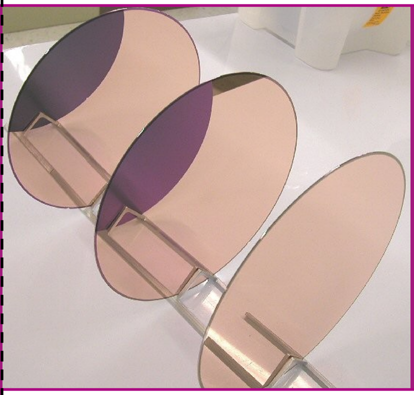
Film Characterization



Product Improvement Through Characterization of Impurities and Composition of Films

Balazs™ NanoAnalysis is experienced in characterizing the composition and impurities of high technology films used in the semiconductor, solar / photovoltaic, biomedical, aerospace and optoelectronics industries. These films may be prepared by sputtering, electroplating or evaporating materials onto substrates that include Si, III-V, II-VI, glass and alloys. Our R&D group, Thin Film Laboratory and Advanced Materials Laboratory are focused on developing analytical protocols for characterizing new materials used for a wide variety of applications (Table 1).

Table 1. Common Films and Their Applications

Common Films	**Film Applications**
Plasma enhanced CVD	Sputtering targets, target bonding, backing plates and crucible liners
Epitaxial	Precision optics for defense, imaging and telecommunications
Polymer	Multi-layer alloy structure for opto- and micro-electronics
Particulate (e.g. ZnO)	Polymer films for advanced chip-scale, wafer level and flip chip packages
Porous (e.g. CdS and SnS)	Liquid polyimides for advanced packaging as wafer level bumping gap filling
Solar thin films	Semiconductor films for photovoltaic panels, solar cells and solar windows
Alloy	Magnetic films for digital storage
Oxide	Multi-layered X-ray mirror
Silicide	Analytical test standards

Film composition, impurities and thickness are important parameters for process development and production. Any variations in these parameters can result in significant yield loss and reliability issues. The integrity of thin films is influenced by the quality of its adhesion to the underlying layer and to the presence of surface imperfections such as pinholes. Reliable thin film adhesion depends greatly on the cleanliness of the surface upon which the film is deposited. Balazs^{TM} offers a suite of analytical metrology for characterizing a variety of films.

Stoichiometry Measurement

The composition of films can affect its properties. For example, the film polarity-dependent resistance switching in GeSbTe thin films depends strongly on Sb composition. Wet chemical preparation of the film followed by ICP-OES analysis (Table 2) provides accurate stoichiometry information that will lead to optimizing its data storage application.

Table 2. Verification of $Ge_xSb_yTe_z$ (GST) Film Stoichiometry

Replicates	1	2	3	4	5	6	7	Average	S.D.	RSD
Ge	1.93	1.99	1.95	1.93	1.94	1.96	1.94	1.95	0.021	1.09%
Sb	2.01	2.03	1.99	2.04	2.05	2.02	1.98	2.02	0.026	1.27%
Te	4.98	4.94	4.92	5.01	4.95	5.03	4.94	4.97	0.041	0.82%

Metal Impurities

Atomic layer deposition (ALD) is preferred over a sputtering process to fill sublithographic holes because of its inherent excellent conformity. Small amounts of impurities are known to increase the crystallization temperature and affect the resistivity of the films. GD-OES and LA ICP-MS are elemental survey techniques that can depth profile or provide total film impurity concentrations in the film. Metal impurities at the surface and at the interface of the film are just as important as these surfaces can affect the performance and quality for the film. Table 3 shows analytical techniques suitable for characterizing a film.

Table 3. Elemental Survey Test Methods

Surface	XPS	Chemical state information, survey analysis
	VPD ICP-MS	Native oxides, survey analysis
In-Film	GD-OES	Large area analysis of blanket films, survey analysis
	LA ICP-MS	Small area analysis, survey analysis
	Direct Strip Etch and ICP-OES	Total film analysis, survey analysis
Interface	GD-OES	Interfacial survey

Organic Composition

Spin-coated thin films of organic-inorganic hybrid materials such as semiconducting perovskite $(C_6H_5C_2H_4NH_3)$ 2SnI4 can form conducting channels. Molecular engineering of the organic and inorganic components of these organic-inorganic hybrid materials is expected to further improve device performance for low-cost thin-film transistors. Organic components in films may be characterized by FTIR, Raman, UV-Vis and TD GC-MS. These techniques are also useful for characterizing precursors used in metal organic chemical vapor deposition (MO-CVD).

Table 4. Organic Composition Test Methods

Surface Residue	Full Wafer Desorption TD GC-MS	Organic compound semi-quantitative survey
	Solvent Extraction and TD GC-MS	Extraction efficiency specific to solvent used, survey
	FTIR-NVR	Residue quantified and identified
In-Film	FTIR	Contaminants detected within analysis depth of the technique
	Raman	

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