Microscopy and vibrational spectroscopy of GaN nanowires on silicon toward scalable quantum devices

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GaN nanowires (NWs) are a promising material platform for quantum photonics and sensing due to their wide bandgap, strong confinement effects, and potential for room-temperature operation. Integrating GaN NWs on silicon substrates is particularly attractive for scalable quantum technologies. Thanks to the strain relaxation at the lateral facets, NWs represent a promising solution for reducing the effect of lattice mismatch and defect formation at the nanoscale.In this work, we present a detailed structural and vibrational characterization of selectively grown GaN nanowire arrays on AlN-buffered silicon. Using a correlative approach based on scanning electron microscopy (SEM), atomic force microscopy (AFM), and micro-Raman spectroscopy, we investigate how growth conditions and substrate engineering influence nanowire morphology, base structure, and vibrational response. This provides insight into strain accommodation and defect formation mechanisms relevant for quantum device performance. Micro-Raman mapping performed on both standing and detached nanowires reveals confined phonon modes, acoustic overtones, and surface optical phonons characteristic of GaN nanostructures. These vibrational features are sensitive to nanoscale geometry, surface effects, and local strain, and provide an effective probe of nanowire structural quality.Overall, this study demonstrates how the combined use of high-resolution microscopy and vibrational spectroscopy can elucidate structure vs property relationships in GaN nanowires on silicon. The results provide experimentally grounded guidance for optimizing nanowire growth and integration, supporting the development of scalable, room-temperature quantum photonic and sensing architectures.