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Cubic Silicon Carbide as Photoelectrode for Hydrogen Generation from Solar-driven Water Splitting

Hydrogen is an attractive energy carrier, advantages being its high energy density (three times that of gasoline) and clean by-product (water) when combusted for energy generation. Thus, harvesting solar energy to produce hydrogen can support reducing the problems of the depletion of fossil fuels, the emissions of CO_2, the environmental pollution, and the energy security of our society.

The photoelectrochemical water splitting into H_2 and O_2 by semiconductors has attracted much attention because of its potential to use the abundance of solar energy and water on Earth. However, it is an enormous challenge to find an efficient visible light-absorption semiconductor electrode which has suitable semiconductor-redox energetics for water splitting. Among all commonly used materials, cubic silicon carbide (3C-SiC) has outstanding properties to convert visible sunlight energy and water into hydrogen, but 3C-SiC has not been available in high quality.

In this project, 3C-SiC will be used as a photo-electrode to absorb and convert solar energy into hydrogen via a photoelectrochemical water-splitting cell. To realize a high solar-to-hydrogen conversion efficiency using 3C-SiC, we will adapt a growth process of high-quality 3C-SiC by exploring optimum doping concentrations for both n- and p-type 3C-SiC, establish a knowledge on the influence of the carrier lifetimes and transport properties on the hydrogen conversion efficiency, and open up a new approach of improving the hydrogen conversion efficiency by means of the nanostructured n- and p-type 3C-SiC electrode. We will demonstrate a practical water-splitting prototype for hydrogen generation with an improved efficiency using 3C-SiC.

The principle of PEC hydrogen generation is demonstrated in Fig. 1. The typical PEC water splitting cell is composed of a semiconductor photoelectrode and a metal counter electrode which are immersed in the aqueous electrolyte. The semiconductor photo-electrode absorbs the sunlight energy and converts incident photons to electron–hole pairs. These carriers are spatially separated from each other by the presence of a built-in electric field which is formed due to the surface potential. The photo-generated minority carriers are swept toward the n-type semiconductor/electrolyte interface to oxidize water (O_2 generation). The photo-generated majority carriers are transported to the metal electrode to reduce water (H_2 generation). For p-type case, H_2 is generated on the semiconductor surface and O_2 on the metal surface. Therefore, H_2 and O_2 can be generated separately by the PEC water splitting only consuming the sunlight energy.

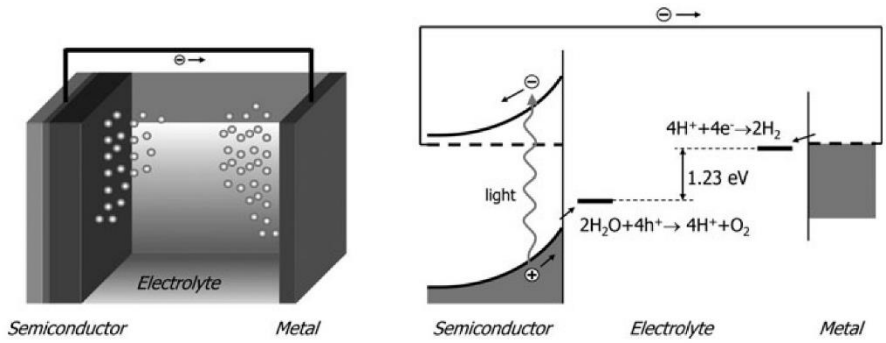

Fig. 1 *Illustration of a photoelectrochemical cell comprising a n-type semiconducting photoanode and a metal cathode. The principle of operation for H_2 generation is presented on the right side.*

A relevant ref. , for example, please see:

- Jun Tae Song et al. Appl. Phys.Lett.103, 213901 (2013),
- M. Kato et al., Int. J. Hydrogen Energy, **39**, 4845–4849 (2014).