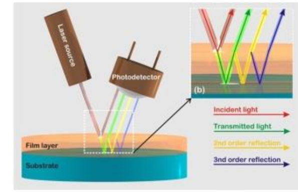
ThetaMetrisis APPLICATION NOTE #034

Thickness measurements of thin and ultra-thin metallic films



Introduction: Film thickness is of vital importance for the performance of the coatings and in particular for the thin and ultrathin films. Therefore it is important to employ very accurate and non-destructive methodologies for the characterization of such films. Optical methods for thickness determination of films offer the advantage of being noncontact, nondestructive, fast, precise, sensitive and reproducible. In this application note we measure the thickness of metallic thin and ultra-thin films using FR-Tools.

Means & Methods: Samples under investigation were thin films of iridium and gold on top of Si wafer. Those films were deposited in a wide thickness range by standard sputtering tools. The characterization of the films was done through specular reflectance measurements by a **ThetaMetrisis FR-pRo UV/VIS** tool, operating at the 280-700nm spectral range.

Results: In the UV/VIS spectral range, metals present high absorbance and the maximum film thickness that can be measured is material dependent several tens of nanometers. For example the maximum film thickness for some metals is presented in the table below.

Metal	Max thickness (nm)	Metal	Max thickness (nm)
Al	30nm	**Au**	50nm
Ti	40nm	**Ir**	45nm
Pt	35nm		

Typical experimental reflectance spectra (black line), and fitted reflectance spectra (red line) as recorded by the FR-Monitor software, for both Au and Ir films, are illustrated in the figures below.

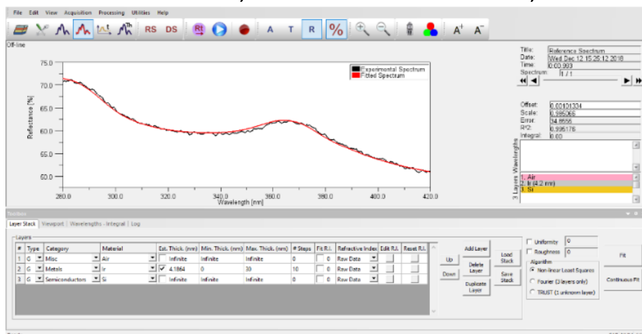


Figure 1: *Experimental and fitted reflectance spectra of* ***Ir ultra-thin film on top of Si*** *at 280-420nm spectral range. The thickness was measured* ***4.2nm.***

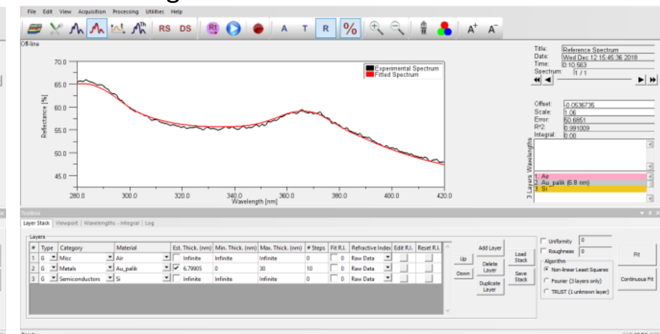


Figure 2: *Experimental and fitted reflectance spectra of* ***Au thin film on top of Si*** *at 280-420nm spectral range. The thickness was measured* ***6.8nm.***

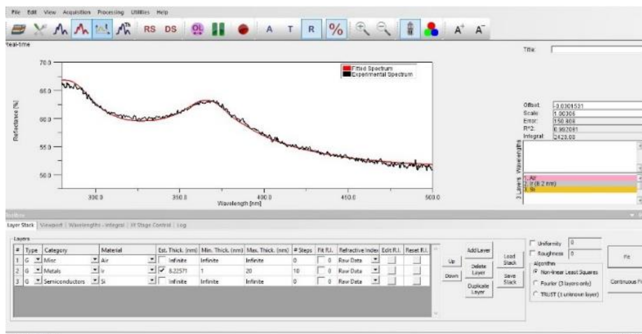


Figure 3: *Experimental and fitted reflectance spectra of* ***Ir ultra-thin film on top of Si*** *at 280-500nm spectral range. The thickness was measured* ***8.2nm.***

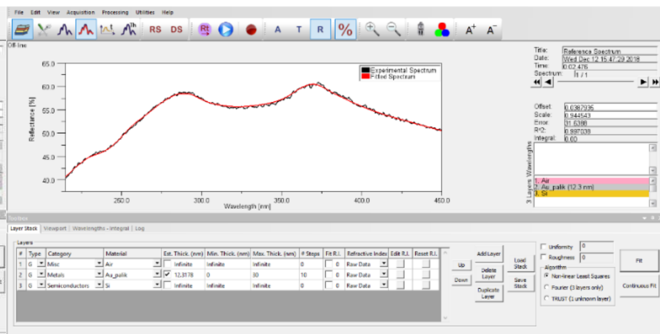


Figure 4: *Experimental and fitted reflectance spectra of* ***Au thin film on top of Si*** *at 300-700nm spectral range. The thickness was measured* ***12.3nm.***

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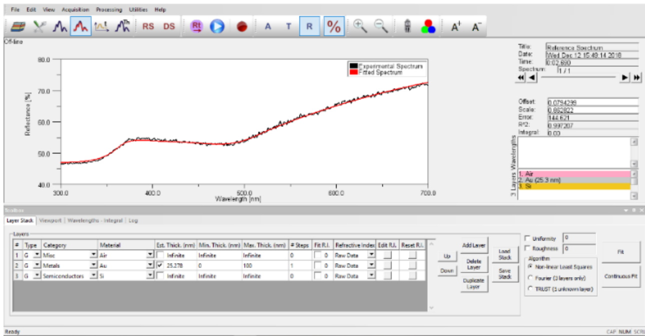


Figure 5: *Experimental and fitted reflectance spectra of **Au thin film on top of Si** at 300-700nm spectral range. The thickness was measured **25.3nm.***

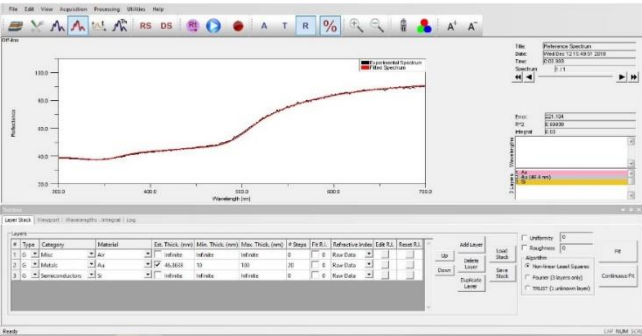
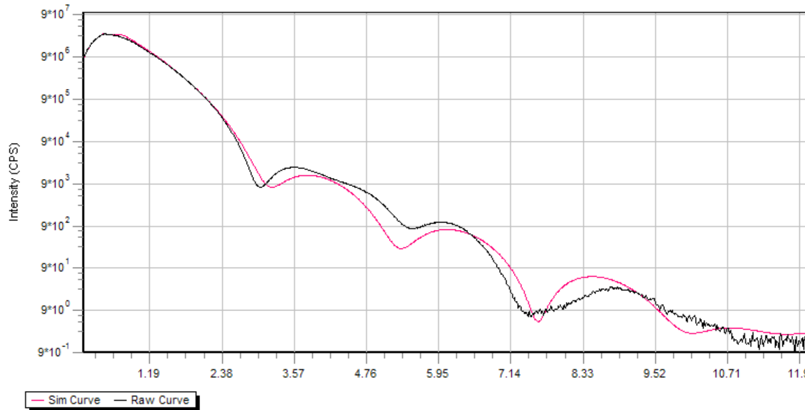


Figure 6: *Experimental and fitted reflectance spectra of **Au thin film on top of Si** at 300-700nm spectral range. The thickness was measured **46.4nm.***

In order to confirm the thickness measurement results, we used the **XRR (X-Ray-Reflectometry) technique**. A typical example of XRR thin-film measurement of ***Ir ultra-thin film on top of Si*** is shown in the figure below.



N	R	Material	Cell input	Thickness	Roughness	Profile	Grading	Density T	Density B	Density N
1	1	Ir	density	2.70	0.000	Sinusoidal	10	0.10000	21.15910	22.56000
2	1	Ir	density	1.25	0.073	No Gradient	10	21.15910	21.15910	22.56000
SUB	1	Si	density	0.00	0.357	No Gradient	0	2.32910	2.32910	2.32910

Figure 7: ***Ir ultra-thin film on top of Si thickness measurement*** using X-Ray Reflectrometry thin-film measurement technique. *The thickness was measured **3.95nm***

Conclusions: The thickness of thin and ultra-thin metallic layers on top of Si was successfully measured using FR-Tools. Thickness measurement results were also identified using XRR technique. FR-Tools are the economical and non-destructive solution for thin and ultra-thin metallic films thickness measurement.

Acknowledgments: The XRR measurements and their analysis were carried out by Dr K. Mergia and Dr I. Michelakaki of the Institute of Nuclear and Radiological Science and Technology of the National Centre of Scientific Research “Demokritos”, using a D8 Bruker X-ray diffractometer with Cu Kα parallel beam stemming from a Göbbel mirror and a scintillator point detector.

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