Nanocomposites and nanomaterials

Mechanical properties of ultrafine grained copper at cryogenic temperatures

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The mechanical properties of Cu–OF polycrystalline samples processed by hydroextrusion (HE) and an equal channel angular hydroextrusion (ECAH) were studied in tension tests at 4.2, 77 and 295 K. The microstructure before tension was examined using Electron Backscatter Diffraction (EBSD) analysis (FEI NovaNanoSEM 230 FE-SEM microscope) and X–ray diffraction methods.

The average grain size after HE and ECAH is measured to be 200-500 nm, whereas the fraction of coarse elongated grains (a few μm) is more pronounced after HE processing. On the contrary the average X–ray chaotic dislocation density is higher after ECAH processing. The orientation maps of electron-backscatter diffraction and ratio of (111)/(220) diffraction peak intensities are sensitive to processing indicating different texture of HE and ECAH copper.

It was shown that the main parameters of "true stress σ – true strain ε" tensile curves are dependent on the test temperature. The increase of yield stress from 400–450 MPa to 550 MPa, the plasticity from 0.02 to 0.2 and the work hardening rate of HE and ECAH samples was observed as temperature decreased from 295 K to 4.2 K. However at intermediate temperature of 77 K the work hardening rate and the plasticity of HE samples were higher as compared with ECAH ones. The phenomenon of unstable (serrated) plastic deformation of both the samples at 4.2 K was observed after few percent of elongation. The mean stress jumps amplitude increases with deformation more slowly for HE samples, correlating with deformation dependence of work hardening rate as compared with ECAH ones.

The temperature dependences of mechanical properties of Cu–OF polycrystals processed by HE and ECAH are discussed in the terms of the thermally activated dislocation motion and the work hardening models taking into account the ultrafine grains, the high dislocation density and the texture evolution due to HE and ECAH processing.