CORAL Name: Ellipsometer-Semilab-SE2000

Location: Upper Cleanroom Mail Aisle, end of U07
Tool Category: Metrology, Film Measurement
Contacts: Paul Tierney

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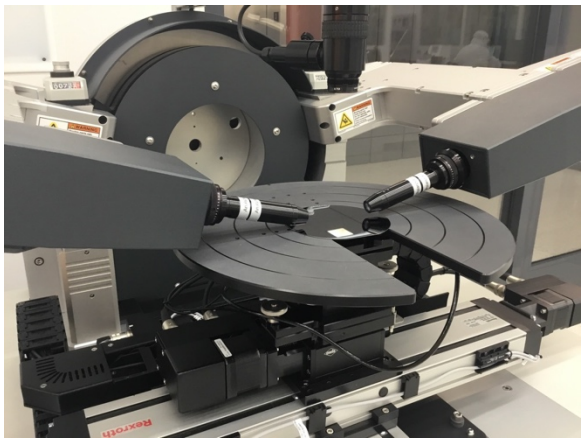
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MIT.nano	Ellipsometer-Semilab-SE2000	
	User Standard Operating Procedure	
	Last revision: 06/26/2023	Version: 1.0 Nicole Bohn

Introduction

The Semilab SE2000 is a spectroscopic ellipsometer with variable wavelength (245 nm to 1700 nm), variable angle goniometer (12.5-90 degrees), rotating polarizer and analyzer. This instrument is used to measure the thicknesses, n/k and other optical properties of simple thin film or multi-layered structures based on an approximate model of the sample. It has an automated wafer stage for multi-point measurement and mapping across larger samples. The instrument can be used to measure samples ranging from small pieces up to 300 mm wafers with a spot size of 500 um.



The instrument is located along the Metrology Wall in the Upper Cleanroom at the end of Bay U7.

Safety

- Be aware of pinch points as the system arms or stage move.
- Press the red EMO (Emergency Off) button on the front of the system in the event of an emergency to shut off the entire system. Contact staff to restart the system.
- Handle samples carefully to avoid breaking wafers or pieces. Use the wafer holder beside the keyboard to assist wafer manipulation.
- Clean up after yourself.
- If the microspot lenses become dislodged, lower the stage and carefully reattach them. There is only one correct alignment, guided by magnets and pins.

User Qualifications and Responsibilities

- Users must receive training from qualified staff prior to gaining access to the instrument.
- Users must engage in CORAL to enable the display. Engage the analysis computer separately. Use CORAL to report system problems or concerns.
- SAM measurement application should already be open. Please leave programs open when finished. Please transfer data via file sharing server or Dropbox. Remove samples when finished and return stage to center.
- Users should have a general concept of their samples for best results: including layer composition and approximate thickness.

Login information:

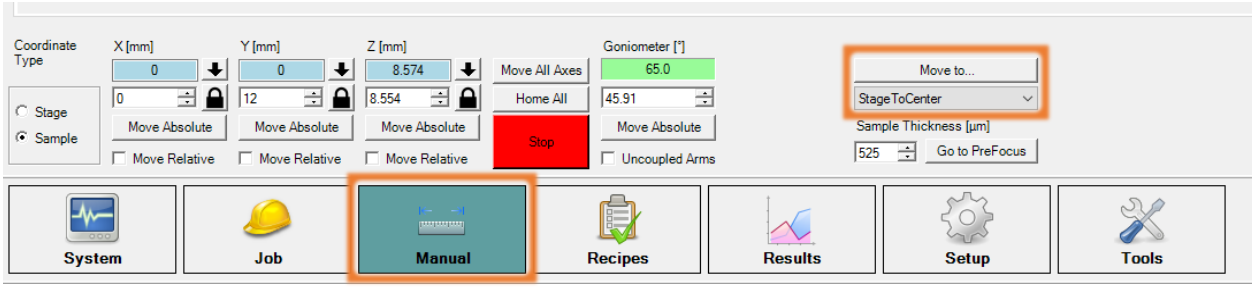
	Username	Password
Computer	Operator	Operator01
SAM suite	Admin	

Operating Procedures

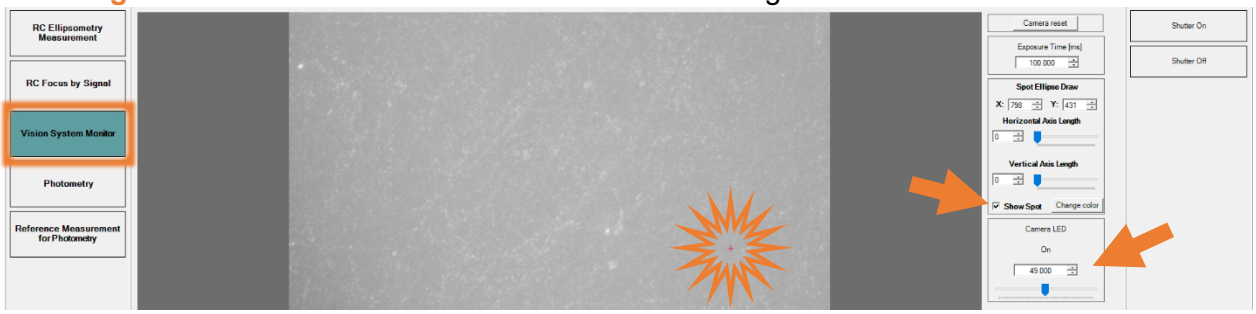
Data Collection

Sample Loading

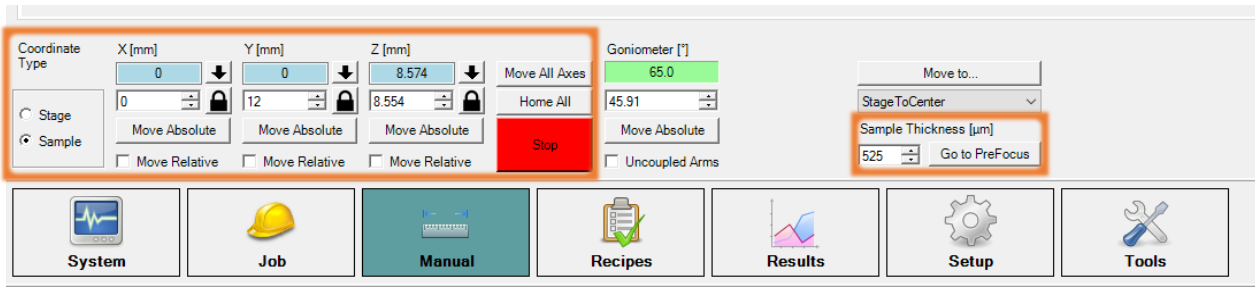
1. Select **MANUAL** from the menu bar at the bottom of the screen



2. Select **ManualLoad** from the dropdown menu then click **Move to…** to move the stage out from under the microspot pieces.
3. Load wafer or piece at center of stage platform.
4. Select **StageToCenter** then click **Move to…** to return the stage to the center.



- *Optional: Use the **Vision System Monitor** (below) to assist centering.*
  - *Adjust the **Camera LED** if the display is dark*
  - *Check **Show Spot** to display the focus spot*
  - *Use the **X, Y, and Z controllers** (below) to precisely move the stage*



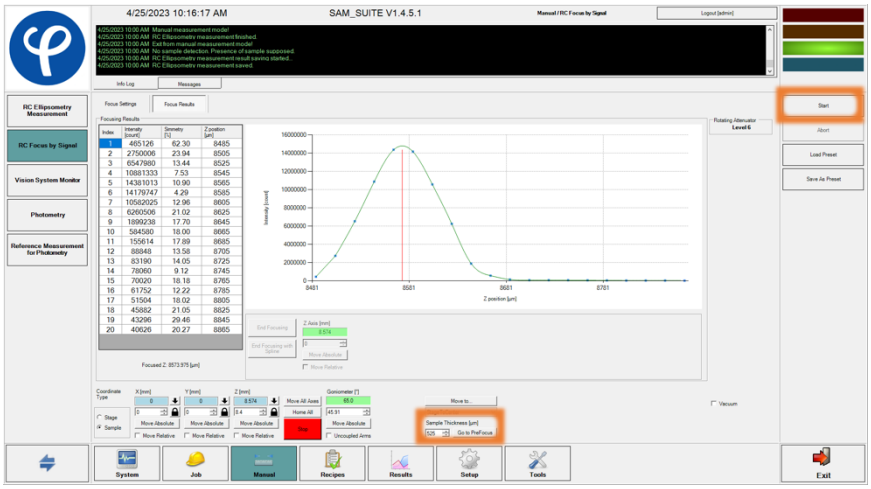
5. Enter an estimated value for the **Sample Thickness (um).**
   a. This refers to the *substrate thickness*, not the film or total thickness
6. Click **Go to PreFocus**

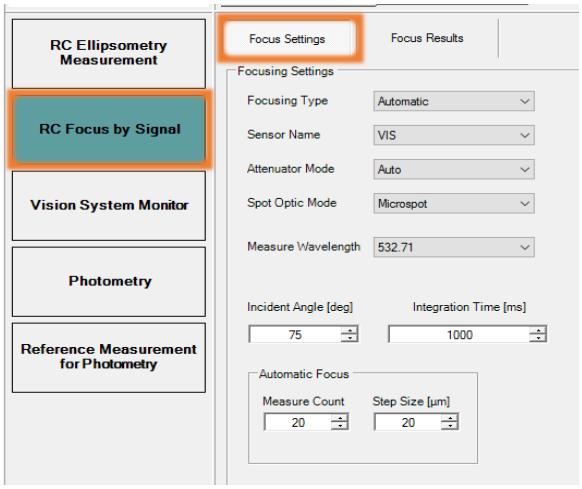
Focus

1. Choose **RC Focus by Signal** and go to the **Focus Settings** tab.
2. Use these default settings:

Focus Settings	
Focusing Type	Auto
Sensor Name	VIS
Attenuator Mode	Auto
Spot Optic Mode	Microspot
Measure Wavelength	Variable
Incident Angle (deg)	75°
Integration Time (ms)	Variable [168ms-5000ms]
Count*	20
Step Size*	25um
**Count and Step Size may be varied for a wider range.*	

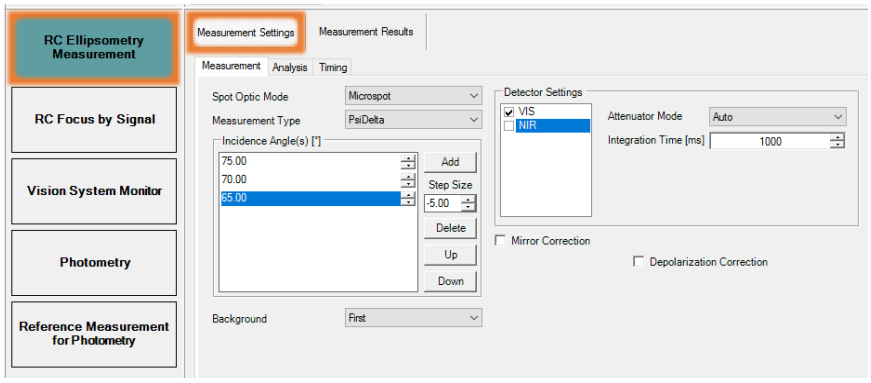
3. Click **Start.**
4. The system will measure the light intensity at increasing Z steps and return a bell curve-like signal and Z value.
    - *If it does not return a bell curve, your sample is outside the focus range. Adjust the **Sample Thickness** and click **Go to PreFocus,** then **Start** again. Repeat until you see a clear bell curve.*
    - It is not necessary to record or save this information.





Measurement

1. Choose **RC Ellipsometry Measurement** and go to the **Measurement Settings** tab

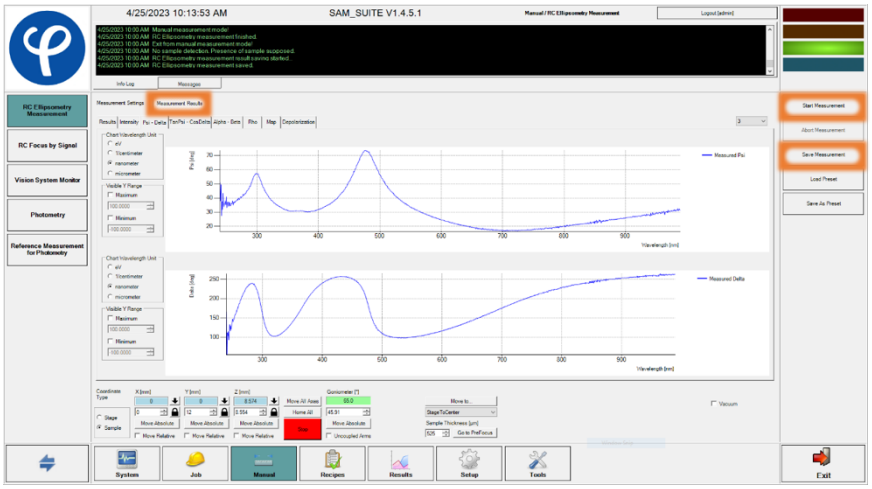


2. Fill in these settings under the **Measurement** and **Timing** tabs

Measurement Settings: Measurement, Timing*

Spot Optics	Microspot
Measurement Type	Psi/Delta
Incident Angle	Variable, multiple [45°-79°]
Detector Settings	VIS and/or NIR
Attenuator	Auto
Background	[First/None/Every/Periodic]
Integration Time	Variable [1000ms]
*Measurement Count	1 [more, if desired]
*Timing	0 [higher, if time between]

*Note – the analysis check box from the **Analysis** tab allows the user to insert a valid saved session file to enable automatic measurement of sample structure, including thickness, n and k values.*



3. Click **Start Measurement**.
   a. The system will begin to collect data based on the conditions from Measurement Settings.
   b. Be aware of stage and system arm movement during this step.
4. Click **Save Measurement**. Save the file to C:\Users\[your folder]

a. Type in a descriptive filename. Data will be saved as .smdx.

*Note – if the analysis box was checked in the **Measurement Settings: Analysis** tab, results will be returned with statistics.*

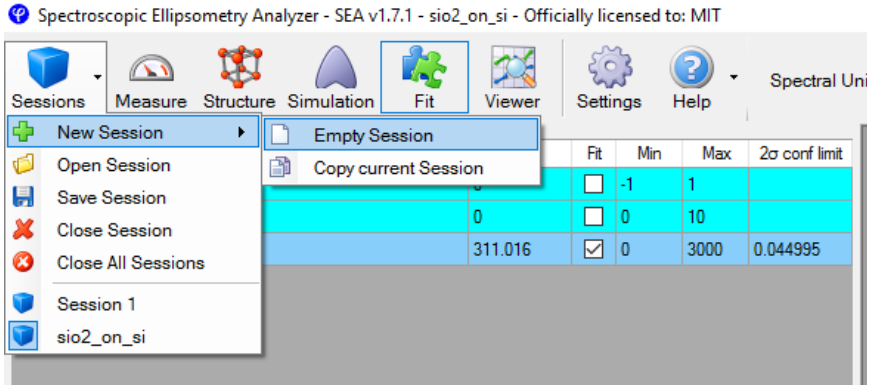
5. Navigate to the **Measurement Results** tab to preview results in this program (above)

Analysis

1. Navigate to the **Spectroscopic Ellipsometry Analysis (SEA)** application.
   a. Press Alt+Tab or the Windows key and navigate to the SEA icon. It should already be open.
2. Proceed from left to right through workflow icons:

Session	Measure	Structure	Fit
Create, load or save a workspace	Import data	Model sample	Refine model and generate reports

*Note – **Simulation** may be used to simulate models based on measurement parameters, but without fitting to measured data.*



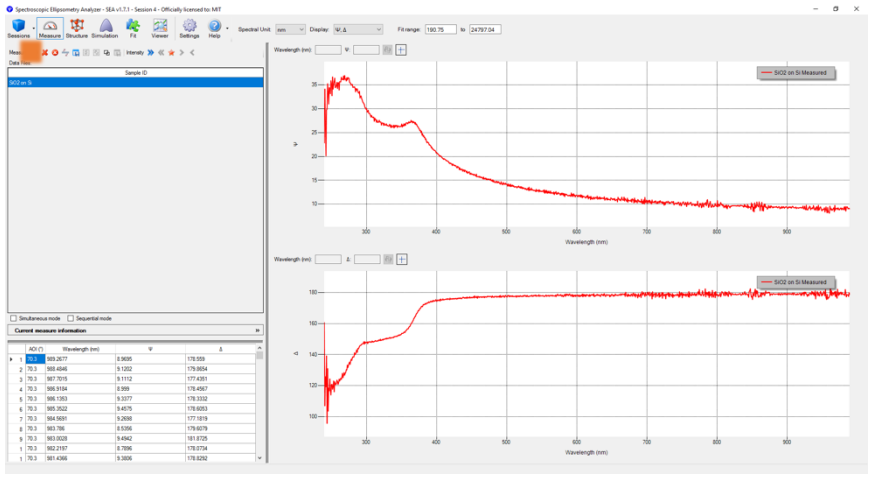
Session

1. Click the drop down arrow and navigate to New Session > Empty Session
   a. You may open a session if you have one saved
   b. This will close any other users' sessions.
   c. **Save your session if you want to use it later.**

Measure

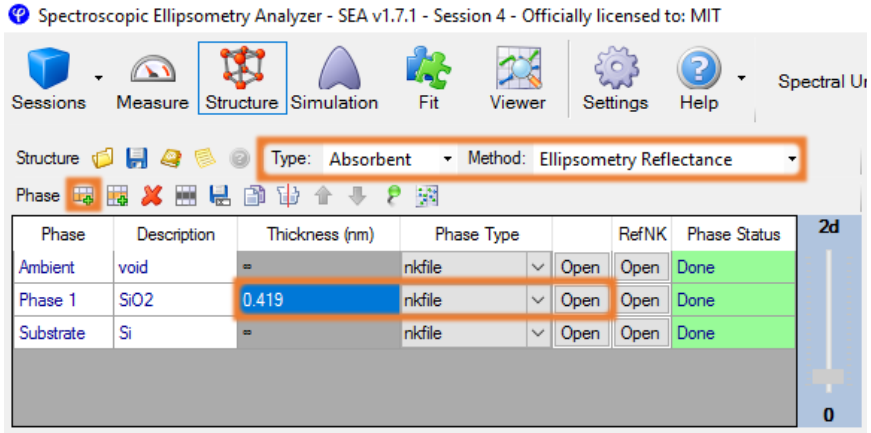
1. Click Measure to go to the Measure page.
2. Click the + and navigate to your folder.
3. Select the .smdx file (or multiple files) and click Open.

4. Measured data displays on this page. Highlight a row under Sample ID to change the displayed dataset(s). Quantitative data is displayed in a table at the bottom.

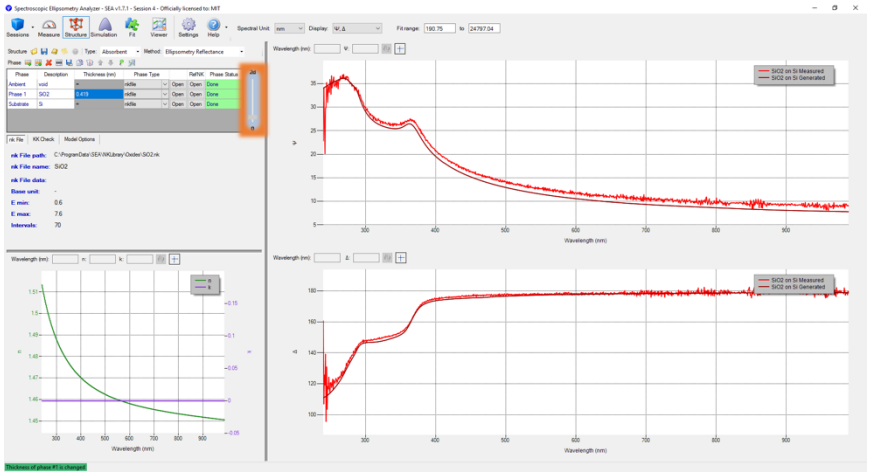


Structure

1. Click Structure to go to the Structure page.
2. Select **Absorbent** for **Type** and **Ellipsometry Reflectance** for **Method** (top)



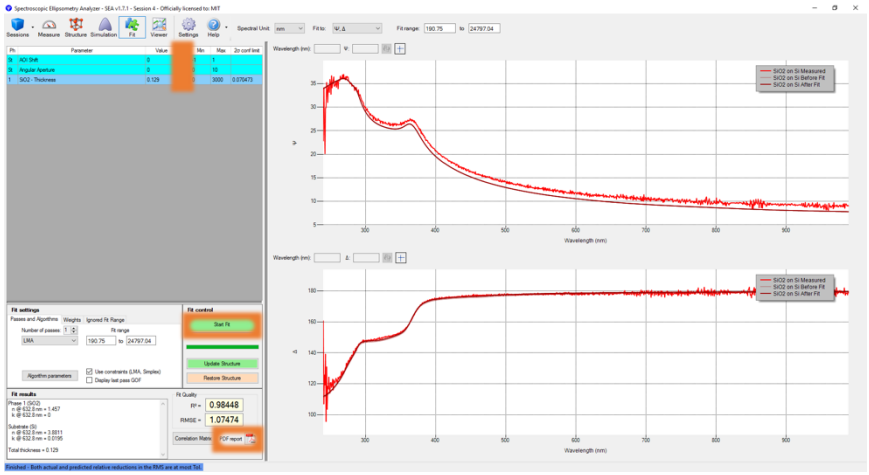
3. The default model assumes the substrate is on the bottom and air (void) is on the top.



   a. Si is selected by default. To change this, select **Open** from the substrate row and navigate to the appropriate nk file for your substrate.
4. Click the **Add Phase** icon 

to add a row.
5. Change the **Phase Type** if needed, otherwise select **Open** for this row and navigate to the appropriate nk file.
   a. *DispersionLaws or nkfile are the most common phase types. Refer to the manual for additional information on these or other phase types.*
6. Type in an estimate for the film thickness, in nm.
7. *Repeat these steps for any additional phases. Use the arrows to the right of the Add Phase icon to reorder phases, if needed.*

The red plots displayed on the right show the measured data compared to the modeled data. Attempt to match the measured data with the model by modifying the phases. Both the Ψ and Δ should look visually similar before proceeding to Fit.



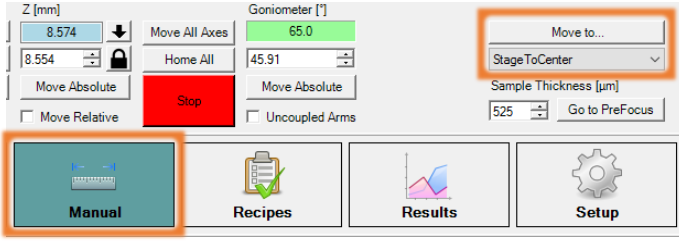
8. Select and highlight a phase to manipulate it.
9. Use the slider on the right to modify the phase thickness until the plots align.
   a. *If the plots do not closely align, try different nk files or phase types.*
   b. *See the Troubleshooting appendix or system manual for additional assistance.*

Fit

1. Click Fit to go to the Fit page.
2. **Check the box under Fit** for the phase (or phases) you want to fit.
   a. *Be careful not to attempt to fit too many phases simultaneously. It may return errant results.*
3. Type in 0.12 for the AOI Shift box to account for sample holder angle correction.
4. Click **Start Fit** button to begin the regression calculation. This will return the R^2 and RMSE values.
   a. *If your R^2 is low, go back to Structure and attempt to modify the model.*
   b. ***Even if the R^2 is close to 1, if the plots do not closely align for both Ψ and Δ, it may not be a good fit.*** *Return to Structure and modify the model.*
5. Select the **PDF icon** provided to generate a .pdf formatted report
6. To save this Workspace to return to later, or for use in automated analysis, select the dropdown arrow beside Session and click Save Session to save this as a .ses file.

Shutdown

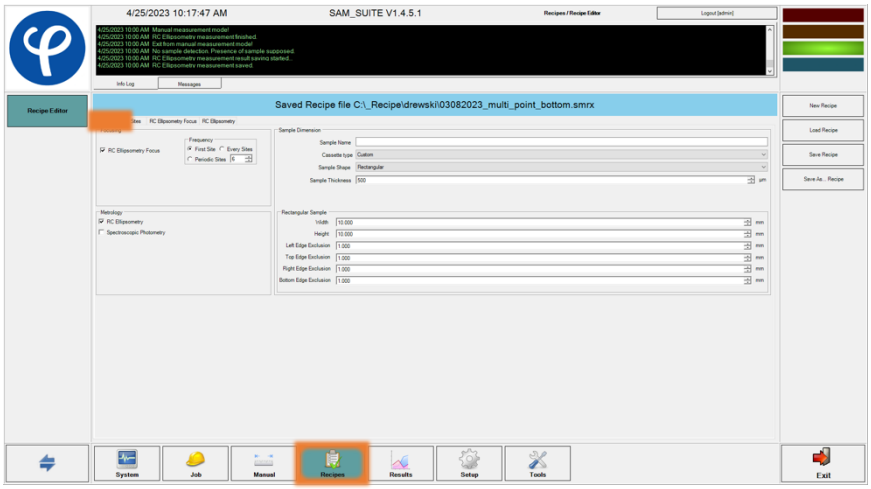
- Navigate back to SAM Suite.
- Remove your sample by selecting **ManualUnload** then click **Move to…**
- Disengage from CORAL.
- Clean up the workspace.



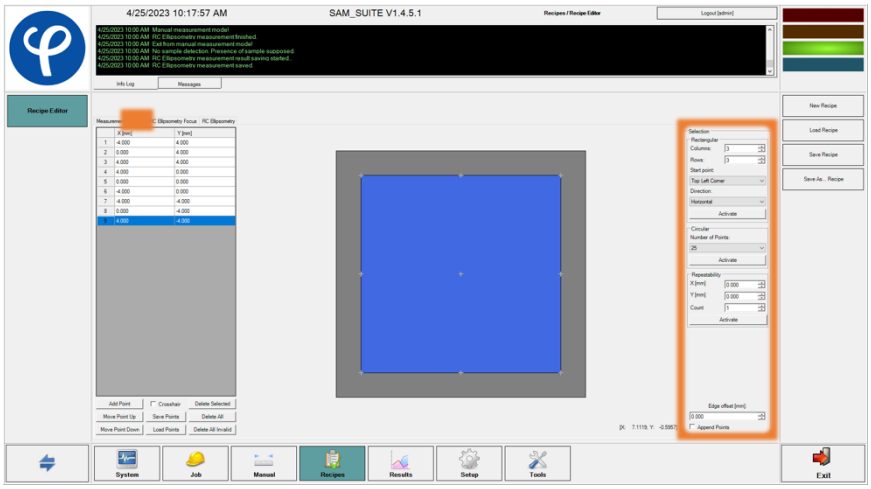
Appendices

Recipes and Jobs: Repeatable Data Collection and Analysis

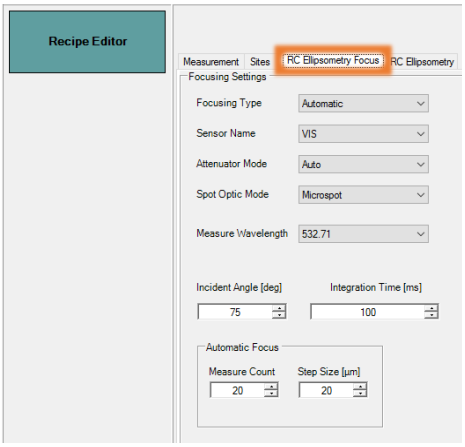
Use the Recipes and Jobs pages of SAM Suite for multi-point measurements or repeatable data collection and analysis.

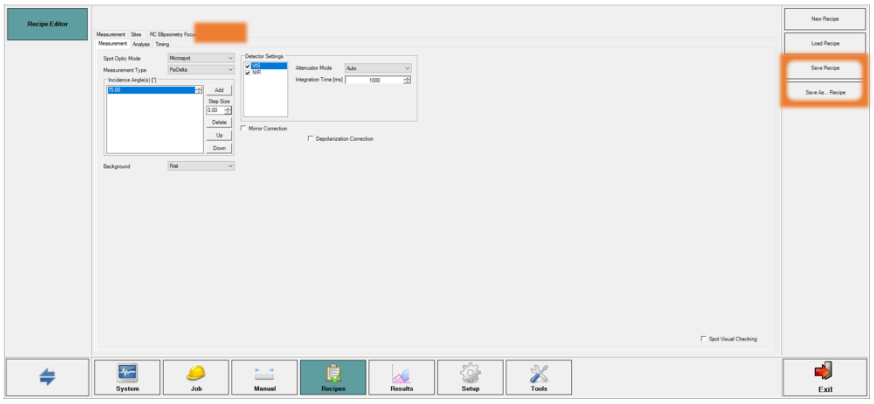


- Load your sample as normal, then begin on the **Measurement** tab of the **Recipes** page.
  - Click New Recipe on the right side menu.
  - Select RC Ellipsometry Focus in the Focusing box for automatic focusing.
    - Input the frequency of focus
  - Select RC Ellipsometry in the Metrology box.
  - Input a sample name, select a sample shape, and input the sample thickness (substrate thickness in um, like for manual setup) in the Sample Dimension box.
    - Input the sample dimensions and edge regions to be excluded (in mm.)

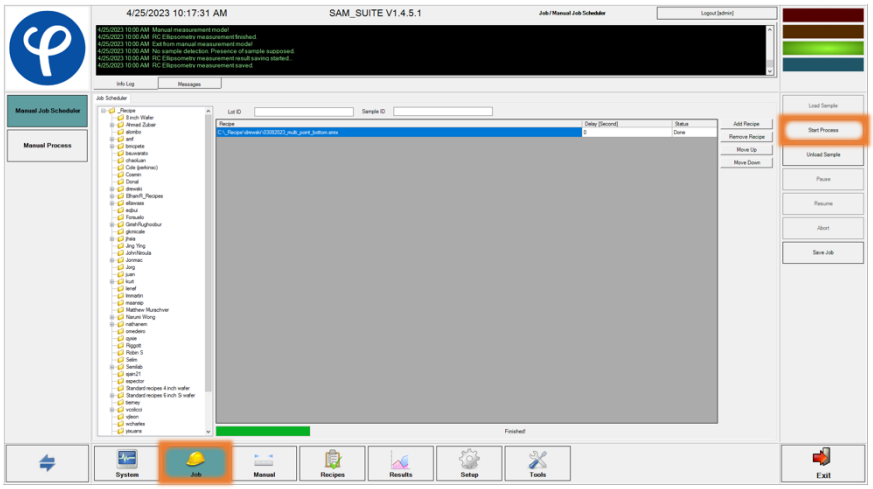


- Go to the **Sites** tab.
  - In the **Selection** box, input the number of columns and rows for rectangular geometries, or the total number of sites for circular geometries. Use the Repeatability option for periodic arrays over a smaller region.
  - Click Activate to update the preview.
  - Use the table on the left to preview the order of measurement points, and reorder them, if desired.
- Go to the **RC Ellipsometry Focus** tab and input the same settings from the Manual Focus section.
  - It may be helpful to confirm the focus through Manual mode prior to starting a recipe measurement.





- Go to the **RC Ellipsometry** tab.
    - Input settings for Measurement, Analysis, and Timing using the same guidelines from Manual setup.
- Click **Save Recipe** or **Save As… Recipe** to save this as a recipe file.

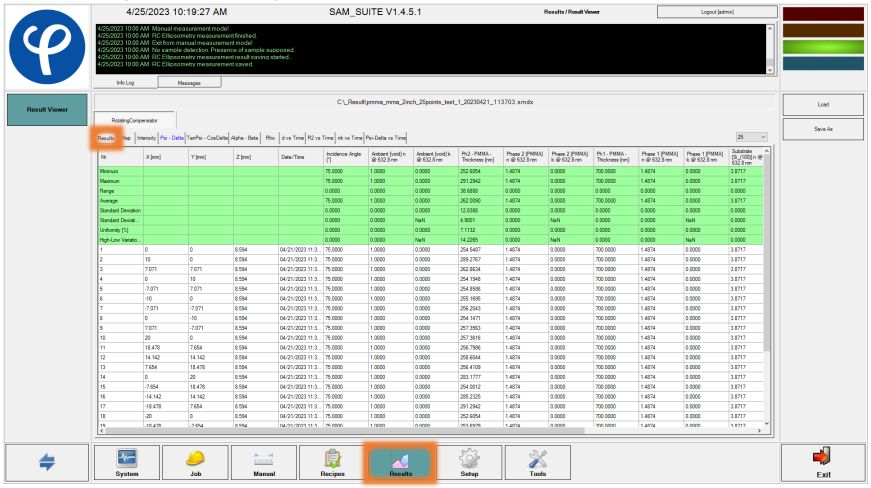


- To run a recipe, open it through the **Job** page. You can add multiple recipes, if needed.
- Load your sample, then click **Start Process** when ready.

Results Page

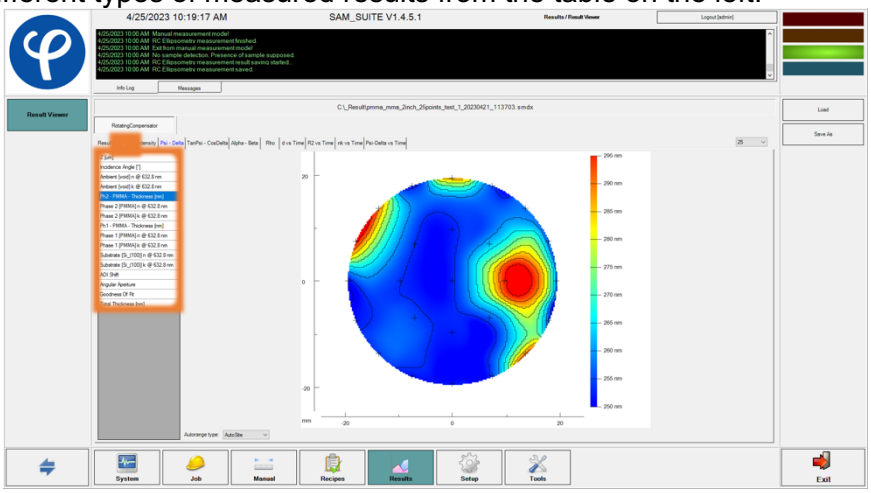
Measurement results may also be viewed through the **Results** page

- On the **Results tab**, they are displayed as a table.



- Multi-point measurements may be viewed as a map on the **Map tab**.

- View different types of measured results from the table on the left.



- Psi-Delta plots can be viewed on the **Psi-Delta tab**, with fitted plots if automatic Analysis was selected and set up.

