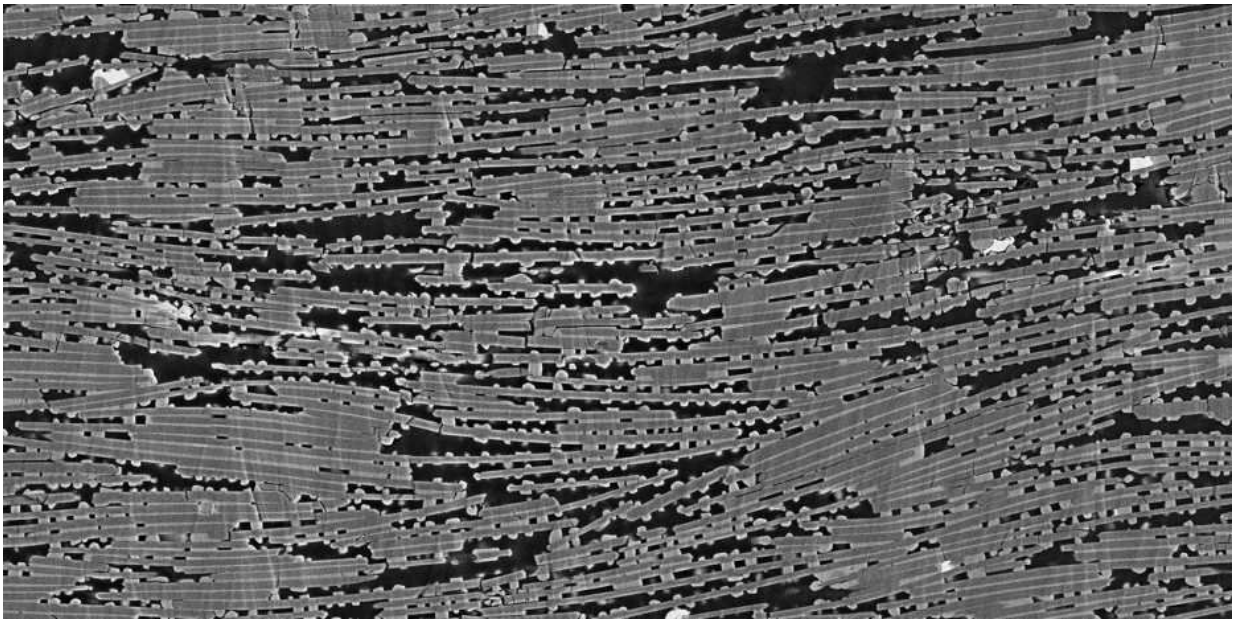
Custom-made artificial mother-of-pearl

December 10 2018, by Peter Rüegg



A cross-section of a mother-of-pearl imitation shows that at temperatures of 800 degrees Celsius and above, nubs form between the platelets, which solidify the material. Credit: Kunal Masania / ETH Zurich

Natural mother-of-pearl, such as mussels, is one of the hardest, most stable and stiff natural materials. Researchers have always been fascinated by it. The structure of mother-of-pearl is exquisite under the electron microscope; it looks like a miniature brick wall, the joints of which are filled with mortar. The bricks are composed of tiny Calcium carbonate plates stacked on top of each other and interconnected with mineral bridges, and filled with a mortar composed of an organic

substance.

ETH researchers from the Group for Complex Materials led by André R. Studart have been investigating and imitating this structure. The materials scientists use a special process developed by them to produce such mother-of-pearl-like materials.

They use commercially available aluminum oxide plates a few dozen micrometers in size and an epoxy resin that acts as a joint cement. In a rotating magnetic field, the researchers align the magnetized plates dissolved in aqueous solution as desired in one direction, and under high pressure and temperatures of around 1000 degrees Celsius they solidify the material with the addition of a resin. This results in a composite material with similar microstructure to natural mother-of-pearl.

Bridges strengthen structure

In order to make the artificial mother-of-pearl even more stable and harder, the team now used such plates coated with titanium oxide. Titanium oxide begins to melt at around 800 degrees, which is a lower melting point than aluminium oxide. Titanioum oxide droplets form on the surface of the platelets and turn into bridges, thus strengthening the entire structure. "These bridges also influence significantly, the strength of the material," says Kunal Masania, co-author of a study that has just been published in the technical journal *PNAS*.

The density of these titanium bridges can be precisely adjusted by pressure and temperature, to produce artificial mother-of-pearl with the desired physical properties such as stiffness, strength and fracture toughness. With the help of a model and experiments, the researchers calculated which pressure and temperature conditions promote the formation of the respective properties that are comparable in stiffness to carbon-fibre composites. With this, the team have established a new

world record in combining stiffness, strength and toughness in this type of bio-inspired material.

With the newly developed technology, mother-of-pearl-like materials can be produced that have tailor-made properties for the respective application. Possible applications include construction, aircraft and space.

More information: Madeleine Grossman et al. Quantifying the role of mineral bridges on the fracture resistance of nacre-like composites, *Proceedings of the National Academy of Sciences* (2018). DOI: 10.1073/pnas.1805094115

Provided by ETH Zurich