TAN-P09

ELECTROCHEMISTRY OF INDIUM AND ELECTROCHEMICAL FORMATION OF Cu-In INTERMETALLIC COMPOUNDS IN CHOLINE CHLORIDE-ETHYLENE GLYCOL (1:2)

S. García[1,2],Y. Castrillejo[1,3] , E. Barrado[1,3], J. A. Rodriguez[4]

[1]Dpto. de Química Analítica. F. Ciencias. U. Valladolid. 47011. Valladolid. SPAIN
[2]Dpto. de Ingeniería Química. UPC. 08019. Barcelona. SPAIN
[3]Institute of Sustainable Processes. Dr. Mergelina s/n 47011 Valladolid. SPAIN
[4] Area Académica de Química, UAEH. Pachuca, Hidalgo. 422184. Pachuca-Hidalgo. MÉXICO
sonia.garcia.gomez@uva.es

Indium and its alloys are suitable materials for producing semiconductor compounds (e.g. InSb, InAs, GaInAs, $CuInSe_2$ and $Cu(In,Ga)Se_2$) which are widely used in electronic and optoelectronic technology. Polycrystalline thin films of the chalcopyrite materials $CuInSe_2$ and $Cu(In,Ga)Se_2$ are proposed as absorbent materials for photovoltaic solar cells, due to their high optical absorption coefficient and p-i-n-type electrical conductivity.

The processes to prepare chalcopyrite absorber layers involve electrodeposition of precursor films of Cu-In alloy, $CuInSe_2$, $Cu(In,Ga)Se_2$ followed by re-crystallization by thermal annealing at high temperature in selenium atmosphere. An alternative to aqueous electroplating solutions is to use as electrolytes low cost room temperature ionic liquids, as the deep eutectic solvents (DES) due to their important properties (i.e high conductivity, relatively wide potential range of electrochemical stability, low vapor pressure and the ability to solvate many metal salts).

As a part of a project to look into the possibilities offered by DES in the formation of semiconductor compounds, the present work is concerned with the electrochemical behaviour of indium in the eutectic mixture ChCl-EG (1:2). The study has been carried out using different substrates as working electrodes: i) W as an inert material and ii) Cu as a reactive electrode.

$InCl_3$, dissolved in the rich chloride media as $InCl_p^{3-p}$, is reduced on a tungsten electrode to indium metal via only one electrochemical step. Conversely, InCl undergoes the following disproportionation reaction when dissolved in the eutectic ChCl:2EG.

$$3InCl(s) + (p-3)Cl^- \rightleftharpoons 2In(0) + InCl_p^{3-p}$$

Transient electrochemical techniques were used in order to study the reaction mechanism and the transport parameters of the electroactive species at a tungsten electrode. The results showed that electrocrystalization of In plays an important role in the electrodeposition process. Experimental current-time transients have been compared with the theoretical models based on instantaneous and progressive nucleation.

Mass transport towards the electrode is a diffusion process, and the diffusion coefficient of In(III) and the activation energy for diffusion have been calculated.

The electro-reduction of In(III) solutions was also investigated at a copper substrate. The resulting cyclic voltammograms evidenced the formation of In-Cu intermetallic compounds. Hence, In-Cu alloy films were obtained by continuous potentiostatic electrolysis and intensiostatic pulse electrolysis. The obtained samples, characterized by XRD and SEM, revealed the formation of the metastable CuIn phase that could be transformed into $Cu_{11}In_9$ by thermal annealing.

Acknowledgements

Authors thank the Junta de Castilla y León (RIS3 de Castilla y León 2014-2020), Project CLU-2017-09 for financial support. S. García, also thanks the youth employment operative programme (European Social Fund, ESF, and youth employment initiative, YEI).