Reduction in Optical Reflection Loss at Intermediate Adhesive Layer for Mechanical Stacked Multi-Junction Solar Cells

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I. Motivation

We have developed transparent and conductive adhesive layer for fabricating mechanical stacked multi-junction solar cells. A low connecting resistivity of 1.0 Ωcm^2 has been achieved using commercial epoxy-type adhesive diffused with 20-μm-sized ITO particles [1]. Optical reflection loss at the intermediate layer has been reduced by introducing Indium-Gallium-Zinc-Oxide (IGZO) layer between adhesive and silicon substrates [2]. In this paper, we report reduction effect in optical reflection loss at intermediate layer in the case of Si and Ge, which have different band gaps.

II. Calculation

We used a layer structure of Si/IGZO/adhesive/IGZO/Ge, as shown in Fig. 1. The band gap and absorption edge and thicknesses were 1.1 eV and 1150 nm, and 500 μm for Si, and 0.67 eV and 1850 nm, and 200 μm for Ge substrates respectively. The thickness and refractive index were 20 μm and 1.3 for the intermediate adhesive layer. The IGZO layers formed on Si and Ge had a thickness of 0 or 200 nm and a refractive index of 1.85. Reflectivity spectra at the Si top surface were calculated using finite element numerical analysis program including multiple reflection and free carrier absorption effects. Fresnel type optical interference effect was also calculated between IGZO interfaces. Resistivity of IGZO and intermediate adhesive layer was set as 0.03 and 500 Ωcm to achieve electrical connection.

III. Results and discussion

Figure 2 shows calculated reflectivity spectra in the cases of 200-nm-thick IGZO layers formed on both Si and Ge (A), 200-nm-thick IGZO formed only on Si (B), only on Ge (C), and no IGZO formed (D). The spectrum (A) gave low reflectivity ranging from 33 to 38 % for wavelength between from 1150 to 1600 nm at which light completely transmits Si and is completely absorbed in Ge. Those values were close to the reflectivity of the Si top surface of 30%. This result indicates IGZO layers caused a good anti-reflection effect at Si and Ge surfaces. The spectra (C) had optical reflectivity ranging from 42 to 45%, which were lower than that of the spectra (B) ranging 45 to 47%, because of higher anti-reflection effect due to higher refractive index of Ge than that of Si. Reflectivity values of the spectra (B) and (C) were lower than those of spectrum (D) ranging 51 to 52%. We will also fabricate samples of Si/IGZO/adhesive/IGZO/Ge to experimentally demonstrate reduction in optical reflection loss in the conference.

References:

[1] S. Yoshidomi, M. Hasumi, and T. Sameshima, 2013 JSAP-MRS Joint Symposia, 18p-M2-4.

[2] S. Kimura, S. Yoshidomi, M. Hasumi, S. Takase, Y. Ando, T. Sameshima: The 75th JSAP Autumn Meeting (2014) 18a-A28-8.

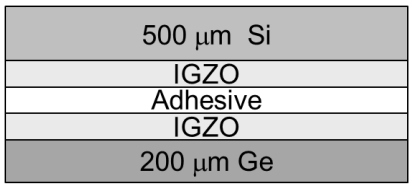

Fig. 1 Cross section of sample structure for calculation.

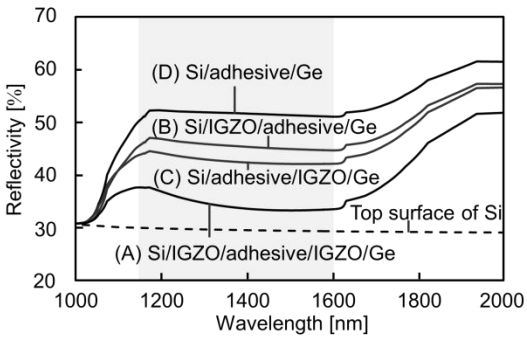

Fig. 2 Calculated reflectivity spectra of (A) Si/200nmIGZO/adhesive/200nmIGZO/Ge, (B) Si/ 200nmIGZO/adhesive/Ge, (C) Si/adhesive/200nmIGZO/Ge, and (D) Si/adhesive/Ge.