Recovery of PH_3 plasma-ion-implantation-induced damages in p-type amorphous silicon by flash lamp annealing

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【Introduction】

Interdigitated back contact silicon heterojunction solar cells have conversion efficiencies as high as 26.7% [1]. However, the fabrication of their interdigitated contacts needs a complex process using photolithography and etching processes [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 n-type a-Si with a good surface passivation quality after PII, a convention thermal annealing at ~250 °C for 30 min is required [3]. In this work, we attempt to apply flash lamp annealing (FLA) for the thermal treatment instead of the conventional annealing process. Since FLA provides millisecond-order pulse light on samples [4], it is expected to be a rapid and low-cost way to improve the passivation quality of the ion-implanted p-a-Si.

【Experimental procedure】

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. Finally, FLA was performed on the ion-implanted p-type a-Si by using a pulse light at fluences of 13.2–17.7 J/cm^2 and a duration of 7 ms. The surface passivation quality of the a-Si films on c-Si before and after the ion implantation was evaluated by measuring effective minority carrier lifetime (τ_{eff}) by microwave photoconductive decay (μ-PCD).

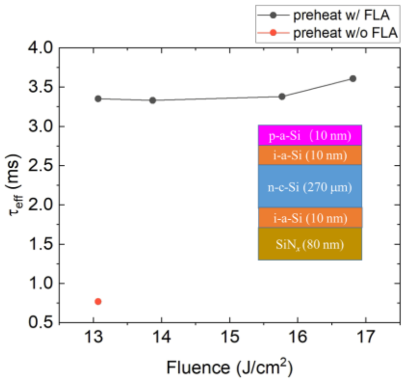

Fig. 1 τ_{eff} of samples preheated at 225 °C for 2 min without and with FLA as a function of the fluence of a flash lamp pulse.

【Results and discussion】

Fig. 1 shows τ_{eff} as a function of the fluence of a flash lamp pulse preheated at 225 °C for 2 min. τ_{eff} of the sample received only preheat at 225 °C for 2 min is also shown in Fig.1. It should be noted that τ_{eff} of the sample before PII is 1–3 ms. Due to ion-implantation-induced damages, τ_{eff} of the sample right after PII is reduced to several μs. As can be seen in Fig.1, τ_{eff} has significantly increased to 3.4–3.6 ms by FLA at a fluence of 13–17.7 J/cm^2, while preheat treatment at 225 °C can help to increase τ_{eff} to ~0.8 ms. According to these results, we can clearly confirm that ion-implantation-induced damages in a-Si are completely recovered by FLA in a very short duration. The improvement in the passivation quality of the a-Si by FLA is considered that the dangling bonds defects produced by the PII is terminated by H ions. On the other hand, FLA with too high fluence heats the surface, break the Si-H bonds, and make the Si dangling bonds increase.

These results are very promising to propose a high throughput process for the fabrication of Si solar cells.

【References】

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