Y-12

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OAK RIDGE Y-12 PLANT

LOCKHEED MARTIN

Y-12 DEVELOPMENT ORGANIZATION TECHNICAL PROGRESS REPORT

Part 5 - Polymers, Ceramics
and Solvents

Period Ending January 1, 1996

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**Y-12 DEVELOPMENT ORGANIZATION
TECHNICAL PROGRESS REPORT**

**Part 5 - Polymers, Ceramics
and Solvents**

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Period Ending January 1, 1996

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HIGHLIGHTS

MICROWAVE HEATING OF MATERIALS

Microwave sintering studies with boron carbide (B_4C) are being evaluated to compare properties of unidirectionally pressed and sintered microwaved pellets with gelcasting of B_4C . The particle blend is a 50/50 blend of 1- μm and 0.1- μm using 5 wt % carbon (Thermax[®]) addition.

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POLYMERS, CERAMICS, AND SOLVENTS

MICROWAVE HEATING OF MATERIALS

M. S. Morrow

Summary

Microwave sintering studies with boron carbide (B_4C) are being evaluated to compare properties of unidirectionally pressed and sintered microwaved pellets with gelcasting of B_4C . The particle blend is a 50/50 blend of 1- μm and 0.1- μm using 5 wt % carbon (Thermax[®]) addition.

The large, dual-frequency microwave furnace was used to determine that scaleup of a large number of parts can be processed simultaneously using a microwave furnace.

Microwave heat treatment of commercial silicon carbide (SiC) resulted in minimal densification, which is thought to result from the exclusion of liquid-phase eutectic, producing sintering aids.

Introduction

The emerging technology of microwave heating and processing of high-temperature materials has been shown to provide unique properties and directions for the materials field.¹⁻⁸ The current investigations are directed primarily toward nonoxide refractories.

Prior Work

Earlier studies were directed toward understanding the peculiarities of microwave processing while directing the effort toward sintering of nonoxide ceramics such as titanium diboride (TiB_2), boron carbide (B_4C), silicon carbide (SiC), and lithium hydride (LiH).⁹⁻⁴⁴ Special materials, such as reaction-bonded silicon nitride (RBSN), were also shown to be excellent materials for microwave processing. As a result of Y-12 Plant discoveries with RBSN, that material is now a primary study area at Oak Ridge National Laboratory (ORNL).⁷⁻²³

Presentation of Experimental Work

Boron Carbide (B_4C)

Boron carbide pellets 3 in. diam $\times$ 0.5 in. high were pressed at 30,000 psi with a conventional press, isostatically pressed at 50,000 psi, and encapsulated with a stucco "shell" system that was newly developed. The green densities of the three pellets equaled 45% of theoretical density. The encapsulate/stucco allows microwaves to penetrate and be absorbed by the pellet in an extremely uniform manner; allows uniform, reproducible densification to 2200°C, and essentially overcomes major problems with field uniformity that have plagued microwave sintering. Microwave sintering will be performed at 2.45 GHz to densify tests gelcast pellets. The results will be evaluated to compare material properties (grain size, hardness, microstructure, and mechanical properties) of the sintered pieces.

Scaleup of a Large Number of Parts

The large, dual-frequency microwave furnace was used to process a large number of RBSN parts. The first experiment consisted of 90 parts, which were successfully nitrided and sintered. Figure 1 shows these parts. The second experiment had 230 parts, which were successfully nitrided and sintered to produce RBSN. Both experiments were successful in demonstrating the feasibility of the scaleup of ceramic parts using microwave heating. ORNL was responsible for having the experiments conducted.

Fig. 1. Reaction-bonded silicon nitride parts processed by the large, dual-frequency microwave furnace.

Future Work

Other large, nonoxide pieces will be microwave sintered. Sintering of gelcast armor tiles will be pursued. Boron carbide sintering studies will be continued to determine the optimum times, temperatures, and carbon levels. The effect of varying microwave frequencies on sintering will be evaluated. Areas in which microwave processing appears to offer significant advantages (i.e., the heat-treatment/nitridation of plasma-sprayed materials) will be explored. Gelcasting will continue to be used.

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