$LaSr_2Mn_2O_7$, which has recently received significant attention due to its colossal magnetoresistance, charge compensation is achieved by the ability of the manganese atom to participate in the compound either as Mn^{3+} or as Mn^{4+}. Another example is oxide high-temperature superconductors. In these, the induction of hole-type charge carriers in the so-called infinite layer CuO_2/Ca/CuO_2 subunits either by a variable oxygen content or by the partial substitution of cations with a lower valence in the doping layers guarantees charge neutrality. Similar to the charged mixed-valence TiO_2 layer at the n-type $LaAlO_3$/$SrTiO_3$ heterointerface[2], the occurrence of conducting CuO_2 layers in high-temperature superconductors is based on the ability of the Cu cation to vary its formal valence from less than +2 to about +2.4. Therefore the method of atomic-scale EELS analysis successfully demonstrated by Nakagawa *et al.* also offers invaluable potential for the investigation of the charge transfer within these naturally layered oxide materials.

Such atomic-scale tailoring and atomic-scale analysis of oxide structures provides an opportunity to find intelligent solutions for interface problems that are otherwise difficult to solve in conventional semiconductor electronics. The great advantage is the large elemental and structural flexibility of perovskite-related materials as well as the fact that there exists a whole variety of different cations with variable valences, such as Ti, Nb, Ta, Bi, Tl, Cu, Ru, Mn, Fe, Co and Ni. Apart from their potential towards 'oxide electronics', atomically engineered polar interfaces offer the possibility to produce unusual low-dimensional charge states with a variety of interesting electronic properties, for example, two-dimensional electron gases. The difficulty remains to avoid structural defects such as grain boundaries, dislocations, stacking faults and other local disorder. Such defects can be highly conductive in some cases[3], leading to dramatic modifications of the electronic properties of nanoelectronic devices especially when their size decreases. Nevertheless, with their revealing investigation, Nakagawa *et al.* take a great step not only towards a quantitative understanding of perovskite interface structures, but also towards a deliberate control of interfacial electronic properties. Their study can be considered a landmark in modern quantitative atomic-resolution electron microscopy.

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MATERIAL WITNESS

Cold comfort

The use of ice formation to produce biomimetic microstructures in ceramic materials (S. Deville *et al.* *Science* 311, 515–518; 2006) is not only an ingenious exploitation of spontaneous self-organization, but a reminder of the potential value of ice to materials scientists.

Deville and colleagues show that the crystallization of ice platelets as water freezes, coupled with the expulsion of solute particles from the ice phase, can be exploited to create porous and lamellar structures toughened in the same way as natural hard materials such as nacre. The researchers froze concentrated suspensions of ceramic microparticles to produce layered ceramic/ice composites. The ice was subsequently removed by freeze drying, and the space filled with a second phase such as epoxy resin or metal. These composites are toughened by deflection of cracks due to delamination at the interfaces. Applying this technique to a slurry of hydroxyapatite powder generated a material four times stronger than conventional porous hydroxyapatite, which could act as a bone substitute.

Here, ice is acting as a self-organizing, removable template. But it's tempting to speculate that the layered ice composite might itself have interesting mechanical properties. For as well as ice determining the morphology of the suspended material, the reverse can be true. The most striking example of this was discovered in 1942 in an extensive and almost unique investigation of ice as a structural material.

This was Project Habbakuk, one of the most extraordinary examples of how war can fertilize technological creativity (L. W. Gold *Interdiscipl. Sci. Rev.* **29**, 373–384; 2004). Habbakuk is often regarded now as a quixotic act of lunacy, but at the time it was supported by Winston Churchill and engaged leading scientists including J. D. Bernal and Max Perutz. The project was the brainchild of Geoffrey Pyke, an eccentric scientific adviser to Britain's war office. He proposed that aircraft carriers might be constructed cheaply from ice, which would be extremely resistant to explosives. This led to testing of the mechanics of ice beams in Canada in 1943, laying the foundations for much of the current understanding of ice as a material (E. M. Schulson *JOM* **51**, 21–27; 1999).

It's a curious substance — plastic and ductile at low strain rates (that's why glaciers flow) but brittle at higher rates. Tests of how the strength of ice could be enhanced by additives involved cardboard, clay and cloth, but the best material was wood pulp. This was partly a result of crack arrest in a manner similar to Deville's composites; but Bernal pointed out that it could also be due to changes in the grain shape and size of ice, an effect known in metals. The composite was named Pykrete.

Project Habbakuk came to nothing; but the construction of oil rigs, roads and airstrips on ice-cover leaves ample reason to be interested in ice mechanics. Pykrete didn't win the war, but it deserves to be taken seriously.

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