Area: Crystalline and Thin Film Silicon PV.

WET CHEMICAL ETCH-BACK SELECTIVE EMITTER FOR PERC SOLAR CELLS

Supawan Joonwichien, Yasuhiro Kida, Masaaki Moriya, Satoshi Utsunomiya, Katsuhiko Shirasawa, and Hidetaka Takato

National Institute of Advanced Industrial Science and Technology (AIST), Japan
Corresponding e-mail: s-joonwichien@aist.ac.jp

This paper demonstrates the introduction of a selective phosphorus emitter formed by a screen-printed resist masking combined with wet chemical etch-back process for industrial-sized (156 mm × 156 mm) passivated emitter and rear cell (PERC). The screen-printed resist masking is printed on the samples to selectively protect the heavily doped emitter (n^{++}) region. While, the wet chemical etch-back process can be done by immersing the samples, in which an n^{++} region is printed with a screen-printed acid resist material, into an etching solution in order to obtain selectively etched-back regions (lightly doped emitter, n^+).[1] Applying selective emitter concept is expected to decrease the recombination losses at the front surface of the PERC cell.

The processing sequence for selective emitter PERC cells is shown in Figure 1. An n^{++} region with sheet resistance (R_{sheet}) of 60 Ω/sq was initially formed. Prior to wet chemical etch-back process, the areas intended for front Ag metallization were masked by a screen-printed resist masking. The samples were divided into 2 groups, aiming to study the impact of different R_{sheet} values of n^+ regions on the cell performance. The mask was subsequently stripped, resulted in n^+ regions (166 and 125 Ω/sq), depending on etching times. Afterwards, the PERC cells were fabricated accordingly (Figure. 1).

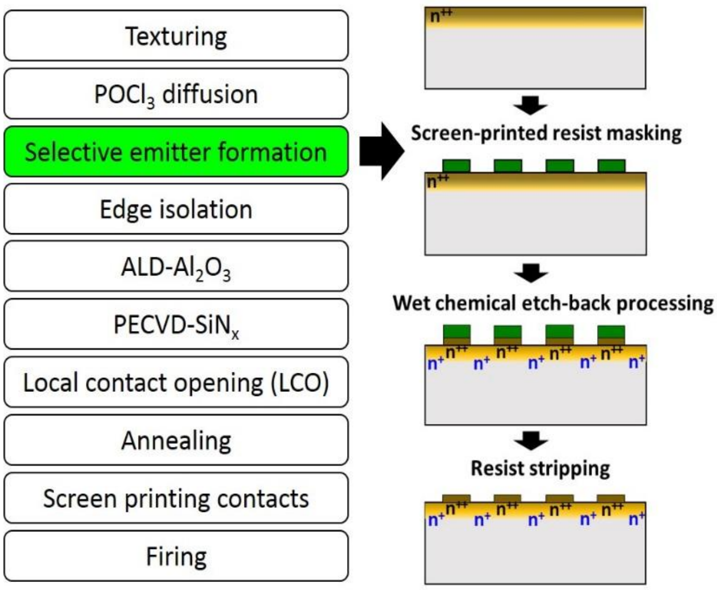

Figure 1: Process sequence of the PERC cells.

As a result (Table 1), the selective emitter PERC cells yielded a significant increase in an open-circuit voltage (V_{oc}) by at least 12 mV and an increase in the short-circuit current density (J_{sc}) by 0.3 mA/cm^2, compared to the homogeneous emitter cells. This is mainly attributed to the reduced emitter saturation current density (J_{0e}) in the etched-back n^+ regions.[2] The R_{sheet} of n^+ regions has greatly impacted the cell parameters, resulted in the increased V_{oc} and the decreased *FF* along with maintaining J_{sc}, when the R_{sheet} of n^+ regions are of 125 and 166 Ω/sq, respectively. The decline in *FF* by 1-2% caused by the higher sheet resistance in the n^+ regions, leading to higher series resistance (R_s) than the homogeneous emitter cells. The result of pseudo-*FF* by Suns-V_{oc} analysis suggests that a narrower front-side Ag finger spacing would be required to reduce the R_s, and is then the improvement of *FF*. Assuming that the *FF* is comparable to the reference cell (> 80%), the conversion efficiency of approximately 21% would be expected for selective emitter cells. These results demonstrate that selective emitter concept applied to PERC cell is a very promising technology to improve the conversion efficiency of the industrial PERC solar cell.

Table 1: The cell parameters of PERC cell with homogeneous emitter structure and selective emitter structure.

	J_{sc} (mA/cm^2)	V_{oc} (mV)	*FF* (%)	Eff (%)
Homogeneous 90 (Ω/sq), 4 cells	38.4	644.5	80.4	19.8
Selective 125/60 (Ω/sq), 6 cells	38.7	656.4	79.8	20.3
Selective 166/60 (Ω/sq), 6 cells	38.6	654.4	78.6	19.9

1. Y. Tao, K. Madani, E. Cho, B. Rounsaville, V. Upadhyaya, and A. Rohatgi, *Appl. Phys. Lett*. **110** (2017) 021101.
2. Y. Schiele, S. Joos, G. Hahn, B. Terheiden, *Energy Procedia* **55** (2014) 295-301.