

A new concept of ultralow density material, Shellular

Abstract

A new ultralow density material (ULDM) named Shellular was introduced recently. Main features of Shellular are the structure of thin continuous smooth shell and superior mechanical properties at density lower than 10^{-2} Mg/m^3 due to its hierarchical architecture. Shellular is supposed to have a configuration of the Triply Periodic Minimal Surfaces (TPMS). TPMS, first discovered by Hermann Schwarz in 1865, has zero (or a constant) mean curvature over the entire surface. TPMSs are regarded as ideal shapes for thin shell architectures with periodicity, because thin shell in a TPMS is not likely to have a stress concentration due to geometrical irregularity, but rather, it supports an external load by coplanar stresses without causing bending due to the zero-mean curvature over the configuration. Hence, the thin shell in a TPMS is another stretching dominate structure in addition to truss cellular materials. Shellular is fabricated as follows: a polymeric template is first formed, followed by the conformal deposition of hard materials on the surface; and then a hollow structure with a micron or submicron wall thickness is then finally etched out of the template. In this lecture, three processes used to form the templates for Shellular, based on 3D UV lithography, bead-arrangement, and wire-weaving are described. The compressive behaviors are evaluated by experiments and analysis in comparison to the predecessors.