Title: MOVPE Growth of High Crystalline Quality GaN and Fabrication of Polymer/GaN based Hybrid Device Structures

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ABSTRACT

GaN belongs to the group III nitrides wide band gap semiconductors and is today the material of choice for the use in high-power, high-frequency electronics, as a result of its superior intrinsic properties. The polarization-induced high-density and high-mobility two-dimensional electron gas (2DEG) forming in (0001) oriented AlGaN/GaN hetero-structures enable the epitaxial structure to be utilized for high electron mobility transistors (HEMTs). GaN is also utilized for the optoelectronics applications such as for efficient blue light emission, enabling solid state white lighting by combining red, blue and green light emitting diodes (LED), solar cells etc.

Bulk GaN of large area is difficult to synthesize. Thus, due to lack of native substrates, GaN-based structures are grown on SiC or sapphire, which results in high threading dislocation density in the active layer of the device. At the material level, the major challenge is the reduction of high density structural defects in hetero-epitaxially grown layers when foreign substrates are used. The main idea of the present work was therefore to tackle this material issues directly, using a bottom-to-top optimization approach to improve the overall quality of GaN-based HEMT epitaxial structures grown on SiC and Sapphire substrates. The bottom-to-top optimization means optimisation of AlN NL to GaN Buffer optimisation. Great effort was put to gain the understanding of the influence of growth parameters on material properties and consequently to establish an advanced and reproducible growth process. Many material

properties of GaN based HEMT structures were achieved in this work, including good structural integrity of AlN nucleation layers for low thermal boundary resistance, control of residual Carbon impurities, and improved crystalline quality of GaN epi-layers grown on SiC and Sapphire substrates.

By combining GaN epitaxial structures with conjugated or conducting polymer films, LEDs may be fabricate at lower cost. Such hybrid structures are promising for future micro-light sources in full-color displays, solar cells, sensors and imaging systems. So, some part of the thesis also deal with synthesis and fabrication of such kind of hetero-structures on cost effective sapphire substrate.

The epitaxial growth of the wide bandgap III-nitride epi-layers like GaN, AlN, AlGaN was all carried out in a vertical close coupled showerhead metalorganic chemical vapor deposition (MOCVD) system. The deposition of the organic polymer films on GaN was done by spin coating technique. A variety of structural characterizations for the III-N epi-layers were routinely used to provide fast feedback for adjusting growth parameters and developing improved growth processes, such as optical microscopy (OM), atomic force microscopy (AFM), high resolution x-ray diffraction (HRXRD), as well as sheet resistance, 2DEG density and mobility measurements based on contactless mapping technique. The advanced characterizations like secondary ion mass spectrometry (SIMS), transmission electron microscopy (TEM) and Cathodoluminiscence (CL) were employed on selective samples. Electrical characterisation i.e. current (I) - voltage (V) and capacitance (C) - voltage (V) measurement was done for the polymer and GaN based hybrid hetero-structures.