Microstructural Understanding of the Mechanical Properties of High-Entropy Alloys

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High-entropy alloys comprise a novel class of scientifically and technologically interesting materials in which "solute" and "solvent" atoms cannot be defined in the conventional sense. Their mechanical properties are fascinating because some of these compositionally complex alloys defeat the usual strength-ductility tradeoff and exhibit simultaneous increases in strength, ductility and fracture toughness as the temperature is decreased, even down to the cryogenic range. I will summarize what we have learned about the mechanical properties of a model FCC high-entropy alloy, and its derivative, single-phase, medium-entropy cousins. Among the topics to be covered are: fundamental deformation mechanisms including slip and twinning; critical resolved shear stresses for these processes and the effects of composition and temperature on their magnitudes; and dislocation structures, Shockley partial separations and stacking fault energies. I will show that our experimental results help explain some of the observed mechanical properties (high work hardening rates and ductility). However, much still remains to be done to explain certain other aspects (e.g., composition dependence of strength).