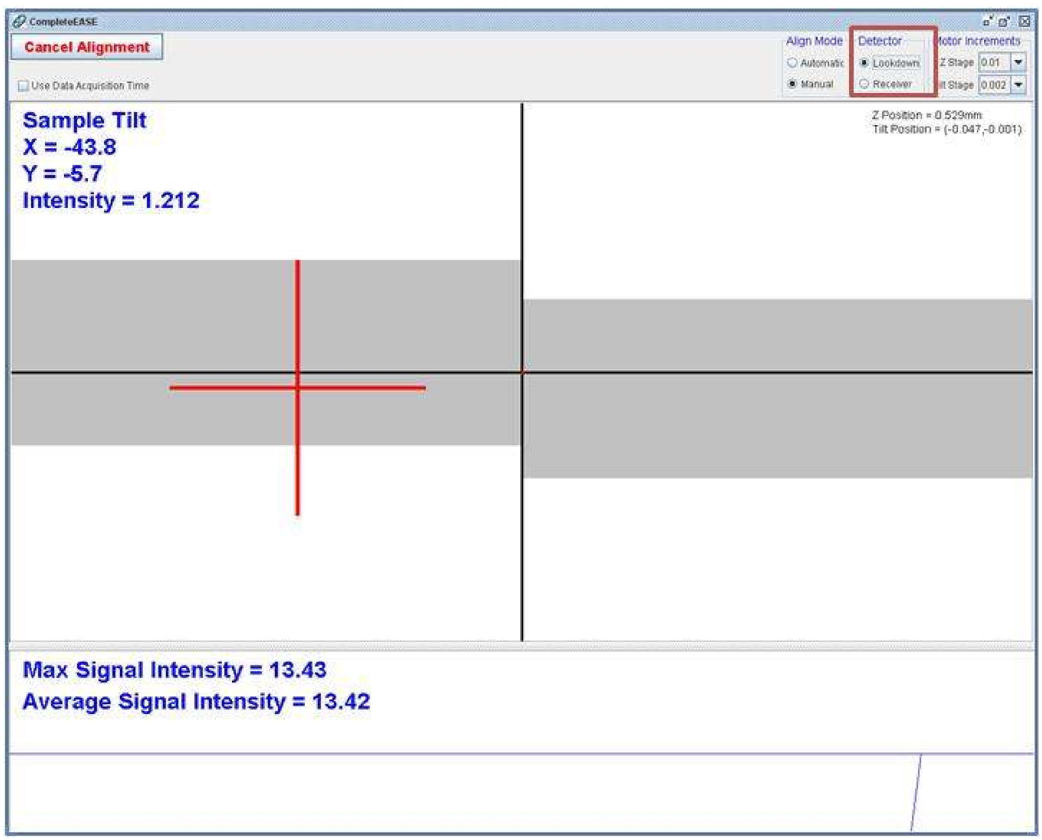


Figure 4-38. Switching Alignment Screen to lookdown detector.

The cross hair may not be centered, which shows that the Look-Down Detector needs to be adjusted to match the Sample Stage (which we have just aligned). Adjust the tilt stage that holds the Look-Down detector to center cross hair on the screen.

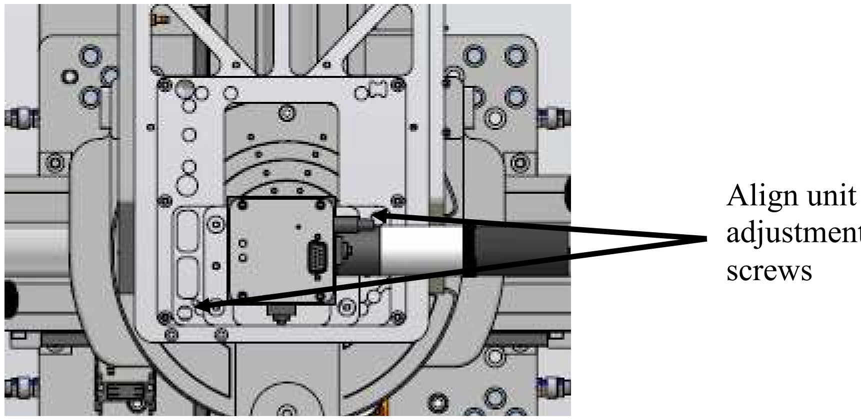


Figure 4-39. Adjusting the Align unit.

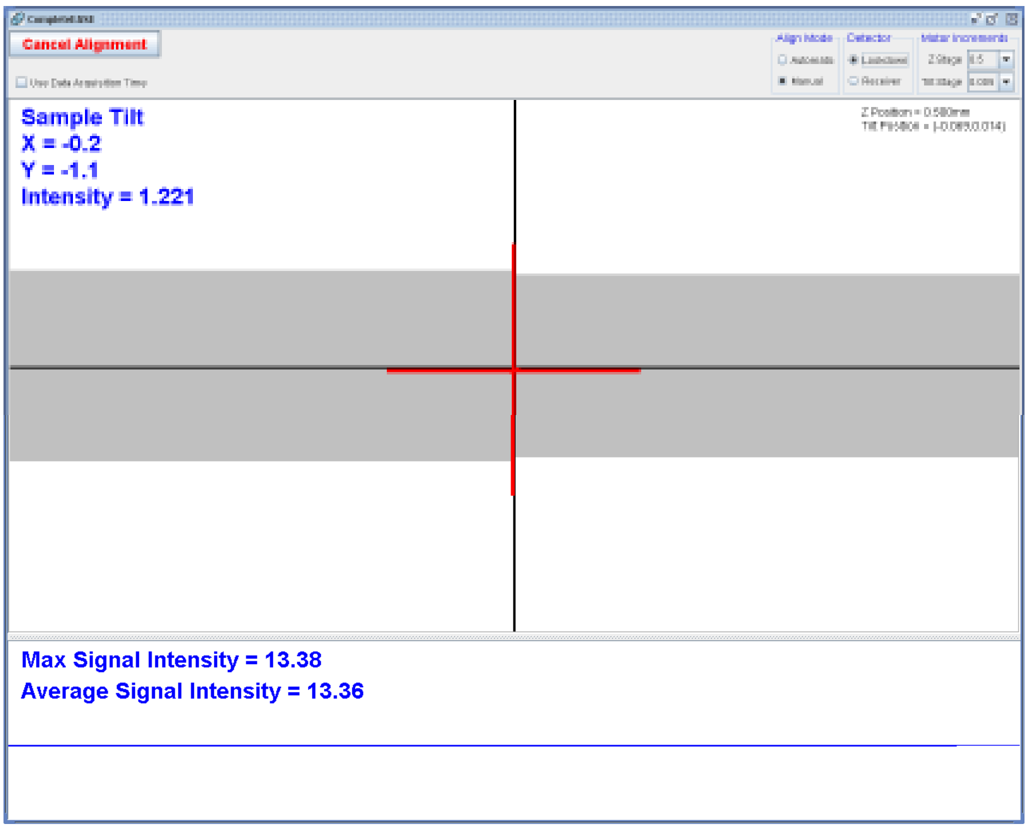


Figure 4-40. Look-Down detector alignment centered.

The Look-Down detector is now aligned to the system. When samples are mounted, this Look-Down detector can be trusted to give the correct sample alignment. After this point, all sample measurements will use automated alignment.

Sample Alignment (With Manual Tip/Tilt)

Note:* *This procedure must be performed every time a sample is mounted on the ellipsometer, prior to measurement or calibration.

1. Place the sample on the sample stage.
2. Under the ***Hardware***>System Tab, select Angle. Type 65 in the dialog box and press 'Ok'.

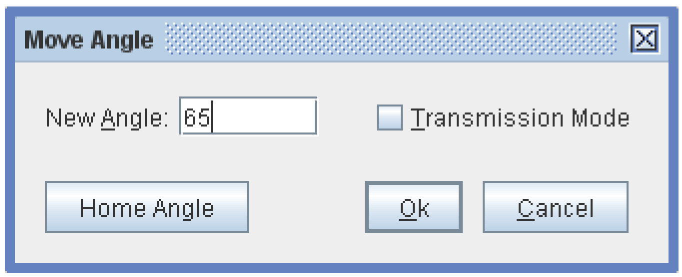


Figure 4-41. Move Angle dialog box.

3. Under the ***Hardware***>General Tab, select Align Sample. When prompted to perform a full system alignment, select 'Yes'.

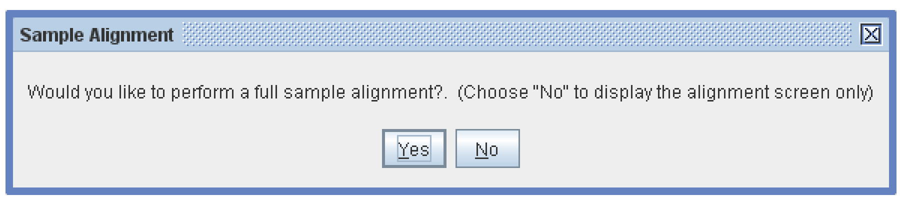


Figure 4-42. Sample Alignment message box.

4. Under the Sample Tilt Alignment drop down menu, select Manual. Under the Sample Height Alignment drop down menu, select Automatic-Quick. Enter the sample thickness into the box. (Cal. Wafer = 0.5mm). The Alignment Angle should be 65°. Press 'Ok'.

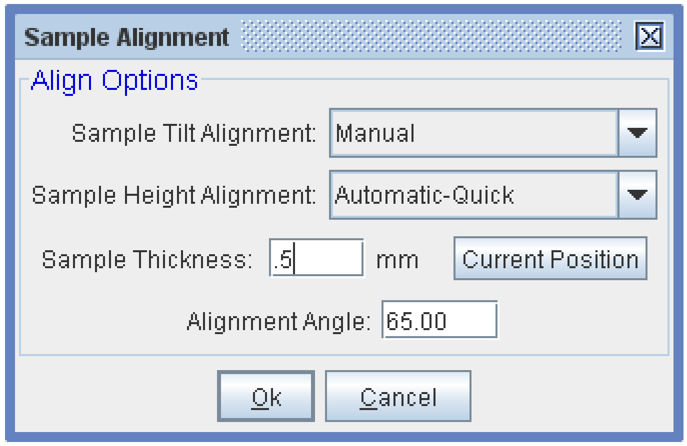


Figure 4-43. Sample Alignment dialog box.

5. Adjust the sample tilt stage knobs until the cross hair is centered.

> ***Note:* The following alignment screen is a generic screen shot. Refer to the system test report for your specific intensity values.**

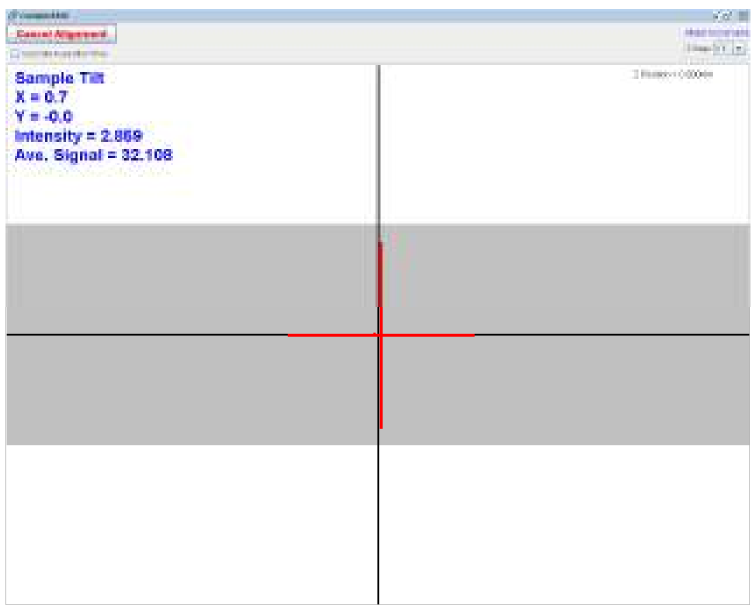


Figure 4-44. Crosshair centered.

6. Select Cancel Alignment (or press ESC) to exit the screen. The system will do an auto Z height search to find the maximum intensity. As long as the sample height is known, it is aligned. If not, these steps may need to be repeated (iterate - tip/tilt, then Z search) until the sample is properly aligned. The software will enforce this action if necessary. Two conditions must be simultaneously met for successful sample alignment:

- The sample surface must be perpendicular to the measurement beam plane of incidence (sample tip/tilt alignment)
- The sample surface must be positioned such that the light is reflected into the Receiver Unit aperture (sample height alignment).

Sample Alignment (With Automated Tip/Tilt)

> ***Note:* This procedure must be performed every time a sample is mounted on the ellipsometer, prior to measurement or calibration.**

Sample alignment on an Auto Angle base with Automated Tip/Tilt alignment is very simple.

1. Set the Angle of Incidence to 65° by selecting

   Hardware>**Controls**>System>'Move Angle'

2. Place the reference sample supplied with the instrument (~25nm SiO_2 on Si) on the sample stage.
3. Select ***Hardware***>**Controls**>General>'Align Sample'
4. Choose Automatic for both Tip/Tilt and Sample Height Alignment (if "Quick" alignment is selected for sample height, be sure that value in Sample Thickness box is a good approximation).

7. The ellipsometer will automatically align tip/tilt and Z such that the following two conditions are met (required for successful sample alignment):
   - The sample surface must be perpendicular to the measurement beam plane of incidence (sample tip/tilt alignment)
   - The sample surface must be positioned such that the light is reflected into the Receiver Unit aperture (sample height alignment).

Manual sample alignment options are still accessible for systems with automated tip/tilt stage. Simply select "Manual" when prompted for tip/tilt or Z alignment when desired (i.e. for low-reflecting samples). Use the Up/Down/Left/Right Arrow keys on keyboard to tip and tilt the sample stage in Manual alignment mode; use PageUp/PageDown keys to raise and lower the Z stage in Manual alignment mode.

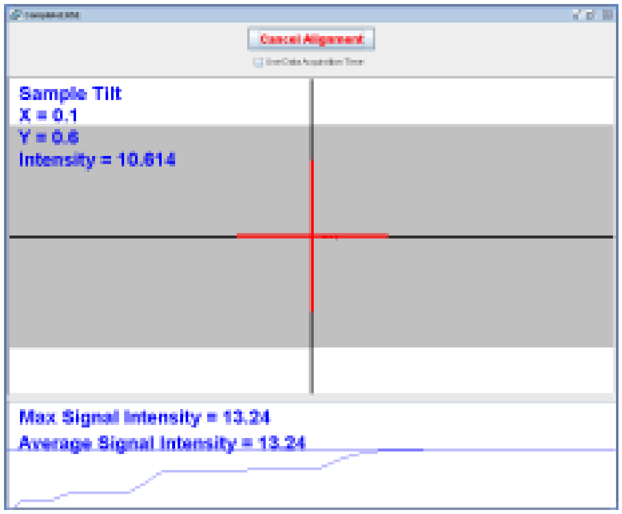


Figure 4-45. Cross hair centered and intensity maximized (beam centered on detector aperture).

> ***Note:* Follow Sample Alignment (With Manual Tip/Tilt) procedures when Look-Down detector is disabled.**

System Check (Calibration)

> ***Note:* A System Check must be performed the first time the system is run, or if the input/output units have been remounted. The standard SiO_2 on Si reference sample supplied with the instrument (or an equivalent "bulk like" sample) should be used for this procedure.**

> ***Note:* A System Check should be performed any time the performance of the instrument is in question.**

1. After the calibration wafer is aligned, select

   ***Hardware*>Controls>General>'System Check'**

2. Click 'Yes' to start the System Check.

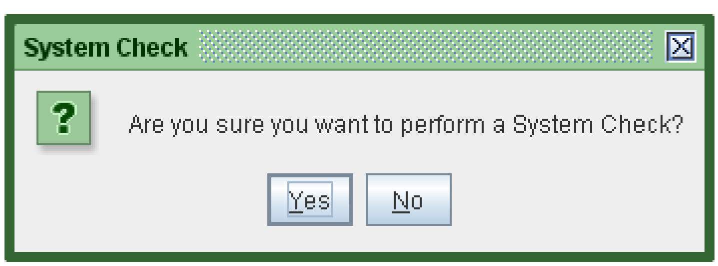


Figure 4-46. System Check.

3. When prompted, mount the calibration wafer (~250Å SiO_2 on Si, supplied with the instrument).

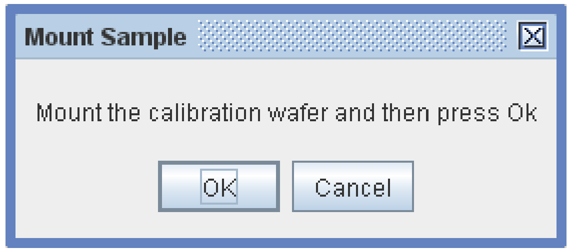


Figure 4-47. Mount Calibration Wafer.

4. CompleteEASE® will automatically open the sample alignment screen. Align the sample as described in the Sample Alignment section above.

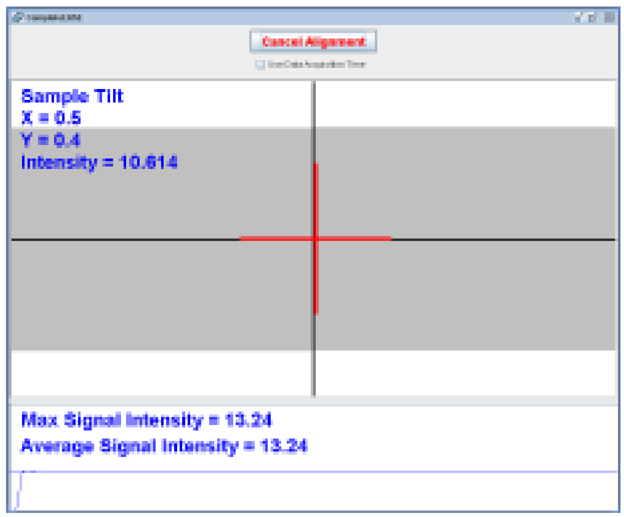


Figure 4-48. Alignment Screen.

5. When finished with the alignment, click 'Cancel Alignment' to begin the calibration.

6. System Check status will be displayed in

***Hardware*>Hardware Status**

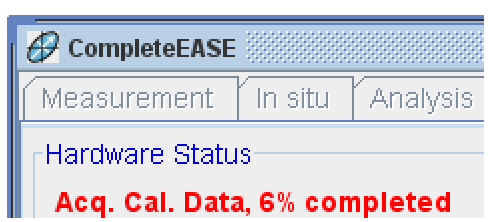


Figure 4-49. Hardware Status.

Evaluating Calibration Results

System Check Successful

If the system check is successful, the following message will appear.

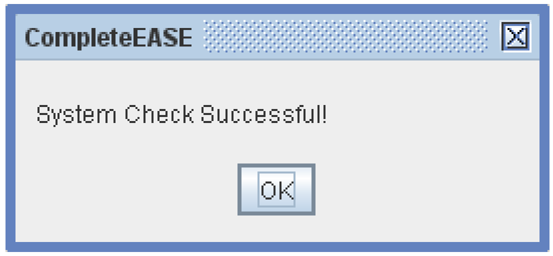


Figure 4-50. System Check Successful.

Take a quick look at the spectroscopic data graph to verify that the data fit is good (Figure 4-51). If the model generated Psi and Delta data are on top of the Experimental data the procedure is finished.

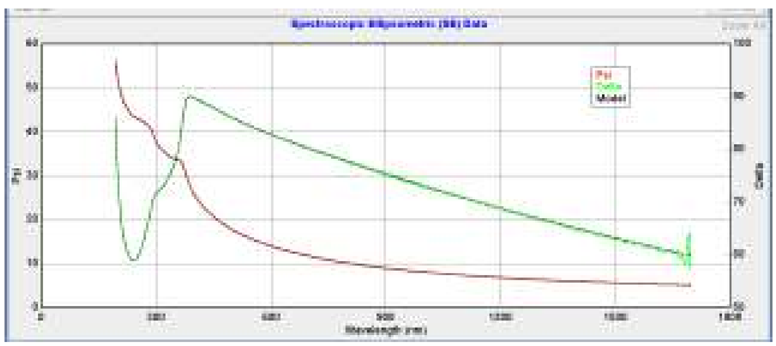


Figure 4-51. A good fit to system check data. It is a good idea to check the system check fit even when the system check is successful.

If the system check is successful, basic testing is finished and the ellipsometer can be used for data acquisition.

System Check Unsuccessful

If the System Check is not successful (that is, the error bars on the determined parameters exceed the acceptance limits), a message box describing the error will be displayed.

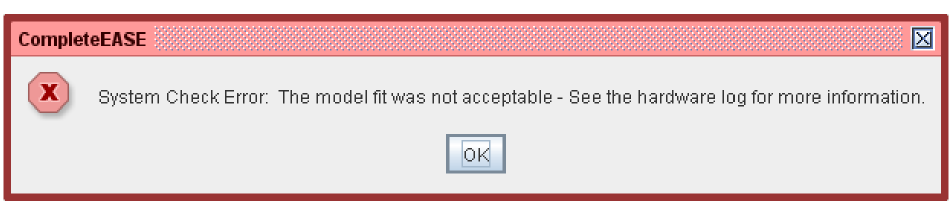


Figure 4-52. System Check Error.

To view the calibration parameters, select

***Hardware*>System Information>'View Hardware Log'**

In most circumstances, the error bars on the Ps (polarizer), Cs (compensator), and As (analyzer) azimuthal calibration parameters all should be less than ±0.01°.

If the system check is not successful, check the following:

1. The system is aligned and the light intensity is adequate.
2. If the intensity is greater than 40, try reducing the intensity by half and calibrating again. This will prevent the detector from being overloaded with light at certain polarizer positions during calibration. If the system check is then successful, adjust the intensity such that it is no greater than 40.
3. Read the troubleshooting section for possible problems and solutions. If a successful system check still cannot be performed, call the J.A. Woollam Company for assistance.

> ***Note: The SiO_2 thickness varies significantly from wafer to wafer (200Å to 300Å). 250Å is the nominal thickness. Your wafer may have SiO_2 thicker or thinner than 250Å.***

4.6. Instrument Shutdown

1. Save any necessary data and/or model files.
2. Select (L) Exit button ☒ in upper right-hand corner of program screen.
3. Exit Windows.
4. Turn off the Computer, Monitor, EC-400 and the Lamp Power Supply Module (M-2000 box). There is no particular order for the turning off system components.

5. Data Acquisition

5.1. Acquiring Ellipsometric Data

Once the System Check is successfully completed, the instrument is ready to collect data.

1. Place sample on sample stage.
2. Select <Prompt for Acquisition Parameters> from

   Measurement>**Measurement Controls**>Recipe:

3. Click 'Measure'.
4. If 'Save Data after Measurement' was checked, the Save Data window appears. Navigate to desired folder, give a filename and comment (optional), and click 'Save'.

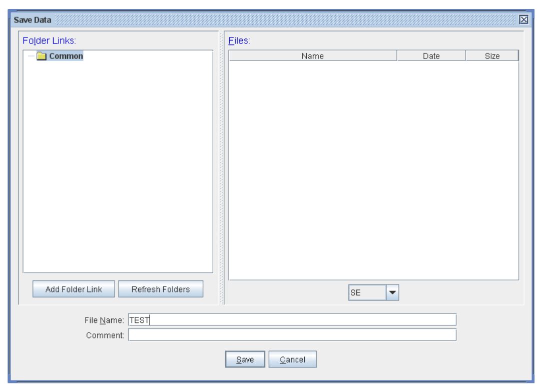


Figure 5-1. Save Data Navigation Box.

5. The Acquisition Parameters Setup window will appear next. Note that options may vary depending on system configuration and accessories (mapping stage, automated tip/tilt alignment, etc).

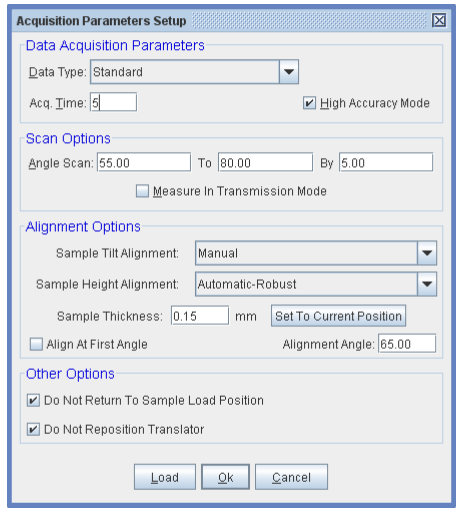


Figure 5-2. Acquisition Parameters Setup.

6. Under **Data Acquisition Parameters**, select 'Data Type' and enter 'Acq. Time' (in seconds). With High Accuracy Mode checked, data is collected with input polarizer set to +45˚ and -45˚ and averaged. This improves data accuracy and is recommended for most applications.

7. Under **Scan Options**, choose angle (or range of angles) to scan.

8. Under **Alignment Options**, there are multiple selections. Choose 'Skip', 'Manual', or 'Automatic' (if system purchase included automated tip/tilt stage) for the Sample Tilt Alignment. Choose 'Skip', 'Manual', 'Automatic-Quick', or 'Automatic-Robust' for Sample Height Alignment. All Auto-Angle bases have automated Z-height alignment.

   - A "Quick" alignment searches a narrow Z range around the Z-height entered in the Sample Thickness box. (Click 'Set to Current Position' to enter current Z-position into the Sample Thickness box.) This option is recommended (to save time) if mapping or many measurements will be made.

   - A "Robust" alignment searches the full Z range of the base. This option is recommended if sample thickness is not known and sample was not previously aligned.

   - 'Skip' may be checked if the sample alignment has already been completed. This is not recommended if the current sample has not yet been aligned.

9. When finished, click 'Ok' to start the measurement sequence. The Align Sample window appears (unless 'Skip' was selected for both tilt and Z alignment); click 'Cancel Alignment' when

finished with sample alignment to close the alignment screen and begin ellipsometric data acquisition.

10. **System Status** will show measurement progress.

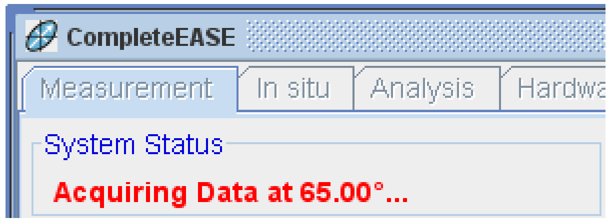


Figure 5-3. System Status during data acquisition.

11. When the measurement is complete, the **System Status** will revert back to 'Waiting to Acquire Data', and data will be displayed in the graph.

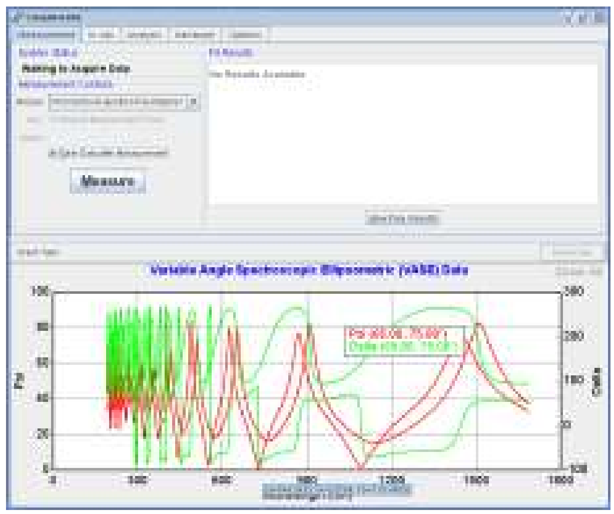


Figure 5-4. Example data after measurement.

5.2. Recipes

Data acquisition and analysis can be completed in one step with CompleteEASE®. This is achieved by using a Recipe. A Recipe combines Data Acquisition Parameters and an Analysis Model, allowing data to be analyzed simultaneously with measurement.

Use of a Recipe requires that Data Acquisition Parameters and an Analysis Model have been saved previously. An example drop-down list containing multiple Recipes is shown below.

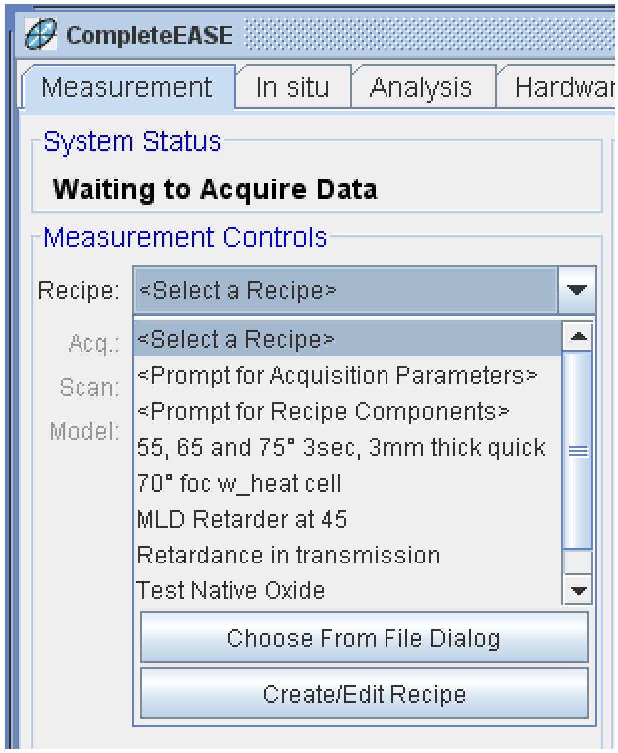


Figure 5-5. Recipe selection.

Prompt for Recipe Components

To measure samples using previously saved Acquisition Parameters and Analysis Model, select <Prompt for Recipe Components>. The **Measurement Controls** panel will update to reflect <Prompt At Measurement Time> for Acq, Scan, and Model. Click 'Measure' to open the Choose Recipe Components dialog box.

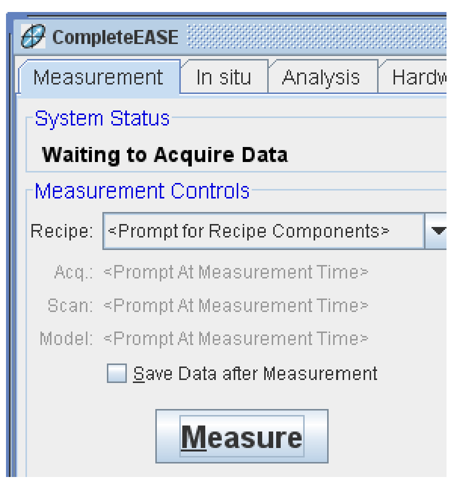


Figure 5-6. <Prompt for Recipe Components>.

Choose desired Acq. Parms and Model and click Ok to start the measurement. (The Scan Pattern option in the figure below is available only for systems with optional sample translation.)

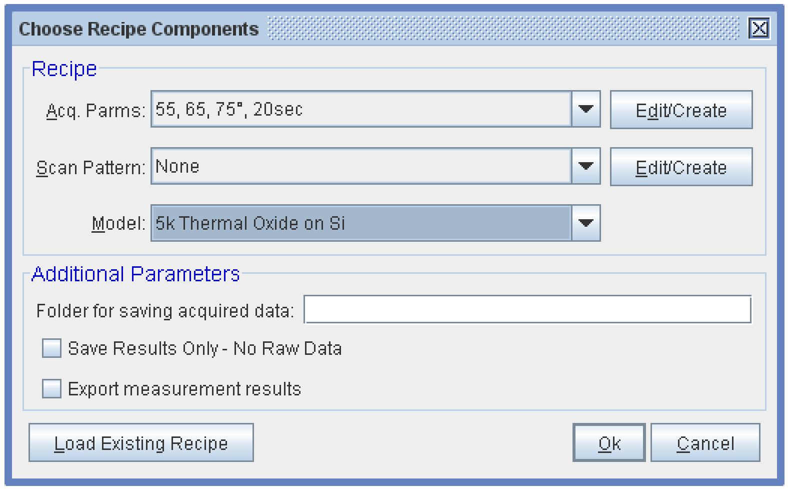


Figure 5-7. Choose Recipe Components.

Creating New Recipes

The instrument may have been supplied with a few default Recipes for use with the calibration wafer, but customized Recipes will be required for specific sample types.

To create a new Recipe using previously saved Acquisition Parameters and Analysis Model, select "Create/Edit Recipe" (shown in Figure 5-5) to open the Create/Edit Recipe dialog box. Choose desired Acq. Parms and Model and click 'Save Recipe' when finished. (The Scan Pattern option in the figure below is available only for systems with optional sample translation.)

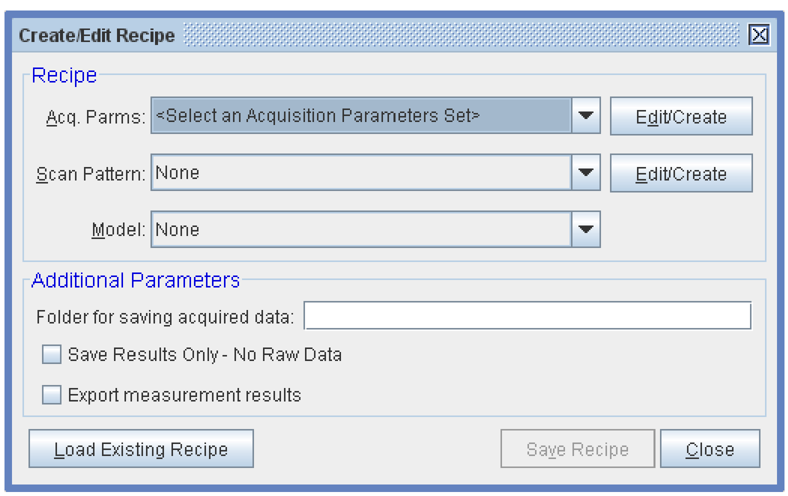


Figure 5-8. Create/Edit Recipe.

Creating New Acquisition Parameters

To create new Acquisition Parameters, select "Create/Edit Recipe" (shown in Figure 5-5), then "Edit/Create" next to Acq. Parms in the **Recipe** panel to open the Acquisition Parameters Setup window.

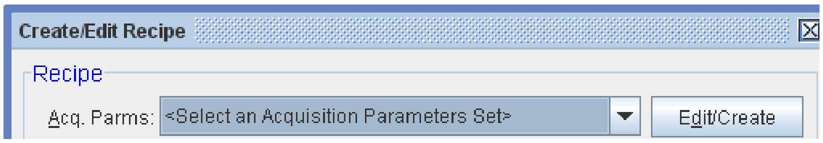


Figure 5-9. Edit/Create Acq. Parms.

Use the 'Save' button near the bottom of the screen after entering desired measurement parameters. Saved Acquisition Parameters will now be available for <Prompt for Recipe Components>, or creating a new Recipe.

Figure 5-10. Save Acquisition Parameters.

Creating New Analysis Models

This is discussed in detail in the CompleteEASE® Data Analysis Manual. View the CompleteEASE® Data Analysis Manual by selecting:

Options>Miscellaneous>'Show Manual'

Using A Recipe

1. To measure and analyze a sample using a Recipe, select the desired Recipe from:

   Measurement>**Measurement Controls**>Recipe:

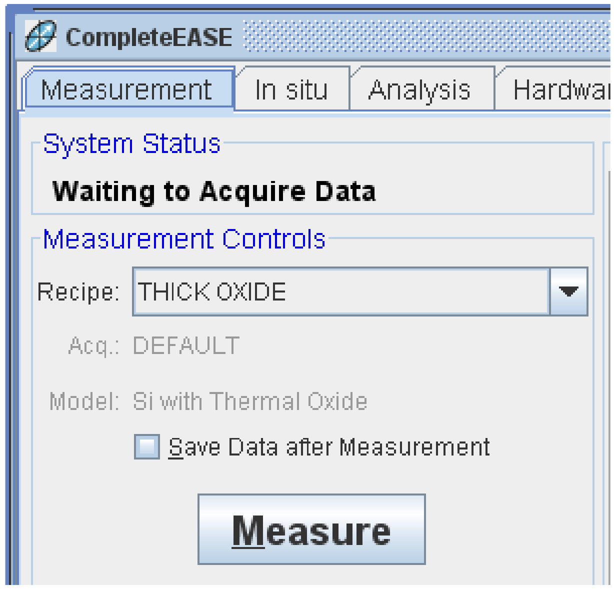


Figure 5-11. Example Recipe.

2. After Recipe is selected, simply click 'Measure'. The measurement sequence will proceed normally, starting with sample alignment (if this is not checked to skip in the Data Acquisition Parameters).

3. After the measurement is completed, the data will be analyzed using the Model contained in the Recipe. Notice that Model fit results are now displayed in ***Measurement***>**Fit Results** panel.

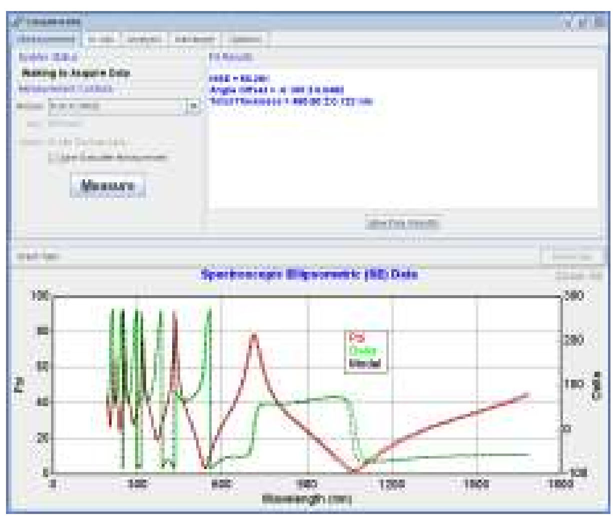


Figure 5-12. Example data after measurement with Recipe.

4. To view the Model used, switch to the ***Analysis*** tab. Note that the ***Analysis***>**Data** panel indicates the data filename given, or if the data has not yet been saved.

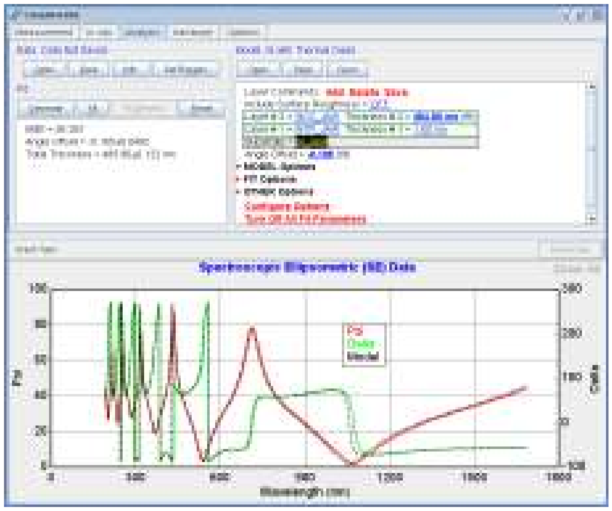


Figure 5-13. Example data after measurement with Recipe – Analysis Tab.

5.3. Data Types

Most applications will require only the Standard Data Type. However, some applications benefit from or require measurement in Transmission Mode, Generalized Ellipsometry, Mueller Matrix, Transmission Intensity, or Reflection Intensity. Data Acquisition for each Data Type is briefly discussed here.

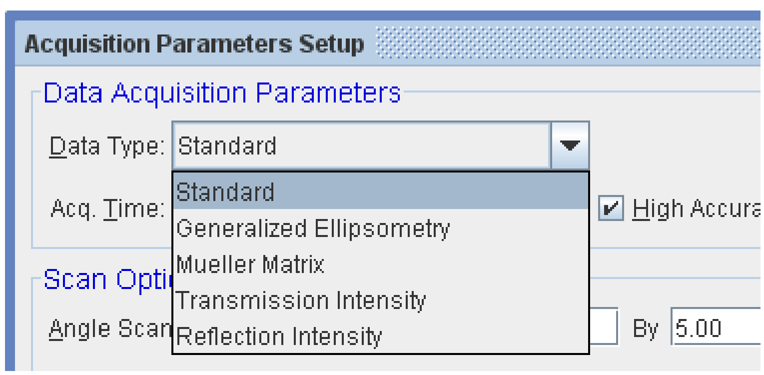


Figure 5-14. Data Types.

To view Acquisition Parameters, select "Create/Edit Recipe" (shown in Figure 5-5), then "Edit/Create" next to Acq. Parms in the **Recipe** panel to open the Acquisition Parameters Setup window.

Standard

The Standard Data Type is used for most applications. This data type acquires ellpsometric Psi and Delta data, as well as reflectance and depolarization data.

> ***Note:* Reflectance data is most accurate using the Reflected Intensity Data Type, described below. Selecting Reflected Intensity Data Type allows baseline measurement from reference sample.**

> ***Note:* Depolarization data is most accurate after performing a DC Offset calculation. To perform, click on *Hardware*>Controls>Calibration>'DC Offset'.**

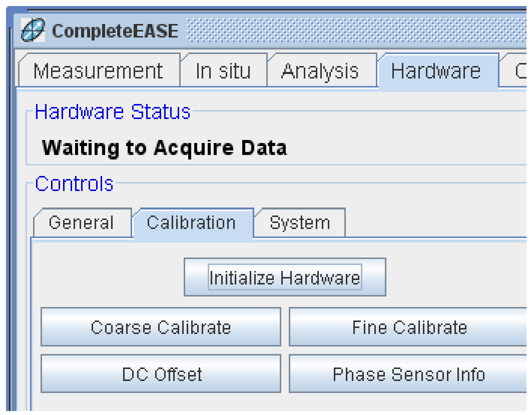


Figure 5-15. DC Offset calculation.

Transmission Mode

In the **Scan Options** panel, this option acquires the selected Data Type in transmission mode through the sample. Note that with this option checked, no choice for angle scan or alignment options is allowed.

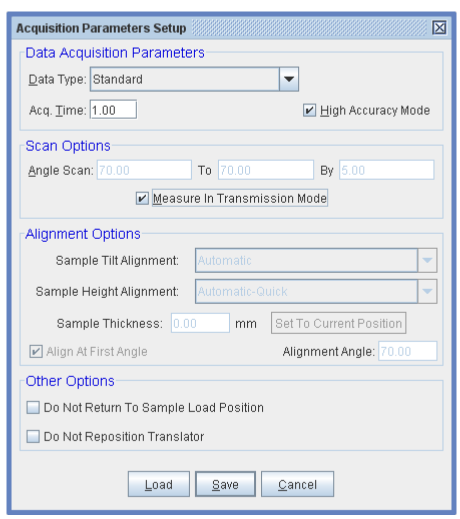


Figure 5-16. Measure in Transmission Mode.

Generalized Ellipsometry

Generalized Ellipsometry is required for some anisotropic samples. Data include both standard ellipsometry measurement and additional terms to describe cross-polarization from the sample.

To acquire Generalized Ellipsometry data, select this option from the Data Type menu under the **Data Acquisition Parameters** panel within the Acquisition Parameters Setup window.

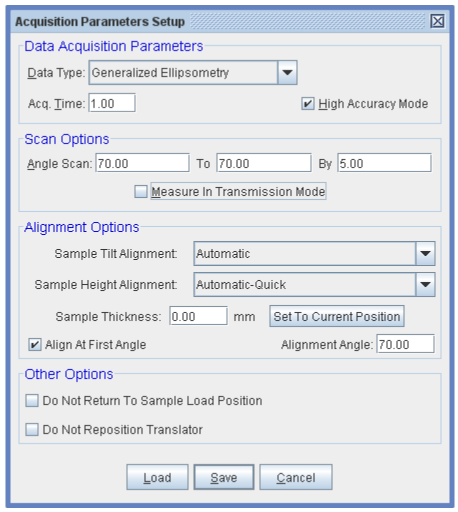


Figure 5-17. Selecting Generalized Ellipsometry Data Type.

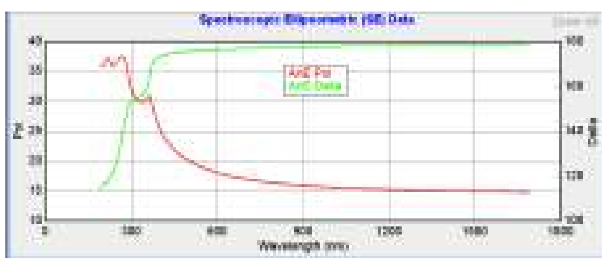


Figure 5-18. Generalized Ellipsometry Data.

Mueller Matrix

Mueller Matrix data is required for complicated samples with both anisotropy and depolarization. The M-2000® measures 11 Mueller Matrix elements.

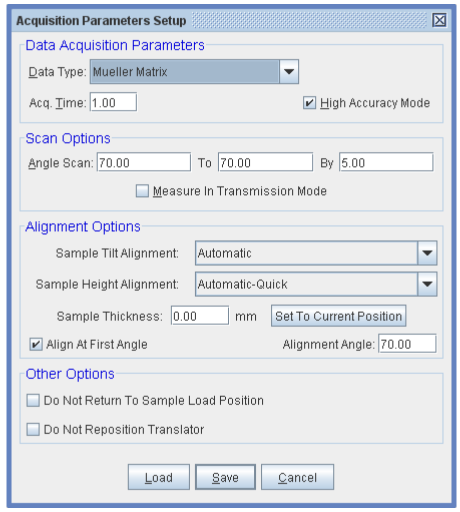


Figure 5-19. Mueller Matrix data acquisition.

After measurement, AnE Psi and Delta data are displayed. To view Mueller Matrix elements, right-click Graph Type, and select one of the Mueller Matrix Data options.

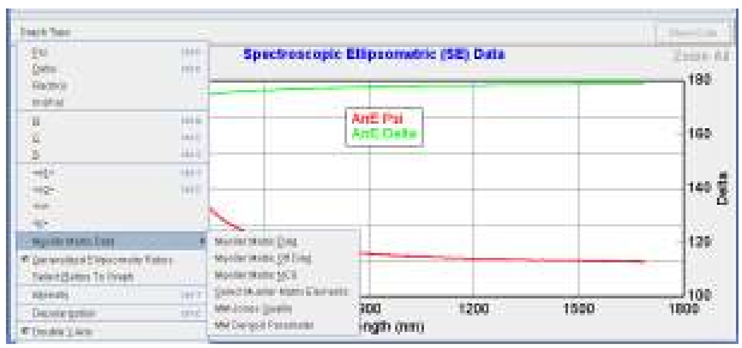


Figure 5-20. Mueller Matrix Data.

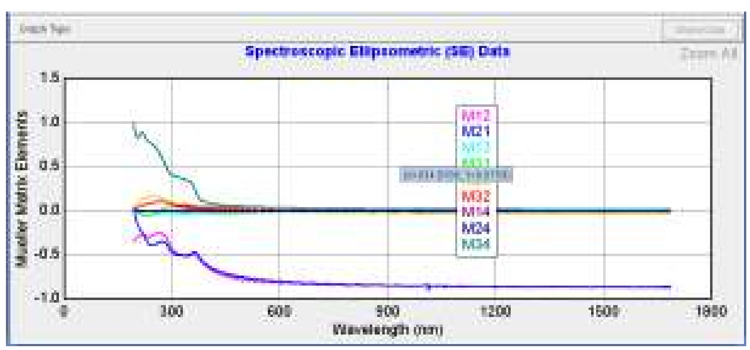


Figure 5-21 Mueller Matrix Data.

To view specific Mueller Matrix elements, choose 'Select Mueller Matrix Elements', and a new window will appear allowing the user to specify which elements to display.

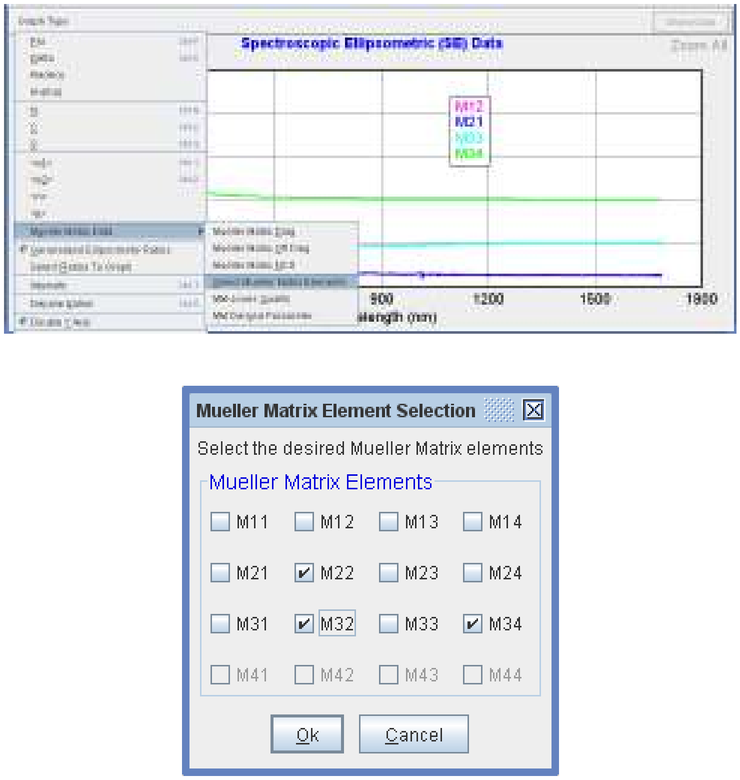


Figure 5-22. Mueller Matrix Element Selection.

Transmission Intensity

Measure the transmitted intensity of the light beam. Transmission Intensity is <u>not</u> the same as an ellipsometry measurement in 'Transmission Mode' (which is not dependent on light intensity). All Transmission Intensity measurements are made at 90˚; note that with this Data Type selected, no angle choice or alignment options are allowed.

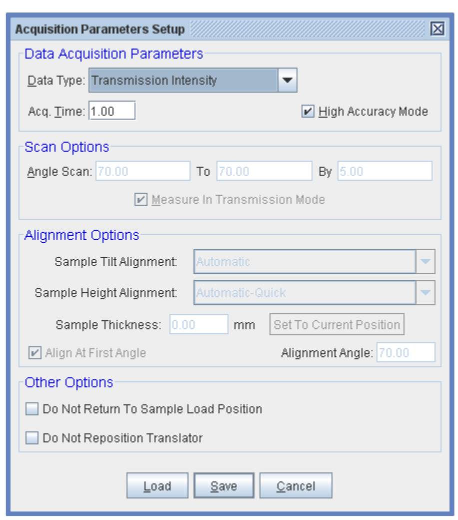


Figure 5-23. Transmission Intensity Data acquisition.

When the measurement is started, the base unit will automatically move the AOI to 90˚, if the instrument is not already at this angle.

Remove any sample present in the beam path for baseline measurement when prompted.

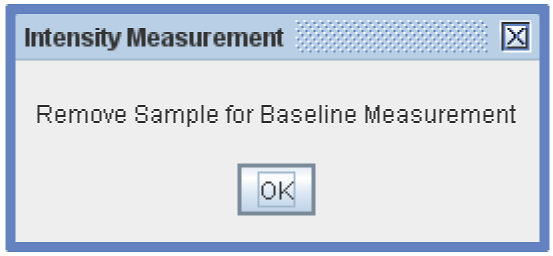


Figure 5-24. Remove sample for baseline measurement.

The **System Status** panel will display Acquiring Baseline.

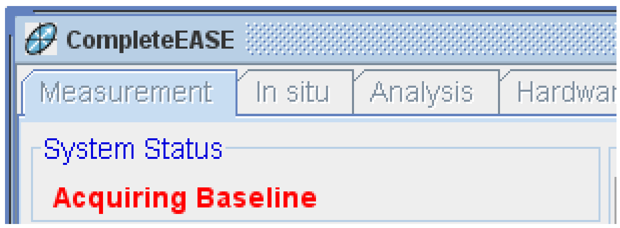


Figure 5-25. System Status – acquiring baseline.

Mount the sample when prompted; no alignment is necessary. The sample surface should be perpendicular to the measurement beam and held steady (by hand or by jig) for duration of measurement.

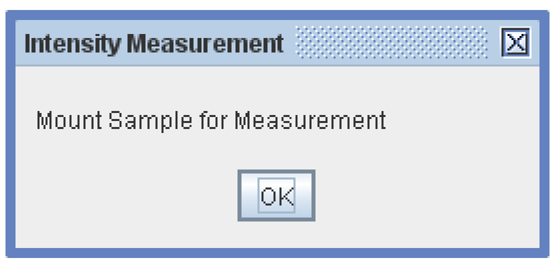


Figure 5-26. Mount sample for transmission measurement.

When the measurement is completed, the Transmission Intensity data is automatically displayed in the Graph.

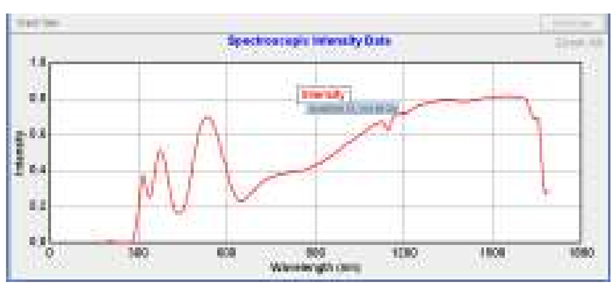


Figure 5-27. Example transmission data.

Reflection Intensity

This Data Type measures the reflected intensity of the light beam. Reflection Intensity is also measured with “Standard” Data Type, but this option is recommended, as it first calculates baseline intensity from a reference sample (thermal oxide on silicon).

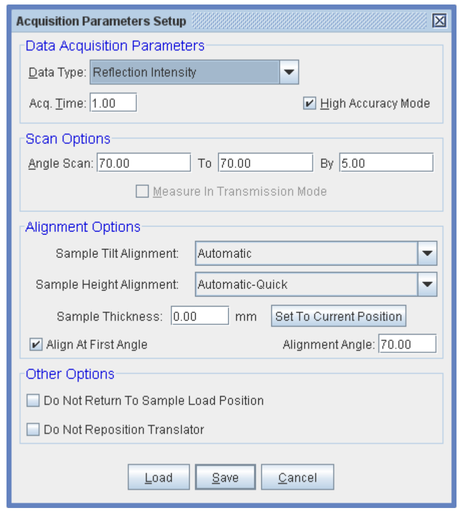


Figure 5-28. Reflection Intensity data acquisition.

When the measurement is started, the user will be prompted to mount the reference sample (thermal oxide on silicon).

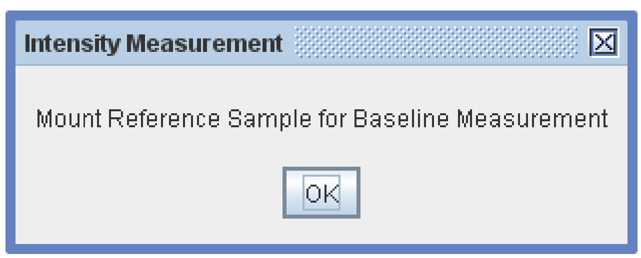


Figure 5-29. Mount reference sample for baseline reflectance measurement.

Align the reference sample, and click ‘Cancel Alignment’ when finished.

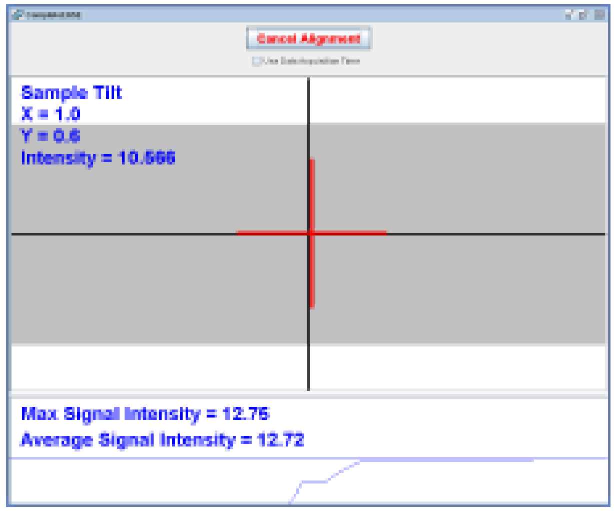


Figure 5-30. Alignment screen.

The system will then acquire a baseline measurement from the reference sample.

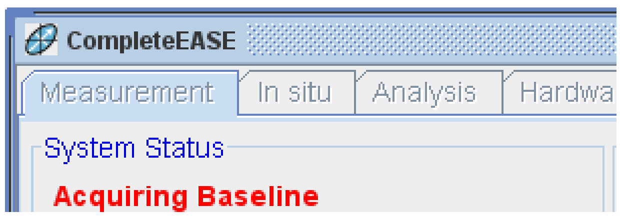


Figure 5-31. System Status – acquiring baseline.

When the baseline measurement is completed, follow the prompt to mount the sample of interest, and align.

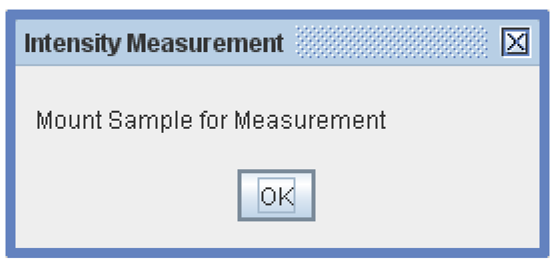


Figure 5-32. Mount sample for reflectance measurement.

After the measurement, Psi and Delta data are initially displayed in the Graph. To view Reflection Intensity data, right-click Graph Type, and select Intensity.

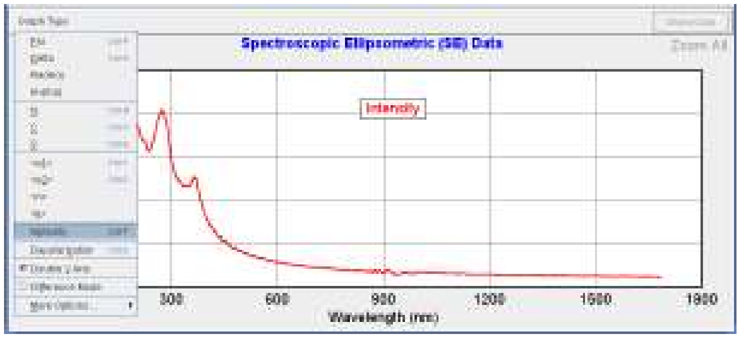


Figure 5-33. Example reflectance data.

5.4. Setting up Routine Test Measurements

The Routine Test Measurement feature in CompleteEASE® is useful for keeping track of system performance over time. This feature can be accessed from the Hardware tab (see below). There is an initial setup procedure required to use this feature which is described in the Initial Setup section of this document. For this feature to be useful it is important to always use the same sample for the measurements.

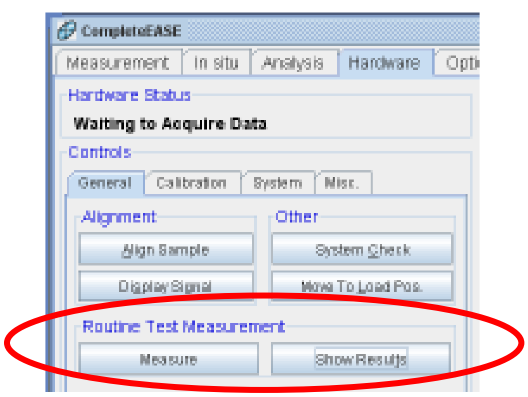


Figure 5-34. Routine Test Measurement in the Hardware tab.

Initial Setup

1) Create a recipe for the sample to be used for the Routine Test Measurement. This is a system dependent step due to the fact that the alignment method can differ from system to system.

2) Create a folder called "Routine Test Measurement" in the \CompleteEASE\Recipe folder and copy the ".recipe" and ".parms" files created in step 1 into this folder. The model created in step 1 should be placed in the \CompleteEASE\Mod folder or one of its sub folders.

3) In CompleteEASE®, choose "Edit Hardware Config." from the "Hardware" tab to bring up the "Edit Hardware Configuration" dialog. Check the box labeled "Show Advanced Config. Options" and then open the "Routine Test Measurements" section in the list on the left (see figure below). Select the "Recipe=" item and type the name of the recipe in the "Edit: Recipe" field at the top right. If you would like the software to prompt the user to perform the test measurement at periodic intervals, set the "Measurement Period" parameter to a value greater than 0. For example, if the "Measurement Period" is set to "1" then the software will prompt the user to perform a test measurement once per day.

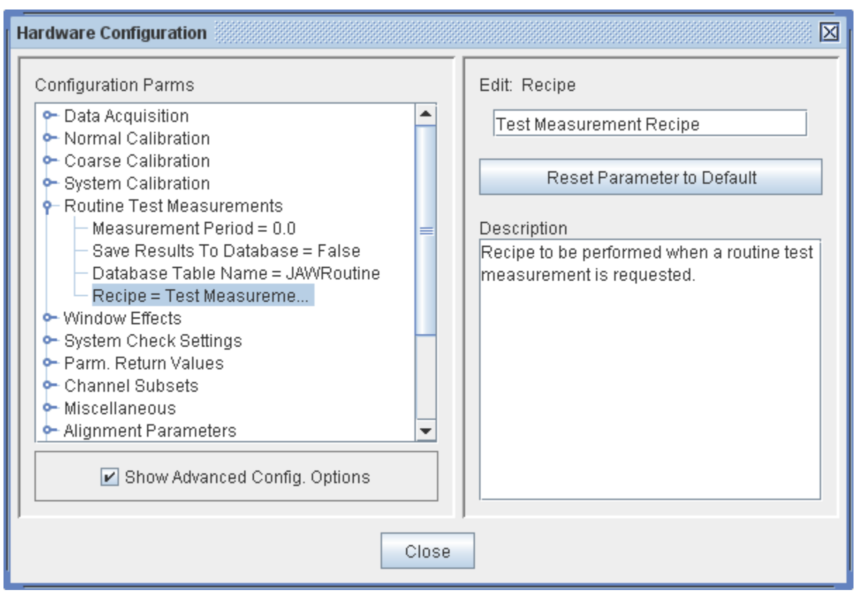


Figure 5-35. Hardware configuration dialog box.

Viewing Routine Test Measurement Results

After completing at least two routine test measurements, the user will be able to view the results by pressing the “Show Results” button in the “Routine Test Measurement” section. The results are displayed on a graph with the parameters plotted versus date. An example can be seen in the graph below.

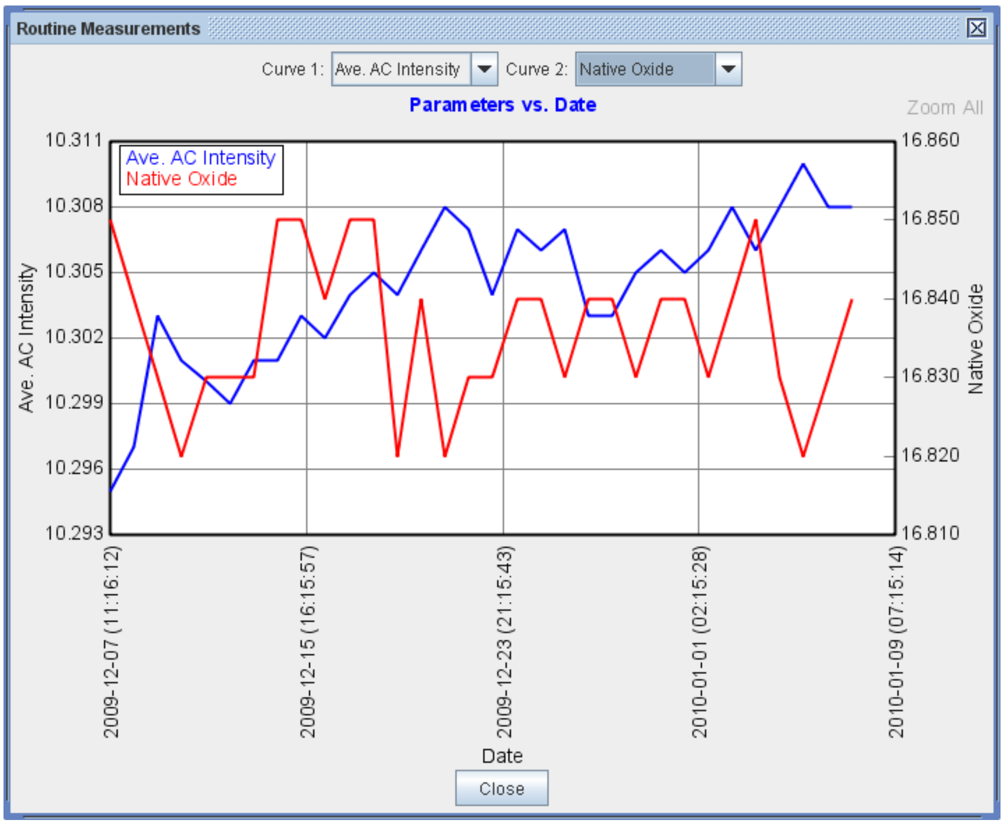


Figure 5-36. Routine Test Measurement Results.

6. Focusing Optics (Optional)

***Note:* This chapter pertains to removable focusing optics, which is an optional accessory that may or may not have been purchased with your instrument.**

6.1. General Overview

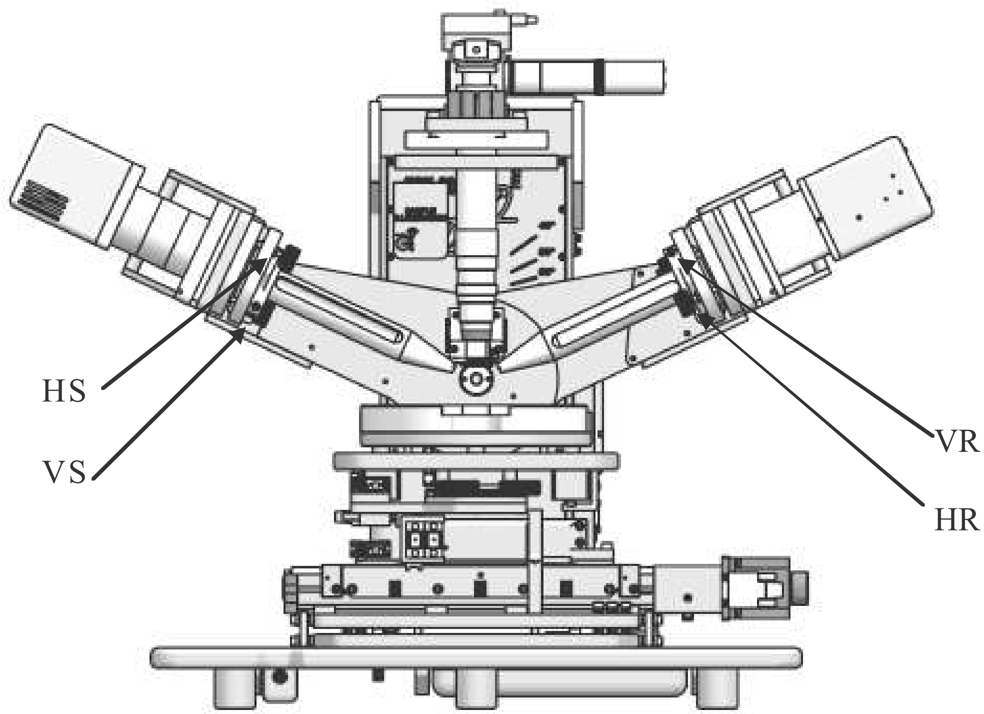


Figure 6-1. Focusing Probes.

The focusing optics consists of the source and receiver tilt stages and two focusing lens mounts. The tilt stages are used to translate the position of each lens that is mounted in the end of the cone shaped lens mounts. Each tilt stage contains a fine adjustment screw for the vertical position (VS and VR) and the horizontal position (HS and HR).

The tilt stages are also equipped with a view port to view the light beam on the detector aperture.

***Caution:* The focusing lenses and their coatings can easily be damaged. Be careful when handling the lens mounts so that nothing touches the lens.**

6.2. Installation

Focusing optics should not be installed during the initial Alignment and Calibration Procedures described earlier in this manual. If the system is ready for general use, the focusing optics can be installed using the following procedure.

1. Select

   ***Hardware*>System Information>'Edit Hardware Config'.**

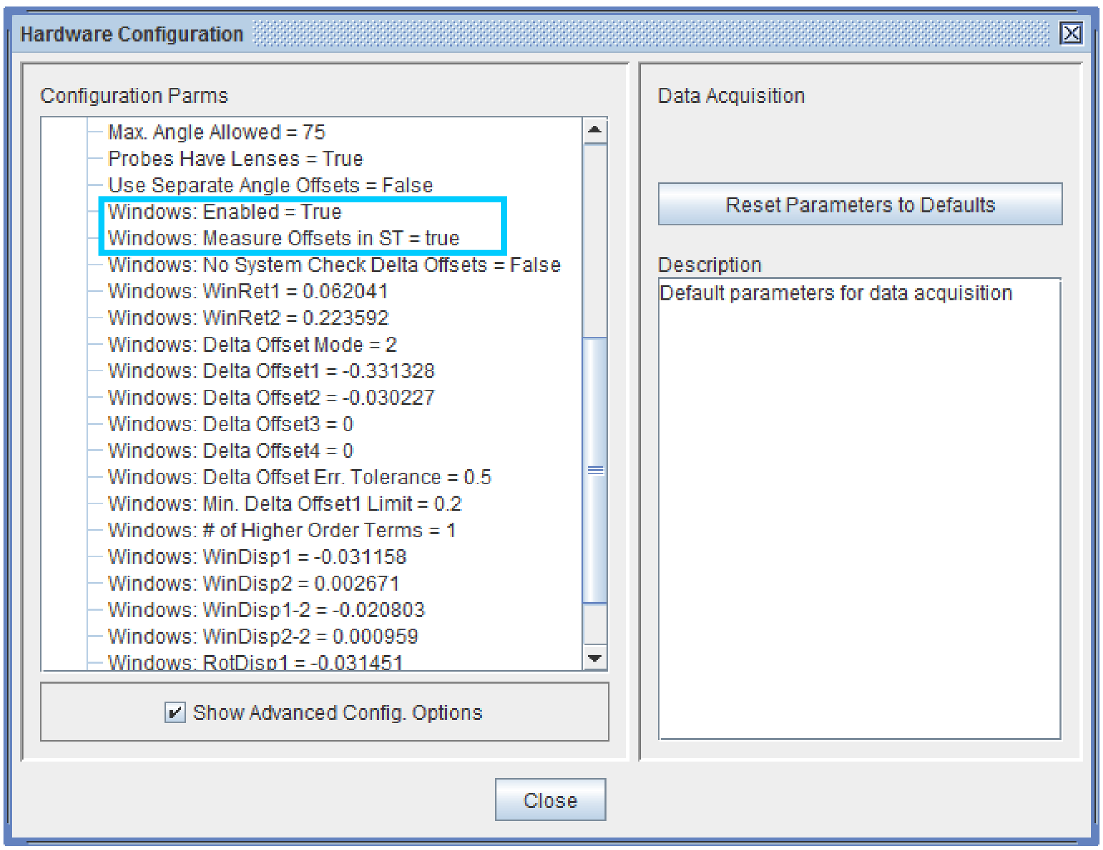


Figure 6-2. Hardware configuration dialog box.

2. Under the Focusing Option, the Windows option should be enabled and set to “Measure Offsets in ST”. If you select the Advanced Options check box, you will see the window effects and delta offsets displayed. DO NOT edit these numbers manually. These are calculated after the alignment is performed. This does not need to be checked each time.
3. Select

    Hardware>**Controls**>System>‘Install Focus Probes’

4. Select Yes when prompted to step through the alignment procedure.

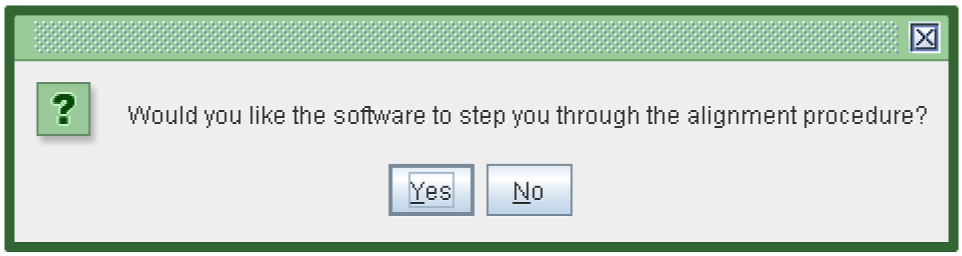


Figure 6-3. Probe alignment message box.

5. Each probe is labeled as Source or Receiver. CompleteEASE® will prompt for attaching each probe. The first prompt is to attach the Receiver probe. Using the three captive thumb screws, attach the Receiver focusing probe to the Receiver probe tilt stage.

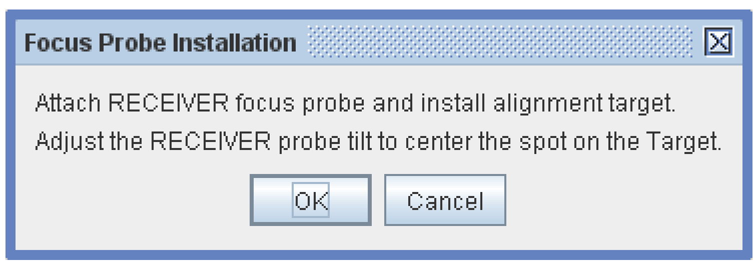


Figure 6-4. Adjust Receiver probe.

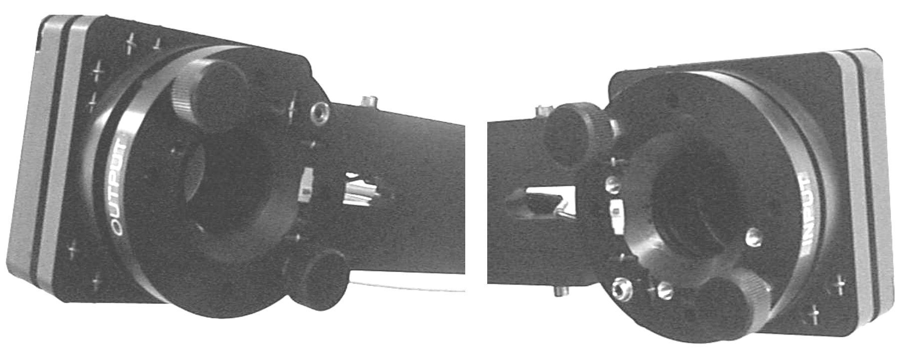


Figure 6-5. Source and Receiver mounting locations.

6. Unscrew the cone-shaped Receiver side lens mount and attach Alignment Target.

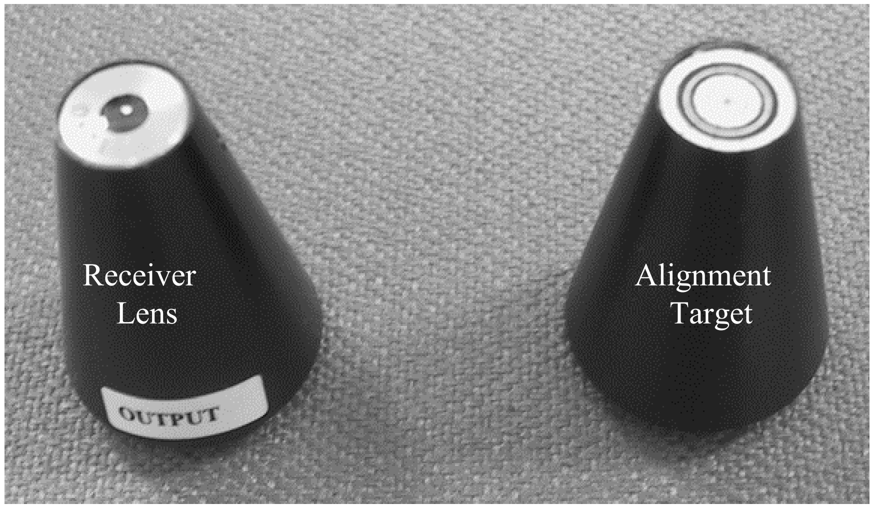


Figure 6-6. Focusing lens and target.

7. Observe the ellipsometer beam on the Alignment Target. For better visibility, reduce the ambient light if possible.
8. Carefully center the beam on the Alignment Target by translating the target with the Vertical Receiver and Horizontal Receiver adjustment screws. MOVE THE TARGET, NOT THE ELLIPSOMETER BEAM. Click OK when finished.
9. The second prompt is to attach the Source probe. Using the three captive thumb screws, attach the Source focusing probe to the Source probe tilt stage.

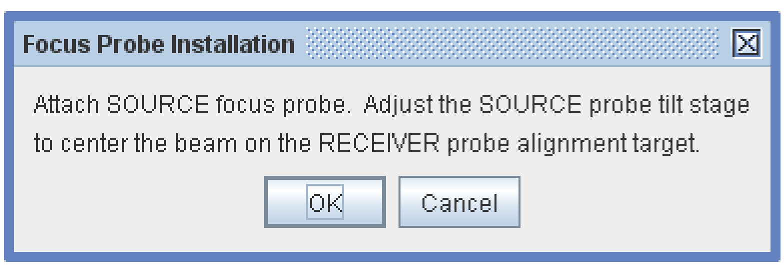


Figure 6-7. Adjust Source probe.

10. Again, observe the ellipsometer beam on the Alignment Target. For better visibility, reduce the ambient light if possible.
11. Carefully center the beam on the Alignment Target by translating the Source side lens with the Vertical Source and Horizontal Source adjustment screws. MOVE THE LENS, NOT THE TARGET OR ELLIPSOMETER BEAM. Click OK when finished.

12. Follow the next prompt by removing the Alignment Target and replacing it with the Receiver side lens. Click OK when finished.

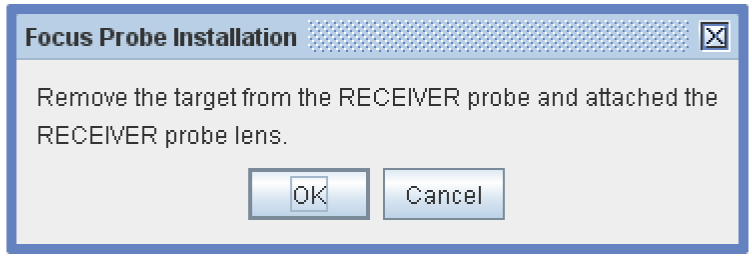


Figure 6-8. Remove target.

13. Lastly, adjust ONLY the RECIEVER (Vertical and Horizontal) adjustment screws to maximize the Intensity. Click OK when finished.

Figure 6-9. Adjust Receiver probe.

14. The signal screen is displayed as a chance to optimize the S-T signal before the measurement is taken. This may be necessary in some system configurations involving the ND filter wheel (see Components section).

15. The software will acquire data in the S-T position and fit for the Delta Offsets introduced by the focusing lenses. These offsets will be written to the Configuration as mentioned earlier.

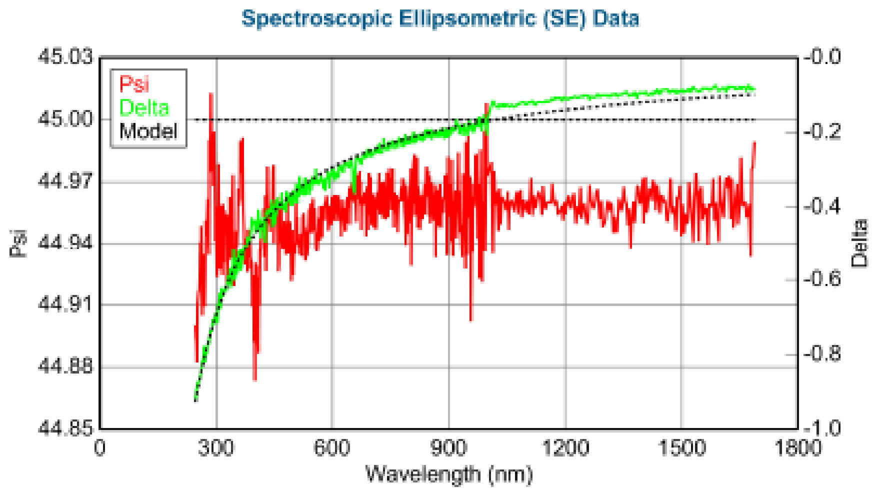


Figure 6-10. S-T data example (Psi and Delta).

16. After the focusing probes are installed, the AOI will move to 70° and the ***Hardware***>**System Information** panel will update as shown below.

Focus Probes: Installed
Window Effects: ON (Focus Option)

Figure 6-11. Focusing Probes installed.

> ***Note: With the focusing probes attached the base cannot be operated in the straight through position. The limit switches behind the probes prevent the stage from moving past 75°. This prevents the probes from running into the sample stage and damaging them.***

6.3. Sample Alignment with Focusing Optics

Focusing Optics reduces the measurement beam size to a few hundred microns or less, and sensitivity to the tip/tilt of the sample stage is greatly reduced. However, sensitivity to Z-height position is greatly increased. Tip/tilt adjustment should be skipped during sample alignment, and Z-height (maximize intensity) should be performed carefully.

1. Place a 250Å SiO_2/Si calibration wafer on the sample stage.
2. Select ***Hardware***>**Controls**>General>'Align Sample'. When prompted to perform a full system alignment, select Yes.

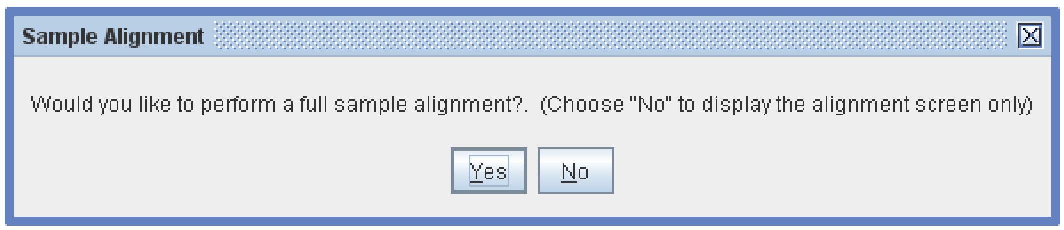


Figure 6-12. Sample Alignment message box.

3. In the Sample Alignment dialog box, select Automatic-Quick in the Sample Height Alignment drop menu. Enter the sample thickness (0.5mm for calibration wafer). Enter 65 in the Alignment Angle box. Press OK.

***Note:* With the focusing probes attached, the Sample Tilt Alignment does not appear unless the system has the Auto Tip/tilt feature. The system is not as sensitive to tilt with a focused beam on the sample. Z height is very critical.**

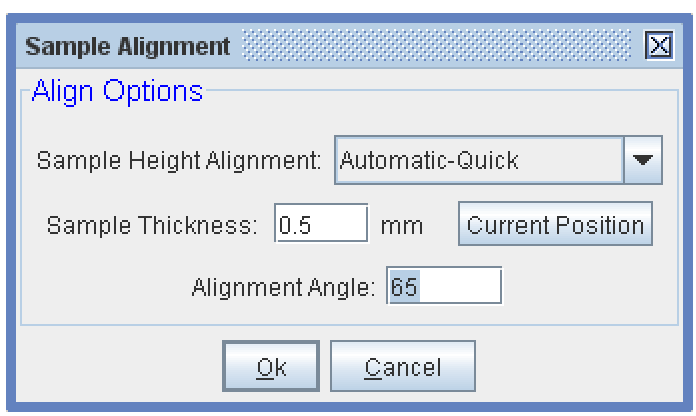


Figure 6-13. Sample Alignment dialog box.

4. The system will perform an Auto-Z height alignment.
5. Select ***Hardware***>**System Information**>'Edit Hardware Config'.
6. Select ***Hardware***>**Controls**>General>'System Check'. Select Yes when prompted to perform the System Check. Press Ok when asked to mount the wafer.
7. In the Sample Alignment dialog box, select Automatic-Quick under the Sample Height Alignment drop menu. If the calibration wafer has already been aligned, click 'Current Position' to enter the current Z-height. Press OK. This will take 1-2 minutes. If the System Check is successful, the system is now ready to take data.
8. If the Psi and Delta data show a "step" in the optional IR spectrometer data, the Receiver unit may need to have the iris(es) opened up (shown in Chapter 4). They may have been closed previously to avoid a detector overload, but with the focusing optics present and off sample, they can be opened to allow more light into the fiber(s).

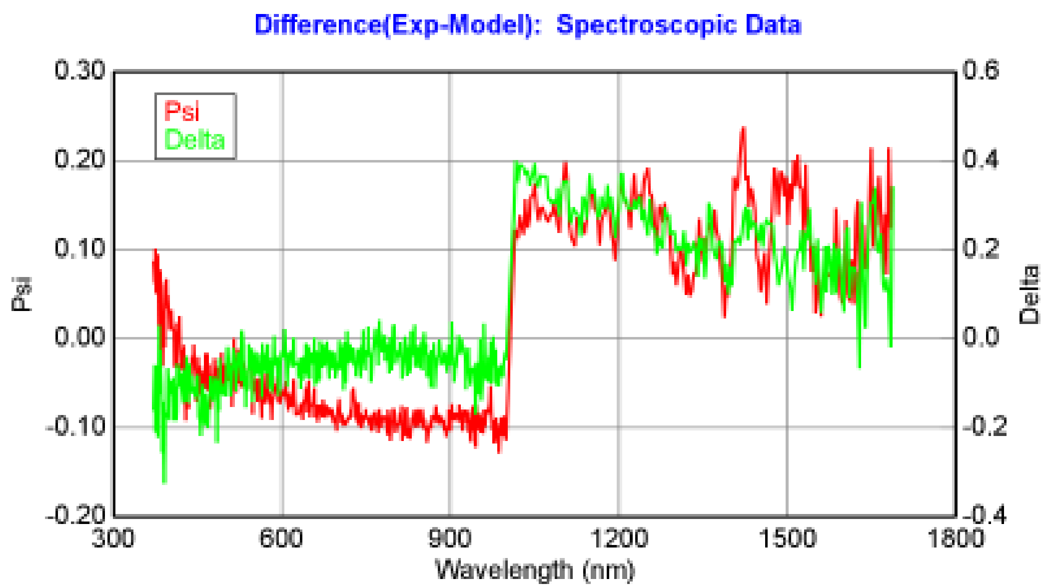


Figure 6-14. Difference plot - Psi/Delta data with step (IR iris not fully open).

9. Open the optional IR iris (if equipped) fully and verify the signal is not overloading the detector by viewing Display Signal screen (***Hardware***>**Controls**>General>'Display Signal').
10. Take data again off of the J.A. Woollam 250Å SiO_2 calibration sample and fit the data as described in the Operation Chapter. Now the "step" between UV and IR spectrometers should be minimized.

6.4. Data Acquisition with Focusing Optics

With Focusing Probes installed, very small changes in Z (sample height) can cause the reflected beam to miss the Detector. Even an Angle of Incidence change introduces small change in Z. Therefore, the Z alignment (sample height) must be performed at each measured angle. For this reason, single-angle measurements are recommended, unless multi-angle measurements are necessary.

If multi-angle measurements are necessary, there are two options.

1. Measure each angle individually. This will result in multiple data files that can be appended together later for analysis.
2. An advanced hardware option can be turned on to prompt for Z alignment at each measured angle. Select ***Hardware***>'Edit Hardware Config' to open the Hardware Configuration window. Check 'Show Advanced Config. Options'. Under 'Alignment Parameters', turn on 'Focus Option: Z Align Each Angle'. This will be true if the System has the Auto-Z capability.

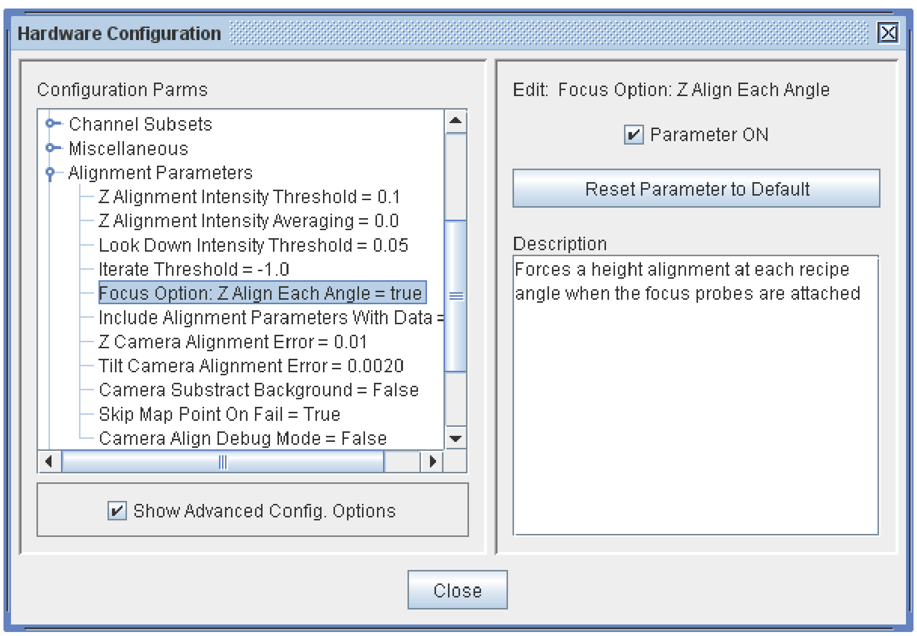


Figure 6-15. Hardware Configuration.

***Note:* The alignment procedure for the focusing optics ensures that the light beam travels along the same pathway as without the focusing optics. However, the accuracy of the procedure is limited. It is necessary to fit for the AOI when analyzing the data.**

6.5. Removal

To remove Focusing Optics, select

Hardware>**Controls**>System>'Remove Focus Probes'

The base will move to the maximum Z height position, maximizing the space between the Focusing Optics and sample stage, and minimizing risk of hitting the sample stage during removal and damaging the optics.

A message will appear letting you know it is safe to remove the Focusing Probes. Loosen the three captive thumb screws for each probe to remove. Store Focusing Probes with protective caps over the lenses.

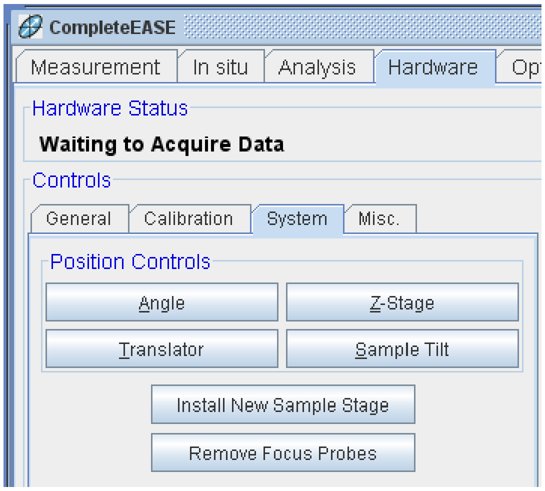


Figure 6-16. Remove Focus Probes.

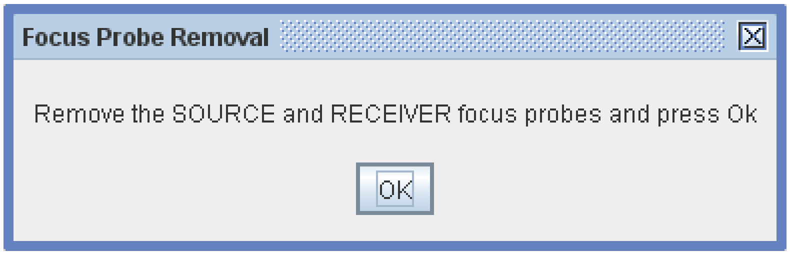


Figure 6-17. Remove Focus Probes.

7. Automated Translation (Optional)

Note: This chapter pertains to automated sample translation, which is an optional accessory that may or may not have been purchased with your instrument.

7.1. General Operation

General translator controls are located in the ***Hardware*** tab. Select

***Hardware*>Controls>System>'Translator'**

to open the Translator dialog box. In Figure 7-1 below, Image Controls are only available for systems with optional Camera accessory.

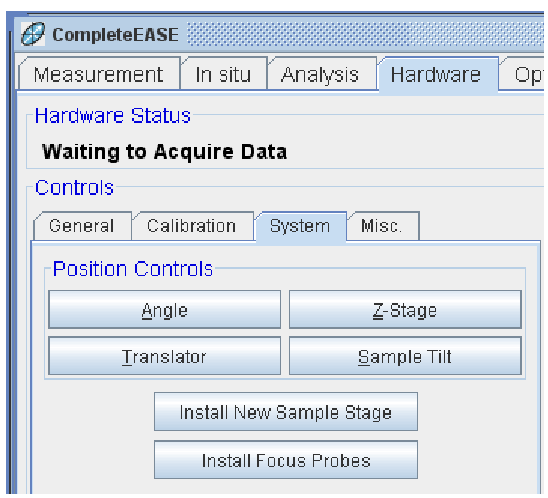


Figure 7-1. Translator controls.

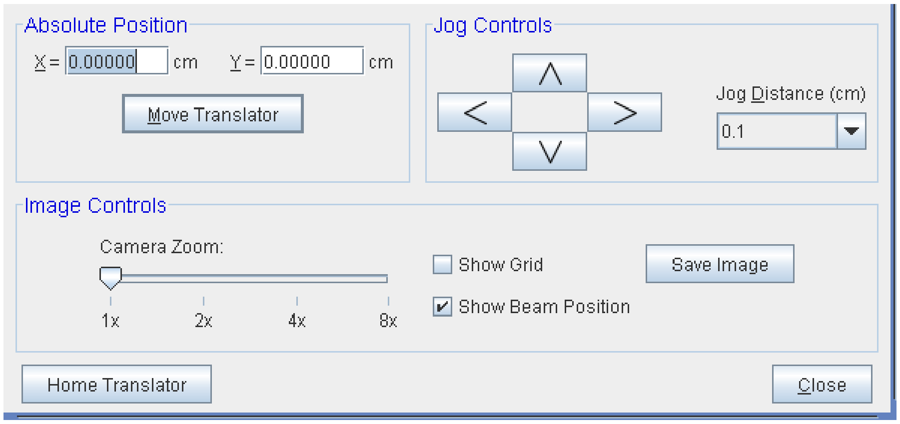


Figure 7-2. Translator dialog box.

The Translator can be moved by entering X and Y coordinates in the **Absolute Position** panel, or by jogging the position left, right, up, and down in the **Jog Controls** panel. The Jog Distance can be varied using the drop-down arrow.

If at any point the translator stage has been manually moved (using knobs on the end of each translator), the software has lost the absolute XY position. To restore, simply 'Home Translator'. Homing the Translator will move Angle and Z height to a position "safe" for translation. The X and Y Translators will then move to their maximum range, trip hard or soft sensor limits, and reset the software translator tracking.

7.2. Scan Patterns

The primary purpose of the Automated Sample Translator option is to automate sample mapping. This is achieved through a Scan Pattern, which is then used with Data Acquisition Parameters and an Analysis Model in a Recipe (see *5.2 Recipes*).

To create a Scan Pattern, open the Scan Pattern Editor window. From the ***Measurement*** tab, choose the Recipe option "Create/Edit Recipe".

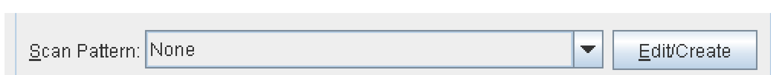


Figure 7-3. Edit/Create Scan Pattern.

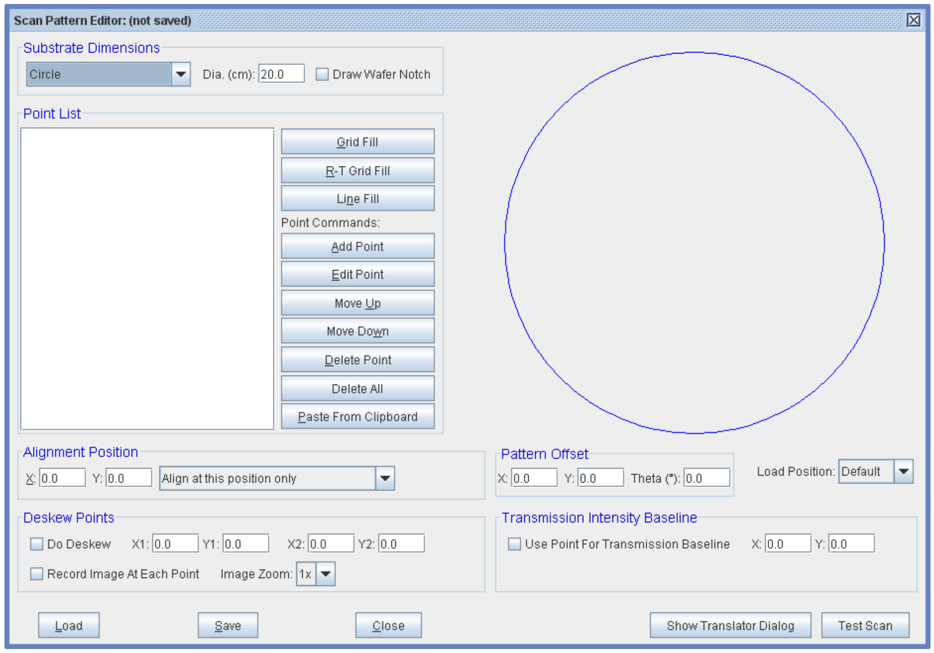


Figure 7-4. Scan Pattern Editor.

The Scan Pattern Editor contains all options available for Scan Patterns including sample size (**Substrate Dimensions**), mapping locations (**Point List**) alignment options (**Alignment Position**), scan offsets (**Pattern Offset**), and more.

Substrate Dimensions

The substrate dimensions can be drawn as a Circle or Rectangle. For circular substrates, the diameter must be entered, and a Wafer Notch can be added if applicable.

For rectangular substrates, the X and Y dimensions must be entered. Scan Patterns for rectangular substrates can be easily set with (0,0) position at the center of the sample, or at the corner of the sample.

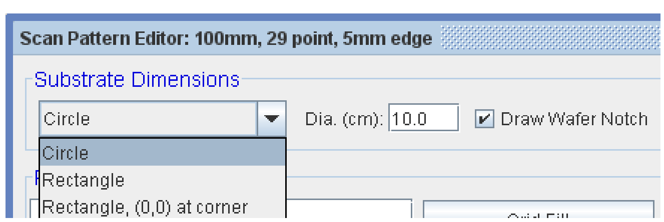


Figure 7-5. Options for Substrate Dimensions.

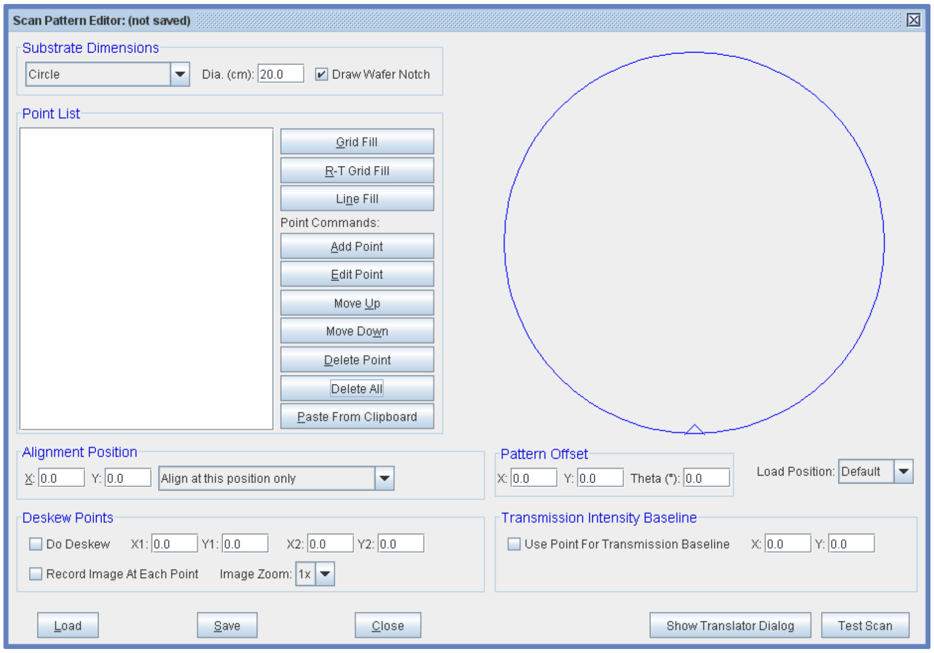


Figure 7-6. Circular substrate, 20cm diameter, wafter notch drawn.

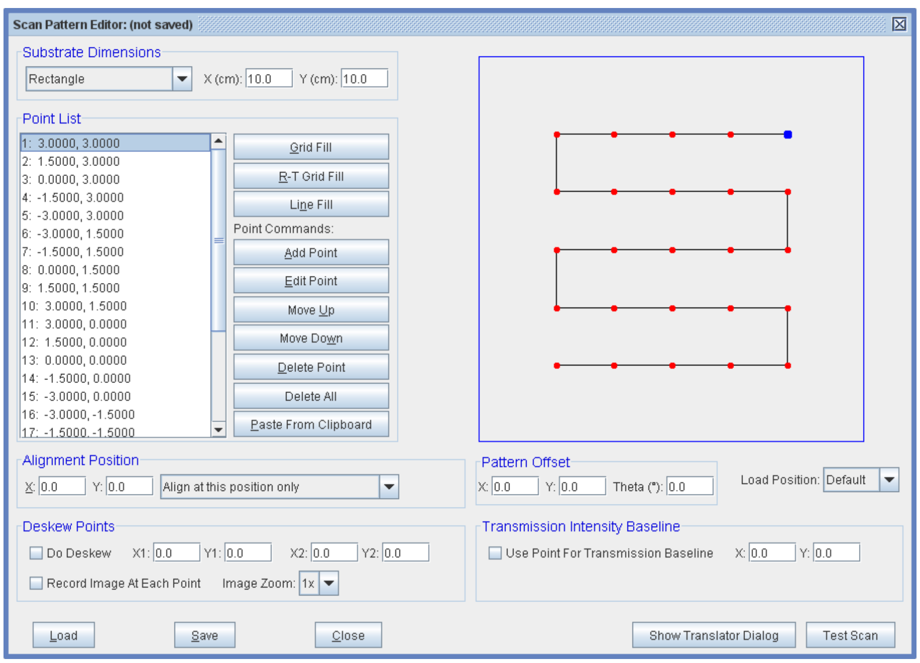


Figure 7-7. Rectangular sample 10x10cm with (0,0) at center.

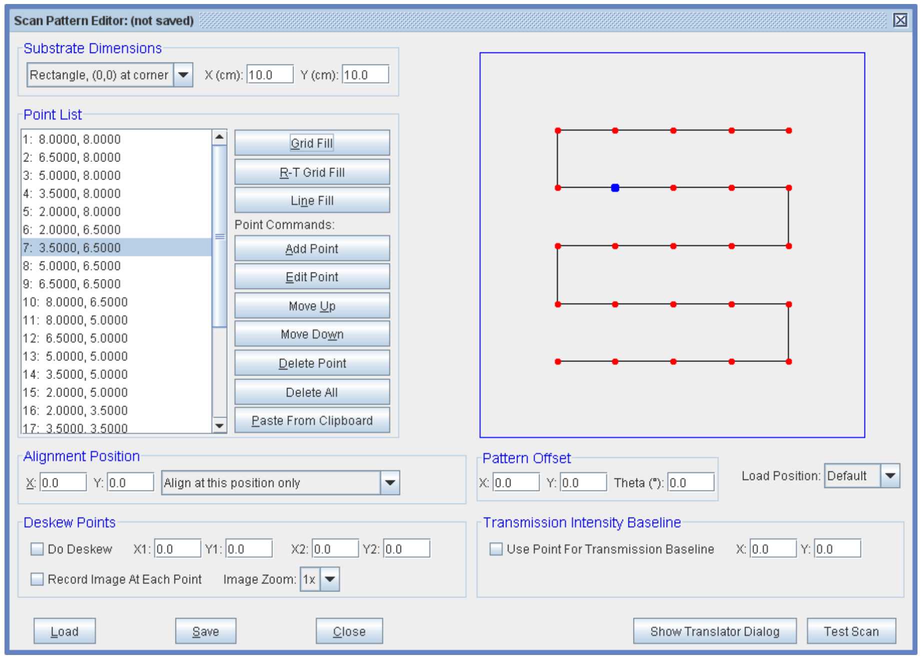


Figure 7-8. Rectangular sample 10x10cm with (0,0) at corner.

Point List and Point Commands

The **Point List** panel is used to add mapping locations to the Scan Pattern. Points can be added one at a time, or using a fixed spacing and grid style.

To add points one at a time, or from a preset list of coordinates, simply click 'Add Point'. A measurement point is added using X and Y coordinates or the current Translator position. A list of coordinates created in another program can also be added using the 'Paste From Clipboard' button.

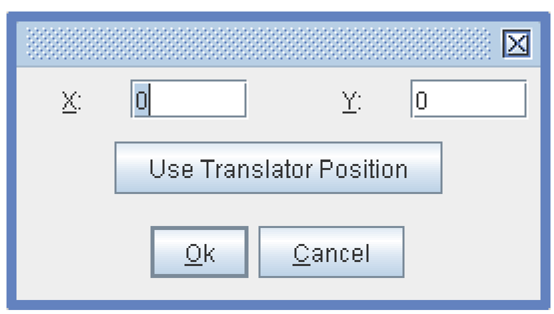


Figure 7-9. Add Point.

As points are added, representative dots will appear in the diagram. Click on a specific point in the point list to select for Point Commands. The selected point appears blue in the diagram.

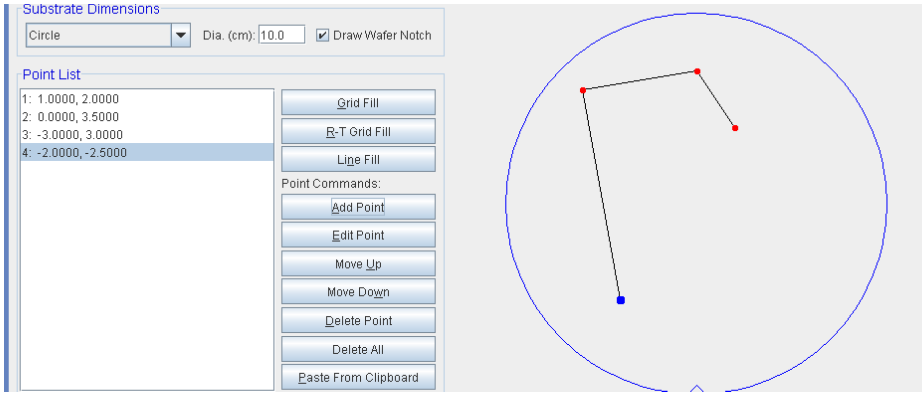


Figure 7-10. Highlighted point in point list.

Use 'Edit Point' to change selected point coordinates.

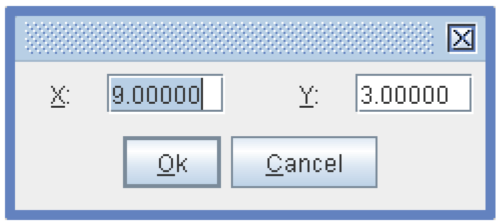


Figure 7-11. Edit Point.

Use 'Move Up' and 'Move Down' to move selected point up or down on the Point List. The sequence of the point list is the order in which locations will be measured.

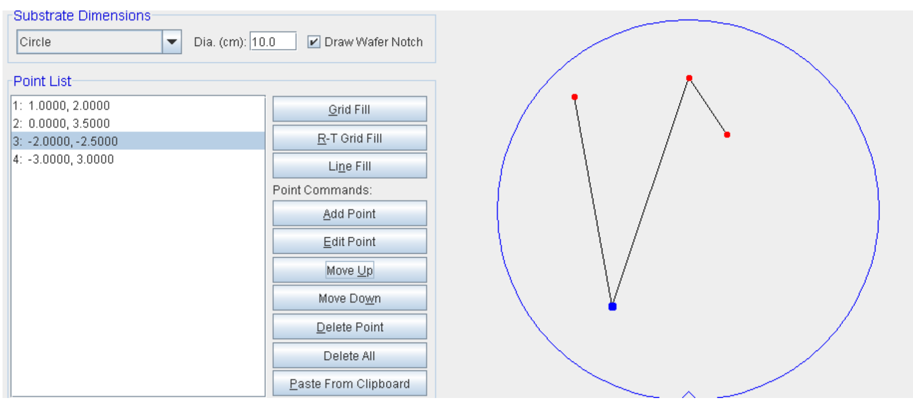


Figure 7-12. Sequence is altered using 'Move Up' and 'Move Down'.

'Delete Point' removes the selected point from the Point List. 'Delete All' removes all points from the Point List.

Grid and Line Fill

To add points using a fixed spacing and grid style, use the 'Grid Fill', 'R-T Grid Fill', and 'Line Fill' buttons. Each option opens a different window. For Grid Fill, Grid Spacing, Grid Margin, and Grid Style (i.e. Square or Hexagonal) must be specified.

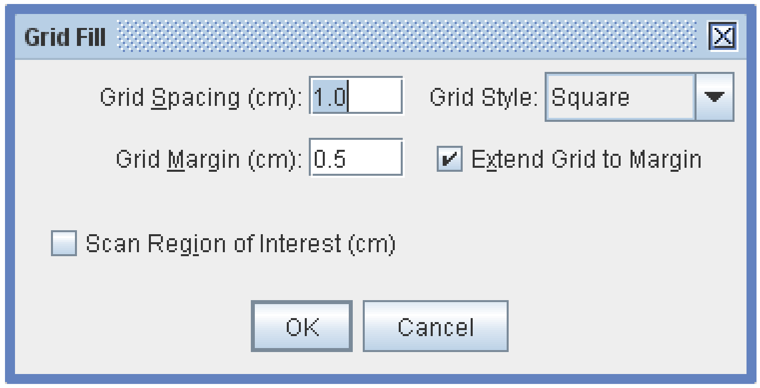


Figure 7-13. Grid Fill.

For R-T Grid Fill, Radius and Theta values must be specified.

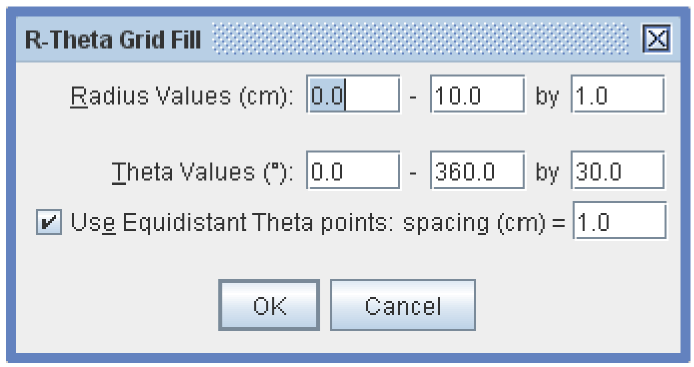


Figure 7-14. R-T Grid Fill.

For Line Fill, the Line Direction, Grid Spacing, Grid Margin, and X or Y Axis Coordinate must be specified. Multiple Line Fills can be added.

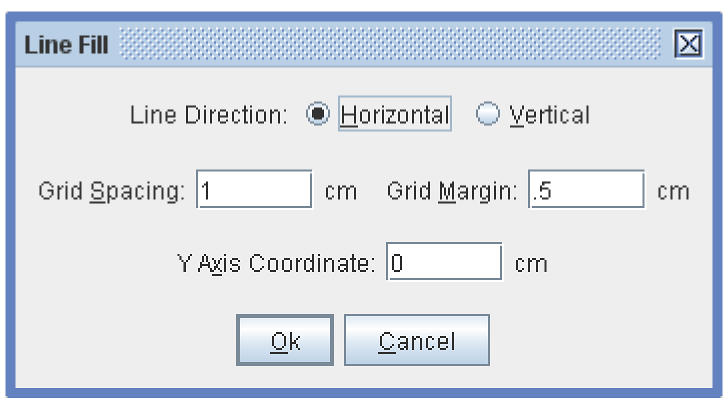


Figure 7-15. Line Fill.

Examples of each grid type are shown in the figures below.

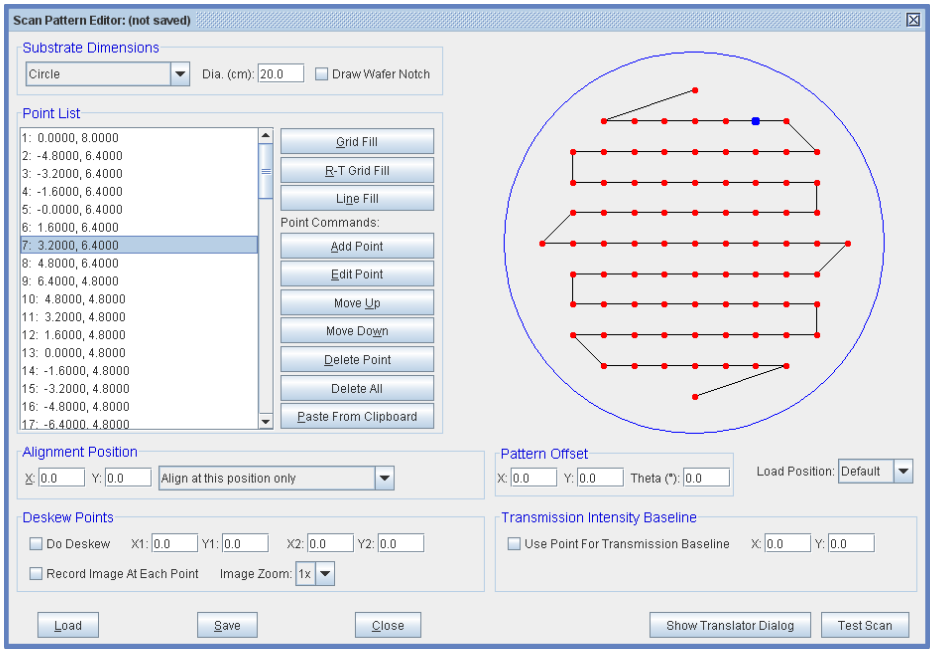


Figure 7-16. Example Square Grid Fill.

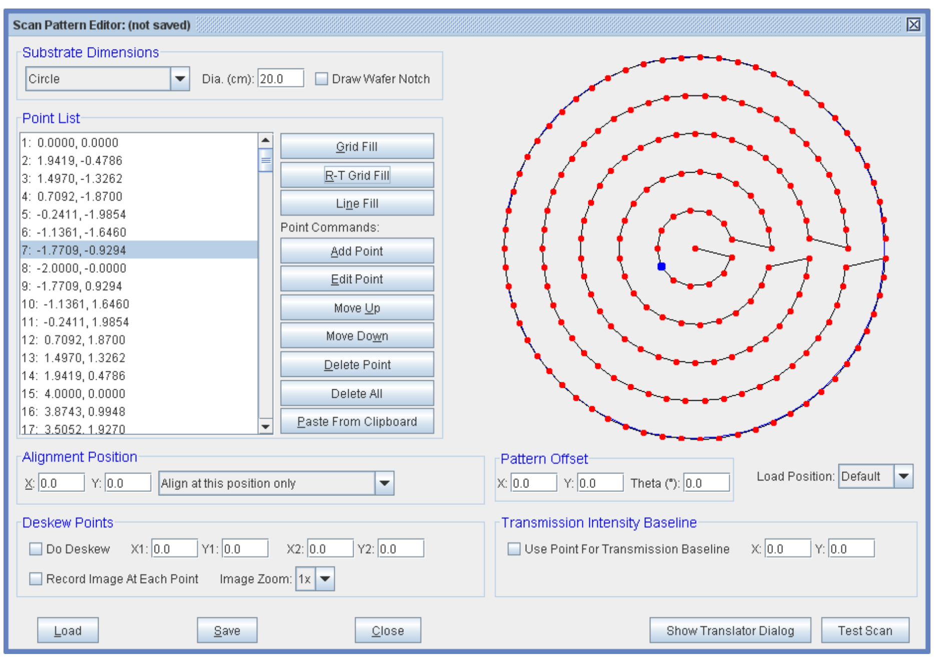


Figure 7-17. Example R-T Grid Fill.

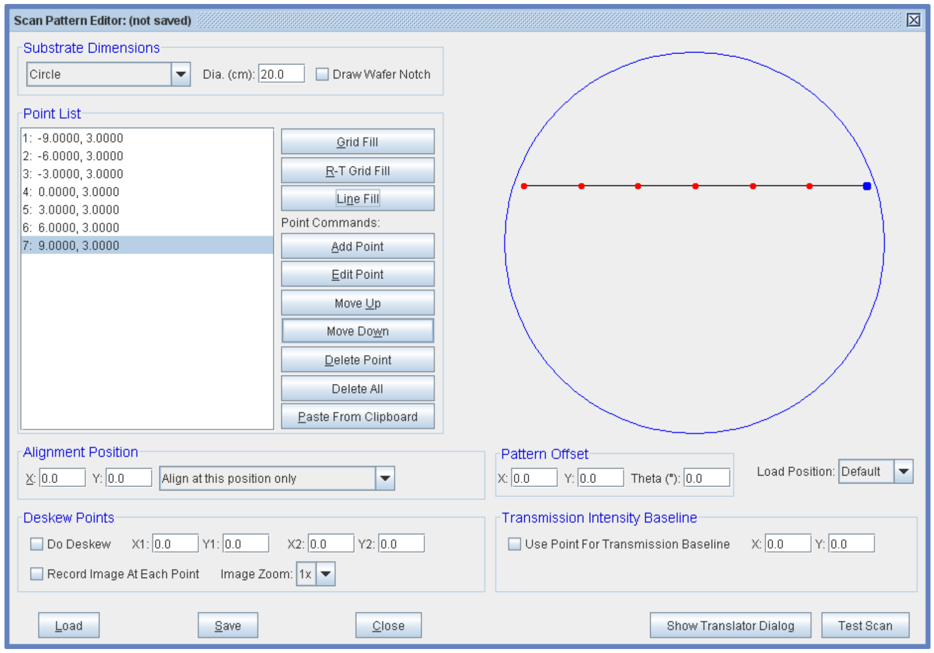


Figure 7-18. Example Line Fill.

Test Scan

The measurement locations can be tested using the 'Test Scan' button. Click this button to observe the translator movement before committing to a full measurement. Note that **Image Controls** shown in the figure below are available only with the optional Camera accessory.

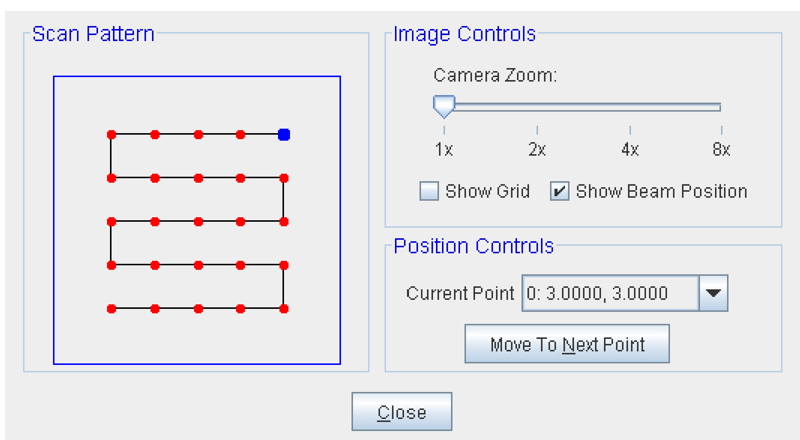


Figure 7-19. Scan Pattern Test.

***Note:* A 180˚ Pattern Offset may be required for correct orientation of wafers with wafer notch. Use the 'Test Scan' function to confirm desired orientation.**

Alignment Position

Alignment options must be specified for each Scan Pattern. Available alignment options are found in the Alignment Position panel, shown in the figure below. The ideal alignment option can depend on several factors including desired measurement time, flatness of sample, and uniformity of sample. For measurements on a flat semiconductor wafer, with uniform film, and normal light beam (no focusing optics), full alignment at the center location only may be adequate. For measurements on a wedged substrate, full alignment at all points may be necessary. For measurements with Focusing Optics, a Z alignment at all points is likely necessary, as the focused beam is highly sensitive to small changes in Z height.

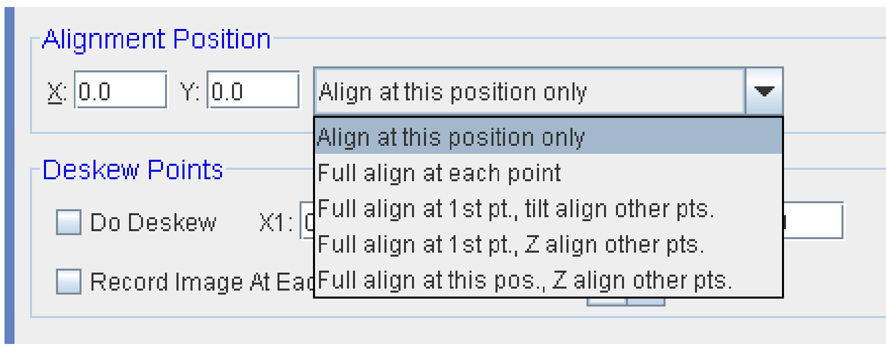


Figure 7-20. Alignment Position.

Save

When all Scan Pattern options have been specified, click 'Save' to save the Scan Pattern for use in a Recipe.

Figure 7-21. Save Scan Pattern.

8. Camera (Optional)

> ***Note:* This chapter pertains to an optional accessory that may or may not have been purchased with your instrument.**

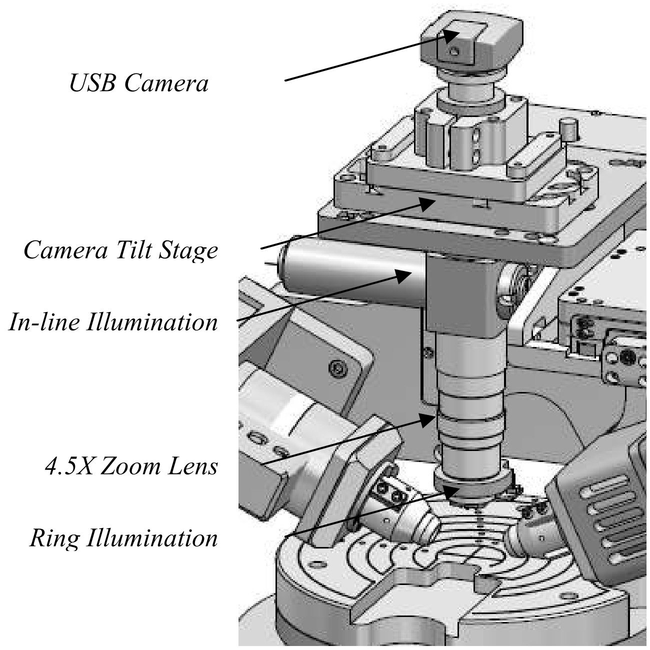


Figure 8-1. USB camera example (may vary based on model)

Instructions in this chapter are performed with focusing lenses attached in order to view the measurement beam on the sample.

8.1. Marking the Measurement Beam Position

1. Align the 250Å calibration wafer on the standard sample stage.
2. Flip the sample over so the rough side is facing up.
3. Set the zoom lens to a fixed position (ex: 2x zoom). After the camera calibrations are performed, the manual zoom must stay at this position. The digital zoom may be used if desired.

4. Select ***Hardware***>**Controls**>*Misc*>'Additional Camera Functions' to open the Camera Functions Window.

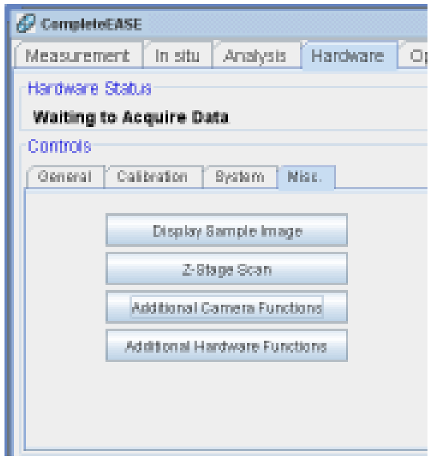


Figure 8-2. Additional Camera Functions button.

5. Select 'Mark Measurement Beam Location'.

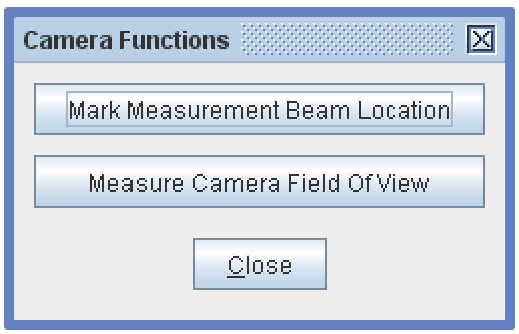


Figure 8-3. Mark Measurement Beam Location button.

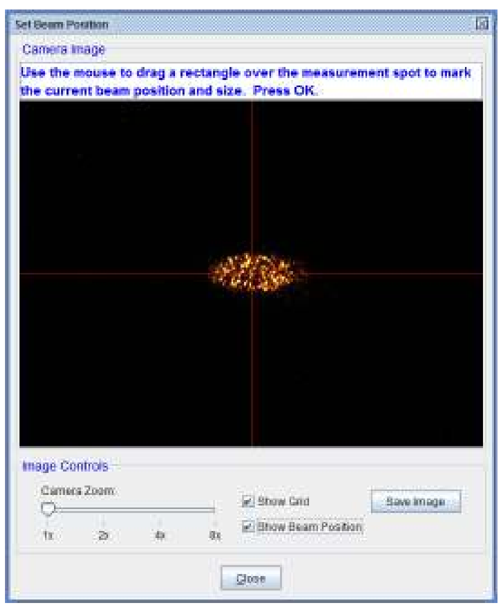


Figure 8-4. Set Beam Position window.

6. If necessary, tilt the camera to center the beam on the screen. Use the diagonal adjustment screws of the camera tilt stage, shown in Figure 8-5.
7. If the camera is not in focus, adjust the Z height of the camera by turning each adjustment screw on the tilt stage by the same amount, shown in Figure 8-5.

Turn all (3) adjustment screws by the same amount in the same direction to move the camera in the Z direction.

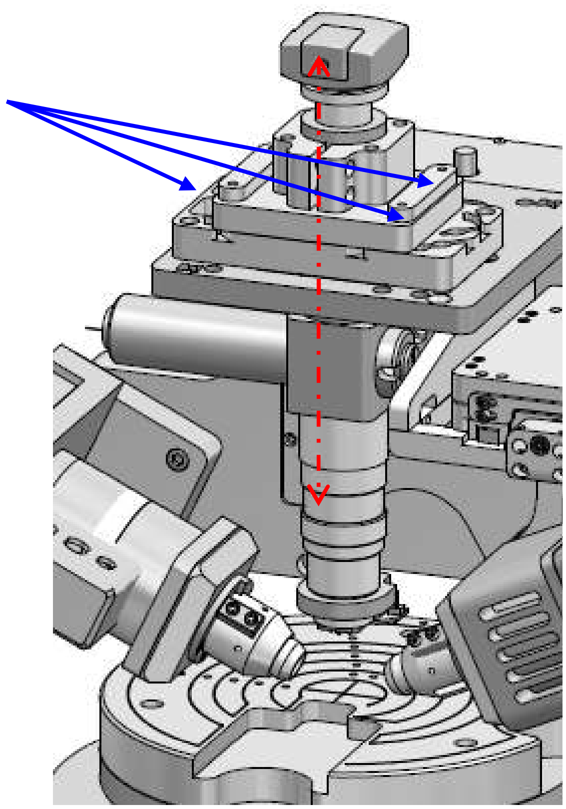


Figure 8-5. Camera tilt stage and adjustment screws.

8. Follow the instructions at the top of the window: "*Use the mouse to drag a rectangle over the measurement spot to mark the current beam position and size.*" This may be performed as many times as needed; it will not save until the window is closed.

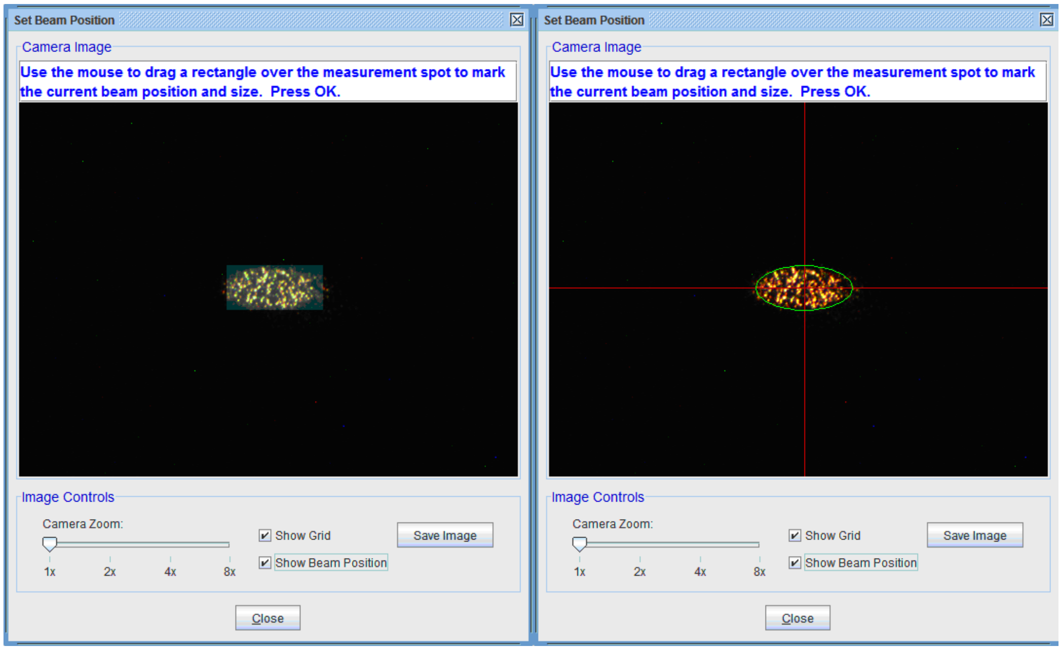


Figure 8-6. Set Beam Position.

9. Close the window when finished.

8.2. Field of View Calibration

1. The previous section (8.1 Marking the Measurement Beam Position) should be complete before proceeding.
2. Select ***Hardware***>**Controls**>***Misc***>'Additional Camera Functions' to open the Camera Functions Window.

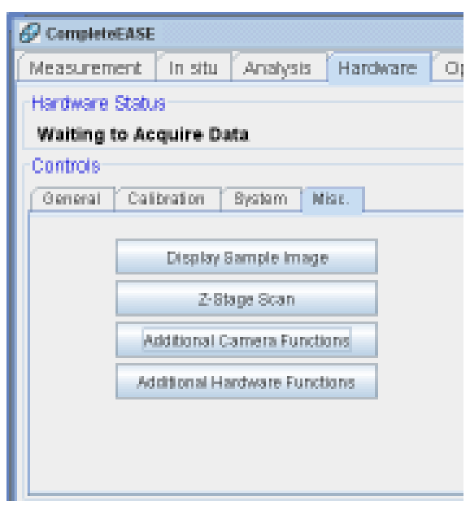


Figure 8-7. Additional Camera Functions button.

3. Select 'Measure Camera Field of View'.

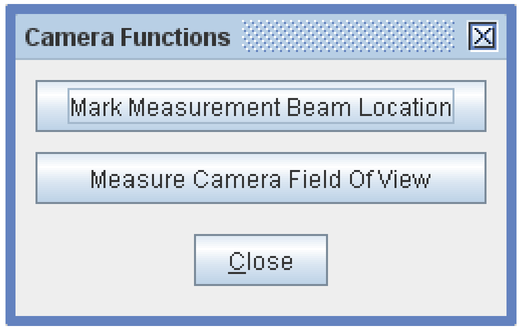


Figure 8-8. Measure Camera Field of View button.

4. Adjust the illumination so the sample surface is visible.

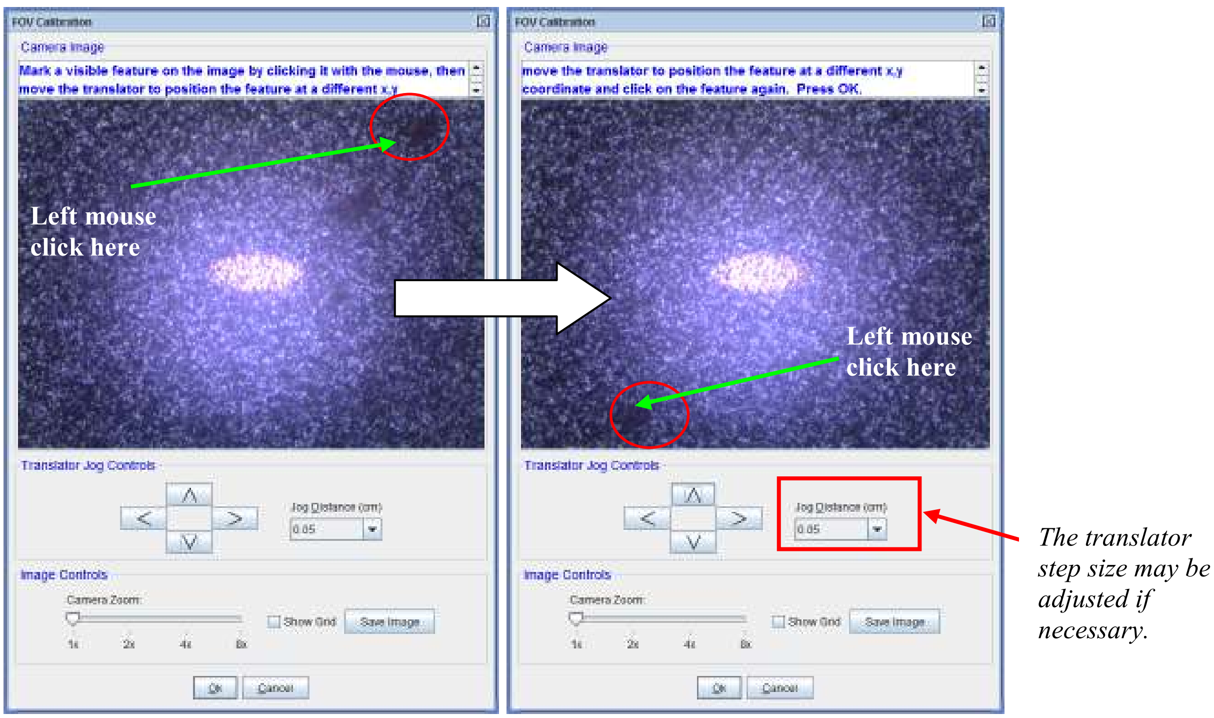


Figure 8-9. Field of View calibration procedure.

5. Follow the instructions at the top of the window: *"Mark a visible feature on the image by clicking it with the mouse, then move the translator to position the feature at a different x,y coordinate and click on the feature again."* Use a fine tip marker to "create" a feature if necessary. (See Figure 8-9. Field of View calibration procedure.)
6. Press OK when finished.

Note:* *If not performed correctly, or not sure, just press Cancel and start again.

7. To test the feature, open the Translator Window (***Hardware***>**Controls**>***System***>'Translator').

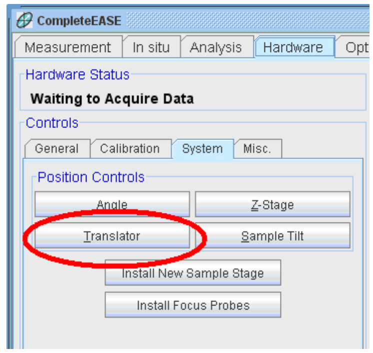


Figure 8-10. Click 'Translator' to open Translator Window.

8. Click on the feature and the translator should move it to the Beam Position.

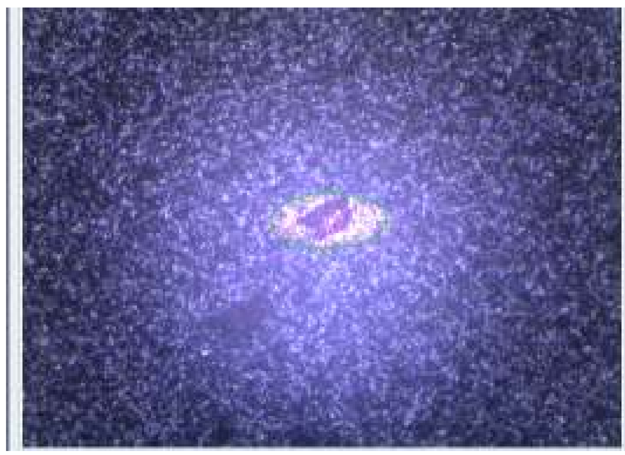


Figure 8-11. Field of View calibration test result.

9. Scheduled Maintenance

The J.A. Woollam Co., Inc. M-2000® Ellipsometers are low maintenance instruments. The only maintenance needed is to change the lamp(s) periodically and to check the alignment of the system.

9.1. D2 & QTH Lamps (M-2000D, DI, U, UI)

The lamps must be replaced after a certain period of time. As a lamp approaches the end of its useful life, intensity levels can fluctuate and spectral intensity can be reduced, both may result in poor or noisy data.

Lamp	Vendor	Model#	Color Temp.	Rating	Typical Lifetime
QTH	ILT	L9404	2900°K	2000 hours	3000 hours
D2	Hamamatsu	L10804	N/A	2000 hours	3000 hours

Table 9-1. Lamps & Typical Lifetimes.

After a new lamp is installed it must be aligned for maximum intensity.

> ***Note:* It is recommended that both lamps be replaced at the same time.**

Lamp Installation/Replacement

> ***Note:* After replacing lamps always follow the lamp alignment procedure to maximize light intensity.**

1. Loosen the (2) M3 thumb screws and remove the cover on the light source.
2. Put on latex gloves and safety goggles.

Warning: The lamps get extremely hot during operation. Always allow them to cool adequately before replacing the lamp.

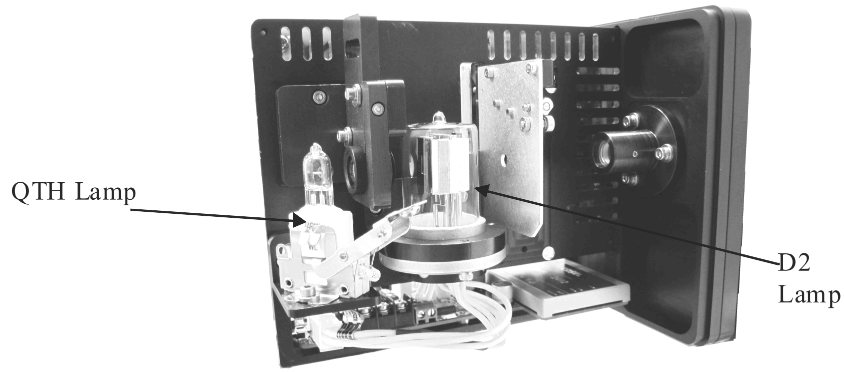


Figure 9-1. Disconnecting the lamps.

3. Disconnect the D2 lamp by unplugging it from the circuit board.
4. Using a M2.5 Allen wrench remove the (2) M3 SHC screws under the lamp holding the D2 lamp in place.

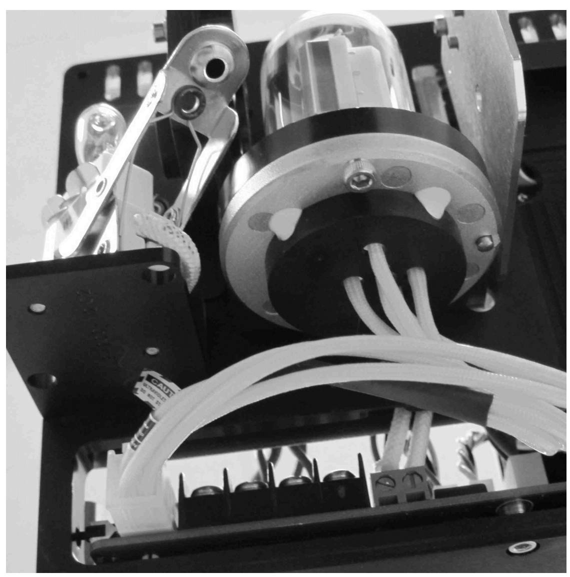


Figure 9-2. M3 SHC screws under D2 lamp.

5. Remove the D2 lamp by sliding out of the mount.
6. To remove the QTH lamp, press the lever slowly down and the QTH lamp will slide up out of its base.

> ***Caution:*** ***Do not touch the quartz portion of the lamps. Fingerprints and oils can shorten the life of the lamp. If you do get a fingerprint on the lamp, clean the fingerprint off with alcohol.***

7. Place the new D2 lamp in the mount and replace and tighten the (2) M3 SHC screws back into place. Plug the D2 lamp connector back into the circuit board.
8. Insert the new QTH lamp into the holder and ensure it is seated down fully. Note the polarity of the lamp connectors and the base, the lamp will only go in the base one way.
9. Replace the cover.
10. Tighten the thumbscrews to lock the cover closed.
11. Reset the hour meter by pressing the reset button located on the hour meter on the front of the M-2000D(I) or M-2000U(I) module.

Lamp alignment

After the lamps have been replaced it is recommended that the lamp housing be aligned for maximum intensity. For the XLS-200, there is no lamp adjustment necessary.

1. Ensure the Base is in the 90° straight thru position and the sample will not block the beam from hitting the receiver unit's aperture.
2. Slightly adjust the source unit tilt stage to center the beam on the receiver aperture if necessary.
3. While in the straight through position open the alignment screen and verify the cross-hair is centered. If not, slightly adjust the receiver unit tilt stage to center the cross-hair.

9.2. Xe Lamp (M-2000X, XI, X-210, and XI-210)

This section describes installation/replacement, alignment, and cleaning of the lamps used in the FLS-300 Light Source (for M-2000X, XI, X-210, and XI-210 systems).

The Xenon arc lamp must be replaced after a certain period of time. As a lamp approaches the end of its useful life, power levels can fluctuate and spectral intensity can be reduced, both result in bad or inaccurate data.

Lamp	Model #	Rating	Typical Lifetime
Hamamatsu	L2174-01	1000 hours	1500 hours

Table 9-2. Arc Lamp Rating & Typical Lifetime.

After a new lamp is installed, it must be focused for maximum intensity. Complete instructions are contained within this section of this manual.

Installation/Replacement

The lamp should be off for at least two hours or the fan run for at least 20 minutes while the lamp is not ignited.

1. Put on latex gloves and safety goggles.
2. Loosen the thumbscrew and remove the access panel on the light source.

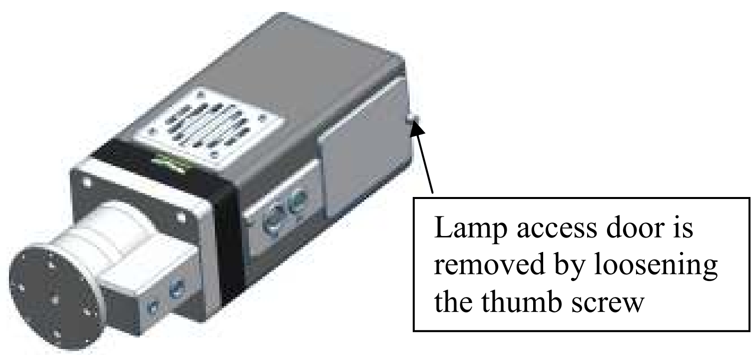


Figure 9-3. Light Source, Access Panel.

> ***Warning:* Compact arc lamps contain highly pressurized gas, and present an explosion hazard <u>even when cold</u>. Wear face protection, such as a full-face shield, gloves and a long sleeve shirt whenever handling lamps.**

3. Loosen the thumb screw and remove the anode holder from the "old lamp".

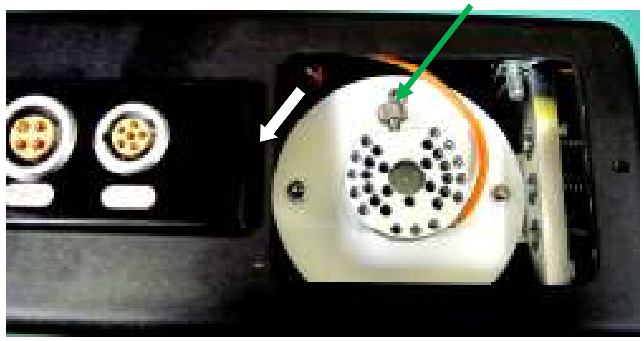


Figure 9-4. Anode Holder.

4. Pull the lamp release lever, in the direction of the arrow, no more than ½" and carefully remove the old lamp.
5. Remove the new lamp from its protective packaging, touching only the metal ends of the lamp.

> ***Caution:* *Do not touch the quartz portion of the lamp. Fingerprints and oils can shorten the life of the lamp. If you do get a fingerprint on the lamp, clean the fingerprint off with alcohol.***

Figure 9-5. Typical Arc Lamp.

6. While pulling the lamp release lever, carefully insert the cathode of the lamp into the cathode holder. When the lamp is in position, release the lever and the lamp will be secured.
7. Place the anode holder onto the anode of the lamp, and then tighten the thumbscrew.
8. Replace the access panel cover.
9. Tighten the thumb screw to lock the rear access panel closed.
10. Reset the hour meter by pressing the reset button located on the front of the M-2000® Lamp Power Supply Module.

> ***Note:* After a lamp has been replaced, the lamp housing needs to be realigned. This is done so that the maximum amount of light is used for sample measurement. The alignment should be close because of the old lamp that was replaced, but fine adjustment is needed to achieve maximum intensity because of the small difference in position of the new lamp.**

Alignment

1. Ensure the base is in the straight through position (90°).
2. Turn on the lamp power supply and ignite the arc lamp. Allow the lamp to warm up for at least 20 minutes.
3. There are two small adjustments screws located on the back of the light source. These are used to control the position of the arc lamp inside the light source.

Figure 9-6. Light Source adjustment screws.

4. Turning off the lights in the room may help facilitate the next few steps.
5. While holding a business card in the path of the beam, adjust the adjustment screws using a 5/64" Allen wrench until the beam is visible (a properly aligned lamp produces a very bright, bluish-white beam).
6. Only slight adjustment is needed to give the beam a uniform spot on the business card. You may need to iterate between the two adjustment screws for best uniformity and intensity.

Bad Spot Good Spot

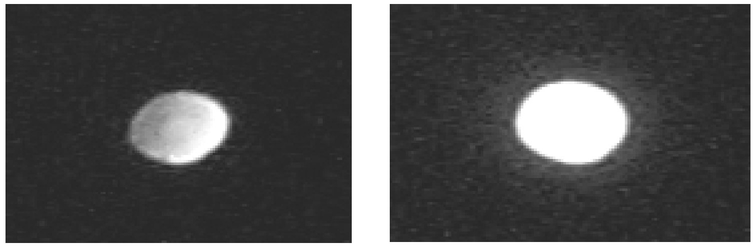


Figure 9-7. Difference between good spot and bad spot.

7. Once the beam is visually bright, use the Ellipsometer to perform the final alignment of the lamp.

8. Open the alignment screen by selecting, ***Hardware*** > **Controls**: > ***General*** > 'Align Sample'. If prompted, select 'No' for "Full Sample Alignment." If the Look-Down detector is an option, select the Receiver Detector Radial button at the top of the screen.

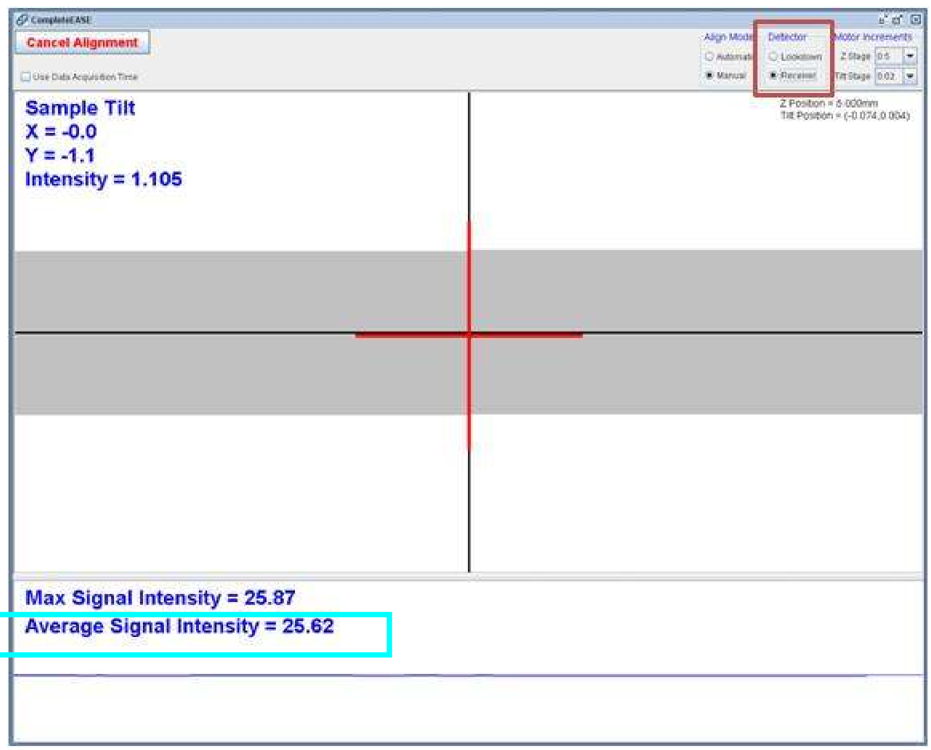


Figure 9-8. Alignment Screen.

9. Adjust the lamp adjustment screws to maximize the Average Signal Intensity displayed at the bottom of the Alignment Screen

10. Adjust the Source unit tilt stage slightly so the beam's spot is centered on the receiver unit's aperture.

11. Using the Receiver unit tilt stage, adjust so the cross hair is centered on the alignment screen.
12. Repeat steps 9 thru 11 until no further improvement is achieved.

Arc Lamp Disposal

1. Wrap lamp in 10 to 15 layers of paper towels.
2. Insert wrapped lamp in a plastic bag and seal the bag.
3. Smash center part of the glass bulb with a hammer.
4. With no pressure, the lamp (wrapped and still in the sealed bag) is safe to dispose.

9.3. QTH Lamp (M-2000V and VI)

This section describes installation/replacement, alignment, and cleaning of the lamp used in the FQTH-100 Light Source (for M-2000V and VI systems).

The QTH lamp must be replaced after a certain period of time. As a lamp approaches the end of its useful life, power levels can fluctuate and spectral intensity can be reduced, both result in bad or inaccurate data.

Lamp	Model #	Color Temp.	Rating	Typical Lifetime
ILT	L7417	3000°K	2000 hours	3000 hours
Oriel	6332	3300°K	50 hours	300 hours

Table 9-3. QTH Lamp & Typical Lifetime.

After a new lamp is installed it must be aligned for maximum intensity. Complete instructions are contained within this section of this manual.

Installation/Replacement

The lamp should be off for at least two hours or until the unit has cooled to room temperature.

1. Put on latex gloves and safety goggles.
2. Loosen (2) thumb screws to remove the cover.

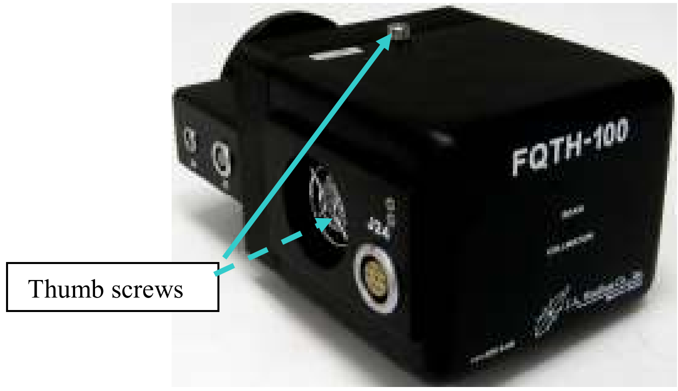


Figure 9-9. Light Source, cover removal.

> ***Warning:* The QTH lamp gets extremely hot during operation. Always allow it to cool adequately before replacing the lamp.**

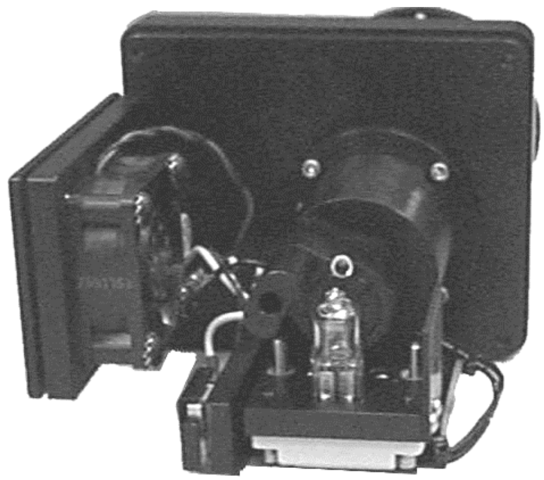


Figure 9-10. QTH mount

3. While holding the QTH bulb, lift up and pull it out of the socket. A slight side to side rocking motion may facilitate this.
4. Remove the new lamp from its protective packaging.

> ***Caution:* Do not touch the quartz portion of the lamp. Fingerprints and oils can shorten the life of the lamp. If you do get a fingerprint on the lamp, clean the fingerprint off with alcohol.**

Figure 9-11. Typical QTH Lamp.

5. Carefully align the two legs of the lamp into the two holes in the socket. There is no polarity on this lamp.
6. Gently push the bulb down into the socket until it is fully seated.
7. Replace the cover.
8. Tighten the thumb screws to lock the cover closed.
9. Reset the hour meter by pressing the reset button located on the front of the M-2000® Lamp Power Supply Module.

> ***Note:* After a lamp has been replaced, the lamp housing needs to be realigned. This is done so that the maximum amount of light is used for sample measurement. The alignment should be close because of the old lamp that was replaced, but fine adjustment is needed to achieve maximum intensity because of the small difference in position of the new lamp.**

Alignment

After a lamp has been replaced, the lamp housing needs to be realigned. This is done so that the maximum amount of the light from the lamp is focused on the tip of the fiber. The alignment should be close because of the old lamp that was replaced, but fine adjustment is needed to achieve maximum intensity because of the small difference in position of the new lamp.

1. Energize the system in accordance with the power up procedure in this manual.
2. Move the AOI to 90°. Select ***Hardware***>**Controls**>General> 'Align Sample'. Choose No when prompted for the full system alignment.
3. Locate the Average Signal reading (bottom of the alignment screen) and make a mental note of the signal value.

4. There is a small adjustment screw located on the bottom of the lamp housing. This screw controls the vertical position of the lamp inside the lamp housing. Using the 1/16" Allen wrench, adjust the screw until the signal reading is maximized.

> ***Note:* The adjustment screw shouldn't need to be turned more than one ore two turns either way. The lamp's position was set at the factory and should be close for most lamps. Only a small adjustment is all that is needed when the lamp has been replaced.**

9.4. Optical Fiber

Upon original installation and anytime the optical fibers have been removed, they should be adjusted for maximum light throughput.

This is achieved by slightly loosening the fiber and slowly rotating it while monitoring the Display Signal Screen for maximum intensity. When this is achieved tighten the fiber down. Perform this for each fiber.

> ***Note:* Over time the optical fiber may become solarized. If the UV intensity becomes weak, it is recommended to replace the Optical fiber.**

9.5. Cleaning

The entire system may be cleaned using a soft cloth and mild detergent or isopropyl alcohol. However, only filtered compressed air or "canned air" should be used to remove dust from any of the optical components.

10. Performance Checks

Use the procedures in this chapter to verify that the instrument is operating properly and determine potential problems, if any. The sections below outline verification/tests in order of increasing complexity. If the first test (*Measure Calibration Wafer*) passes, it is unlikely that any further testing is needed. Similarly, if the second test (

System Check) passes, it is unlikely that the more involved checks are needed.

10.1. Measure Calibration Wafer

The quickest way to verify ellipsometer operation is to measure the calibration wafer and/or straight-through (air). A SiO_2 (thermal oxide) on Si calibration wafer is included with every instrument.

To measure the calibration wafer:

1. Follow the Sample Alignment Procedure as described in *4.5 Alignment and Calibration Procedures, Sample Alignment*.
2. Acquire "Standard" Ellipsometry data at a few angles (i.e. 65˚, 70˚, and 75˚).
3. Use the built-in analysis model for Thermal Oxide on Silicon to analyze the data (see *CompleteEASE® Data Analysis Manual* for details).
4. Confirm that a good fit to the data is achieved.
5. To measure air, select "Measure in Transmission Mode" in the Acquisition Parameters Setup box or measure Angle Scan from 90° to 90°. A high accuracy, 5 second measurement is recommended.

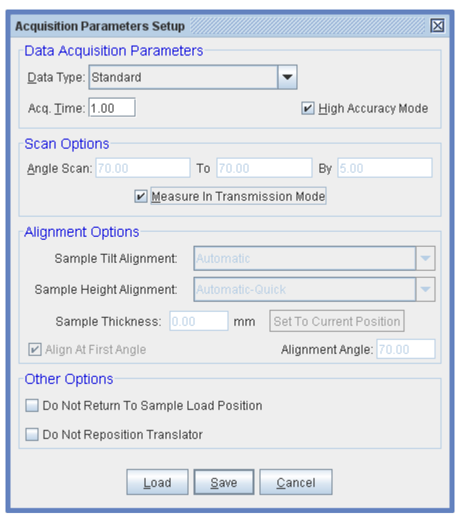


Figure 10-1. S-T Acquisition Parameters Setup.

6. Evaluate the S-T measurement. The M-2000® spec. refers to the Psi and Delta results:
   Psi = 45° ± 0.075 for 95% of the meas. wvls.
   Delta = 0° ± 0.05 for 95% of the meas. wvls.

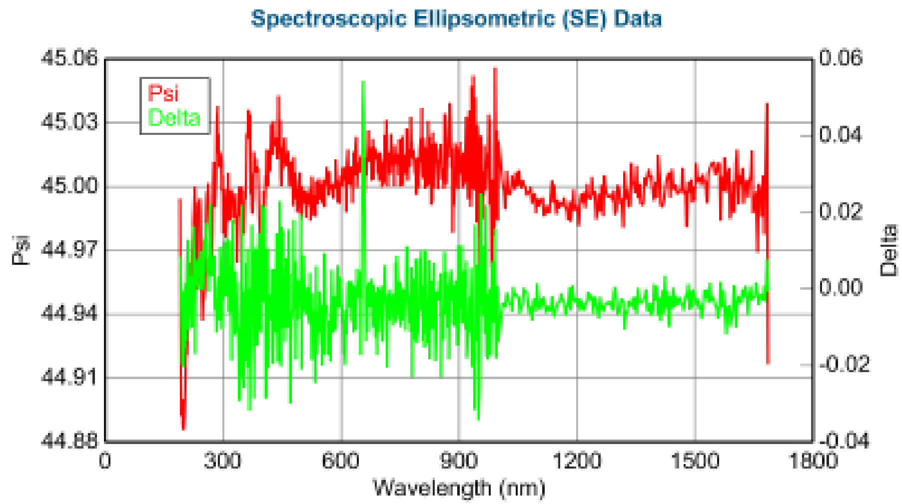


Figure 10-2. Example S-T measurement (M-2000DI)

7. Successful measurement of S-T (air) and/or the calibration wafer is a strong indicator that the tool is working properly. If the measurement is not successful, a System Check should be performed.

10.2. System Check

A System Check is another easy way to verify that the instrument is operating properly. A System Check can be performed instead of simply measuring the calibration wafer. A System Check should be performed if measurement of the calibration wafer and/or S-T (air) is unsuccessful.

A System Check executes a quick calibration of the ellipsometer optics and measurement of the calibration wafer. The System Check procedure, and discussion for successful vs. unsuccessful System Check, is described in *4.5 Alignment and Calibration Procedures, System Check (Calibration)*.

10.3. Verify Sample Alignment

Proper operation of the instrument relies on proper sample alignment. If the sample is misaligned, measured data (and results) will not be accurate. The Sample Alignment procedure (*4.5 Alignment and Calibration Procedures, Sample Alignment*) must be performed for each sample that is mounted on the ellipsometer, prior to acquiring data.

Successful Sample Alignment requires that the following conditions are simultaneously satisfied:

- The tip/tilt of the sample should be aligned such that the sample surface is perpendicular to the plane of incidence; alignment screen crosshairs should be centered.
- The Z height of the sample should be aligned such that the Receiver Unit is collecting the reflected beam; intensity is maximized.
- Alignment should be maintained with angle change (the cross hair should not move more than 15 units in X or Y on the Receiver unit Detector).

> ***Note:* Reflected intensity is a function of angle; therefore, the intensity will change as angle changes, but the reflected beam should remain centered on Receiver Aperture for all angles.**

If these conditions cannot be simultaneously satisfied, the System Alignment should be verified.

Verify Signal/Lamp Intensity

Intensity can vary from lamp to lamp, and system to system. There are no set intensity cutoff values where the lamp intensity becomes too low for operation. It is good practice to monitor intensity under consistent conditions (i.e. straight-through (90°), or same sample at same angle) over time. To view intensity, select

Hardware>**Controls**>General>'Display Signal'

If experimental data appear noisy in all or part of the spectrum, the lamp may need to be changed. See rated lifetimes for lamps in Scheduled Maintenance Chapter.

The lamp intensity should not overload the detector. If the 'Display Signal' screen indicates that the detector is overloaded, reduce the intensity by adjusting the iris on the fiber tube (located on Receiver Unit) or the Filter Wheel (if installed). Detector overloading can be a sample phenomenon. If the ellipsometer is used for highly reflective samples (i.e. metallic substrates) and low reflecting samples (i.e. bare glass), the intensity may need to be adjusted on a sample-by-sample basis.

10.4. Verify System Alignment

> ***Note: A System Alignment should only be performed when the instrument is first delivered, after mounting the Light Source and Receiver components onto a base or chamber, or if the integrity of the alignment is in question.***

> ***Note: Alignment of the Light Source and Receiver tilt stages on the base should only be adjusted when the base is in the straight-through position.***

If all other tests are unsuccessful, the System Alignment should be checked. See *Alignment and Calibration Procedures* for instructions. If the System Alignment is changed, a System Check MUST be performed when completed to calibrate the Ellipsometer optics.

10.5. System Calibration

System Calibration Using the Factory Setup Model

A System Calibration is performed when the wavelengths of the instrument are known to be incorrect or the compensator or spectrometer has been changed. These situations occur if the M-2000 box or light source has been replaced. This document describes the System Calibration procedure for determining the wavelengths and compensator calibration coefficients. DO NOT attempt this procedure unless instructed to do so by the J. A. Woollam Co.

Overview of the Calibration Procedure

Performing a System Calibration involves iterating between two steps - the System calibration and the Wavelength calibration. The first step measures the positions of the optical elements and the Retardance of the compensator at the currently accepted wavelengths. The second step measures a wavelength correction by acquiring data on three known samples and fitting the data to a model assuming the wavelengths are not known exactly. The first step is then repeated using the newly measured wavelength correction.

Calibration Procedure

Before starting the calibration, make sure that the 2nm, 25nm, and 1000nm oxide samples are available. Certain systems will also need to the 60nm or 10nm oxide sample available.

System Calibration

***Note:* The System Alignment and Sample Alignment must be correct and understood by the user before ever attempting a System Calibration. If done incorrectly, the system may not be functional.**

1. Load the Factory_Setup model from the Calibration Wafers folder. Only the System Calibration and Wavelength Calibration sections will be used. The other sections are used for initial setup of the ellipsometer at the factory.

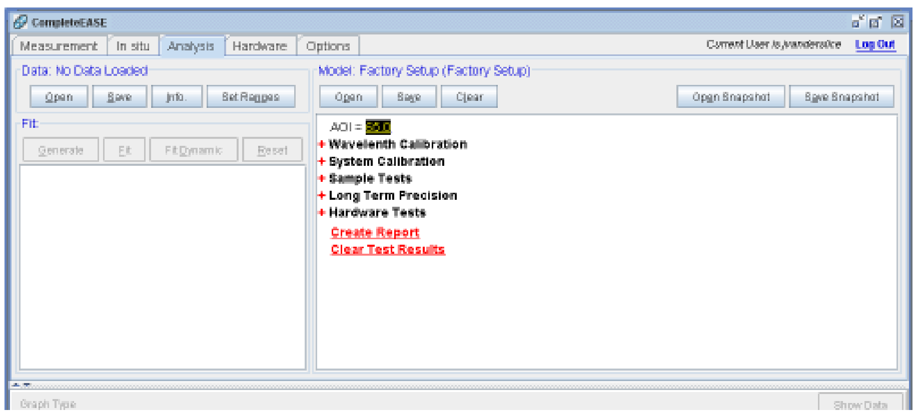


Figure 10-3. Factory Setup model loaded in the Model window.

2. Verify System Calibration Settings - View the settings for the System Calibration by expanding System Calibration section. Check the hardware manual for the ellipsometer for the appropriate models. These settings are dependant on the base type and the wavelength range of the instrument. If the settings are incorrect, change them in the hardware configuration dialog which can be accessed by choosing "Edit Hardware Config." from the "Hardware" tab.

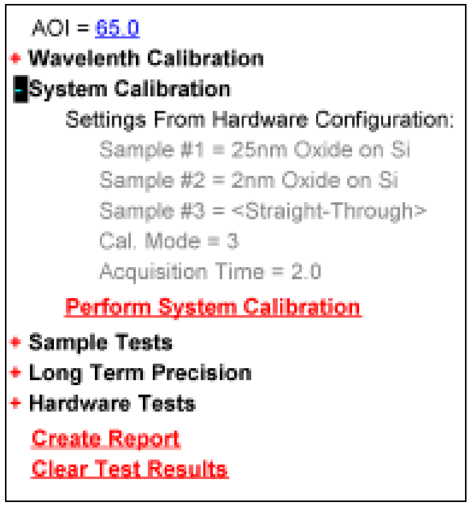


Figure 10-4. *Example of configuration settings for a multi-angle system.*

3. Press Perform System Calibration and follow instructions to complete the System Calibration. If asked about performing a full sample alignment, choose Yes and enter a sample thickness of 0.5mm for the calibration wafer.

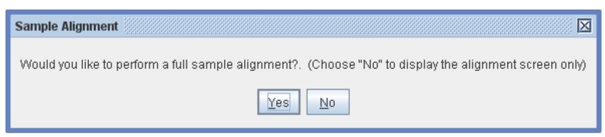


Figure 10-5. *Choose to perform a full sample alignment.*

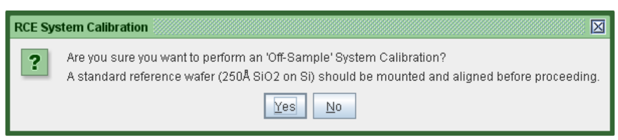


Figure 10-6. *Last chance to opt out of system calibration.*

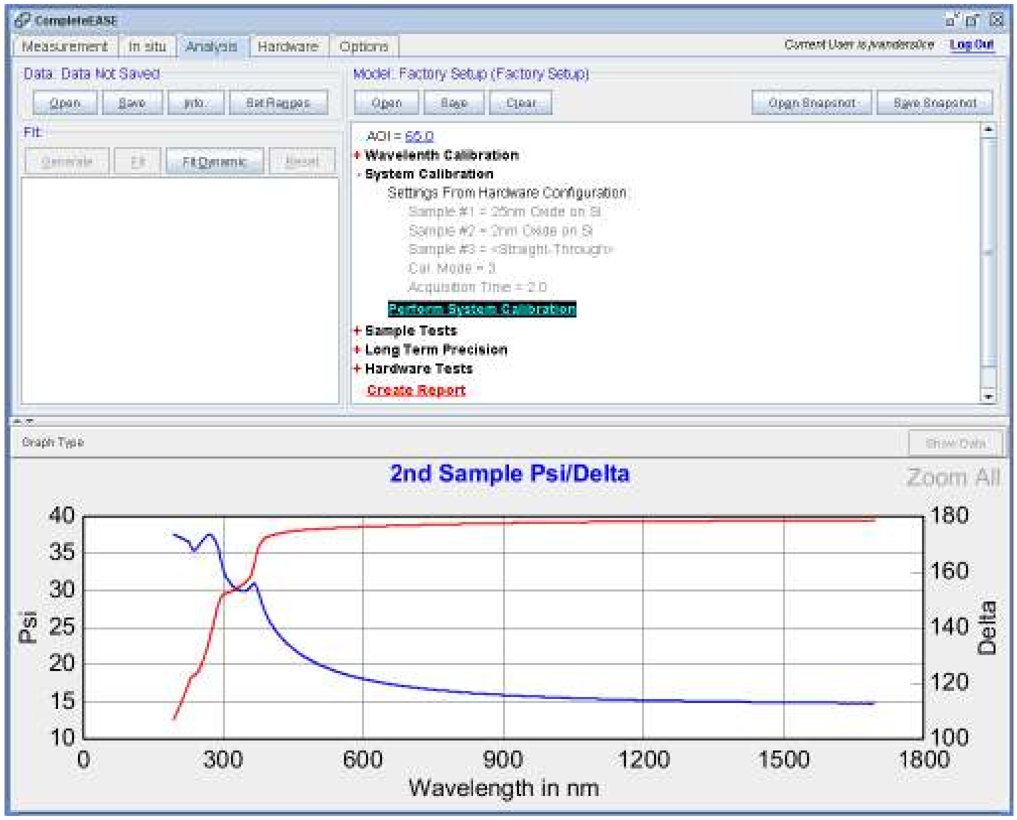
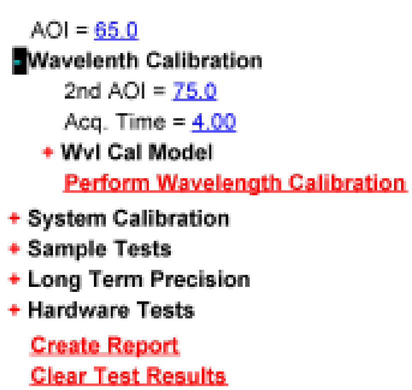


Figure 10-7. Calibration finished.

The system calibration is finished when the graph title shows "2nd Sample Psi/Delta".

Wavelength Calibration

1. Expand **Wavelength Calibration** section – do not change items in **Wvl Cal Model** section unless given instructions to do so.



2. Press Perform Wavelength Calibration and follow the instructions. When the process is completed successfully, you will be asked if you want to write the wavelength correction values to the hardware.cnf file. If all points on the curve are within ±0.8 of 0 then choose no, otherwise choose yes. If yes is chosen then you will need to perform a System Calibration again after the software finishes reinitializing the system.

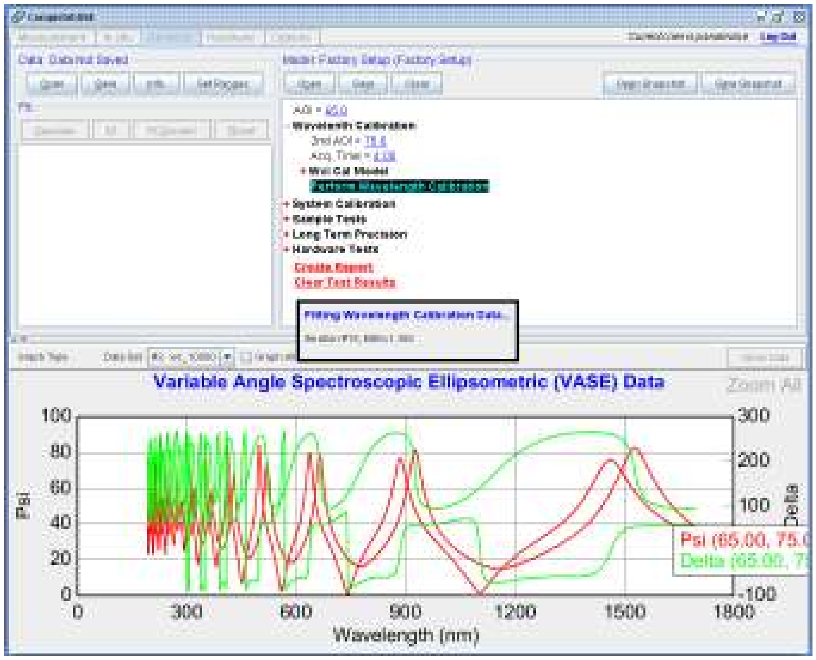


Figure 10-8. *Performing Wavelength Calibration*

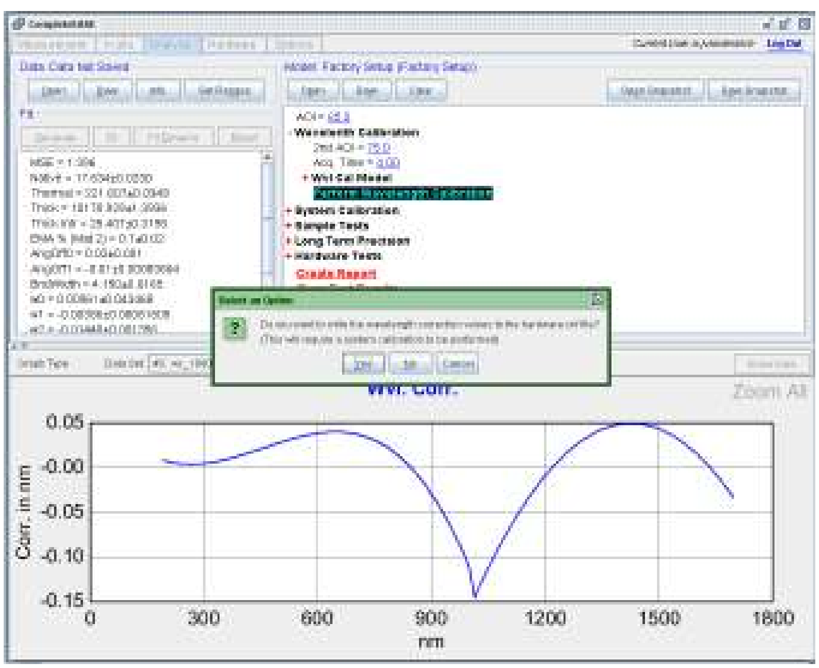


Figure 10-9. *Wavelength Calibration was successful – It is not necessary to write correction values since the correction is less than ±0.8nm*

SYSTEM CALIBRATION WITH FILTER WHEEL OPTION

When performing the system calibration using a filter wheel, there are some factors to consider. Since the Straight-through position is included in the calibration, the signal needs to be optimized throughout the entire spectrum. If a higher density filter is selected, the DUV signal is lower with respect to the overall average signal. As seen below, if a lower density filter is selected and the iris(es) on the Receiver unit is closed down to avoid 'Overload', the DUV signal is optimized. This results in a much better calibration result at these lower wavelengths.

Examples of filter wheel positions vs. Signal Intensity:

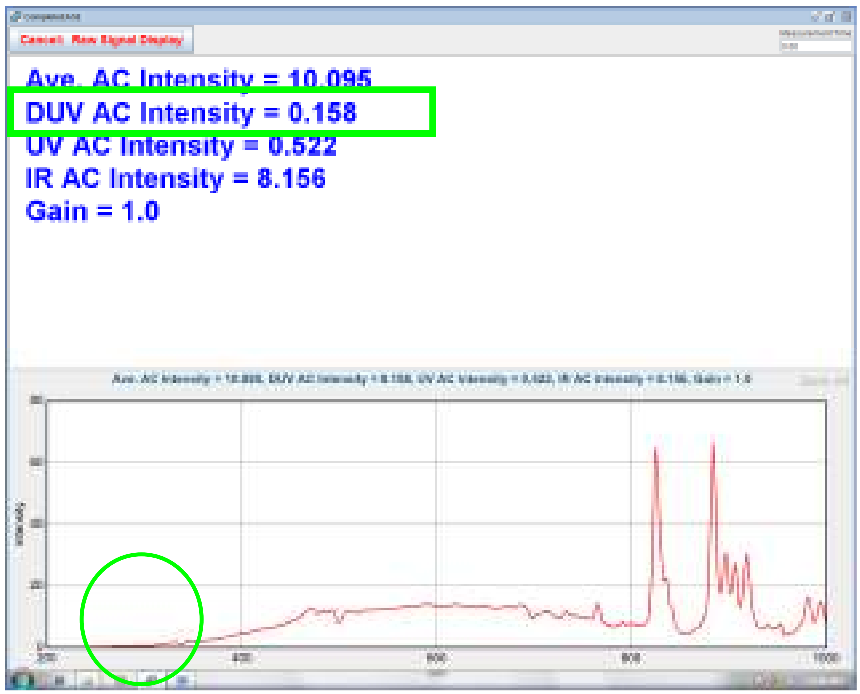


Figure 10-10. Filter 6 with iris open.

Figure 10-11. Filter 4 with iris closed to avoid Overloading the Spectrometer.

Figure 10-12. Overloaded Spectrometer.

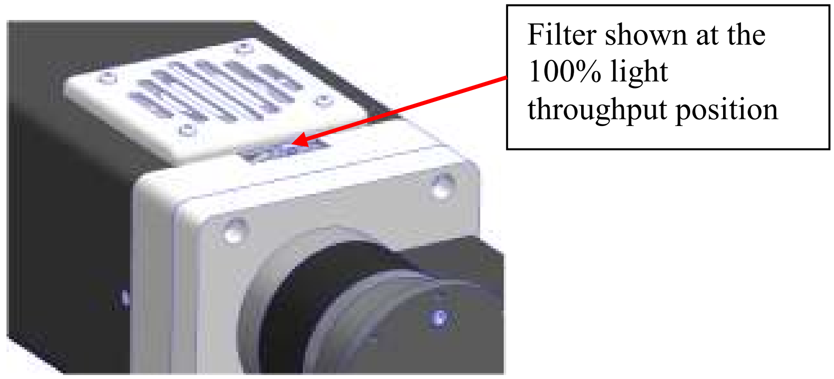


Figure 10-13. Filter Wheel Option.

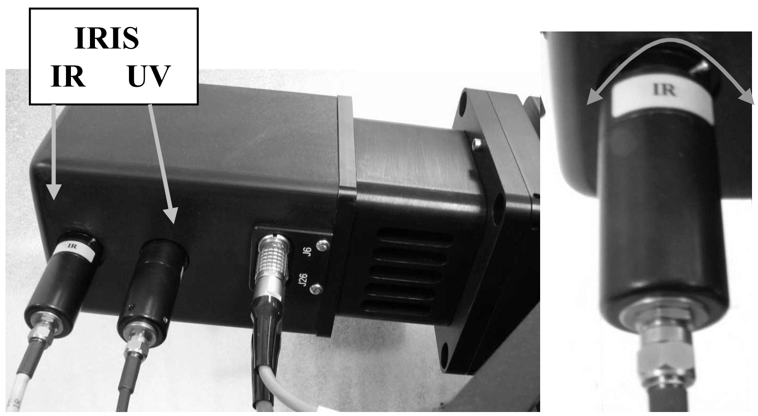


Figure 10-14. Receiver unit iris.

11. Troubleshooting

11.1. General Procedures

Check for the following LEDs on the system components:

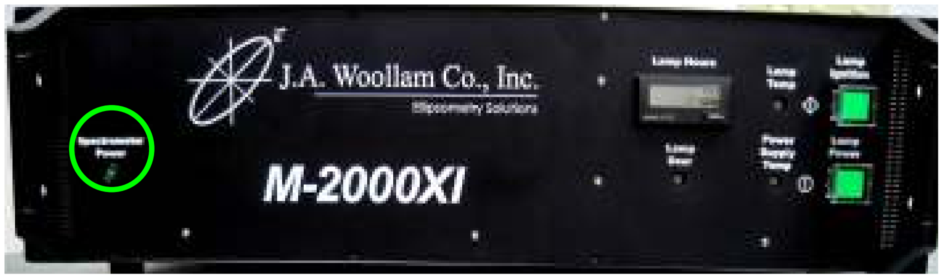


Figure 11-1. Spectrometer power LED.

Figure 11-2. EC-400 power LED's

Debug Clip

Click ***Options***>**About CompleteEASE**>'Create Debug File' to create a debug file for sending details to the J.A. Woollam Company or representative. The file created is located in *C:\CompleteEASE\CompleteEASE_Debug.zip*. Email this file to your J.A. Woollam Co., Inc. representative to aid in debugging problems with your ellipsometer system along with any other pertinent information/symptoms (i.e., Signal Intensity).

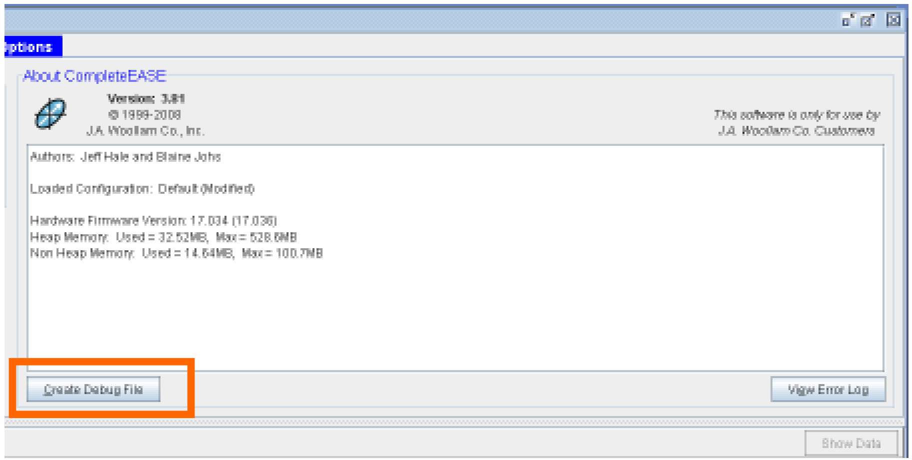


Figure 11-3. 'Create Debug File'.

11.2. Common Screen Error messages

Phase Sensor Error Message

Figure 11-4. Phase sensor error message.

This message is generally caused by the following sources: (1) RCE motor is not running – Light Source motor. (2) Phase sensor malfunctions inside the Source motor. (3) EC-400 control module has electronic problems (motor driver, etc.). (4) Electrical connections between J1 and J2 or J3 and J4 are not secured.

User key points: Is the motor spinning (vibrating) to the touch?

Polarizer Homing Error Message

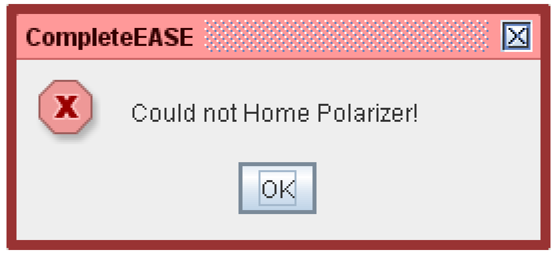


Figure 11-5 Polarizer home error message.

This message indicates that the analyzer's home sensor is not working. It could be the sensor itself or the connection (cable) between J26 and J25. Check the cable connections and that the pins on the connectors all look normal.

This could also indicate that the power to the analyzer motor is not delivered. This could be caused by the power cable connections. Examine the connectors J6 and J5 and reconnect the cable. This could also be that the EC-400 control module has electronic problems (motor driver, etc.).

User key points: Listen/feel – Is the motor turning?

Spectrometer is not scanning

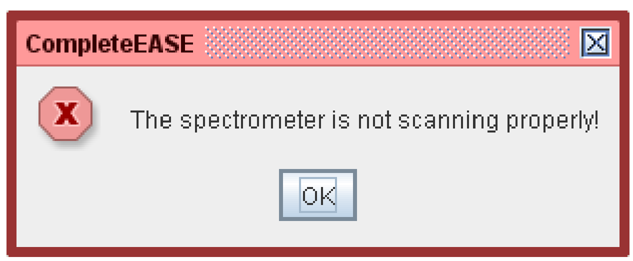


Figure 11-6 Spectrometer error message.

Examine the cables and cable connections at J7 and J8, J9 and J10, and J11 and J12. The cable connects J7 and J8 is the spectrometer power cable. J9 and J10, J11 and J12 are spectrometer digital line cables with color code. Be sure to connect them correctly.

User key points: Is the spectrometer power LED ON? – located on the front of the M-2000® detector box.

Communication problems

If the software will not communicate with the system (EC-400), the following parameters need to be investigated. The software will NOT give an error message, it simply will not initialize because the TCP/IP link cannot be established. This can be verified by viewing the log file (***Options***>**About CompleteEASE**>'View Error Log').

Example:

2009-6-23 [12:52:24] - initSocket Error, Connection timed out: connect

Compare the IP address displayed in the error message box with the one displayed on the LCD on the EC-400 front panel. If they are different, correct one displayed on the EC-400 to match the other one by following the procedures described in ***Setup EC-400***.

- If there are two network cards in the operator's computer, make sure that the other network card has a different IP address than the one used for the ellipsometer.
- Check the IP settings on the network card for ellipsometer in the operator's computer as described in the Network Card Installation Chapter.

11.3. General Problems

SYMPTOM	CAUSE	SOLUTION
The cross hair on the alignment screen jumps around.	Misalignment	Perform system alignment described in this manual.
	No white light.	Check light and lamp problems chart.
One or more motors do not turn.	Loose connection.	Check all cable connections.
	Blown fuse.	Check fuses on the EC-400
	Bad Motor Driver.	Replace Driver (call the J.A. Woollam Co., Inc.).
Alignment not sensitive to the sample tilt or optical receiver unit tilt.	The sample is not properly aligned.	Re-align the sample, ensuring that the beam is centered on the aperture of the receiver unit.

Table 11-1. General Problems.

11.4. Software Problems and Error Messages

SYMPTOM	CAUSE	SOLUTION
CompleteEASE® does not initialize.	Cables are not plugged into computer or EC-400.	Ensure all cables are inserted and fastened.
	Recent hardware changes to computer i.e. new cards such as a network card.	Remove recent additions to computer until ellipsometer works. Then correct hardware settings of new cards such that they don't conflict with current settings.

Table 11-2. Software Problems and Error Messages.

11.5. Calibration Problems

SYMPTOM	CAUSE	SOLUTION
Calibration fits are not very good.	Sample is not aligned properly.	Re-align the sample.
	Signal intensity is weak on some channels due to sample reflection properties.	Use the standard SiO_2 on Si reference sample supplied with the instrument for calibration
You installed the CompleteEASE® software on a new computer, and you cannot get good calibration fits.	Calibration files not installed on the new computer	Copy cnf files from the previous computer into the C:\CompleteEASE\cnf directory of the new computer

Table 11-3. Calibration Problems.

11.6. Signal Screen Problems

SYMPTOM	CAUSE	SOLUTION
Signal screen shows flat lines on all channels.	Cables not connected properly.	Make proper cable connections.

Table 11-4. Signal Screen Problems.

11.7. Lamp and Light Problems

SYMPTOM	CAUSE	SOLUTION
No White Light.	Lamp is not on.	Turn on lamp power supply.
	Fiber optic cable is not connected.	Check Fiber connections.
	Fiber optic cable is damaged.	Replace Fiber Optic Cable.
	Lamp is out of alignment.	Align lamp.
Lamp intensity fluctuates or is weak.	Lamp out of alignment.	Align lamp.
	Lamp may be mounted loosely in housing.	Check lamp mount (after power off and cool down for 1hr).

Table 11-5. Lamp and Light Problems.

12. Specifications

12.1. Components

EC-400

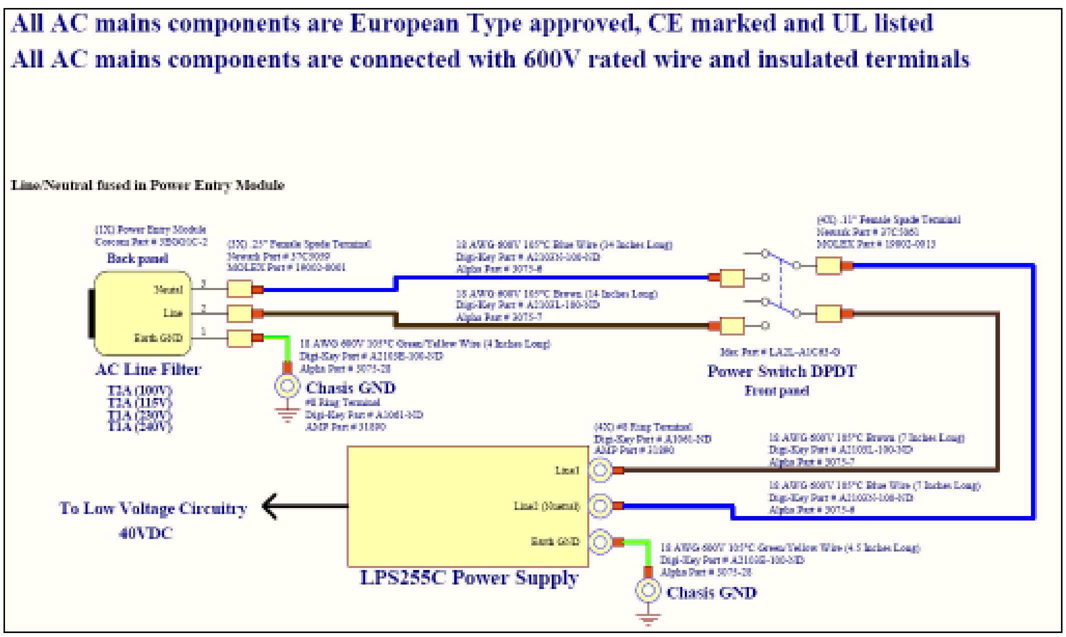
Input Voltage: 100/115/230/240VAC.

Frequency: 50-60Hz.

Current: 1A1A/.4A/.4A.

Fuses: (2) T2/T2A/T1A/T1A.

EC-400



M-2000® Detector / Lamp Power Supply Modules

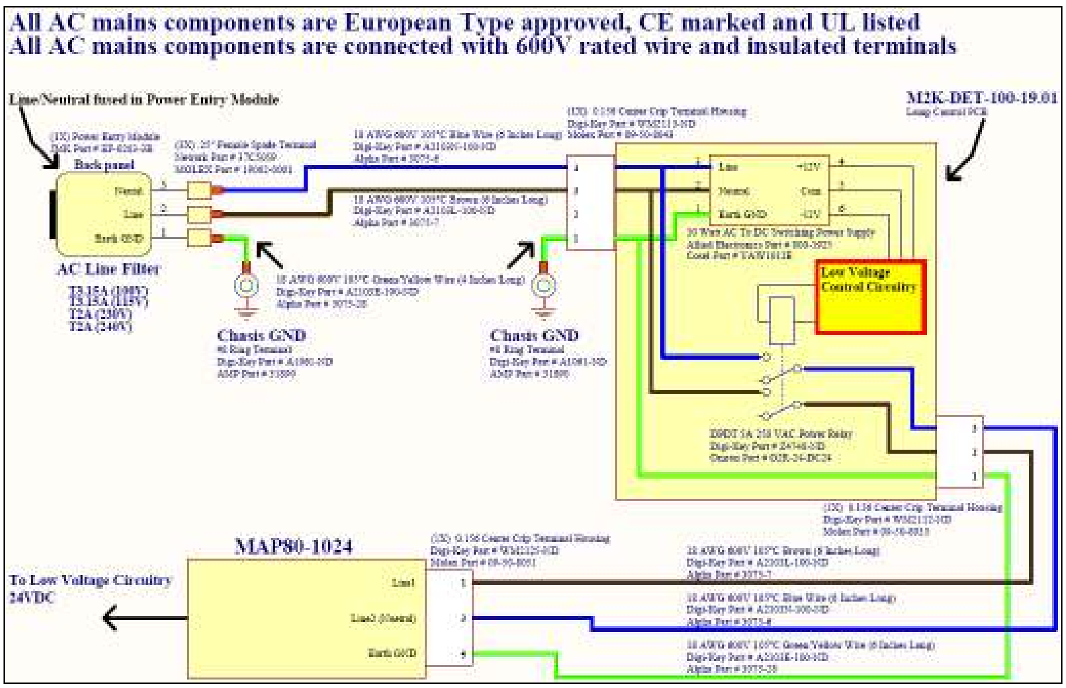
Input Voltage: 100/115/230/240VAC.

Frequency: 50-60Hz.

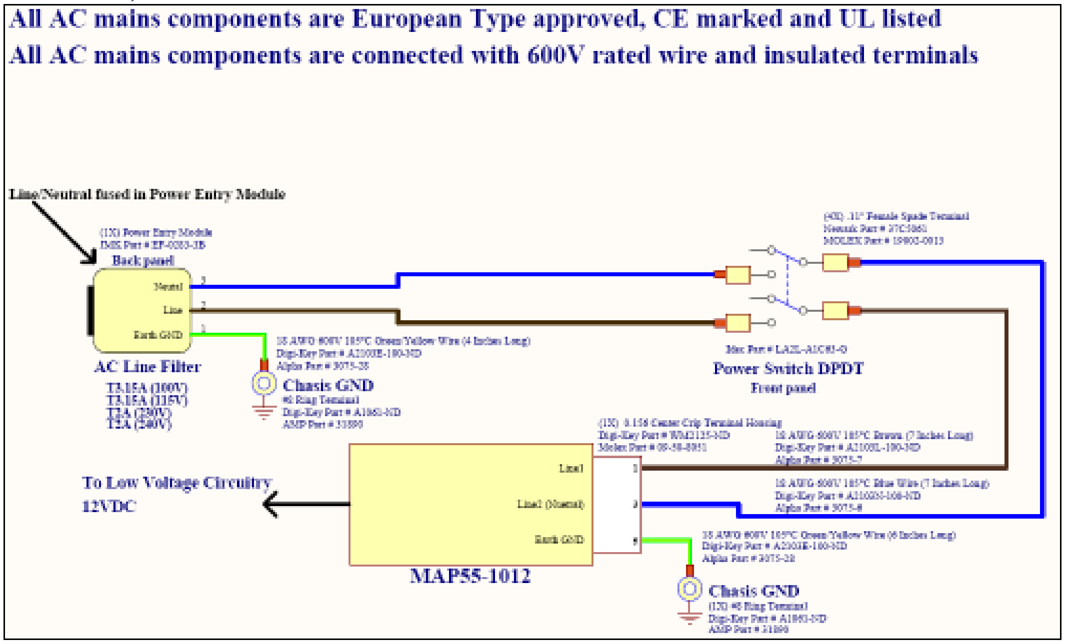
Current: 2A/2A/1A/1A.

Fuses: (2) T3.15A/T3.15A/T2A/2TA.

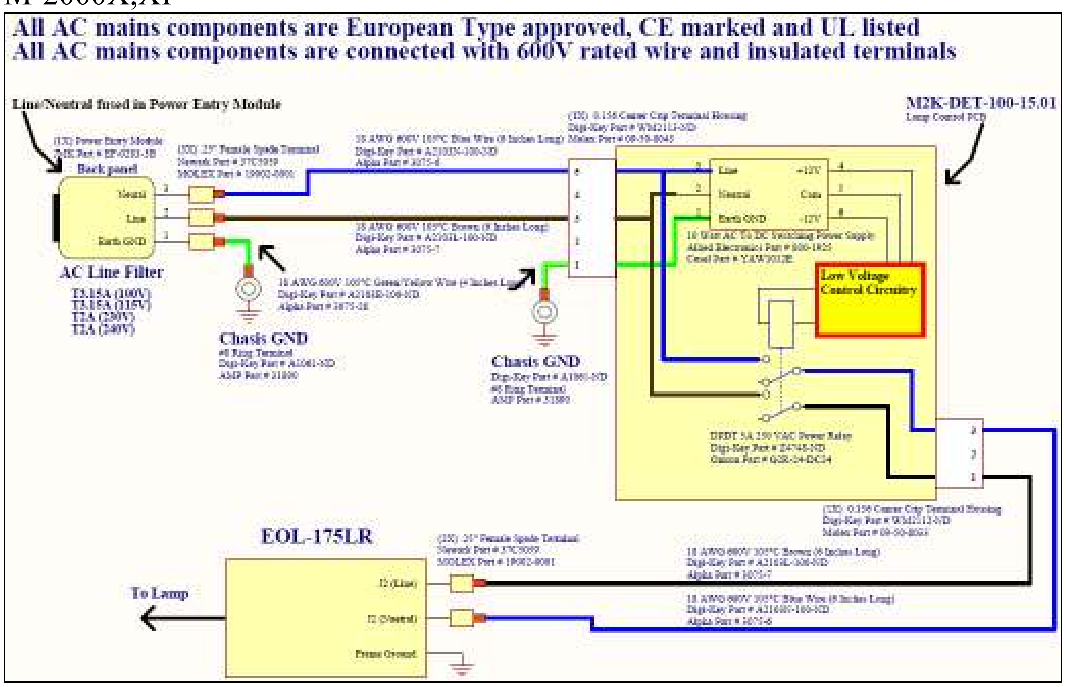
M-2000D,DI,U,UI



M-2000V,VI



M-2000X,XI



EPM-224 (Optional)

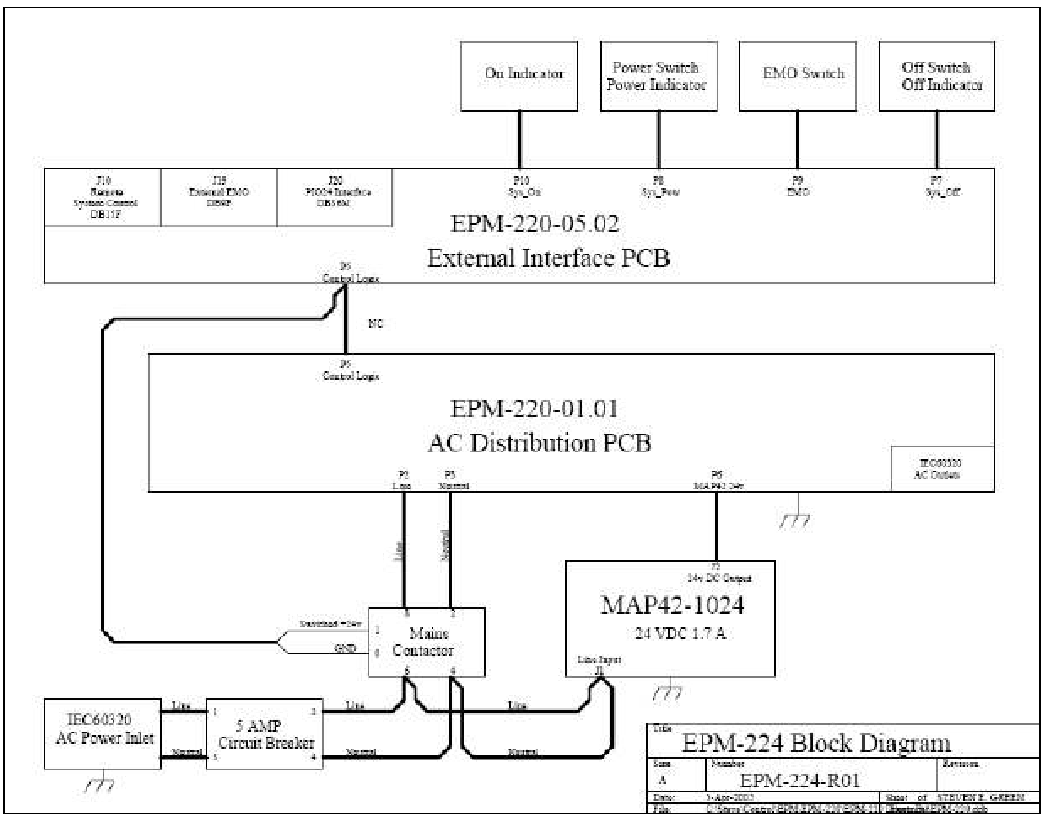
Input Voltage: 100-120/200-240VAC.

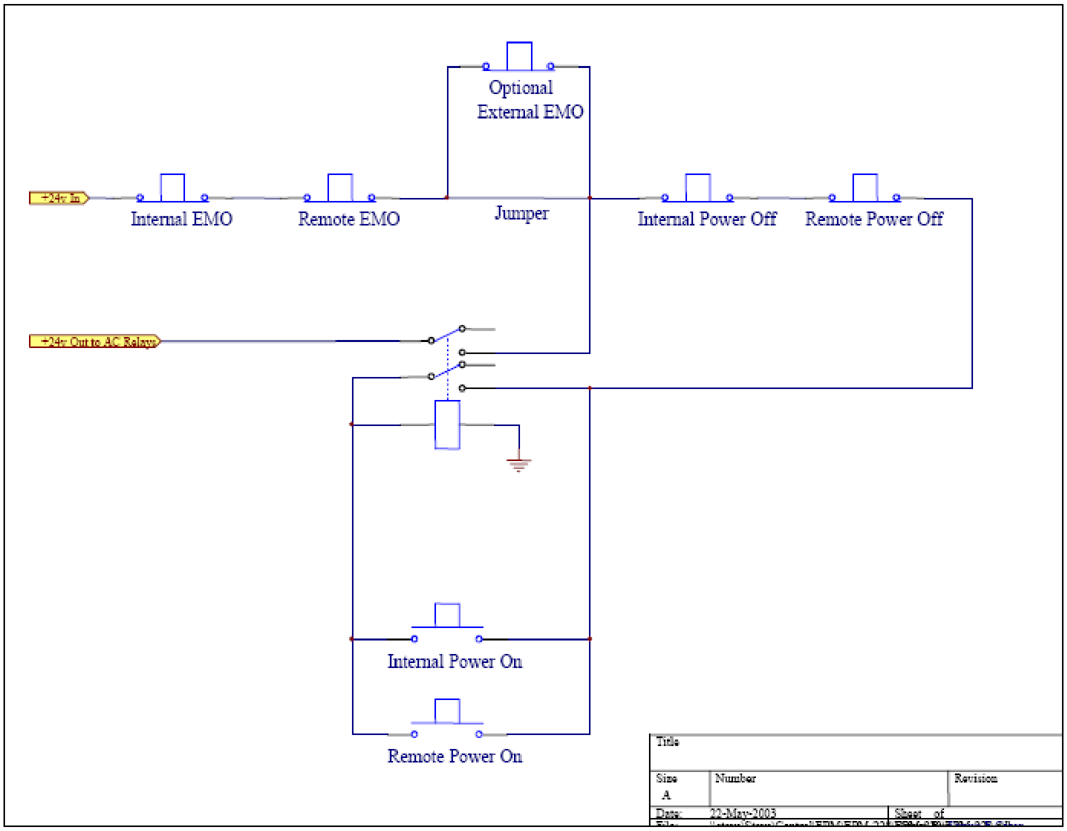
Frequency: 50-60Hz.

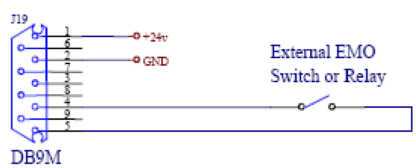
Current: 5A MAX.

Circuit Breaker: UL489, 5A.

EPM-224







Pin 1: Fused +24 volts from internal power supply. Always on. 1/2 amp capacity.
Pin 2: Ground
Pin 3: No Connection
Pin 4: EMO circuit
Pin 5: EMO circuit
Pins 6-9: No Connection

Power and ground are provided to power potential interface circuitry. 1/2 amp maximum draw.

Opening switch or relay connected to pins 4 and 5 will activate EMO, shutting down AC power.

For the External EMO to be functional, an internal jumper located next to the EMO Interface connector must be in the 'Enable' position.

Title	EPM-220 Series External EMO Interfa	
Size A	Number	Revision
Date: 22-May-2003	Sheet of	

Surge Suppressor

Supplied by manufacturer.

Computer

Supplied by manufacturer.

Monitor

Supplied by manufacturer.

13. Network Card Installation

13.1. Windows 7 Network Setup

1. It is recommended that the instrument's computer be independent of any existing network. However, if it is necessary for the computer to be connected to an existing network, it is the preferred way that two separate network cards are used. One card to communicate with the network and another card to communicate with the ellipsometer.
2. Before installing the new network card, go to **Start Menu -> Control Panel**. Under the Network and Internet category, select **View network status and tasks**.

Figure 13-1. Windows 7 Control Panel.

3. Select **Change adapter settings** from the left-hand side pane

Figure 13-2. Network and Sharing Center.

4. Take note of the current network configuration. In this example, there is a single network interface card installed that is currently connected. In the following steps, we will add another interface to this list.

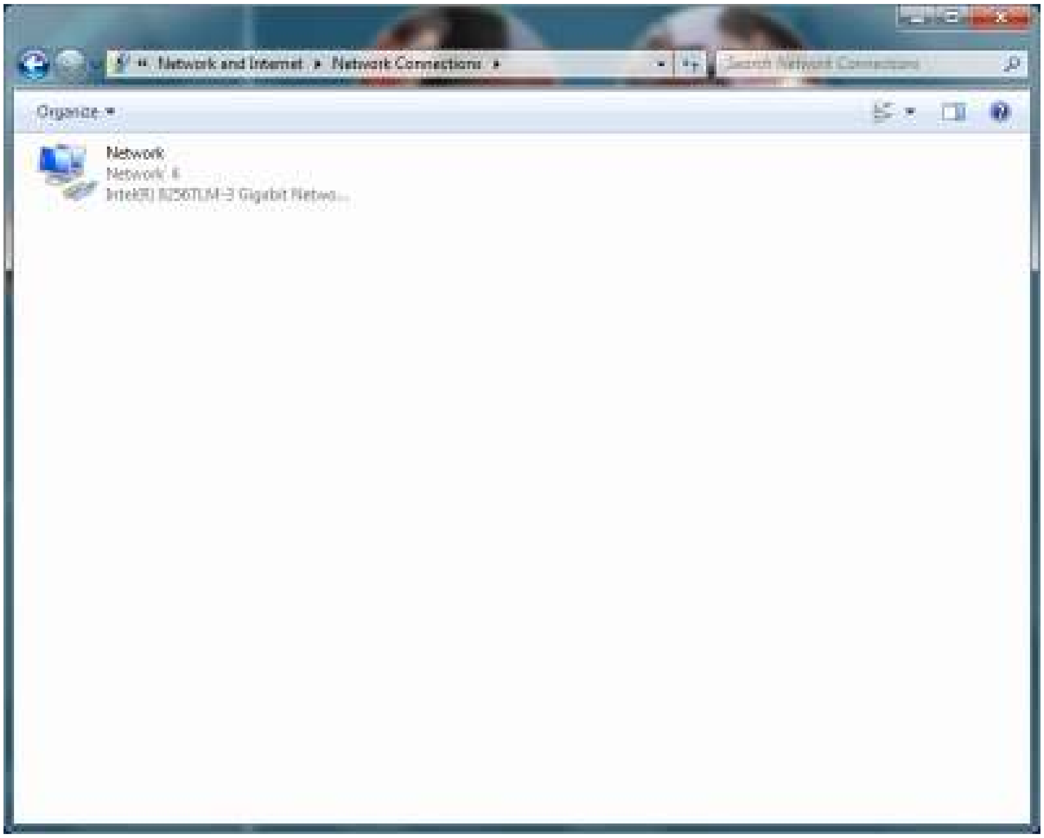


Figure 13-3. Network Connections.

5. Shut down the computer and install the new network card.
6. Windows 7 should automatically install the driver for the new network card. If it does not, consult the software that was bundled with the new card for manual driver installation instructions.

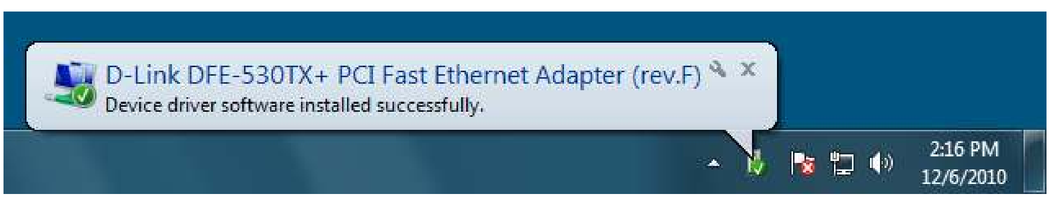


Figure 13-4. New driver installed.

7. If we repeat steps (1) – (3) we will see that there is now an additional card displayed. In this example, the new card is disconnected with the name "Local Area Connection". Double click the network card to open up its **Properties** dialog

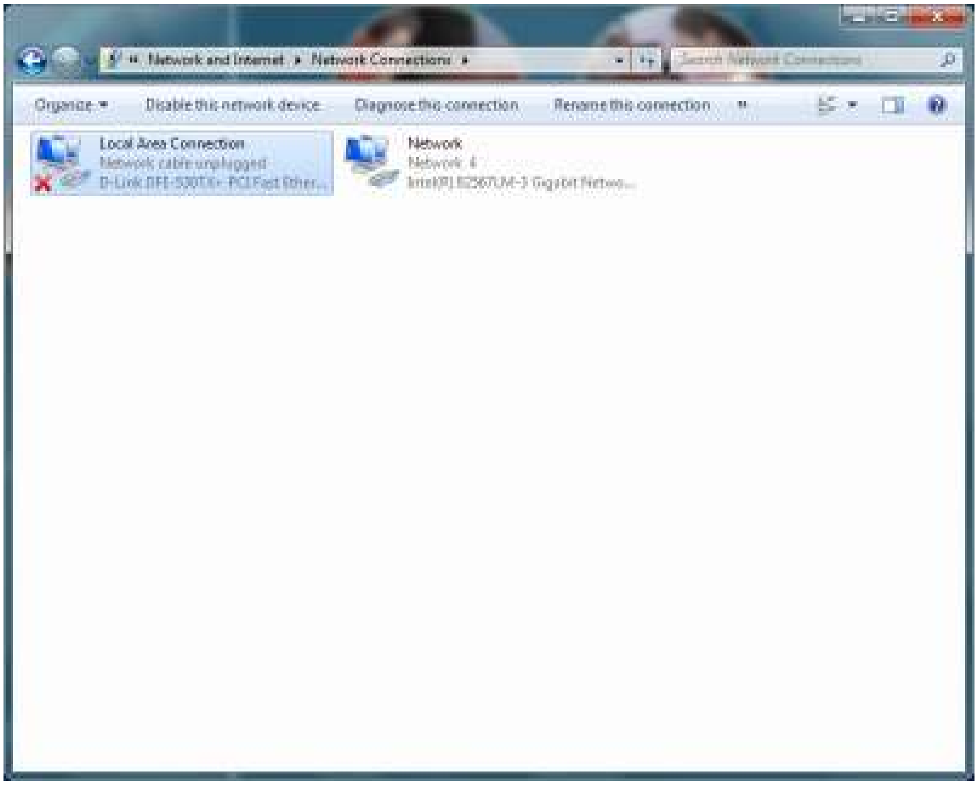


Figure 13-5. Network Connections.

8. Disable all connections for this card EXCEPT **Internet Protocol Version 4 (TCP/IPv4)**. Select this last remaining connection type and select **Properties**

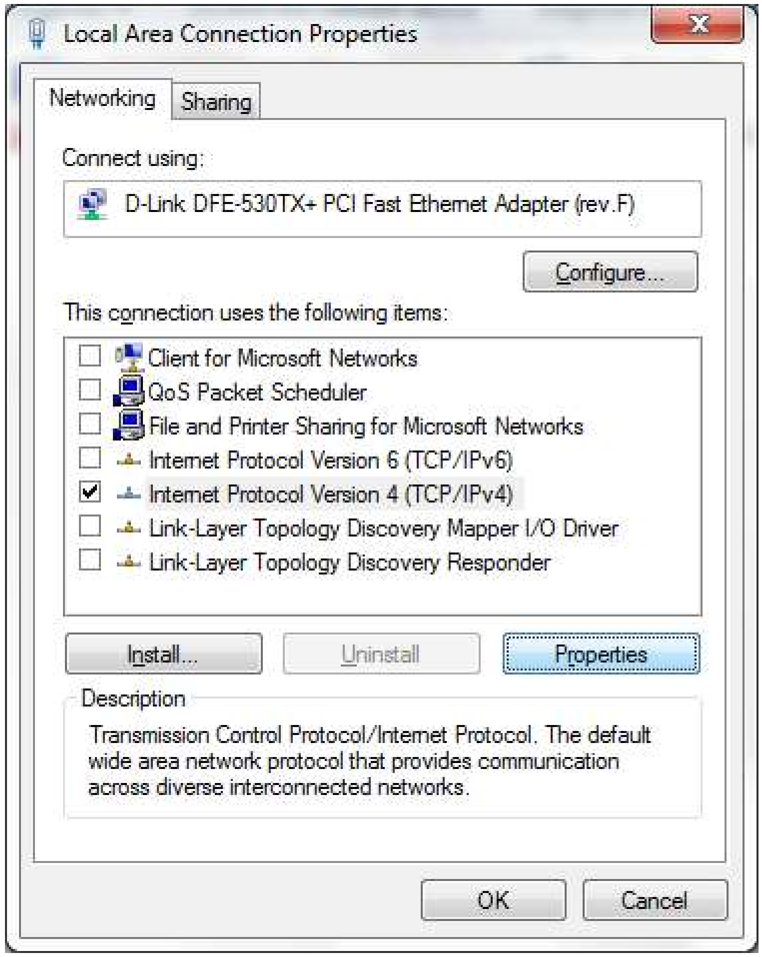


Figure 13-6. Local Area Connections Properties.

9. The TCP/IPv4 properties dialog is displayed. Select **Use the following IP address** and enter in **192.168.0.1** with subnet mask **255.255.255.0** and select OK.

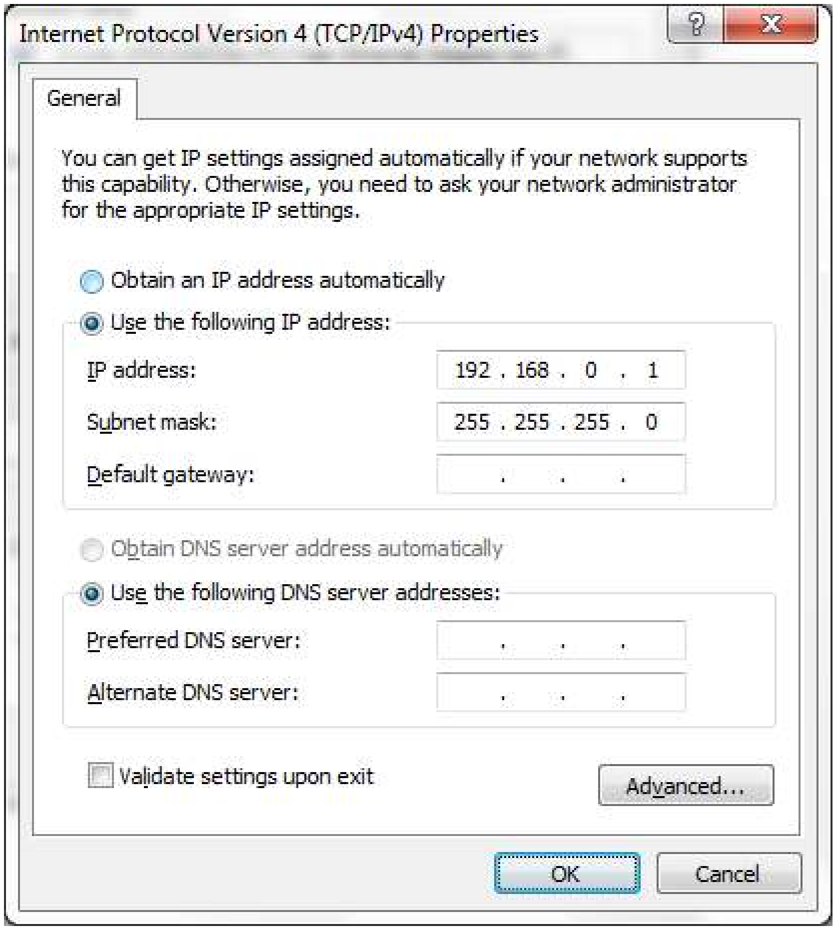


Figure 13-7. Internet Protocol Properties.

10. The newly installed network card now provides the instrument computer with capabilities of joining a network while remaining connected to the ellipsometer.
11. Run CompleteEASE® to initialize the hardware and confirm the new installation was succesful.

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