PhD Position

Atomic-scale construction of an artificial neuron

The tip of a scanning tunnelling microscope (STM) can manipulate individual atoms and molecules on a surface with atomic precision. Such atomic manipulation is the cutting edge of bottom-up nanoscience. Conventional atomic manipulation occurs exclusively in the tunnel junction, that is, local to the tip. We will use, and investigate, a new form of atomic manipulation that is being pioneered at Bath – nonlocal manipulation [1]. Here the effect of the STM is spread across a surface, up to tens of nanometers, allowing thousands of individual molecules and atoms to be simultaneously manipulated (see figure 1).

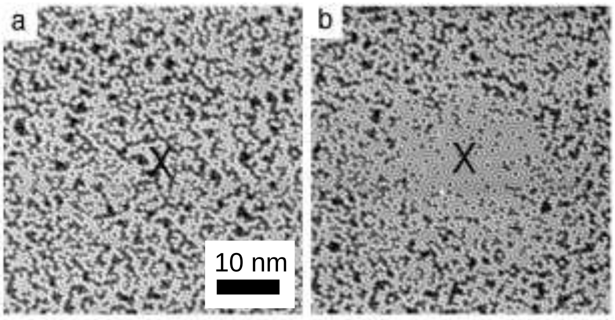

Figure 1: STM images (a) with a large dose of molecules, which image as dark-spots, and (b) after charge injection at the site marked X. Nonlocal desorption of chlorobenzene molecules remote from the injection site is evident.

Details of the project

It has recently been shown both in theory [2] and experiment [3] that electrical flow along a semiconducting p-n junction is physically analogous to the flow of an electric signal along the membrane wall of the axon section of a neuron (fig. 2). This opens the way to manufacturing arrays of artificial neurons in a semiconducting substrate to build a neural network.

This project will have the construction and characterisation of an atomic scale linear p-n junction as its main aim. To get to this ambitious goal we will further develop techniques and software within the group to allow truly automated atomic manipulation experiments. A silicon surface will be exposed to a benzene derivative. Nonlocal manipulation (possibly with the aid of an E-field) will be used to create benzene free tracks, that can subsequently be exposed to molecules that carry dopant atoms – boron or phosphorous. The samples will be thermally annealed to create linear tracks of n or p type silicon. This is an ambitious project with interesting and exciting science at all stages and with potentially striking results.

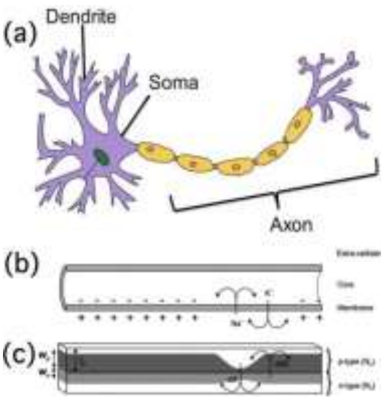

Figure 2: (a) Biological neuron showing dendrites, soma and axon. (b) Schematic of Axon membrane. (c) Semiconductor extended pn-junction analogue of biological Axon.

[1] Sloan PA, et al., 048301, Phys. Rev. Lett., 105, 2010.
[2] Nogaret A, et al., 874, Europhys. Lett., 68, 2004.
[3] Samardak A, et al., 226802, Phys. Rev. Lett., 102, 2009.

Applications: Applicants should have a background in the physical sciences and have or expect to gain a First or Upper Second Class UK Honours degree, or the equivalent from an overseas University. Possible funding sources include the Doctoral Training Account (for UK applicants) or Faculty/University studentships and scholarships. Applications from self-funded students are always welcome.

Contact Dr Peter Sloan (P.Sloan@bath.ac.uk) or Dr Alain Nogaret (a.r.nogaret@bath.ac.uk) for further information on the project.

Website http://blogs.bath.ac.uk/atomic-manipulation/