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Ultrafast Sintering-Quenching Enables Interlocked Cu-Fe-Based Composites Beyond Immiscibility Limits

Positive mixing-enthalpy systems such as Cu-Fe are attractive for structural-functional integration but are difficult to process because liquid-phase immiscibility drives segregation and weak interfaces in conventional sintering. We report an ultrafast high-temperature sintering-quenching (UHSQ) strategy to kinetically stabilize a homogeneous Cu-Fe-based composite with robust interfacial bonding. In this route, rapid Joule-heating sintering is immediately followed by ultrafast quenching, which suppresses thermocapillary segregation, limits elemental cross-diffusion, and controls devitrification of Fe55Cr25Mo16B2C2 reinforcement. The process creates a hierarchical architecture consisting of multiphase nanocrystals and nanoscale rivet-like interlocking Cu/Fe interfaces. For Cu-50 vol% Fe55Cr25Mo16B2C2, the composite reaches ~685 MPa yield strength at room temperature and retains ~290 MPa at 923 K, with ultrahigh hardness (~900 HV average; up to ~1297 HV), 40–50× wear-resistance improvement versus pure Cu, and 15–20% IACS conductivity. The results demonstrate that UHSQ extends UHS from rapid densification to interface-dominated microstructure engineering, providing a scalable pathway to overcome immiscibility barriers in positive-enthalpy metallic composites for high-load tribological and electrically demanding applications.

Professional Status of the Speaker

Senior Scientist

Interest in submitting a paper in a special issue of

No interest

Invitation letter for visa

Yes

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