L.2: Setting up a Nitride Molecular Beam Epitaxy facility

Gallium nitride and its alloys with Aluminium and Indium are important due to their numerous applications in light emitters and detectors. Compared to Silicon and GaAs-based devices, GaN-based devices are more radiation tolerant owing to their wider bandgap. It makes GaN-based materials an attractive candidate for applications in high radiation environments like nuclear reactors, particle accelerators, and spacecraft. Keeping this in mind, a Nitride Molecular Beam Epitaxy (MBE) facility has been set up at RRCAT. The system can be used to grow high crystalline quality layers of nitride materials e.g., GaN, AlGaN, InGaN, InAlN, and their quaternary alloys with high compositional/thickness uniformity. It has a triple chamber configuration, and the sample is transferred across the three chambers under ultra-high vacuum conditions with the help of a magnetic transfer rod as shown in Figure L.2.1.

The system was recently commissioned, where an ultimate vacuum of 1×10^{-11} (2×10^{-10}) Torr was achieved in the growth (buffer) chamber. MBE Growth of GaN epitaxial layer (3923000) and GaN/AlGaN multi-quantum well (3923001) was carried out and the pictures of two samples are shown in the inset of Figure L.2.1.

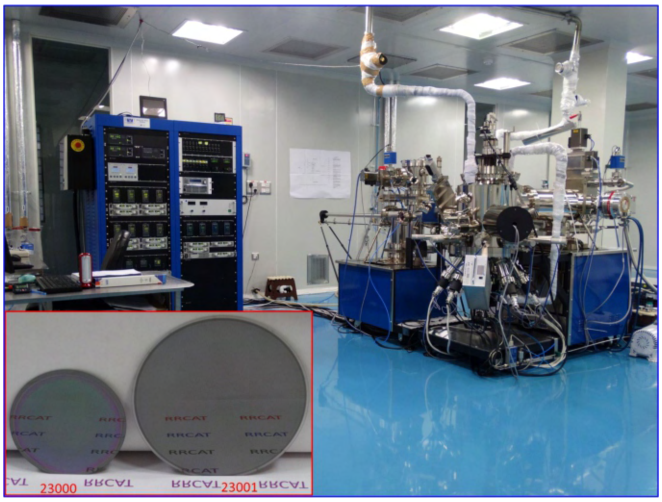

Fig. L.2.1: Photograph of a Nitride MBE facility at RRCAT, inset shows the image of GaN (2" dia.) and GaN/AlGaN multi-quantum well (3"dia.) samples.

The nitride MBE facility has been in regular use since its commissioning where several GaN epitaxial layers are grown on Sapphire under different conditions. In order to reduce the dislocations density, ~30 nm thick AlN buffer layer is first grown subsequent to the nitridation of the substrate. MBE growth conditions like growth temperature, III/V flux ratio, growth rate, buffer layer thickness, etc. are currently being optimized. It is also known that the density of dislocations reduces with the thickness of GaN layer. In view of this layer, thickness of GaN epitaxial layers is also varied. Photoluminescence (PL) spectrum of a GaN sample with 6.7 µm thickness is shown in Figure L.2.2. An intense PL peak at 363 nm with a narrow full width at half maximum (FWHM) is clearly seen. Further, defect feature, which is seen in the visible range is considerably suppressed indicating a low density of defects in the layer. HRXRD pattern of the same sample is shown in the inset of Fig. L.2.2, where a FWHM of ~350 arcsec is observed. It confirms a good crystalline quality of the GaN layer grown by MBE.

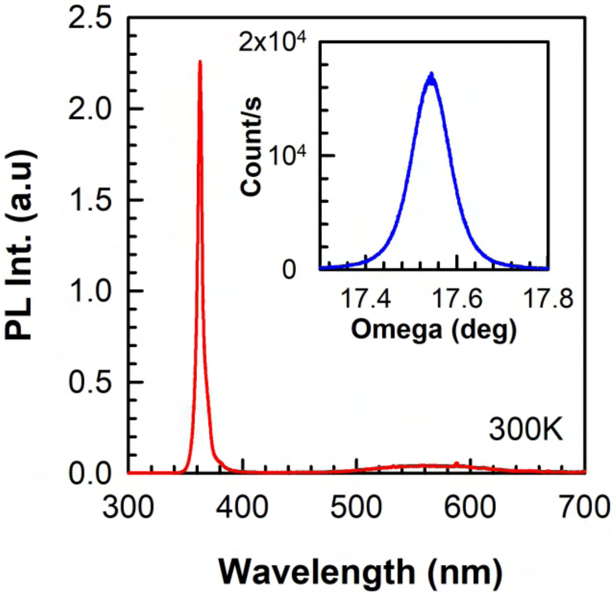

Fig. L.2.2: PL spectrum of 6.7 µm thick GaN layer, inset shows HRXRD pattern of the same sample.

Another important characteristic of the MBE facility is associated with the uniformity of grown layer. GaN epilayer (6.7 µm thick) was grown under optimized conditions and a plot of thickness non-uniformity across full 3" diameter wafer is shown in Fig. L.2.3. It is seen that the thickness non-uniformity lies below ±1%, which confirms an excellent control on the MBE growth process.

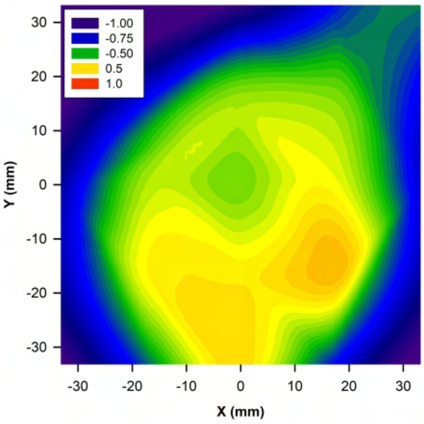

Fig. L.2.3: Thickness uniformity map across 3" diameter GaN/Sapphire sample grown by MBE.

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