Selective Area Growth of III-Nitride nanostructures: from nanoLEDs to pseudo substrates

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New advances on Selective Area Growth (SAG) of InGaN/GaN nanostructures by plasma-assisted MBE on GaN/sapphire templates and Si (111) substrates are presented. Both, axial and core-shell structures are considered. Very intense green emission (figure 1) is achieved on axial structures grown on Si(111) with very little EL drift with temperature and quite small droop effects.

Strain relaxation mechanisms at the InGaN/GaN interface in axial LED structures are studied in cases of fixed or graded In composition of the InGaN active region. Lattice pulling effects leading to a graded In composition initial transient are observed. Cracks and a high density of defects develop in abrupt interfaces (fixed In%) for high In content (plastic relaxation), whereas in graded structures a smooth In% change leads to elastic relaxation.

First results on core-shell InGaN/GaN structures grown by MBE on GaN templates are also presented (figure 2). Cylindrical nanorods are etched down by ICP in a GaN template (3 micron thick) on sapphire. GaN and InGaN layers are then grown both in axial and radial directions so that the initial GaN cylinder is covered in a conformal way. Hexagonal symmetry is fully recovered once the GaN layer is grown. Potential advantages of this core-shell structure as compared to the axial one are twofold: the increase of emission surface (lateral area) and the absence of internal electric fields (m-plane). The crystal perfection is quite high as compared to 2D films of similar composition.

Ordered arrays of GaN and InGaN axial nanostructures are grown on non-polar and semi-polar directions and subsequently merged into a continuous film to produce high quality pseudo substrates. Results show that in both cases the resulting films exhibit a very strong luminescence, orders of magnitude higher that from the substrate used. PL and spatially resolved CL measurements on individual nanostructures as well as nanorods ensembles show that the In incorporation strongly depends on the crystal plane considered. Semi-polar GaN templates have a huge density of stacking faults that is almost 100% filtered after coalescence of the nanostructures grown on top.

Figure 1. EL from a green nanoLED array.  Figure 2. SEM image of core-shell nanoLEDs