Densification Study of $SiC:Al_2O_3:Y_2O_3$ with Polymer Additions

A.L.E. Godoy, J.C. Bressiani and A.H.A. Bressiani,
Instituto de Pesquisas Energéticas e Nucleares,IPEN, Centro de Ciência e Tecnologia de Materiais,
Av. Prof. Lineu Prestes, 2242- Cidade Universitária- SP, CEP- 05508-000
e-mail. analucia@.ipen.br, abressia@.ipen.br

Keywords: SiC, densification and polymeric precursors

Abstract: The influence of polymer precursor additions on liquid phase sintering of $SiC:Al_2O_3:Y_2O_3$ has been evaluated. Two polymer precursors were used: polymethylhydrogen-siloxane and D_4V_i (1,3,5,7-tetramethyl-1,3,5,7-tetraviniylcyclotetrasiloxane). The ceramic phase had the following composition in wt%: 91.6 SiC, 4.2 Al_2O_3 and 4.2 Y_2O_3. The composites were prepared using the following ceramic phase to polymer ratios in wt%: 82.7: 17.3; 74.0: 26.0 and 71.5: 28.5. Density measurements were carried out using a helium picnometry and the Archimedes method. The crystalline phases were identified by X-ray diffraction analysis and the microstructures were observed by optical and scanning electron microscopy.

I. Introduction

Silicon carbide is an important structural ceramic material. Besides high hardness, it has excellent oxidation resistance, high thermal conductivity, good wear and thermal shock resistance and good high temperature mechanical strength [1,2]. This combination of properties is due mostly to the strong covalent type chemical bond (up to 88%), between the silicon and carbon atoms. This type of bonding also makes its densification difficult [3]. One of the most important applications of this material is as a refractory, due to its relatively high thermal stability and oxidation resistance [4]. Presently, SiC based materials are widely used as furnace parts in the porcelain industry, for hard metal sintering, abrasive wheels, abrasive powders, heat exchanger piping and automotive industry components [5,6].

An important characteristic of SiC is its polytypism. A large number of polytypes are known; the cubic polytype is referred to as β-SiC and the other non-cubic structures (hexagonal and rhombohedral) as α-SiC [3]. It has been suggested that the type of SiC formed is controlled by the impurities present in it [7]. The impurities that exercise the most influence on the type of SiC formed are those with elements from groups III and V of the periodic table, that is, the electronic acceptors (Al, B, etc.) and the electronic donors (N, P).

Solid state densification of covalent structural ceramics like SiC are difficult, even at high temperatures. Hence, they are often liquid phase sintered with oxide additions, which upon cooling form secondary glass phases of silicon oxynitride or silicon oxycarbide.

In liquid phase sintering, a viscous liquid forms at the sintering temperature and this is very important for the densification of various materials [8]. It is important to have complete wetting of the solid by the liquid for the liquid phase sintering process to take place. Another important factor in liquid phase sintering is dissolution of the solid in the liquid and its re-precipitation.

In this process, the pressed powder is heated to a temperature at which there is liquid formation, normally made possible by a eutectic composition. The quantity, the viscosity of the liquid phase

10104