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Forming Functions by Microarchitectural Organization in Biological Materials

Integration of variant functional properties has been an abiding challenge for engineering materials, wherein adding a new function often comes with adding new materials with different chemical composition introducing heterogeneities and mismatches to the structure. From a materials perspective, heterogeneities and mismatches are known as prime sources of structural complexity and defect. Biological materials have been a prominent source of inspiration for materials scientists and engineers to conquer the challenges in developing high-performance materials. One recent inspiration has been drawn by looking at how biological materials remarkably attain "multi-functionality", wherein mechanical, optical, and surface properties can co-exist and provide "self-responsiveness" to environmental factors yet relying on limited building blocks and minimum variations in elemental composition.

The key foundation of these achievements can be found in the ways that biological materials are crafted. In stark contrast with engineering materials, biological materials are formed through an organic-assisted bottom-up assembly and growth mechanism. This bottom-up formation allows an artful modulation of ultrastructural components and controls the packing and organizations of building blocks in different length scales, providing a toolbox for introducing heterogeneities in the architectural arrangement of building blocks (rather than chemical modifications). Remarkably, nature is honed to adapt and utilize such hetero-architectures to achieve promising multifunctional properties. In this talk, by introducing a series of functional microarchitectures in biological models, from multi responsive plants to self-damage-regulating and transparent biogenic ceramics, I present how functions can be encoded by microarchitectural organization and how functional responses to external stimuli can be site-specifically regulated. Incorporation of these material design strategies into additive manufacturing techniques can cater to the growing needs for the development of self-responsive and self-sustaining multifunctional materials.

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