Quantum Transport in Schottky Barrier MOSFETs

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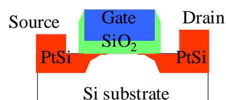
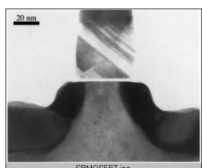
Introducing the Schottky Barrier MOSFET



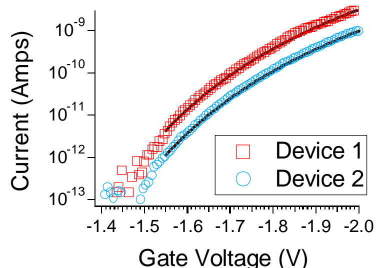
Schematic of SBMOSFET



XTEM of smallest device

SBMOSFETs are different from conventional MOSFETs in that the source and drain consist of Schottky barriers instead of p-n junctions and there is no intentional doping. The devices were proposed as an alternative for tera-scale integration because of better scaling properties at small dimensions. The devices had a gate oxide thickness of 34 Angstroms and PtSi Schottky Barriers. Here we focus on electrical transport at low temperatures.

Direct Tunneling in 3D

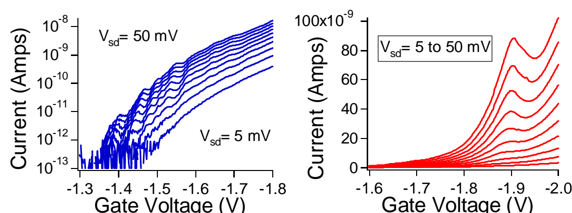


At low temperatures the current transport is limited by direct tunneling through the Schottky barrier. The current I vs. gate voltage V_g is given by:

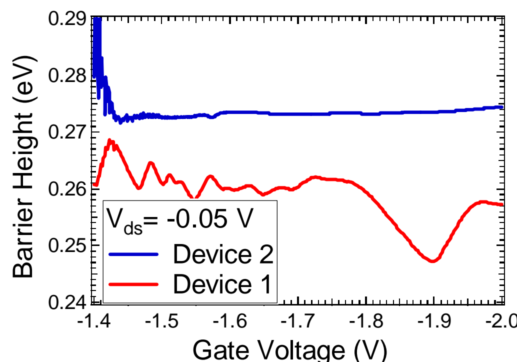
$$I_{ds}(V_g) = C(V_a)E_{00}(V_g)\exp\left[-\frac{\phi_b}{E_{00}(V_g)}\right]$$

Where E_{00} is the reduced energy, C_{ox} is the oxide capacitance, ϕ_b is the Schottky barrier height, and V_a is the applied bias. The data (colored markers) in the graph are from a p-inversion layer and fit well to this expression (solid lines).

Tunneling Inhomogeneities and Localized States



With increasing source drain bias V_{sd} the I vs V_g characteristic of device 1 develops nonmonotonicities that can be attributed to inhomogenieties in the local barrier (left) or localized impurities (right). Using the tunneling equation we can determine the effect of these nonuniformities on the effective barrier height (below). Note that device 2 does not exhibit any nonmonotonicities.



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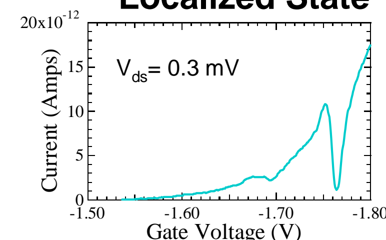
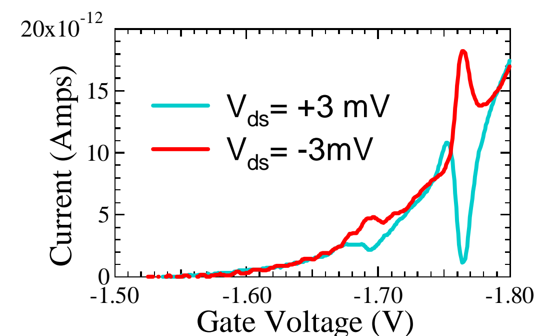
Quantum Interference in a Localized State



In some devices an impurity located close to the metal contact reduces the local barrier height sufficiently so that both resonant tunneling and direct tunneling occur and result in quantum interference at low bias voltages. I-V_g measurements can thus show resonant dips indicative of destructive interference.

Quantum Interference Reversal



The asymmetry of the Schottky barrier results in rectifying behavior in the direct tunneling component, and destructive interference can change to constructive interference with a change in bias direction.