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Linearly Polarized Single Photon Emission from Nonpolar, Semipolar and Polar Quantum Dots in GaN/InGaN Nanowires

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Abstract : The study reports how the pencil-like morphology of a homoepitaxially grown GaN nanowire can be exploited for the fabrication of a thin conformal InGaN nanoshell, hosting nonpolar, semipolar and polar single photon sources (SPSs). All three SPS types exhibit narrow emission lines (FWHM~0.35 - 2 meV) and high degrees of linear optical polarization (P > 70%) in the low-temperature micro-photoluminescence (μ-PL) experiments and are characterized by a pronounced antibunching in the photon correlation measurements ($g_{corrected}(2)(0) < 0.3$). The quantum-dot-like exciton localization centers induced by compositional fluctuations within the InGaN nanoshell are identified as the driving mechanism for the single photon emission. As confirmed by the low-temperature transmission electron microscopy combined with cathodoluminescence (TEM-CL) study, the crystal region (i.e. non-polar m-, semi-polar r- and polar c-facets) hosting the single photon emitters strongly affects their emission wavelength, which ranges from ultra-violet for the non-polar to visible for the polar SPSs. The photon emission lifetime is also found to be facet-dependent and varies from sub-nanosecond time scales for the non- and semi-polar SPSs to a few nanoseconds for the polar ones. These differences are mainly attributed to facet-dependent indium content and electric field distribution across the hosting InGaN nanoshell. The hereby reported pencil-like InGaN nanoshell is the first single nanostructure able to host all three types of single photon emitters and is thus a promising building block for tunable quantum light devices integrated into future photonic and optoelectronic circuits.

Keywords : GaN nanowire, InGaN nanoshell, linear polarization, nonpolar, semipolar, polar quantum dots, single-photon sources
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