

A semiconductor wafer inside a mobile phone, for example, needs to be several centimeters in scale. Scientists need to understand and control the types of defects present in the materials and to make the synthesis process more robust.

Besides high thermal conductivity, BAs has other desirable properties for thermal control, including chemical inertness and a coefficient of thermal expansion similar to that of silicon. Still, Cahill warns that “we have no idea if boron arsenide

can be produced at a practical volume. Maybe eventually, but would it be cost-effective? We just don’t know.”

Shi adds, “It remains a grand challenge to understand the defect-formation mechanism.” Now that scientists have a method for synthesizing nearly defect-free crystal, they can also introduce specific defects. Boundary and point defects could affect phonon transport and thermal conductivity in different ways. In that way, BAs offers the op-

portunity to study the origin of high thermal conductivity itself.

Rachel Berkowitz

## PHYSICS UPDATE

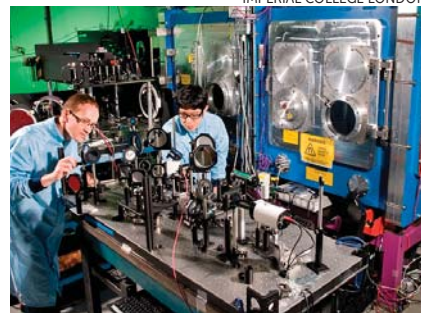
These items, with supplementary material, first appeared at [www.physicstoday.org](http://www.physicstoday.org).

### MAKING PIONS WITH LASERS

Of the 140 or so two-quark composites known as mesons, pions are the lightest. First discovered from tracks left by cosmic rays in photographic emulsions, pions are brought fleetingly to life whenever high-energy protons slam into other particles. Besides Earth’s atmosphere, pions are also produced in particle accelerators, supernova explosions, and the interstellar medium. Now an inter-

national team led by Karl Krushelnick of the University of Michigan has demonstrated a new way to make pions: with short, intense pulses of laser light. The method depends on laser wakefield acceleration (LWFA). When a plasma is hit with a laser pulse, the electrons respond far faster than the sluggish, heavier ions do. As the pulse propagates, it is followed by a wake—a wave of charge separation—whose electric field gradient exceeds those in conventional accelerators by at least 1000 times. In their implementation of LWFA, Krushelnick and his collaborators used 43 fs pulses from the 300 TW Astra Gemini laser at the UK’s Rutherford Appleton

Laboratory (the photo shows the experiment at the facility). A pion-producing shot begins when laser pulses are fired into a cell containing helium gas. The resulting ionization and wakefield acceleration generate a beam of 1 GeV electrons, which passes through a 1.5-cm-thick lead target to produce additional electrons, positrons, and gamma rays. Electrons and positrons are removed from the beam by magnets. The surviving gammas hit the final target, a 20-cm-long rod of aluminum. When a gamma encounters an  $^{27}\text{Al}$  nucleus, it yields either  $^{26}\text{Al}$  and a neutron or, at higher energies,  $^{27}\text{Mg}$  and a positive pion. Positive pions last just 26 ns before they decay into an antimuon and a muon neutrino. The researchers inferred the particles’ presence by recording the 843 keV gammas, which the unstable  $^{27}\text{Mg}$  nuclei emit when they decay. With the help of the FLUKA simulation code, the team estimated that each shot generated  $150 \pm 50$  pions. (W. Schumaker et al., *New J. Phys.* **20**, 073008, 2018.) —CD



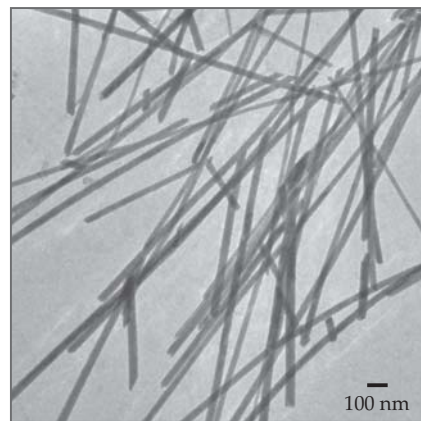
IMPERIAL COLLEGE LONDON

### ARAGONITE CRYSTALS GROW IN TIGHT SPACES

Calcium carbonate’s two common forms, calcite and aragonite, are widely found in nature—most notably, in the shells of mollusks and sea snails. Aragonite’s abundance is puzzling, though. Despite being only slightly less stable than calcite, aragonite almost never crystallizes from solution in ambient conditions. Researchers seeking the secret to aragonite biomineralization have examined several possibilities—the presence of proteins, scaffold molecules, and organic additives, for instance—all of which can influence nucleation processes. Fiona Meldrum and her colleagues at the University of Leeds in the UK have now shown that the secret may be much simpler: confinement. They found that aragonite crystallizes inside submicron-diameter pores of arbitrary depth without any special additives and in amounts that depend only on the diameter of the pore.

The finding emerged from dozens of ex-

periments using pores created by accelerating heavy ions and shooting them through polycarbonate films. In different-sized pores the researchers precipitated calcium carbonate by mixing two aqueous solutions—one made of calcium chloride and magnesium chloride, the other made of sodium carbonate and sodium sulfate. Analyzing the precipitates with x-ray diffraction and Raman spectroscopy revealed a trend with pore size: As the diameter was reduced from 1200 nm to 25 nm, the percentage of aragonite increased while that of calcite decreased. Whereas the largest pores contained almost entirely calcite, reactions in the smallest ones produced nothing but aragonite rods, as pictured here, even in the absence of magnesium or sulfate ions. The researchers speculate that the effect is attributable to the local ionic environment of the confining, curved surface. A slightly negative charge at the pore membrane



produces an inhomogeneous ion distribution near the pore’s center, which is thought to promote the nucleation of aragonite. The effect may also be tunable. A linear relationship exists between the weight percentage of aragonite and the inverse of the pore diameter. (M. Zeng et al., *Proc. Natl. Acad. Sci. USA* **115**, 7670, 2018.) —RMW PT