Optimization of Process Parameters for Faster Deposition of CuIn_{1-x}Ga_xSe_2 and CuIn_{1-x}Ga_xSe_{2-y}S_y Thin Film Solar Cells

Thin film solar cells have the potential to be an important contributor to the world energy demand in the 21st century. Among all the thin film technologies, CuInGaSe_2 (CIGS) thin film solar cells have achieved the highest efficiency. However, the high price of photovoltaic modules has been a major factor impeding the growth of photovoltaic modules for terrestrial applications. Reduction in cost of PV modules can be realized by several ways including choosing scalable processes amenable to large area deposition, reduction in the materials consumption of active layers, and attaining faster deposition rates suitable for in-line processing. Selenization-sulfurization of sputtered metallic Cu-In-Ga precursors is known to be more amenable to large area deposition.

Sputter-deposited molybdenum thin film is commonly employed as a back contact layer for CIGS solar cells. However, there are several difficulties in fabricating an optimum back contact layer. It is known that molybdenum thin films deposited at higher sputtering power and lower gas pressure exhibit better electrical conductivity. However, such films exhibit poor adhesion to the soda-lime glass substrate. On the other hand, films deposited at lower discharge power and higher pressure although exhibit excellent adhesion show lower electrical conductivity. Therefore, a multilayer structure is normally used so as to get best from the two deposition regimes. A multi-pass processing is not desirable in high volume production because it prolongs total production time and correspondingly increases the manufacturing cost. In order to make manufacturing compliant with an in-line deposition, it is justifiable having fewer deposition sequences. Thorough analysis of pressure and power relationship of film properties deposited at various parameters has been carried out. It has been shown that it is possible to achieve a molybdenum back contact of desired properties in a single deposition pass by choosing the optimum deposition parameters. It is also shown that the film deposited in a single pass is actually a composite structure. CIGS solar cells have successfully been completed on the developed single layer back contact with National Renewable Energy Laboratory (NREL) certified device efficiencies >11%. The optimization of parameters has been carried out in such a way that the deposition of back contact and metallic precursors can be carried out in identical pressure conditions which is essential for in-line deposition without a need for load-lock.

It is know that the presence of sodium plays a very critical role during the growth of CIGS absorber layer and is beneficial for the device performance. The effect of sodium location during the growth of the absorber layer has been studied so as to optimize its quantity and location in order to get devices with improved performance. NREL certified devices with efficiencies >12% have been successfully completed.

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The public is welcome to attend.