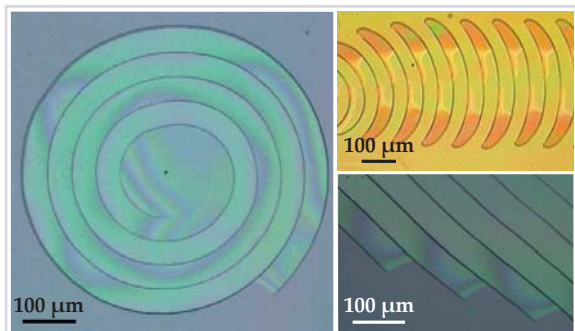




Optical microscope images of 0.5- to 10- μm -thick glass coatings deposited on silicon substrates reveal unusual spiral, crescent-shaped, and parallel-band crack patterns. The patterns result from a novel collaborative mechanism in which fracture and film delamination occur simultaneously. Interference fringes appear and move in each pattern as the film peels up from the underlying substrate and later settles back down. (Adapted from ref. 1.)

the film peel up from the substrate in the area between the cracks. “The propagation occurs thanks to the cooperation between the delamination and the crack propagation,” explains Marthelot. And that “collaborative” process allows an initial crack template to replicate itself: New cracks run parallel to previous fracture paths, with the distance between cracks governed by the thickness of the film. Enough new cracks and you get a parallel band, as seen in the lower

technologies like stretchable electronics, because films tend to be less strongly bonded to flexible substrates and could develop bigger stresses during use.

But what about spirals and crescent shapes? Aren’t they isolated cracks? The trick is for a crack to follow its own previous path at a given distance. For a crack that initiates at a point defect, the result is a spiral, as shown in the left panel of the figure. In a crescent-shaped

right panel of the figure.

Fracture energy is a property of the film, but varying film thickness changes the elastic energy and chemically pre-treating the substrate can change the adhesion energy. Armed with those two control knobs, the group has explored the parameter space of elastic energy, fracture energy, and adhesion energy to see where films should be safe from cracks. “We provide a novel and more general condition for the stability of thin films,” says Marthelot. And the new criteria might be particularly relevant to

pattern, the crack starts along an elongated defect, but can’t make the sharp turn around the defect’s edge. Instead, a new area on the far side of the defect slowly starts to delaminate and, in turn, triggers propagation along a returning branch, as in the upper right panel of the figure.

The new fracture mechanism, the researchers suggest, could turn cracks—usually considered a nuisance—into a novel design tool to tailor surface microstructures. It could be used to make small objects like microsprings from spirals and cantilevers from parallel bands, and the crack paths themselves could be used as nanofluidic channels in medical applications. The challenge now is to get a better handle on initiating specific crack patterns. Marthelot says the team plans to try out several ideas, including intentionally putting in defects on the substrate prior to deposition, scratching the film with an atomic force microscope tip, and using a femtosecond laser to cut the film.

Sung Chang

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physics update

These items, with supplementary material, first appeared at <http://www.physicstoday.org>.

UV light and peptides hit a triplet. Our bodies are full of proteins and their smaller cousins, peptides, both made up of chains of amino acids. And dangling off to one side of many of those amino acids is a so-called aromatic ring—a benzene-like ring of six carbon atoms. When a peptide containing an aromatic amino acid absorbs UV light, it has plenty of energy to break its bonds and fly apart—perhaps initiating events that can lead to skin cancer or cataracts—but it usually doesn’t. A group of physical chemists at the Swiss Federal Institute of Technology in Lausanne wanted to know whether those molecules survive on their own or whether they need help. With gas-phase peptides suitably isolated, the researchers first promoted the biomolecules to the excited singlet state with a UV laser. They then induced fragmentation with appropriate IR pulses. Through a systematic spectroscopic study involving a number of molecular resonances and pulse timings, they discovered that in just a few nanoseconds—before the molecules can dissipate their energy by returning to the ground state—a significant fraction of them are unexpectedly shunted aside into a long-lived triplet state. Left on their own, those very triplet states, persisting for tens of milliseconds, could cause lasting biological damage. Fortunately for us, peptides in our bodies are not isolated; they somehow get

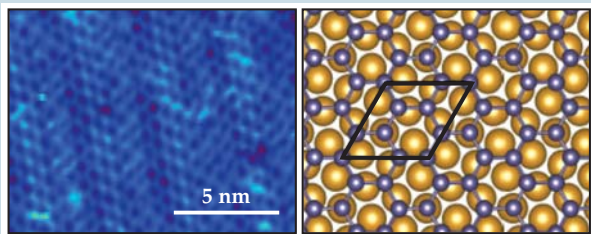
help from surrounding molecules in shedding their excess energy . . . but additional sunscreen never hurts. (A. V. Zabuga et al., *J. Chem. Phys.*, in press.) —SGB

Polarized electrons see mirrored molecules differently.

Amino acids and other biologically important molecules can be distinguished from their mirror images; the two chiral forms, designated as right-handed and left-handed, are called enantiomers. For reasons that remain unknown, only one of the two possible enantiomers is found in living organisms. Longitudinally polarized electrons, too, exist in a pair of mirror-related forms. The right-handed electrons with spin and momentum parallel are distinct from left-handed electrons with spin and momentum antiparallel. The difference is of more than academic interest; in particle physics the weak interactions break parity (inversion) symmetry, and electrons produced in beta decay are predominantly left-handed. Could the preferred handedness chosen by the weak interactions be related to the preferred handedness in living organisms? A necessary (but not sufficient) condition would be that longitudinally polarized electrons can react differently with mirror-related enantiomers. To test that requirement, Joan Dreiling and Timothy Gay (University of Nebraska–Lincoln) studied dissociation reactions in which a polarized electron impinges on a gas of the chiral molecule 3-bromocamphor ($\text{C}_{10}\text{H}_{15}\text{BrO}$) and knocks out a bromine ion Br^- . In a series of experiments, the researchers shot left- and right-handed electrons at chirally

pure enantiomers of $C_{10}H_{15}BrO$ and determined reaction rates by measuring the current of Br^- produced in the dissociation. For the lowest-energy electrons studied (less than 0.1 eV), when the handedness of the electrons and $C_{10}H_{15}BrO$ matched, the current obtained was greater than in the mismatched case by a few parts in 10^4 . No current difference was observed when polarized electrons reacted with a 50-50 mixture of the two molecular enantiomers. (J. M. Dreiling, T. J. Gay, *Phys. Rev. Lett.* **113**, 118103, 2014.) —SKB

Graphene's newest cousin, germanene. As interest in graphene has exploded over the past decade, so, too, has interest in other two-dimensional materials, in the expectation that they will likewise exhibit unusual and impressive electrical and optical properties. Boron nitride, in which B and N alternately replace carbon atoms in graphene's honeycomb lattice, was quick out of the gate. A Turkish team predicted in 2009 that silicon and germanium would be stable in a free-standing, low-buckled honeycomb geometry. Within a few years, several groups reported success in synthesizing single layers of silicene, the Si analogue of graphene. Now María E. Dávila (Madrid Institute of Materials Science), Angel Rubio (University of the Basque Country), Guy Le Lay (Aix-Marseille University), and their colleagues present compelling evidence



for the Ge version, germanene. Although Le Lay and his coworkers had successfully used a silver template in 2012 for silicene, initial attempts to synthesize germanene on a silver substrate failed. But noting that gold deposited on Ge forms clean interfaces, the researchers switched to depositing Ge on Au. And among the many phases in the resulting Ge film were large domains that showed a telltale honeycomb pattern in scanning tunneling micrographs. Earlier this year a Chinese team reported observations of buckled germanene on platinum in STM. The European researchers went further: Low-energy electron diffraction, x-ray spectroscopy, and advanced density functional calculations all pointed to the regions indeed being nearly flat, single-layer germanene, though perhaps with some Au atoms sneaking in. (M. E. Dávila et al., *New J. Phys.* **16**, 095002, 2014.) —RJF

Solving mazes with glowing plasma. In 2002 Andreas Manz of Imperial College London and his collaborators demonstrated a novel way to solve mazes. First, they etched a maze pattern onto a microfluidic chip using laser lithography. Then they filled the device with low-pressure helium. To find the shortest path to the center of the maze, they attached electrodes to the entrance and center of the maze. Turning up the voltage to 20–30 kV triggered the abrupt formation of a glowing plasma discharge that picked out and lit up the shortest path. Now Alexander Dubinov of the Russian Federal Nuclear Center in Sarov and his collaborators have devised a way to make the maze-solving technique cheaper and potentially more practical. Manz's original approach entailed etch-



ing a new chip for each maze pattern, which is time-consuming and expensive. The use of helium and high voltages also push up the cost. Dubinov's mazes consist of polyamide walls sandwiched between plexiglass. They are filled with low-pressure air and operate at voltages of a few kilovolts.

Thanks to the ease with which the walls can be reconfigured, Dubinov and his collaborators could readily investigate how the plasma solves the mazes. They discovered,

for example, that when the shortest path includes sections that require electrons to move away from the anode, the voltage needed to solve the maze drops. With further development, the technique could enable robots to navigate mazes and solve other topological problems. (A. E. Dubinov et al., *Phys. Plasmas* **21**, 093503, 2014.) —CD

Fourier plane imaging microscopy. These days the compound microscope is nearly as ubiquitous in physics and materials science labs as in biology and medical venues. In its simplest form, the instrument uses two-stage magnification—

once with an objective lens close to the sample and once again with the eyepiece. The resulting image is formed at the real focal plane where we typically place our eye or a camera; its resolution is determined by the well-known Rayleigh diffraction limit, though various tricks can be employed to improve the resolution somewhat. The intermediate image, appearing within the microscope's barrel at the so-called rear objective focal plane or Fourier plane, is rarely considered to have its own merits. But Texas Tech graduate student Daniel Dominguez, his adviser Luis Grave de Peralta, and their colleagues decided

to take a closer look by inserting a second camera to image the Fourier plane. They fabricated photonic crystals (PCs) with nicely periodic holes or pillars as test samples for their microscope setup, whose expected resolution is about 440 nm. At the instrument's eyepiece, hole spacings of 500 nm and 450 nm in the PCs were clearly resolved, but smaller spacings were not. A very different image appeared at the Fourier plane, however, with some diffraction information clearly visible (top image, for a 250-nm PC). By carefully extrapolating the arcs into full diffraction rings, the physicists could reconstruct a real-plane image with the correct periodicity (bottom). The technique seems robust and can work for non-periodic samples, although the origins of the Fourier-plane details are still under investigation. (D. Dominguez et al., *J. Appl. Phys.* **116**, 103102, 2014.) —SGB ■

