Si MOSFET with a Nanoscale Void Channel

Hong Koo Kim

University of Pittsburgh

A two-dimensional electron gas (2DEG) induced at a materials interface serves as the backbone of a semiconductor field-effect transistor (FET) structure. Electrons travel in the in-plane direction while being confined and controlled in the vertical direction. The in-plane transport in a solid state medium in conjunction with a vertical control of channel conductance is the standard geometry of conventional FETs. In this talk I will present an alternative channel medium and configuration for ultrafast, energy-efficient transport of electrons. We have observed room-temperature low-voltage (~1V) emission of 2DEG into a nanoscale air channel that was vertically etched into a silicon metal-oxide-semiconductor (MOS) structure. Here the low-voltage emission is enabled by Coulombic repulsion of electrons (inversion or accumulation) near the edge of 2DEG. The Coulombic repulsion reduces the energy barrier to electron emission, leading to a high emission current density (~105 A/cm2) under a bias of only 1 V. The emitted electrons travel with a ballistic speed in the nanoscale void (air) channel, offering a transit time of <~100 fs. Based on the emission and transport of 2DEG we developed a field effect transistor that demonstrates an on/off ratio of 500, and a turn-on gate voltage of 0.5 V under ambient conditions. The emission of two-dimensional electron systems into nanoscale void channels could enable a new class of low-power, high-speed electronics.