Nanoengineering of metallic alloys for machining tools: Multiscale computational and in situ TEM investigation of mechanisms

Influence of carbon nanotubes (CNT), hexagonal boron nitride (h-BN) and tungsten carbide (WC) nano-reinforcement on the mechanical and tribological properties of the Cu-Ni binder alloy was investigated experimentally and numerically. In situ TEM and multiscale micromechanical finite element (FE) modeling were used to study the mechanisms of deformation of the nanomodified binder. Complex reinforcement by 0.1% CNT +0.1% hBN +0.69% WC increases the tensile strength of the materials from 155 to 346MPa, bending strength from 420 to 832 MPa, hardness from 2.1 to 2.4GPa and elastic modulus from 98 to 123GPa. The complex reinforcement changes the wear mechanism and significantly enhanced the tribological properties of the binders, decreasing the coefficient of friction from 0.47 to 0.28 and wear rate from 12.3 to 6.7·10−6 mm3/N/m. The failure of the nanomodified binder was found to be caused by the emergence and propagation of microcracks along the interface between hBN particles and the matrix. Carbon nanotubes inhibit the propagation of cracks, significantly increasing the mechanical and tribological properties of Cu-Ni binders.

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