to fit the nucleus of the cubic polymorph (Fig. 2b). Conversely, the nucleus of a triclinic crystal would be a poor fit to pores with right-angled corners because the crystal would need to incorporate either strain or defects. As a consequence, right-angled pores should selectively favour nucleation of the cubic polymorph. Another application of nanopatterned surfaces may be found in surface-induced ice nucleation. On the basis of work on rough surfaces, it is reasoned that sticky and entropic and enthalpic constraints, as well as on physicochemical variables, will certainly lead to further insights into the hardening mechanism, which remains to be fully understood.

The incorporation of organic materials in a crystal host is a non-equilibrium process that strongly depends on kinetic, entropic and enthalpic constraints, as well as on physicochemical variables, including the occlusions’ size, shape, surface chemistry and (possibly) rigidity. In addition, the properties of the host crystal need to be taken into account. As established by earlier work with smaller additives, near-equilibrium crystal growth rates are sufficiently slow that the chemistry of the additive material is a key factor in determining its crystallographic location and orientation. More recently, larger materials, such as polymers and proteins, have also been shown to be selectively incorporated onto specific crystal facets. For these systems, experiments with in situ atomic force microscopy are unravelling...
the underlying mechanisms leading to the observed morphology, including various instabilities in the crystal growth front when macromolecules bind to step edges. However, as the size of the additive increases beyond the dimensions of the unit cell of the host crystal, the role of surface chemistry seems to diminish and incorporation becomes significantly less dependent on the specific crystal lattice. For example, when either carboxylate-functionalized polymer particles (200–250 nm) or neutral agarose hydrogel fibres (10–20 nm) are trapped within single crystals, incorporation is random along the crystallographic directions. In the context of those studies, the inclusion of 20-nm anionic micelles achieved by Kim and colleagues is surprising. Despite the fact that they are similar in size to the hydrogel fibres and in surface chemistry to the polymer particles, the micelles selectively adsorb on specific crystal facets. This result shows that the right combination of surface chemistry, size and rigidity can lead to the oriented incorporation of objects larger than previously thought possible. However, further understanding of the interplay of the relevant factors involved in the mechanism of incorporation, including the kinetic competition between crystal growth and adsorption of organic material, is needed to determine design criteria for the pairing of host crystals with occlusion materials that achieve a desired degree of inclusion and crystallographic selectivity.

In the future, bio-inspired synthetic approaches such as that of Kim and co-authors could be used to tune the mechanical properties of inherently brittle inorganic single crystals and to obtain a better understanding of the microscopic origin of the enhanced mechanical properties of the organic–inorganic composites. We foresee the application of synthetic approaches to a variety of host crystals and occlusion materials with electronic, phononic or magnetic properties, eventually leading to functional, nanostructured, single-crystal components.

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### References


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### QUANTUM INFORMATION

**Noisy neighbours under control**

The ability to control the nuclear spins in a semiconductor quantum dot is an important step towards a long-lived and controllable electron spin qubit.

**Guido Burkard**

The solid state has been the arena for numerous demonstrations of quantum mechanical effects. Lately, coherent control of single quantum systems has been achieved in a variety of systems, including single atoms and photons, as well as solid-state systems. One example of a two-state quantum system is the spin of an electron, which constitutes an interesting realization of a quantum bit (qubit). In solid state, the interaction between two qubits can typically be made strong rather easily, which is a big advantage if one aims to construct a quantum information processor. The disadvantage, however, is that solid-state qubits tend to interact with a high number of other particles in their environment, which essentially results in...