Glued III-V on Si tandem cells using hybrid transparent conductive layers

Jerónimo Buencuerpo,[1,2] Phuong-Linh Nguyen,[1,2,3] Philippe Baranek,[2,3] Oliver Höhn,[4] David Lackner,[4] Frank Dimroth,[4] Marco Faustini,[5] Stéphane Collin,[1,2] Andrea Cattoni[1,2]

[1] *Centre de Nanosciences and Nanotechnologies (C2N), CNRS, Paris-Saclay University, Palaiseau, France*

[2] *Institut Photovoltaïque d'Ile-de-France (IPVF), Palaiseau, France*

[3] *EDF R&D, EFESE, Technologie du Solaire, Palaiseau, France*

[4] *Fraunhofer Institute for Solar Energy Systems (ISE), Freiburg, Germany*

[5] *Laboratoire Chimie de la Matière Condensée de Paris, Sorbonne Université, CNRS, Paris, France*

The solar market is dominated by single junction Si solar cells. Tandem solar cells are the next step towards improving efficiency. III-V on Si has a promising demonstrated efficiency (35.9%), but the transfer so far has been done with expensive Wafer bonding [1], Pd [2] or Ag-coated spheres [3]. We design and fabricate a 2-terminal AlGaAs/ARC/Glue/ARC/TOPCon tandem cell using sol-gel derived TiO_2 ARCs and PEDOT:PSS-based glue, being a more cost-effective approach. Both are compatible with low temperature gluing lamination process.

The ARCs ensure Ohmic contact with the sub-cells and the transmission of low-energy photons to the Si cell. The gluing layer ensures the electrical interconnection between sub-cells and an enhanced photon recycling in the top cell (up to 0.9% tandem efficiency improvement). We use electromagnetic simulations to optimize the ARC/Glue/ARC stack and achieve current matching; current reflections' losses remain essentially equal to those of the direct bonding architecture (1.0 mA/cm^2). SnO_2, TiO_2 ARCs and PEDOT:PSS-based glue are synthesized and deposited by spin-coating. The lamination process is performed in air, using a simple hydraulic press at low curing temperature (120 °C). Compared to conventional direct bonding, this method does not require expensive wafer surface preparation or wafers surface activation under vacuum.

We fabricate a 1st-generation $Al_{0.25}Ga_{0.75}As$/TOPCon tandem cell with a surface area of 1 cm^2. The 1st-generation cells show a promising V_{OC} (1.73 V), while the efficiency is currently limited by high series resistance. The 2nd generation is under fabrication to solve this problem. We are also incorporating light-management strategies to minimize the use of III-V materials and improve the efficiency in both subcells.

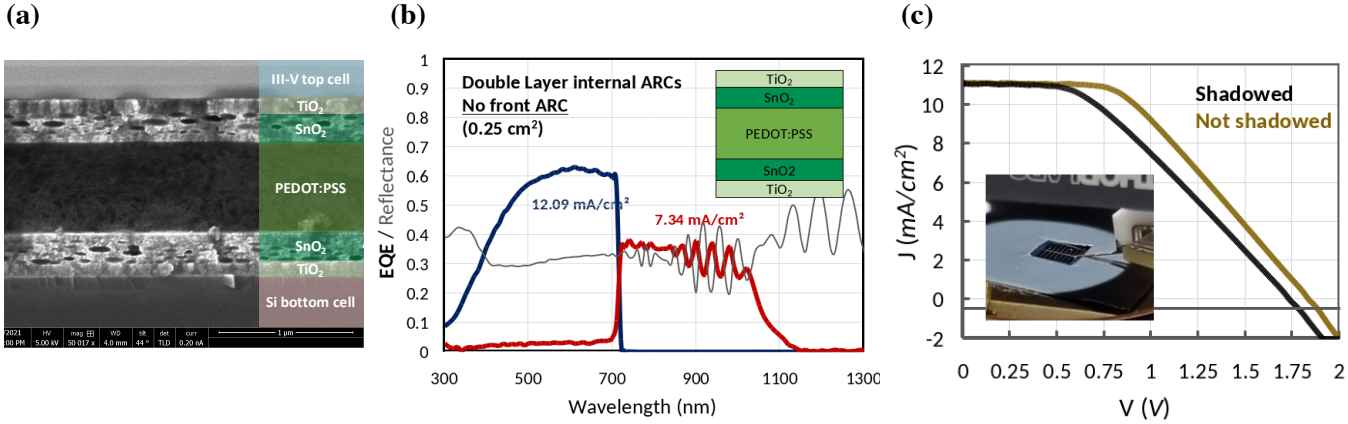

Figure 1: SEM Cross-sectional view of the Hybrid Glue using inorganic internal ARC through sol-gel (TiO_2 and SnO_2) and PEDOT:PSS as polymer and conductive gluing layer (b) External Quantum Efficiency of the cell after processing (c) IV Measurement of the solar cell under the solar simulator.

[1] P. Schygulla *et al., Prog Photovolt Res Appl* **8**, 869 (2021)

[2] Makita, K. *et al., Progress in Photovoltaics: Research and Applications* **28**, 16 (2020)

[3] M. Schnabel *et al., Sustainable Energy Fuels* **4**, 549 (2020)