## Investigation of strain and lattice parameters distribution in epitaxial laterally overgrown InGaN/GaN structures

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GaN and its ternary alloys with In and Al (InGaN, AlGaN) are wide and direct band gap semiconductor materials used for fabrication of optoelectronic devices such as light emitting diodes and laser diodes. However, due to limited availability of suitable bulk substrates many types of device structures are still grown on foreign substrates. As a result, high dislocation density in planar epitaxial layers ($10^8$-$10^9$/cm2) strongly limits the efficiency of radiative recombination processes. One way to overcome this issue is when the planar architecture of the layer is gradually replaced by more sophisticated 3 dimensional structures in order to efficiently decrease the dislocation density in lattice mismatched epitaxial layers. In particular, remarkable results are achieved by application of the Epitaxial Lateral Overgrowth (ELO) approach. There are many reports showing that ELO is a powerful technique for reducing dislocation density by 3–4 orders of magnitude.

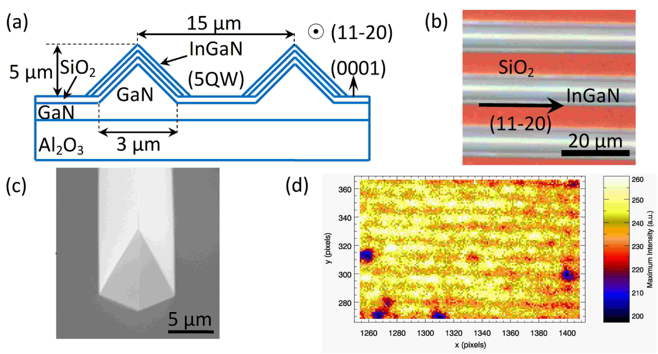


Fig. 1. Schematic cross-section (a) and plane view (b) of InGaN/GaN ELO layer on sapphire substrate covered by GaN buffer and by $SiO_2$ mask. Stripes are parallel to (11-20) direction. Panel (c) presents SEM image of the single ELO stripe. Part (d) shows experimental results of spatial distribution of local diffraction intensity in the sample measured with the diffraction plane parallel to the seeding lines. Pixel size is 1.4 µm.

The aim of this work was to investigate with synchrotron, using spatially resolved Rocking Curve Imaging (RCI) technique, distribution of strain and lattice parameters in specially designed ELO structures [1]. The samples studied are composed as follows: first the epitaxial GaN layer on sapphire substrate was covered by a thin $SiO_2$ mask. Next the 3 µm wide seeding windows spaced by 15 µm were opened in the mask. The growth of the GaN ELO layers by metal-organic chemical-vapor deposition (MOCVD) started in mask free seeding areas of the GaN/sapphire template. Finally the five InGaN quantum wells with GaN barriers were grown on GaN stripes (Fig. 1a-c). Figures 1(a) and (b) show schematic cross-section of two ELO stripes and plane view of the structure, respectively. The SEM image (Fig. 1c) shows a characteristic shape of the single ELO stripe.

Such sophisticated architecture of the sample is ideal to demonstrate the potential of RCI technique. As it was reported earlier [2] the RCI technique combines the features of X-ray imaging (very high spatial resolution) and X-ray diffractometry (very high angular resolution). In our experiment the monochromatic synchrotron X-ray beam illuminates the sample which is rotated in small steps around an axis perpendicular to the diffraction plane near its Bragg angle. The diffraction images are recorded for each angular position of the sample by using a CCD camera (2048×2048 pixels, 1.4µm pixel size). The signal is analyzed with specialized software [1]. Experiments reported here were performed at the beamline ID19 in ESRF, Grenoble, France. Figure 1(d) presents the spatial distribution of local diffraction intensities in the sample. Signals originating from the GaN buffer and the ELO InGaN/GaN stripes are clearly distinguished. Even local mosaicity on the stripes is detected, which is due to high spatial resolution offered by RCI technique. The results of RCI analysis are compared with those obtained by laboratory technique of spatially resolved X-ray diffraction (SRXRD) [3]. Unfortunately, a small distance between seeding windows resulted in an overlap of signals originating from individual stripes, so it was very hard to investigate spatial distribution of sample parameters. Therefore, we found RCI technique irreplaceable to see differences between InGaN/GaN stripes and the rest of the sample.

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