

Spatially resolved strain analysis in GaN/Al_xGa_{1-x}N nanowires — cathodoluminescence and X-ray diffraction studies

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Near-band-gap excitonic emission shift can be used as a strain probe in semiconductors. Spatially and spectrally resolved cathodoluminescence (CL) spectroscopy and imaging allows us to observe and analyse the strain state and its distribution in the heterostructure nanowires (NWs). The X-ray Diffraction (XRD) studies and calculations of c- and a-lattice parameters provide an information about the out- and in-plane strain values, respectively. The results from both techniques enable detailed analysis of the strain in the nanoscale.

GaN nanowires with Al_xGa_{1-x}N segments ($x = 0.2, 0.5, 1$) and accompanying Al-rich shell surrounding the lower part of the NW were grown on in-situ nitridated Si(111) substrates without any catalyst by plasma-assisted molecular-beam epitaxy. NWs were characterised with the use of scanning and transmission electron microscopy. Luminescent properties of individual NWs were studied by low-temperature CL spectroscopy and imaging. High resolution XRD technique was used to determine accurate values of lattice parameters of the NW heterostructures.

CL maps and line-scans taken along the individual NWs have shown a strong localised luminescence in the core-shell region. The blue-shifted near-band-gap emission of GaN core, compressively strained by Al-rich shell, with a value of 3.50-3.57 eV (depending on Al content in the Al_xGa_{1-x}N segment and shell) was observed. The calculations of the out-of-plane strain (responsible for blue-shift of CL energy) from XRD studies revealed presence of the compressive strain in the GaN core on the level of 1.1 to almost 2 GPa. Comparison of the average values of CL energy and XRD results, allowed us to find the relationship between the blue-shift of CL luminescence and the compressive out-of-plane strain in GaN core.

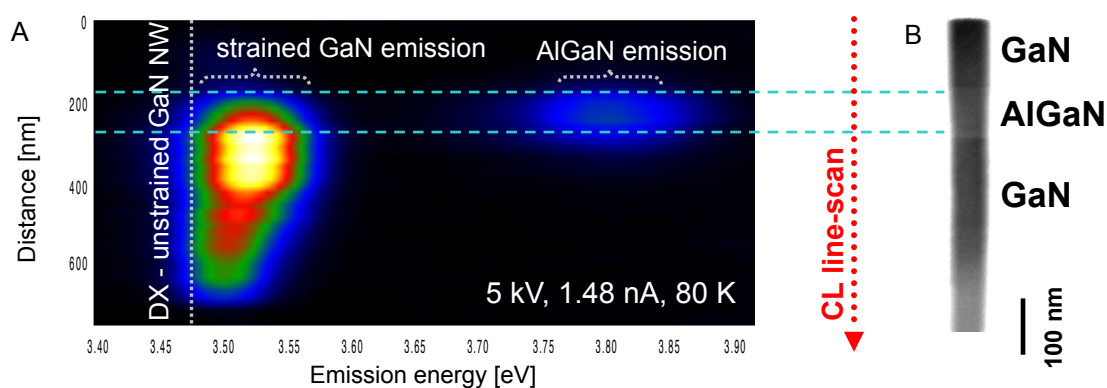


Fig. 1. A. CL spectra series (line-scan) taken along individual GaN/Al_{0.2}Ga_{0.8}N NW with strong blue-shifted GaN core emission visible, B. SEM-TE image of the NW.

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