HORIBA Scientific

Application Note

Photovoltaic

Glow Discharge Spectrometry

GD 17

Features and Benefits of Pulsed RF GD OES for the development of PV cells

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Abstract

Pulsed RF Glow Discharge Optical Emission Spectrometry offers Ultra Fast Elemental Depth Profiling capability of thin films PV solar cells allowing the optimisation and control of each stage of the evaporation, deposition or heat treatment processes and permitting to quickly react to observed variations.

Key words

PV, Thin films, Optimisation of the deposition, Depth Profile Analysis, Gradients, Interfaces, GD OES, Pulsed RF source

Introduction

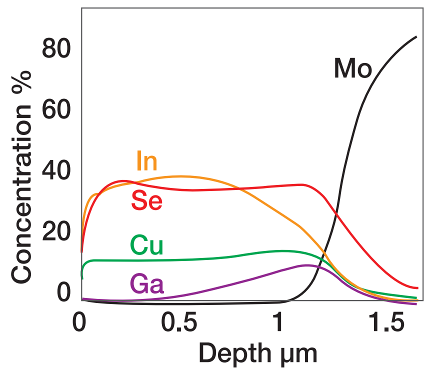
Thin films PV feature multilayered materials deposited either on glass or on flexible substrates. Compositional gradients and interfaces are crucial for high efficiency. Pulsed RF Glow Discharge Optical Emission Spectrometry provides Ultra Fast Elemental Depth Profiling and helps to optimize the laboratory research and to follow the up-scaling at the manufacturing level.

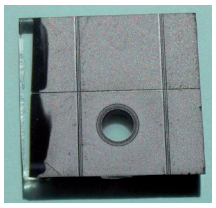
Instrumentation

The GD Profiler 2 couples an advanced Pulsed RF Glow Discharge Source to a high resolution, wide spectral range Optical Emission Spectrometer.

The source permits a precise and fast sputtering of a representative part of the material investigated (typically 4mm in diameter). The pulsed RF operation is crucial to avoid unwanted diffusion of the elements during the measurements

The spectrometer simultaneously measures all elements of interest (Na, H, O, Si, C, Ca, C, Zn, Cd, Te, Cu, In, Ga, Se, Mo, Sn, Al etc) as a function of the sputtered depth.





Analysis of a CIGS absorber layer by pulsed RF GD-OES

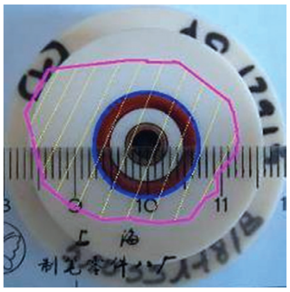
Key Features

SPEED: Less than 3 minutes to profile an entire cell and reach the glass substrate

EASE of USE: The GD source does not require any UHV, the sample to analyse is simply placed against an o'ring facing the anode tube in which the plasma is confined

DEPTH RESOLUTION: Nanometre (sample roughness dependant)

GD Profiler 2

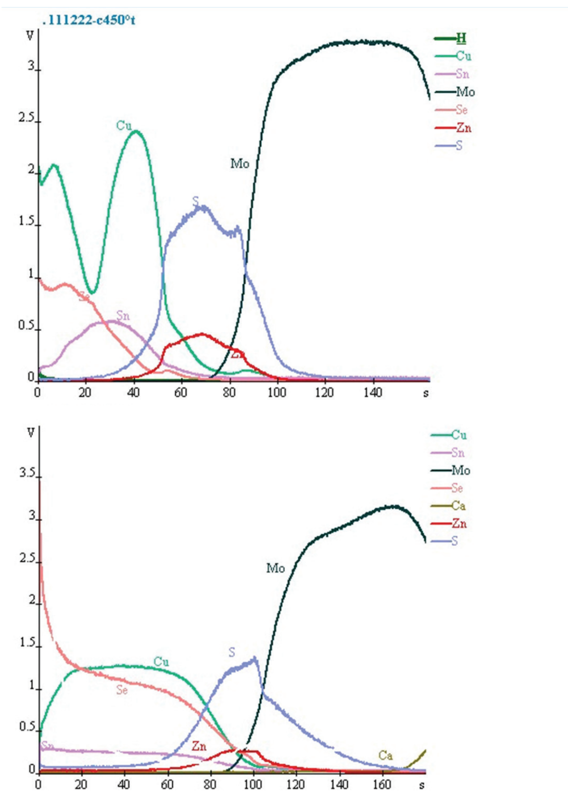


View of the source with schematized sample placed on it

Applications

Results on Si thin films and Chalcopyrite (CIGS) are extensively described in the 2 references mentioned at the end of this Application Note. We will here show 2 illustrative results on CZTSSe, a semiconducting compound which has received increasing interest since the late 2000s for applications in solar cells as it is composed of only abundant and non-toxic elements. Recent material improvements for CZTS have increased efficiency to just above 11% in laboratory cells, but more work is needed for their commercialization.

Pulsed RF GD OES GD allows for the observation of diffusion and interaction with intermediate compounds, leading to the final material. It also allows for the optimization of growth parameters in order to obtain high quality thin films.



Comparative Pulsed RF GD depth profiles of 2 samples: ZnS-Cu-Sn precursors on Mo. Graph 1 Selenization and Anealing at 450°C, Graph 2 Selenization and Annealing at 570°C

Courtesy of G. Altamura (CEA Grenoble): Formation and growth mechanisms during selenization process at different temperatures. Results presented at the 6th International GD day, Paris 2012.

Extra features

The unique characteristics of the RF GD plasma have also been used with great benefits to clean cross sections of PV cells before SEM observation or to reach embedded interfaces below encapsulation. A dedicated application note will present these results.

References

Formation mechanisms of Cu(In,Ga)Se2 solar cells prepared from electrodeposited precursors. F. Oliva, C. Broussillou, M. Annibaliano, N. Frederich, P.P. Grand, A. Roussy, P. Collot, S. Bodnar. Thin Solid Films 535 (2013) 127–132

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