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Toughening and energy-dissipation in metamaterials

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Lattice metamaterials have been shown to exhibit a number of beneficial properties, ranging from acoustic damping to negative Poisson response. Now, with the proliferation of additive manufacturing technologies, such structures are becoming more accessible and cost-effective. However, as previously observed in metal foams and nanoporous materials, the observed toughness of low-density materials tends to be far inferior to the constituent material. According to Gibson-Ashby scaling, such structures are expected to suffer a precipitous drop in fracture toughness as the relative density decreases. Moreover, manufacturing heterogeneities can cause a minority of weakest struts to trigger a localization that propagates to structural failure. In this presentation, we discuss strategies to architect toughening mechanisms that protect from localization or dissipate energy in novel ways, breaking free from Gibson-Ashby limits. In this talk, we honor Rob Ritchie's extensive mastery and use of fracture toughening mechanisms, in systems ranging from teeth to high entropy alloys.

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