Real Time In-Line Monitoring

Integration test results

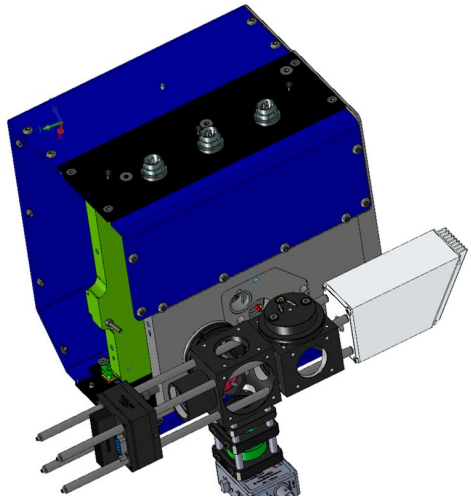
As part of its work in the project APPOLO (Hub of Application Laboratories for Equipment Assessment in Laser Based Manufacturing) under the FP7 EU framework, Amsys has adopted its surface inspection technology for real-time in-line monitoring of laser processing of surfaces. Although the first application deals specifically with laser scribing of CIGS layers in manufacturing of flexible PV systems, the developed tool is directly applicable to a wide variety of laser scribing, patterning, and surface conditioning applications.

The monitoring tool was integrated into laser scribing equipment in the scribing laboratory at FTMC – Fiziniu ir Technologijos Mokslu Centras, Vilnius, Lithuania. The tool was specifically adapted for integration with the laser scanner LS170 manufactured by Next Scan Technologies (NST), but it can be readily incorporated into any other scanning equipment.

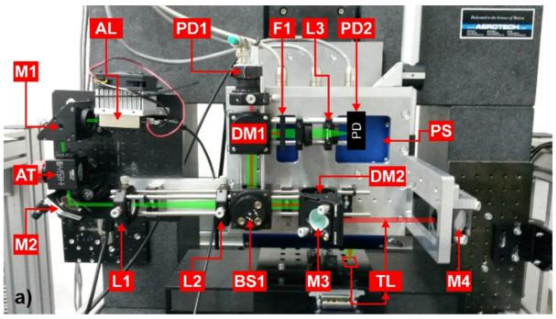
First laser scribing and off-line and in-line real-time monitoring experiments were successfully performed in conjunction with the APPOLO Working Group Workshop conducted at FTMC in April 2016.

Conclusions

- **The system can used be for real-time monitoring of laser scribing at all stages of the CIGS manufacturing process.**
- **The monitoring system is not limited to the maximum scanning speed of 100 m/s of the LS170 scanner.**
- **The monitoring system can be used for real-time high-speed laser scribing and other laser material processing applications**
- **The monitoring system is not limited to the LS170 scanner and can be directly adapted to a wide variety of other scanners**



Monitoring system (detail) integrated with LS170 polygon scanner of Next Scan Technologies (NST)



Monitoring system integrated into the laser scribing system at FTMC: AL is the analytical laser of the monitoring system, TL is the technological scribing laser, PS is the polygon scanner. M1, M2 are deflection mirrors, DM are dichroic mirrors, L are lenses, and PD are monitoring detectors.

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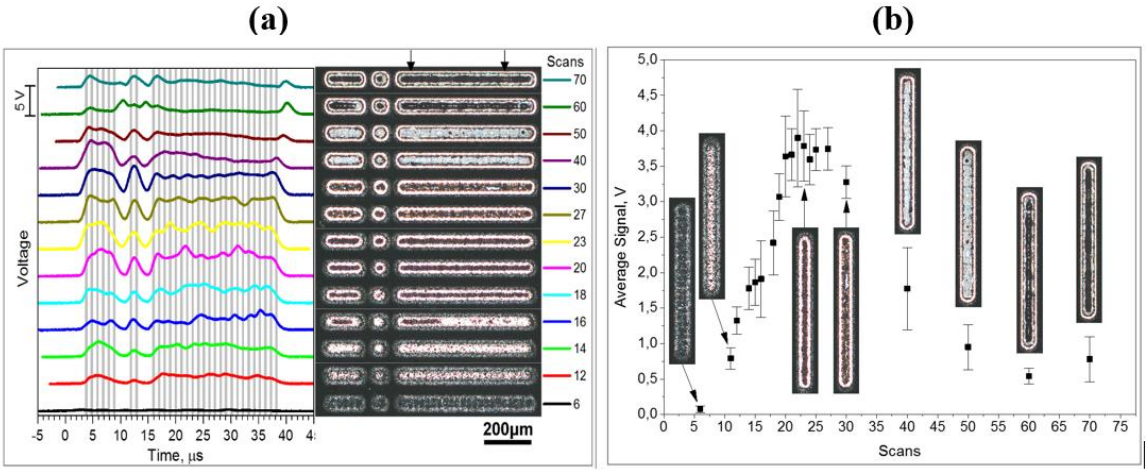
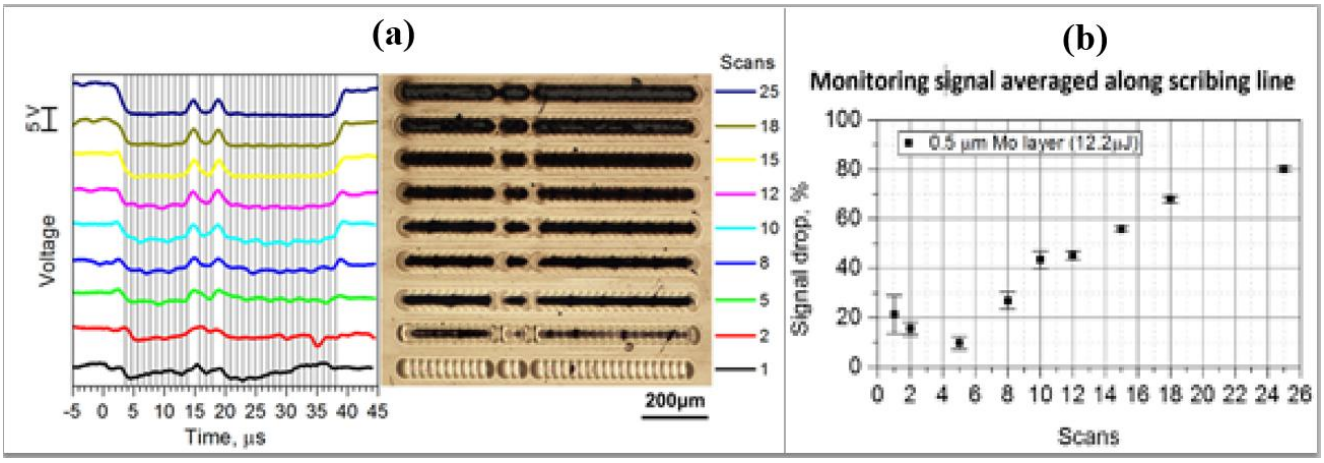
Monitoring of scribing of CIGS cells without front contact (P2 process)

The CIGS samples without front contact were made as a three-layer sandwich: 25 µm-thick polyimide substrate, 0.5 µm-thick molybdenum film and a 2 µm-thick CIGS film on top. The laser scribing of these samples was performed using 30% of the maximum pulse energy (12.2 µJ) and gradually increasing the number of scans per scribe.



(a): Monitoring signals and microscope pictures of consecutive scribing scans. Interruption of the scribing near the beginning of the scans were made intentionally, to illustrate missing pulse detection.
(b): Average (along the scan line) monitoring signal as a function of the number of scribing scans. Initially, the monitoring signal increases as the absorbing CIGS film is removed and underlying Mo film is exposed. After ~30 scans) the signal starts dropping when the Mo film, in turn, is scribed out and the polyimide substrate is uncovered.

Monitoring of scribing of Mo layer on polyimide (P1 process)



(a): Monitoring signals and microscope picture of consecutive scribing scans of 0.5 µm thick Mo layer on a polyimide substrate. The interruptions of scribing in the center was made intentionally to illustrate missing pulse detection.
(b): Monitoring signal drop relative to unprocessed area with increasing number of scribing scans. Increase in scattered signal in scans 2 – 4 is probably due to appearance of debris