

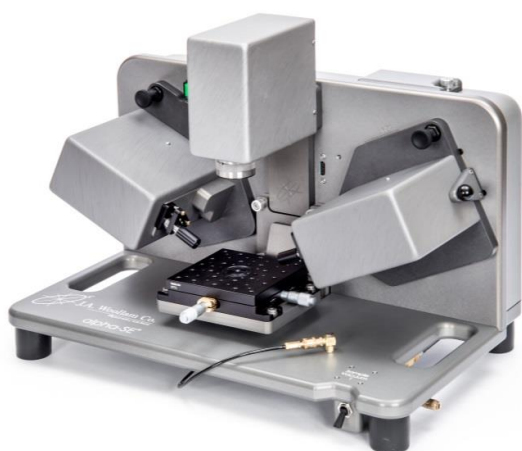
# Absorbing Films

This note contains information related to procedures needed to determine refractive index and thickness of absorbing films using Interference Enhancement. Interference Enhancement requires that the absorbing film is deposited over thick oxide ( $\sim 500\text{nm}$ ) on silicon or similar sample type. Other strategies are possible but not detailed here.

Ellipsometer types	M-2000, RC2, alpha-SE
Software	CompleteEASE
Typical data required	Standard ellipsometric data at 2-3 angles between $50^\circ$ - $75^\circ$
Typical model required	blank.mod
Considerations	-film should not be fully opaque -specific substrate type required

# 1. Measure Sample

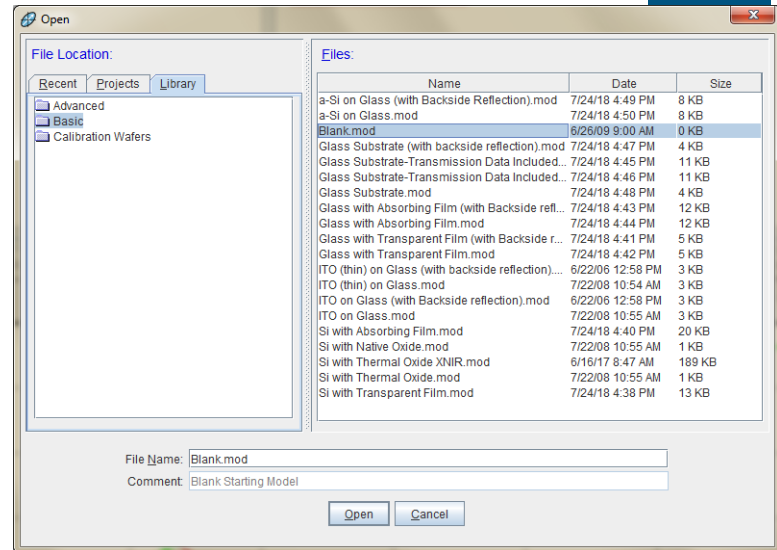
- Typical data for this application requires standard ellipsometric data in reflection mode 2-3 angles between  $50^\circ$ - $75^\circ$ .
- Consult hardware manual if needed.





1. Measure sample or open saved data

2. Open “Blank.mod” to start  
(New versions of CompleteEASE automatically start with this model loaded. If needed, from the **Model** panel, click ‘Open’. Browse the Library tab, Basic folder to find Blank.mod. Click ‘Open’ to load the model structure into the Model panel.)

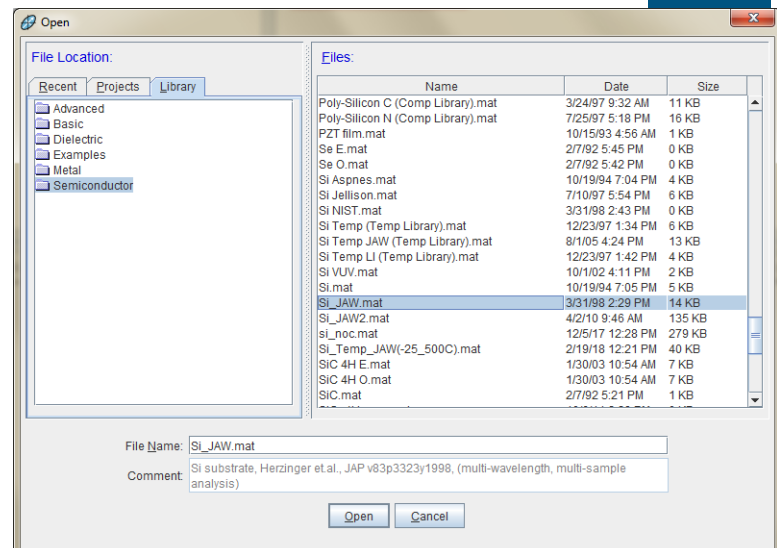


3. Click on “none” to open material file library

Substrate = none

4. Browse Library tab, Semiconductor folder to find si\_jaw.mat

5. Click “Open” to add the material file to the model structure

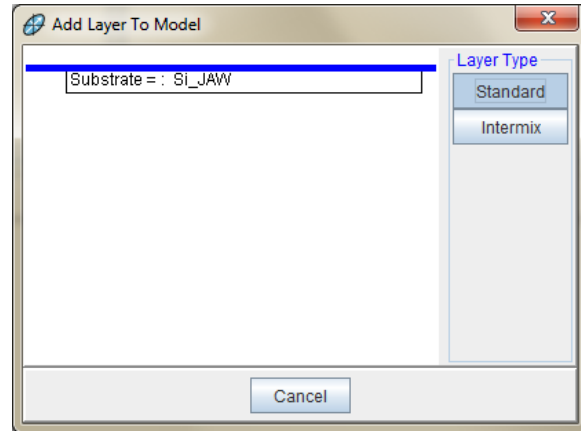




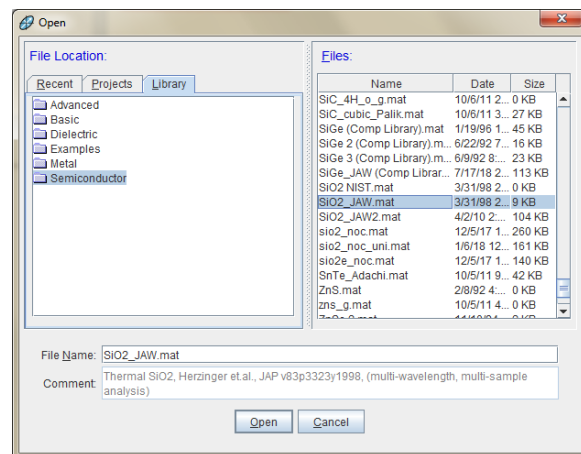
6. Click the Layer Command “**Add**” to add layer(s)

Layer Commands: **Add Delete Save**  
 Include Surface Roughness = **OFF**  
 Substrate = **Si\_JAW**

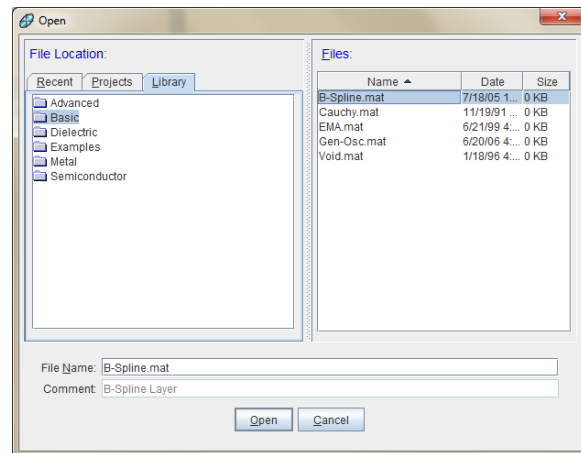
7. Use mouse to position blue bar above substrate and click once



8. Browse Library tab, Semiconductor folder to find sio2\_jaw.mat



9. Click “Open” to add material to model structure



10. Use Layer Command “Add” again to add B-Spline layer above oxide layer. The B-Spline is found in Library tab, Basic folder.

+ Layer # 2 = **B-Spline** Thickness # 2 = **0.00 nm**  
 Layer # 1 = **SiO2\_JAW** Thickness # 1 = **0.00 nm**  
 Substrate = **Si\_JAW**



11. Expand the **+B-Spline Layer**, **+Nodes** section to select a Starting Mat

12. Click on (Starting Mat =) **“none”** to open material file library

Layer # 2 = **B-Spline** Thickness # 2 = **0.00 nm**  
 Resolution (eV) = **0.300** 13 Pts. (1.240-4.960 eV) **Draw Node Graph**  
 Fit Opt. Const. = **ON**  
 Use KK Mode = **OFF**

**- Nodes**  
 Init. values: n = **1.500** k = **0.00** Starting Mat = **none**  
 Force E2 Positive = **OFF**  
 Assume Transparent Region = **OFF**  
 Show Nodes = **OFF**  
 Node Spacing Spectral Ranges: **Add Delete Delete All**

**+ Advanced**  
 Layer # 1 = **SiO2\_JAW** Thickness # 1 = **0.00 nm**  
 Substrate = **Si\_JAW**

13. Browse the Library tab, Metal folder to find a starting material file appropriate for your material

Open

File Location: **Recent Projects Library**

**Files:**

Name	Date	Size
Ni_Zollner.mat	11/8/16	8 KB
Ni.mat	10/6/11	1 KB
<b>NiFe.MAT</b>	<b>10/5/11</b>	<b>2 KB</b>
NiFe (Lorentz).mat	5/5/95	3... 0 KB
NiP.mat	10/5/11	1 KB
NiP (Lorentz).mat	1/18/96	6... 0 KB
Os_Palik.mat	10/6/11	8... 1 KB
Pd.mat	10/6/11	8... 0 KB

File Name: **NiFe.MAT**  
 Comment: **NiFe optical constants measured by JAW. 279-767nm**

**Open Cancel**

(Metal optical constants are highly variable. The .mat files in the software library are best used as starting values only. If your material is included in the library, choose any of the available options. If not, choose any similar material file.)

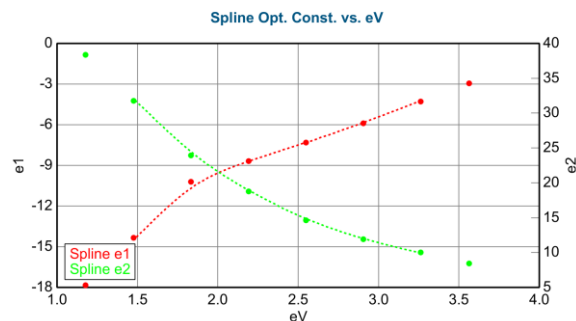
Layer # 2 = **B-Spline** Thickness # 2 = **0.00 nm**  
 Resolution (eV) = **0.300** 6 Pts. (1.476-3.263 eV) **Draw Node Graph**  
 Fit Opt. Const. = **ON**  
 Use KK Mode = **OFF**

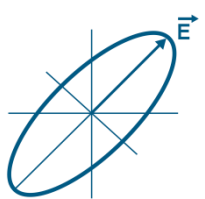
**- Nodes**  
 Init. values: n = **1.500** k = **0.00** Starting Mat = **NiFe**  
 Force E2 Positive = **OFF**  
 Assume Transparent Region = **OFF**  
 Show Nodes = **OFF**  
 Node Spacing Spectral Ranges: **Add Delete Delete All**

**+ Advanced**  
 Layer # 1 = **SiO2\_JAW** Thickness # 1 = **0.00 nm**  
 Substrate = **Si\_JAW**

14. Click ‘Open’ to add the material file as a Starting Mat within the B-Spline model

(The B-Spline layer will automatically adjust nodes to best match the Starting Mat)





## 15. Enter approximate thicknesses for the oxide layer and absorbing film.

If unknown, use mouse wheel to scroll thicknesses until model generated data approximately match experimental data. Previous measurement of oxide thickness can be helpful.

Layer # 2 = **B-Spline** Thickness # 2 = **30.00 nm** (fit)  
 Resolution (eV) = **0.300** 6 Pts. (1.476-3.263 eV) **Draw Node Graph**  
 Fit Opt. Const. = **ON**  
 Use KK Mode = **OFF**

**Nodes**  
 Init. values: n = **1.500** k = **0.00** Starting Mat = **NiFe**  
 Force E2 Positive = **OFF**  
 Assume Transparent Region = **OFF**  
 Show Nodes = **OFF**  
 Node Spacing Spectral Ranges: **Add Delete Delete All**

**Advanced**  
 Layer # 1 = **SiO2\_JAW** Thickness # 1 = **500.00 nm** (fit)  
 Substrate = **Si\_JAW**

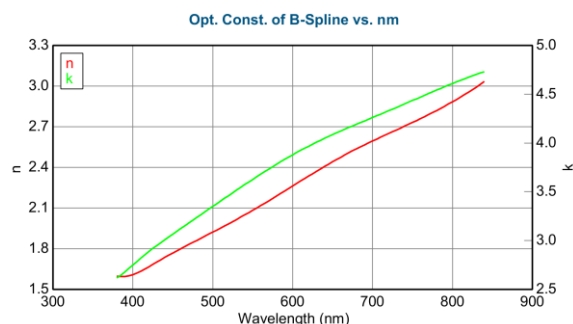
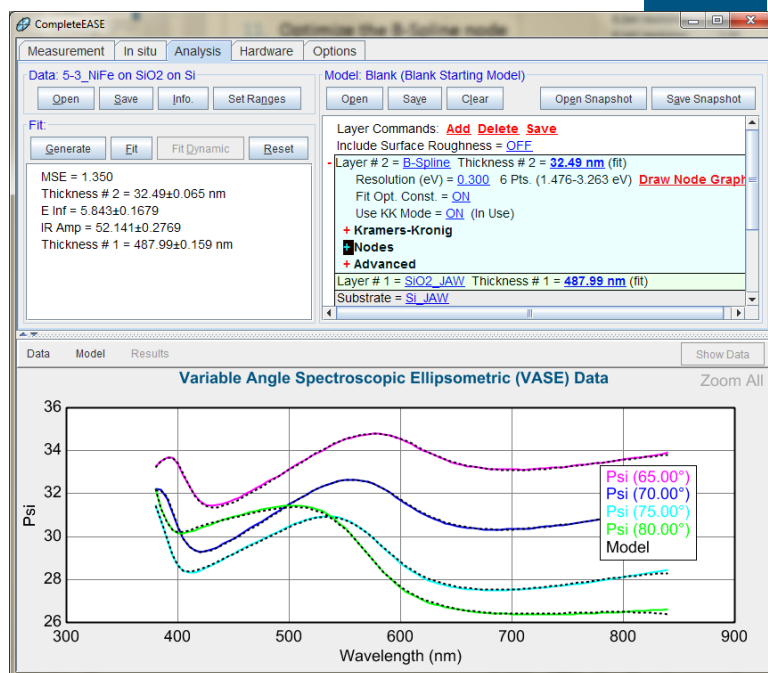
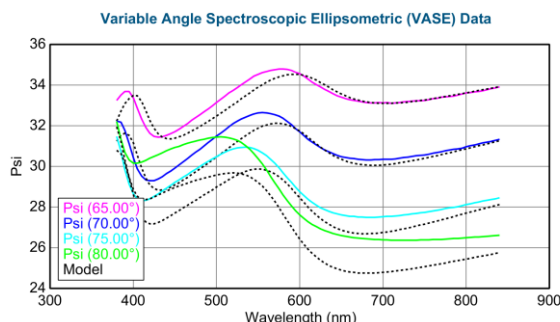
## 16. From the Fit panel, click 'Fit'

## 17. Optimize the B-Spline node resolution if needed

- Default B-Spline node resolution is 0.3eV
- Try slightly higher or lower node resolution (0.2, 0.4) and refit.
- Slowly increase or decrease to minimize MSE and visually match experimental data
- Stop when visual match to the data is achieved to avoid oversampling the data.
- 0.1-0.4eV is typically good for most metals.

## 18. Evaluate result by considering:

- Do the model generated curves visually match the experimental curves?
- What is the MSE value?
- Do the optical constants appear physically reasonable? Metals should have increasing k towards IR wavelengths due to free carrier absorption. Use KK mode within B-Spline to enforce physical relationship between n and k.





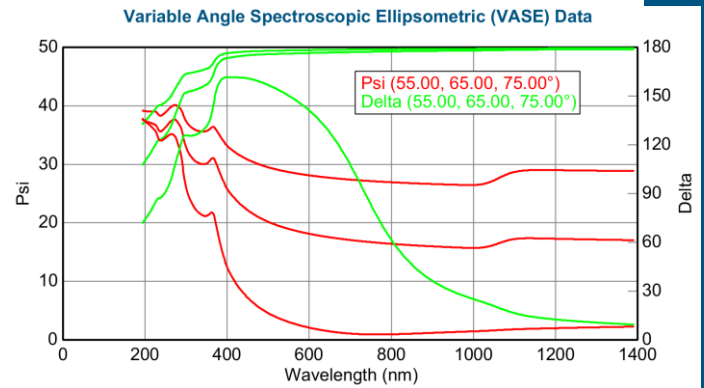
## Backside reflections

If substrate is double side polished, reflections from the substrate backside may be present in the data.

Backside reflections will cause a step in the data near the substrate material's bandgap. Detection of these reflections will depend on the spectral range of your ellipsometer.

When this occurs, you can exclude this region from your analysis or account for backside reflections in your model.

To include this effect in your model, expand +MODEL Options, turn ON "Include Substrate Backside Correction", and enter substrate thickness into the model.



Layer Commands: [Add](#) [Delete](#) [Save](#)

Include Surface Roughness = [OFF](#)

Layer # 1 = [NTVE\\_JAW](#) Thickness # 1 = [1.67 nm](#) (fit)

Substrate = [SI\\_JAW](#) Substrate Thickness = [0.5000 mm](#)

### - MODEL Options

Angle Offset = [0.00](#)

Include Substrate Backside Correction = [ON](#)

Transmission SE Data = [OFF](#) Reverse Direction = [OFF](#)

# Back Reflections = [5.000](#)

% 1st Reflection = [100.00](#)

Model Calculation = [Ideal](#)

### + FIT Options

### + OTHER Options

[Configure Options](#)

[Turn Off All Fit Parameters](#)