Paragraph Ran in the Queries

Paper Title: On the plastic deformation mechanism of Al0.6CoCrFeNi high entropy alloy: In-situ EBSD study and crystal plasticity modeling

Content :

Mechanical property of $Al_{0.6}CoCrFeNi$ HEAs with different microstructures

The stress-strain curves of CG and FG samples are depicted in Fig. 6. For CG sample, the corresponding values were determined as 508 MPa for yield strength and 1050 MPa for tensile strength. For FG sample, the yield strength and tensile strength values were measured as 586 MPa and 1152 MPa, respectively. Additionally, the tensile elongation percentages for CG and FG samples were recorded as 45.9 % and 47.9 %, respectively. The tensile strength of FG sample exceeded that of CG sample, and the elongation of the FG sample was slightly higher than that of the CG sample. FG sample had a grain size significantly smaller than that of CG sample, as depicted in Fig. 2, indicating a high grain boundary density in FG. Furthermore, there were notable disparities in both size and distribution of FCC and BCC phase between FG and CG. It was indicated that for dual phase $Al_{0.6}CoCrFeNi$ HEA, optimized microstructure could enhance the strength of alloys through synergistic effects of refined grain strengthening and second phase strengthening without compromising plasticity. The present study provides novel perspective for designing alloys with enhanced strength and ductility.In order to understand the differences in mechanical properties between FCC and BCC phase in CG and FG samples, nanoindentation tests were conducted on both CG and FG samples to obtain the mechanical properties of both phases. The nanoindentation results are presented in Fig. 7. Static displacement method was employed for all nanoindentation tests, with a maximum indentation depth of 200 nm. For CG sample, it exhibited a maximum load of 3.65 mN in FCC phase and 5.39 mN in BCC phase. For FG sample, the maximum load of FCC phase was 3.83 mN, while that of BCC phase was 5.38 mN. The maximum load of BCC phase was significantly higher than that of FCC phase for both CG and FG samples. Regarding the hardness value of CG sample, the hardness values of FCC and BCC phase were 4.72 GPa and 7.83 GPa respectively. For FG sample, FCC and BCC phase exhibited a value of 4.73 GPa and 7.02 GPa respectively. For both CG and FG sample, BCC phases were significantly harder than FCC phase. The hardness of FCC phase in CG and FG sample was very close, whereas BCC phase showed higher hardness in CG sample than in FG sample. The above results showed that the micro-mechanical properties of FCC and BCC phases in both CG and FG sample exhibited slight differences. The disparities in tensile properties could be primarily attributed to the distinct microstructure characteristics of grains and phases. In Section 2.1, it is shown that FG sample contains 15.3 % proportion of BCC phases, whereas CG sample had 24.2 % proportion of BCC phase. Given that CG sample had a higher fraction of hard BCC phases, it would contribute to a higher strength. However, FG sample demonstrated superior tensile strength, due to other strengthening mechanisms such as refined grains and phases. The distinct strengthening mechanism will be further discussed in the subsequent sections.

The mechanical response of different phases during tensile deformation

In order to study the effects of phase distribution and grain size on stress distribution and plastic deformation, uniaxial tensile tests were simulated using the CPFEM model based on EBSD scans of polycrystalline aggregates. Fig. 16 illustrates the evolution of mechanical response for FG and CG samples under different strains. The stress contours of all scales were consistently standardized for ease of comparison. In the case of CG sample, when a 2 % strain was applied, high Mises stress initially emerges in the phase boundaries region, as depicted in Fig. 16c. The distribution of high Mises stress in the BCC phase and at the grain boundary of the FCC phase was observed when the strain reaches 6 %. After the strain reached 18 %, the high Mises stress was predominantly distributed in the BCC phase. The $Al_{0.3}CoCrFeNi$ HEA with B2 precipitates, as reported by Ma et al. [53], exhibited a transition of stress concentration from the phase boundary to the grain boundary. It is evident that the stress distribution of the CG sample exhibited significant non-uniformity during tensile deformation. The mechanical response of CG under different strains revealed that the initial occurrence of high Mises stress located at the phase boundaries, followed by its subsequent generation at both BCC phase and FCC grain boundaries. For the FG sample, it was the BCC phase that initially exhibited high stress, followed by elevated stress in the grain boundary region of the FCC phase. In contrast to the CG sample, the overall stress distribution in the FG sample became relatively uniform at a strain of 18 %, while in the CG sample, high stress concentration is observed primarily within the BCC phase. This observation aligns with the distribution pattern of KAM value and LABs depicted in section 3.2. The microstructure characteristics of the FG sample indicated a more uniform stress distribution during tensile deformation compared to the CG sample, thereby preventing significant local stress concentration and resulting in fracture failure of the sample.