3rd Generation Solar Cells for Green H_2 Production by Water Splitting

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Energy is a constant and primary resource in our lives, global energy demand is increasing yearly and so does the need for clean and renewable sources. Green H2 production through solar water splitting is a promising solution to address the current global energy challenges. Photoelectrochemical (PEC) cells are one of the most promising ways to convert solar energy into hydrogen: traditionally comprising of a photoanode or photocathode (n-type or p-type semiconductor, respectively) and metal counter electrode (CE) both emerged in an aqueous electrolyte, these devices use sunlight to drive electrolysis of water, producing H_2 and O_2 molecules [1]. Tandem PEC cells use both a photoanode and photocathode, discarding the need for a metal CE and allowing for bigger efficiencies than single absorber PEC cells. We carried out numerical simulations using Shockley-Queisser limit that indicate a theoretical STH efficiency of around 21.6% for a bandgap pairing of 1.33 & 1.87 eV of the photoelectrodes, being in agreement with literature [5]. There are several semiconductors that can be used as photoelectrodes, with the most appealing being those that are inexpensive, non-toxic, and composed of abundant materials, including Fe_2O_3, WO_3, and TiO_2 (for n-type) [2,3,4]. Cupric Oxide (CuO) is a p-type semiconductor that is inexpensive, non-toxic, environmentally friendly and abundant material with reported tunable bandgap in the range [1.2-2.6] eV based on preparation conditions [6], making it a suitable candidate for a tandem PEC cell photocathode. Although having an exceptional maximum theoretical current density of -35 mA/cm^2, reported efficiencies are still far from theoretical value and long-term stability is still a concern and topic of active research. In this work, different cost-effective and scalable fabrication methods of CuO thin films are exploited, mostly relying on electrodeposition and annealing procedures. Several electrodeposition parameters are optimized, including applied voltage, pH and deposition rates. The obtained CuO thin films are characterized in terms of morphology and structure as well as their photoelectrochemical performance by J-V measurements under illumination.

References

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Figures

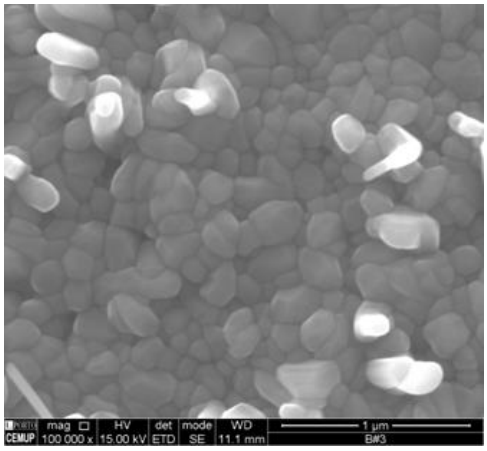

Figure 1: Synthetized CuO by electrodeposition of Cu at pH 2.7 and posterior annealing at 550ºC.