Area: Thin-Film Compound Semiconductor PV

EFFECT OF SB-DOPED N$^+$-BASI$_2$ SURFACE LAYER ON THE CARRIER TRANSPORT PROPERTIES AND SPECTRAL RESPONSE

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1. Introduction

We have paid special attention to semiconducting BaSi$_2$ because BaSi$_2$ is an attractive material for thin-film solar cell. It is composed of earth-abundant elements, Ba and Si. It has a bandgap of 1.3 eV, matching the solar spectrum. In addition, it has a large absorption coefficient $\alpha = 3 \times 10^4$ cm^{-1} at 1.5 eV and a large minority-carrier lifetime $\tau \sim 10$ µs, giving a large minority-carrier diffusion length $L \sim 10$ µm for thin-film solar cell. Because of these characteristics, an energy conversion efficiency η of over 25% can be expected for 2-µm-thick BaSi$_2$ pn junction diode [1]. Recently, we achieved a conversion efficiency approaching 10% with B-doped p-BaSi$_2$/n-Si heterojunction solar cells [2]. Our next target is a BaSi$_2$ p-n homojunction solar cell. Contact resistance R_C is one of the most important parameters that directly affects the η. In our previous work, the contact resistance reached a minimum of 0.35 Ω·cm^2 in Al/B-doped p-BaSi$_2$. The purpose of this study is to reduce the contact resistance between surface electrode and Sb-doped n-BaSi$_2$. Furthermore, we confirmed Sb-doped n$^+$-BaSi$_2$/undoped n-BaSi$_2$/n$^+$-Si structure promotes the transport of photogenerated carriers by measuring its spectral response.

2. Experiment

For R_C measurements, we used high-resistivity floating-zone p-Si (111) substrates (ρ > 1000 Ω·cm). We used a two-step growth technique, that is, a conventional growth method for BaSi$_2$ to form 300-nm-thick Sb-doped n-BaSi$_2$ epitaxial layers by molecular beam epitaxy. After that, a 3-nm-thick a-Si passivation layer was deposited [3]. Next, 150-nm-thick Al or ITO surface electrodes were made by sputtering. The electron concentration n of Sb-doped n-BaSi$_2$ depends of growth temperature T_S[4]. Samples were fabricated at T_S = 460 – 520 ºC and the n values were measured by the van der Pauw method. Contact resistance was measured by the transfer length method. Finally, Sb-doped n$^+$-BaSi$_2$ (20 nm)/undoped n-BaSi$_2$ (500 nm)/n$^+$-Si were grown by the same method and the photoresponse properties were measured. The bias voltage was applied so that the photogenerated holes were transferred to the ITO electrode.

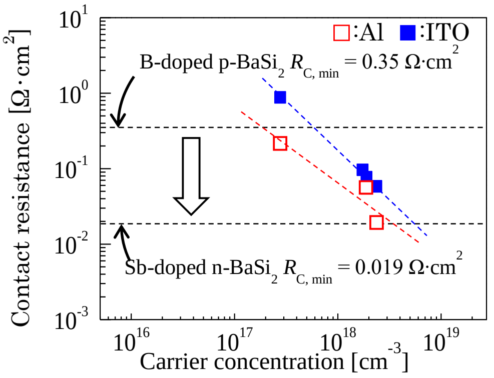

Figure 1: Relationship between R_C and carrier concentration.

3. Results and discussion

Figure 1 shows the relationship between R_C and n. The dependence of R_C on the sheet resistance R_{sheet} is given by

$$R_C = R_{sheet} \times L_t^2, \ (1)$$

where L_t is the transfer length. [5]. The increase in carrier concentration causes a decrease in R_{sheet}, leading to a decrease in R_C. The R_C reached a minimum of 0.019 Ω·cm^2 for Al/Sb-doped n-BaSi$_2$ at $n = 2.4 \times 10^{18}$ cm^{-3}. This value is more than one order of magnitude smaller than 0.35 Ω·cm^2 obtained for Al/B-doped p-BaSi$_2$. Figure 2 shows the *IQE* spectrum of Sb-doped n$^+$-BaSi$_2$/undoped n-BaSi$_2$/n$^+$-Si. There is no built-in potential in the device, and hence we applied a small bias voltage of 0.3 V. The *IQE* increased sharply for wavelengths shorter that the band gap (1.3 eV), and reached around 75% in a wide wavelength range. Large J_{SC} can therefore be expected in BaSi$_2$ pn homojunction diodes.

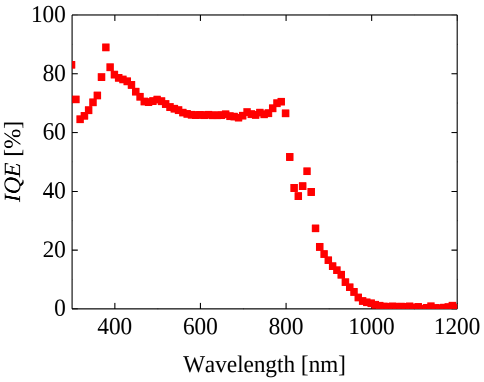

Figure 2: *IQE* spectrum of n$^+$/undoped n-BaSi$_2$/n$^+$-Si at a bias voltage of 0.3V.

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