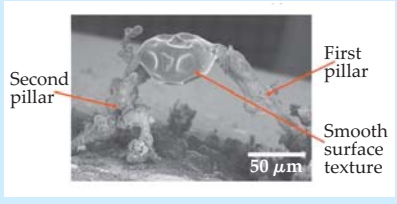
physics update

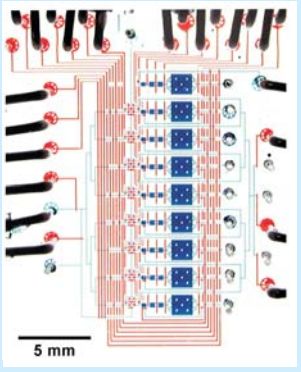
Supplementary material related to these items can be found at www.physicstoday.org.

Jet-powered microscaffolds for tissue growth. In some biological applications, cells need to be "seeded" into an artificial structure that provides mechanical support while allowing the cells to grow and function in their own microenvironment. Often, scaffolds are made using lithographic techniques on polymeric materials, but the required instrumentation is expensive. In recent years ink-jet printing has been used; the ink-jet droplets are usually 100 μm across or larger, making architectures smaller than that difficult to fabricate. Now Suwan Jayasinghe (University College London) and Alice Sullivan (Queen Mary, University of London) have found bioscaffolds to be a surprising application of the industrial electrospraying technique. In ES, the chemical or material of interest is suspended in a solvent and the solution is drawn out of a needle by a strong electric field. While being accelerated toward an electrode, the drops shrink and fission as the solvent evaporates. ES is used not only to paint metal surfaces but also as a workhorse of mass spectrometry wherein the material of interest becomes ionized as the drops evaporate. Jayasinghe and Sullivan used their own formulation of a siloxane-based colloidal suspension and found that in a small window of applied voltage and flow rate, a nearly mono distribution of nanoscale droplets could be generated, from 50 nm to 1 μm across depending on the parameters' values. Using a point-shaped target electrode held beneath a glass slide and in line with the jetting needle, the researchers could grow a pillar of siloxane residue in 300 seconds. They made a second pillar and connected it to the first by slowly moving the jetting needle, then grew another structure at the top of the arch, creating the fully three-dimensional architecture seen here. Finally, by growing smooth-muscle cells on it, they showed their polymeric microstructure to be biocompatible. (A. C. Sullivan, S. N. Jayasinghe, *Biomicrofluidics* **1**, 034103, 2007.) —SGB



Reversing the Casimir force. Metamaterials can be used to fabricate high-resolution "perfect" lenses and even invisibility cloaks (see PHYSICS TODAY, February 2007, page 19). Ulf Leonhardt and Thomas Philbin, both at the University of St. Andrews in Scotland, reveal another surprising property of negatively refracting perfect lenses: They can reverse the direction of the attractive Casimir force between parallel conducting plates. As Hendrik Casimir demonstrated in 1948, in otherwise empty space the electromagnetic zero-point energy increases with the conductors' separation, whence the attractive force. The physicists' analysis of the force-reversal exploits a special property of the left-handed materials used to make perfect lenses: The constitutive Maxwell equations for such materials are the same as they would be in an empty space obtained by changing the sign of the coordinate perpendicular to the conducting plates. What's the implication for the Casimir force? Suppose that the space between conducting plates is largely filled with a left-handed medium and that the plates' separation is increased by a small distance. Because of the coordinate sign change, the zero-point energy behaves as it would in an empty space when the conductors are brought together—it decreases. The Casimir force is thus repulsive. Leonhardt and Philbin estimate that the force could be great enough to levitate a piece of 500-nm-thick aluminum foil. (U. Leonhardt, T. G. Philbin, *New J. Phys.* **9**, 254, 2007.) —SKB

Obtaining a complete genome from a single cell. The human mouth teems with some 700 different species of bacteria. But except for the few microbes responsible for gum disease, tooth decay, and bad breath, the vast majority remain unexplored. Indeed, because most microbes are resistant to growth outside their own complex ecosystems, fewer than 1% of Earth's species of bacteria have been cultured. A group of bioengineers and medical researchers led by Stanford University's Stephen Quake has now developed a microfluidic device that circumvents the need to culture cells at all and avoids contamination from stray DNA in solution. The device, shown here, is a dense network of tiny pipes, valves, pumps, and reaction chambers lithographically patterned on a rubber microchip. In a proof-of-principle experiment, the researchers analyzed a single cell from a rare phylum of bacteria (TM7) that thrives between teeth and gums. In one of its eight parallel processors (the ninth is a control), the chip isolated a microbial cell, opened it to extract the DNA, and then mixed that DNA with nanoliters of reagents to make millions of copies. Off chip, the researchers then successfully sequenced most of the genome. They expect the approach to offer insight into Earth's tremendous microbial diversity. (Y. Marcy et al., *Proc. Natl. Acad. Sci. USA* **104**, 11889, 2007.) —RMW



Compact proton therapy. For killing malignant tumors, protons are potentially more effective than x rays because protons deposit most of their cell-killing energy at the end of their trajectory—in the tumor—and very little in the intervening healthy tissue. To be therapeutic, the protons must be accelerated to 70–250 MeV depending on the nature of the tumor and its location in the human body; such energies require a large facility and an expensive accelerator. (For more, see "Treating Cancer with Protons," PHYSICS TODAY, September 2002, page 45.) At the July meeting of the American Association of Physicists in Medicine (AAPM), Thomas Mackie, a professor at the University of Wisconsin and cofounder of TomoTherapy Inc, presented a new proton-therapy design developed by George Caporaso and colleagues at Lawrence Livermore National Laboratory and licensed by Mackie's company. Using laminated high-gradient insulators that can withstand enormous electric fields without breaking or breaking down, the new "dielectric wall accelerator" can energize protons to 100 MeV in just 1 meter. Its compact size means that the accelerator could be mounted on a gantry and rotated around a patient to precisely aim the proton beam. In addition, a DWA-based system could vary both proton energy and proton-beam intensity, allowing further control over where the particles dump their energy in the patient. Mackie cautions that a prototype is only now being built at Livermore and clinical trials of the system are many years away. (AAPM paper TH-C-AUD-9.) —BPS ■