Unique Optical Properties of Catalyst-free GaN-based Nanowires

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GaN nanowires grown by catalyst-free molecular beam epitaxy represent unique materials for nano-optics applications. Because of their formation process, they are defect-free single crystals with extremely low chemical impurity concentration and oriented with well-defined crystalline axes and surface planes. The nanowires also provide a platform for heterojunction growth through addition of Al and/or In, providing flexibility in band gap tuning and 3D geometry. Our extensive optical characterization of these materials will be discussed, including surface recombination velocity measurements, temperature-dependent time-resolved photoemission, and optically pumped lasing. Their high dielectric contrast makes for unique optical cavity and waveguide properties. We have determined growth conditions that lead to selective epitaxy of nanowire arrays, which opens the possibility of photonic crystal design with high dielectric contrast as well as a number of specialized device applications. The nanowires also display extremely high mechanical quality factor *Q* in the as-grown cantilever mode, with resonances in the range of 10 kHz to > 2 MHz and *Q* ranging from tens of thousands in free vibration to well over 10^6 under feedback. In addition, GaN nanowires can be intentionally doped both n-type and p-type, allowing electrically driven optical emission. The wide band gap (3.4 eV) of GaN presents challenges to efficient electrical contacts, and the small dimensions of nanowires exacerbate the difficulty in characterizing basic parameters such as carrier concentration and mobility. This work will be placed in the larger context of semiconductor nanowire research.

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