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# A REVIEW: ELECTRODEPOSITION OF CUINTE2 FILM FROM AN ACIDIC SOLUTION

Physics

**R. V. Suryawanshi** Dept. of Electronics, Azad Mahavidyalaya Ausa, Dist. Latur- [M.S.].

**R. M. Mahindrakar** Dept. of Physics, Arts Science & Commerce College, Naldurg, Ta, Tuljapur, Dist. Dharashiv-[M.S.].

## ABSTRACT

Research aimed to electrochemically deposit copper-indium-telluride (CuInTe ) films from an acidic solution containing CuCl , InCl , TeO , and HCl. While a flat film with near-stoichiometric composition was deposited at 303 K, it was not polycrystalline. Increasing the temperature to 363 K allowed for the deposition of a polycrystalline CuInTe film with near-stoichiometric composition and increased indium content at a lower over potential. The band gap of the polycrystalline CuInTe film electrodeposited at 363 K was measured at 0.98 eV.

## KEYWORDS

Electrochemically deposit; polycrystalline CuInTe ; near-stoichiometric; the band gap.

## INTRODUCTION

The paper investigates the electrodeposition of copper-indium-telluride ($CuInTe_2$), a ternary semiconductor of significant interest for photovoltaic and optoelectronic applications. Traditional synthesis routes for such materials typically involve high-temperature and vacuum-based techniques, such as the Bridgman and thermal evaporation methods, which are costly and less scalable. In contrast, electrodeposition offers a low-cost, low-temperature, and controllable route for large-area thin film fabrication. $CuInTe_2$ is a direct bandgap semiconductor (0.92–1.04 eV), close to the ideal range for solar energy conversion, and can be fabricated as both p- and n-type. However, prior to this study, few reports existed on its electrochemical preparation. In this paper therefore sought to develop and optimize a reproducible method for depositing stoichiometric, crystalline $CuInTe_2$ films from an acidic electrolyte.

The objective of the study was to develop an electrodeposition process capable of producing stoichiometric and crystalline $CuInTe_2$ thin films under controlled electrochemical conditions. Specifically, the authors aimed to investigate the effects of deposition potential and temperature on film composition and morphology. Determine the optimal conditions for forming polycrystalline $CuInTe_2$. Measure the optical band gap to verify semiconductor quality.

### Experimental Methodology

The $CuInTe_2$ films were deposited potentiostatically from acidic aqueous solutions containing $CuCl_2$, $InCl_3$, $TeO_2$, HCl and distilled-deionized water (pH 1.0). All chemicals were of reagent grade and were used without pretreatment The three-electrode setup was used, consisting of a titanium cathode, a platinum counter electrode, and an Ag/AgCl reference electrode. Deposition was conducted at 303 K and 363 K to study temperature effects. The pH of the solution was measured at room temperature (i.e. 298 K) with a conventional glass electrode calibrated using saturated KCl aqueous solution. Cathodic electrodeposition was performed under potentiostatic conditions using a conventional three electrode setup comprised of a potentiostat (Hokuto Denko HA-501) connected to a function generator (Hokuto Denko HB-104) and a coulometer (Fuso Seisakujyo HECS-343B). An Ag/AgCl electrode immersed in saturated KCl was used as a reference. Cathodic linear sweep voltammetric measurements were obtained by scanning the potential of the working electrode at a constant rate of 2 mV/s. Film characterization included; ICP Spectroscopy for elemental composition, XRD for phase identification, SEM for surface morphology, UV–Vis Spectroscopy for band gap estimation.

## RESULTS AND DISCUSSION

Cathodic polarization curve shows reduction of Cu, In, and Te species began at -200 mV, -600 mV, and -120 mV, respectively. Co-deposition occurred via induced or under potential deposition (UPD) of indium on copper telluride. Composition results showed that indium incorporation increased with more negative potentials and higher temperature. Stoichiometric of Cu:In:Te (1:1:2) was achieved at -660 mV and 363K.Surface Morphology (SEM) revealed smooth, compact surfaces at -660 mV compared to rougher deposits at -700 mV. Crystallinity at 303 K, shows the films were largely amorphous, containing Cu–Te and In–Te phases. At 363 K, clear diffraction peaks of CuInTen appeared ((112), (204), (116)), confirming polycrystalline growth.The direct bandgap was determined as 0.98 eV, consistent with literature values for CuInTen thin films, confirming good semiconductor quality. Strengths of the Study shows that the films are successfully deposited at low-temperature i.e. electrodeposition of $CuInTe_2$. Clear correlation between potential, temperature, and film composition. Comprehensive characterization linking structure and optical behavior. Pioneering work in wet-chemical synthesis of $CuInTe_2$. Also there are some limitations such as absence of electrical or photovoltaic performance data, Limited crystallographic i.e. no lattice or grain size analysis, narrow range of electrolyte compositions studied, limited mechanistic insight into the deposition process kinetics. Work represented in this paper is one of the earliest demonstrations of ternary chalcopyrite electrodeposition.

By achieving near-stoichiometric CuInTen at moderate temperatures, the study established a foundation for scalable, cost-effective production of Cu–In–chalcogenide materials used in thin-film photovoltaics. The electrodeposition approach offers versatility for similar systems like $CuInSe_2$ and $CuInS_2$, widely studied for solar energy applications.

## CONCLUSION

Ishizaki et al. (2004) effectively demonstrated the electrodeposition of $CuInTe_2$ films with controllable composition and improved crystallinity through optimized potential and temperature.

The findings highlight the feasibility of using low-temperature electrochemical techniques to fabricate ternary semiconductor materials for photovoltaic use. Further studies should focus on understanding the growth mechanism, improving crystalline quality, and evaluating device-level performance to realize full technological potential.

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