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Manipulation of threading dislocation densities within novel Nitride based UV Multiple Quantum Wells

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Nitride light emitting diodes(LEDs) are proven to be one of the most efficient sources of coherent and incoherent light. There is a great need for compact and tunable Ultra-Violet(UV) light sources with higher efficiences, as current applications use bulky, high voltage Hg or Xe based lamps, with associated enviornmental hazzard on disposal. Such devices would have applications in water and medical sterilisation as well. With an efficiency of ~1% for $Al_xGa_{1-x}N/Al_yGa_{1-y}N$ structures compared to 70% for blue emitting $In_zGa_{1-z}N$/GaN LEDS there are many areas where such devices can be improved.

One of the most important reasons for the low efficiency is due to high threading dislocation densities (TDDs) in AlGaN buffer layers grown on AlN on Sapphire. Our approach is to grow this layer by metal organic vapour phase epitaxy on a low dislocation density GaN layer, which is then removed in a flip chip process. The key to this approach is to form a relaxed AlGaN layer on GaN, but to ensure that the relaxation process does not generate threading dislocations or cracks, and that the top surface of the AlGaN buffer is smooth.

Using Weak-Beam Dark-Field imaging is particularly suited to examining dislocations by imaging the strain field around dislocation cores. For GaN and its alloys using g = <0002> will make all edge type threading dislocations invisible, leaving only screw type visible. Conversely g = 1/3 <11-20> will make all screw threading dislocations invisible leaving only edge visible. Using this imaging mode it is clear that the buffer layers cut down the TDDs of screw type but drastically increases the amount of edge type. As edge type threading dislocations are known to have a less deleterious effect on internal quantum efficiency than screw type, this growth technology has the potential to improve the performance of UV LEDs when used in conjunction with appropriate processing. Additionally, in-situ TEM annealing studies of nano-rod structures of this material will be investigated to manipulate the dislocations under thermal treatment and highlight the key structural changes occurring in the reactor at these temperatures.