Optical Studies of High-field Electron and Hole Transport in Nitride-based Wide Bandgap Semiconductor Nanostructures

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The most significant results from this grant support are:

(1) By using the technique of Raman spectroscopy, we have shown that recently observed luminescence in InN at around 0.8 eV is the bandgap of InN; and this luminescence cannot be due to deep-level radiative emission in InN (Figures 1 and 2). This work has not only settled down a recent controversy over the bandgap of InN but also set a platform in the nitride community for the development of high-performance electronic devices based on InN and its related materials.

(2) By using the technique of Compton scattering, we have demonstrated that electron drift velocity in InN can be as high as 5 x 10^7 cm/sec at room temperature (Figure 3). This work has confirmed that InN has the largest electron drift velocity in nitride-based semiconductors, and has laid the foundation that the quality of InN available nowadays is good enough for manufacturing various types of high-performance electronic devices.

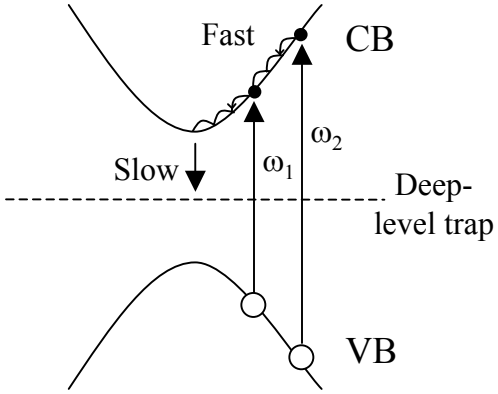

Figure 1: Demonstration that deep-level radiative emission at around 0.8 eV in InN is not consistent with our findings on non-equilibrium LO phonon populations.

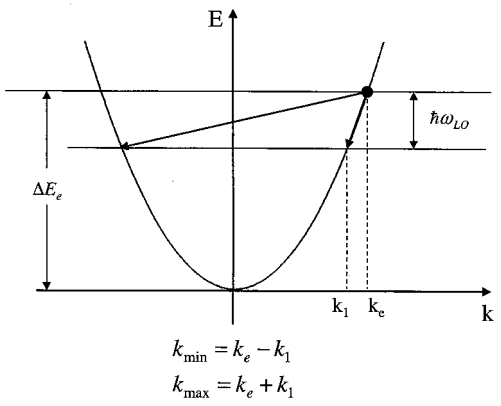

Figure 2: Diagram showing the minimum and maximum LO phonon wavevectors that an electron with a given energy can emit. This consideration has been found to be consistent with our findings on non-equilibrium LO phonon populations and as a result, justified that the bandgap of InN is around 0.8 eV.

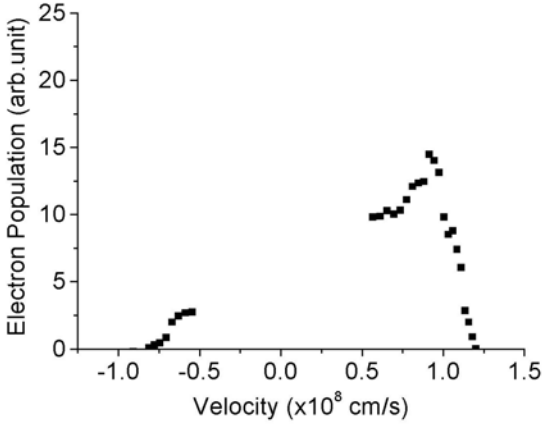

Figure 3: Non-equilibrium electron distribution measured by Compton scattering indicates that electron drift velocity reaches as high as 5×10^7 cm/sec at room temperature.

Education:

This research program has provided research training for my graduate student – Wei Liang. The facilities also provide research experience for a high school student – Shaw-Wei D. Tsen (Corona Del Sol high school, AZ) on the development of a new, accurate, quantitative technique for the detection of beta carotene, lycopene in fruits and vegetables.

Outreach:

The PI has joined the "Southwest Center for Education and the Natural Environment" (SCENE, AZ) as a mentor. This program is hosted by the Center for Environmental Studies at Arizona State University. Its primary goal is to provide research experience for high school students. He expects to provide research experience for two high school students on the area of ultrafast dynamics in semiconductors starting this September.