

Microstructure Characterization of Al₂O₃-ZrO₂ Composites

A.L.E. Godoy, Ana H. A. Bressiani, and J.C. Bressiani
Instituto de Pesquisas Energéticas e Nucleares, IPEN-CNEN/SP,
Caixa Postal 11049, CEP-05422- 970

Alumina matrix materials with zirconia fine particles uniformly embedded show improved bending strength and toughness. These mechanical properties are due to mechanisms related to stress induced martensitic transformation in ZrO₂ (tetragonal to monoclinic) and microcrack formation^[1,2]. To find the relationship between the mechanical properties and the processing parameters, a material microstructure characterization is essential. Microstructure characterization of 15 vol % ZrO₂ - Al₂O₃ and 15 vol % Y₂O₃: ZrO₂ - Al₂O₃ was performed by using a scanning electron microscopy (SEM) and X-rays diffraction (XRD). Bar shaped samples were prepared by mixing Al₂O₃ - A16-SG (Alcoa Co.) to zirconia from three different sources: ZrO₂ produced by the Nuclear and Energy Research Institute (IPEN-Brazil), after 20 hours ball-milling (sample BC); ZrO₂ (produced from 6h ball-milled zirconium hydroxide followed by calcining at 1000°C during 1 h) after ball-milling during 5 h (sample BH); and 2 mol % Y₂O₃ stabilized zirconia from Toyo Soda (sample BY). Such mixtures were homogenized in water during 3 hours, dried and sieved through 60 mesh grid. Samples were uniaxially pressed in the shape of bars and sintered at 1600°C during 1 hour. These conditions are suitable to process those materials as shown by dilatometric test results (see Figure 1). The table I presents typical density values, hardness and tetragonal phase volumetric percentage (T.P.) for the BC, BH and BY samples. Densities are given with respect to the theoretical density values (TD).

SAMPLE	% TD	HARDNESS (GN/m ²)	T.P. (vol %)
BC	97.6	19.3	68
BH	96.4	16.2	38
BY	97.4	18.1	100

Table I- Main values for BC, BH and samples.

Figures 2, 3, and 4 show micrograph pictures obtained by SEM from back scattered electrons for sample fracture surfaces. These microstructures show similar characteristics even though sample BY has ZrO₂ particle sizes lower than the others. It is also noted that ZrO₂ grains (bright region in the micrographs) are rounded and found in intergranular positions in the alumina matrix. The BH sample shows a ZrO₂ particle distribution much more heterogeneous with larger agglomerates than the other two samples leading to higher alumina grain growth and larger pores. That is the reason why those materials show lower density and hardness values.

From these results it is expected that for zirconia provided by IPEN the processing method used to obtain the sample BC should be adopted rather than the one used for the BH sample. To get higher amount of tetragonal phase in the sample BC it is necessary to reduce the ZrO₂ particle size or to use Y₂O₃ doped zirconia.

References

1. F. Ye, T.C. Lei, Q. C. Meng, Y. Zhou, J. Mater. Science, 30 (1995) 4549-55.
2. N. Claussen, J. Amer. Ceram. Soc. 59 (1976) 49.

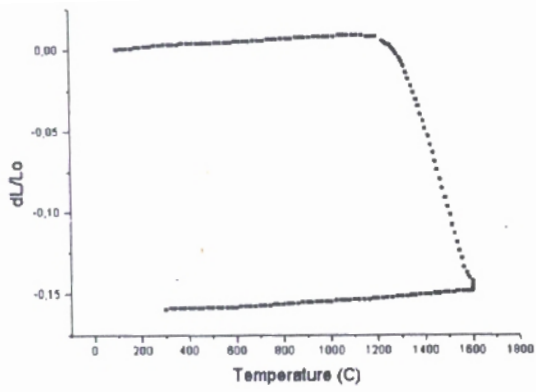


Figure 1 - BY sample dilatometric curve.

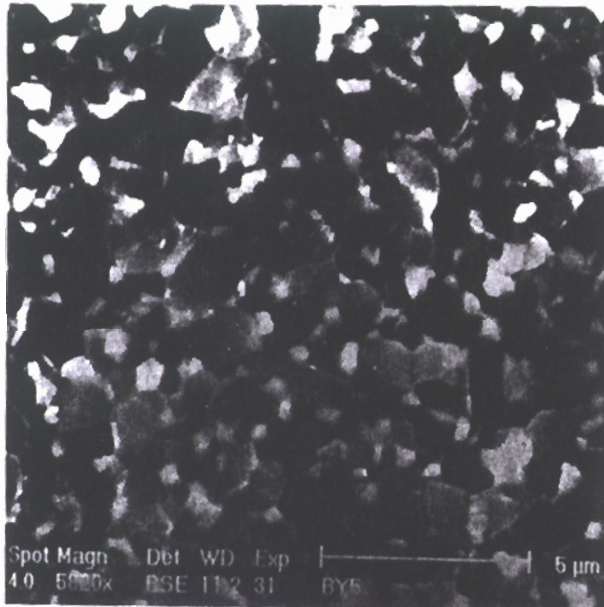
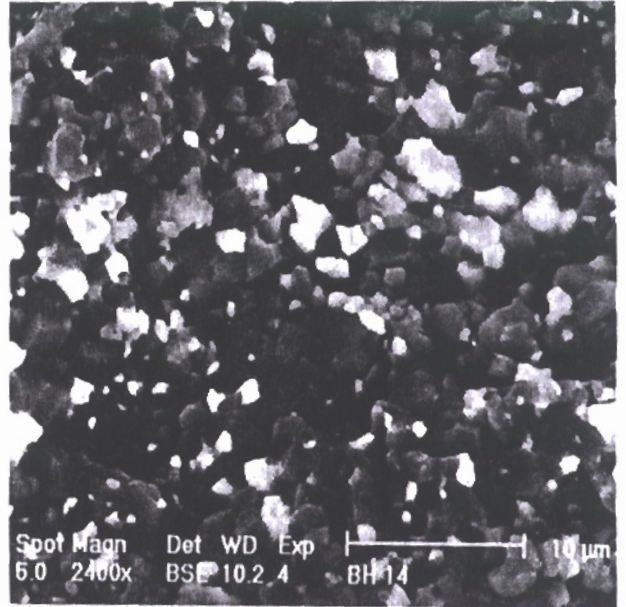
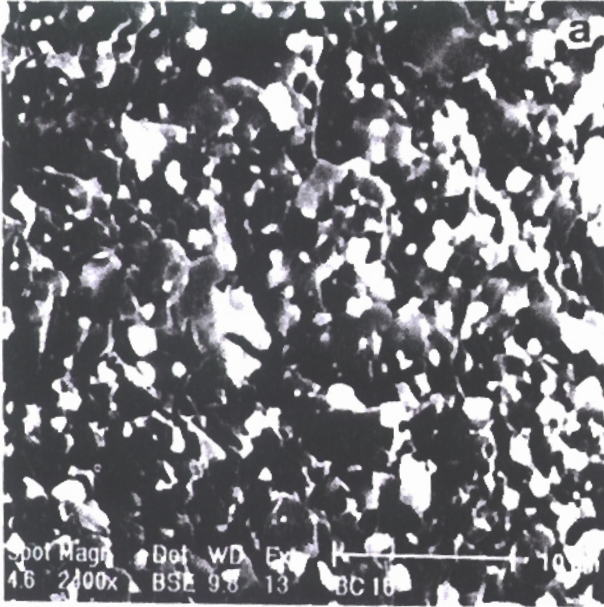


Figure 2 - BC, BH and BY samples micrographs.