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Effect of Si content in Al paste on local Al rear contacts in PERC cell

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PERC structure

Screen-printed Ag paste
ARC
n^+–emitter
Local BSF
Passivation layer
SiN_x capping layer
Screen-printed Al paste

Images not to scale

Cross-sectional SEM image of local contact

Local-BSF can reduce the charge carrier recombination at the rear contact due to the built-in electric field

A. Our previous report presented at SiliconPV 2017

- IQE maps were obtained for a small area of 5 mm × 8 mm at a single wavelength of 1000 nm, indicating the position of the passivation layers and bottom local-BSF at the rear of the PERC cells.
- The detailed IQE measurements are described by Mochizuki T. *et al.*, Presented at the PVSEC, Singapore, 2016.

1. T. Mochizuki et al., Presented at the PVSEC-26, 2016, Singapore.
2. S. Joonwichien et al., To be presented at SiliconPV, 2017, Freiburg, Germany.

Low IQE signal: High surface recombination velocity at Al-BSF due to ***void formation*** [1, 2]

Fig. 1. IQE maps showing the IQE of a local-BSF contact and non-opened passivation layers at the rear.

B. Hypothesis for local contact formation[3, 4]

Illustration is motivated by Elias URREJOLA et al. (ISE, Sunways AG)

Al-Si equilibrium diagram

Speculation of void formation
Strong driving force in Si diffusion to Al paste
Si diffuses far away into the paste
Si could not diffuse back to contact site on time during cooling
Strong driving force in Si diffusion is needed to be suppressed

3. T. Dullweber and J. Schmidt, IEEE J. Photovolt., 6, 1366-1381 (2016).
4. M. Rauer et al., IEEE Electron Device Letters, 32, 916-918 (2011).

Research aim

- We aim to study the effect of the presence of Si content in the Al paste on the formation of Al–BSF locally underneath the alloy (Eutectic layer) and on the PERC cell performance.
- To investigate whether Si content in Al paste could suppress a strong driving force in Si diffusion, resulting in a suppression of void formation.

C. PERC cell processing

Process steps
Random texturing and cleaning (Cz-Si, p-type, 200 μm, 2.1 Ω.cm)
$POCl_3$ front diffusion and PSG removal
10 nm Al_2O_3 deposition (Ozone-ALD)
Rear and Front SiN_x deposition (PECVD)
Laser contact opening (LCO) with line-shaped
Post deposition annealing (PDA)
KOH/HF treatment
Rear Al printing: 1. Paste A: without Si; 2. Paste B: with Si
Front Ag printing
Firing

D. SEM analysis

Two types of local contacts were observed.

1. A filled contact with Al-BSF
2. A complete void with Al-BSF

Filled contact with Al-BSF

Si-free Al paste

With Si in the paste

	No Si	With Si
Al-BSF thickness, μm	4–6	6–8

- Driving force in Si diffusion is suppressed.
- Al-Si melt diffusion process locates near the contact.
- More time for Al-Si to penetrate into Si bulk
- Thicker Al-BSF

Complete void with Al-BSF

Si-free Al paste: Void fraction ~ 25% of total local contact area

With Si in the paste: Void fraction ~ less than 5 %; Thicker Al-BSF

Area fraction of voids reduces! from 25% to 5%

Voids occur in between T_{peak} and during cooling down.

E. I-V characterization

Higher V_{oc} due to thicker BSF

Without considering the series resistance from metallization

F. Conclusion

Si content in the Al paste significantly impacted the I-V parameters of the PERC cells and the local contact formation.

1. PERC cells using Al paste with Si showed an increase in V_{oc}, partly due to a thicker Al–BSF beneath the rear contacts.
2. Voids with an Al–BSF were observed, with Al–BSF thicknesses comparable to those of deep filled contacts.
3. By adding Si into the paste, suppression of the driving force in Si diffusion can help to reduce the void formation, and to enhance the performance of PERC cells.
4. Optimization for Al rear printing is highly recommended when Al paste containing Si content is used.