Semiconsoft,Inc

Thin Film Measurement solution
Software, sensors, custom development
and integration

Measurement of thin films in deep wells

SUMMARY.

Measurement of the thin films on the bottom of a deep well i.e. the well with high aspect ratio, presents a challenge. Small spot measurement requires high-NA objective. However, high-NA objective also limits the depth of the well that can be measured.

In this example, our MProbe ™ Vis MSP* system was used to measure oxide (SiO2) layer on the bottom of the round wells. The wells diameters were 80µm, 40µm, 20µm and 10µm - all 100µm deep. The top surface of the sample (Si) had photoresist layer left after lithography. Round wells geometry were selected because it is most difficult to measure as compared to square wells or vias of the same geometry. 20x APO objectives with long working distance (35mm) was use for this measurement. The measurement spot size was ~ 20um. The reason for using this objective was because it has the lowest NA (0.29), which is critical for measurement in the deep wells.

Measurements in 80µm and 40µm wells gave a clean signal and were easy to align and focus. In measurements of 20µm and 10µm wells, a part of the light beam was reflected from the top PR, so both oxide thickness and PR thickness signal were present in the measurement, as expected. However, it was still easy to distinguish and determine oxide thickness because of the significantly the thicknesses of oxide and PR were significantly different. The thickness of oxide was ~ 1.6 µm, the thickness of PR ~ 3 µm

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* MProbe is a registered trademark of Semiconsoft,Inc, Inc. MProbe™ Vis MSP brochure can be found at: http://www.semiconsoft.com/html/download/brochure/MProbeMicro_brochure2012.pdf

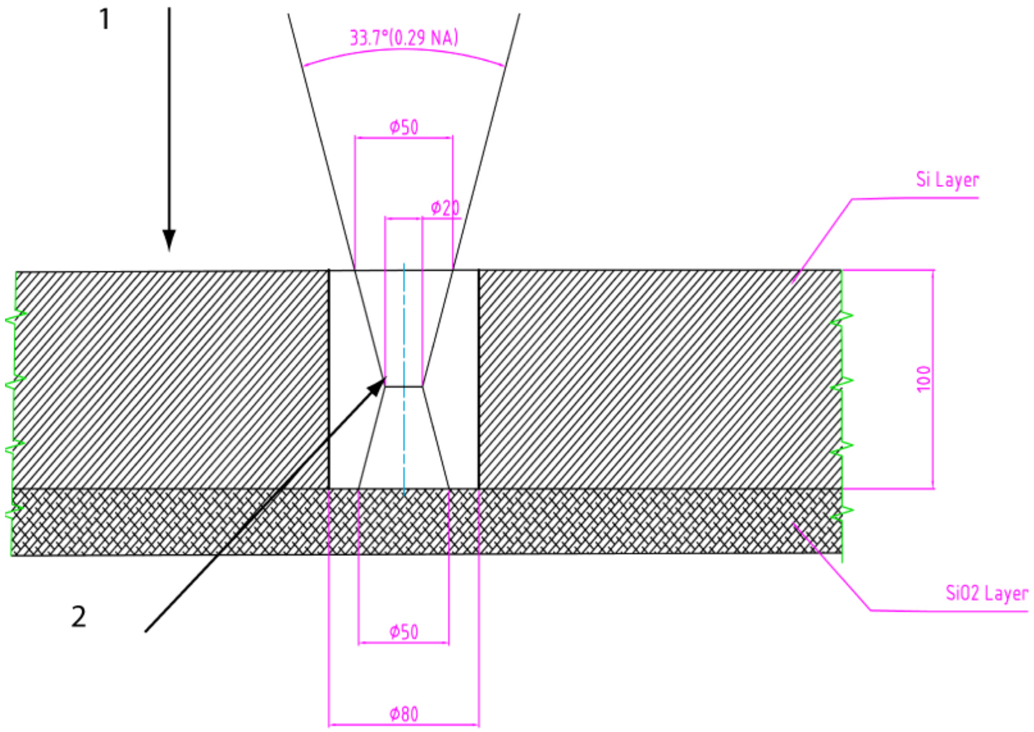


Fig. 1 Light geometry of the measurement in the deep well (all dimensions are in µm)

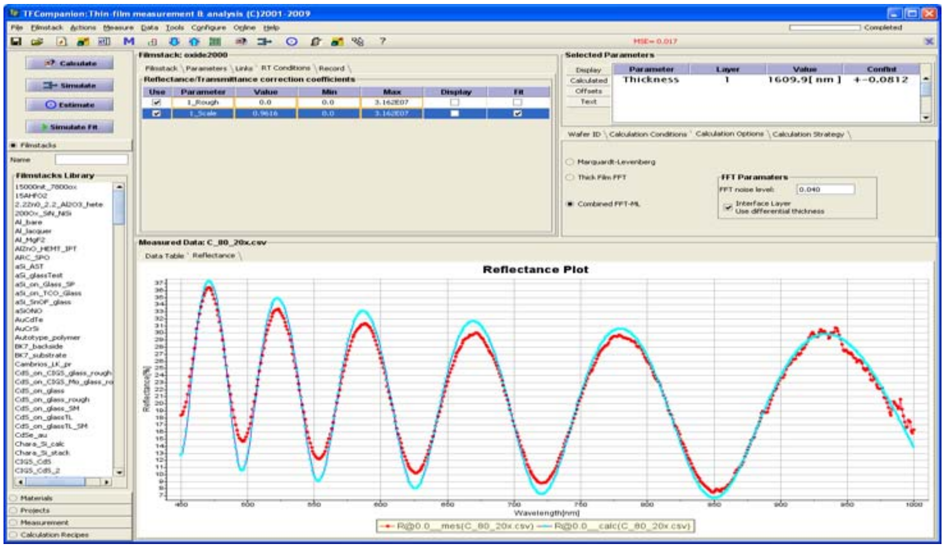
1 – Direction of the incident light from the objective

2 – Focusing position (middle of Si layer) for optimal measurement.

Light geometry of the measurement in a deep well is presented on Fig. 1.
It shows that the beam diameter at the top of the well is ~ 50µm, so it can easily fit in the 80µm and obstruction effect in 40µm geometry is small. This is indeed confirmed experimentally. This picture demonstrates the importance of low NA of the objective.

DETAILS.

I. Measurement of 80µm Round/circular well (aspect ratio -1.25)


TFCompanion: Thin-film measurement & analysis (C)2001-2009

MSE= 0.017

Filmstack: oxide2000

Reflectance/Transmittance correction coefficients

Use	Parameter	Value	Min	Max	Display	Fit
☑	1_Rough	0.0	0.0	3.162E07	☐	☐
☑	1_Scale	0.9616	0.0	3.162E07	☐	☑

Selected Parameters

Parameter	Layer	Value	Confint
Thickness	1	1609.9[nm]	+-0.0812

○ Marquardt-Levenberg

○ Thick Film FFT

● Combined FFT-ML

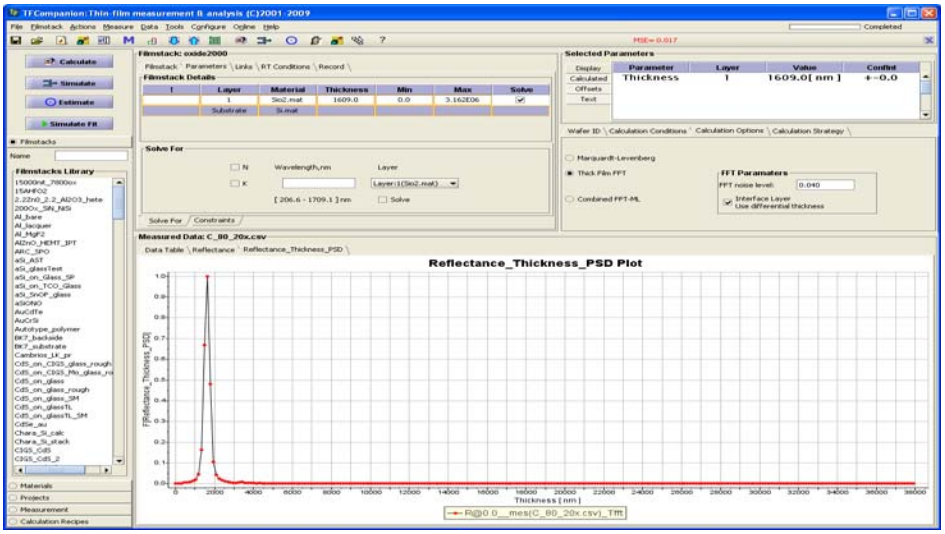
FFT Paramaters

FFT noise level: 0.040

☑ Interface Layer Use differential thickness

Measured Data: C_80_20x.csv

Fig.2. Fit of measured to model data. Thickness 1609nm


TFCompanion: Thin-film measurement & analysis (C)2001-2009

MSE= 0.017

Filmstack: oxide2000

Filmstack Details

!	Layer	Material	Thickness	Min	Max	Solve
	1	Sio2.mat	1609.0	0.0	3.162E06	☑
	Substrate	Si.mat				

Solve For

☐ N Wavelength,nm Layer

☐ K Layer:1(Sio2.mat)

[206.6 - 1709.1] nm ☐ Solve

Selected Parameters

Parameter	Layer	Value	Confint
Thickness	1	1609.0[nm]	+-0.0

○ Marquardt-Levenberg

● Thick Film FFT

○ Combined FFT-ML

FFT Paramaters

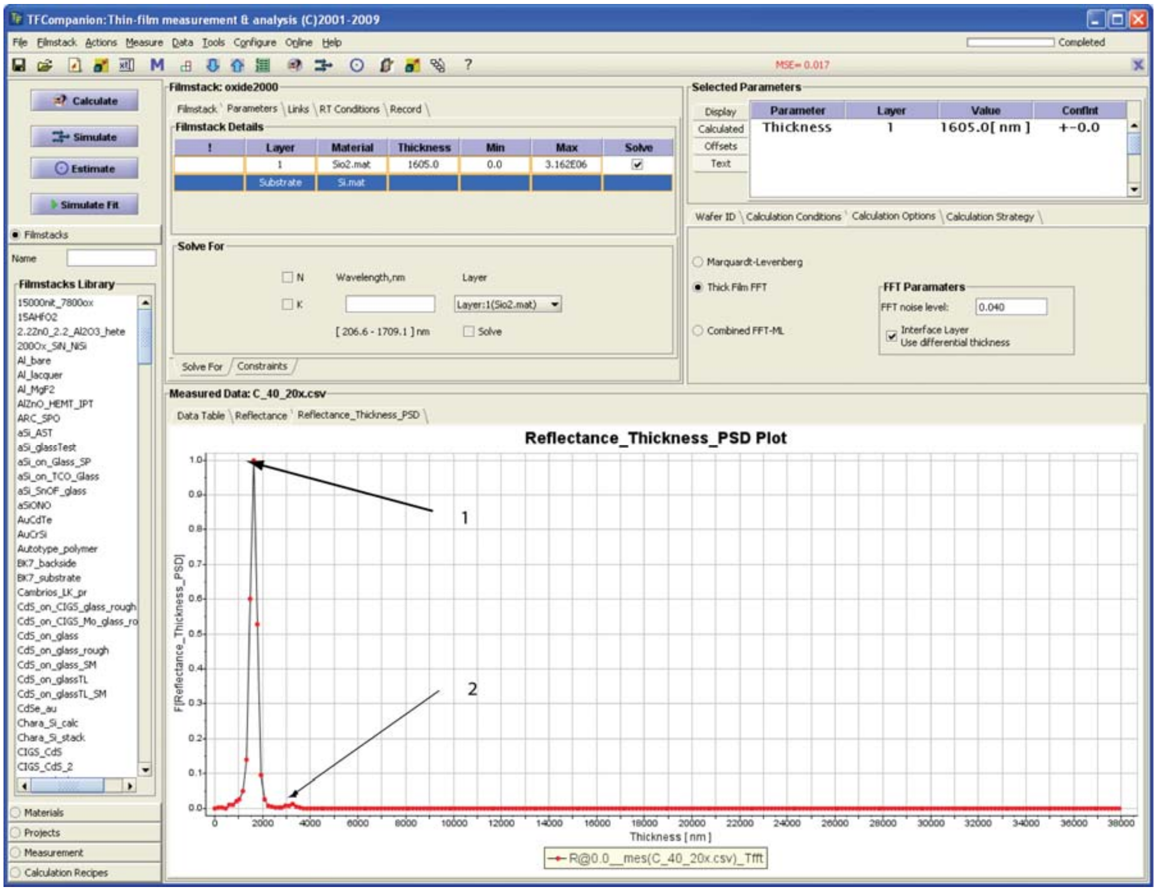
FFT noise level: 0.040

☑ Interface Layer Use differential thickness

Measured Data: C_80_20x.csv

Fig. 3. Same data as Fig, 2 but using FFT for thickness determination. (Thickness 1609nm). Peak position indicates the thickness value. The presence of only one clear peak indicates that there is no noticeable reflection from PR coated area – the light beam goes cleanly in the well.

II Measurement in 40μm Round/circular well (aspect ratio - 2.5)



TFCompanion:Thin-film measurement & analysis (C)2001-2009

MSE= 0.017

Completed

Filmstack: oxide2000

Filmstack Details

!	Layer	Material	Thickness	Min	Max	Solve
	1	Sio2.mat	1605.0	0.0	3.162E06	☑
	Substrate	Si.mat				

Solve For

☐ N Wavelength,nm Layer

☐ K Layer:1(Sio2.mat)

[206.6 - 1709.1] nm ☐ Solve

Selected Parameters

Parameter	Layer	Value	ConfInt
Thickness	1	1605.0[nm]	+-0.0

○ Marquardt-Levenberg

● Thick Film FFT

○ Combined FFT-ML

FFT Paramaters

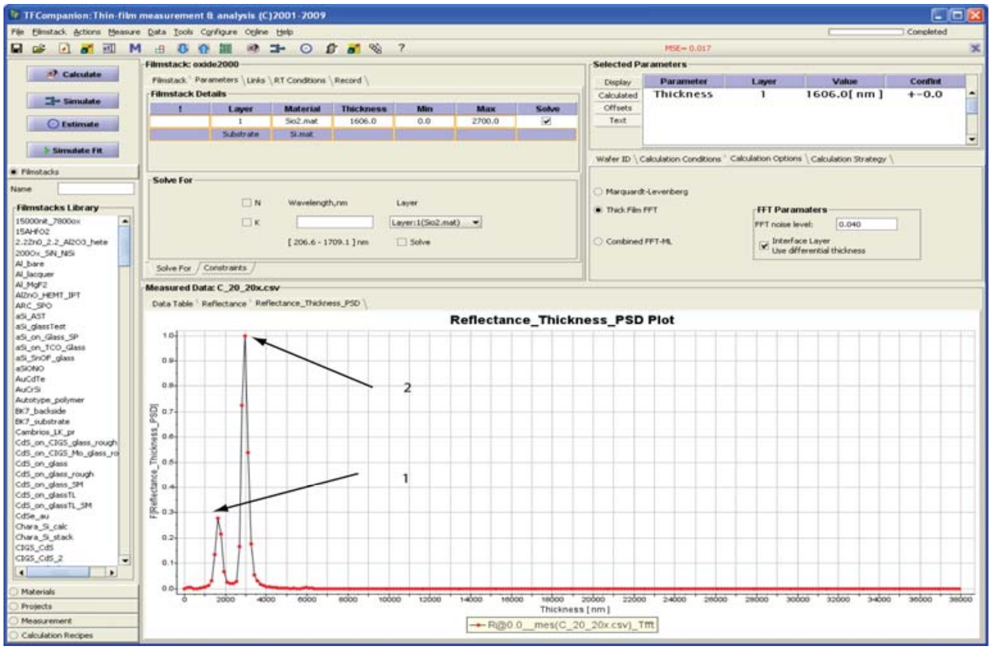
FFT noise level: 0.040

☑ Interface Layer Use differential thickness

Measured Data: C_40_20x.csv

Fig. 4 40μm diameter well, oxide thickness 1605 nm. 1st – peak correspond to oxide layer. 2nd – peak correspond to PR layer. PR peak is small indicating that a very small fraction of light is reflected from PR coated area.

III Measurement 20µm Round/circular well (aspect ratio- 5)



Filmstack: oxide2000

Filmstack Details

!	Layer	Material	Thickness	Min	Max	Solve
	1	Sio2.mat	1606.0	0.0	2700.0	☑
	Substrate	Si.mat				

Solve For

☐ N Wavelength,nm Layer
☐ K Layer:1(Sio2.mat)
[206.6 - 1709.1] nm ☐ Solve

Selected Parameters

Parameter	Layer	Value	Confint
Thickness	1	1606.0[nm]	+-0.0

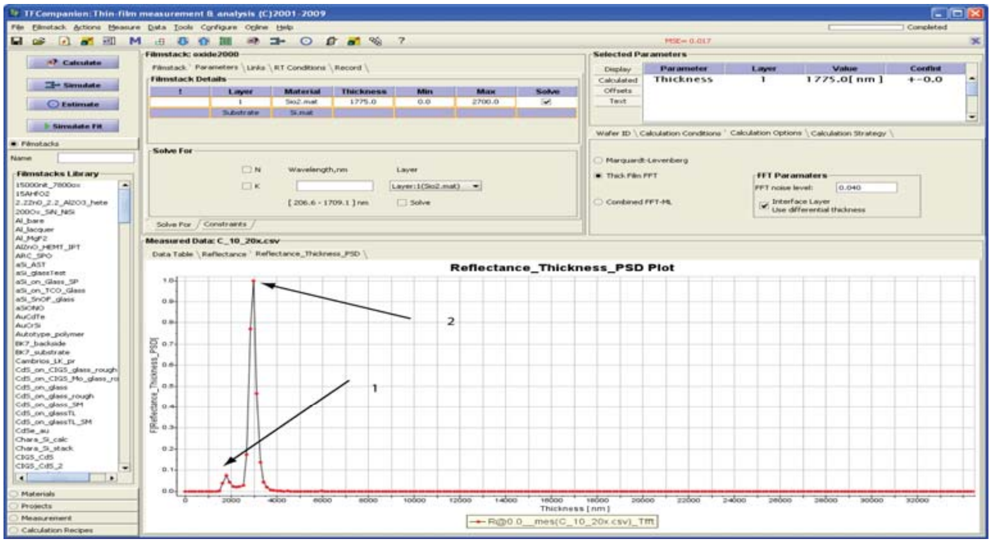
○ Marquardt-Levenberg
● Thick Film FFT
○ Combined FFT-ML

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

Measured Data: C_20_20x.csv

Fig. 5. 20µm well, oxide thickness 1606 nm. 1st – peak corresponding to oxide layer. 2nd – peak corresponding to PR layer. Good portion of light is reflected from the PR but we can clearly determine oxide thickness as well

IV. Measurement 10µm Round/circular well (aspect ration - 10)



Filmstack: oxide2000

Filmstack Details

!	Layer	Material	Thickness	Min	Max	Solve
	1	Sio2.mat	1775.0	0.0	2700.0	☑
	Substrate	Si.mat				

Solve For

☐ N Wavelength,nm Layer
☐ K Layer:1(Sio2.mat)
[206.6 - 1709.1] nm ☐ Solve

Selected Parameters

Parameter	Layer	Value	Confint
Thickness	1	1775.0[nm]	+-0.0

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

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

Measured Data: C_10_20x.csv

Fig. 6 10µm well, oxide thickness 1775 nm. 1st – peak corresponding to oxide layer. 2nd – peak corresponding to PR layer Thickness 1606nm. Large portion of light is reflected from the PR but we can still clearly determine oxide thickness.