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Impact of Al_2O_3/ZrO_2 Composite, Qualitative Comparison of Compositions

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Introduction The ceramic composites Al_2O_3/ZrO_2 are used for different kind of implants since they are nontoxic and nonallergic [1]. The composites of different composition of both compounds are obtained by sintering at the temperature 1600°C. The amount of zirconia in the composite is normally up to 30% volume. The investigation of such properties like Youngs modulus, toughness and flexural strength is presented in [2]. The properties of ZrO_2 compound with stabilization of Y_2O_3 are described in [3].

Problem statement The aim of the presentation is to evaluate behavior of the composites under impact loading at the mesoscale pointing out the crack initiation regions. We take into account two compositions of the composites that are given in Fig. 1. The white clusters stand for ZrO_2 and the dark one are the grains of Al_2O_3. The F1 composition consists of 80%Al_2O_3 and 20%ZrO_2. The F2 composition contains 60%Al_2O_3 and 40%ZrO2.

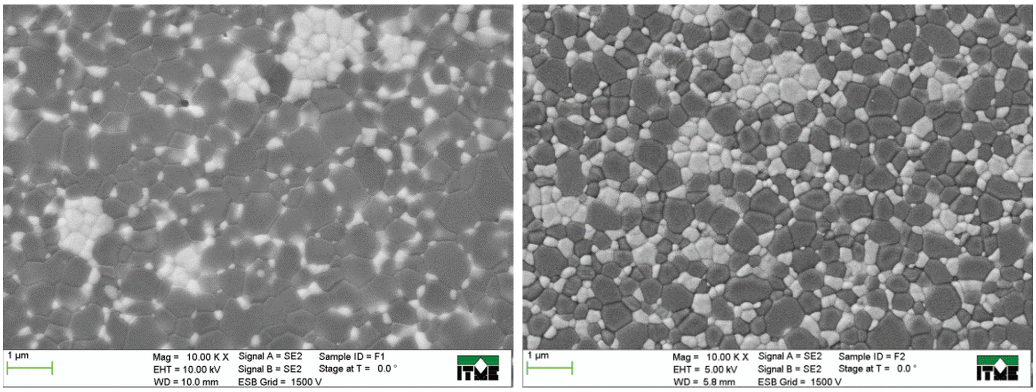

Figure 1: Microstructures of Al_2O_3/ZrO_2: a) composition F1; b) composition F2

Both components of the composite are brittle. In the case of Al_2O_3, the Youngs modulus is in the range of 215–413 GPa and tensile strength is in the range of 69–665 MPa. When concerning ZrO_2 the Youngs modulus is in the range of 100–250 GPa, and the tensile strength is in the range of 115–700 MPa. We use Drucker-Prager type constitutive models. A feature that decreases the load carrying capacity of the composite are voids that are presented in Fig. 3.

Numerical models A basic model of a polycrystal sample that hits a rigid wall is give in Fig. 3 (a). In this case, we present a model of a sample with thin, however, finite thickness interfaces. The model is done in the framework of the peridynamics theory. The grains are perfectly elastic while the interfaces are elastic with damage condition. The polycrystal models of this kind but with finite element method, were successfully analysed in [4, 5, 6].

We extend the models towards Al_2O_3/ZrO_2 material that characterises an important feature from point of view of numerical modelling, namely, thin interfaces. Our new model allows analysis of the composite including imperfections due to existence of voids.

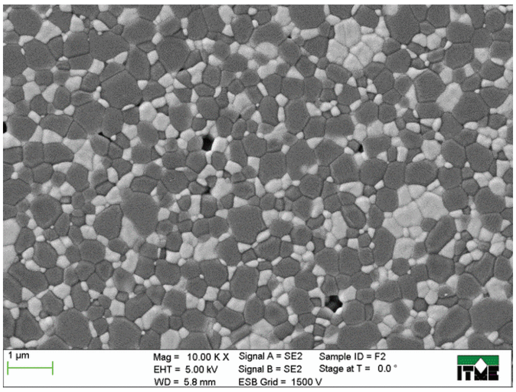

Figure 2: Imperfections in the form of voids

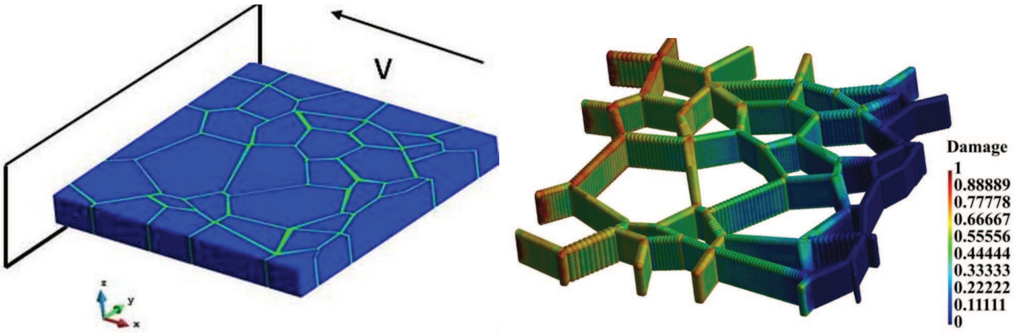

Figure 3: Example of numerical model: a) impact scheme; b) damage distribution in grain interfaces, peridynamics model

Closing remarks We present new meso-scale models that are valid for two-phase composites in the framework of finite elments and non-local meshless method that is peridynamics. The models include influence of voids that is a feature that decreases the load carrying capacity of the material.

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