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Tesselation – a natural strategy for improving fracture resistance

Surface tiling or three-dimensional tessellation are well-known ways of filling surfaces or volumes, respectively, for example in brick-and-mortar arrangements. Similar strategies are used by Nature at the microscopic level and even at the nano-scale to assemble materials with excellent fracture resistance, based on comparably weak components[1]. Best known is the widely studied nacre found in some sea shells, but the principle is much more general and nearly omnipresent in skeletons of vertebrates, in insect cuticles or tough protein-based fibers. Tesselated materials often result from a step-wise assembly and – in addition to improved fracture properties as compared to a homogenenous bulk-like material – they may have a range of interesting mechanical behaviors including actuation[2] and mechanosensing with extreme sensitivity[3]. For periodic multilayers, the simplest version of a tessellation, one can define a criterium according to which strength and damage tolerance are considerably improved with respect to the homogenous bulk[4]. Rotational plywood structures that are found in many biological materials, such as bones or insect carapaces, follow similar rules[5] and are critical for reducing fracture resistance in bone[6]. Since the fabrication of graded materials is becoming more economical with advances in 3d-fabrication, one can foresee that tessellated materials may become an interesting direction for materials development.

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