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# INTERNATIONAL PATENTING TRENDS IN ADVANCED MATERIALS: CERAMICS

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*Japan and the United States lead all other nations in the formation of international patent families involving ceramics technology.*

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This report is the third in a three-part series that examines America's technological position vis-à-vis that of five other countries—Japan, Germany, France, the United Kingdom, and South Korea—in technical areas likely to be important to future economic competitiveness. The areas examined are advanced manufacturing, biotechnology, and advanced materials; the indicator used to determine a country's relative strength and interest in these areas is international patent activity. To facilitate patent search and analysis, the three broad areas were each represented by a narrower subfield. This report examines advanced ceramic technologies as a proxy for advanced materials.<sup>1</sup>

### International Patenting Activity

Tabulated by priority year, this indicator provides a first measure of the extent of each nation's inventive activity. These patent family counts represent inventions important enough to be patented outside of the country of origin. During the first half of the 1990s, these six countries generated a total of 968 international patent families in the field of advanced ceramics. Annual totals varied from a high of 264 in 1990 to 134 in 1994, which is the last priority year available for this study (figure 1).<sup>2</sup> Patenting

<sup>1</sup>These data were developed under contract for the National Science Foundation by Moge Research & Analysis Associates and cover the period 1990-94; they were extracted from the Derwent World Patents Index Database published by Derwent Publications, Ltd. The technology areas selected for this study met several criteria:

- Each technology appeared on the lists of "critical" technologies deemed important to future U.S. economic competitiveness or national security (see Moge 1991; OSTP 1995; and Popper, Wagner, and Larson 1998).
- Each technology could be characterized by the output of patentable products or processes.
- Each technology could be defined sufficiently to permit construction of accurate patent search strategies.
- Each technology yielded a sufficient population for statistical analysis.

<sup>2</sup>The declining number of international patent families formed during the period does not necessarily indicate any drop in inventive activity. It may only reflect the younger age of these inventions.

activity in this six-country group accounts for more than 90 percent of all families in this technology area.

Japan and the United States lead all other nations in the formation of international pat-

*As used here, **advanced ceramics** are defined as ceramics (i.e., inorganic, non-metallic solids) with compositions not usually found in traditional ceramics. These compositions include oxides, carbides, nitrides, and borides, as well as aluminate, titanate, zirconia, and modified silicates.*

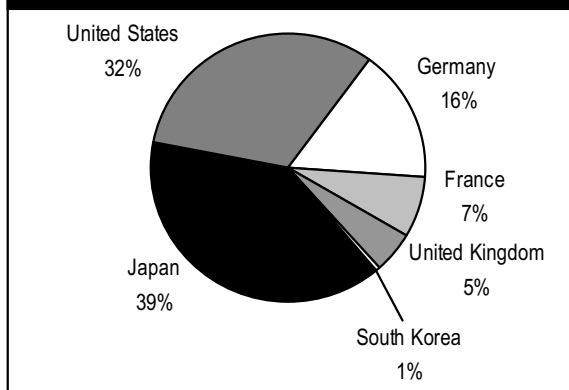
*The analysis is built around the concept of a **patent family** which consists of all the patent documents published in different countries associated with a single invention. The first application filed anywhere in the world is the **priority application**: it is assumed that the country in which the priority application was filed is the country in which the invention was developed. Similarly, the **priority year** is the year the priority application was filed. The **basic patent** is the first patent or patent application published in any of the roughly 40 countries covered in the database used (Derwent World Patents Index Latest ).*

*International patent families are used to mitigate bias introduced by national systems, such as Japan's, that encourage large numbers of domestic patent applications. An international patent family is created when patent protection is sought in at least one other country besides that in which the earliest priority application was filed.*

*The **three indicators** used in this assessment are overall trends in international inventive activity, highly cited inventions, and the size of international patent families.*

## International Patenting Trends in Advanced Materials: Ceramics—page 2

**Figure 1. Advanced ceramics technology:  
number of international patent families by  
priority year and country: 1990-94**



Priority country	1990	1991	1992	1993	1994	Total
Japan.....	108	102	61	60	50	381
United States.....	87	71	60	43	49	310
Germany.....	33	45	33	19	21	151
France.....	19	16	13	12	9	69
United Kingdom....	13	13	7	10	4	47
South Korea.....	4	5	0	0	1	10
Total.....	264	252	174	144	134	968

**SOURCE:** Derwent World Patents Index Database (London: Derwent Publications, Ltd.), special tabulations by Moge Research & Analysis Associates under contract to the National Science Foundation.

ent families involving advanced ceramics technology. Together they accounted for more than 70 percent of the total formed in the 5-year period examined. Japan held 39 percent of the total families formed during this period (381 international families); the United States held 32 percent (310 international families).

### Highly Cited Advanced Ceramics Inventions

Interpatent citations are an accepted method of gauging the technological value or significance of different patents. These citations, provided by the patent examiner, indicate the “prior art”—the technology in related fields of invention taken into account in judging the novelty of the present invention. The number of citations a patent receives from later patents can serve as an indicator of its technical importance or value. In fact, Carpenter, Narin, and Woolf (1981) have shown that, on average, technologically important U.S. patents receive twice as many examiner citations as does the average U.S. patent, reinforcing the validity of interpatent citation as an indicator of patent quality.

Of the 968 international patent families formed by the six countries during the 1990-94 period, 23 were considered highly cited inventions.<sup>3</sup> Japan generated the greatest number of international patent families in this technology area during the period, but the United States had the greatest number of highly cited inventions with 15 (or 65 percent of all highly cited international patent families). Japan was second with 4. When each country’s number of highly cited international patent families is adjusted to account for its overall volume of international patenting in this technology (citation ratio), the United States again leads all six nations. The United States had a citation ratio of 2.0—that is, U.S. inventors’ share of highly cited international patent families was twice its share of the total international patent families formed during this period. Japan’s citation ratio, 0.4, suggests that the four highly cited international families it produced during this period were below the level expected given the total number of international patent families the country generated. The United Kingdom had only two highly cited international families, but exceeded expectations in this indicator with a citation ratio of 1.8 (table 1). France and Germany each had one highly cited international patent family; this again was below expectations given their respective shares of total international patent families in this technology.

### Average International Patent Family Size

Given the significant costs associated with obtaining patent protection in multiple countries, the average international patent family attempts to measure the perceived commercial potential of an invention by adding a market-size indicator for each country in which patent protection is being sought.<sup>4</sup>

<sup>3</sup>The data used here include all patent families with priority application dates from 1990-94 with four or more citations. The citation counts are those placed on European Patent Office (EPO) patents by EPO examiners, as the EPO citations are believed to be a less biased and broader source of citation than those of the U.S. Patent and Trademark Office. See Claus and Higham (1982). To adjust for the advantage countries with large numbers of international inventions would have on this indicator, a country’s share of highly cited patents is divided by its share of total patent families.

<sup>4</sup>The market-size indicator is a ratio of a country’s GDP to that of the United States valued in purchasing power parities at current U.S. dollars.

Japan produced the greatest number of international patent families in this technology area, but the United States had the highest number of highly cited ceramics inventions.

## International Patenting Trends in Advanced Materials: Ceramics—page 3

**Table 1. Advanced ceramics: International patent families, highly cited patent families, and citation ratios, by selected priority country: 1990-94**

Priority country	Number of international families	Number of highly cited international families <sup>1</sup>	Country share of total	Country share of highly cited	Citation ratio <sup>2</sup>
			Percent		
Total.....	968	23	100.0	100.0	1.0
United States.....	310	15	32.0	65.2	2.0
Japan.....	381	4	39.4	17.4	0.4
Germany.....	151	1	15.6	4.3	0.3
France.....	69	1	7.1	4.3	0.6
United Kingdom.....	47	2	4.9	8.7	1.8
South Korea.....	10	0	1.0	0.0	0.0

<sup>1</sup>An international patent family was considered highly cited if the number of citations it received ranked it within the top 1 percent compared with all other ceramics technology patent families. The top 1 percent threshold was used so that those counted as highly cited would more certainly represent important inventions. For this technology area, the top 1 percent received four or more citations.

<sup>2</sup>A citation ratio of greater than 1.0 indicates that a country has a higher share of highly cited international patent families than might be expected based on its share of total international families.

**SOURCE:** Derwent World Patents Index Database (London: Derwent Publications, Ltd.), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

Based on an adjusted average international family size, the advanced ceramics inventions with the highest perceived commercial potential, on average, were produced in France; these were closely followed by those produced in the United States (table 2). The United States also had the second largest number of international patent families for the period examined. Japan, the most prolific inventor of advanced ceramics technologies during the 1990-94 period, trailed the United States and the large European nations in terms of average commercial potential for each invention. South Korean inventions showed the lowest commercial value based on this indicator: the country was at a relative disadvantage due to its small home market. Conversely, since most inventions are first patented in the country in which the inventor resides, U.S. inventions have an edge in the calculation for this indicator because of the large size of the U.S. economy. Using international patent families as the unit of comparison—as is done here—reduces this bias. Because of its market size, the United States attracts most commercially important inventions and is likely to be a member of many of the international patent families included in this indicator.

### Summary of U.S. Position

Taken together, these indicators suggest strong U.S. inventive activity in advanced ceramics

**Table 2. Advanced ceramics technology: number of international patent families and average international family size: 1990-94**

Priority country	Number of families	Average international family size	Adjusted average international family size <sup>1</sup>
France.....	69	11.2	1.9
United States.....	310	9.8	1.8
United Kingdom.....	47	11.6	1.7
Germany.....	151	9.7	1.7
Japan.....	381	5.3	1.6
South Korea.....	10	3.2	1.3

<sup>1</sup>Adjusted by adding a market-size indicator for each country in which patent protection is being sought. The market-size indicator is a ratio of a country's GDP to that of the United States valued in purchasing power parities at current U.S. dollars.

**NOTE:** Patent family size is determined by the number of countries for which patent protection is sought for a single invention.

**SOURCE:** Derwent World Patents Index Database (London: Derwent Publications, Ltd.), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

technology. Although the nation produced the second largest number of international patent families in this category during the period studied, its inventions were the most highly cited and had nearly the highest average

## International Patenting Trends in Advanced Materials: Ceramics—page 4

commercial potential when compared with inventive activity in the other five nations.

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