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Bioinspired Hierarchical Materials for Superior Toughness and Strength

By

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Abstract

Load-bearing biological materials such as shell, mineralized tendon and bone generically exhibit staggered structure at nanoscale, and 2-7 levels of structural hierarchy from nanoscale, to micro-scale and macro-scale. With these fabulous structures, the biological materials achieve superior mechanical performances, especially compared to their constituent materials, i.e., brittle minerals and soft proteins. Two key questions about the architectures of load-bearing biological materials remain unanswered or answered not enough: why staggered structures are selected by nature and what determines the number of hierarchical levels in these materials. To address the first question, we developed a universal framework to characterize the mechanical properties of arbitrary microstructures, and showed that staggered structures can provide superior overall properties including stiffness, strength and resilience. For the second question, we developed a quasi-self-similar hierarchical model and showed that, depending on the mineral content, there exists an optimal hierarchy for maximal toughness of load-bearing biological materials. These studies are helpful not only to understand the structure-property relationship in

biocomposites but also to design bio-inspired green (environment-friendly) or super strong materials.

Biography

Dr. Zhang is a Professor of Department of Engineering Mechanics, Wuhan University (WHU). He received his B.Eng. degree from WHU in 2003, and M.Eng. and Ph.D. degrees from Tsinghua University (THU) in 2008. From 2008 to 2014, he had worked as a Scientist and Independent Investigator at Institute of High Performance Computing, Singapore, and also had worked as a visiting scholar at Brown University, USA. From 2014, he joined Wuhan University as a professor. Dr. Zhang has published more than 20 research papers and has been cited over 300 times. He is a member of several international research societies, including International Association of Computational Mechanics and MRS, etc. He serves as a reviewer for more than 10 international journals, including JMPS, PNAS, Nature Communication, Nano Letter, APL, and etc. His research interest mainly focus on Biomechanics and Biomimetics, Nano-/Micro-structured Composites, Multi-scale Computational Mechanics, and etc.

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