Renewable Energy Research Center

Developed Al rear grids for bifacial PERC concept

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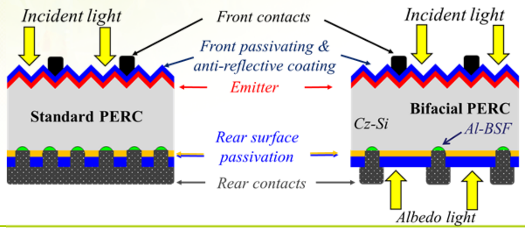
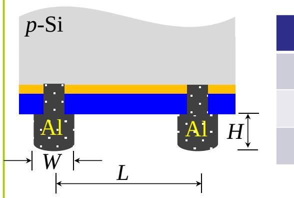
Upgrading standard PERC with bifacial concepts

Bifacial solar cells can absorb irradiance from the front and rear sides, resulting in higher energy yield for the same module area as compared to their traditional solar panels.



Experimental

PERC solar cells with different rear Al grid designs were fabricated in order to determine the influence of metallization fraction on *I-V* parameters.



W = finger width, H = finger height,
L = pitch between fingers

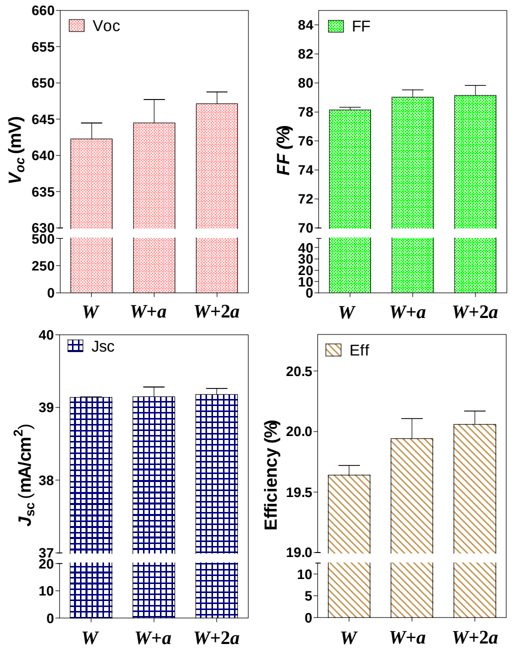
Parameters	
Al grid width, W	W, $W+a$ μm, $W+2a$ μm
Al grid height, H	H
LCO height	0.5 mm

I-V parameters at one sun

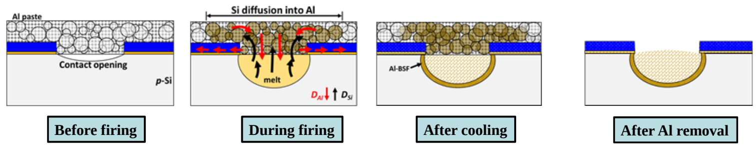
Results･Discussion

❑ One-sun *I-V* parameters of bifacial PERCs

The observed results clearly show an increase in the open-circuit voltage (V_{oc}), fill factor (FF), and conversion efficiency values with an increase in the Al grid width, and the change in the short-circuit current density (J_{sc}) was negligible. The improved V_{oc} was possibly due to the high quality of surface passivation, which relates to the Al diffusion into passivation stacks mechanism.

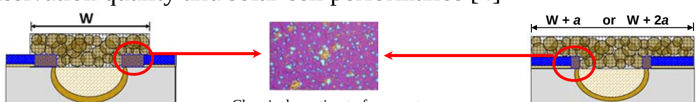


❑ Physical mechanism of the local contact formation of rear-side of PERC



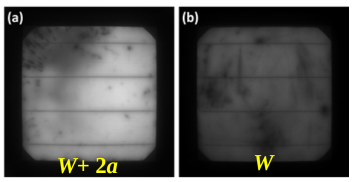
- At the peak firing temp., liquid Al penetrates and comes into contact with the Si surface in the openings, wherein the Al at the interface is saturated by Si first. Then, Si subsequently dissolves into the liquid Al mass from edges of the interface in all directions until the maximum Si concentration of Si in the melt reaches equilibrium or the Al-Si liquid saturates, according to the liquids line in the phase diagram [1]–[3].
- During cooling, the solubility of Si in the Al-Si melt decreases, and Si diffuses back to the contact site; the back-diffusion process is driven by the difference in the Si concentration at the interface. The epitaxial recrystallization of Si heavily doped with Al atoms starts to form the Al-BSF at the bottom of the contact sites.

❑ Possible reasons for different Al grid designs effects on rear surface passivation quality and solar cell performance [4]



- The Al atoms from Al melt diffuse in all directions, either lateral or vertical to the surfaces and react with the Si in the films, resulted in the formation of the Al–Si alloy-like material present in the majority of the Al printed areas.
- The chemically reacted areas were suspected to be decreased as the screen width (W) increased, where the wider screen would result in less time for Al diffusion into passivation stacks.

In order to confirm the recombination activity of sample surfaces, photoluminescence imaging (PL) measurement was used. As a result, PL contrast was diminished and these abundant spots were likely to cause the degradation in the surface passivation quality, leading to a reduced V_{oc} of a cell.



Note that bright and dark regions in the PL images indicate the lower and higher surface recombination activities, respectively.

(a) ***W+ 2a***: Full-area screen-printed PERC with less spots (due to chemical reaction).
(b) ***W***: Full-area screen-printed PERC with spots covering a whole surface area.

References

[1] J. L. Murray and A. J. McAlister, "The Al-Si (Aluminum-Silicon) system," Bulletin of Alloy Phase Diagrams, vol. 5, p. 74, 1984. doi:10.1007/BF02868729
[2] S. Joonwichien, S. Utsunomiya, Y. Kida, M. Moriya, K. Shirasawa, and H. Takato, " Improved rear local contact formation using Al paste containing Si for industrial PERC solar cell," *IEEE J. Photovol.*, vol. 8, no. 1, pp. 54–58, 2018.
[3] S. Joonwichien, M. Moriya, S. Utsunomiya, Y. Kida, K. Shirasawa, and H. Takato, Metal-induced recombination losses associated with Si present within passivation layers and aluminum paste for PERCs," in *Proc. 46th IEEE PVSC, 2019.*
[4] S. Joonwichien, M. Moriya, S. Utsunomiya, Y. Kida, K. Shirasawa, and H. Takato, "Understanding metallization-induced losses mechanism in rear-side of fully screen-printed *p*-type PERC solar cells," *IEEE J. Photovol.*, to be published (2019).