Markus Buehler
CEE, MIT

Biomaterials by design - modeling, synthesis, testing

Biological materials exhibit architectures at multiple length scales that give rise to exceptional properties such as mechanical resilience, mechanomutability and multifunctionality. We show how modeling has led the way to identifying the core principles that link the molecular structure of biomaterials at scales of nanometers to macroscopic length-scales through hierarchical structures. Exploiting these insights, we report a joint computational-experimental analysis to emulate biological composites, incorporating simple and fragile base materials to create synthetic composites with superior fracture mechanical properties. We use multi-material 3D printing to create specimens of our computer models and perform complementary laboratory testing. Our model predictions of fracture mechanisms and trends of the mechanical properties are in good agreement with the experimental findings. We also review recent work on the design of de novo silk materials, integrating a multiscale modeling and experimental approach towards the development of materials designed from the molecular scale upwards.