

MRSEC SEMINAR SERIES

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Sub-1K Cold-Electron Transport at Room Temperature

Electron thermal excitation following the Fermi-Dirac distribution is a natural thermodynamic phenomenon, but it typically limits functionality of various electron systems. For example, it nullifies the Coulomb blockade in single-electron transport. It is also the root cause of the excessive heat dissipation of modern CMOS integrated circuits. This talk presents an approach in which thermally excited electrons are filtered out by a quantum state and the energy-filtered cold electrons are injected into various dimensional systems; zero-dimensional systems (metal nanoparticles or semiconductor quantum dots) as well as three-dimensional systems (e.g., bulk Si). Cold-electron transport to metal nanoparticles (10 nm Au nanoparticles) shows single-electron transport at room temperature. Single-electron transistors fabricated using CMOS-compatible processes demonstrate Coulomb staircase and Coulomb oscillations at room temperature. Cold-electron transport to 5.5 nm and 7 nm CdSe quantum dots (QDs) shows abrupt current jumps in current-voltage (I-V) characteristics and narrow peak widths (full widths at half maximum: ~15 mV) in differential conductance (dI/dV) measurements, corresponding to an effective electron temperature of 45 Kelvin at room temperature. Cold-electron injection to Si demonstrates extremely abrupt current jumps in I-Vs, realizing effective electron temperatures of less than 1 Kelvin at room temperature. We will also discuss potential applications of the cold-electron transport, such as energy-efficient transistors. This work has been carried out through collaboration between UTA and NU MRSEC with supports from the National Science Foundation (DMR-2122128, DMR-1720139, and ECCS-2031770).

Bio: Professor Seong Jin Koh received his B.S. and M.S. degrees in Metallurgical Engineering from Seoul National University, South Korea. He received his Ph.D. in Materials Science and Engineering in 1998 from University of Illinois at Urbana-Champaign (UIUC) and had a post-doc training (1998-2000) at Materials Research Laboratories (MRL) at UIUC. His PhD and post-doc work at UIUC investigated single-atom surface diffusion, long-range interactions between two single atoms on metal surfaces, and interactions between a single atom and an atomic chain (1D cluster of atoms). He joined Bell Labs (Lucent Technologies/Agere Systems, Orlando, FL) as a member of technical staff (2000-2003), where he worked on developing low-k/Cu technologies for next generation integrated circuits. He joined UTA in 2003. His research area at UTA includes single-electron transistors, cold-electron transport, and nanobiotechnology. He is a recipient of NSF CAREER award.



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