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Imaging Few-Electron Quantum Dots in InAs/InP Nanowires[1]

ANIA BLESZYNSKI, Department of Physics, Yale University

Heterostructure semiconducting nanowires provide an excellent system to make high quality, ultra-small quantum dots for future applications in nano-electronics, spintronics, and quantum information processing. We use a liquid helium cooled scanning probe microscope (SPM) as a movable gate to image electrical conduction through an InAs quantum dot grown inside an InAs/InP heterostructure nanowire. Electrical transport measurements in the few-electron Coulomb-blockade regime exhibit the shell structure of quantum dot states down to the last electron. SPM images are formed by recording nanowire conductance as the charged SPM tip is scanned above the nanowire. The images display rings of peaked conductance centered on the quantum dot; the rings correspond to Coulomb-blockade oscillations of the quantum dot. In this way the tip locates the quantum dot and can be used as a movable gate to change the induced charge on a single dot in a spatially dependent way, down to zero electrons. We have also imaged homogeneous InAs nanowires. At 4K, the wires exhibit Coulomb blockade oscillations in conductance versus backgate voltage that are indicative of multiple quantum dots in series. The images reveal the location of the quantum dots along the wire and the tip voltage can tune their charge state.

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