

Electrodeposition and characterization of hematite films obtained from DMSO solution

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Recently, with the continuous reduction of fossil fuels and the consequent increase of carbon dioxide in the atmosphere, many researches are focused on the utilization of new and more efficient renewable energy sources. In this context, solar energy is one of the most promising because it is free and can be transformed in both directly in electricity through solar cells or into chemical species of interest using photoelectrochemical cells (PEC). In both cases, semiconductor materials are essential for the fabrication of these devices. Metal oxides with semiconductor properties are ideal materials for these purposes due to their stability, benign nature, abundance and environmental compatibility. Thus, α -Fe₂O₃ (hematite) due to its properties (n-type semiconductor, stable in most electrolytes at pH > 3, band gap between 2–2.2 eV which is sufficient to utilize approximately 40% of the incident sunlight) is a good candidate to be used in photoelectrochemical and photovoltaic devices.

Numerous techniques have been reported for α -Fe₂O₃ thin films deposition such as chemical vapor deposition (CVD), organometallic chemical vapor deposition (MOCVD), plasma-enhanced chemical vapor deposition (PECVD), atomic layer deposition (ALD). All these techniques require high temperature and low pressure and are expensive. However, electrochemical methods are low cost techniques because the equipment required is simple and they work under atmospheric conditions. Numerous studies have demonstrated electrodeposition of α -Fe₂O₃ films and nanostructures, employing aqueous electrolytes.

The present study presents results obtained in the electrodeposition of thin films of α -Fe₂O₃ (hematite) from DMSO solutions employing FeCl₃ and molecular oxygen as precursors. The films were obtained using cyclic voltammetry at different temperatures. As grown films were photoelectrochemically inactive, and XRD analysis confirms the absence of hematite peaks in the films. After an annealing treatment (500°C - 700°C) the films become photoelectrochemically active and peaks corresponding to hematite structure appear in the corresponding diffractograms (Figure 1).

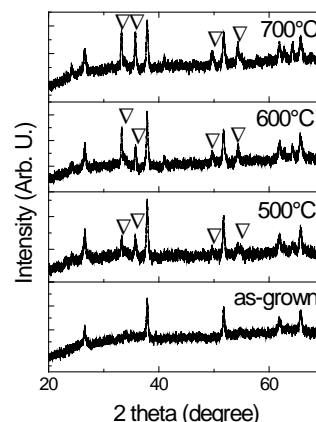


Figure 1: XRD of α -Fe₂O₃ films with different annealing treatment. The symbol ∇ indicated the signal corresponding to hematite.

Different techniques have been employed to characterize the films and to determine how their properties depend on the conditions of electrodeposition and the annealing temperature (photocurrent analysis, UV-Vis spectroscopy, Mott-Schottky plots, IMPS and IPCE). A strong dependence of the photoelectrochemical properties and structural characteristics on the annealing temperature has been established. Thus, the FWHM of the XRD peak corresponding to the more intense signal of hematite becomes sharper with increasing temperature of annealing. At the same time, the photocurrent increases to higher values of photocurrent and electron-hole recombination decreases (Figure 2).

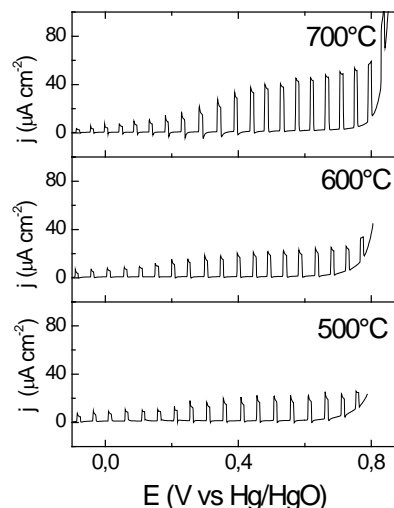


Figure 2: Photocurrent of α -Fe₂O₃ films treated at different temperature. The measurements were carried out with white light in a 0.1 NaOH solution.

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