Engineering III-V core−(multi)shell nanowires for advanced photonics and photovoltaics

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Nanowires (NWs) of III-V semiconductors possess great potentials for next generation energy conversion and light emitting devices. The design and growth of device-quality NW hetero-structures rely on detailed correlations between NW nano-scale size/structural/compositional properties, their functional properties and self-assembly conditions.

We report on the MOVPE growth of III-V core-(multi)shell NWs and discuss their structural and optical properties. The absorption of GaAs-AlGaAs core-shell NWs was studied by spectroscopic analysis, and correlated with the NW size and local array density, showing strong near band-edge GaAs optical absorption; a first ever estimate of the GaAs near band-edge absorption enhancement factor as function of the core-shell NW inner structure in the range 22−190 in obtained, depending on actual AlGaAs shell thickness; the result is ascribed to improved wave-guiding of incident light into the GaAs core by the surrounding AlGaAs shell.

A thin GaAs shell in between two AlGaAs barrier shells lead to the formation of a quantum well tube (QWT). We studied QWT emissions in individual GaAs-AlGaAs core-multishell NWs by cathodoluminescence (CL) measurements performed in a high-resolution SEM. For each NW values of the GaAs QWT thickness (within the 3-7 nm range) were extracted from SEM-measured NW diameters through a fine-tuned multishell growth model, the latter being validated against experimental data (core diameter and GaAs and AlGaAs shell thickness) obtained from HR-TEM investigation of a GaAs-AlGaAs QWT nanowire. The dependence of QWT emissions on GaAs shell thickness is demonstrated for single NWs and compared with theoretical values, the energy difference being ascribed to exciton localization at QWT thickness fluctuations.