Inorganic Materials for Solar Energy Conversion and Storage

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Abstract:

In order to power our planet using the sun, efficient and low-cost solar conversion materials and new technologies for large-scale energy storage are needed.

I will first present progress in growing GaAs - a near ideal solar conversion material - in thin film format using a simple atmospheric-pressure close-source vapor transport (CSVT) method with a solid GaAs source and water vapor as a transport agent. We use non-aqueous photoelectrochemistry to analyze the properties of the CSVT GaAs without fabricating more-complicated solid-state devices. Contrary to expectations, we found that the water vapor used as a transport agent did not adversely affect the electronic properties of the CSVT GaAs. The best CSVT GaAs had minority carrier diffusion lengths in excess of 1 micron and solar conversion efficiencies in the unoptimized photoelectrochemical test cell near 10%. These results demonstrate that the electronic quality of CSVT GaAs is sufficient for use in solar fuels and photovoltaics applications, and motivate significant further study. Incipient efforts to grow GaAs on alternative substrates and to control the nanostructure to reduce reflectivity and further improve carrier collection will also be discussed.

In order to directly store solar energy in the form of chemical fuels, for instance by splitting water into hydrogen and oxygen, semiconductors must be coupled with electrocatalyst films that ideally don't absorb visible light. I will present the solution synthesis, structural/compositional characterization, and oxygen-evolution electrocatalytic properties of ultra-thin (2-3 nm thick) electrocatalyst films of first-row transition metal oxides. We use quartz-crystal microgravimetry, voltammetry, and steady-state Tafel measurements to compare the intrinsic electrocatalytic activity of the oxides and *in-situ* spectroelectrochemistry to quantify the optical properties at electrode potentials where water oxidation is taking place. We find several compositions that are largely transparent and have significantly higher activities in basic media than iridium oxide control films.