CERAPHITE, A HARD AND HIGH STRENGTH NEW CARBON MATERIAL

C. Nakayama, M. Okawa, H. Nagashima
Research Laboratory of Toshiba Ceramics Co., Ltd.
30 Soya, Hatano City, Kanagawa Prefecture, Japan

Introduction

There are a number of different raw materials and methods used in the manufacture of carbon materials (carbon and graphite products) to achieve desired characteristics. For most carbon materials, however, the properties are determined by two factors, the raw materials used and the manufacturing techniques applied. Up to this time considerable research concerning relation between the properties and the said factors has been made by many researchers enabling us to state that properties of a carbon material can be controlled by careful selection of raw materials and establishment of a suitable manufacturing process.

CERAPHITE, the subject of our presentation, is a new type carbon material possessing the characteristics common to glassy carbon materials, such as excellent hardness, high strength and high corrosion resistance, etc., as described below, and it originated from a new conception using a new manufacturing process. CERAPHITE has been developed using as its raw material the carbon made and supplied by Kureha Chemical Industry Co., Ltd., and is ready to be offered to the market.

Manufacturing process

Most carbon materials are made from mixtures of carbon filler and binder pitch. The behaviors of these two in the baking process are quite different from each other and hence difficulties arise. In the baking of a body shaped from the mixture, the binder pitch which is a green material softens, melts, emits gas, foams and contracts while the carbon filler which is not a green material does not act in the same ways, but expands. As a result of this difference in their behaviors when heated, the structure of processed materials usually becomes porous and is weak. This makes it difficult to produce a strong and dense carbon material.

To cope with this difficulty, we tried to develop a homogeneous raw material 1) eliminating binder pitch. The raw material for CERAPHITE was prepared from petroleum pitch through thermal and chemical treatments. It was then crushed, pressure-molded and the shaped bodies were baked in a furnace. In the baking, the carbon does not melt but its particles cohere together. In this heat treatment, the thermal and atmospheric conditions are made uniform for every part of the shaped body. Also adjustments are made both in the preparation of the raw material of CERAPHITE and in the manufacturing process to make the cohesion of particles tight, to expel pores from between the particles and to minimize pores and cracks which may have existed in the particles themselves.

In the case of products made of glassy carbon materials, it is generally thought that a thickness more than several millimeters is difficult to achieve whereas there is no such restriction on the thickness of products made with CERAPHITE. Larger shapes can be manufactured, the size of a large piece presently being 180mm in thickness, 250mm in diameter and 1000mm in length, and the weight of a piece can reach 30kgs. CERAPHITE coming out of a baking furnace is in the shape of blocks, columns, cylinders or crucibles etc., which can be further diversified into desired shapes by machining. To date CERAPHITE has been made into a variety of shapes without causing either a notable difference in the homogeneity and the other properties, nor with increases in size has the homogeneity and quality deteriorated, although deterioration normally tends to arise as a product increases in size.

Properties and Characteristics

As shown in Table 1, CERAPHITE is a hard and strong carbon material with a low open porosity and a high electric resistivity. CERAPHITE is isotropic and the ratio of electric resistivities is as low as max. 1.03.

The graph of X ray Diffraction Parameters of CERAPHITE is shown in Fig. 1. CERAPHITE is a typical non-readily graphitizable carbon, high in the parameter of Co(002) and low in the parameters of Lc(002) and La(110). The changes in its X ray parameters are not remarkable in the range of 2000-2500°CHTT, but in the area exceeding about 2600°CHTT, crystallization becomes apparent and the properties of CERAPHITE change correspondingly.

The microscopic structure of CERAPHITE shows the homogeneity of very fine particles with extremely tight particle-to-particle cohesion. The pores remaining between particles are very small, less than 1μm, and the major part of them are closed pores, as shown in Fig. 2.

CERAPHITE is characterized by its high resistivity to acids. Very little corrosion takes place in the boiling acids -

nitric acid, sulfuric acid and their mixture. Also it resists to molten metals such as aluminum and silicon, etc.

Applications

By virtue of its strength, CERAPHITE is excellent as a material for making hot press molds for manufacture of ceramic products. When used as boats, crucibles and susceptors for production of semiconductor materials, CERAPHITE suffers very little from corrosion in the chemical etching. Owing to its wear resistance, CERAPHITE is considered as a material for bearings and vanes in machinery and also for bioengineering use.

Table 1. Typical Properties of CERAPHITE

Bulk Density	1.60
Flexural Strength (kg/cm^2)	800
Compressive Strength (kg/cm^2)	2700
Tensile Strength (kg/cm^2)	550
Young's Modulus ($10^5 kg/cm^2$)	1.7
Scleroscope Hardness	110
Coefficient of Thermal Expansion ($10^{-6}/°C$)	3.0
Thermal Conductivity (cal/cm·sec·°C) (at 93.5°C)	0.037
Open Porosity (%)	4.7
Electrical Resistivity (10^{-3}Ohm·cm)	3.9
Anisotropy (Ratio of Electric Resistivities)	max. 1.03
Ash Content (%)	max. 0.1

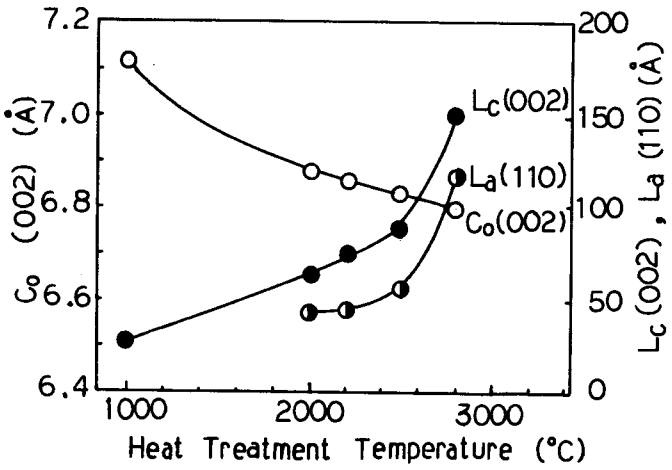

Fig.1 X ray Diffraction Parameters

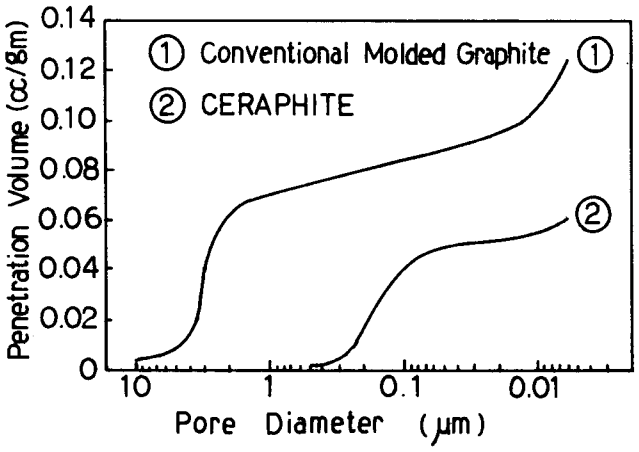

Fig.2 Cumulative Pore Size Curves

Reference

1) S. Ōtani et al., Tanso No.52, 13, (1968)