physics update

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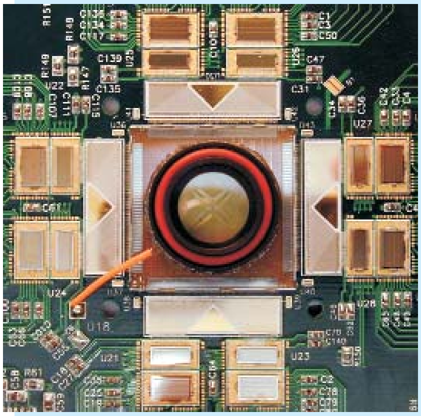
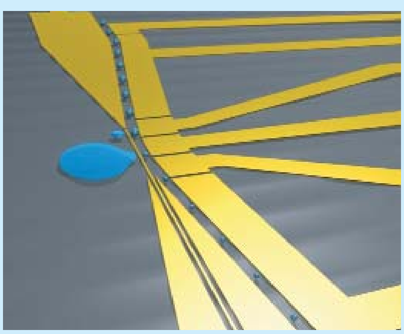
Particle-physics technology meets the eye. The retina is the layered, paper-thin "wallpaper" on the back of the eye that senses incoming light using the rods and cones of the input layer and then electrically encodes that information in the middle layers. The output layer of the retina has ganglion cells (about 1 for every 100 rods and cones) to gather and collate the encoded electrical signals and send them through the optic nerve to the brain. Although about 22 different morphological types of retinal ganglions are currently known to exist in primates, biologists know in detail how only a handful of them respond to visual images. Enter Alan Litke (University of California, Santa Cruz) and his familiarity with the silicon-microstrip detector technology used in experiments at SLAC and CERN. Along with circuit designer Władysław Dabrowski (AGH University of Science and Technology, Krakow, Poland) and other colleagues, Litke developed a detector array (see the figure) that packs 512 microelectrodes into a mere 1.7 mm^2. In collaboration with E. J. Chichilnisky at the Salk Institute in La Jolla, California, the team began to study the retina in monkeys. The scientists have now identified and characterized the behavior of a new ganglion cell type that they call the upsilon cell. For each of several in vitro preparations, they focused dynamic visual stimuli onto the retina and simultaneously recorded the electrical activity of about 250 ganglion cells, 5–10 of which turned out to be upsilons. The upsilons' sparseness was offset by their large area of sensitivity; their collective detection mosaic covers the retina nicely. The researchers also found that the new cell type sums signals nonlinearly and responds sharply to highly transient stimuli; that finding led the team to speculate that upsilons are important for the visual detection of motion. (D. Petrusca et al., *J. Neurosci.* **27**, 11019, 2007.) —SGB



Dynamic quantum dots with tunneling. In a QD, electrons are restricted to a region of space so tiny as to enforce a quantum regime; the electrons may only have certain discrete energies, which can be useful, depending on the circumstances, in producing laser light or in detectors and maybe even future computers. QDs are usually fabricated in a semiconductor and controlled with voltages applied to nearby electrodes. In recent years, though, fast-moving QDs have been fashioned by trapping electrons in the minima of surface acoustic waves that zip through a channel past static surface gates. (For more on SAWs, see PHYSICS TODAY, March 2002, page 42.) A team of physicists at the Cavendish Laboratory at the University of Cambridge has now determined the tunneling rate of electrons from such dynamic QDs, a necessary step for putting the traveling dots to practical use. The experimenters calculated the tunneling rates for the case of 1, 2, or 3 electrons trapped in each QD (blue dots in the artist's rendition; the actual device is also shown) and the SAWs moving at about 2800 m/s past a tunneling barrier to a two-dimensional electron gas (the big blue blob). They found that the tunneling occurred on a 600-ps time scale and that its rate was controlled by both the number of electrons in each dot and the voltage on the barrier. (M. R. Astley et al., *Phys. Rev. Lett.* **99**, 156802, 2007.) —PFS



An ultrafast, ultralarge change in reflectivity can be brought about with femtosecond lasers. In a recent experiment, 30-fs laser pulses impinging on an organic salt target produced a very rapid phase change in the material, taking it from an insulator to a semimetal. Reporting on his work at the September 2007 Frontiers in Optics meeting in San Jose, California, Jiro Itatani (Lawrence Berkeley National Laboratory and Japan Science and Technology Agency) said that the material's reflectivity changed greatly along with its electronic properties. In fact, within 60 fs the reflectivity more than doubled, a far larger change than the few percent normally seen in photoresponsive materials. The laser pulse was not particularly intense; less than one photon was absorbed per molecule. Itatani thinks that the large, fast changes are driven by light-induced motions of the salt molecules that are strongly coupled to the electronic degrees of freedom. The dramatic reflectivity changes could come in handy for direct ultrafast optical switching. —PFS

A new way to control cardiac chaos. Ordinary heart contractions are triggered by regular waves of electric depolarization of the cardiac cellular membrane. If, however, some portions of heart tissue are electrically anomalous, high-frequency rotating spiral waves can arise and propagate, inducing the overall activity of the heart to become chaotic and perhaps deadly. The usual treatment is either to administer a massive electrical shock—defibrillation, up to 4000 volts and 15 amps—to disrupt the waves, or to deliver trains of low-amplitude pulses. The former treatment is very traumatic and the latter cannot terminate high-frequency waves. Alain Pumir and Valentin Krinsky of the CNRS Nonlinear Institute in Nice, France, and their colleagues try to undo the threat not by jolting the whole heart but by aiming countermeasures just at the spirals' origins. Their scheme, called wave emission from heterogeneities (WEH), paces the heart using virtual electrodes. An electric field pulse creates virtual electrodes by altering the membrane potential of cardiac cells near conductivity anomalies. Changing the electric field affects different anomalies and thus changes the number and positions of the electrodes, which emit their own waves that can terminate the spirals. Operating at energies far below those needed for defibrillation, WEH can selectively target high-frequency rotating waves and thereby overcome the disadvantages of both current treatments. Initial simulations and experiments on heart tissue from rats were encouraging, and the method is now being tested at Cornell University and the Max Planck Institute in Göttingen, Germany. (A. Pumir et al., *Phys. Rev. Lett.*, in press.) —PFS ■