Ben-Gurion University of the Negev
Blaustein Institutes for Desert Research
The Swiss Institute for Dryland Environmental and Energy Research
Alexandre Yersin Department of Solar Energy and Environmental Physics

Title:

Iron-Oxide (Rust) for Solar Energy Conversion and Storage: Novel Insights into Semiconductor|Electrolyte Interface via Dynamical Systems Approach

Speaker:

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Abstract:

Solar-powered fuel production is a promising route to store radiant solar power in the form of chemical energy. Photovoltaic (PV) devices have demonstrated significant solar power conversion efficiency, but they lack the storage capacity which is needed for power leveling of intermittent power sources such as solar irradiation. Semiconductor photoelectrodes can absorb sunlight and convert part of it into chemical energy. This direct solar to fuel conversion (e.g., hydrogen) offers potential advantages in efficiency and cost in comparison to PV-powered electrolysis (power to gas) systems. Despite the potential for high efficiency and low cost, in practice the performance of photoelectrodes for solar fuel production lags far behind that of PV-powered electrolysis. Improving their efficiency and performance requires detailed understanding of the underlying processes that govern the photovoltage and photocurrent produced at the semiconductor photoelectrode|electrolyte interface, and specifically the role of surface states that responsible for high charge recombination.

Iron oxide is one of the most promising photoanode candidates for water photo-oxidation, which is the limiting factor in water splitting processes. However, it is also notoriously known for fast recombination of charge carriers and thus, is a critical problem resulting in a major loss that limits the photocurrent. To study in detail the photo-electrochemical limiting factors, we exploited electrolytes containing various concentrations of hydrogen peroxide (H_2O_2). The latter acts as a hole scavenger and thus, allows for insights into the competition between recombination reactions and the photo-anodic water splitting reactions. Empirical observations produced surprising nonlinear current-voltage relations which triggered formulation of a novel chemical mechanism and respective nonlinear model equations. Not only we were able to reproduce the experimental results but the analysis also predicted an appearance of bistability regime in some parameters range. By designing corresponding experiments, hysteresis has been indeed found experimentally, manifesting the need for spatiotemporal theory for electrochemistry with semiconducting electrodes, in general.

The work is in collaboration with experimental groups of Avner Rothschild (Technion) and Iris Visoly-Fisher (BIDR).

Tuesday, June 20, 2017, 11:00
Lecture room, Physics Building (ground floor)