Elemental Analysis of Chalcopyrite Thin Film Absorbers and Monolithic Integration for 2nd Generation Photovoltaic Cells

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Compared to traditional wafer-based crystalline silicon technologies applied in the P/V industry, monolithic integration of thin film solar cells can lead to devices of comparable performance but with significant manufacturing advantages: lower consumption of materials, fewer processing steps and easier automation and finally lower costs. Monolithic integration is required to achieve these advantages, since this eliminates multiple processing steps and handling operations during formation of the absorber and during module assembly. Laser scribing of thin films for PV applications is the key step in moving from small cells to their monolithic integration into large-area panels. The basic cell layout is: a back contact electrode (molybdenum –Mo), the p/n heterojunction semiconductor absorber (e.g. Copper indium gallium selenide–CIGS)/ZnSe, a top transparent conducting (TCO) electrode and three patterning steps P1, P2, P3 for monolithic integration.

We deposited CIGS thin films absorbers on soda lime glass substrates by e – beam evaporation and annealed them at different temperatures. X-ray diffraction (XRD) was used to study the crystallinity and measure the grain size of the films. Topographical and morphological studies on the CIGS thin films have been performed using Atomic Force Microscopy (AFM). For CIGS (P2) patterning, we used an (UV) Nd:YAG pulsed laser and investigated the scribing parameters. To achieve the desired channel width (~50 μm), we had to optimise the focusing lens distance from the target. We managed this on line, by applying Laser Induced Plasma Spectroscopy (LIPS) techniques (fig.1). Applying this technique to laser scribing of the CIGS thin films, we recorded the laser-induced emissions of copper (Cu), indium (In) and gallium (Ga) from the sample. This method allowed us to study the stability of the ratios of elements along each sample and from sample to sample (fig. 2) after the annealing process. This is the first step towards a quantitative elemental analysis of a multi-element thin film.

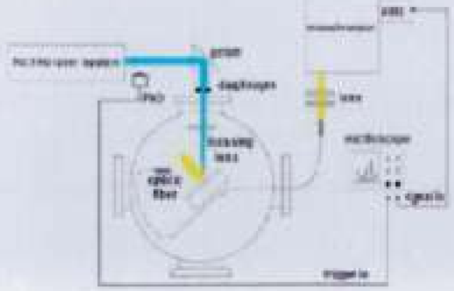

Fig. 1. Thin films laser scribing set-up and LIPS diagnostics

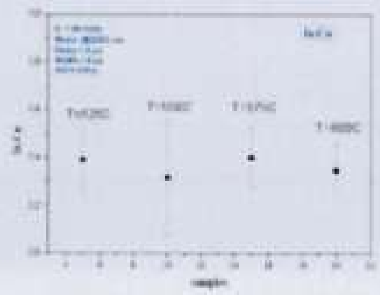

Fig. 2. The stability of the ratio of In/Cu elements of CIGS thin films annealed at different temperatures

Keywords: Thin films photovoltaic cells, chalcopyrite compounds, e-beam evaporation, XRD, AFM, laser scribing, LIPS.