# Silicon Heterojunction Solar Cells with Flash Lamp Annealing on a Counter-Doped n-a-Si Film

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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 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 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. In our previous work, we have confirmed that applying FLA results in a good passivation quality of counter-doped n-a-Si [5]. In this work, we attempt to evaluate silicon heterojunction (SHJ) solar cells' properties with counter-doped n-a-Si treated by FLA.

The SHJ cells were fabricate by forming stacked layers of 10-nm-thick p-a-Si/10-nm-thick i-a-Si on both sides of a mirror polished 270-μm-thick n-c-Si (100) wafer by catalytic chemical vapor deposition (Cat-CVD). P and H ions were then implanted into one side of the p-a-Si film 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 kept at 5 keV and $3\times10^{16}$ $cm^{-2}$, respectively. FLA was performed on the ion-implanted p-type a-Si, after a pre-annealing at 200 °C for 5 min, by using a pulse light at fluences of 13.4, 15.5 and 16.5 J/cm$^2$ and a duration of 7 ms. After forming ITO films and Ag electrodes on both sides of the wafers by RF sputtering and thermal evaporation, a post-annealing at 200 °C for 30 min was performed. The solar cells were characterized by measuring *J–V* characteristics under 1-sun illumination.

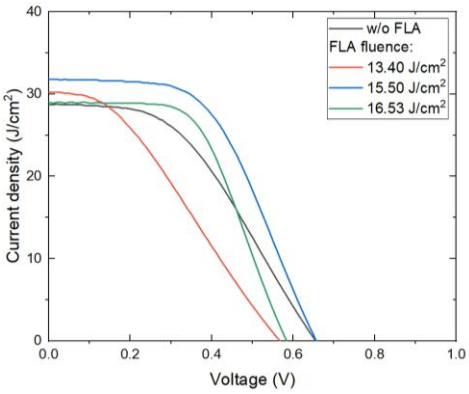


Fig. 1 *J–V* curves of solar cells w/o and w/ FLA on PII p-a-Si films.

Table I. Performance of SHJ cells.

| FLA fluence (J/cm$^2$) | 13.4 | 15.5 | 16.5 | w/o FLA |
|---|---|---|---|---|
| $J_{sc}$ (mA/cm$^2$) | 30.2 | 31.7 | 29.0 | 28.7 |
| $V_{oc}$ (mV) | 567 | 657 | 584 | 655 |
| FF | 0.48 | 0.53 | 0.57 | 0.44 |
| $\eta$ (%) | 8.14 | 11.02 | 9.57 | 8.37 |

Fig. 1 shows the *J–V* curves of SHJ cells with and without FLA treatment on the PII p-a-Si film. The results of short circuit current density ($J_{sc}$), open circuit voltage ($V_{oc}$), fill factor (FF), and conversion efficiency ($\eta$) are summarized in Table I. The operation of SHJ cells with and without FLA could be confirmed. By increasing the FLA fluence, the FF was significantly improved. This is considered to be due to enhancement in the electrical conduction of the counter-doped n-a-Si film resulting from the activation of implanted P atoms. The cause of degradation in $J_{sc}$ and $V_{oc}$ at a FLA fluence of 16.5 J/cm$^2$ is still unclear, and a further investigation is needed. The η of 11 % of the SHJ cell treated by FLA at 15.5 J/cm$^2$ exhibits a promising result of combining FLA and PII to fabricate the low cost IBC-SHJ cells.

【References】

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