High efficiency Hetero-Junction: from pilot line to industrial production

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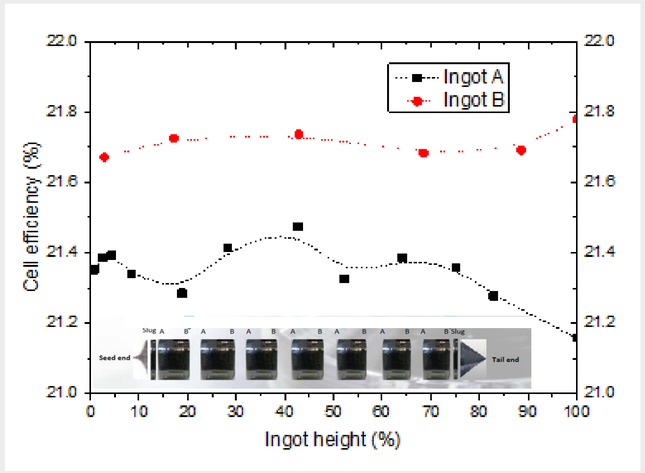
Context

Silicon heterojunction (SHJ) technology allow to reach an efficiency of 26% [1]. Enel Green Power (EGP) is the ENEL company focused on production of energy by renewable and sustainable sources and already produced more than 6 million of thin film silicon PV. Recently EGP has started the 3SUN 2.0 program for the development and manufacturing of HJT cells and modules by converting its facilities, in close partnership with CEA-INES. The HJT technology allows to achieve higher efficiency solar cells with high bifacial factor. The combination of high efficiency and bifacial factor will enable EGP-3SUN HJT solar cells to compete on the market due to the low achievable LCOE in the utility scale segment.

Material Selection

Studies have been performed at CEA-INES pilot line to evaluate the impact of wafers properties on cell efficiencies:

- Ingots A - res: 1 – 7 Ω.cm; τ > 2 ms
- Ingots B - res: 0.2 - 2 Ω.cm; τ >500 µs

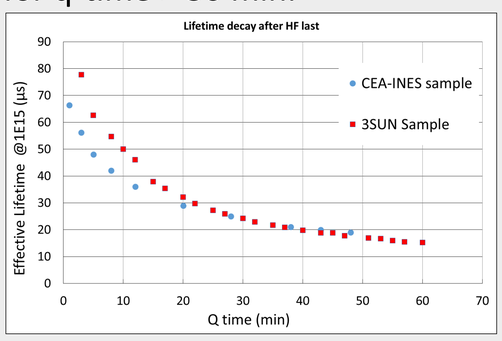


Cells efficiencies with 4 busbars cell design of 21.3% (ingot A) and 21.7% (ingot B) are quite stable over all the height. A clear step of 0.35% is attributed to different bulk material properties.

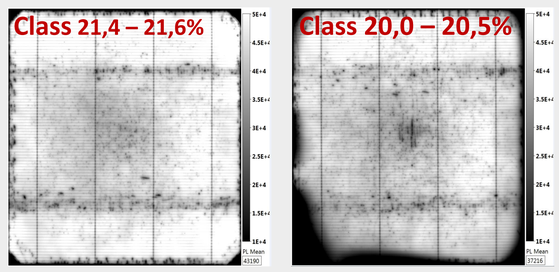
Manufacturing aspects towards high efficiency HJT production

Fully automated production line with covered conveyors, clean environment and reduced human intervention:

Automatic N_2 buffer :
→ prevent surface oxidation for q-time > 30 min.

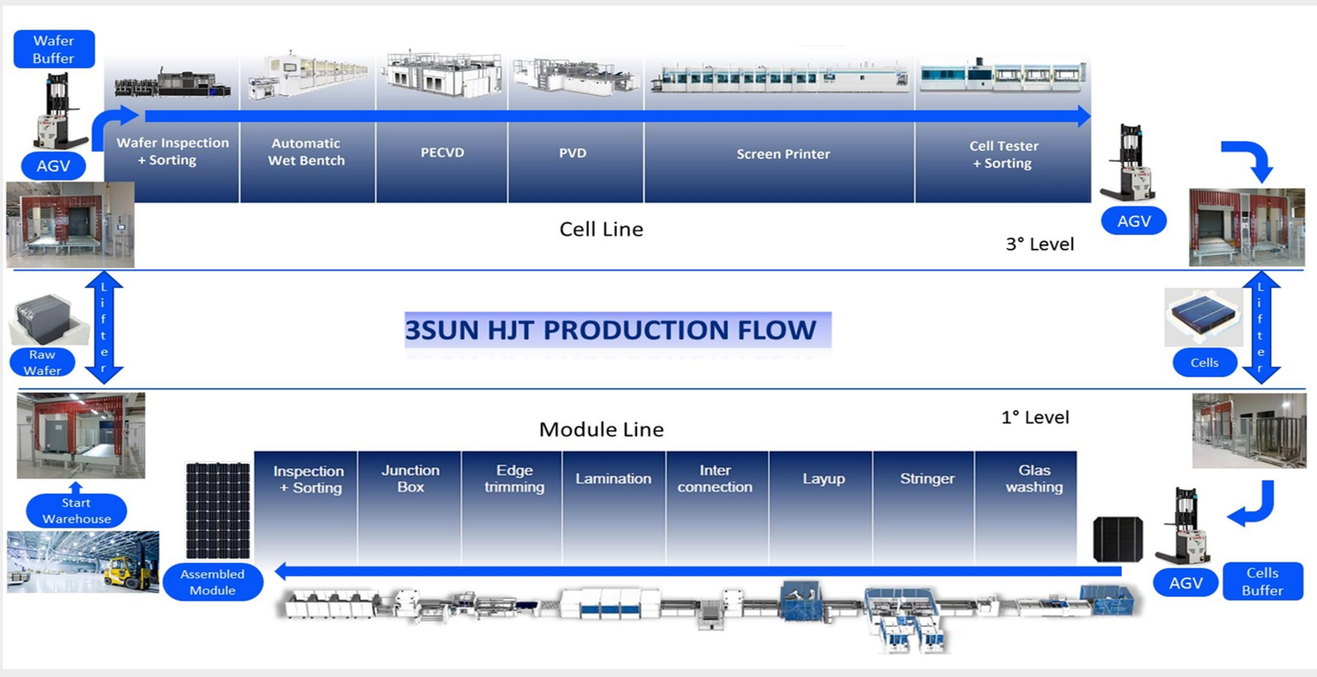


On line PL equipment:
→ wafers defective regions monitoring [3]



Gentle wafer handling:
→ reduce belt marks or rubbing

Innovative cell layout:
→ save silver paste and reducing shadowing.

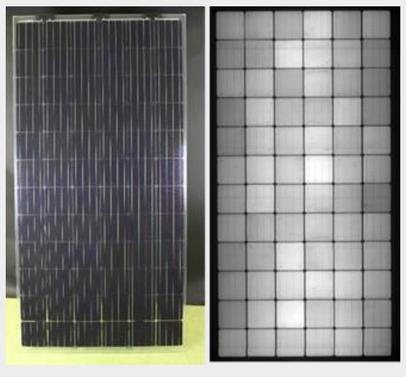


Modules efficiency

Bifacial SHJ modules made and measured on flash-tester at CEA-INES with dark background and electroluminescence (EL) [4].

Side	Pmax (Wc)	Voc (V)	Isc (A)	FF (%)
Front side	380,7	53,4	9,15	77,9
Back side	331,5	53,3	7,95	78,2

No defects (crack, dark spots) are visible.



Integrated EL:
→ control stringer and lamination process.

MES complete integration:
→ Control process through SPC, DOE and data correlation
→ Cells traceability using wafer virtual ID
→ Material traceability
→ OEE analysis
→ Data mining

Conclusion & Perspectives

Strong collaboration between EGP and CEA-INES produced very good results on the deployment of SHJ technology at large production scale. Pre-production tests to evaluate the impact of wafers properties on cell efficiencies have been performed at CEA-INES pilot line. Results demonstrates material quality has strong effect on cell efficiency. EGP-3SUN 2.0 fully automated line is designed to ensure high efficiency bifacial HJT panels production at a large scale.

[1] K. Yoshikawa, H. Kawasaki, , et al, Nature Energy 2, 17032 2017
[2] M. Taguchi et al., IEEE Journal of Photovoltaics, Vol. 4, no. 1, pp 96-99, 2014
[3] O. Nos, W. Favre, F. Jay, F. Ozanne et al., "Sol. Energy Mater. Sol. Cells, 144, pp210-220, 2016
[4] A. Battaglia, W. Favre et al., proceedings of the EU PVSEC, 2017

AMPERE AUTOMATED PHOTOVOLTAIC CELL AND MODULE INDUSTRIAL PRODUCTION TO REGAIN AND SECURE EUROPEAN RENEWABLE ENERGY MARKET

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