Study on minority-carrier lifetime mapping of $BaSi_2$ formed on multicrystalline Si substrates

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Introduction

Barium disilicide ($BaSi_2$) has been attracting attention as a new candidate material for thin-film solar cell for the following reasons. First and most important, both a long minority-carrier lifetime (~10 μs) and a diffusion length (~10 μm) can be utilized. In addition, the absorption coefficient of $BaSi_2$ ($\alpha=3\times10^4$ cm^{-1}@1.5 eV) is about 30 times larger than that of crystalline Si. Moreover, the band gap of $BaSi_2$ is 1.3 eV, which matches the solar spectrum [1-3]. Recently, we have formed $BaSi_2$ on inexpensive substrates, such as multicrystalline Si (mc-Si) and glass. It is thus significant to investigate the properties of non-epitaxial $BaSi_2$ films formed on those substrates. Grain boundaries (GBs) of $BaSi_2$ were thought to influence the recombination activities of minority-carriers (holes). However, according to our previous investigations by Kelvin probe force microscopy (KFM), GBs in non-epitaxial $BaSi_2$ films formed on mc-Si are not considered to be recombination centers. But the minority-carrier lifetime of $BaSi_2$/mc-Si is still not clear. In this work, we measured the minority-carrier lifetime mappings of $BaSi_2$ formed on a mc-Si substrate.

Experiment

We used a mc-Si wafer with small and randomly oriented grains for the growth of $BaSi_2$. A 500 nm thick undoped n-$BaSi_2$ ($n \sim 10^{16}$ cm^{-3}) capped with 8 nm α-Si was grown on 1×1 cm^2 mc-Si by MBE method. The crystal orientation of $BaSi_2$ was investigated by X-ray diffraction (XRD). The minority-carrier lifetime mapping was measured by microwave-detected photoconductivity decay (μ-PCD) method. Electron-hole pairs were generated by a 5 ns laser pulse with a wavelength of 349 nm and photoconductivity decay was measured by the reflectivity of microwave with the frequency of 26 GHz.

Results &Discussions

Figure 1 presents the *θ-2θ* XRD pattern of the sample. We see that non-epitaxial parts such as $BaSi_2$ (301) and $BaSi_2$ (411) exist in the $BaSi_2$/mc-Si, which is due to the different crystal orientation of the Si grains in the mc-Si. On the other hand, the lifetime of $BaSi_2$/mc-Si ranged from 0 to 20 μs. This result indicates that diverse orientation of $BaSi_2$ may cause the variation of minority-carrier lifetime. Figure 2 presents the AFM topographic image for the sample. The RMS value representing roughness of the sample surface is 13, which is larger than α-Si capping layer. Therefore we thought that the effectivity of surface passivation might be another factor that influenced the minority-carrier lifetime.

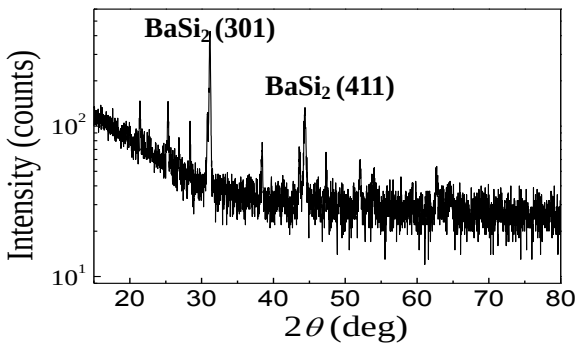

Fig 1 *θ-2θ* XRD pattern of the sample. The layer thickness of $BaSi_2$ is approximately 500 nm.

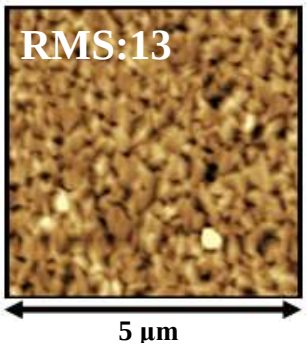

Fig 2 AFM topographic image for the $BaSi_2$/mc-Si. The observation area is 5×5 μm^2.

References

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