The influence of Ge substrate modification on photoresponse properties of evaporated $BaSi_2$ films for thin-film solar cells application

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1. Introduction

A compound semiconductor of barium disilicide ($BaSi_2$) has recently received much interest as one of the candidates for absorbing materials in thin-film solar cells. The remarkable features of $BaSi_2$ include appropriate band gap of 1.3 eV, high absorption coefficient (~3×10^4 cm^{-1} at 1.5 eV), long minority carrier lifetime (~10 μs), and abundant-element components. In order to fabricate $BaSi_2$ on large-scale area, thermal evaporation (TE) is a suitable method. Using this method, $BaSi_2$ was successfully grown on various flat substrates such as Si, Ge, glass, and CaF_2. Surface modification of the Ge substrate before growing $BaSi_2$ would improve absorptance by light trapping, and give impact on photoresponse properties.

2. Experimental

p-Ge (100) (ρ = 5-10 Ωcm) substrates, after cleaning with acetone to remove organic contamination, were etched by 70% HNO_3 solution for 15 min to form domes on the surface. Then, they were cleaned in 5% HF for 3 min prior to the deposition of 75-nm-thick amorphous Si supply layer by sputtering. Next, the growth of 300-nm-thick $BaSi_2$ films was carried out by TE method at substrate temperature of 500 °C. For comparison, $BaSi_2$ films were also grown on flat Ge substrates (without etching).

In order to investigate the vertical photocurrent, 80-nm-thick indium tin oxide (ITO) and 200-nm-thick Al were deposited on the surface of $BaSi_2$ film and the backside of Ge substrate, respectively. The photocurrent was measured by a lock-in technique using a 450 W xenon and 400 W halogen lamps with a monochromator to produce monochromatic light with a constant power of 50 μW/cm^2.

3. Results and discussion

Figure 1 shows the photoresponse properties of ITO/$BaSi_2$/p-Ge (modified and flat)/Al structures under forward and reverse bias voltages of 3 V. The photocurrent is generated by the light absorption and electron-hole pairs separation by electric field. For $BaSi_2$/modified Ge, the photoresponsivity can be observed clearly whereas that for $BaSi_2$/flat Ge is very weak and noisy. This suggests that the crystalline quality and/or interface property of $BaSi_2$/modified Ge is better than that of $BaSi_2$/flat Ge. It can be explained by the increase in interface area and reduction of film stress when evaporating $BaSi_2$ on modified Ge at high temperature in comparison with that on flat Ge. The result is confirmed by Raman spectra analysis, XRD, and excess carrier lifetime measurements. Moreover, the result also shows the effect of substrate modification on enhancing the absorption by light trapping, which is confirmed by optical properties measurement. The onset of photocurrent is at photon energy of 1.29 eV, which is supposed as the band-gap value of $BaSi_2$.

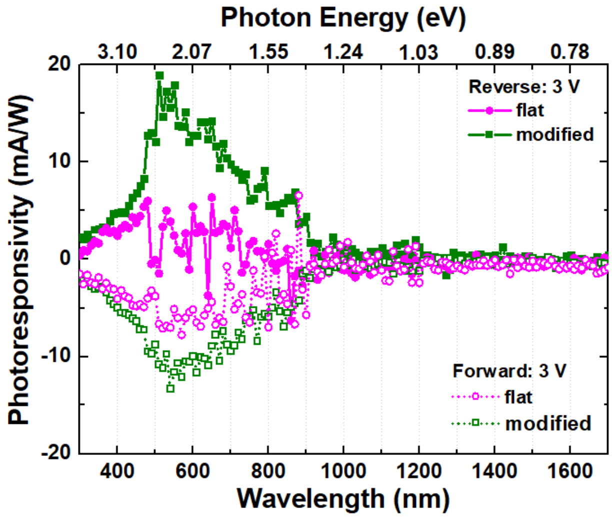

Fig. 1 Photoresponse spectra of ITO/$BaSi_2$/n-Si (modified and flat)/Al structures under forward and reverse bias voltages of 2 V.

4. Conclusion

We have shown photoresponse properties of evaporated $BaSi_2$ films on modified and flat Ge substrates. The results showed that the film grown on the former have better properties than that on the latter.

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References:

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