Impact resistance of high-entropy alloys

Zezhou Li, Shiteng Zhao, Senhat Alotaibi, Marc Meyers — *University of California, San Diego*

Bingfeng Wang, Yong Liu, — *Central South University*

Haoyan Diao, Peter Liaw — *The University of Tennessee, Knoxville*

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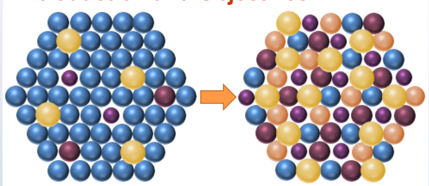
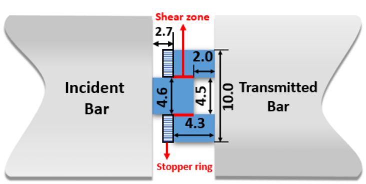
Introduction and Objectives



Conventional alloys *High-entropy alloys*

High-entropy alloys (HEAs) are equiatomic, multi-element systems that can crystallize as a single phase, despite containing multiple elements with different crystal structures.

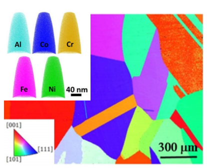
Dynamic testing

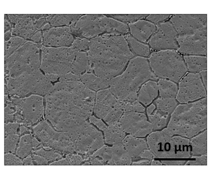


Experimental Set-Up: Split Hopkinson Pressure Bar

Adiabatic shear localization is recognized as an important failure mechanism of materials and is produced by the temperature rise in a narrow region, especially formed under high strain-rate deformation.

Microstructure

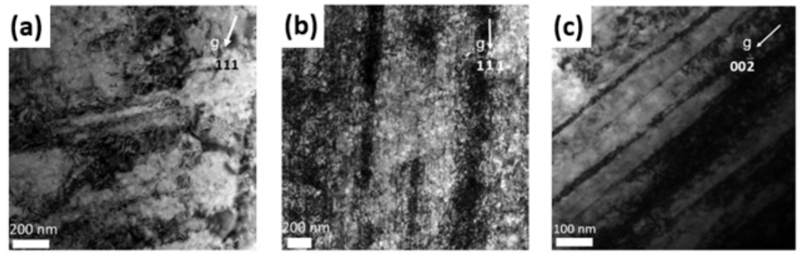




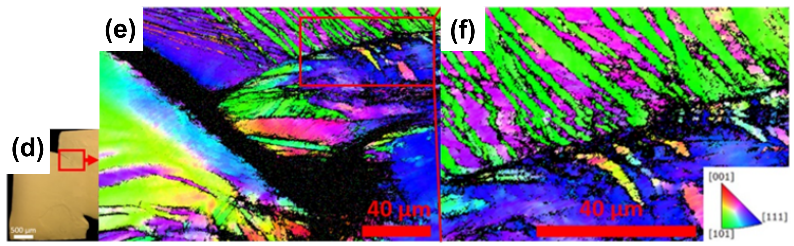
$Al_{0.3}CoCrFeNi$ HEA *CrMnFeCoNi HEA*

$Al_{0.3}CoCrFeNi$ HEA has high densities of annealing twins and coarse-grained CrMnFeCoNi HEA obtains average grain size ~10 µm. These two kinds of single phase (fcc) high-entropy alloys were subjected to dynamic loading to examine their dynamic properties, such as dynamic strength and shear localization.

Impact resistance of the $Al_{0.3}CoCrFeNi$ high-entropy alloy



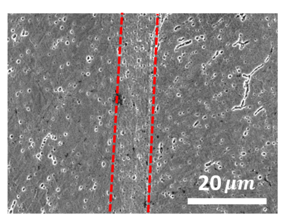
Dislocation Generation (10^{-4} s^{-1}) Entangled dislocations and deformation twins (1800 s^{-1})

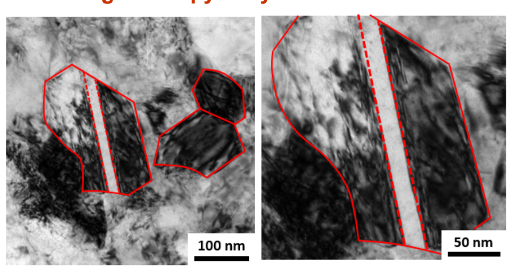


Deformed specimens Continuous deformation-twinning hardening near the inserted tip

The combination of multiple strengthening mechanisms such as solid-solution hardening, forest dislocation hardening (Figs. 2(a) and 2(b)), as well as mechanical twinning (Figs. 2(c)) leads to a high work-hardening rate in this alloy. No adiabatic shear band could be observed at a shear strain ~1.1 as depicted in Fig. 2(d). Figs. 2(e) and 2(f) show the formation of profuse mechanical twins near the inserted tip in the hat-shaped specimen, indicating twinning-induced continuous strain-hardening, which suppresses shear localization in competition with the thermal softening effect.

Impact resistance of the CrMnFeCoNi high-entropy alloy

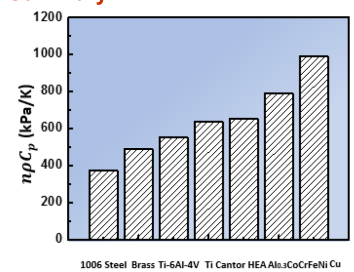


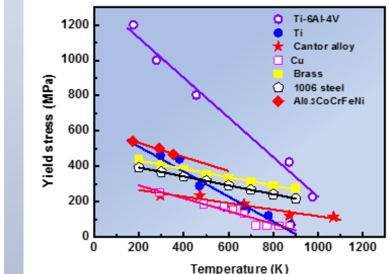


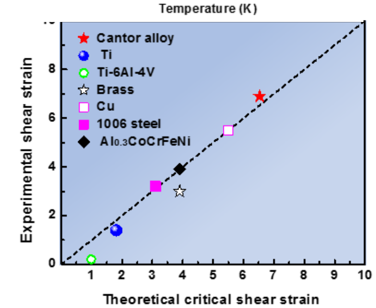
Shear band formed at a large shear strain ~7 Nanocrystalline grains formed inside the shear band

The evolution of plastic deformation, coupled with temperature rise inside the shear band, leads to the formation of a dislocated/twinned microstructure that breaks up the initial coarse-grained grains into small regions.

Summary







The combination of excellent strain-hardening ability and modest thermal softening gives rise to remarkable resistance to shear localization, which makes fcc HEAs an excellent candidate for impact resistance applications.

Acknowledgements

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