

Characterization and Regulation of Local Chemical Orderings in High-Entropy Alloys via 3D Atom Probe Tomography

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With the increase of configurational entropy, the chemical complexity of materials gradually rises. The design philosophy of high entropy alloys (HEAs), based on the concept of entropy, has emerged as a promising approach to achieving the synergistic enhancement of mechanical properties such as strength and ductility. However, the complex atomic environment in these alloys makes the formation mechanisms of sub-microscopic or atomic-scale local structures and their influence on mechanical properties still unclear. This study focuses on three representative systems: high entropy disordered alloys, Nb-based nanocrystalline alloys, and high entropy MAX phase alloys. By integrating three-dimensional atom probe tomography (3D-APT) with advanced transmission electron microscopy (TEM), we investigate the formation and evolution of local chemical ordering (LCO) in different alloy systems. Starting from the atomic scale, we systematically explore the formation mechanisms, thermodynamic origins, and the role of LCOs in regulating defect evolution. Furthermore, we reveal the cross-scaled correlation between LCOs and mechanical properties. This report provides an in-depth analysis and summarizes effective strategies for tailoring atomic-scale structures in various alloy systems, offering new insights into the design of high-performance materials through local-ordering engineering.