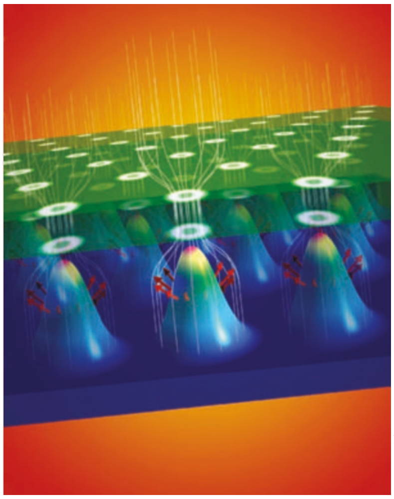
Spintronics under control?

Spintronics — the use of the spin of an electron as well as its charge to store and control information in electronic devices — holds great promise for increased data-processing capacity in the ever smaller and faster devices being developed today. Now, Berciu, Rappoport and Jankó report a fast and efficient process that can be used to create and manipulate spin textures and currents (*Nature* 435, 71–75; 2005) — one of the difficulties to date in the effective development of spintronic systems. The authors propose a hybrid of superconductors (SCs) and diluted magnetic semiconductors (DMSs) to manipulate the local spin and charge textures formed in the DMS by the magnetic flux bundles (vortices) penetrating the SC when in a magnetic field (see Figure). As long as the vortices move slowly so that the Doppler shift in the bound state energy is smaller than the binding energy, the charge and spin texture adiabatically follows a moving vortex. The vortex therefore acts as a 'tweezer', such that control of the position of the vortices in turn controls the spin and charge textures in the DMS. This hybrid system has great potential in applied and basic condensed matter physics.



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Optical superlattices such as photonic crystals are a convenient way to engineer the band structure of materials, resulting in the formation of mini-bandgaps and allowing control over the propagation of light. Unfortunately, photonic structures are rather static, which means that their optical properties cannot be changed once they have been produced. Maurício Moraes de Lima and colleagues (*Physical Review Letters* 94, 126805; 2005) now demonstrate the formation of a dynamic optical superlattice induced by acoustic phonons in a photonic microcavity. Surface acoustic waves are generated by a transducer and used to modulate the band structure of the optical microcavity. Using reflectance measurements they were able to measure the influence of this modulation on the superlattice's band structure, and the formation of stop bands due to the interaction between photons and phonons. This was then taken one step further with the observation of a two-dimensional photonic lattice. Apart from their appealing physical properties, these dynamic phonon-induced superlattices could find potential applications in optical switches, frequency shifters or modulators.

Magnetic assembly

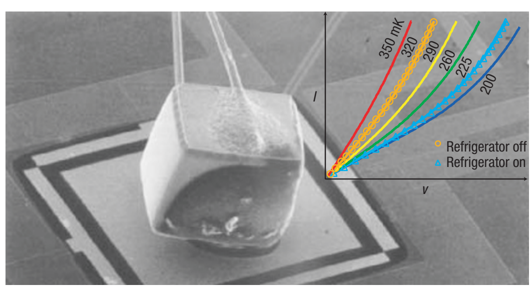
The field of molecular electronics has undergone a period of reanalysis in recent years, with researchers turning to relatively simple devices in an attempt to differentiate the properties of the metal contacts from intrinsic device characteristics. Once the device properties are fully understood, researchers will need a high-yield device fabrication process that does not damage the active molecular units. Researchers have now developed such a method for assembling molecular junctions incorporating a variety of organic monolayers (D. P. Long *et al. Applied Physics Letters* **86**, 153105; 2005). David Long and colleagues made electrically conductive and magnetically susceptible silica colloids by a two-step metallization technique, and then fabricated arrays of devices composed of a set of electroplated permalloy metal tips separated by a 1-μm gap. An intense magnetic field forms between these tips, which traps individual microspheres between them with a success rate of 60%. The researchers functionalized the magnetic electrodes with three organic 'molecular wire' monolayers, and showed that the magnetic assembly technique produces junctions with reproducible I-V characteristics. The device properties are similar to those displayed by previous crossed-wire and nanowire-based molecular junctions, validating use of the magnetic assembly technique for molecular transport measurements.

Layer cake for lasing

A double-layered organic structure may be the key to wavelength-programmable electrically pumped diode lasers. Thin films of azobenzene-containing polymers make surface-relief gratings — having modulations identical to the interference pattern — when exposed to interfering coherent light at an adsorption wavelength. They would be ideal materials for a distributed-feedback laser (in which optical feedback is provided by the periodic modulation of refractive index or optical gain) with programmable lasing wavelength, because, at will, their surface-relief gratings can be easily erased with heat or uniform light, and rewritten on exposure to another interference pattern. But on mixing a laser dye directly into the azopolymer film, the azobenzene quenched any fluorescence, thus reducing the optical gain. However, if a layer of the azopolymer was placed on top of a layer of polymer doped with the laser dye, the quenching did not occur (K. Ubukata, T. Isoshima and M. Hara *Advanced Materials* http://dx.doi.org/10.1002/adma.200402080). This new dynamic system based on light-induced mass transport at the microscale is advantageous and competitive with respect to existing organic or semiconductor differential-feedback lasers.

The edge of freezing

Refrigerators that operate without moving parts have the potential to provide more reliable and efficient cooling for a range of applications. However, at temperatures below 1 K — necessary for improving the performance and sensitivity of instruments such as high-resolution X-ray detectors and other sensing equipment — conventional solid-state refrigerators do not work. To address this need, Anna Clark and colleagues describe a relatively simple metal–insulator–superconductor (MIS) device that can operate at temperatures of just a few hundred millikelvin (*Applied Physics Letters* 86, 173508; 2005). The device works by allowing only hot electrons in a metal to tunnel across a thin insulating junction between it and a superconductor. This cools the metal by a mechanism that is analogous to evaporative cooling, but which occurs entirely in the solid state. They demonstrate the potential of this concept by cooling a 250-μm-sided germanium cube, placed on top of a free-standing silicon nitride membrane suspended by four pairs of MIS junctions (see Figure), from 320 to 240 mK.



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