

Ice templates define porous ceramics

CERAMICS

Controlling the size and morphology of pores can be a critical factor in the production of ceramic biomaterials. Researchers from Lawrence Berkeley National Laboratory (LBNL) have shown how ice crystals can be used to define multilayered porous alumina structures [Deville *et al.*, *Acta Mater.* (2007) 55, 1965].

Freeze casting is used to achieve this control. As aqueous ceramic slurries are frozen, columns of ice grow and particles from the slurry are trapped between them. Sintering then leaves a solid ceramic material with pores that replicate the ice structure. By manipulating the freezing conditions and the starting slurry, it should be possible to tailor the microstructure of the end-product.

Eduardo Saiz and colleagues performed their freeze-casting experiments on aqueous alumina slurries of varying concentrations. They observed that homogenous freezing produces a lamellar porous architecture with long-range order, both parallel and perpendicular to the ice front. The microstructure of the sintered material is influenced by the volume of water in the starting suspension; lamellae are not produced from slurries with a high (>80 wt.%) ceramic content. In addition, the faster the freezing speed, the finer the microstructure produced. "Using very fast freezing we can get ~1-2 μm lamellas. This is of the order of the CaCO_3 layers in nacre," says Saiz. The LBNL team now aims to make model hybrid inorganic/organic and metal/ceramic materials by infiltrating freeze-cast porous materials with a second phase. They are also using the ice template approach to fabricate hydroxyapatite scaffolds for osseous bone tissue engineering.

Paula Gould

Shape-shifting material under the spotlight

MECHANICAL BEHAVIOR

Japanese chemists at Osaka City and Kyushu Universities have prepared molecular crystals that show very rapid shape changes under ultraviolet (UV) light, which reverse when exposed to visible light [Kobatake *et al.*, *Nature* (2007) 446, 778]. The speed and repeatability of the change in shape opens up the exciting possibility of actuators that can be operated remotely using light.

"[These materials] may find applications as microtweezers to move cells or devices to control the flow in microreactors," says Masahiro Irie of Kyushu University.

The researchers investigated thin, rectangular crystals of two different diarylethene compounds. These molecules include azobenzene chromophores that undergo molecular rearrangements under light, switching between *trans* and *cis* forms. While light-deformable films and gels have previously been created from azobenzene-containing polymers, their response takes seconds or even minutes. In contrast, the molecular crystals change shape in just 25 μs . The UV photoisomerization reaction leads one compound to go from a square to a lozenge shape, while a single crystal of the other compound contracts

in size by ~5-7%. The initially open-ring compounds transform into closed-ring isomers, leading to a change in color – the crystals become blue or violet rather than transparent. The molecular motion alters the crystal packing to give a large change in the crystal lattice. The deformed crystals are thermally stable and revert to their original form under visible light. "The isomerization of molecules at the molecular level is amplified to the bulk mechanical work of the crystals, just as with muscles in biological system," explains Irie.

Rod-like crystals could be made to bend and relax repeatedly in response to cycles of UV and visible light. The power produced during bending is even sufficient to move Au microparticles.

"Light-induced changes in the shape and color of materials are well-known in materials science," comments Bruce Garetz of Polytechnic University. "What makes these diarylethene single crystals remarkable is the stability of the deformed state, the reversibility of the deformation through many cycles, and the high speed of the process," he told *Materials Today*.

Jonathan Wood

Just add water for polymer origami

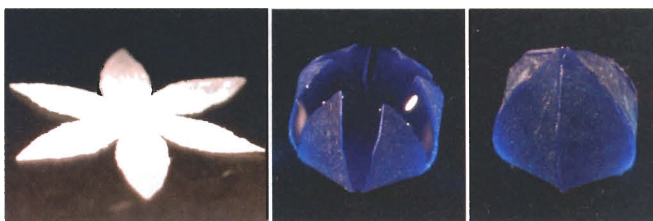
POLYMERS

Researchers from the École Supérieure de Physique et de Chimie Industrielles (ESPCI) and the École Polytechnique in France have devised a simple way to turn polymer membranes into

predefined three-dimensional shapes [Py *et al.*, *Phys. Rev. Lett.* (2007) 98, 156103]. Their technique, which relies on elastic sheets folding around evaporating water drops, could be used to mass produce micro- or nanoscale objects.

"We knew that capillarity could bend very flexible structures," says Charlotte Py. "For instance, the way wet hair assembles into clumps is because of capillarity. It is also responsible for causing damage in nanotechnologies, when small components come into contact with moisture and collapse. We wanted to use this same effect to create something."

The team created three-dimensional structures from 40-80 μm thick polydimethylsiloxane (PDMS) membranes. They manually cut a variety of millimeter-sized geometrical



Polymer origami sees a drop of water wrapped up by a PDMS sheet. (Reprinted with permission. © 2007 American Physical Society.)

shapes from the PDMS layers and placed these on a superhydrophobic surface. A droplet of water (1-80 μl) was deposited on the center of each shape and allowed to evaporate

at room temperature. As the water volume decreases, the elastic membrane is pulled closer around the shrinking drop by existing surface tension.

Sufficiently thin sheets can enclose the liquid completely, retaining the resultant three-dimensional structure once all water has evaporated. Each shape is determined by the initial pattern of the cut PDMS. For example, a cross-shaped net leads to a cube, while a flower-like shape folds up into a sphere-like structure (as shown above).

The technique could be used to fabricate large quantities of three-dimensional structures for microelectromechanical systems (MEMS), or to activate MEMS actuators, says Py.

Paula Gould