Hydrogen generation by water splitting using TiO_2 and SiC in tandem structure

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Introduction

Conventional Hydrogen Generation Method
- Use fossil fuels
- Emit CO_2

Method with Water Splitting by Light Illumination
- Not use fossil fuels
- No CO_2 emission

However, the splitting efficiency is low.
We use the tandem structure to increase efficiency!

Samples Condition

Sample	4H-SiC/3C-SiC		TiO_2
Material	Epitaxial	p-type 3C-SiC	n-type TiO_2
	Substrate	p^+-type 4H-SiC	
Surface treatment		Pt-loaded	None
Doping density		$N_A < 1\times10^{15}$	N_B 0.01wt%
Bandgap		3.2eV / 2.2eV	3.2eV

We fabricated the samples by fixing the material on a polycarbonate plate by wax with only the surface exposed.

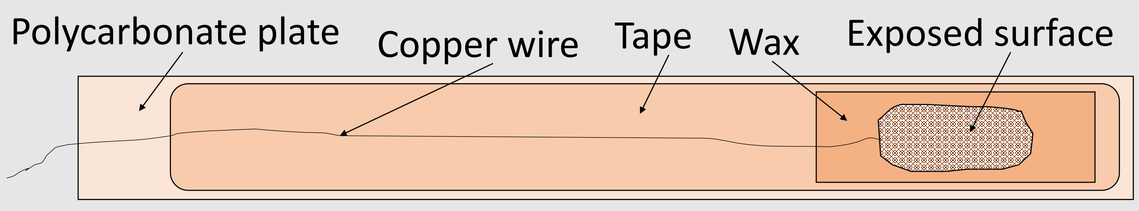
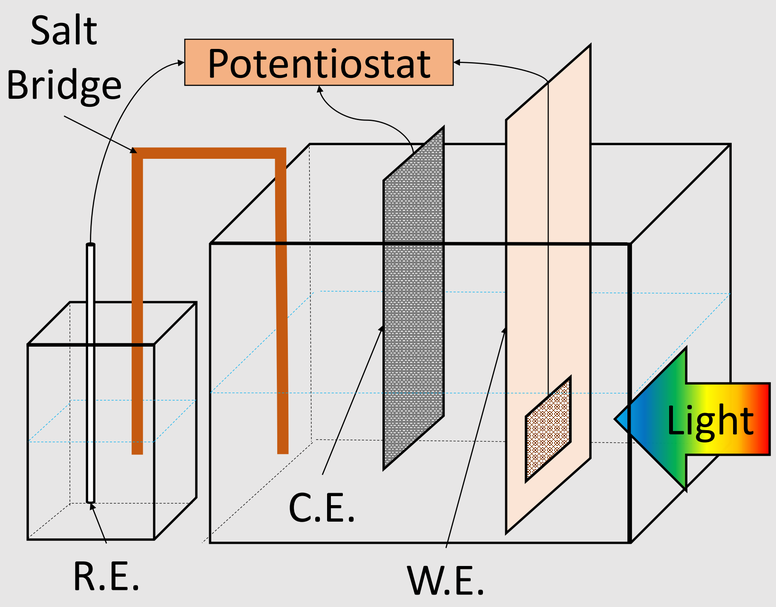


Fig.1 Sample fabrication

Photoelectrochemical (PEC) Analysis



- Three electrode system
- 0.1W/cm² light intensity
- 1mol/L of H_2SO_4 electrolyte
- (W.E.): Samples
- (C.E.): Pt
- (R.E.): Ag/AgCl

Fig.2 Schematic of chopped PEC analysis

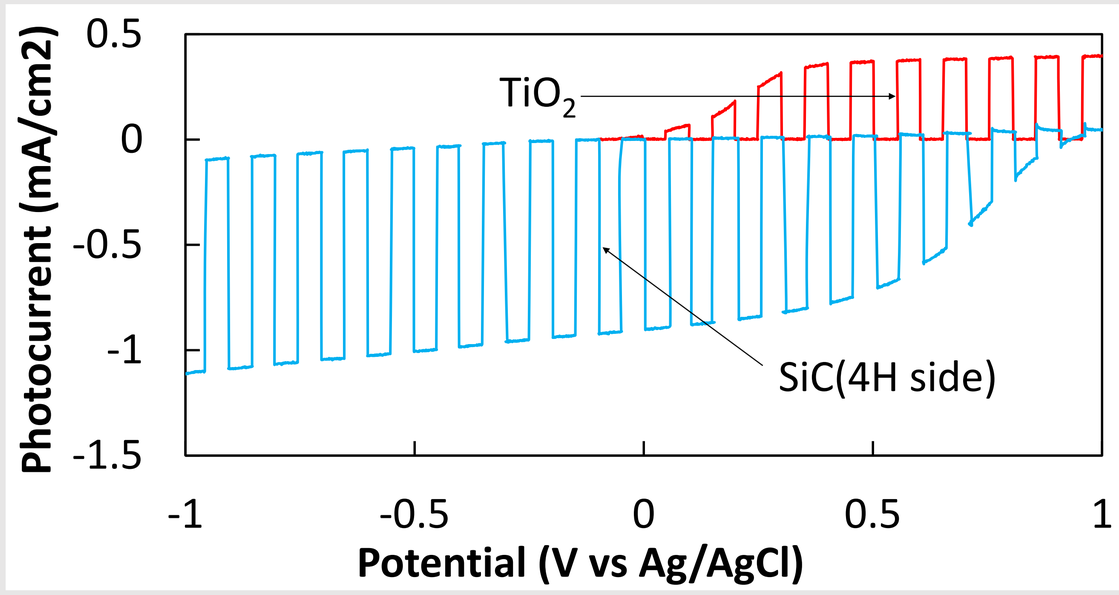
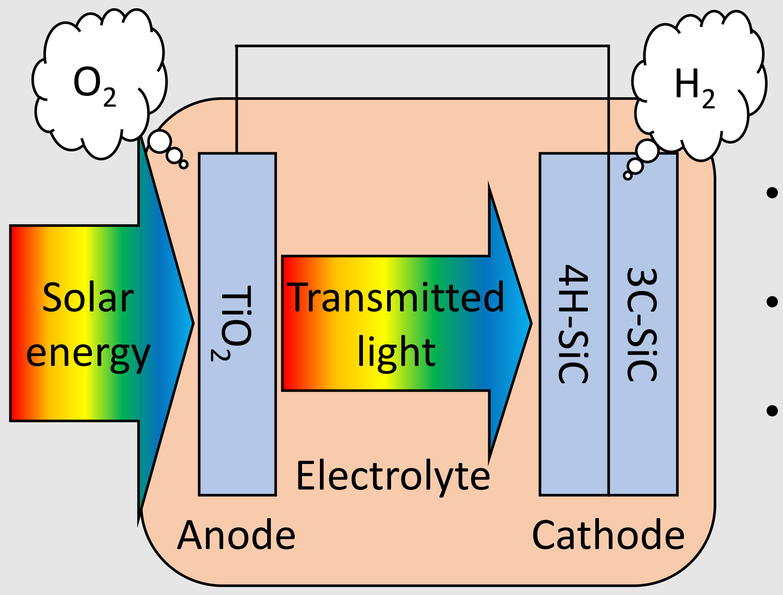


Fig.3 PEC analysis result of TiO_2 and SiC(4H side)

By PEC analysis, we can confirm the photoresponse of the TiO_2 and SiC sample.

Tandem Structure

By laminating plurality of semiconductors in series, solar energy that cannot be absorbed by the first few layers can be absorbed by the next few layers.



- Two electrode system
- 0.1W/cm² light intensity
- 1mol/L of H_2SO_4 electrolyte

Fig.4 Schematic diagram of the tandem structure.

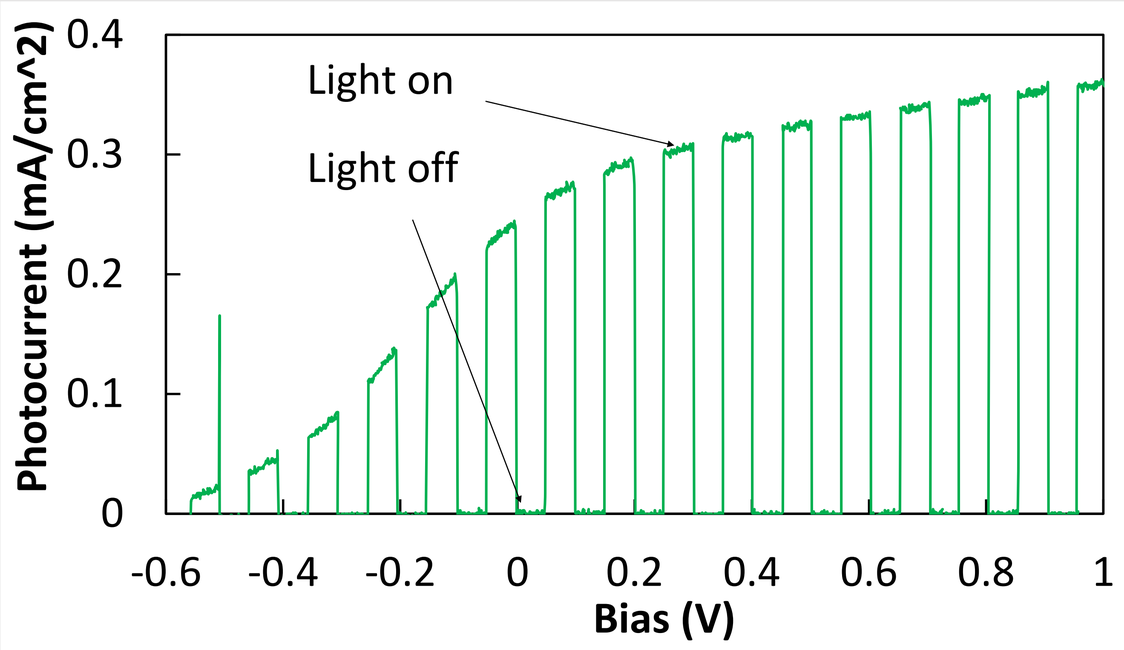


Fig.5 I-V Characteristics of tandem structure

Solar-to-hydrogen Conversion Efficiency

The solar-to-hydrogen conversion efficiency η can be obtained by

$$\eta\,(\%) = \frac{1.23 \times |I|}{L} \times 100$$

- (I): Photocurrent (with no additional bias)
- (L): Light intensity
- (1.23): Redox potential width between H^+/H_2 and O_2/H_2O

As shown in Fig. 5, The conversion efficiency of tandem structure is 0.295%. Although the efficiency of 0.72% has been reported for p-type SiC by Naoto Ichikawa[1], their photoelectrochemical cell was not self-driven model.

Conclusion

- *The tandem structure showed a self-driven solar-to-hydrogen conversion efficiency of 0.295%.*
- *Tandem structure is a promising method for the solar-to-hydrogen conversion technology.*

Reference

[1] Naoto Ichikawa et al., International Journal of Hydrogen Energy, 42, 22698 - 22703 (2017)