# Hierarchical heterostructure induces high entropy alloy to achieve high strength and ductility

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**Abstract** Heterostructures have achieved surprising performance in breaking the strength-ductility trade-off. In this paper, we successfully introduced hierarchical multiple component microstructure into the newly designed dual-phase (FeCoNiV)96Al3Ti alloy by tuning composition and adjusting thermal-mechanical process, including heterogeneous precipitation of fine B2 (~220 nm) precipitates in the L12 matrix. Within B2 island, there are L12 grains (~722nm) and B2 grains (~900nm) with small grain size, among which the B2 grains have a fine microstructure of spinodal decomposition (~17 nm). This hierarchical multiple hetero-structures result in (FeCoNiV)96Al3Ti alloy achieving extraordinary combination of strength and ductility at both 298 K and 77 K, i.e., the ultimate tensile strength of 1750 MPa and the tensile elongation of 22% at 298 K and the ultimate tensile strength of 2100 MPa and the tensile elongation of 26% at 77 K. The remarkable combination of strength and ductility at both cryogenic and room temperatures is attributed to the synergistic effect of multiple deformation mechanisms, namely Orowan-bypass mechanism, stacking faults, and Lomer-Cottrell locks, and nanotwins. This study provides a new approach for tailoring the microstructure of alloys and designing hetero-structured materials.

**Keywords:** High entropy alloy; heterogeneous microstructure; Mechanical properties; Deformation mechanism