SPECTROSCOPIC REFLECTANCER AND REFRACTIVE INDEX MEASUREMENT .

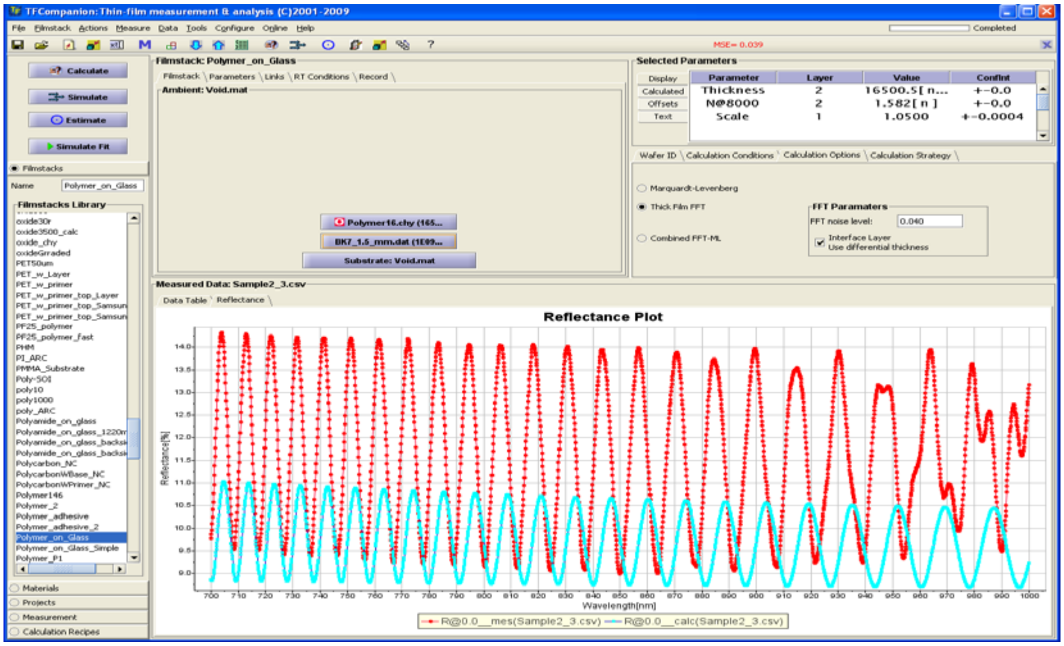
Spectroscopic reflectance is a powerful method of thickness and optical constants measurement. The thickness of, practically, any translucent material in 1nm -1mm thickness range can be measured. Optical constants can be measured for material thicknesses 20nm -20µm. However, there is one limitation – in order to measure optical constants, material need to be absorbing (k>0). If material has k=0, thickness and refractive index cannot be measured independently – they are correlated. The k>0 requirement is easily understood intuitively – absorption constraints the thickness and thus de-correlates thickness and refractive index measurement.

One approach is to select wavelength range where k>0 (typically in UV). For example, SiN or TiO2 have k=0 in the visible range but nice absorption edge in the UV, so using UVVis spectrum one can reliably determine thickness and n & k of these materials. Some materials, like SiO2, are dielectric in a very wide spectral range but, in many cases, they have some surface roughness or non-uniformity that causes light scattering. Small light scattering has the effect similar to absorption and allows to determine thickness and R.I. independently especially in thicker films (several µm).

There is one special case when R.I. of dielectric film can be determined very accurately along with the thickness without a need for absorption. This happens when there are 2 layers (or layer on substrate) that have similar R.I., one R.I. (e.g. substrate) is known and film is relatively thick (several µm). For example, 16um polymer film on glass (glass R.I. 1.5, polymer R.I. ~ 1.6).

Two figures below (Fig.1 and Fig. 2) show the effect of the R.I. on reflectance spectrum. Optical contrast (difference between R.I. of the materials) affects strongly the amplitude of interference fringes (peaks of constructive and deconstructive interference). The better is optical contrast – the stronger is amplitude. As a result, R.I. index can be determined independently – thickness has no effect on the amplitude of interference peaks. This allows us to determine R.I. and improve accuracy of thickness measurement at the same time.

Note. In this example, polymer was deposited on a thin glass (~ 1.3mm) and backside reflectance of the glass was included in the model. This is typical to LCD applications. Polymer dispersion (R.I.) was represented using Cauchy approximation (see Fig. 3)



MSE= 0.039

Name: Polymer_on_Glass

Filmstack: Polymer_on_Glass

Ambient: Void.mat

Polymer16.chy (165...

BK7_1.5_mm.dat (1E09...

Substrate: Void.mat

Selected Parameters

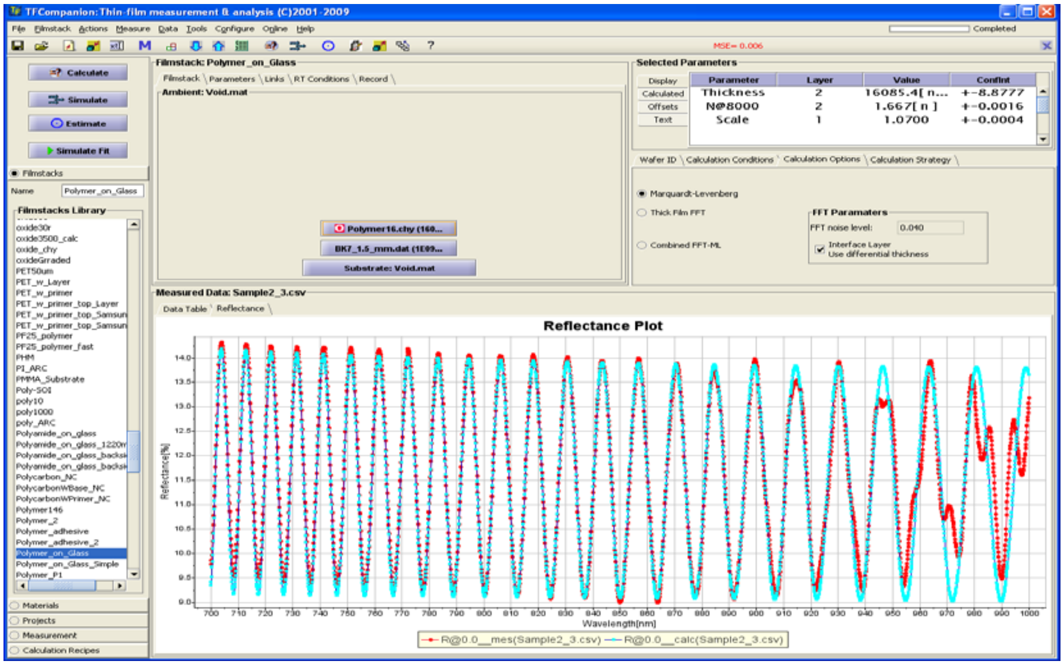
Parameter	Layer	Value	Confint
Thickness	2	16500.5[n...	+-0.0
N@8000	2	1.582[n]	+-0.0
Scale	1	1.0500	+-0.0004

○ Marquardt-Levenberg
● Thick Film FFT
○ Combined FFT-ML

FFT Paramaters
FFT noise level: 0.040
☑ Interface Layer Use differential thickness

Measured Data: Sample2_3.csv

Fig. 1. Polymer on glass. Reflectance spectrum 700-1000nm. Fit between measured (RED) and model (Blue) data for polymer R.I.=1.582 at 800nm. Small amplitude of the model data shows that R.I. of the polymer is higher



MSE= 0.006

Name: Polymer_on_Glass

Filmstack: Polymer_on_Glass

Ambient: Void.mat

Polymer16.chy (160...

BK7_1.5_mm.dat (1E09...

Substrate: Void.mat

Selected Parameters

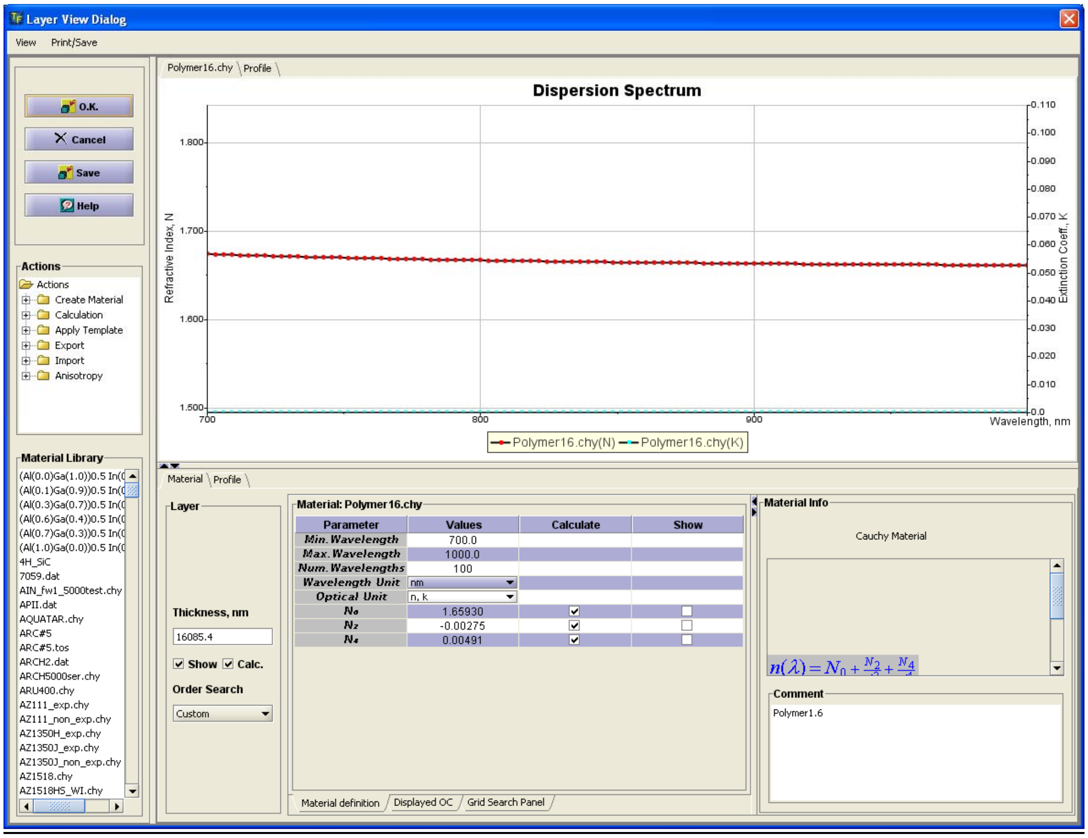
Parameter	Layer	Value	Confint
Thickness	2	16085.4[n...	+-8.8777
N@8000	2	1.667[n]	+-0.0016
Scale	1	1.0700	+-0.0004

● Marquardt-Levenberg
○ Thick Film FFT
○ Combined FFT-ML

FFT Paramaters
FFT noise level: 0.040
☑ Interface Layer Use differential thickness

Measured Data: Sample2_3.csv

Fig. 2. Same as Fig.1 but polymer R.I. is adjusted to 1.667 at 800nm. . Fit between measured (RED) and model (Blue) data is good now. Both thickness and R.I. can be determined independently.



Thickness, nm: 16085.4

☑ Show ☑ Calc.

Order Search: Custom

Material: Polymer16.chy

Parameter	Values	Calculate	Show
Min. Wavelength	700.0		
Max. Wavelength	1000.0		
Num. Wavelengths	100		
Wavelength Unit	nm		
Optical Unit	n, k		
N_0	1.65930	☑	☐
N_2	-0.00275	☑	☐
N_4	0.00491	☑	☐

Comment: Polymer1.6

Fig. 3 R.I. of the polymer film (700-1000nm) determined from the measurement. R.I. dispersion is represented using Cauchy approximation