

## CHARACTERIZATION OF $\text{Al}_2\text{O}_3$ -SiC-ZrO<sub>2</sub> POWDER COMPOSITE

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Improvements in mechanical properties of structural ceramics have been achieved by adding zirconia and silicon carbide to alumina ceramics. The  $\text{Al}_2\text{O}_3$ -SiC-ZrO<sub>2</sub> powder composite can be obtained employing cheap minerals such as kaolinite or kyanite and zircon as precursors.

Advanced ceramic composites, based on alumina and silicon carbide have been synthesized by carbothermal reactions from inexpensive precursor materials such as kaolinite, kyanite, pyrophyllite, etc<sup>1</sup>. Zircon ( $\text{ZrSiO}_4$ ), which is a common Zr mineral, was introduced as part of a ceramic composite increasing fracture toughness due to zirconia formation in the composite synthesis process<sup>2</sup>. This paper presents the characterization of  $\text{Al}_2\text{O}_3$ -SiC-ZrO<sub>2</sub> composite powders<sup>2</sup>.

A powder mixture of  $\text{Al}_2\text{O}_3$ , SiC and ZrC is preferentially formed from carbothermal reaction of kaolinite or kyanite, carbon and zircon. After formation, ZrC must be oxidized into ZrO<sub>2</sub> to obtain  $\text{Al}_2\text{O}_3$ -SiC-ZrO<sub>2</sub> composite powder. Variations in kaolinite or kyanite and zircon contents do not result in different product formation, but in different compositions of  $\text{Al}_2\text{O}_3$ , SiC and ZrC.

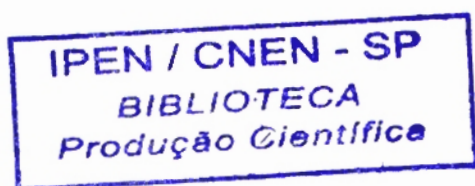
The carbothermal reaction of 51.6 wt% kaolinite, 24.4 wt% zircon and 24 wt% carbon results in a composite powder with 35.1%  $\text{Al}_2\text{O}_3$ , 37.6% SiC and 22.7% ZrC, as determined by quantitative x-ray diffraction analysis, using the internal standard technique. The three phases are homogeneously distributed as observed by MEV (Fig. 1) with EDS analysis. There is no need for further grinding to reduce grain size or homogenize the composite powder. An usual aspect of the powder is the presence of fine particles of ZrC (< 1 $\mu\text{m}$ ) distributed in a matrix of  $\text{Al}_2\text{O}_3$  and SiC. Grain size analyses showed that the carbothermal reaction results in products with particles finer than those of the raw materials. After oxidation, the resulting powder has the same morphological characteristics of the mixture of  $\text{Al}_2\text{O}_3$ , SiC and ZrC powders (Fig. 2). Finer particles of ZrC led to formation of tetragonal ZrO<sub>2</sub>. Not infrequently, ZrC particles are not well dispersed during the oxidation step in an electric furnace. Coarse ZrC particles and agglomerates favour the formation of monoclinic ZrO<sub>2</sub>. Figs. 3 and 4 show the  $\text{Al}_2\text{O}_3$ , SiC and ZrO<sub>2</sub> observed by MET. Figs. 5-a, -b and -c depict these phases identified by SAD pattern. The tetragonal ZrO<sub>2</sub> phase probably increases fracture toughness.

The introduction of ZrO<sub>2</sub> increased the fracture toughness of the hot pressed  $\text{Al}_2\text{O}_3$ -SiC-ZrO<sub>2</sub> composite by 40% as compared with  $\text{Al}_2\text{O}_3$ -SiC composite.

### References

1. A.C.D. Chaklader et al., *J. Mat. Synth. Process*, 1 (1993) 145.
2. S.M.B. Veiga et al., *Proc. Int. Symp. Advanced Ceramics for Structural & Tribological Applications, 34<sup>th</sup> CIM Conf. Metallurgists* (1995) 107.

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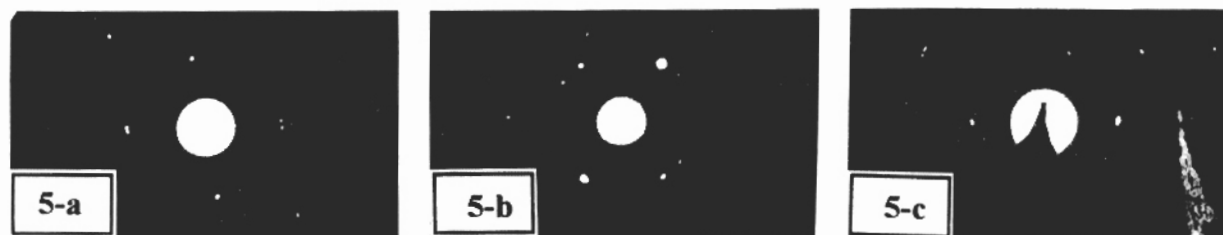
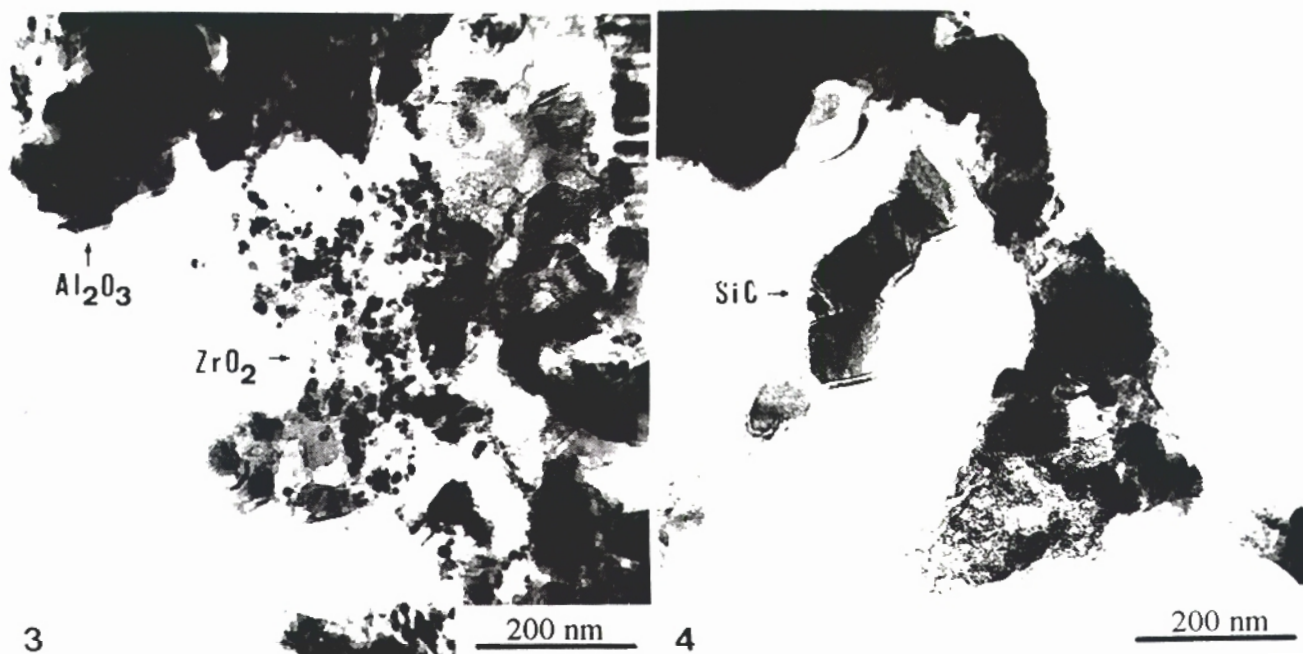
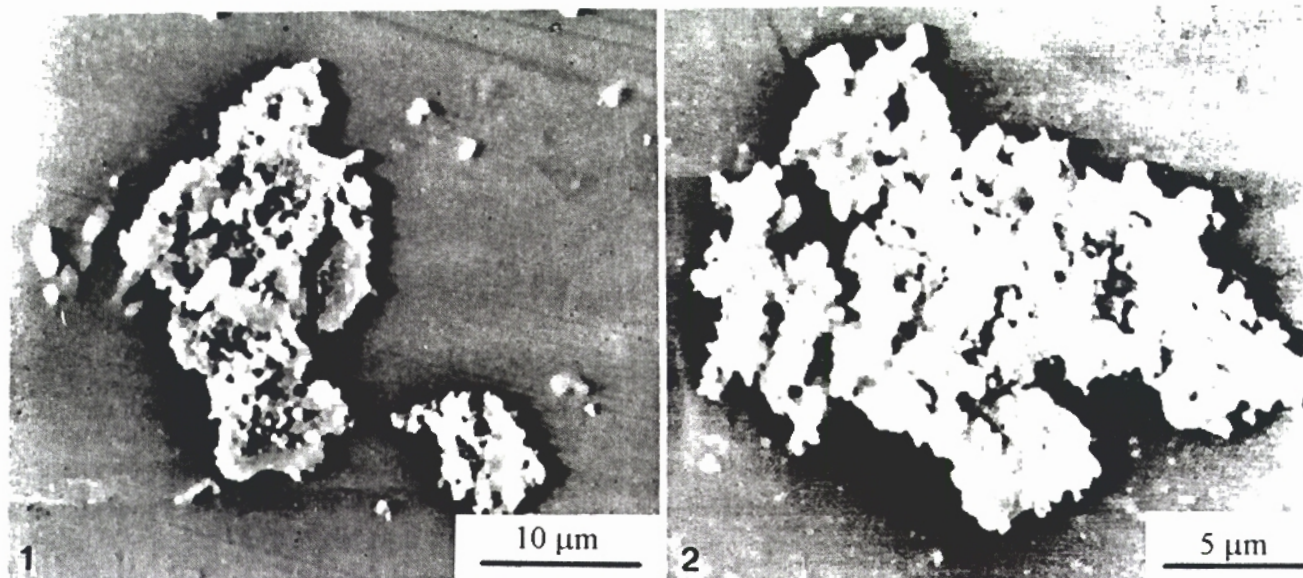


FIG. 1 - SEM micrograph of Al<sub>2</sub>O<sub>3</sub>-SiC-ZrC powder observed by back-scattered electrons.  
 FIG. 2 - SEM micrograph of Al<sub>2</sub>O<sub>3</sub>-SiC-ZrO<sub>2</sub> powder observed by back-scattered electrons.  
 FIG. 3 - Al<sub>2</sub>O<sub>3</sub> and ZrO<sub>2</sub> phases in the Al<sub>2</sub>O<sub>3</sub>-SiC-ZrO<sub>2</sub> composite powder observed in MET.  
 FIG. 4 - SiC phase in the Al<sub>2</sub>O<sub>3</sub>-SiC-ZrO<sub>2</sub> composite powder observed in MET.  
 FIG. 5 - SAD pattern of Al<sub>2</sub>O<sub>3</sub> (a), ZrO<sub>2</sub> (b) and SiC (c).