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Modelling intergranular and transgranular micro-cracking in polycrystalline materials

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Abstract

In this work, a grain boundary formulation for intergranular and transgranular micro-cracking in three-dimensional polycrystalline aggregates is presented. The formulation is based on the displacement and stress boundary integral equations of solid mechanics and it has the advantage of expressing the polycrystalline problem in terms of grain boundary variables only. The individual grains within the polycrystalline morphology are modelled as generally anisotropic linear elastic domains with random spatial orientation. Transgranular micro-cracking is assumed to occur along specific cleavage planes, whose orientation in space within the grains depend upon the crystallographic lattice. Both intergranular and transgranular micro-cracking are modelled using suitably defined cohesive laws, whose parameters characterise the behaviour of the two mechanisms. The algorithm developed to track the inter/transgranular micro-cracking history is presented and discussed. Several numerical tests involving pseudo-3D and fully 3D morphologies are performed and analysed. The presented numerical results show that the developed formulation is capable of tracking the initiation and evolution of both intergranular and transgranular cracking as well as their competition, thus providing a useful tool for the study of damage micro-mechanics.

Keywords: Polycrystalline materials; Transgranular cracking; Intergranular cracking; Micro-mechanics; Cohesive zone modelling; Boundary element method.

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