The Fine Ceramics Industry In Japan

By Kunio Nakajima

In Japan, the term "fine ceramics" is used to refer to ceramics made of extremely pure ultra-minute particles, formed, sintered and treated under highly controlled conditions, and possessing outstanding performance characteristics. Depending on the raw materials used and the forming and sintering methods employed, fine ceramics can possess special properties which cannot be duplicated by metals or plastics. Great expectations are thus held for the fledgling industry.

What is the background to Japan's current fine ceramics boom? Is it, as some claim, somewhat overheated? And where will it go from here?

Background

Having experienced two traumatic oil crises since 1973, Japan has launched an all-out national effort to slash energy consumption. One of the most successful achievements in this drive has been the development of continuous casting technology and its application to steel production. Since 1973, when the first oil shock rocked the world, the steel industry has reduced its energy needs 85% in terms of the basic unit of energy consumption. This figure was reached in 1982, when the adoption rate of continuous casting in the steel industry hit about 80%.

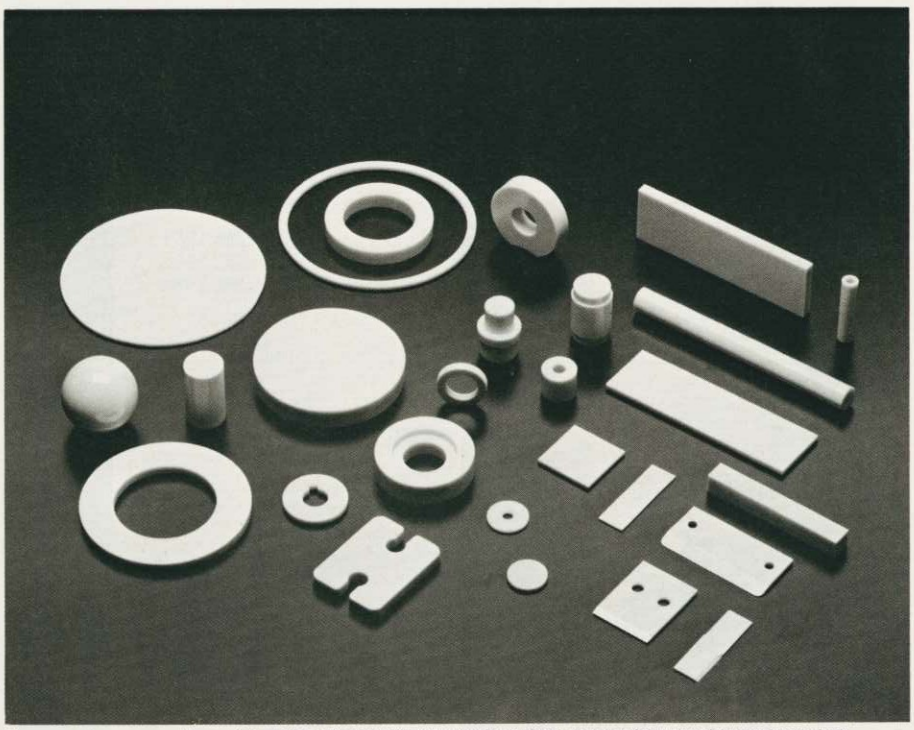
The key to the development of continuous casting technology was the use in refractory bricks of a heat- and friction-resistant inorganic synthetic compound of silicon nitride and alumina-carbon. This example of the great contributions to technical innovation made by industrial materials was especially important in that it established the feasibility of using fine ceramics in structural materials. Silicon nitride and silicon carbide are the nucleus ingredients employed for making fine ceramics, and research on possible applications for high-temperature high-strength material is now underway in many countries.

Equally noteworthy were the energy-saving efforts made by the automotive industry. These were directed toward improving the thermal efficiency of automobile engines and reducing the overall weight of the car body. Obviously, the higher the temperature an engine can endure, the higher its efficiency. However, there is a limit to the temperatures conventional engine materials can withstand, and attention thus focused on the possibility of using fine ceramics as heat-resistant car engine materials, as well as low-weight structural material.

In Japan, it is said that the high technology industries of the 1990s will be those concerned with the development of oil-alternative energy sources (nuclear power, geothermal, and solar), new uses for coal, aviation and space exploration and the systems related to them, and the exploration and utilization of ocean resources. They also include information and electronic industries, biotechnology, medical care, and food systems. Every industrial sector is working vigorously to develop and systematize these industries.

Industry's R&D efforts in these fields will demand the creation of new materials that meet their often exacting requirements. It is no exaggeration to say that the development of practical materials holds the key to the future of high technology. Fine ceramics are attracting great attention along with new metals and high functional resins, but have come in for special scrutiny because of their superb ability to withstand rigorous environmental conditions, particularly temperature, pressure and corrosion.

In addition to being an important industrial material for new industries, fine ceramics have promise of evolving into a full-fledged industry in their own right. In the 1960s, such basic materials industries as steel and petrochemicals, in concert with the petroleum and electric power industries, contributed greatly to regional development in Japan through the rise of giant coastal industrial zones. In the 1990s, knowledge-intensive industries like fine ceramics are expected to become the new engines of regional development.



Fine ceramics are used in a wide variety of products. (Photo: Toyo Soda, a manufacturer of power ceramics)

The present situation

Fine ceramics were first put to practical use only a relatively short time ago. Now they are used in electronic apparatus and machine tools. Moreover, the makers and users of fine ceramics are spread over a great variety of business lines.

These factors have made it difficult to arrive at a definitive definition of fine ceramics. Nor has its position as a full-fledged industry been firmly established. For these reasons, statistics on production, shipments, imports and exports broken down by the raw materials used and by final applications are not readily available. Few surveys have been conducted either on trends in the industry or on participating enterprises. Even data on the progress of R&D in this field is hard to come by.

In short, it is nearly impossible to paint an exact picture of the Japanese fine ceramics industry as it exists today. The following is an attempt to broadly sketch out the current state of fine ceramics in Japan, drawing on available data and documents and on the opinions of leading companies and experts.

Fig. 1 Production Value of Fine Ceramics Raw Materials

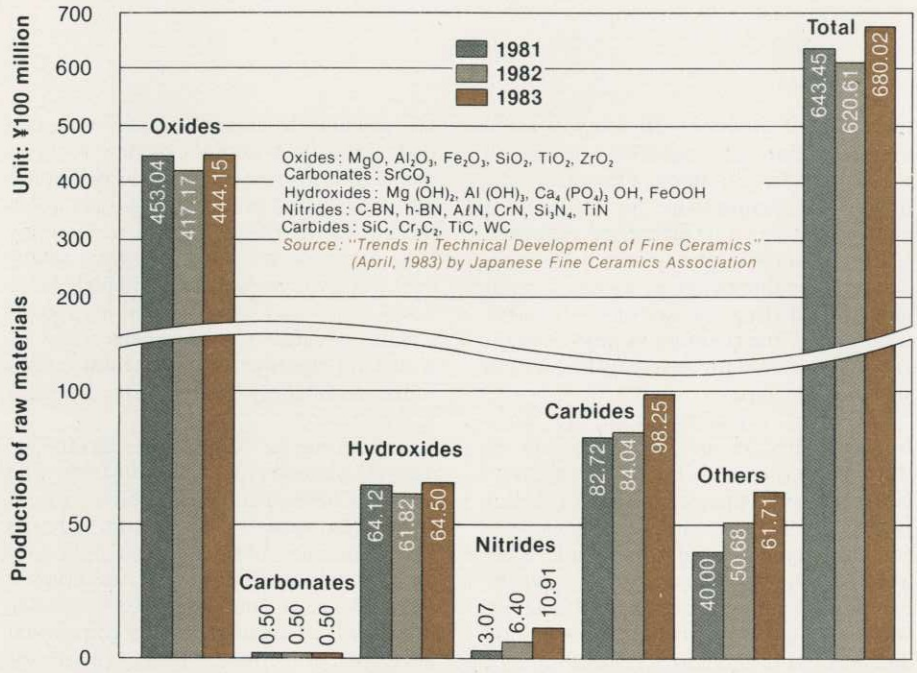
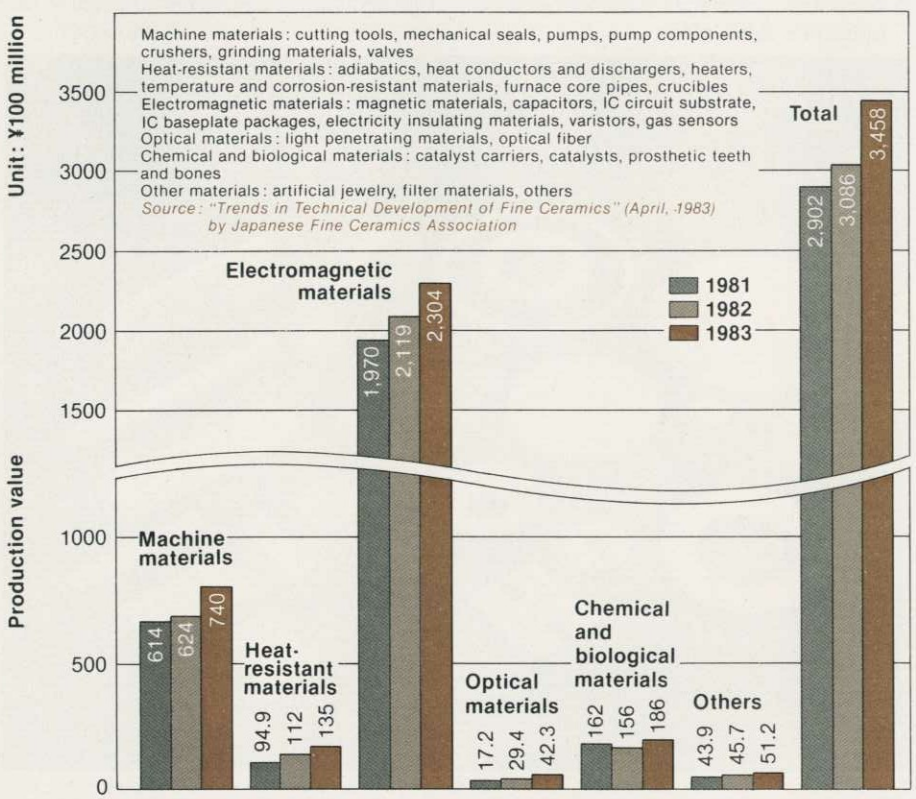


Fig. 2 Production Value of Fine Ceramics Materials



1. Production

a) Production of raw material ingredients

The ingredients of fine ceramics are classified into oxides, such as alumina, magnesia and zirconia, and non-oxides, such as silicon carbide and silicon nitride. Production of these ingredients in Japan in 1981 was valued at about ¥65 billion (Fig. 1).

Oxides accounted for two-thirds of total production. Nitrides came to only about 1.0% of the total, but their share is rising rapidly.

b) Production of materials

Production of fine ceramics materials reached approximately ¥300 billion in 1981, and is projected to reach ¥350 billion in 1983 (Fig. 2). Classified by application, about two-thirds of the total output is used as electro-magnetic material in capacitors, IC circuit substrates and packages, while one-quarter is used as mechanical material in cutting tools. The output of heat-resistant fine ceramics, the center of greatest interest, is still extremely small, although vigorous efforts are being made to develop better methods for their manufacture and to expand their range of applications. Other materials are being used as catalyst carriers, or for making prosthetic teeth and bones.

Trends over the past several years suggest that many other products can potentially be made with fine ceramics, including gas detecting sensors, mechanical seals, semiconductor heat treatment jigs, and optical fibers.

2. Industry's interest in fine ceramics

Given this tremendous potential, the strong interest displayed in fine ceramics has not been limited to companies in the ceramic industry but extends to almost every sector. This can be seen from the membership of the Japanese Fine Ceramics Association (JFCA), established in July last year (Fig. 3).

3. Trends in R&D

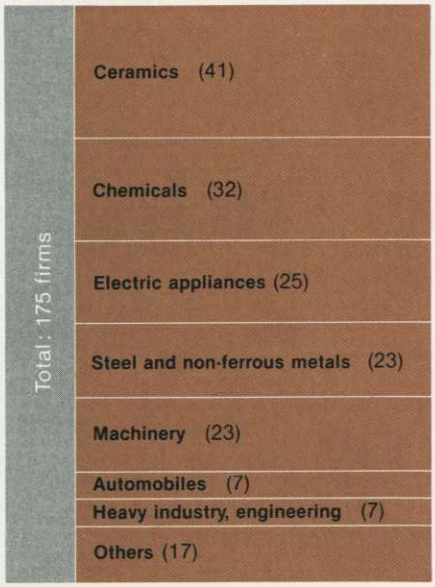
It goes without saying that R&D holds the key to the development of fine ceramics. R&D is being pushed by industry, government and universities, and sometimes by all three in concert. A typical case of the latter is the development of fine ceramics structural material which is

strong and highly resistant to heat, corrosion and wear. This R&D is one of the themes of the "Next Generation Industrial Basic Technology Research and Development System" inaugurated last October as a 10-year project.

Energy conservation and the development of alternative energy sources is an important task not only for Japan but for all countries. The development of fine ceramics to be used in pursuit of this goal is extremely important, and both private sector companies and state-operated experimental and research organs are active participants.

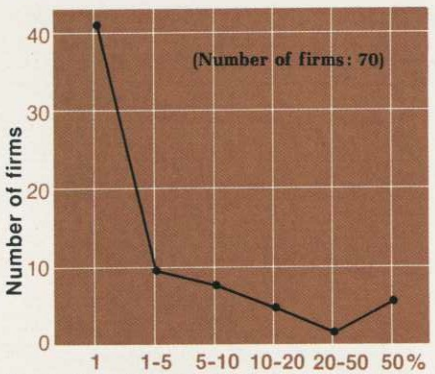
Purely private sector R&D in fine ceramics is also in full swing. According to a JFCA survey of member companies, R&D expenditure for fine ceramics accounted for 20–50% of their total R&D outlays, despite the fact that in many of the companies fine ceramics accounted for less than 1% of total sales in 1981 (Fig. 4). The growth rate for fine ceramics R&D is also far higher than the overall R&D growth rate (Fig. 5). Clearly, in all the companies surveyed, fine ceramics R&D spending has been positioned as investment in anticipation of high future growth.

Fig. 3
Member Companies of Japanese Fine Ceramics Association by Business



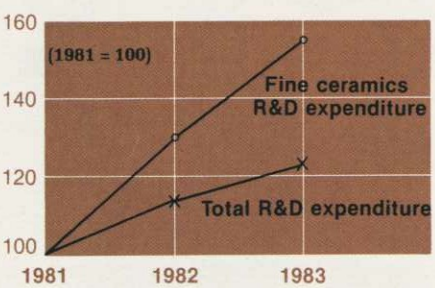
(As of April 30, 1983)

Fig. 4
Proportion of Fine-Ceramics-Related Sales to Total Sales



Source: Survey by Japanese Fine Ceramics Association

Fig. 5 Growth Rate of R&D Expenditure



Source: Survey by Japanese Fine Ceramics Association

Future prospects

Fine ceramics are considered the star industry of the 1990s, with an assuredly bright future. Surveys conducted by banks, securities firms and think tanks all forecast that fine ceramics will grow into a trillion yen industry. Yet it is the frank feeling of many in the industry that the future is not really so rosy as it might seem.

This feeling stems from the fact that there are a host of problems which must be solved before fine ceramics can be applied to the structural materials on which the industry's future depends. The technical problems include how to achieve the required purities and fineness of the ingredients, and the development of technologies for precise manufacturing, joining and adhesion in relation to forming large and complex shapes through molding and sintering. Manufacturing technologies must also be developed for mass production, quality control and cost reduction. Methods are especially needed for assessing quality without destroying the product itself. And designs must be worked out which put to best use the properties in which fine ceramics excel while covering their weaknesses. It is only when these and other problems are solved that the future of fine ceramics can really be said to be bright.

The development of these technologies, moreover, will require systems for accumulating, storing and retrieving data relating to material properties. Standardized methods are needed for evaluating test results. Data and statistical material must be compiled.

This is the so-called infrastructure needed for the development of the new fine ceramics industry. And it is the task of government to build up this infrastructure as quickly as possible.

Even as it is an interdisciplinary field, fine ceramics is inter-industry. Therefore, R&D will call for active cooperation among various industries, while some companies are already cooperating with firms in other countries. Severe competition is already shaking the budding industry, but along with it there is cooperation, as in the development of methodology for evaluation and standardization.

One typical application example of fine ceramics is an automobile engine.

Competition has to take place under certain rules. On this point, it should be recalled that among the 22 themes for joint research proposed at the Versailles Summit in 1982 and approved at the Williamsburg Summit this year was the standardization of new materials, including fine ceramics. U.S.-West German cooperation in research on fine ceramics for use in engines, underway since 1979 as an IEA (International Energy Agency) project, precisely addresses this problem.

Japan also recognizes the need for positive cooperation in standardization efforts. The Japan External Trade Organization (JETRO) is currently conducting a study on the possibilities for international cooperation in fine ceramics.

In August this year, the U.S. National Academy of Engineering was to send a mission to Japan to study the state of fine ceramics R&D in the country. In October, an international symposium on ceramics for engines is to convene in Hakone. This symposium is expected to draw some 80 leading experts from a dozen countries. It is hoped that such exchanges will further promote international understanding and cooperation in this promising new industry. ●

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Nakajima, 42, entered MITI in 1968 after graduating from the Tokyo Institute of Technology and was engaged in work related to the chemical industry. He was appointed to his present position in July 1982.