MOVPE self-assembly and nano-scale properties of III-V core-(multi)shell nanowires for photonics and photovoltaics

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Over the last two decades free-standing nanowire (NW) heterostructures based on III-V compound semiconductors have being attracting a steady research interest in reason of their unique potentials to the fabrication of novel and efficient nanophotonic [1] and photovoltaic devices [2], and – more recently – in the field of quantum technology [3]. A general approach to their synthesis is through application of bottom-up nanotechnology processes using well-established epitaxial growth technologies. Among the latter, metalorganic vapor phase epitaxy (MOVPE) would be the preferred one, in reason of its easy industrial scalability.

Rational design of self-assembly technologies resulting in the growth of NWs with properties tuned/optimized for the specific application is still a major challenge in the field: a common difficulty to this goal is the precise correlation of the resulting nano-scale inner size/structural/ compositional properties (and their inherent fluctuations) of as-grown NW heterostructures, their resulting functional properties and employed nano-epitaxial growth conditions.

This talk will present results obtained by the Lecce group on the MOVPE self-assembly of III-V core-(multi)shell NWs. Growth of both simple core-shell and core-multishell NW dense arrays will be presented, along with their resulting nano-scale structural and optical properties. In GaAs-AlGaAs core-shell NWs a strong enhancement of near band-edge GaAs optical absorption and its dependence on overgrown AlGaAs shell thickness is demonstrated, a result of improved wave-guiding of incident light into the GaAs core by the surrounding AlGaAs shell [4]. Insertion of a few nanometers thin GaAs shell in between two thicker AlGaAs shells may lead to the formation of a quantum well tube (QWT) structure. A direct correlation between the nanoscale luminescence properties of GaAs-AlGaAs QWT NWs, their thickness variation and inner 3d structure at the single-NW level by means of high spatial resolution cathodoluminescence spectroscopy and imaging will be reported [5].

Precise control of shell thicknesses within these structures is necessary to fine tune the optical properties of abovementioned nanostructures. A general growth model able to predict each shell thickness (and possible sources of fluctuation) in core-multishell NWs dense arrays will be presented and validated for the case of GaAs-AlGaAs core-multishell NWs containing multiple GaAs QWTs. Model extension to molecular beam epitaxy growth will be discussed.

References

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