The influence of point defects present in the different substrates on InGaN/GaN QWs properties and stability at elevated temperatures

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Despite the great interest in light emitters based on InGaN/GaN QWs, the quality of these structures, especially those with high indium content, is insufficient. This is why these structures are characterized by In-content fluctuations, high concentration of point defects and misfit dislocations for the layers above the critical thickness. Such defects to sa called “green gap” i. e. low luminousity of the emitters in the green region of spectrum [1].

In our study, we focus on the role of the point defects diffusion from the layers below the InGaN QWs, on their optical and structural properties as well as on their thermal stability, considering a substrates with a low and high density of extended defects. The motivation for examining point defect diffusion was that the thermal decomposition of indium-rich (around 20%) quantum wells, grown by MOVPE method, always starts from the first grown QW [2].

In order to study the effect of point defects, two samples were prepared – bulk GaN substrate and one Si doped GaN layer grown by MOVPE method on standard sapphire template. Both two samples were divided into to parts and then one part was implanted with He ions. Energies and doses were chosen to introduce only point defects and their distribution was constant in the layer from surface to a depth of about 700 nm. Structural and optical studies (PAS, HRXRD and PL) confirmed the formation of a large number of point defects, but no formation of extended and planar defects or amorphization of GaN layers (STEM) had occurred.

On such prepared GaN substrates implanted with He ions and unimplanted, $In_{0,2}Ga_{0,8}N$/GaN QWs were grown in one epitaxial process by MOVPE method. To study the role of point defects diffusion, on structural and optical properties as well as thermal decomposition of this QWs, the grown structures have been annealed at temperature 900ºC, 920ºC and 940ºC. In addition, in order to clearly focus on the impact of point defects, the quantum wells were grown on two thicknesses of the GaN layer separating it from the substrate: 50 nm and 250 nm. STEM images, HRXRD scans and PL spectra before and after annealing indicate that the InGaN/GaN QWs grown on the implanted layers with thinner spacer (50 nm) degrade more rapidly at a lower annealing temperature compare to QWs grown on unimplanted layers or on thicker spacer (250 nm).

References

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