Low Current Integrated Solar Cells (i-Cell) for Low Cost and High Efficiency PV Modules

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1) Context / Study motivation

The major challenge facing the photovoltaic industry is still finding ways to produce solar cells with high conversion efficiency and low production cost. One promising concept is the crystalline Silicon Thin-Film (c-Si TF) solar cells. Only a small amount of the high purity silicon is needed for the active layer of the solar cells. The layer active is then attached to the low cost substrate. The integrated solar cell concept developed by S'Tile based on mono (c-Si TF) solar cells and using Si sintered as a substrate and back electrode can bring its contribution to the hatching of solar cells technology with low-cost and high efficiency. During the two next years, different authors presented very promising results on this topic [1, 2, 3]. However, all these authors used glass as substrates of the active layer of the solar cells. These substrates are not compatibles with conventional solar cells manufacturing processes especially for the high-temperature processes. Also the thermal expansion mismatch is still a potential problem. S'Tile is distinguished by the use of the Mono-EQ which is a silicon wafer equivalent to the standard monocrystalline silicon wafers for realizing the i-Cell [4]. In this paper we report a new concept of solar cell : the i-Cell and present the solar cell results.

2) Description of approach and techniques

The i-Cell or integrated cell is a cell without busbar, producing a low current and high voltage. It is made from Mono-EQ® wafers carried by the transfer of thin foil of monocrystalline silicon on integrated sintered silicon substrates. An i-Cell is composed of several subcells connected in series by using conventional processes. Much like a tandem solar cell, the current of an i-Cell is equivalent to the current in the sub-cell while the total voltage is the sum of the voltages of each sub-cell. For the i-Cell fabrication, firstly, low-cost insulating substrates are produced by sintering of metallurgical grade silicon powder. Then conductive areas are then realized on the sintered substrate by screen printing allowing to obtain the so-called integrated sintered substrate composed by conductive wells separated by insulated zones.
The thin leaves of monocrystalline silicon transferred on these sintered integrated, constitute mono-equivalents wafers (Mono-EQ®). Integrated cells (i-Cell) are then manufactured by standard industrial processes. In an i-Cell, thin film is the active part that converts solar energy into electrical energy. The sintered integrated substrate is used as a mechanical support and as the rear electrode of the integrated solar cell.

3) Results / Conclusions / Perspectives

New concept of high voltage and low current solar cells was developed. Busbar free integrated solar cells (i-Cell) with efficiency of 19,58 % using Al-BSF structure solar cells processes were obtained. The integrated cells consist to several sub-cells realized by laser ablation on the top of the Mono-EQ and which are interconnected in series with finger shape contacts printed by screen printing process. The voltage of the i-Cell is 4 times higher than the voltage of a conventional high-performance cell. The current is 4 times lower. This reduces resistive losses in the cell and increase its performance. This lower current delivered by the i-Cell also allows for module integration, to use less copper compared to conventional cells We demonstrate with our new concept of busbar free solar cells based mono Si thin foil bonded on silicon sintered substrate, the cost of the cells can be is reduced by 30% compared to classic mono-Si solar cells. For the perspectives, S'Tile is working to reduce much more the spacing between two susbcells allowing thus to increase the compacity. New results on this work will be presented soon.

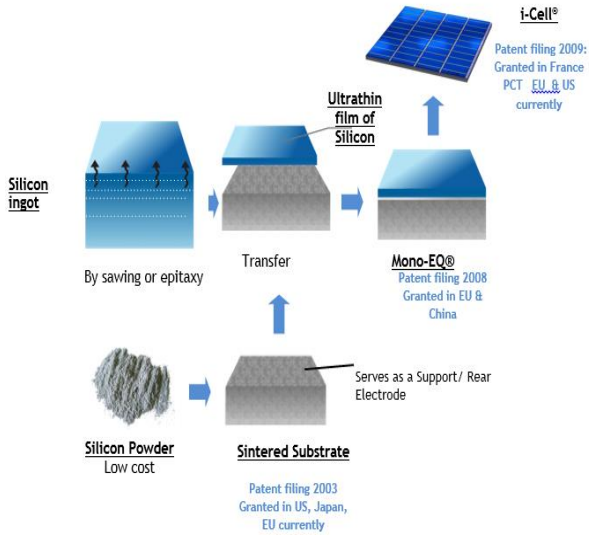

Figure 1 : Production process flow of the i-Cell

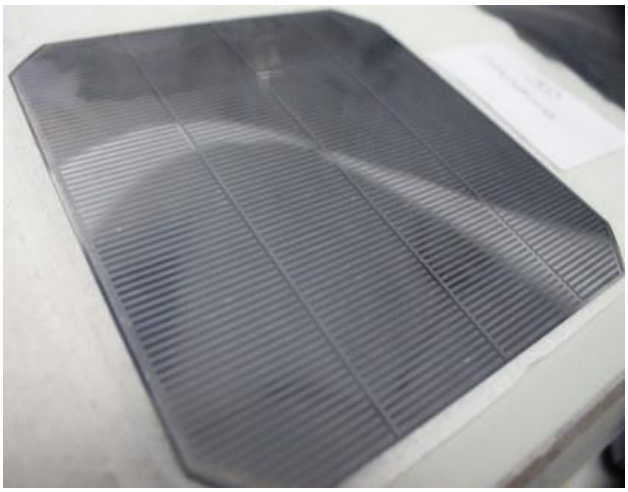

Figure 2: *An integrated sintered substrate, the conductive zones (in clear) are separated by insulative zones (in dark)*

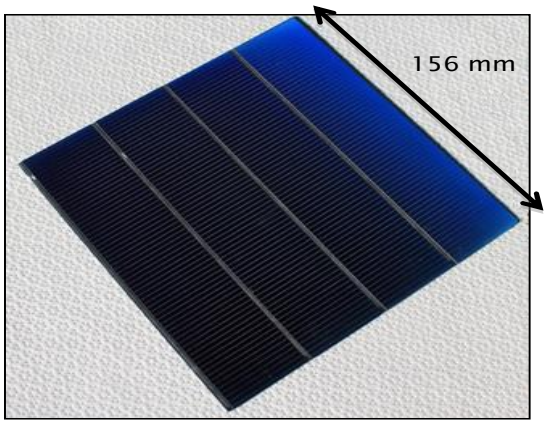

Figure 3: A prototype i-Cell® 156x156 mm

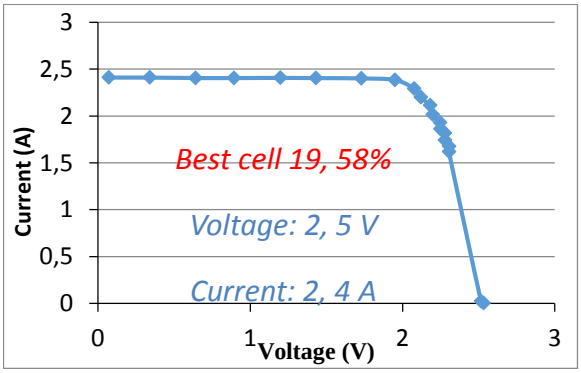

Figure 4 : I-V curve of an integrated solar cell (i-Cell)

SOURCES OF COST REDUCTION	COST VARIATION (c€/W)	REDUCTION COMPARED TO THE STANDARD
Ultra-thin wafer of Silicon pure monocrystalline	- 8	- 50%
Silver	- 3	- 50%
Sintered support and bonding	+ 3,5	
Assembling the module	-1,5	
Copper	- 1,5	- 90%
REDUCTION TOTAL COST OF MATERIALS	- 9	
REDUCTION TOTAL COST OF MODULE	**-10,5**	**- 26%**

Table 1: Reducing the cost of modules made from i-cells in 2018 ***Compared with monocrystalline*** *high performance modules.*

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