

Development of oxide photoelectrodes for water splitting

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Photocatalytic and photoelectrochemical water splitting can be used to harvest solar energy, producing hydrogen gas. The energy collection process is similar to a solar cell, except that instead of extracting an electric current, photocarriers generated in a semiconductor are directly utilized to drive a chemical reaction. The semiconductor material used as a photoelectrode in a photoelectrochemical reaction cell has to be stable in water and provide carriers with a sufficient overpotential relative to the redox potentials of water. A common materials selection strategy is thus to start with a water-stable oxide semiconductor and tune the bandgap of the semiconductor to obtain optimal light absorption efficiency while still being able to split water. In our work, the starting point is SrTiO_3 , which we dope with several noble metals, such as Rh, Ir, Pt, etc. to reduce the bandgap from the 3.2 eV of intrinsic SrTiO_3 . Especially Rh- and Ir-doped SrTiO_3 are known to work as hydrogen- and oxygen-evolution photoelectrodes.

Despite the potential benefits of photoelectrochemical fuel production, the efficiency of the energy conversion process is still low. Our purpose is to determine the rate-limiting factors of the water splitting reaction on doped SrTiO_3 surfaces. It appears that the biggest issue in doped SrTiO_3 is the limited photocarrier diffusivity due to the presence of shallow trap states and the short carrier lifetime caused by unoccupied dopant states in the mid-gap region. I will review recent progress in the development of doped perovskite semiconductor photoelectrodes and discuss strategies of coping with the presence of unfavorable defect states.