Strong and conductive copper

For many applications, metals having both high mechanical strength and electrical conductivity are required. However, synthetic methods used to strengthen pure metals — such as grain refinement and solid solution alloying — result in a significant decrease in electrical conductivity. Researchers at the Shenyang National Laboratory for Materials Science have now developed a processing technique for producing copper that exhibits a tensile strength ten times higher than conventional coarse-grain copper, while retaining a conductivity that is comparable to unprocessed samples (L. Lu, Y. Shen, X. Chen, L. Qian and K. Lu. *Science* http://dx.doi.org/10.1126/science.1092905). Their approach, based on a pulsed electro-deposition technique, provides a high density of twin boundaries while minimizing the scattering of conduction electrons. Although the origin of the ultra-high strength and plastic deformation mechanism is not fully understood, the authors believe it is due to the effective blockage of dislocation motion by coherent twin boundaries, which, contrary to other types of grain boundaries, exhibit low resistivity.

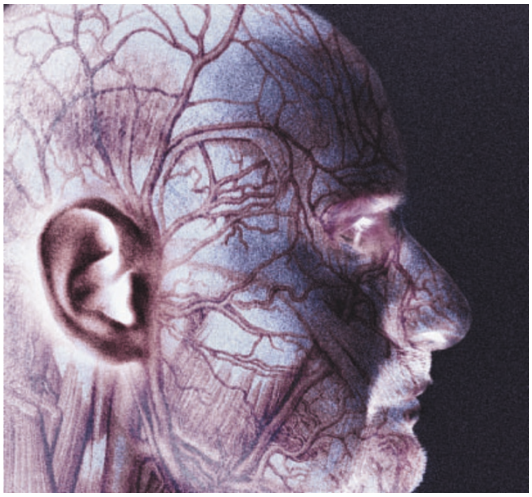
Precious superconductors

As well as holding pride of place as the most sought-after of all precious gemstones, diamond possesses a dazzling array of technologically useful properties. As well as being the hardest, most thermally conducting, and chemically resistant of all known materials it is also biocompatible, highly transparent and of great interest for use in the electronics industry. And now, to top it all off, Evgeni Ekimov and colleagues report (E. A. Ekimov, *et al. Nature* 428, 542–545; 2004) that under the correct conditions, it can also become a superconductor. The diamonds they used were grown by the conventional industrial technique of subjecting graphite to high pressure and temperature, but to make it electrically conducting they added 2.8% of boron during growth, which contributes positive charge carriers (holes) to the material. Then, by measuring its electrical, magnetic and thermal properties at a few degrees above absolute zero, they find it exhibits all the hallmarks of a bulk, type-II superconductor with a transition temperature of around 4 K and a critical magnetic field of over 3.5 T. The authors suggest that their finding could also lead to the presence of superconductivity in silicon and germanium, which have the same crystal structure as diamond.

GOING VERTICAL

Many predict that the current rate of miniaturization of electronics using conventional materials and device structures will become unsustainable within the next decade. The race is therefore well and truly on to find new ways for reducing the size and increasing the density of these devices. Transistors and other electronic devices based on semiconductor nanowires are a leading contender in this race. However, most devices demonstrated so far involve orienting nanowires flat on the surface of a substrate, increasing the surface area required by each individual device, thereby limiting the number that can be integrated onto a single chip. Writing in *Nano Letters*, Pho Nguyen and colleagues demonstrate field effect transistors constructed from semiconducting indium oxide nanowires grown directly out of and vertical to a substrate's surface (P. Nguyen *et al. Nano Letters* http://dx.doi.org/10.1021/nl0498536). This approach not only reduces the area taken up by individual transistors, but could potentially make it easier for them to be connected together to form complex circuits.

Microfluidics solves the haemostasis puzzle



Richard Feynman said: "What I cannot create, I do not understand". Haemostasis is one of these elusive phenomena. Its 80 reactions, coupled in the flowing blood, lead to an exquisite self-regulated system that maintains the blood in a fluid state in normal conditions, and causes clot formation — but only beyond a certain damage threshold. This is a difficult puzzle for modellers, because the system has to be viewed as a whole. A microfluidic system, devised by scientists at the University of Illinois, now provides a model that strips down haemostasis to its basic interactions: 'initiation', competing with 'inhibition', and eventually 'precipitation' (M. K. Runyon, B. L. Johnson-Kerner and R. F. Ismagilov, *Angewandte Chemie - International Edition* **43**, 1531–1536; 2004). A formulation, simply consisting of three chemical reactions (one of which mimics blood clotting with the precipitation of a gel), placed in a microfluidic device designed to mimic the morphology of the human vascular system, reproduces the key responses of haemostasis: dependence on the flow, threshold response and localized clotting. Such a functional model provides new clues on how to create artificial vessels. Moreover, it allows the authors to venture new hypotheses about the evolution of haemostasis or even the genesis of the vascular system.

Enzyme ink

Enzymes are manifold and so are their functionalities. Several enzymes can be bought off the shelf. A group of researchers at Duke University (North Carolina) have tapped into their potential for biochemical manipulations to pattern surfaces (J. Hyun, J. Kim, S. L. Craig and A. Chilkoti. *Journal of the American Chemical Society* http://dx.doi.org/10.1021/ja049956q). With a modification of dip-pen nanolithography, they laid a pattern of DNAase I (an enzyme that breaks the bonds between nucleotide molecules) on a substrate covered with an oligonucleotide-terminated self-assembled monolayer. After activation of the enzyme with a solution of Mg^{2+} ions, the oligonucleotides are removed and nanotrenches remain where the enzyme was originally deposited. A surface biochemical reaction performed by enzymes tethered to the tip of an atomic force microscope has previously been reported, however, the possibility of simply dipping the tip in an enzyme solution is new, and offers a much more versatile way to perform localized biochemical reactions and achieve patterning. This is an example of how the nanotechnology toolbox is getting larger and ever more practical.