Influence of Al fraction on the defect spectra of MOCVD grown β-$(Al_xGa_{1-x})_2O_3$

Hemant Ghadi, Evan Cornuelle, Joe F. McGlone, A F M Anhar Uddin Bhuiyan, Hongping Zhao, Aaron Arehart, and Steven A. Ringel
Department of Electrical and Computer Engineering
The Ohio State University
Columbus, OH 43210

Abstract:

Beta phase gallium oxide (β-Ga_2O_3) is an ultra-wide bandgap (UWBG) semiconductor with advantages such as superior device figures of merit for both RF and high-voltage applications and high radiation hardness due to higher bond strength associated with smaller lattice constant. Alloying β-Ga_2O_3 with aluminum produces β-$(Al_xGa_{1-x})_2O_3$ and is essential for heterostructure-based devices with higher radiation tolerance. These UWBG semiconductors and designed heterostructures are attracting interest for circuit and sensing applications in a harsh radiation environment. Critical to success in real-world applications, it is crucial to understand the defect states in β-$(Al_xGa_{1-x})_2O_3$. The present study addresses the initial exploration of the defect characterization using conventional electrical characterization and deep-level thermal and optical based defect spectroscopies (DLOS, DLTS) on β-$(Al_xGa_{1-x})_2O_3$ at varying alloy compositions and will be compared with the reported defect spectra on β-Ga_2O_3.

β-$(Al_xGa_{1-x})_2O_3$ epitaxial layer was grown by MOCVD atop a commercially available β-Ga_2O_3 (010) Sn-doped EFG-grown substrates. The nominal Al mole fraction was 3,5,7 and 10%, confirmed by high-resolution x-ray diffraction. Ni Schottky diodes were fabricated on the β-$(Al_xGa_{1-x})_2O_3$ epitaxial layer, and Ti/Al/Ni/Au ohmic contacts were deposited on the Sn-doped substrate. The average net ionized doping concentration for the series of samples from 3% to 10% Al were 1.2, 1.1, 1.0, and 0.8×10^{18} cm^{-3}, respectively. The Schottky barrier heights (SBH) for each sample were extracted from IPE measurements and were found to increase with Al composition; however, the calculated values of SBH were influenced by surface pinning. Compared to defect spectra on β-Ga_2O_3, the β-$(Al_xGa_{1-x})_2O_3$ material demonstrated a higher defect concentration by 10-100 times. A total of five defect levels were measured, three by DLTS and two deeper defects by DLOS in each β-$(Al_xGa_{1-x})_2O_3$ sample. Specific trends and detailed discussion on each defect states with dependence on Al composition will be discussed in the workshop.

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