# BULK SUPERCRYSTALLINE CERAMIC-ORGANIC NANOCOMPOSITES: NEW PROCESSING ROUTINES AND INSIGHTS ON THE MECHANICAL BEHAVIOR

Diletta Giuntini, Hamburg University of Technology (TUHH), Hamburg, Germany
diletta.giuntini@tuhh.de
Berta Domènech, Hamburg University of Technology (TUHH), Hamburg, Germany
Büsra Bor, Hamburg University of Technology (TUHH), Hamburg, Germany
Alexander Plunkett, Hamburg University of Technology (TUHH), Hamburg, Germany
Gerold A. Schneider, Hamburg University of Technology (TUHH), Hamburg, Germany

Key Words: Supercrystal, Nanocomposite, Ceramic, Hierarchical Material, Mechanical Behavior.

In the strive to produce nature-inspired hierarchical materials with an enhanced combination of mechanical properties, supercrystalline ceramic-organic nanocomposites have been produced in bulk form and characterized from a variety of perspectives. Through an interdisciplinary collaboration at the crossroad between materials science, chemistry and mechanical engineering, a bottom-up approach has been designed. It consists of a sequence of self-assembly, pressing and heat treatment, and it leads to macroscopic poly-supercrystalline materials with exceptional mechanical properties and behavior. The crosslinking of the organic phase induced by the heat treatment does not only increase the materials' stiffness, hardness and strength (elastic modulus up to 70 GPa, hardness up to 5 GPa and bending strength up to 630 MPa), but alters also their constitutive response. Fracture toughness values higher than theoretical predictions have emerged (~ 1 MPa·m$^{1/2}$), implying the presence of extrinsic toughening mechanisms, such as the crack-path deviation observed at indents' corners. Ex-situ nanoindentation and in-situ SAXS/microcompression studies also suggest the possibility for supercrystalline materials to accommodate compressibility and plastic-like deformation. Defects analogous to the ones typically observed in crystalline lattices, such as stacking faults, dislocations and slip bands, are detected at the superlattice scale (even if one order of magnitude larger than the atomic one, and with interactions among the nano-building blocks controlled by the organic phase). Correlations between defects, processing and mechanical properties have been drawn by adapting the classic theories of mechanical behavior of materials. These same materials are additionally being used as bricks for the development of novel hierarchical composites, via additive manufacturing or fluidized bed techniques.

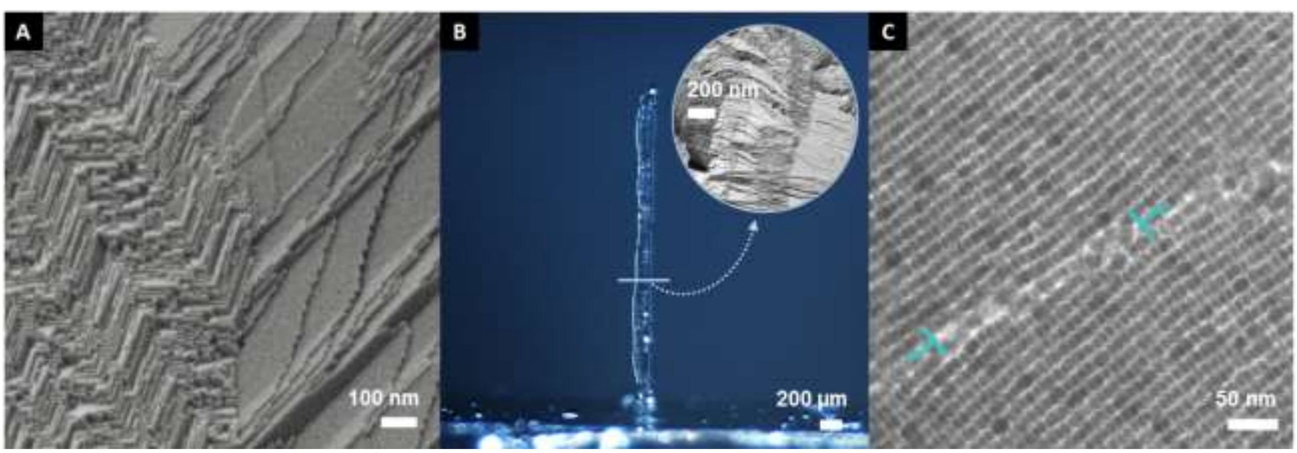


*Figure 1 – (A) Structure of poly-supercrystalline nanocomposite; (B) 3D-printed supercrystalline pillar and its nanostructure; (C) edge dislocations inside bulk supercrystal.*