Improving the local Al-contacts for PERC cells: void formation suppression using Al paste consisting of Si content, and it impacts on cell performance

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We attempt to improve the performance of passivated emitter and rear cell (PERC) cells by focusing on the local Al-contacts at rear. This work presents the effects of Si content in the Al paste on the characteristic of local contacts, void formation after firing, and its impact on the PERC cell performance. For this purpose, the rear side of PERC cells is metalized with two different PERC Al pastes—one contains Si content in the Al paste, and another has no Si content. These two pastes (Paste A and Paste B) were provided by the same supplier to avoid the differences caused by different manufacturing processes.

As a result, Si content in the Al paste has significant impacts on the I–V parameters of the cells. The open-circuit voltages (V_{oc}) are higher for PERC cells using Al paste with Si content. Scanning electron microscopy (SEM) was used to analyze the local rear contact geometry and the thicknesses of the aluminum–back surface field (Al–BSF) after firing process (Fig. 1). It is seen that the average thickness of local BSF beneath the rear contacts is in a range of 4–6 μm when the Al paste with no Si content was used (Fig. 1a), while the Al paste with Si content offers a greater at a depth of several micrometers (6–8 μm), which would result in greater electron shielding. A thicker Al–BSF beneath the rear contacts could be one of the reasons for the higher V_{oc} for PERC using Al paste consisting Si content.

It is interesting observed that the contact depth (the eutectic layer) is significantly decreased (Fig. 1b) for PERC cells using paste with Si content. This can be explained that during alloying at the peak temperature, the maximum amount of Si from the contact sites is dissolved and distributed in the Al-paste matrix due to a strong Si concentration gradient within the Al-Si melt. Whereas, Al in the Al paste diffuses to the local contact sites to form the BSF. During cooling ramp, excessive Si is rejected from the melt and diffuses back into the contact to recrystallize epitaxially on the Si surface [1, 2]. By adding Si in the Al paste, this is believed to suppress the driving force during alloying, thereby reducing a strong lateral Si diffusion to the paste. An additional Si in the paste would result in the rejection of excessive Si from the Al-Si melt during cooling, leading to an accumulation of Si in contact sites, thereby a reducing in contact depth. From the SEM analysis, we observed a high density of complete voids for Paste A with no Si content, and they appear to have an Al–BSF with depths ranging from ~3 to 4 μm, while voids are rarely observed, and the thickness of an Al–BSF was observed to be a similarly deep filled contacts (~6–8 μm) for Paste B. Our results suggest that this deeper BSF observed for PERC cells using Al paste with Si content could be the one of the reasons for a higher V_{oc}. These results suggest that by adding Si content in the Al paste, could help to suppress the void formation, leading to a good contact for obtaining a high efficiency PERC solar cells.

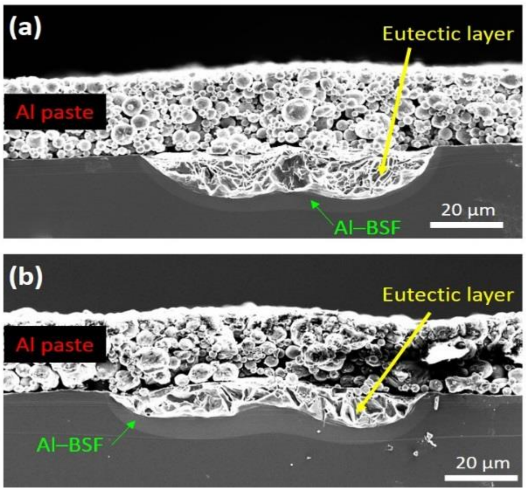

Fig. 1. SEM cross-sectional images of local Al contacts using (a) Paste A with no Si content in the Al paste, and (b) Paste B consisting of Si content.

[1] E. Urrejola, K. Peter, H. Plagwitz, and G. Schubert, *Journal of Applied Physics*, vol. 107, 124516, 2010.

[2] C. Kranz, B. Wolpensinger, R. Brendel, and T. Dullweber, *IEEE Journal of Photovoltaics*, vol. 6 (4), 830-836, 2016.