

Metal Substrates

This note contains information related to procedures needed to determine the refractive index of metal substrates. The procedure is identical for metal films greater than ~35-50nm on other substrates, as these will effectively block the underlying material.

This information can then be used for subsequent analysis of coated samples using the same substrate.

Ellipsometer types	M-2000, RC2, alpha-SE
Software	CompleteEASE
Typical data required	Standard ellipsometric data at 2-3 angles between 50°-75°
Typical model required	Blank.mod
Considerations	Surface roughness & oxides



 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.)

 Click on "<u>none</u>" to open material file library

Advanced	Name a-Si on Glass (with Backside Reflection).mod a-Si on Glass.mod	Date 7/24/18 4:49 PM 7/24/18 4:50 PM	8 KB 8 KB
Calibration Wafers	Blank.mod Glass Substrate (with backside reflection).mod Glass Substrate-Transmission Data Included Glass Substrate-Transmission Data Included Glass Substrate.mod	6/26/09 9:00 AM 7/24/18 4:47 PM 7/24/18 4:45 PM 7/24/18 4:46 PM 7/24/18 4:48 PM	0 KB 4 KB 11 KB 11 KB 4 KB
	Glass with Absorbing Film (with Backside refl Glass with Absorbing Film, mod Glass with Transparent Film (with Backside r Glass with Transparent Film, mod ITO (thin) on Glass (with backside reflection) ITO (thin) on Glass mod	7/24/18 4:43 PM 7/24/18 4:44 PM 7/24/18 4:41 PM 7/24/18 4:42 PM 6/22/06 12:58 PM 7/22/08 10:54 AM	12 KB 12 KB 5 KB 5 KB 3 KB 3 KB
	ITO on Glass.mod ITO on Glass.mod Si with Absorbing Film.mod Si with Native Oxide.mod Si with Native Oxide.mod	6/22/06 12:58 PM 7/22/08 10:55 AM 7/24/18 4:40 PM 7/22/08 10:55 AM 6/16/17 8:47 AM	3 KB 3 KB 20 KB 1 KB 189 KB
	Si with Thermal Oxide.mod Si with Transparent Film.mod	7/22/08 10:55 AM 7/24/18 4:38 PM	1 KB 13 KB
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Open File Location: Recent Projects Library Advanced Dielectric	Name B-Spline.mat 7 Cauchy.mat 1 EMA.mat	Date /18/05 10: 0 1/19/91 12 0 /21/99 4:5 0	Size KB KB KB
Open File Location: Recent Projects Library Advanced Basic Dielectric Examples	Files: B-Spline.mat 7 Cauchy.mat 1 EMA.mat 6 Gen-Osc.mat 6	Date // /18/05 10: 0 1/19/91 12 0 /21/99 4:5 0 /20/06 4:4 0	Size KB KB KB KB
Open File Location: Recent Projects Library Advanced Basic Dielectric Examples Metal Semiconductor	Name B-Spline.mat 7 Cauchy.mat 1 EMA.mat 6 Gen-Osc.mat 6 Void.mat 1	Date /18/05 10: 0 1/19/91 12 0 /21/99 4:5 0 /20/06 4:4 0 /18/96 4:1 0	Size KB KB KB KB KB KB
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🔗 Open

- 4. Browse Library tab, Basic folder to find B-Spline.mat
- Click "Open" to add the material file to the model structure



- Expand the +Substrate and +Nodes section within the B-Spline
- Click on (Starting Mat =) "<u>none</u>" to open material file library
- Browse the Library tab, Metal folder to find a starting material file appropriate for your material

(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.)



File Location:	<u>F</u> iles:		
Recent Projects Library	Name	Date	Size
Advanced	ALMAT	10/6/11 8:3 1	I KB
Basic	AI2O3 Mirror UC.mat	4/7/15 9:04 0) KB
	Al_nk.mat	10/6/11 8:3 4	I KB
Examples	AITi_nk.mat	10/6/11 8:3 2	2 KB
Metal	AITiC_nk.mat	10/6/11 8:3 1	2 KB
Semiconductor	Au 2.mat	10/5/11 3:1 1	KB
	Au.mat	10/5/11 3:1 2	2 KB
	Au_nk1.mat	10/6/11 8:3 6	6 KB
File <u>N</u> ame: Au.mat Comment: Gold (From Palik I: pp.2)	93-294): 207-1823nm		

9. 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)





10. From the Fit panel, click'Fit'

11. Optimize the B-Spline node resolution

- 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.

MSE 0.3eV resolution 5.674 0.2eV resolution 2.51 0.1eV resolution 1.04 0.05eV resolution 0.724 0.01eV resolution 0.0393



12. 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.

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If the result is acceptable, save the material file with a unique name for subsequent analysis of coatings on same or similar substrates

(Right-click on "B-Spline and click 'Save Layer Optical Constants'. For metals, tabulated format is usually best. Use Recent or Projects tab to locate desired folder.)

Surface Roughness & Oxides

It is usually not possible to independently determine surface roughness or native oxide thickness on metal substrates. These effects are included in the optical properties of the results from this procedure. To see how the presence of roughness or oxide could affect the result, add one or the other to the model as a fixed quantity and refit the data.

 Substrate =
 B-Spline

 MODEL Op
 Graph Layer Optical Constants

 FIT Options
 Graph Layer Absorption Coefficient

 OTHER Opt
 Save Layer Optical Constants

 Configure
 Parameterize Layer

 Turn Off Al
 Convert To EMA

 Convert To Anisotropic
 Convert To Anisotropic

х A Save Layer Optical Constants Choose the format for saving the layer's optical constants Fixed B-Spline Cancel Editable B-Spline Tabulated Save File Location: Files Recent Projects Library Name Size Date Common Add Folder Link File Name Comment: B-Spline Layer Save Cancel