EXPERIMENTAL ASSESSMET OF MECHANICAL PROPERTIES AND NUMERICAL MODELLING OF TWO-PHASE CERAMIC COMPOSITES SUBJETED TO LOW VELOCITY AND IMPACT LOADING

DANIEL PIETRAS[1], ROMAN GIELETA[2], ELIGIUSZ POSTEK[3], ALEXIS RUSINEK[4], TOMASZ SADOWSKI[1]

[1] Lublin University of Technology, 20-618 Lublin, Poland
[2] Military University of Technology, 00-908 Warsaw 46, Poland
[3] Institute of Fundamental Technological Research, Polish Academy of Sciences, 02-106 Warsaw, Poland
[4] Université de Lorraine, CNRS UMR 7239, Arts et Métiers Sciences et Technologie, LEM3, F-57000 Metz, France

ABSTRACT

Gradual degradation of brittle composites exhibits different mechanical responses under uniaxial tension and uniaxial compression. In this paper, we analysed cracking processes and failure under quasi-static loading of a two-phase ceramic material made of an Al_2O_3 and ZrO_2 mixture subjected to tension and compression. Constitutive modelling of two-phase ceramic composites obeys the description of: (1) elastic deformations of initially porous material, (2) limited plasticity and (3) cracks initiation and propagation.

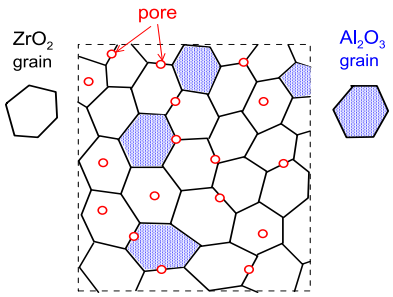

Fig. 1. Internal structure of the Al_2O_3/ZrO_2 ceramic composite.

Modelling of polycrystalline ceramics at the mesoscopic level under mechanical loading is related to the analysis of a set of grains, i.e. Representative Volume Element (RVE), Fig. 2. The basic elements of the defect structure inside a polycrystal are: micro- and mesocracks, kinked and wing cracks. To obtain a macroscopic response of the material, one can calculate averaged values of stress and strain over the RVE using an analytical approach.

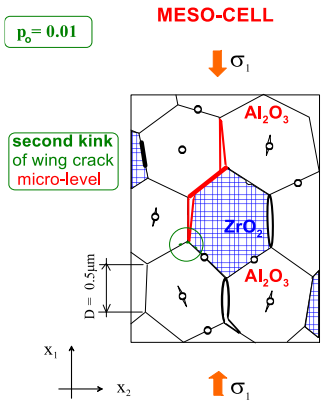

Fig. 2. RVE

High-strain-rate degradation process was illustrated for Al_2O_3/ZrO_2 composite, which was subjected to a short compressive impulse. The pulse duration was 10- 7s, Fig. 3.

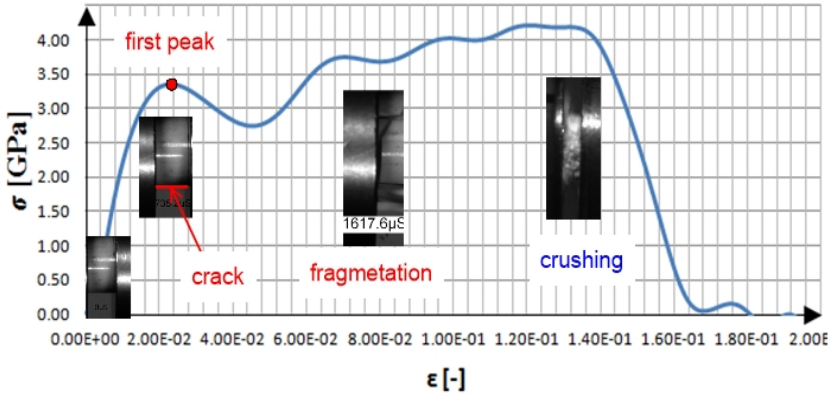

Fig. 3. SHPB response of the Al_2O_3/ZrO_2 ceramic composite

In the proposed more advanced finite elements formulation, it was necessary to take into account the following data and phenomena appearing inside of the RVE: (1) spatial distribution of the composite constituents, (2) system of grain boundaries/binder interfaces modelled by interface elements, (3) rotation of brittle grains.

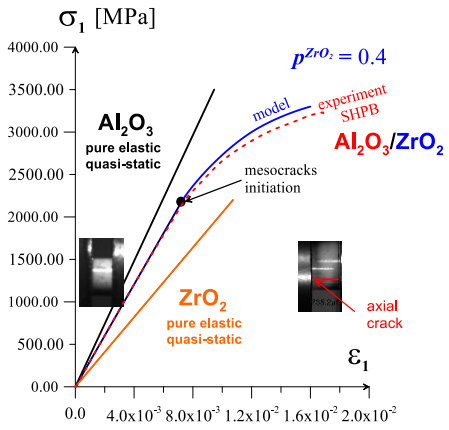

Fig. 4. Numerical model of the first stage of deformation of the Al_2O_3/ZrO_2 ceramic composite subjected to SHPB test