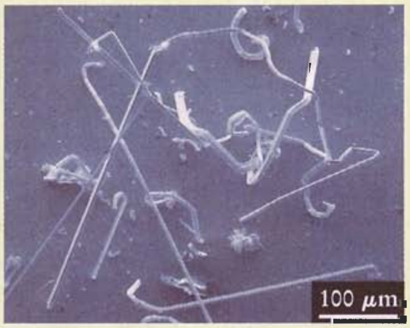
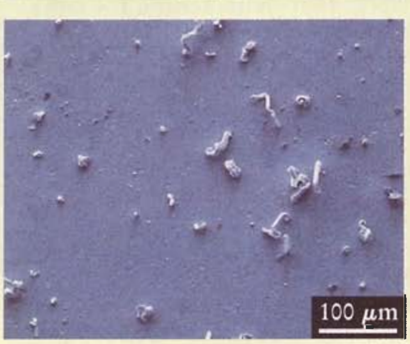
Physics Update

A rice-sized magnetometer can do the job of much bigger units and measure magnetic fields with a sensitivity of 50 picotesla. Researchers at NIST in Boulder, Colorado, exploit the fact that rubidium atoms have quantum levels whose energies depend on the ambient magnetic field. With a rubidium vapor confined in a tiny cell and a precisely tuned laser beam propagating through the cell, the researchers measure the magnetic field by monitoring the absorbed light. The laser, optics, cell, and detector are all fabricated in a 12-mm^3 package, about the size of the same group's atomic clock (see PHYSICS TODAY, October 2004, page 9). What's more, the device could potentially be manufactured in large batches using wafer-level fabrication techniques. With a few more years of development, the device's tiny power consumption, compact size, and low price could move it ahead of several existing magnetometer designs for applications like geophysical exploration, medical diagnostics, and detection of underwater or underground iron objects. (P. D. D. Schwindt et al., *Appl. Phys. Lett.* **85**, 6409, 2004.) —PFS

Soft-metal whiskers need oxygen to grow, according to researchers at Drexel University in Philadelphia. Over a period of days or weeks at room temperature, tiny protrusions can sprout spontaneously like hair from soft metallic surfaces of, for example, tin or indium. The phenomenon has resisted interpretation for more than 50 years and poses a reliability problem for semiconductor manufacturers; unexpected whisker-induced short circuits have led to failures of heart pacemakers, avionic relays, and satellites. The Drexel scientists placed soft-metal compounds in an evacuated glass tube and in air. Those in air were also partially coated with fingernail polish. After three months, only the samples directly exposed to air grew whiskers (top photo). The researchers think that oxygen diffusion at grain boundaries creates soft-metal oxides with a larger volume than the pristine metal. The resulting stress field then pushes the whiskers out. The incipient whiskers seen on the evacuated-tube sample (bottom) were attributed to trace amounts of oxygen in the tube or adsorbed on the surface. (M. W. Barsoum et al., *Phys. Rev. Lett.* **93**, 206104, 2004.) —PFS





Laser lightning rod. With a peak power of 10 MW, a peak voltage of 100 MV, and peak currents of tens of kiloamps, natural lightning is notoriously unpredictable. Producing lightning on demand—for performing scientific studies or protecting sensitive sites—is usually done by firing a rocket into an overhead cloud. The rocket spools out a long wire, which provides a conducting path between the charged cloud and the grounded Earth. Soon, however, ultrashort laser pulses might accomplish the same thing. A team of scientists from France and Germany has used 170-fs laser pulses in the lab to generate self-guided plasma filaments that triggered and guided high-voltage discharges across a 1.2-m gap, even with a dense rain cloud in the experimental chamber, as shown here. Compared to dry air, a cloud's presence reduced the discharge probability for a given laser shot. But according to the researchers, with many laser-shot repetitions per second, the real-world effectiveness of the technique should be undiminished. Next, the team will perform open-air lightning experiments. (R. Ackermann et al., *Appl. Phys. Lett.* **85**, 5781, 2004.) —PFS

Electron-beam welding (EBW) leaves the vacuum. The highest-quality welds currently achievable are done using beams of accelerated electrons to melt and join the metal pieces. But because the required electron guns cannot function in normal atmospheric conditions, the welding must take place in a vacuum chamber and is thus possible only for small pieces. Ady Hershcovitch of Brookhaven National Laboratory has now gotten around that limitation with a plasma window that isolates the vacuum of EBW beam sources but allows the electron beams to pass through and weld materials at ambient conditions up to 50 mm away. The window is formed with a plasma 40–50 times hotter than room temperature, confined by electric and magnetic fields. The plasma's high pressure effectively excludes the ambient atmosphere from the vacuum region that houses the gun. Additionally, the plasma window focuses the electron beams to improve weld quality. With the plasma window and a robot arm, EBW may become a viable option for large manufacturing applications such as cars, airplanes, or ships. Acceleron Inc has licensed the technology from Brookhaven. (A. Hershcovitch et al., *Phys. Plasmas* **12**, in press, May 2005.) —JRR