Traps in MOCVD n-GaN studied by deep level transient spectroscopy and minority carrier transient spectroscopy

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It is important to characterize deep levels to realize the high performance of GaN-based devices since they act as traps and generation-recombination centers. It is well known that current collapse in AlGaN/GaN high electron mobility transistors is a big issue related to trapping of carriers[1]. We present our results on the characterization of traps in n-GaN grown by MOCVD[2-8]. Deep level transient spectroscopy (DLTS) is a powerful tool to detect traps[9] and has been successfully used to characterize traps in various semiconductors such as Si, GaAs etc. In this work, DLTS with a bipolar rectangular weighting function is employed to characterize traps in n-GaN with higher sensitivity[10].

Sapphire and free-standing HVPE-grown n^+-GaN substrates are used for the MOCVD growth of Si-doped GaN. DLTS is applied to various devices such as Schottky diodes, p^+n diodes and MOS structures. Comparison of electron traps is made between n-GaN on sapphire and n^+-GaN substrates from DLTS spectra using bias pulses for Schottky diodes. Hole traps in n-GaN are observed by the application of forward injection pulses for GaN p^+n diodes formed on n^+-GaN substrates. Hole traps are also detected for Schottky diodes by minority carrier transient spectroscopy (MCTS) using above-band-gap light pulses. From MOS structures formed on n-GaN on sapphire and n^+-GaN substrates, interface state distributions are obtained in addition to traps in-GaN.

Carbon is one of the important impurities in GaN-based devices sine C doping produce high resistivity buffer layers. Traps in n-GaN intentionally doped with carbon on SiC substrates are reported. Electron traps and hole traps, related to carbon, are shown using DLTS and MCTS for Schottky diodes. Current deep level transient spectroscopy (DLTS) with a bipolar rectangular weighting function in the unit of coulomb is applied to the characterization of traps in high-resistivity MOCVD GaN doped with carbon. Electrons or holes generated by the illumination of the above-band-gap light are captured by traps and then emitted during the light-off period, resulting in the current transients which are processed into DLTS signals.

A total of five electron traps and a total of six hole traps are found in MOCVD n-GaN. Their energy levels and capture cross sections are reported with the Arrhenius plots of thermal emission rates. Trap concentrations for these traps are also shown, although they vary from sample to sample. In addition to these traps, one electron and one hole trap are reported to be carbon-related defects.

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