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The glass-glass module using n-type bifacial solar cell with PERT structure and its performance

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Abstract

In this work, the industrial glass-glass module was developed using bifacial n-type solar cell. The passivation emitter and rear total diffusion cells (PERT) structure solar cell combined boron spin-on with POCl3 diffusion and double sides H-pattern screen printing metallization. With the assistance of the spin-on single side doping method, an average efficiency of 20% with 90% bifaciality was obtained in our laboratory, 6*10 cells bifacial glass-glass modules were fabricated in industrial line. The PID about 3.5% was obtained after 600 hrs under 85℃-85% humidity with a bias of -1000 V, while the LID was about 0.19 % under the IEC standard of 60 kW·h/m2 illumination. As expected, power output gains of 15% on sand and 30% on snow were recorded for the glass-glass bifacial modules compared with mono-facial modules in our outdoor experiments.

Keywords: n-type solar cell; PERT; bifacial; glass-glass module

1. Introduction

The glass-glass module is featured by better reliability, lower PID and better mechanical strength. Thus, it is suitable for extreme environments, such as high humidity, high temperature, high windy conditions, and also BIPV. The lifetime of glass-glass module should be greater than 30 years. Compared with the p-type solar cell, n-type solar cell features high performance and low LID. Besides, recently, n-type solar cell technology has been drawing more

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and more attention of the researchers all over the world [1, 2]. According to the forecast of the ITRPV 2015, technology with cell efficiency greater than 24% for large scale production should use n-type material, while market share of n-type solar cell will be around 40% in 2024. Especially, n-type bifacial solar cell with PERT structure shows higher performance because of rear total diffused and good double-sides passivation with low surface recombination rate. To realize PERT structure, quite a lot technological platforms can be selected such as diffusion [3], implantation [1,3], CVD deposition [4], or advanced metallization technologies. More importantly, PERT can be easily developed from traditional p-type cells without vast gap.

In this work, we developed PERT cell based on boron paste spin coating can be combined with POCl3 diffusion, industrial screen printing was applied as the metallization method.

2. Experiments

The n-type PERT solar cells were fabricated on 6 inch CZ phosphorous-doped silicon wafers with resistivity of 0.8–4 Ω·cm and thickness of 180 μm. The PERT solar cells were fabricated in industrial scale tools. The main process flow is shown in Fig.1. Both sides random pyramids, front side spin-on boron paste and baking, boron diffusion in a quartz furnace formed homogeneous junction. Besides, the BSF was fabricated in the industrial $POCl_3$ diffusion system. Thermal Oxide silicon and direct PECVD silicon nitride were deposited on both sides as stack passivation layers, both sides metallization is H-pattern fingers by screen printing.

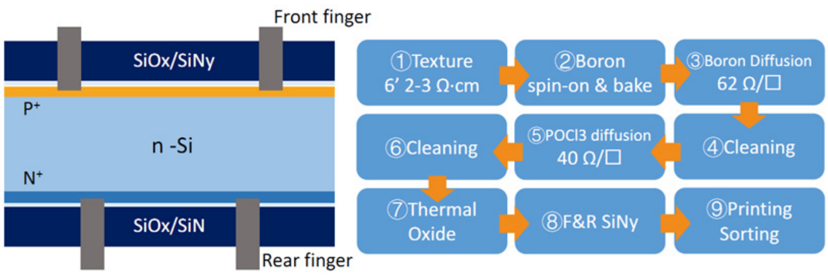

Fig.1. Solar cell structure (L) and Process flow (R)

The modules were encapsulated by EVA with the nPERT solar cells mentioned above. In the process, three-part non-shading junction box and no metal frame structure were applied, while front 2.5 mm antireflection glass and rear 2.5 mm float glass were adopted.

The system was set up with four 270 W bifacial panels in series with MPPT and dynamic loading in outdoor testing basement in Suzhou, China. The same mono-panels were mounted as reference. The installation parameters were 37° tilt angle face south, 15 cm height and no backside shield. The system with changeable 8 m2 background, such as sand, white foam (as snow) and raw grass was applied.

3. Results and discussions

3.1. Solar cell

Liquid boron ink was spun on the surface homogeneously and baked immediately at 150℃ for about 1min. The emitter and BSF was formed in quartz furnace step by step, while front and rear contact with Ag-Al and Ag paste respectively. Solar cells were measured by commercial solar simulator under STC 25℃ @1sun.

Table 1 shows the optimized 50pcs batch of solar cell results. The mean front efficiency is 20%, while it is 18.21% for the rear average efficiency, which means an average bifaciality greater than 90%. The best front efficiency is 20.2%. Due to the single side diffusion, no more diffusion etching for back side was required. Furthermore, better efficiency should be obtained by optimizing doping profiles for B and P respectively to suit the surface passivation.

Table 1. IV parameters of nPERT solar cell

	Eff (%)	Voc (mV)	Isc (mA/cm^2)	FF (%)
Mean	20.10	652	38.9	78.9
Mean$_{rear}$	18.21	647	36.2	77.6
Best	20.20	654	38.6	80.0

3.2. Module performance

The standard module STC IV measurement was performed by TUV. The median module power was 270 W. Reliability was tested at CPVT. The PID about 3.5% was obtained after 600hrs under 85℃-85% humidity with a bias of -1000 V. The EL images before and after PID testing are shown in Fig. 2.

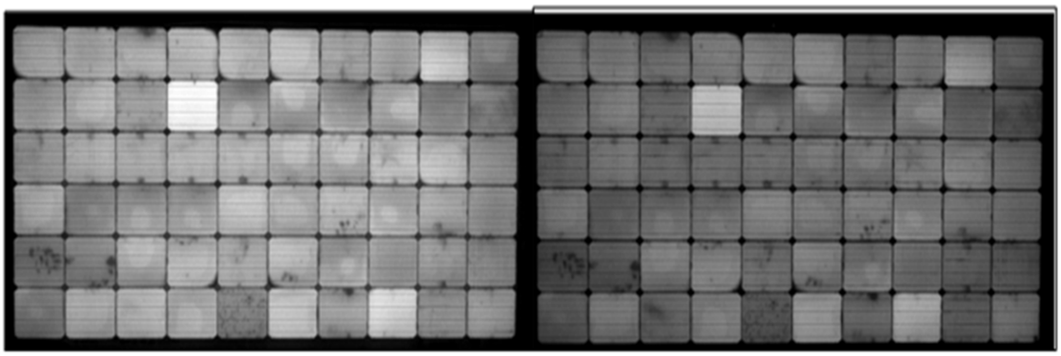

Fig. 2. EL image before (L) and after(R) PID testing

The LID was about 0.19 % under the IEC standard of 60 kW·h/m^2 illumination. The LID curve is shown in Fig.3. According to the result, after 60 kW·h/m^2 illumination, the PV device is quite stable.

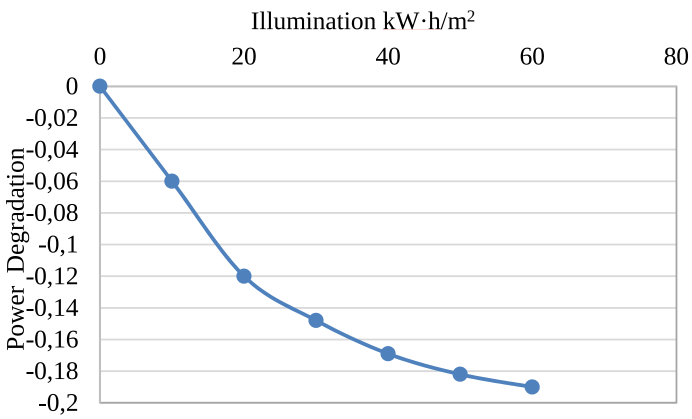

Fig.3. Module decay under illumination.

3.3. Outdoor experiments

The output collections were conducted during the same period with changeable background of raw grass, sand and manmade foam for both bifacial and monofacial modules. All the sample modules have been exposed to sunlight for a long time before the installation to get a stable condition. The output was normalized by 1 kW for each group.

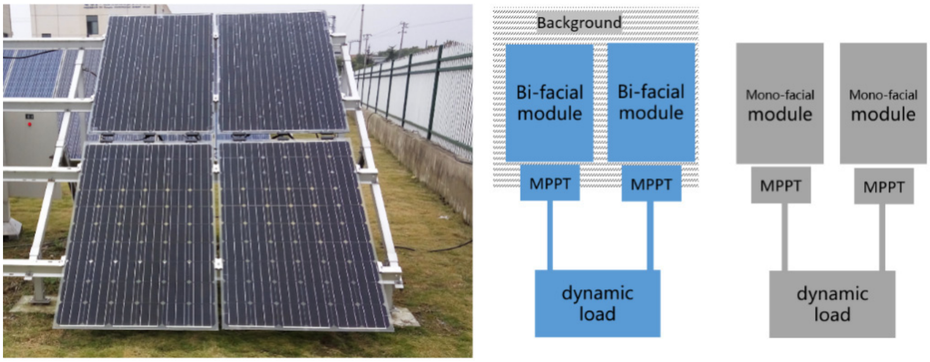

Fig. 4. On-site Photo and System Set-up Schematic Diagram

The power output comparison is shown in Fig.5. Power gains of different background were almost 7.6% on grass, 15% on sand and 29.2% on snow, which just fit well with other researchers [5, 6] and the simulation. Power gains in the experiment is extremely high for the reflections of half open filed and nearby white building. It is clear that rear side absorption is the main reason for the power gain of the bifacial modules.

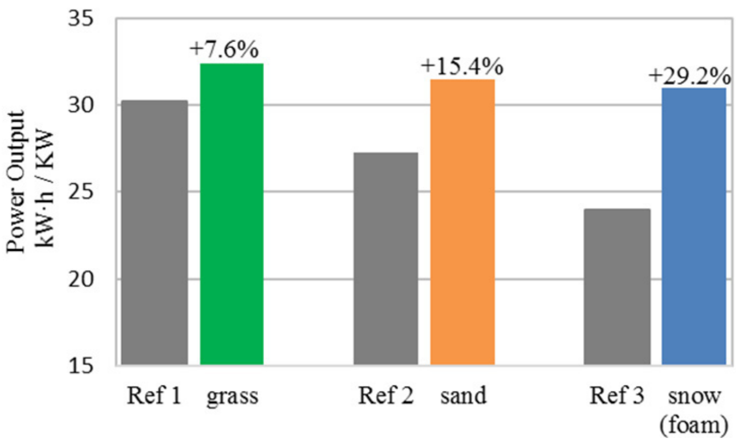

Fig. 5. Output gains (Ref 1, Ref 2 and Ref 3: monofacial; under grass, sand, snow: bifacial)

4. Conclusion and outlook

Efficiency greater than 20% was obtained on nPERT solar cells by using boron spin-on coating and $POCl_3$ diffusion. Bifacial glass-glass module shows an excellent anti-PID and LID-free performance. Power output gains of bifacial module with n-type PERT solar cell are almost 7.6% on grass, 15% on sand and 29.2% on snow with different backgrounds. Further researches on the nPERT solar cell for mass production, as well as bifacial module application on large scale system for long term data collection are carried out on Talesun PV plants at different locations.

Acknowledgements

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