TITLE: “Phonon Lasing” as a Mechanism for Velocity Saturation in GaN HEMT

Jacob B Khurgin

Johns Hopkins University, Baltimore, MD, United States.

Velocity saturation plays the most important role in determining operational characteristics of field effect transistors. While the causes of velocity saturation in GaAs and InP high electron mobility transistors (HEMT’s) are well known, the cause of saturation has not been indisputably determined for the GaN –based HEMT’s. Moreover, the saturation velocity in GaN HEMT has been shown experimentally to be a strong function of carrier density, with higher doped GaN channels showing lower saturation velocity. The source of this dependence also remains unclear.

In this work, we show that the cause of velocity saturation in GaN may well be stimulated emission of LO phonons. In high fields the shift of the Fermi distribution of electrons can lead to the situation in which probability of stimulated emission of LO phonons for certain wave vectors exceeds the probability of absorption of these phonons, creating the phonon gain, analogous to the photon gain in a laser. This gain is proportional to the electron density. Once the “lasing” threshold is reach velocity saturates as all the additional kinetic energy acquired by electrons is lost via the “phonon lasing”. Our model, built upon this process predicts saturation velocity values very close to the experimental results, not only indicating that “phonon lasing” is a highly probable cause of velocity saturation in GaN HEMT’s, but also shedding light on the way to increase the saturation velocity and thus the speed of the devices.