Probing a single dopant in ultra-scaled CMOS transistors

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We use the microelectronics technology to fabricate silicon transistors channels with a very small volume, i.e. short, narrow and thin (10x50x20 nm). Low temperature spectroscopy of such devices reveals the characteristics of single dopants which have diffused from the highly-doped source and drain to the channel below the gate [1].
We observe direct electronic transport through a single arsenic dopant, and extract its ionization energy. This energy is about twice the ideal value calculated for a bulk Si host crystal. This is due to the so-called 'dielectric confinement effect', arising from materials with a different dielectric constant than Si very close to the dopant, and was calculated recently for a nanowire geometry [2]. Our measurements also shed light on the large sample-to-sample variability observed at 300K as it is due to thermally broadened transport through these dopant states.

[1] M. Pierre et al., Nature Nanotechnology, published online 6 dec. 2009
[2] M. Diarra et al., Phys. Rev. B75, 045301 (2007).