

Physics of III-N Field Effect Transistors, Michael Shur

Wurtzite (hexagonal) symmetry makes the device physics of GaN/AlN/InN heterostructure field effect transistors (HFETs) to be quite different from that of more conventional GaAs/InAs/InP and Si FETs. Spontaneous and piezoelectric polarization at AlGaIn/GaN and AlGaInN/InGaIn interfaces leads to the formation of two-dimensional (2D) electron gas with concentrations 10 to 20 times higher than that for more conventional FETs and with enhanced electron mobilities but a reduced peak velocity. Quantum well designs (incorporating AlN spacers and InGaIn quantum well between the wide band gap AlGaIn barrier layer and GaN buffer) have been used to control the electron transfer from the 2D channel into adjacent layers. High electric fields at the gate edges leads to an additional strain and hot electron effects causing the current collapse and gate lag. Large electron densities in the HFET channels minimize 1/f noise making it to be smaller than even in highly doped GaN films. This device physics necessitates new approaches to the device design. Inverted HFET devices are expected to have a reduced access resistance, a larger current carrying capability, lower gate leakage and a better thermal control. Insulated gate heterostructure field effect transistors demonstrated superior performance and reliability. Field plates, recessed and double recessed gates, and drain field controlled electrodes have been used to control current collapse and improve device reliability. Power and RF switching applications of III-N based transistors have emerged to take advantage of superior current carrying capabilities and low access resistance.



Michael Shur has held research or faculty positions at A.F. Ioffe Institute, Cornell, Oakland University, University of Minnesota, and University of Virginia, where he was John Money Professor of Electrical Engineering and served as Director of Applied Electrophysics Laboratories. He is now Patricia W. and C. Sheldon Roberts'48 Professor of Solid State Electronics, Professor of Physics, Applied Physics and Astronomy, Director of Center for Broadband Data Transport Science and Technology, and Director of the RPI Research Site of the NSF I/UCR Center "Connection One." In 2001-2002, he served as Acting Director of Center for Integrated Electronics at RPI. Dr. Shur is a Fellow of IEEE, Fellow of the American Physical Society, Fellow of Electrochemical Society, a member of Eta Kappa Nu, and Tau Beta Pi, Electromagnetic Academy, Materials Research Society, ASEE, an elected member, former Chair of US Commission D, International Union of Radio Science, elected

Member of NRC of URSI, life member of Sigma Xi, of Humboldt Society of America, and AAAS. Dr. Shur is Editor-in-Chief of the International Journal of High Speed Electronics and Systems, Editor of the book series on Selected Topics in Electronics and Systems published by World Scientific, Member of the Honorary Board of Solid State Electronics, Vice-President for publications of the IEEE Sensor Council, and Chair, IEEE Recognitions Award Committee. He is also Distinguished Microwave Lecturer of IEEE, MTT and Distinguished Lecturer of IEEE, EDS. In 1990-1993, he served as an Associate Editor of IEEE Transactions on Electron Devices. Dr. Shur has also served as Chair, Program Chair, Organizing and Program Committee Member of many IEEE conferences. He is one of co-developers of AIM-Spice and co-founder of Sensor Electronics Technology, Inc. In 1994, the Saint Petersburg State Technical University awarded him an Honorary Doctorate. He has published many technical papers, books, and has over thirty patents on semiconductor devices and circuits. Several of his papers received the best paper awards. Among his other awards are the Gold Medal of the Russian Ministry of Education, van der Ziel Award, Senior Humboldt Research Award, the Pioneer Award from Compound Semi, RPI School of Engineering Research Award, and Commendation for Excellence in Technical Communications. Dr. Shur was also listed by ISI as one of the most quoted researchers in his field.