Multiple hafnium germanate interphase for SiC / SiC_f composites

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Fiber-reinforced ceramic composites achieve high toughness through distributed damage mechanisms. These mechanisms are dependent on matrix cracks deflecting into fiber/matrix interfacial debonding cracks. Oxidation resistance of the fiber coatings often used to enable crack deflection is an important limitation for long-term use in many applications. Hafnium germanates have a high potential as interface coating in fiber reinforced ceramic composite materials due to a number of termomechanical properties and oxidation resistance. Unfortunately, there is not a lot of information about hafnium germanates. Especially, the method of thin films deposition on substrates of complex geometric shape has not been studied.

The aim of this work was to prepare stable sol suitable for forming the nanosized coatings on the SiC fibers and to investigate the surface modification SiC fibers in terms of morphology and the tensile strength.

The special sol-gel approach was developed to obtain stable for a long period of time sols via dissolving the stoichiometric quantities of $HfOCl_2$ and GeO_2 in de-ionized water. Both solutions were then mixed and stirred. The precipitate was washed and dissolved in water by ultrasonic dispersion. Further, a small amount of polyethylene glycol (PEG) was added. The fibers were immersed in mixed oxide sol, dried and then calcined at 900 °C. The elemental, phase composition and morphology were studied by modern analytical techniques. The tensile strength of single filaments was measured using Instron machine.

According to SEM images the coating was relatively uniform throughout the length of the fiber (Fig). The thickness of the first layer was equal to 200–250 nm. It was found that the accumulation of defects at the surface increases with the amount of the coating layers and sol concentration. The PEG addition allowed us to improve the surface morphology. It was established that the mechanical tensile strength of the fibers only slightly decreased in comparison with that of the initial fiber treated at the same temperature.

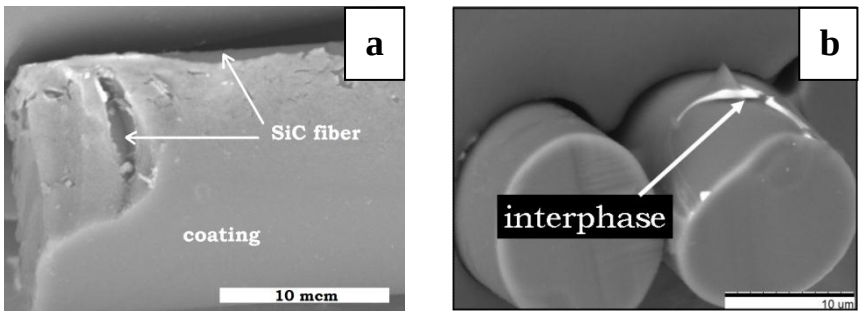

Fig. SEM images of the coated SiC fiber (*a*), fracture surface of SiC/$HfGeO_4$/SiC_f minicomposites (*b*)