CRITICAL TECHNOLOGY ASSESSMENT OF THE U.S. SEMICONDUCTOR MATERIALS INDUSTRY

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Overview

The first five years of the 1990s were a period of tremendous growth for the semiconductor materials industry. The increase in production of computers swelled the need for semiconductors, as did the significant increase in semiconductor orders from the communications industry, various consumer products manufacturers, and the automotive industry. The U.S. re-emerged over Japan as the largest producer of semiconductors in 1995. As a result, most segments of the U.S. semiconductor materials industry -- manufacturing equipment, components and parts, and raw materials -- were healthier in 1995 than they were in 1991.

The 1990s also witnessed the increased globalization of the semiconductor manufacturing and semiconductor materials industry. Japan remains the second most important producer, but major new industry centers emerged in such nations as South Korea and Taiwan, and nascent but important industries appeared in Singapore, Malaysia, and Hong Kong. This increased competition and the rising costs of research and development forced some smaller U.S. companies to join larger corporate entities, domestic or foreign, to win needed capital for expansion.

Global competition has impaired one significant area of the U.S. semiconductor materials industry. Total shipments of domestic packaging materials declined in several important areas between 1991 and 1995, the time period studied for all aspects of this assessment. In addition, total research and development in this area fell a dramatic 94 percent between 1991 and 1995. The decline in R&D was indicative of the abandoned effort by two U.S. companies to challenge the foreign domination of the U.S. ceramic materials industry. The episode demonstrates that even in a time of sharply increasing demand for semiconductors, global competition has itself also correspondingly increased.

Background

* This critical technology assessment of the domestic semiconductor materials industry was initiated to assess the capabilities and competitiveness of the U.S. industry. The U.S. Government is interested in the ability of the domestic supplier chain to meet the needs projected in the industry's National Technology Roadmap to the 21st Century, a 15-year business plan. A primary objective of this assessment is to provide industry executives and government policy makers with information and analysis on the production and technology status, economic performance, and international competitiveness of private sector firms involved in the semiconductor materials industry. A more detailed version of this assessment which contains proprietary industry data was prepared for senior government policy advisors.

materials, shipping and handling materials, and assembly materials. U.S. plants outperform foreign plants in the packaging materials category.

* Forty-eight respondents planned to add a total of 69 new factories, a figure indicative of a rapidly growing industry. Approximately 27 percent are to be built overseas, almost all in such Asian nations as Japan, Singapore, South Korea, and Taiwan. This figure is higher than the 22 percent of total plants currently identified by respondents as located in foreign nations.

* No respondents had any future plans for plant closings and only three firms reported a previous closure. Two factories closed so companies could move production into newer facilities. One factory closed in 1990 because of overseas competition.

Cooperative Agreements

* The capital intensive nature of the industry, particularly the high cost of research and development, generated a large number of joint projects. Survey respondents reported a total of 191 such cooperative agreements, with a roughly even number of agreements between U.S. firms and foreign firms.

* The most common type of domestic agreement was for the research and development of new products. There were also a number of distributor agreements and agreements concerning the use of patents.

* Of the agreements with foreign firms, 40 percent were with Japanese companies. South Korea was second with 11 percent and Taiwan third with eight percent. Overall, 70 percent of the foreign cooperative agreements were with companies based in the Asian nations of Hong Kong, Japan, Malaysia, Singapore, South Korea, and Taiwan.

* The largest number of foreign cooperative agreements were either patent license agreements or sales agreements, each with 30 percent. Research and development agreements, which were first on the list of domestic agreements, were fifth on the list of foreign cooperative agreements.

Financial Data

* Financial information was collected on both a corporate basis and on a divisional basis, since many companies in the semiconductor materials industry are operating units of large diversified corporations. When the corporation's sole business was semiconductor materials, the study combined that corporate information with the semiconductor material divisional data to calculate the total semiconductor material sales covered by the survey.

* Total domestic employment grew by 32.8 percent, while total foreign employment increased by 50.5 percent. The ratio of foreign to domestic workers increased from 24.4 percent in 1991 to 27.6 percent in 1995, demonstrating the increasing importance of the foreign semiconductor materials industry.

* Foreign firms hired a significantly lower number of new workers in the important labor categories of production workers and scientists/engineers. Only 58.2 percent of new employees hired by foreign companies were in these two categories. By contrast, of new employees domestic firms added between 1991 and 1995, 81.6 percent were either production workers or scientists/engineers.

* The different rate of growth within employment categories significantly narrowed the gap between foreign and domestic firms in the percentage of total employment comprised of scientists/engineers and production workers. Employees in these two categories comprised 67.5 percent of total domestic employment in 1991, as compared to 79 percent in foreign firms. In 1995, domestic firms increased the figure to 71 percent while the number for foreign firms had declined to 72 percent.

* Total domestic salaries for the companies with complete information rose from $282.989 million to $406.598 million, an increase of 43.7 percent. The largest increase was in the category of production workers, which grew by 52.4 percent overall.

* The average salary for domestic production workers ($24,633 in 1991) and engineers/scientists ($39,345 in 1991) experienced increases of 11.2 percent and 4.6 percent, respectively. The average domestic management salary rose from $62,251 to $68,184, or 9.5 percent. Salaries for marketing and sales as well as administration employees rose 15.4 percent and 18.9 percent each, from $44,470 and $36,378 to $51,314 and $43,257, respectively.

* Total foreign employment salaries from reporting firms rose from $18.848 million to $31.733 million from 1991 to 1995, an increase of over 68 percent. Average annual salaries for both management and administration fell, the first from $21,206 to $21,069 (0.6 percent) and the second from $5,890 to $4,081 (30.7 percent). The annual salary for foreign marketing and sales employees rose by 27.4 percent, from $24,257 to $30,898, making them the highest paid workers in the foreign semiconductor materials industry.

* Foreign marketing and sales personnel were the closest to wage parity with U.S. workers of any category of semiconductor employees. In 1995, they earned 60.2 percent of the wage of a U.S. marketing and sales employee.

* The category with the next closest wage parity was foreign engineers and scientists, who made $21,008, or 51 percent of their American counterparts at $41,160. Foreign production workers earned $7,661 in 1995, 28 percent of a U.S. worker's salary of

occurred in the last year of the survey, 1995. Domestic packaging materials shipments in the 1991-1994 period grew by only 12 percent.

* Domestic shipments of packaging materials (PM) actually declined in three subcategories. Shipments of PM4 (bonding processes) declined by 14 percent between 1991 and 1995. Shipments of PM6 (die attach materials) declined by almost 28 percent during the same period. Shipments of the largest category, PM2 (ceramic packaging), declined by four percent.

* Foreign shipments in PM9 (other packaging materials) rose from 1.4 percent of total PM9 shipments in 1991 to 18.3 percent in 1995. Foreign shipments of PM2 (ceramic packaging) increased from 47 percent to 62 percent. Foreign shipments in PM3 (encapsulating resins) remained at approximately 74 percent of total PM3 shipments.

Defense Shipments

* Few respondents reported a significant level of military shipments. Total military shipments for the 22 firms with five reported years of such sales declined from over $33 million in 1991 to $13 million in 1995. A small increase in wafer fab shipments was overshadowed by a decline in packaging materials shipments.

* Respondents both experienced and expected little decrease in sales from defense spending reductions. In a time of a rapidly expanding world market for semiconductor materials, the decline in the U.S. military budget has not significantly affected the U.S. semiconductor industry.

Research and Development

* Fifty-four companies operated 88 research and development (R&D) facilities, 72 in the United States and 16 overseas, equally divided between Europe and Asia. The 17 companies that owned more than one R&D facility accounted for 39 of the 72 domestic R&D centers and 12 of the 16 overseas R&D facilities.

* These 17 companies, accounting for only 15 percent of survey participants, owned approximately 58 percent of the research and development facilities listed in this survey.

* Research and development spending rose in almost every materials category. Total R&D spending, excluding packaging materials, rose from $40 million in 1991 to $67 million in 1995, an increase of 67.7 percent.

* Surveyed firms listed seven key imported components and parts (27 percent) with no known domestic source and seven items (27 percent) in which the domestic source was inadequate. Frequently listed items were leadframes, burn-in sockets, scanning magnet and beam lines, and optical equipment.

* Quality was more important than price in the importation of components and parts. Price was listed once as the sole reason for importing, and once in conjunction with inadequate domestic supply. By contrast, respondents listed better quality 10 times - - three times alone, four times paired with inadequate domestic supply, twice paired with faster delivery time, and once paired with supplement to domestic supply.

* Respondents listed 85 key imported raw materials, with 58 (68 percent) from Japanese suppliers, 14 (14 percent) from German suppliers, and the remainder from Australia, Canada, Finland, France, the Netherlands, Norway, Switzerland, and the United Kingdom.

* Twenty-nine items of key imported raw materials (34 percent) were imported because of no known domestic supplier, and 25 items (29.5 percent) were imported because the domestic supply was inadequate. Frequently listed items were silicon, resins, fillers, quartz, and high purity minerals and chemicals.

* Price was listed 18 times as a reason to import raw materials. Five items were imported for lower costs alone, six items were listed as imported because of lower costs and an inadequate domestic source, five items as lower costs and better quality, and two items as lower costs and other. However, quality was listed 31 times. Four items were imported on grounds of better quality alone. Respondents paired better quality with inadequate domestic source 11 times, with supplement to domestic source seven times, with lower costs five times, and with other four times.

Competitiveness

* Respondents were asked to estimate the foreign share (as a percentage) of the domestic market for each material subcategory. These figures provide one rough measure of the competitiveness of particular sectors of the U.S. semiconductor materials industry. Absent categories and subcategories signify areas where respondents did not supply enough information to estimate the foreign market share of the U.S. market.

- The U.S. materials industry is rapidly expanding production capacity to meet increased market demands. Based on the survey data, a 38 percent increase in the number of plants is expected by 1998.

- Competition in the semiconductor materials industry also increased, both because of the strong existing industry in Japan and the development of new production centers in a number of Asian nations. This competition, combined with the industry's strong need for high levels of research and development funds, rewards size and has created a tendency toward consolidation.

- Respondents were split on the effects of such consolidation for the relative position of the U.S. semiconductor industry. Some believed foreign companies might use their lower costs abroad to dominate the U.S. market, as well as buy small innovative U.S. firms in need of capital. An equivalent number believed that the semiconductor industry requires a continuing large investment in research and development and that capital -- whether foreign or domestic -- provides needed resources for technological innovation.

- Competitive pressures have weakened some sectors of the U.S. materials industry. This market for ceramic packaging materials, and numerous other packaging materials subcategories, are now largely controlled by foreign firms.

- A modest but growing number of other specific semiconductor materials identified in the report can only be bought in sufficient quality and quantity from foreign producers. Among the most important are silicon products, resins, quartz, leadframes, burn-in sockets, optical equipment, and high purity minerals and chemicals.

- Trends in the next five years promise to bring even more competition to the semiconductor materials field. The industry appears to be moving toward a competitive phase similar to the last half of the 1980s, even while retaining the large annual growth rates of the first half of the 1990s.