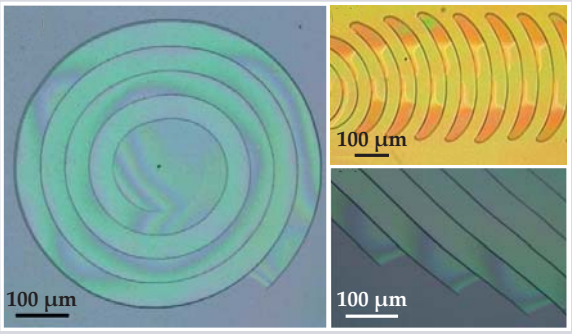


**Optical microscope images** of 0.5- to 10-μm-thick glass coatings deposited on silicon substrates reveal unusual spiral, crescent-shaped, and parallel-band crack patterns. The patterns result from a novel collaborative mechanism in which fracture and film delamination occur simultaneously. Interference 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 right panel of the figure.

Fracture energy is a property of the film, but varying film thickness changes the elastic energy and chemically pretreating 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 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 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**

## References

1. J. Marthelot et al., *Phys. Rev. Lett.* **113**, 085502 (2014).
2. M. Sendova, K. Willis, *Appl. Phys. A* **76**, 957 (2003); N. Wan et al., *Phys. Rev. B* **80**, 014121 (2009).
3. B. Audoly, P. M. Reis, B. Roman, *Phys. Rev. Lett.* **95**, 025502 (2005).

# 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 ($C_{10}H_{15}BrO$) and knocks out a bromine ion $Br^-$. In a series of experiments, the researchers shot left- and right-handed electrons at chirally