Flames: In-line monitoring of layer properties and thickness in thin-film PV processes

LayTec has developed an in-line monitoring system that is capable of measuring the optical properties and thickness of all layers throughout the solar cell manufacturing process. The new technology will help thin film PV producers control their production in-line, thereby enhancing yield. Additionally, it will accelerate development cycles and help transfer and ramp up established processes to new lines.

With its product-line Flames IR, LayTec provides an outstanding in-line monitoring system commercially available for the production of thin film solar cells. Flames IR is capable of monitoring the film thickness of all layers throughout the process: transparent conducting oxide (TCO), absorber and buffer layers (Fig. 1). Flames IR is available in various editions for copper indium gallium selenide (CIGS), CdTe and a-Si based thin-film solar cell production processes.

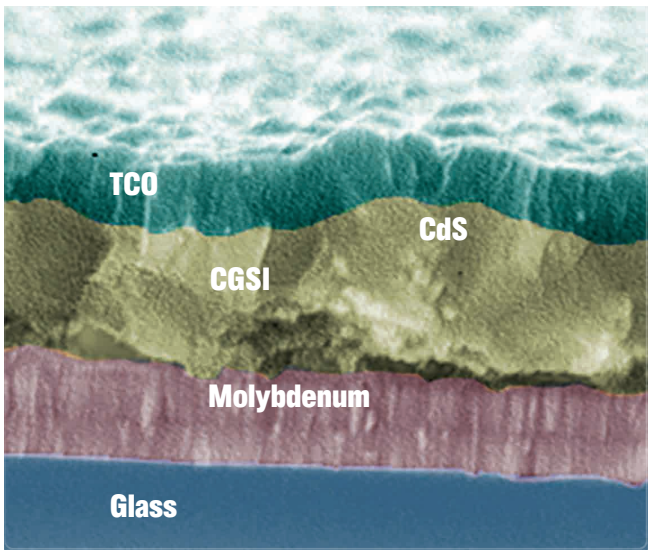

Fig. 1: Layer of CIGS-based solar cell.

The monitoring system is based on spectroscopic reflectance measurements. One of the superior properties of the system is the ability to measure accurate film thickness despite the reduced reflectance from rough absorber layers as used in today's thin-film PV production.

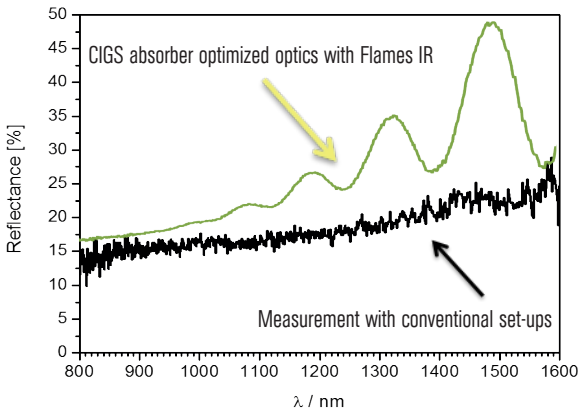

Fig. 2 Reflectance measurement with conventional set-up and with advanced optics suitable for very rough absorber layer materials like CdTe, CIGS, textured poly-Si.

Absorber surfaces are intentionally rough and show stray light effects of the absorber layers. LayTec has found a very robust way to establish film-thickness measurements even under these difficult conditions. With a newly developed optical set-up, data from both transparent and metalized thin film PV cells (with CIGS or CdTe absorbers) were measured (Fig. 2). Typical reflectance spectra from a CIGS solar cell process are shown in Fig. 3.

Reflectance measurements after each deposition step allow a thickness determination for each layer in the whole process. The position and number of interference fringes measured by the spectrometer is automatically analyzed in order to determine the film thickness.

While the TCO and CdS film thicknesses can be detected with a spectrometer operating in the visible to near-infrared spectral range (500 - 1000 nm), a determination of the film thickness of the absorber requires an infrared reflectance measurement, as these materials absorb the visible light.

The accuracy of the measurement is in the range of 1 % for absorber layers, and 2 % for TCO layers, respectively. The determination of the CdS layers, however, is more challenging, as these layers are thin and grown directly on the rough absorber layer.

For CdS layers below 50 nm it is very important that the absorber layer reflectance spectra are taken before CdS deposition in the same process.

Reflectance spectra are thus detected prior to, and after each layer deposition. By an automated analysis of these two reflectance spectra, the film thickness control of each layer can be established. The accuracy of the measurement depends on the total thickness and the knowledge of the n and k values of the underlying layers in a multi-layer process. Despite the challenge, thanks to LayTec's expertise accuracies better than 2 % were achieved for CdS thickness measurements in-line by this new method.

Additionally, to the precise layer thickness, the following solar cell features can be monitored in-line: the color of absorber, texture and surface roughness and variations in the TCO conductivity for TCO on glass. LayTec's in-line monitoring system Flames IR makes a real difference for comprehensive process control and effective process development of thin-film PV cells.

For more information please visit www.laytec.de/Flames or contact info@laytec.de.

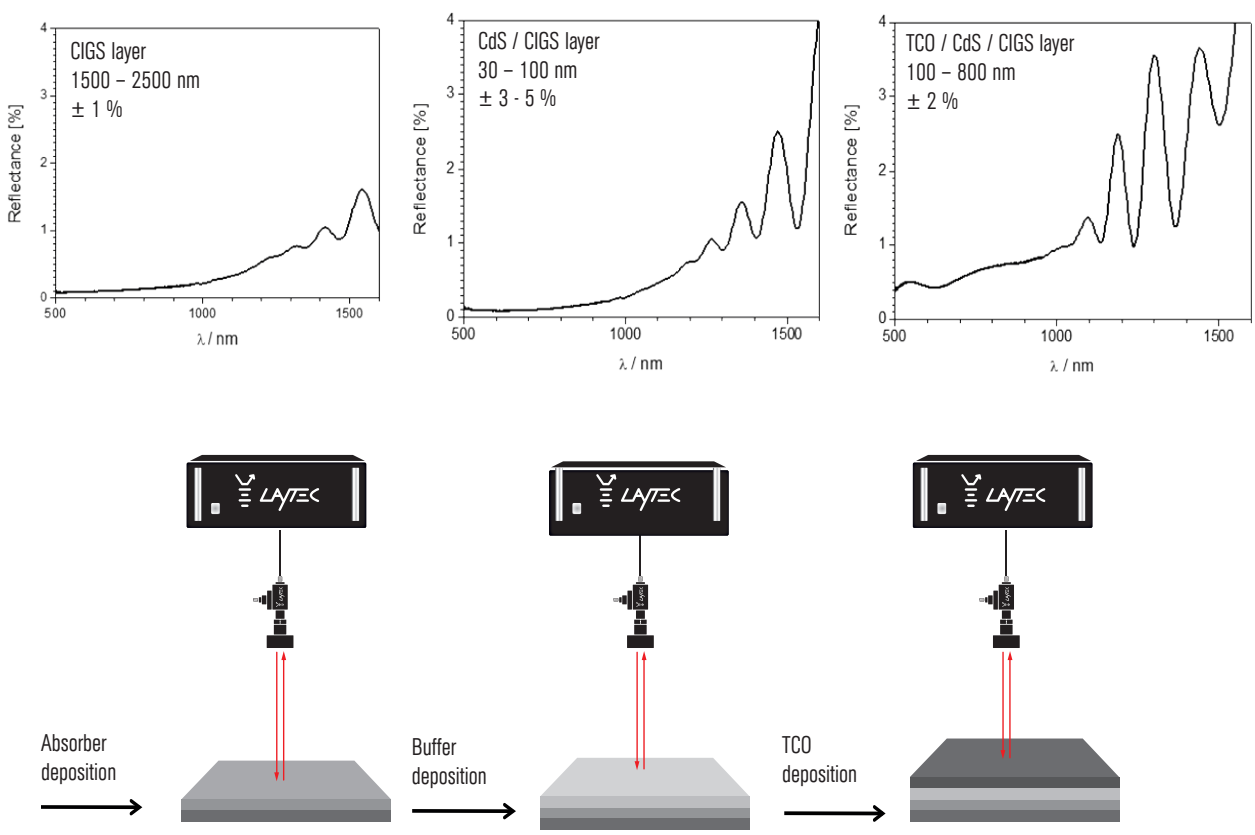

Fig. 3: Layer by layer monitoring: Reflectance measurement after each deposition step leads to complete control of the entire PV-layer deposition process.

LayTec AG
Seesener Str. 10-13
10709 Berlin, Germany

Tel.: +49 (0)30 89 00 55-0
Email: info@laytec.de
Web: laytec.de