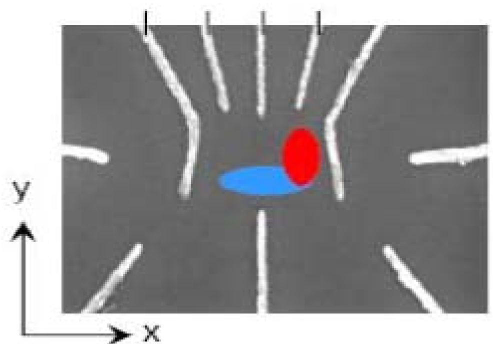
Electron Spins in Single-Electron Transistors (DoD, ARL-ARO)

Single-electron transistors (i.e., quantum dots with leads attached) offer superb potential for the requisite qubits needed to enable quantum computers. Results generated from measurements of single electron spin showed that the excited spin state in a GaAs single electron transistor can live for as long one second. However, the decoherence time in the excited state is known to be short, because of the coupling to nuclear spins. Therefore, single-electron transistors in Si quantum wells have also been fabricated; it is now possible to make the decoherence time very long by using isotopically pure Si. These measurements involved two important technological improvements in single-electron counting techniques. First, computational triggers were developed, which make it possible to store only the critical events when an electron enters or leaves the quantum dot. This reduces the storage required by four orders of magnitude. Second, active feedback control was used to correct for background charge effects. The resulting long lifetimes make applications to qubits extremely promising.



Micrograph of GaAs single-electron transistor used in the experiments. The electrodes are approximately 50 nm wide. Adjustments to the voltages on the electrodes change the potential in the way illustrated by the red and blue ovals. For the blue the potential rises more rapidly along the y direction, so the energy of the first excited state along y increase going from red to blue.

Reference/Publication

Radu, I.P., J. B. Miller, C. M. Marcus, M. A. Kastner, L. N. Pfeiffer and K. W. West, “Quasi-particle properties from tunneling in the nu=5/2 fractional quantum Hall state,” *Science*, 320, 899 (2008).