Laser scribing of nanocomposite thin films for the development of large scale monolithic photovoltaic panels

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Abstract
This thin film photovoltaics promises to reduce manufacturing cost of solar cell modules, on one side due to reduced material usage and on the other due to monolithic series connection of cells requiring relatively simple automation compared to the lay-up and wire soldering used in wafer-based technologies.

In this work we have grown Mo thin films on glass and PET substrates by PLD. Using an Nd:YAG laser system we scribed thin films of Mo and CIGS for P1 and P2 patterning. The morphology of channels was studied by Atomic Force Microscopy. LIPS technique was used in-situ to optimize focal spot size for laser scribing. LIPS was further used to investigate the homogeneity of the chalcopyrite thin films.

Basic Solar cell layout

Fig 1: Typical description of a thin film solar cell with chalcopyrite absorber

Monolithic Integration
Laser scribing of thin films for photovoltaic applications is the key step in moving from small cells to their monolithic integration into large area panels.

By applying alternating deposition and patterning steps, one achieves the well known cell stripes connected by monolithic interconnect regions.

Patterning is necessary to isolate adjacent bottom contacts (P1), provide a connection channel between the top and bottom electrodes of adjacent cells (P2), and to isolate adjacent top electrodes (P3).

Fig 2: Monolithic series connection of cells

Pulsed Laser Deposition

Fig 3: Pulsed Laser Deposition (PLD) setup

Thin films laser scribing

The ablative properties of the films were examined as a function of the:
- Wavelength of laser radiation
- Pulse energy and
- Irradiation dose [1]

To achieve the desired channel width (~50μm), we optimized the focusing lens distance from the target. We managed this on line, by applying Laser Induced Plasma Spectroscopy (LIPS) techniques.

Results - Observations

Channel widths were about 47 μm and 44 μm for Mo and CIGS, respectively, using an Nd:YAG laser system at 355 nm and with an overlap of ~30%.

Morphological and topographical studies of Heat Affected Zones (HAZ) and also of channel’s edges have been performed using Atomic Force Microscopy (AFM).

Fig 7: AFM image of P1 scribe of the Mo back contact

We recorded the laser induced emissions of Copper (Cu), Indium (In) and Gallium (Ga) from CIGS thin films using LIPS techniques, and studied the stability of the ratios of elements along each sample and from sample to sample.

Fig 8: The stability of the ratio of In/Cu elements of CIGS thin films annealed at different temperatures

Conclusions

- Good adhesion of Mo thin films on glass and PET substrates by PLD.
- On - line control of scribing process using LIPS technique.
- Optimization of laser parameters for scribing.
- Channel widths of P1 and P2 are match the demands of the thin film solar cell industry.
- LIPS techniques have been successfully applied to test lateral stoichiometry of CIGS

References