

Thick film measurement Accuracy Improvement New Software features

FFT based algorithm for thickness measurement is fast, convenient and, frequently, is the only viable approach for thick films measurement. But measurement accuracy using this algorithm can be lower as compared to direct curve fitting. Some of the new features were added to improve the accuracy.

Background

The accuracy of the thickness measurement with FFT algorithm depends on how accurately the position of the peak can be determined.

The maximum error of the measurement can be determined as $(X_{n+1}-X_n)/2$, where X_n and X_{n+1} are points adjacent to a peak (Fig. 1)

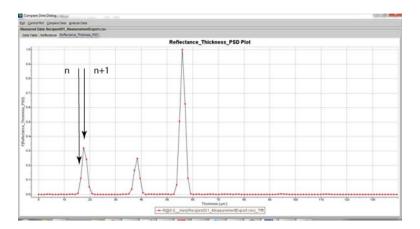


Fig. 1. FFT points resolution. Distance between adjacent FFT points (bins) determines maximum error.

To improve accuracy one can:

- 1. Increase the number of points
- 2. Interpolate between the points
- 3. Fit a Gaussian to a peak and determine position from the fitted function.

4. Apodization (filter the data). It does not, in most cases, improve accuracy directly but helps avoid aliases and additional peaks, especially in noisy signals.

All these options are now available in the software and are reviewed here using an example of a coating on polymer film.

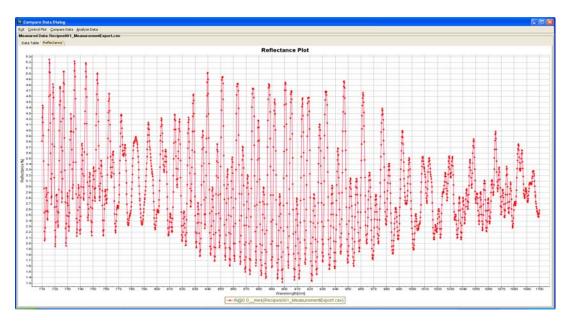


Fig. 2 Measured reflectance spectrum of coating (~ 18 $\mu m)$ on 38 μm PET

I. Increasing the number of points

FFT points are spread in the maximum measurable thickness range. Frequently, only part of the thickness range is of interest. In our example, the maximum measurable thickness is 280 μ m but the thicknesses of the sample are 18 μ m and 38 μ m.

We can increase the number of points using a method that is sometimes called "oversampling".

Measuremen	Templates \ Material T	emplate \ Source	ces Directories Precision I	efaults Simulation Ca	kulation \			
	Calcu	lation Algorit	hm				Results History	
			Calculation Algorithm:	Thick Film FFT	-			
		FFT cond	level: 0.040	Special Pre-pr	-		Remove Outliers Dispaly Chart	2 % of av
FFT Option	5 Filtering Options		Death Adv	inced Detection Optio			FFT Resolution	
							Accuracy	Default 🔫
Remo	ve step	2.0 Tr	mes average Peak o	n Slope	Total Thickness Only			
Remo	ve Spike/Peaks(high)	1.7 R	mes average 🛛 🗆 Low Th	ickness	800	nm	Data Filter	Nattal 💌
Remo	we Spike/Peaks(low)	1.08 Te	mes average	tal Intensity			Resolution	4 -
			Marquardt Param		Stop Conditions			
			Start Lambda	0.01	Max. Iterations	200		
			Lambda Scale	2.0	Num. Digits	8		
			Max Lambda	120.0	Gradient	1E-8		
			ForwardToCenter	0.1	Residual Sum	1E-8		

Fig. 3. Resolution improvement by using increased number of FFT points. 1 is default resolution, 4 – maximum resolution

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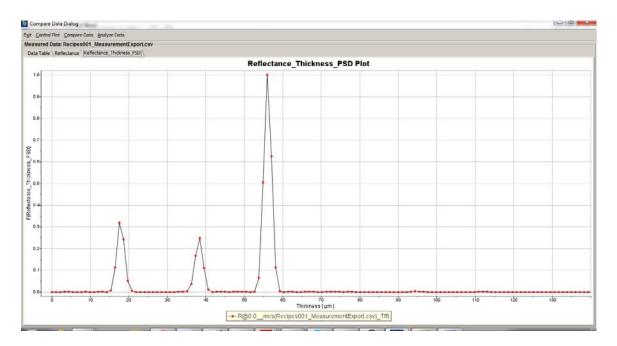


Fig. 4 Peaks using default resolution (1)

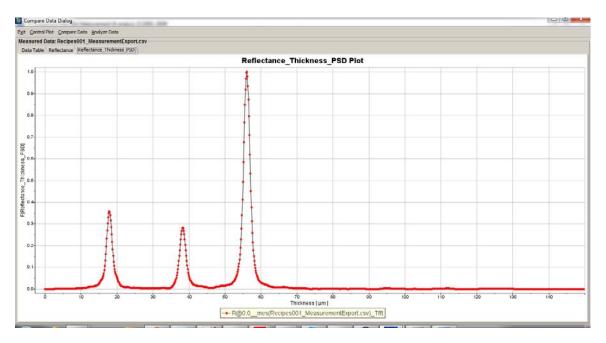


Fig. 5 Peaks using high resolution (4)

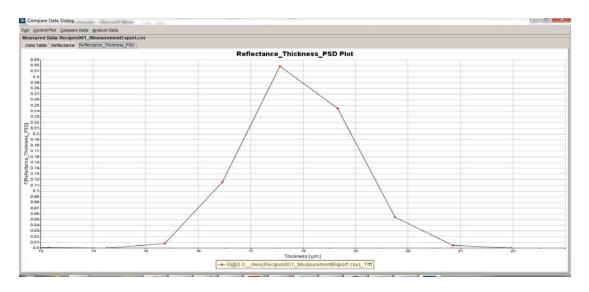


Fig. 6 Peak detail from fig. 4 (default resolution - 1)

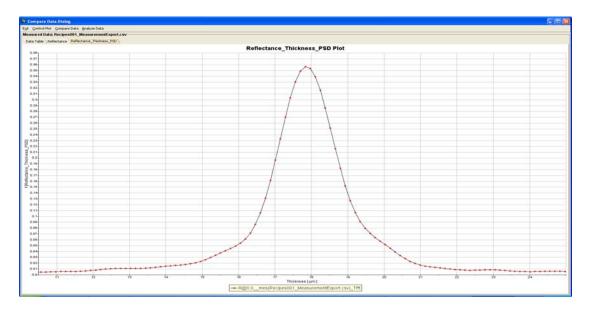


Fig.7 Peak detail from Fig. 5 (high resolution -4)

Resolution	1	2	3	4
Maximum possible				
error (µm)	0.548	0.274	0.137	0.068

 Table. 1
 Maximum possible measurement error depending on the resolution

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II. Interpolation between the points or curve fit.

M	easurement Templates \ Material Template \ So		ults \ Simulation \ Calculation \	-	
	Calculation Algo	Calculation Algorithm:	Thick Film FFT 👻	Results History	
Ca	Melp FFT no	nditions ise level: 0.040 erface layer	Special Pre-processing Remove trend	Remove Outliers	2 % of ave
	FT Options	Peak Advanc	ed Detection Options	FFT Resolution	Default -
	Remove step 2.0	Times average Peak on Sk	pe Total Thickness Only	Picca acy	- Contract
	Remove Spike/Peaks(high) 1.7	Times average	ess 800	nm Data Filter	Nattal 👻
	Remove Spike/Peaks(low)	Times average	intensity	Resolution	4 •
		Marguardt Param	Stop Conditions		
		Start Lambda 0.	D1 Max. Iterations	200	
		Lambda Scale 2.	Num. Digits	8	
		Max Lambda 12	0.0 Gradient	1E-8	
		ForwardToCenter 0.	1 Residual Sum	16-0	

Fig. 8. Selecting accuracy level.

Three levels of accuracy are available:

- a). Default no interpolation or fit
- b). High accuracy. Gaussian interpolation between the points
- c). Maximum accuracy. Gaussian curve fit to the peak.

Resolution/Accuracy	1	2	3	4
Default	-0.3547	0.2166	-0.0691	-0.0691
High	-0.0402	-0.0475	-0.0563	-0.0625
Maximum	-0.0136	0.0005	0.0068	0

Table 2. Actual measurement error (in μ m) depending on the Accuracy/ resolution setting. 1

8.6381 µm determined at the maximum accuracy/resolution setting is used as a reference ("true" thickness value).

III. Apodization – data filtering

	Measurement Templates \ Material Template \ Source		Its \ Simulation \ Calculation \		
	Calculation Algorit	hm		Results History	
		Calculation Algorithm:	Thick Film FFT 🛛 🔻		
Sa	Save FFT cond	litions		Remove Outliers	2 % of av
Ca	TFT noise		Special Pre-processing Remove trend	Dispaly Chart	
Help	FFT Options			FFT Resolution	
neds	FFT Data Filtering Options	Peak Advance	d Detection Options	Accuracy	Default 👻
	Remove step 2.0 Ti	mes average Peak on Slop	é Total Thickness Only		
	Remove Spike/Peaks(high) 1.7 Te	mes average	800	nm Data Filter	Nattall 👻
	Remove Spike/Peaks(low) 1.08 Ta	mes average	tensity	Resolution	4 -
		Marguardt Param	Stop Conditions		
		Start Lambda 0.0	Max. Iterations	200	
		Lambda Scale 2.0	Num. Digits	8	
		Max Lambda 120	0 Gradient	1E-8	
		ForwardToCenter 0.1	Residual Sum	16-0	

Fig. 9 Selecting apodization filter

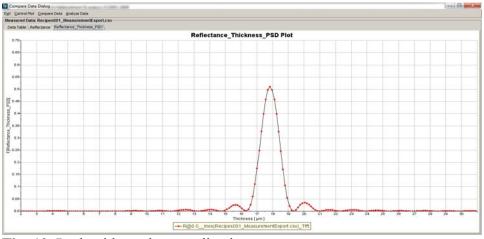


Fig. 10. Peak without data apodization.

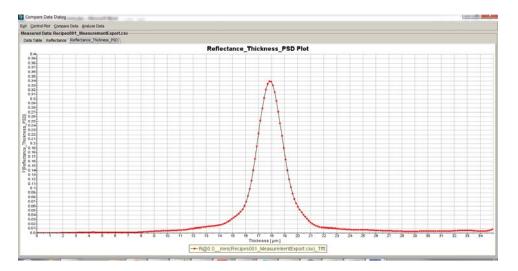


Fig. 11. Peak with data apodization (peak is the same as on Fig. 10) 83 Pine Hill Rd. Southborough, MA 01772 Phone +1.617.388.6832 Fax. +1.508.858.5473 email: info@semiconsoft.com http://www.semiconsoft.com

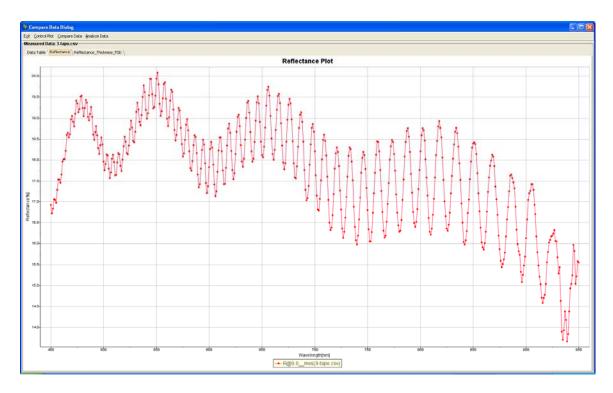


Fig. 12. Reflectance spectrum of GaN on sapphire

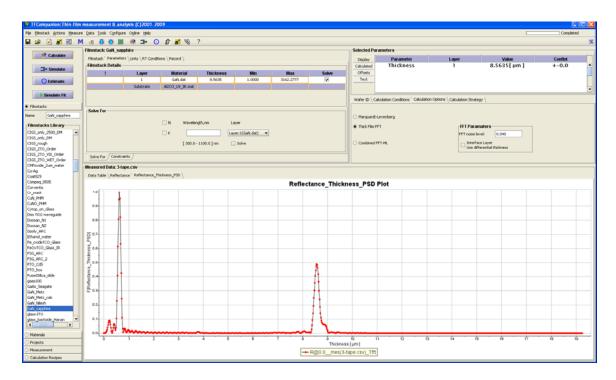


Fig. 13 Measurement of GaN (fig. 12) without data apodization

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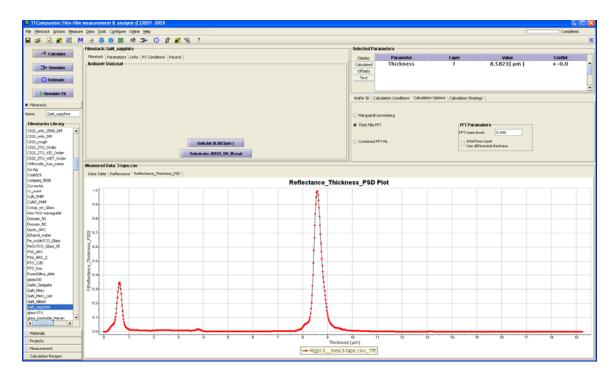


Fig. 14 Measurement of GaN (Fig. 12) with data apodization