Advanced Lab Course

Semiconductor Photoelectrochemistry

Chair of Experimental Semiconductor Physics (Prof. Sharp), Walter Schottky Institute

Am Coulombwall 4, 85748 Garching

Technical University of Munich

Abstract

The photocatalytic conversion of sunlight into chemical fuels using semiconductors is a promising approach for sustainable energy storage that overcomes the limitations of intermittent solar radiation. In such a process, often called artificial photosynthesis, semiconductors are responsible for capturing sunlight and transporting charge to solid/liquid interfaces where chemical reactions proceed. Currently, semiconductor materials form the basis for key technologies such as modern microprocessors, light emitting diodes, and solar cells. However, to apply semiconductors for solar energy conversion to high energy density fuels, they need to meet a challenging combination of different requirements, such as a suitable energetic band alignment with the desired redox reaction energy levels, a high photoactivity in the visible light range and stability in harsh electrochemical conditions. Finding suitable, efficient and stable materials remains a challenge of current research. An essential method for investigating semiconducting materials for their suitability is to characterize their photoelectrochemical (PEC) properties.

In this laboratory module, you will perform state-of-the-art photoelectrochemical measurements with the semiconductor bismuth vanadate ($BiVO_4$) for the application of solar water splitting into H_2 and O_2. You will prepare your own $BiVO_4$ photoanode, setup and operate a three-electrode PEC reactor, ensure photoexcitation with sun-like light with a solar simulator and analyze the $BiVO_4$ PEC characteristics in electrolyte with a potentiostat. In addition to the practical experience, you will gain insights into the fundamental charge carrier transfer mechanisms across the semiconductor/liquid interface and understand the competitive kinetics of photocarrier recombination and chemical reactions that are unique to such systems.

Keywords

Semiconductors, photoelectrochemistry, solar energy conversion, semiconductor/liquid interfacial energetic alignment, photocarrier recombination, redox reaction kinetics, cyclic voltammetry, potentiostat, reference electrodes.

Experimental setup

Photoelectrochemical reactor in three-electrode configuration with working, counter and reference electrode, photoexcitation by a LOT-Quantum Design solar simulator, and electrical control and measurement by a Gamry Instruments potentiostat.