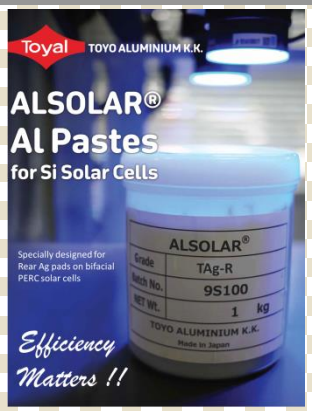
Rear Ag paste development for Bifacial PERC solar cells

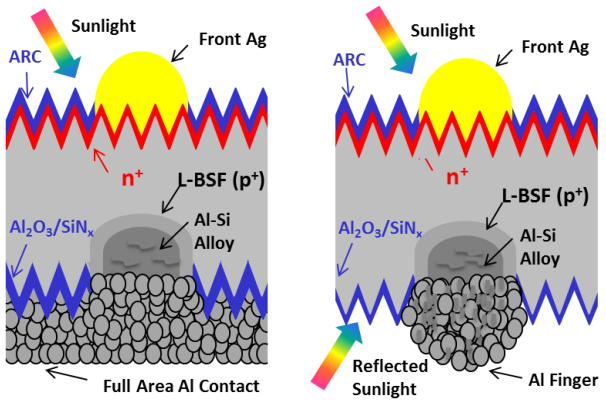
Kosuke Tsuji
Hino Photovoltaic Laboratory
Core Technology Center,
TOYO Aluminium K.K.



【1. Introduction】

Bifacial PV modules are increasing its market share due to their higher energy output and manufacturing compatibility in mass production. The cell efficiency already reach over 22 % by top runner producers. On the other hand, the photovoltaic market always demand high effciency performance and low cost material.

Especialy, since the rear side passivation layer of bifacial PERC cell(Fig.1) is thinner than that of standard PERC cell (see ALSOLAR® for PERC solat battery Technical Report). Therefore, it is more sensitive to metallization process and in particular, the Rear Ag tabbing paste/Al paste interface where two glass systems are ineracting during the co-firing process(Fig.2).



(a) (b)

Fig. 1 Structure images of solar cell
(a) PERC, (b) bifacial PERC

To address this issue, several researchers have been interested in such interreaction mechanism focusing on the Ag/Al alloy formation during the firing process [1-3]. However, the interreactions of the glass frit (GF) systems of Ag and Al, were not fully understood.

Hence, in this work we investigated the impact of GF chemistries of Al paste combined with one Ag tabbing paste. Also introduce our excelent rear Ag paste, which could not only reduce the damage to passivation layer, but reduce the cost too.

【2. Investigation of the impact of GF in Al paste】

In this work, p-type PERC bifacial solar cells with 90 nm SiN_x layer on rear side were used. Two different Al pastes with two different GF chemistries combined with one Ag tabbing paste were screen-printed to find out the damage mechanisms at the Ag/Al interfaces. The Ag paste improved its adhesion on substrate by optimization Ag particle size even if low Ag contents were used. For metallization process, Ag pastes were screen-printed at first, followed by printing Al pastes with 0.5 mm overlap of Ag/Al as can been seen in Figure.2. The pastes were dried and fired in conventional belt furnace.

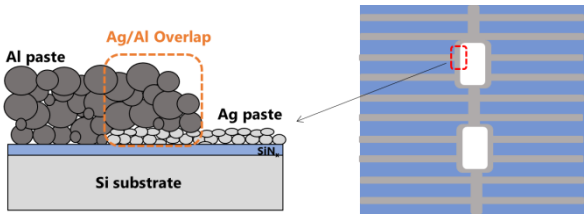
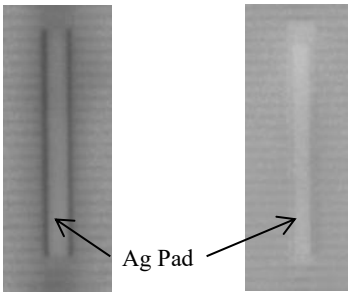


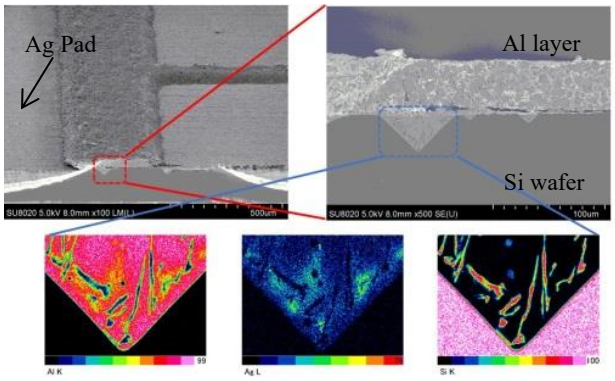
Fig. 2 Cross sectional images of Al/Ag interface

The effects of each GF to the passivation layer underneath the Ag/Al interface were investigated by photoluminescence technique (PL). As can be seen in Fig. 3, the PL images show the dark area around the Ag/Al interface metallized by Al paste included Pb GF confirming the change damage to passivation layer, nevertheless Al paste with Pb free GF was not.



(a)Pb GF (b) Pb free GF

Fig. 3 PL Images



Al Ag Si

Fig. 4 Cross sectional SEM and EDS images of Ag/Al interface by using Pb GF

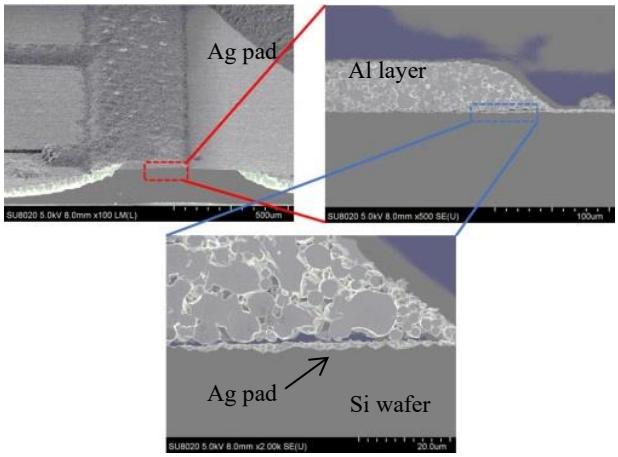


Fig. 5 Cross sectional SEM images of Ag/Al interface by using Pb free GF

In addition, the interface of Al/Ag was observed by SEM and EDS. Fig. 4 shows several spiking under the Ag/Al interface. According the EDX analysis, they consists Ag-Al and Al-Si. This is indicated that Pb GF in Al pastes etched the SiN_x through the Ag paste and silicon were diffused into Al matrix and formed Al-Si alloys while no spikes were found for Pb-Free Al paste.

Therefore, the Pb fritted Al paste combination with Rear Ag pads will damage the passivation layer and as consequences, reduce the solar cell convention efficiency. Toyal ALSOLAR® is the only company that produce its Al pastes Pb-free for high efficiency and the sake of better enviroment and performance.

The table below shows the cell performance of combination Pb-free Al paste and our Ag-pad paste (TAg-R).

	***Jsc*(mA/cm²)**	***Voc*(mV)**	***FF***	***Eff*(%)**
Ref	**1**	**1**	**1**	**1**
TAg-R	**+0.01**	**+2.0**	**-**	**+0.05**

【3. Conclusion】

We found out that the degradation between Ag/Al overlap region comes from the GF chemistry in the Al Paste. Pb GF caused a significant degradation due to the firethrong of SiN_x layer under the Ag/Al interface.

Pb-free Al paste is suitable for bifacial PERC applications, and combination with our Ag paste (TAg-R series) not only improve the efficiency, but lower costs and contribute to better future as environment friendly product.

References

[1] U. Tobias *et al*., Energy Procedia 92, 236-241(2016).

[2] U. Tobias *et al*., Energy Procedia 124, 930-935(2017)

[3] Z. Jiefeng *et al*., Applied Sciences 9, 891(2019).