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Breaking immiscibility barriers: ultrafast sintering of interlocked Cu-Fe-based composites

Positive mixing-enthalpy systems such as Cu-Fe are difficult to process because liquid-phase immiscibility drives phase segregation and weak interfaces during conventional sintering. Building on ultrafast high-temperature sintering (UHS), we introduce ultrafast high-temperature sintering-quenching (UHSQ), where rapid Joule-heating sintering is immediately followed by ultrafast quenching to kinetically freeze a non-equilibrium microstructure. The approach suppresses elemental segregation, limits interfacial diffusion, and promotes a tight Cu/Fe-based interlocked architecture. In Cu-50 vol% $Fe_{55}Cr_{25}Mo_{16}B_2C_2$ composites, rapid processing and quenching generate multiphase nanocrystals in the reinforcement and rivet-like nanoscale interfacial features, enabling efficient load transfer and strong interfacial cohesion. The resulting composite reaches ~685 MPa tensile yield strength at room temperature and retains ~290 MPa at 923 K, with ultrahigh hardness (~900 HV average; up to ~1297 HV) and 40–50× higher wear resistance than pure Cu, while maintaining 15–20% IACS electrical conductivity. These results demonstrate that UHSQ extends UHS from fast densification to interface-controlled microstructure engineering, providing a scalable route for high-performance immiscible metallic composites for tribological and high-current applications.

Professional Status of the Speaker

Doctoral or Master Student

Interest in submitting a paper in a special issue of

No interest

Invitation letter for visa

Yes

Author: SHEN, Shiji (City University of Hong Kong / City University of Hong Kong, Dongguan)

Co-author: Prof. WU, Zhenduo (City University of Hong Kong (Dongguan))

Presenter: SHEN, Shiji (City University of Hong Kong / City University of Hong Kong, Dongguan)

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