

بسم الله الرحمن الرحيم



HOSSAM MAGHRABY



شبكة المعلومات الجامعية التوثيق الالكتروني والميكروفيلم



HOSSAM MAGHRABY

جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها
على هذه الأقراص المدمجة قد أعدت دون أية تغيرات



يجب أن

تحفظ هذه الأقراص المدمجة بعيدا عن الغبار



HOSSAM MAGHRABY



بعض الوثائق الأصلية تالفة



HOSSAM MAGHRABY



بالرسالة صفحات

لم ترد بالأصل



HOSSAM MAGHRABY

STUDY OF PHYSICAL, THERMAL AND MECHANICAL PROPERTIES OF SOME CERAMIC MATERIAL.

THESIS

B12907

DOCTOR OF PHILOSOPHY IN SCIENCE

530241 (Solid State Physics)

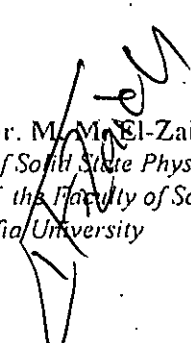
BY

HALA MOHAMED ABO-MOUSTAFA

M. Sc. Degree in Science

Solid State

SUPERVISED BY


Prof. Dr. M. M. El-Zaidia
*Prof. of Solid State Physics and
Dean of the Faculty of Science
Menoufia University*

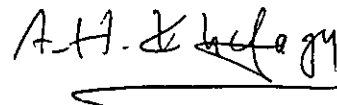
Prof. I. Ali Khan
*Prof. of Physics
Institute of Plasma Physics
KFA Juelich - Germany*

Prof. Dr. M. A. Ewaida
*Prof. of Solid State
Faculty of Science
Menoufia University*



Dr. A. H. Khafagy
*Assistant Prof. of solid state
Faculty of Science
Menoufia University*

1996



ACKNOWLEDGMENTS

The author likes to express her deep gratitude to Prof. Dr. M. M. El Zaidia Prof. of Solid State Physics and Dean of the Faculty of Science Menoufia University Shebin El-Kom Egypt for his supervision, valuable suggestions and discussions through this research work, and for his efforts during the period of setting up the thesis in the present form.

The author is indebted to Dr. Ali Khan Institute of Plasma Physics-KFA Juelich Germany for his supervision, suggesting the plan of the work, stimulating discussions and interpretations through this research work, and for his efforts during the period of setting up the thesis in the present form.

The author also likes to express her deep thanks to Prof. Dr. M. A. Ewaida and Assist. Prof. Dr. A. H. Khafagy Faculty of Science Menoufia University Shebin El-Kom Egypt for their supervision, encouragement, valuable suggestions, and helpful discussions.

This work was carried out in the laboratories of the Institute for Materials in Energy Systems KFA Juelich - Germany.

The author, wishes to offer her thanks to the head of the institute Dr. D. Stöver and Dr. H. P. Buchkremer for giving help, cooperation and providing the research facilities of the installation for carrying out this work.

The author, wishes to offer her thanks to all the staff members of the Institute for Materials in Energy Systems and KFA Juelich - Germany.

The author also likes to express her thanks to Prof. Dr. A. Abdl Kader head of Physics Department, Faculty of Science, Menoufia University for his kind encouragement.

The author, wishes to offer her thanks to all the staff members of the Physics department Faculty of Science Menoufia University Shebin El-Kom Egypt.

Abstract.

The applications of RB-Si-SiC and RB-Si-SiC-MoSi₂ are based on a reaction sintering process, whereby a compacted body of (α -SiC + C/Cf) and (α -SiC + C/Cf + Mo/MoSi₂) respectively are sintered and then infiltrated by silicon which impregnates the body, converting both carbon powder or carbon fibers to β -SiC or fibrous β -SiC respectively which bond the original alpha grains and transforms Mo₃C₂ produced by sintering to MoSi₂.

The dependence of the green density on both uniaxial pressing and grain size of SiC powder was investigated. The results obtained from these measurements revealed that the green density increases as the pressure increases up to 300 MPa, after this point the green density remains constant with increasing pressure. The green density increases as the grain size of SiC powder increases. The effect of the green density on sintered and infiltrated density was investigated. However the sintered and infiltrated densities are improved by increasing the green density.

X-ray diffraction patterns were used to find out the different phases formed in the specimens after sintering and infiltration. The obtained results showed that the Mo₃C₂ formed after sintering due to the addition of Mo or MoSi₂, disappeared after infiltration through the formation of MoSi₂. The results showed also that with increasing the content of carbon powder or carbon fibers, the volume of secondary SiC after infiltration increases on the expense of residual free silicon. Finally, these results showed no evidence of carbon particles, carbon fibers and SiO₂ phases after infiltration.

Chemical analysis was performed for representative sintered and infiltrated specimens for the determination of free carbon after sintering as well as free carbon,

nitrogen and free silicon after infiltration. The results showed that the specimens after sintering contained free carbon more than in the green specimens. The obtained values of nitrogen are very small and independent of the composition. Also the results showed that free silicon values could be reduced by the addition of Mo powder instead of MoSi_2 .

The microstructure of the infiltrated specimens was examined. The results showed the appearance of free silicon as to be in a good homogeneous state with the two phases of SiC and MoSi_2 . The infiltrated specimens with the addition of carbon fibers appeared to be in a better homogeneous distribution condition than those with carbon powder.

The mechanical properties like hardness, fracture toughness, bending strength and elastic modulus were investigated.

The dependence of the hardness and fracture toughness on the volume percent of the free silicon were studied, the results showed that as the volume of the free silicon decreases, the value of the hardness and fracture toughness appears to increase. The specimens which contain MoSi_2 have slightly lower hardness and fracture toughness than those without MoSi_2 .

Three-point bending tests at room temperature were carried out. The results showed that the infiltrated specimens of carbon fibers have higher bending strength than those of carbon powder. The effect of the mean surface area of free silicon on both bending strength and elastic modulus was investigated. The results showed that the values of the bending strength and elastic modulus decrease as the mean surface area of free silicon increases. The bending strength and elastic modulus were measured as a function of addition carbon powder or carbon fibers content. The results indicated that as the content of carbon powder or carbon fibers increases, the bending strength and elastic modulus also increase up to 13 wt. % of C/Cf content, and then decrease.

Four-point high temperature bending strength is measured in two composites of SiC-Si-MoSi₂ and SiC-Si. The results showed that the bending strength for the two composites increases as the temperature increases from room temperature to 1200 °C. It suddenly decreases at 1400 °C, the melting point of silicon.

The Weibull modulus was calculated. It was found that the infiltrated specimens with carbon fibers have higher values of Weibull modulus than those with carbon powder. The infiltrated specimens containing MoSi₂ have lower values of Weibull modulus than those without MoSi₂.

Room temperature thermal conductivity measurements were conducted. The dependence of the thermal conductivity on the mean intercepts length of SiC particles showed that, as the mean intercepts length of SiC particles increases the thermal conductivity increases. The thermal conductivity of the infiltrated specimens of carbon fibers has lower values than those of carbon powder. The thermal conductivity was recorded as a function of adding carbon fibers content and it was, thereby, found that as the carbon fibers content increases, the thermal conductivity first increases up to 13 wt. % of infiltrated fibers and then decreases. The results showed that the infiltrated specimens containing MoSi₂ have lower thermal conductivity than those without MoSi₂.

Thermal expansion coefficient was measured up to 1000 °C. The thermal expansion coefficient was found to increase as the temperature increases. The results showed also the thermal expansion coefficient of the infiltrated specimens containing MoSi₂ to have higher values than those without MoSi₂.

CONTENTS.

ABSTRACT.

ACKNOWLEDGMENTS.

CONTENTS.

Chapter 1 : Ceramics and Ceramics Properties.

1.1. Introduction.	1
1.2. The Main Uses of Ceramics.	8
1.3. Silicon Carbide Materials.	12
1.4. The Aim of the Present Work.	18

Chapter 2 : Theoretical Review.

2.1. Ceramic Microstructures.	19
2.2. X-ray Diffraction.	21
2.3. Mechanical Properties.	23
2.3.1 Hardness.	23
2.3.2. Fracture Toughness.	24
2.3.3. Bending Strength.	27
2.3.4. Elastic Modulus.	30
2.4. Principle Types of Probability Distribution.	31
2.5. Thermal Properties.	34
2.5.1. Thermal Expansion.	34
2.5.2. Thermal conductivity.	35
2.6. Previous Work on Silicon Carbide Composite Materials.	38

Chapter 3 : Experimental Techniques of Measurements.

3.1. Materials.	64
3.2. The Mixing of the Powder.	65
3.3. The Pressing.	65
3.4. The Sintering.	67
3.5. The infiltration.	69
3.6. Chemical Analysis.	70
3.7. X-ray Diffraction.	71
3.8. The Microstructure Investigations.	71
3.9. Thermogravimetric Analysis.	73
3.10. Sample Preparation.	73
3.11. Mechanical Properties Measurements.	74
3.12. Thermal Properties Measurements.	75

Chapter 4 : Results and Discussions.

4.1. Density Investigations.	77
4.2. Thermogravimetric and Differential Thermal Analysis.	81
4.3. X-ray Analysis.	83
4.4. Chemical Analysis.	101
4.5. The Microstructure.	104
4.5. The Grain Size Distributions.	129
4.7. The mechanical Properties.	133
4.7.1. The Hardness and Fracture Toughness.	133
4.7.2. Bending Strength and Elastic Modulus.	140
4.7.3. High Temperature Bending Strength.	149
4.7.4. The Weibull Modulus.	150
4.8. Thermal Properties.	154
4.8.1. Thermal Conductivity.	154
4.8.2. Thermal Expansion.	159

Conclusion.

164

References.

172

Chapter 1

Ceramics and Ceramics Properties

1.1. Introduction.

Today, ceramic products touch our lives in many ways, as shown in Figure (1-1). Pottery and porcelain vessels, glass, and cement are only among the more familiar. Their applications include the magnets in television sets, optical fibers for telecommunications, automobile spark plugs, and the insulators for Japan's high-speed trains. They are widely used in electronics, not only as magnets and as insulators, but also as heating elements and substrates for integrated circuits. As engineering ceramics, they appear in ceramic engines and cutting tools. In bioceramics, they are used for artificial teeth and bones.

Technical ceramics are defined as those ceramics that exhibit a high degree of industrial efficiency through their carefully designed microstructures and superb dimensional precision. In technical ceramics, rigorously selected materials are used in products with a precisely regulated chemical composition, fabricated under strictly controlled methods of shaping and firing.

Engineering ceramics is a technical term sometimes used in the same way as technical ceramics. In general, technical ceramics has a broader meaning; engineering ceramics is often more strictly confined to ceramics for structural applications. Thus, engineering ceramics is a subset of technical ceramics, including principally ceramics with superior mechanical properties, such as high strength, abrasion resistance, and lubrication ability. These ceramics have found applications in ceramic engines, cutting tools, grinding materials, and materials for bearings.

Advanced ceramics or high-technology ceramics is used for many of the same materials and products as technical ceramics. These terms, however, particularly emphasize the special value or advanced features which heighten the commercial value of technical ceramics. Like engineering ceramics and technical ceramics, they are general designations for ceramics used in industrial applications.