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Numerical Modelling of Two-phase Ceramic Composite Response under Uniaxial Loading

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1. Introduction

Two-phase ceramic composites (e.g. Al_2O_3 + ZrO_2 - Zirconia-toughened Alumina [1–3]), due to their extremely high strength and increasing toughness are widely used nowadays in various industries (e.g. as refractory materials, thermal barrier coatings [4–6], etc.). Appropriate prediction of design life of these materials under complex manufacturing and loading conditions requires a fine-scale damage model. At the macroscale, the main dissipative mechanism is brittle cracking, that can be faithfully modelled within the framework of classical Linear Elastic Fracture Mechanics (LFEM). However, many essential properties, such as fracture toughness, depend on microstructural phenomena, related to grain size, orientation, residual stresses and various toughening mechanisms, that are intentionally introduced into the microstructure. Thus, a good understanding of these processes is the most important tool for a fully conscious design of these advanced materials, from manufacturing to the end of structural lifetime.

In this paper, a basic framework with a numerical example for two-dimensional micromechanical analysis of multiphase brittle composites is described, using two radically different theoretical and numerical approaches – continuum mechanics with cohesive-type cracks and completely discrete (peridynamical) theory.

2. Image-based analysis

Obtaining a realistic microstructural model to serve as a Representative Volume Element (RVE) is a preliminary step in any micromechanical analysis and can be performed in two different ways. Various imaging techniques usually provides a 2D scan (Fig. 1), that can be imported directly into the analysis environment, which is a typical procedure for metals and alloys with a complex non-granular structure. Due to raster nature of image aqcuisition itself,