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Ceramic Technology Project Database:
September 1993 Summary Report

B. L. P. Keyes

**CERAMIC TECHNOLOGY
PROJECT**

MANAGED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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Metals and Ceramics Division

CERAMIC TECHNOLOGY PROJECT DATABASE:
SEPTEMBER 1993 SUMMARY REPORT

B. L. P. Keyes

Date Published: January 1994

NOTICE: This document contains information of a preliminary nature. It is subject to revision or correction and therefore does not represent a final report.

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ABSTRACT

Data presented in this report represent an intense effort to improve processing methods, testing methods, and general mechanical properties of candidate ceramics for use in advanced heat engines. This work was performed by many facilities and represents only a small part of the data generated by the Ceramic Technology Project (CTP) since 1986. Materials discussed include GN-10, GS-44, GTE PY6, NT-154, NT-164, sintered-reaction-bonded silicon nitrides, silicon nitride combined with rare-earth oxides, NT-230, Hexoloy SX-G1, Dow Corning's β - Si_3N_4 , and a few whisker-reinforced ceramic composites.

Information in this report was taken from the project's semiannual and bimonthly progress reports and from final reports summarizing the results of individual studies. Test results are presented in tabular form and in graphs. All data, including test rig descriptions and material characterizations, are stored in the CTP database and are available to all project participants on request.

The objective of this report is to make available the test results from these studies but not to draw conclusions from those data.

INTRODUCTION

Participants in the Ceramic Technology Project (CTP) are constantly improving existing materials, altering testing and analytical methods, and developing new materials and methodologies that would make ceramic engines and engine components feasible. The high-temperature resistance of ceramics makes them attractive to not only the automotive industry, but to other specialized areas, such as the tool manufacturing and aerospace industries, as well. As time passes, even more applications will be found for the ceramics being developed today if the information on these materials is passed along to those who can use it.

The purpose of this effort is to gather and make available all test results generated within the CTP. Silicon-based materials are the focus of this report, including silicon nitride-based, silicon carbide-based, and whisker-reinforced silicon nitride-based ceramics. Programs generating these data are described briefly as well. Most of the information was extracted from the project's semiannual and bimonthly progress reports, facility data sheets, and technical reports from individual programs. Test results are represented in

tabular and graphical forms and include associated details about the test facilities, material characteristics, and compositions, if such information was available.

Tribology studies were excluded due to the amount of detail needed to describe and characterize such data; wear data will be published in the future in a separate report comprised only of tribology information.

Ceramics not containing obvious reinforcement materials, such as whiskers or fibers, are referred to in this report as being monolithic. Other definitions of the term "monolithic" involve material phases and do not apply to this usage. Efforts to clarify the definition of "composite" are in progress in American Society for Testing and Materials (ASTM) Committee C-28 on Advanced Ceramics and will be incorporated into database terminology when available. For this report, a ceramic matrix composite refers to a monolithic ceramic to which reinforcing materials have been added.

Note that file names and field names may not be spelled fully in this document and in the database. Computer software limits the size of the file name to eight characters (not including the three-character file extension) and field names to ten characters. An effort was made to retain the essence of the descriptive words within the available space. The degrees symbol, "°", is a special character that cannot be stored in the database due to software limitations and is, therefore, omitted in some of the tables. Other omitted characters are spelled out when possible, such as "Beta" for the Greek character β . All efforts are made to keep the stored information as true to the originals as the limitations of the software and equipment permit.

DATABASE STATUS

The CTP database presently contains 9261 records on 27 different types of tests, 670 material characterizations, 13 lubricant characterizations, 102 coating characterizations, and 2367 other associated records. A more detailed description may be found in Table 1.

A major improvement was accomplished in August 1993 when the equipment for storing photo-micrographs was procured and installed on an existing computer system. Since database personnel prefer the Macintosh for handling graphics over the IBM-compatible that now houses the database, it was decided to base the image storage system on it. Both systems were upgraded with CD-ROM readers, more memory, larger capacity Bernoulli drives (150 MB), and for the Macintosh, image-handling software. The images are transferrable between the systems and may be converted to several different formats. Micrographs are scanned into Macintosh memory using

Hewlett Packard's (HP's) Deskscan and an HP Scanjet IIC. Images are enhanced, if necessary, and cropped using Adobe Photoshop, then cataloged using Kodak's Shoebox Image Manager and Aldus Fetch. (Part of this exercise involved finding the software that would perform best; thus, these two packages were selected.) Results of the initial round of image storing are shown in Appendix A, Sect. 5b of this report.

Work on the computerized user interface for the database continued in fiscal year (FY) 1993, but was not finished as planned due to several problems. The original version is being written for IBM/386/486-compatible microcomputers using dBASE IV™ (version 1.5) programming language and should run with only the dBASE IV runtime modules that will be supplied with the interface. Work on the Macintosh version will begin once the PC version has been debugged.

New features in version 1.5 allowed more flexibility and better menu drivers than in the previous version, so many of the earlier menus were rewritten to take advantage of these features. Another problem appeared in August 1993 when the system was updated to include images of micrographs. Version 1.5 of dBASE does not permit storage of images with the test and numeric data. A text index to the micrographs is included in the dBASE version of the database with hopes of finding a way to include the actual images eventually. Work on the interface is expected to resume very soon.

Minor modifications were made to some of the existing file structures during the early stages of work on the interface. These changes were necessary for the program to access the correct information based on a user's request. Most of the changes were structural only and had little impact on the information already stored. Since the interface is still being written, more changes may be forthcoming. All alterations will be documented in a future publication.

Several new files were added to the database during the past fiscal year. The micrograph index (named PCPHOTO) and image files have already been mentioned. CRPCRVS contains creep curve information so that original test values may be stored and reanalyzed in the future. STPCRCP was designed to handle data generated by tests in which the stress was stepped periodically, thus producing a larger quantity of information than is normally stored in a creep, stress-rupture, or tensile test. Only a small amount of data exists in the last two files at this time.

DATA BACKGROUND

Tracking down background information for a specific batch of a material is a time-consuming, often frustrating, experience that is often necessary to confirm the validity of the data. The fabricator's assigned batch number of a material is frequently lost as the material proceeds through its processing life. Some of the data in this report include the original batch codes assigned to the materials by the fabricators. When no batch identifier is reported with data in the source document, a code is assigned by database personnel based on the name of the material fabricating facility and the company, lab, or individual reporting the data. It is possible for material with a fabricator's batch code to be the same as a material with a locally assigned batch code if, for example, data for the material were reported without the original fabricator's code. Unless the unknown-batch-code data are exact duplicates of known-batch-code data, the unknown-batch-code data are assigned a unique identifier to distinguish them from other batches of the same material.

Data tables for this report are organized according to type of data: Appendix A contains available background information on the ceramics presented in this report, including the new micrograph images; Appendix B contains the experimental text data arranged in sections by property type. Some of the test data listed in Appendix B may not be represented by materials in Appendix A but will be included in a later report if and when such information becomes available. It is the policy for this to store the available information for future use, whether or not a complete set of information is available on a material. However, complete sets are preferred and sought as time permits.

All information presented in this report was produced by programs funded by the CTP. Many of these programs sought to improve specific types of structural ceramics, with silicon nitrides being the most studied, followed closely by zirconia-based ceramics. Other programs developed new test methods to predict more accurately the mechanical behavior of advanced ceramics at room and elevated temperatures. Test results from both types of programs were extracted from the CTP semiannual and bimonthly progress reports and from technical reports generated within the individual programs. Data sheets were received from Ken Liu and Matt Ferber, both from Oak Ridge National Laboratory (ORNL). A brief description of the programs generating data for this report follows. The work breakdown structure [(WBS) element] designation precedes each program title.

1.1.1.3 - High-Temperature Hexoloy SX Silicon Carbide - S. K. Lau and G. V. Srinivasan (The Carborundum Company)

The objectives of this program are to establish a property data base and analysis for Hexoloy SX-G1, to optimize the processing conditions for that material using a designed experimental method, and to develop an improved version of the current SX material. All Hexoloy SX data in this report were produced under this task.

1.1.2.4 - Microwave Sintering of Silicon Nitride - T. N. Tiegs, J. O. Kiggans, K. Ploetz, and D. Coffey (ORNL)

The goals of this task are to identify those aspects of microwave processing of silicon nitrides that might accelerate densification, permit sintering to high density with much lower levels of sintering aids, lower the sintering temperature, or produce unique microstructures. Dense silicon nitride materials annealed in a microwave unit of 2.45 or 28 gigahertz have been used in this program.

1.2.2.1 - Development of Ceramic Matrix Composites for Application in the Ceramic Technology for Advanced Heat Engines Project - H. C. Yeh, E. Solidum, K. Karasek, S. Bradley, J. Schienle, G. Stranford, and D. Yuhas (Garrett Ceramic Components Division of Allied Signal Aerospace Company)

Multiphased in scope, the goal of this program is to maximize the toughness in a high-strength, high-temperature silicon carbide whisker-reinforced silicon nitride matrix material that can be formed to shape by slip casting and densified by a method amenable to complex shape mass production. The ASEA glass encapsulation hot isostatic pressing (HIP) technique was used throughout the program. In this report, GN-10 was used as the basic silicon nitride material into which various quantities of silicon carbide whiskers were added. An evaluation of silicon carbide whiskers from different sources is also included.

1.2.3.1 - Dispersion-Toughened Ceramic Composites - T. N. Tiegs, P. F. Becher, P. A. Menchhofer, W. H. Elliott, D. J. Kim, and D. W. Coffey (ORNL)

Improving toughness properties of structural ceramics using silicon carbide whiskers or other forms of reinforcement in various matrices is the goal of this activity. Present studies involve using rare earth oxides to promote in situ acicular grain growth in silicon nitrides.

3.1 - Ceramic Characterization and Standards for Heat Engines - S. Malghan, S. Wiederhorn, B. Hockey, G. Quinn, and S. M. Hsu (National Institute of Standards and Technology)

This task addresses five critical areas of standards development: (1) ceramic powder characterization standards and methods, (2) tensile test method development, (3) characterization of structural ceramics, (4) characterization of silicon nitride powders that have been subjected to high-energy attrition milling, and (5) development of mechanical test method standards in support of the CTP and ATTAP programs.

3.2.1.4 - Tensile Cyclic Fatigue of Structural Ceramics - K. C. Liu, C. O. Stevens, and C. R. Brinkman (ORNL)

This ongoing program has the task of designing, developing, and demonstrating uniaxial tension-tension dynamic fatigue testing of structural ceramics at elevated temperatures, and to develop baseline data on tensile fatigue behavior of ceramics at room and elevated temperatures.

3.2.1.5 - Tensile Stress-Rupture Development - K. C. Liu, C. O. Stevens, H. Pih, and C. R. Brinkman (ORNL)

The primary purpose of this program is to develop the capability for performing uniaxial tensile stress-rupture and creep tests at high temperatures in the region where creep can occur.

3.2.2.2 - Life Prediction Methodology for Ceramic Components of Advanced Vehicular Heat Engines - P. K. Khandelwal (Allison Gas Turbine Division, General Motors Corporation)

The objective of this program is to develop and demonstrate the necessary nondestructive examination technology, materials database, and design methodology for predicting useful life of structural ceramic components of advanced heat engines. The methodology will be demonstrated through confirmatory testing of ceramic components in near-anticipated-use conditions, addressing fast fracture, slow crack growth, creep, and oxidation failure modes. Tensile and creep tests on GTE PY6 (batch code = AGTD/HIP) were run at Southern Research Institute at elevated temperatures and are reported in Appendix B.

3.2.2.3 - Life Prediction Methodology for Ceramic Components of Advanced Heat Engines - J. Cuccio [Garrett Auxiliary Power Division (GAPD) of Allied Signal Aerospace Company]

GAPD's approach to ceramic life prediction consists of comprehensive testing of various specimen geometries under both uniaxial and multiaxial loads at different

environmental conditions to determine strength-controlling flaw distributions and to identify various failure mechanisms. The information gathered will be used to develop material behavior models that will be integrated with stress and thermal analyses to create a failure risk integration analysis computer program to predict the life of ceramic components.

3.3.1.4 - Environmental Effects in Toughened Ceramics - N. L. Hecht [University of Dayton Research Institute (UDRI)]

Environmental effects on mechanical properties of commercially available ceramics for use in vehicular heat engines are the primary concern of this program. UDRI also characterizes many materials for this and other activities.

All data in this report are contained in two appendices. Material characterizations and background information are located in Appendix A. Tabular and graphical representations of the test results may be found in Appendix B. Please note that all Weibull analyses shown in Appendix B were calculated using the least-squares method. The least-squares method is not the most accepted method, but the software to produce maximum likelihood analyses is being revised for database purposes and should be operable for use in the next database summary report.

SYSTEM ACCESS

Direct access to the master database is very limited to protect the integrity of the master files. Experience has shown that major disasters often occur when too many people have direct access to unprotected files at the microcomputer level. Since most users would prefer to have the data in a familiar format, to subset, analyze, and rearrange to suit their needs, this method satisfies both situations; the master files are protected and the user gets the data in a readily consumable form. While direct access is faster, the process of downloading across phone lines can be time consuming and hazardous to the integrity of the data being transmitted. This database was designed as a repository, not a full-function analytical tool.

Access to the data is attained by calling the database administrator and requesting all files or just those pertaining to certain materials or test types. The information requested by the user (in the user-designated format, including software and disk type) will then be downloaded from the master files, reformatted, if necessary, and sent to the user when possible. No plans are being considered for direct access from outside systems at this time. Direct transfer is available by special arrangement but may be time consuming due to

the sizes and numbers of files. No guarantee is given for the validity of data transmitted directly because of possible phone line problems.

Several file formats, other than dBASE IV, are available for files downloaded for users. These formats have been categorized as either Apple Macintosh-compatible files (on 3.5-in. floppy disks, 90- or 150-MB Bernoulli cartridges) or IBM PC-compatible files (on 3.5-in. floppy disks up to 1.44 MB, 5.25-in. floppy disks from 360 KE to 1.2 MB, or 90- or 150-MB Bernoulli cartridges). Available Macintosh file types include Microsoft EXCEL™, SYLK, FOXBASE™, and plain printable ASCII. IBM file types are Lotus 1-2-3™, Microsoft EXCEL™, DIF, SDF, SYLK, plain ASCII, delimited ASCII, and dBASE IV. Other formats may be available by special arrangement. At the present, the image files are available only in the PICT format for the Macintosh due to time considerations, although selected images may be translated to other formats by special request, provided the quantity is not too large. When requesting information from the database, users should indicate disk size, disk density, and file type.

With computer diseases becoming so rampant, users should be aware that precautions are taken to ensure that the disks they receive from the database are disease free. Only new disks are used for transmittals to avoid spreading any computer diseases that might be hiding. No recycled, reformatted disks are sent to users. Both the master system, a Northgate Elegance 486/25, and the Macintosh IICx are checked regularly for such illnesses; none have been found so far. Use of both computers is limited to one person who screens incoming software carefully to avoid contamination of either system. No information is downloaded from public bulletin boards to either system. Both computers have virus detection software installed, and all efforts are made to ensure both systems remain disease free. If users have problems with disks received from the database, they should inform database personnel immediately so steps can be taken to correct the problems.

FUTURE PLANS

Development of the computerized user interface using the dBASE IV programming language is in progress. The interface will link the many database files together, providing better access to information in the system. This interface will be available to all users of the database who request it and will not require a full copy of dBASE IV to operate. Runtime modules of dBASE IV will be included with the interface for the user's convenience.

Storage of more creep curves, stepped stress test data, micrographs, and material processing information will be emphasized during the coming year when work on the user interface permits. Investigations into methods of storing image data with the text and numeric data on the 486 system will continue as well.

Efforts have begun on the development of a module in the user interface to convert database information to a format compatible for NASA's CARES analysis program. Other work has delayed progress on this task temporarily.

The next database summary report is scheduled for September 1994.

OTHER CTP DATABASE SUMMARY REPORTS

M. K. Booker, *Ceramics Technology for Advanced Heat Engines Project Database: A Summary Report*, ORNL/M-462, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., Oak Ridge, Tennessee.

B. L. P. Booker, *Ceramics Technology for Advanced Heat Engines Project Database: September 1988 Summary Report*, ORNL/M-755, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., Oak Ridge, Tennessee.

B. L. P. Keyes, *Ceramics Technology for Advanced Heat Engines Project Database: March 1989 Summary Report*, ORNL/M-1098, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., Oak Ridge, Tennessee.

B. L. P. Keyes, *Ceramics Technology for Advanced Heat Engines Project Database: September 1989 Summary Report*, ORNL/M-1286, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., Oak Ridge, Tennessee.

B. L. P. Keyes, *Ceramics Technology Project Database: March 1990 Summary Report*, ORNL/M-1860, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., Oak Ridge, Tennessee.

B. L. P. Keyes, *Ceramics Technology Project Database: September 1990 Summary Report*, ORNL/M-1861, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., Oak Ridge, Tennessee.

B. L. P. Keyes, *Ceramics Technology Project Database: September 1991 Summary Report*, ORNL/M-1862, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., Oak Ridge, Tennessee.

B. L. P. Keyes, *Ceramics Technology Project Database: September 1992 Summary Report*, ORNL/M-2775, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., Oak Ridge, Tennessee.

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TABLE 1. CTP DATABASE SUMMARY AS OF SEPTEMBER 30, 1993

Material Class	Brazen Specimens					Creep	Cyclic Fatigue	Density	Dynamic Fatigue	Elasticity
	MOR ^a 4	Shear Str.	Toughness	Torsion	Tor. Fatigue					
Alumina							15	5	9	28
Alumina + reinforcing fibers							10	7		
Alumina + Zirconia										
Mullite										2
Mullite + reinforcing fibers										11
SiAlON										
Silicon Carbide		12					17	10	23	15
Silicon Nitride	87	48		15	7	260	36	64	76	135
Silicon Nitride + reinforcing fibers						9	15	65	14	74
Zirconia	241	58	43				51	158		119
Zirconia + reinforcing fibers										
Other				6				4		
Totals	328	118	43	21	7	269	144	313	122	384

Material Class	Fracture Toughness	Hardness	Interrupted Fatigue	MOR ^a		Oxidation Rate	Poisson's Ratio	Shear Modulus	Tensile	Stress Rupture
				3-Pt Bend	4-Pt Bend					
Alumina	39	4			418				15	13
Alumina + reinforcing fibers	39				145				11	
Alumina + Zirconia					7					
Mullite	1			1	4					
Mullite + reinforcing fibers	12			9	20					
SiAlON					52			1		
Silicon Carbide	38	27			275				86	13
Silicon Nitride	153	124		10	1305	1	31	30	214	101
Silicon Nitride + reinforcing fibers	56				164	3	62	61	50	
Zirconia	377	24	239		1613				16	17
Zirconia + reinforcing fibers					2					
Other	2	39			61					3
Totals	717	218	239	20	4066	4	93	92	392	147

^a MOR = modulus of rupture.

TABLE 1. CONTINUED

Material Class	Thermal Conductivity	Thermal Contraction	Thermal Diffusivity	Thermal Expansion	Thermal Shock	Torsion	X-ray Diffraction	Material Char.	Chemistry
Alumina	16			1	2			15	14
Alumina + reinforcing fibers	39		20	4	6			102	
Alumina + Zirconia		23		21				12	
Mullite								2	
Mullite + reinforcing fibers	8							33	
SiAlON	6							2	
Silicon Carbide				23			17	77	68
Silicon Nitride	23		23	58		3	49	296	8
Silicon Nitride + reinforcing fibers	9		17	14				69	
Zirconia							72	49	44
Zirconia + reinforcing fibers								5	
Other			6	40		4		8	17
Totals	101	23	66	161	8	7	138	670	151

Material Class	Wear Resistance	Coatings	Lubricants	Micro-graphs
Alumina-based	9	3		
Alumina + reinforcing fibers	1			
SiAlON				
Silicon Carbide	3			37
Silicon Nitride	22			62
Silicon Nitride + reinforcing fibers				16
Chromia based	98	20		
Zirconia based	13	16		
Enamels	5	10		
Other	126	53	13	

Totals	277	102	13	115	
Grand Total (characterization data not including text records)					900
Grand Total (test data only)					8417

APPENDIX A. MATERIAL CHARACTERISTICS AND BACKGROUND DATA

Section 1a - Material Background - Origination Information

Material	Batch Code	Material Class	Fabricator	Vintage
SIALON-Based Ceramics				
NT-451	NORTON/REF.	SIALON	Norton Company	
SiAlON+2%(3Y2O3+5Al2O3)	ORNL/TIEGS1124	SIALON/YOALO	Oak Ridge National Laboratory	
SiAlON4.5+2%(3Y2O3+5Al2O3)	ORNL/TIEGS1124	SIALON/YOALO	Oak Ridge National Laboratory	
Silicon Carbide-Based Ceramics				
Beta-SiC	DOWCORN/UDRI/1	SIC/BETA	Dow Corning	
HEXOLOY SX-G1	CARB/1/1990	SIC	Carborundum Company	01/1990
HEXOLOY SX-G1	CARB/6/91	SIC	Carborundum Company	06/1991
HEXOLOY SX-G1	CARB/8/1991/MIX1	SIC	Carborundum Company	08/1991
HEXOLOY SX-G1	CARB/8/1991/MIX2	SIC	Carborundum Company	08/1991
HEXOLOY SX-G1	CARB/8/1991/MIX3	SIC	Carborundum Company	08/1991
HEXOLOY SX-G1	CARB/9/1990	SIC	Carborundum Company	09/1990
HEXOLOY SX-G1	CARB/9/1991/B	SIC	Carborundum Company	08/1991
HEXOLOY SX-G1	CARB/9/1991/C	SIC	Carborundum Company	08/1991
HEXOLOY SX-G1	CARB/9/1991/D	SIC	Carborundum Company	08/1991
HEXOLOY SX-G1	CARB/9/1991/F	SIC	Carborundum Company	08/1991
NT-230	NORTON/UDRI	SIC	The Norton Company	1990
Silicon Nitride-Based Ceramics				
CERALLOY 147-3	CERADYNE/UDRI/2	SIN	Ceradyne, Inc.	
GS-44	GARRETT/UDRI/1	SIN	Garrett Ceramic Components/A-S	
GN-10	ORNL/KCL92	SIN	Garrett Ceramic Components/A-S	
GN-10	GCCD/UDRI/1	SIN	Garrett Ceramic Components/A-S	
GN-10	GCCD/NIST/1	SIN	Garrett Ceramic Components/A-S	
GTE PY6	AGTD/HIP	SIN	GTE Laboratories	
NT-154	ORNL/KCL92	SIN	The Norton Company	
NT-154	NORTON/GAPD	SIN	The Norton Company	
NT-164	NORTON/UDRI-92	SIN	The Norton Company	
Si3N4+8%Y+3.5%Si+1.9%Sr	ORNL/TRSN-17-3	SIN/Y/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+8.1%Nd+2.7%Si+1.2%Sr	ORNL/TRSN-13-3	SIN/ND/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+12%Y2O3+4%Al2O3	ORNL/TIEGS1124	SIN/YO/ALO	Oak Ridge National Laboratory	
Si3N4+4%Y2O3	ORNL/TIEGS1124	SIN/YO	Oak Ridge National Laboratory	
Si3N4+6%Y2O3+2%Al2O3	ORNL/TIEGS1124	SIN/YO/ALO	Oak Ridge National Laboratory	
Si3N4+Y2O3+Al2O3	ORNL/TM-132	SIN/YO/ALO	Oak Ridge National Laboratory	1992
Si3N4+La2O3+Al2O3	ORNL/TM-133	SIN/LAO/ALO	Oak Ridge National Laboratory	1992
Si3N4+6Y+2Al	ORNL/TRSN-1-1	SIN/Y/AL	Oak Ridge National Laboratory	1992
Si3N4+6Y+2Al	ORNL/TRSN-1-2	SIN/Y/AL	Oak Ridge National Laboratory	1992

Section 1a - continued

Material	Batch Code	Material Class	Fabricator	Vintage
Si3N4+6Y+2Al	ORNL/TRSN-1-3	SIN/Y/AL	Oak Ridge National Laboratory	1992
Si3N4+6Y+2Al	ORNL/TRSN-1-5	SIN/Y/AL	Oak Ridge National Laboratory	1992
Si3N4+6Y+2Al	ORNL/TRSN-1-6	SIN/Y/AL	Oak Ridge National Laboratory	1992
Si3N4+7.4La+3.2Si	ORNL/TRSN-10-1	SINLA/SI	Oak Ridge National Laboratory	1992
Si3N4+7.4La+3.2Si	ORNL/TRSN-10-2	SINLA/SI	Oak Ridge National Laboratory	1992
Si3N4+7.4La+3.2Si	ORNL/TRSN-10-3	SINLA/SI	Oak Ridge National Laboratory	1992
Si3N4+7.4La+3.2Si	ORNL/TRSN-10-5	SINLA/SI	Oak Ridge National Laboratory	1992
Si3N4+7.4La+3.2Si	ORNL/TRSN-10-6	SINLA/SI	Oak Ridge National Laboratory	1992
Si3N4+5.6Y+2.7Si+1.3Sr	ORNL/TRSN-11-1	SIN/Y/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+5.6Y+2.7Si+1.3Sr	ORNL/TRSN-11-2	SIN/Y/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+5.6Y+2.7Si+1.3Sr	ORNL/TRSN-11-3	SIN/Y/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+5.6Y+2.7Si+1.3Sr	ORNL/TRSN-11-5	SIN/Y/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+5.6Y+2.7Si+1.3Sr	ORNL/TRSN-11-6	SIN/Y/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+7.9La+2.7Si+1.3Sr	ORNL/TRSN-12-1	SIN/LA/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+7.9La+2.7Si+1.3Sr	ORNL/TRSN-12-2	SIN/LA/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+7.9La+2.7Si+1.3Sr	ORNL/TRSN-12-3	SIN/LA/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+7.9La+2.7Si+1.3Sr	ORNL/TRSN-12-5	SIN/LA/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+7.9La+2.7Si+1.3Sr	ORNL/TRSN-12-6	SIN/LA/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+8.1Nd+2.7Si+1.2Sr	ORNL/TRSN-13-1	SIN/ND/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+8.1Nd+2.7Si+1.2Sr	ORNL/TRSN-13-2	SIN/ND/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+8.1Nd+2.7Si+1.2Sr	ORNL/TRSN-13-5	SIN/ND/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+8.1Nd+2.7Si+1.2Sr	ORNL/TRSN-13-6	SIN/ND/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+7.8Y+4.3Si	ORNL/TRSN-14-1	SIN/Y/SI	Oak Ridge National Laboratory	1992
Si3N4+7.8Y+4.3Si	ORNL/TRSN-14-2	SIN/Y/SI	Oak Ridge National Laboratory	1992
Si3N4+7.8Y+4.3Si	ORNL/TRSN-14-3	SIN/Y/SI	Oak Ridge National Laboratory	1992
Si3N4+7.8Y+4.3Si	ORNL/TRSN-14-5	SIN/Y/SI	Oak Ridge National Laboratory	1992
Si3N4+7.8Y+4.3Si	ORNL/TRSN-14-6	SIN/Y/SI	Oak Ridge National Laboratory	1992
Si3N4+10.8La+4.2Si	ORNL/TRSN-15-1	SIN/LA/SI	Oak Ridge National Laboratory	1992
Si3N4+10.8La+4.2Si	ORNL/TRSN-15-2	SIN/LA/SI	Oak Ridge National Laboratory	1992
Si3N4+10.8La+4.2Si	ORNL/TRSN-15-3	SIN/LA/SI	Oak Ridge National Laboratory	1992
Si3N4+10.8La+4.2Si	ORNL/TRSN-15-5	SIN/LA/SI	Oak Ridge National Laboratory	1992
Si3N4+10.8La+4.2Si	ORNL/TRSN-15-6	SIN/LA/SI	Oak Ridge National Laboratory	1992
Si3N4+11.1Nd+4.2Si	ORNL/TRSN-16-1	SIN/ND/SI	Oak Ridge National Laboratory	1992
Si3N4+11.1Nd+4.2Si	ORNL/TRSN-16-2	SIN/ND/SI	Oak Ridge National Laboratory	1992
Si3N4+11.1Nd+4.2Si	ORNL/TRSN-16-3	SIN/ND/SI	Oak Ridge National Laboratory	1992
Si3N4+11.1Nd+4.2Si	ORNL/TRSN-16-5	SIN/ND/SI	Oak Ridge National Laboratory	1992
Si3N4+11.1Nd+4.2Si	ORNL/TRSN-16-6	SIN/ND/SI	Oak Ridge National Laboratory	1992
Si3N4+8.2Y+3.5Si+1.9Sr	ORNL/TRSN-17-1	SIN/Y/SI/SR	Oak Ridge National Laboratory	1992

Section 1a - continued

Material	Batch Code	Material Class	Fabricator	Vintage
Si3N4+8.2Y+3.5Si+1.9Sr	ORNL/TRSN-17-2	SIN/Y/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+8.2Y+3.5Si+1.9Sr	ORNL/TRSN-17-5	SIN/Y/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+8.2Y+3.5Si+1.9Sr	ORNL/TRSN-17-6	SIN/Y/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+11.4La+3.3Si+1.8Sr	ORNL/TRSN-18-1	SIN/LA/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+11.4La+3.3Si+1.8Sr	ORNL/TRSN-18-2	SIN/LA/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+11.4La+3.3Si+1.8Sr	ORNL/TRSN-18-3	SIN/LA/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+11.4La+3.3Si+1.8Sr	ORNL/TRSN-18-5	SIN/LA/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+11.4La+3.3Si+1.8Sr	ORNL/TRSN-18-6	SIN/LA/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+11.7Nd+3.3Si+1.8Sr	ORNL/TRSN-19-1	SIN/ND/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+11.7Nd+3.3Si+1.8Sr	ORNL/TRSN-19-2	SIN/ND/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+11.7Nd+3.3Si+1.8Sr	ORNL/TRSN-19-3	SIN/ND/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+11.7Nd+3.3Si+1.8Sr	ORNL/TRSN-19-5	SIN/ND/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+11.7Nd+3.3Si+1.8Sr	ORNL/TRSN-19-6	SIN/ND/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+11.2La+5.5Si+1.8Sr	ORNL/TRSN-2-1	SIN/LA/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+11.2La+5.5Si+1.8Sr	ORNL/TRSN-2-2	SIN/LA/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+11.2La+5.5Si+1.8Sr	ORNL/TRSN-2-3	SIN/LA/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+11.2La+5.5Si+1.8Sr	ORNL/TRSN-2-5	SIN/LA/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+11.2La+5.5Si+1.8Sr	ORNL/TRSN-2-6	SIN/LA/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+9.6Y+5.3Si	ORNL/TRSN-20-1	SIN/Y/SI	Oak Ridge National Laboratory	1992
Si3N4+9.6Y+5.3Si	ORNL/TRSN-20-2	SIN/Y/SI	Oak Ridge National Laboratory	1992
Si3N4+9.6Y+5.3Si	ORNL/TRSN-20-3	SIN/Y/SI	Oak Ridge National Laboratory	1992
Si3N4+9.6Y+5.3Si	ORNL/TRSN-20-5	SIN/Y/SI	Oak Ridge National Laboratory	1992
Si3N4+9.6Y+5.3Si	ORNL/TRSN-20-6	SIN/Y/SI	Oak Ridge National Laboratory	1992
Si3N4+10.9La+5.2Si+1.7Sr	ORNL/TRSN-21-3	SIN/LA/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+10.9La+5.2Si+1.7Sr	ORNL/TRSN-21-5	SIN/LA/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+10.9La+5.2Si+1.7Sr	ORNL/TRSN-21-6	SIN/LA/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+5.8La+6.5Yb+5.2Si+1.7Sr	ORNL/TRSN-22-3	SIN/LA/YB/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+5.8La+6.5Yb+5.2Si+1.7Sr	ORNL/TRSN-22-5	SIN/LA/YB/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+5.8La+6.5Yb+5.2Si+1.7Sr	ORNL/TRSN-22-6	SIN/LA/YB/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+8.8Yb+3.2Si	ORNL/TRSN-23-3	SIN/YB/SI	Oak Ridge National Laboratory	1992
Si3N4+8.8Yb+3.2Si	ORNL/TRSN-23-5	SIN/YB/SI	Oak Ridge National Laboratory	1992
Si3N4+8.8Yb+3.2Si	ORNL/TRSN-23-6	SIN/YB/SI	Oak Ridge National Laboratory	1992
Si3N4+4Y+2.5Si	ORNL/TRSN-24-3	SIN/Y/SI	Oak Ridge National Laboratory	1992
Si3N4+4Y+2.5Si	ORNL/TRSN-24-5	SIN/Y/SI	Oak Ridge National Laboratory	1992
Si3N4+4Y+2.5Si	ORNL/TRSN-24-6	SIN/Y/SI	Oak Ridge National Laboratory	1992
Si3N4+5.7La+2.5Si	ORNL/TRSN-25-3	SIN/LA/SI	Oak Ridge National Laboratory	1992
Si3N4+5.7La+2.5Si	ORNL/TRSN-25-5	SIN/LA/SI	Oak Ridge National Laboratory	1992
Si3N4+5.7La+2.5Si	ORNL/TRSN-25-6	SIN/LA/SI	Oak Ridge National Laboratory	1992

Section 1a - continued

Material	Batch Code	Material Class	Fabricator	Vintage
Si3N4+5.8Nd+2.5Si	ORNL/TRSN-26-3	SIN/ND/SI	Oak Ridge National Laboratory	1992
Si3N4+5.8Nd+2.5Si	ORNL/TRSN-26-5	SIN/ND/SI	Oak Ridge National Laboratory	1992
Si3N4+5.8Nd+2.5Si	ORNL/TRSN-26-6	SIN/ND/SI	Oak Ridge National Laboratory	1992
Si3N4+6.8Yb+2.5Si	ORNL/TRSN-27-3	SIN/YB/SI	Oak Ridge National Laboratory	1992
Si3N4+6.8Yb+2.5Si	ORNL/TRSN-27-5	SIN/YB/SI	Oak Ridge National Laboratory	1992
Si3N4+6.8Yb+2.5Si	ORNL/TRSN-27-6	SIN/YB/SI	Oak Ridge National Laboratory	1992
Si3N4+8Y+5.7Si+1.8Sr	ORNL/TRSN-3-1	SIN/Y/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+8Y+5.7Si+1.8Sr	ORNL/TRSN-3-2	SIN/Y/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+8Y+5.7Si+1.8Sr	ORNL/TRSN-3-3	SIN/Y/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+8Y+5.7Si+1.8Sr	ORNL/TRSN-3-5	SIN/Y/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+8Y+5.7Si+1.8Sr	ORNL/TRSN-3-6	SIN/Y/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+11.5Nd+5.5Si+1.8Sr	ORNL/TRSN-4-1	SIN/ND/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+11.5Nd+5.5Si+1.8Sr	ORNL/TRSN-4-2	SIN/ND/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+11.5Nd+5.5Si+1.8Sr	ORNL/TRSN-4-3	SIN/ND/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+11.5Nd+5.5Si+1.8Sr	ORNL/TRSN-4-5	SIN/ND/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+11.5Nd+5.5Si+1.8Sr	ORNL/TRSN-4-6	SIN/ND/SI/SR	Oak Ridge National Laboratory	1992
Si3N4+10.6La+6.3Si	ORNL/TRSN-5-1	SIN/LA/SI	Oak Ridge National Laboratory	1992
Si3N4+10.6La+6.3Si	ORNL/TRSN-5-2	SIN/LA/SI	Oak Ridge National Laboratory	1992
Si3N4+10.6La+6.3Si	ORNL/TRSN-5-3	SIN/LA/SI	Oak Ridge National Laboratory	1992
Si3N4+10.6La+6.3Si	ORNL/TRSN-5-5	SIN/LA/SI	Oak Ridge National Laboratory	1992
Si3N4+10.6La+6.3Si	ORNL/TRSN-5-6	SIN/LA/SI	Oak Ridge National Laboratory	1992
Si3N4+7.6Y+6.5Si	ORNL/TRSN-6-1	SIN/Y/SI	Oak Ridge National Laboratory	1992
Si3N4+7.6Y+6.5Si	ORNL/TRSN-6-2	SIN/Y/SI	Oak Ridge National Laboratory	1992
Si3N4+7.6Y+6.5Si	ORNL/TRSN-6-3	SIN/Y/SI	Oak Ridge National Laboratory	1992
Si3N4+7.6Y+6.5Si	ORNL/TRSN-6-5	SIN/Y/SI	Oak Ridge National Laboratory	1992
Si3N4+7.6Y+6.5Si	ORNL/TRSN-6-6	SIN/Y/SI	Oak Ridge National Laboratory	1992
Si3N4+3.8Y+5.3La+6.4Si	ORNL/TRSN-7-1	SIN/Y/LA/SI	Oak Ridge National Laboratory	1992
Si3N4+3.8Y+5.3La+6.4Si	ORNL/TRSN-7-2	SIN/Y/LA/SI	Oak Ridge National Laboratory	1992
Si3N4+3.8Y+5.3La+6.4Si	ORNL/TRSN-7-3	SIN/Y/LA/SI	Oak Ridge National Laboratory	1992
Si3N4+3.8Y+5.3La+6.4Si	ORNL/TRSN-7-5	SIN/Y/LA/SI	Oak Ridge National Laboratory	1992
Si3N4+3.8Y+5.3La+6.4Si	ORNL/TRSN-7-6	SIN/Y/LA/SI	Oak Ridge National Laboratory	1992
Si3N4+5.3Y+3.3Si	ORNL/TRSN-8-1	SIN/Y/SI	Oak Ridge National Laboratory	1992
Si3N4+5.3Y+3.3Si	ORNL/TRSN-8-2	SIN/Y/SI	Oak Ridge National Laboratory	1992
Si3N4+5.3Y+3.3Si	ORNL/TRSN-8-3	SIN/Y/SI	Oak Ridge National Laboratory	1992
Si3N4+5.3Y+3.3Si	ORNL/TRSN-8-5	SIN/Y/SI	Oak Ridge National Laboratory	1992
Si3N4+5.3Y+3.3Si	ORNL/TRSN-8-6	SIN/Y/SI	Oak Ridge National Laboratory	1992
Si3N4+7.6Nd+3.2Si	ORNL/TRSN-9-1	SIN/ND/SI	Oak Ridge National Laboratory	1992
Si3N4+7.6Nd+3.2Si	ORNL/TRSN-9-2	SIN/ND/SI	Oak Ridge National Laboratory	1992

Section 1a - continued

Material	Batch Code	Material Class	Fabricator	Vintage
Si ₃ N ₄ +7.6Nd+3.2Si	ORNL/TRSN-9-3	SIN/ND/SI	Oak Ridge National Laboratory	1992
Si ₃ N ₄ +7.6Nd+3.2Si	ORNL/TRSN-9-5	SIN/ND/SI	Oak Ridge National Laboratory	1992
Si ₃ N ₄ +7.6Nd+3.2Si	ORNL/TRSN-9-6	SIN/ND/SI	Oak Ridge National Laboratory	1992
SN-253	KYOCERA/UDRI/93	SIN	Kyocera	
SNW-1000	ORNL/KCL-93	SIN	WESGO	1990
SRBSN+9%Y ₂ O ₃ +3%Al ₂ O ₃	ORNL/1124/9304	SIN/SRB	Oak Ridge National Laboratory	1993
SRBSN+11.5%La ₂ O ₃ +3%Al ₂ O ₃	ORNL/TM-136	SIN/SRB	Oak Ridge National Laboratory	1992
SRBSN+11.5%La ₂ O ₃ +3%Al ₂ O ₃	ORNL/TM-137	SIN/SRB	Oak Ridge National Laboratory	1992
SRBSN+Y ₂ O ₃ +MgO+Al ₂ O ₃	ORNL/TM-138	SIN/SRB	Oak Ridge National Laboratory	1992
SRBSN+11.5%La ₂ O ₃ +3%Al ₂ O ₃	ORNL/TM-139	SIN/SRB	Oak Ridge National Laboratory	1992
SRBSN+11.5%La ₂ O ₃ +3%Al ₂ O ₃	ORNL/TM-141	SIN/SRB	Oak Ridge National Laboratory	1992
SRBSN+9%Y ₂ O ₃ +3%Al ₂ O ₃	ORNL/TM-142	SIN/SRB	Oak Ridge National Laboratory	1992
SRBSN+9%Y ₂ O ₃ +3%Al ₂ O ₃	ORNL/TM-145	SIN/SRB	Oak Ridge National Laboratory	1992
SRBSN+11.5%La ₂ O ₃ +3%Al ₂ O ₃	ORNL/TM-150	SIN/SRB	Oak Ridge National Laboratory	1992
SRBSN+11.5%La ₂ O ₃ +3%Al ₂ O ₃	ORNL/TM-152	SIN/SRB	Oak Ridge National Laboratory	1992

Section 1b - Material Background - Composition and Processing

Material	Batch Code	Primary Matrix	Additives	Densification Process
SiAlON-Based Ceramics				
NT-451	NORTON/REF.	Si+Al ₂ O ₃ +N		
SiAlON+2%(3Y ₂ O ₃ +5Al ₂ O ₃)	ORNL/TIEGS1124	Si ₄ Al ₂ O ₂ N ₆	2%[(3Y ₂ O ₃)+5(Al ₂ O ₃)]	HOT PRESSED
SiAlON4.5+2%(3Y ₂ O ₃ +5Al ₂ O ₃)	ORNL/TIEGS1124	Si _{4.5} Al _{1.5} O _{1.5} N _{6.5}	2%[(3Y ₂ O ₃)+5(Al ₂ O ₃)]	HOT PRESSED
Silicon Carbide-Based Ceramics				
Beta-SiC	DOWCORN/UDRI/1	SiC		
HEXOLOY SX-G1	CARB/1/1990	SiC	proprietary	SINTERED
HEXOLOY SX-G1	CARB/6/91	SiC	proprietary	SINTERED + POST-SINTER TREATMENT
HEXOLOY SX-G1	CARB/8/1991/MIX1	SiC	proprietary	SINTERED + POST-SINTER TREATMENT
HEXOLOY SX-G1	CARB/8/1991/MIX2	SiC	proprietary	SINTERED + POST-SINTER TREATMENT
HEXOLOY SX-G1	CARB/8/1991/MIX3	SiC	proprietary	SINTERED + POST-SINTER TREATMENT
HEXOLOY SX-G1	CARB/9/1990	SiC	proprietary	SINTERED
HEXOLOY SX-G1	CARB/9/1991/B	SiC	proprietary	SINTERED + POST-SINTER TREATMENT
HEXOLOY SX-G1	CARB/9/1991/C	SiC	proprietary	SINTERED + POST-SINTER TREATMENT
HEXOLOY SX-G1	CARB/9/1991/D	SiC	proprietary	SINTERED + POST-SINTER TREATMENT
HEXOLOY SX-G1	CARB/9/1991/F	SiC	proprietary	SINTERED + POST-SINTER TREATMENT
NT-230	NORTON/UDRI	SiC	proprietary	
Silicon Nitride-Based Ceramics				
CERALLOY 147-3	CERADYNE/UDRI/2	Si ₃ N ₄		
GS-44	GARRETT/UDRI/1	Si ₃ N ₄		
GN-10	ORNL/KCL92	Si ₃ N ₄		
GN-10	GCCD/UDRI/1	Si ₃ N ₄		
GN-10	GCCD/NIST/1	Si ₃ N ₄		
GTE PY6	AGTD/HIP	Si ₃ N ₄		
NT-154	ORNL/KCL92	Si ₃ N ₄		
NT-154	NORTON/GAPD	Si ₃ N ₄		
NT-164	NORTON/UDRI-92	Si ₃ N ₄		
Si ₃ N ₄ +8%Y+3.5%Si+1.9%Sr	ORNL/TRSN-17-3	Si ₃ N ₄ (Ube Indust. gr.E-10)	8.2w%Y,3.5w%Si,1.9w%Sr	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si ₃ N ₄ +8.1%Nd+2.7%Si+1.2%Sr	ORNL/TRSN-13-3	Si ₃ N ₄ (Ube Indust. gr.E-10)	8.1w%Nd,2.7w%Si,1.2w%Sr	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si ₃ N ₄ +12%Y ₂ O ₃ +4%Al ₂ O ₃	ORNL/TIEGS1124	Si ₃ N ₄	12%Y ₂ O ₃ ,4%Al ₂ O ₃	HOT PRESSED
Si ₃ N ₄ +4%Y ₂ O ₃	ORNL/TIEGS1124	Si ₃ N ₄	4%Y ₂ O ₃	HOT PRESSED
Si ₃ N ₄ +6%Y ₂ O ₃ +2%Al ₂ O ₃	ORNL/TIEGS1124	Si ₃ N ₄	6%Y ₂ O ₃ ,2%Al ₂ O ₃	HOT PRESSED
Si ₃ N ₄ +Y ₂ O ₃ +Al ₂ O ₃	ORNL/TM-132	Si ₃ N ₄ (Ube Indust. gr.E-10)	Y ₂ O ₃ ,Al ₂ O ₃	SINT (CONVENTIONAL)
Si ₃ N ₄ +La ₂ O ₃ +Al ₂ O ₃	ORNL/TM-133	Si ₃ N ₄ (Ube Indust. gr.E-10)	La ₂ O ₃ ,Al ₂ O ₃	SINT (CONVENTIONAL)
Si ₃ N ₄ +6Y+2Al	ORNL/TRSN-1-1	Si ₃ N ₄ (Ube Indust. gr.E-10)	6w%Y2Al	GPS/1850C/2h/50psi/1900C/2h/300psi
Si ₃ N ₄ +6Y+2Al	ORNL/TRSN-1-2	Si ₃ N ₄ (Ube Indust. gr.E-10)	6w%Y2Al	GPS/1900C/2h/100psi/1950C/2h/300psi

Section 1b - continued

Material	Batch Code	Primary Matrix	Additives	Densification Process
Si3N4+6Y+2Al	ORNL/TRSN-1-3	Si3N4 (Ube Indust. gr.E-10)	6w%Y2Al	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+6Y+2Al	ORNL/TRSN-1-5	Si3N4 (Ube Indust. gr.E-10)	6w%Y2Al	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+6Y+2Al	ORNL/TRSN-1-6	Si3N4 (Ube Indust. gr.E-10)	6w%Y2Al	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+7.4La+3.2Si	ORNL/TRSN-10-1	Si3N4 (Ube Indust. gr.E-10)	7.4w%La,3.2w%Si	GPS/1850C/2h/50psi/1900C/2h/300psi
Si3N4+7.4La+3.2Si	ORNL/TRSN-10-2	Si3N4 (Ube Indust. gr.E-10)	7.4w%La,3.2w%Si	GPS/1900C/2h/100psi/1950C/2h/300psi
Si3N4+7.4La+3.2Si	ORNL/TRSN-10-3	Si3N4 (Ube Indust. gr.E-10)	7.4w%La,3.2w%Si	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+7.4La+3.2Si	ORNL/TRSN-10-5	Si3N4 (Ube Indust. gr.E-10)	7.4w%La,3.2w%Si	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+7.4La+3.2Si	ORNL/TRSN-10-6	Si3N4 (Ube Indust. gr.E-10)	7.4w%La,3.2w%Si	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+5.6Y+2.7Si+1.3Sr	ORNL/TRSN-11-1	Si3N4 (Ube Indust. gr.E-10)	5.6w%Y,2.7w%Si,1.3w%Sr	GPS/1850C/2h/50psi/1900C/2h/300psi
Si3N4+5.6Y+2.7Si+1.3Sr	ORNL/TRSN-11-2	Si3N4 (Ube Indust. gr.E-10)	5.6w%Y,2.7w%Si,1.3w%Sr	GPS/1900C/2h/100psi/1950C/2h/300psi
Si3N4+5.6Y+2.7Si+1.3Sr	ORNL/TRSN-11-3	Si3N4 (Ube Indust. gr.E-10)	5.6w%Y,2.7w%Si,1.3w%Sr	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+5.6Y+2.7Si+1.3Sr	ORNL/TRSN-11-5	Si3N4 (Ube Indust. gr.E-10)	5.6w%Y,2.7w%Si,1.3w%Sr	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+5.6Y+2.7Si+1.3Sr	ORNL/TRSN-11-6	Si3N4 (Ube Indust. gr.E-10)	5.6w%Y,2.7w%Si,1.3w%Sr	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+7.9La+2.7Si+1.3Sr	ORNL/TRSN-12-1	Si3N4 (Ube Indust. gr.E-10)	7.9w%La,2.7w%Si,1.3w%Sr	GPS/1850C/2h/50psi/1900C/2h/300psi
Si3N4+7.9La+2.7Si+1.3Sr	ORNL/TRSN-12-2	Si3N4 (Ube Indust. gr.E-10)	7.9w%La,2.7w%Si,1.3w%Sr	GPS/1900C/2h/100psi/1950C/2h/300psi
Si3N4+7.9La+2.7Si+1.3Sr	ORNL/TRSN-12-3	Si3N4 (Ube Indust. gr.E-10)	7.9w%La,2.7w%Si,1.3w%Sr	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+7.9La+2.7Si+1.3Sr	ORNL/TRSN-12-5	Si3N4 (Ube Indust. gr.E-10)	7.9w%La,2.7w%Si,1.3w%Sr	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+7.9La+2.7Si+1.3Sr	ORNL/TRSN-12-6	Si3N4 (Ube Indust. gr.E-10)	7.9w%La,2.7w%Si,1.3w%Sr	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+8.1Nd+2.7Si+1.2Sr	ORNL/TRSN-13-1	Si3N4 (Ube Indust. gr.E-10)	8.1w%Nd,2.7w%Si,1.2w%Sr	GPS/1850C/2h/50psi/1900C/2h/300psi
Si3N4+8.1Nd+2.7Si+1.2Sr	ORNL/TRSN-13-2	Si3N4 (Ube Indust. gr.E-10)	8.1w%Nd,2.7w%Si,1.2w%Sr	GPS/1900C/2h/100psi/1950C/2h/300psi
Si3N4+8.1Nd+2.7Si+1.2Sr	ORNL/TRSN-13-5	Si3N4 (Ube Indust. gr.E-10)	8.1w%Nd,2.7w%Si,1.2w%Sr	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+8.1Nd+2.7Si+1.2Sr	ORNL/TRSN-13-6	Si3N4 (Ube Indust. gr.E-10)	8.1w%Nd,2.7w%Si,1.2w%Sr	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+7.8Y+4.3Si	ORNL/TRSN-14-1	Si3N4 (Ube Indust. gr.E-10)	7.8w%Y,4.3w%Si	GPS/1850C/2h/50psi/1900C/2h/300psi
Si3N4+7.8Y+4.3Si	ORNL/TRSN-14-2	Si3N4 (Ube Indust. gr.E-10)	7.8w%Y,4.3w%Si	GPS/1900C/2h/100psi/1950C/2h/300psi
Si3N4+7.8Y+4.3Si	ORNL/TRSN-14-3	Si3N4 (Ube Indust. gr.E-10)	7.8w%Y,4.3w%Si	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+7.8Y+4.3Si	ORNL/TRSN-14-5	Si3N4 (Ube Indust. gr.E-10)	7.8w%Y,4.3w%Si	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+7.8Y+4.3Si	ORNL/TRSN-14-6	Si3N4 (Ube Indust. gr.E-10)	7.8w%Y,4.3w%Si	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+10.8La+4.2Si	ORNL/TRSN-15-1	Si3N4 (Ube Indust. gr.E-10)	10.8w%La,4.2w%Si	GPS/1850C/2h/50psi/1900C/2h/300psi
Si3N4+10.8La+4.2Si	ORNL/TRSN-15-2	Si3N4 (Ube Indust. gr.E-10)	10.8w%La,4.2w%Si	GPS/1900C/2h/100psi/1950C/2h/300psi
Si3N4+10.8La+4.2Si	ORNL/TRSN-15-3	Si3N4 (Ube Indust. gr.E-10)	10.8w%La,4.2w%Si	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+10.8La+4.2Si	ORNL/TRSN-15-5	Si3N4 (Ube Indust. gr.E-10)	10.8w%La,4.2w%Si	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+10.8La+4.2Si	ORNL/TRSN-15-6	Si3N4 (Ube Indust. gr.E-10)	10.8w%La,4.2w%Si	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+11.1Nd+4.2Si	ORNL/TRSN-16-1	Si3N4 (Ube Indust. gr.E-10)	11.w%Nd,4.2w%Si	GPS/1850C/2h/50psi/1900C/2h/300psi
Si3N4+11.1Nd+4.2Si	ORNL/TRSN-16-2	Si3N4 (Ube Indust. gr.E-10)	11.w%Nd,4.2w%Si	GPS/1900C/2h/100psi/1950C/2h/300psi
Si3N4+11.1Nd+4.2Si	ORNL/TRSN-16-3	Si3N4 (Ube Indust. gr.E-10)	11.w%Nd,4.2w%Si	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+11.1Nd+4.2Si	ORNL/TRSN-16-5	Si3N4 (Ube Indust. gr.E-10)	11.w%Nd,4.2w%Si	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+11.1Nd+4.2Si	ORNL/TRSN-16-6	Si3N4 (Ube Indust. gr.E-10)	11.w%Nd,4.2w%Si	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+8.2Y+3.5Si+1.9Sr	ORNL/TRSN-17-1	Si3N4 (Ube Indust. gr.E-10)	8.2w%Y,3.5w%Si,1.9w%Sr	GPS/1850C/2h/50psi/1900C/2h/300psi

Section 1b - continued

Material	Batch Code	Primary Matrix	Additives	Densification Process
Si3N4+8.2Y+3.5Si+1.9Sr	ORNL/TRSN-17-2	Si3N4 (Ube Indust. gr.E-10)	8.2w%Y,3.5w%Si,1.9w%Sr	GPS/1900C/2h/100psi/1950C/2h/300psi
Si3N4+8.2Y+3.5Si+1.9Sr	ORNL/TRSN-17-5	Si3N4 (Ube Indust. gr.E-10)	8.2w%Y,3.5w%Si,1.9w%Sr	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+8.2Y+3.5Si+1.9Sr	ORNL/TRSN-17-6	Si3N4 (Ube Indust. gr.E-10)	8.2w%Y,3.5w%Si,1.9w%Sr	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+11.4La+3.3Si+1.8Sr	ORNL/TRSN-18-1	Si3N4 (Ube Indust. gr.E-10)	11.4w%La,3.3w%Si,1.8w%Sr	GPS/1850C/2h/50psi/1900C/2h/300psi
Si3N4+11.4La+3.3Si+1.8Sr	ORNL/TRSN-18-2	Si3N4 (Ube Indust. gr.E-10)	11.4w%La,3.3w%Si,1.8w%Sr	GPS/1900C/2h/100psi/1950C/2h/300psi
Si3N4+11.4La+3.3Si+1.8Sr	ORNL/TRSN-18-3	Si3N4 (Ube Indust. gr.E-10)	11.4w%La,3.3w%Si,1.8w%Sr	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+11.4La+3.3Si+1.8Sr	ORNL/TRSN-18-5	Si3N4 (Ube Indust. gr.E-10)	11.4w%La,3.3w%Si,1.8w%Sr	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+11.4La+3.3Si+1.8Sr	ORNL/TRSN-18-6	Si3N4 (Ube Indust. gr.E-10)	11.4w%La,3.3w%Si,1.8w%Sr	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+11.7Nd+3.3Si+1.8Sr	ORNL/TRSN-19-1	Si3N4 (Ube Indust. gr.E-10)	11.7w%Nd,3.3w%Si,1.8w%Sr	GPS/1850C/2h/50psi/1900C/2h/300psi
Si3N4+11.7Nd+3.3Si+1.8Sr	ORNL/TRSN-19-2	Si3N4 (Ube Indust. gr.E-10)	11.7w%Nd,3.3w%Si,1.8w%Sr	GPS/1900C/2h/100psi/1950C/2h/300psi
Si3N4+11.7Nd+3.3Si+1.8Sr	ORNL/TRSN-19-3	Si3N4 (Ube Indust. gr.E-10)	11.7w%Nd,3.3w%Si,1.8w%Sr	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+11.7Nd+3.3Si+1.8Sr	ORNL/TRSN-19-5	Si3N4 (Ube Indust. gr.E-10)	11.7w%Nd,3.3w%Si,1.8w%Sr	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+11.7Nd+3.3Si+1.8Sr	ORNL/TRSN-19-6	Si3N4 (Ube Indust. gr.E-10)	11.7w%Nd,3.3w%Si,1.8w%Sr	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+11.2La+5.5Si+1.8Sr	ORNL/TRSN-2-1	Si3N4 (Ube Indust. gr.E-10)	11.5w%La,5.5w%Si,1.8w%Sr	GPS/1850C/2h/50psi/1900C/2h/300psi
Si3N4+11.2La+5.5Si+1.8Sr	ORNL/TRSN-2-2	Si3N4 (Ube Indust. gr.E-10)	11.5w%La,5.5w%Si,1.8w%Sr	GPS/1900C/2h/100psi/1950C/2h/300psi
Si3N4+11.2La+5.5Si+1.8Sr	ORNL/TRSN-2-3	Si3N4 (Ube Indust. gr.E-10)	11.5w%La,5.5w%Si,1.8w%Sr	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+11.2La+5.5Si+1.8Sr	ORNL/TRSN-2-5	Si3N4 (Ube Indust. gr.E-10)	11.5w%La,5.5w%Si,1.8w%Sr	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+11.2La+5.5Si+1.8Sr	ORNL/TRSN-2-6	Si3N4 (Ube Indust. gr.E-10)	11.5w%La,5.5w%Si,1.8w%Sr	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+9.6Y+5.3Si	ORNL/TRSN-20-1	Si3N4 (Ube Indust. gr.E-10)	9.6w%Y,5.3w%Si	GPS/1850C/2h/50psi/1900C/2h/300psi
Si3N4+9.6Y+5.3Si	ORNL/TRSN-20-2	Si3N4 (Ube Indust. gr.E-10)	9.6w%Y,5.3w%Si	GPS/1900C/2h/100psi/1950C/2h/300psi
Si3N4+9.6Y+5.3Si	ORNL/TRSN-20-3	Si3N4 (Ube Indust. gr.E-10)	9.6w%Y,5.3w%Si	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+9.6Y+5.3Si	ORNL/TRSN-20-5	Si3N4 (Ube Indust. gr.E-10)	9.6w%Y,5.3w%Si	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+9.6Y+5.3Si	ORNL/TRSN-20-6	Si3N4 (Ube Indust. gr.E-10)	9.6w%Y,5.3w%Si	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+10.9La+5.2Si+1.7Sr	ORNL/TRSN-21-3	Si3N4 (Ube Indust. gr.E-10)	10.9w%La,5.2w%Si,1.7w%Sr	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+10.9La+5.2Si+1.7Sr	ORNL/TRSN-21-5	Si3N4 (Ube Indust. gr.E-10)	10.9w%La,5.2w%Si,1.7w%Sr	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+10.9La+5.2Si+1.7Sr	ORNL/TRSN-21-6	Si3N4 (Ube Indust. gr.E-10)	10.9w%La,5.2w%Si,1.7w%Sr	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+5.8La+6.5Yb+5.2Si+1.7Sr	ORNL/TRSN-22-3	Si3N4 (Ube Indust. gr.E-10)	5.8w%La,6.5w%Yb,5.2w%Si,1.7%Sr	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+5.8La+6.5Yb+5.2Si+1.7Sr	ORNL/TRSN-22-5	Si3N4 (Ube Indust. gr.E-10)	5.8w%La,6.5w%Yb,5.2w%Si,1.7%Sr	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+5.8La+6.5Yb+5.2Si+1.7Sr	ORNL/TRSN-22-6	Si3N4 (Ube Indust. gr.E-10)	5.8w%La,6.5w%Yb,5.2w%Si,1.7%Sr	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+8.8Yb+3.2Si	ORNL/TRSN-23-3	Si3N4 (Ube Indust. gr.E-10)	8.8w%Yb,3.2w%Si	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+8.8Yb+3.2Si	ORNL/TRSN-23-5	Si3N4 (Ube Indust. gr.E-10)	8.8w%Yb,3.2w%Si	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+8.8Yb+3.2Si	ORNL/TRSN-23-6	Si3N4 (Ube Indust. gr.E-10)	8.8w%Yb,3.2w%Si	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+4Y+2.5Si	ORNL/TRSN-24-3	Si3N4 (Ube Indust. gr.E-10)	4w%Y,2.5w%Si	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+4Y+2.5Si	ORNL/TRSN-24-5	Si3N4 (Ube Indust. gr.E-10)	4w%Y,2.5w%Si	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+4Y+2.5Si	ORNL/TRSN-24-6	Si3N4 (Ube Indust. gr.E-10)	4w%Y,2.5w%Si	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+5.7La+2.5Si	ORNL/TRSN-25-3	Si3N4 (Ube Indust. gr.E-10)	5.7w%La,2.5w%Si	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+5.7La+2.5Si	ORNL/TRSN-25-5	Si3N4 (Ube Indust. gr.E-10)	5.7w%La,2.5w%Si	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+5.7La+2.5Si	ORNL/TRSN-25-6	Si3N4 (Ube Indust. gr.E-10)	5.7w%La,2.5w%Si	GPS/1750C/1h/100psi/1900C/2h/300psi

Section 1b - continued

Material	Batch Code	Primary Matrix	Additives	Densification Process
Si3N4+5.8Nd+2.5Si	ORNL/TRSN-26-3	Si3N4 (Ube Indust. gr.E-10)	5.8w%Nd,2.5w%Si	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+5.8Nd+2.5Si	ORNL/TRSN-26-5	Si3N4 (Ube Indust. gr.E-10)	5.8w%Nd,2.5w%Si	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+5.8Nd+2.5Si	ORNL/TRSN-26-6	Si3N4 (Ube Indust. gr.E-10)	5.8w%Nd,2.5w%Si	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+6.8Yb+2.5Si	ORNL/TRSN-27-3	Si3N4 (Ube Indust. gr.E-10)	6.8w%Yb,2.5w%Si	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+6.8Yb+2.5Si	ORNL/TRSN-27-5	Si3N4 (Ube Indust. gr.E-10)	6.8w%Yb,2.5w%Si	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+6.8Yb+2.5Si	ORNL/TRSN-27-6	Si3N4 (Ube Indust. gr.E-10)	6.8w%Yb,2.5w%Si	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+8Y+5.7Si+1.8Sr	ORNL/TRSN-3-1	Si3N4 (Ube Indust. gr.E-10)	8w%Y,5.7w%Si,1.8w%Sr	GPS/1850C/2h/50psi/1900C/2h/300psi
Si3N4+8Y+5.7Si+1.8Sr	ORNL/TRSN-3-2	Si3N4 (Ube Indust. gr.E-10)	8w%Y,5.7w%Si,1.8w%Sr	GPS/1900C/2h/100psi/1950C/2h/300psi
Si3N4+8Y+5.7Si+1.8Sr	ORNL/TRSN-3-3	Si3N4 (Ube Indust. gr.E-10)	8w%Y,5.7w%Si,1.8w%Sr	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+8Y+5.7Si+1.8Sr	ORNL/TRSN-3-5	Si3N4 (Ube Indust. gr.E-10)	8w%Y,5.7w%Si,1.8w%Sr	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+8Y+5.7Si+1.8Sr	ORNL/TRSN-3-6	Si3N4 (Ube Indust. gr.E-10)	8w%Y,5.7w%Si,1.8w%Sr	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+11.5Nd+5.5Si+1.8Sr	ORNL/TRSN-4-1	Si3N4 (Ube Indust. gr.E-10)	11.5w%Nd,5.5w%Si,1.8w%Sr	GPS/1850C/2h/50psi/1900C/2h/300psi
Si3N4+11.5Nd+5.5Si+1.8Sr	ORNL/TRSN-4-2	Si3N4 (Ube Indust. gr.E-10)	11.5w%Nd,5.5w%Si,1.8w%Sr	GPS/1900C/2h/100psi/1950C/2h/300psi
Si3N4+11.5Nd+5.5Si+1.8Sr	ORNL/TRSN-4-3	Si3N4 (Ube Indust. gr.E-10)	11.5w%Nd,5.5w%Si,1.8w%Sr	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+11.5Nd+5.5Si+1.8Sr	ORNL/TRSN-4-5	Si3N4 (Ube Indust. gr.E-10)	11.5w%Nd,5.5w%Si,1.8w%Sr	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+11.5Nd+5.5Si+1.8Sr	ORNL/TRSN-4-6	Si3N4 (Ube Indust. gr.E-10)	11.5w%Nd,5.5w%Si,1.8w%Sr	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+10.6La+6.3Si	ORNL/TRSN-5-1	Si3N4 (Ube Indust. gr.E-10)	10.6w%La,6.3w%Si	GPS/1850C/2h/50psi/1900C/2h/300psi
Si3N4+10.6La+6.3Si	ORNL/TRSN-5-2	Si3N4 (Ube Indust. gr.E-10)	10.6w%La,6.3w%Si	GPS/1900C/2h/100psi/1950C/2h/300psi
Si3N4+10.6La+6.3Si	ORNL/TRSN-5-3	Si3N4 (Ube Indust. gr.E-10)	10.6w%La,6.3w%Si	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+10.6La+6.3Si	ORNL/TRSN-5-5	Si3N4 (Ube Indust. gr.E-10)	10.6w%La,6.3w%Si	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+10.6La+6.3Si	ORNL/TRSN-5-6	Si3N4 (Ube Indust. gr.E-10)	10.6w%La,6.3w%Si	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+7.6Y+6.5Si	ORNL/TRSN-6-1	Si3N4 (Ube Indust. gr.E-10)	7.6w%Y,6.5w%Si	GPS/1850C/2h/50psi/1900C/2h/300psi
Si3N4+7.6Y+6.5Si	ORNL/TRSN-6-2	Si3N4 (Ube Indust. gr.E-10)	7.6w%Y,6.5w%Si	GPS/1900C/2h/100psi/1950C/2h/300psi
Si3N4+7.6Y+6.5Si	ORNL/TRSN-6-3	Si3N4 (Ube Indust. gr.E-10)	7.6w%Y,6.5w%Si	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+7.6Y+6.5Si	ORNL/TRSN-6-5	Si3N4 (Ube Indust. gr.E-10)	7.6w%Y,6.5w%Si	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+7.6Y+6.5Si	ORNL/TRSN-6-6	Si3N4 (Ube Indust. gr.E-10)	7.6w%Y,6.5w%Si	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+3.8Y+5.3La+6.4Si	ORNL/TRSN-7-1	Si3N4 (Ube Indust. gr.E-10)	3.8w%Y,5.3w%La,6.4w%Si	GPS/1850C/2h/50psi/1900C/2h/300psi
Si3N4+3.8Y+5.3La+6.4Si	ORNL/TRSN-7-2	Si3N4 (Ube Indust. gr.E-10)	3.8w%Y,5.3w%La,6.4w%Si	GPS/1900C/2h/100psi/1950C/2h/300psi
Si3N4+3.8Y+5.3La+6.4Si	ORNL/TRSN-7-3	Si3N4 (Ube Indust. gr.E-10)	3.8w%Y,5.3w%La,6.4w%Si	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+3.8Y+5.3La+6.4Si	ORNL/TRSN-7-5	Si3N4 (Ube Indust. gr.E-10)	3.8w%Y,5.3w%La,6.4w%Si	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+3.8Y+5.3La+6.4Si	ORNL/TRSN-7-6	Si3N4 (Ube Indust. gr.E-10)	3.8w%Y,5.3w%La,6.4w%Si	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+5.3Y+3.3Si	ORNL/TRSN-8-1	Si3N4 (Ube Indust. gr.E-10)	5.3w%Y,3.3w%Si	GPS/1850C/2h/50psi/1900C/2h/300psi
Si3N4+5.3Y+3.3Si	ORNL/TRSN-8-2	Si3N4 (Ube Indust. gr.E-10)	5.3w%Y,3.3w%Si	GPS/1900C/2h/100psi/1950C/2h/300psi
Si3N4+5.3Y+3.3Si	ORNL/TRSN-8-3	Si3N4 (Ube Indust. gr.E-10)	5.3w%Y,3.3w%Si	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+5.3Y+3.3Si	ORNL/TRSN-8-5	Si3N4 (Ube Indust. gr.E-10)	5.3w%Y,3.3w%Si	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+5.3Y+3.3Si	ORNL/TRSN-8-6	Si3N4 (Ube Indust. gr.E-10)	5.3w%Y,3.3w%Si	GPS/1750C/1h/100psi/1900C/2h/300psi
Si3N4+7.6Nd+3.2Si	ORNL/TRSN-9-1	Si3N4 (Ube Indust. gr.E-10)	7.6w%Nd,3.2w%Si	GPS/1850C/2h/50psi/1900C/2h/300psi
Si3N4+7.6Nd+3.2Si	ORNL/TRSN-9-2	Si3N4 (Ube Indust. gr.E-10)	7.6w%Nd,3.2w%Si	GPS/1900C/2h/100psi/1950C/2h/300psi

Section 1b - continued

Material	Batch Code	Primary Matrix	Additives	Densification Process
Si3N4+7.6Nd+3.2Si	ORNL/TRSN-9-3	Si3N4 (Ube Indust. gr.E-10)	7.6w%Nd,3.2w%Si	GPS/1750C/2h/100psi/1800C/.5h/300psi
Si3N4+7.6Nd+3.2Si	ORNL/TRSN-9-5	Si3N4 (Ube Indust. gr.E-10)	7.6w%Nd,3.2w%Si	GPS/1850C/.5h/100psi/1800C/2h/300psi
Si3N4+7.6Nd+3.2Si	ORNL/TRSN-9-6	Si3N4 (Ube Indust. gr.E-10)	7.6w%Nd,3.2w%Si	GPS/1750C/1h/100psi/1900C/2h/300psi
SN-253	KYOCERA/UDRI/93	Si3N4	(not known)	(not known)
SNW-1000	ORNL/KCL-93	Si3N4	(not known)	(not known)
SRBSN+9%Y2O3+3%Al2O3	ORNL/1124/9304	Si3N4	9w%Y2O3+3w%Al2O3	PRE-SINT/Ar/1200C/1H
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-136	Si (Elkem Metals Gr.metal.Si)	11.5w%La2O3,3w%Al2O3	SINT (CONVENTIONAL)
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-137	Si (Elkem Metals Gr. Si-HQ)	11.5w%La2O3,3w%Al2O3	SINT (CONVENTIONAL)
SRBSN+Y2O3+MgO+Al2O3	ORNL/TM-138	Si (Elkem Metals Gr.metal.Si)	5w%Y2O3,2w%MgO,3w%Al2O3	SINT (CONVENTIONAL)/1800C/4H
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-139	Si (Elkem Metals Gr. Si-HQ)	11.5w%La2O3,3w%Al2O3	SINT (CONVENTIONAL)
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-141	Si (Elkem Metals Gr. Si-HQ)	11.5w%La2O3,3w%Al2O3	SINT (CONVENTIONAL)
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-142	Si (Elkem Metals Gr. Si-HQ)	9w%Y2O3,3w%Al2O3	SINT (CONVENTIONAL)
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-145	Si (Elkem Metals Gr.metal.Si)	9w%Y2O3,3w%Al2O3	SINT (CONVENTIONAL)
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-150	Si (Elkem Metals Gr. Si-HQ)	11.5w%La2O3,3w%Al2O3	SINT (CONVENTIONAL)
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-152	Si (Elkem Metals Gr. Si-HQ)	11.5w%La2O3,3w%Al2O3	SINT (CONVENTIONAL)

Section 1c - Material Background - Room-Temperature Properties

Material	Batch Code	Density g/cm ³	% Theo. Density	Young's Modulus GPa	Bend Strength MPa	Hardness Test	Hardness Value	Temp. Range °C	Coeff. of Thermal Expansion	Poisson's Ratio	Toughness Test	KIC MPa√m
SIALON-Based Ceramics												
NT-451	NORTON/REF.	3.24		306.0	867.0		13.75GPa			0.277		6.20
SiAlON+2%(3Y2O3+5Al2O3)	ORNL/TIEGS1124	3.12		253.0	0.0							
SiAlON4.5+2%(3Y2O3+5Al2O3)	ORNL/TIEGS1124	3.21		284.0	0.0							
Silicon Carbide-Based Ceramics												
Beta-SiC	DOWCORN/UDRI/1	3.15		412.0	442.0	MICROINDNT	2769kg/mm2	25-1400	6.780		CONTRLFLAW	2.00
HEXOLOY SX-G1	CARB/1/1990	3.21			827.0							
HEXOLOY SX-G1	CARB/6/91	3.21			586.0							
HEXOLOY SX-G1	CARB/8/1991/MIX1	3.21			827.0							
HEXOLOY SX-G1	CARB/8/1991/MIX2	3.21			896.0							
HEXOLOY SX-G1	CARB/8/1991/MIX3	3.21			779.0							
HEXOLOY SX-G1	CARB/9/1990	3.21			917.0							
HEXOLOY SX-G1	CARB/9/1991/B	3.07			779.0							
HEXOLOY SX-G1	CARB/9/1991/C	3.18			779.0							
HEXOLOY SX-G1	CARB/9/1991/D	3.08			779.0							
HEXOLOY SX-G1	CARB/9/1991/F	2.78			779.0							
NT-230	NORTON/UDRI	3.08		402.3	435.0							2.30
Silicon Nitride-Based Ceramics												
CERAMLOY 147-3	CERADYNE/UDRI/2											
GS-44	GARRETT/UDRI/1											
GN-10	ORNL/KCL92	3.33		283.00	779.0							3.60
GN-10	GCCD/UDRI/1	3.33		283.00	779.0							3.60
GN-10	GCCD/NIST/1											
GTE PY6	AGTD/HIP	3.24										5.80
NT-154	ORNL/KCL92											
NT-154	NORTON/GAPD											
NT-164	NORTON/UDRI-92	3.10		306.1								4.00
Si3N4+8%Y+3.5%Si+1.9%Sr	ORNL/TRSN-17-3	2.12	64.7									
Si3N4+8.1%Nd+2.7%Si+1.2%Sr	ORNL/TRSN-13-3	2.37	71.1									
Si3N4+12%Y2O3+4%Al2O3	ORNL/TIEGS1124	3.32		299.0								
Si3N4+4%Y2O3	ORNL/TIEGS1124	3.20		305.0								
Si3N4+6%Y2O3+2%Al2O3	ORNL/TIEGS1124	3.25		310.0								
Si3N4+Y2O3+Al2O3	ORNL/TM-132											
Si3N4+La2O3+Al2O3	ORNL/TM-133											
Si3N4+6Y+2Al	ORNL/TRSN-1-1	3.25	99.3									
Si3N4+6Y+2Al	ORNL/TRSN-1-2	3.24	99.2									

Section 1c - continued

Material	Batch Code	Density g/cm ³	% Theo. Density	Young's Modulus GPa	Bend Strength MPa	Hardness Test	Hardness Value	Temp. Range °C	Coeff. of Thermal Expansion	Poisson's Ratio	Toughness Test	KIC MPa√m
Si3N4+6Y+2Al	ORNL/TRSN-1-3	2.98	91.0									
Si3N4+6Y+2Al	ORNL/TRSN-1-5	3.06	93.7									
Si3N4+6Y+2Al	ORNL/TRSN-1-6	3.07	93.9									
Si3N4+7.4La+3.2Si	ORNL/TRSN-10-1	3.29	99.9									
Si3N4+7.4La+3.2Si	ORNL/TRSN-10-2	3.29	99.9									
Si3N4+7.4La+3.2Si	ORNL/TRSN-10-3	2.83	85.9									
Si3N4+7.4La+3.2Si	ORNL/TRSN-10-5	3.00	91.2									
Si3N4+7.4La+3.2Si	ORNL/TRSN-10-6	3.19	97.1									
Si3N4+5.6Y+2.7Si+1.3Sr	ORNL/TRSN-11-1	2.36	72.7									
Si3N4+5.6Y+2.7Si+1.3Sr	ORNL/TRSN-11-2	2.47	75.9									
Si3N4+5.6Y+2.7Si+1.3Sr	ORNL/TRSN-11-3	2.09	64.3									
Si3N4+5.6Y+2.7Si+1.3Sr	ORNL/TRSN-11-5	2.24	69.0									
Si3N4+5.6Y+2.7Si+1.3Sr	ORNL/TRSN-11-6	2.31	71.0									
Si3N4+7.9La+2.7Si+1.3Sr	ORNL/TRSN-12-1	2.80	84.3									
Si3N4+7.9La+2.7Si+1.3Sr	ORNL/TRSN-12-2	2.94	88.5									
Si3N4+7.9La+2.7Si+1.3Sr	ORNL/TRSN-12-3	2.36	70.9									
Si3N4+7.9La+2.7Si+1.3Sr	ORNL/TRSN-12-5	2.55	76.9									
Si3N4+7.9La+2.7Si+1.3Sr	ORNL/TRSN-12-6	2.71	81.7									
Si3N4+8.1Nd+2.7Si+1.2Sr	ORNL/TRSN-13-1	2.76	82.7									
Si3N4+8.1Nd+2.7Si+1.2Sr	ORNL/TRSN-13-2	2.96	88.7									
Si3N4+8.1Nd+2.7Si+1.2Sr	ORNL/TRSN-13-5	2.53	75.7									
Si3N4+8.1Nd+2.7Si+1.2Sr	ORNL/TRSN-13-6	2.70	80.8									
Si3N4+7.8Y+4.3Si	ORNL/TRSN-14-1	3.24	99.5									
Si3N4+7.8Y+4.3Si	ORNL/TRSN-14-2	3.26	100.1									
Si3N4+7.8Y+4.3Si	ORNL/TRSN-14-3	2.60	79.8									
Si3N4+7.8Y+4.3Si	ORNL/TRSN-14-5	2.91	89.1									
Si3N4+7.8Y+4.3Si	ORNL/TRSN-14-6	3.12	95.9									
Si3N4+10.8La+4.2Si	ORNL/TRSN-15-1	3.34	99.6									
Si3N4+10.8La+4.2Si	ORNL/TRSN-15-2	3.34	99.8									
Si3N4+10.8La+4.2Si	ORNL/TRSN-15-3	2.67	79.6									
Si3N4+10.8La+4.2Si	ORNL/TRSN-15-5	3.02	90.3									
Si3N4+10.8La+4.2Si	ORNL/TRSN-15-6	3.27	97.7									
Si3N4+11.1Nd+4.2Si	ORNL/TRSN-16-1	3.39	100.0									
Si3N4+11.1Nd+4.2Si	ORNL/TRSN-16-2	3.38	99.7									
Si3N4+11.1Nd+4.2Si	ORNL/TRSN-16-3	2.61	77.0									
Si3N4+11.1Nd+4.2Si	ORNL/TRSN-16-5	2.77	81.6									
Si3N4+11.1Nd+4.2Si	ORNL/TRSN-16-6	3.29	97.2									
Si3N4+8.2Y+3.5Si+1.9Sr	ORNL/TRSN-17-1	2.63	80.1									

Section 1c - continued

Material	Batch Code	Density g/cm ³	% Theo. Density	Young's Modulus GPa	Bend Strength MPa	Hardness Test	Hardness Value	Temp. Range °C	Coeff. of Thermal Expansion	Poisson's Ratio	Toughness Test	KIC MPa√m
Si3N4+8.2Y+3.5Si+1.9Sr	ORNL/TRSN-17-2	2.77	84.3									
Si3N4+8.2Y+3.5Si+1.9Sr	ORNL/TRSN-17-5	2.49	75.9									
Si3N4+8.2Y+3.5Si+1.9Sr	ORNL/TRSN-17-6	2.60	79.1									
Si3N4+11.4La+3.3Si+1.8Sr	ORNL/TRSN-18-1	3.23	95.6									
Si3N4+11.4La+3.3Si+1.8Sr	ORNL/TRSN-18-2	3.35	99.1									
Si3N4+11.4La+3.3Si+1.8Sr	ORNL/TRSN-18-3	2.73	80.9									
Si3N4+11.4La+3.3Si+1.8Sr	ORNL/TRSN-18-5	2.67	79.0									
Si3N4+11.4La+3.3Si+1.8Sr	ORNL/TRSN-18-6	3.10	91.8									
Si3N4+11.7Nd+3.3Si+1.8Sr	ORNL/TRSN-19-1	3.07	90.0									
Si3N4+11.7Nd+3.3Si+1.8Sr	ORNL/TRSN-19-2	3.28	96.2									
Si3N4+11.7Nd+3.3Si+1.8Sr	ORNL/TRSN-19-3	2.36	69.3									
Si3N4+11.7Nd+3.3Si+1.8Sr	ORNL/TRSN-19-5	2.50	73.4									
Si3N4+11.7Nd+3.3Si+1.8Sr	ORNL/TRSN-19-6	2.99	87.6									
Si3N4+11.2La+5.5Si+1.8Sr	ORNL/TRSN-2-1	3.35	99.8									
Si3N4+11.2La+5.5Si+1.8Sr	ORNL/TRSN-2-2	3.35	99.7									
Si3N4+11.2La+5.5Si+1.8Sr	ORNL/TRSN-2-3	2.74	81.5									
Si3N4+11.2La+5.5Si+1.8Sr	ORNL/TRSN-2-5	3.11	81.5									
Si3N4+11.2La+5.5Si+1.8Sr	ORNL/TRSN-2-6	3.28	97.6									
Si3N4+9.6Y+5.3Si	ORNL/TRSN-20-1	3.27	99.8									
Si3N4+9.6Y+5.3Si	ORNL/TRSN-20-2	3.28	100.1									
Si3N4+9.6Y+5.3Si	ORNL/TRSN-20-3	2.83	86.4									
Si3N4+9.6Y+5.3Si	ORNL/TRSN-20-5	2.82	86.0									
Si3N4+9.6Y+5.3Si	ORNL/TRSN-20-6	3.16	96.4									
Si3N4+10.9La+5.2Si+1.7Sr	ORNL/TRSN-21-3	2.81	83.7									
Si3N4+10.9La+5.2Si+1.7Sr	ORNL/TRSN-21-5	2.97	88.4									
Si3N4+10.9La+5.2Si+1.7Sr	ORNL/TRSN-21-6	3.18	94.5									
Si3N4+5.8La+6.5Yb+5.2Si+1.7Sr	ORNL/TRSN-22-3	2.93	86.0									
Si3N4+5.8La+6.5Yb+5.2Si+1.7Sr	ORNL/TRSN-22-5	3.09	90.6									
Si3N4+5.8La+6.5Yb+5.2Si+1.7Sr	ORNL/TRSN-22-6	3.24	94.9									
Si3N4+8.8Yb+3.2Si	ORNL/TRSN-23-3	2.77	82.6									
Si3N4+8.8Yb+3.2Si	ORNL/TRSN-23-5	3.00	89.3									
Si3N4+8.8Yb+3.2Si	ORNL/TRSN-23-6	3.29	97.9									
Si3N4+4Y+2.5Si	ORNL/TRSN-24-3	2.41	74.9									
Si3N4+4Y+2.5Si	ORNL/TRSN-24-5	2.62	81.3									
Si3N4+4Y+2.5Si	ORNL/TRSN-24-6	3.02	93.9									
Si3N4+5.7La+2.5Si	ORNL/TRSN-25-3	2.58	78.9									
Si3N4+5.7La+2.5Si	ORNL/TRSN-25-5	2.83	86.6									
Si3N4+5.7La+2.5Si	ORNL/TRSN-25-6	3.17	96.8									

Section 1c - continued

Material	Batch Code	Density g/cm ³	% Theo. Density	Young's Modulus GPa	Bend Strength MPa	Hardness Test	Hardness Value	Temp. Range °C	Coeff. of Thermal Expansion	Poisson's Ratio	Toughness Test	KIC MPa√m
Si3N4+5.8Nd+2.5Si	ORN/LSN-26-3	2.64	80.5									
Si3N4+5.8Nd+2.5Si	ORN/LSN-26-5	2.93	89.3									
Si3N4+5.8Nd+2.5Si	ORN/LSN-26-6	3.15	96.2									
Si3N4+6.8Yb+2.5Si	ORN/LSN-27-3	2.70	81.2									
Si3N4+6.8Yb+2.5Si	ORN/LSN-27-5	2.92	88.0									
Si3N4+6.8Yb+2.5Si	ORN/LSN-27-6	3.24	97.7									
Si3N4+8Y+5.7Si+1.8Sr	ORN/LSN-3-1	3.24	99.0									
Si3N4+8Y+5.7Si+1.8Sr	ORN/LSN-3-2	3.27	99.9									
Si3N4+8Y+5.7Si+1.8Sr	ORN/LSN-3-3	2.52	77.1									
Si3N4+8Y+5.7Si+1.8Sr	ORN/LSN-3-5	2.94	90.0									
Si3N4+8Y+5.7Si+1.8Sr	ORN/LSN-3-6	3.09	94.4									
Si3N4+11.5Nd+5.5Si+1.8Sr	ORN/LSN-4-1	3.38	99.8									
Si3N4+11.5Nd+5.5Si+1.8Sr	ORN/LSN-4-2	3.39	99.9									
Si3N4+11.5Nd+5.5Si+1.8Sr	ORN/LSN-4-3	2.72	80.4									
Si3N4+11.5Nd+5.5Si+1.8Sr	ORN/LSN-4-5	2.94	86.7									
Si3N4+11.5Nd+5.5Si+1.8Sr	ORN/LSN-4-6	3.22	94.9									
Si3N4+10.6La+6.3Si	ORN/LSN-5-1	3.33	99.9									
Si3N4+10.6La+6.3Si	ORN/LSN-5-2	3.30	99.0									
Si3N4+10.6La+6.3Si	ORN/LSN-5-3	2.74	82.3									
Si3N4+10.6La+6.3Si	ORN/LSN-5-5	3.06	92.0									
Si3N4+10.6La+6.3Si	ORN/LSN-5-6	3.19	95.9									
Si3N4+7.6Y+6.5Si	ORN/LSN-6-1	3.25	100.0									
Si3N4+7.6Y+6.5Si	ORN/LSN-6-2	3.25	100.1									
Si3N4+7.6Y+6.5Si	ORN/LSN-6-3	2.82	86.8									
Si3N4+7.6Y+6.5Si	ORN/LSN-6-5	2.94	90.3									
Si3N4+7.6Y+6.5Si	ORN/LSN-6-6	3.17	97.4									
Si3N4+3.8Y+5.3La+6.4Si	ORN/LSN-7-1	3.29	99.8									
Si3N4+3.8Y+5.3La+6.4Si	ORN/LSN-7-2	3.30	99.9									
Si3N4+3.8Y+5.3La+6.4Si	ORN/LSN-7-3	2.90	87.9									
Si3N4+3.8Y+5.3La+6.4Si	ORN/LSN-7-5	2.99	90.5									
Si3N4+3.8Y+5.3La+6.4Si	ORN/LSN-7-6	3.28	99.4									
Si3N4+5.3Y+3.3Si	ORN/LSN-8-1	3.22	99.3									
Si3N4+5.3Y+3.3Si	ORN/LSN-8-2	3.24	100.1									
Si3N4+5.3Y+3.3Si	ORN/LSN-8-3	2.63	81.0									
Si3N4+5.3Y+3.3Si	ORN/LSN-8-5	2.82	87.0									
Si3N4+5.3Y+3.3Si	ORN/LSN-8-6	3.15	97.2									
Si3N4+7.6Nd+3.2Si	ORN/LSN-9-1	3.32	100.0									
Si3N4+7.6Nd+3.2Si	ORN/LSN-9-2	3.31	99.8									

Section 1c - continued

Material	Batch Code	Density g/cm ³	% Theo. Density	Young's Modulus GPa	Bend Strength MPa	Hardness Test	Hardness Value	Temp. Range °C	Coeff. of Thermal Expansion	Poisson's Ratio	Toughness Test	KIC MPa√m
Si3N4+7.6Nd+3.2Si	ORNL/TRSN-9-3	2.80	84.4									
Si3N4+7.6Nd+3.2Si	ORNL/TRSN-9-5	3.01	90.6									
Si3N4+7.6Nd+3.2Si	ORNL/TRSN-9-6	3.19	96.2									
SN-253	KYOCERA/UDRI/93	3.45		316.0	839.0	MICROINDNT	1599kg/mm2	25-1400	4.550		CONTRLFLAW	6.20
SNW-1000	ORNL/KCL-93											
SRBSN+9%Y2O3+3%Al2O3	ORNL/1124/9304											
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-136											
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-137											
SRBSN+Y2O3+MgO+Al2O3	ORNL/TM-138	3.06	91.3									
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-139											
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-141											
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-142											
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-145											
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-150											
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-152											

Section 2a - Material Information on Reinforced Ceramics

Material	Batch Code	Fabricator	Vendor's Designation	Primary Matrix	Primary Powder	Sintering Aids, Additives	Mixing Method	Forming Method	Densification Method
GN-10+SiCw10(AM7)	GCCD/4IT	Garrett Ceramic Component	GN-10/SiC	Si3N4(GN-10)	DENKA 9S, LOT 91096	(GN-10 ADDITIVES)	BALL MILL/PLAST.BOT.	SLIP-CAST	HIPed*
GN-10+SiCw10(AM7)	GCCD/5IT	Garrett Ceramic Component	GN-10/SiC	Si3N4(GN-10)	DENKA 9S, LOT 91096	(GN-10 ADDITIVES)	BALL MILL/PLAST.BOT.	SLIP-CAST	HIPed*
GN-10+SiCw20(AC3)	GCCD/(12/89)	Garrett Ceramic Component	GN-10/SiC	Si3N4(GN-10)		(GN-10 ADDITIVES)		SLIP-CAST	HIPed*
GN-10+SiCw20(AM5)	GCCD/(3/88)	Garrett Ceramic Component	GN-10/SiC	Si3N4(GN-10)		(GN-10 ADDITIVES)		SLIP-CAST	HIPed*
GN-10+SiCw20(AM5E)	GCCD/3/88ETCHED	Garrett Ceramic Component	GN-10/SiC	Si3N4(GN-10)		(GN-10 ADDITIVES)		SLIP-CAST	HIPed*
GN-10+SiCw20(AM7)	GCCD/4IT	Garrett Ceramic Component	GN-10/SiC	Si3N4(GN-10)	DENKA 9S, LOT 91096	(GN-10 ADDITIVES)	BALL MILL/PLAST.BOT.	SLIP-CAST	HIPed*
GN-10+SiCw20(AM7)	GCCD/5IT	Garrett Ceramic Component	GN-10/SiC	Si3N4(GN-10)	DENKA 9S, LOT 91096	(GN-10 ADDITIVES)	BALL MILL/PLAST.BOT.	SLIP-CAST	HIPed*
GN-10+SiCw20(T105)	GCCD/TAT105	Garrett Ceramic Component	GN-10/SiC	Si3N4(GN-10)		(GN-10 ADDITIVES)		SLIP-CAST	HIPed*
GN-10+SiCw30(AM7)	GCCD/4IT	Garrett Ceramic Component	GN-10/SiC	Si3N4(GN-10)	DENKA 9S, LOT 91096	(GN-10 ADDITIVES)	BALL MILL/PLAST.BOT.	SLIP-CAST	HIPed*
GN-10+SiCw30(AM7)	GCCD/5IT	Garrett Ceramic Component	GN-10/SiC	Si3N4(GN-10)	DENKA 92, LOT 91096	(GN-10 ADDITIVES)	BALL MILL/PLAST.BOT.	SLIP-CAST	HIPed*
GN-10+SiCw40(AM7)	GCCD/4IT	Garrett Ceramic Component	GN-10/SiC	Si3N4(GN-10)	DENKA 9S, LOT 91096	(GN-10 ADDITIVES)	BALL MILL/PLAST.BOT.	SLIP-CAST	HIPed*
GN-10+SiCw40(AM7)	GCCD/5IT	Garrett Ceramic Component	GN-10/SiC	Si3N4(GN-10)	DENKA 9S, LOT 91096	(GN-10 ADDITIVES)	BALL MILL/PLAST.BOT.	SLIP-CAST	HIPed*

*The actual HIPing parameters are proprietary, but the relations between the parameters are as given: T1 = baseline, T2 = T1 + 100°C, T3 = T1 + 150°C, T4 = T1 + 200°C, H1 = baseline, H2 = 4H1, where T is temperature in centigrade and H is time in hours. See Appendix B for properties on specific densification treatments.

Section 2b - Material Information on Reinforced Ceramics - Reinforcement Information

Material	Batch Code	SiC Whisker Name	Whisker Batch Code	Whisker Quantity	Whisker Treatment
GN-10+SiCw10(AM7)	GCCD/4IT	AM7	AM/(3/89)ETCHED	10w%	HF-ETCHED
GN-10+SiCw10(AM7)	GCCD/5IT	AM7	AM/(3/89)ETCHED	10w%	HF-ETCHED
GN-10+SiCw20(AC3)	GCCD/(12/89)	AC3	ACMC/12-89	20w%	
GN-10+SiCw20(AM5)	GCCD/(3/88)	AM5	AM/(5/88)	20w%	NONE
GN-10+SiCw20(AM5E)	GCCD/3/88ETCHED	AM5E	AM/(5/88)ETCHED	20w%	HF-ETCHED
GN-10+SiCw20(AM7)	GCCD/4IT	AM7	AM/(3/89)ETCHED	20w%	HF-ETCHED
GN-10+SiCw20(AM7)	GCCD/5IT	AM7	AM/(3/89)ETCHED	20w%	HF-ETCHED
GN-10+SiCw20(T105)	GCCD/TAT105	T105	SCW#1-S-105/297	20w%	
GN-10+SiCw30(AM7)	GCCD/4IT	AM7	AM/(3/89)ETCHED	30w%	HF-ETCHED
GN-10+SiCw30(AM7)	GCCD/5IT	AM7	AM/(3/89)ETCHED	30w%	HF-ETCHED
GN-10+SiCw40(AM7)	GCCD/4IT	AM7	AM/(3/89)ETCHED	40w%	HF-ETCHED
GN-10+SiCw40(AM7)	GCCD/5IT	AM7	AM/(3/89)ETCHED	40w%	HF-ETCHED

Section 2c - Material Information on Reinforced Ceramics - Room-Temperature Properties

Material	Batch Code	Vintage	Density g/cm ³	% Theo. Density	Bend Strength MPa	KIC Mpa√m
GN-10+SiCw10(AM7)	GCCD/4IT	1989	3.30	100.0		
GN-10+SiCw10(AM7)	GCCD/5IT	1989	3.31	100.0		
GN-10+SiCw20(AC3)	GCCD/(12/89)	1989			614.0	7.020
GN-10+SiCw20(AM5)	GCCD/(3/88)	1989			654.0	6.620
GN-10+SiCw20(AM5E)	GCCD/3/88ETCHED	1989			638.0	6.940
GN-10+SiCw20(AM7)	GCCD/4IT	1989	3.27	100.0		
GN-10+SiCw20(AM7)	GCCD/5IT	1989	3.30	100.0		
GN-10+SiCw20(T105)	GCCD/TAT105	1989			539.0	5.870
GN-10+SiCw30(AM7)	GCCD/4IT	1989	3.26	100.0		
GN-10+SiCw30(AM7)	GCCD/5IT	1989	3.30	100.0		
GN-10+SiCw40(AM7)	GCCD/4IT	1989	3.24	100.0		
GN-10+SiCw40(AM7)	GCCD/5IT	1989	3.29	100.0		

Section 3a - Reinforcement Materials - Origination and Composition

Reinforcement Designation	Chemistry	Batch Code	Form	Fabricator	Special Treatment	Condition as Used	Vintage	Diameter Range μm	Length Range μm
T105	SiC	SCW#1-S-105/297	WHISKERS	Tatcho	NONE	AS RECEIVED		0.1-1.0um	>100um
AM5	SiC	AM(3/88)	WHISKERS	American Matrix Company	NONE	AS RECEIVED	05/1988	0.2-5.0um	5-50um
AM5E	SiC	AM/3/88ETCHED	WHISKERS	American Matrix Company	ACID-ETCHED (HF) BY AMC	AS RECEIVED	03/1988	0.2-5.0um	5-50um
AM7	SiC	AM/3/89ETCHED	WHISKERS	American Matrix Company	ACID-ETCHED (HF) BY AMC	AS RECEIVED	03/1989		
AM8	SiC	AM/3/89ETCHED	WHISKERS	American Matrix Company	ACID-ETCHED (HF) BY AMC	AS RECEIVED	03/1989		
AT1	SiC	ACT/GR.L7V5	WHISKERS	Advanced Ceramic Tech.		VERY CLEAN, LOW OXY.	11/1989	0.05-0.4um	0.05-0.4um
KE1	SiC	KERA/GR.9A#49-51	WHISKERS	Keramont Corporation		AS RECEIVED	09/1989	0.05-0.6um	2-120um
KS3	SiC	KOBE/AT(3/89)	WHISKERS	Kobe Steel Company		AS RECEIVED	03/1989	<1um	5-50um
KS4	SiC	KOBE/AT(4/89)	WHISKERS	Kobe Steel Company		AS RECEIVED	04/1989	0.5-2.5um	10-125um
TK6	SiC	TOKAI/TWS-400	WHISKERS	Tokai Carbon Company		AS RECEIVED	02/1989	0.5-1.5um	10-50um
TK7	SiC	TOKAI/TWS-100	WHISKERS	Tokai Carbon Company		AS RECEIVED	05/1989		
AC3	SiC	ACMC/12-89	WHISKERS	Amer.Composite Matls.Co.		AS RECEIVED	12/1989	0.2-1.0um	5-100um

Section 3b - Reinforcement Materials - Material Descriptions

Reinforcement Designation	Batch Code	Surface Details	Fault Types	General Shape	Particulate Matter Present	Comments
T105	SCW#1-S-105/297	Fe-Ca PARTICLES ON SURF.	IWANGA-A, STACKING-B	BENT, IRREG. SEGMENTS		10% APPEARED TO BE HOLLOW
AM5	AM/(3/88)	ROUGH, IRREGULAR	STACKING ONLY	STRAIGHT	Fe-Ni-Ca PARTICLES	
AM5E	AM/3/88ETCHED					LIKE AM5, BUT SHARPER
AM7	AM/3/89ETCHED	ROUGH, IRREGULAR	STACKING ONLY	STRAIGHT, LARGE DIAMS		ROUGH SURFACE, STRAIGHT
AM8	AM/3/89ETCHED					
AT1	ACT/GR.L7V5	IRREGULAR, SOME Fe/Ni/Cr	MOST STACKING, FEW CHEV.	STRAIGHT, SOME BRANCHING	VERY CLEAN, FEW PARTICLES	
KE1	KERA/GR.9A#49-51	SiO2	STACKING AND CHEVRON	CONTORTED	Fe,Na,Mg,P,Ca,C	SHOULD BE CLEANED FIRST
KS3	KOBE/AT(3/89)		MOST STACKING, SOME CHEV.	GOOD	LOW	
KS4	KOBE/AT(4/89)		SOME Cr INCLUSIONS	GOOD	LOW	
TK6	TOKAI/TWS-400		CHEVRON			
TK7	TOKAI/TWS-100					
AC3	ACMC/12-89	SMOOTH		FAIRLY STRAIGHT		

Section 4 - Chemical Information

Material	Batch Code	Analysis Method	Material Condition	Units	Chemistry	Comments
Silicon Carbide Whiskers						
SiCw(AM7)	AM/3/89ETCHED	XRAY PHOTO SPECT	AS RECEIVED	at. %	Si:33.7; C:34.9; O:18.0; N:2.2; Ca:5.5; Fe:0.3; F:4.7	
SiCw(AM5E)	AM/3/88ETCHED	XRAY PHOTO SPECT	AS RECEIVED	at. %	Si:38.6; C:38.2; O:16.3; N:3.7; Ca:0.9; F:1.5; Al:0.8	
SiCw(AM5)	AM/(3/88)	XRAY PHOTO SPECT	AS RECEIVED	at. %	Si:33.2; C:18.3; O:45.6; Ca:1.7	
SiCw (KE1)	KERA/GR.9A#49-51	NEUTRON ACTIVATN	AS RECEIVED	ppm	O:3.0w%; N:2.2w%; Fe:0.54w%; Cl:150; Co:0.4; Cr:7.3; Mg:20; Na:480; Ni:<10	
SiCw (TK7)	TOKAI/TWS-100	NEUTRON ACTIVATN	AS RECEIVED	ppm	O:0.6w%; N:3.9w%; Fe:<0.05w%; Cl:40; Co:0.4; Cr:21; Mg:10; Na:25; Ni:<50	
SiCw (TK6)	TOKAI/TWS-400	NEUTRON ACTIVATN	AS RECEIVED	ppm	O:0.5w%; N:1.1w%; Fe:<0.05w%; Cl:40; Co:2700; Cr:62; Mg:<10; Na:24; Ni:<150	
SiCw (KS3)	KOBE/AT(3/89)	NEUTRON ACTIVATN	AS RECEIVED	ppm	O:0.5w%; N:1.6w%; Fe:0.13w%; Cl:40; Co:2.6; Cr:720; Mg:60; Na:52; Ni:<150	

Section 5a - Micrograph Index

Figure Number	Material	Batch Code	WBS Study	Photo Number	Responsible Facility	Microscope Type	Scale or Power
1.1	SiCw(AC3)	ACMC/12/89	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	STEM	1um=4mm
1.2	SiCw(AM5)	AM/(3/88)	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	STEM	
1.3	SiCw(AT1)	ACT/GR.L7V5	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	STEM	6.4um=25.4mm
1.4	SiCw(AT1)	ACT/GR.L7V5	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	STEM	0.2um=14mm
1.5	SiCw(AT1)	ACT/GR.L7V5	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	STEM	0.2um=7mm
1.6	SiCw(AT1)	ACT/GR.L7V5	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	STEM	0.2um=7mm
1.7	SiCw(KE1)	KERA/Gr.9A#49-51	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	STEM	20um=25.4mm
1.8	SiCw(KE1)	KERA/Gr.9A#49-51	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	STEM	2um=6mm
1.9	SiCw(KE1)	KERA/Gr.9A#49-51	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	STEM	0.2um=6mm
1.10	SiCw(KE1)	KERA/Gr.9A#49-51	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	STEM	0.2um=6mm
1.11	SiCw(KE1)	KERA/Gr.9A#49-51	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	STEM	0.1um=6mm
1.12	SiCw(AM7)	AM/3/89ETCHED	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	STEM	1um=3mm
1.13	SiCw(AM7)	AM/3/89ETCHED	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	STEM	1um=3mm
1.14	SiCw(KS3)	KOBE/AT(3/89)	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	STEM	10um=12mm
1.15	SiCw(KS3)	KOBE/AT(3/89)	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	STEM	0.2um=6mm
1.16	SiCw(KS4)	KOBE/AT(4/89)	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	STEM	10um=16mm
1.17	SiCw(KS4)	KOBE/AT(4/89)	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	STEM	0.1um=4mm
1.18	SiCw(TK6)	TOKAI/TWS-400	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	STEM	10um=16mm
1.19	SiCw(TK6)	TOKAI/TWS-400	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	STEM	1um=4mm
1.2	SiCw(TK6)	TOKAI/TWS-400	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	STEM	0.1um=8mm
1.21	SiCw(TK7)	TOKAI/TWS-100	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	STEM	0.1um=4mm
1.22	SiCw(TK7)	TOKAI/TWS-100	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	STEM	1um=4mm
1.23	SiCw(TK7)	TOKAI/TWS-100	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	STEM	1um=8mm
1.24	SiCw		1.2.3.1-ORNL	4190	Oak Ridge National Laboratory	SEM	1.5um=30mm
1.25	SiCw		1.2.3.1-ORNL	9890	Oak Ridge National Laboratory	SEM	3.33um=10mm
1.26	SiCw		1.2.3.1-ORNL	9803	Oak Ridge National Laboratory	SEM	3.33um=10mm
1.27	SiCw		1.2.3.1-ORNL	9906	Oak Ridge National Laboratory	SEM	3.33um=10mm
1.28	SiCw		1.2.3.1-ORNL	9905	Oak Ridge National Laboratory	SEM	3.33um=10mm
1.29	SiCw		1.2.3.1-ORNL	8141	Oak Ridge National Laboratory	SEM	5um=10mm
1.30	SiCw		1.2.3.1-ORNL	8143	Oak Ridge National Laboratory	SEM	1um=10mm
1.31	SiCw		1.2.3.1-ORNL	24064	Oak Ridge National Laboratory	SEM	1.5um=30mm
1.32	SiCw		1.2.3.1-ORNL	24065	Oak Ridge National Laboratory	SEM	2um=10mm
1.33	SiCw		1.2.3.1-ORNL	9891	Oak Ridge National Laboratory	SEM	3.33um=10mm
1.34	SiCw		1.2.3.1-ORNL	2665	Oak Ridge National Laboratory	SEM	1um=30mm

Section 5a - continued

Figure Number	Material	Batch Code	WBS Study	Photo Number	Responsible Facility	Microscope Type	Scale or Power
1.35	SiCw		1.2.3.1-ORNL	2653	Oak Ridge National Laboratory		1um=30mm
1.36	GN-10	GCCD/NIST/1	3.1.1.-NIST		NIST	TEM	
1.37	GN-10	GCCD/NIST/1	3.1.1.-NIST		NIST	TEM	
1.38	GN-10	GCCD/NIST/1	3.1.1.-NIST		NIST	TEM	
1.39	GN-10	GCCD/NIST/1	3.1.1.-NIST		NIST	TEM	
1.4	SN-253	KYOCERA/UDRI/93	3.3.1.4-UDRI	0833	Univ. of Dayton Research Inst.	SEM	
1.41	SN-253	KYOCERA/UDRI/93	3.3.1.4-UDRI	0834	Univ. of Dayton Research Inst.	SEM	
1.42	SN-253	KYOCERA/UDRI/93	3.3.1.4-UDRI	0829	Univ. of Dayton Research Inst.	SEM	
1.43	SN-253	KYOCERA/UDRI/93	3.3.1.4-UDRI	0831	Univ. of Dayton Research Inst.	SEM	
1.44	NT-154	NORTON/ORNL	3.1.1.4-ORNL		Oak Ridge National Laboratory	SEM	
1.45	NT-154	NORTON/ORNL	3.1.1.4-ORNL		Oak Ridge National Laboratory	SEM	
1.46	NT-154	NORTON/NIST/1	3.1.1.-NIST		NIST	TEM	
1.47	NT-154	NORTON/NIST/1	3.1.1.-NIST		NIST	TEM	
1.48	NT-154	NORTON/NIST/1	3.1.1.-NIST		NIST	TEM	
1.49	NT-154	NORTON/NIST/1	3.1.1.-NIST		NIST	TEM	
1.50	NT-154	NORTON/UDRI/2	3.3.1.4-UDRI		Univ. of Dayton Research Inst.	SEM	
1.51	NT-154	NORTON/NIST/1	3.1.1.-NIST		NIST	TEM	
1.52	GTE PY6		1.1.4.3-GTEL		GTE Laboratories	SEM	
1.53	GTE PY6		1.1.4.3-GTEL		GTE Laboratories	SEM	
1.54	GTE PY6		1.1.4.3-GTEL		GTE Laboratories	SEM	
1.55	SNW-1000		3.4.1.2-NCAT	133	North Carolina A&T Universty	SEM	
1.56	SNW-1000		3.4.1.2-NCAT		North Carolina A&T Universty	SEM	7.2um=10mm
1.57	SNW-1000		3.4.1.2-NCAT		North Carolina A&T Universty	SEM	7.2um=8mm
1.58	GS-44	ORNL/GCC-AS CRDA	3.1.1.4-ORNL		Oak Ridge National Laboratory	SEM	
1.59	GS-44	ORNL/GCC-AS CRDA	3.1.1.4-ORNL		Oak Ridge National Laboratory	SEM	
1.60	GS-44	ORNL/GCC-AS CRDA	3.1.1.4-ORNL		Oak Ridge National Laboratory	SEM	
1.61	GS-44	ORNL/GCC-AS CRDA	3.1.1.4-ORNL		Oak Ridge National Laboratory	SEM	
1.62	Si3N4+6%Y2O3+2%Al2O3	ORNL/TIEGS1124	1.2.3.1-ORNL	T014399	Oak Ridge National Laboratory	SEM	
1.63	Si3N4+6%Y2O3+2%Al2O3	ORNL/TIEGS1124	1.2.3.1-ORNL	T015970	Oak Ridge National Laboratory	SEM	
1.64	Si3N4+12%Y2O3+4%Al2O3	ORNL/TIEGS1124	1.1.2.4-ORNL	24045	Oak Ridge National Laboratory	SEM	
1.65	Si3N4+12%Y2O3+4%Al2O3	ORNL/TIEGS1124	1.1.2.4-ORNL	25707	Oak Ridge National Laboratory	SEM	
1.66	Si3N4+8%Y2O3+4%SiO2	ORNL/TIEGS1124	1.1.2.4-ORNL	23739	Oak Ridge National Laboratory	SEM	
1.67	Si3N4+8%Y2O3+4%SiO2	ORNL/TIEGS1124	1.1.2.4-ORNL	25955	Oak Ridge National Laboratory	SEM	
1.68	Si3N4+La2O3+Al2O3	ORNL/TM-133	1.1.2.4-ORNL	25694	Oak Ridge National Laboratory	SEM	

Section 5a - continued

Figure Number	Material	Batch Code	WBS Study	Photo Number	Responsible Facility	Microscope Type	Scale or Power
1.69	Si3N4+La2O3+Al2O3	ORNL/TM-133	1.1.2.4-ORNL	25779	Oak Ridge National Laboratory	SEM	
1.70	Si3N4+11%La2O3+4%SiO2		1.1.2.4-ORNL	22556	Oak Ridge National Laboratory	SEM	
1.71	Si3N4+11%La2O3+4%SiO2		1.1.2.4-ORNL	25952	Oak Ridge National Laboratory	SEM	
1.72	Si3N4		1.2.2.1-GCCD		Garrett Ceramic Components/A-S	SEM	10.0um=8mm
1.73	Si3N4		1.2.2.1-GCCD		Garrett Ceramic Components/A-S	SEM	10.0um=8mm
1.74	Si3N4		1.2.2.1-GCCD		Garrett Ceramic Components/A-S	SEM	10.0um=8mm
1.75	Si3N4		1.2.2.1-GCCD		Garrett Ceramic Components/A-S	SEM	10.0um=8mm
1.76	Si3N4		1.2.3.1-ORNL	T014476	Oak Ridge National Laboratory	SEM	
1.77	Si3N4		1.2.3.1-ORNL	T015883	Oak Ridge National Laboratory	SEM	
1.78	HEXOLOY SX-G1	CARB/8/91	1.1.1.3-CARB		Carborundum Company	SEM	25X
1.79	HEXOLOY SX-G1	CARB/8/91	1.1.1.3-CARB		Carborundum Company	SEM	
1.80	HEXOLOY SX-G1	CARB/8/91	1.1.1.3-CARB		Carborundum Company	SEM	
1.81	HEXOLOY SX-G1	CARB/8/91	1.1.1.3-CARB		Carborundum Company	SEM	500X
1.82	HEXOLOY SX-G1	CARB/8/91	1.1.1.3-CARB		Carborundum Company	SEM	50X
1.83	HEXOLOY SX-G1	CARB/8/91	1.1.1.3-CARB		Carborundum Company	SEM	50X
1.84	HEXOLOY SX-G1	CARB/8/91	1.1.1.3-CARB		Carborundum Company	SEM	1um=1mm
1.85	HEXOLOY SA	CARBRNDM/UDRI/2	3.3.1.4-UDRI	393	Univ. of Dayton Research Inst.	SEM	500X
1.86	NT-230	NORTON/UDRI/1	3.3.1.4-UDRI		Univ. of Dayton Research Inst.		500X
1.87	NT-230	NORTON/UDRI/1	3.3.1.4-UDRI		Univ. of Dayton Research Inst.		500X
1.88	NT-230	NORTON/UDRI/1	3.3.1.4-UDRI		Univ. of Dayton Research Inst.	SEM	
1.89	GN-10+SiCw20(AM5E)	GCCD/3/88ETCHED	1.2.2.1-GCCD	00047	Garrett Ceramic Components/A-S	SEM	5um=10mm
1.90	GN-10+SiCw20(T105)	GCCD/TAT105	1.2.2.1-GCCD	00017	Garrett Ceramic Components/A-S	SEM	2um=10mm
1.91	GN-10+SiCw20(AM5E)	GCCD/3/88ETCHED	1.2.2.1-GCCD	221014	Garrett Ceramic Components/A-S	SEM	
1.92	GN-10+SiCw20(AC3)	GCCD/(12/89)	1.2.2.1-GCCD	221433	Garrett Ceramic Components/A-S	SEM	
1.93	GN-10+SiCw20(AC3)	GCCD/(12/89)	1.2.2.1-GCCD	221437	Garrett Ceramic Components/A-S	SEM	
1.94	GN-10+SiCw20(AC3)	GCCD/(12/89)	1.2.2.1-GCCD	221439	Garrett Ceramic Components/A-S	SEM	
1.95	GN-10+SiCw20(AM7)	GCCD/4IT	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	OPTICAL	6.67um=1mm
1.96	GN-10+SiCw20(AM7)	GCCD/4IT	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	OPTICAL	3.33um=1mm
1.97	GN-10+SiCw20(AM7)	GCCD/4IT	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	OPTICAL	3.33um=1mm
1.98	GN-10+SiCw30(AM7)	GCCD/4IT	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	OPTICAL	3.33um=1mm
1.99	GN-10+SiCw10(AM7)	GCCD/4IT	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	OPTICAL	3.33um=1mm
1.100	GN-10+SiCw10(AM7)	GCCD/5IT	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	OPTICAL	3.33um=1mm
1.101	GN-10+SiCw10(AM7)	GCCD/5IT	1.2.2.1-GCCD		Garrett Ceramic Components/A-S	OPTICAL	3.33um=1mm

Silicon Carbide Whisker Micrographs

Figure 1.1. Morphology of ACMC SiC whiskers.

Figure 1.2. Morphology of American Matrix AM5 SiC whiskers.

Figure 1.3. Morphology of Advanced Ceramics Technology AT1 SiC whiskers.

Figure 1.4. Branched AT1 SiC whiskers with a split in the faulting structure.

Figure 1.5. Branched AT1 SiC whiskers with chevron and stacking faults.

Figure 1.6. Irregular surfaces for AT1 SiC whiskers.

Silicon Carbide Whisker Micrographs

Figure 1.7. Morphology of Keramont (KE1) SiC whiskers.

Figure 1.8. Contorted KE1 SiC whiskers.

Figure 1.9. Chevron and stacking faults for KE1 SiC whiskers.

Figure 1.10. Fibrous particles rich in calcium, iron, and magnesium attached to KE1 whisker surface.

Figure 1.11. Central whisker defect in KE1 SiC whisker.

Silicon Carbide Whisker Micrographs

Figure 1.12. Morphology of American Matrix AM7 SiC whiskers.

Figure 1.13. Particles rich in calcium on AM7 SiC whiskers.

Figure 1.14. Morphology of Kobe Steel (KS3) SiC whiskers.

Figure 1.15. Lots of stacking faults on KS3 SiC whiskers. Arrow points to chromium-rich particle.

Figure 1.16. Morphology of Kobe Steel KS4 SiC whiskers.

Figure 1.17. Chromium-rich particle (arrow) attached to KS4 SiC whisker.

Silicon Carbide Whisker Micrographs

Figure 1.18. Morphology of Tokai TWS-400 TK6 SiC whiskers.

Figure 1.19. Distorted shapes in Tokai TK6 SiC whiskers.

Figure 1.20. Cobalt/iron-rich particles on a TK6 SiC whisker.

Figure 1.21. Particles rich in titanium and cobalt (arrow) on Tokai TK7 SiC whiskers.

Figure 1.22. Morphology of Tokai Carbon TK7 SiC whiskers.

Figure 1.23. Twisted TK7 SiC whiskers.

Silicon Carbide Whisker Micrographs

Figure 1.24. SiC whiskers grown with Fe catalyst showing distorted whisker growth at bottom of powder bed due to high SiO levels.

Figure 1.25. SiC whiskers grown with Fe catalyst showing a range of whisker diameters. Heating rate was 20°C/min to 1600°C in Ar-4%H₂.

Figure 1.26. SiC whiskers grown with Fe catalyst showing a range of whisker diameters. Heating rate was 200°C/min to 1600°C in Ar-4%H₂.

Figure 1.27. SiC whiskers grown with Fe catalyst showing range of whisker diameters. Heating rate was 2°C/min to 1600°C in Ar-4% H₂.

Figure 1.28. SiC whiskers grown with Fe catalyst showing variation of diameters along length. Heating rate was 2°C/min to 1600°C in Ar-4% H₂.

Silicon Carbide Whisker Micrographs

Figure 1.29. SiC whiskers grown with FeSi catalyst showing whisker diameters with smooth surfaces. Heating rate was 20°C/min to 1700°C in Ar-4% H₂.

Figure 1.30. SiC whiskers grown with FeSi catalyst showing end of whisker and unusual growth habit. Heating rate was 20°C/min to 1700°C in Ar-4% H₂.

Figure 1.31. SiC whiskers grown with B₂O₃ catalyst showing crystallographic changes along length of whiskers.

Figure 1.32. SiC whiskers grown with B₂O₃ catalyst showing fine whisker diameters. Heating rate was 20°C/min to 1600°C in Ar-4% H₂.

Silicon Carbide Whisker Micrographs

Figure 1.33. SiC whiskers grown with Fe catalyst showing catalyst balls on ends of whiskers.

Figure 1.34. SiC whiskers grown with Co catalyst.

Figure 1.35. SiC whiskers grown with Ni catalyst.

Micrographs of Silicon Nitride-Based Ceramics

Figure 1.36. Cavities appear to initiate within small triple grain junctions and grow along two grain interfaces during tensile creep testing.

Figure 1.37. Continued interfacial cavity growth in direction normal to tensile stress eventually results in joining of individual grain segments to form creep cracks.

Figure 1.38. Microstructure of GN-10 illustrating varied B-Si₃N₄ grain size and morphology.

Figure 1.39. Crystalline second phase produced in GN-10 by partial devitrification of intergranular glass originally present during processing.

Micrographs of Silicon Nitride-Based Ceramics

Figure 1.40. Specimen #21, SN-253, tested at 1350°C at 0.004 cm/s crosshead speed.

Figure 1.41. Specimen #12, SN-253, tested at 20°C at 0.00004 cm/s crosshead speed.

Figure 1.42. Fracture surface of Specimen #10, SN-253, tested at 20°C at 0.04 cm/s crosshead speed.

Figure 1.43. Fracture surface of Specimen #3, SN-253, tested at 20°C at 0.004 cm/s crosshead speed.

Micrographs of Silicon Nitride-Based Ceramics

Figure 1.44. Image showing voids at $\text{Si}_3\text{N}_4/\text{Si}_3\text{N}_4$ boundaries in a "precycled" NT-154 specimen subjected to tensile creep testing at 1370°C and 100 MPa.

Figure 1.45. Image showing voids at $\text{Si}_3\text{N}_4/\text{Si}_3\text{N}_4$ boundaries in an annealed NT-154 specimen subjected to tensile creep testing at 1370°C and 100 MPa.

Micrographs of Silicon Nitride-Based Ceramics

Figure 1.46. NT-154 microstructure illustrating variable size and morphology of B-Si₃N₄ grains.

Figure 1.47. Localized strain contrast contours at grain boundary in NT-154 creep samples cooled under load, indicating grain-to-grain contact.

Figure 1.48. Comparison of intergranular phase distribution in NT-154 before tensile creep testing. Notice the multi-grain junctions contain small crystallites dispersed in residual glass.

Figure 1.49. Tensile creep tested NT-154 showing that crystal growth occurred, leaving residual glass only at narrow crystalline interfaces: $\alpha = \text{Y}_2\text{Si}_2\text{O}_7$.

Micrographs of Silicon Nitride-Based Ceramics

Figure 1.50. Fracture surface of a tensile stress-rupture specimen of NT-154 tested at 1300°C, 300 MPa, 0.5 s.

Figure 1.51. Distribution of ellipsoidal cavities typically produced at grain boundaries in NT-154 during tensile creep at 1350 to 1400°C. Cavities nucleate within narrow glassy interfaces, then grow into adjacent silicon nitride grains.

Micrographs of Silicon Nitride-Based Ceramics
(continued)

Figure 1.52. Baseline GTE PY6 microstructure.

Figure 1.53. HF-treated GTE PY6 microstructure.

Figure 1.54. Modified GTE PY6 microstructure.

Micrographs Silicon Nitride-Based Ceramics
(continued)

Figure 1.55. High magnification showing a pore observed in the central area of the cross section of a creep-tested polished sample of SNW-1000.

Figure 1.56. GTE SNW-1000 creep-tested specimen showing linking of small pores.

Figure 1.57. GTE SNW-100 creep-tested specimen showing pore softening.

Micrographs of Silicon Nitride-Based Ceramics
(continued)

Figure 1.58. Low-magnification SEM image of the fracture surface from as-processed control GS-44.

Figure 1.59. Low-magnification SEM image of the fracture surface from microwave-annealed GS-44.

Figure 1.60. High-magnification image of the fracture surface from as-processed control GS-44.

Figure 1.61. High-magnification image of the fracture surface from microwave-annealed GS-44.

Micrographs of Silicon Nitride-Based Ceramics

Figure 1.62. Fracture surface of Si_3N_4 -6% Y_2O_3 -2% Al_2O_3 hot pressed at 1725°C for 60 min.

Figure 1.63. Fracture surface of Si_3N_4 -6% Y_2O_3 -2% Al_2O_3 hot pressed at 1800°C for 90 min.

Figure 1.64. Fracture surface of dense Si_3N_4 -12% Y_2O_3 -4% Al_2O_3 as fabricated.

Figure 1.65. Fracture surface of dense Si_3N_4 -12% Y_2O_3 -4% Al_2O_3 after microwave annealing at 1800°C for 2 h in a 2.45-GHz cavity.

Micrographs of Silicon Nitride-Based Ceramics

Figure 1.66. Fracture surface of dense Si_3N_4 -8% Y_2O_3 -4% SiO_2 as fabricated.

Figure 1.67. Fracture surface of dense Si_3N_4 -8% Y_2O_3 -4% SiO_2 after microwave annealing at 1800°C for 2 h in a 2.45-GHz cavity.

Figure 1.68. Fracture surface of dense Si_3N_4 -11% La_2O_3 -3% Al_2O_3 as fabricated.

Figure 1.69. Fracture surface of dense Si_3N_4 -11% La_2O_3 -3% Al_2O_3 after microwave annealing at 1800°C for 2 h in a 2.45-GHz cavity.

Micrographs of Silicon Nitride-Based Ceramics

Figure 1.70. Fracture surface of dense Si_3N_4 -11% La_2O_3 -4% SiO_2 as fabricated.

Figure 1.71. Fracture surface of dense Si_3N_4 -11% La_2O_3 -4% SiO_2 after microwave annealing at 1800°C for 2 h in a 2.45-GHz cavity.

Figure 1.72. Fracture surface of Si_3N_4 with GN-10 sintering aids, hot pressed at 1725°C for 1 h.

Figure 1.73. Fracture surface of Si_3N_4 with GN-10 sintering aids, hot pressed at 1800°C for 1.5 h.

Micrographs of Silicon Nitride-Based Ceramics

Figure 1.74. Experimental Si_3N_4 with GN-10 sintering aids prepared in a small spray drier (SEM image).

Figure 1.75. Experimental Si_3N_4 with GN-10 sintering aids prepared in a small spray drier (SEM backscattered image).

Figure 1.76. Secondary electron image of control Si_3N_4 with GN-10 sintering aids prepared in a small spray drier.

Figure 1.77. Backscattered electron image of control Si_3N_4 with GN-10 sintering aids prepared in a small spray drier.

Micrographs of Silicon Carbide-Based Ceramics

Figure 1.78. Low magnification of the fracture surface of a Hexoloy SX-G1 flexure bar tested at room temperature. Strength at flaw was 786 MPa.

Figure 1.80. Fracture surface of a Hexoloy SX-G1 flexure bar tested at room temperature. Strength at flaw was 786 MPa.

Figure 1.79. Fracture surface of a Hexoloy SX-G1 tensile specimen tested at room temperature. Tensile strength was 411 MPa.

Figure 1.81. Fracture surface of a Hexoloy SX-G1 tensile specimen tested at room temperature. Tensile strength was 411 MPa.

Micrographs of Silicon Carbide-Based Ceramics

Figure 1.82. Fracture surface of a Hexoloy SX-G1 tensile specimen tested at 1370°C under a constant stressing rate of 0.11 MPa/s. Tensile strength was 279 MPa.

Figure 1.83. Fracture surface of a Hexoloy SX-G1 tensile specimen tested at 1370°C under a constant stressing rate of 0.11 MPa/s. Tensile strength was 279 MPa.

Figure 1.84. Microstructure of Hexoloy SX-G1 from the etched surface.

Figure 1.85. Typical fracture surface of Hexoloy SA tested in tensile stress rupture at 200 MPa.

Figure 1.86. Polished section of NT-230.

Figure 1.87. Polished and etched section of NT-230.

Figure 1.88. Plasma-etched section of NT-230.

Micrographs of Silicon Carbide-Reinforced Silicon Nitride-Based Ceramics

Figure 1.89. Whiskers observed on fracture surface of AM5E whisker-reinforced GN-10 composite suggest crack-bridging toughening.

Figure 1.90. Tateho (T105) whisker-reinforced GN-10 composite showed no evidence of whisker toughening.

Figure 1.91. Whisker pullout sockets on GN10+SiCw20(AM5E) suggests bridging toughening mechanism.

Figure 1.92. Whisker pullout sockets on GN10+SiCw20(AC3) suggests bridging toughening mechanism.

Micrographs of Silicon Carbide-Reinforced Silicon Nitride-Based Ceramics

Figure 1.93. Tensile surface fracture origin in GN-10+SiCw20(AC3) whisker-reinforced composite.

Figure 1.94. Tensile surface fracture origin in GN-10+SiCw20(AC3) whisker-reinforced composite, higher magnification.

Figure 1.95. An example of whisker agglomerates and associated large pore clusters present in composites [GN-10+SiCw20(AM7)].

Figure 1.96. Random whisker orientation in GN-10+SiCw20(AM7) (GCCD/4IT) parallel to casting direction.

Figure 1.97. Random whisker orientation in GN-10+SiCw20(AM7) (GCCD/4IT) perpendicular to casting direction.

Micrographs of Silicon Carbide-Reinforced Silicon Nitride-Based Ceramics

Figure 1.98. Random whisker orientation in GN-10+SiCw30(AM7), (GCCD/4IT), parallel to casting direction.

Figure 1.99. Random whisker orientation in GN-10+SiCw10(AM7), (GCCD/4IT), perpendicular to casting direction.

Figure 1.100. Preferred whisker orientation in GN-10+SiCw10(AM7), (GCCD/5IT), parallel to casting direction.

Figure 1.101. Preferred whisker orientation in GN-10+SiCw10(AM7), (GCCD/5IT), perpendicular to casting direction.

Section 6 - General Material Notes

Material	Batch Code	Topic	Text
Silicon Carbide-Based Materials			
AM5E	AM/3/88ETCHED	PROCESS	Whisker cleaning procedure: (1) Whiskers dispersed in solution of concentrated HCl (12M) diluted with 50% distilled water. (2) Mixture then boiled. Allowed to cool overnight. (3) Excess liquid was poured off. (4) Whiskers were rinsed three times in deionized water. (5) Whiskers then dispersed in concentrated HF solution diluted with 50% distilled water. (6) Mixture stirred for 4 h. (7) Allowed to stand overnight. (8) Excess liquid poured off. (9) Rinsed in deionized water 3 times. (10) HIP for 30 min in a graphite crucible in argon.
HEXOLOY SX-G1	CARB/8/1991	PROCESS	Two 20-lb batches of SiC powder were mixed with sintering additives and spray dried into soft, flowable agglomerates. Resulting powder was then compacted into 6.35-mm square plates and isostatically pressed to 117 MPa. Green plates were post treated to > 99% theoretical density. MOR bars (3 x 4 x 48 mm) were then machined from the plates. Green rods (216- x 23-mm-diam) were isostatically pressed to 117 MPa, then pressureless sintered to 96% TD. A post-treatment process boosted density to > 99%. Rods were then machined into ORNL buttonhead tensile specimens.
Silicon Nitride-Based Materials			
SRBSN+9%Y2O3+3%Al2O3	ORNL/1124/9304	PROCESS	Si, alpha Si3N4, Al2O3, and Y2O3 powders were turbo milled in isopropyl alcohol. The slurry was then dried and sieved through a 40-mesh screen. Pellets (about 100 g) were formed by uniaxial pressing in a 76-mm-diam die, then isostatic pressed at 5 kg/cm ² to give green densities of 1.59-1.62 g/cm ³ . The resulting disks (70- x 15-mm-diam) were presintered in Ar/1200C/1h, then bisque-machined to produce either complex parts or thin rectangular pieces (4.5 mm thick x 6.5 mm wide x 45 to 74 mm long). Two arrangements were used for the multi-sample experiments: Setup 1: Bisque-fired samples, stacked on BN plates, were surrounded by dense Si3N4 milling media. Eight bisque-fired samples were equispaced vertically against the inner surface of the BN crucible, hereafter referred to as the picket fence (PF) arrangement. Setup 2: Called the close-pack-mixed (CPM) arrangement; no pickets were used. Dense, previously processed SRBSN samples with the same composition were placed along the outer edges of each BN plate surrounding an inner group of 4 bisque-fired TM145 samples. Microwave processing of complex SRBSN pieces was done by stacking 2 or 3 pieces on alternating layers of BN plates and surrounding by dense Si3N4 milling media. In all three methods, samples were enclosed in a BN

Section 6 - continued

Material	Batch Code	Topic	Text
Silicon Nitride-Based Materials			
SRBSN+9%Y ₂ O ₃ +3%Al ₂ O ₃	ORNL/1124/9304	PROCESS	crucible which was packed in Si ₃ N ₄ powder. An Mo-sheathed thermocouple (TC) with a BN sleeve was inserted between the sample layers to measure the temperature. Nitridation was done in a static atmosphere of N ₂ -4%H ₂ -5%He at about 0.1 MPa with additional N ₂ added as the reaction proceeded. After nitridation, the temperature was increased to the sintering temperature and maintained for the appropriate time. An entire heating cycle to 1800C required about 25 h. The conventional processing was done in a graphite-resistance heated furnace in a 2-step process. Step 1: Pre-sintered pieces were stacked on BN plates in a graphite crucible and heated to 1450C in flowing N ₂ in 34 h. Step 2: Samples then were cooled and covered with Si ₃ N ₄ packing powder and heated in flowing nitrogen at 5C/min to 1800C. Microwave processing using the PF arrangement produced uneven heating, extreme warping, and slumping. Densities varied greatly, depending on the positions in the arrangement. The CPM arrangement provided better results, but densities increased from the top to the bottom layers.
Si ₃ N ₄ +11.5%La ₂ O ₃ +3%Al ₂ O ₃	ORNL/TM-132	PROCESS	Starting components: Ube Industries E-10 Si ₃ N ₄ powder, Molycorp gr. 5600 Y ₂ O ₃ - (< 99.9%), Ceralox gr. HP Al ₂ O ₃
Si ₃ N ₄ +La ₂ O ₃ +Al ₂ O ₃	ORNL/TM-153	PROCESS	Starting components: Ube Industries gr. E-10 Si ₃ N ₄ powder, Molycorp gr. 5200 La ₂ O ₃ > 99.99% pure, Ceralox gr. HP Al ₂ O ₃ (.5 um particles)
SRBSN+Y ₂ O ₃ +MgO+Al ₂ O ₃	ORNL/TM-138	PROCESS	Starting components: Elkem Metals Co., gr. metallurgical Si, Starck gr. S1 Si ₃ N ₄ , Molycorp gr. 5210 rare-earth mixture (< 1% CeO ₂)
SRBSN+11.5%La ₂ O ₃ +3%Al ₂ O ₃	ORNL/TM-139	PROCESS	Starting components: Elkem Metals Co. gr. Si-HQ, Molycorp gr. 5205 La ₂ O ₃ (> 99.9%), Starck gr. LC-10N Si ₃ N ₄
SRBSN+11.5%La ₂ O ₃ +3%Al ₂ O ₃	ORNL/TM-136	PROCESS	Starting components: Elkem Metals Co. gr. metallurgical Si, Molycorp gr. 5232 - rare-earth mixture (< 1% CeO ₂ , 0.5 w% Fe ₂ O ₃), Starck gr. S1 Si ₃ N ₄
SRBSN+11.5%La ₂ O ₃ +3%Al ₂ O ₃	ORNL/TM-137	PROCESS	Starting components: Elkem Metals Co. gr. Si-HQ, Molycorp gr. 5205 La ₂ O ₃ (> 99.9%), Starck gr. LC-10N Si ₃ N ₄

Section 6 - continued

Material	Batch Code	Topic	Text
Silicon Nitride-Based Materials			
SRBSN+11.5%La ₂ O ₃ +3%Al ₂ O ₃ ORNL/TM-141		PROCESS	Starting components: Elkem Metals Co. gr. Si-HQ, Molycorp gr. 5205 La ₂ O ₃ > 99.9%, Reynolds gr. RC-HP DBM Al ₂ O ₃ .
SRBSN+9%Y ₂ O ₃ +3%Al ₂ O ₃ ORNL/TM-142		PROCESS	Starting components: Elkem Metals Co. gr. Si-HQ, Molycorp gr. 5600 Y ₂ O ₃ > 99.99% pure, Reynolds gr. RC-HP DBM Al ₂ O ₃ .
SRBSN+9%Y ₂ O ₃ +3%Al ₂ O ₃ ORNL/TM-145		PROCESS	Starting components: Elkem Metals Co. gr. metallurgical Si, Molycorp gr. 5600 Y ₂ O ₃ > 99.99% pure, Reynolds gr. RC-HP DBM Al ₂ O ₃ .
SRBSN+11.5%La ₂ O ₃ +3%Al ₂ O ₃ ORNL/TM-150		PROCESS	Starting components: Elkem Metals Co. gr. Si-HQ, Molycorp gr. 5205 La ₂ O ₃ > 99.9%, Reynolds gr. RC-HP DBM Al ₂ O ₃ .
SRBSN+11.5%La ₂ O ₃ +3%Al ₂ O ₃ ORNL/TM-152		PROCESS	Starting components: Elkem Metals Co. gr. Si-HQ, Molycorp gr. 5205 La ₂ O ₃ > 99.9%, Reynolds gr. RC-HP DBM Al ₂ O ₃ .
Silicon Carbide Whisker-Reinforced Silicon Nitride-Based Materials			
GN-10+SiCw		GENERAL	The actual HIPing parameters are proprietary, but the relations between the parameters are as given: T ₁ = BASELINE, H ₁ = BASELINE, T ₂ = T ₁ + 100C, H ₂ = 4H ₁ , T ₃ = T ₁ + 150C, T ₄ = T ₁ + 200C, where T = TEMP in C, H = TIME in hours.
GN-10+SiCw10(AM7)	GCCD/4IT	PROCESS	The slip was blended in a plastic bottle with five Si ₃ N ₄ (5/8-in.-diam) balls. Whiskers were gradually added, then tumbled on the rack for a set period of time. Solids content of slip was reduced by 5 w% from prior mixes [GN-10+SiCw20(AM5)] to allow better dispersion of whiskers.
GN-10+SiCw20(AC3)	GCCD/(12/89)	PROCESS	Fracture flaws were all surface. Green form processing was the same as for GN-10+SiCw20(AM5).
GN-10+SiCw20(AM5)	GCCD/(3/88)	PROCESS	Few details were provided about the actual mixing process. The green form was slip cast, then ASEA glass-encapsulated and HIPed. The billets cracked during HIPing due to high SiO ₂ layer on whisker surface. Billets were 63.5 mm diam by 76.2 mm long.

Section 6 - continued

Material	Batch Code	Topic	Text
Silicon Carbide Whisker-Reinforced Silicon Nitride-Based Materials			
GN-10+SiCw20(AM5E)	GCCD/3/88ETCHED PROCESS		Green-forming processing same as for GN-10+SiCw20(AM5) except that the whiskers were HF-etched to remove the SiO layer. One billet cracked during densification. Fracture flaws were both surface and internal.
GN-10+SiCw20(AM7)	GCCD/4IT	PROCESS	See GN-10+SiCw10(AM7) for details.
GN-10+SiCw20(T105)	GCCD/TAT105	PROCESS	Green-form processing for Tateho whiskers was the same as for the AM5 whiskers. None of the billets cracked during densification. Microscopy revealed no evidence of SiC whiskers internally. Most fracture origins were on the surface, with only a few internal.
GN-10+SiCw30(AM7)	GCCD/4IT	PROCESS	See GN-10+SiCw10(AM7) for details.
GN-10+SiCw40(AM7)	GCCD/4IT	PROCESS	See GN-10+SiCw10(AM7) for details.

APPENDIX B. TEST RESULTS

Section 1 - Test Background Information

Test Rig	Test Type	WBS Code	Test Description
CREPNISTDR	CREEP	3.1-NIST	The double reduction specimen was used in this test. The gage length was 11 mm, the cross section was 2.20 x 2.25 mm. This type of specimen is 2.5 mm at the flange end but is cut down in the gage section to compensate for the extreme stress concentrations at the end of the gage section.
CREPNISTIF	CREEP	3.1-NIST	The specimen used in this test is an integral flag type which is a dogbone with flags built into the specimen near the end of the gage section. Gage dimensions are 14 mm length with 2.25 x 2.25 mm cross section. Uniform x-section only 9 mm.
CREPNISTMN	CREEP	3.1-NIST	The specimens used in this test were modified dogbone type with a 15-mm gage section and a 2.25 x 2.25 mm cross section at gage center.
CREPORN1	CREEP	3.2.1.5-ORNL	Specimen geometry: Buttonhead tensile rods with a 6.3-mm-diam, 32-mm-long uniform gage section. All circumferential marks in gage section were removed by final longitudinal grinding to a 0.4-um (rms) finish. Gage section was not surface polished. Tests were performed on a lever-arm creep-testing machine equipped with a microprocessor-driven slider resting atop the arm to maintain closed-loop, load/stress control. Constant load control precision was about 0.05 kgf. Self-aligning grips were incorporated into the load-train assembly. Furnace was low-profile, 2-zone controlled-resistance type that heats the center of the specimen leaving ends for "cold-gripping." Temperature gradient between gage center and end was less than 0.5% of maximum temperature at center. Strain was measured using a laser-based diffractive strain extensometer. Specimens were loaded by deadweight using the lever arm.
CREPORN2	CREEP	1.2.3.1-ORNL	Creep tests are performed using 4-point bend fixtures and standard MOR bars (HTML).
CREPSORI1	CREEP	3.2.2.2-AGTD	Tensile creep and stress-rupture tests for Allison Gas Turbine Division of General Motors Corp. were performed at Southern Research Institute (SORI) using buttonheaded specimens. Few details were provided.
ARCHIMEDES	DENSITY	GENERAL	The Archimedes method uses the weight and volume of water displaced as the object placed in the water container to determine the density.

Section 1 - continued

Test Rlg	Test Type	WBS Code	Test Description
CHEVRON NOT3	FRACTUFF	GENERAL	A chevron-notched MOR bar is broken in a 3-point bend fixture.
CHEVRON NOTC	FRACTUFF	GENERAL	A standard MOR bar specimen is chevron notched ("V" notch) in the center of the specimen perpendicular to the long axis, then broken in a 4-point bend fixture.
CONTROLLEDF3	FRACTUFF	GENERAL	An MOR bar is indented once with a Vickers or Knoop diamond indenter, then broken in a 3-point bend fixture.
CONTROLLEDFL	FRACTUFF	GENERAL	Controlled flaw technique - an MOR bend specimen is indented on a polished tensile surface using a Vickers or Knoop indenter, aligning the pyramid edges with the longitudinal axis of the specimen. The bar is then broken in a 4-point bend fixture. For this method, no crack lengths have to be measured. Fracture strength is relative to indentation load. This method can also take residual stress existence into consideration. Reference: Chantikul, P., Anstis, G.R., et al., "A Critical Evaluation of Indentation Techniques for Measuring Fracture Toughness: II, Strength Method," J. Am. Ceram. Soc. 64 [9], 539-43 (1981).
MICROINDENT	FRACTUFF	GENERAL	Micro-indentation method - Several indentations are made on polished specimen surface, using a Vickers or Knoop diamond pyramid indenter. Fracture toughness is then calculated using the lengths of the resulting microcracks and the hardness value for the tested material. Reference: Anstis, G.R., Chantikul, P., et al., "A Critical Evaluation of Indentation Techniques for Measuring Fracture Toughness: I, Direct Crack Measurements," J. Am. Ceram. Soc. 64 [9], 533-38 (1981).
MODIFIED CFT	FRACTUFF	GENERAL	Like controlled flaw, except more than one indentation is made on the tensile surface of the specimen. The first indentation is made in the center of an MOR bend bar. The other indentations are made within the inner span for a 4-point fixture, but far enough away from the center to avoid interaction. The bar is then broken. KIC is calculated based on indentation load, applied stress, and a crack-geometry parameter. This method attempts to merge the controlled flaw and the multiple indentation techniques and is useful in assessing toughness in materials suspected of deforming by other than constrained plastic flow. Reference: Cook, R.F., and Lawn, B.R., "A Modified Indentation Toughness Technique," J. Am. Ceram. Soc. 66 [11], C-200 (1983).

Section 1 - continued

Test Rlg	Test Type	WBS Code	Test Description
TUFFCARB1	FRACTUFF	1.1.1.3-CARB	Specimen bars 3 x 4 x 50 mm were chevron notched, then broken in a 4-point bend fixture (20-mm, 40-mm spans) at a crosshead speed of 0.5 mm/min. Five samples were broken at each temperature.
TUFFGCCD1	FRACTUFF	1.2.2.1-GCCD	MOR 3-point bend bars (50.8 x 6.35 x 6.35 mm) were chevron notched in the center to 3.81 mm deep at a 30° angle. Garrett Turbine Engine Company performed the 3-point bend tests to break the specimens. Work performed by Jim Schienle, Hun Yeh, and M. Martin of Garrett Ceramic Components Division and GTEC.
TUFFGCCD1I	FRACTUFF	1.2.2.1-GCCD	Specimen bars 3 x 4 x 50 mm were indented by Vickers w 20-kg load, then broken in a 4-point bend fixture (38.1-mm, 19.05-mm spans) to determine the retained strength.
TUFFOR93A	FRACTUFF	1.1.2.4-ORNL	Two indentations were made with a 10-kg load, then the results averaged.
TUFFUDRI1	FRACTUFF	3.3.1.4-UDRI	In the controlled surface flaw method, a Knoop or Vickers diamond indenter was used to produce a small crack in the tensile surface of a bend bar made from the material being tested. The indented specimens are then loaded into a 3-point bend fixture, with the top knife edge directly over the indentation, and rapidly broken. In the micro-indentation method, toughness is determined by measuring the length of the crack produced by a Vickers indenter. Work was performed under the direction of N.L. Hecht at the University of Dayton Research Institute (UDRI). An Instron Universal Testing Machine (model 1123) was used for the 3-point bend test.
MOEUDRI1	MOE	3.3.1.4-UDRI	The elastic modulus was measured by a Grindo-Sonic (Model MR3ST) Transient Impulse/Elastic Modulus Apparatus. Work was performed under the supervision of N.L. Hecht at the UDRI.
MORCARB1	MOR4PTB	1.1.1.3-CARB	Standard MIL-1942B MOR bar specimens (3 x 4 x 50 mm) were broken in a 4-point bend fixture with inner span of 20 mm, outer span of 40 mm. Crosshead speed was 0.5 mm/min. Twenty specimens were broken at each of the selected temperatures.
MOR4DD1	MOR4PTB	NA	These data were provided by David Giles, Detroit Diesel. Tests were performed as per MIL-STD-1942, with specimens 3 x 4 x 50 mm.

Section 1 - continued

Test Rig	Test Type	WBS Code	Test Description
MOR4GCCD1	MOR4PTB	1.2.2.6-GCCD	All specimens were 3 x 4 x 50-mm bars. Room-temperature tests used a fixture with spans of 38.1 and 19.05 mm. High-temperature tests used a fixture with spans of 40 and 20 mm.
MIL-STD1942B	MOR4PTB	GENERAL	This test method and specimen geometry are now the ASTM standard for MOR 4-point bend tests. Specimen bars are 3 x 4 x 50 mm. Testing fixture has a 20-mm inner span and a 40-mm outer span.
MOR4UDRI2	MOR4PTB	3.3.1.4-UDRI	Bend tests were made using two Instron Universal Testing Machines (Model 1123) following MIL-STD-1942(MR). High-temperature measurements were conducted in two ATS #3320 high-temperature furnaces. Test specimens were 3 x 4 x 50 mm with the tensile surface ground and polished to 0.4- μ m finish [MIL-STD-1942(MR), size B]. Long edges were rounded and polished to minimize edge failures. The 4-point bend tests had outer spans of 40 mm, inner spans of 20 mm. Bend fixtures for room-temperature tests were made from steel. For higher temperatures, the fixtures were made of SiC.
STRPGCCD1	STRSRUPT	1.2.2.6-GCCD	Stress-rupture was performed using 3 x 4 x 50-mm bars placed in a 4-point fixture (40-, 20-mm spans) and loaded with 2 kg at room temperature to ensure proper alignment. The furnace was heated rapidly to test temperature and held for 15 min before loading the specimen, to allow for thermal equilibrium. After loading the specimen and applying the test fixture, the time needed to break the test bar, if it did break at the given load, was then noted.
STRPORN1	STRSRUPT	3.2.1.5-ORN1	Stress-rupture was performed using buttonheaded cylindrical bar specimens in tension. For more details, see TENSORNL1 and CREPORN1.
STRPSORI	STRSRUPT	3.2.2.2-AGTD	Tensile creep and stress-rupture tests for Allison Gas Turbine Division of General Motors were performed at SORI using buttonheaded specimens. Few details were provided.
STRPUDRI1	STRSRUPT	3.3.1.4-UDRI	Stress-rupture tests were performed at the UDRI using standard 4-point bend bars (MIL-STD1942B: 3 x 4 x 50 mm) in a 4-point bend fixture.

Section 1 - continued

Test Rlg	Test Type	WBS Code	Test Description
TENSORNL1	TENSILE	3.2.1.4-ORNL	Specimens were buttonheaded, uniform gage with 6.3 mm diam x 25.4 gage length. Specimen was finished in longitudinal direction with a diamond grinding wheel. No polishing was done in the gage section. Loads were either constant, using a triangular wave, or incremental step, with a hold period after reaching each stress level. Tensile load was at a ramp rate of 70 MPa/s. Specimens were heated by induction heater, with temperature being measured by a two-color pyrometer. Strain was measured directly with mechanical extensometers capable of accurate reading at high temperatures. Cyclic loads were applied in triangular form at 0.5 Hz.

Section 2 - Creep Test Results

Material	Batch Code	Testing Environment	Specimen Number	Test Temp. °C	Stress MPa	Rupture Time Hours	Time Disc. Hours	Total Strain %	Specimen Geometry	Comments
Silicon Nitride-Based Ceramics										
Test Rig = CREPNISTDR, WBS code = 3.1-NIST										
GN-10	GCCD/NIST1	AMBIENT AIR		1275	138	10.30		0.007	DOUBLE REDUCTION	
GN-10	GCCD/NIST1	AMBIENT AIR		1275	138	36.30		0.007	DOUBLE REDUCTION	
GN-10	GCCD/NIST1	AMBIENT AIR		1275	138	38.10		0.008	DOUBLE REDUCTION	
GN-10	GCCD/NIST1	AMBIENT AIR		1275	138	40.40		0.007	DOUBLE REDUCTION	
GN-10	GCCD/NIST1	AMBIENT AIR		1275	138	42.60		0.005	DOUBLE REDUCTION	
GN-10	GCCD/NIST1	AMBIENT AIR		1275	138	45.60		0.007	DOUBLE REDUCTION	
GN-10	GCCD/NIST1	AMBIENT AIR		1275	138	49.50		0.006	DOUBLE REDUCTION	
GN-10	GCCD/NIST1	AMBIENT AIR		1275	138	59.90		0.008	DOUBLE REDUCTION	
GN-10	GCCD/NIST1	AMBIENT AIR		1275	138	91.90		0.007	DOUBLE REDUCTION	
GN-10	GCCD/NIST1	AMBIENT AIR		1275	138	97.00		0.008	DOUBLE REDUCTION	
GN-10	GCCD/NIST1	AMBIENT AIR		1275	138	100.80		0.009	DOUBLE REDUCTION	
GN-10	GCCD/NIST1	AMBIENT AIR		1275	138	397.00		0.014	DOUBLE REDUCTION	
Test Rig = CREPNISTIF, WBS code = 3.1-NIST										
GN-10	GCCD/NIST1	AMBIENT AIR		1275	138	33.70		0.008	INTEGRAL FLAG DGBONE	
GN-10	GCCD/NIST1	AMBIENT AIR		1275	138	38.40		0.008	INTEGRAL FLAG DGBONE	
GN-10	GCCD/NIST1	AMBIENT AIR		1275	138	54.20		0.012	INTEGRAL FLAG DGBONE	
GN-10	GCCD/NIST1	AMBIENT AIR		1275	138	69.00		0.010	INTEGRAL FLAG DGBONE	
GN-10	GCCD/NIST1	AMBIENT AIR		1275	138	109.00		0.014	INTEGRAL FLAG DGBONE	
Test Rig = CREPNISTMN, WBS code = 3.1-NIST										
GN-10	GCCD/NIST1	AMBIENT AIR		1275	138	81.20		0.007	MOD.NIST DOG BONE	
GN-10	GCCD/NIST1	AMBIENT AIR		1275	138	93.90		0.008	MOD.NIST DOG BONE	
GN-10	GCCD/NIST1	AMBIENT AIR		1275	138	116.50		0.010	MOD.NIST DOG BONE	
GN-10	GCCD/NIST1	AMBIENT AIR		1275	138	122.00		0.009	MOD.NIST DOG BONE	
GN-10	GCCD/NIST1	AMBIENT AIR		1275	138	127.60		0.008	MOD.NIST DOG BONE	
GN-10	GCCD/NIST1	AMBIENT AIR		1275	138	136.70		0.011	MOD.NIST DOG BONE	
GN-10	GCCD/NIST1	AMBIENT AIR		1275	138	168.30		0.009	MOD.NIST DOG BONE	
Test Rig = CREPSORI1, WBS code = 3.2.2.2-GAPD										
GTE PY6	AGTD/HIP	AMBIENT AIR	341A*	1200	125		240.0	0.053	BH-GAGE=6.35X35MM	TEST STOPPED
GTE PY6	AGTD/HIP	AMBIENT AIR	635B*	1200	150		232.0	0.271	BH-GAGE=6.35X35MM	TEST STOPPED
GTE PY6	AGTD/HIP	AMBIENT AIR	517B*	1200	160		360.0	0.173	BH-GAGE=6.35X35MM	TEST STOPPED

Section 2 - continued

Material	Batch Code	Testing Environment	Specimen Number	Test Temp. °C	Stress MPa	Rupture Time Hours	Time Disc. Hours	Total Strain %	Specimen Geometry	Comments
Silicon Nitride-Based Ceramics										
Test Rig = CREPSOR11, WBS code =3 2.2.2-GAPD										
GTE PY6	AGTD/HIP	AMBIENT AIR	636A*	1200	175		389.0	0.124	BH-GAGE=6.35X35MM	TEST STOPPED
GTE PY6	AGTD/HIP	AMBIENT AIR	452A	1200	178	0.73			BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	629A*	1200	181	291.00			BH-GAGE=6.35X35MM	GAGES SLIPPED IN TEST
GTE PY6	AGTD/HIP	AMBIENT AIR	514A	1200	185	0.01		0.061	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	448A	1200	190	0.16		0.014	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	460A	1200	200	2.06		0.165	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	463B	1200	225	0.55		0.165	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	453A	1200	250	0.48		0.175	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	533B*	1260	125	721.00			BH-GAGE=6.35X35MM	GAGES SLIPPED IN TEST
GTE PY6	AGTD/HIP	AMBIENT AIR	488B	1260	150	0.92		0.049	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	515A*	1260	175		1154.0	0.338	BH-GAGE=6.35X35MM	TEST STOPPED
GTE PY6	AGTD/HIP	AMBIENT AIR	463A	1260	175	364.00		0.201	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	486A	1260	177	266.24		0.106	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	528A	1260	180	0.48		0.085	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	456A	1260	180	0.21		0.099	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	626B*	1300	150		473.0	0.320	BH-GAGE=6.35X35MM	TEST STOPPED
GTE PY6	AGTD/HIP	AMBIENT AIR	634B*	1300	151		624.0	0.275	BH-GAGE=6.35X35MM	TEST STOPPED
GTE PY6	AGTD/HIP	AMBIENT AIR	188B	1300	175	772.00		0.549	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	491B	1300	175			0.074	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	188B	1300	176	0.36		0.113	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	514B	1300	178	0.83		0.123	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	341B	1300	180	3.32		0.171	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	343B	1300	185	0.96		0.193	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	77A	1300	200	0.69		0.125	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	334B	1300	249	0.24		0.167	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	201A	1300	275	0.01		0.110	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	464A*	1370	66	617.00			BH-GAGE=6.35X35MM	GAGES SLIPPED IN TEST
GTE PY6	AGTD/HIP	AMBIENT AIR	522B	1370	71	287.00		0.147	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	84B	1370	74	287.00		0.701	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	80A	1370	75	387.00			BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	457A	1370	79				BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	55A	1370	86	0.01		0.147	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	521B*	1370	91		106.0		BH-GAGE=6.35X35MM	TEST STOPPED

Section 2 - continued

Material	Batch Code	Testing Environment	Specimen Number	Test Temp. °C	Stress MPa	Rupture Time Hours	Time Disc. Hours	Total Strain %	Specimen Geometry	Comments
Silicon Nitride-Based Ceramics										
Test Rig = CREPSORI1, WBS code =3.2.2.2-GAPD										
GTE PY6	AGTD/HIP	AMBIENT AIR	522A*	1370	95		146.0	0.048	BH-GAGE=6.35X35MM	TEST STOPPED
GTE PY6	AGTD/HIP	AMBIENT AIR	535B*	1370	95		74.0	0.134	BH-GAGE=6.35X35MM	TEST STOPPED
GTE PY6	AGTD/HIP	AMBIENT AIR	490B	1370	100	0.61		0.130	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	524A	1370	105	8.13		0.377	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	192B	1400	75	844.00		1.019	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	523B	1400	86	4.50		0.116	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	195B	1400	100	12.97		0.310	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	530B	1400	110	2.89		0.131	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	171A	1400	125	1.96		0.296	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	60A	1400	150	0.03		0.138	BH-GAGE=6.35X35MM	
GTE PY6	AGTD/HIP	AMBIENT AIR	340A	1400	175	0.02		0.131	BH-GAGE=6.35X35MM	
Test Rig = CREPORN12, WBS code =3.2.2.3-GAPD										
NT-154	NORTON/GAPD	AMBIENT AIR	3-27	982	455	336.00			BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	3-18*	982	455		808.0		BH-GAGE=6.35X35MM	TEST STOPPED
NT-154	NORTON/GAPD	AMBIENT AIR	2-54*	982	460		602.0		BH-GAGE=6.35X35MM	TEST STOPPED
NT-154	NORTON/GAPD	AMBIENT AIR	2-38*	982	470		512.0		BH-GAGE=6.35X35MM	TEST STOPPED
NT-154	NORTON/GAPD	AMBIENT AIR	2-75	1149	445	0.02			BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	3-19	1204	335	469.00		0.442	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	3-37	1204	340	177.00		0.355	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-30	1204	340	566.00			BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	3-39	1204	345	636.00			BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-28*	1204	350		457.0	0.465	BH-GAGE=6.35X35MM	TEST IN PROGRESS
NT-154	NORTON/GAPD	AMBIENT AIR	3-75	1204	375	252.00		0.337	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-149	1204	375	66.00		0.269	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	3-54	1204	375	43.00		0.206	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	3-66	1204	375	24.00		0.198	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	3-34	1204	375	19.00		0.183	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-146	1204	375	12.00		0.150	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-164	1204	375	0.84		0.125	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-72	1204	375	0.50			BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	3-121	1204	385		501.0		BH-GAGE=6.35X35MM	TEST STOPPED
NT-154	NORTON/GAPD	AMBIENT AIR	3-73	1204	400	1.10			BH-GAGE=6.35X35MM	

Section 2 - continued

Material	Batch Code	Testing Environment	Specimen Number	Test Temp. °C	Stress MPa	Rupture Time Hours	Time Disc. Hours	Total Strain %	Specimen Geometry	Comments
Silicon Nitride-Based Ceramics										
Test Rig = CREPORN2, WBS code =3.2.2.3-GAPD										
NT-154	NORTON/GAPD	AMBIENT AIR	2-142	1260	305	46.00		0.464	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-119	1371	130	588.00		2.123	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-130	1371	135	280.00		1.845	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-124	1371	140	586.00		2.125	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-45	1371	145	57.00		1.117	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-46	1371	145	73.00		1.193	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-50	1371	145	90.00		1.547	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	1-17	1371	145	111.00		1.384	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-101	1371	145	112.00		1.417	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-162	1371	145	117.00		1.720	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-136	1371	145	122.00		1.502	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	3-35	1371	145	236.00		1.747	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	1-13	1371	145	266.00		1.890	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-63	1371	145	293.00		1.767	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	1-12	1371	145	368.00		2.046	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-92	1371	145	368.00		1.940	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-7	1371	145	373.00		1.894	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-120	1371	145	385.00		2.042	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	3-50	1371	145	443.00		1.936	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-57**	1371	145		143.0	1.502	BH-GAGE=6.35X35MM	**TEST IN PROGRESS
NT-154	NORTON/GAPD	AMBIENT AIR	2-113	1371	150	208.00		1.721	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-126	1371	155	24.00		0.779	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-109	1371	180	0.14		0.188	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-69	1371	180	0.24		0.162	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-72	1371	180	0.24		0.239	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	1-16	1371	180	0.84		0.375	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	1-19	1371	180	1.60		0.438	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	3-69	1371	180	1.80		0.406	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-34	1371	180	5.60		0.570	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-116	1371	180	6.80		0.637	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	1-7	1371	180	6.80		0.660	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-91	1371	180	8.60		0.751	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	1-840	1371	180	14.00		0.844	BH-GAGE=6.35X35MM	

Section 2 - continued

Material	Batch Code	Testing Environment	Specimen Number	Test Temp. °C	Stress MPa	Rupture Time Hours	Time Disc. Hours	Total Strain %	Specimen Geometry	Comments
Silicon Nitride-Based Ceramics										
Test Rig = CREPORN12, WBS code =3.2.2.3-GAPD										
NT-154	NORTON/GAPD	AMBIENT AIR	2-60	1371	180	19.00		0.858	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-140	1371	180	25.00		0.896	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	2-118	1371	180	28.00		0.928	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	3-23	1371	180	64.00		1.243	BH-GAGE=6.35X35MM	
NT-154	NORTON/GAPD	AMBIENT AIR	3-29	1400	150	80.00		1.635	BH-GAGE=6.35X35MM	
Test Rig = CREPORN11, WBS code = 3.2.1.5-ORN1										
SNW-1000	ORN1/KCL-93	AMBIENT AIR	MA-6	1200	140	368.65		0.590		MW-ANN/1400C/20h
SNW-1000	ORN1/KCL-93	AMBIENT AIR	MA-1	1200	140	2976.90		2.645		MW-ANN/1400C/20h
SNW-1000	ORN1/KCL-93	AMBIENT AIR	MA-5	1200	160	7.42		0.609		MW-ANN/1400C/20h
SNW-1000	ORN1/KCL-93	AMBIENT AIR	MA-4	1200	160	12.10				MW-ANN/1400C/20h
SNW-1000	ORN1/KCL-93	AMBIENT AIR	MA-3	1200	180	16.65		1.328		MW-ANN/1400C/20h
SNW-1000	ORN1/KCL-93	AMBIENT AIR	MA-9	1200	120	933.30		1.290		MW-ANN/1500C/20h
SNW-1000	ORN1/KCL-93	AMBIENT AIR	MA-10	1200	130	427.10		1.736		MW-ANN/1500C/20h
SNW-1000	ORN1/KCL-93	AMBIENT AIR	MA-8	1200	140	71.51		0.664		MW-ANN/1500C/20h
SNW-1000	ORN1/KCL-93	AMBIENT AIR	MA-7	1200	160	3.42		0.127		MW-ANN/1500C/20h

Figure 2.2. Strain versus rupture time for NT-154 tested at 1371°C.

Figure 2.3. Geometry effects on the creep strength of GN-10 from NIST study.

Figure 2.4. Temperature effects on creep-rupture life of GTE PY6.

Section 3 - Density Results

Material	Batch Code	Test Method	Specimen Code	Heat Treatment	Densification Method	Test Temp. °C	Density g/cm ³	% Theo. Density	Comments
Silicon Nitride-Based Ceramics									
WBS Code = 1.2.2.1-GCCD									
GN-10	GCCD/BASELINE		195-3-1	T1/H1	HIP	21	3.3100		
GN-10	GCCD/BASELINE		195-3-2	T1/H1	HIP	21	3.3100		
GN-10	GCCD/BASELINE		195-3a-2	T1/H1	HIP	21	3.3000		
GN-10	GCCD/BASELINE		195-4a-1	T2/H1	HIP	21	3.3000		
GN-10	GCCD/BASELINE		195-4a-2	T2/H1	HIP	21	3.3000		
GN-10	GCCD/BASELINE		195-4-1	T2/H2	HIP	21	3.3000		
WBS Code = 1.1.2.4-ORNL									
Si3N4+Y2O3+Al2O3	ORNL/TM-132		TM-132		SINT/1700C/1h/MICROWAVE	25	3.2700	98.5	
Si3N4+La2O3+Al2O3	ORNL/TM-133		TM-133		SINT/1700C/1h/MICROWAVE	25	3.3200	98.3	
WBS Code = 1.1.2.4-ORNL									
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-137		TM-137		SINT/1800C/1h/CONVENTNL	25	3.0900	91.3	
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-137		TM-137		SINT/1800C/1h/MICROWAVE	25	3.3700	99.9	
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-139		TM-139J		SINT/1800C/4h/CONVENTION	21	3.2000	95.4	
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-139		TM-139K		SINT/1800C/4h/CONVENTION	21	3.2000	95.4	
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-139		TM-139G		SINT/1800C/1h/MICROWAVE	21	2.9200	86.5	
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-139		TM-139H		SINT/1800C/1h/MICROWAVE	21	2.9200	86.5	
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-139		TM-139L		SINT/1800C/2h/MICROWAVE	21	3.2300	96.4	
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-139		TM-139M		SINT/1800C/2h/MICROWAVE	21	3.2300	96.4	
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-141		TM-141		SINT/1800C/1h/MICROWAVE	25	3.3500	99.4	
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-150		TM-150		SINT/1800C/1h/MICROWAVE	25	3.1600	93.6	
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-152		TM-152		SINT/1800C/1h/MICROWAVE	25	3.3400	99.1	
WBS Code = 1.1.2.4-ORNL									
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-142		TM-142		SINT/1800C/2h/MICROWAVE	25	3.2500	97.7	
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-145	ARCHIMEDES	SUM4/L1M	SIN	MW/CPM	20	3.2180		LAYER 1 (TOP)
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-145	ARCHIMEDES	SUM4/L2M	SIN	MW/CPM	20	3.2270		LAYER 2 (NEXT TO TOP)
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-145	ARCHIMEDES	SUM4/L3M	SIN	MW/CPM	20	3.2260		LAYER 3 (FROM TOP)
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-145	ARCHIMEDES	SUM4/L4M	SIN	MW/CPM	20	3.2450		LAYER 4 (FROM TOP)
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-145	ARCHIMEDES	SUM4/L5M	SIN	MW/CPM	20	3.2430		BOTTOM LAYER
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-145	ARCHIMEDES	SUM4/L1C	SIN	GRAPHITE FURNACE/CPM	20	3.1880		TOP LAYER
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-145	ARCHIMEDES	SUM4/L2C	SIN	GRAPHITE FURNACE/CPM	20	3.1880		LAYER 2 (FROM TOP)
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-145	ARCHIMEDES	SUM4/L3C	SIN	GRAPHITE FURNACE/CPM	20	3.1870		LAYER 3 (FROM TOP)
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-145	ARCHIMEDES	SUM4/L4C	SIN	GRAPHITE FURNACE/CPM	20	3.1880		LAYER 4 (FROM TOP)
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-145	ARCHIMEDES	SUM4/L5C	SIN	GRAPHITE FURNACE/CPM	20	3.1970		LAYER 5 (FROM TOP)

Section 3 - continued

Material	Batch Code	Test Method	Specimen Code	Heat Treatment	Densification Method	Test Temp. °C	Density g/cm ³	% Theo. Density	Comments
Silicon Nitride-Based Ceramics									
WBS Code = 1.1.2.4-ORNL									
SRBSN+9%Y ₂ O ₃ +3%Al ₂ O ₃	ORNL/TM-145		TM-145		SINT/1800C/1h/MICROWAVE	25	3.1200	93.7	
SRBSN+9%Y ₂ O ₃ +3%Al ₂ O ₃	ORNL/TM-145		TM-145		SINT/1800C/2h/MICROWAVE	25	3.2300	97.0	
WBS Code = 1.1.2.4-ORNL									
SRBSN+Y ₂ O ₃ +MgO+Al ₂ O ₃	ORNL/TM-138		TM-138I		SINT/1800C/4h/CONVENTION	21	3.0600	91.3	
SRBSN+Y ₂ O ₃ +MgO+Al ₂ O ₃	ORNL/TM-138		TM-138J		SINT/1800C/4h/CONVENTION	21	3.0600	91.3	
SRBSN+Y ₂ O ₃ +MgO+Al ₂ O ₃	ORNL/TM-138		TM-138E		SINT/1800C/4h/MICROWAVE	21	3.1800	94.8	
SRBSN+Y ₂ O ₃ +MgO+Al ₂ O ₃	ORNL/TM-138		TM-138F		SINT/1800C/4h/MICROWAVE	21	3.1800	94.8	
Silicon Carbide Whisker-Reinforced Silicon Nitride-Based Ceramics									
WBS Code = 1.2.2.1-GCCD									
GN-10+SiCw10(AM7)	GCCD/4IT		SUMMARY	T1/H1(PROPRIET)	HIP	21	3.2900	99.7	
GN-10+SiCw10(AM7)	GCCD/4IT		SUMMARY	T1/H2(PROPRIET)	HIP	21	3.2900	99.7	
GN-10+SiCw10(AM7)	GCCD/4IT		SUMMARY	T2/H1(PROPRIET)	HIP	21	3.3000	100.0	
GN-10+SiCw10(AM7)	GCCD/5IT		SUMMARY	T1/H1(PROPRIET)	HIP	21	3.3000	100.0	
GN-10+SiCw10(AM7)	GCCD/5IT		SUMMARY	T1/H2(PROPRIET)	HIP	21	3.3000	100.0	
GN-10+SiCw10(AM7)	GCCD/5IT		SUMMARY	T2/H1(PROPRIET)	HIP	21	3.3000	100.0	
GN-10+SiCw10(AM7)	GCCD/5IT		SUMMARY	T2/H2(PROPRIET)	HIP	21	3.3100	100.3	
WBS Code = 1.2.2.1-GCCD									
GN-10+SiCw20(AM7)	GCCD/4IT		SUMMARY	T1/H1(PROPRIET)	HIP	21	3.1700	96.4	
GN-10+SiCw20(AM7)	GCCD/4IT		SUMMARY	T1/H2(PROPRIET)	HIP	21	3.2700	99.4	
GN-10+SiCw20(AM7)	GCCD/4IT		SUMMARY	T2/H1(PROPRIET)	HIP	21	3.2800	99.7	
GN-10+SiCw20(AM7)	GCCD/4IT		SUMMARY	T2/H2(PROPRIET)	HIP	21	3.2700	99.4	
GN-10+SiCw20(AM7)	GCCD/4IT		SUMMARY	T3/H2(PROPRIET)	HIP	21	3.2800		
GN-10+SiCw20(AM7)	GCCD/4IT		SUMMARY	T4/H2(PROPRIET)	HIP	21	3.2700		
GN-10+SiCw20(AM7)	GCCD/5IT		SUMMARY	T1/H1(PROPRIET)	HIP	21	3.3000	100.3	
GN-10+SiCw20(AM7)	GCCD/5IT		SUMMARY	T1/H2(PROPRIET)	HIP	21	3.3000	100.3	
GN-10+SiCw20(AM7)	GCCD/5IT		SUMMARY	T2/H1(PROPRIET)	HIP	21	3.2900	100.0	
GN-10+SiCw20(AM7)	GCCD/5IT		SUMMARY	T2/H2(PROPRIET)	HIP	21	3.3000	100.3	
GN-10+SiCw20(AM7)	GCCD/5IT		SUMMARY	T3/H2(PROPRIET)	HIP	21	3.3000		
GN-10+SiCw20(AM7)	GCCD/5IT		SUMMARY	T4/H2(PROPRIET)	HIP	21	3.2900		
WBS Code = 1.2.2.1-GCCD									
GN-10+SiCw30(AM7)	GCCD/4IT		SUMMARY	T1/H1(PROPRIET)	HIP	21	3.1700	96.6	
GN-10+SiCw30(AM7)	GCCD/4IT		SUMMARY	T1/H2(PROPRIET)	HIP	21	3.2100	97.6	
GN-10+SiCw30(AM7)	GCCD/4IT		SUMMARY	T2/H1(PROPRIET)	HIP	21	3.2600	99.4	

Section 3 - continued

Material	Batch Code	Test Method	Specimen Code	Heat Treatment	Densification Method	Test Temp. °C	Density g/cm ³	% Theo. Density	Comments
Silicon Carbide Whisker-Reinforced Silicon Nitride-Based Ceramics									
WBS Code = 1.2.2.1-GCCD									
GN-10+SiCw30(AM7)	GCCD/4IT		SUMMARY	T3/H2(PROPRIET)	HIP	21	3.2600		
GN-10+SiCw30(AM7)	GCCD/4IT		SUMMARY	T4/H2(PROPRIET)	HIP	21	3.2500		
GN-10+SiCw30(AM7)	GCCD/5IT		SUMMARY	T1/H1(PROPRIET)	HIP	21	3.2100	97.9	
GN-10+SiCw30(AM7)	GCCD/5IT		SUMMARY	T1/H2(PROPRIET)	HIP	21	3.2900	100.3	
GN-10+SiCw30(AM7)	GCCD/5IT		SUMMARY	T2/H1(PROPRIET)	HIP	21	3.3000	100.6	
GN-10+SiCw30(AM7)	GCCD/5IT		SUMMARY	T2/H2(PROPRIET)	HIP	21	3.3000	100.6	
GN-10+SiCw30(AM7)	GCCD/5IT		SUMMARY	T3/H2(PROPRIET)	HIP	21	3.2900		
GN-10+SiCw30(AM7)	GCCD/5IT		SUMMARY	T4/H2(PROPRIET)	HIP	21	3.2800		
WBS Code = 1.2.2.1-GCCD									
GN-10+SiCw40(AM7)	GCCD/4IT		SUMMARY	T1/H1(PROPRIET)	HIP	21	3.0100	92.3	
GN-10+SiCw40(AM7)	GCCD/4IT		SUMMARY	T1/H2(PROPRIET)	HIP	21	3.0500	93.6	
GN-10+SiCw40(AM7)	GCCD/4IT		SUMMARY	T2/H2(PROPRIET)	HIP	21	3.2400	99.4	
GN-10+SiCw40(AM7)	GCCD/5IT		SUMMARY	T1/H1(PROPRIET)	HIP	21	3.2600	100.0	
GN-10+SiCw40(AM7)	GCCD/5IT		SUMMARY	T1/H2(PROPRIET)	HIP	21	3.2900	100.9	
GN-10+SiCw40(AM7)	GCCD/5IT		SUMMARY	T2/H2(PROPRIET)	HIP	21	3.2900	100.9	

Section 4 - Fracture-Toughness Test Results

Material	Batch Code	Heat Treatment	Test Env.	Specimen Number	Type of Toughness Test	Test Temp. °C	Specimen Width mm	Specimen Thick. mm	Indent. Load	K(IC) MPa√m	Crosshead Speed mm/min	Std. Dev.
Silicon Carbide-Based Ceramics												
Test Rig = TUFFCARB1, WBS code = 1.1.1.3-CARB												
HEXOLOY SX-G1	CARB/9/1991/C	SINTERED+POSTRET	AIR	SUMRY5	CHEVRON-NOTCHED	21	3.00	4.00		3.77	0.500	
HEXOLOY SX-G1	CARB/9/1991/D	SINTERED+POSTRET	AIR	SUMRY5	CHEVRON-NOTCHED	21	3.00	4.00		3.87	0.500	
HEXOLOY SX-G1	CARB/8/1991	SINTERED+POSTRET	AIR	SUMRY5	CHEVRON-NOTCHED	21	3.00	4.00		4.05	0.500	
HEXOLOY SX-G1	CARB/9/1991/F	SINTERED+POSTRET	AIR	SUMRY5	CHEVRON-NOTCHED	21	3.00	4.00		4.25	0.500	
HEXOLOY SX-G1	CARB/9/1991/B	SINTERED+POSTRET	AIR	SUMRY5	CHEVRON-NOTCHED	21	3.00	4.00		4.43	0.500	
HEXOLOY SX-G1	CARB/8/1991	SINTERED+POSTRET	AIR	SUMRY5	CHEVRON-NOTCHED	1000	3.00	4.00		3.10	0.500	
HEXOLOY SX-G1	CARB/8/1991	SINTERED+POSTRET	AIR	SUMRY5	CHEVRON-NOTCHED	1232	3.00	4.00		3.30	0.500	
HEXOLOY SX-G1	CARB/8/1991	SINTERED+POSTRET	AIR	SUMRY5	CHEVRON-NOTCHED	1370	3.00	4.00		2.50	0.500	
Silicon Nitride-Based Ceramics												
Test Rig = TUFFOR93A, WBS code = 1.1.2.4-ORNL												
SRBSN+9%Y2O3+3%Al2O3	ORNL/1124/9304	SINT/MW/CPM/SINT/1800C/1.5H	AIR	MWA	MICROINDENTATION	25	3.00	8.25	10.0	6.56		
SRBSN+9%Y2O3+3%Al2O3	ORNL/1124/9304	SINT/MW/CPM/SINT/1800C/1.5H	AIR	MWB	MICROINDENTATION	25	3.00	5.85	10.0	6.39		
SRBSN+9%Y2O3+3%Al2O3	ORNL/1124/9304	SINT/MW/CPM/SINT/1800C/1.5H	AIR	MWC	MICROINDENTATION	25	3.00	4.10	10.0	6.23		
SRBSN+9%Y2O3+3%Al2O3	ORNL/1124/9304	SINT/MW/CPM/SINT/1800C/1.5H	AIR	MWD	MICROINDENTATION	25	3.00	3.55	10.0	6.19		
SRBSN+9%Y2O3+3%Al2O3	ORNL/1124/9304	SINT/MW/CPM/SINT/1800C/1.5H	AIR	MWE	MICROINDENTATION	25	3.00	3.15	10.0	6.29		
SRBSN+9%Y2O3+3%Al2O3	ORNL/1124/9304	SINT/MW/CPM/SINT/1800C/1.5H	AIR	MWF	MICROINDENTATION	25	3.00	2.80	10.0	6.30		
SRBSN+9%Y2O3+3%Al2O3	ORNL/1124/9304	SINT/CONV/CPM/SINT/1800C/1.5H	AIR	CNA	MICROINDENTATION	25	3.00	8.25	10.0	5.59		
SRBSN+9%Y2O3+3%Al2O3	ORNL/1124/9304	SINT/CONV/CPM/SINT/1800C/1.5H	AIR	CNB	MICROINDENTATION	25	3.00	5.85	10.0	5.17		
SRBSN+9%Y2O3+3%Al2O3	ORNL/1124/9304	SINT/CONV/CPM/SINT/1800C/1.5H	AIR	CNC	MICROINDENTATION	25	3.00	4.10	10.0	5.80		
SRBSN+9%Y2O3+3%Al2O3	ORNL/1124/9304	SINT/CONV/CPM/SINT/1800C/1.5H	AIR	CND	MICROINDENTATION	25	3.00	3.55	10.0	5.55		
SRBSN+9%Y2O3+3%Al2O3	ORNL/1124/9304	SINT/CONV/CPM/SINT/1800C/1.5H	AIR	CNE	MICROINDENTATION	25	3.00	3.15	10.0	5.48		
SRBSN+9%Y2O3+3%Al2O3	ORNL/1124/9304	SINT/CONV/CPM/SINT/1800C/1.5H	AIR	CNF	MICROINDENTATION	25	3.00	2.80	10.0	5.43		
Test Rig = TUFFGCCD, WBS code = 1.2.2.1-GCCD												
GN-10	GCCD/BASELINE	HIP/T1/H1	AIR	SUMMARY	INDENTATION	21				4.20		
GN-10	GCCD/BASELINE	HIP/T1/H2	AIR	SUMMARY	INDENTATION	21				6.10		0.4
GN-10	GCCD/BASELINE	HIP/T2/H1	AIR	SUMMARY	INDENTATION	21				6.90		0.5
GN-10	GCCD/BASELINE	HIP/T2/H2	AIR	SUMMARY	INDENTATION	21				7.00		0.4
GN-10	GCCD/BASELINE	HIP/T2/H2	AIR	SUMMARY	CHEVRON-NOTCHED	21	6.00	3.00		5.67		0.13
GN-10	GCCD/BASELINE	HIP/T2/H2	AIR	SUMMARY	CHEVRON-NOTCHED	1200	6.00	3.00		5.48		0.11
Test Rig = TUFFOR93A, WBS code = 1.1.2.4-ORNL												
GS-44	ORNL/GCC-AS CRDA	BASELINE-NONE	AIR	SUMMARY	INDENTATION	25				8.04		.16
GS-44	ORNL/GCC-AS CRDA	ANN/1600C/10h/MW	AIR	SUMMARY	INDENTATION	25				8.05		0.14
GS-44	ORNL/GCC-AS CRDA	ANN/1700C/10h/MW	AIR	SUMMARY	INDENTATION	25				8.09		0.14
GS-44	ORNL/GCC-AS CRDA	ANN/1800C/2h/MW	AIR	SUMMARY	INDENTATION	25				7.79		0.51

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Section 4 - continued

Material	Batch Code	Heat Treatment	Test Env.	Specimen Number	Type of Toughness Test	Test Temp. °C	Specimen Width mm	Specimen Thick. mm	Indent. Load	K(IC) MPa√m	Crosshead Speed	Std. Dev.
Silicon Carbide Whisker-Reinforced Silicon Nitride-Based Ceramics												
Test Rig = TUFFGCCD, WBS code = 1.2.2.1-GCCD												
GN-10+SiCw10(AM7)	GCCD/5IT	HIP/T1/H2	AIR	SUMMARY	INDENTATION	21				6.90		2
Test Rig = TUFFGCCD, WBS code = 1.2.2.1-GCCD												
GN-10+SiCw20(AM7)	GCCD/4IT	HIP/T2/H2	AIR	SUMMARY	CHEVRON-NOTCHED	21	6.00	3.00		5.99		0.4
GN-10+SiCw20(AM7)	GCCD/5IT	HIP/T2/H2	AIR	SUMMARY	CHEVRON-NOTCHED	21	6.00	3.00		6.11		0.2
GN-10+SiCw20(AM7)	GCCD/5IT	HIP/T1/H1	AIR	SUMMARY	INDENTATION	21				5.40		0.4
GN-10+SiCw20(AM7)	GCCD/5IT	HIP/T1/H2	AIR	SUMMARY	INDENTATION	21				6.50		0.2
GN-10+SiCw20(AM7)	GCCD/5IT	HIP/T2/H1	AIR	SUMMARY	INDENTATION	21				6.10		0.3
GN-10+SiCw20(AM7)	GCCD/4IT	HIP/T2/H2	AIR	SUMMARY	INDENTATION	21				6.30		0.2
GN-10+SiCw20(AM7)	GCCD/5IT	HIP/T2/H2	AIR	SUMMARY	INDENTATION	21				6.90		0.5
GN-10+SiCw20(AM7)	GCCD/4IT	HIP/T3/H2	AIR	SUMMARY	INDENTATION	21				5.79		0.44
GN-10+SiCw20(AM7)	GCCD/5IT	HIP/T3/H2	AIR	SUMMARY	INDENTATION	21				5.98		0.22
GN-10+SiCw20(AM7)	GCCD/4IT	HIP/T2/H2	AIR	SUMMARY	CHEVRON-NOTCHED	1200	6.00	3.00		5.74		0.23
GN-10+SiCw20(AM7)	GCCD/5IT	HIP/T2/H2	AIR	SUMMARY	CHEVRON-NOTCHED	1200	6.00	3.00		5.48		0.18
Test Rig = TUFFGCCD, WBS code = 1.2.2.1-GCCD												
GN-10+SiCw30(AM7)	GCCD/5IT	HIP/T2/H2	AIR	SUMMARY	CHEVRON-NOTCHED	21	6.00	3.00		6.02		0.46
GN-10+SiCw30(AM7)	GCCD/4IT	HIP/T2/H2	AIR	SUMMARY	CHEVRON-NOTCHED	21	6.00	3.00		6.40		0.4
GN-10+SiCw30(AM7)	GCCD/4IT	HIP/T3/H2	AIR	SUMMARY	INDENTATION	21				5.60		0.25
GN-10+SiCw30(AM7)	GCCD/5IT	HIP/T3/H2	AIR	SUMMARY	INDENTATION	21				5.74		0.21
GN-10+SiCw30(AM7)	GCCD/5IT	HIP/T1/H2	AIR	SUMMARY	INDENTATION	21				6.10		0.2
GN-10+SiCw30(AM7)	GCCD/5IT	HIP/T2/H1	AIR	SUMMARY	INDENTATION	21				6.20		0.4
GN-10+SiCw30(AM7)	GCCD/5IT	HIP/T1/H1	AIR	SUMMARY	INDENTATION	21				6.30		1
GN-10+SiCw30(AM7)	GCCD/5IT	HIP/T2/H2	AIR	SUMMARY	INDENTATION	21				6.30		0.2
GN-10+SiCw30(AM7)	GCCD/4IT	HIP/T2/H2	AIR	SUMMARY	INDENTATION	21				6.50		0.7
GN-10+SiCw30(AM7)	GCCD/5IT	HIP/T2/H2	AIR	SUMMARY	CHEVRON-NOTCHED	1200	6.00	3.00		5.42		0.3
GN-10+SiCw30(AM7)	GCCD/4IT	HIP/T2/H2	AIR	SUMMARY	CHEVRON-NOTCHED	1200	6.00	3.00		5.95		0.42
Test Rig = TUFFGCCD, WBS code = 1.2.2.1-GCCD												
GN-10+SiCw40(AM7)	GCCD/5IT	HIP/T1/H2	AIR	SUMMARY	INDENTATION	21				5.20		0.6
GN-10+SiCw40(AM7)	GCCD/5IT	HIP/T2/H2	AIR	SUMMARY	INDENTATION	21				6.50		0.4

Figure 2.5. A comparison of fracture-toughness values at room temperature and around 1400°C for two silicon carbide ceramics.

Figure 2.6. Microwave annealing improves the fracture toughness of SRBSN+9% Y₂O₃+3% Al₂O₃ at room temperature over conventional heating methods.

Figure 2.7. Heat-treatment effects on the fracture toughness of GN-10-based ceramics tested at room temperature.

Section 5 - Modulus of Elasticity Test Results

Material	Batch Code	Heat Treatment	Test Env.	Specimen Number	Modulus Test	Test Temp. °C	Young's Modulus GPa	Comments
S'AlON-Based Ceramics								
WBS code = 1.1.2.4-ORNL								
SiAlON+2%(3YO+5AlO)	ORNL/TIEGS1124	ANN/1200C/10h	AIR	SUMMARY		25	250.70	NORMAL ANNEAL
SiAlON+2%(3YO+5AlO)	ORNL/TIEGS1124	ANN/1200C/20h	AIR	SUMMARY		25	249.30	NORMAL ANNEAL
SiAlON+2%(3YO+5AlO)	ORNL/TIEGS1124	ANN/1400C/10h	AIR	SUMMARY		25	254.40	NORMAL ANNEAL
SiAlON+2%(3YO+5AlO)	ORNL/TIEGS1124	ANN/1400C/20h	AIR	SUMMARY		25	254.40	NORMAL ANNEAL
SiAlON+2%(3YO+5AlO)	ORNL/TIEGS1124	ANN/1500C/10h	AIR	SUMMARY		25	253.10	NORMAL ANNEAL
SiAlON+2%(3YO+5AlO)	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	252.80	
SiAlON+2%(3YO+5AlO)	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	254.60	
SiAlON+2%(3YO+5AlO)	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	252.80	
SiAlON+2%(3YO+5AlO)	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	257.90	
SiAlON+2%(3YO+5AlO)	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	252.80	
SiAlON+2%(3YO+5AlO)	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	254.70	
SiAlON+2%(3YO+5AlO)	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	252.80	
SiAlON+2%(3YO+5AlO)	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	254.70	
SiAlON+2%(3YO+5AlO)	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	252.00	
SiAlON+2%(3YO+5AlO)	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	257.90	
SiAlON+2%(3YO+5AlO)	ORNL/TIEGS1124	MW-ANN/1200C/10h	AIR	SUMMARY		25	255.20	MICROWAVE ANNEAL
SiAlON+2%(3YO+5AlO)	ORNL/TIEGS1124	MW-ANN/1200C/20h	AIR	SUMMARY		25	271.10	MICROWAVE ANNEAL
SiAlON+2%(3YO+5AlO)	ORNL/TIEGS1124	MW-ANN/1400C/10h	AIR	SUMMARY		25	253.70	MICROWAVE ANNEAL
SiAlON+2%(3YO+5AlO)	ORNL/TIEGS1124	MW-ANN/1400C/20h	AIR	SUMMARY		25	266.70	MICROWAVE ANNEAL
SiAlON+2%(3YO+5AlO)	ORNL/TIEGS1124	MW-ANN/1500C/10h	AIR	SUMMARY		25	267.90	MICROWAVE ANNEAL
WBS code = 1.1.2.4-ORNL								
SiAlON4.5+2%(3YO+5AlO)	ORNL/TIEGS1124	ANN/1200C/10h	AIR	SUMMARY		25	281.80	NORMAL ANNEAL
SiAlON4.5+2%(3YO+5AlO)	ORNL/TIEGS1124	ANN/1200C/20h	AIR	SUMMARY		25	279.10	NORMAL ANNEAL
SiAlON4.5+2%(3YO+5AlO)	ORNL/TIEGS1124	ANN/1400C/10h	AIR	SUMMARY		25	285.30	NORMAL ANNEAL
SiAlON4.5+2%(3YO+5AlO)	ORNL/TIEGS1124	ANN/1400C/20h	AIR	SUMMARY		25	282.60	NORMAL ANNEAL
SiAlON4.5+2%(3YO+5AlO)	ORNL/TIEGS1124	ANN/1500C/10h	AIR	SUMMARY		25	284.80	NORMAL ANNEAL
SiAlON4.5+2%(3YO+5AlO)	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	283.30	
SiAlON4.5+2%(3YO+5AlO)	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	288.80	
SiAlON4.5+2%(3YO+5AlO)	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	283.38	
SiAlON4.5+2%(3YO+5AlO)	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	283.60	
SiAlON4.5+2%(3YO+5AlO)	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	282.90	
SiAlON4.5+2%(3YO+5AlO)	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	284.90	
SiAlON4.5+2%(3YO+5AlO)	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	282.90	
SiAlON4.5+2%(3YO+5AlO)	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	284.90	
SiAlON4.5+2%(3YO+5AlO)	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	286.00	

Section 5 - continued

Material	Batch Code	Heat Treatment	Test Env.	Specimen Number	Modulus Test	Test Temp. °C	Young's Modulus GPa	Comments
SiAlON-Based Ceramics								
WBS code = 1.1.2.4-ORNL								
SiAlON4.5+2%(3YO+5AlO)	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	283.60	
SiAlON4.5+2%(3YO+5AlO)	ORNL/TIEGS1124	MW-ANN/1200C/10h	AIR	SUMMARY		25	285.70	MICROWAVE ANNEAL
SiAlON4.5+2%(3YO+5AlO)	ORNL/TIEGS1124	MW-ANN/1200C/20h	AIR	SUMMARY		25	287.40	MICROWAVE ANNEAL
SiAlON4.5+2%(3YO+5AlO)	ORNL/TIEGS1124	MW-ANN/1400C/10h	AIR	SUMMARY		25	294.30	MICROWAVE ANNEAL
SiAlON4.5+2%(3YO+5AlO)	ORNL/TIEGS1124	MW-ANN/1400C/20h	AIR	SUMMARY		25	296.80	MICROWAVE ANNEAL
SiAlON4.5+2%(3YO+5AlO)	ORNL/TIEGS1124	MW-ANN/1500C/10h	AIR	SUMMARY		25	288.20	MICROWAVE ANNEAL
Silicon Nitride-Based Ceramics								
WBS code = 1.1.2.4-ORNL								
Si3N4+12%Y2O3+4%Al2O3	ORNL/TIEGS1124	ANN/1200C/10h	AIR	SUMMARY		25	306.70	NORMAL ANNEAL
Si3N4+12%Y2O3+4%Al2O3	ORNL/TIEGS1124	ANN/1200C/20h	AIR	SUMMARY		25	297.30	NORMAL ANNEAL
Si3N4+12%Y2O3+4%Al2O3	ORNL/TIEGS1124	ANN/1400C/10h	AIR	SUMMARY		25	306.20	NORMAL ANNEAL
Si3N4+12%Y2O3+4%Al2O3	ORNL/TIEGS1124	ANN/1400C/20h	AIR	SUMMARY		25	299.90	NORMAL ANNEAL
Si3N4+12%Y2O3+4%Al2O3	ORNL/TIEGS1124	ANN/1500C/10h	AIR	SUMMARY		25	294.20	NORMAL ANNEAL
Si3N4+12%Y2O3+4%Al2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	298.60	
Si3N4+12%Y2O3+4%Al2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	287.10	
Si3N4+12%Y2O3+4%Al2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	299.60	
Si3N4+12%Y2O3+4%Al2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	292.50	
Si3N4+12%Y2O3+4%Al2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	299.60	
Si3N4+12%Y2O3+4%Al2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	292.50	
Si3N4+12%Y2O3+4%Al2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	298.20	
Si3N4+12%Y2O3+4%Al2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	287.10	
Si3N4+12%Y2O3+4%Al2O3	ORNL/TIEGS1124	MW-ANN/1200C/20h	AIR	SUMMARY		25	302.70	MICROWAVE ANNEAL
Si3N4+12%Y2O3+4%Al2O3	ORNL/TIEGS1124	MW-ANN/1400C/10h	AIR	SUMMARY		25	304.60	MICROWAVE ANNEAL
WBS code = 1.1.2.4-ORNL								
Si3N4+4%Y2O3	ORNL/TIEGS1124	ANN/1200C/10h	AIR	SUMMARY		25	295.30	
Si3N4+4%Y2O3	ORNL/TIEGS1124	ANN/1200C/20h	AIR	SUMMARY		25	295.10	NORMAL ANNEAL
Si3N4+4%Y2O3	ORNL/TIEGS1124	ANN/1400C/10h	AIR	SUMMARY		25	310.30	NORMAL ANNEAL
Si3N4+4%Y2O3	ORNL/TIEGS1124	ANN/1400C/20h	AIR	SUMMARY		25	306.10	NORMAL ANNEAL
Si3N4+4%Y2O3	ORNL/TIEGS1124	ANN/1500C/10h	AIR	SUMMARY		25	308.50	NORMAL ANNEAL
Si3N4+4%Y2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	294.80	
Si3N4+4%Y2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	312.90	
Si3N4+4%Y2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	309.20	
Si3N4+4%Y2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	308.00	
Si3N4+4%Y2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	312.50	

Section 5 - continued

Material	Batch Code	Heat Treatment	Test Env.	Specimen Number	Modulus Test	Test Temp. °C	Young's Modulus GPa	Comments
Silicon Nitride-Based Ceramics								
WBS code = 1.1.2.4-ORNL								
Si3N4+4%Y2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	309.20	
Si3N4+4%Y2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	308.00	
Si3N4+4%Y2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	312.60	
Si3N4+4%Y2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	312.50	
Si3N4+4%Y2O3	ORNL/TIEGS1124	MW-ANN/1200C/10h	AIR	SUMMARY		25	308.80	MICROWAVE ANNEAL
Si3N4+4%Y2O3	ORNL/TIEGS1124	MW-ANN/1200C/20h	AIR	SUMMARY		25	313.00	MICROWAVE ANNEAL
Si3N4+4%Y2O3	ORNL/TIEGS1124	MW-ANN/1400C/10h	AIR	SUMMARY		25	312.40	MICROWAVE ANNEAL
Si3N4+4%Y2O3	ORNL/TIEGS1124	MW-ANN/1400C/20h	AIR	SUMMARY		25	307.80	MICROWAVE ANNEAL
Si3N4+4%Y2O3	ORNL/TIEGS1124	MW-ANN/1500C/10h	AIR	SUMMARY		25	308.10	MICROWAVE ANNEAL
WBS code = 1.1.2.4-ORNL								
Si3N4+6%Y2O3+2%Al2O3	ORNL/TIEGS1124	ANN/1200C/10h	AIR	SUMMARY		25	312.60	NORMAL ANNEAL
Si3N4+6%Y2O3+2%Al2O3	ORNL/TIEGS1124	ANN/1200C/20h	AIR	SUMMARY		25	305.70	NORMAL ANNEAL
Si3N4+6%Y2O3+2%Al2O3	ORNL/TIEGS1124	ANN/1400C/10h	AIR	SUMMARY		25	309.50	NORMAL ANNEAL
Si3N4+6%Y2O3+2%Al2O3	ORNL/TIEGS1124	ANN/1400C/20h	AIR	SUMMARY		25	310.50	NORMAL ANNEAL
Si3N4+6%Y2O3+2%Al2O3	ORNL/TIEGS1124	ANN/1500C/10h	AIR	SUMMARY		25	307.30	NORMAL ANNEAL
Si3N4+6%Y2O3+2%Al2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	310.50	
Si3N4+6%Y2O3+2%Al2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	300.60	
Si3N4+6%Y2O3+2%Al2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	310.50	
Si3N4+6%Y2O3+2%Al2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	300.70	
Si3N4+6%Y2O3+2%Al2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	310.70	
Si3N4+6%Y2O3+2%Al2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	295.70	
Si3N4+6%Y2O3+2%Al2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	310.50	
Si3N4+6%Y2O3+2%Al2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	295.70	
Si3N4+6%Y2O3+2%Al2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	311.10	
Si3N4+6%Y2O3+2%Al2O3	ORNL/TIEGS1124	AS FABRICATED	AIR	SUMMARY		25	300.70	
Si3N4+6%Y2O3+2%Al2O3	ORNL/TIEGS1124	MW-ANN/1200C/10h	AIR	SUMMARY		25	307.90	MICROWAVE ANNEAL
Si3N4+6%Y2O3+2%Al2O3	ORNL/TIEGS1124	MW-ANN/1200C/20h	AIR	SUMMARY		25	304.90	MICROWAVE ANNEAL
Si3N4+6%Y2O3+2%Al2O3	ORNL/TIEGS1124	MW-ANN/1400C/10h	AIR	SUMMARY		25	305.20	MICROWAVE ANNEAL
Si3N4+6%Y2O3+2%Al2O3	ORNL/TIEGS1124	MW-ANN/1400C/20h	AIR	SUMMARY		25	305.60	MICROWAVE ANNEAL
Si3N4+6%Y2O3+2%Al2O3	ORNL/TIEGS1124	MW-ANN/1500C/10h	AIR	SUMMARY		25	309.90	MICROWAVE ANNEAL
WBS code = 1.2.2.1-GCCD								
GN-10	GCCD/BASELINE	HIP/T1/H1	AIR	195-3-1	ULTSONIC	25	338.65	
GN-10	GCCD/BASELINE	HIP/T1/H1	AIR	195-3-1	ULTSONIC	25	324.24	DIFFERENT ORIENTATION
GN-10	GCCD/BASELINE	HIP/T1/H1	AIR	195-3-2	ULTSONIC	25	312.97	

Section 5 - continued

Material	Batch Code	Heat Treatment	Test Env.	Specimen Number	Modulus Test	Test Temp. °C	Young's Modulus GPa	Comments
Silicon Nitride-Based Ceramics								
WBS code = 1.2.2.1-GCCD								
GN-10	GCCD/BASELINE	HIP/T1/H1	AIR	195-3-2	ULTSONIC	25	326.71	DIFFERENT ORIENTATION
GN-10	GCCD/BASELINE	HIP/T1/H2	AIR	195-3A-1	ULTSONIC	25	301.76	
GN-10	GCCD/BASELINE	HIP/T1/H2	AIR	195-3A-1	ULTSONIC	25	309.57	
GN-10	GCCD/BASELINE	HIP/T2/H1	AIR	195-4A-1	ULTSONIC	25	297.46	
GN-10	GCCD/BASELINE	HIP/T2/H1	AIR	195-4A-1	ULTSONIC	25	313.05	
GN-10	GCCD/BASELINE	HIP/T2/H1	AIR	195-4A-2	ULTSONIC	25	341.49	
GN-10	GCCD/BASELINE	HIP/T2/H1	AIR	195-4A-2	ULTSONIC	25	310.30	
GN-10	GCCD/BASELINE	HIP/T2/H1	AIR	195-4A-2	ULTSONIC	25	322.45	
GN-10	GCCD/BASELINE	HIP/T2/H2	AIR	195-4-1	ULTSONIC	25	330.54	
GN-10	GCCD/BASELINE	HIP/T2/H2	AIR	195-4-1	ULTSONIC	25	295.94	
GN-10	GCCD/BASELINE	HIP/T2/H2	AIR	195-4-1	ULTSONIC	25	318.54	
WBS code= 3.3.1.4-UDRI								
NT-164	NORTON/UDRI-92		AIR	AVERAGE	SONIC	1000	295.70	
NT-164	NORTON/UDRI-92		AIR	AVERAGE	SONIC	1250	291.70	
NT-164	NORTON/UDRI-92		AIR	AVERAGE	SONIC	1350	290.60	
Silicon Carbide Whisker-Reinforced Silicon Nitride-Based Ceramic								
WBS code = 1.2.2.1-GCCD								
GN-10+SiCw10(AM7)	GCCD/4IT	HIP/T1/H1	AIR	190-3-3	ULTSONIC	25	324.07	
GN-10+SiCw10(AM7)	GCCD/4IT	HIP/T1/H1	AIR	190-3-3	ULTSONIC	25	324.24	
GN-10+SiCw10(AM7)	GCCD/4IT	HIP/T1/H2	AIR	190-4-3	ULTSONIC	25	312.76	
GN-10+SiCw10(AM7)	GCCD/4IT	HIP/T1/H2	AIR	190-4-3	ULTSONIC	25	337.59	
GN-10+SiCw10(AM7)	GCCD/4IT	HIP/T2/H1	AIR	222-4-24	ULTSONIC	25	328.09	
GN-10+SiCw10(AM7)	GCCD/4IT	HIP/T2/H1	AIR	222-4-24	ULTSONIC	25	328.69	
GN-10+SiCw10(AM7)	GCCD/4IT	HIP/T2/H1	AIR	222-4-24	ULTSONIC	25	324.58	
GN-10+SiCw10(AM7)	GCCD/5IT	HIP/T1/H1	AIR	196-3-1	ULTSONIC	25	327.19	
GN-10+SiCw10(AM7)	GCCD/5IT	HIP/T1/H2	AIR	196-4-1	ULTSONIC	25	353.24	
GN-10+SiCw10(AM7)	GCCD/5IT	HIP/T1/H2	AIR	196-4-1	ULTSONIC	25	339.09	
GN-10+SiCw10(AM7)	GCCD/5IT	HIP/T1/H2	AIR	196-4-1	ULTSONIC	25	330.55	
GN-10+SiCw10(AM7)	GCCD/5IT	HIP/T2/H1	AIR	214-4-1	ULTSONIC	25	324.36	
GN-10+SiCw10(AM7)	GCCD/5IT	HIP/T2/H1	AIR	214-4-1	ULTSONIC	25	329.51	
GN-10+SiCw10(AM7)	GCCD/5IT	HIP/T2/H1	AIR	214-4-1	ULTSONIC	25	331.02	
GN-10+SiCw10(AM7)	GCCD/5IT	HIP/T2/H2	AIR	214-3-2	ULTSONIC	25	314.61	
GN-10+SiCw10(AM7)	GCCD/5IT	HIP/T2/H2	AIR	214-3-2	ULTSONIC	25	326.83	
GN-10+SiCw10(AM7)	GCCD/5IT	HIP/T2/H2	AIR	214-3-2	ULTSONIC	25	323.31	

Section 5 - continued

Material	Batch Code	Heat Treatment	Test Env.	Specimen Number	Modulus Test	Test Temp. °C	Young's Modulus GPa	Comments
Silicon Carbide Whisker-Reinforced Silicon Nitride-Based Ceramic								
WBS code = 1.2.2.1-GCCD								
GN-10+SiCw20(AM7)	GCCD/4IT	HIP/T1/H1	AIR	185-3-1	ULTSONIC	25	295.03	
GN-10+SiCw20(AM7)	GCCD/4IT	HIP/T1/H1	AIR	185-3-1	ULTSONIC	25	306.12	
GN-10+SiCw20(AM7)	GCCD/4IT	HIP/T1/H2	AIR	185-4-2	ULTSONIC	25	309.92	
GN-10+SiCw20(AM7)	GCCD/4IT	HIP/T2/H1	AIR	226-4-2	ULTSONIC	25	331.15	
GN-10+SiCw20(AM7)	GCCD/4IT	HIP/T2/H1	AIR	226-4-2	ULTSONIC	25	334.65	
GN-10+SiCw20(AM7)	GCCD/4IT	HIP/T2/H1	AIR	226-4-2	ULTSONIC	25	327.71	
GN-10+SiCw20(AM7)	GCCD/5IT	HIP/T1/H1	AIR	211-3-1	ULTSONIC	25	326.12	
GN-10+SiCw20(AM7)	GCCD/5IT	HIP/T1/H1	AIR	211-3-1	ULTSONIC	25	337.64	
GN-10+SiCw20(AM7)	GCCD/5IT	HIP/T1/H2	AIR	221-4-1	ULTSONIC	25	318.85	
GN-10+SiCw20(AM7)	GCCD/5IT	HIP/T1/H2	AIR	221-4-1	ULTSONIC	25	323.69	
GN-10+SiCw20(AM7)	GCCD/5IT	HIP/T2/H1	AIR	199-4-3	ULTSONIC	25	330.38	
GN-10+SiCw20(AM7)	GCCD/5IT	HIP/T2/H1	AIR	199-4-3	ULTSONIC	25	328.10	
GN-10+SiCw20(AM7)	GCCD/5IT	HIP/T2/H2	AIR	199-3-2	ULTSONIC	25	321.74	
GN-10+SiCw20(AM7)	GCCD/5IT	HIP/T2/H2	AIR	199-3-2	ULTSONIC	25	327.71	
GN-10+SiCw20(AM7)	GCCD/5IT	HIP/T2/H2	AIR	199-3-2	ULTSONIC	25	329.41	
WBS code = 1.2.2.1-GCCD								
GN-10+SiCw30(AM7)	GCCD/4IT	HIP/T1/H1	AIR	228-3-2	ULTSONIC	25	308.81	
GN-10+SiCw30(AM7)	GCCD/4IT	HIP/T1/H1	AIR	228-3-2	ULTSONIC	25	317.74	
GN-10+SiCw30(AM7)	GCCD/4IT	HIP/T1/H1	AIR	228-3-2	ULTSONIC	25	326.90	
GN-10+SiCw30(AM7)	GCCD/4IT	HIP/T1/H2	AIR	228-4-2	ULTSONIC	25	329.19	
GN-10+SiCw30(AM7)	GCCD/4IT	HIP/T1/H2	AIR	228-4-2	ULTSONIC	25	343.49	
GN-10+SiCw30(AM7)	GCCD/4IT	HIP/T1/H2	AIR	228-4-2	ULTSONIC	25	324.47	
GN-10+SiCw30(AM7)	GCCD/4IT	HIP/T2/H1	AIR	188-4-1	ULTSONIC	25	339.29	
GN-10+SiCw30(AM7)	GCCD/4IT	HIP/T2/H1	AIR	188-4-1	ULTSONIC	25	346.26	
GN-10+SiCw30(AM7)	GCCD/5IT	HIP/T1/H1	AIR	201-2-2	ULTSONIC	25	291.31	
GN-10+SiCw30(AM7)	GCCD/5IT	HIP/T1/H1	AIR	201-2-2	ULTSONIC	25	322.17	
GN-10+SiCw30(AM7)	GCCD/5IT	HIP/T1/H2	AIR	201-3-1	ULTSONIC	25	339.99	
GN-10+SiCw30(AM7)	GCCD/5IT	HIP/T1/H2	AIR	201-3-1	ULTSONIC	25	336.94	
GN-10+SiCw30(AM7)	GCCD/5IT	HIP/T2/H1	AIR	205-4-1	ULTSONIC	25	326.05	
GN-10+SiCw30(AM7)	GCCD/5IT	HIP/T2/H1	AIR	205-4-1	ULTSONIC	25	342.06	
GN-10+SiCw30(AM7)	GCCD/5IT	HIP/T2/H2	AIR	205-3-1	ULTSONIC	25	327.73	
WBS code = 1.2.2.1-GCCD								
GN-10+SiCw40(AM7)	GCCD/4IT	HIP/T1/H1	AIR	193-3-2	ULTSONIC	25	270.78	
GN-10+SiCw40(AM7)	GCCD/4IT	HIP/T1/H1	AIR	193-3-2	ULTSONIC	25	294.57	

Section 5 - continued

Material	Batch Code	Heat Treatment	Test Env.	Specimen Number	Modulus Test	Test Temp. °C	Young's Modulus GPa	Comments
Silicon Carbide Whisker-Reinforced Silicon Nitride-Based Ceramic								
WBS code = 1.2.2.1-GCCD								
GN-10+SiCw40(AM7)	GCCD/4IT	HIP/T1/H2	AIR	193-4-1	ULTSONIC	25	266.46	
GN-10+SiCw40(AM7)	GCCD/4IT	HIP/T1/H2	AIR	193-4-1	ULTSONIC	25	273.35	
GN-10+SiCw40(AM7)	GCCD/4IT	HIP/T2/H2	AIR	233-4-2	ULTSONIC	25	357.73	
GN-10+SiCw40(AM7)	GCCD/4IT	HIP/T2/H2	AIR	233-4-2	ULTSONIC	25	368.60	
GN-10+SiCw40(AM7)	GCCD/5IT	HIP/T1/H1	AIR	202-3-3	ULTSONIC	25	325.27	
GN-10+SiCw40(AM7)	GCCD/5IT	HIP/T1/H1	AIR	202-3-3	ULTSONIC	25	329.09	
GN-10+SiCw40(AM7)	GCCD/5IT	HIP/T1/H2	AIR	202-4-1	ULTSONIC	25	425.77	
GN-10+SiCw40(AM7)	GCCD/5IT	HIP/T1/H2	AIR	202-4-1	ULTSONIC	25	359.46	
GN-10+SiCw40(AM7)	GCCD/5IT	HIP/T2/H2	AIR	208-3-2	ULTSONIC	25	345.24	

Figure 2.8. Heat-treatment effects on the modulus of elasticity of several silicon nitride-based ceramics tested at room temperature.

Figure 2.9. Heat-treatment effects on the modulus of elasticity of several silicon nitride-based ceramics.

Figure 2.10. Heat-treatment and reinforcement volume effects on the modulus of elasticity of GN-10-based ceramics at room temperature.

Section 6 - Modulus of Rupture Four-Point Bend Test Results

All tests were run in ambient air.

Material	Batch Code	Heat Treatment	Specimen Number	Test Temp °C	Specimen Width mm	Specimen Thick. mm	Bend Strength MPa	Flaw Type	Crosshead Speed	Std. Dev.	Comments
SiAlON-Based Ceramics											
Test Rig = MOR4DD1, Data from Detroit Diesel											
NT-451	SZ0178		1	21	3.00	4.00	861.0	SURFACE DEFECT			
NT-451	SZ0178		2	21	3.00	4.00	745.0	NEAR-SURFACE INCLUSION			
NT-451	SZ0178		3	21	3.00	4.00	930.0	SURFACE DEFECT			
NT-451	SZ0178		4	21	3.00	4.00	862.0	SURFACE DEFECT			
NT-451	SZ0178		5	21	3.00	4.00	820.0	SURFACE INCLUSION			
NT-451	SZ0178		6	21	3.00	4.00	889.0	SURFACE DEFECT			
NT-451	SZ0178		7	21	3.00	4.00	848.0	SURFACE DEFECT			
NT-451	SZ0178		8	21	3.00	4.00	896.0	CORNER DEFECT			
NT-451	SZ0178		9	21	3.00	4.00	883.0	MISSING ORIGIN			
NT-451	SZ0178		10	21	3.00	4.00	896.0	SURFACE DEFECT			
NT-451	SZ0178		11	21	3.00	4.00	800.0	SURFACE DEFECT			
NT-451	SZ0178		12	21	3.00	4.00	827.0	SURFACE DEFECT			
NT-451	SZ0178		15	21	3.00	4.00	814.0	NEAR-SURFACE INCLUSION			
NT-451	SZ0178		14	21	3.00	4.00	703.0	CORNER DEFECT			
NT-451	SZ0178		16	21	3.00	4.00	834.0	SURFACE DEFECT			
NT-451	SZ0178		17	21	3.00	4.00	834.0	CORNER DEFECT			
NT-451	SZ0178		18	21	3.00	4.00	883.0	NEAR-SURFACE INCLUSION			
NT-451	SZ0178		19	21	3.00	4.00	869.0	MISSING ORIGIN			
NT-451	SZ0178		20	21	3.00	4.00	869.0	SURFACE DEFECT			
NT-451	SZ0178		21	21	3.00	4.00	855.0	SURFACE DEFECT			
NT-451	SZ0178		22	21	3.00	4.00	876.0	MISSING ORIGIN			
NT-451	SZ0178		23	21	3.00	4.00	814.0	SURFACE DEFECT			
NT-451	SZ0178		24	21	3.00	4.00	827.0	MISSING ORIGIN			
NT-451	SZ0178		25	21	3.00	4.00	869.0	SURFACE DEFECT			
NT-451	SZ0179		26	21	3.00	4.00	903.0	CORNER DEFECT			
NT-451	SZ0179		27	21	3.00	4.00	758.0	SURFACE DEFECT			
NT-451	SZ0179		28	21	3.00	4.00	848.0	SURFACE DEFECT			
NT-451	SZ0179		29	21	3.00	4.00	869.0	SURFACE DEFECT			
NT-451	SZ0179		30	21	3.00	4.00	855.0	SURFACE DEFECT			
NT-451	SZ0179		31	21	3.00	4.00	889.0	SURFACE DEFECT			
NT-451	SZ0179		32	21	3.00	4.00	876.0	MISSING ORIGIN			
NT-451	SZ0179		33	21	3.00	4.00	924.0	SURFACE DEFECT			
NT-451	SZ0179		34	21	3.00	4.00	855.0	SURFACE DEFECT			
NT-451	SZ0179		35	21	3.00	4.00	848.0	CORNER DEFECT			
NT-451	SZ0179		36	21	3.00	4.00	869.0	SURFACE DEFECT			
NT-451	SZ0179		37	21	3.00	4.00	717.0	SURFACE DEFECT			
NT-451	SZ0179		38	21	3.00	4.00	903.0	SURFACE DEFECT			
NT-451	SZ0179		39	21	3.00	4.00	876.0	CORNER DEFECT			
NT-451	SZ0179		40	21	3.00	4.00	855.0	SURFACE DEFECT			

Section 6 - continued

Material	Batch Code	Heat Treatment	Specimen Number	Test Temp °C	Specimen Width mm	Specimen Thick. mm	Bend Strength MPa	Flaw Type	Crosshead Speed	Comments
SiAlON-Based Ceramics										
Test Rig = MOR4DD1, Data from Detroit Diesel										
NT-451	SZ0179		41	21	3.00	4.00	717.0	SURFACE DEFECT		
NT-451	SZ0179		42	21	3.00	4.00	855.0	SURFACE DEFECT		
NT-451	SZ0179		43	21	3.00	4.00	772.0	SURFACE DEFECT		
NT-451	SZ0179		44	21	3.00	4.00	648.0	NEAR-SURFACE PORE		
NT-451	SZ0179		45	21	3.00	4.00	869.0	SURFACE DEFECT		
NT-451	SZ0179		46	21	3.00	4.00	827.0	MISSING ORIGIN		
NT-451	SZ0179		47	21	3.00	4.00	841.0	SURFACE DEFECT		
NT-451	SZ0179		48	21	3.00	4.00	841.0	MISSING ORIGIN		
NT-451	SZ0179		49	21	3.00	4.00	876.0	SURFACE DEFECT		
NT-451	SZ0179		50	21	3.00	4.00	862.0	SURFACE DEFECT		
NT-451	NORTON/REF.		SUMMARY	22			888.0			CHARACTERISTIC STRENGTH
NT-451	NORTON/REF.		SUMMARY	1000			756.0			CHARACTERISTIC STRENGTH
NT-451	NORTON/REF.		SUMMARY	1000			737.0			
Silicon Carbide-Based Ceramics										
Test Rig = MIL-1942B, WBS Code=3.3.1.4-UDRI										
Beta-SiC	DOWCORN/UDRI/1		AVG10	21	3.00	4.00	463.0	3SURF/2EDGE/6PITS	0.004cm/s	22.00
Beta-SiC	DOWCORN/UDRI/1		AVG5	21	3.00	4.00	421.0	53SURF	0.00004cm/s	33.00
Beta-SiC	DOWCORN/UDRI/1		AVG5	1250	3.00	4.00	442.0	2SURF/1EDGE/2PITS	0.004cm/s	72.00
Beta-SiC	DOWCORN/UDRI/1		AVG5	1250	3.00	4.00	464.0	2SURF/1PIT/1INCLUSION	0.00004cm/s	19.00
Beta-SiC	DOWCORN/UDRI/1		AVG5	1350	3.00	4.00	460.0	2VOLINC/2EDGINC/SURFPT	0.004cm/s	62.00
Beta-SiC	DOWCORN/UDRI/1		AVG5	1350	3.00	4.00	475.0	2SURF/1PIT/2INCL	0.00004cm/s	52.00
Test Rig = MOR4CARB1, WBS Code = 1.1.1.3-CARB										
HEXOLOY SX-G1	CARB/1/1990		SUMRY12	21	3.00	4.00	827.0			MOR4 RANGE=586 TO 986MPa
HEXOLOY SX-G1	CARB/6/91		SUMRY20	21	3.00	4.00	586.0			MOR4 RANGE=345 TO 738MPa
HEXOLOY SX-G1	CARB/8/1991		SUMRY20	21	3.00	4.00	780.0	VOL. DEFECTS IN Si	0.5mm/min	
HEXOLOY SX-G1	CARB/8/1991/MIX1		SUMRY10	21	3.00	4.00	827.0			MOR4 RANGE=593 TO 1076MPa
HEXOLOY SX-G1	CARB/8/1991/MIX2		SUMRY20	21	3.00	4.00	896.0			MOR4 RANGE=696 TO 1007MPa
HEXOLOY SX-G1	CARB/8/1991/MIX3		SUMRY15	21	3.00	4.00	779.0			MOR4 RANGE=434 TO 965MPa
HEXOLOY SX-G1	CARB/9/1990		SUMRY10	21	3.00	4.00	917.0			MOR4 RANGE=696 TO 1069MPa
HEXOLOY SX-G1	CARB/9/1991/B		SUMRY20	21	3.00	4.00	627.0	VOLUME, POOLS	0.5mm/min	
HEXOLOY SX-G1	CARB/9/1991/C		SUMRY20	21	3.00	4.00	724.0	VOLUME, SURFACE-MACH.	0.5mm/min	
HEXOLOY SX-G1	CARB/9/1991/D		SUMRY20	21	3.00	4.00	496.0	VOLUME & SURFACE-MACH.	0.5mm/min	
HEXOLOY SX-G1	CARB/9/1991/F		SUMRY20	21	3.00	4.00	648.0	VOLUME, POOLS	0.5mm/min	
HEXOLOY SX-G1	CARB/8/1991		SUMRY20	1000	3.00	4.00	580.0	VOL. DEFECTS IN Si	0.5mm/min	
HEXOLOY SX-G1	CARB/8/1991		SUMRY20	1232	3.00	4.00	531.0	VOL. DEFECTS IN Si	0.5mm/min	
HEXOLOY SX-G1	CARB/8/1991		SUMRY20	1370	3.00	4.00	421.0	SURFACE, GLASSY PHASE	0.5mm/min	GLASSY PHASE FORM. IN FLAW
HEXOLOY SX-G1	CARB/9/1991/B		SUMRY20	1371	3.00	4.00	365.0		0.5mm/min	
HEXOLOY SX-G1	CARB/9/1991/C		SUMRY20	1371	3.00	4.00	352.0		0.5mm/min	

Section 6 - continued

Material	Batch Code	Heat Treatment	Specimen Number	Test Temp °C	Specimen Width mm	Specimen Thick. mm	Bend Strength MPa	Flaw Type	Crosshead Speed	Std. Dev.	Comments
Silicon Carbide-Based Ceramics											
Test Rig = MOR4CARB1, WBS Code = 1.1.1.3-CARB											
HEXOLOY SX-G1	CARB/9/1991/D		SUMRY20	1371	3.00	4.00	269.0		0.5mm/min		
HEXOLOY SX-G1	CARB/9/1991/F		SUMRY20	1371	3.00	4.00	339.0		0.5mm/min		
Silicon Nitride-Based Ceramics											
Test Rig = MOR4GCCD1, WBS Code = 1.2.2.1-GCCD											
GN-10	GCCD/BASELINE	HIP/T3	SUMMARY5	21	3.00	4.00	753.5	ALL SURFACE			
GN-10	GCCD/BASELINE	HIP/T4	SUMMARY5	21	3.00	4.00	592.0	FAIL.ORIG.50% SURFACE			
GN-10	GCCD/BASELINE	HIP/T2/H2	SUMMARY10	21	3.00	4.00	890.0			124.00	
GN-10	GCCD/BASELINE	HIP/T2/H2	SUMMARY5	1375	3.00	4.00	514.0			22.00	
Test Rig = MIL-1942B, WBS Code = 3.3.1.4-UDRI											
GS-44	GARRETT/UDRI/I	AGE/1100C/200h	AVG2	21	3.00	4.00	1160.0	1SURF/1EDGE	0.00004cm/s	162.00	
GS-44	GARRETT/UDRI/I		AVG4	21	3.00	4.00	984.0	3SURF/1VOL.INC.	0.004cm/s	24.00	
GS-44	GARRETT/UDRI/I		AVG5	1050	3.00	4.00	635.0	5SURF	0.00004cm/s	66.00	
Test Rig = MIL-1942B, WBS Code = 1.1.2.4-ORNL											
GS-44	ORNL/GCC-AS CRDA	ANN/1600C/10h/MW	SUMMARY	25	3.00	4.00	931.0				5.00
GS-44	ORNL/GCC-AS CRDA	ANN/1700C/10h/MW	SUMMARY	25	3.00	4.00	910.0				3.00
GS-44	ORNL/GCC-AS CRDA	ANN/1800C/2h/MW	SUMMARY	25	3.00	4.00	931.0				3.00
GS-44	ORNL/GCC-AS CRDA	BASELINE-NONE	SUMMARY	25	3.00	4.00	961.0				10.00
GS-44	ORNL/GCC-AS CRDA	ANN/1600C/10h/MW	SUMMARY	900	3.00	4.00	690.0				11.00
GS-44	ORNL/GCC-AS CRDA	ANN/1700C/10h/MW	SUMMARY	900	3.00	4.00	710.0				5.00
GS-44	ORNL/GCC-AS CRDA	ANN/1800C/2h/MW	SUMMARY	900	3.00	4.00	634.0				5.00
GS-44	ORNL/GCC-AS CRDA	BASELINE-NONE	SUMMARY	900	3.00	4.00	697.0				7.00
GS-44	ORNL/GCC-AS CRDA	ANN/1600C/10h/MW	SUMMARY	1100	3.00	4.00	448.0				7.00
GS-44	ORNL/GCC-AS CRDA	ANN/1700C/10h/MW	SUMMARY	1100	3.00	4.00	386.0				5.00
GS-44	ORNL/GCC-AS CRDA	ANN/1800C/2h/MW	SUMMARY	1100	3.00	4.00	413.0				5.00
GS-44	ORNL/GCC-AS CRDA	BASELINE-NONE	SUMMARY	1100	3.00	4.00	434.0				3.00
Test Rig = MIL-1942B, WBS Code = 1.2.3.1-ORNL											
Si3N4+10.6La+6.4Si	ORNL/SC-283-1	GPS	SUMMARY	25	3.00	4.00	556.0				25.00
Si3N4+10.6La+6.4Si	ORNL/SC-283-3	GPS	SUMMARY	25	3.00	4.00	612.0				26.00
Si3N4+10.6La+6.4Si	ORNL/SC-283-4	GPS	SUMMARY	25	3.00	4.00	499.0				101.00
Si3N4+10.6La+6.4Si	ORNL/SC-283-5	GPS	SUMMARY	25	3.00	4.00	647.0				33.00
Si3N4+10.6La+6.4Si	ORNL/SC-283-6	GPS	SUMMARY	25	3.00	4.00	463.0				47.00
Si3N4+10.6La+6.4Si	ORNL/SC-283-7	GPS	SUMMARY	25	3.00	4.00	767.0				60.00
Si3N4+10.6La+6.4Si	ORNL/SC-283-1	GPS	SUMMARY	1200	3.00	4.00	574.0				74.00
Si3N4+10.6La+6.4Si	ORNL/SC-283-3	GPS	SUMMARY	1200	3.00	4.00	532.0				61.00
Si3N4+10.6La+6.4Si	ORNL/SC-283-4	GPS	SUMMARY	1200	3.00	4.00	555.0				40.00
Si3N4+10.6La+6.4Si	ORNL/SC-283-5	GPS	SUMMARY	1200	3.00	4.00	510.0				53.00
Si3N4+10.6La+6.4Si	ORNL/SC-283-6	GPS	SUMMARY	1200	3.00	4.00	546.0				46.00

Section 6 - continued

Material	Batch Code	Heat Treatment	Specimen Number	Test Temp °C	Specimen Width mm	Specimen Thick. mm	Bend Strength MPa	Flaw Type	Crosshead Speed	Std. Dev.	Comments
Silicon Nitride-Based Ceramics											
Test Rig = MIL-1942B, WBS Code = 1.2.3.1-ORNL											
Si3N4+10.6La+6.3Si	ORNL/TRSN-5-1	GPS	SUMMARY	25	3.00	4.00	341.0			142.00	
Si3N4+10.6La+6.3Si	ORNL/TRSN-5-1	GPS	SUMMARY	1200	3.00	4.00	525.0			61.00	
Test Rig = MIL-1942B, WBS Code = 1.2.3.1-ORNL											
Si3N4+7.4La+3.2Si	ORNL/TRSN-10-1	GPS	SUMMARY	25	3.00	4.00	470.0			68.00	
Si3N4+7.4La+3.2Si	ORNL/TRSN-10-2	GPS	SUMMARY	25	3.00	4.00	518.0			28.00	
Si3N4+7.4La+3.2Si	ORNL/TRSN-10-1	GPS	SUMMARY	1200	3.00	4.00	498.0			55.00	
Si3N4+7.4La+3.2Si	ORNL/TRSN-10-2	GPS	SUMMARY	1200	3.00	4.00	533.0			12.00	
Test Rig = MIL-1942B, WBS Code = 1.2.3.1-ORNL											
Si3N4+10.8La+4.2Si	ORNL/TRSN-15-1	GPS	SUMMARY	25	3.00	4.00	411.0			55.00	
Si3N4+10.8La+4.2Si	ORNL/TRSN-15-2	GPS	SUMMARY	25	3.00	4.00	311.0			133.00	
Si3N4+10.8La+4.2Si	ORNL/TRSN-15-1	GPS	SUMMARY	1200	3.00	4.00	288.0			115.00	
Si3N4+10.8La+4.2Si	ORNL/TRSN-15-2	GPS	SUMMARY	1200	3.00	4.00	435.0			58.00	
Test Rig = MIL-1942B, WBS Code = 1.2.3.1-ORNL											
Si3N4+11.4La+3.3Si+1.8Sr	ORNL/TRSN-18-1	GPS	SUMMARY	25	3.00	4.00	376.0			40.00	
Si3N4+11.4La+3.3Si+1.8Sr	ORNL/TRSN-18-2	GPS	SUMMARY	25	3.00	4.00	480.0			25.00	
Si3N4+11.4La+3.3Si+1.8Sr	ORNL/TRSN-18-1	GPS	SUMMARY	1200	3.00	4.00	420.0			37.00	
Si3N4+11.4La+3.3Si+1.8Sr	ORNL/TRSN-18-2	GPS	SUMMARY	1200	3.00	4.00	422.0			13.00	
Test Rig = MIL-1942B, WBS Code = 1.2.3.1-ORNL											
Si3N4+11.2La+5.5Si+1.8Sr	ORNL/TRSN-2-1	GPS	SUMMARY	25	3.00	4.00	542.0			50.00	
Si3N4+11.2La+5.5Si+1.8Sr	ORNL/TRSN-2-2	GPS	SUMMARY	25	3.00	4.00	374.0			54.00	
Si3N4+11.2La+5.5Si+1.8Sr	ORNL/TRSN-2-1	GPS	SUMMARY	1200	3.00	4.00	310.0			9.00	
Si3N4+11.2La+5.5Si+1.8Sr	ORNL/TRSN-2-2	GPS	SUMMARY	1200	3.00	4.00	309.0			32.00	
Test Rig = MIL-1942B, WBS Code = 1.2.3.1-ORNL											
Si3N4+La2O3+Al2O3	ORNL/TM-133	SINT/1700C/1h/MW	SUMMARY	25	3.00	4.00	654.0			16.00	
Test Rig = MIL-1942B, WBS Code = 1.2.3.1-ORNL											
Si3N4+11.1Nd+4.2Si	ORNL/TRSN-16-1	GPS	SUMMARY	25	3.00	4.00	412.0			102.00	
Si3N4+11.1Nd+4.2Si	ORNL/TRSN-16-2	GPS	SUMMARY	25	3.00	4.00	508.0				
Si3N4+11.1Nd+4.2Si	ORNL/TRSN-16-1	GPS	SUMMARY	1200	3.00	4.00	436.0			122.00	
Si3N4+11.1Nd+4.2Si	ORNL/TRSN-16-2	GPS	SUMMARY	1200	3.00	4.00	319.0			72.00	
Test Rig = MIL-1942B, WBS Code = 1.2.3.1-ORNL											
Si3N4+7.6Nd+3.2Si	ORNL/TRSN-9-1	GPS	SUMMARY	25	3.00	4.00	631.0			80.00	
Si3N4+7.6Nd+3.2Si	ORNL/TRSN-9-2	GPS	SUMMARY	25	3.00	4.00	379.0			80.00	
Si3N4+7.6Nd+3.2Si	ORNL/TRSN-9-1	GPS	SUMMARY	1200	3.00	4.00	543.0				
Si3N4+7.6Nd+3.2Si	ORNL/TRSN-9-2	GPS	SUMMARY	1200	3.00	4.00	343.0			24.00	

Section 6 - continued

Material	Batch Code	Heat Treatment	Specimen Number	Test Temp °C	Specimen Width mm	Specimen Thick. mm	Bend Strength MPa	Flaw Type	Crosshead Speed	Std. Dev.	Comments
Silicon Nitride-Based Ceramics											
Test Rig = MIL-1942B, WBS Code = 1.2.3.1-ORNL											
Si3N4+11.7Nd+3.3Si+1.8Sr	ORNL/TRSN-19-2	GPS	SUMMARY	25	3.00	4.00	320.0			27.00	
Si3N4+11.7Nd+3.3Si+1.8Sr	ORNL/TRSN-19-2	GPS	SUMMARY	1200	3.00	4.00	262.0			160.00	
Test Rig = MIL-1942B, WBS Code = 1.2.3.1-ORNL											
Si3N4+11.5Nd+5.5Si+1.8Sr	ORNL/TRSN-4-1	GPS	SUMMARY	25	3.00	4.00	510.0			9.00	
Si3N4+11.5Nd+5.5Si+1.8Sr	ORNL/TRSN-4-2	GPS	SUMMARY	25	3.00	4.00	444.0			126.00	
Si3N4+11.5Nd+5.5Si+1.8Sr	ORNL/TRSN-4-1	GPS	SUMMARY	1200	3.00	4.00	378.0			61.00	
Si3N4+11.5Nd+5.5Si+1.8Sr	ORNL/TRSN-4-2	GPS	SUMMARY	1200	3.00	4.00	333.0			18.00	
Test Rig = MIL-1942B, WBS Code = 1.2.3.1-ORNL											
Si3N4+6Y+2Al	ORNL/TRSN-1-1	GPS	SUMMARY	25	3.00	4.00	765.0			70.00	
Si3N4+6Y+2Al	ORNL/TRSN-1-2	GPS	SUMMARY	25	3.00	4.00	525.0			79.00	
Si3N4+6Y+2Al	ORNL/TRSN-1-1	GPS	SUMMARY	1200	3.00	4.00	447.0			18.00	
Si3N4+6Y+2Al	ORNL/TRSN-1-2	GPS	SUMMARY	1200	3.00	4.00	354.0			40.00	
Test Rig = MIL-1942B, WBS Code = 1.2.3.1-ORNL											
Si3N4+7.9Y+2.7Ba+3.4Si	ORNL/SC-291-4	GPS	SUMMARY	25	3.00	4.00	752.0			64.00	
Si3N4+7.9Y+2.7Ba+3.4Si	ORNL/SC-291-4	GPS	SUMMARY	1200	3.00	4.00	375.0			19.00	
Test Rig = MIL-1942B, WBS Code = 1.2.3.1-ORNL											
Si3N4+3.8Y+5.3La+6.4Si	ORNL/SC-282-1	GPS	SUMMARY	25	3.00	4.00	672.0			39.00	
Si3N4+3.8Y+5.3La+6.4Si	ORNL/SC-282-3	GPS	SUMMARY	25	3.00	4.00	745.0			25.00	
Si3N4+3.8Y+5.3La+6.4Si	ORNL/SC-282-4	GPS	SUMMARY	25	3.00	4.00	424.0			151.00	
Si3N4+3.8Y+5.3La+6.4Si	ORNL/SC-282-5	GPS	SUMMARY	25	3.00	4.00	707.0			8.00	
Si3N4+3.8Y+5.3La+6.4Si	ORNL/SC-282-6	GPS	SUMMARY	25	3.00	4.00	465.0			8.00	
Si3N4+3.8Y+5.3La+6.4Si	ORNL/SC-282-7	GPS	SUMMARY	25	3.00	4.00	712.0			40.00	
Si3N4+3.8Y+5.3La+6.4Si	ORNL/SC-282-1	GPS	SUMMARY	1200	3.00	4.00	525.0			25.00	
Si3N4+3.8Y+5.3La+6.4Si	ORNL/SC-282-3	GPS	SUMMARY	1200	3.00	4.00	471.0			9.00	
Si3N4+3.8Y+5.3La+6.4Si	ORNL/SC-282-4	GPS	SUMMARY	1200	3.00	4.00	490.0			41.00	
Si3N4+3.8Y+5.3La+6.4Si	ORNL/SC-282-5	GPS	SUMMARY	1200	3.00	4.00	411.0			103.00	
Si3N4+3.8Y+5.3La+6.4Si	ORNL/SC-282-6	GPS	SUMMARY	1200	3.00	4.00	456.0			47.00	
Si3N4+3.8Y+5.3La+6.4Si	ORNL/SC-282-7	GPS	SUMMARY	1200	3.00	4.00	422.0			157.00	
Test Rig = MIL-1942B, WBS Code = 1.2.3.1-ORNL											
Si3N4+3.8Y+5.3La+6.4Si	ORNL/TRSN-7-2	GPS	SUMMARY	25	3.00	4.00	344.0			113.00	
Test Rig = MIL-1942B, WBS Code = 1.2.3.1-ORNL											
Si3N4+7.6Y+6.5Si	ORNL/SC-281-3	GPS	SUMMARY	25	3.00	4.00	531.0			37.00	
Si3N4+7.6Y+6.5Si	ORNL/SC-281-4	GPS	SUMMARY	25	3.00	4.00	471.0			15.00	
Si3N4+7.6Y+6.5Si	ORNL/SC-281-6	GPS	SUMMARY	25	3.00	4.00	578.0			11.00	
Si3N4+7.6Y+6.5Si	ORNL/SC-281-7	GPS	SUMMARY	25	3.00	4.00	672.0			32.00	

Section 6 - continued

Material	Batch Code	Heat Treatment	Specimen Number	Test Temp °C	Specimen Width mm	Specimen Thick. mm	Bend Strength MPa	Flaw Type	Crosshead Speed	Std. Dev.	Comments
Silicon Nitride-Based Ceramics											
Test Rig = MIL-1942B, WBS Code = 1.2.3.1-ORNL											
Si3N4+7.6Y+6.5Si	ORNL/SC-281-3	GPS	SUMMARY	1200	3.00	4.00	488.0			8.00	
Si3N4+7.6Y+6.5Si	ORNL/SC-281-4	GPS	SUMMARY	1200	3.00	4.00	200.0			122.00	
Si3N4+7.6Y+6.5Si	ORNL/SC-281-6	GPS	SUMMARY	1200	3.00	4.00	549.0			11.00	
Si3N4+7.6Y+6.5Si	ORNL/SC-281-7	GPS	SUMMARY	1200	3.00	4.00	506.0			59.00	
Test Rig = MIL-1942B, WBS Code = 1.2.3.1-ORNL											
Si3N4+7.8Y+4.3Si	ORNL/TRSN-14-1	GPS	SUMMARY	25	3.00	4.00	460.0			109.00	
Si3N4+7.8Y+4.3Si	ORNL/TRSN-14-2	GPS	SUMMARY	25	3.00	4.00	427.0			20.00	
Si3N4+7.8Y+4.3Si	ORNL/TRSN-14-1	GPS	SUMMARY	1200	3.00	4.00	370.0			66.00	
Si3N4+7.8Y+4.3Si	ORNL/TRSN-14-2	GPS	SUMMARY	1200	3.00	4.00	291.0			38.00	
Test Rig = MIL-1942B, WBS Code = 1.2.3.1-ORNL											
Si3N4+9.6Y+5.3Si	ORNL/TRSN-20-2	GPS	SUMMARY	25	3.00	4.00	386.0			23.00	
Si3N4+9.6Y+5.3Si	ORNL/TRSN-20-2	GPS	SUMMARY	1200	3.00	4.00	309.0			24.00	
Test Rig = MIL-1942B, WBS Code = 1.2.3.1-ORNL											
Si3N4+7.6Y+6.5Si	ORNL/TRSN-6-2	GPS	SUMMARY	25	3.00	4.00	398.0			197.00	
Test Rig = MIL-1942B, WBS Code = 1.2.3.1-ORNL											
Si3N4+5.3Y+3.3Si	ORNL/TRSN-8-1	GPS	SUMMARY	25	3.00	4.00	310.0			16.00	
Si3N4+5.3Y+3.3Si	ORNL/TRSN-8-2	GPS	SUMMARY	25	3.00	4.00	503.0			88.00	
Si3N4+5.3Y+3.3Si	ORNL/TRSN-8-1	GPS	SUMMARY	1200	3.00	4.00	385.0			29.00	
Si3N4+5.3Y+3.3Si	ORNL/TRSN-8-2	GPS	SUMMARY	1200	3.00	4.00	496.0			6.00	
Test Rig = MIL-1942B, WBS Code = 1.2.3.1-ORNL											
Si3N4+8Y+5.6Si+1.8Sr	ORNL/SC-293-1	GPS	SUMMARY	25	3.00	4.00	730.0			51.00	
Si3N4+8Y+5.6Si+1.8Sr	ORNL/SC-293-3	GPS	SUMMARY	25	3.00	4.00	543.0			41.00	
Si3N4+8Y+5.6Si+1.8Sr	ORNL/SC-293-4	GPS	SUMMARY	25	3.00	4.00	647.0			17.00	
Si3N4+8Y+5.6Si+1.8Sr	ORNL/SC-293-5	GPS	SUMMARY	25	3.00	4.00	778.0			28.00	
Si3N4+8Y+5.6Si+1.8Sr	ORNL/SC-293-6	GPS	SUMMARY	25	3.00	4.00	697.0			56.00	
Si3N4+8Y+5.6Si+1.8Sr	ORNL/SC-293-1	GPS	SUMMARY	1200	3.00	4.00	464.0			34.00	
Si3N4+8Y+5.6Si+1.8Sr	ORNL/SC-293-3	GPS	SUMMARY	1200	3.00	4.00	526.0			49.00	
Si3N4+8Y+5.6Si+1.8Sr	ORNL/SC-293-4	GPS	SUMMARY	1200	3.00	4.00	424.0			30.00	
Si3N4+8Y+5.6Si+1.8Sr	ORNL/SC-293-5	GPS	SUMMARY	1200	3.00	4.00	447.0			20.00	
Si3N4+8Y+5.6Si+1.8Sr	ORNL/SC-293-6	GPS	SUMMARY	1200	3.00	4.00	475.0			20.00	
Test Rig = MIL-1942B, WBS Code = 1.2.3.1-ORNL											
Si3N4+8Y+5.7Si+1.8Sr	ORNL/TRSN-3-1	GPS	SUMMARY	25	3.00	4.00	452.0			19.00	
Si3N4+8Y+5.7Si+1.8Sr	ORNL/TRSN-3-2	GPS	SUMMARY	25	3.00	4.00	475.0			33.00	
Si3N4+8Y+5.7Si+1.8Sr	ORNL/TRSN-3-1	GPS	SUMMARY	1200	3.00	4.00	258.0			26.00	
Si3N4+8Y+5.7Si+1.8Sr	ORNL/TRSN-3-2	GPS	SUMMARY	1200	3.00	4.00	297.0			45.00	

Section 6 - continued

Material	Batch Code	Heat Treatment	Specimen Number	Test Temp °C	Specimen Width mm	Specimen Thick. mm	Bend Strength MPa	Flaw Type	Crosshead Speed	Std. Dev.	Comments
Silicon Nitride-Based Ceramics											
Test Rig = MIL-1942B, WBS Code = 3.3.1.4-UDRI											
SN-253	KYOCERA/UDRI/93		AVG10	21	3.00	4.00	859.0	9SURF/1EDGE	0.004cm/s	99.00	
SN-253	KYOCERA/UDRI/93		AVG10	21	3.00	4.00	819.0	7SURF/2EDGE/1INCLUSION	0.00004cm/s	63.00	
SN-253	KYOCERA/UDRI/93		AVG10	1250	3.00	4.00	732.0	7SURF/1EDGE/2INCLUSION	0.004cm/s	38.00	
SN-253	KYOCERA/UDRI/93		AVG5	1250	3.00	4.00	421.0	5SURF	0.00004cm/s	33.00	
SN-253	KYOCERA/UDRI/93		AVG10	1350	3.00	4.00	617.0	8SURF/1EDGE/1INCLUSION	0.004cm/s	43.00	
SN-253	KYOCERA/UDRI/93		AVG5	1350	3.00	4.00	572.0	5SURFACE	0.0004cm/s	32.00	
SN-253	KYOCERA/UDRI/93		AVG5	1350	3.00	4.00	505.0	5SURFACE	0.00004cm/s	42.00	APPEARANCE OF SLOW CRACK GROWTH
Test Rig = MIL-1942B, WBS Code = 1.1.2.4-ORNL											
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-145	SINT/MW/CPM	SUM8/L1M	20	3.00	4.00	660.0			39.00	TOP LAYER
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-145	SINT/MW/CPM	SUM8/L2M	20	3.00	4.00	619.0			53.00	LAYER 2 (FROM TOP)
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-145	SINT/MW/CPM	SUM8/L3M	20	3.00	4.00	638.0			64.00	LAYER 3 (FROM TOP)
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-145	SINT/MW/CPM	SUM8/L4M	20	3.00	4.00	724.0			54.00	LAYER 4 (FROM TOP)
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-145	SINT/MW/CPM	SUM8/L5M	20	3.00	4.00	714.0			87.00	BOTTOM LAYER
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-145	SINT/CONV/CPM	SUM8/L1C	20	3.00	4.00	509.0			66.00	TOP LAYER
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-145	SINT/CONV/CPM	SUM8/L2C	20	3.00	4.00	446.0			74.00	LAYER 2 FROM TOP
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-145	SINT/CONV/CPM	SUM8/L3C	20	3.00	4.00	502.0			37.00	LAYER 3 FROM TOP
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-145	SINT/CONV/CPM	SUM8/L4C	20	3.00	4.00	463.0			32.00	LAYER 4 FROM TOP
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-145	SINT/CONV/CPM	SUM8/L5C	20	3.00	4.00	534.0			32.00	BOTTOM LAYER
Test Rig = MIL-1942B, WBS Code = 1.1.2.4-ORNL											
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-137	SINT/1800C/1h	SUMMARY	25	3.00	4.00	480.0			86.00	
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-137	SINT/1800C/1h/MW	SUMMARY	25	3.00	4.00	480.0			86.00	
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-141	SINT/1800C/1h/MW	SUMMARY	25	3.00	4.00	310.0			54.00	
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-139J	SINT/1800C/4h	SUMMARY	25	3.00	4.00	415.0			54.00	
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-139	SINT/1800C/4h/MW	SUMMARY	25	3.00	4.00	415.0			54.00	
SRBSN+11.5%La2O3+3%Al2O3	ORNL/TM-139J	SINT/1800C/4h	SUMMARY	1000	3.00	4.00	269.0			31.00	
Test Rig = MIL-1942B, WBS Code = 1.1.2.4-ORNL											
SRBSN+Y2O3+MgO+Al2O3	ORNL/TM-138E	SINT/MW/1800C/4h	SUMMARY	25	3.00	4.00	466.0			35.00	
SRBSN+Y2O3+MgO+Al2O3	ORNL/TM-138F	SINT/MW/1800C/4h	SUMMARY	25	3.00	4.00	422.0			34.00	
SRBSN+Y2O3+MgO+Al2O3	ORNL/TM-138E	SINT/MW/1800C/4h	SUMMARY	1000	3.00	4.00	338.0			52.00	
SRBSN+Y2O3+MgO+Al2O3	ORNL/TM-138F	SINT/MW/1800C/4h	SUMMARY	1000	3.00	4.00	325.0			9.00	
Test Rig = MIL-1942B, WBS Code = 1.1.2.4-ORNL											
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-142	SINT/1800C/1h/MW	SUMMARY	25	3.00	4.00	526.0			17.00	
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-142	SINT/1800C/2h/MW	SUMMARY	25	3.00	4.00	677.0			45.00	
SRBSN+9%Y2O3+3%Al2O3	ORNL/TM-145	SINT/1800C/2h/MW	SUMMARY	25	3.00	4.00	785.0			98.00	

Section 6 - continued

Material	Batch Code	Heat Treatment	Test Env.	Specimen Number	Test Temp. °C	Specimen Width mm	Specimen Thickness mm	Bend Strength MPa	Flaw Type	Std. Dev.
Silicon Carbide Whisker-Reinforced Silicon Nitride-Based Ceramics										
Test Rig = MOR4GCCD1, WBS code = 1.2.2.1-GCCD										
GN-10+SiCw20(AM7)	GCCD/4IT	HIP/T2/H2	AIR	SUMMARY10	21	3.00	4.00	708.0	FAIL. ORIG. 100% SURFACE 60% SURFACE, 40% INTERNAL	83.00
GN-10+SiCw20(AM7)	GCCD/4IT	HIP/T3/H2	AIR	SUMMARY5	21	3.00	4.00	643.8		
GN-10+SiCw20(AM7)	GCCD/4IT	HIP/T4/H2	AIR	SUMMARY5	21	3.00	4.00	445.9	60% SURFACE, 40% INTERNAL 60% SURFACE, 40% INTERNAL 80% SURFACE, 20% INTERNAL	77.00
GN-10+SiCw20(AM7)	GCCD/5IT	HIP/T2/H2	AIR	SUMMARY10	21	3.00	4.00	756.0		
GN-10+SiCw20(AM7)	GCCD/5IT	HIP/T3/H2	AIR	SUMMARY5	21	3.00	4.00	707.3		
GN-10+SiCw20(AM7)	GCCD/5IT	HIP/T4/H2	AIR	SUMMARY5	21	3.00	4.00	683.1		
GN-10+SiCw20(AM7)	GCCD/4IT	HIP/T2/H2	AIR	SUMMARY5	1375	3.00	4.00	381.0		20.00
GN-10+SiCw20(AM7)	GCCD/5IT	HIP/T2/H2	AIR	SUMMARY5	1375	3.00	4.00	393.0		26.00
Test Rig = MOR4GCCD1, WBS code = 1.2.2.1-GCCD										
GN-10+SiCw30(AC3)	GCCD/(3/88)	HIP	AIR	SUMMARY10	21	3.18	6.36	614.0		130.00
GN-10+SiCw30(AM5)	GCCD/(5/88)	HIP	AIR	SUMMARY10	21	3.18	6.36	654.0		56.00
GN-10+SiCw30(AM5E)	GCCD/5/88ETCHED	HIP	AIR	SUMMARY10	21	3.18	6.36	638.0		68.00
GN-10+SiCw30(AM7)	GCCD/4IT	HIP/T2/H2	AIR	SUMMARY10	21	3.00	4.00	626.0		49.00
GN-10+SiCw30(AM7)	GCCD/4IT	HIP/T3/H2	AIR	SUMMARY5	21	3.00	4.00	515.4	40% SURFACE, 60% INTERNAL	110.00
GN-10+SiCw30(AM7)	GCCD/4IT	HIP/T4/H2	AIR	SUMMARY5	21	3.00	4.00	624.5	50% SURFACE, 50% INTERNAL	
GN-10+SiCw30(AM7)	GCCD/5IT	HIP/T2/H2	AIR	SUMMARY10	21	3.00	4.00	648.0	20% SURFACE, 80% INTERNAL 40% SURFACE, 60% INTERNAL	
GN-10+SiCw30(AM7)	GCCD/5IT	HIP/T3/H2	AIR	SUMMARY5	21	3.00	4.00	679.7		
GN-10+SiCw30(AM7)	GCCD/5IT	HIP/T4/H2	AIR	SUMMARY5	21	3.00	4.00	591.3		
GN-10+SiCw30(AM7)	GCCD/4IT	HIP/T2/H2	AIR	SUMMARY5	1375	3.00	4.00	362.0		34.00
GN-10+SiCw30(AM7)	GCCD/5IT	HIP/T2/H2	AIR	SUMMARY5	1375	3.00	4.00	419.0		57.00
GN-10+SiCw30(T105)	GCCD/TAT105	HIP	AIR	SUMMARY10	21	3.18	6.36	539.0		43.00

Figure 2.11. A comparison of bend strengths for three silicon carbide-based ceramics.

Heat Treatment

Figure 2.12. The effects of microwave annealing and test temperature on the bend strength of GS-44.

Figure 2.13. The effects of temperatures on gas pressure-sintered silicon nitride-based ceramics.

Figure 2.14. Heat-treatment effects on the bend strength of several GN-10-based ceramics at room temperature.

Section 7 - Poisson's Ratio Calculations

Material	Batch Code	Heat Treatment	Test Env.	Specimen Number	Poisson's Ratio	Test Temp. °C
Silicon Nitride-Based Ceramics						
WBS code = 1.2.2.1-GCCD						
GN-10	GCCD\BASELINE	T1/H1	AIR	195-3-1	0.26	21
GN-10	GCCD\BASELINE	T1/H1	AIR	195-3-1	0.28	21
GN-10	GCCD\BASELINE	T1/H1	AIR	195-3-2	0.26	21
GN-10	GCCD\BASELINE	T1/H1	AIR	195-3-2	0.26	21
GN-10	GCCD\BASELINE	T1/H1	AIR	195-3-2	0.28	21
GN-10	GCCD\BASELINE	T1/H2	AIR	195-3a-1	0.27	21
GN-10	GCCD\BASELINE	T1/H2	AIR	195-3a-1	0.29	21
GN-10	GCCD\BASELINE	T1/H2	AIR	195-4-1	0.25	21
GN-10	GCCD\BASELINE	T1/H2	AIR	195-4-1	0.27	21
GN-10	GCCD\BASELINE	T1/H2	AIR	195-4-1	0.29	21
GN-10	GCCD\BASELINE	T1/H2	AIR	195-4a-1	0.27	21
GN-10	GCCD\BASELINE	T1/H2	AIR	195-4a-1	0.29	21
GN-10	GCCD\BASELINE	T1/H2	AIR	195-4a-1	0.30	21
GN-10	GCCD\BASELINE	T1/H2	AIR	195-4a-2	0.20	21
GN-10	GCCD\BASELINE	T1/H2	AIR	195-4a-2	0.24	21
GN-10	GCCD\BASELINE	T1/H2	AIR	195-4a-2	0.27	21
Silicon Carbide Whisker-Reinforced Silicon Nitride-Based Ceramics						
WBS code = 1.2.2.1-GCCD						
GN-10+SiCw10(AM7)	GCCD\4IT	T1/H1	AIR	190-3-3	0.25	21
GN-10+SiCw10(AM7)	GCCD\4IT	T1/H1	AIR	190-3-3	0.27	21
GN-10+SiCw10(AM7)	GCCD\4IT	T1/H2	AIR	190-4-3	0.28	21
GN-10+SiCw10(AM7)	GCCD\4IT	T1/H2	AIR	190-4-3	0.27	21
GN-10+SiCw10(AM7)	GCCD\4IT	T2/H1	AIR	222-4-2	0.26	21
GN-10+SiCw10(AM7)	GCCD\4IT	T2/H1	AIR	222-4-2	0.26	21
GN-10+SiCw10(AM7)	GCCD\4IT	T2/H1	AIR	222-4-2	0.27	21
GN-10+SiCw10(AM7)	GCCD\5IT	T1/H1	AIR	196-3-1	0.25	21

Section 7 - continued

Material	Batch Code	Heat Treatment	Test Env.	Specimen Number	Poisson's Ratio	Test Temp. °C
Silicon Carbide Whisker-Reinforced Silicon Nitride-Based Ceramics						
WBS code = 1.2.2.1-GCCD						
GN-10+SiCw10(AM7)	GCCD\5IT	T1/H2	AIR	196-4-1	0.26	21
GN-10+SiCw10(AM7)	GCCD\5IT	T1/H2	AIR	196-4-1	0.26	21
GN-10+SiCw10(AM7)	GCCD\5IT	T1/H2	AIR	196-4-1	0.24	21
GN-10+SiCw10(AM7)	GCCD\5IT	T2/H1	AIR	214-4-1	0.26	21
GN-10+SiCw10(AM7)	GCCD\5IT	T2/H1	AIR	214-4-1	0.25	21
GN-10+SiCw10(AM7)	GCCD\5IT	T2/H1	AIR	214-4-1	0.26	21
GN-10+SiCw10(AM7)	GCCD\5IT	T2/H2	AIR	214-3-2	0.27	21
GN-10+SiCw10(AM7)	GCCD\5IT	T2/H2	AIR	214-3-2	0.26	21
GN-10+SiCw10(AM7)	GCCD\5IT	T2/H2	AIR	214-3-2	0.26	21
WBS code = 1.2.2.1-GCCD						
GN-10+SiCw20(AM7)	GCCD\4IT	T1/H1	AIR	185-3-1	0.24	21
GN-10+SiCw20(AM7)	GCCD\4IT	T1/H1	AIR	185-3-1	0.23	21
GN-10+SiCw20(AM7)	GCCD\4IT	T1/H2	AIR	185-4-2	0.28	21
GN-10+SiCw20(AM7)	GCCD\4IT	T2/H1	AIR	226-4-2	0.25	21
GN-10+SiCw20(AM7)	GCCD\4IT	T2/H1	AIR	226-4-2	0.23	21
GN-10+SiCw20(AM7)	GCCD\4IT	T2/H1	AIR	226-4-2	0.25	21
GN-10+SiCw20(AM7)	GCCD\5IT	T1/H1	AIR	211-3-1	0.25	21
GN-10+SiCw20(AM7)	GCCD\5IT	T1/H1	AIR	211-3-1	0.22	21
GN-10+SiCw20(AM7)	GCCD\5IT	T1/H2	AIR	211-4-1	0.25	21
GN-10+SiCw20(AM7)	GCCD\5IT	T1/H2	AIR	211-4-1	0.26	21
GN-10+SiCw20(AM7)	GCCD\5IT	T2/H1	AIR	199-4-3	0.25	21
GN-10+SiCw20(AM7)	GCCD\5IT	T2/H1	AIR	199-4-3	0.25	21
GN-10+SiCw20(AM7)	GCCD\5IT	T2/H2	AIR	199-3-2	0.24	21
GN-10+SiCw20(AM7)	GCCD\5IT	T2/H2	AIR	199-3-2	0.25	21
GN-10+SiCw20(AM7)	GCCD\5IT	T2/H2	AIR	199-3-2	0.26	21

Section 7 - continued

Material	Batch Code	Heat Treatment	Test Env.	Specimen Number	Poisson's Ratio	Test Temp. °C
Silicon Carbide Whisker-Reinforced Silicon Nitride-Based Ceramics						
WBS code = 1.2.2.1-GCCD						
GN-10+SiCw30(AM7)	GCCD4IT	T1/H1	AIR	228-3-2	0.21	21
GN-10+SiCw30(AM7)	GCCD4IT	T2/H1	AIR	188-4-1	0.24	21
GN-10+SiCw30(AM7)	GCCD4IT	T2/H1	AIR	188-4-1	0.24	21
GN-10+SiCw30(AM7)	GCCD4IT	T1/H1	AIR	228-3-2	0.26	21
GN-10+SiCw30(AM7)	GCCD4IT	T1/H2	AIR	228-4-2	0.24	21
GN-10+SiCw30(AM7)	GCCD4IT	T1/H2	AIR	228-4-2	0.23	21
GN-10+SiCw30(AM7)	GCCD4IT	T1/H1	AIR	228-3-2	0.24	21
GN-10+SiCw30(AM7)	GCCD4IT	T1/H2	AIR	228-4-2	0.23	21
GN-10+SiCw30(AM7)	GCCD5IT	T2/H1	AIR	205-4-1	0.21	21
GN-10+SiCw30(AM7)	GCCD5IT	T2/H1	AIR	205-4-1	0.26	21
GN-10+SiCw30(AM7)	GCCD5IT	T1/H1	AIR	201-2-2	0.19	21
GN-10+SiCw30(AM7)	GCCD5IT	T2/H2	AIR	205-3-1	0.24	21
GN-10+SiCw30(AM7)	GCCD5IT	T1/H2	AIR	201-3-1	0.24	21
GN-10+SiCw30(AM7)	GCCD5IT	T1/H2	AIR	201-3-1	0.24	21
GN-10+SiCw30(AM7)	GCCD5IT	T1/H1	AIR	201-2-2	0.23	21
WBS code = 1.2.2.1-GCCD						
GN-10+SiCw40(AM7)	GCCD4IT	T2/H2	AIR	233-4-2	0.22	21
GN-10+SiCw40(AM7)	GCCD4IT	T1/H2	AIR	193-4-1	0.20	21
GN-10+SiCw40(AM7)	GCCD4IT	T1/H2	AIR	193-4-1	0.21	21
GN-10+SiCw40(AM7)	GCCD4IT	T1/H1	AIR	193-3-2	0.17	21
GN-10+SiCw40(AM7)	GCCD4IT	T2/H2	AIR	233-4-2	0.16	21
GN-10+SiCw40(AM7)	GCCD4IT	T1/H1	AIR	193-3-2	0.19	21
GN-10+SiCw40(AM7)	GCCD5IT	T1/H2	AIR	202-4-1	0.07	21
GN-10+SiCw40(AM7)	GCCD5IT	T2/H2	AIR	205-3-1	0.23	21
GN-10+SiCw40(AM7)	GCCD5IT	T1/H1	AIR	202-3-3	0.22	21
GN-10+SiCw40(AM7)	GCCD5IT	T1/H2	AIR	202-4-1	0.22	21
GN-10+SiCw40(AM7)	GCCD5IT	T1/H1	AIR	202-3-3	0.21	21

Section 8 - Shear Modulus Test Results

Material	Batch Code	Heat Treatment	Test Env.	Specimen Number	Shear Modulus GPa	Test Temp. °C
Silicon Nitride-Based Ceramics						
WBS code = 1.2.2.1-GCCD						
GN-10	GCCD\BASELINE	T1/H1	AIR	195-3-1	128.93	21
GN-10	GCCD\BASELINE	T1/H1	AIR	195-3-1	132.46	21
GN-10	GCCD\BASELINE	T1/H1	AIR	195-3-2	122.68	21
GN-10	GCCD\BASELINE	T1/H1	AIR	195-3-2	127.87	21
GN-10	GCCD\BASELINE	T1/H1	AIR	195-3-2	129.95	21
GN-10	GCCD\BASELINE	T1/H2	AIR	195-3a-1	116.93	21
GN-10	GCCD\BASELINE	T1/H2	AIR	195-3a-1	121.79	21
GN-10	GCCD\BASELINE	T1/H2	AIR	195-4-1	114.86	21
GN-10	GCCD\BASELINE	T1/H2	AIR	195-4-1	125.79	21
GN-10	GCCD\BASELINE	T1/H2	AIR	195-4-1	132.53	21
GN-10	GCCD\BASELINE	T1/H2	AIR	195-4a-1	111.80	21
GN-10	GCCD\BASELINE	T1/H2	AIR	195-4a-1	115.71	21
GN-10	GCCD\BASELINE	T1/H2	AIR	195-4a-1	123.46	21
GN-10	GCCD\BASELINE	T1/H2	AIR	195-4a-2	122.26	21
GN-10	GCCD\BASELINE	T1/H2	AIR	195-4a-2	134.11	21
GN-10	GCCD\BASELINE	T1/H2	AIR	195-4a-2	137.79	21
Silicon Carbide Whisker-Reinforced Silicon Nitride-Based Ceramics						
WBS code = 1.2.2.1-GCCD						
GN-10+SiCw10(AM7)	GCCD\4IT	T1/H1	AIR	190-3-3	129.74	21
GN-10+SiCw10(AM7)	GCCD\4IT	T1/H1	AIR	190-3-3	127.36	21
GN-10+SiCw10(AM7)	GCCD\4IT	T1/H2	AIR	190-4-3	122.86	21
GN-10+SiCw10(AM7)	GCCD\4IT	T1/H2	AIR	190-4-3	132.05	21
GN-10+SiCw10(AM7)	GCCD\4IT	T2/H1	AIR	222-4-2	129.40	21
GN-10+SiCw10(AM7)	GCCD\4IT	T2/H1	AIR	222-4-2	129.85	21
GN-10+SiCw10(AM7)	GCCD\4IT	T2/H1	AIR	222-4-2	128.97	21
GN-10+SiCw10(AM7)	GCCD\5IT	T1/H1	AIR	196-3-1	131.25	21

Section 8 - continued

Material	Batch Code	Heat Treatment	Test Env.	Specimen Number	Shear Modulus GPa	Test Temp. °C
Silicon Carbide Whisker-Reinforced Silicon Nitride-Based Ceramics						
WBS code = 1.2.2.1-GCCD						
GN-10+SiCw10(AM7)	GCCD\5IT	T1/H2	AIR	196-4-1	131.28	21
GN-10+SiCw10(AM7)	GCCD\5IT	T1/H2	AIR	196-4-1	136.46	21
GN-10+SiCw10(AM7)	GCCD\5IT	T1/H2	AIR	196-4-1	139.98	21
GN-10+SiCw10(AM7)	GCCD\5IT	T2/H1	AIR	214-4-1	131.40	21
GN-10+SiCw10(AM7)	GCCD\5IT	T2/H1	AIR	214-4-1	131.76	21
GN-10+SiCw10(AM7)	GCCD\5IT	T2/H1	AIR	214-4-1	128.96	21
GN-10+SiCw10(AM7)	GCCD\5IT	T2/H2	AIR	214-3-2	129.72	21
GN-10+SiCw10(AM7)	GCCD\5IT	T2/H2	AIR	214-3-2	123.89	21
GN-10+SiCw10(AM7)	GCCD\5IT	T2/H2	AIR	214-3-2	128.06	21
WBS code = 1.2.2.1-GCCD						
GN-10+SiCw20(AM7)	GCCD\4IT	T1/H1	AIR	185-3-1	124.01	21
GN-10+SiCw20(AM7)	GCCD\4IT	T1/H1	AIR	185-3-1	118.51	21
GN-10+SiCw20(AM7)	GCCD\4IT	T1/H2	AIR	185-4-2	120.85	21
GN-10+SiCw20(AM7)	GCCD\4IT	T2/H1	AIR	226-4-2	132.72	21
GN-10+SiCw20(AM7)	GCCD\4IT	T2/H1	AIR	226-4-2	132.76	21
GN-10+SiCw20(AM7)	GCCD\4IT	T2/H1	AIR	226-4-2	133.66	21
GN-10+SiCw20(AM7)	GCCD\5IT	T1/H1	AIR	211-3-1	137.88	21
GN-10+SiCw20(AM7)	GCCD\5IT	T1/H1	AIR	211-3-1	130.60	21
GN-10+SiCw20(AM7)	GCCD\5IT	T2/H1	AIR	199-4-3	132.23	21
GN-10+SiCw20(AM7)	GCCD\5IT	T2/H1	AIR	199-4-3	131.38	21
GN-10+SiCw20(AM7)	GCCD\5IT	T2/H2	AIR	199-3-2	133.06	21
GN-10+SiCw20(AM7)	GCCD\5IT	T2/H2	AIR	199-3-2	130.37	21
GN-10+SiCw20(AM7)	GCCD\5IT	T2/H2	AIR	199-3-2	128.71	21

Section 8 - continued

Material	Batch Code	Heat Treatment	Test Env.	Specimen Number	Shear Modulus GPa	Test Temp. °C
Silicon Carbide Whisker-Reinforced Silicon Nitride-Based Ceramics						
WBS code = 1.2.2.1-GCCD						
GN-10+SiCw30(AM7)	GCCD4IT	T1/H1	AIR	228-3-2	124.11	21
GN-10+SiCw30(AM7)	GCCD4IT	T1/H1	AIR	228-3-2	125.60	21
GN-10+SiCw30(AM7)	GCCD4IT	T1/H1	AIR	228-3-2	135.03	21
GN-10+SiCw30(AM7)	GCCD4IT	T1/H2	AIR	228-4-2	130.52	21
GN-10+SiCw30(AM7)	GCCD4IT	T1/H2	AIR	228-4-2	133.63	21
GN-10+SiCw30(AM7)	GCCD4IT	T1/H2	AIR	228-4-2	139.54	21
GN-10+SiCw30(AM7)	GCCD4IT	T2/H1	AIR	188-4-1	136.54	21
GN-10+SiCw30(AM7)	GCCD4IT	T2/H1	AIR	188-4-1	140.00	21
GN-10+SiCw30(AM7)	GCCD5IT	T1/H1	AIR	201-2-2	118.83	21
GN-10+SiCw30(AM7)	GCCD5IT	T1/H1	AIR	201-2-2	135.08	21
GN-10+SiCw30(AM7)	GCCD5IT	T1/H2	AIR	201-3-1	136.21	21
GN-10+SiCw30(AM7)	GCCD5IT	T1/H2	AIR	201-3-1	137.29	21
GN-10+SiCw30(AM7)	GCCD5IT	T2/H1	AIR	205-4-1	129.46	21
GN-10+SiCw30(AM7)	GCCD5IT	T2/H1	AIR	205-4-1	141.90	21
GN-10+SiCw30(AM7)	GCCD5IT	T2/H2	AIR	205-3-1	132.65	21
WBS code = 1.2.2.1-GCCD						
GN-10+SiCw40(AM7)	GCCD4IT	T1/H1	AIR	193-3-2	113.75	21
GN-10+SiCw40(AM7)	GCCD4IT	T1/H1	AIR	193-3-2	126.25	21
GN-10+SiCw40(AM7)	GCCD4IT	T1/H2	AIR	193-4-1	111.46	21
GN-10+SiCw40(AM7)	GCCD4IT	T1/H2	AIR	193-4-1	112.78	21
GN-10+SiCw40(AM7)	GCCD4IT	T2/H2	AIR	233-4-2	146.24	21
GN-10+SiCw40(AM7)	GCCD4IT	T2/H2	AIR	233-4-2	158.97	21
GN-10+SiCw40(AM7)	GCCD5IT	T1/H1	AIR	202-3-3	134.35	21
GN-10+SiCw40(AM7)	GCCD5IT	T1/H1	AIR	202-3-3	134.91	21
GN-10+SiCw40(AM7)	GCCD5IT	T1/H2	AIR	202-4-1	147.21	21
GN-10+SiCw40(AM7)	GCCD5IT	T1/H2	AIR	202-4-1	198.60	21

Section 8 - continued

Material	Batch Code	Heat Treatment	Test Env.	Specimen Number	Shear Modulus GPa	Test Temp. °C
Silicon Carbide Whisker-Reinforced Silicon Nitride-Based Ceramics						
WBS code = 1.2.2.1-GCCD						
GN-10+SiCw40(AM7)	GCCD\5IT	T2/H2	AIR	205-3-1	140.23	21
SiAlON-Based Ceramics						
Data from Detroit Diesel						
NT-451	NORTON/REF.			SUMMARY	119	22

Figure 2.15. Heat-treatment effects on the shear modulus of GN-10-based ceramics at room temperature.

Section 9 - Stress-Rupture Test Results

Material	Batch Code	Heat Treatment	Test Env	Specimen Number	Test Temp °C	Stress MPa	Rupture Time Hours	Time Disc. Hours	Creep Strain %	Minimum Creep Rate m/m/s	Comments
Silicon Carbide-Based Ceramics											
Test Rig = STRPUDRI1, WBS code = 3.3.1.4-UDRI											
NT-230	NORTON/UDRI		AIR	67*	1350	237	30.00				*SPEC. BENT 187 MM
NT-230	NORTON/UDRI		AIR	60*	1350	237	116.80				*SPEC. BENT 112 MM
NT-230	NORTON/UDRI		AIR	61*	1350	237	116.80				*SPEC. BENT 106 MM
NT-230	NORTON/UDRI		AIR	68*	1350	237	118.60				*SPEC. BENT 174 MM
NT-230	NORTON/UDRI		AIR	69*	1350	237	120.20				*SPEC. BENT 163 MM
NT-230	NORTON/UDRI		AIR	66*	1350	305	30.00				*SURFACE FAILURE
NT-230	NORTON/UDRI		AIR	65*	1350	305	106.30				*SPEC. BENT 191 MM
NT-230	NORTON/UDRI		AIR	63*	1350	305	163.00				*SPEC. BENT 169 MM
NT-230	NORTON/UDRI		AIR	64*	1350	305	163.00				*SPEC. BENT 164 MM
Silicon Nitride-Based Ceramics											
Test Rig = STRPORN1, WBS code = 3.2.1.4-ORN1											
GN-10	ORN1/KCL92		AIR	F-2	1204	207	41.16		0.8710	3.5E-08	
GN-10	ORN1/KCL92		AIR	E-2	1204	207	57.35		0.6330	1.54E-08	
GN-10	ORN1/KCL92		AIR	F-3	1204	224	9.92		0.5130	1.34E-07	
GN-10	ORN1/KCL92		AIR	F-4	1204	224	13.55		0.6620	1.24E-07	
GN-10	ORN1/KCL92		AIR	G-2	1204	241	23.48		0.4930	4.37E-08	
GN-10	ORN1/KCL92		AIR	F-1	1260	155	12.65		1.1910	1.65E-07	
GN-10	ORN1/KCL92		AIR	E-3	1260	155	20.76		0.8790	6.51E-08	
GN-10	ORN1/KCL92		AIR	G-3	1260	172	13.78		0.7400	1.05E-07	
GN-10	ORN1/KCL92		AIR	E-1	1315	103	18.40		1.1010	9.69E-08	
Test Rig = STRPUDRI1, WBS code = 3.3.1.4-UDRI											
GN-10	GCCD/UDRI/1		AIR	38	1300	274	14.70				SPECIMEN BENT
GN-10	GCCD/UDRI/1		AIR	40	1300	274	23.20				SPECIMEN BENT
GN-10	GCCD/UDRI/1		AIR	37	1300	274	104.30				SPECIMEN BENT
GN-10	GCCD/UDRI/1		AIR	39	1300	274	104.90				SPECIMEN BENT
GN-10	GCCD/UDRI/1		AIR	35	1350	274	5.40				PITTING
GN-10	GCCD/UDRI/1		AIR	36	1350	274	112.80				SPECIMEN BENT
GN-10	GCCD/UDRI/1		AIR	33	1350	300	7.00				EDGE
GN-10	GCCD/UDRI/1		AIR	34	1350	300	7.30				EDGE
GN-10	GCCD/UDRI/1		AIR	31	1350	465	3.20				
GN-10	GCCD/UDRI/1		AIR	32	1350	465	32.60				SURFACE FLAW

Section 9 - continued

Material	Batch Code	Heat Treatment	Test Env	Specimen Number	Test Temp °C	Stress MPa	Rupture Time Hours	Time Disc. Hours	Creep Strain %	Minimum Creep Rate m/m/s	Comments
Test Rig = STRPORN12, WBS code = 1.1.2.4-ORNL											
GS-44	ORNL/GCC-AS CRDA	ANN/1800C/2h/MW	AIR	SUMMARY	900	379	0.07				
GS-44	ORNL/GCC-AS CRDA	BASELINE-NONE	AIR	SUMMARY	900	379	0.30				
GS-44	ORNL/GCC-AS CRDA	ANN/1600C/10h/MW	AIR	SUMMARY	900	379		24.0			
GS-44	ORNL/GCC-AS CRDA	ANN/1700C/10h/MW	AIR	SUMMARY	900	379		24.0			
GS-44	ORNL/GCC-AS CRDA	ANN/1800C/2h/MW	AIR	SUMMARY	900	413	0.01				
GS-44	ORNL/GCC-AS CRDA	ANN/1700C/10h/MW	AIR	SUMMARY	900	413	4.21				
GS-44	ORNL/GCC-AS CRDA	ANN/1600C/10h/MW	AIR	SUMMARY	900	413	724.00				
Test Rig = STRPORN11, WBS code = 3.2.1.4-ORNL											
NT-154	ORNL/KCL92		AIR	NTC-32	1204	362		159.7	0.1540	1.14E-09	TEST STOPPED
NT-154	ORNL/KCL92		AIR	NTC-33*	1204	362	0.30		0.0096	5.56E-08	LARGE INTERNAL FLAW
NT-154	ORNL/KCL92		AIR	NTC-34*	1204	362	2.31		0.0157	3.02E-09	LARGE INTERNAL FLAW
Test Rig = STRPUDRI1, WBS code = 3.3.1.4-UDRI											
NT-164	NORTON/UDRI-92		AIR	84	1350	261	102.00				SPECIMEN BENT
NT-164	NORTON/UDRI-92		AIR	13	1350	261	102.00				SPECIMEN BENT
NT-164	NORTON/UDRI-92		AIR	83	1350	261	102.70				SPECIMEN BENT
NT-164	NORTON/UDRI-92		AIR	82	1350	385	0.40				EDGE FLAW
NT-164	NORTON/UDRI-92		AIR	80	1350	385	0.65				SURFACE FLAW
NT-164	NORTON/UDRI-92		AIR	81	1350	385	1.05				SURFACE FLAW
NT-164	NORTON/UDRI-92		AIR	78	1350	385	3.70				SPECIMEN BENT
NT-164	NORTON/UDRI-92		AIR	79	1350	385	108.70				SURFACE FLAW
NT-164	NORTON/UDRI-92		AIR	77	1350	527	5.30				SURFACE FLAW
Test Rig = STRPUDRI1, WBS code = 3.3.1.4-UDRI											
SN-253	KYOCERA/UDRI/93		AIR	73*	1092	412	2.40				FAILED IN HEATUP
SN-253	KYOCERA/UDRI/93		AIR	59	1270	309		66.0			242 UM DEFLECTION
SN-253	KYOCERA/UDRI/93		AIR	60	1270	309		66.0			315 UM DEFLECTION
SN-253	KYOCERA/UDRI/93		AIR	63	1315	412	6.40				SPECIMEN FRACTURED
SN-253	KYOCERA/UDRI/93		AIR	64	1315	412		133.0			1006 UM DEFLECTION
SN-253	KYOCERA/UDRI/93		AIR	61	1350	309		102.0			1089 UM DEFLECTION
SN-253	KYOCERA/UDRI/93		AIR	62	1350	309		102.0			890 UM DEFLECTION
SN-253	KYOCERA/UDRI/93		AIR	74	1350	412		101.0			1410 UM DEFLECTION
SN-253	KYOCERA/UDRI/93		AIR	65	1350	412	33.00				SPECIMEN FRACTURED

Figure 2.16. Stress-rupture test results for GN-10 tested at Oak Ridge National Laboratory (ORNL) at the University of Dayton Research Institute (UDRI).

Figure 2.17. Stress-rupture test results for several silicon nitride-based ceramics tested at 1350°C.

Section 10 - Tensile Test Results

Material	Batch Code	Test Env.	Specimen Number*	Test Temp °C	Tensile Strength MPa	Weibull Modulus	Specimen Geometry	Comments
Silicon Carbide-Based Ceramics								
Test Rig = TENSORNL1, WBS code = 1.1.1.3-CARB								
HEXOLOY SX-G1	CARB/8/1991	AIR	SUMMARY15	21	446	3	ORNL Buttonhead	STRESS RATE = 11 MPa/s
HEXOLOY SX-G1	CARB/8/1991	AIR	SUMMARY8	1000	384	6.5	ORNL Buttonhead	STRESS RATE = 11 MPa/s
HEXOLOY SX-G1	CARB/8/1991	AIR	SUMMARY8	1232	325	4.3	ORNL Buttonhead	STRESS RATE = 11 MPa/s
HEXOLOY SX-G1	CARB/8/1991	AIR	SUMMARY6	1370	286	4.5	ORNL Buttonhead	STRESS RATE = 11 MPa/s
HEXOLOY SX-G1	CARB/8/1991	AIR	SUMMARY2	1370	281		ORNL Buttonhead	STRESS RATE = 0.11 MPa/s

* The number of tests used to calculate the average strength values is provided after "SUMMARY."

Section 11 - Thermal Conductivity Results

Material	Batch Code	Specimen Number	Thermal Conductivity W/m*K	Test Temp. °C
SiAlON-Based Ceramic				
Data from Detroit Diesel				
NT-451	NORTON/REF.	SUMMARY	19.8	30
NT-451	NORTON/REF.	SUMMARY	15.2	400
NT-451	NORTON/REF.	SUMMARY	14.6	600
NT-451	NORTON/REF.	SUMMARY	12.3	900
NT-451	NORTON/REF.	SUMMARY	11.2	1000
NT-451	NORTON/REF.	SUMMARY	9.9	1200

Section 12 - Thermal Diffusivity Results

Material	Batch Code	Specimen Number	Thermal Diffusivity cm ² /s	Test Temp. °C
SiAlON-Based Ceramic				
Data from Detroit Diesel				
NT-451	NORTON/REF.	SUMMARY	0.870	30
NT-451	NORTON/REF.	SUMMARY	0.045	400
NT-451	NORTON/REF.	SUMMARY	0.040	600
NT-451	NORTON/REF.	SUMMARY	0.032	900
NT-451	NORTON/REF.	SUMMARY	0.029	1000
NT-451	NORTON/REF.	SUMMARY	0.025	1200

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Arlington VA 22209

James H. Adair
University of Florida
Materials Science & Engineering
317 MAE Bldg.
Gainesville FL 32611-2066

Donald F. Adams
University of Wyoming
Mechanical Engineering Department
P.O. Box 3295
Laramie WY 82071

Jalees Ahmad
AdTech Systems Research Inc.
Solid Mechanics
1342 N. Fairfield Road
Dayton OH 45432-2698

Yoshio Akimune
NISSAN Motor Co., Ltd.
Materials Research Laboratory
1 Natsushima-Cho
Yokosuka 237
JAPAN

Mufit Akinc
Iowa State University
322 Spedding Hall
Ames IA 50011

Ilhan A. Aksay
Princeton University
A313 Engineering Quadrangle
Princeton NJ 08544-5263

R. G. Alexander
BASE
26 Malvern Close
Kettering Northants NN16 8JP
UNITED KINGDOM

Richard L. Allor
Ford Motor Company
Materials Systems Reliability
P.O. Box 2053, Room S-2031
Dearborn MI 48121-2053

Joseph E. Amaral
Instron Corporation
Corporate Engineering Office
100 Royale Street
Canton MA 02021

Edward M. Anderson
Aluminum Company of America
N. American Industrial Chemical
P.O. Box 300
Bauxite AR 72011

Norman C. Anderson
Ceradyne, Inc.
Ceramic-to-Metal Division
3169 Redhill Avenue
Costa Mesa CA 92626

Don Anson
BCL
Thermal Power Systems
505 King Avenue
Columbus OH 43201-2693

Thomas Arbanas
G.B.C. Materials Corporation
580 Monastery Drive
Latrobe PA 15650-2698

Frank Armatiss
3M Company
Building 60-1N-01
St. Paul MN 55144-1000

Everett B. Arnold
Detroit Diesel Corporation
Mechanical Systems Technology
13400 Outer Drive West
Detroit MI 48239-4001

Bertil Aronsson
Sandvik AB
S-12680
Stockholm Lerkrogsvagen 19
SWEDEN

Dennis Assanis
University of Illinois
Dept. of Mechanical Engineering
1206 W. Green Street
Urbana IL 61801

V. S. Avva
North Carolina A&T State Univ.
Dept. of Mechanical Engineering
Greensboro NC 27411

Patrick Badgley
Adiabatics, Inc.
3385 Commerce Drive
Columbus IN 47201

Sunggi Baik
Pohang Institute of Sci. & Tech.
P.O. Box 125
Pohang 790-600
KOREA

John M. Bailey
Consultant
Caterpillar, Inc.
P.O. Box 1875
Peoria IL 61656-1875

Bob Baker
Ceradyne, Inc.
3169 Redhill Avenue
Costa Mesa CA 92626

Frank Baker
Aluminum Company of America
Alcoa Technical Center
Alcoa Center PA 15069

Clifford P. Ballard
AlliedSignal Aerospace Company
Ceramics Program
P.O. Box 1021
Morristown NJ 07962-1021

B. P. Bandyopadhyay
University of North Dakota
Mechanical Engineering Department
Grand Forks ND 58202-8359

P. M. Barnard
Ruston Gas Turbines Limited
P.O. Box 1
Lincoln LN2 5DJ
ENGLAND

Harold N. Barr
Hittman Corporation
9190 Red Branch Road
Columbia MD 21045

Renald D. Bartoe
Vesuvius McDanel
510 Ninth Avenue
Box 560
Beaver Falls PA 15010-0560

David L. Baty
Babcock & Wilcox - LRC
P.O. Box 11165
Lynchburg VA 24506-1165

Donald F. Baxter, Jr.
ASM International
Advanced Materials & Processes
Materials Park OH 44073-0002

M. Brad Beardsley
Caterpillar Inc.
Technical Center Bldg. E
P.O. Box 1875
Peoria IL 61656-1875

John C. Bell
Shell Research Limited
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P.O. Box 1
Chester CH1 3SH
ENGLAND

M. Bentele
Xamag, Inc.
259 Melville Avenue
Fairfield CT 06430

Larry D. Bentsen
BFGoodrich Company
R&D Center
9921 Brecksville Road
Brecksville OH 44141

Joseph C. Bentz
ENCERATEC
2525 Sandcrest Drive
Columbus IN 47203

Louis Beregszazi
Defiance Precision Products
P.O. Drawer 428
Defiance OH 43512

Tom Bernecki
Northwestern University
1801 Maple Avenue
Evanston IL 60201-3135

Charles F. Bersch
Institute for Defense Analyses
1801 N. Beauregard Street
Alexandria VA 22311

Ram Bhatt
NASA Lewis Research Center
21000 Brookpark Road
Cleveland OH 44135

Deane I. Biehler
Caterpillar Inc.
Engineering Research Materials
P.O. Box 1875, Bldg. E
Peoria IL 61656-1875

John W. Bjerklie
Consolidated Natural Gas Service
Co. Inc.
Research Department
Pittsburgh PA 15222-3199

William D. Bjorndahl
TRW, Inc.
One Space Park, MS:R6-2188
Building 01, Room 2040
Redondo Beach CA 90278

Keith A. Blakely
Advanced Refractory Technologies,
Inc.
699 Hertel Avenue
Buffalo NY 14207

Edward G. Blanchard
Netzsch Inc.
119 Pickering Way
Exton PA 19341

Bruce Boardman
Deere and Company Technical Ctr.
3300 River Drive
Moline IL 61265

Russell Bockstedt
Hoechst Celanese Corporation
150 JFK Parkway
Short Hills NJ 07078

M. Boehmer
DLR German Aerospace Research
Estab.
Postfach 90 60 58
D-5000 Koln 90
GERMANY

Lawrence P. Boesch
EER Systems Corp.
1593 Spring Hill Road
Vienna VA 22182-2239

Donald H. Boone
Boone & Associates
2412 Cascade Drive
Walnut Creek CA 94598-4313

Tom Booth
AlliedSignal, Inc.
AiResearch Los Angeles Division
2525 West 190th Street
Torrance CA 90509-2960

Tibor Bornemisza
Sundstrand Power Systems
4400 Ruffin Road
San Diego CA 92186-5757

J.A.M. Boulet
University of Tennessee
Engineering Science and Mechanics
Knoxville TN 37996-2030

H. Kent Bowen
Massachusetts Institute of
Technology
77 Massachusetts Ave., Rm E40-434
Cambridge MA 02139

Leslie J. Bowen
Materials Systems
53 Hillcrest Road
Concord MA 01742

Steven C. Boyce
Air Force Office of Scientific
Research
AFOSR/NA Bldg. 410
Bolling AFB DC 20332-6448

Gary L. Boyd
Ceramic Engineering Consulting
328 Sneath Way
Alpine CA 91901

Steve Bradley
UOP Research Center
50 E. Algonquin Road
Des Plaines IL 60017-6187

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Cummins Engine Company, Inc.
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1310 Beulah Road
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John J. Brennan
United Technologies Corporation
Silver Lane, MS:24
East Hartford CT 06108

Jeff D. Bright
Ceramatec, Inc.
2425 South 900 West
Salt Lake City UT 84108

Terrence K. Brog
Golden Technologies Company
4545 McIntyre Street
Golden CO 80403

Gunnar Broman
317 Fairlane Drive
Spartanburg SC 29302

Al Brown
High-Tech Materials Alert
P.O. Box 882
Dayton NJ 08810

Jesse J. Brown
VPI & SU
Ctr. for Advanced Ceram Materials
Blacksburg VA 24061-0256

Sherman D. Brown
University of Illinois
Materials Science and Engineering
105 South Goodwin Avenue
Urbana IL 61801

S. L. Bruner
Ceramatec, Inc.
2425 South 900 West
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Walter Bryzik
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AMERCOM, Inc.
8928 Fullbright Avenue
Chatsworth CA 91311

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Massachusetts Institute of
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77 Massachusetts Ave., Room 1-280
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Ethyl Corporation
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Chand Kare Technical Ceramics
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Idaho National Engineering Lab
P.O. Box 1625
Idaho Falls ID 83415-3525

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U.S. Army Materials Technology
AMTL-EMM
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AlliedSignal Aerospace Company
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Idaho National Engineering Lab
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North Carolina State University
Materials Engineering Department
P.O. Box 7907
Raleigh NC 27695

Thomas DeAngelis
Carborundum Company
Niagara Falls R&D Center
P.O. Box 832
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George DeBell
Ford Motor Company
Material Systems Reliability
P.O. Box 2053, Room S-2023
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RSA Research Group
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Holbrook NY 11741

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Union Carbide Specialty Powders
1555 Main Street
Indianapolis IN 46224

John Dodsworth
Vesuvius Research & Development
Technical Ceramics Group
Box 560
Beaver Falls PA 15010

B. Dogan
 Institut für Werkstofforschung
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 Columbus OH 43201-2693

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Chuck J. Dziedzic
 Coors Ceramics Company
 17750 West 32nd Avenue
 Golden CO 80401

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 Engineered Materials & Processes
 P.O. Box 5800
 Albuquerque NM 87185-5800

Jeffrey Eagleson
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 1001 Connecticut Avenue, N.W.
 Washington DC 20036

Harry E. Eaton
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 Silver Lane
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 Niagara Falls NY 14302-0832

J. J. Eberhardt
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 CE-34, Forrestal Building
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Jim Edler
 Eaton Corporation
 26201 Northwestern Highway
 P.O. Box 766
 Southfield MI 48037

G. A. Eisman
 Dow Chemical Company
 Ceramics and Advanced Materials
 52 Building
 Midland MI 48667

William A. Ellingson
 Argonne National Laboratory
 Energy Technology Division
 9700 S. Cass Avenue
 Argonne IL 60439

William S. Ellis
 Machined Ceramics
 629 N. Graham Street
 Bowling Green KY 42101

Glen B. Engle
Nuclear & Aerospace Materials
16716 Martincoit Road
Poway CA 92064

Jeff Epstein
Ceramic Technologies, Inc.
12739 Ashford Knoll
Houston TX 77082

Kenneth A. Epstein
Dow Chemical USA
800 Building
Midland MI 48667

Art Erdemir
Argonne National Laboratory
9700 S. Cass Avenue
Argonne IL 60439

E. M. Erwin
Lubrizol Corporation
1819 East 225th Street
Euclid OH 44117

John N. Eustis
U.S. Department of Energy
Industrial Energy Efficiency Div
CE-221, Forrestal Building
Washington DC 20585

W. L. Everitt
Kyocera International, Inc.
8611 Balboa Avenue
San Diego CA 92123

Gordon Q. Evison
332 S. Michigan Avenue
Suite 1730
Chicago IL 60604

John W. Fairbanks
U.S. Department of Energy
Office of Propulsion Systems
CE-322, Forrestal Building
Washington DC 20585

Tim Fawcett
Dow Chemical Company
Advanced Ceramics Laboratory
1776 Building
Midland MI 48674

Robert W. Fawley
Sundstrand Power Systems
Div. of Sundstrand Corporation
P.O. Box 85757
San Diego CA 92186-5757

John J. Fedorchak
GTE Products Corporation
Hawes Street
Towanda PA 18848-0504

Jeff T. Fenton
Vista Chemical Company
900 Threadneedle
Houston TX 77079

Larry Ferrell
Babcock & Wilcox
Old Forest Road
Lynchburg VA 24505

Raymond R. Fessler
BIRL
1801 Maple Avenue
Evanston IL 60201

Ross F. Firestone
Ross Firestone Company
188 Mary Street
Winnetka IL 60093-1520

Sharon L. Fletcher
Arthur D. Little, Inc.
15 Acorn Park
Cambridge MA 02140-2390

Thomas F. Foltz
Textron Specialty Materials
2 Industrial Avenue
Lowell MA 01851

Renee G. Ford
Materials and Processing Report
P.O. Box 72
Harrison NY 10528

John Formica
Supermaterials
2020 Lakeside Avenue
Cleveland OH 44114

Edwin Frame
Southwest Research Institute
P.O. Drawer 28510
San Antonio TX 78284

Armanet Francois
French Scientific Mission
4101 Reservoir Road, N.W.
Washington DC 20007-2176

R. G. Frank
Technology Assessment Group
10793 Bentley Pass Lane
Loveland OH 45140

David J. Franus
Forecast International
22 Commerce Road
Newtown CT 06470

Marc R. Freedman
NASA Lewis Research Center
21000 Brookpark Road, MS:49-3
Cleveland OH 44135

Douglas Freitag
LTV Missiles Division
P.O. Box 650003, MS:WT-21
Dallas TX 75265

Brian R.T. Frost
Argonne National Laboratory
9700 S. Cass Avenue, Bldg. 900
Argonne IL 60439

Lawrence R. Frost
Instron Corporation
100 Royall Street
Canton MA 02021

George A. Fryburg
Norton/TRW Ceramics
7A-4 Raymond Avenue
Salem NH 03079

Xiren Fu
Shanghai Institute of Ceramics
1295 Ding-xi Road
Shanghai 200050
CHINA

J. P. Gallagher
University of Dayton Research
Institute
300 College Park, JPC-250
Dayton OH 45469-0120

Garry Garvey
Golden Technologies Company Inc.
4545 McIntyre Street
Golden CO 80403

Joy A. Garwood
Norton Company
Advanced Ceramics
Goddard Road
Northboro MA 01532-1545

Richard Gates
NIST
Materials Bldg., A-256
Gaithersburg MD 20899

L. J. Gauckler
ETH-Zurich
Sonneggstrasse 5
CH-8092 Zurich 8092
SWITZERLAND

George E. Gazza
U.S. Army Materials Technology
Ceramics Research Division
405 Arsenal Street
Watertown MA 02172-0001

D. Gerster
CEA-DCOM
33 Rue De La Federation
Paris 75015
FRANCE

John Ghinazzi
Coors Technical Ceramics Company
1100 Commerce Park Drive
Oak Ridge TN 37830

Robert Giddings
General Electric Company
P.O. Box 8
Schenectady NY 12301

A. M. Glaeser
University of California
Lawrence Berkeley Laboratory
Hearst Mining Building
Berkeley CA 94720

Joseph W. Glatz
Naval Air Propulsion Center
Systems Engineering Division
P.O. Box 7176, PE24
Trenton NJ 08628

W. M. Goldberger
Superior Graphite Company
R&D
2175 E. Broad Street
Columbus OH 43209

Allan E. Goldman
U.S. Graphite, Inc.
907 W. Outer Drive
Oak Ridge TN 37830

Stephen T. Gonczy
Allied Signal Research
P.O. Box 5016
Des Plaines IL 60017

Jeffrey M. Gonzales
GTE Products Corporation
Hawes Street
Towanda PA 18848-0504

Robert J. Gottschall
U.S. Department of Energy
ER-131, MS:G-236
Washington DC 20545

Earl Graham
Cleveland State University
Dept. of Chemical Engineering
Euclid Avenue at East 24th Street
Cleveland OH 44115

John W. Graham
Astro Met, Inc.
9974 Springfield Pike
Cincinnati OH 45215

G. A. Graves
U. of Dayton Research Institute
300 College Park
Dayton OH 45469-0001

Robert E. Green, Jr.
Johns Hopkins University
Materials Science and Engineering
Baltimore MD 21218

Lance Groseclose
General Motors Corporation
Allison Gas Turbine Division
P.O. Box 420, MS:W-5
Indianapolis IN 46206

Thomas J. Gross
U.S. Department of Energy
Transportation Technologies
CE-30, Forrestal Building
Washington DC 20585

Mark F. Gruninger
Union Carbide Corporation
Specialty Powder Business
1555 Main Street
Indianapolis IN 46224

Ernst Gugel
Cremer Forschungsinstitut
GmbH&Co.KG
Oeslauer Strasse 35
D-8633 Roedental 8633
GERMANY

Donald L. Guile
Corning Glass Works
SP-DV-1-9
Corning NY 14831

John P. Gyekenyesi
NASA Lewis Research Center
21000 Brookpark Road, MS:6-1
Cleveland OH 44135

Nabil S. Hakim
Detroit Diesel Corporation
13400 Outer Drive West
Detroit MI 48239

Philip J. Haley
General Motors Corporation
P.O. Box 420, MS:T12A
Indianapolis IN 46236

Judith Hall
Fiber Materials, Inc.
Biddeford Industrial Park
5 Morin Street
Biddeford ME 04005

Y. Hamano
Kyocera Industrial Ceramics Corp.
5713 E. Fourth Plain Blvd.
Vancouver WA 98661-6857

Y. Harada
IIT Research Institute
10 West 35th Street
Chicago IL 60616

R. A. Harmon
25 Schalren Drive
Latham NY 12110

Norman H. Harris
Hughes Aircraft Company
P.O. Box 800520
Saugus CA 91380-0520

Alan M. Hart
Dow Chemical Company
1776 Building
Midland MI 48674

Pat E. Hart
Battelle Pacific Northwest Labs
Ceramics and Polymers Development
P.O. Box 999
Richland WA 99352

Stephen D. Hartline
Norton Company
Advanced Ceramics
Goddard Road
Northboro MA 01532-1545

Michael H. Haselkorn
Caterpillar In.
Technical Center, Building E
P.O. Box 1875
Peoria IL 61656-1875

N. B. Havewala
Corning Inc.
SP-PR-11
Corning NY 14831

John Haygarth
Teledyne WAA Chang Albany
P.O. Box 460
Albany OR 97321

Norman L. Hecht
U. of Dayton Research Institute
300 College Park
Dayton OH 45469-0172

Peter W. Heitman
General Motors Corporation
P.O. Box 420, MS:W-5
Indianapolis IN 46206-0420

Robert W. Hendricks
VPI & SU
210 Holden Hall
Blacksburg VA 24061-0237

Wynne Henley
Hertel Cutting Technologies Inc.
1000 Clearview Court
Oak Ridge TN 37830

Thomas L. Henson
GTE Products Corporation
Chemical & Metallurgical Division
Hawes Street
Towanda PA 18848

Thomas P. Herbell
NASA Lewis Research Center
21000 Brookpark Road, MS:49-3
Cleveland OH 44135

Marlene Heroux
Rolls-Royce, Inc.
2849 Paces Ferry Road, Suite 450
Atlanta GA 30339-3769

Robert L. Hershey
Science Management Corporation
1255 New Hampshire Ave., N.W.
Suite 1033
Washington DC 20036

Hendrik Heystek
Bureau of Mines
Tuscaloosa Research Center
P.O. Box L
University AL 35486

Robert V. Hillery
GE Aircraft Engines
One Neumann Way, M.D. H85
Cincinnati OH 45215

Arthur Hindman
Instron Corporation
100 Royall Street
Canton MA 02021

Hans Erich Hintermann
CSEM
Rue Breguet 2
Neuchatel 2000
SWITZERLAND

Shinichi Hirano
Mazda R&D of North America, Inc.
1203 Woodridge Avenue
Ann Arbor MI 48105

Tommy Hiraoka
NGK Locke, Inc.
1000 Town Center
Southfield MI 48075

Fu H. Ho
General Atomics
P.O. Box 85608
San Diego CA 92186-9784

John M. Hobday
U.S. Department of Energy
Morgantown Energy Technology Ctr
P.O. Box 880
Morgantown WV 26507

Clarence Hoenig
Lawrence Livermore National Lab
P.O. Box 808, Mail Code L-369
Livermore CA 94550

Thomas Hollstein
Fraunhofer-Institut fur
Werkstoffmechanik
Wohlerstrabe 11
D-7800 Freiburg
GERMANY

Richard Holt
National Research Council Canada
Structures and Materials Lab
Ottawa Ontario K1A 0R6
CANADA

Michael Horgan
Materials Engineering Magazine
1100 Superior Avenue
Cleveland OH 44114

Woodie Howe
Coors Technical Ceramics Company
1100 Commerce Park Drive
Oak Ridge TN 37830

Stephen M. Hsu
NIST
Gaithersburg MD 20899

Hann S. Huang
Argonne National Laboratory
9700 S. Cass Avenue
Argonne IL 60439-4815

Gene Huber
Precision Ferrites & Ceramics
5576 Corporate Drive
Cypress CA 90630

Harold A. Huckins
Princeton Advanced Technology
4 Bertram Place
Hilton Head SC 29928

Fred R. Huettig
Advanced Magnetics Inc.
45 Corey Lane
Mendham NJ 07945

Brian K. Humphrey
Lubrizol Petroleum Chemicals Co.
3000 Town Center, Suite 1340
Southfield MI 48075-1201

Robert M. Humrick
Dylon Ceramic Technologies
3100 Edgehill Road
Cleveland Heights OH 44118

Lorretta Inglehart
National Science Foundation
Division of Materials Research
1800 "G" Street, N.W., Room 408
Washington DC 20550

Michael S. Inoue
Kyocera International, Inc.
8611 Balboa Avenue
San Diego CA 92123-1580

Joseph C. Jackson
U.S. Advanced Ceramics Assoc.
1600 Wilson Blvd., Suite 1008
Arlington VA 22209

Osama Jadaan
U. of Wisconsin-Platteville
1 University Plaza
Platteville WI 53818

Said Jahanmir
NIST
Materials Bldg., Room A-237
Gaithersburg MD 20899

Curtis A. Johnson
General Electric Company
P.O. Box 8
Schenectady NY 12301

Sylvia Johnson
SRI International
333 Ravenswood Avenue
Menlo Park CA 94025

Thomas A. Johnson
Lanxide Corporation
P.O. Box 6077
Newark DE 19714-6077

W. S. Johnson
Indiana University
One City Centre, Suite 200
Bloomington IN 47405

Walter F. Jones
Air Force Office of Scientific
Research
Bolling Air Force Base
Washington DC 20332-6448

Jill E. Jonkouski
U.S. Department of Energy
9800 S. Cass Avenue
Argonne IL 60439-4899

L. A. Joo
Great Lakes Research Corporation
P.O. Box 1031
Elizabethton TN 37643

A. David Joseph
SPX Corporation
700 Terrace Point
Muskegon MI 49443

Adam Jostsons
Australian Nuclear Science &
Technology
New Illawarra Road
Lucas Heights New South Wales
AUSTRALIA

Matthew K. Juneau
Ethyl Corporation
451 Florida Street
Baton Rouge LA 70801

Hartmut Kainer
Didier-Werke AG
Anlagentechnik Wiesbaden
D-62 Wiesbaden
GERMANY

Tom Kalamasz
Norton/TRW Ceramics
7A-4 Raymond Avenue
Salem NH 03079

Lyle R. Kallenbach
Phillips Petroleum
Mail Drop:123AL
Bartlesville OK 74004

Nick Kamiya
Kyocera Industrial Ceramics Corp.
25 Northwest Point Blvd., #450
Elk Grove Village IL 60007

Roy Kamo
Adiabatics, Inc.
3385 Commerce Park Drive
Columbus IN 47201

Chih-Chun Kao
Industrial Technology Research
Institute
195 Chung-Hsing Road, Sec. 4
Chutung Hsinchu 31015 R.O.C.
TAIWAN

Keith R. Karasek
AlliedSignal Aerospace Company
50 E. Algonquin Road
Des Plaines IL 60017-5016

Martha R. Kass
U.S. Department of Energy
Oak Ridge Operations
Building 4500N, MS:6269
Oak Ridge TN 37831-6269

Robert E. Kassel
Ceradyne, Inc.
3169 Redhill Avenue
Costa Mesa CA 92626

Allan Katz
Wright Laboratory
Metals and Ceramics Division
Wright-Patterson AFB OH 45433

R. Nathan Katz
Worcester Polytechnic Institute
100 Institute Road
Worcester MA 01609

Tony Kaushal
Detroit Diesel Corporation
13400 Outer Drive, West
Detroit MI 48239-4001

Ted Kawaguchi
Tokai Carbon America, Inc.
375 Park Avenue, Suite 3802
New York NY 10152

Noritsugu Kawashima
TOSHIBA Corporation
4-1 Ukishima-Cho
Kawasaki-Ku Kawasaki 210
JAPAN

Lisa Kempfer
Penton Publishing
1100 Superior Avenue
Cleveland OH 44114-2543

Frederick L. Kennard, III
General Motors Corporation
AC Rochester, Dept. 32-24, EB
1300 N. Dort Highway
Flint MI 48556

David O. Kennedy
Lester B. Knight Cast Metals Inc.
549 W. Randolph Street
Chicago IL 60661

George Keros
Photon Physics
3175 Penobscot Building
Detroit MI 48226

Pramod K. Khandelwal
General Motors Corporation
Allison Gas Turbine Division
P.O. Box 420, MS:W05
Indianapolis IN 46206

Jim R. Kidwell
AlliedSignal Engines
P.O. Box 52180
Phoenix AZ 85072-2180

Shin Kim
Korea Institute of Machinery &
Metals
66 Sangnam-dong, Changwon
Kyungnam 641-010
KOREA

W. C. King
Mack Truck, Z-41
1999 Pennsylvania Avenue
Hagerstown MD 21740

Carol Kirkpatrick
MSE, Inc.
P.O. Box 3767
Butte MT 59702

Tony Kirn
Caterpillar Inc.
Defense Products Department, JB7
Peoria IL 61629

James D. Kiser
NASA Lewis Research Center
21000 Brookpark Road, MS:49-3
Cleveland OH 44135

Max Klein
900 24th Street, N.W., Unit G
Washington DC 20037

Richard N. Kleiner
Golden Technologies Company
4545 McIntyre Street
Golden CO 80403

Stanley J. Klima
NASA Lewis Research Center
21000 Brookpark Road, MS:6-1
Cleveland OH 44135

Albert S. Kobayashi
University of Washington
Mechanical Engineering Department
Mail Stop:FU10
Seattle WA 98195

Shigeki Kobayashi
Toyota Central Research Labs
Nagakute Aichi 480-11
JAPAN

Richard A. Kole
Z-Tech Corporation
8 Dow Road
Bow NH 03304

E. Kostiner
University of Connecticut
Chemistry Department, U-60
Storrs CT 06269-3060

Joseph A. Kovach
Eaton Corporation
32500 Chardon Road
Willoughby Hills OH 44094

Kenneth A. Kovaly
Technical Insights Inc.
P.O. Box 1304
Fort Lee NJ 07024-9967

Ralph G. Kraft
Spraying Systems Company
North Avenue at Schmale Road
Wheaton IL 60189-7900

Arthur Kranish
Trends Publishing Inc.
1079 National Press Building
Washington DC 20045

A. S. Krieger
Radiation Science, Inc.
P.O. Box 293
Belmont MA 02178

Pieter Krijgsman
Ceramic Design International
Holding B.V.
P.O. Box 68
Hattem 8050-AB
THE NETHERLANDS

Waltraud M. Kriven
University of Illinois
105 S. Goodwin Avenue
Urbana IL 61801

Edward J. Kubel, Jr.
ASM International
Advanced Materials & Processes
Materials Park OH 44073

Dave Kupperman
Argonne National Laboratory
9700 S. Cass Avenue
Argonne IL 60439

Oh-Hun Kwon
North Company
Advanced Ceramics
Goddard Road
Northboro MA 01532-1545

W. J. Lackey
GTRI
Materials Science and Tech. Lab
Atlanta GA 30332

Jai Lala
Tenmat Ltd.
40 Somers Road
Rugby Warwickshire CV22 7DH
ENGLAND

Hari S. Lamba
General Motors Corporation
9301 West 55th Street
LaGrange IL 60525

Richard L. Landingham
Lawrence Livermore National Lab
P.O. Box 808, L-369
Livermore CA 94550

James Lankford
Southwest Research Institute
6220 Culebra Road
San Antonio TX 78228-0510

Stanley B. Lasday
Business News Publishing Co.
1910 Cochran Road, Suite 630
Pittsburgh PA 15220

S. K. Lau
Carborundum Company
Technology Division
P.O. Box 832, B-100
Niagara Falls NY 14302

Edward A. Lauder
Advanced Composite Materials Corp
1525 S. Buncombe Road
Greer SC 29651-9208

J. Lawrence Lauderdale
Babcock & Wilcox
1850 "K" Street, Suite 950
Washington DC 20006

Jean F. LeCostaouec
Textron Specialty Materials
2 Industrial Avenue
Lowell MA 01851

Benson P. Lee
Interscience, Inc.
9718 Lake Shore Boulevard
Cleveland OH 44108

Burtrand I. Lee
Clemson University
Olin Hall
Clemson SC 29634-0907

June-Gunn Lee
KIST
P.O. Box 131, Cheong-Ryang
Seoul 130-650
KOREA

Ran-Rong Lee
Ceramics Process Systems
Corporation
155 Fortune Boulevard
Mildford MA 01757

Stan Levine
NASA Lewis Research Center
21000 Brookpark Road, MS:49-3
Cleveland OH 44135

Alan V. Levy
Lawrence Berkeley Laboratory
One Cyclotron Road, MS:62-203
Berkeley CA 94720

Ai-Kang Li
Materials Research Labs., ITRI
195-5 Chung-Hsing Road, Sec. 4
Chutung Hsinchu 31015 R.O.C.
TAIWAN

Winston W. Liang
Hong Kong Industrial Technology
Centre
78 Tat Chee Avenue
4/F, HKPC Building -- Kowloon
HONG KONG

Robert Licht
Norton Company
Advanced Ceramics
Goddard Road
Northboro MA 01532-1545

E. Lilley
Norton Company
Advanced Ceramics
Goddard Road
Northboro MA 01532-1545

Chih-Kuang Lin
National Central University
Dept. of Mechanical Engineering
Chung-Li 32054
TAIWAN

Laura J. Lindberg
AlliedSignal Aerospace Company
Garrett Fluid Systems Division
P.O. Box 22200
Tempe AZ 85284-2200

Hans A. Lindner
Cremer Forschungsinstitut
GmbH&Co.KG
Oeslauer Strasse 35
D-8633 Rodental 8866
GERMANY

Ronald E. Loehman
Sandia National Laboratories
Chemistry & Ceramics Dept. 1840
P.O. Box 5800
Albuquerque NM 87185

Jeffrey C. Logas
Winona State University
115 Pasteur Hall
Winona MN 55987

Bill Long
Babcock & Wilcox
P.O. Box 11165
Lynchburg VA 24506

L. A. Lott
EG&G Idaho, Inc.
Idaho National Engineering Lab
P.O. Box 1625
Idaho Falls ID 83415-2209

Raouf O. Loutfy
MER Corporation
7960 S. Kolb Road
Tucson AZ 85706

Gordon R. Love
Aluminum Company of America
Alcoa Technical Center
Alcoa Center PA 15960

Lydia Luckevich
Ortech International
2395 Speakman Drive
Mississauga Ontario L5K 1B3
CANADA

James W. MacBeth
Carborundum Company
Structural Ceramics Division
P.O. Box 1054
Niagara Falls NY 14302

H. MacLaren
General Electric Company
1000 Western Avenue
Lynn MA 01910

George Maczura
Aluminum Company of America
3450 Park Lane Drive
Pittsburgh PA 15275-1119

David Maginnis
Tinker AFB
OC-ALC/LIIRE
Tinker AFB OK 73145-5989

Frank Maginnis
Aspen Research, Inc.
220 Industrial Boulevard
Moore OK 73160

Tai-il Mah
Universal Energy Systems, Inc.
4401 Dayton-Xenia Road
Dayton OH 45432

Kenneth M. Maillar
Barbour Stockwell Company
83 Linskey Way
Cambridge MA 02142

S. G. Malghan
NIST
I-270 & Clopper Road
Gaithersburg MD 20899

Lars Malmrup
United Turbine AB
Box 13027
Malmo S-200 44
SWEDEN

John Mangels
Ceradyne, Inc.
3169 Redhill Avenue
Costa Mesa CA 92626

Murli Manghnani
University of Hawaii
2525 Correa Road
Honolulu HI 96822

Russell V. Mann
Matec Applied Sciences, Inc.
75 South Street
Hopkinton MA 01748

William R. Manning
Champion Aviation Products Div
P.O. Box 686
Liberty SC 29657

Ken Marnoch
Amercom, Inc.
8928 Fullbright Avenue
Chatsworth CA 91311

Robert A. Marra
Aluminum Company of America
Alcoa Technical Center
Alcoa Center PA 15069

Chauncey L. Martin
3M Company
3M Center, Building 60-1N-01
St. Paul MN 55144

Steve C. Martin
Advanced Refractory Technologies
699 Hertel Avenue
Buffalo NY 14207

Kelly J. Mather
William International Corporation
2280 W. Maple Road
Walled Lake MI 48088

James P. Mathers
3M Company
3M Center, Bldg. 201-3N-06
St. Paul MN 55144

Ron Mayville
Arthur D. Little, Inc.
15-163 Acorn Park
Cambridge MA 02140

F. N. Mazadarany
General Electric Company
Bldg. K-1, Room MB-159
P.O. Box 8
Schenectady NY 12301

James W. McCauley
Alfred University
Binns-Merrill Hall
Alfred NY 14802

Louis R. McCreight
2763 San Ramon Drive
Rancho Palos Verdes CA 90274

Colin F. McDonald
McDonald Thermal Engineering
1730 Castellana Road
La Jolla CA 92037

B. J. McEntire
Norton Company
TRW Ceramics
Goddard Road
Northboro MA 01532-1545

Chuck McFadden
Coors Ceramics Company
600 9th Street
Golden CO 80401

Thomas D. McGee
Iowa State University
110 Engineering Annex
Ames IA 50011

Carol McGill
Corning Inc.
Sullivan Park, FR-02-08
Corning NY 14831

James McLaughlin
Sundstrand Power Systems
4400 Ruffin Road
P.O. Box 85757
San Diego CA 92186-5757

Matt McMonigle
U.S. Department of Energy
Improved Energy Productivity
CE-231, Forrestal Building
Washington DC 20585

J. C. McVickers
AlliedSignal Engines
P.O. Box 52180, MS:9317-2
Phoenix AZ 85072-2180

D. B. Meadowcroft
"Jura," The Ridgeway
Oxshott
Leatherhead Surrey KT22 OLG
UNITED KINGDOM

Joseph J. Meindl
Reynolds International, Inc.
6603 W. Broad Street
P.O. Box 27002
Richmond VA 23261-7003

Michael D. Meiser
AlliedSignal, Inc.
Ceramic Components
P.O. Box 2960, MS:T21
Torrance CA 90509-2960

George Messenger
National Research Council of
Canada
Building M-7
Ottawa Ontario K1A 0R6
CANADA

D. Messier
U.S. Army Materials Technology
SLCMT-EMC
405 Arsenal Street
Watertown MA 02172-0001

Arthur G. Metcalfe
Arthur G. Metcalfe and
Associates, Inc.
2108 East 24th Street
National City CA 91950

R. Metselaar
Eindhoven University
P.O. Box 513
Eindhoven 5600 MB
THE NETHERLANDS

David J. Michael
Harbison-Walker Refractories Co.
P.O. Box 98037
Pittsburgh PA 15227

Ken Michaels
Chrysler Motors Corporation
P.O. Box 1118, CIMS:418-17-09
Detroit MI 48288

Bernd Michel
Institute of Mechanics
P.O. Box 408
D-9010 Chemnitz
GERMANY

David E. Miles
Commission of the European Comm.
rue de la Loi, 200
B-1049 Brussels
BELGIUM

Carl E. Miller
AC Rochester
1300 N. Dort Highway, MS:32-31
Flint MI 48556

Charles W. Miller, Jr.
Centorr Furnaces/Vacuum
Industries
542 Amherst Street
Nashua NH 03063

R. Minimmi
Enichem America
2000 Cornwall Road
Monmouth Junction NJ 08852

Michele V. Mitchell
AlliedSignal, Inc.
Ceramic Components
P.O. Box 2960, MS:T21
Torrance CA 90509-2960

Howard Mizuhara
WESGO
477 Harbor Boulevard
Belmont CA 94002

Helen Moeller
Babcock & Wilcox
P.O. Box 11165
Lynchburg VA 24506-1165

Francois R. Mollard
Concurrent Technologies Corp.
1450 Scalp Avenue
Johnstown PA 15904-3374

Phil Mooney
Panametrics
221 Crescent Street
Waltham MA 02254

Geoffrey P. Morris
3M Company
3M Traffic Control Materials
Bldg. 209-BW-10, 3M Center
St. Paul MN 55144-1000

Jay A. Morrison
Rolls-Royce, Inc.
2849 Paces Ferry Road, Suite 450
Atlanta GA 30339-3769

Joel P. Moskowitz
Ceradyne, Inc.
3169 Redhill Avenue
Costa Mesa CA 92626

Brij Moudgil
University of Florida
Material Science & Engineering
Gainesville FL 32611

Christoph J. Mueller
Sprechsaal Publishing Group
P.O. Box 2962, Mauer 2
D-8630 Coburg
GERMANY

Thomas W. Mullan
Vapor Technologies Inc.
345 Route 17 South
Upper Saddle River NJ 07458

M. K. Murthy
MkM Consultants International
10 Avoca Avenue, Unit 1906
Toronto Ontario M4T 2B7
CANADA

David L. Mustoe
Custom Technical Ceramics
8041 West I-70 Service Rd. Unit 6
Arvada CO 80002

Curtis V. Nakaishi
U.S. Department of Energy
Morgantown Energy Technology Ctr.
P.O. Box 880
Morgantown WV 26507-0880

Yoshio Nakamura
Faicera Research Institute
3-11-12 Misono
Sagamihara, Tokyo
JAPAN

Stefan Nann
Roland Berger & Partner GmbH
Georg-Glock-Str. 3
40474 Dusseldorf
GERMANY

K. S. Narasimhan
Hoeganaes Corporation
River Road
Riverton NJ 08077

Robert Naum
Applied Resources, Inc.
P.O. Box 241
Pittsford NY 14534

Malcolm Naylor
Cummins Engine Company, Inc.
P.O. Box 3005, Mail Code 50183
Columbus IN 47202-3005

Fred A. Nichols
Argonne National Laboratory
9700 S. Cass Avenue
Argonne IL 60439

H. Nickel
Forschungszentrum Juelich (KFA)
P.O. Box 1913
Juelich 1-5170 BRD NRW
GERMANY

Dale E. Niesz
Rutgers University
Center for Ceramic Research
P.O. Box 909
Piscataway NJ 08855-0909

Paul W. Niskanen
Lanxide Corporation
P.O. Box 6077
Newark DE 19714-6077

David M. Nissley
United Technologies Corporation
Pratt & Whitney Aircraft
400 Main Street, MS:163-10
East Hartford CT 06108

Bruce E. Novich
Ceramics Process Systems Corp.
155 Fortune Boulevard
Milford MA 01757

Daniel Oblas
50 Meadowbrook Drive
Bedford MA 01730

Don Ohanehi
Magnetic Bearings, Inc.
1908 Sussex Road
Blacksburg VA 24060

Robert Orenstein
General Electric Company
55-112, River Road
Schenectady NY 12345

Norb Osborn
Aerodyne Dallas
151 Regal Row, Suite 120
Dallas TX 75247

Richard Palicka
Cercom, Inc.
1960 Watson Way
Vista CA 92083

Muktesh Paliwal
GTE Products Corporation
Hawes Street
Towanda PA 18848

Joseph E. Palko
General Electric Company
55-113, River Road
Schenectady NY 12345

Joseph N. Panzarino
Saint-Gobain/Norton Industrial
Ceramics
Northboro Research Center
Goddard Road
Northboro MA 01532-1545

Pellegrino Papa
Corning Inc.
MP-WX-02-1
Corning NY 14831

Terry Paquet
Boride Products Inc.
2879 Aero Park Drive
Traverse City MI 49684

E. Beth Pardue
MPC
8297 Williams Ferry Road
Lenior City TN 37771

Soon C. Park
3M Company
Building 142-4N-02
P.O. Box 2963
St. Paul MN 55144

Harmut Paschke
Schott Glaswerke
Christoph-Dorner-Strasse 29
D-8300 Landshut
GERMANY

James W. Patten
Cummins Engine Company, Inc.
P.O. Box 3005, Mail Code 50183
Columbus IN 47202-3005

Robert A. Penty
Eastman Kodak Company
1669 Lake Avenue
Rochester NY 14652-5150

Robert W. Pepper
Textron Specialty Materials
2 Industrial Avenue
Lowell MA 01851

Peter Perdue
Detroit Diesel Corporation
13400 Outer Drive West,
Speed Code L-04
Detroit MI 48239-4001

Bruce Peters
Dow Chemical Company
Building 52
Midland MI 48667

John J. Petrovic
Los Alamos National Laboratory
Group MST-4, MS:G771
Los Alamos NM 87545

Frederick S. Pettit
University of Pittsburgh
Pittsburgh PA 15261

Ben A. Phillips
Phillips Engineering Company
721 Pleasant Street
St. Joseph MI 49085

Richard C. Phoenix
Ohmtek, Inc.
2160 Liberty Drive
Niagara Falls NY 14302

Bruce J. Pletka
Michigan Technological University
Metallurgical & Materials Engr.
Houghton MI 49931

John P. Pollinger
AlliedSignal, Inc.
Ceramic Components
P.O. Box 2960, MS:T21
Torrance CA 90509-2960

P. Popper
High Tech Ceramics International
Journal
22 Pembroke Drive - Westlands
Newcastle-under-Lyme
Staffs ST5 2JN
ENGLAND

F. Porz
Universitat Karlsruhe
Institut fur Keramik Im
Maschinendau
Postfach 6980
D-7500 Karlsruhe
GERMANY

Harry L. Potma
Royal Netherlands Embassy
Science and Technology
4200 Linnean Avenue, N.W.
Washington DC 20008

Bob R. Powell
General Motors Technical Center
Metallurgy Department
Box 9055
Warren MI 48090-9055

Stephen C. Pred
ICD Group, Inc.
1100 Valley Brook Avenue
Lyndhurst NJ 07071

Karl M. Prewo
United Technologies Research Ctr.
411 Silver Lane, MS:24
East Hartford CT 06108

Peter E. Price
Industrial Materials Technology
P.O. Box 9565
Andover MA 01810

Vimal K. Pujari
Norton Company
Advanced Ceramics
Goddard Road
Northboro MA 01532-1545

George Quinn
NIST
Ceramics Division, Bldg. 223
Gaithersburg MD 20899

Ramas V. Raman
Ceracon, Inc.
1101 N. Market Boulevard, Suite 9
Sacramento CA 95834

Charles F. Rapp
Owens Corning Fiberglass
2790 Columbus Road
Granville OH 43023-1200

Dennis W. Readey
Colorado School of Mines
Metallurgy and Materials Engr.
Golden CO 80401

Wilfred J. Rebello
PAR Enterprises, Inc.
12601 Clifton Hunt Lane
Clifton VA 22024

Harold Rechter
Chicago Fire Brick Company
7531 S. Ashland Avenue
Chicago IL 60620

Robert R. Reeber
U.S. Army Research Office
P.O. Box 12211
Research Triangle Park NC 27709

K. L. Reifsnider
VPI & SU
Engineering Science and Mechanics
Blacksburg VA 24061

Paul E. Rempes
McDonnell Douglass Aircraft Co.
P.O. Box 516, Mail Code:0642263
St. Louis MO 63166-0516

Gopal S. Revankar
John Deere Company
3300 River Drive
Moline IL 61265

K. Y. Rhee
Rutgers University
P.O. Box 909
Piscataway NJ 08854

James Rhodes
Advanced Composite Materials Corp
1525 S. Buncombe Road
Greer SC 29651

Roy W. Rice
W. R. Grace and Company
7379 Route 32
Columbia MD 21044

David W. Richerson
2093 E. Delmont Drive
Salt Lake City UT 84117

Tomas Richter
J. H. France Refractories
1944 Clarence Road
Snow Shoe PA 16874

Michel Rigaud
Ecole Polytechnique
Campus Universite De Montreal
P.O. Box 6079, Station A
Montreal, P.Q. Quebec H3C 3A7
CANADA

Barry Ringstrom
Superior Graphite Company
P.O. Box 2373
Smyrna GA 30081

John E. Ritter
University of Massachusetts
Mechanical Engineering Department
Amherst MA 01003

Frank L. Roberge
AlliedSignal Engines
P.O. Box 52180
Phoenix AZ 85072-2180

W. Eric Roberts
Advanced Ceramic Technology, Inc.
990 "F" Enterprise Street
Orange CA 92667

Y. G. Roman
TNO TPD Keramick
P.O. Box 595
Eindhoven 5600 AN
HOLLAND

Michael Rossetti
Arthur D. Little, Inc.
15 Acorn Park
Cambridge MA 01240

Barry Rossing
Lanxide Corporation
P.O. Box 6077
Newark DE 19714-6077

Steven L. Rotz
Lubrizol Corporation
29400 Lakeland Boulevard
Wickliffe OH 44092

Robert Ruh
Wright Laboratory
WL/MLLM
Wright-Patterson AFB OH 45433

Robert J. Russell
17 Highgate Road
Framingham MA 01701

Jon A. Salem
NASA Lewis Research Center
21000 Brookpark Road
Cleveland OH 44135

W. A. Sanders
NASA Lewis Research Center
21000 Brookpark Road, MS:49-3
Cleveland OH 44135

J. Sankar
North Carolina A&T State Univ.
Dept. of Mechanical Engineering
Greensboro NC 27406

Yasushi Sato
NGK Spark Plugs (U.S.A.), Inc.
1200 Business Center Drive, #300
Mt. Prospect IL 60056

Maxine L. Savitz
AlliedSignal, Inc.
Ceramic Components
P.O. Box 2960, MS:T21
Torrance CA 90509-2960

Ashok Saxena
GTRI
Materials Engineering
Atlanta GA 30332-0245

David W. Scanlon
Instron Corporation
100 Royall Street
Canton MA 02021

Charles A. Schacht
Schacht Consulting Services
12 Holland Road
Pittsburgh PA 15235

Robert E. Schafrik
National Materials Advisory Board
2101 Constitution Ave., N.W.
Washington DC 20418

James Schienle
AlliedSignal Engines
P.O. Box 52180, MS:1302-2P
Phoenix AZ 85072-2180

John C. Schneider
San Juan Technologies
P.O. Box 49326
Colorado Springs CO 80949-9326

Gary Schnittgrund
Rocketdyne, BA05
6633 Canoga Avenue
Canoga Park CA 91303

Mark Schomp
Lonza, Inc.
17-17 Route 208
Fair Lann NJ 07410

Joop Schoonman
Delft University of Technology
P.O. Box 5045
2600 GA Delft
THE NETHERLANDS

Robert B. Schulz
U.S. Department of Energy
Office of Transportation Matr's.
CE-34, Forrestal Building
Washington DC 20585

Murray A. Schwartz
Materials Technology Consulting
30 Orchard Way, North
Potomac MD 20854

Peter Schwarzkopf
SRI International
333 Ravenswood Avenue
Menlo Park CA 94025

William T. Schwessinger
Multi-Arc Scientific Coatings
1064 Chicago Road
Troy MI 48083-4297

W. D. Scott
University of Washington
Materials Science Department
Mail Stop:FB10
Seattle WA 98195

Nancy Scoville
Thermo Electron Technologies
P.O. Box 9046
Waltham MA 02254-9046

Thomas M. Sebestyen
U.S. Department of Energy
Advanced Propulsion Division
CE-322, Forrestal Building
Washington DC 20585

Brian Seegmiller
Coors Ceramics Company
600 9th Street
Golden CO 80401

T. B. Selover
AICRE/DIPPR
3575 Traver Road
Shaker Heights OH 44122

Charles E. Semler
Semler Materials Services
4160 Mumford Court
Columbus OH 43220

Thomas Service
Service Engineering Laboratory
324 Wells Street
Greenfield MA 01301

Kish Seth
Ethyl Corporation
P.O. Box 341
Baton Rouge LA 70821

Karleen Seybold
AlliedSignal Engines
P.O. Box 52180
Phoenix AZ 85072-2180

William J. Shack
Argonne National Laboratory
9700 S. Cass Avenue, Bldg. 212
Argonne IL 60439

Peter T.B. Shaffer
Technical Ceramics Laboratories,
4045 Nine/McFarland Drive
Alpharetta GA 30201

Richard K. Shaltens
NASA Lewis Research Center
21000 Brookpark Road, MS:302-2
Cleveland OH 44135

Robert S. Shane
1904 NW 22nd Street
Stuart FL 34994-9270

Ravi Shankar
Chromalloy
Research and Technology Division
Blaisdell Road
Orangeburg NY 10962

Terence Sheehan
Alpex Wheel Company
727 Berkley Street
New Milford NJ 07646

Dinesh K. Shetty
University of Utah
Materials Science and Engineering
Salt Lake City UT 84112

Masahide Shimizu
New Ceramics Association
Shirasagi 2-13-1-208, Nakano-ku
Tokyo 165
JAPAN

Thomas Shreves
American Ceramic Society, Inc.
735 Ceramic Place
Westerville OH 43081-8720

Jack D. Sibold
Coors Ceramics Company
4545 McIntyre Street
Golden CO 80403

Johann Siebels
Volkswagen AG
Werkstofftechnologie
Postfach 3180
Wolfsburg 1
GERMANY

George H. Siegel
Point North Associates, Inc.
P.O. Box 907
Madison NJ 07940

Richard Silbergliitt
FM Technologies, Inc.
10529-B Braddock Road
Fairfax VA 22032

Mary Silverberg
Norton Company
Goddard Road
Northboro MA 01532-1545

Gurpreet Singh
Department of the Navy
Code 56X31
Washington DC 20362-5101

Maurice J. Sinnott
University of Michigan
5106 IST Building
Ann Arbor MI 48109-2099

John Skildum
3M Company
3M Center
Building 224-2S-25
St. Paul MN 55144

Richard H. Smoak
Smoak & Associates
3554 Hollyslope Road
Altadena CA 91001-3923

Jay R. Smyth
AlliedSignal Engines
111 S. 34th Street, MS:503-412
Phoenix AZ 85034

Rafal A. Sobotowski
British Petroleum Company
Technical Center, Broadway
3092 Broadway Avenue
Cleveland OH 44115

A. G. Solomah
SAC International Ltd.
1445 Bonhill Road, #13
Mississauga Ontario L5T 1V3
CANADA

S. Somiya
Nishi Tokyo University
3-7-19 Seijo, Setagaya
Tokyo 157
JAPAN

Boyd W. Sorenson
DuPont Lanxide Composites
1300 Marrows Road
Newark DE 19711

Charles A. Sorrell
U.S. Department of Energy
Advanced Industrial Concepts
CE-232, Forrestal Building
Washington DC 20585

C. Spencer
EA Technology
Capenhurst Chester CH1 6ES
UNITED KINGDOM

Allen Spizzo
Hercules Inc.
Hercules Plaza
Wilmington DE 19894

Richard M. Spriggs
Alfred University
Center for Advanced Ceramic
Technology
Alfred NY 14802

Charles Spuckler
NASA Lewis Research Center
21000 Brookpark Road, MS:5-11
Cleveland OH 44135-3191

M. Srinivasan
Material Solutions
P.O. Box 663
Grand Island NY 14702-0663

Gordon L. Starr
Cummins Engine Company, Inc.
P.O. Box 3005, Mail Code:50182
Columbus IN 47202-3005

Tom Stillwagon
AlliedSignal, Inc.
Ceramic Components
P.O. Box 2960, MS:T21
Torrance CA 90509-2960

H. M. Stoller
TPL Inc.
3754 Hawkins, N.E.
Albuquerque NM 87109

Paul D. Stone
Dow Chemical USA
1776 "Eye" Street, N.W., #575
Washington DC 20006

F. W. Stringer
Aero & Industrial Technology Ltd.
P.O. Box 46, Wood Top
Burnley Lancashire BB11 4BX
UNITED KINGDOM

Thomas N. Strom
NASA Lewis Research Center
21000 Brookpark Road, MS:86-6
Cleveland OH 44135

M. F. Stroosnijder
Institute for Advanced Materials
Joint Research Centre
21020 Ispra (VA)
ITALY

Karsten Styhr
30604 Ganado Drive
Rancho Palos Verdes CA 90274

T. S. Sudarshan
Materials Modification, Inc.
2929-P1 Eskridge Center
Fairfax VA 22031

M. J. Sundaresan
University of Miami
P.O. Box 248294
Coral Gables FL 33124

Patrick L. Sutton
U.S. Department of Energy
Office of Propulsion Systems
CE-322, Forrestal Building
Washington DC 20585

Willard H. Sutton
United Technologies Corporation
Silver Lane, MS:24
East Hartford CT 06108

J. J. Swab
U.S. Army Materials Technology
Ceramics Research Division,
SLCMT-EMC
405 Arsenal Street
Watertown MA 02172

Robert E. Swanson
Metalworking Technology, Inc.
1450 Scalp Avenue
Johnstown PA 15904

Steve Szaruga
Air Force Wright Aeronautical Lab
WL/MLBC
Wright-Patterson AFB OH
45433-6533

Yo Tajima
NGK Spark Plug Company
2808 Iwasaki
Komaki-shi Aichi-ken 485
JAPAN

Fred Teeter
5 Tralee Terrace
East Amherst NY 14051

Monika O. Ten Eyck
Carborundum Company
Technology Division
P.O. Box 832
Niagara Falls NY 14302

David F. Thompson
Corning Glass Works
SP-DV-02-1
Corning NY 14831

Merle L. Thorpe
Hobart Tafa Technologies, Inc.
20 Ridge Road
Concord NH 03301-3010

T. Y. Tien
University of Michigan
Materials Science and Engineering
Dow Building
Ann Arbor MI 48103

D. M. Tracey
Norton Company
Advanced Ceramics
Goddard Road
Northboro MA 01532-1545

L. J. Trostel, Jr.
Box 199
Princeton MA 01541

W. T. Tucker
General Electric Company
P.O. Box 8, Bldg. K1-4C35
Schenectady NY 12301

Masanori Ueki
Nippon Steel Corporation
1618 Ida
Nakahara-Ku Kawasaki 211
JAPAN

Filippo M. Ugolini
ATA Studio
Via Degli Scipioni, 268A
ROMA, 00192
ITALY

Donald L. Vaccari
General Motors Corporation
Allison Gas Turbines
P.O. Box 420, Speed Code S49
Indianapolis IN 46206-0420

Carl F. Van Conant
Boride Products, Inc.
2879 Aero Park Drive
Traverse City MI 49684

Marcel H. Van De Voorde
Commission of the European Comm.
P.O. Box 2
1755 ZG Petten
THE NETHERLANDS

O. Van Der Biest
Katholieke Universiteit Leuven
Dept. Metaalkunde en Toegepaste
de Croylaan 2
B-3030 Leuven
BELGIUM

Michael Vannier
Washington University, St. Louis
510 S. Kings Highway
St. Louis MO 63110

Stan Venkatesan
Southern Coke & Coal Corporation
P.O. Box 52383
Knoxville TN 37950

V. Venkateswaran
Carborundum Company
Niagara Falls R&D Center
P.O. Box 832
Niagara Falls NY 14302

Dennis Viechnicki
U.S. Army Materials Technology
405 Arsenal Street
Watertown MA 02172-0001

Ted Vojnovich
U.S. Department of Energy, ST-311
Office of Energy Research, 3F077P
Washington DC 20585

John D. Volt
E.I. Dupont de Nemours & Co. Inc.
P.O. Box 80262
Wilmington DE 19880

John B. Wachtman
Rutgers University
P.O. Box 909
Piscataway NJ 08855

Shigetaka Wada
Toyota Central Research Labs
Nagakute Aichi 480-11
JAPAN

Janet Wade
AlliedSignal Engines
P.O. Box 52180, MS:1303-2
Phoenix AZ 85072-2180

Richard L. Wagner
Ceramic Technologies, Inc.
537 Turtle Creek South Dr., #24D
Indianapolis IN 46227

J. Bruce Wagner, Jr.
Arizona State University
Center for Solid State Science
Tempe AZ 85287-1704

Daniel J. Wahlen
Kohler, Co.
444 Highland Drive
Kohler WI 53044

Ingrid Wahlgren
Royal Institute of Technology
Studsvik Library
S-611 82 Nykoping
SWEDEN

Ron H. Walecki
AlliedSignal, Inc.
Ceramic Components
P.O. Box 2960, MS:T21
Torrance CA 90509-2960

Michael S. Walsh
Vapor Technologies Inc.
2100 Central Avenue
Boulder CO 80301

Chien-Min Wang
Industrial Technology Research
Institute
195 Chung-Hsing Road, Sec. 4
Chutung Hsinchu 31015 R.O.C.
TAIWAN

Robert M. Washburn
ASMT
11203 Colima Road
Whittier CA 90604

Gerald Q. Weaver
Carborundum Specialty Products
42 Linus Allain Avenue
Gardner MA 01440-2478

Kevin Webber
Toyota Technical Center, U.S.A.
1410 Woodridge, RR7
Ann Arbor MI 48105

Karen E. Weber
Detroit Diesel Corporation
13400 Outer Drive West
Detroit MI 48239-4001

James K. Weddell
Du Pont Lanxide Composites Inc.
P.O. Box 6100
Newark DE 19714-6100

R. W. Weeks
Argonne National Laboratory
MCT-212
9700 S. Cass Avenue
Argonne IL 60439

Ludwig Weiler
 ASEA Brown Boveri AG
 Eppelheimer Str. 82
 D-6900 Heidelberg
 GERMANY

James Wessel
 Dow Corning Corporation
 1800 "M" Street, N.W., #325 South
 Washington DC 20036

Robert D. West
 Therm Advanced Ceramics
 P.O. Box 220
 Ithaca NY 14851

Ian A. White
 Hoeganaes Corporation
 River Road
 Riverton NJ 08077

Sheldon M. Wiederhorn
 NIST
 Building 223, Room A329
 Gaithersburg MD 20899

John F. Wight
 Alfred University
 McMahon Building
 Alfred NY 14802

D. S. Wilkinson
 McMaster University
 1280 Main Street, West
 Hamilton Ontario L8S 4L7
 CANADA

James C. Williams
 General Electric Company
 Engineering Materials Technology
 One Neumann Way, Mail Drop:H85
 Cincinnati OH 45215-6301

Steve J. Williams
 RCG Hagler Bailly, Inc.
 1530 Wilson Boulevard, Suite 900
 Arlington VA 22209-2406

Thomas A. Williams
 National Renewable Energy Lab
 1617 Cole Boulevard
 Golden CO 80401

Craig A. Willkens
 Norton Company
 Advanced Ceramics
 Goddard Road
 Northboro MA 01532-1545

Roger R. Wills
 TRW, Inc.
 Valve Division
 1455 East 185th Street
 Cleveland OH 44110

David Gordon Wilson
 Massachusetts Institute of
 Technology
 77 Massachusetts Ave., Room 3-455
 Cambridge MA 02139

Matthew F. Winkler
 Seaworthy Systems, Inc.
 P.O. Box 965
 Essex CT 06426

Gerhard Winter
 Hermann C. Starck Berlin GmbH
 P.O. Box 25 40
 D-3380 Goslar 3380
 GERMANY

W. L. Winterbottom
 Ford Motor Company
 20000 Rotunda Drive
 SRL, Room E-3182
 Dearborn MI 48121

William T. Wintucky
 NASA Lewis Research Center
 Terrestrial Propulsion Office
 21000 Brookpark Road, MS:86-6
 Cleveland OH 44135

Thomas J. Wissing
 Eaton Corporation
 Engineering and Research Center
 P.O. Box 766
 Southfield MI 48037

James C. Withers
 MER Corporation
 7960 S. Kolb Road
 Building F
 Tucson AZ 85706

Dale E. Wittmer
Southern Illinois University
Mechanical Engineering Department
Carbondale IL 62901

Warren W. Wolf
Owens Corning Fiberglass
2790 Columbus Road, Route 16
Granville OH 43023

Egon E. Wolff
Caterpillar Inc.
Technical Center
P.O. Box 1875
Peoria IL 61656-1875

George W. Wolter
Howmet Turbine Components Corp.
Technical Center
699 Benston Road
Whitehall MI 49461

James C. Wood
NASA Lewis Research Center
21000 Brookpark Road, MS:86-6
Cleveland OH 44135

Marrill Wood
LECO Corporation
P.O. Box 211688
Augusta GA 30917-1688

Wayne L. Worrell
University of Pennsylvania
3231 Walnut Street
Philadelphia PA 19104

John F. Wosinski
Corning Inc.
ME-2 E-5 H8
Corning NY 14830

Ian G. Wright
BCL
505 King Avenue
Columbus OH 43201

Ruth Wroe
ERDC
Capenhurst Chester CH1 6ES
ENGLAND

Bernard J. Wrona
Advanced Composite Materials Corp
1525 S. Buncombe Road
Greer SC 29651

Carl C. M. Wu
Naval Research Laboratory
Ceramic Branch, Code 6373
Washington DC 20375

John C. Wurst
U. of Dayton Research Institute
300 College Park
Dayton OH 45469-0101

Neil Wyant
ARCH Development Corp.
9700 S. Cass Avenue, Bldg. 202
Argonne IL 60439

Roy Yamamoto
Texaco Inc.
P.O. Box 509
Beacon NY 12508-0509

John Yamanis
AlliedSignal Aerospace Company
P.O. Box 1021
Morristown NJ 07962-1021

Harry C. Yeh
AlliedSignal, Inc.
Ceramic Components
P.O. Box 2960, MS:T21
Torrance CA 90509-2960

Hiroshi Yokoyama
Hitachi Research Lab
4026 Kuji-Cho
Hitachi-shi Ibaraki 319-12
JAPAN

Thomas M. Yonushonis
Cummins Engine Company, Inc.
P.O. Box 3005, Mail Code 50183
Columbus IN 47202-3005

Thomas J. Yost
Corning Inc.
Technical Products Div., 21-1-2
Corning NY 14831

Jong Yung
Sundstrand Aviation Operations
4747 Harrison Avenue
Rockford IL 61125

A. L. Zadoks
Caterpillar Inc.
Technical Center, Building L
P.O. Box 1875
Peoria IL 61656-1875

Avi Zangvil
University of Illinois
104 S. Goodwin Avenue
Urbana IL 61801

Charles H. Zenuk
Transtech
1340 N. Via Ronda Oeste
Tucson AZ 85715-4830

Carl Zweben
General Electric Company
P.O. Box 8555, VFSC/V4019
Philadelphia PA 19101

Assistant Manager for Energy Research
and Development
DOE
Oak Ridge Operations Office
P.O. Box 2001
Oak Ridge TN 37831-8600

DOE
Office of Scientific and
Technical Information
Office of Information Services
P.O. Box 62
Oak Ridge TN 37831

END

DATE

FILMED

4/7/94