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Modeling of fracture of chromium-alumina microcantilever beams in bending

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Abstract

Local deformation and failure modes in chromium-alumina MMC manufactured by powder metallurgy are investigated experimentally and by FE modeling. Microcantilver beams machined by FIB-milling are loaded through nonindenter tip until specimen's failure with simultaneous SEM observation of deformation and fracture mechanisms on the microscale. Micromechanical load-displacement curves are recorded from these experiments and respective deformation modes and failure mechanism are identified by SEM. The role of interface between chromium and alumina particles is closely examined. Numerical simulations of the bending experiments are performed using image processing of the real microcantilever microstructure to get a finite element mesh for computations in ABAQUS 6.13 environment. Since the cohesive elements do not work for the complex interfaces with zero thickness, an alternative model of the cohesive surface with appropriate cohesive strength, interfacial stiffness and fracture energy is employed. To reduce computational effort the interfaces are considered to be imperfectly bonded only in regions where detachment of alumina particles from the chromium matrix has occured, the remaining parts being assumed as perfectly bonded. A bilinear traction and separation constitutive model is used to simulate the debonding mechanism. A sensitivity analysis is carried out to estimate appropriate values of the unknown interfacial properties. The model is capable of reproducing the overall load-displacement response of the chromium- alumina composite specimens in micromechanical bending as well as the crack growth trajectory as observed by SEM.

Keywords: MMC, fracture, deformation modes, micromechanical testing, interface, FE modelling

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