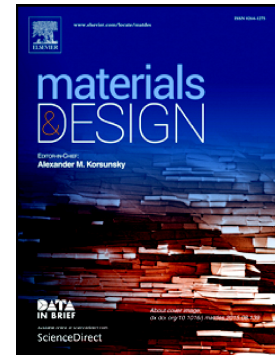


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Particle-induced damage in Fe – TiB₂ high stiffness metal matrix composite steels

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Abstract

Fe – TiB₂ metal matrix composites, termed high modulus steels, have great potential for lightweight design applications due to their high stiffness/density ratio. However, the observed embrittlement, caused by the TiB₂ particles, critically limits application of these steels. Experimental studies to identify the influence of particle microstructure on ductility and toughness is complex in view of the multitude of parameters affecting microstructural damage. We therefore pursue instead an integrated computational materials engineering approach to gain understanding and derive guidelines for optimizing the particle microstructure and thus improve the mechanical properties, particularly the damage tolerance of these high modulus steels. Key microstructural parameters such as particle clustering degree, size and volume fraction were investigated. Model geometries were statistically and systematically generated with varied particle configurations from random to clustered distributions. Simulations were performed using a crystal plasticity Fast Fourier transformation method coupled with a novel phase field damage model. The influence of particle configuration on damage initiation and evolution was evaluated from the simulation results, and it was observed that microstructures with homogeneous particle distributions of 7 to 15 vol.% TiB₂, devoid of large TiB₂ particles stemming from primary solidification, appear most favorable for obtaining high modulus steels with optimized mechanical properties.

Keywords: metal matrix composites; damage simulation; particle damage; phase field method; spectral method

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