8th. World Congress on Computational Mechanics (WCCM8)
5th European Congress on Computational Methods in Applied Sciences and Engineeering (ECCOMAS 2008)
June 30 –July 5, 2008
Venice, Italy

MICROMECHANICAL MATERIAL MODELING OF INTERPENETRATED METAL-CERAMIC COMPOSITES

*** Romana Piat, Mickael Guichard and Thomas Böhlke**

Institute of Engineering Mechanics, University of Karlsruhe (TH),
Postfach 6980, D-76128 Karlsruhe, Germany
Romana.Piat@kit.edu, http://www.itm.uni-karlsruhe.de/

Key Words: *Homogenization, Metal-Ceramic Composites, Multiscale Microstructure Modeling.*

ABSTRACT

An innovative melt-infiltrated metal-ceramic material is made of an eutectic aluminium-silicium alloy ($Al12\,Si$) metal matrix embedded by squeeze-casting into a porous alumina (Al_2O_3) ceramic matrix. The microstructure of the material obtained presents some lamellar-like domains with geometrical characteristics which are dependent on the manufacturing parameters.

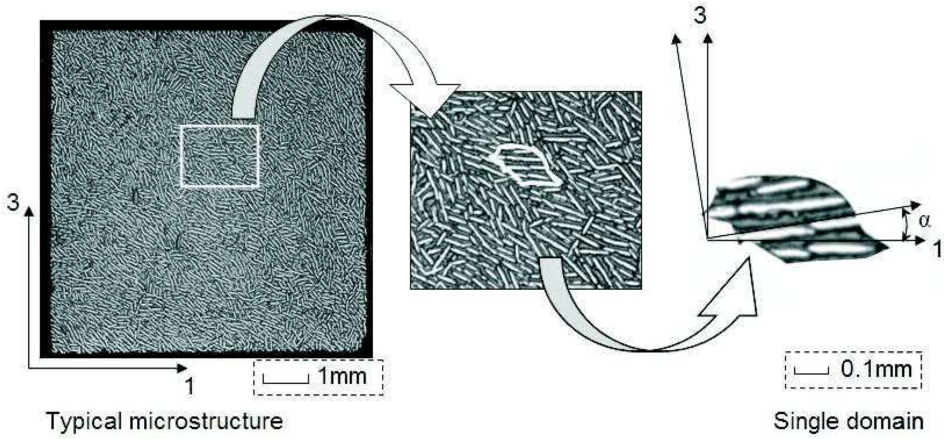

Fig. 1: Polarized light microscopy micrograph of the typical microstructure of interpenetrated metal-ceramic composites and two phase single domain.

Fig. 1 shows a typical microstructure of the specimen. The aluminium inclusions (in white) are local oriented in the same direction and form domains with the same inclusions orientation. These inclusions appear as elliptical cylinders extruded in the freeze casting direction, i.e. perpendicular to the (x_1, x_3) plane. The aim of our study is to find a good micromechanical model in order to deduce the mechanical properties of the single domains and of the whole material as a function of the microstructural geometry and the material parameters of alumina and aluminium. Firstly, the statistical analysis of polarized light microscopy micrographs of the cross section of the specimen were performed. Domains with the same inclusions orientation, so-called single domains or semi-crystals were detected, selected and measured. These statistical data were used for microstructure modeling. The material modeling was performed by a two-step homogenization procedure using a combination of different micromechanical models (Fig. 2). Predicted material properties were compared with ultrasonic measurements [2] for a single domain and for the whole microstructure.

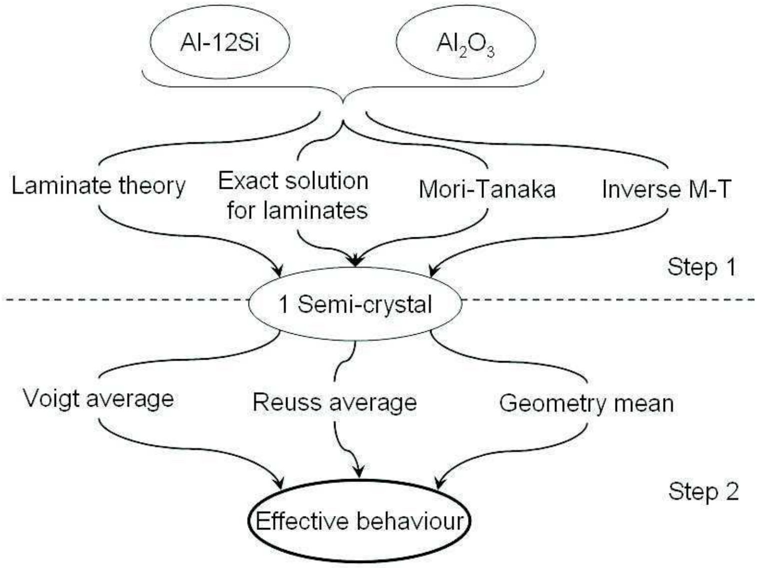

Fig. 2: Micromechanical models used.

For one single domain the inverse Mori-Tanaka method (M-T)gives the best results in comparison to the values resulting from ultrasonic measurements. A relatively large number of all possible combinations of both homogenization steps gives good results. The best one, however, seems to be the association of the exact solution for laminates associated to the Reuss approximation. In our approximation, the inclusions are modeled as perfect cylinders and microstructural changes in the freeze casting direction are not taken into account, but the real microstructure is not so ideal and calculated stiffness in the freeze casting direction (C_{2222}) is unfairly over-estimated.

REFERENCES

[1] S. Nemat-Nasser and M. Hori, *Micromechanics: Overall properties of heterogeneous materials*, Elsevier, 1999.

[2] S. Roy and A. Wanner, “Metal matrix composites from freeze-cast ceramic preforms: Domain structure and elastic properties”. *Comp. Sci. and Tech.*, article in press, doi:10.1016/j.compscitech.2007.06.013, 2007.