Structure optimization of GaAs/AlGaAs nanowires for tandem solar cells on silicon

M.Vettori[1a,b], P. Regreny[1a], J. Penuelas[1a], C. Chevalier[1b], N. Chauvin[1b], V. Piazza[2a], A. Ahmed[2a], M. Tchernycheva[2a], G. Patriarche[2b], A. Cattoni[2b], F. Oehler[2b], J.C. Harmand[2b], A. Fave[1b], M. Gendry[1a]

1: INL, UMR 5270 CNRS, Université de Lyon,
[a] Ecole Centrale de Lyon, Ecully 69134, France; [b] INSA de Lyon, Villeurbanne 69621, France
2: C2N, UMR 9001 CNRS,
[a] Université Paris Sud, Université Paris Saclay, Orsay 91405, France;
[b] Site de Marcoussis, Route de Nozay, Marcoussis, 91460, France
Contact: marco.vettori@doctorant.ec-lyon.fr

Semiconductor nanowires (NWs) have become a subject of broad interest in photovoltaics, being possible building blocks of high efficiency tandem solar cells (TSC) [1, 2]. Nevertheless, the many steps required to optimize every phase of the fabrication process still make the development of effective NW-based TSC a challenging task.

In such a context, we developed a project [3] whose aim is to obtain a TSC based on a Si(111) bottom cell coupled to a top one consisting in a ordered array of p-GaAs core/p-n $Al_{0.2}Ga_{0.8}As$ shell NWs. A substantial part of our research work [3] was committed to optimizing the growth of these structures. In order to fulfil this purpose we decided to proceed step by step to outline the best final structure of the NWs.

The optimization process began by searching for the best growth parameters to obtain PV active p-n core-shell GaAs NWs and p-GaAs core/p-n $Al_{0.2}Ga_{0.8}As$ shell NWs on epi-ready Si(111) substrates. Having achieved good results in terms of both morphology and crystallinity (Fig. 1a), the optoelectronic properties of the PV active region were investigated by Electron Beam Induced Current (EBIC) spectroscopy: the results demonstrated good diodic behaviour of the radial p-n junction, showing a remarkable PV response from these structures.

After that, we aimed to evaluate the effect on NWs of three different types of passivation shells ($Al_{0.5}Ga_{0.5}As$/GaAs, $Ga_{0.5}In_{0.5}P$, and $Al_{0.5}In_{0.5}P$), starting by studying their optoelectronic properties by photoluminescence (PL) spectroscopy on passivated GaAs NWs, then extending the analysis to the PV active GaAs and GaAs/AlGaAs NWs. Finally, we tried to transfer the know-how acquired so far from epi-ready to Si(111) patterned substrates with a SiO_2 mask. This objective was accomplished by firstly optimizing the growth of GaAs NWs (Fig. 1b), then extending the procedure to the PV active GaAs/$Al_{0.2}Ga_{0.8}As$ core/shell NWs (Fig. 1c). In both cases results were positive, showing the possibility to obtain high yields of vertical NWs, thus suggesting that such structures can actually act as building blocks for a TSC.

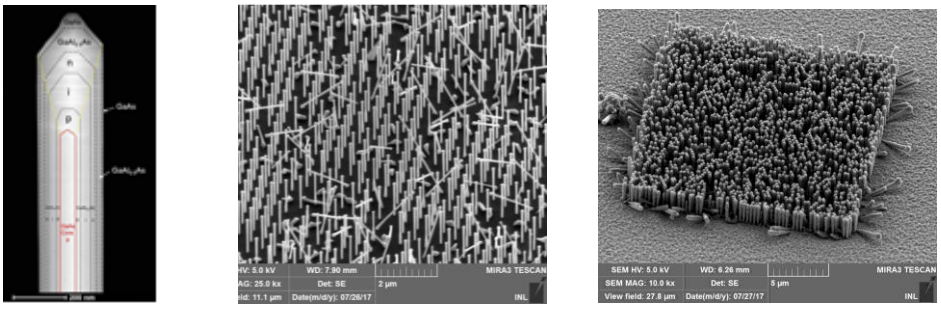

Fig. 1: a) TEM image of a core-shell GaAs/AlGaAs NW. **b)** Ordered array of GaAs NWs. **c)** Ordered array of core-shell GaAs/AlGaAs NWs.

References

[1] R. LaPierre, *J. Appl. Phys.* **2011**, 110, 014310
[2] Y. Wang, Y. Zhang, D. Zhang, S. He and X. Li, *Nanos. Res. Lett.* **2015**, 10, 269
[3] HETONAN project funded by ANR (http://inl.cnrs.fr/projects/hetonan/)