Fall 2017 Joint Colloquium
Materials Department & Materials Research Laboratory

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11:00 am, Elings 1601

Damage-Tolerance in Engineering and Biological Materials

The ability of a material to undergo limited deformation is a critical aspect of conferring toughness as this feature enables the local dissipation of high stresses which would otherwise cause the material to fracture. The mechanisms of such deformation can be widely diverse. Although plasticity from dislocation motion in crystalline materials is most documented, inelastic deformation can also occur via *in situ* phase transformations in certain metals and ceramics, sliding of mineralized collagen fibrils in tooth dentin and bone, rotation of such fibrils in skin, frictional motion between mineral "platelets" in seashells, and even by mechanisms that also lead to fracture such as shear banding in glasses and microcracking in geological materials and bone. Resistance to fracture (toughness) is thus a compromise - a combination of two, often mutually exclusive, properties of strength and deformability. It can also be considered as a mutual competition between intrinsic damage processes that operate ahead of the tip of a crack to promote its advance and extrinsic crack-tip shielding mechanisms that act mostly behind the crack tip to locally diminish crack-tip stresses and strains.

Here we examine the interplay between strength and ductility and between intrinsic and extrinsic mechanisms in developing the fracture toughness of (i) high-entropy alloys, where a synergy of dislocation and twinning mechanisms results in marked strain hardening to simultaneously create strength and ductility, (ii) bulk-metallic glasses, where the promotion of shear banding from local sites of unstable short-range order may provide the origin of ductility in these hard alloys, and (iii) in biological and natural composites where intrinsic toughening at the nanoscale is complemented by extrinsic toughening at micro- to near macro-scales.

Bio

Robert O. Ritchie is the H.T. & Jessie Chua Distinguished Professor of Engineering at the University of California, Berkeley, and Senior Faculty Scientist at the Lawrence Berkeley National Laboratory. He received M.A., Ph.D. and Sc.D. degrees in Physics/Materials Science, all from Cambridge University. He is known for his research into the mechanics and micro-mechanisms of fracture and fatigue of a broad range of structural and biological materials, where he has provided a microstructural basis for their damage-tolerance and fatigue resistance. He is a Fellow of the Royal Society and the Royal Academy of Engineering in the U.K., the U.S. National Academy of Engineering, the Russian Academy of Sciences and the Royal Swedish Academy of Engineering Sciences.

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