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 concept to fabricate tandem solar cells but is impractical due to thermal- and lattice-match constraints. In this context, nanowires (NWs) appear as an elegant solution where the matching constraints are relaxed in 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 junction fabrication and address several issues related to the fabrication of GaAs NW core-shell solar cells (Figure **a**). i) We achieve high yield (>95%) of vertical nanowires uniformly over large patterned areas (>1 cm²); ii) We demonstrate the fabrication of stacking-faults-free zinc-blende Be-doped GaAs NWs as already reported by Zhang et al.[2]; iii) We determine the doping levels of single GaAs NWs by fitting cathodoluminescence spectra with the generalized Planck's law[3]; iv) We encapsulate the NW array in a polymer, contact the top of the nanowires with a transparent conductive oxide and perform device characterization.

We will present thorough opto-electrical characterizations of GaAs core-shell p-i-n homojunctions and GaAs/GaInP core-shell heterojunction, with in situ passivation. These first-generation devices exhibit efficiencies up to 2.1% under AM1.5G illumination. The heterojunction shows a V_{oc} of 0.6 V, higher than the state-of-the-art GaAs core-shell junction NW solar cells, which demonstrates the relevance of such design. We examine the effects occurring under concentrated light and investigate the energy barriers for photocurrent extraction by comparison with 1-D simulations. We perform top-view µ-PL mappings to detect faults in the device at the nanowire scale.

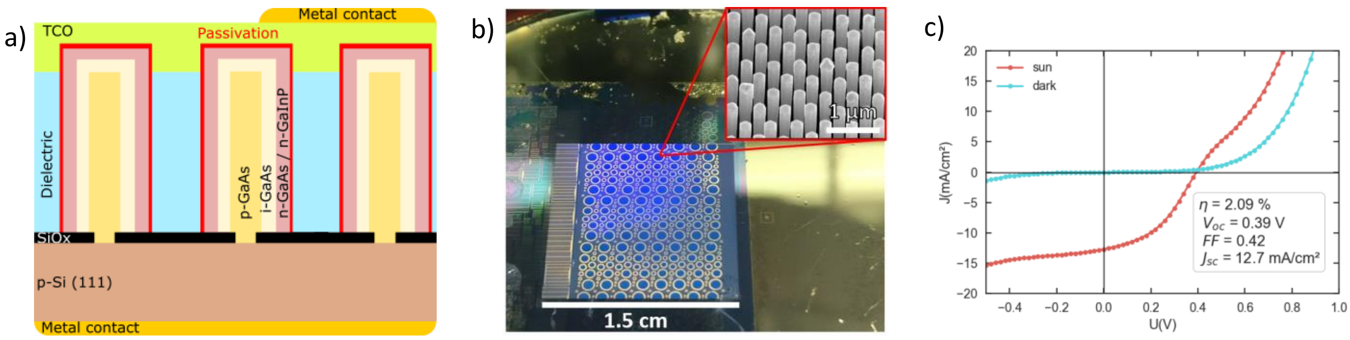

***Figure a)** Sketch of the top-junction nanowire solar cell structures that we fabricate. In the heterojunction design, the n-GaAs shell is replaced by a n-GaInP shell. **b)** Photograph of a complete GaAs nanowire solar cell device. Inset: scanning electron micrograph of the nanowire array **c)** J-V curves of a GaAs homojunction solar cell, in the dark and under AM1.5G illumination*

References

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