13

$Cu(InGa)Se_2$ Solar Cells

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13.1 INTRODUCTION

$Cu(InGa)Se_2$-based solar cells have often been touted as being among the most promising of solar cell technologies for cost-effective power generation. This is partly due to the advantages of thin films for low-cost, high-rate semiconductor deposition over large areas using layers only a few microns thick and for fabrication of monolithically interconnected modules. Perhaps more importantly, very high efficiencies have been demonstrated with $Cu(InGa)Se_2$ at both the cell and the module levels. Currently, the highest solar cell efficiency is 18.8% with 0.5 cm^2 total area fabricated by the National Renewable Energy Laboratory (NREL) [1]. Furthermore, several companies have demonstrated large area modules with efficiencies $>$12% including a confirmed 13.4% efficiency on a 3459 cm^2 module by Showa Shell [2]. Finally, $Cu(InGa)Se_2$ solar cells and modules have shown excellent long-term stability [3] in outdoor testing. In addition to its potential advantages for large-area terrestrial applications, $Cu(InGa)Se_2$ solar cells have shown high radiation resistance, compared to crystalline silicon solar cells [4, 5] and can be made very lightweight with flexible substrates, so they are also promising for space applications.

The history of $CuInSe_2$ solar cells starts with the work done at Bell Laboratories in the early 1970s, even though its synthesis and characterization were first reported by Hahn in 1953 [6] and, along with other ternary chalcopyrite materials, it had been characterized by several groups [7]. The Bell Labs group grew crystals of a wide selection of these materials and characterized their structural, electronic, and optical properties [7–9]. The first $CuInSe_2$ solar cells were made by evaporating n-type CdS onto p-type single crystals of $CuInSe_2$ [10]. These devices were initially recognized for their potential as near-infrared photodetectors since their spectral response was broader and more uniform than Si photodetectors. Optimization for solar cells increased the efficiency to 12% as measured under outdoor illumination “on a clear day in New Jersey” [11].

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