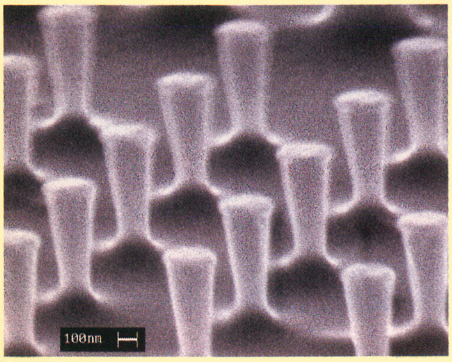
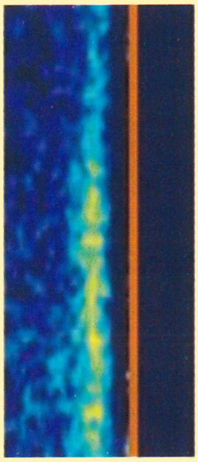
Physics Update

Light has been slowed by seven orders of magnitude. In general, light travels slower in optical materials than in vacuum; the higher the material's index of refraction, however, the greater the toll that absorption takes on the light beam. But in an experiment at the Rowland Institute for Science in Cambridge, Massachusetts, Lene Hau and her coworkers cooled a cloud of sodium atoms to ultralow temperatures and set up a particular laser-induced quantum interference—electromagnetically induced transparency (see the article in PHYSICS TODAY, July 1997, page 36). They were able to cancel absorption and to slow light in the cloud by creating a very steep variation in the refractive index around an atomic resonance line (although the refractive index of the medium remained close to unity). The low temperatures (50–2000 nK) strongly promoted the quantum interference by reducing thermal motion and increasing atomic densities in the clouds. Indeed, the slowest light propagation velocity (17 m/s) was obtained when the sodium was in a Bose–Einstein condensate. The researchers also observed very large nonlinear optical effects. For example, the measured intensity-dependent index of refraction was 14 orders of magnitude larger than that of an optical fiber and a million times greater than any previously measured refractive index. Hau says that the work makes possible nonlinear optics at extremely low light levels. (L. V. Hau *et al.*, *Nature* **397**, 594, 1999.) —PFS

A single-photon turnstile, a device in which photons are emitted one at a time under controlled circumstances, has been created by a team of scientists from Japan and the US. In essence, the researchers used the Coulomb blockade effect to produce a quantization of photon emission, analogous to quantization of electrical conductance. They made a quantum well sandwich, with the central well isolated by tunnel barriers from an n-type well on one side and a p-type well on the other. By carefully adjusting the voltage across the device, the researchers could coax either a single electron or a single hole into the central well. By modulating the voltage periodically, they were able to combine a lone electron with a lone hole to produce a lone photon during each voltage modulation period. The device, which operates at mK temperatures, was a tiny post some 700 nm tall, chosen from an array of such posts, shown here. For more on quantized conductance, see PHYSICS TODAY, July 1996, page 22. (J. Kim *et al.*, *Nature* **397**, 500, 1999.) —PFS



Wire-guided neutral atoms. Researchers at the University of Innsbruck in Austria have demonstrated two different ways of guiding cold lithium atoms taken from a magnetooptic trap and placed near a thin current-carrying wire. Although the atoms are neutral, they have a magnetic moment and thus can interact with the wire's magnetic field. Atoms having their moments parallel to the field feel a force driving them toward higher fields; such atoms orbited around the wire while their companions having antiparallel moments left the region, seeking lower fields. However, the addition of a second magnetic field, perpendicular to the wire, created a "tube" of low magnetic field alongside the wire. The low-field-seekers could then be guided through the tube, as shown in the image; the wire (orange line) carries a 1 A current. This second guide is especially interesting because the wires can be mounted on a surface, allowing for easy miniaturization of the guides and traps for various atom-optics experiments. Jörg Schmiedmayer says that the group is now testing a beam splitter made from two intersecting wires. (J. Denschlag *et al.*, *Phys. Rev. Lett.* **82**, 2014, 1999.) —PFS



Tunable x-ray waveguide with an air gap. At synchrotron light sources, the floods of x rays created by electron beams must first be tamed before they can be used in experiments—for example, to study a complex fluid or to probe the structure of some tiny biological sample. A typical waveguide for x rays uses a light element, such as carbon, between two reflecting surfaces; but x rays are also absorbed in such devices, limiting their usefulness. Now, researchers at the University of Amsterdam have built a waveguide out of two parallel reflecting plates with only air between them. Not only are x-ray losses greatly reduced, but the gap can be used to hold a liquid sample for study. The device can be tuned to a single wave mode by adjusting the plate separation (to as close as 250 nm). When multiple modes are sent in, coherence between them is preserved over the entire length of the device—about 5 mm. (M. J. Zwanenburg *et al.*, *Phys. Rev. Lett.* **82**, 1696, 1999.) —PFS