透明導電薄膜を用いたメカニカルスタックソーラーセルの光反射ロス低減

Transparent and conductive layers used for Reducing Optical Reflection Loss for Fabricating Mechanically Stacked Multi-Junction Solar Cells

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Introduction

We have proposed mechanically stacked multi-junction solar cells using the epoxy adhesive dispersed with 20-µm-sized ITO conductive particles. We have also proposed the introduction of Indium Gallium Zinc Oxide (IGZO) transparent and conductive thin films formed by plasma sputtering method to reduce optical reflection loss at intermediate adhesive region caused by difference of refractive indexes [1]. In this paper, we report SnO_2 anti-reflection layer formed by spin coating for establishing low cost processing. We also report change in the optical reflection loss with different incident angles.

Experimental procedure

We prepared 500-µm-thick crystalline GaAs and crystalline Si substrates. The SnO_2 colloid were coated on the top surfaces of these substrates by spin coating. The samples were then heated at 200 ^oC for 1 h to form 157-nm thick SnO_2 films with a refractive index of 1.57. GaAs and Si substrates were subsequently stacked with the SnO_2 surface facing each other with Cemedine adhesive containing 20-µm-diameter ITO particles dispersed at 3.8 wt%. The adhesive was solidified by pressuring under 0.8 MPa N_2 gas for 2 h. GaAs and Si stacked sample with 130-nm thick IGZO layers formed by plasma sputtering was also measured for comparison. Optical reflectivity spectra from 250 to 1500 nm were measured by a spectrometer with normal incident. Optical reflectivity spectra from 650 to 1100 nm with the incident angle from 10 to 60^o were also measured by a home-made spectrometer.

Results and discussion

Figure 1 shows optical reflectivity spectra for the samples of GaAs/adhesive/Si, GaAs/157nm-SnO_2/adhesive/157nm-SnO_2/Si, and GaAs/130nm-IGZO/adhesive/130nm-IGZO/Si. In the region hatched from 902 to 1020 nm, which the top GaAs substrate is transparent and bottom Si substrate is opaque, the optical reflectivity of the sample with the SnO_2 layers ranged from 38 to 40 %. That was higher than that of the sample with the IGZO layers (34%) and lower than that of the direct staking sample of GaAs and Si (40~45%). Those results indicate that the SnO_2 layers play a role of anti-reflection for stacking GaAs and Si with epoxy adhesive. The effective absorption ratio of bottom Si substrate A_{eff} was estimated by the following equation (1)

$$A_{eff} = \frac{\int_{902}^{1020}\{100-R(\lambda)\}d\lambda}{\int_{902}^{1020}\{100-r(\lambda)\}d\lambda} \quad (1)$$

where R(λ) and r(λ) is optical reflectivity of the stacked sample and the top surface of the top substrate determined by measuring a GaAs substrate, respectively. Figure 2 shows A_{eff}

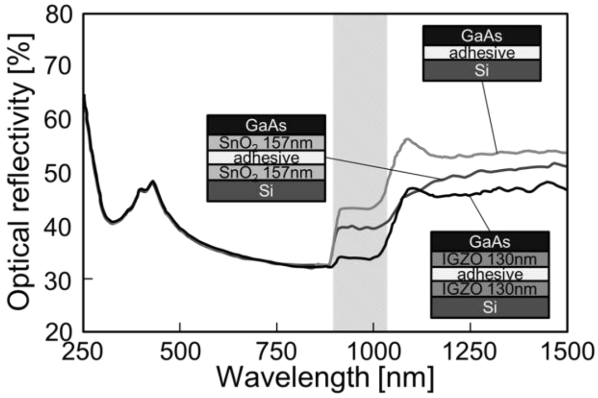

Fig. 1. Optical reflectivity with normal incident

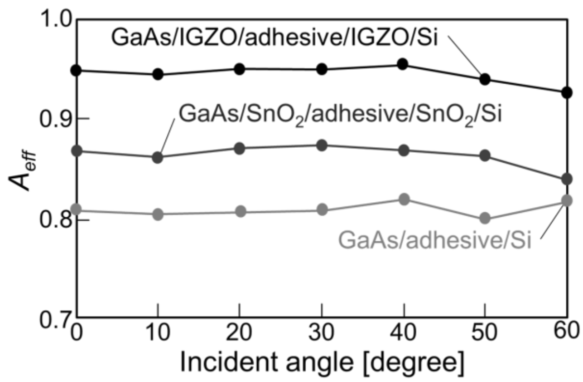

Fig. 2. A_{eff} as a function of incident angle of light

as a function of the incident angle. The stacked sample with 130-nm IGZO had high A_{eff} ranging from 0.92 to 0.95. The stacked sample with 157-nm SnO_2 had A_{eff} ranging from 0.84 to 0.87. While the direct stacked sample had low A_{eff} ranging from 0.80 to 0.82. Low refractive index of SnO_2 of 1.57, which was close to that of adhesive layer of 1.47, results in low A_{eff} with the case of 130-nm thick IGZO whose refractive index is 1.85. Research of transparent conductive material with a high refractive index is necessary

Conclusion

157-nm thick SnO_2 layers formed by spin coating were applied to reduce the optical reflection loss for the stacking sample of GaAs and Si. Reduction of optical reflectivity was observed. A_{eff} ranged from 0.84 to 0.87 for light incident angle from 0 to 60^o, while 130-nm-thick IGZO realized higher A_{eff} ranged from 0.92 to 0.95.

References

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