Photovoltaic Contamination Solution

Analysis - Starting Materials to Solar Products

Balazs™ NanoAnalysis is experienced in analyzing contamination in various solar substrate materials, PV specialty chemicals and gases, ultrapure water, process films, cell process equipment, and the cleanroom environment. Balazs™ understands the need to bring solar cell manufacturing costs down and to continually improve and introduce new solar process technologies and equipment to the production line. Our scientists have experience with the solar technologies and our analytical staff are experts in materials characterization and in resolving contamination issues relating to the manufacturing processes of solar cell and panel production.

Solar Technologies

- Silicon wafer substrates: mono-crystalline and polycrystalline
- Thin film: copper indium (gallium) diselenide (CIS and CIGS), CdTe and amorphous or microcrystalline Si
- III-V materials in multi-junction photovoltaic cells: InGaP/GaAs, InGaAs/Ge), and InGaAsP/InP
- Organic photovoltaic (OPV) and dye sensitized solar cell (DSC) devices

Table 1. Characterization Matrix for Materials and Solar Cell Processes

Materials and Processes for Solar Cell Production	AES	EDS	GD-OES	IC	ICP-MS	ICP-OES	LA ICP-MS	SIMS	TXRF	VPD	XRF	FTIR	Raman	XPS	GC-MS	TD GC-MS	TOF-SIMS	TGA	SEM
PV-Si																			
Wet Etch																			
Wet Clean																			
CVD/PECVD/PVD																			
Film Deposition																			
Doping																			
Thermal Anneal																			
Water																			
Specialty Chemical																			
Specialty Gases																			
Gas (CDA, N_2, etc)																			

Elemental information
Chemical bonding
Organic information
Thermal
Imaging

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Photovoltaic Silicon

Metals can affect solar cell yield and performance. Monitoring the total concentrations of individual metals and their spatial and size distribution is important during substrate processing.

Figure 1. Bulk Si chunks

- ICP-MS provides bulk multi-element survey at 8N-10N (ppbw) detection sensitivities. Balazs™ is developing this as a Standard Test Method (STM) for the SEMI Photovoltaic Committee
- GD-OES and LA ICP-MS are two advanced multi-element survey depth profiling techniques. Their high sputtering rates, in the order of microns/minute, makes them ideal for profiling trace metal impurities in the bulk of the material. They can detect metals present as intragranular inclusions in the material or as nanoprecipitates along a grain boundary. In addition, these techniques can determine the composition of the material at >1 atomic% level.
- SIMS provides element-specific distribution analysis with ppbw detection sensitivity for most elements when 1-3 elements are monitored in a single profile.

Specialty Chemicals and Gases

A wide variety of PV chemicals (organic, acid and base) and gases (reactive, inert and specialty) are used in a solar cell production line. Through high performance analysis of incoming chemicals and gases it is possible to minimize surface defects after cleaning and etching. These analyses are a cost effective way to improve the conversion efficiency by avoiding issues relating to non-uniformity, phase separation and defects in the deposited films.

Thin Films

A complete characterization of thin films such as CdTe, CdS, CIS and CIGS will ensure their designed properties are optimized for solar cell efficiency. Any imperfections in the film can affect electron transport.

- ICP-MS and IC - surface extraction for metallic and ionic quantification
- GD-OES - depth profiling and interfacial multi-element surveys
- LA ICP-MS - multi-element survey in bulk and depth profiling modes
- SIMS - single to 3 elements depth profiling
- FTIR and Raman - structural and amorphous/crystallinity information
- TD GC-MS – organic identification
- SEM - layer thickness uniformity
- XRF - elemental composition and thickness

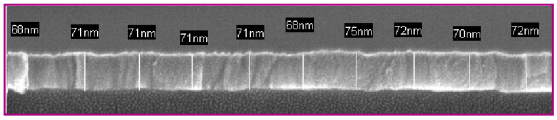

Figure 2. Cross-section of a PV film showing thickness and structural information

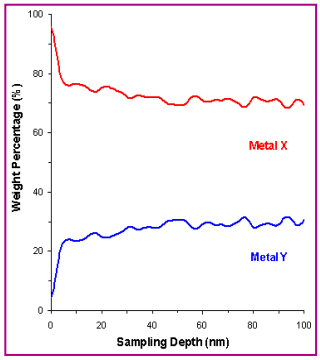

Figure 3. GD-OES stoichiometric depth profile of a solar film after surface treatment. Result correlated with PL, PCD and XPS

Clean Manufacturing

Following clean manufacturing practices in the facility and on the process line will minimize the risk of introducing extraneous contamination during solar cell production and module assembly. Balazs™ offers on-site Gap Analysis and Optima™ training for your production line engineers and supply chain.

Table 2. Contamination Test Matrix for Optimizing Solar Manufacturing Operations

Contamination Control During Manufacturing Operations	AES	DSE	EDS	GD-OES	IC	ICP-MS	ICP-OES	LA ICP-MS	SIMS	TXRF	VPD	XRF	FTIR	Raman	XPS	GC-MS	TD GC-MS	TOF-SIMS	TGA	SEM
Airborne Molecular Contamination																				
Surface Molecular Contamination																				
Tool Parts Cleanliness																				

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