Nanostructuration of GaN: Towards Single-Photon Emission for Quantum Technologies

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Abstract: GaN nanostructures, fabricated via photo-electroless etching, exhibit promising optical properties, and their potential for room-temperature quantum applications is actively being explored. These nanostructures have been extensively analysed using advanced spectroscopy and microscopy techniques.

Single Photon Sources (SPSs) are capable of producing coherent streams of single photons characterised by distinct quantum properties, including high coherence and controllable quantum correlations. These attributes render SPSs vital components for a variety of quantum technologies and sensing applications. Gallium Nitride (GaN), traditionally recognised for its roles in power electronics and lighting technologies, is increasingly being explored for its potential in quantum technologies. This is largely due to the exceptional electro-optical properties of its nanostructured counterparts, which have demonstrated the ability to generate SPSs that operate in the blue and visible spectrum at or near room-temperature [1,2].

The nanostructuring of GaN, including the formation of mesoporous and nanoporous structures as well as nanowires, has been successfully achieved using Photo-Electroless Etching (PEE), a highly precise and cost-effective technique. The structural composition of these nanostructures was verified through Energy Dispersive X-ray Spectroscopy (EDX), while their morphological transformations were examined using Scanning Electron Microscopy (SEM) and Atomic Force Microscopy (AFM). Additionally, room-temperature Cathodoluminescence (CL) and Photoluminescence (PL) spectroscopy were employed to evaluate the optical properties of the nanostructures. This analysis revealed a clear correlation between the emission characteristics and the morphology of the nanostructured GaN substrates.

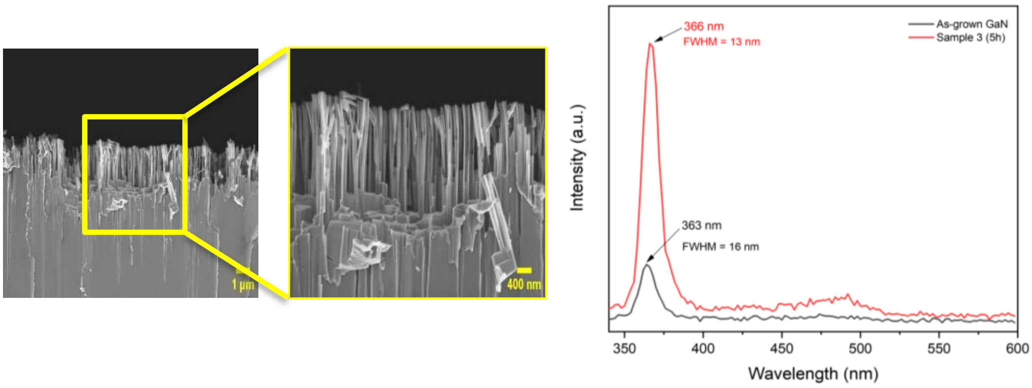

Fig. 1. A cross-sectional view of the GaN nanowires after an etching duration of 5 hours is presented. The corresponding spectrum illustrates the cathodoluminescence response of the nanowires in comparison to the as-grown GaN substrate, demonstrating an enhanced optical response. This improvement is attributed to the superior crystalline quality of the nanowires, as evidenced by the reduction in the full-width at half-maximum (FWHM) values from 16 nm in the as-grown substrate to 13 nm in the nanowires.

References

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