Doctoral Dissertation Abstract

STRUCTURAL AND ELECTRICAL CHARACTERIZATION OF GAN-BASED SEMICONDUCTOR COMPOUNDS

Dominika Majchrzak

The presented dissertation concerns the structural and electrical characterization of gallium nitride semiconductor compounds using X-ray photoelectron spectroscopy, atomic force microscopy and Hall effect measurements as well as their growth using molecular beam epitaxy. Group III-nitrides are used in optoelectronics (e.g. light-emitting diodes, lasers) and in transistors. However, the device technology based on these materials still struggles with such problems as high defect density in AlGaN structures and low p-type concentration in p-AlGaN layers. These problems are especially significant in semiconductor structures with high Al concentration used in deep UV emitters.

The aim of the work was to optimize the growth of AlGaN layers with a high aluminum content, along with an indication of the potential applications of the obtained results in the light-emitting diode fabrication technology.

In the first part of the results chapter, the physicochemical properties of p-GaN (0001) were studied after epitaxial growth and air-exposure, and also after applying various cleaning techniques. Furthermore, the pulsed low flux Al deposition technique was presented, which allowed to reduce the AlN layer roughness and eliminate the unfavorable enrichment in Al and N. The AlGaN growth kinetics deposited with plasma-assisted molecular beam epitaxy under Ga-rich conditions was also studied, indicating an Al incorporation probability reduction in the Ga-droplet regime. Moreover, the influence of the graded layer thickness on the electro-transport properties of p-AlGaN contact structures was studied.

In the presented dissertation, arsenic diluted materials based on gallium nitride were also characterized and their significant application potential was indicated. The three-stage surface cleaning technique developed as part of the doctoral thesis allowed for the proper examination of the physicochemical properties of GaNAs and AlGaNAs compounds. The conducted analysis showed the antisurfactant properties of As at the growth of GaN microrods. In this part of the work, the possible use of the GaN microrods as an AFM tip was

shown, the increased temperature stability of the GaNAs band gap in comparison to GaN was indicated, and a novel wurtzite structure AlGaNAs material was presented.