Developing InGaN Buffer Layers for Tailoring Red and Longer-Wavelength Nitride-Based Devices

Julita Smalc-Koziorowska

Institute of High Pressure Physics PAS, Sokolowska 29/37 01142 Warsaw, Poland

The tunable direct bandgap of nitride semiconductors, ranging from 6.2 eV for AlN to 3.42 eV for GaN and 0.64 eV for InN, makes these materials perfect candidates for the design of full-color emitters. The near UV and blue emitters based on moderate In content InGaN layers (up to 20%) are already in common use, for example in energy efficient lighting solutions. However, increasing the In content, which is required to realize longer wavelength emitters still faces obstacles, and high In-content layers commonly exhibit very low crystal quality. Theoretical studies show that the introduction of high In contents above 30% in coherently grown InGaN layers requires substrates with lattice constants larger than GaN. [1] One of the obvious solutions is to use relaxed InGaN layers as possible substrates for nitride-based structures that emit light in the red part of the spectrum. There are several approaches to obtain relaxed InGaN layers. While most of them are based on the elastically relaxed layers obtained by preparing a compliant layer (e.g. porous GaN) and subsequent patterning [2] in our attempt we focus on InGaN layers plastically relaxed by introducing misfit dislocations [3]. In this approach it is possible to obtain substrates with a higher in-plane lattice constant at the moderate cost of a higher dislocation density (TDD). To keep the TDD as low as possible, we focused on InGaN layers with In content in the range of 17-20% deposited on ammonothermally grown GaN substrates with very low initial TDD in the range of 10^4 cm-2.

This presentation will focus on recent developments in the technology of growing and processing InGaN buffer layers. We performed detailed investigations on the nucleation and glide of misfit dislocations, which are the key mechanism governing the plastic relaxation of the InGaN layer. Heterogeneous dislocation formation and its influence on the quality of deposited structures with InGaN QWs are addressed. The surface quality of the InGaN layers can be significantly improved by chemical-mechanical polishing, which has a positive effect on the structural quality of the subsequent epitaxy process.. Also, the polishing reveals threading dislocations in InGaN layers, which are difficult to investigate by conventional etching approaches. The polished buffer layers were used for further epitaxy of InGaN quantum well (QW) structures.

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