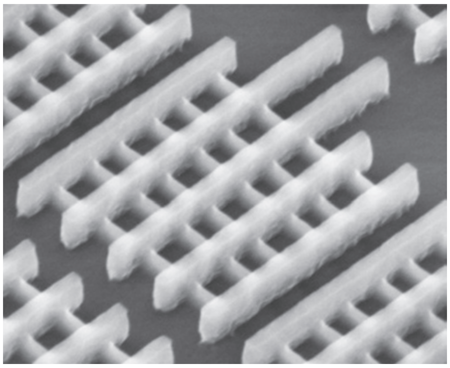
SEMICONDUCTOR DEVICES

Intel goes 3D

http://newsroom.intel.com/docs/DOC-2035 (May 2011)



Feature sizes have been getting smaller in the semiconductor industry for decades, but devices have remained resolutely flat. Now Intel has announced that it will start manufacturing three-dimensional transistors later this year. The new Tri-Gate transistors will have gate lengths of 22 nm, compared with the 32-nm gates found in the company's existing devices.

In a conventional transistor the electric current between the source and drain electrodes is controlled by a voltage applied to a third electrode, the gate, which is separated from the channel carrying the current by a flat insulating or dielectric layer. In the Tri-Gate transistors, the dielectric layer and gate electrode cover the sides and top of an extremely thin silicon fin. Moreover, it is possible to have two or more fins connected together.

The increased control over the channel current provided by the 3D design means that these transistors have lower operating voltages and leakage currents than existing devices, which will reduce power consumption. The performance of the new devices is also 37% better than that of existing ones at low voltages. And if the semiconductor industry continues to follow Moore's law, gate lengths will continue to drop, to 14 nm in 2013 and 10 nm in 2015.

DNA NANOMACHINES

Finding their way into worms

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Nucleic acids have been used as scaffolds to build a variety of programmable structures but the application of these structures inside a living organism has yet to be shown. Previously, Yamuna Krishnan and colleagues at the Tata Institute of Fundamental Research in India showed that a DNA nanomachine (called an I-switch) built from two DNA duplexes can function as a pH sensor inside living cells. Now, in two separate publications the Indian team have shown that the I-switch and a second DNA nanomachine (called the icosahedral) can map pH changes inside a worm.

The I-switch consists of three DNA strands: two strands are partially hybridized to a third strand and the end of one of the two strands consists of an acceptor dye and the other a donor dye pair. At low pH, the assembly adopts a 'closed state' and the pair of dyes gets closer to each other and undergoes fluorescence resonance energy transfer. When injected into the *Caenorhabditis elegans* worm, the I-switch was taken up by specific cells (known as coelomocytes) into membrane-bound vesicles known as endosomes in a process called endocytosis. The I-switch could map the changes in pH of the maturing endosome inside the living organism.

The DNA icosahedral, also built from DNA motifs, has a central cavity that contained a pH-sensitive fluorescent dye. The encapsulated dye was taken up by cells from the *Drosophila* fruit fly differently from the free dye and, like the I-switch, the icosahedral–dye complex can map pH changes associated with endosome maturation in coelomocytes of the worm.

CONDENSED MATTER PHYSICS

Living in harmony

Science **332,** 940–944 (2011)

Magnetism and superconductivity are closely related in many ways. Superconductors can expel weak applied magnetic fields, but they lose their ability to carry electric current without resistance in strong magnetic fields, and it is generally assumed that magnetism and superconductivity cannot co-exist in the same material. Now Katharina Franke and co-workers at the Free University of Berlin have studied the interaction between these two phenomena at the level of single atoms, and shown that they can co-exist.

The Berlin team used scanning tunnelling microscopy and spectroscopy to study individual magnetic molecules of manganese phthalocyanine (MnPc) on a lead surface, which was superconducting at the cryogenic temperatures used in the experiments. In particular they explored the competition between a magnetic effect known as Kondo screening, which can co-exist with superconductivity, and magnetic interactions that are strong enough to break up the Cooper pairs of electrons that are essential for superconductivity.

Under certain conditions they found that two distinct states co-existed in a Moire pattern. In one state the Kondo screening effect was complete and the Cooper pairs remained intact, so the superconductivity was preserved. In the other state the screening was not strong enough to prevent the magnetic moment of the MnPc molecule breaking up the Cooper pairs and destroying the superconductivity.

FUEL CELLS

Three in one

Adv. Funct. Mater. doi:10.1002/adfm.201002471 (2011)

Fuel cells can convert chemical energy into electricity, and are typically composed of an anode and a cathode separated by an electrolyte membrane. In solid oxide fuel cells, the electrolyte is an oxide that can conduct negative oxygen ions from the cathode to the anode. These fuel cells work at high temperatures (up to around 1,000 °C), but reducing the thickness of the electrolyte can decrease their operating temperatures and nanoscale membranes have previously been fabricated. Bin Zhu and colleagues at the Royal Institute of Technology (KTH), Stockholm, have now been able to remove the electrolyte altogether, creating a fuel cell from a single homogenous layer.

The layer is made from a mixture of samarium-doped ceria and nanoparticles of a LiNiZn-based oxide, and has both ionic and semiconducting properties. Moreover, when hydrogen and air are supplied to either side of the layer, the composite can act as a catalyst for both the oxidation of hydrogen and the reduction of oxygen. On one side, hydrogen is broken down into protons and electrons, a function similar to that of the anode of a typical fuel cell; whereas on the other, electrons are received through an external circuit and oxygen from the air is split into negative oxygen ions, just like a fuel cell's cathode. Water is then thought to be generated through the direct combination of protons and oxygen ions on the surface of the particles.

The exact nature of the underlying processes is still unclear, but the Swedish team show that the one-layer fuel cells can convert hydrogen and air into electricity and water with a power output of more than 600 mW cm^{-2} at 550 °C.