III-V nanowires on Si for high-efficiency tandem solar cells

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To exceed the efficiency limit of Si single junction solar cells (current record: 26.7%), a possible pathway is to make tandem solar cells by combining a top III-V cell onto a Si bottom cell. Efficiencies exceeding 33% have been demonstrated by wafer bonding of III-V layers on Si, but this costly process can hardly be extended at an industrial level. The direct epitaxy of III-V semiconductors layers on Si is an appealing concept but it is impractical due to thermal- and lattice-mismatch. The direct growth of III-V nanowires (NWs) on Si is another elegant but challenging path, where the matching constraints can be relaxed with small NW diameters and lead to high quality III-V semiconductors with the optimum band gap.

Recently, in the framework of the C2N/IPVF collaboration, we made several decisive steps along this path: we achieved high yield (>95%) of vertical nanowires uniformly arranged over large patterned areas (>1 cm^2); we demonstrated the fabrication of GaAs NWs without stacking faults; we developed a method for the quantitative determination of the doping level (n and p) in single GaAs NWs by cathodoluminescence; and we developed a process to encapsulate and contact NW arrays that led to first-generation NW solar cells. We also introduced a core-shell heterostructure for further V_{oc} improvements.

In this context, the short-term objective of this work is to simulate (both optically and electronically) the first generation of nanowire solar cells fabricated in our labs, to contribute to the analysis of optoelectronic and luminescence characterizations, and to propose further improvements in the design of next-generation NW solar cells.

This work will be done in close collaboration with the C2N, IPVF and EDF teams, in both C2N and IPVF buildings (close to each other on the Paris-Saclay campus in Palaiseau).