Reduced recombination losses for PERC cell using a selective emitter structure formed by screen-printed resist masking combined with etch-back process

○(P) S. Joonwichien, Y. Kida, M. Moriya, S. Utsunomiya, K. Shirasawa, and H. Takato

National Institute of Advanced Industrial Science and Technology (AIST)

E-mail: s-joonwichien@aist.go.jp

We present the improvement of the p-type passivated emitter and rear cell (PERC) with a selective emitter (SE) structure using screen-printed resist masking combined with wet chemical etch-back process. The structure of SE PERC solar cell is displayed in Fig. 1. The concept of an SE structure is based on removal of the highly doped layers (n^{++}) in the areas not intended for metallization. For p-type solar cells, the lightly doped emitter areas (n^{+}) obtained by the above mentioned process lead to a reduced Auger recombination and Shockley-Read-Hall (SRH) recombination, thereby improving the performance of PERCs. An n^{+} emitter by etch-back process showing high sheet resistance (R_{sheet}) ensures a better blue response, resulting in high internal quantum efficiency.

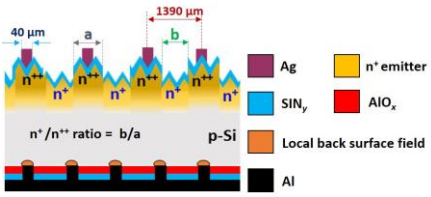

Fig. 1 PERC with an SE structure.

As a result (**Table I**), the SE structure had a considerable impact on the *I-V* parameters of the PERCs, showing an increase in the open-circuit voltage (V_{oc}), but a decrease in the short-circuit current density (J_{sc}) and fill factor (*FF*) compared with homogeneous emitter (HE) cells. The improved V_{oc} was mainly attributed to the reduced the saturation current density (J_0) in the n^{+} regions because the SRH recombination at the passivation layer and the Auger recombination in the emitter are both low. A decreased J_{sc} when SE structure was applied is due to a trade-off between competitive recombination mechanism in n^{++} and n^{+} regions. By optimizing the initial R_{sheet} of n^{++} regions and the n^{+}/n^{++} ratio, the J_{sc} and V_{oc} significantly improved. In addition, the experimental results of PERCs have been modeled using PC1D simulating program to calculate and compare the influence of SE structure, initial R_{sheet} of n^{++}, and n^{+}/n^{++} ratio on the V_{oc}. The diminished *FF* for SE structure was due to higher series resistance (R_s) at n^{+} regions and the recombination current in the depletion region of the pn-junction, as confirmed by TLM measurement and the simulation by Two-diode model. These results suggest that the improvement of the emitter by an SE structure is essential for improving conversion efficiency of industrial-sized PERC solar cells.

Table I *I-V* parameters for the industrial HE PERCs and SE PERCs with a cell area of 239 mm^2.

	R_{sheet} (Ω/sq)	n^{+}/n^{++} ratio	J_{sc} (mA/cm^2)	V_{oc} (mV)	*FF* (%)	*Eff* (%)
HE 1	95	–	39.5 ± 0.1	651 ± 1.2	79.7 ± 0.3	20.5 ± 0.1
SE 1	140/95	5	38.6 ± 0.1	658 ± 1.6	77.8 ± 0.9	19.8 ± 0.3
SE 2 (optimized cells)	140/60	13	39.4 ± 0.1	663 ± 0.6	77.6 ± 0.3	20.3 ± 0.1

Acknowledgement: This work was supported by NEDO.