# First Room-Temperature, Operational, Single-Electron Transistors From Focused Ion-Beam Deposition

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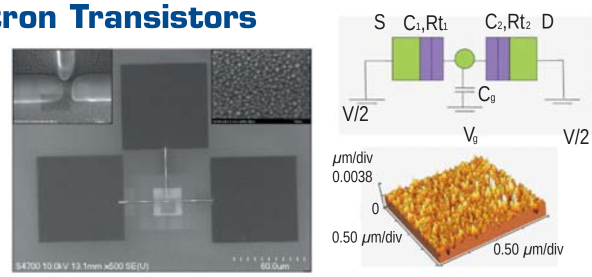
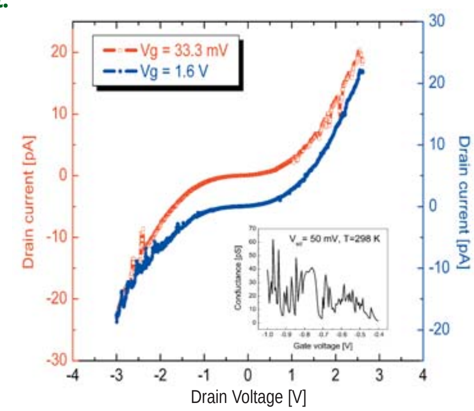



***Micrograph of fabricated room-temperature SET (inset on left shows active device area, and inset on right shows conducting nanoislands). Pictorial view of the device structure is shown at top right, and a micrograph of the fabricated nanoislands in Tungsten is shown at bottom right.***

Single-electron transistors (SET), operating on the principle of Coulomb blockade (CB) in nanostructures, are promising candidates for future ultra-low-power and high-density integrated devices. SETs are similar to field-effect transistors, but the channel is replaced by a conducting island sandwiched between two tunnel junctions. Because the channel is reduced to a conducting island with dimensions of only a few nanometers, the energy levels in the island are discrete. To observe the CB effect at room temperature, the tunnel resistance of the tunnel junctions must be much greater than the quantum resistance (~26.0kΩ), requiring ultra-low junction capacitances in the range of a few attoFarads, and limiting the average diameter of the quantum-confining islands to below 10nm. Progress towards the realization of room-temperature-operating SETs has been slow because of the technological limitations in the fabrication of nanostructures with sub-10nm dimensions. Room-temperature operation is a critical requirement for practical applications of these devices in logic circuits, as memory elements, sensitive electrometers, and nanosensors. Fabrication of uniform-sized, sub-10nm, quantum-confining islands in a device configuration has been a major challenge in the progress of SET technology. Our novel approach to fabricating SETs uses tungsten nanoislands that exhibit excellent room-temperature operation. Our approach was made possible by recent developments in focused ion beam (FIB) deposition. Several measures suggest success with this method. One, the nanoislands fabricated by FIB deposition have an average diameter of 8nm. Two, the resistance per tunnel junction of the device is calculated to be 25.13GΩ, which is over five orders of magnitude higher than the threshold quantum resistance 26.0kΩ, thus enabling the confinement of electrons to the tungsten quantum dots. Three, the effective capacitance of the device is estimated to be 0.499aF, which yields capacitance of individual tunnel junctions at 0.947aF and charging energy of the device at 160.6meV. Thus, the estimated charging energy is much higher than the thermal fluctuations at room temperature, resulting in the observation of Coulomb blockade and Coulomb oscillations even at room temperature. ■




***Room-temperature device characteristics showing clear Coulomb blockade and oscillations.***