

A stirring-free photoelectrochemical cell for solar hydrogen production

Direct conversion of solar energy to hydrogen via photoelectrochemical (PEC) water splitting is a promising approach to a sustainable-energy society, because hydrogen is storable, transportable, and can be converted to electricity without producing carbon dioxide. PEC cells composed of a semiconductor photocathode and photoanode connected in series have attracted considerable attention as a relatively simple and efficient means of driving the overall water splitting reaction without the application of an external bias voltage.

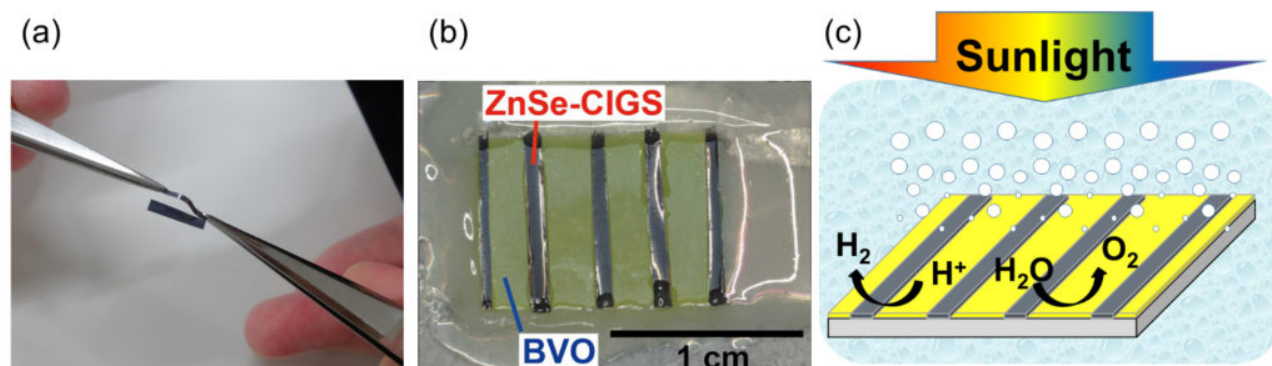


Fig. 1. Photographic images of (a) a ZnSe-CIGS photocathode prepared on a Ti foil substrate and (b) an integrated PEC cell, and (c) schematic illustrating the overall water splitting reaction over the integrated PEC cell under illumination.

This work demonstrates an integrated PEC cell capable of driving the water splitting reaction without a need to stir the electrolyte, thus improving the energy conversion efficiency. Given the absence of forced convection in the electrolyte, it is important for the photoelectrodes to be situated as close as possible to one another in the cell so as to facilitate the mass transfer of reactants. For this reason, a new flexible photocathode is employed.

A Mo-coated Ti foil is used as the substrate for a thin film of the photocathode material $(\text{ZnSe})_{0.85}(\text{CuIn}_{0.7}\text{Ga}_{0.3}\text{Se}_2)_{0.15}$ (ZnSe-CIGS). A soda-lime glass nanolayer is inserted between the Mo layer and the Ti foil because doping with Na greatly enhances the carrier concentration in the photocathode. A photographic image of the resulting flexible photocathode is presented in Figure 1(a). In contrast to a conventional glass plate substrate, this ZnSe-CIGS photocathode on the Ti foil can be readily cut and manipulated. This material is first cut into 0.1×1 cm sections, and then arrayed on the surface of the photoanode to fabricate the integrated PEC cell. BiVO_4 (BVO) is employed as the photoanode material because of its high quantum efficiency and durability. Figure 1(b) shows a photographic image of the integrated PEC cell, while Figure 1(c) illustrates hydrogen

and oxygen evolution from the surfaces of the ZnSe-CIGS photocathode and BVO photoanode, respectively. Most importantly, the reaction sites are located very close to one another, facilitating the in-plane diffusion of reactants.

As a result, the integrated PEC cell exhibits a solar-to-hydrogen conversion efficiency of 1.0% without stirring of the electrolyte solution. This value is higher than those reported for conventional parallel PEC cells due to the superior mass transfer of reactants via in-plane diffusion. The current study therefore suggests a viable approach to constructing a scalable and efficient PEC water splitting system.

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Publication

[Overall water splitting by photoelectrochemical cells consisting of \(ZnSe\)_{0.85}\(CuIn_{0.7}Ga_{0.3}Se₂\)_{0.15} photocathodes and BiVO₄ photoanodes.](#)

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