A new film thickness measurement technique: Differential Interferometric Profiling (DIP) similarities and complementarities with ellipsometry

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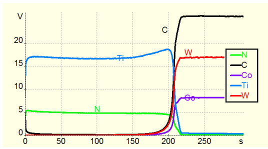
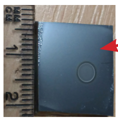
Aim of the work

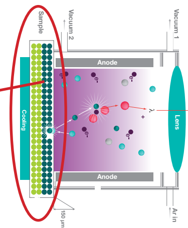
This works reports a new instrument, that provides composition information on films as a function of depth. It is the result of the combination of GD-OES* technique, a fast and powerful elemental profiling technique, with an interferometer that determines the etched depth as a function of time.

* K. Shimizu et al. , H. Habazaki, P. Skeldon and G. E. Thomson, Radiofrequency GDOES: a powerful technique for depth profiling analysis or thin films, Surf. Interface Anal. 35, 564 (2003).

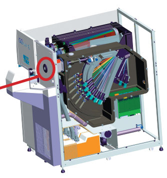




Sample after analysis

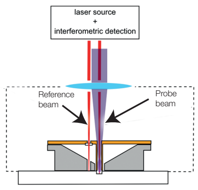


Working principle of GD-OES

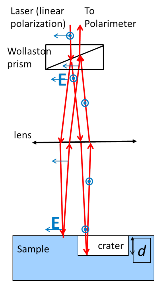


GD-OES Profiler

Experimental details



A differential laser interferometer has been integrated in the GD-OES setup.
Its probe beam is reflected by the crater bottom, and reference beam by the un-etched sample surface



It is a polarization-based interferometer of the same familiy as Nomarsky DIC in microscopy.

It determines:

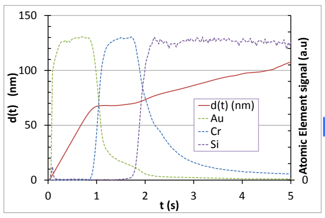
$$\frac{R(t)}{R(0)} = \rho(t)e^{-i\Delta(t)}$$

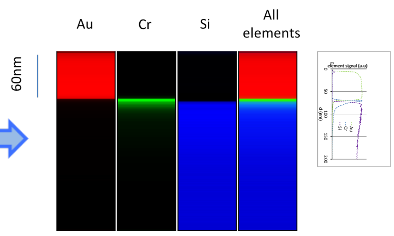
It is an «ellipsometry-like» quantity

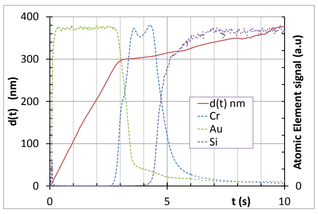
For opaque materials, the depth d is obtained from the phase measured by the interferometer:

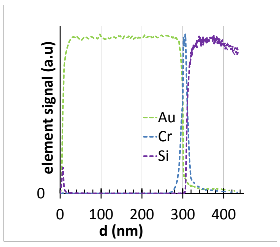
$$\Delta(t) = \frac{4\pi}{\lambda} . d(t)$$

Results on Au thin films

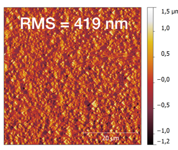


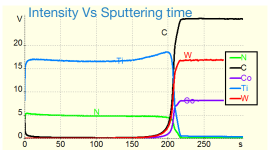






Results on a rough sample, PVD-deposited TiN coating





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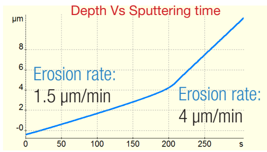
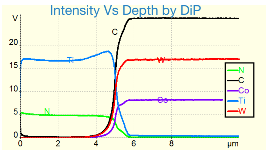
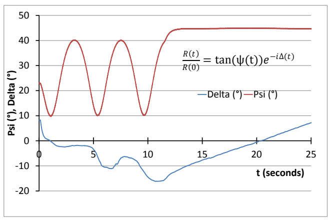


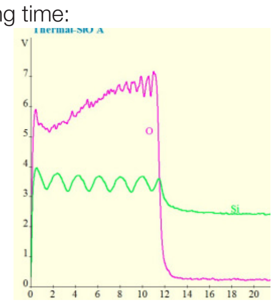


Total depth:
- 11.6 µm by DiP
- 11.5 µm by profilometer

Case of transparent layers

SiO_2/Si sample: interferometric signal and composition signals recorded on as a function of etching time:





Opaque layer approximation is not valid=> optical modelling is required

Is DiP creating opportunities to you?

	Ellipsometry	DiP	complementarity	similarity	opportunity
Instrumentalist point of view					
working principle	polarimetry	includes a normal incidence interferometer			
	oblique incidence Rp(λ)/Rs(λ)	normal incidence R(t)/R(0)			
modelling activity	many well-established fitting procedures	still has to be investigated and developped for transparent films and multilayers			+++
Composition information	deduced from optical index	elemental composition			
Laboratory user point of view					
applicable to	light-penetrable films	transparent and opaque films			+++
	mirror-like and moderately diffusive samples	mirror-like to highly diffusive samples (laser)			+
Thickness range	subnm - 10µm	5nm - 100µm			
Thickness retrieval algorithm	Material model + fitting procedure	opaque layers: thickness is obtained directly from interferometric Phase			++
		light-penetrable layers: Fresnel coefficient fitting procedure required			
Composition information	deduced from optical index	elemental composition			
Time required for a measurement	few minutes	few minutes			+++
skills required to operate instrument	accessible to any material scientist	accessible to any material scientist or technical staff			+++
Price	$$	$$+50%			
Analysis spot size	few mm to 10µm	5mm			
Reuse of sample	non-destructive	destructive			

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