Nano to atomic-scale silicon wires

Nanowires have received considerable attention in recent years for their potential use as building blocks, sensors and interconnects in nanoelectronics. Our group studies the diffusive transport properties and dephasing mechanisms of nano-scale wires defined by local P-doping of silicon using STM lithography. Using this technology, we are able to create highly-doped, planar wires and have observed ohmic conduction within the dopant plane for wires with widths down to 8nm at cryogenic temperatures. The future direction of this project entails further size reduction of STM-defined wires to study what limits conduction at the atomic scale.

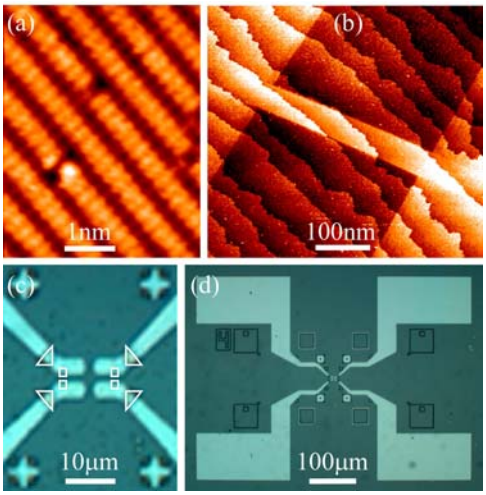

Figure 1: STM images of (a) the hydrogen-terminated Si surface demonstrating atomic-resolution and (b) a 50 nm × 310 nm wire pattern using STM lithography. Optical microscope images of (c) the central contact area showing overlap between the registration markers and the ohmic metal and (d) the entire device.

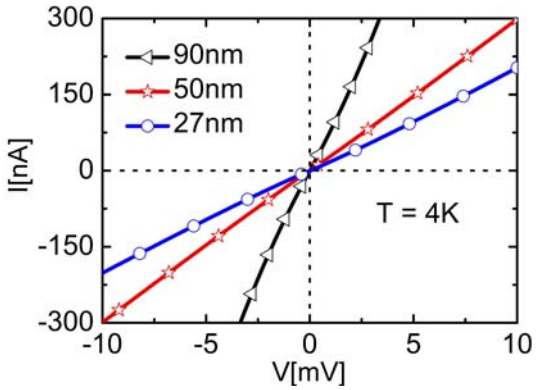

Figure 2: Four-terminal I–V characteristics of 90 nm (triangles), 50 nm (stars) and 27 nm (circles) wide P:Si wires at 4 K showing ohmic conduction with low resistivities down to 1 × 10^{-8} Ωcm.

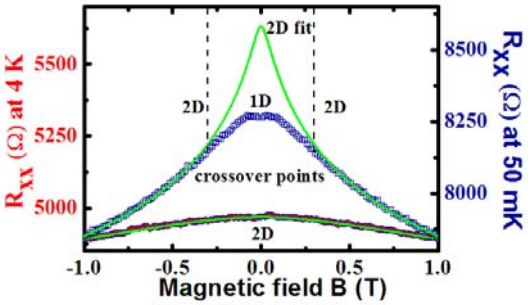

Figure 3: Crossover from 2D to 1D weak localisation is observed in the magneto-transport of a 90 nm wide Si:P quantum wire when lowering the bath temperature from 4K to 50mK. Comparison with fits to 2D weak localisation theory (green lines) allows us to calculate the electrical width of the wire, which is found to be equal to the STM defined lithographic width.

[1] F.J. Ruess, K.E.J. Goh, M.J. Butcher, T.C.G. Reusch, L. Oberbeck, B. Weber, A.R. Hamilton and M.Y. Simmons, "*Narrow, highly P-doped, planar wires in silicon created by scanning probe microscopy*" Nanotechnology **18,** 044023 (2007)

[2] F.J. Ruess, L. Oberbeck, K.E.J. Goh, M.J. Butcher, E. Gauja, A.R. Hamilton and M.Y. Simmons, "The use of etched registration markers to make four terminal electrical contacts to STM-patterned nanostructures", Nanotechnology **16**, 2446 (2005)

[3] F.J. Ruess, L. Oberbeck, M.Y. Simmons, K.E.J. Goh, A.R. Hamilton, T. Hallam, N.J. Curson and R.G. Clark, "Toward atomic-scale device fabrication in silicon using scanning probe microscopy", Nano Letters **4**, 1969 (2004)