



Thin Film Photovoltaic Analysis with Solar Metrology SMX Products

X-Ray Fluorescence (XRF) is a well accepted technique for thin-film metrology in a number of industries and is now being applied to the emerging field of thin-film photovoltaic development and manufacturing. XRF is an atomic spectroscopy that directly measures the mass per unit area of thin-film depositions. Spectra of the elemental components of the depositions are acquired simultaneously and non-destructively, which makes XRF an ideal technique for in-process monitoring, as well as off-line laboratory analysis. Film characterization provided by the technique includes: single and multi layer mass-thickness (mass per unit area), Wt.% and At.% of the elemental components of each layer. Already implemented for control of CIGS absorber films⁽¹⁾, XRF shows great promise for the metrology of other photovoltaic thin films.

Solar Metrology is engaged in the development of XRF tools specifically tailored to thin-film PV development and process control. Our SMX measurement system is a suite of 4 tools:

- **SMX-BEN:** Bench-top laboratory configuration
- **SMX-FPV:** Full Panel system for near process monitoring
- **SMX-IHL:** In-Line system that can be equipped with thermal shield (shielded to panel temperatures of up to 300° C)
- **SMX-ISI:** In-Situ system customized for process environments

The following table presents a typical SMX system output for a CIGS / Mo / Glass development. In this case, the measured mass thickness (mg / cm²) for both the CIGS and Mo layers is converted to linear thickness by dividing by the respective densities of each layer.

Thickness	CIGS Composition				Thickness
<u>CIGS μm</u>	<u>Atomic%</u> <u>Cu</u>	<u>Atomic %</u> <u>In</u>	<u>Atomic%</u> <u>Ga</u>	<u>Atomic%</u> <u>Se</u>	<u>Mo μm</u>
2.25	19.51	16.38	8.16	55.95	1.20

(1) I.L. Eisgruber, et al, In situ X-ray fluorescence used for real-time control of CuIn_xGa_{1-x}Se₂ thin film composition, Thin Solid Films 408 (2002) 64-72.