Terahertz Plasma Wave Electronics

Michael S. Shur
Center for Broadband Data Transport Science and Technology
ECSE, and Physics
Rensselaer Polytechnic Institute
http://nina.ecse.rpi.edu/shur/ shurm@rpi.edu

Modern microelectronics and nanoelectronics devices rely on the drift of electron localized at the interfaces between different materials, such silicon and silicon dioxide or gallium arsenide and aluminum gallium arsenide. Hence, the electron drift transit time in the active region of a device determines the maximum device speed. Instead of the electron drift, we propose to use the waves of the electron density to detect or generate electrical signals. Such waves are referred to as "plasma waves". In deep submicron field effect transistors (FETs), the velocity of the surface plasma waves is more than an order of magnitude higher that the electron drift velocity and, therefore, deep submicron devices using the excitation, propagation, and generation of these waves should operate at terahertz frequencies. A short field effect transistor made from a material with a high mobility should act as a resonant cavity for the surface plasma waves. Such transistor could be used as tunable resonant detector of terahertz radiation. Recently, we demonstrated the resonant detection experimentally in 0.15 micron AlGaAs/GaAs FETs at 2.5 THz, 1.2 THz, and 600 GHz. According to our theory, a deep submicron transistor should also operate as a resonant tunable emitter of terahertz radiation when excited by a small DC current. Our preliminary experimental results support this prediction. Plasma wave electronics might find numerous applications ranging from the detection of hazardous biological and chemical agents to environmental monitoring and medical applications.