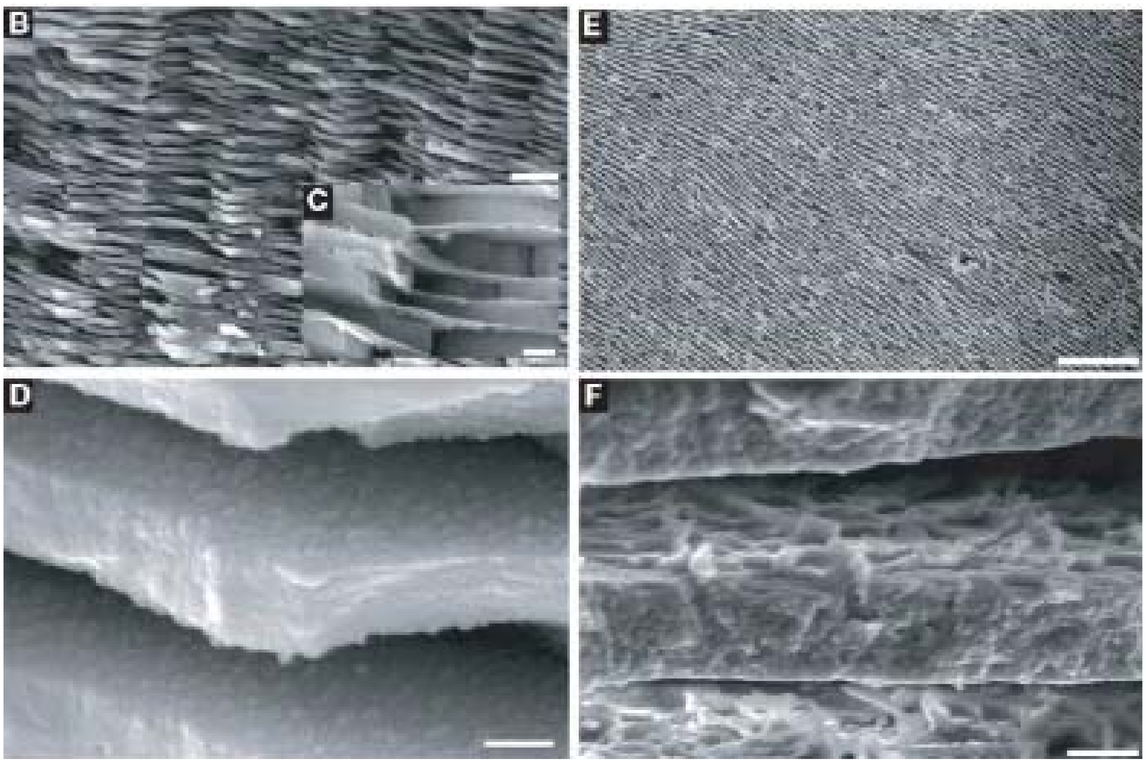
Freezing as a Path to Build Complex Composites

Materials that are strong, ultra-lightweight, and tough are in demand for a range of applications, requiring architectures and components carefully designed from the micrometer down to the nanometer scale. Nacre, a structure found in many mollusk shells, and bone are frequently used as examples for how nature achieves this through hybrid organic-inorganic composites. Unfortunately, it has proven extremely difficult to copy nacre-like clever designs into synthetic materials, partly because their complicated structures need to be imitated at several length scales. A group of scientists at Lawrence Berkeley National Laboratory has demonstrated how the physics of ice formation can be used to develop sophisticated porous and layered-hybrid materials, including artificial bone, ceramic-metal composites, and porous scaffolds with strengths up to four times higher than those of materials currently used.



In the above figure natural nacre has a brick-mortar-bridges microstructure where inorganic calcium carbonate layers are held together by organic protein ''glue'' (B and C); with the roughness of the inorganic walls (D) a key provider to the final mechanical properties of nacre. The layered microstructure of the ice tempered dense composites resembles that of nacre (E). The particles generate a characteristic roughness on the lamella surface (F) that mimics that of the inorganic component of nacre. Scale bars indicate (B) 5 mm, (C) 0.5 mm, (D) 0.3 mm, (E) 300 mm, and (F) 10 mm.

Deville, S., Eo Saiz, RK Nalla, AP Tomsia, *Science*, 2006, 311(27), 515-518.6

Contributing Agencies: NIDCR and DOE