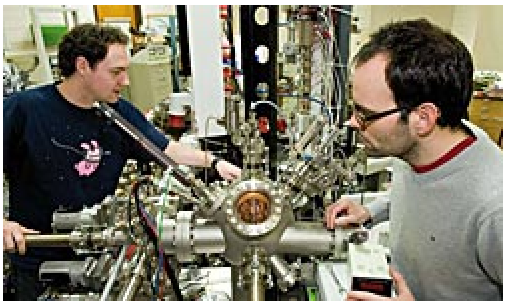
Scaling down to diamond quantum electronics



Dr Pakes, right, and honours student Andrew Ford in the La Trobe Physics laboratory.

Over the past three decades researchers have been competing to reduce the size of basic electronic devices. Intel has been leading the commercial effort with its recent announcement of the 'Atom' processor which incorporates transistors on the scale of tens of nanometres.

One nanometre is equal to a millionth of a metre so Intel's silicon chip is certainly winning on economies of scale.

La Trobe physicist Chris Pakes is aiming to scale the technology down further into the realm of quantum physics. He and co-researchers are talking about one-dimensional nano-wires and individual atoms performing the tasks of transistors, not using silicon, but diamond.

Dr Pakes and Professor John Riley lead an international team that has received one million dollars in research funding to investigate the semi-conductor properties of diamond as a new material for nano-chips.

Diamonds are now being made artificially. They come as single crystals, numbered and packaged in grids for the laboratory.

At La Trobe the stones end up in a scanning tunnelling microscope where they get plenty of loving attention as physicists fiddle with molecules called fullerenes, finding ways of pushing them into patterns on the diamond surface to form tiny electronic components.

A chain of fullerenes will induce in the diamond a wire one nanometre wide, operating at the quantum level. Here, a new set of functions comes into play. Particles will begin to behave like waves, electrons will travel in a more orderly fashion – one at a time – and the mathematical equations that normally govern electronics will no longer apply.

'If you take a standard piece of wire and increase its width, the wire's conductivity will increase over a continuous range of values,' Dr Pakes says. 'In quantum electronics if you take a nano-wire and change its width continuously you get a discrete set of properties. Resistance, for example, will relate to the 'quantised' energy levels of an electron when it is confined in the nano-wire.'

This is fundamental physics; experimental nanotechnology being built from the ground up, circuitry being laid one molecule at a time.

'There may be applications twenty to thirty years down the track in a quantum device or computer,' the physicist says. 'If this research works, and can be scaled up, computer power will be orders of magnitude greater.'

Diamond has several advantages over silicon, he says. Some quantum effects for example can be demonstrated at room temperature, giving them greater commercial potential.

'I believe it's by looking at fundamental science that real progress will be made in nano-industries. Diamonds are hard to work with, but if we can control them at the atomic scale we can potentially control them at any scale.

'In terms of research much of the exciting work has happened in the last five years. They are a relatively new material.'

The research funding includes $718,000 from an ARC Discovery Grant and an ARC Linkage Infrastructure, Equipment and Facilities Grant, which went towards buying a low-temperature scanning tunnelling microscope.

Collaborators include scientists from the University of Nottingham (UK), Kavli Institute of Nanoscience (Netherlands) and the Univeristaet Erlangen (Germany).