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 PV film modules is required for large-scale PV applications. The goal of this project is 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. The 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.

Budget: $141,620

Universities: UCF/FSEC

Progress Summary

The main objective of the current reporting period was elucidating the relation between the sputtering parameters such as working pressure, sputtering power and the working distance and the properties of the molybdenum back contact film. Experiments were carried out with various combinations of sputtering power and working gas pressure. The sheet resistance of the film was measured by four probe technique using an in-house built four probe measurement setup. Residual stress analysis was conducted with beam bending test with very thin glass strips that were specially procured for these experiments. Average roughness and thickness of the film were determined using a Dektak profilometer. X-ray diffraction (XRD) was carried out to estimate the crystallite size.

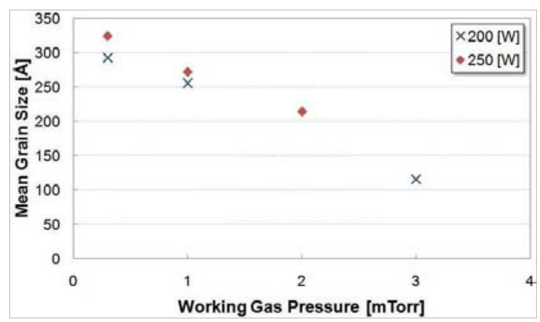

FIGURE 1: VARIATION OF MEAN GRAIN SIZE WITH WORKING GAS PRESSURE

The sputtering power was varied from 200 W to 300 W in 25 W increments and the working gas pressure was varied from 5 mTorr to 0.1 mTorr. It was observed that the deposition rate increased with increasing sputtering power and the working gas pressure did not have a significant effect. A very good agreement is observed between experimental data and the fast atom model by Ekpe which indicates that the deposition of the fast sputtering atom is dominant mechanism in this system. The XRD of Mo films deposited using various process parameters suggest that the lattice parameter variation was not significant with changes in sputter power and pressure. It was found out that the lattice parameter was in the range of 3.141 to 3.148 Å. From the XRD analysis, the mean grain size was estimated using the Scherrer's equation.

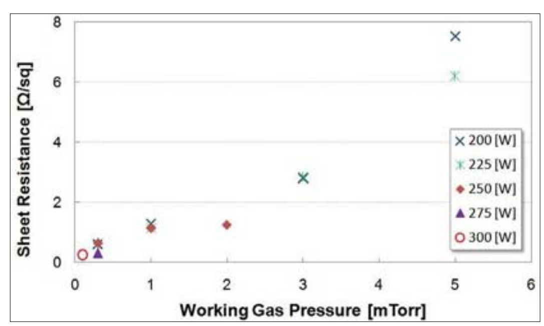

FIGURE 2: VARIATION OF SHEET RESISTANCE WITH WORKING GAS PRESSURE AND SPUTTERING POWER

The variation of mean grain size with respect to sputtering power and working gas pressure is shown in figure 1. From the figure it can be clearly seen that the mean grain size increased with increasing power and decreasing pressure. It is suggested that grain growth was facilitated by the atomic peening effect at lower pressure, hence grain coarsening occurred. The energetic incident atoms provide the energy to the Mo film to grow in ordered manner as well as enhance the growth rate, resulting in large grains. Sheet resistance of the film was measured and it was found out that the sheet resistance of the Mo films is strongly influenced by the gas pressure as compared to the sputtering power (Figure 2). The sheet resistance of the Mo thin films with thickness of about 7000 Å was found to be in range of 0.036 to 7.53Ω/□. With decreasing pressure and less scattering of sputtered atoms, the films become less porous and more tightly packed. This results in the decrease in film resistivity. Residual stress state was found to be strongly dependent on the kinetic energy of incident Mo atoms and backscattered Ar atoms to the substrate. At lower gas pressure and higher discharge voltage, incident atoms are more energetic and incident to the substrate normally because of their longer mean free path and higher flying speed. These energetic incident atoms cause the atomic peening effect, resulting in densely packed microstructure. By increasing the gas pressure or decreasing the voltage, incident atoms become less energetic and atomic peening diminishes. As a result, interglanular and interatomic spacing increase to develop tensile stress which is exerted by attractive force among the grains and atoms. Further increment of pressure or decrement of voltage makes the film more porous. When the spacing exceeds certain value so that the attractive force is not effective the film exhibits no stress.

The future work in the next reporting period would be concentrated on verifying the effect of working distance on properties of Mo films. Moreover, experiments will be carried out to determine the effect of metallic ratios of the absorber film on device performance. Experiments will also be performed to improve the efficiency of CIGS thin film solar cells.