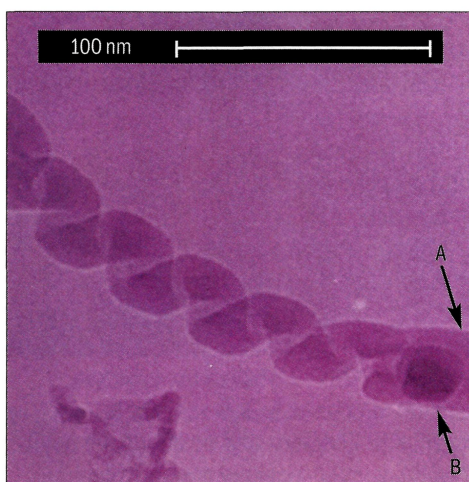


Technology gets a nanospring for possible future detectors

Twist a nanowire into a helix and what do you get? A nanospring, of course. Although wires that are tens of nanometres in diameter are not actually wrapped to make springs, they are grown that way through a process known as vapour-liquid-solid (VLS) growth mode. VLS growth occurs when a catalyst droplet resting on a surface absorbs wire-building material from a surrounding vapour. Once the concentration of the building material reaches supersaturation in the droplet, a portion of the material is secreted out of the droplet base and a wire gradually forms. The material deposition can be asymmetric and the wire develops into a helical nanospring.

Until recently the mechanism that leads to this asymmetry has been unclear, but now researchers at the University of Idaho have proposed a model that sheds new light on nanowire formation. It seems that a small catalyst droplet, which is roughly the same diameter as a growing nanowire, remains centred on top of the wire. The resulting growth is linear. However, if the droplet exceeds the wire diameter, its balance atop the structure is uncertain and a small perturbation can bump the droplet to one side, abruptly nudging the growth pattern from straight to helical.

Nanosprings can be used to make highly sensitive magnetic field detectors. Alternatively, nanosprings could serve as



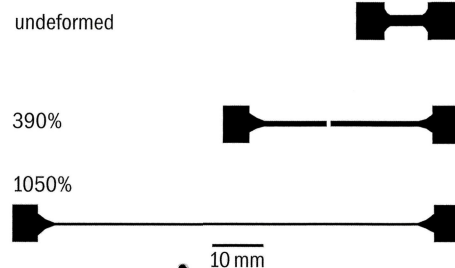
A scanning electron microscope captured this image of the transition from linear to helical growth in a boron carbide structure built up through a process known as vapour-liquid-solid growth mode. Up to point A, the nanowire had grown linearly. A small perturbation disturbed the droplet responsible for depositing material as it passed point B, transforming the nanowire into a nanospring (left).

positioners, or even as tiny conventional springs, for nanomachines of the future.

Further reading

D N McIlroy *et al.* 2001 *App. Phys. Lett.* 3 September.

New ceramics can be stretched faster



New ceramics retain their shape under extreme stretching.

A ceramic devised in Japan can be rapidly stretched to 10 times its initial length and retain its new shape. The new mixture can also be deformed a thousand times as fast as existing superplastic ceramics, which snap if bent or pulled too fast. This has made it difficult for ceramics to profit from the swift moulding techniques that are used for metals and polymers.

Ceramics contain metals and other elements, such as metal oxides, or combinations of non-metals, such as silicon carbide. Most are brittle, like pottery. Engine and turbine parts are made from the few, such as silicon carbide, that are extremely tough and resist corrosion better than metals. Superplasticity arises in ceramics consisting of tiny grains that can slide over one another, and the sliding is better if the grains are very small. The new material's grains are less than one-thousandth of 1 mm (1 μm) across. Grain sliding can cause two problems. First, it leaves holes that have to be filled by loose atoms. Second, it can be accompanied by grain growth. As grains get bigger, they are more likely to crack. The faster the deformation, the more likely it is that holes will form and grains will grow.

Researchers at the Japanese National Institute for Materials Science in Tsukuba have minimized both of these problems with their blend of zirconium oxide, magnesium aluminate spinel and alumina. At 1650 °C the ceramic can be stretched very far, very fast.

Further reading

B N Kim *et al.* 2001 *Nature* **413** 288-291.

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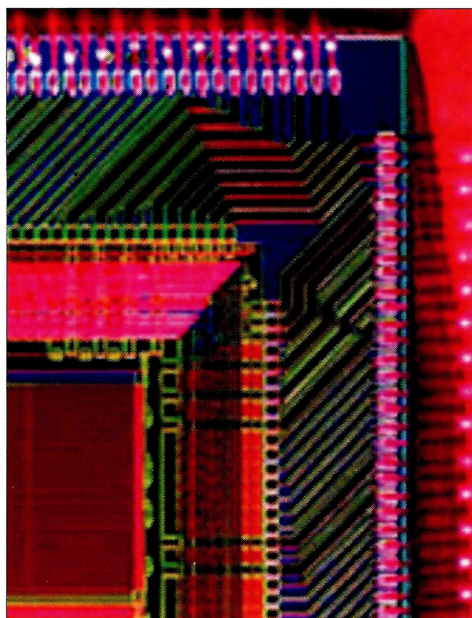
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New visits programme after LEP closure

Silicon chips can offer much more capacity

Silicon chips could hold thousands of times more transistors than the billions that they house today, researchers at Georgia Institute of Technology have calculated. This opens up the prospect of trillion-transistor chips and of "terascale integration" (TSI) circuits. Such a level of miniaturization would increase computer speed and capability by as much as the difference between the machines of today and the cumbersome microcomputers that appeared in the early 1980s.

Neither fundamental physics nor materials science rules out TSI, although the technical challenges are immense. TSI would require devices – made from layers of electrically conducting silicon and insulating silica – that are much smaller than today's. Silica layers, for example, would have to be less than one-millionth of 1 mm (1 nm) across, and components would need to be less than 10 nm wide. Existing methods cannot carve



One of today's silicon chips – soon to be a museum-piece?

such fine-scale silicon circuits, so new fabrication techniques will be needed.

At the fundamental level, the uncertainty principle of quantum mechanics restricts how fast devices can switch between two states – "on" and "off" – and the speed of light ultimately limits how quickly signals can travel.

In terms of materials, layer thickness is limited by silica's "leakiness" (*CERN Courier* October p11), which interferes with the electrical isolation of the silicon terminals in transistors. Another big restriction comes from the accuracy with which dopant atoms can be mixed with very small volumes of silicon. Dopants fine-tune the electrical properties of silicon. If they are unevenly distributed at small scales, the device can fail. Nevertheless, they seem to be on schedule for 2011.

Further reading

J D Meindl *et al.* 2001 *Science* **293** 2044–9.

Anomalous acoustoelectric effect creates a counter wind that pulls charges

Just as wind drags autumn leaves along a street, when an acoustic wave propagates through an electrically conducting surface, it can drag electric charge along with it. This "acoustic wind", known more formally as the acoustoelectric (AE) effect, has been discovered by a Russia-Poland-Ukraine collaboration.

Studying the electric current produced by the AE effect can provide important information on how electrically charged particles interact with the crystal lattice of a conducting material. Such materials include "manganites" – manganese-based compounds that can exhibit "colossal magnetoresistance" – in which electrical conductivity becomes tremendously sensitive to external pressure and applied magnetic fields.

Investigating the AE effect in a manganite thin film on a lithium niobium oxygen (LNO) substrate, the researchers observed an unusual effect. Sending an acoustic wave in a certain direction produced a much weaker electric current than expected for that direction. The reason is that, in addition to the ordinary acoustic wind, a counter wind was

"blowing" against the acoustic wave. The counter wind arose from the fact that the substrate was "piezoelectric" – one in which electric fields were generated by pressure.

When the acoustic wave created an alternating pattern of compression and expansion in the substrate, the compressed regions produced electric fields that pointed in the direction of the counter wind and interacted with the electrons on the thin film. Since the manganites increase their conductivity dramatically when compressed, this encouraged a flow of electrons in the reverse direction.

While this anomalous AE effect is probably too weak for technological applications, measuring it could provide a new method for studying the effects of pressure on a conducting material. This could be useful when conventional measurement methods are difficult, as is the case for thin films or quantum wells, wires or dots.

Further reading

Y Ilisavskii *et al.* 2001 *Phys. Rev. Lett.* 1 October.

Superconducting tool to test chips

A superconducting single-photon detector built by a Russia-US collaboration has immediate applications in testing computer chips and, more speculatively, for interplanetary communication.

The researchers fabricated extremely thin strips of niobium nitride – a metallic compound that becomes superconducting near absolute zero. The detector was made using these strips, each only 1 μm wide and several atoms thick.

The detector enabled the researchers to "see" single visible and infrared photons, because the superconducting strips lack the electrical noise that ordinarily obscures a single-photon signal.

The detector can record the small amount of infrared light that is released when a transistor switches on or off. The detector can detect bursts as short as picoseconds, so it could be used to monitor the performance of high-speed transistors.

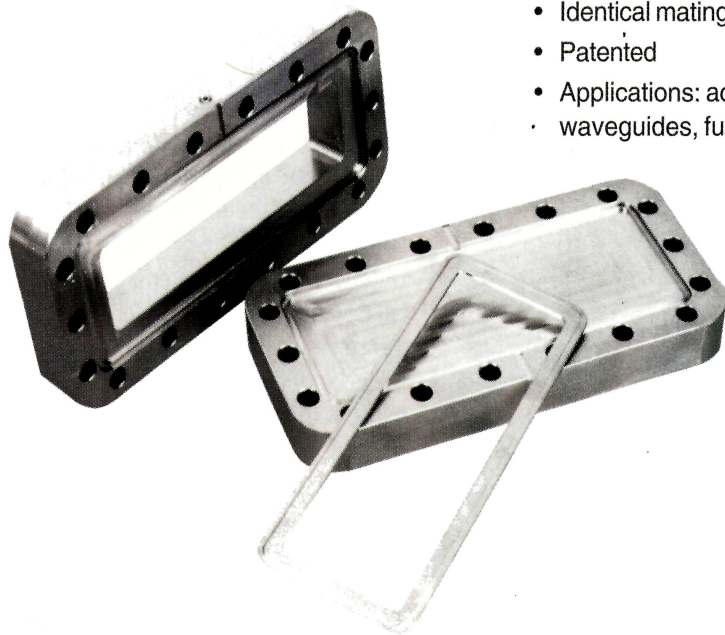
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G N Gol'tsman *et al.* 2001 *App. Phys. Lett.* 6 August.

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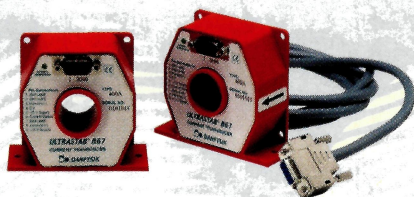
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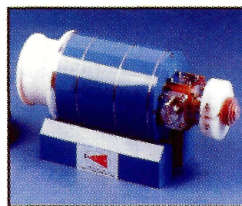
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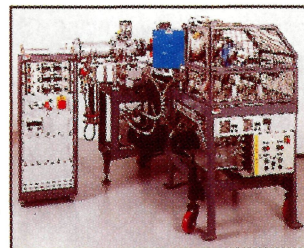
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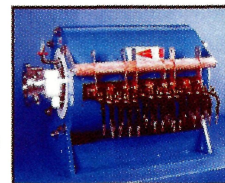
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