that of the parent solid). This condition may not be satisfied generally because the chemical potential of the liquid depends on thermodynamic conditions (Fig. 1c). If the liquid is less stable than the parent solid (that is, if it has a higher chemical potential), the solid–solid transition would most likely occur through a diffusionless martensitic route.

Experiments and computer simulations of model colloidal particles are ideal for investigating whether solid–solid transition pathways depend on thermodynamic conditions, and can also provide clues on phase-transition mechanisms in atomic or molecular systems[11,12]. Still, accurate knowledge of the equilibrium phase diagram is required, which is difficult to achieve experimentally. In this respect, simulations can provide useful guidance[13] — in fact, the stability range for the triangular and square lattices had been predicted earlier[14]. With advances in particle synthesis, video microscopy and the characterization of model colloidal systems, one would expect that the effects of constant pressure, particle asymmetry and particle softness — conditions that are generally more realistic — will soon be evaluated. ❒

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MATERIAL WITNESS

THE FINAL CUT

Origami — the folding of flat sheets — has been a well-advertised approach to engineering structures with diverse properties that can be efficiently and easily collapsed and unfolded[1]. But there is another constructive paper art in Far East Asia that has received less attention: kirigami, in which paper is cut into intricate patterns. This approach often involves folding too: the archetypal kirigami form is a scene, often a building, made from strips and facets that emerge from the hinge of a folded sheet.

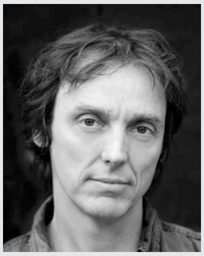
Although kirigami is essentially of Japanese origin, it has long been familiar throughout the world in the form of the snowflake decoration made by folding and nicking a sheet (a method sadly apt to yield snowflakes with four-fold rather than six-fold symmetry). Paper-cut snowflakes — simply outlines rather than genuine kirigami — featured in one of the first serious studies of their forms, *Cloud Crystals* (1864) by the keen-eyed American amateur Frances Chickering.

Kirigami has, however, so far enjoyed scant attention in materials science — among rare examples, there has been interest in applying its methods at the nanoscale to graphene to alter its mechanical properties[2,3]. Now, Cho *et al.* have attempted to give kirigami engineering a more systematic conceptual basis[4]. They describe a general approach for enabling a sheet of flexible material to adopt an arbitrary geometry by reverse-engineering the system of cuts needed to attain it. No folding is employed here: the deformations of the sheet come solely from making a series of slits that fragment the sheet into smaller blocks connected at their corners, which will then rotate under tension so that the blocks open out into an expanded network.

In general these blocks might be squares or triangles. Their rotation depends on leaving a small amount of material at the ends of the cuts, and on these hinges being sufficiently flexible to deform while strong enough not to simply tear. The design parameters here are material-dependent: the researchers demonstrate their ideas with elastomeric sheets, but say that metals might be used if the hinge stresses can be kept below the yield strength.

The amount of expansion of the fabric (shown here to reach up to 800%) can be adjusted by imposing a fractal hierarchy on the cuts. Each square block, say, can be divided into smaller squares and so forth. By varying the degree of the hierarchy from place to place, the sheet can adopt all kinds of curved grid-like geometry, including non-Euclidean ones. As a demonstration, Cho *et al.* cut a silicone rubber sheet, coated with a layer of carbon nanotubes to make it electrically conducting, so that it can be wrapped around a baseball without wrinkles while retaining the connectivity that enables it to wire up a light-emitting diode across the ball's surface.

There is an echo here of the reverse problem of projecting the Earth onto a flat world map. Cho *et al.*'s method of covering a sphere with a sheet is certainly more elegant than the ungainly Goode homolosine cartographic projection, with its awkward rents in the oceans — but at the considerable cost, perhaps, of fragmenting the surface into countless little pieces. ❒



PHILIP BALL

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