Using GD-OES to Characterize Challenging Thin-Films and Advanced Materials

By Dr. Fuhe Li

Introduction
This article summarizes the use and advantages of using Glow Discharge Optical Emission Spectroscopy (GD-OES) as part of an overall analysis program for advanced materials (i.e. hafnium and zirconium precursors) and any other thin-films. Other equipment and techniques such as Laser Ablation IC-PMS and SIMS provide complimentary data to provide a comprehensive analytical report of a sample (Table 1).

Technique	Elements Detected	Profiling Mode	Analysis Area	Detection Limit
GD-OES	Periodic Table	Survey	4 mm	ppm
	Including H, O, C, N and Cl	Simultaneous up to 46 elements		
LA-ICP-MS	Periodic Table	Survey	5 µm	ppm - ppb
	Except for He, H, F, N, Ar, and O	Simultaneous up to 85 elements		
SIMS	Periodic Table	Sequential	75 µm	ppm - ppb
	H to U	1-5 elements per film thickness		

Table 1: Summary of equipment/techniques used in material analysis

GD-OES provides fast, simultaneous analysis of all elements of interest including carbon, nitrogen, oxygen, hydrogen and chlorine. It is an ideal tool for thin film characterization, contamination identification and depth profiling. Accommodating fragile samples using an RF plasma source operating in pulse mode, use of GD-OES is ideal for semiconductor and other high-tech industries.

Thank you to Horiba Jobin Yvon for providing the majority of the pictures and graphs used in this article.

Principles of Function

The basic principle of operation relies on an applied voltage from an anode to the sample (acting as the cathode) in an argon-rich environment. Electron interactions with the argon gas create positively charged argon ions that are drawn to the sample surface. Upon collision at the sample surface (sputtering), atoms are released from the sample. These atoms become excited and de-excited upon collision with argon, ultimately leading to photon emission. The photons, or the 'glow', are measured via optical emission spectrometry to identify elemental make-up of the surface. Figures 2 and 3 summarize the aspects of a typical sputter spot on a sample surface.

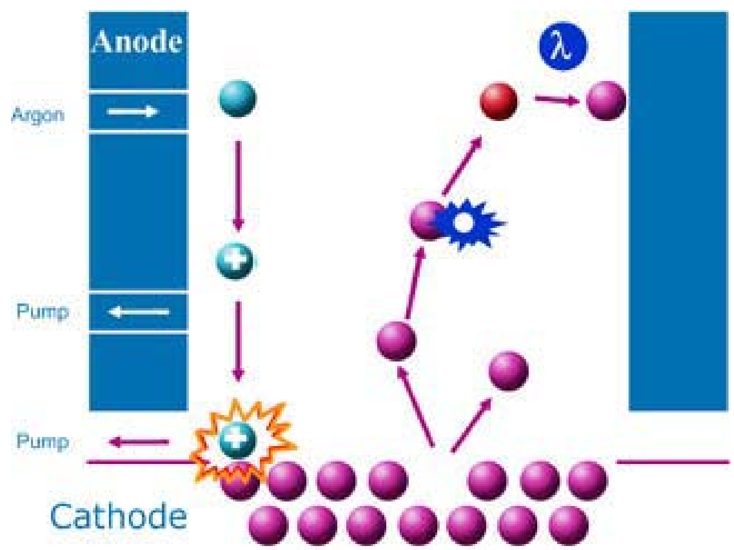

Figure 1: Example of glow discharge 'sputter' interaction

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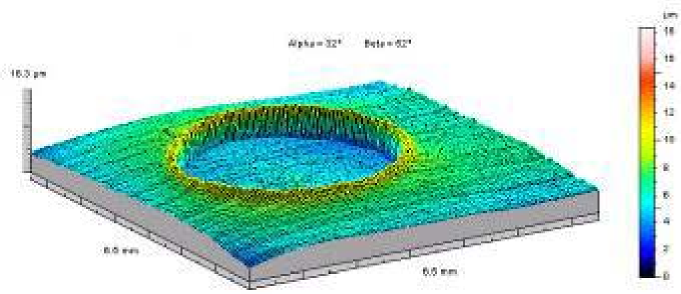


Figure 2: Typical glow discharge crater shape

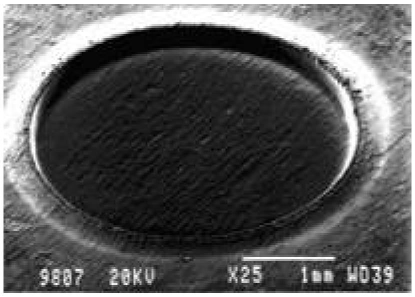
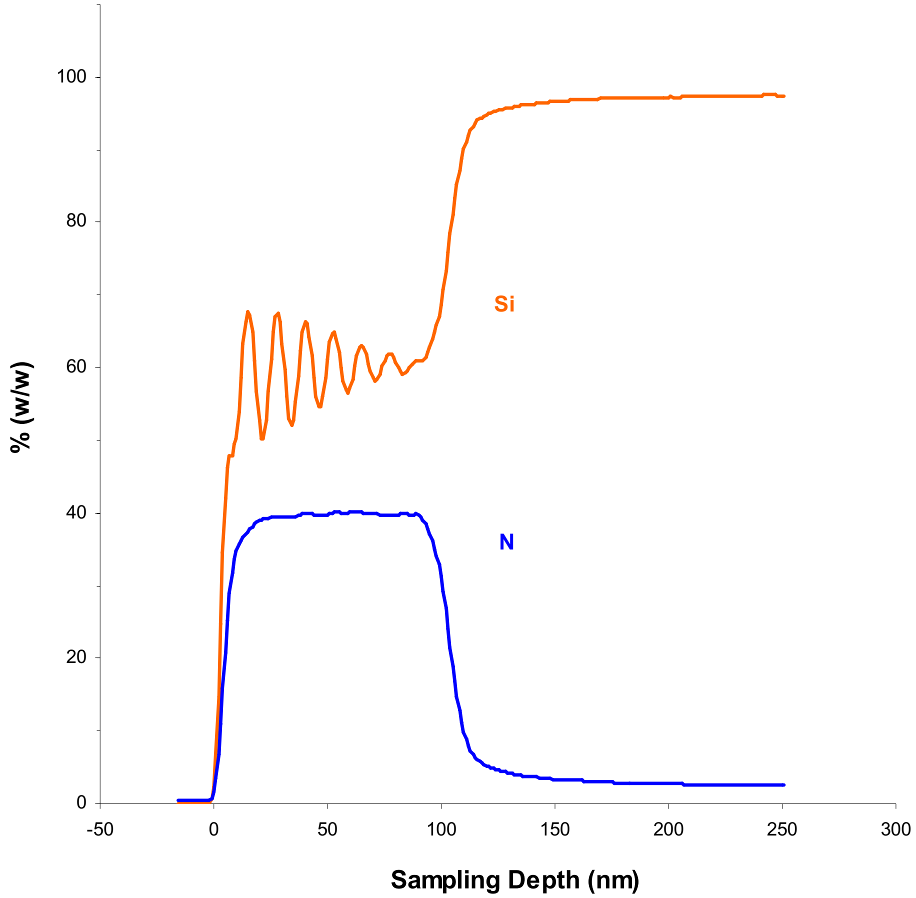


Figure 3: SEM image of a sputter spot

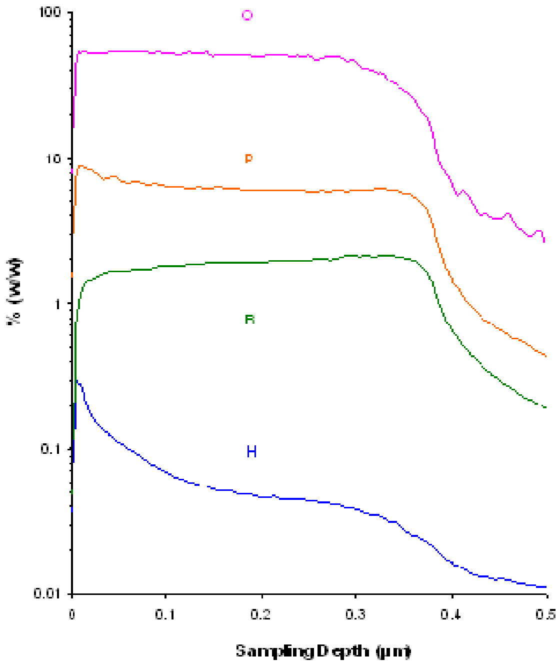
Examples of GD-OES Analyses for Various Films

The following pictures and graphs illustrate the range materials the GD-OES methods analyze. The results provide data to characterize a thin-film, identify contamination and provide high-resolution depth profiling.

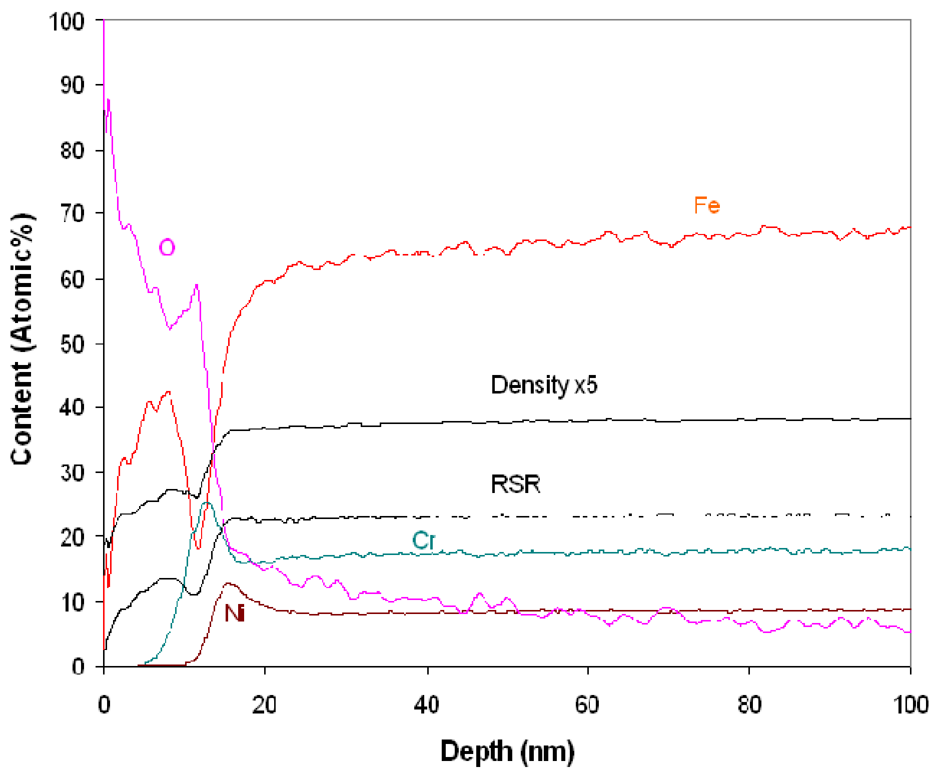
Si_3N_4 Films



BPSG Films



Thin Oxide on Stainless Steel



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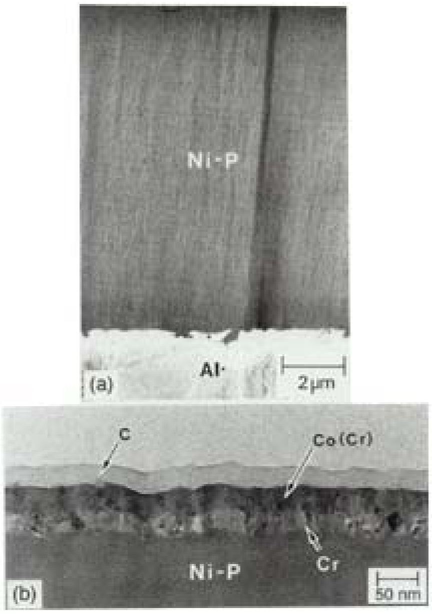
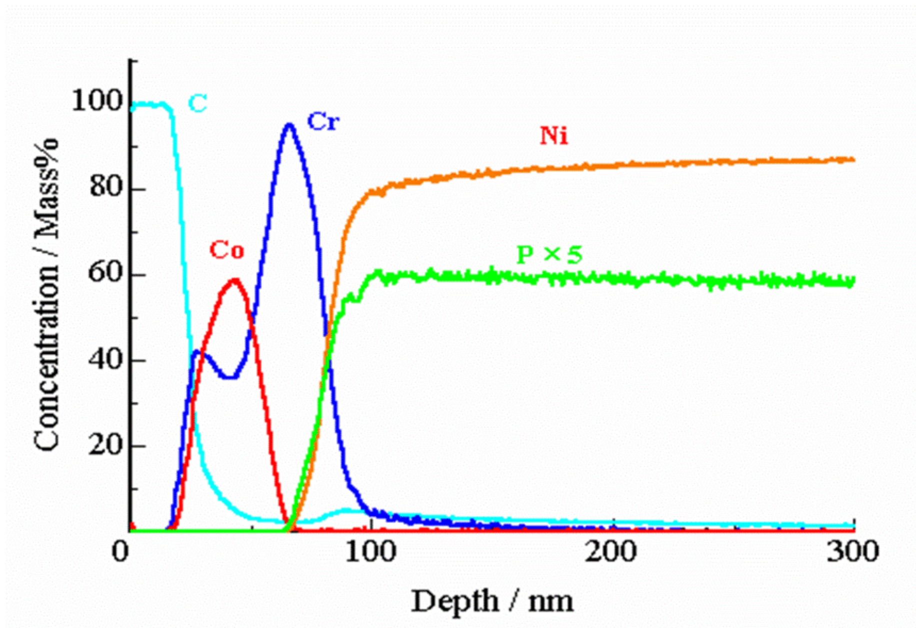
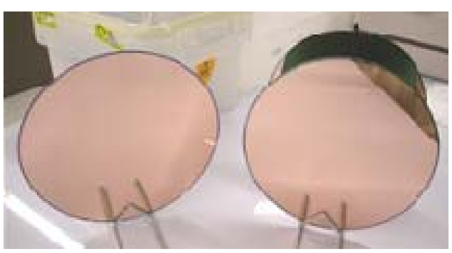
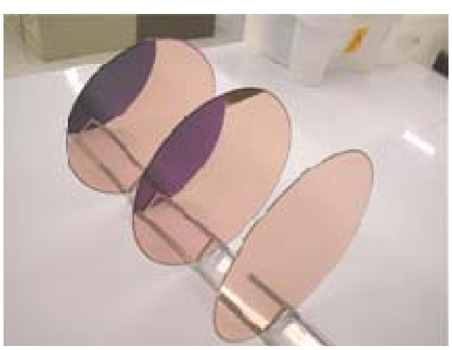
Hard Disk Analysis

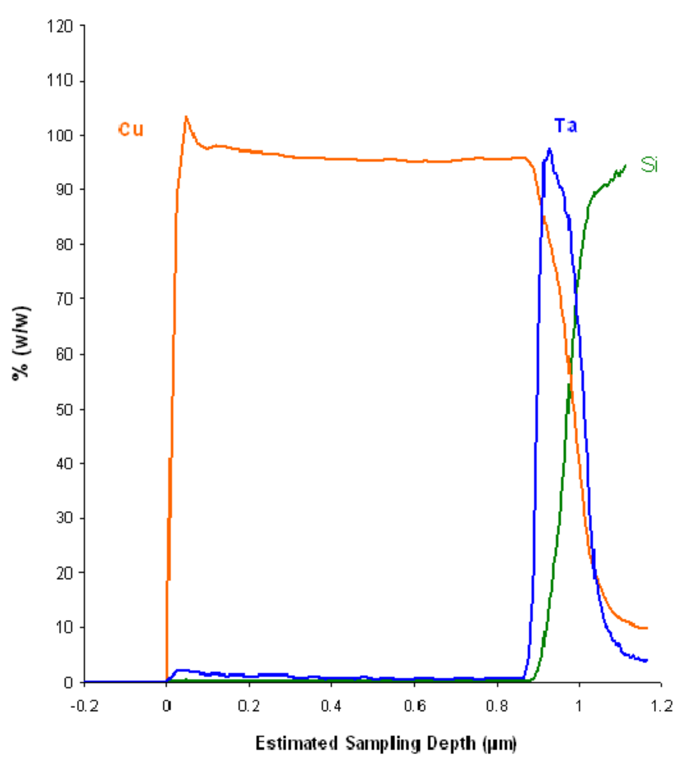




Copper Film Consistency







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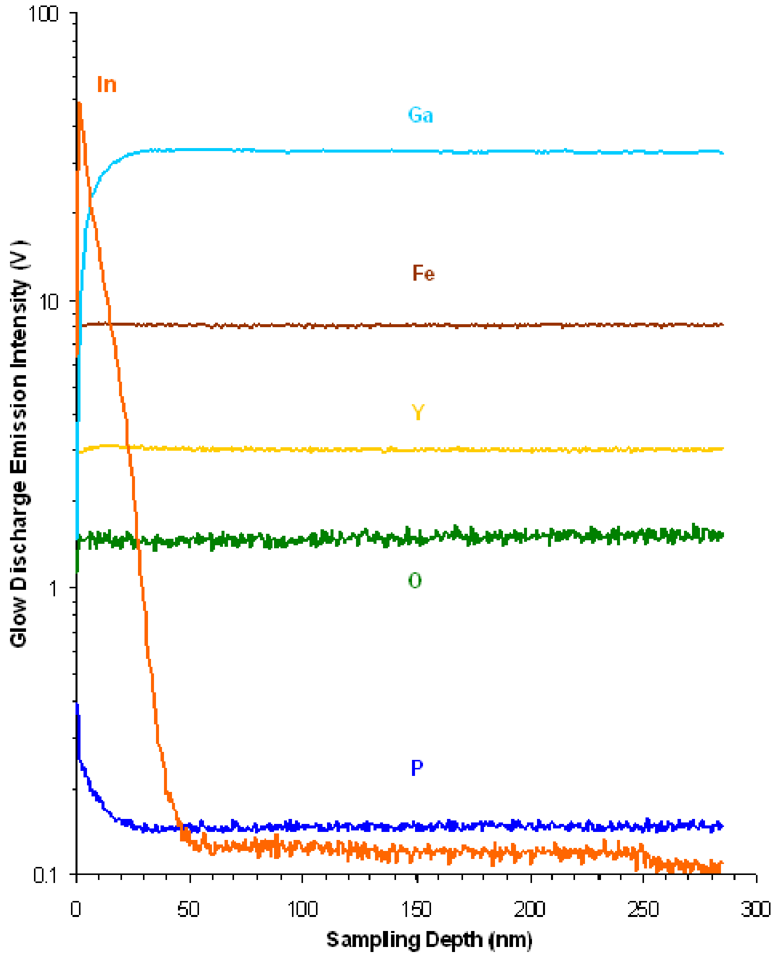
Solar Cell - InGaP Profile



Benefits of Using GD-OES in Conjunction With Other Techniques

- **Simultaneous depth profiling capability-** GD-OES can be used for elemental survey by simultaneously depth profiling more than 40 elements in a film or a material while maintaining a similar depth resolution to SIMS
- **Ultra-fast analysis**
- **No charge effect-** Use of an RF plasma source, instead of an ion or electron beam, for sputtering allows for conductive and insulating films to be analyzed without sample modification and the disruptive presence of charge effects.
- **Large sample spot (4mm)**- Provides a more representative sampling for heterogeneous materials.
- **Increased sensitivity and higher spectral resolution-** when compared with techniques such as Auger and ESCA

Read more about thin-film and depth profiling program