Characterization of p-$BaSi_2$/n-Si solar cells using Boron-doped p-$BaSi_2$ on textured n-Si (001) grown by molecular beam epitaxy

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[Introduction]

Barium disilicide ($BaSi_2$) has attractive features for solar cell application such as a suitable band [1], a large minority-carrier lifetime (τ ~ 10 μs) [2] and a large minority-carrier diffusion length (L ~ 10 μm) [3]. Power conversion efficiency (η) was expected to be larger than 25% only in a 2-μm-thick $BaSi_2$ pn junction diode [4]. In our previous work, it was demonstrated that *a*-axis of $BaSi_2$ was oriented normal to the (111)-oriented texture on the Si(001) substrate and light trapping took place [5]. To ensure how thickness and hole concentration of boron(B)-doped p-$BaSi_2$ influence the performance of p-$BaSi_2$/n-Si hetero-junction solar cell, in this study, we attempted to grow a series of B-doped p-$BaSi_2$ with different thickness and hole concentration on textured Si (001).

[Experiment]

First, a 5-nm-thick $BaSi_2$ layer was grown to control the crystal orientation of $BaSi_2$ over layers by reactive deposition epitaxy process. Second, approximately 20-, 50-, 75-, and 100-nm-thick B-doped $BaSi_2$ layers were grown by molecular beam epitaxy (MBE) with various sets of B K-cell temperature (T_B) and substrate temperature (T_S). (T_B, T_S) were set at (1230ºC, 600 ºC); (1230 ºC, 650 ºC), and (1300 ºC, 650 ºC), respectively, and the hole concentration (p) was found to be 2.0×10^{18}, 4.6×10^{18}, and 3.6×10^{18} cm^{-3}, respectively. Then, a 3-nm-thick a-Si layer was prepared over the $BaSi_2$ layers to prevent oxidation of $BaSi_2$. After that, ITO electrode with a diameter of 1 mm and thickness of 80nm was sputtered on the front side. 150 nm Al was sputtered at the back. Afterwards, J-V characteristics and photoresponse were measured.

[Results & Discussions]

Figure 1 shows J-V curves of a series of samples measured under AM1.5 illumination. p was 3.6×10^{18} cm^{-3}. As the p-$BaSi_2$ film increases from 20 to 75 nm, the solar cell performance was improved. The conversion efficiency (η) increases from 0.17% to 4.52% and the open-circuit voltage was increased from 0.04 to 0.30 V. For further increase in p-$BaSi_2$ layer thickness up to 125 nm, however, the η goes down to 3.18% and the short-circuit current density decreases from 27.6 to 21.2 mA/cm^2.

Figure 2 shows the EQE spectra of the samples of various p-$BaSi_2$ thicknesses. With increasing the layer thickness, the EQE decreases especially in the short wavelength range, meaning that the contribution of photogenerated carriers in the p-$BaSi_2$ becomes small.

[Acknowledgments]

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[Reference]

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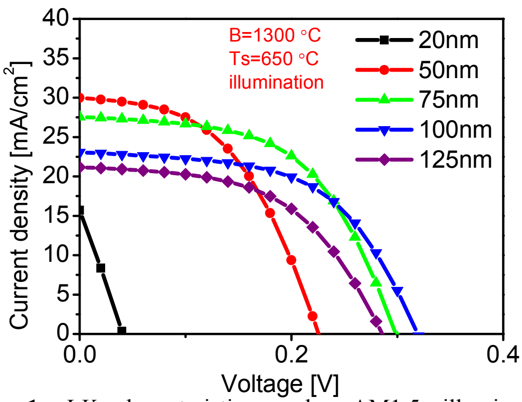

Fig. 1 J-V characteristics under AM1.5 illumination measured for samples with different p-$BaSi_2$ thicknesses.

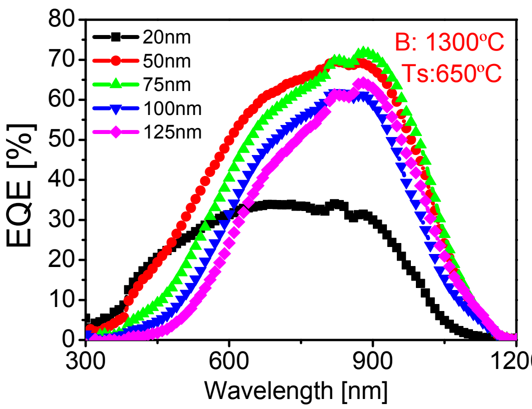

Fig. 2 *EQE* spectra for p-$BaSi_2$/n-Si heterojunction solar cells with various p-$BaSi_2$ thicknesses.