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Development and processing of SiAlON nano-ceramics by Spark Plasma Sintering

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Abstract. The development of SiAlON-based ceramics has shown great impact in the cutting/drilling tool industry and for other engineering applications. It is highly desirable to reduce the cost of the cutting tools by increasing their service lifetime. Potential ways to improve tool life is by preparing these SiAlON-based ceramics adopting non-conventional synthesis routes and by using different precursors. The present study reports the results of synthesis of Ba-SiAlON-based nano-ceramics via the spark plasma sintering (SPS) technique. Generally, metal nitride and metal oxide precursors are used for synthesizing self-reinforced SiAlON ceramics. In this work, nano-sized precursors including amorphous-Si_3N_4 and crystalline β-Si_3N_4, SiO_2, AlN, Al_2O_3 and BaO were used, which could be a novel way to synthesize Ba-SiAlONs at lower temperatures with enhanced performance. The properties of these SiAlONs are tailored by optimizing the synthesis parameters. The synthesized samples were characterized by X-ray diffraction and field emission scanning electron microscopy to study the effect of processing parameters on microstructure, density and hardness.

Introduction

Generally, ceramics are inactive materials because of their low self-diffusivity. However, the use of nano-sized grains and fast consolidation techniques such as spark plasma sintering (SPS) results improvement in reaction kinetics during processing. This could ultimately lead to improvement in the microstructure and mechanical properties of ceramics. Alumino-silicate oxynitrides (SiAlONs) are promising hard materials suitable for harsh environments. These materials have several engineering applications, such as in turbine blades and cutting tools. High strength, hardness and wear resistance are the potential advantages of SiAlONs [1-4]. For the preparation of these ceramics, various combinations of precursors can be used. The key compound in these ceramics is silicon nitride (Si_3N_4) which forms a solid solution in which silicon and nitrogen are replaced by aluminum and oxygen respectively to give β-$Si_{6-z}Al_zO_zN_{8-z}$. Densification of SiAlONs requires the addition of metal oxides such as Y_2O_3 or MgO in order to form liquid phases at evaluated temperatures depending upon their ratio in the mixture. A liquid phase is essential for densification and solution-precipitation processes allowing interlocking of the grains in the microstructure [2, 5-9].

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