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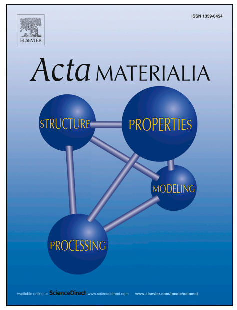

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Grain boundary properties of a nickel-based superalloy: characterisation and modelling

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Abstract

Miniaturised tensile tests coupled with in-situ scanning electron microscopy are used to deduce the grain boundary properties of a nickel-based superalloy at 750°C. This allows the damage initiation, evolution and failure processes to be observed directly. The significant variation in ductility – consistent with the limited number of grain boundaries being present – is rationalised using a crystal plasticity approach calibrated by experiments on single crystals loaded along the ⟨001⟩, ⟨011⟩, and ⟨111⟩ directions. Quantitative strength and toughness values for the grain boundaries are estimated using a cohesive zone method. The modelling approach is used to determine an approximation of the size of the representative volume element (RVE) needed for volume-averaged behaviour.

Keywords: superalloys, grain boundaries, damage modelling, crystal plasticity, scanning electron microscopy

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1. Introduction

The grain boundaries of nickel-based superalloys – in common with many polycrystalline alloys – can be their Achilles' heel [1, 2, 3, 4]. Grain boundaries can indeed impair the macroscopic response, because they can support crack initiation and hence quasi-brittle behaviour, which is of practical relevance for their application in high temperature systems [5, 6, 7, 3]. Hence, the local geometry, nature and orientation of a grain boundary with respect to the lo-