

CuIn₃Se₅ Colloidal Nanocrystals and Its Ink-Coated Films for Photovoltaics

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Abstract : CuIn₃Se₅ material is indexed as ordered vacancy compounds having excellent matching properties with CuInGaSe (CIGS) solar absorber layer. For example, the valence band offset of CuIn₃Se₅ with CIGS is nearly 0.3 eV, and the lattice mismatch is less than 1%, besides the absence of discontinuity in their conduction bands. Thus, CuIn₃Se₅ can work as a passivation layer for repelling holes from CIGS/CdS interface and hence to reduce the interface carriers recombination and consequently enhancing the efficiency of CIGS/CdS solar cells. Theoretically, it was reported earlier that an improvement in the efficiency of p-CIGS-based solar cell with a thin ~100 nm of n-CuIn₃Se₅ layer is expected. Recently, a reported experiment demonstrated significant improvement in the efficiency of Molecular Beam Epitaxy (MBE) grown CIGS solar cells from 13.4 to 14.5% via inserting a thin layer of MBE-grown Cu(In,Ga)₃Se₅ layer at the CdS/CIGS interface. It should be mentioned that CuIn₃Se₅ material in either bulk or thin film form, are usually fabricated by high vacuum physical vapor deposition techniques (e.g., three-source co-evaporation, RF sputtering, flash evaporation, and molecular beam epitaxy). In addition, achieving photosensitive films of n-CuIn₃Se₅ material is important for new hybrid organic/inorganic structures, where inorganic photo-absorber layer, with n-type conductivity, can form n-p junction with organic p-type material (e.g., conductive polymers). A detailed study of the physical properties of CuIn₃Se₅ is still necessary for better understanding of device operation and further improvement of solar cells performance. Here, we report on the low-cost synthesis of CuIn₃Se₅ material in nano-scale size, with an average diameter ~10nm, using simple solution-based colloidal chemistry. In contrast to traditionally grown bulk tetragonal CuIn₃Se₅ crystals using high Vacuum-based technology, our colloidal CuIn₃Se₅ nanocrystals show cubic crystal structure with a shape of nanoparticles and band gap ~1.33 eV. Ink-coated thin films prepared from these nanocrystals colloids; display n-type character, 1.26 eV band gap and strong photo-responsive behavior with incident white light. This suggests the potential use of colloidal CuIn₃Se₅ as an active layer in all-solution-processed thin film solar cells.

Keywords : nanocrystals, CuInSe, thin film, optical properties

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