Metallization Strategies for a Fired Passivating Contact

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Introduction

A promising pathway for improving the efficiency of industrial partial rear contact (PRC) solar cells is replacing their rear contact with full-area passivating contacts[1].

A Fired Passivating Contact (FPC) can be directly integrated with the firing of the front side metallization for a potentially "lean" processing sequence[2].

Current status of FPC based on SiCx(p)/SiOx[2]:

• $V_{OC}>700\,\text{mV}$, $J_0\approx12.5\,\text{mA/cm}^2$ and $R_c<70\,\text{mΩcm}^2$

• Integrated with a standard SHJ at front side, $V_{OC}=698\,\text{mV}$, FF=79.5%, $\eta=21.9\%$

Next step: define an industrially compatible metallization process for FPCs

Optimizing SiCx(p) composition and thickness

- 30nm SiCx(p)
- 60nm SiCx(p)
- 90nm SiCx(p)

- $V_{OC,\text{met}}=655\,\text{mV}$
- $V_{OC,\text{n-met}}=693\,\text{mV}$
- $V_{OC,\text{met}}=656\,\text{mV}$
- $V_{OC,\text{n-met}}=695\,\text{mV}$

Increasing the thickness of SiCx(p) and C-content (i.e. C-rich SiCx(p)) mitigate the degradation of surface passivation in the metallized area

Optimization of firing conditions

- High contact resistivity values were obtained regardless of the firing conditions (i.e. peak temperature and duration)

Results

Integrating hydrogenation and metallization of the FPC in a single industrial firing

Firing at $\approx800^\circ\text{C}$, $\approx10\,\text{sec}$

100 nm
1.4 nm
200 µm
1.4 nm
100 nm

SiNx ITO SiCx(p) SiOx

Ag

During the firing, the Ag-paste etches through the SiNx establishing an electrical contact with the SiCx(p). Hydrogen is released from SiNx and passivates interfacial defects.

Challenges:

- Hydrogenation
- Metallization
- Prevent degradation of surface passivation of the FPC due to Ag-penetration

Solutions

- Optimizing SiCx(p) composition and thickness
- Optimization of firing conditions
- Inserting an ITO between the SiCx(p) and SiNx layers

Inserting an ITO between the SiCx(p) and SiNx layers

- 20nm ITO
- 40nm ITO
- 60nm ITO

$V_{OC,\text{met}}=660\,\text{mV}$
$V_{OC,\text{n-met}}=661\,\text{mV}$
$V_{OC,\text{met}}=661\,\text{mV}$
$V_{OC,\text{n-met}}=652\,\text{mV}$

- The sample with 40nm of ITO has the lowest contact resistivity $R_c=143\,\text{mΩcm}^2$

- Samples with thinner ITO have better lifetime due to more hydrogen diffusion

- The composition of ITO should be optimized to enhance surface passivation

Open question:

- Which path does the current take?

In further studies, measurements should be repeated after a selective etching of the SiNx/ITO stack between the Ag-pads.

Conclusion

Increasing the thickness of SiCx(p) and C-content of the FPC alleviate the degradation of surface passivation in the metallized area. However, a direct contact between the FPC and the Ag paste remained elusive.

Inserting an ITO between the FPC and the SiNx prevents Ag-penetration and made it possible to achieve lower contact resistivity values. However, further studies are required to improve the hydrogen transport through the ITO and for a deeper investigation of the contact formation between Ag/ITO and ITO/FPC.

References

1. Glunz, S.W., et al. 31st EUPVSEC, Sep. 2015, Hamburg
2. Ingenito, A., et al., Accepted for publication on Nature energy.