Homo Epitaxial Growth of GaN and AlGaN Drift Layers on HVPE and Ammono GaN Substrates for High Power Vertical devices

Byeongchan So[1], Adamantia Logotheti[1,2], Jovana Colvin[1], Dat Tran[3], Minho Kim[3], Alexis Papamichail[3], Navya Garigapati[4], Erik Lind[4], Michal Bockowski[5], Vanya Darakchieva[1,3]
[1] Center for III-Nitride Technology, C3NiT-Janzén, Solid State Physics and NanoLund, Lund University, 221 00 Lund, Sweden, [2] Volvo Car Corporation, 405 31, Gothenburg, Sweden, [3] Center for III-Nitride Technology, C3NiT-Janzén, Department of Physics, Chemistry and Biology (IFM), Linköping University, SE-58183 Linköping, Sweden, [4] Department of Electrical and Information Technology and NanoLund, Lund University, 22 100 Lund, Sweden, [5] Institute of High Pressure Physics, Polish Academy of Sciences, Sokolowska 29/37, Warsaw 01-142, Poland

GaN and related nitride semiconductors hold great promise to improve efficiency and performance of next generation power devices. To fully leverage the exceptional characteristics of (Al)GaN materials, such as high critical electric field and superior Baliga's figure-of-merit, necessitates a vertical device design requiring high quality GaN substrates [1]. GaN substrates produced via hydride vapor phase epitaxy (HVPE) exhibit dislocation density of ~10^6cm-2. In contrast, ammonothermal GaN substrates present a compelling alternative with significantly lower dislocation densities of ~104 cm-2 [2]. Understanding the growth mechanisms of (Al)GaN drift layers on both types of substrates and respective growth optimization are crucial for realization of vertical power devices.

In this work, we present a comprehensive study of 5-㎛m-thick GaN and AlGaN (~ Al 8%) drift layers grown on HVPE and ammonothermal GaN substrates by MOCVD. X-ray diffraction, atomic force microscopy, cathodoluminescence imaging and spectroscopy and capacitance-voltage measurements were employed to assess material properties. The GaN layers grown on HVPE substrates show increased rocking curve (RC) broadening as compared with the substrates (Fig.1), while the opposite trend was found for GaN on ammonothermal substrates with exceptionally low RC widths of 9 arcsec for the (0002) and 16 arcsec for the (10-15) diffraction peaks. For the AlGaN on HVPE GaN substrate graded buffer layer was introduced to avoid crack formation, while on the ammonothermal substrates crack-free AlGaN can be readily achieved. The AlGaN properties and growth mechanism on the two types of GaN substrates are discussed in view of strain, curvature, and defect densities.