Correlated micro-photoluminescence spectroscopy, transmission electron microscopy and atom probe tomography on a single nano-object containing core-shell InGaN/GaN multi-quantum wells.

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In this work, we present the first correlated study of micro-photoluminescence (µ-PL) [1], high-resolution scanning transmission electron microscopy (HR-STEM) and laser-assisted atom probe tomography (APT) [2] on a single nano-object, a portion of a GaN wire containing a core-shell InGaN/GaN multiple quantum-well (MQW) system (Fig. 1). The sample was prepared by focused ion beam (FIB) in the form of a nano-chunk (a cylinder of several hundreds of nm diameter containing an optically active portion of the QW set) for the optical characterization, and successively of a field-emission tip for the structural characterization. Our results show that isolating a small portion of the wire in a nano-chunk provides a gain of information in µPL analysis (Fig. 2), with the apparition of narrow lines, distributed in the energy interval 2.9 – 3.3 eV, that were not visible when analyzing the whole wire by µPL. These data can be then put in relationship with the structural HR-STEM (Fig. 3) study and the APT study (Fig.4), which make accessible the crystallography and In distribution within the quantum wells in 3D. The QWs present a pattern of In-rich (up to 20% of InN fraction) and In-poor regions propagating through adjacent quantum wells. The set of results is discussed in the framework of an effective mass approximation for the calculation of exciton emission energies in InGaN quantum wells. All results consistently indicate that the exciton recombination occurs at the potential minima localized at the In-rich regions in the QWs. This approach is particularly promising in the case of semiconductor nanowires containing a few quantum emitters [3]. Furthermore, the optical spectroscopy can be implemented as an in-situ technique within the atom probe itself. This work is performed in the framework of the French Labex program EMC3 under the contract ASAP.

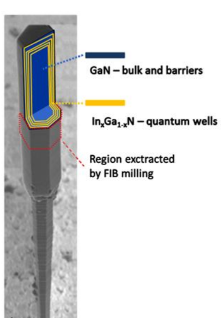
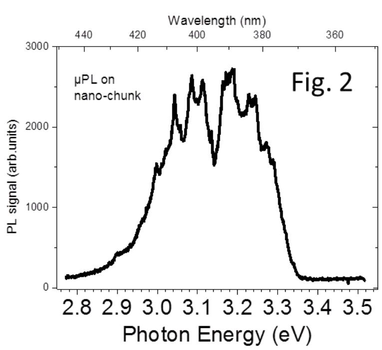


Fig. 1



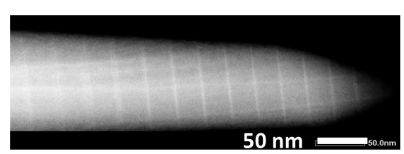


Fig. 3

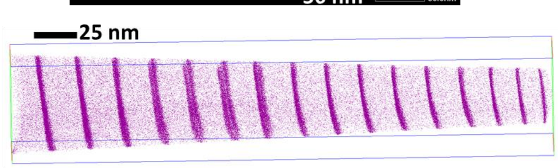


Fig. 4

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