Type of presentation: Poster

MS-5-P-1520 TEM investigation of wound highly porous oxide (WHIPOX) ceramic matrix composites (CMC)

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Oxide ceramics are widely used as structural materials for long-term high-temperature applications in oxidizing atmospheres. Monolithic ceramics are not suitable for many applications due to their brittle fracture behavior. This brittleness can be overcome by fiber reinforcement of ceramics. The so called ceramic matrix composites (CMCs) show pseudoplastic behavior, if the fibre-matrix bonding is relatively weak [1]. Weak fibre-matrix bonds can be achieved e.g. by porous or low toughness fibre-coatings. A less expansively alternative is according to Lange et al., the use of a highly porous Si_3N_4 or mullite matrix instead of a dense matrix and a weak-fibre-matrix interphase [2]. In this work a CMC with Al_2O_3-fibres and a porous Al_2O_3-matrix, produced at the German Aerospace Center Cologne, the so called WHIPOX (wound highly porous oxide) CMC, which is a promising material for the application in gas turbines, was characterized by Transmission Electron Microscopic (TEM) methods. The WHIPOX-material was manufactured by filament winding as described in [3]. Thin cross sections from the samples embedded in an epoxy-resin were prepared by the Focused Ion Beam (FIB) technique. The lamellae were investigated using a FEI Tecnai F20 (TEM) operated at 200 kV. For TEM investigation of the sinter degree within the Al_2O_3-matrix and of the matrix-fibre interface TEM bright field images, selected area diffraction patterns as well as STEM HAADF images and EDX spectra have been acquired experimentally. In addition STEM Tomography has been performed. Figure 1 shows the overview STEM BF image of a matrix area (sintering temperature 1200 °C) enclosed by two fibers. The Al_2O_3-grain size within the fibers is homogeneous with a maximum diameter of about 200 nm, whereas the Al_2O_3-grains within the porous matrix show a maximum diameter of about 700 nm. The STEM HAADF image in Figure 2 shows the existence of small, below 100 nm in size, bright ZrO_2-particles with homogeneous distribution within the matrix, which can be found also between matrix-grains and between matrix-fibre-grains. The ZrO_2-particles got into the matrix during preparation. The comparison with a sample which was manufactured without ZrO_2, leads us to the assumption that the ZrO_2-particles decrease the sintering activity and hence have a positive effect on the matrix-structure. Figure 3 shows a tomogram, which was reconstructed from a STEM ADF tilting series (-60° till +60°). Besides the influence of the ZrO_2-particles also the influence of the sintering temperature onto the matrix-structure was investigated.

References

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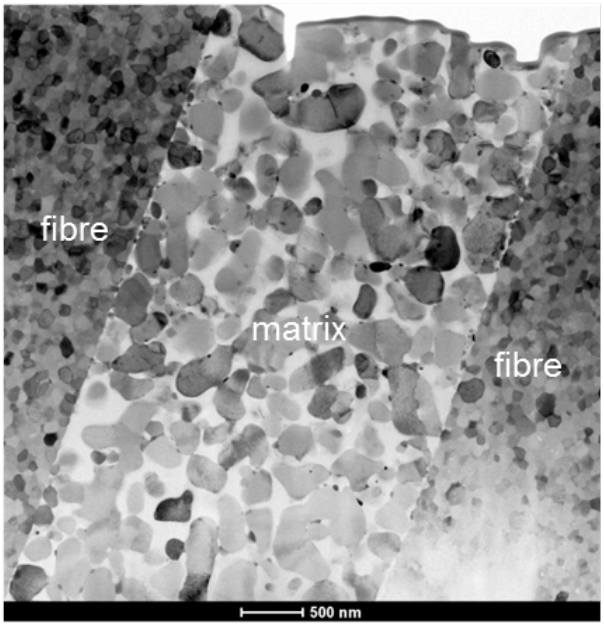

Fig. 1: STEM BF image of the matrix area between two fibers

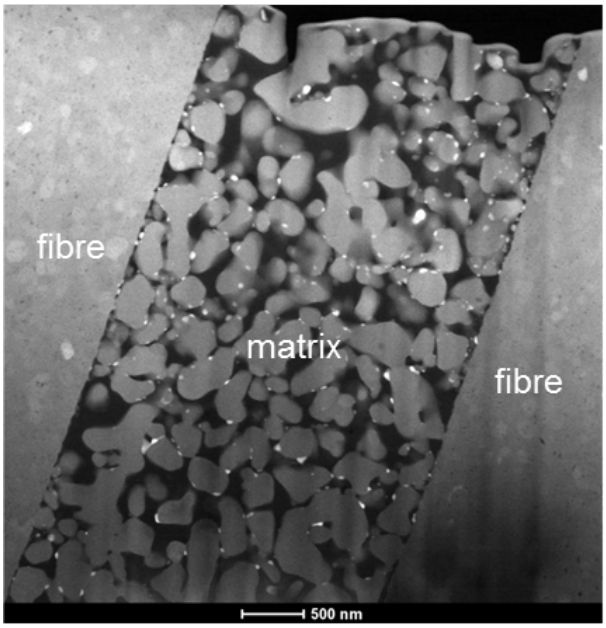

Fig. 2: STEM HAADF image of the matrix area between two fibers

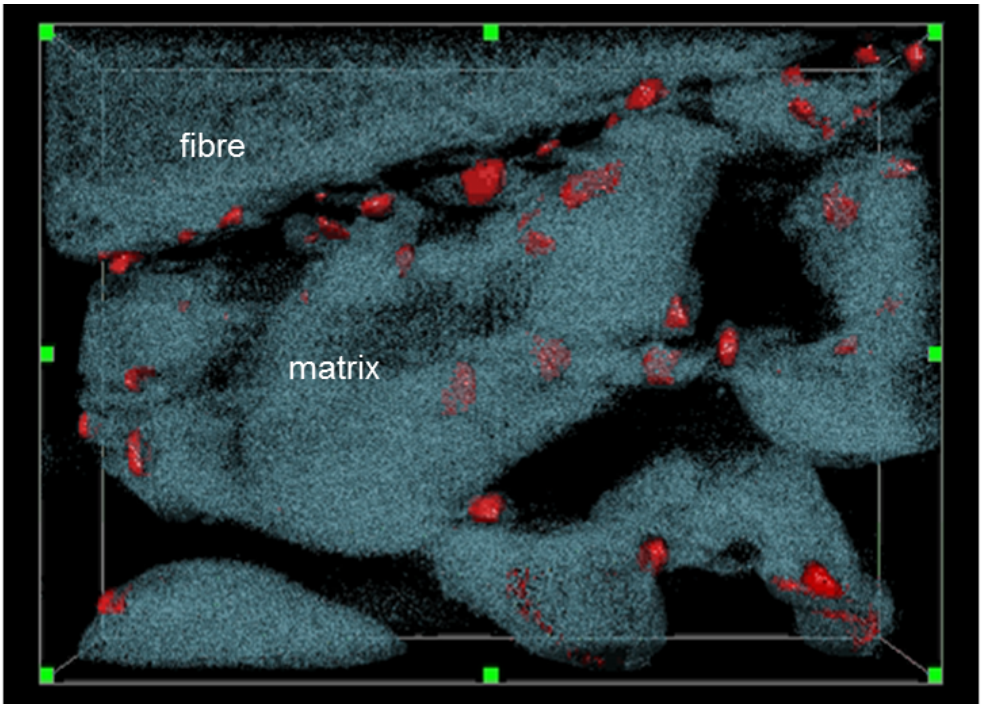

Fig. 3: Reconstructed tomogram: Al_2O_3-matrix grains and Al_2O_3-fibre (blue) und ZrO_2 particle (red)