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Electrodeposition of High-Purity Continuous Indium Thin Films towards Indium Phosphide Solar Cells

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Solar cells composed of single-crystalline III-V semiconductors have shown the highest efficiencies of any single junction solar cells yet developed. Thus they are prime targets for large-scale commercialization; however, the traditional methods of producing these cells require costly processing procedures and large amounts of expensive precursor material. This has limited the utilization of these cells to high-end applications such as in satellites. InP is of particular interest for thin film solar cells due to its near ideal band gap and its low surface recombination velocity (approximately 10^3 cm/s). The cost of indium for any large scale deployment of InP solar cells is a major concern though. To this end, we have investigated the electrodeposition of thin indium films followed by phosphorization to produce high quality InP films. This approach is motivated by the fact that electrodeposition is a highly selective process, unlike physical and chemical vapor deposition methods, and enables high materials utilization rate.

Here, a method of aqueous electrodeposition is developed to produce indium thin films on molybdenum foil. Pulsed deposition is utilized to increase the control over the film growth mechanism and bath temperature, pulse rate, and metal precursor are found to be key experimental parameters. The In films are produced to be continuous and of extremely high purity. This is the first time films of this thickness (1-3 microns) and of this high purity have been reported for indium. Electrodeposited indium thin films were then phosphorized to achieve InP films. The InP films showed grains ranging from 10 to 100 microns with electron mobility of 500 cm^2/V-s and minority carrier lifetimes of 2 ns. These properties compare well to the electronic properties of InP produced from evaporated indium using the same phosphorization process. The results demonstrate the high-purity of the electrodeposited indium and the promise of this approach towards conserving expensive precursor materials while still being able to obtain high-quality solar cell materials.