Shooting on diamonds with the fastest gun in the world

CARBON

The behaviour of carbon under high pressure in the vicinity of the melt boundary has been investigated by scientists actively in the last years. Recently, the group around Marcus Knudson of the Sandia National Laboratories, Albuquerque, has been able to study this phenomenon with an order of magnitude improvement in accuracy, allowing quantitative modelling for the first time [Knudson ***et al.***, *Science* (2008) **322**, 1822]. The pressures ranging from 550 to 1400 GPa were obtained by magnetic acceleration of small 17-by-40 mm copper pellets, called flyer plates. "It's the fastest gun in the world," says Knudson jokingly, although thus he actually understates the performance of the so called Sandia Z machine, which can accelerate the flyer plates to propulsion velocities in excess of 20km/s – i.e. about twice the Earth's escape velocity. To generate this propulsion, several million amperes are employed to produce a magnetic field expanding in about 200 ns, by which the plates are then accelerated and shot onto a variety of diamond samples with diameters of 6 mm, backed by quartz or sapphire. "The plates are designed so that they reach a terminal velocity within a few millimetres," explains Knudson. "At that point the plates impact the samples. It is this high velocity impact that creates the rather large shock waves that propagate through the samples." These shock wave impacts facilitate the study of the behaviour of carbon under highest pressures near the melt boundary, i.e. around the triple point between diamond, bc8 (a long-theorized but never-before-confirmed state of solid carbon) and liquid carbon. Experimental results are compared with *ab initio* molecular dynamics simulations, thus gaining and strengthening insights, valuable for different branches of physics. Astrophysicists reckon that high pressure carbon may be present in vast quantities in gas giants, particularly Uranus and Neptune (as much as 10 to 15% of the total planetary mass). On Earth, nuclear physicists are considering diamond as an ablator material for the use in inertial confinement fusion capsules, so the knowledge gained from Sandia's "fastest gun" may provide data useful in the development of fusion power. "This work – both experimental and computational – provides rich understanding of the properties of carbon in this high energy density regime, which will aid in the design of fusion capsules and pressure pulses to drive these capsules to fusion conditions," says Knudson.

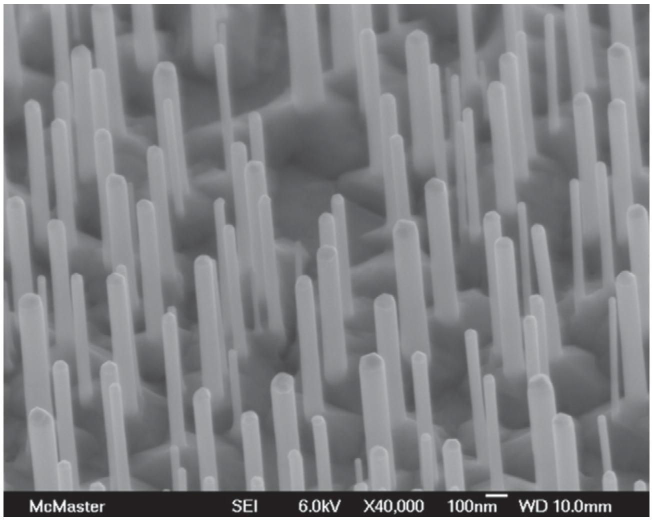
Michel Fleck

Tiny wires promise intense energy

ENERGY GENERATION MATERIALS

Given the limited reserves of fossil and nuclear fuels, it seems evident that our future energy demands will have to be met by renewable energy sources. Yet despite intense research the required technologies have not reached the point where they can directly compete with traditional energy sources.

Now the group of Ray LaPierre at the McMaster University, Canada, has reported one of the latest advances in the search for cost-efficient solar cells [Czaban *et al.*, *Nano Letters*, 10.1021/nl802700u]. Their study centered on the development of photovoltaic cells based on GaAs core-shell nanowires. "Conventional solar cells rely on single-crystal silicon cells for their operation, offering power conversion efficiencies in the range of only 15 to 20% for commercial systems, while being expensive to manufacture," LaPierre tells *Materials Today*. "As a result, researchers have focused on reducing material costs by using thin absorber layers, inexpensive deposition technologies, and inexpensive substrates. However, these methods typically produce polycrystalline material, resulting in carrier recombination at bulk defects and low conversion efficiencies."



A SEM image showing individual GaAs nanowires. (Courtesy of Ray LaPierre).

Semiconductor nanowires present a promising way out of this problem. The tiny one-dimensional rods have lengths of a few microns, and thicknesses of just a few tens to 100 nm. Because they can be grown using self-assembly, the nanowires achieve excellent electronic and optical properties, comparable to those of traditional cells, while being much cheaper to manufacture. Their geometry also causes the incident light to be trapped inside the material, giving them a black appearance and resulting in very low reflection losses.

Each of the wires contains a single p-n junction, manufactured by adding dopants during the growth phase. Initially Be is added, resulting in a core of p-type material, which is then switched to Te, resulting in an outer layer of n-type material. Their study is the first to examine the effects of adding Te, as opposed to the more traditional Si, since as a group VII element Te is a n-type dopant both with respect to Ga (group III) and As (group V). They found that its addition affected both the geometry of the nanowires as well as the electronic properties.

The researchers also studied the energy conversion of the nanowires and found efficiencies up to 0.35%, marking an improvement from previous studies. While still limited, LaPierre is convinced that additional research will allow nanowire-based systems to surpass traditional solar cells.

Peter Dedecker