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Alumina - cubic boron nitride composite materials

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Declaration

I declare that this thesis is my own work. It is being submitted for the degree of Doctor of Philosophy in the University of the Witwatersrand. It has not been submitted before for any other degree or examination in any other university.

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Aron Tamisa Shonhiwa

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Abstract

Alumina – cubic boron nitride composites (30% cBN by volume) with a hardness of 24.6 GPa, fracture toughness of 3.9 MPa $m^{1/2}$ and a density of 96.5% were successfully synthesized via the reaction bonded aluminum oxide process. This involved initially heat treating mixtures of aluminum with alumina and cubic boron nitride in an oxidizing atmosphere so as to oxidize the aluminum into new alumina crystallites. This initial heat treatment was done at temperatures not exceeding 1000 ^oC so as to avoid oxidation of cubic boron nitride. X- ray diffraction and gravimetry were used to assess the degree of oxidation of aluminum into alumina during the oxidation stage. It was not possible to fully oxidize all the aluminum and at higher temperatures (1000 ^oC) some of the cubic boron nitride started to form B_2O_3. The optimum oxidizing temperature was found to be 800 ^oC.

The second heat treatment , meant for densification was done in an inert atmosphere (argon and vacuum) in a graphite heated hot press furnace at 1300 ^oC under a pressure of 80 MPa for 2 hours.

Phase analysis , microstructural analysis and density measurements were done using X-ray diffraction, Scanning electron microscopy and the Archimedes method respectively. Hardness and fracture toughness were determined using the indentation method.

After hot pressing there was no evidence of hexagonalisation . All the cubic boron nitride was present in the cubic form and was evenly distributed within the alumina matrix . The degree of densification decreased with increase in cubic boron nitride loading. Hardness and fracture toughness on the other hand increased with increasing cubic boron nitride loading.

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