Control of Carbon in MOCVD-grown GaN for Power Devices by Supersaturation

Adroit Materials [1], NC State Univ. [2], Tech. Univ. Berlin[3], IHPP. Unipress.[4], °Seiji Mita[1], Felix Kaess[2,3], Jingqiao Xie[2], Luis H. Hernandez-Balderrama[2], Shun Washiyama[2], Pramod Reddy[2], Andrew Klump[2], Alexander Franke[2], Ronny Kirste[1], Axel Hoffmann[3], Erhard Kohn[2], Tomasz Sochack[4], Michal Bockowski[4], Ramón Collazo[2], and Zlatko Sitar[1,2]

E-mail: smita@ncsu.edu

Achieving high electron mobility in the low doping regime (n < 5x10^{16} cm^{-3}) is still difficult for MOCVD-grown GaN, however, indispensable to realize a high quality drift region for GaN-based power Schottky diodes. We identified that carbon was the main defect attributing to the sudden reduction of the electron mobility, the electron mobility collapse, in n-type MOCVD-GaN. SIMS has been performed in conjunction with C concentration and the thermodynamic Ga supersaturateion model. By controlling the ammonia flow rate, the input partial pressure of Ga precursor, and the diluent gas within the Ga supersaturateion model, the C concentration in Si-doped GaN was controllable from 6x10^{19} cm^{-3} to values as low as 2x10^{15} cm^{-3}. It was found that the electron mobility collapsed as a function of free carrier concentration, once the Si concentration closely approached the C concentration. Lowering the C concentration to the order of 1x10^{15} cm^{-3} by optimizing Ga supersaturation achieved controllable free carrier concentration down to 5x10^{15} cm^{-3} with a peak electron mobility of 820 cm^2/Vs was obtained without observing the mobility collapse (Fig. 1). Further carbon control led to the achievement of the necessary high carrier concentrations in the back contacts while allowing for controllable, low carrier concentrations in the drift layers; a carrier concentration of 2x10^{16} cm^{-3} with a mobility of 1100 cm^2/Vs was obtained for GaN on sapphire. Homoepitaxial GaN on ammonothermal GaN substrates showed a narrow PL DBX peak of 100 μeV, suggesting the higher quality of this material (Fig. 2). Results on the performance and further limitations of Schottky diodes based on these achievements will be discussed.

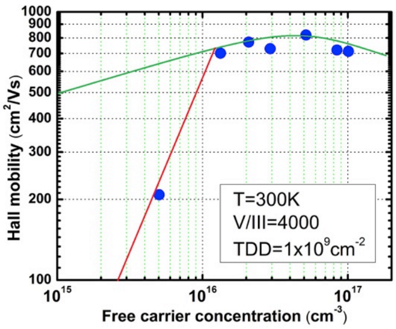

Fig.1. Plot of room temperature μ vs. n of Si-doped GaN on sapphire substrates.

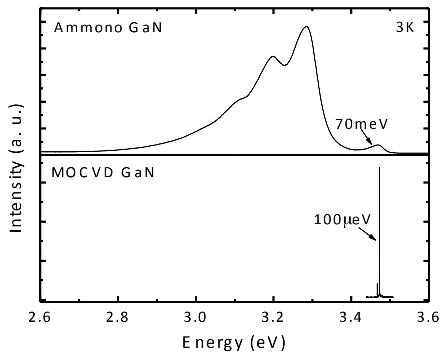

Fig.2. Homoepitaxial GaN with band edge luminescence (DBX transition).