Paragraph Ran in the Queries

Paper Title: Microstructure and mechanical properties of CoCrFeNiAl0.5Ti0.1 high entropy alloy rod

Content :

Mechanical properties

3.3.1. Nanoindentation study of $CoCrFeNiAl_{0.5}Ti_{0.1}$ rod

To investigate the differences in mechanical properties and morphology between the precipitated phases and the matrix in $CoCrFeNiAl_{0.5}Ti_{0.1}$ alloy rod, the surface of the polished alloy sample was examined using a three-dimensional optical profilometer. Fig. 7(a) displays the load-penetration depth nanoindentation plot for the material. The plot delineates the mechanical behavior of the precipitated phases and the matrix, with separate curves representing the load applied versus the penetration depth. The precipitate phase exhibits a shallower penetration depth at equivalent load levels compared to the matrix, signifying a greater hardness or resistance to deformation. Fig. 7(b) reveals that the surface of the alloy consists of undulating hills and valleys at the nanoscale, likely due to the differences in hardness and modulus of elasticity between the two phases. During the mechanical polishing process, the Ni_2AlTi precipitated phase, characterized by higher hardness and modulus, exhibited less wear and remained more prominent on the surface. Conversely, the FCC structured matrix, with lower hardness and modulus, experienced more significant wear, resulting in a more recessed surface. The height difference between the highest and lowest points on the alloy surface is approximately 30 nm.

Tensile properties of $CoCrFeNiAl_{0.5}Ti_{0.1}$ rod

From the tensile stress-strain curve in Fig. 10, the forged $CoCrFeNiAl_{0.5}Ti_{0.1}$ alloy demonstrates notable strength and plasticity under both low and room temperature conditions. At room temperature, the tensile strength of the $CoCrFeNiAl_{0.5}Ti_{0.1}$ HEA was recorded at 1146 MPa with an elongation of 16.7 %. At a reduced temperature of 200 K, the tensile strength increased to 1204 MPa, and the elongation rose to 18.3 %. The alloy exhibited exceptional mechanical properties at 77 K, achieving a tensile strength of 1423 MPa and an elongation of 14.2 %. As the temperature decreases from 298 K to 200 K, the deformation mechanism shifts from dislocation slip to a combination of dislocation slip and nanotwinning, facilitated by the lower stacking fault energy in the FCC matrix. The integration of nanotwinning with dislocation slip enhances the alloy's ductility. Nanotwins effectively accommodate plastic deformation across various grain orientations and impede dislocation movement, increasing fracture resistance. With further cooling to 77 K, dislocation mobility significantly decreases, restricting essential dislocation movement. Consequently, reduced thermal energy impairs the alloy's ability to strain through dislocation movement, increasing brittleness and susceptibility to crack initiation and propagation under stress, thereby reducing plasticity.To investigate the persistence of the precipitation strengthening effect in the $CoCrFeNiAl_{0.5}Ti_{0.1}$ HEA at high temperatures, additional mechanical property tests were conducted under high-temperature conditions. Tensile tests were performed at temperatures of 873 K, 1073 K, and 1273 K, with a strain rate of $1 \times 10^{-3}\ s^{-1}$. The stress-strain curves from these tests are displayed in Fig. 11. As shown, the tensile strength of the $CoCrFeNiAl_{0.5}Ti_{0.1}$ HEA remains above 700 MPa at 873 K. However, at 1073 K, the strength decreases to approximately 160 MPa. Further increase to 1273 K results in significant softening of the alloy.