Low-Field and Hot-Electron Transport, Device Fabrication and Characteristics in GaN-based HEMTs

Galium Nitride (GaN) based High Electron Mobility Transistors (HEMTs) provides high frequency and high power device performance due to GaN has high electron mobility (~2000 cm^2/Vs in room temperature) and wide band gap (~3.4 eV in room temperature). The factors affecting the device performance and reliability of GaN-based HEMTs can be examined in detail owing to investigations of low-field transport using Hall Effect measurements and investigations of high-field and hot-electron transport using nanosecond pulsed I-V measurements.

These HEMTs have a widely usage area in high power, high frequency and high temperature applications for modern electronics. Despite of this widely usage area, AlGaN/GaN based electronics devices have some problems during the operation. One of these problems is current collapse in current-voltage characteristics. For long years, Si_3N_4 surface passivation is used in surface of heterostructure to prevent current collapse. Because electrons trapped by surface states in surface leads to current collapse and this passivation layer reduces surface states in surface. Therefore, number of trapped electrons is decreased and current collapse is suppressed at certain amount. Low-field transport and hot-electron transport investigations can play important role in better understanding the behind mechanisms of this method. In my PhD thesis studies, the effect of Si_3N_4 passivation layer on two dimensional electron gas in AlGaN/GaN heterostructures was investigated with temperature dependent Hall effect and hot-electron dynamics measurements of different sample groups. In low-field transport investigations, since carrier density is increased with surface passivation, it was found that effect of interface roughness scattering mechanism on mobility is increased. In analyses with hot-electron dynamics measurements performed in Gazi University Lisesivdin Research Group, experimental observation of the negative differential resistance phenomena in drift velocity-electric field characteristics of AlGaN/GaN heterostructures was firstly achieved.

The transport mechanisms in these HEMT structures are not only decisive for device performance properties but fabrication steps during device fabrication is also important. As a second part of this seminar, the fabrication steps and characteristics of AlGaN/GaN HEMTs with high resistive buffer structure consisted of periodically carbon-doped (PCD) GaN buffer layer and AlGaN back barrier layer will be present. The studies performed in Nitride Semiconductor Device Laboratory, Kyungpook National University, South Korea led to the development of AlGaN/GaN based HEMTs with high figure of merit and breakdown voltage of over 2 kV.