A Multiscale Framework to Quantify the Competing Failure Mechanisms in Metal Matrix Composites

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Abstract

The development of high performance MMCs requires careful microstructure design which can improve fracture toughness while maintaining high strength. Although a great deal of research has focused on the effect of microstructural properties on fracture toughness and strength of MMCs, the relations being established are mostly qualitative. In metal matrix composite materials, reinforcement cracking and interface debonding are two competing failure mechanisms observed during the crack-reinforcements interactions. For ductile MMCs, the fracture resistance depends on the sum of energy spent on both surface generation and the plastic deformation of the matrix material. Interface debonding usually leads to more tortuous crack paths and in turn enhances surface energy dissipation. However, it is not clear if this form of fracture can also lead to more pronounced plastic deformation in the metal matrix. While more significant plastic energy dissipation is beneficial to the toughening of a MMC, it has negative effect on its material strength. The objective of this study is to elucidate the two levels of competitions by considering the effect of microstructure and loading conditions: one being the competition between interface debonding and reinforcement cracking, and the other being the competition between crack formation and the deformation of matrix material. The systematic studies focus on Al/SiC metal matrix composites. The cohesive parameters employed in the computational models are calibrated through Digital Image Correlation analysis.

Keywords: **Microstructure, Fracture toughness, Metal Matrix Composites**