Silver sulphide switch

Mechanical relay switches were once considered as crucial devices for the development of future computers. However, due to their limitations in terms of operating speed and down sizing, semiconductor devices have eventually replaced them. Recently, a lot of research effort has been aimed at developing a reliable switch that can beat even silicon technology in more powerful and smaller electronics. Terabe and co-workers now propose an atomic-scale switch that exploits the mixed conducting properties of silver sulphide, and overcomes the drawbacks of mechanical switches (*Nature* 433, 47–50; 2005). The resulting devices function by controlling the tunnel gap created by alternately annihilating and forming an atomic bridge between two electrodes. Terabe *et al.* show that these devices can switch between 'on' and 'off' states at room temperature and at small operating voltages. The authors believe the stability, reliability and ease of operation of their discovery will be useful both for logics and fast memory operation, and should contribute to a new type of computer architecture.

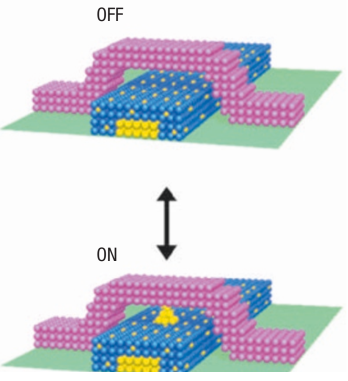

Image reprinted from *Nature*.

BIOSENSORS WIRED UP

Researchers in California present a new method of manufacturing biomolecular functionalized nanowires and show their usefulness as bioaffinity sensors (*Journal of the American Chemical Society* http://dx.doi.org/10.1021/ja044486l). Unlike two-dimensional field-effect transistors, one-dimensional nanowires avoid the reduction in conductance changes caused by lateral current shunting to the point that even single-molecule detection becomes possible. Unfortunately, up to now the techniques used to manipulate nanowires have only been adequate for proof-of-concept studies, and scaling up to high-density sensor arrays of individually addressable elements has remained a dream. Now this dream has come closer to realization thanks to a one-step protocol for the fabrication of a polypyrrole nanowire containing a protein, avidin. The nanowire is positioned directly between two electrodes during its formation by electrochemical polymerization. The resistance changes registered on exposure to biotin-containing solutions of variable concentration confirms the functionality of the system as a biosensor.

Highly plastic metallic glasses

Bulk metallic glasses have twice the strength of their crystalline metal alloy counterparts, but their applications have been limited by near-zero plasticity. Unlike crystalline alloys, which harden under strain due to the interaction between dislocations, metallic glasses show strain softening. Plastic deformation in metallic glasses typically occurs in a highly localized manner, limiting the plasticity to less than 2%. Most efforts to overcome the problem of limited plasticity have focused on metallic glass–crystalline nanocomposites, but Jan Schroers and William Johnson (*Physical Review Letters* **93,** 255506; 2004) have now reported a monolithic bulk metallic glass with a plasticity of up to 20%. Unusually, the glass — an alloy of platinum, copper, nickel and phosphorus — builds up a large number of shear bands under compression, rather than the single shear band formed in most metallic glasses. Because of the large Poisson ratio — the ratio of transverse to longitudinal strain — of the glass, the tips of the shear bands tend to extend rather than initiate cracks, leading to a high global ductility and high fracture toughness. The researchers suggest that a large Poisson ratio and low glass-transition temperature may be used as a means of identifying other ductile bulk metallic glasses.

Nothing is better

An essential element in the construction of most types of field-effect transistor is a robust gate dielectric. Silicon oxide is the usual dielectric of choice for conventional transistors made from silicon, but for ones made from single-crystal organic semiconductors, Etienne Menard and colleagues suggest using nothing more than free space (*Advanced Materials* **16,** 2097–2101; 2005). Using imprint lithography, the authors create surface impressions in a metal-coated polymer substrate to form raised source and drain electrodes separated by a recessed gate electrode. By placing an organic crystal between the raised contacts, they create a transistor with a gap of free space separating the channel from the gate. The use of a free-space gate dielectric avoids problems such as material defects and chemical interactions that are associated with the use of conventional organic dielectrics. Not only does this enable the construction of devices with exceptional performance — and the first demonstration of an n-type single-crystal organic transistor — but allows the properties of the semiconducting materials that form the basis of these devices to be assessed more easily. Moreover, because the channels can be exposed directly to the environment, they could be adapted to gas-sensing applications.

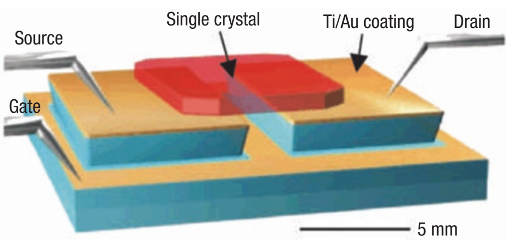

Image reprinted from *Advanced Materials*.

Big bullying bismuth

The embrittlement of metals by impurities often leads to failure by fast fracture. One way this happens is the segregation of impurity elements to the grain boundaries of the metal — for example, small traces of bismuth in copper — but the mechanism by which this occurs has long been debated. However, in *Nature* (432, 1008–1011; 2004), Schweinfest *et al.* report first-principles quantum-mechanical calculations showing that the embrittlement is due to an atomic size effect, rather than the prevailing view that it is caused by charge transfer between the metal atoms and the impurity element. They calculate that bismuth segregates to the grain boundaries because of its low solubility in the bulk. When it arrives there, it gets in between the copper atoms, and, being a larger atom, pushes them apart, weakening the interatomic bonding, thus leading to fracture of the metal. The authors also showed that this mechanism applies to impurities of mercury and lead in copper, and suggest it could be extended to all oversized impurities in a metal.