III-V core-(multi)shell nanowires arrays for photonics and photovoltaics: insights of their MOVPE growth and nanoscale properties

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Free-standing nanowire (NW) heterostructures based on III-V compound semiconductors continuous to attract huge research interest in reason of their unique physics properties: indeed, III-V NWs offer significant advantages over conventional (planar) devices, including intrinsic anti-reflection property and excellent light absorption efficiency [1]; NW heterostructures can elastically adapt the lattice mismatches between constituent materials without nucleating dislocations, and may show quasi 1-dimensional quantum confinement [2]. These properties make III-V NWs of great potentials for the fabrication of novel and efficient nanophotonic [3-5], and photovoltaic devices [6].

A general approach to the synthesis of III-V NWs is through the application of a variety of self-assembly processes (e.g., the vapour-liquid-solid mechanism –VLS [7,8]) using well-established epitaxial growth technologies; among others, vapour phase epitaxy (MOVPE) has a prominent role in reason of its easy industrial scalability.

The talk will give an overview of the main results achieved at the "*Photovoltaic and Quantum Technology Semiconductor (PHOQUS)*" Joint Laboratory established between the Univ. of Salento and the CNR-IMM Institute (Italy) on the MOVPE growth and optical/ structural properties of III-V NW heterostructures. The growth of dense arrays of GaAs-AlGaAs core-(multi)shell NWs will be presented and the effects of changing the NW density and growth conditions on the shell growth rates is analyzed through a mass-transport growth model; the degree of conformal growth during shell overgrowth will be thus assessed for the first time. These findings will be applied to the growth of GaAs quantum well tube (QWT) NWs, whose optical (radiative) and inner structural properties have been studied in ref. [2] and will ultimately allow to evaluate the truly 1-dimensional quantum confinement of charge carriers within the QWTs. Also, the first ever experimental estimate of the GaAs near band-edge absorption enhancement factor of GaAs-AlGaAs core-shell NWs will be presented. Strong absorption enhancement (up to about 190× that of equivalent planar structures) will be reported [1] and ascribed to improved wave-guiding of incident light into the GaAs cores by the surrounding AlGaAs shells. Theoretical modelling will allow to generalize these findings and further estimate the optical absorptance of the NW arrays as function of their geometry (NW density, lengths, etc.), of utmost importance for their photovoltaic applications.

Keywords: III-V core-(multi)shell nanowires, MOVPE growth, nanowire growth modelling, nanoscale properties, quantum confinement

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