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Structural and Optical Properties of Group-III Nitride Nanorods

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Introduction

One-dimensional group-III Nitride nanorods (NR), have drawn a large interest during the past decade thanks to great prospects for improved optoelectronics by e.g., increased quantum efficiency, higher sensitivity, lower heat generation, etc. as compared to bulk and quantum well-based devices.
Magnetron Sputter Epitaxy (MSE) allows for epitaxial growth of Al1-xInxN NRs as well as GaN NRs.[1,2] Moreover, low temperature group-III N epilayer growth is possible by MSE[3] and it is easily scalable to large areas, which make it an industrially potent, yet unexploited, technique.

Results

Al1-xInxN NRs grown on ZrTiN seed layers feature In-rich cores and Al-rich shells, as observed by high resolution electron microscopy (HREM) and quantitative valence electron energy loss spectroscopy using scanning transmission electron microscopy. Such nanorods exhibit near band-edge optical emission at ˜5 eV, as observed by cathode luminescence. An internal composition gradient in Al1-xInxN nanorods leads to a curved-lattice epitaxial growth (CLEG) [4] which is utilized for high precision tailoring of nanorod morphologies, such as spirals and zig-zag shapes which opens the possibility to obtain new unique optical properties. For example, Al1-xInxN spirals with a pitch of ˜200 nm can be designed to produce either fully right-handed or left-handed circularly polarized reflected light at specific wavelengths in the UV-regime (see Fig 1).

High quality GaN NRs were grown by MSE at 1000℃ on Si(111), 4-H SiC(0001) and SiOx substrates, using a liquid Ga-target. NRs can be grown at a thickness ˜35 nm and lengths up to several μm without extended defects as seen in HREM. Low-temperature micro photoluminescence (μPL) reveal intense and sharp band-edge emission, characteristic of donor-bound exitons, with a FWHM = 1.7 meV at 3.48 eV. (see Fig. 2)

In conclusion, we show that reactive Magnetron Sputter epitaxy (MSE) can be used to produce high quality group-III Nitride NRs, with optical properties comparable to e.g., MBE grown structures, as well as new tailored NRs by CLEG, featuring unique polarizing properties.

Are you currently a postgraduate student? (Yes/No)

No

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