NEBRASKA CENTER FOR ENERGY SCIENCES RESEARCH

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Nebraska Center for Energy Sciences Research

Development of Inexpensive Manufacturing Methods for High Efficiency Solar Cells

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Abstract

The manufacturing cost of high-efficiency, thin-film photovoltaic devices is significantly lowered if non-vacuum methods are employed throughout the process. This has stimulated research in solution-based preparation and non-vacuum processing of nanocrystalline $Cu(In,Ga)(S,Se)_2$ (CIGSS) absorber layers. Reported techniques revolve around the solvothermal preparation of nanocrystalline oxide and sulfide precursors that are reacted with the toxic gas H_2Se to incorporate selenium. In this project, we propose to develop a new CIGSS device manufacturing process that employs non-vacuum methods while eliminating the need for toxic gases and extreme reaction conditions for the production of the absorber layer. Each device will consist of stacked thin films. Molybdenum will be sputtered onto a soda-lime glass substrate. This will be followed by the successive deposition of nanocrystalline $Cu(In,Ga)S_2$ and Se precursors. Annealing in an inert atmosphere will complete the absorber layer formation. The solar cell will be completed by the deposition of the necessary top optically transparent contact and the fine highly conductive grid. Novel science and engineering will be required in the preparation and deposition of the CIGSS absorber layer. Our group will employ our newly-developed low-temperature solvent-based methods for preparing nanocrystalline $Cu(In,Ga)S_2$ and $Cu(In,Ga)Se_2$ precursors. Conditions for nanoparticle deposition and precursor layer reaction will be investigated and optimized. We anticipate that the CIGSS absorber preparation technique and the solar cell fabrication method will be patentable and lead to low cost manufacturing.

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In this project, we propose to develop a new inexpensive manufacturing method for high-efficiency solar cells. Central to this effort is the preparation and processing of the absorber layer material. While $Cu(In,Ga)Se_2$ is a leading industrial standard as a solar cell absorber material, a low bandgap (1.1eV) and lack of an inexpensive technique for fabricating dense, continuous films have limited module manufacture. Both issues will be addressed in this project through the preparation and use of $Cu(In,Ga)Se_xS_{2-x}$ (CIGSS) absorber precursor materials. The substitution of sulfur for some of the selenium accomplishes two critical tasks; it increases the band gap of the material thereby utilizing the solar optical spectrum more efficiently, and dense, continuous CIGSS material can be grown via industrially scalable non-vacuum, non-toxic spray deposition methods. In our approach $Cu(In,Ga)S_2$ and Se precursor materials will be prepared in nanocrystalline form via low-temperature solution-based procedures and spray deposited prior to heat processing (annealing) that drives the reaction to form the final CIGSS absorber material. A solar cell prototype will be fabricated from this material at the laboratory-scale, and optimized. The goal is a 15% or higher cell efficiency. This serves as the basis for an industrial-scale solar cell manufacturing method that will significantly lower solar cell production costs. This work will result in two patentable processes – one for the nanocrystalline CIGSS preparation and one for the manufacturing method. Initial assistance in completing an efficient solar cell will come from the Process Development and Integration Laboratory at the National Renewable Energy Laboratory (NREL) in Golden, CO. This work and collaboration with NREL will fit well with the large scale “Solar Cell Nano-manufacturing” pre-proposal ($1M/yr for 3 yrs with renewal for 3 additional years) we will submit to the Nebraska DOE-EPSCoR Program.