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∂-doped silicon devices for quantum electronics and optics

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For solid-state quantum computing the ability to deterministically confine donors in a semiconductor is crucial, not only to create quantum bits defined by the electron or nuclear spin of a dopant, but also to fabricate control systems such as gates mediated by one-dimensional wires or two-dimensional "delta"(∂) layers.
The aim of this work is to achieve two-dimensional confinement of arsenic and phosphorus in silicon, i.e., to create a smooth and conductive ∂ layer. Low-temperature magnetoresistance measurements in up to 9 T magnetic field and 360 degrees sample rotation (rotation axis perpendicular to the magnetic field) is used as a tool to probe the dimensionality and confinement of the electrons in the doped layers [1] and to study other characteristics of these electrons [2]. For example, these characteristics include interactions between dopant atoms, the spin-orbit and spin-spin coupling, the metal-insulator transition, and their dependence on dopant species. The goal is to reduce the dimensionality of the confinement to one and zero dimensions and to create ordered single-atom arrays, as well as to measure their quantum electro-optic properties [3].

[1]D. F. Sullivan, B. E. Kane, and P. E. Thompson. Appl. Phys. Lett. 85, 6362 (2004). [2] G. Matmon, E. Ginossar, B. J. Villis, A. Kolker, T. Lim, H. Solanki, S. R. Schofield, N. J. Curson, J. Li, B. N. Murdin, A. J. Fisher and G. Aeppli, Phys. Rev. B 97, 155306 (2018).
[3]Chick, S. et al. Coherent superpositions of three states for phosphorous donors in silicon prepared using THz radiation. Nat. Commun. 8, 16038 (2017).

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