Structural properties and strain relaxation in high alloy content InGaN films grown on AlN/Al_2O_3 templates by MBE

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InGaN alloy thin films of high indium content are a strong candidate for high efficiency photovoltaic and optoelectronic applications. In recent work [1] we made a systematic study on samples deposited by plasma-assisted molecular beam epitaxy (PAMBE) on GaN/Al_2O_3 templatesby varying the growth temperature under almost stoichiometric conditions. In the current work, direct deposition on MOVPE (0001) AlN/Al_2O_3 templateswas employed, as AlN exhibits high resistivity, a higher thermal conductivity compared to GaN leading to lessself-heating, refractoriness, and transparency. Transmission electron microscopy (TEM) methods were used, including high resolution TEM (HRTEM), scanning TEM (STEM) and geometrical phase analysis (GPA), together with high resolution X-ray diffraction (HR-XRD), in order to study thecomplex microstructural behavior.

The defect content and crystalline quality of the films were characterized and a critical comparison of the microstructures of these films with films grown on GaN templates regarding the phenomena of compositional pulling, phase separation and sequestration was undertaken. The mechanism of TD introduction from BSFs was found to be operating also in this case. By lowering the growth temperature, the spontaneous formation of an InGaN sequestration layer was gradually suppressed. The InGaN/AlN heteroepitaxial interface was observed to have a prominent role in defining the defect content of the films. In particular, the large misfit promotes the creation of a defected interfacial region, characterized by regular misfit dislocation arrays,generatingTD inverse half-loopsdue to the initial coalescence of InGaN nuclei. Furthermore, BSFs overlap during the initial stages of growth causing the introduction of interfacial areas with zinc-blende stacking. These phenomena are discussed in correlation to the growth conditions influencing indium adatom mobility.

[1]Bazioti et al., Journal of Applied Physics **118**, 155301 (2015).

Acknowledgement: Work co-financed by the EU (ESF) and Greek national funds - Research Funding Program: THALES, project NITPHOTO.