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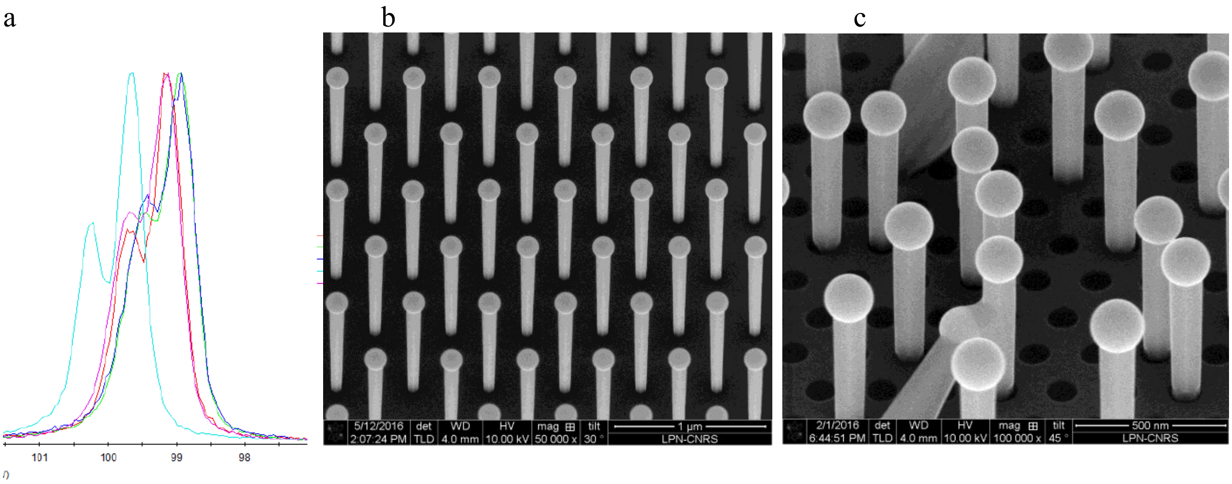
III-V nanowires on Si: steps towards the realization of a monolithic multi-junction on a silicon active substrate

Despite the astonishing rate of development of devices based on novel materials in recent years, the production of solar cells is still largely dominated by silicon. It is clearly evident how the introduction of any new technology has to face the competition with Si in terms of fabrication costs and availability of materials. In order to increase the viability of such novel concepts, the coupling with Si active substrates in a tandem design appears very appealing, since it combines the potential benefits of a new technology with the reliability of a well-established one.

We propose the integration of III-V nanowire solar cells with Si solar cell substrates, for the realization of a dual junction device.

To this aim, we investigate the MBE growth of self-catalyzed GaP and GaAs nanowires on Si (111) substrates, coated with a silicon dioxide layer periodically patterned into an array of nano-holes. The nanowire solar cell will serve as top junction in the tandem. We show how critical is the mask fabrication process to achieve high yields of vertical nanowires, highlighting the strong dependence on the substrate doping level. The understanding of the process is mandatory in view of a coupling with an active Si substrate/cell. In particular, we have observed by XPS that a residual oxide layer is always present when a diluted wet HF etching of the oxide mask is performed: the surface concentration of this residual oxide increases with the doping level of the p-type Si substrates. The growth of nanowires is consequently affected, with poor yields of vertical nanowires when using heavily doped p-Si substrates. This must be considered in the design and fabrication of devices with tandem architecture, usually involving heavily doped layers.

We also report on the characterization of GaP and GaAs nanowires by cathodoluminescence and TEM.



*The figures show **a)** XPS spectra of deoxidized Si surfaces, showing a chemical shift of the Si 2p signal due to the different doping of the substrates and the different surface oxidation states (on x axis, XPS-measured binding energy, corrected for charge effects) **b)** SEM picture of an array of GaP nanowires grown on intrinsic Si (111) patterned substrate and **c)** SEM picture of an array of GaP nanowires grown on patterned heavily doped p-Si (111).*