Contact resistance between PH_3 plasma-ion-implanted p-type amorphous silicon and ITO at various flash lamp annealing conditions

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Interdigitated back contact silicon heterojunction (IBC-SHJ) solar cells have conversion efficiencies as high as 26.7% [1]. However, the fabrication of their interdigitated contacts needs complex processes such as using photolithography and etching [2]. Therefore, we have proposed a simplified and low-cost fabrication method by using phosphine (PH_3) plasma ion implantation (PII) through a hard-mask to convert electrical conduction type of p-type amorphous Si (a-Si) to n-type one in selected areas. To obtain a counter-doped n-a-Si with a good surface passivation quality after PII, a convention thermal annealing at ~250 °C for 30 min is required [3]. Since flash lamp annealing (FLA) provides millisecond-order pulse light on samples [4], it is expected to be a rapid and low-cost way to obtain a high-quality counter-doped n-a-Si. We have previously confirmed that applying FLA results in a good passivation quality of counter-doped n-a-Si [5]. In this work, the contact resistivity between the PII p-a-Si and indium tin oxide (ITO) have been evaluated at variation of FLA conditions.

We prepared samples consisting of p-a-Si/i-a-Si/n-c-Si/i-a-Si/SiN_x, in which p-a-Si, i-a-Si, and SiN_x films were formed by catalytic chemical vapor deposition (Cat-CVD). P and H ions were then implanted into p-a-Si films by PII in ULVAC PVI-3000 system equipped with no mass separator. PH_3 was used as a source gas. Ion energy and ion dose were 5 keV and 3×10^{16} cm^{-2}, respectively. Then, FLA was performed on the ion-implanted p-type a-Si by using a pulse light at fluences of 12.4–22.5 J/cm^2 and a duration of 5–10 ms, with preheat conditions for 5 min at 200 and 225 °C. In this study, we evaluated the contact resistance between the PII p-a-Si and ITO by transfer length method (TLM) [6]. After FLA process, the samples were immersed in 5wt% HF for 30 s to remove a native oxide layer on the surface of the PII p-a-Si. The ITO and Ag electrodes were formed on the PII p-a-Si through a hard mask with different distances *d* from 1 to 6 mm by sputtering and vacuum thermal evaporation, respectively.

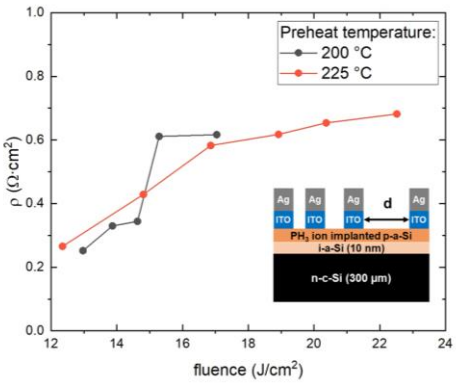

Fig. 1 Contact resistance between PII p-a-Si and ITO as a function of FLA fluence at preheat temperatures of 200 and 225 °C.

Fig. 1 shows contact resistance between PII p-a-Si and ITO as a function of FLA fluence at preheat temperatures of 200 and 225 °C. After PII and FLA, total resistance was significantly reduced, indicating that the p-a-Si layer is converted to n-a-Si and the diode structure was transformed to a resistor. A contact resistance is estimated to be 0.2–0.7 Ω·cm^2 after FLA at a fluence of 12–22 J/cm^2. We have already confirmed the operation of the SHJ cell fabricated by using this n-a-Si [7]. However, contact resistance slightly increases with an increase in FLA fluence. We proposed that one of the reasons for this phenomenon is due to the activation of B atoms which are compensated with the activated P atoms. Another possible reason to be considered is the creation of metastable defects in a-Si by high irradiation intensity [8].

【References】

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