Fabrication and characterization of III-V nanowire solar cells on silicon

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Direct epitaxy of III-V material on Si is an appealing approach to fabricate tandem solar cells but it is hindered by thermal- and lattice-match constraints. In this context, nanowires (NWs) appear as an elegant solution as the lattice matching constraints are relaxed thanks to the small NW diameter, so that high quality III-V semiconductors with the optimum band gap can be directly grown on Si substrates. In addition, light management and absorption enhancement are expected in a well-designed periodic nanowire array. Such nanowires-on-Si tandem solar cell designs could lead to efficiencies exceeding 33% at AM1.5G[1].

In this work, we focus on the top cell fabrication, consisting of an ordered array of GaAs NW core-shell junctions (Figure a) directly grown on inactive p-type Si(111). We address several issues related to its fabrication. We will present the detailed fabrication steps of both GaAs core-shell p-i-n radial homojunctions and GaAs/GaInP core-shell radial heterojunctions. The optimization of key processing steps ensures a perfect selective growth and a high yield (>95%) of vertical NWs. We demonstrate stacking-faults-free zinc-blende Be-doped GaAs NWs (previously reported by Zhang et al.[2]) and wide-bandgap GaAsP nanowires with homogeneous axial and radial compositions[3]. Following from opto-electrical characterization of encapsulated and contacted NWs, these first-generation devices were found to exhibit efficiencies up to 2.1% under AM1.5G illumination. The heterojunction shows a V_{OC} of 0.6 V, higher than the reported state-of-the-art GaAs NW core-shell junctions [4], which demonstrates the relevance of such design.

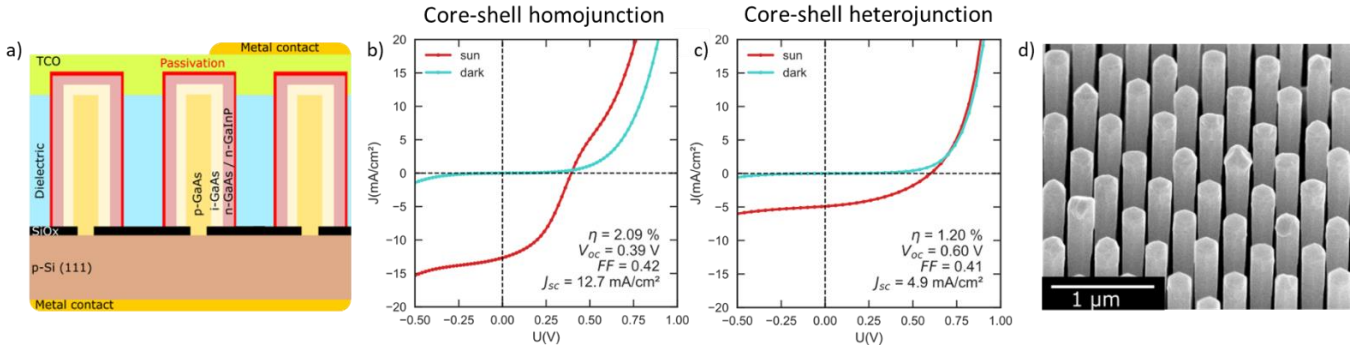

Figure a) Schematic of the top-junction NW based solar cell. In the heterojunction design, the n-GaAs shell is replaced by a n-GaInP shell. - JV-characteristics (dark and under AM1.5G)of **b)** a GaAs NW core-shell homojunction and **c)** a GaAs/InGaP NW core-shell heterojunction . **d)** 45° tilt SEM micrograph of ap-i-n GaAs NW homojunction; the total surface area of the NWs array is a 1.5 × 1.5 cm² with a yield of vertical NWs > 95%

References

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