

## Spectroscopic Ellipsometer --- J. A. Woollam alpha-SE

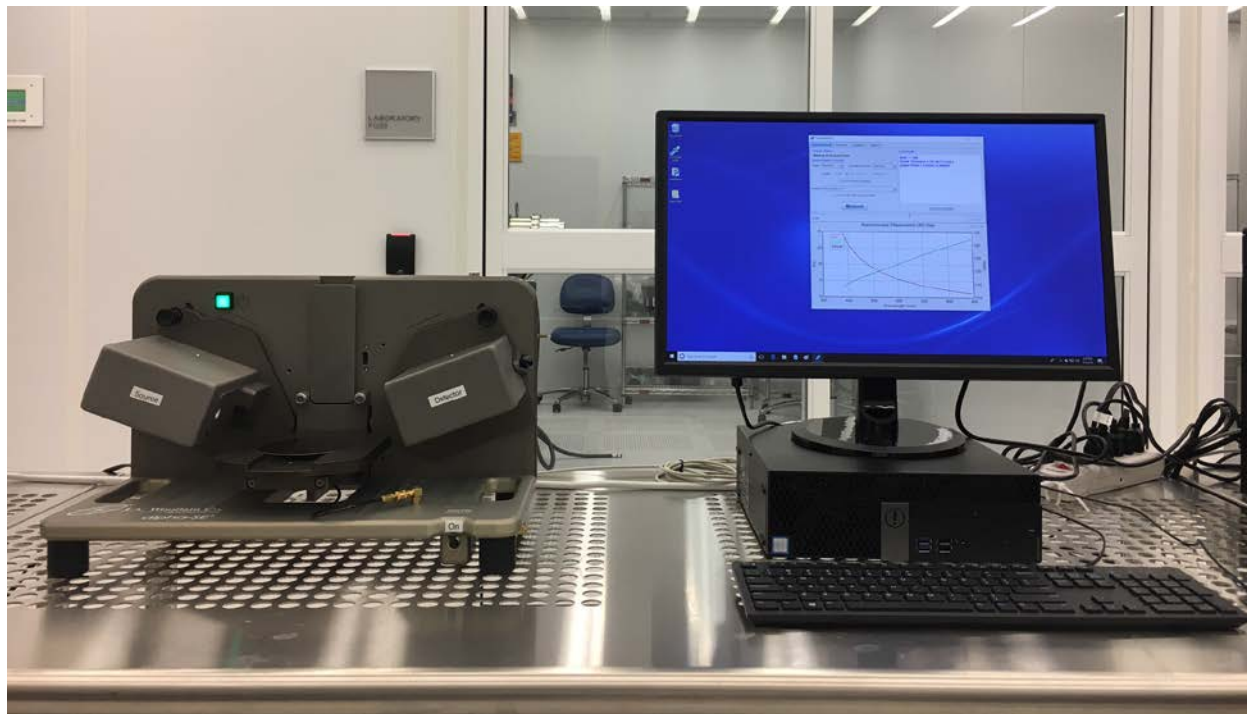


Figure 1: J. A. Woollam alpha-SE spectroscopic ellipsometer

### Introduction

An ellipsometer measures the change in polarization as light reflects or transmits from a material structure. The measured data is fitted to models to determine the material's thickness and the optical properties ( $n$  and  $k$ ). Ellipsometers have high sensitivity and are extensively used to characterize layers from a few angstroms to 100 nm.

### Feature and specifications

- 1) Wavelength 380 - 900 nm
- 2) The measurement angle is set at  $70^\circ$ . Contact staff if you need a different or multiple angles.
- 3) Auto sample alignment
- 4) Fast data acquisition: 3 ~ 30 sec depending on the mode
- 5) Light spot diameter ~ 3 mm
- 6) Focus probes reduce the light spot diameter to ~ 0.3 mm

### Safety

- 1) Keep hands/fingers/body parts away from the instrument when the sample stage is moving.
- 2) Never look directly into the light beam.

### Precautions

- 1) Contact staff if you need to use the focus probes.
- 2) Turn off the equipment after use. The lamp has a limited lifetime.

### Operating Procedure

- 1) Activate the equipment in FOM.
- 2) Switch on the power switch of the ellipsometer.

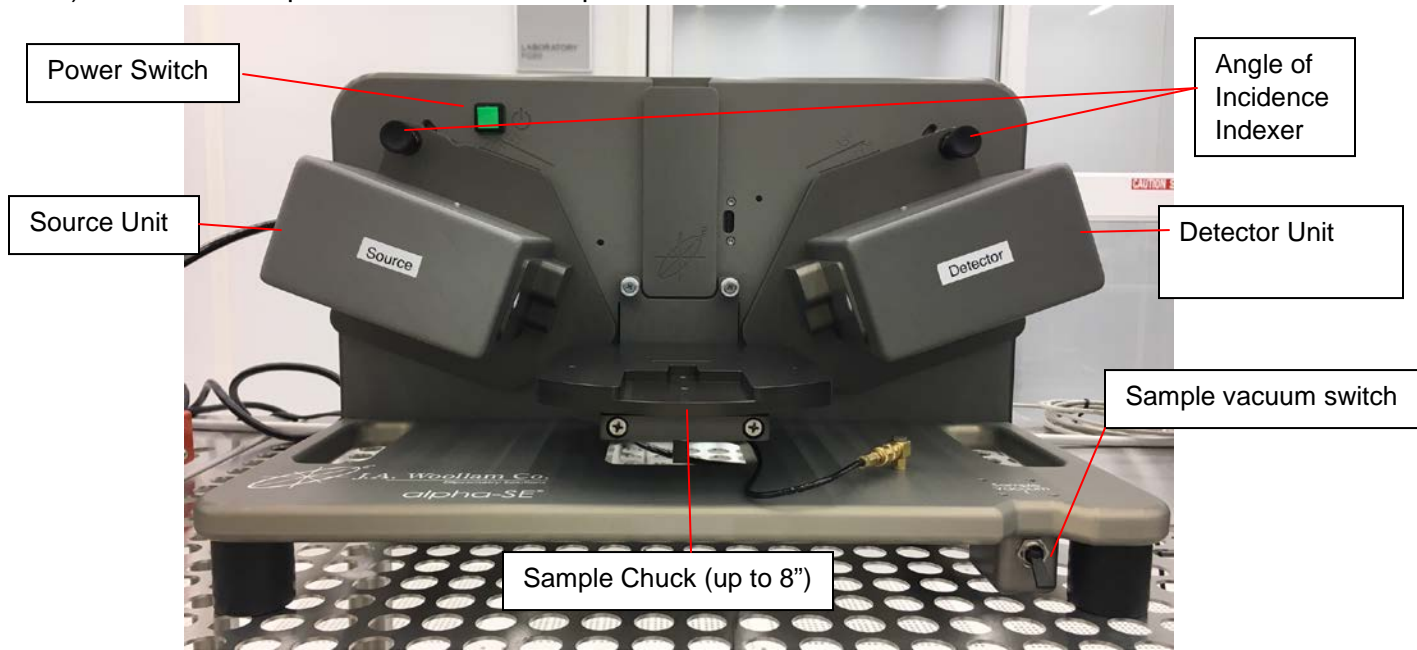


Figure 2: Parts of the ellipsometer

- 3) Mount the sample on the sample chuck. Switch on the vacuum (Figure 2).
- 4) Double click the 'CompleteEASE' on the desktop.
- 5) The system will automatically initialize. Wait until 'Waiting to Acquire Data' is displayed (Figure 3).

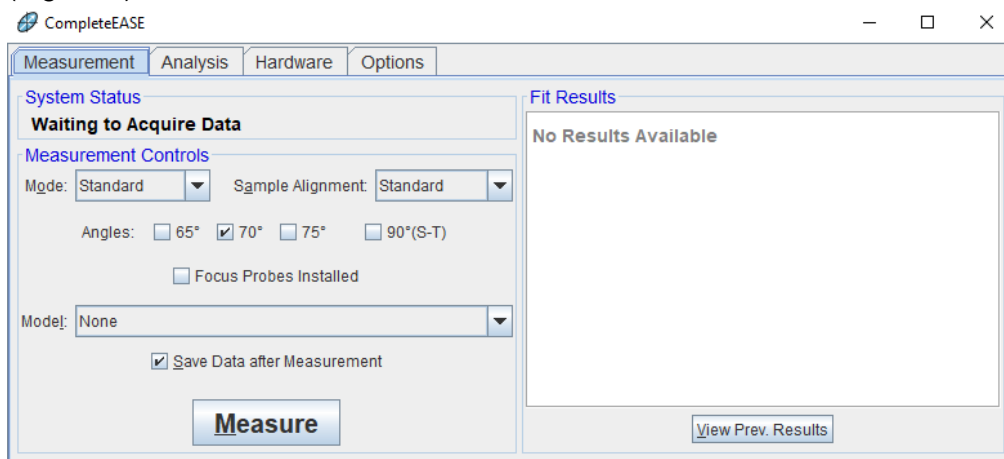


Figure 3: Set up data acquisition

Select measurement 'Mode', 'Sample Alignment', 'Model' for data analysis, and whether to 'Save Data after Measurement'. Table 1 provides details for each of these choices.

The measurement angle is set at 70°. Please contact staff if you need a different or multiple measurement angles. If your sample is not well described by the models in the library, select 'None' and build your model later (in step 8).

**Note: For most measurements, the “Standard” mode and “Standard” sample alignment sufficient.**

**Please contact staff if you need to use focus probes. Otherwise, don't check the box of 'Focus Probes Installed'.**

Category	Option	Description
Mode	Standard	Use for most measurements (~ 10 seconds)
	Fast	Quick measurements (~ 3 seconds)
	Long	Low reflectivity samples or high precision measurements (~30 seconds)
	Transmission	Collects Intensity Transmission measurements
	M.M.	Mueller-matrix measurement – for anisotropic and depolarizing samples
	M.M. Long	High Accuracy Mueller-matrix measurement
Sample Alignment	None	Stage location is below beam for Straight-Through (90°) measurements.
	Standard	Use for standard reflected measurements. This setting does a quick search for the light beam near the previous alignment position.
	Robust	A thorough alignment of the light beam that searches over the full translation range. Use for glass substrates with multiple reflected beams or when substrate thickness varies significantly from previous sample.
	Fixed Height	Moves sample stage to height described in hardware configuration file.
	Prompt Height	Allows user to enter the sample stage height for measurement. It is often helpful to first perform a Z-stage scan from the <i>Hardware</i> tab.
Model	None	Collects data only, allowing analysis at a later time.
	“Choose from File Dialog”	All default models are saved within various folders including: <i>Common</i> , <i>Advanced</i> , <i>Basic</i> , and <i>Calibration Wafers</i> . Only models in the COMMON folder will appear in the drop-down list.

Table 1: Measurement setting

- 6) Click on “Measure”. The ellipsometer will align the Z-height to detect reflected light from the sample and then collect data.  
If a model is selected, the collected data will be analyzed to determine the film properties. Otherwise, go to the ‘Analysis’ tab after the measurement.  
If the “Save Data after Measurement” is checked, a dialog box will appear for saving the data.
- 7) If your sample cannot be described by the models in the library, you can build your model following these steps:
  - 8.1) In Analysis tab, click ‘Open’ under ‘Model’. Select ‘Blank.mod’ in the Basic folder. (Figure 4)
  - 8.2) In Layer Commands, click ‘Add’. In the prompt window, click above the substrate (Figure 5)
  - 8.3) Choose the material of the film from the library. One material may have several files sourcing from different references. Please refer to the comment of each file (Figure 6).
  - 8.4) Similarly, click on the ‘Substrate = Si’ and choose the substrate material.
  - 8.5) Click on the ‘Thickness #1 = 0.00 Å” next to the layer material. Enter the estimated value of the thickness and check ‘Fit’ on the right (Figure 7).

8.6) If you don't have a good estimation of the thickness, click the '+' on the left of the 'FIT Options' to open the list and click the 'OFF' next to 'Perform Thickness Pre-Fit' to switch it to 'ON' (Figure 7).

**Note:** Here we only describe the most general case. If you have transparent films/substrates, absorbing layers, or materials not in the library etc., please contact staff and seek assistance for building a model.

8.7) Click 'Save' under 'Model' to save the model.

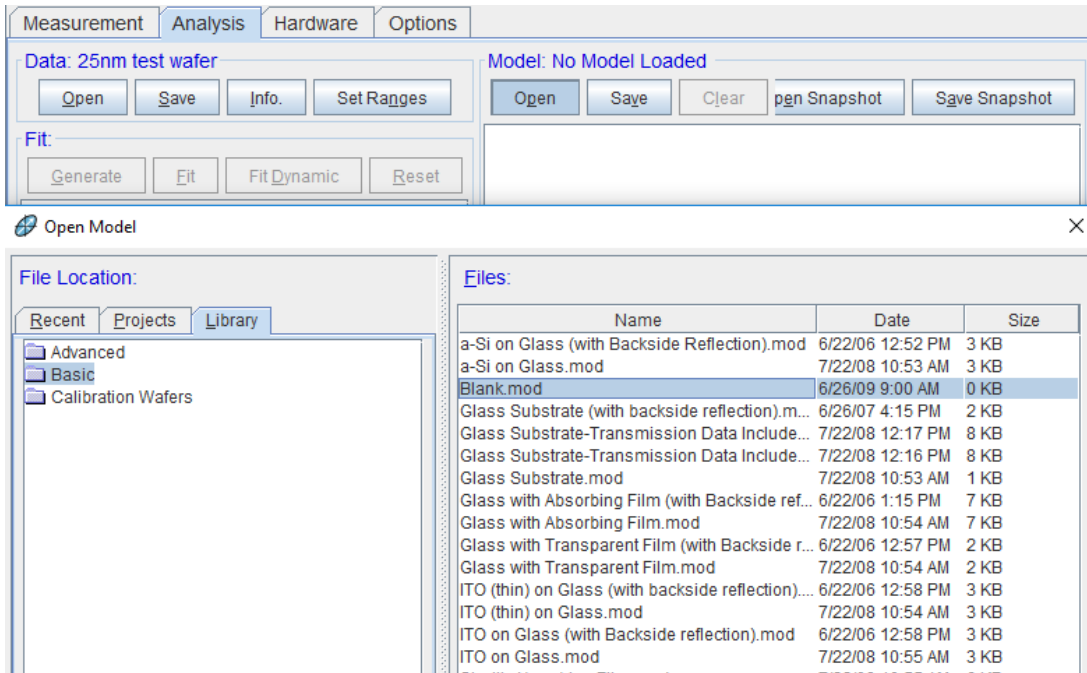


Figure 4: for step 8.1

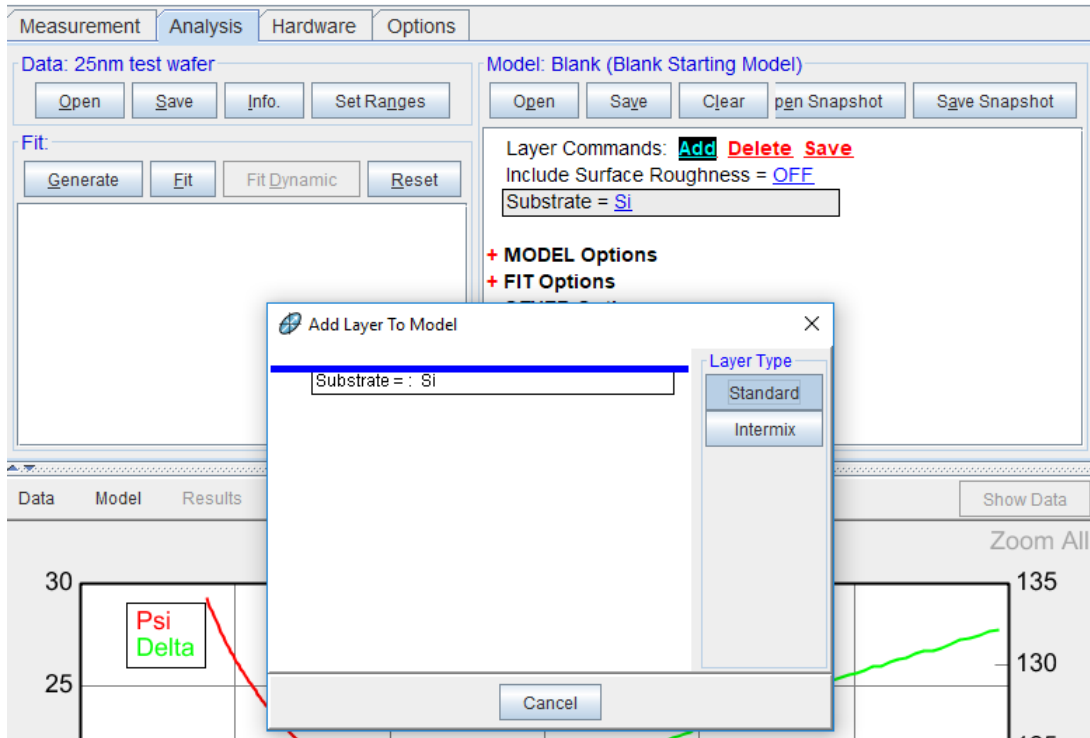


Figure 5: for step 8.2

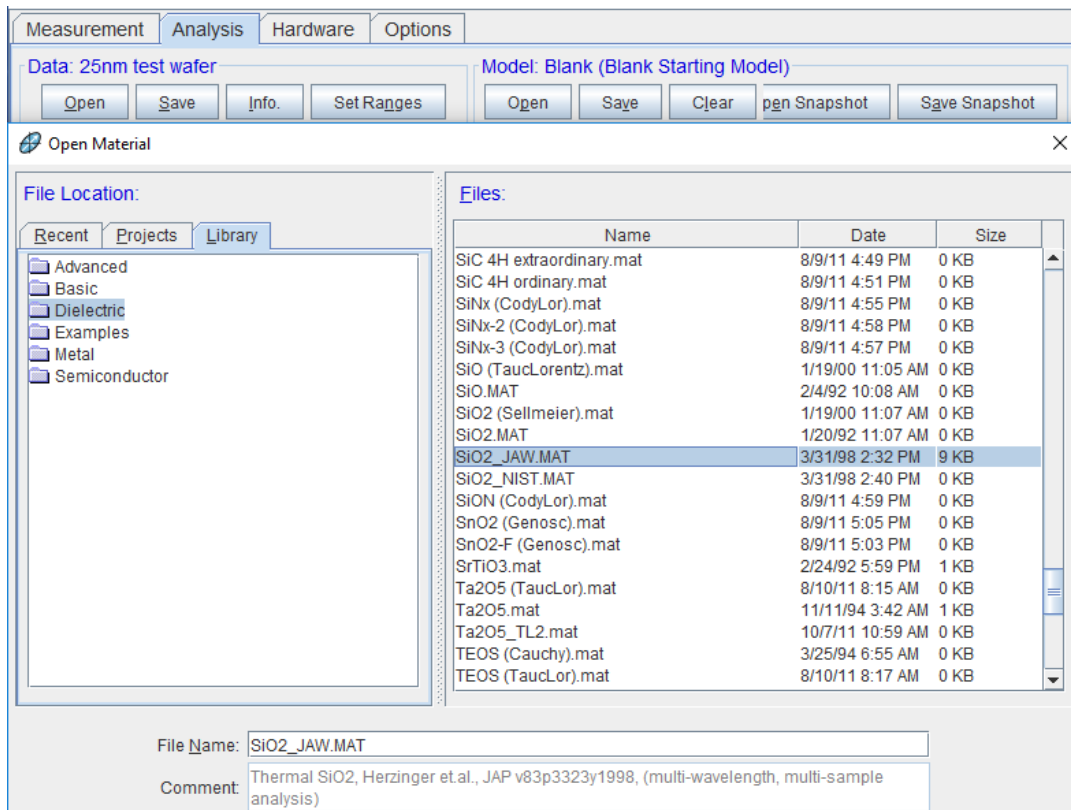


Figure 6: for step 8.3 and 8.4

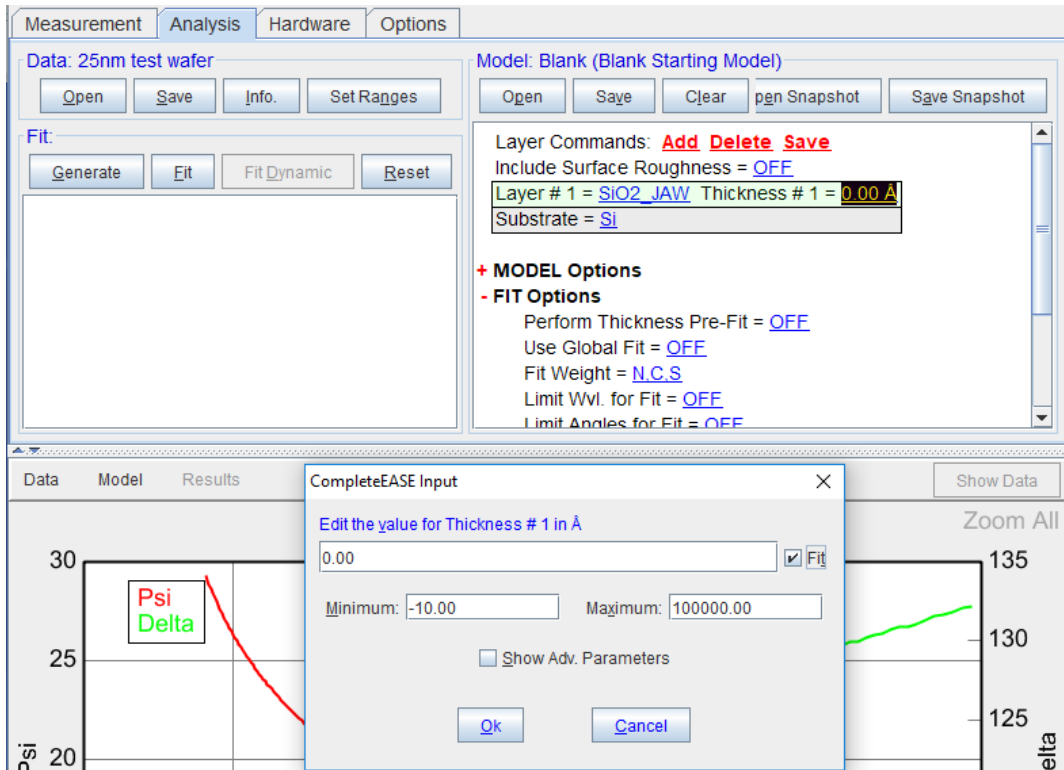


Figure 7: for step 8.6 and 8.7

- 8) Click 'Fit' under 'Fit' (Figure 8). The curves will be fitted and the results will be displayed. The parameter Mean Squared Error (MSE) is used to examine how well the model data fits the experimental data. The lower the MSE value, the better the data fit. A value below 3 is considered excellent, below 20 is good.
- 9) The n and k values can be displayed by clicking the data and choosing <Pseudo> Transforms... (Figure 9)
- 10) Right-click on the blank under 'Fit', you will be able to copy the MSE and thickness values to a clipboard.  
Right click on the graph to copy the data to the clipboard.
- 11) Open NotePad, paste and save the data.
- 12) Turn off the vacuum and unload the sample.
- 13) Close the 'CompleteEASE'. Switch off the vacuum and the main power.
- 14) Log off in FOM.

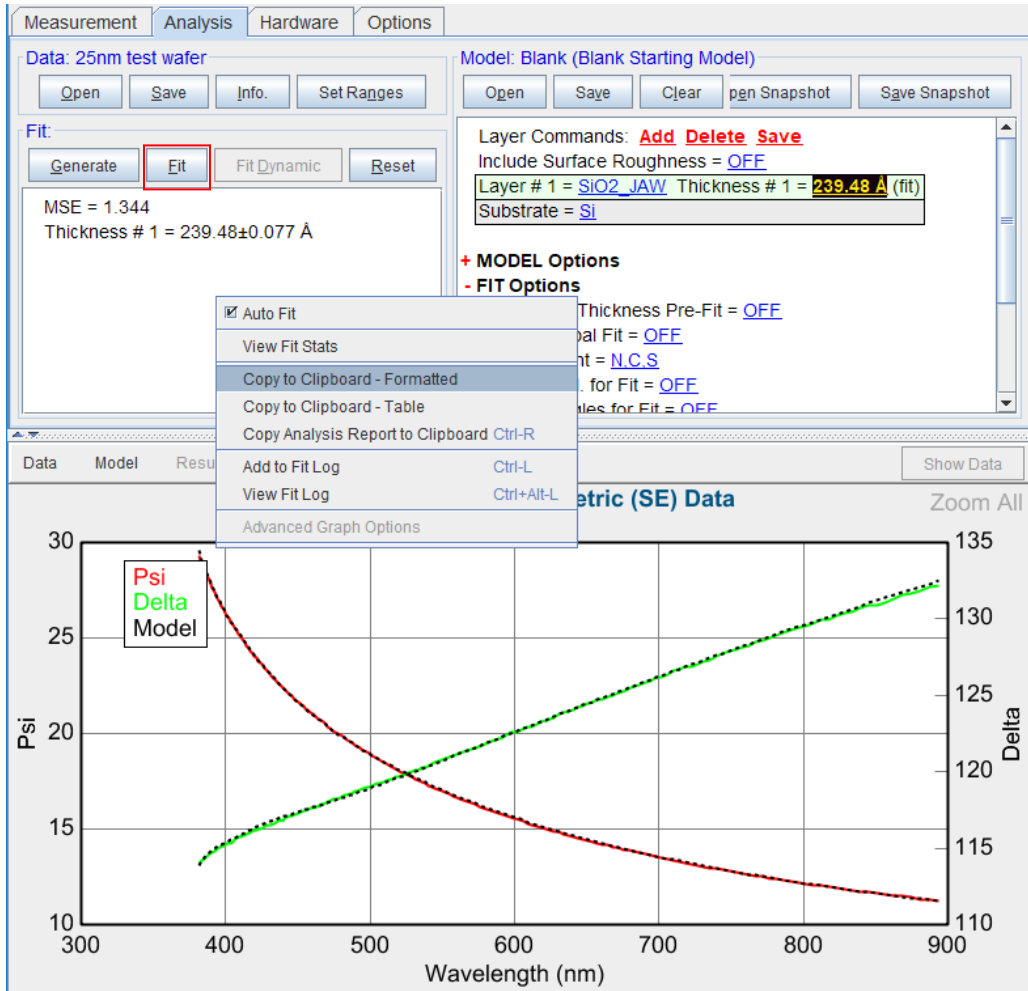


Figure 8: fit the curve and save the result.

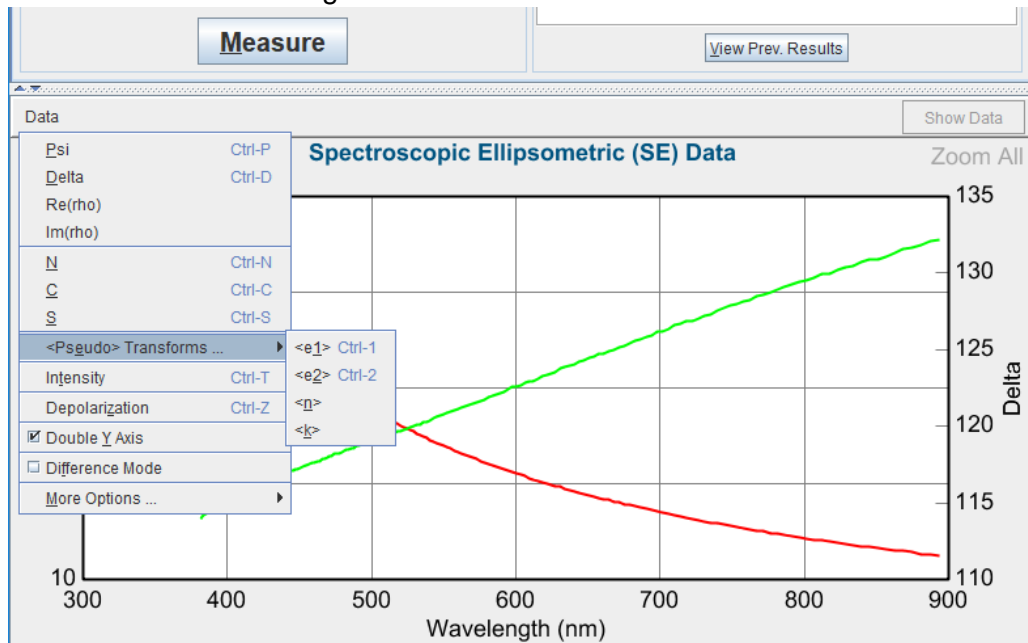


Figure 9: display n and k data.