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Photoelectrochemical solar cells from TiO_2 nanotubes modified by electrodeposited Cu_2O and Fe_2O_3

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The storage of solar energy through photoelectrochemical water splitting to produce hydrogen fuel is a promising route to address the challenge of solar energy's inherent intermittency [1]. TiO_2 nanotube arrays can be formed by anodizing Ti foils in fluoride containing water/ethylene glycol electrolytes. They exhibit beneficial properties for photoelectrochemical applications such as high surface area, 1D charge transport, and stability in solution and under irradiation [2]. A major challenge to using TiO_2 as a photoanode is the wide bandgap of 3.2 eV that only enables this material to absorb UV light. We sensitized these nanotube arrays with narrow bandgap oxides Cu_2O and Fe_2O_3 (bandgap ~2.1eV) to extend the absorption into the visible portion of the solar spectrum, yielding an increase in integrated quantum efficiency from 0.5% to 2% [3-4]. In order to further enhance the efficiency, a better understanding of the electrochemical and electronic structure of these materials is required. We have characterized the Cu_2O/TiO_2 and Fe_2O_3/TiO_2 systems using the Mott-Schottky technique, obtaining the flat band potentials and doping concentrations. Additionally, we have studied the effect of the water to ethylene glycol ratio of the anodization electrolyte on the photocurrent efficiency of TiO_2 nanotubes, with an electrolyte of 11 vol% water in ethylene glycol producing the highest quantum efficiencies in the UV. Nanotubes prepared in a range of electrolytes with varying water content were examined with electrochemical impedance, Raman spectroscopy and x-ray diffraction. We propose that the changes in crystallinity from varying the water content have a significant influence on the quantum efficiency.

References:

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