REVIEW PAPER ON COMPARISION OF BIFACIAL AND PASSIVATED EMITTER AND REAR CONTACT

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ABSTRACT

Solar modules made from Polycrystalline Silicon (poly-Si) cells with metal Back Surface Field have dominated the solar industry for more than 3 decades.

However, a number of other Silicon cell based technologies have been gaining ground, which promise Modules with higher efficiencies, as well as higher generation in terms of kWh/kWp.

Here, we will focus on the following technologies which have good potential for capturing larger market share:

1. Passivated Emitter and Rear Contact (PERC) modules
2. Bifacial modules

In this paper, we will compare the cell architecture, process flow, performance parameters, advantages and drawbacks of PERC and Bifacial modules, against the well-established poly-Si modules.

I. PERC MODULES

A. Cell and Module Architecture

In PERC cells, two additional processing steps are included, so that passivation of the rear contact can be achieved. First a layer of Al2O3 is deposited on the backside of the wafer, and then SiN is deposited over the Aluminium Oxide layer to complete the passivation layer. Then, holes are created in that passivation layer using a laser beam, so that localized Back Surface Field (BSF) is created. After this step, metal contact is deposited on the back side of the wafer, similar to standard poly-Si cells (Fig. 1)

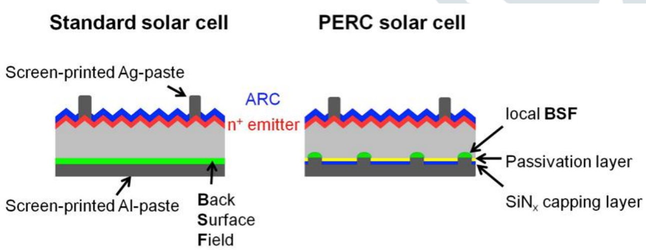

Fig. 1. *Cross –section of Standard Solar Cell vs PERC Solar Cell*

(Ref: Institute for Solar Energy Research in Hamelin, ISFH)

The module assembly steps for PERC are identical to those used for conventional poly-Si modules, and use a metal frame with an opaque back sheet.

B. Performance Parameters

For PERC cells, modules with 72 cells are available in capacities upto 380 Wp, which translates to module efficiency of 19.6%. This should be compared with typical Wattage of 320 Wp for poly-Si modules, which is equivalent to 16.46% module efficiency. Thus, PERC modules typically have 10 to 18% higher efficiency over poly-Si modules (depending on the capacity of the module being used).

In addition, field data by Module manufacturer Longi Solar shows an increase of atleast 3% in energy generation measured in kWh/kWp, over poly-Si modules.

C. Advantages

The increase in generation in PERC modules can be attributed to the following causes:

a) In PERC , the passivation layer at the bottom of the cell, reflects light back into the bulk of the Solar cell, thus increasing the probability that the incident photons will be able to generate electrons.

b) Longer wavelengths photons are not easily absorbed at the top of the cell. They are either absorbed near the bottom of the cell, or tend to pass through the metallic layer back contact in poly-Si modules. On the other hand, for PERC cells the back passivation layer helps to reflect longer wavelengths back into the base of the solar cell. Thus, PERC modules perform better in conditions where longer wavelength light tends to dominate, especially during early mornings and evenings(Fig. 2).

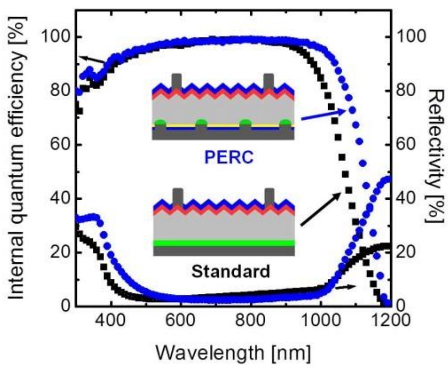

Fig. 2. *Relative performance of Standard Cell vs PERC Cells, as a function of Wavelength*

(Ref: Institute for Solar Energy Research in Hamelin, ISFH)

3) In PERC cells, the surface of the metal back contacts is much smaller compared to conventional poly-Si cells. In conventional poly-Si cells, electrons generated near the metal back contact tend to be captured by the metal layer, without contributing to device current. In contrast, in PERC cells the passivation layer, prevents them from being captured by the metal contact, and makes it possible for electrons to move to the interface. Drawbacks

PERC modules have been known to suffer from higher rates of Light Induced Degradation (LID) as compared with conventional cells. The LID rates for PERC cells are in the range of 3-5%, as compared with 1-3% LID for poly-Si modules. However, manufacturers are now offering PERC modules, with better processing and higher quality, which is supposed to bring LID down to conventional levels.

II. BIFACIAL MODULES

A. Cell and Module Architecture

The Bifacial cell is designed to capture light from the front, as well as the back side, unlike conventional poly-Si cells, which are monofacial. The Bifacial cell is produced by making some changes to the PERC cell architecture. In Bifacial cells, the back contact metal layer is selectively removed, so that light can enter the cell from the backside also (Fig. 3). Also, the back passivation layer is made thinner, to allow more light into the cell from the rear side.

Bifacial modules use a Glass-Glass architecture, with the rear backsheet replaced by a transparent glass sheet. In this way, light can enter the solar cell from the front as well as the back side.

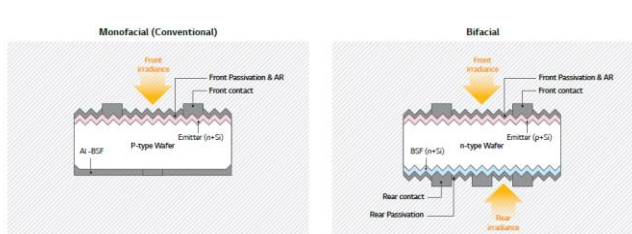

Fig. 3. *Difference in Cell architecture between poly-Si (Monofacial) and Bifacial cells (Ref: LG Electronics)*

B. Performance Paramenters

For Bifacial modules, we have to consider the energy generated due to light entering from the frontE_{front}, and also the energy generated by light entering from the backE_{back} (Fig. 4).

Here,

$E_{total} = E_{front} + \beta E_{back}$

Where, $\beta$is the Bifaciality of the module defined as the ratio of Rear Power to Front power measured at STC conditions.

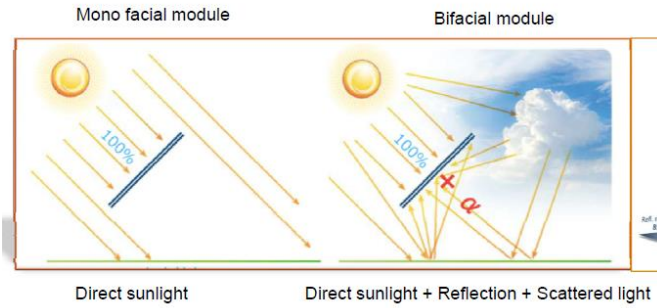

Fig. 4. *Bifacial modules produce power from Reflected light, as well as scattered light (Ref: Longi Solar)*

Now, the backside generation from Bifacial modules is strongly dependent on the albedo of the surface, on which the modules are installed. The Albedo for a surface is defined as the ratio of the light reflected from that surface, to the light incident on the surface

The albedo of different surfaces can vary from 16% for concrete to 60% for metal sheets. Further, the albedo of a surface will vary with time depending on factors like aging, soiling, corrosion etc.

Also, the backside generation of Bifacial modules depends on the installation height of the module, with optimum gain achieved at 0.5 mtrs height. This implies that Bifacial modules will not provide much of an advantage when installed on metal roofs, since solar modules are typically installed flush with the roof.

According to a study by LG Electronics, a Bifacial gain of 5-10% can be expected on concrete roofs, depending on the geographical location. Thus a module of 360 Wp capacity, will function as a 396 Wp module assuming a 10% Bifacial gain. By using highest efficiency PERC modules, it is possible for wattages of individual modules to cross 400 Wp.

In Bifacial modules, the main advantage comes from the extra generation that is produced due to light striking the back of the modules. Bifacial modules provide all the typical advantages of PERC modules, with additional advantage of bifacial gain.

C. Drawbacks

Bifacial modules share the disadvantages of higher LID with PERC modules. In addition, their performance is more uncertain, as it depends on a large number of external factors. Thus, estimation of generation can be tricky when using Bifacial modules.

III. CONCLUSION

PERC are increasingly occupying higher market share in the solar industry. PERC modules offer higher efficiency as well as generation values, and offer an attractive proposition to solar installers and consumers alike.

Bifacial modules while offering even higher efficiencies, continue to be a niche product, as their application is limited to areas with high albedo. They should be selected strategically, where they can make the maximum impact.

IV. REFERENCES

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