Tandem III-V on Si cells using multifuntional bonding layers

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Abstract: Tandem solar cells are the demonstrated route to improve the efficiency over 30%, therefore, overcoming the limited single junction Si current technology. Integration of different bandgap materials with Si require combining other technologies, such as perovskites III-V, or CIGS. III-V on Si has already demonstrated the highest efficiency with 3 junctions (2J III-V on Si) with 36.1 % [1]. However, the approach used requires chemical mechanical polishing and wafer bonding to combine the III-V epitaxy and the Si cell. This step increases and limits the up-scalability of current devices [2]. Here we present our latest results on the multifunctional bonding layer based on polymers (PEDOT:PSS), with working III-V/Si tandems, and surpassing our latest devices [3]. The layers developed have high transparency, are conductive and able to accommodate moderate roughness, without requirement of polishing.

We present the first devices of our second generation of bonding tandem cells, using a proprietary process compatible with low temperature (<160°C), with minimal losses in optical transmission. The top junction cell is made of $Al_{0.25}Ga_{0.75}As$ with 1.73 eV bandgap to achieve current matching, with a p-type TOPCON cell, both provided by the Fraunhofer ISE.

The first tandem device has a high V_{oc} of 1.71 V and a short-circuit current of 12.5 mA/cm^2 (without an anti-reflective coating) with 13.3% efficiency. The FF (62%) limitation was studied using Isc-Voc measurements done at different irradiation. An upper FF of 75% for the current configuration, showing a series resistance as the main problem. We will show the results on the improved transparency, detailed analysis of the conductivity and the road-map towards lowering the series resistance of the multifunctional layer, and the efficiency of the bonded tandem cells.

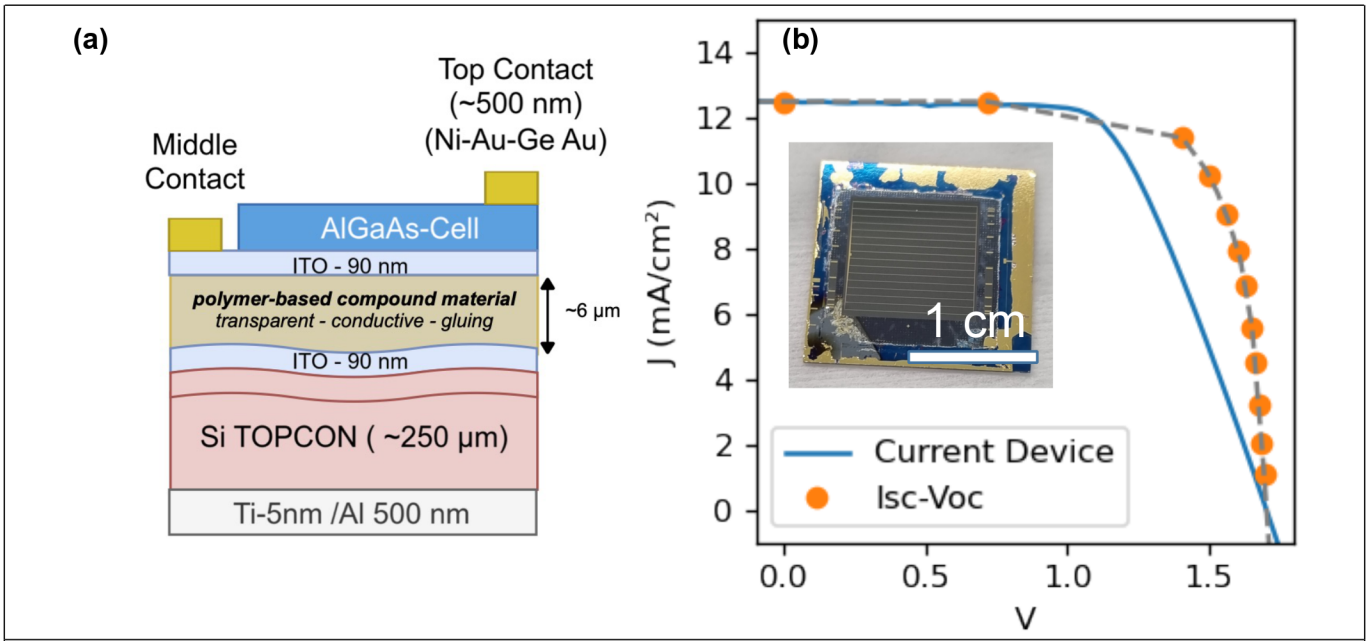

Figure: (a) Scheme of the bonded tandem III-V on Si cell, (b) IV curve for the current device of 1cm^2 (inset macroscopic picture) for the pseudo-IV curve through Isc-Voc measurements.

[1] P. Schygulla *et al.*, *Progress in Photovoltaics: Research and Applications*, (2024)
[2] K. A. Horowitz et al NREL/TP-6A20-72103, Nov. 2018. doi: 10.2172/1484349.
[3] P.-L. Nguyen, "Gluing III-V//Si with transparent conductive layers for tandem solar cells," PhD, Université Paris-Saclay, 2022.

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