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Microstructure and Mechanical Properties of Silicon Carbide Matrix Composites Reinforced With Graphene

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Extended Abstract

Silicon carbide, due to the strong covalent bonds, is characterized by superior hardness, excellent thermal, chemical and erosion resistance. However, character of the bonds and presence of SiO_2 on the SiC surface imposes low sinterability of pure SiC. For that reason, to achieve sinters with high density and good mechanical properties, addition of sintering activators is necessary. The most common used activators are B-C and metallic oxides like Al_2O_3–Y_2O_3 or Al_2O_3–Y_2O_3–MgO. Doping of silicon carbide with boron and carbon positively affects densification and leads to decrease sintering temperature to the range of 1600 – 1900 ^oC. Boron inhibits densification via grain boundaries diffusion. However, absence of carbon efficiently limits diffusion by the presence of SiO_2 layer, which is excellent diffusion barrier. Thus the role of carbon is to rid from the SiC powders of the passivating oxide layer and consequently permit densification to take place. Similarly, as in the case of boron and carbon, also oxide activators influence the kinetic of silicon carbide sintering. Even though silicon carbide is characterized by excellent mechanical and thermal properties its application has been limited due to the relatively low fracture toughness. To improve this parameter whiskers, particles or fibers can be added as a reinforcing phase. One of the most promising material, which can be used as a reinforcing phase in silicon carbide matrix composites, is graphene (Gn). In recent years there has been a growing interest in graphene as a reinforcing phase at polymer, metallic and ceramic composites. It is related to the fact that graphene possesses outstanding electronic and physico-chemical properties. However, production of such composites causes many problems. The main research challenge it to obtain a uniform distribution of Gn in composite matrix. Another one is possible degradation of graphene during sintering at high sintering temperature. The method allowing to avoid degradation of graphene during sintering is Spark Plasma Sintering (SPS) method (also known as Field Assist Sintering Technique – FAST). The main advantage of this technique is relatively low sintering temperature (200-300 ^oC lower compared to conventional sintering methods). Furthermore, the method enables conducting process with high heating rate and short dwell time. This leads to fabrication of composites characterized with fine (even nonmetric), uniform grain size and high physical properties.

The aim of this work was development of SiC-Gn composites characterized by high density and good mechanical properties. Addition of graphene should simultaneously improve mechanical properties of silicon carbide matrix and act as a one of sintering activator. Effect of different ratios of boron and graphene on properties of composites SPS sintered in the range of temperatures between 1600-1900 ^oC was analyzed.