DIRECT OBSERVATION OF DISLOCATION PLASTICITY IN FeCrCoMnNi HIGH-ENTROPY ALLOYS

Subin Lee, Max-Planck-Institut für Eisenforschung
s.lee@mpie.de
María Jazmin Duarte, Max-Planck-Institut für Eisenforschung
Michael Feuerbacher, Forschungszentrum Jülich
Christoph Kirchlechner, Max-Planck-Institut für Eisenforschung
Christian Liebscher, Max-Planck-Institut für Eisenforschung
Sang Ho Oh, Sungkyunkwan University
Gerhard Dehm, Max-Planck-Institut für Eisenforschung

Key Words: High-entropy alloys, Dislocation plasticity, *in situ* TEM, Strengthening mechanisms, Friction stress

In the past decade, high-entropy alloys (HEAs) have been intensively investigated not only because of fundamental scientific interests, but also their outstanding mechanical properties, for example, high ductility and fracture toughness. Among hundreds of different combinations of principal elements, the equiatomic FeCrCoMnNi alloy, the so-called Cantor alloy, has been studied as a model system, which is a single phase material with face-centered cubic (FCC) structure at room temperature and shows outstanding ductility and strain hardening especially at cryogenic temperatures.

However, dislocation-based deformation mechanisms of HEAs remain elusive and require a fundamental understanding in order to tailor their mechanical properties. Several models have been suggested possible strengthening mechanisms of HEAs, for instance, the high entropy effect and the lattice distortion effect. In the case of the Cantor alloy, the main strengthening mechanism was identified as deformation twinning with critical twinning stress of 720 MPa. At room temperature, dislocation slip by full dislocations is dominant, however, at strains exceeding 20 % and high flow stresses, deformation twinning was also observed. To reveal the hardening mechanism in more detail, direct observation of dislocation plasticity and deformation dynamics is required.

Here, we present a study correlating the microstructure and dislocation plasticity of a single crystalline FeCrCoMnNi FCC single phase HEA by employing in-situ transmission electron microscope (TEM) compression and tensile deformation. Moreover, an atomic-scale chemical analysis is conducted by aberration-corrected scanning TEM energy dispersive X-ray spectroscopy (STEM-EDS) and atom probe tomography to investigate chemical inhomogeneity, for example, precipitate formation or local inhomogeneity.

Compression tests with sub-micron pillars with 250 and 120 nm diameter show less pronounced mechanical size effects in the alloy compared to other FCC metals as the size exponent is measured as 0.53. It suggests that relatively strong inherent hardening processes are present which attenuate the FCC reported size scaling exponent, which is typically 0.6 to 1.0 for pure FCC metals. The elemental distribution and lattice strains at the atomic scale are rather uniform without long-range ordering analyzed by high-resolution scanning TEM (STEM) and atom probe tomography. Finally, dislocation glide motion was directly observed during *in situ* TEM tensile tests. The local shear stress measured from gliding of individual dislocations is exceeding 400 MPa. Kink-pair-like glide behavior and periodic fluctuation in the stacking fault width suggest that local pinning points, severe lattice distortion or short-range ordering hinder dislocation motion in HEAs.