Semiconsoft,Inc

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

THIN METALS MEASUREMENT WITH MPROBE

Optical thickness measurement using spectroscopic reflectance or transmittance is predicated on the film being translucent, i.e. light need to be able to penetrate the film and reflectance from the bottom interface returned back. Only in this case, one can measure optical phase (δ) and analyze it to determine thickness and n &k of the material. Optical phase $\delta = \frac{2\pi d}{\lambda} n$, where d – thickness of the film, λ – wavelength of light, n – refractive index of the material.

In case of the metal films, only films below 40 or 50 nm thicknesses can be measured. The actual measurable thickness depends on the type of the metal. Table I list measurable thicknesses for several metals. It assumes that metal surface is smooth (mirror) – surface roughness will cause scattering and decrease of the measurable thickness.

Metal	Maximum thickness, nm	Comments
Au	**45 nm**	
Ag	**60 nm**	
Al	**30 nm**	
Cu	**60 nm**	
Co	**35 nm**	
Fe	**55 nm**	
Pt	**35 nm**	
Ni	**40 nm**	
W	**55 nm**	
TiN	**65 nm**	For stoichiometric TiN

Table I. Measurable thickness of different metal using UVVis reflectance spectrum (200nm - 1000nm).

Another challenge of metal films measurement is the measurement precision. Typically, one uses shorter wavelengths (UV) for precise measurement of thin films <20nm (at shorter wavelengths, optical phase δ is larger – hence better precision). But, in case of the metal films, this is limited by high absorption in UV. Estimated precision of metal films measurement is listed in Table II.

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

Thickness, nm	Precision , nm	Precision, %
1 nm	**0.1 nm**	10 %
10 nm	**0.2 nm**	2 %
20 nm	**0.5 nm**	2.5 %
30 nm	**1 nm**	3.3 %
40 nm	**2 nm**	5 %
50 nm	**2.5 nm**	5 %

Table 2. Precision of W film measurement depending on the thickness (using measured reflectance precision: 0.5%).

Precision decreases with increase of the film thickness. It does not present a significant problem when a single metal film need to measured. However, the problem becomes apparent if one tries to measure a very thin metal film on the bottom of the film stack. For example, let us take (2.5nmNi / 2.5nm W) x10 structure. The total thickness of the metal stack is 50 nm – this is about a maximum measurable thickness for W or Ni., So one maybe able to measure this thickness, assuming clean and smooth interfaces. However, if one would try to determine the thickness of the bottom W layer - the error is expected to be 2.5 nm i.e. 100% of the layer thickness. So, one may be only able to measure thicknesses of the top few layers.

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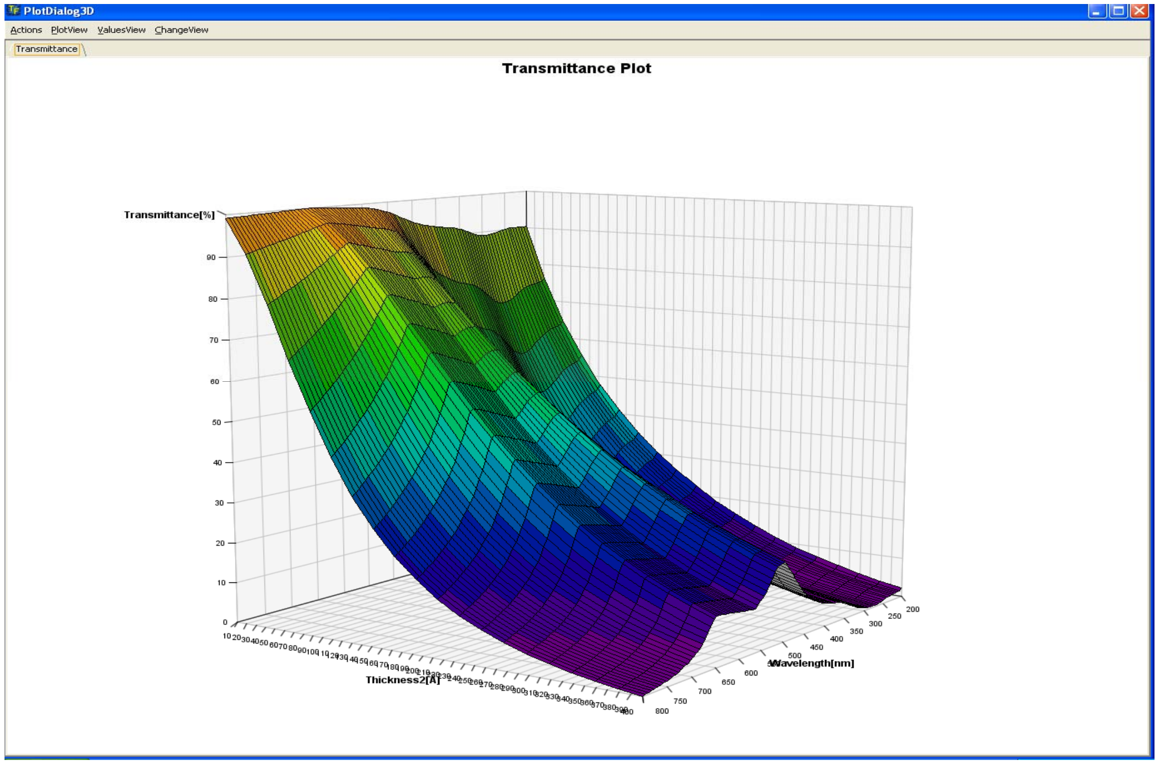
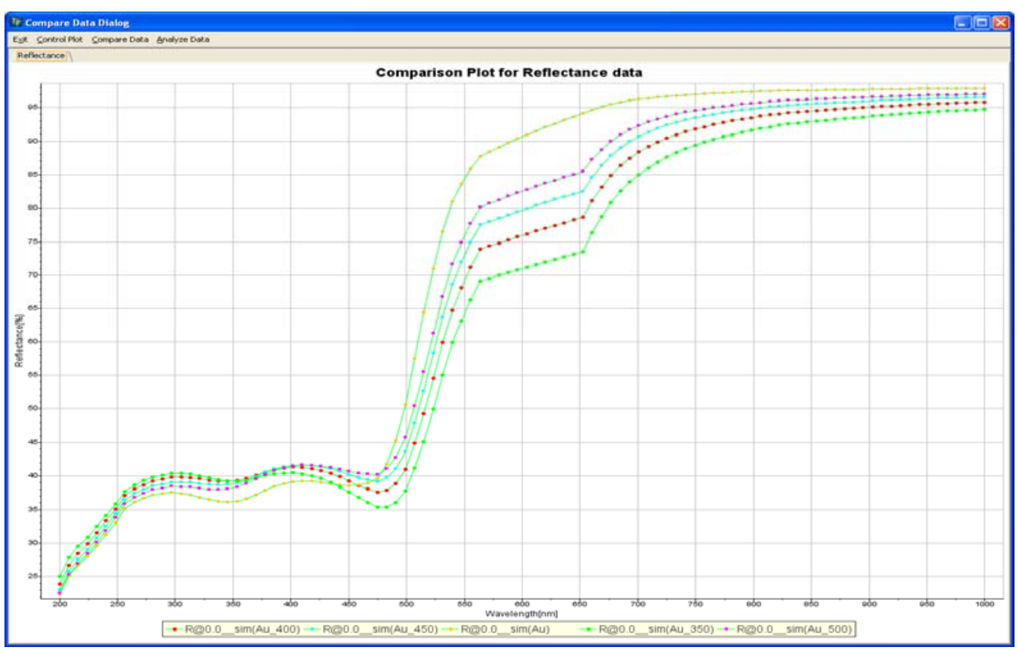


Fig. 1 Transmittance of the Au layer (Y – Transmittance, X – thickness, Z – Wavelength). Transmittance decrease rapidly with the thickness.



Fig, 2 Reflectance spectrum of Au film in quartz,. Spectra from top to bottom: Au substrat (solide Au), 50nm, 45 nm, 40 nm and 35nm Au film. 50nm Au reflectance can be clearly distinguished from Au substrate reflectance in the Vis range.

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