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Fabrication of $CuInS_2/Cu_2O$ heterojunction using electrodeposition technique to use in photovoltaic applications

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$CuInS_2$ is a promising PV material due to its direct band gap of 1.5 eV which is very closer to the theoretically optimum energy band gap of 1.4 eV suitable for photovoltaic applications. On the other hand $CuInS_2$ based solar cells were also reported having a conversion efficiency of 12.5 %. Further enhancement of $CuInS_2$ based solar cells can be expected by optimizing the growth conditions and choosing proper window material for $CuInS_2$ in order to fabricate more efficient heterojunction solar cells. Cu_2O is one of the attractive materials for this purpose, due to its optoelectronic properties (high absorption coefficient and direct bad gap of 2 eV). Among the $CuInS_2$ growth techniques, sulphurisation of electrodeposited Cu and In stack layers by annealing in hydrogen sulphide or sulphur environment is an attractive technique.In this method thin films of Cu were first electrodeposited at -700 mV Vs SCE for 20 min in an aqueous solution of 0.1 M sodium acetate and 0.01 M cupric acetate on Ti substrates. The temperature of the bath was maintained at 55 ^oC. Subsequently, In films on Ti/Cusubstrates were electrodeposited at -1.1 V Vs SCE in an aqueous solution of 25 mM $InCl_3$. All the Ti/Cu/In films were annealed at 130 ^oC for 4 hours in air for the formation of Cu-In alloy. Cu/In atomic ratio of alloy films were adjusted to 0.6, 0.7, 0.8, 0.9, 1 and 1.5 by changing the In deposition period. Sulphurisation of Cu-In alloy was carried out at 500 ^oC for 30 min in 100% H_2S gas with a constant flow rate. After the sulphurisation, bluish grey colored $CuInS_2$films were obtained. The film quality of $CuInS_2$ was very subjective to the Cu-In alloy preparation conditions and methodology being adopted. Dark and light I-V measurements of the films were obtained in PEC containing 0.1 M sodium acetate solution. Results revealed that $CuInS_2$ films produce n-type photoconductivity in PEC and the best films were grown when the Cu/In ratio was maintained at 0.7. In order to fabricate the $CuInS_2/Cu_2O$ heterojunction, Cu_2O was electrodeposited on the $Ti/CuInS_2$ electrode in lactate bath at -450 mV Vs SCE for 40 min. The pH of the bath was set to 12 and temperature was maintained at 55 ^oC. Formation of the $CuInS_2/Cu_2O$ heterojunction was studied using dark and light I-V characteristics in PEC containing 0.1 M sodium acetate. Results revealed the possibility of fabrication of photoactive $CuInS_2/Cu_2O$ heterojunction. To our knowledge, this is the first report of the possibility of fabrication of photoactive $CuInS_2/Cu_2O$ heterojunction by electrodeposition technique. This study will pave the way to develop a low cost $CuInS_2/Cu_2O$ thin film heterostructure suitable for photovoltaic solar cells.

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