

Formation of hydrogenated amorphous Si layers by RF plasma generator on Al-capped Si(111) substrate: application to BaSi₂ solar cells

Univ. Tsukuba¹ ◦ Z. Xu¹, T. Deng¹, R. Takabe¹, K. Toko¹, T. Suemasu¹

E-mail: s1620372@u.tsukuba.ac.jp

Introduction

BaSi₂ is a good candidate for future solar cell. It has many advantages such as a band gap of 1.3 eV, suitable for the solar spectrum, a large absorption coefficient of $3 \times 10^4 \text{ cm}^{-1}$ at 1.5 eV, exceeding those of CIGS [1], and a large minority-carrier diffusion length of ca. 10 μm [2]. In our previous work, we have realized the conversion efficiency of 9.9% in a p-BaSi₂/n-Si (111) heterojunction solar cell capped with a pure amorphous Si (a-Si) layer [3]. However, a-Si is a long-range disorder material and contains a lot of dangling bonds. As a result, the dangling bonds act as defects and hinder photogenerated carriers to reach the top surface electrodes. Thus, we need to diminish the defects in the a-Si by hydrogasification which is hydrogenated amorphous Si (a-Si:H). In this study, we attempted to grow a-Si:H layers by different methods and apply it to BaSi₂ heterojunction thin film solar cells.

Experiment

Usually a-Si:H is fabricated by plasma enhanced chemical vapor deposition (PECVD) [4]. We used MBE method and radio frequency (RF) plasma generator to try to form a-Si:H layers on a Si(111) substrate covered with a 200-nm-thick Al layer, in order to prevent laser light pass through Si substrate. We employed different conditions as shown below. We deposited pure a-Si layers (150 nm) for 3 h at a substrate temperature of 180°C by electron beam gun as reference. For sample 1 (post-depo), we supplied H atoms for 1.5 h at 180 °C after the growth of the a-Si layer. For sample 2 (co-depo), we deposited a-Si layers with a simultaneous supply of H atoms for 3 h at 180°C. The power of the plasma generator was kept at 70 W. In order to change the amount of H, we kept the beam equivalent pressure (BEP) of H₂ as $1 \times 10^{-3} \text{ Pa}$. The H emission spectra were measured to confirm the purity of hydrogen gas. The Raman spectra was used to check the presence of Si-H bonds. The peaks at 480 cm^{-1} , 2000 cm^{-1} and 2090 cm^{-1} indicate Si-Si, Si-H and H-Si-H bonds, respectively [5]. The laser of microscopic Raman spectrometer is 532 nm.

Results & Discussions

Figure 1 shows the H emission spectrum at BEP = 10^{-3} Pa . The peaks at 434, 486, 656 nm originate from Balmer series ($n=2$). From the H spectrum, we confirmed that the purity of H. Figure 2 shows the Raman spectra of the reference, sample 1 and sample 2. The peak at 480 cm^{-1} corresponds to Si-Si bonds in the a-Si layers. We can see this peak for all the samples. The peak at 2000 cm^{-1} , seen in samples 1 and 2, shows Si-H bonds [5]. The peak at 2090 cm^{-1} demonstrate the H-Si-H bonds [5] and only sample 2 contains this peak. On the basis of these results, we next plan to apply the method used for sample 2 to a-Si:H/p-BaSi₂/n-Si solar cells.

Reference [1] K. Toh, *et al.*, Jpn. J. Appl. Phys. **50** (2011) 068001. [2] M. Baba, *et al.*, J. Cryst. Growth **348** (2012) 75. [3] S. Yachi, *et al.*, Appl. Phys. Lett. **109** (2016) 072103. [4] R. C. Chittick, *et al.*, J. Elec. Soci. **116** (1969) 77. [5] M. H. Brodsky, *et al.*, Phys. Rev. B. **16** (1977) 3556.

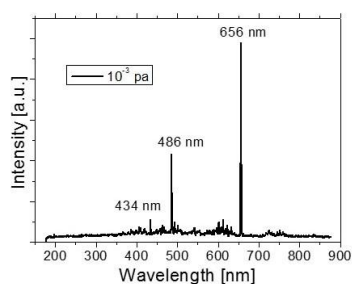


Fig 1 H emission spectra

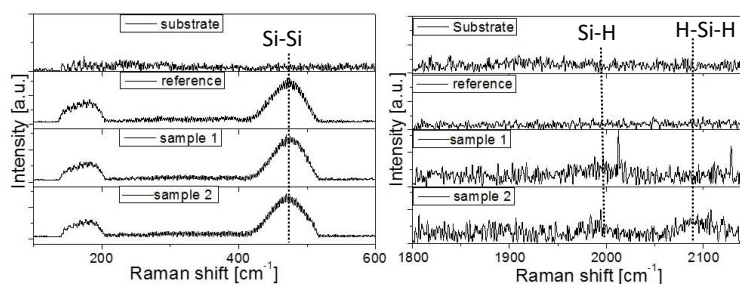


Fig 2 Raman spectra of a-Si and a-Si:H