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Construction of photo-thermal voltaic system using black semiconductors

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1. Introduction

Solar cell based semiconductors (Si, GaAs, CIS, CIGS and so on) are widely used. The light wavelength which can be used for energy conversion depends on their bandgap width; the limitation of single crystalline silicon is approximately 1100 nm [1]. The longer-wavelength, semiconductor cannot harvest light efficiently and be used for conversion. In addition, the shorter-wavelength light (i.e. UV light) becomes loss as thermal energy and rising up the cell temperature causes reducing the conversion efficiency. We focused on the heat generated by light absorber using for the energy conversion. Black semiconductor (i.e. black silicon; b-Si, black germanium; b-Ge) which has nanoneedle structures on the surface of substrate can be used low reflection and high absorption of light. In this study, we constructed the photo-thermal voltaic conversion system via black semiconductors and thermo-electro devices and evaluated its efficiency of light absorption.

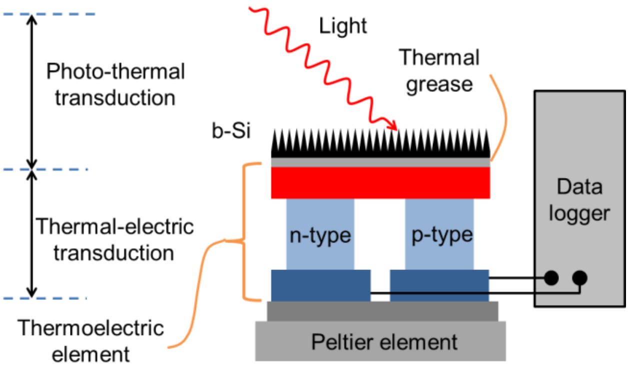

Fig.1. Photo-thermal voltaic System

2. Experiment

b-Si substrate was fabricated using dry etching process with inductive coupled plasma-reactive ion etching (ICP-RIE) flowing SF_6-O_2 gas [2]. Fig.1 shows schematic illustration of the photo-thermal voltaic system used in this study. Substrates (b-Si, Si, Al foil on ceramic plate) were pasted on the hot side of thermal voltaic cell (Nihon-Techmo co. Ltd.), the cold side was kept at constant on the peltier device. The light was irradiated with metal halide lamp (72.8 mW/cm^2). We recorded the output voltage with the data logger (ADC-16, Pico technology Ltd.).

3. Results and Discussion

Experimental results of energy conversion were shown in Fig.2. Output voltage were rising with time and had become constant after 20 s. This is because thermal diffusion in the substrate. Compared to the Al foil on ceramic plate (reflective substrate, 70% reflection), Si (mirror polished surface, 30% reflection) had 3.3 times larger output voltage, b-Si (9% reflection) had 4.6 times larger. This result indicated that the increase of light absorption efficiency improved the conversion efficiency.

4. Conclusion

We demonstrated the photo-thermal voltaic conversion using b-Si, strong light absorber. Heat generation with b-Si achieved 4.6 times larger than reflective material. For further improvement of this system, using b-Ge (for broad band light harvesting), assembling of gold nano particle (efficient heat generation using plasmon resonance) are now under consideration.

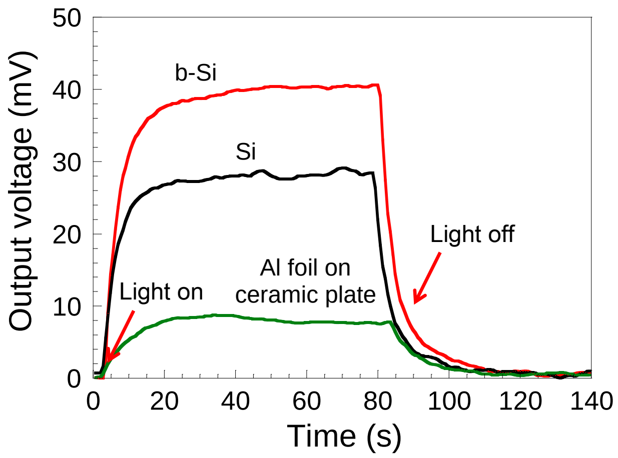

Fig.2. Output characteristics for substrates. The irradiated light power was 72.8 mW/cm^2 in the area.

References

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