Efficient Hydrogen Production by Photoelectrochemical Water Splitting Using a ZnSe:Cu(In,Ga)Se_2 Photocathode

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Photoelectrochemical (PEC) water splitting is a promising method to produce hydrogen from water without emitting carbon dioxide. Among various types of the PEC systems, a PEC cell consisting of a photocathode and photoanode connected in series without an external bias voltage is expected to be a relatively simple and efficient system. It has been reported that a $(ZnSe)_{0.85}(CuIn_{0.7}Ga_{0.3}Se_2$ $(CIGS))_{0.15}$ photocathode shows a relatively high onset potential of ~0.9 V_{RHE}, large photocurrent of 4.9 mA cm^{-2} at 0.6 V_{RHE} under simulated sunlight, and long absorption edge of 850~900 nm [1], which means that this photocathode is suitable for the PEC cell. In the present work, a PEC cell using the $(ZnSe)_{0.85}(CIGS)_{0.15}$ photocathode and a photoanode has been fabricated to demonstrate spontaneous water splitting reaction.

The $(ZnSe)_{0.85}(CIGS)_{0.15}$ thin film was prepared by co-evaporation method in a high vacuum chamber. Cadmium sulfide for p-n junction, a binary of Mo/Ti as a conductive layer [2] and Pt as a hydrogen evolution reaction catalyst were subsequently deposited onto the film. A $BiVO_4$ modified with a NiFe-(oxy)hydroxide/borate as an oxygen evolution reaction catalyst [3] was employed as the photoanode. Since the $BiVO_4$ photoanode is semi-transparent, a tandem-type PEC cell as shown in Fig. 1 can be constructed. In this scheme, photons with wavelengths longer than the absorption edge of $BiVO_4$ (~510 nm) pass throw the photoanode and are utilized by the photocathode. The current-potential curves for each photoelectrode under chopped sunlight are shown in Fig. 2. The intersection corresponds to the working potential and photocurrent of the cell.

As a result, the tandem-type PEC cell showed the water splitting reaction with a Faradaic efficiency of unity. The initial value of solar-to-hydrogen conversion efficiency was found to be 1.6%. The detail of reaction condition and the result will be discussed in the presentation.

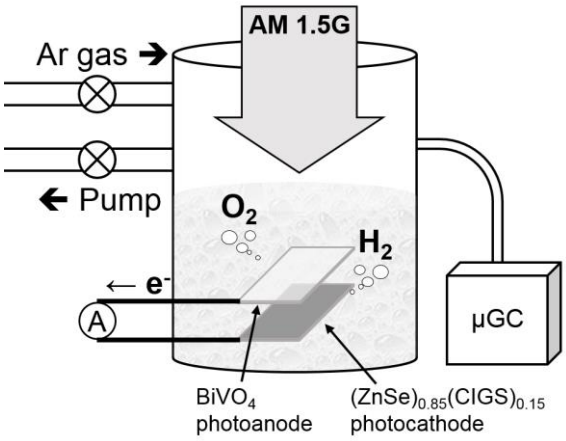

Fig. 1 Scheme of the tandem-type PEC cell with a gas quantification system.

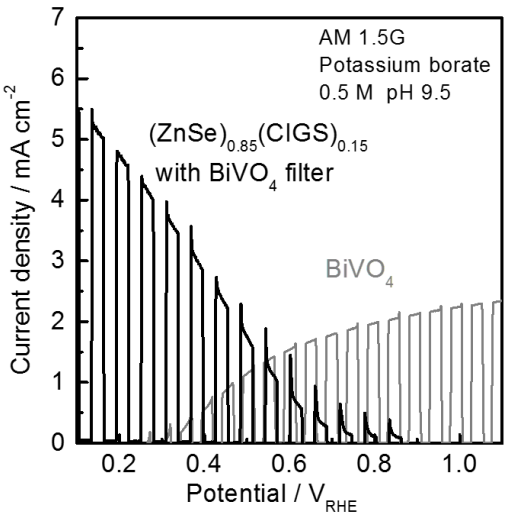

Fig. 2 Current-potential curves for a BiVO4 photoanode and a $(ZnSe)_{0.85}(CIGS)_{0.15}$ photocathode with a $BiVO_4$ filter.

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