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Japan's Semiconductor Supply Chain Structure and Its Implications for South Korea

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I. Introduction

As the competition for technological supremacy between the United States and China has intensified since the 2020s, the Japanese government is also staking its future on the "revival" of its semiconductor industry by strengthening its supply chain. Japan's global market share in semiconductor products peaked at around 50% in the 1980s but has since fallen to around 10% in the 2020s. It is now maintaining its presence in the so-called legacy semiconductor sector, which includes power semiconductors, microcontrollers (MCUs), and CMOS image sensors. In the semiconductor manufacturing equipment and materials sector, which maintains a relatively high global market share, certain semiconductor materials—such as yellow phosphorus, helium, rare gases, and fluorite—are exposed to the risk of supply chain disruptions due to high import dependence on specific countries.

This WEB paper analyzes the supply chain structure of Japan's semiconductor industry and examines the government's semiconductor industry policy from the perspective of strengthening supply chain resilience, with the aim of exploring future directions for cooperation between Japan and South Korea in the semiconductor industry. In the second section we analyze the input structure of Japan's semiconductor industry using input-output analysis, while also assessing the import dependency of Japanese semiconductor products and materials to examine the supply chain structure of the industry. The third section provides an overview of the industrial policies the Japanese government has been pursuing since 2020 to revitalize the semiconductor industry, with a particular focus on the next-generation semiconductor project—the Rapidus 2-nanometer foundry. Section IV proposes a cooperation agenda between South Korea and Japan which involves: first, the sharing of supply chain information regarding export control, and joint procurement of semiconductor raw materials; and second, the joint development of semiconductor back-end packaging technologies and cooperation in the field of AI semiconductors.

II. The Structure of Japan's Semiconductor Supply Chain

1. Analysis of the Input Structure of Japan's Semiconductor Industry

According to our analysis of Japan’s 2020 input-output (I-O) tables, among Japan’s semiconductor industries, the sector with the highest external dependency ratio is integrated circuits, and the intermediate goods for integrated circuits were found to have a very high external dependency ratio. Japan’s external dependency ratio for manufactured goods used in integrated circuit production reached 48.3%, while its ratios for intermediate goods used in integrated circuit and wafer production were calculated at 100.0% and 51.0%, respectively (see Table 1). Among the inputs for integrated circuit production, other non-ferrous metal ingots (29.5%) showed a relatively high level of external dependence; for semiconductor device production, other inorganic chemical products (28.6%) showed a relatively high level of external dependence; and for wafer production, other non-ferrous metal products (100%), other non-ferrous metal ingots (80.5%), and inorganic chemical products (26.9%) showed relatively high levels of external dependence. However, Japan shows low external dependency for certain materials used as intermediate inputs in semiconductor production, such as polishing agents, industrial plastic products, and glass processing products. In other words, the domestic production rate for other plastic products used as inputs in the production of integrated circuits and semiconductor devices is over 78%; moreover, the domestic production rate for abrasives, plastic films and sheets, and industrial plastic products reaches 99%. In 2020, South Korea’s dependence on Japan for primary plastic products—one of the top 10 intermediate inputs in the country’s integrated circuit production—reached 63%, while dependence on Japan for abrasives, another key intermediate input, stood at 58%.

Table 1. Results of Input Structure Analysis of Japan's Semiconductor Industry (2020)

	IC (Integrated Circuit)		Semiconductor Device		Wafer (Other Electronic Parts)	
	Input Industry	External Dependency	Input Industry	External Dependency	Input Industry	External Dependency
Total	Manufacturing	48.3%	Manufacturing	19.0%	Manufacturing	26.5%
Top 3 Input industry	IC	100.0%	Other Electronic Parts	13.9%	Other Electronic Parts	16.3%

	Other Electronic Parts	15.0%	Electronic Circuits	8.7%	Electronic Circuits	8.6%
	Other Non-Ferrous Metal Ingots	29.5%	Other Electrical and Mechanical Equipment	99.1%	IC	51.0%
Top 3 Import dependency	Other Electrical and Mechanical Equipment	100.0%	Wires and Cables	45.5%	Other Non-Ferrous Metal Products	100.0%
	Wires and Cables	49.0%	Methane Derivatives	33.3%	Other Non-Ferrous Metal Ingots	80.5%
	Methane Derivatives	37.8%	Carbon and Graphite Products	25.8%	Semiconductor Device	80.5%
Materials & Raw materials	Other Inorganic Chemical Products	13.0%	Other Inorganic Chemical Products	28.6%	Other Inorganic Chemical Products	26.9%
	Carbon and Graphite Products	28.0%	Other Non-Ferrous Metal Ingots	6.3%	Carbon and Graphite Products	26.7%

Note: The degree of External Dependency was calculated as the ratio of imports to the sum of imports and domestic production for the relevant industry.

Source: Author's calculations.

2. Analysis of Japan's Import Dependency of Semiconductor Products and Materials

As of 2024, Japan remains highly dependent on Taiwan in terms of its country-specific import reliance for semiconductor products, evident in, for example, its import reliance on Taiwan for items such as “unimplemented processors and controllers (90%),” “other unimplemented integrated circuits (90%),” and “unpackaged DRM (93%)” (see Table 2). This shows that Japan relies on Taiwanese foundries such as TSMC and UMC for IC manufacturing. Japan’s reliance on imports from specific countries is particularly high for certain semiconductor materials, such as silicon carbide (89% from China), phosphoric acid and polyphosphoric acid (90% from China), fluorite (73% from China), hydrogen fluoride (97% from China), and yellow phosphorus (99% from Vietnam). According to Fuji Keizai (2025), Japanese imports of gallium (a raw material for GaN wafers) and tungsten oxide (a raw material for tungsten hexafluoride) are also highly dependent on specific countries, and cerium (a rare earth element, CE), which is one of the raw materials for CMP slurry, also faces a high risk of supply chain disruption.

Table 2. Semiconductor Products and Raw Materials with ≥70% Import Dependency on Specific Countries (2024)

Industrial Classification in the I-O Table	Items	Import Partner Country	2018	2024	
			Import Dependency (%)	Import Dependency (%)	Import Amount (100 mill. Yen)
IC	Unimplemented processors and controllers	Taiwan	93%	90%	1,523.8
	Unimplemented other integrated circuits	〃	42%	90%	1,541.9
	Unpackaged DRAM	〃	70%	93%	10.9
Semiconductor Manufacturing Equipment	Wafer manufacturing equipment	Germany	12%	70%	23.0
Other Inorganic Chemical Industrial Products	Silicon carbide	China	87%	89%	18.8
	Yellow phosphorus	Vietnam	94%	99%	13.8
	Phosphoric acid, polyphosphoric acid	China	99%	90%	5.6
	Hydrogen fluoride	〃	100%	97%	19.4
	Hydrogen peroxide	Korea	91%	86%	1.6
Other Non-Ferrous Metals	Polycrystalline high-purity metallic silicon	U.S.A.	84%	79%	75.2
	Nitric acid (sulfuric-nitric acid)	Korea	100%	99%	5.6
Other Minerals	Fluorite: Contains at least 97% potassium fluoride	China	72%	73%	1.3
Propylene	Propene, Propylene	Korea	98%	97%	13.5
Other Intermediates	n-Butyl acetate	China	88%	91%	1.8
Pigment	Stripper	〃	70%	79%	7.5

Note: Calculated only for semiconductor items with 2024 import value of 100 million yen or more.
Source: Author's calculations.

III. The Japanese Government's Semiconductor Strategy

1. The Japanese Government's Semiconductor Industry Policy

Since the enactment of the Economic Security Promotion Act in May 2022, the Japanese government has been implementing industry policies to strengthen the semiconductor supply chain and enhance industrial competitiveness. Based on this Act, the Japanese government's industrial policy is characterized by designating semiconductors as “critical materials (national strategic materials)” and providing government subsidies to relevant companies. In December 2022, 11 items—including semiconductors, batteries, cloud services, permanent magnets, machine tools and industrial robots, aircraft parts and materials, critical minerals, liquefied natural gas, and ship parts—were designated as “critical materials,” and in March 2024, advanced electronic components (capacitors, high-frequency filters) and certain minerals (gallium, germanium, uranium) were added.

In June 2023, the Ministry of Economy, Trade and Industry (METI) revised the Semiconductor and Digital Industry Strategy launched in June 2021, and presented a three-phase semiconductor strategy aimed at expanding the size of Japan's domestic semiconductor market to approximately 15 trillion yen by 2030—a threefold increase from the 2020 level (approximately 5 trillion yen). The first phase involves strengthening existing legacy semiconductor production facilities, including TSMC’s Kumamoto plant; the second phase aims to begin mass production of advanced logic semiconductors at the Rapidus foundry by the late 2020s; and the third phase aims to commercialize future semiconductor technologies, such as optoelectronic convergence technology. In November 2024, METI announced a policy titled “Framework for Strengthening the AI and Semiconductor Industrial Base,” which can be regarded as the “Semiconductor Strategy 2025.” Under the goal of increasing total public and private investment in the semiconductor industry to 50 trillion yen by 2030, this plan calls for the government to allocate a total budget of 10 trillion yen to R&D, design and development, and manufacturing in the AI semiconductor sector. As shown in Table 3, the Japanese government’s semiconductor support programs implemented to date have focused on three areas: government subsidies, tax credits, and infrastructure development. However, these semiconductor industry policies appear to have failed to prioritize and focus effectively, as their scope of support is too broad—encompassing not only advanced logic and memory semiconductors but also legacy semiconductors, semiconductor manufacturing equipment, and materials and raw materials suppliers.

Table 3. Japanese Government's Support Programs for Semiconductor Industry

	Government Subsidy			Tax Credit	Infrastructure Development
Program	Fund Projects for Domestic Production of Advanced Semiconductors	Legacy Semiconductor Supply Chain Strengthening Project	Economic Security Fund Projects	Tax Incentives to Promote Domestic Production in Strategic Industries	Grant Program for Promoting Infrastructure Development to Support Regional Industrial Restructuring
Enable Act/legislation	5G Promotion Act	Government Budget projects (46.5 billion yen)	Economic Security Promotion Act	Act on the Strengthening of Industrial Competitiveness	Central government grants to local governments

Target	Advanced logic semiconductors, memory semiconductors (TSMC Kumamoto Plant, Kioxia, Western Digital, Micron)	Legacy semiconductors (MCUs, power semiconductors, analog semiconductors). Support for 27 domestic legacy semiconductor factories	Legacy semiconductors (Renesas Electronics, etc.), semiconductor manufacturing equipment (Canon), semiconductor components and materials (Ibiden, etc.), semiconductor raw materials (FC-BGA substrates, etc.)	Legacy semiconductors	Support for industrial water supply infrastructure, sewer system improvements, and road maintenance in connection with the construction and expansion of semiconductor plants by Rapidus, Kioxia, Micron, and TSMC
Government Subsidy Rate	Up to 30% of the amount of capital investment1)	Up to 1/3 of the capital investment amount (maximum: 15 billion yen)	Up to 1/3 of the capital investment amount	-	Central government grants to local governments
Tax Credit Amount	-	-	-	Up to 20% of corporate income tax over a period of 10 years following the commencement of production and sales of eligible items	-
Budget for Infrastructure Development	-	-	-	-	A total budget allocation of 14.95 billion yen for fiscal years 2023 and 2024

Note: Calculated only for semiconductor items with 2024 import value of 100 million yen or more.
Source: Author's calculations.

2. Challenges for Rapidus

The Japanese government is currently placing its industrial policy's top priority on the next-generation semiconductor project—the Rapidus 2-nanometer foundry—and the development of AI semiconductors. Just as the Japanese government refers to Rapidus as a "government-backed company," it recognizes that operating a cutting-edge semiconductor foundry is difficult to achieve with private capital alone. Furthermore, based on past experience, it believes that Rapidus cannot produce advanced logic semiconductors on its own, and is therefore actively pursuing technical cooperation with U.S. and European semiconductor companies such as IBM and imec. In December 2022, Rapidus signed a strategic partnership agreement with IBM to acquire a license for 2-nanometer-generation GAA test chips. In April 2023, the company dispatched approximately 150 engineers to IBM's R&D center in Albany, New York, to advance technical collaboration. In December 2022, it signed a Memorandum of Cooperation (MOC) with imec in Belgium, agreeing to dispatch engineers, establish an imec hub in Japan, and form a partnership with LSTC. A representative R&D support program among the Japanese government's next-generation semiconductor projects is the project to develop front-end and back-end semiconductor manufacturing technologies, which utilizes NEDO's "Post-5G Fund." In the development of back-end semiconductor manufacturing technologies, Rapidus is focusing on 2.xD and 3D packaging technologies and is currently conducting collaborative projects with TSMC and Samsung Electronics in parallel with its own program. Rapidus is dedicating its full efforts to the development of ultra-low-power AI accelerators, AI server systems and control technologies, and ultra-low-power, high-density AI computing platforms and optimal operation technologies. Notable AI semiconductor technology development projects currently underway in Japan include the joint development of edge AI semiconductor technology by LSTC and the U.S.-based company Tensorrent; the development of cutting-edge automotive SoC technology by ASRA, a technology research consortium led by Toyota, Honda, and Nissan; the development of AI semiconductors for telecommunications by EdgeCortix; and the development of AI semiconductors for computing resources (MN-core) by Preferred Networks.

Whether the Japanese government will achieve its goal of revitalizing the semiconductor industry depends on the success of Rapidus. The challenges Rapidus currently faces include securing sufficient private funding, mass-producing 2-nanometer-class semiconductors, acquiring customers, and recruiting talent. Notably, Japanese semiconductor companies have been reluctant to invest in Rapidus, citing the fact that Rapidus has yet to achieve tangible results in terms of technological development and customer acquisition, as well as the uncertain outlook for supply and demand of the advanced semiconductors Rapidus plans to mass-produce. The technical issues surrounding Rapidus's mass production of 2-nanometer-class semiconductors can be summarized as a debate over the "short turnaround time (TAT)" that Rapidus is promoting as a key component of its advanced semiconductor foundry strategy. Rapidus emphasizes a strategy of providing end-to-end contract manufacturing services—from design through front-end and back-end processes to packaging—leveraging its short TAT technology. However, some observers point out that securing customers as a foundry is crucial for Rapidus's "short TAT technology" strategy and small-volume production strategy to establish a viable and sustainable business model. In addition, Rapidus faces the following technical challenges: establishing manufacturing technology for the 2-nanometer process (introduction of GAA FETs), the introduction and stable operation of EUV lithography technology, smooth technical cooperation and technology transfer with overseas partners (IBM, imec), vulnerabilities in the domestic supply chain, improving semiconductor manufacturing yield, and developing advanced packaging and chiplet design.

IV. Policy Implications for South Korea

First, as part of a joint response to the resurgence of "resource nationalism," the governments of South Korea and Japan should explore ways to cooperate in the areas of sharing supply chain information regarding export control, and joint procurement of semiconductor raw materials. Semiconductor raw materials for which Japan has a high degree of supply dependence on specific countries include silicon carbide (China), phosphoric acid and polyphosphoric acid (China), fluorite (China), hydrogen fluoride (China), sulfuric acid (Vietnam), gallium (China) and cerium (China). Similarly, South Korea also exhibits very high dependence on specific countries for certain semiconductor raw materials, such as sulfuric acid, fluorite, rare gases, and tungsten.

Second, with regard to next-generation semiconductor industry cooperation between South Korea and Japan, it is necessary to closely monitor policy trends of the Japanese government while focusing, for now, on joint development of back-end packaging technologies and cooperation in the field of AI semiconductors. While joint R&D investment between South Korean and Japanese companies in semiconductor back-end packaging technology is generating expectations—particularly Samsung Electronics' collaboration with a Japanese semiconductor materials company—there is a need to expand this partnership to include a long-term collaboration with Rapidus. In November 2024, METI announced a policy titled "Framework for Strengthening the AI and Semiconductor Industrial Base," pledging to enhance support for R&D, design & development, and manufacturing of AI semiconductors; the South Korean government needs to consider measures to promote industrial cooperation in Japan with Japanese companies in the AI semiconductor sector.