Sulfurization of Thin-Film Copper Antimony Sulfide for Low Cost and Environmental Friendly Solar Cells

Jin, Richard

Current common commercial solar cells use either crystalline silicon or thin-film cadmium telluride. Silicon in bulk crystalline form is expensive and cadmium is toxic. It is therefore desirable to develop solar cells with materials that are low cost and environmental friendly. Copper antimony sulfide (CuSbS) is a very attractive candidate because all the elements are low cost and non-toxic, and has an energy band gap suitable for photovoltaic applications. However, the conversion efficiency of CuSbS solar cells is lacking. This project uses sulfurization to improve the crystalline structure of CuSbS thin-films and increase the solar cell conversation efficiency. Sulfurization of CuSbS thin-films grown by magnetron sputtering is employed at different temperatures. The thin-films under each sulfurization condition are characterized with X-ray diffraction, Hall measurements, and UV-Vis absorption spectroscopy. Multiple solar cells are made with CuSbS thin-films and conversion efficiencies are measured using a solar simulator. It is found that sulfurization transforms as-grown CuSbS thin-films from amorphous to crystalline. Sulfurization under 340°C makes a predominantly Cu3SbS4 crystal structure, while treatment above 340°C exhibits a mixed phase crystal structure of CuSbS2 and Sb2S3. The hole carrier density is increased and the energy band gap is decreased after sulfurization. Sulfurization at 310°C produces the best CuSbS solar cell with a conversion efficiency of 0.66%, which is more than 40% improvement over the best solar cells previously produced in the same lab. These results demonstrate the great potential for further improvement of thin-film CuSbS for low cost and environmental friendly solar cells.

Awards Won: