CONDENSED-MATTER PHYSICS

Particle physics in a nanowire

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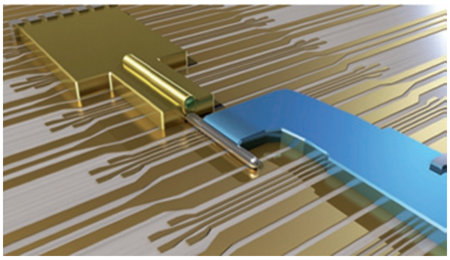

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Some of the most important ideas in particle physics, such as spontaneous symmetry breaking, have their origins in condensed-matter physics. Analogues of one of the most elusive particles predicted by theorists, the magnetic monopole, have also been detected in condensed-matter systems. Now Leo Kouwenhoven of the Delft University of Technology and co-workers have seen evidence for another elusive particle — the Majorana fermion — in experiments with semiconductor nanowires.

Fundamental particles such as electrons and quarks have antiparticles with the opposite electric charge, and so are clearly different from their antiparticles. However, it has been known since the 1930s that it is theoretically possible that some neutral particles are identical to their antiparticles.

Condensed-matter physicists became interested in Majorana fermions two years ago when theorists predicted that they could emerge as charge-neutral and zero-energy quasiparticles in a superconductor. Kouwenhoven and co-workers have now detected such quasiparticles in InSb nanowires attached to a superconducting electrode at one end and a normal metal electrode at the other. The signature of the fermions is a zero-energy peak that is not influenced by changes in the gate voltage applied to the device, or changes in the magnetic field applied along the nanowire. However, as predicted by theory, the peak disappears if the magnetic field is removed or the superconducting electrode is replaced by a normal electrode. *PR*

SUPERCONDUCTIVITY

Light controlled

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A small amount of chemical doping induces superconductivity — electrical conduction with zero resistivity — in certain cuprate oxides. The degree and chemical nature of the doping species controls the number of charge carriers introduced in the material, as well as the critical temperature (T_c) below which superconductivity behaviour is observed. However, the amount of chemical doping must be set beforehand, during the preparation step.

Yoram Dagan and colleagues at Tel-Aviv University and the Shanghai Institute of Materia Medica have now found that it is possible to modulate the number of charges in cuprate superconductor films by depositing a self-assembled monolayer on their surface. The monolayer is made of light-sensitive polar compounds, such as an azobenzene derivative, or nanostructures, such as a porphyrin–nanotube composite. On irradiation with light, charges are transferred from the cuprate oxide to the monolayer, resulting in a hole-doped superconductor with a different T_c. The process is reversed when the light is switched off.

Although the effect is relatively small — amounting to about 2 K difference in T_c — the study clearly demonstrates that functional self-assembled monolayers can be used to control the T_c of superconductive cuprate oxides. The effect could be exploited to make dissipationless electrical switches or functional devices for memory storage. *AM*

FIELD-EFFECT TRANSISTORS

Biomolecular turn-ons

Appl. Phys. Lett. **100,** 143108 (2012)

Transistors can make good biosensors. The usual approach is to functionalize the gate oxide of a field-effect transistor with receptors for specific, charged biomolecules. When these are captured, they modulate the conductance of the channel, which can be measured. Deblina Sarkar and Kaustav Banerjee of the University of California, Santa Barbara have now predicted that tunnel field-effect transistors could be used to make biosensors that are even better.

Both tunnel and conventional field-effect transistors use a gate electrode to control the barrier to carrier flow. In a conventional device, carrier injection over this barrier is thermally assisted, restricting turn-on speeds to 60 mV of gate voltage for every factor of 10 increase in current at room temperature. In a tunnel transistor, however, carriers tunnel from band to band at a rate that is independent of temperature. This leads to faster turn-on.

Moreover, a transistor-based biosensor is most sensitive while it is turning on because in that regime, the change in current for a given change in gate voltage is greatest. This means faster turn-on translates to better performance. Sarkar and Banerjee calculate that a tunnel transistor's fast turn-on translates to an increase in biomolecule sensitivity of four orders of magnitude. The response time also improves by one order of magnitude. *MS*

ELECTRON TOMOGRAPHY

Atomic resolution

Nature **483,** 444–447 (2012)

Electron microscopes are frequently used to image the atomic structure of a material, and instruments with aberration-corrected electron lenses have even yielded images with a resolution of around 0.5 Å. Characterizing the three-dimensional (3D) structure of a material is also possible using electron tomography in which a 3D reconstruction is computed from a series of projection images obtained while rotating the sample. However, the resolution of such methods is typically around 1 nm^3. Three-dimensional atomic imaging has been achieved before but required prior knowledge of the material's lattice structure to reconstruct the 3D image. Jianwei Miao and colleagues at the University of California, Los Angeles and Lawrence Berkeley National Laboratory have now developed an electron tomography method that can obtain atomic resolution without such prior knowledge.

The approach uses an alignment procedure that relies on the centre of mass of a sample and allows a series of projection images to be aligned to a common axis with atomic-level precision. This is combined with a reconstruction method termed equally sloped tomography, which acquires a tilt series of projections with equal slope increments, rather than with constant angular increments as is used in conventional tomography. The tilt series is obtained using an annular dark-field scanning transmission electron microscope. With the approach, Miao and colleagues were able to determine the 3D structure of a gold nanoparticle with a resolution of 2.4 Å using a series of only 69 projections. *OV*

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