The promise of MBE-grown III-nitride devices

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Nitride-based devices are nowadays spreading from optoelectronics (lasers, LEDs), to electronics (HEMTs, HBTs), and to sensors (piezoelectric, UV, ozone, biological). Our work has been focused on nitride compound growth by molecular beam epitaxy (MBE). We find that wurtzite GaN layers grown by plasma-assisted MBE on Si(111) and sapphire reveal strong morphology changes as a function of the III/V ratio. For nominally N-rich conditions, GaN nanocolumns are reproducibly grown with diameters ranging from 600 to 1500 Å. These nanocolumns are fully relaxed from lattice and thermal strain and are of very good crystal quality characterized by strong and narrow (2 meV) photoluminescence excitonic lines at 3.472–3.478 eV. The nanocolumns arise because of reduced Ga adatom diffusion due to the excess nitrogen (Ga balling). Luminescence emission at 3.41 eV can be related to structural defects at the bottom columns interface, most probably Ga interstitials.

Si doping yields $2x10^{19}$ and $8x10^{19}$ electrons/cm^3 in compact GaN and AlGaN (up to 45%) layers respectively. In addition, Si doping decreases the threading dislocation density while enhancing the layer biaxial tensile strain. We have studied and compared *p*-type doping with Be, Mg and C. Carbon shows a low solubility, in agreement with theoretical predictions. Mg doping is relatively efficient, leading to hole densities in the mid 10^{17} cm^{-3} range. Be is the shallowest acceptor level (90–100 meV), but its efficiency is hampered by the generation of deep Be-related traps, most probably Ga vacancy–Be interstitial complexes, and by self-compensation by Be interstitials. These hypotheses are in agreement with positron annihilation spectroscopy results, the effects of Mg co-doping with Be, and the presence of a strong Be-related yellow luminescence.

UV detectors and heterojunction LEDs, Bragg reflectors, and HEMTs are some examples of device applications possible for our structures.