

New Physics of Electron Transport in Nitrides

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The physics of the electron transport in AlN/GaN/InN-based wide band gap semiconductors is different from that for more conventional semiconductors, such as Si or GaAs. In wide band gap semiconductors, the polar optical phonon energy is large (much larger than the thermal energy at room temperature). As a consequence, in low electric fields, the dominant optical polar scattering occurs in two steps – photon absorption and re-emission resulting in an elastic scattering process.¹ In high electric fields, an electron runaway plays a key role determining the peak field and peak velocity in these compounds.² The runaway effects are further enhanced in two-dimensional electron gas at the AlGaN/GaN or AlGaInN/InGaN heterointerfaces. As a result, the peak electron drift velocity and peak electric field of the 2D electrons in compound semiconductors are smaller than the 3D electrons in these materials. This prediction agrees with the results of Monte-Carlo simulations and with the measured peak velocities. In very short (e.g. sub-0.1 micron) GaN structures, ballistic and overshoot effects become important.⁴ We will discuss the consequences of these effects for deep submicron AlGaInN/GaN field effect transistors.

¹ B. Gelmont, K. S. Kim, and M. S. Shur, Monte Carlo Calculation of Electron Transport in Gallium Nitride, *J. Appl. Phys.* 74 (3), pp. 1818-1821, 1 August (1993); M. S. Shur, B. Gelmont, and M. A. Khan, High Electron Mobility in Two-Dimensional Electrons Gas in AlGaN/GaN Heterostructures and in Bulk GaN, *J. Electronic Materials*, Vol. 25, No. 5, pp. 777-785 May (1996)

² B. E. Foutz, S. K. O'Leary, M. S. Shur, and L. F. Eastman, Polar optical phonon instability and intervalley transfer in III-V semiconductors, *Solid State Communications*, Vol. 118 (2), pp. 79-83 (2001)

³ A. Dmitriev, V. Kachorovskii, M. S. Shur, and M. Strosio, Electron Drift Velocity of Two Dimensional Electron Gas in Compound Semiconductors, *International Journal of High Speed Electronics and Systems*, Invited, Volume 10, No 1, pp. 103-110, March 2000

⁴ B. E. Foutz, L. F. Eastman, S. K. O'Leary, M. S. Shur, and U. V. Bhapkar, Velocity overshoot and ballistic transport in indium nitride, *Mat. Res. Soc. Proc.* Vol. 482, pp. 821-825 (1998)