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PHASE AND ELEMENTAL COMPOSITION OF SPRAY DEPOSITED $CuInS_2$ THIN FILMS FOR SOLAR CELLS

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$CuInS_2$ (CIS) with chalcopyrite structure has been successfully used as a light absorber material in thin film solar cells. Optimum band gap of 1.5 eV, high absorption coefficient (more than 10^4 cm^{-1}) and chemical stability make this material important for photovoltaic applications.

In present study CIS films were prepared by low-cost spray pyrolysis method at 250 ºC and 350 ºC in air using aqueous solutions of $CuCl_2$, $InCl_3$ and $SC(NH_2)_2$ at molar ratio of precursors Cu:In:S=1:1:3 and Cu:In:S=1.1:1:3.25. Post- deposition treatment of the films was made at 500 ºC in H_2S atmosphere. Films were characterized by X-ray diffraction (XRD), optical transmittance spectra and X-ray photoelectron spectroscopy (XPS) techniques. As-sprayed CIS was used as an extremely thin absorber layer in nanostructured solar cells. Solar cells were characterized with the help of current-voltage characteristics recorded in dark and under halogen lamp illumination.

CIS films obtained by spray of Cu-rich spray solutions at 350 ºC are composed of roguesite phase with crystallite size of 40 nm according to XRD. The secondary CuxS phase which supports the crystallization of the film is preferably segregated on the film surface, and could be easily removed by chemical etching. CIS films obtained by spray of the solutions with Cu/In=1.0 has mean crystallite size of 20 nm.

According to XPS, the films deposited at 350 ºC show graded elemental composition and contain oxygen bonded to metal in amount ca 5 - 16 at%. Non-uniform composition of the film reflects in electrical resistivity measured across the film surface or perpendicularly. Post-deposition thermal treatment increases crystallinity of the film as well as the optical band gap value. Indium oxide phase, present in as-sprayed films obviously on grain boundaries, is turned into the sulfide phase.

CIS films obtained at 250 ºC are low-crystalline with oxygen content less than 1 at.% and show uniform distribution of the elements in the film thickness. Post-deposition treatment increases the crystallite size up to 80-100 nm. The films obtained by spray at low temperature are multiphase independent of Cu/In in spray solution, as some Cu_xS is segregated on the film surface and In_2S_3 phase is formed upon H_2S treatment probably due to decomposition of the second Cu-In-S ternary compound formed initially.

The nanostructured solar cells based on ZnO nanorods and using thin spray-deposited CIS films as an absorber layer were prepared and characterized. The energy conversion efficiency of 4% has been recorded for the cells at AM1.5.