Effect of Hot-Pressing Time on Physical and Tribological Properties of Silicon Nitride with MgO Additive

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Silicon Nitride containing 5 wt% MgO was hot-pressed at 1800°C and 300 kg/cm², and physical and tribological properties of sintered bodies were measured as a function of hot-pressing time. The bulk density increased with hot-pressing time up to 60 min. The fracture toughness increased and the Vickers hardness decreased with increasing hot-pressing time, but these values remained essentially constant after 60 min sintering. The coefficient of friction on a hot-pressed silicon carbide disk did not change, but the specific wear rate decreased rapidly with hot-pressing time up to 60 min, and approached a constant value, 5×10^{-8} mm²/kg. The bodies hot-pressed up to 30 min consisted of mixed small and relatively large grains. But the grain growth occurred and fibrous microstructures were fully developed after 60 min sintering, and only β-phase was detected by X-ray diffraction. As a conclusion, the physical and tribological properties of sintered silicon nitride were almost constant after 60 min hot-pressing, which was consistent with the change of microstructure accompanied by $\alpha\rightarrow\beta$ phase transformation.
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Joining of Silicon Carbide Ceramics with Si_3N_4-Y_2O_3-La_2O_3-MgO Mixture

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Normally sintered silicon carbide was joined with a Si_3N_4-Y_2O_3-La_2O_3-MgO mixture having a composition, Si_3N_4 : Y_2O_3+La_2O_3=35-65 : 65-35(mol%), at 1600°-1800°C for 30-90 min in argon (provided that Y_2O_3/La_2O_3 molar ratio is unity and MgO content equals to 20 wt%). The highest room temperature joining strength, 397 MPa, was obtained by joining at 1700°C for 60 min with a composition, Si_3N_4 : Y_2O_3+La_2O_3=55 : 45(mol%). The strength measurement at high temperature (holdihg time : 10 min) showed that the strength of the same specimen was more than 300 MPa up to 1000°C, but decreased rapidly above 1000°C. The joining strength decreased with holding time above 900°C. The thickness of the joining layer was about 20 μm. No diffusion into silicon carbide matrix of Y, La and Mg, ingredients in the joining agent, was observed, and the joining agent formed a glassy phase after joining. These results imply that joining of silicon carbide ceramics occurred only by the wetting of oxynitride of Si_3N_4-Y_2O_3-La_2O_3-MgO system (the bending strength : about 280 MPa). The lowering of joining strength at high temperature was attributed to the softening above T_g and to the brittleness due to crystallization of oxynitride glass.
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Influence of Size and Shape on Homogeneity of Powder Compacts Formed by Cold Isostatic Pressing (Part 1)

Press Forming of Thick Cylinders

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The influence of size and diameter/thickness (D/T) ratio on the homogeneity of cylindrical silicon carbide powder compacts formed by cold isostatic pressing has been studied. The degree of inhomogeneity was estimated by the measurement of spatial *distribution of bulk density, Vickers microhardness and pore size distribution for the specimens cut out from the compacts. The degree of inhomogeneity in the density and hardness was relatively smaller than that in uniaxially die-pressed compacts. However, the distribution patterns of the density and hardness which were similar to each other showed the presence of high density and high hardness layer near the surface of the compacts. Furthermore, inhomogeneity was found locally in the inner part of the compacts. A considerable decrease in volume fraction of the smaller sized pores was recognized at the corner edge of the cylindrical compacts. The volume of the inhomogeneous layer near the upper surface in the compacts with a larger D/T ratio tends to be reduced with decreasing D/T ratio. For the same D/T ratio, however, the homogeneity did not depent on the size of the compacts. This behavior could be explained by the difference in damping behavior of the applied pressure between the radial and axial directions.* [*Received January 20, 1986*]

Thermal Fatigue Behavior of Y_2O_3-Containing Tetragonal Zirconia Polycrystals (Y-TZP)

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The theremal fatigue behavior of 3 mol% Y_2O_3-containing tetragonal zirconia polycrystals (Y-TZP) with average grain sizes of 0.4 μm (Z3Y-I) and 1.0 μm (Z3Y-II) was studied by quenching into water bath at 20°C. The retained strength distribution of Z3Y-I subjected to multiple cycle quench at $\Delta T = 350°$ and 300°C showed a shoulder at a certain F level, which corresponds to the initiation point of thermal shock damage. The F level increased with increasing thermal shock cycle number. For Z3Y-I at $\Delta T = 350°$, the proportion of damaged specimens was half for 1 cycle quenching and most for 10 cycles. At $\Delta T = 300°C$, the proportion of damaged specimens was none for 1 cycle, a few for 8 cycles and half for 60 cycles, but at 250°C, no crack iwas generated at 90 thermal shock cycles. On the other hdnd, the strength distribution of Z3Y-II subjected to multiple cycle quench at 350°C was similar to that of Z3Y-I at $\Delta T = 350°C$, but those of Z3Y-II at $\Delta T = 300°$ and 250°C were followed by decreasing standard deviation, and the difference between maximum and minimum strengths was within about 3.1% for the thermal shock cycles above fifteen. The average strength of Z3Y-II subjected to 75 thermal shock cycles at $\Delta T = 300°C$ and 90 cycles at $\Delta T = 250°C$ were about 60 and 76% of the original strength before water quench, respectively. The thickness of zone transformed from tetragonal to monoclinic phase by chemical reaction with hot water was 103 μm for 30 thermal shock cycles, 155 μm for 50 cycles and 356 μm for 75 cycles at $\Delta T = 300°C$, and 36 μm for 60 cycles and 211 μm for 90 cycles at $\Delta T = 250°C$. [*Received February 19, 1986*]

Solid Particle Erosion of Brittle Materials (Part 1)

——The Relation between Erosive Wear and Properties of Gas Pressure Sintered Si_3N_4——

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Erosive wear by solid particle impingement was tested for 16 kinds of Si_3N_4 which were gas-pressure sintered at different temperatures using different raw material powders containing various amounts of additives. Testing conditions were as follows : #30 SiC abrasive grains, abrasive grain speed of 250-300 m/s and an impingement angle of 80°. The volume eroded was great when the target Si_3N_4 had a low density and large grain size. This corresponds to the tendency that the eroded volume increases with decreasing hardness and fracture toughness. The erosion results were tested four equations that relate the erosive wear to the hardness (Young's modulus) and fracture toughness of the target. The equation $V \propto H^{-1/4} K_C^{-4/3}$, which was proposed theoretically by Evans, was found to best describe the experimental results.

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