World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:12, No:08, 2018

$CuIn_3Se_5$ Colloidal Nanocrystals and Its Ink-Coated Films for Photovoltaics

Authors : M. Ghali, M. Elnimr, G. F. Ali, A. M. Eissa, H. Talaat

Abstract : $CuIn_3Se_5$ material is indexed as ordered vacancy compounds having excellent matching properties with CuInGaSe (CIGS) solar absorber layer. For example, the valence band offset of $CuIn_3Se_5$ 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, $CuIn_3Se_5$ 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-$CuIn_3Se_5$ 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 $Cu(In,Ga)_3Se_5$ layer at the CdS/CIGS interface. It should be mentioned that $CuIn_3Se_5$ 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-$CuIn_3Se_5$ 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 $CuIn_3Se_5$ 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 $CuIn_3Se_5$ material in nano-scale size, with an average diameter ~10nm, using simple solution-based colloidal chemistry. In contrast to traditionally grown bulk tetragonal $CuIn_3Se_5$ crystals using high Vacuum-based technology, our colloidal $CuIn_3Se_5$ 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 $CuIn_3Se_5$ as an active layer in all-solution-processed thin film solar cells.

Keywords : nanocrystals, CuInSe, thin film, optical properties
Conference Title : ICNN 2018 : International Conference on Nanomaterials and Nanotechnology
Conference Location : Vancouver, Canada
Conference Dates : August 09-10, 2018