University of Central Florida

Development of High Throughput CIGS Manufacturing Process

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Description: A reduction in the cost of CIGS and other thin film PV modules is required for broad PV applications. The project objective is to develop a high-rate deposition process for synthesis of CIGS absorbers and other layers by employing in-line and batch deposition techniques. The goal is finally to attract a PV manufacturing company to Florida by developing a high-rate manufacturing process for $CuIn_xGa_{1-x}Se_2$ (CIGS) solar cells.

Budget: $141,620
Universities: UCF/FSEC

Executive Summary

In order to commercialize thin film PV technology it is essential to develop a process that has high yield and low production cost. A versatile methodology was adopted in order to improve and optimize the deposition parameters for each of the layers for preparation of $CuIn_xGa_{1-x}Se_2$ (CIGS) thin film solar cells. The initial efforts were directed towards increasing the deposition rates of metallic precursors deposited by DC magnetron sputtering. The rate was increased to ~7.5 Å/sec which is significant for laboratory level. Further increments in the deposition rates were achieved by changing the working distance between the metallic targets and the substrate. Reducing the working distance from 90mm to 70mm further increased the deposition rate to 11.4 Å/sec, which is an increase by 1.5 times. For an efficient industrial process, the deposition rates will need to be incremented along with efficient cooling mechanism for the metal targets.

The cost of production can also be lowered by reducing the total material utilization without adversely affecting the device performance. Optimization of silicon nitride barrier layer was carried out to minimize the sodium out-diffusion from the sodalime glass substrate. The experimentation suggested 800 Å to be the optimum thickness of silicon nitride barrier layer.

Efforts were focused on optimizing the parameters for the molybdenum back contact. Molybdenum back contact in $CuIn_{1-x}Ga_xSe_2$ (CIGS) solar cells is usually deposited with DC magnetron sputtering. Properties of thin films are dependent on process conditions. Films deposited at high power and low pressure, tend to be more conductive. However, such films exhibit poor adhesional strength since the films are under compressive stress. Films deposited at low power and high pressure tend to be under tensile stress and exhibit higher roughness and resistivity, while the films adhere very well to the sodalime glass substrate. Therefore, it has been a practice to deposit multi-layered Mo back contact to achieve properties of good adhesion and higher conductivity. Deposition of multi-layered back contact results in either increases in deposition time if a single target is used or increases in foot print if multiple targets are used. Both of these effects result in increases in the total cost of production.

Hence experiments were carried out to understand effects of working pressure, sputtering power and working distance on molybdenum film properties with the final aim to develop a process recipe for deposition of a single molybdenum film with acceptable properties of both good adhesion and higher conductivity. Adhesive tape test was performed on each film to determine the adhesional strength of the films. Moreover, the sheet resistance and the average roughness for each film were measured using a four probe measurement setup and the Dektak Profilometer, respectively. Resistivity was found to be dependent on working gas pressure. All experiments were carried out on narrow and long glass strips in order to estimate the residual stress in the film by using the bend test method. It was found that the residual stress is strongly influenced by the kinetic energy of the incident sputtered atoms and the backscattered argon atoms which in turn is determined by the sputtering power and working gas pressure. This work is continuing in order to understand the effects of various sputtering parameters and determine the possible route to develop single layer molybdenum films with the required properties of near zero stress, low resistivity and good adhesion to substrate.

Electron back scattered diffraction (EBSD) has also been introduced in this work for characterization of CIGS solar cells. This is a powerful technique which allows crystallographic information such as the grain orientation, grain boundaries and also the grain size to be obtained.

This Project has been completed. Final report here.