NANO HIGHLIGHT
2D Donor Patterns in Silicon: an Epitaxial Building Block for Nanoscale Integrated Circuits

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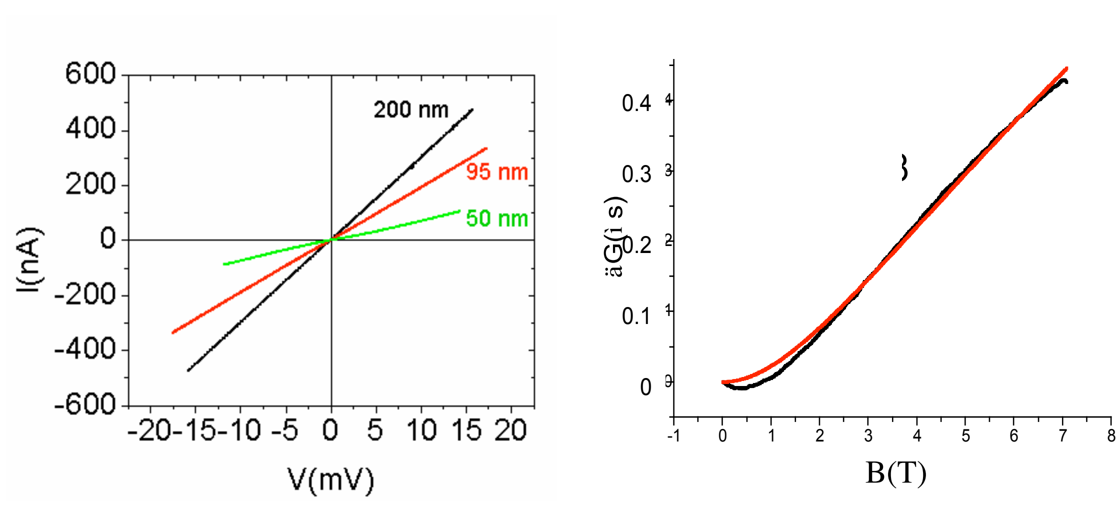
Phosphorous-donor wires 5-200 nm wide and 1μm long have been fabricated in crystalline silicon. The patterning was achieved by using low-energy (7 eV) electron beams from a scanning tunneling microscope to desorb H atoms from a single-layer H-resist on the Si(100) surfaces in ultrahigh vacuum. After H is removed from the patterned region, the sample is exposed to phosphine (PH_3) gas so that PH_3 molecules will be selectively adsorbed onto the patterned region. The P atoms will be incorporated into the Si crystal with minimum lateral diffusion by growing a 3 nm epitaxial layer at low temperatures over the original surface. To activate the P atoms as electron donors, the sample is annealed briefly to 500 °C.[2] The contacts in the device templates were pre-implanted with As ions. The figures below show that these P-donor wires conduct metallically at cryogenic temperatures and the magnetoresistance agrees with 2-D weak localization theory. The sheet resistance is between 4.3 and 8.6 K_/sq.

The significance of our approach to nanoelectronics is many fold: (1) it is compatible with current microtechnology, (2) epitaxial structure could improve device performance thanks to less defects and impurities and allows 3D architecture, (3) large scale implementation is possible by using photolithography in ultrahigh vacuum environment, and (4) one can select precursor molecules for both *n*- and *p*-type doping to allow formation of *pn* junctions, tunnel junctions, and integration of field effect transistors with single electron transistors for special applications.



I-V characteristics and magnetoresistance of the nanoscale P-donor wires embedded in Si at 0.3 K. The red curve (right panel) is a fit of 2-D weak localization theory.

[1] For further information about this project email to **tcshen@cc.usu.edu**

[2] T.-C. Shen, J. S. Kline, T. Schenkel, S. J. Robinson, J.-Y. Ji, C. L.Yang, R. R. Du, J. R. Tucker, "Nanoscale electronics based on 2D dopant patterns in silicon", J. Vac. Sci. Technol. B **22**, 3182 (2004).