Title: Process for epitaxial growth of GaN nanorod arrays of varying diameters on the same substrate.

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Abstract:

The lateral relaxation of lattice misfit strain in heterostructures grown on nanoscale substrates substantially increases the range of lattice misfit and overlayer thickness that can be accommodated without the introduction of extended defects when compared to conventional planar heteroepitaxy. In the case of (In,Ga)N, nanoheteroepitaxy offers the possibility of increasing the maximum InN mole fraction that can be accommodated in quantum confined structures, thereby promising a broader range of emission wavelengths for GaN-based LEDs. To take advantage of this aspect of nanoscale strain engineering for white light emitters or tunable monolithic sources, it will be necessary to develop processes for fabricating arrays of GaN nanorods with spatially varying diameters in specific patterns. In this presentation, we describe a process for attaining control of GaN nanorod dimensions without nanolithography or foreign catalysts. The process yields monocrystalline, vertically aligned and faceted GaN nanorods with diameters ranging from 50 nm to 100 nm distributed in the form of microscale subarrays, each exhibiting monodisperse feature sizes. The process begins with electron-beam evaporation of a 60 nm SiO_x film followed by a 1 μm Al film onto a (0001) GaN film. The Al film is subjected to a two-step anodization process resulting in a porous anodic alumina (PAA) film approximately 250 nm in thickness. Pore widening in phosphoric acid is then used to increase the PAA pore diameter. The PAA pore pattern is then transferred into the SiO_x film using reactive ion etching. Finally, the alumina template is selectively etched away. The remaining porous silica template defines the positions and diameters of the GaN nanorods grown selectively within the pores by organometallic vapor phase epitaxy. A low V/III ratio along with hydrogen as the carrier gas results in <0001> oriented GaN nanorods with prismatic $\{1\bar{1}00\}$ facets, terminated by a cap defined by pyramidal $\{1\bar{1}01\}$ facets. Diameter control of the nanorods is achieved by varying the anodization potential and pore widening time in selected areas of the wafer through photolithography, resulting in controlled variation of nanorod diameter across the wafer. The implications of these nanorod array substrates for studies of strain effects in heteroepitaxy, as well as their potential impact on band engineering in electronic and photonic devices will be discussed.

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