Improvement of Carrier Concentration of As-doped $BaSi_2$ Grown by Molecular Beam Epitaxy

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Introduction

Barium disilicide ($BaSi_2$) is one of the suitable materials for thin film solar cells due to its electrical and optical properties [1]. Currently, one of the challenges in realizing the high performing $BaSi_2$ homojunction solar cells is the fabrication of high-quality n-type $BaSi_2$ layer [1]. Previously, the fabrication and improvements of its photoresponsivity of n-type As-doped $BaSi_2$ thin film has been demonstrated grown by molecular beam epitaxy (MBE) using GaAs as the source of arsenic doping [2,3]. However, the carrier concentration is not well controlled. In our latest experiments, the activation ratio of doped arsenic atoms is quite low, approximately around 5 – 10%. In this study, the Ba-to-Si deposition rate ratio (R_{Ba}/R_{Si}) is increased in hope to increase more silicon vacancy (V_{Si}) for arsenic to occupy.

Experimental Method

In this work, As-doped $BaSi_2$ films were grown on top of p-Si(111) substrates using MBE method. The steps of thin-film growth are carried out as in the previous report [2]. The substrate temperature (T_S) during growth was set to 550°C and GaAs crucible temperature (T_{GaAs}) was varied between 700°C – 750°C. The R_{Ba}/R_{Si} was varied between 2.2 – 3.1. The carrier concentration and mobility were measured at room temperature using Van der Pauw method. The photoresponsivity was measured using a xenon lamp and a 25-cm focal length single monochromator (Bunko Keiki SM-1700A and RU-60N). SIMS measurements are carried out to identify the arsenic concentration incorporated into the grown films.

Results and Discussion

The trend of carrier properties against R_{Ba}/R_{Si} is shown in Fig.1. As can be seen, the carrier concentration increased from 5.95×10^{17} cm^{-3} (R_{Ba}/R_{Si} = 2.2) to 9.96×10^{17} cm^{-3} (R_{Ba}/R_{Si} = 2.8). This can be interpreted as more arsenic is electronically activated through occupying V_{Si} sites. The electron mobility shows the opposite trend of carrier concentration, meaning the dopants acting as scatterer [4]. However, at R_{Ba}/R_{Si} = 3.1, the observed carrier type was p-type.

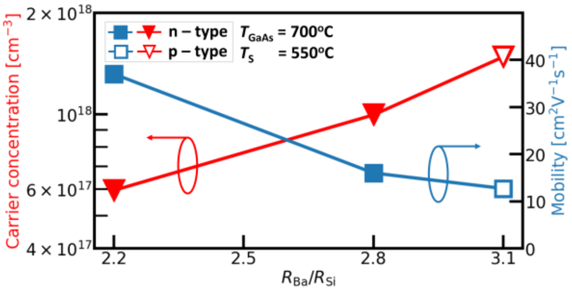

Figure 1. Carrier properties vs R_{Ba}/R_{Si}. Red marker denotes carrier concentration while blue marker denotes Hall mobility measured at room temperature.

The photoresponsivity spectra in reverse bias mode (V_{bias} = –0.5V) are shown in Fig. 2. The photoresponsivity at R_{Ba}/R_{Si} = 2.2 and 2.8 are quite similar while significantly lower photoresponsivity peaks are observed for R_{Ba}/R_{Si} = 3.1 sample.

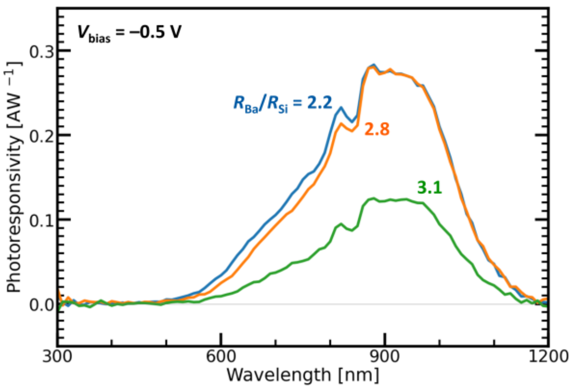

Figure 2. Photoresponsivity of grown $BaSi_2$ films at R_{Ba}/R_{Si} = 2.2, 2.8, and 3.1 measured at V_{bias} = –0.5V.

Reference

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