Sintering Behavior of Si_3N_4-TaC based composites

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Abstract: Silicon nitride was the first nitride developed for engineering applications. The excellent combination of thermomechanical properties makes silicon nitride a good candidate for applications where high hardness and mechanical properties are fundamental. However, the low fracture toughness of this material limits its use as structural material. The improve of mechanical properties of silicon nitride comes from many factors, like refined microstructure by restraining grain growth, localized stress, crack tip bridging, etc. Within these factors, microstructure formation of the silicon nitride is critically important for the final properties. The design of silicon nitride based composite materials is of particular interest because of their improved high temperature strength and fracture toughness. In this work, Si_3N_4-TaC particulate composite was investigated. For this study was prepared a basis composition (CB) with 90%wt α-Si_3N_4, 6%wt and 4%wt Y_2O_3 and Al_2O_3, respectively. TaC (20%vol) was added into CB and after mixture, in high-energy milling, the powder was compacted into pellets. The kinetics of sintering was studied by means of dilatometry. The shrinkage rate versus time and temperature curves exhibit two well-defined peaks. The first peak refers to the particle rearrangement process and the second, more pronounced, to solution-reprecipitation process. It is quite clear that the presence of TaC particles has small influence on sintering kinetics of silicon nitride. It was observed the complete $\alpha \rightarrow \beta$-Si_3N_4 phase transformation. The microstructure shows good homogeneity both in regard of grain size and secondary phase distribution.

Introduction

In the last 20 years has been given increasing importance to ceramic materials for engineering applications, despite their inherent brittleness. Because of their high strength, hardness and thermal stability, silicon nitride ceramics are among the most important materials for structural applications. The need for further improvement in the mechanical reability of silicon nitride has recently led to the development of high-strength and high toughness ceramics, such as fiber-, whisker- or particulate-reinforced silicon nitride ceramics[1].
Silicon Carbide was used as an addition to silicon nitride more than 20 years ago. Although silicon nitride monolithic ceramics exhibit very attractive properties, the design of silicon nitride based composite materials is of particular interest because of their improved high temperature strength and fracture toughness[2, [3, [4, [5, [6].
The improve of mechanical properties of silicon nitride based composites comes from many factors, like refined microstructure by restraining grain growth, localized stress, crack tip bridging, etc. Within these factors, microstructure formation of the silicon nitride matrix is critically important for the final properties[7].
There are three stages for the microstructure formation in silicon nitride ceramics: β-Si_3N_4 nucleation, $\alpha \rightarrow \beta$-Si_3N_4 phase transformation and rod like β-Si_3N_4 grain growth (Ostwald