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Single-dopant spectroscopy in triple-gate nano MOSFETs[1]

SVEN ROGGE, Kavli Institute of NanoScience, Delft University of Technology, Lorentzweg 1, 2628 CJ Delft, The Netherlands

In this talk we discuss the physics of transport through a single dopant atom in semiconductor matrix to which we have spectroscopic access in a prototype silicon MOSFET. These FinFETs are three dimensional nano-scale devices consisting of a lithographically defined Si nanowire surrounded by a gate. They are fabricated on a Si-on-insulator substrate and have an active region as small as 50x60x35nm^3. The electronic states of the dopant appear as resonances in the low temperature conductance at energies below the conduction band edge. We can set the charge on the dopant by means of the gate electrode and observe the single and doubly charged donor state which is under magnetic field successively being occupied by a spin-up and then a spin-down electron. The binding energy of the neutral D^0 state is consistent with that of an arsenic donor. The D^- state with two electrons shows a reduced charging energy compared to bulk Si due to the electrostatic coupling with electrodes. The level spectrum of the dopant exhibits a large separation of the ground state from excited states but is not bulk-like. This is also due to the close proximity to the gate which leads to a strong electric field and the formation of a second well close to the interface that overlaps with the donor well. The manipulation of the dopant wavefunction by an electric field (Stark effect) is a key element in Si quantum electronics, *e.g.* the solid-state quantum computer. We discuss the level spectrum of this gated D^0 system for different field strengths up to 50 MV/m and relate it to theory. At these high fields the charge still remains localized but shows a strongly altered level spectrum.
Recent references: H. Sellier *et al.*, Transport Spectroscopy of a Single Dopant in a Gated Silicon Nanowire, PRL 97, 206805 (2006) and H. Sellier *et al.*, Sub-threshold channels at the edges of nanoscale triple-gate silicon transistors, cond-mat/0603430

[1]in collaboration with H. Sellier, G.P. Lansbergen, J. Caro (Kavli Institute of NanoScience, Delft, The Netherlands) and N. Collaert, I. Ferain, M. Jurczak, S. Biesemans (IMEC, Leuven, Belgium)