

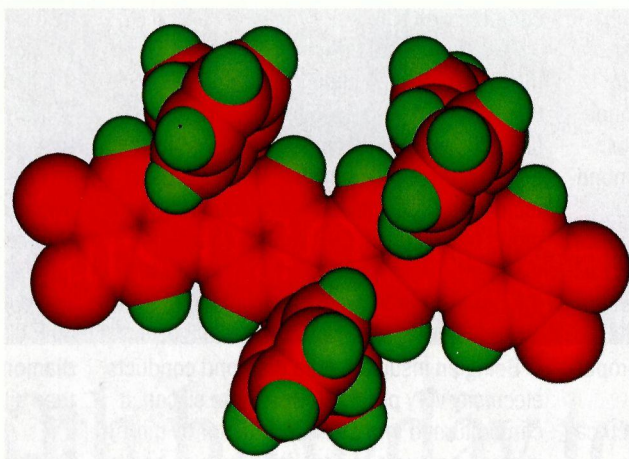
Edited by Archana Sharma

Impurities shed light on polymers

A dash of impurity could show the way to more efficient light-emitting diodes (LEDs) made from plastics – organic optoelectronic devices. According to a recent paper in *Physical Review Letters*, palladium atoms present at extremely small quantities in a polymer LED cause the material to phosphoresce.

Polymer LEDs are devices made from conjugated polymers – repeating chains of organic molecules rich in double bonds between carbon atoms. They offer the promise of producing LEDs from moulded plastic. These would be easily tunable from one colour to another. The caveat is that much of the electrical energy applied produces heat instead of light.

Researchers in Germany have now found that a new conjugated polymer for LEDs emits a pink glow, rather than the blue-green they expected. This shift also endured even after the voltage was turned off. Investigations revealed the presence of palladium atoms, (left over from the catalyst used to synthesize the polymer) at a level of 80 ppm, or one for



Small levels of palladium impurity in this polymer have unexpectedly caused it to phosphoresce, opening a route to better polymer LEDs. (J Lupton, MPI for Polymer Research, Mainz.)

every 1700 units of the polymer.

This level of impurity is hard to produce in a polymer using current techniques. Metallorganic polymers also phosphoresce, but each unit in these compounds contains a metal atom. The ubiquitous metal atoms strongly affect the electronic structure and drastically reduce the light-producing efficiency of metallorganics. In contrast, the new material is 99.9% metal-free.

Nevertheless, the small numbers of palladium atoms turn out to play a crucial role. When a voltage is applied to a semiconductor, a positive charge forms at one terminal and a negative charge at the other. These combine to form a neutral “exciton”, which rapidly decays into a photon (if it has enough energy) or converts to heat. If a metal atom such as palladium is around, it can convert some less energetic excitons into phosphorescence.

The effect suggests that light-emission can probe the properties of these lower-energy excitons, which researchers have rarely seen directly, as well as the chem-

istry of related materials. Metal impurities might also help polymer LEDs generate more light or improve the performance of organic dye lasers or single photon-emitters.

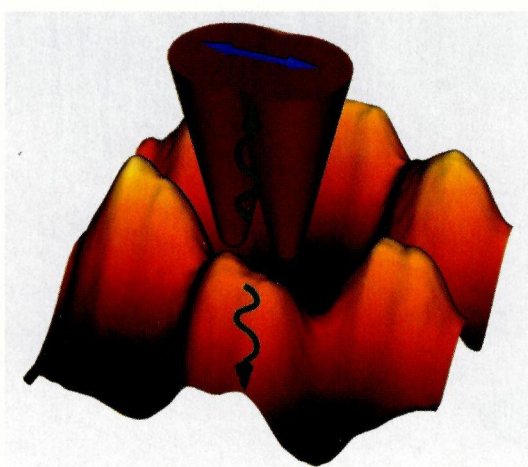
Further reading

J M Lupton *et al.* 2002 Intrinsic room-temperature electrophosphorescence from a pi-conjugated polymer *Phys. Rev. Lett.* **89** 167401.

New technique demonstrates friction at the atomic scale

In a major technical breakthrough, researchers at the University of Augsburg in Germany have employed a special atomic force microscope to measure the friction between a tungsten tip and a silicon surface. Atomic force microscopy uses a sensitive cantilevered arm with a tip just one atom wide to measure the electrostatic attraction between arm and surface. This allows a 3D map to be drawn up based on the force measurements.

Friction is caused by the dissipation of energy as atoms shift out of place and back again when macroscopic objects slide against each other. As long ago as 1929, the British physicist G A Tomlinson described friction as being due to a “plucking action of one atom on to the other”,



In this illustration, each atom appears as a double peak. The microscope probe (red) swings with constant amplitude over a silicon surface. The energy needed to maintain constant amplitude is measured and corresponds to the friction loss between the probe and surface atoms. (Alexander Herrnberger.)

microscopy, the German team drags the tip, which oscillates back and forth, across the surface, giving an excellent measure of friction.

Further reading

but it has taken until now to show he was right.

In a variation of the atomic force technique, called frequency modulation lateral force

F J Giessibl, M Herz and J Mannhart 2002 Friction traced to the single atom *Proc. Natl. Acad. Sci. USA* **99** 12006–12010.

Diamonds increase their worth in research

The beauty of diamonds has always belied their utility. They are known as the hardest, most thermally conductive and chemically resistant material. Diamond coating technology has been applied to produce superior abrasives and cutting tools, such as diamond-turning machinery for optics fabrication. However, the technique also promises applications in electronics and optics if methods for epitaxial growth can be perfected. Researchers from Sweden and the UK have made films of synthetic diamond that have electrical properties approaching those of silicon.

The electrons and holes that carry electrical currents in semiconducting materials are twice as mobile in these new films as in their forerunners. Devices based upon them, such as transistors, might work fast enough to

compete with silicon.

The researchers have improved the microwave plasma chemical-vapour deposition (CVD) process used to make diamond films by breaking off carbon atoms from carbon-rich methane molecules. The new CVD technique produces thick, high-quality diamond films. Earlier, CVD generated a disorderly mosaic of tiny crystallites in which the boundaries between grains disrupted the flow of an electrical current.

Being an insulator, pure diamond conducts electricity very poorly. However, like silicon, it can be turned into a semiconductor by mixing in small amounts of impurities such as boron or nitrogen. For this study, boron-doped diamond was made by adding diborane, a boron-hydrogen compound, to the CVD

mixture of methane and hydrogen. Industrial diamond was used as the support that helped the films' carbon atoms to line up properly.

Diamond microelectronics has a long way to go in replacing silicon, but diamond devices may function in situations where silicon electronics fails. For example, diamond chips could work at temperatures of several hundred degrees, whereas silicon devices generally fail above 150°C. Diamond can also carry much more power than silicon, so diamond-based devices could be smaller than silicon ones.

Further reading

J Isberg *et al.* 2002 High carrier mobility in single-crystal plasma-deposited diamond *Science* **297** 1670-1672.

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