Kumamoto Semiconductor Industry Promotion Vision

Kumamoto, a prefecture that supports semiconductor infrastructure and continues to challenge the future

February, 2023

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Foreword

Semiconductors are used in a wide range of applications, from major consumer electronics such as TVs, PCs and smartphones to economic and social infrastructure such as transportation, medical care and finance and have become an essential part of our lives. In addition, as technologies such as 5G, AI, automated driving, and DX evolve and transform society, semiconductors are expected to become increasingly important.

Under these circumstances, in November 2021, TSMC, a global semiconductor manufacturer, has decided to build its first Japanese plant in Kumamoto. This is a national project aimed at strengthening domestic semiconductor production. I have high expectations for Kumamoto to play a great role in economic security as a base for the semiconductor industry, and also, I feel a great responsibility.

With the expected impact on various fields such as an establishment of new bases of related companies, job creation, and population growth, Kumamoto Prefecture has taken the opportunity of TSMC's expansion to formulate the "Kumamoto Semiconductor Industry Promotion Vision," a policy for future industrial promotion activities, in order to further promote not only the semiconductor industry but also other industries in Kumamoto and realize the growth of the prefectural economy in all areas of the prefecture.

The vision sets the direction for actions to be taken over the next 10 years based on three strategies, including strengthening the semiconductor supply chain to become “Kumamoto, a region that continues to support and challenge semiconductor infrastructure.”

In order to realize our vision and achieve Kumamoto’s sustainable development, Kumamoto Prefectural Government will further develop Kumamoto’s strengths in the semiconductor industry and actively disseminate relevant information to the world, thus reinforcing Kumamoto’s advantages as a global hub.

In addition, I will work with conviction to maximize the gross happiness of the people of Kumamoto so that the young people who will lead the next generation can have dreams and hopes.

Kumamoto will not miss the great opportunity of TSMC’s entry into Kumamoto, and will do our utmost to realize the new Silicon Island of Kyushu through cooperation among industry, academia, government and financial sector, as well as with other prefectures in Kyushu.

March, 2023

蒲島郁夫

Ikuo Kabashima
Governor of Kumamoto Prefecture

Chapter I Purpose of formulation

1 Purpose of developing vision

With the rapid spread of the Internet and smartphones over the past five decades, and with the development of information and communication technologies, digital services have penetrated society worldwide, and the progress of digitalization has played an essential role in supporting the lives of the people. In addition, digitalization was further accelerated in response to the new coronavirus that began at the end of 2019, and the rapid expansion of demand for information-related goods and the move toward carbon neutrality in 2050 have exposed the tight global semiconductor supply-demand situation. Furthermore, the environment surrounding the digital industry, digital infrastructure, and semiconductors that serve as the foundation of the digital industry is undergoing major changes, including trade issues related to advanced technologies such as semiconductors and digital-related technologies stemming from U.S.-China relations and supply chain disruptions caused by economic security.

Major countries such as the United States, European, and others have started to attract production bases through subsidies to produce semiconductors domestically for the sake of defense and economic security, and are investing in research and development of advanced technologies.

Against this backdrop, in June 2021, “the Semiconductor and Digital Industry Strategy Review Conference[1]” of the Ministry of Economy, Trade and Industry compiled the "Strategy for the Semiconductor and Digital Industries[2]" setting forth the direction to be pursued and future actions to be taken in the Japanese semiconductor field. In November 2021, “the Council for the Realization of New Capitalism[3]”, hosted by the Cabinet Secretariat, issued an Emergency Recommendation, setting "Support for international joint development of advanced semiconductors that will be the foundation of a digital society, support for the establishment of semiconductor plants in our country, and renovation of domestic plants" as the strategic direction for economic security.

Later, in the same month, TSMC of Taiwan, the world's largest semiconductor manufacturer, announced that it would establish a contract semiconductor manufacturing subsidiary "Japan Advanced Semiconductor Manufacturing" (JASM) together with Sony Semiconductor Solutions Corporation and build its first Japanese plant in Kumamoto. In February 2022, Denso Corporation made a minority investment in JASM.

Furthermore, in December 2022, a media reported Sony Group was considering the construction of a new semiconductor plant in the city of Koshi, Kumamoto Prefecture, which is expected to be operational after fiscal year 2025, with the aim of strengthening its domestic base by producing

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[1] A meeting hosted by the Ministry of Economy, Trade and Industry that brings together business people, experts and relevant ministries in the semiconductor and digital industries to share information and exchange views on future policy directions.
https://www.meti.go.jp/policy/mono_info_service/joho/conference/semicon_digital.html

[2] An industrial strategy developed with a comprehensive view of the semiconductor, digital infrastructure and digital industries that will be essential for digitalization to support Japan's future growth. 2021 Announced on June 4.

[3] In order to realize a new capitalism based on the concepts of "a virtuous cycle of growth and distribution" and "the development of a new society after the corona," as advocated by Prime Minister Kishida, a meeting was held to present a vision and advance the concretization of it.
https://www.cas.go.jp/jp/seisaku/atarashii_sihonsyugi/index.html

image sensors where the company has strengths.

To promote the smooth construction and operation of the new plant, which is of an unprecedented scale in the history of the prefecture's administration, and further improve the prefecture government through further accumulation of the semiconductor industry, Kumamoto Prefecture, which is also an industrial cluster of semiconductor-related industries, established “the Headquarters for the Promotion of Enhancement of Semiconductor Industry Cluster[4]”. It is headed by the governor and is proceeding with initiatives to facilitate the smooth acceptance of new facilities.

Taking the opportunity of TSMC's expansion into Kumamoto, Kumamoto Prefecture formulates the "Kumamoto Semiconductor Industry Promotion Vision," which is a policy for future industrial promotion activities, in order to further promote not only the semiconductor industry but also other industries in Kumamoto Prefecture and realize the growth of the prefectural economy in all areas of the prefecture.

2 What does this vision mean for our policies?

Based on “Basic Policies for the Creation of a New Kumamoto” formulated in March 2021, this vision is a plan for a specific industry sector in “Kumamoto Industrial Growth Vision”, which is a guideline for the overall industrial policy of the prefecture and indicates the direction of future semiconductor-related industrial measures in Kumamoto.

3 Period for the plan

The period is ten years from fiscal year 2023 to fiscal year 2032.

Necessary reviews will be conducted intermittently, even within the planning period, according to changes in the social environment and status of initiatives.

[4] A cross-agency organization established by the prefecture on November 18, 2021 to promote the smooth construction and operation of the new plant and to boost the prefectural government by further integrating the semiconductor industry in light of TSMC's decision to build the plant.

Chapter II

Changes in the Environment Surrounding the Semiconductor Industry and Current Situation and Issues in Kumamoto Prefecture

1 Changes in the social environment

1.1 Changes in Industrial Structure Due to the Fourth Industrial Revolution and the Realization of Society 5.0

The fourth industrial revolution, driven by technological innovations such as artificial intelligence (AI), internet of things (IoT), big data, and blockchain[5], has impacted not only economic activities such as production, sales, and consumption but also a wide range of areas such as health, healthcare, and public services, as well as the way people work and live, including telework. In addition, the creation of new added value through various connections has prompted new business models and has brought about major changes in the industrial structure.

Specifically, digitalization is leading to a transformation from the traditional vertical pyramid structure of companies and industry units to a layered industrial structure[6] that provides value across industries or a convergence of both types.

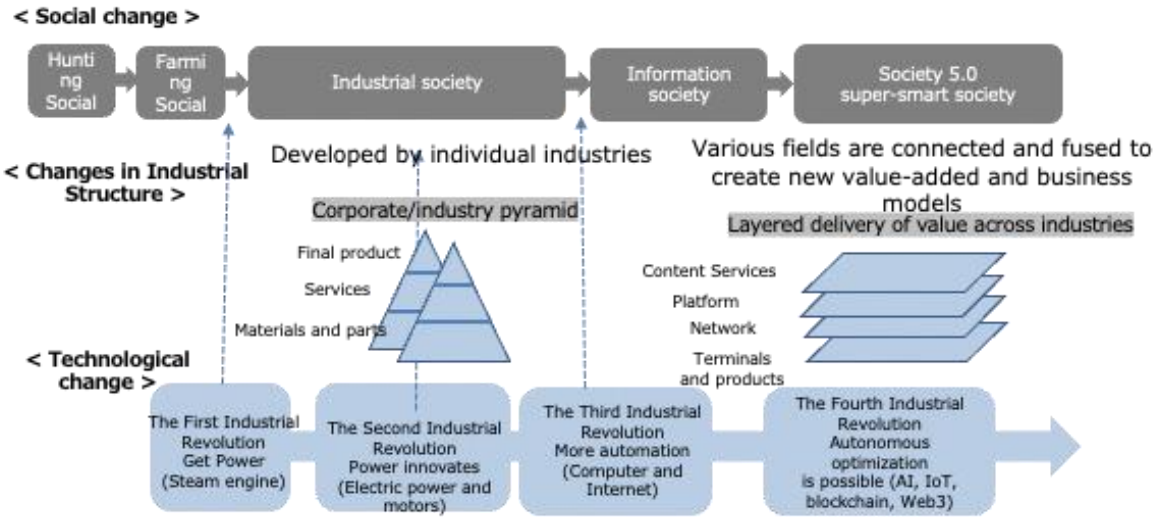

Figure 1 Realization of Society 5.0 and Changes in Industrial Structure Due to the Fourth Industrial Revolution

(Source: Based on various publicly available information)

Under these circumstances, the automotive industry, which is undergoing technological innovation in new areas called "CASE" such as Connected, Autonomous/Automated, Shared &

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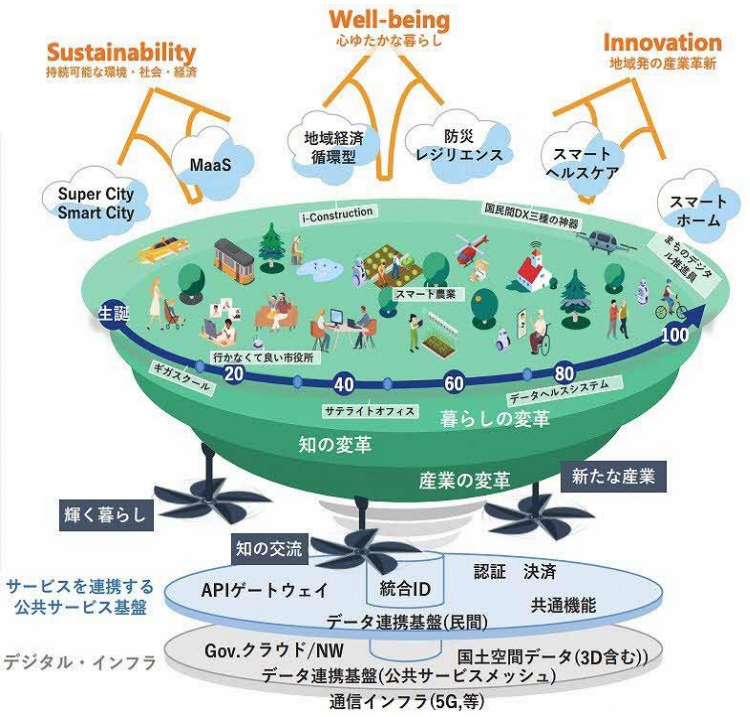
[5] A type of database in which transaction records are processed and recorded in a decentralized manner using cryptography by directly connecting terminals on an information and communications network, a basic technology used for virtual currencies such as bitcoin.

[6] It refers to an industrial structure in which each layer (hierarchy), which is a component of an industry, is established independently as a product/service and consumers have direct access to each layer and are free to choose from.

Services, and Electric, undergoes a major structural change only once a century. The automotive industry is also expected to generate a huge demand for semiconductors in the future, especially owing to the innovations in electric vehicles (BEV) by the electrification of vehicles, connected vehicles utilizing various sensors, and autonomous automated driving.

Furthermore, Japan has set out to realize Society 5.0, a super-smart society that achieves both economic development and resolution of social issues to bring wealth to people through a highly integrated system of cyberspace (virtual space) and physical space (real space) that incorporates the technologies of the 4th Industrial Revolution into every industry and social life. In particular, the "Vision for Digital Garden City Nation" aims to solve social issues and enhance the attractiveness of local regions while using digital technology, and is expected to support the digitization and digital transformation (DX) of local regions, thereby increasing the demand for semiconductors in local regions.

Column 1: What is the Vision for Digital Garden City Nation?



It is the most important pillar of Japan's growth strategy for realizing the "New Capitalism," and presents a new vision of local regions where is both convenient and attractive while retaining the affluence of the region.

Specifically, through collaboration between industry, government, and academia, the project aims to solve problems faced by local regions, such as work, transportation, education, and medical care, through digital implementation, thereby realizing an enriching life in which no one is left behind with enjoying the benefits of digitalization.

The vision is to revitalize local communities by utilizing their uniqueness, to achieve bottom-up economic growth from the local to the national level and aims to create a sustainable economy and society.

Source: Digital Agency, "The 2nd meeting for realizing Digital Garden City Nation" materials (December 2021)

1.2 Accelerating digitalization in the wake of the pandemic

In Japan, with a declining population and shortage of human resources, the de-population of local regions and the decline of local industries have become major issues, therefore, digitalization has been promoted.

The global outbreak of the new coronavirus, which began at the end of 2019, has led to rapid digitization across society, and the use of ICT for enabling contactless and non-face-to-face lifestyles, including telework, online education, and online medical practice, is rapidly advancing. Internet traffic volume in Japan doubled in the two years from November 2019 to November 2021, also shows that the demand for ICT-related devices, such as personal computers, is rapidly increasing.

In addition, digitalization during the new coronavirus and rapid development of various technologies, including AI and IoT, have prompted the government to incorporate these technologies into local city/municipality development and promote smart city initiatives to improve the quality of citizens' lives and efficiency of urban activities as a basic agenda for future city/municipality development and as a comprehensive showcase for Society 5.0.

Furthermore, in the urgent recommendations of the “Council for the Realization of New Capitalism”, the "Vision for Digital Garden City Nation" was proposed to solve regional issues such as depopulation and aging populations by implementing digital technologies to revitalize local regions and to promote the implementation of digital technologies such as telework, drone home delivery and automatic delivery from local regions, comprehensive and integrated promotion of DX by local SMEs, development of an ICT environment for education, and active investment in building a foundation for revitalizing local regions. In response to these developments, local governments are taking steps toward DX in their communities, and demand for semiconductors, one of the key products in supporting technologies needed to digitize all industries, including 5G, big data, AI, IoT, autonomous driving, robotics, smart cities, and DX, is expected to increase.

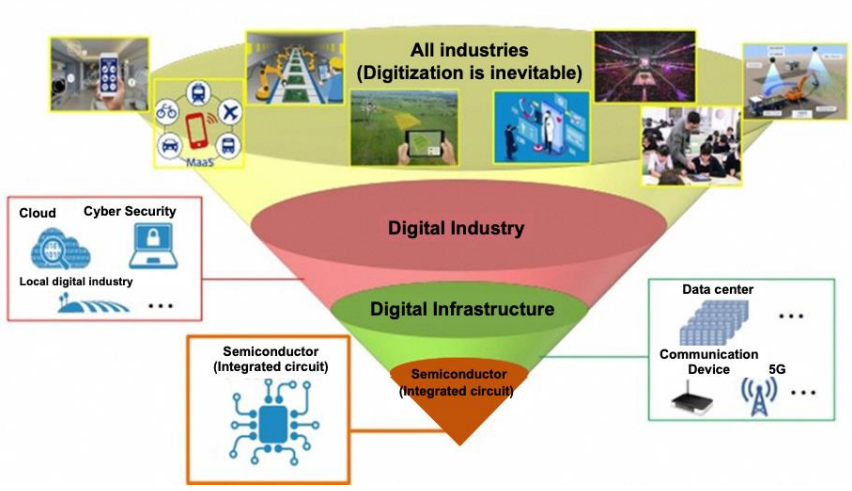


Figure 2 Semiconductors Needed in All Industries

Source: Ministry of Economy, Trade and Industry's "Semiconductor Strategy" (June 2021).

1.3 Changes in the environment surrounding economic security, increasing scale of natural disasters, and impact of the new coronavirus have revealed the vulnerability of supply chains.

With the spread of the new coronavirus, cities were locked down, travel restrictions were imposed internationally, factories were shut down, supply chains were disrupted, which resulted in severe global shortage of semiconductors. Therefore, the resulting stagnation in economic activity, countries have just realized that securing semiconductors is extremely important for economic security.

In addition, in the United States, several semiconductor plants in Texas stopped production due to power outages caused by cold weather; in Taiwan, a severe drought affected the production of semiconductors as it consumes a lot of water in the manufacturing process; and in China, power consumption regulations restrict the operation of semiconductor plants. The above scenarios have caused disruptions to the semiconductor supply chain due to the scale of natural disasters worldwide. Other factors, such as increasing transportation costs and impact of the Ukrainian crisis, have combined to expose vulnerabilities in the semiconductor supply chain globally.

Semiconductor industry is threatened by international cyber-terrorism because, as mentioned above, it is a key industry from a security perspective. While promoting DX in the industry, it is also constantly threatened by cyberterrorism. With advancement in Internet in recent years, "cyber-attacks" have become increasingly complex and sophisticated, and the methods of "industrial espionage" are also expected to become more sophisticated.

1.4 Expanding efforts for achieving SDGs

In September 2015, the United Nations (UN) Summit adopted the “Sustainable Development Goals (SDGs)". SDGs aims to build a society in which no one is left behind as an international goal from 2016 to 2030, and sets 17 goals to realize a sustainable world (Figure 3).

Semiconductors are essential for achieving these goals. For example, the global trend toward decarbonization aimed at reduction in greenhouse gas emissions, a major cause of climate change, is seen as an opportunity for economic growth. Efforts to achieve Green Transformation (GX)[7], which aims to reduce emissions and improve industrial competitiveness, will also utilize the performance of power semiconductors, which are semiconductors that supply and control electricity, reduce power losses, and result in energy-saving performance of equipment.

In addition, more companies are rushing to adopt sustainable procurement, an initiative aimed at sustainable procurement, through social considerations in the supply chain, and this is expected to have a significant impact on the global supply chain in the future.

[7] The goal is to transform the entire economic and social system by shifting away from fossil fuels and other sources of greenhouse gas emissions to decarbonized gas and renewable energy sources such as solar and wind power.

The Natural and living environments have changed significantly over the last decade because of ongoing global warming and climate change (frequent occurrence of extreme weather events), and even in Kumamoto Prefecture, large-scale natural disasters have impacted corporate activities. The pursuit of these diverse goals will contribute to the resolution of the social background and issues surrounding Kumamoto Prefecture, and contribute to the development of a sustainable city. Therefore, keeping the principles of SDGs in mind is important when promoting semiconductor-related industries.

Figure 3. 17 Goals of the SDGs

Source: United Nations

Column 2: What is sustainable procurement?

In recent years, to further promote global SDGs initiatives, the International Organization for Standardization (ISO) supplemented ISO 26000, “Guide to Social Responsibility”, with the official publication of ISO 20400 "Sustainable Procurement - Guidance" in November 2017 to provide guidelines for companies and organizations to contribute to sustainable development through procurement.

In addition, CDP, a UK international environmental non-profit organization (NGO) working to "Keeping a healthy and prosperous economy for people and the planet," encourages investors, businesses, and local governments to disclose and collect information on their environmental impact, and this collected information has a significant impact on the decisions of investors, businesses, and policymakers globally. In 2020, the total investment exceeded USD 106 trillion, and in 2021, the total number of prominent investors will exceed 590.

In this way, the response to social demands placed on companies is now incorporated into procurement indicators as well. It is not only the manufacturing and sales processes in which the company is involved are evaluated, but society is beginning to demand that the company fulfill its social responsibilities in all processes, from the procurement of raw materials to its all suppliers.

For example, TSMC also requires all Tier 1 suppliers to complete its Sustainable Management Self-Assessment Questionnaire by 100% as a procurement condition.

2 Changes in the semiconductor industry

2.1 Market trends in domestic and overseas semiconductor-related industries

2.1.1 Sales and market share of semiconductor devices

According to a study by World Semiconductor Market Statistics (WSTS), global semiconductor market was approximately USD 5,559 billion in 2021, a significant growth of 26.2% over the previous year. The global economy is also gradually becoming more active due to the impact of the new coronavirus, and the semiconductor market forecasts a strong demand for a wide range of applications, continuing the strong growth trend of the previous year.

Global market growth in 2022 is expected to increase of 4.3% over the previous year. However, the growth is expected to be slower than the previous year due to continuing global inflation, the slowdown in China and the impact of Russia's invasion of Ukraine.

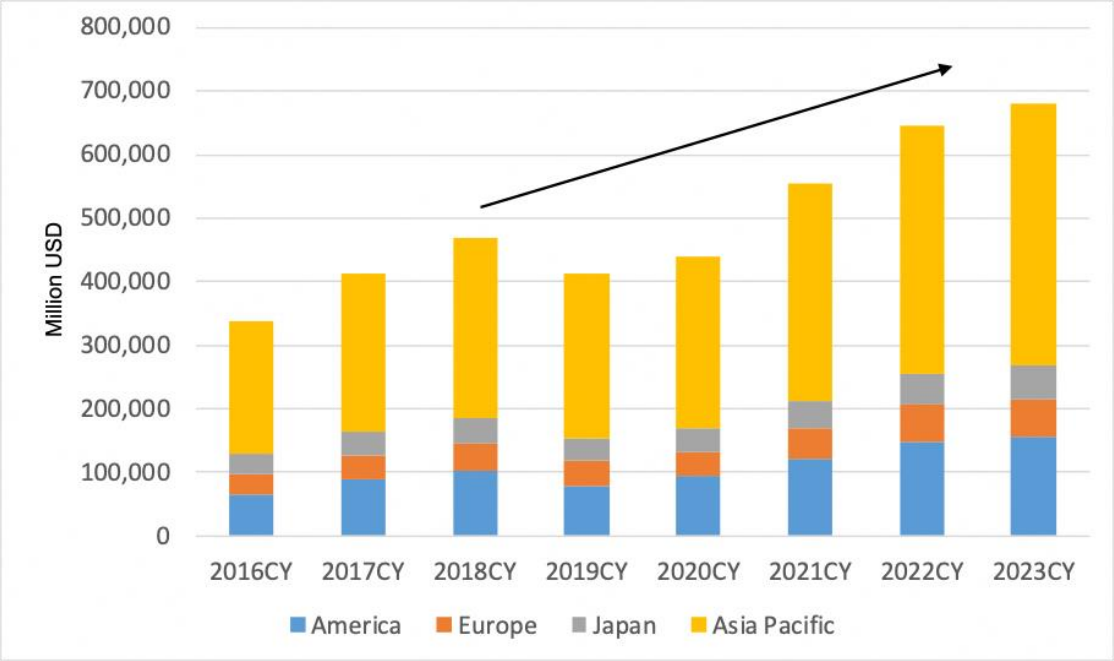


Figure 4 Global Semiconductor Market by Region

*Projected after 2022

Source: "WSTS Spring 2022 Autumn Semiconductor Market Forecast," WSTS Japan Council (November 2022)

With such growth in global semiconductor market, the position of Japanese companies in the world is gradually declining. In 1988, the Japanese semiconductor industry accounted for approximately 50% of the world's sales share, far ahead of the United States, which was second at the time, at 36.8%, but since then Japanese share has gradually declined, falling to 10.0% in 2019.

The reasons cited for this include high costs due to excessive quality, headhunting of domestic engineers by overseas companies causing technology outflow, funding crunch for huge investments and slow decision-making, and slow shifting of business models from vertical integration to horizontal division of labor. Further losses of market share are feared, and from the standpoint of economic security, there is an urgent need to regain the market in the future.

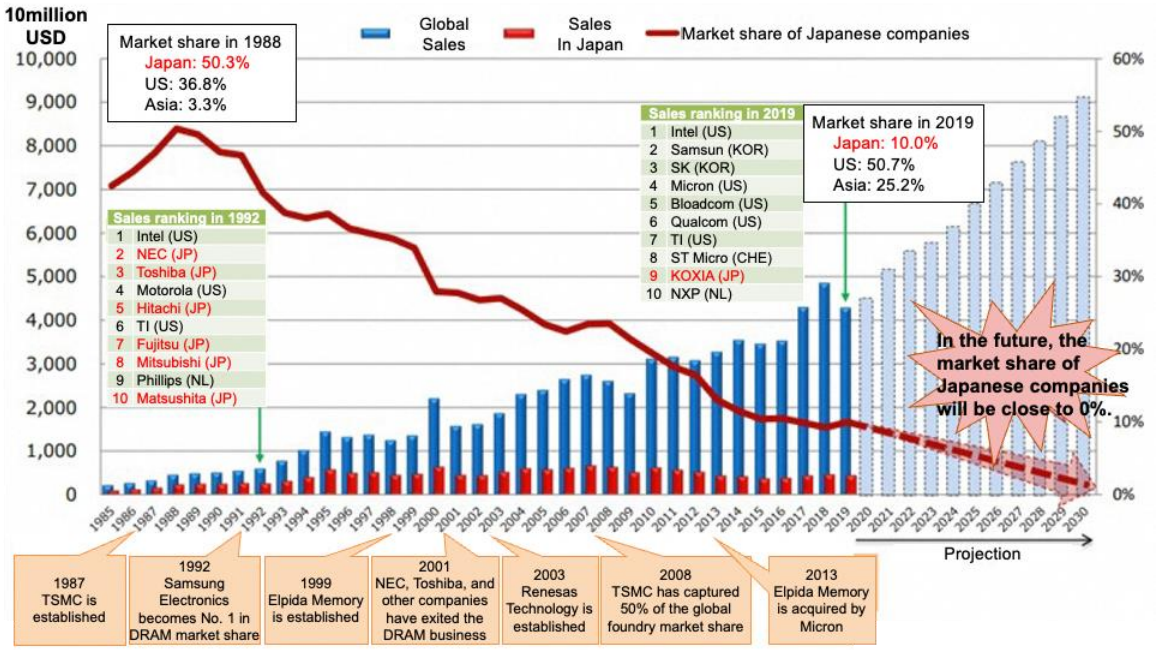


Figure 5: Trends in Sales and Market Share of Japanese Companies

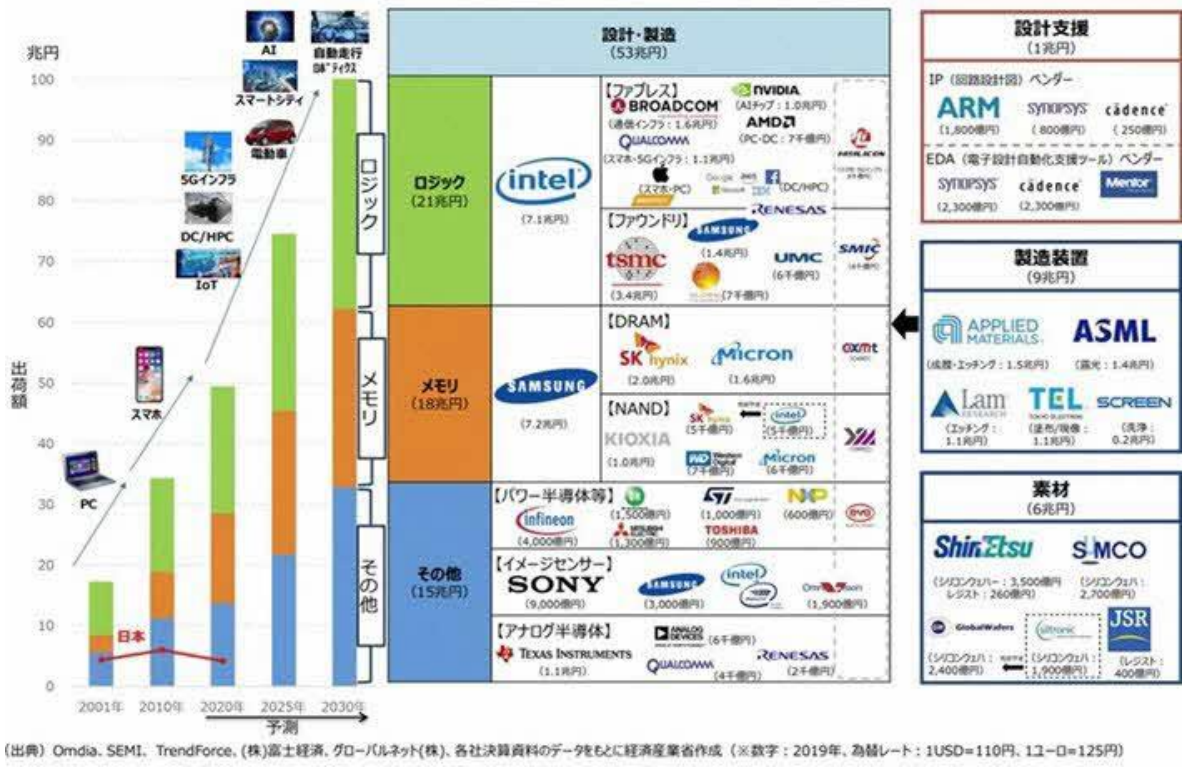
Source: Ministry of Economy, Trade and Industry's "Semiconductor Strategy" (June 2021).

2.2 Changes in the semiconductor market, users and applications

The semiconductor industry has rapid technological innovation and requires huge capital investment, and makes it difficult to adjust the timing of capital investment and inventory control. As a result, the supply-demand balance is prone to fluctuations, and the industry has grown while experiencing the so-called "silicon cycle," a phenomenon in which business booms and busts occur at regular intervals.

Semiconductors were often embedded in devices, such as PCs and smartphones. Recently, with the advent of the Fourth Industrial Revolution, the use of semiconductors in a wider range of devices is expected with growing industries and life scenes where digital technology is actively used, such as IoT, data centers, 5G infrastructure, robotics, autonomous vehicles, and smart cities.

Therefore, the Ministry of Economy, Trade, and Industry estimates that the global semiconductor market will double to approximately USD 900 billion by 2030.



(出典) Omdia、SEMI、TrendForce、(株)富士経済、グローバルネット(株)、各社決算資料のデータをもとに経済産業省作成（※数字：2019年、為替レート：1USD=110円、1ユーロ=125円)

Figure 6 Semiconductor Market and Key Players

Source: Semiconductor and Digital Industry Strategy Review Conference

"Document 5 Global Semiconductor Market and Major Players" (March 2021)

2.3 Changes in semiconductor manufacturing technology

2.3.1 Changes in semiconductor manufacturers' business models

The dominant business model for semiconductor manufacturers in the 1980s was the integrated semiconductor company (IDM), which designed and manufactured its products. Since the 1990s, there has been a movement (selection and concentration) to outsource all but the most important parts of the company's business to other companies, as the investment required for the advancement of miniaturization technology has increased. This has led the emergence of companies specializing in specific technical fields and a gradual horizontal division of labor.

Consequently, foundries, whose business model involves manufacturing of semiconductors from many customers, were in a better position than vertically integrated IDMs in terms of efficiency and rate of return on R&D and capital investment. As the world's largest foundry, TSMC made an aggressive investment in manufacturing technology in the 2000s and successfully implemented a strategy to achieve high yields in the conventional manufacturing process at low cost and in a short period of time. As such, since 2010, the foundry industry has gained international status, and TSMC's international status has also risen, resulting in the acceleration of its manufacturing technology.

2.3.2 Potential semiconductor manufacturing technology

In recent years, the pace of miniaturization has slowed, and miniaturization using conventional methods has saturated, and research and development of manufacturing technology is transforming to realize further speedup and higher integration.

In the Future Summits 2022 held in May 2022, imec (see column (3)), an independent advanced semiconductor research institute in Belgium, presented its vision of overcoming the conventional limits of miniaturization through a combination of technological developments, such as the development of high-power, high-numerical aperture, next-generation semiconductor lithography equipment, development of next-generation transistor structures and adoption of new materials, and improvement of wiring layer structures.

In addition to the conventional method of increasing the integration level in two dimensions, three-dimensional staked packaging technology, which achieves high-speed communication and power saving by stacking multiple wafers and chips in three dimensions, has gained attention of companies and research institutes in various countries.

2.3.3 Future development of semiconductor three-dimensional staked packaging technology

Currently, in semiconductor three-dimensional staked packaging technology, chip stacking of the same type of function performed by Micron, Samsung, SK Hynix, Kioxia, etc. (DRAM memory (up to 12 layers)) and wafer stacking of different functions performed by SCK, etc. (CMOS image sensor (up to three layers)) are mass-produced.

In addition, Intel, TSMC, Samsung, and UMC are conducting research on logic LSI stacking technology but have not started with mass production stage because of issues such as productivity, yield loss after stacking, and heat dissipation countermeasures.

In addition, research and development on three-dimensional stacking, in which multiple chips with various functions, such as sensors, memory, and logic, are currently being conducted at multiple institutions with different stacking methods. For example, basic research is being conducted mainly in design at the University of Tokyo and manufacturing at Tohoku University.

To develop and commercialize the results of basic research related to these three-dimensional stacked packaging technologies in applied research, it is necessary to have an environment in which design and manufacturing technologies are studied and prototyped as one unit. However, such an environment has not yet been realized in Japan, and mass production has not yet been achieved.

Column 3: Current status and future of Japan's semiconductor and digital industry strategies

In addition to the United States, South Korea, and Taiwan, which have the top semiconductor manufacturers, Europe is also attracting Intel plants in Germany, accelerating the development of next-generation semiconductors globally.

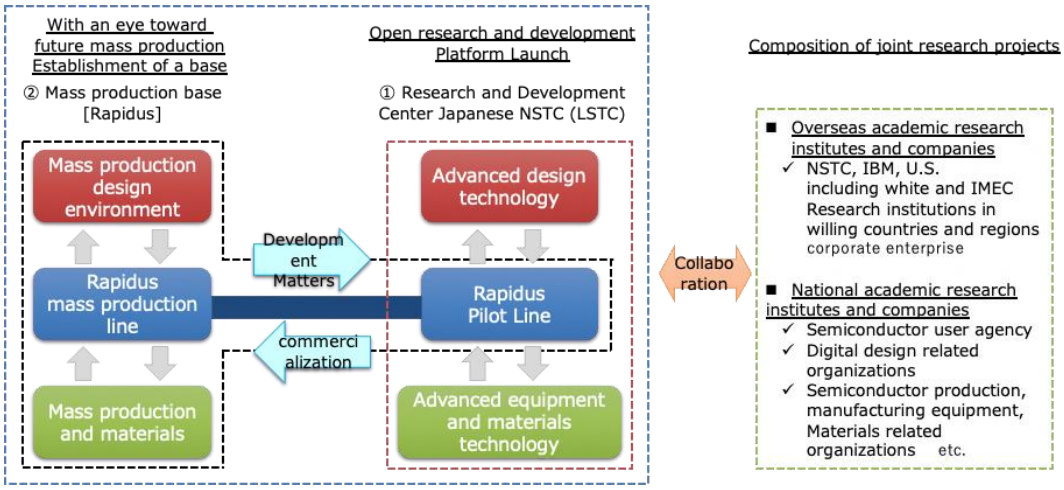
The field effect transistor (FET) structure of leading-edge semiconductors will change significantly from a fin structure to a gate all-around (GAA) structure and a CFET structure in the future, and a transformation stage has come that requires advanced production technology for mass production.

To catch up, the Japanese public and private sectors are working together to develop a new infrastructure for the mass production of short-TAT for next-generation semiconductors (beyond 2 nm).

Specifically:

① In addition to launching the Leading-edge Semiconductor Technology Center (LSTC), there is an open research and development center for advanced design and elemental technology for advanced devices and materials.

② We established Rapidus Corporation, a mass production facility with the aim of launching a mass production system in the future.



Source: Ministry of Economy, Trade and Industry,

"Current status and future of semiconductor and digital industry strategies" (Dec. 2022)

Leading-edge Semiconductor Technology Center (LSTC):

It is the Advanced Semiconductor Technology Center of the Technology Research Association, which was established and authorized in December 2022 as a research and development base for realization of mass production technology for next-generation semiconductors. It establishes an open R&D platform in Japan and abroad to collaborate with international organizations and formulates and implements technology development projects related to semiconductors with short TAT and 2 nm nodes or smaller to realize mass production of next-generation semiconductors. The initial participating institutions were the National Institute for Materials Science, RIKEN, National Institute of Advanced Industrial Science and Technology, Rapidus Corporation, Tohoku University, University of Tsukuba, University of Tokyo, Tokyo Institute of Technology, Osaka University, and the High Energy Accelerator Research Organization.

Rapidus Corporation:

Aiming to become a mass production and manufacturing base for the next generation of semiconductors with 2 nm node or less, the company was established in August 2022 as a joint venture by eight of Japan's top engineers: Kioxia Corporation, the SONY Group Corporation, SoftBank Corporation, Denso Corporation, Toyota Motor Corporation, NEC Corporation, Nippon Telegraph and Telephone Corporation, and MUFG Bank, Ltd. Together with LSTC, we aim to build a mass production base for the next generation of semiconductors in Japan, and have started R&D of 2 nm generation semiconductor integration technology and short TAT manufacturing technology based on Japan-U.S. collaboration, with a development cost of 70 billion yen from the government's "Research and Development Project for Next-Generation Semiconductors in the Post-5G Fund Project." In December 2022, the company signed a Memorandum of Cooperation (MOC) with the Interuniversity Microelectronics Centre (imec) and signed a joint development partnership with IBM.

Interuniversity Microelectronics Centre (imec):

The Flemish Regional Government of the Kingdom of Belgium is a leading open innovation international research organization in the field of semiconductor nanoelectronics and digital technology based in Leuven. Researchers from more than 70 countries are currently conducting cutting-edge research.

To strengthen the research, development, and production of semiconductors in the EU and achieve a stable supply of semiconductors, we play a major role together with the National Research Institute for Alternative Energy and Atomic Energy, CEA-Leti in France, and the Fraunhofer Institute in Germany[8].

[8] Europe's largest applied research organization in the field of science and technology, conducting practical applied research for private and public companies and for the benefit of society as a whole.

2.4 Ripple Effects of Attracting Semiconductor Factories

In general, the attraction of a semiconductor plant is expected to have a strong ripple effect on the local economy, not only through the huge direct investment in plant and equipment, but also through the revitalization of various industries related to food, clothing, and housing, including the employment of workers from surrounding industries, the development of housing and educational environments, and the improvement of transportation infrastructure.

For example, Kyushu Financial Group Inc. announced an estimate that the economic ripple effect of the new plant that TSMC is building in Kikuyo-cho, Kikuchi-gun, Kumamoto Prefecture, will be approximately USD 582.28 (JPY 4.29 trillion) over the 10 years from 2022 to 2031. In addition, Kioxia HD, a major semiconductor manufacturer, is currently constructing a new semiconductor fabrication plant in Iwate Prefecture, and in addition to direct investment totaling more than 1 trillion yen, the project is expected to create 1,000 jobs, and infrastructure improvements such as road and intersection improvements to ease traffic congestion are also underway in parallel. In addition, the project is expected to have a major economic impact on the entire prefecture. In Hiroshima Prefecture, U.S. memory giant Micron Technology plans to invest about USD 1.9 trillion (JPY 140 billion) in facilities for the mass production of advanced DRAM products, which is expected to employ about 3,900 people. In response, Hiroshima Prefecture said, "The semiconductor industry will make huge investments over a period of time, which will have a positive impact on the prefectural economy and local employment.

3 Measures for semiconductor-related industries in other countries

3.1 Trends in global supply chain construction

3.1.1 Measures for building supply chains

As disruption risks in supply chain disruption are increasing owing to natural disasters, new coronavirus disease, trade friction, and other factors, other countries are implementing industrial policies, including massive investment support, to secure an important production base for semiconductors from the perspective of economic security.

- Industrial Cluster in Taiwan

  Since the 1980s, science parks have been formed as part of the nation's planned economy aimed at establishing a science and technology industry in Taiwan, and global companies have concentrated in various areas of the semiconductor supply chain, especially in design, pre-processing, and post-processing. In recent years, particularly in the materials and manufacturing equipment fields, Taiwan government has set a target to increase the percentage of procurement within Taiwan by 2030 and have formed a special zone for semiconductor materials in Taiwan to promote various measures.

  In addition, as measures to attract companies, Taiwan government offers preferential treatment for investment in Taiwan, develop infrastructure to contribute to the construction of factory sites, provide various educational programs for human resource development, develop laws to secure talented human resources from overseas, and establish programs and provide subsidies for research and development of cutting-edge semiconductors.

  The Hsinchu Science Park in northern Taiwan has many world-class companies in the semiconductor manufacturing process (materials, manufacturing equipment, design, pre-processing, and post-processing). It was established with the aim of creating an environment for the creation of new products and technologies for research and development, production, labor, living, and leisure to attract talented human resources, incorporate advanced technologies, and serve as a base for the development of high-tech industries, and by promoting integration to facilitate collaboration at various stages in the upstream, midstream, and downstream high-tech industries. However, in recent years, various issues have been identified, such as shortages of electricity, water, labor, and land due to large-scale integration and congestion.

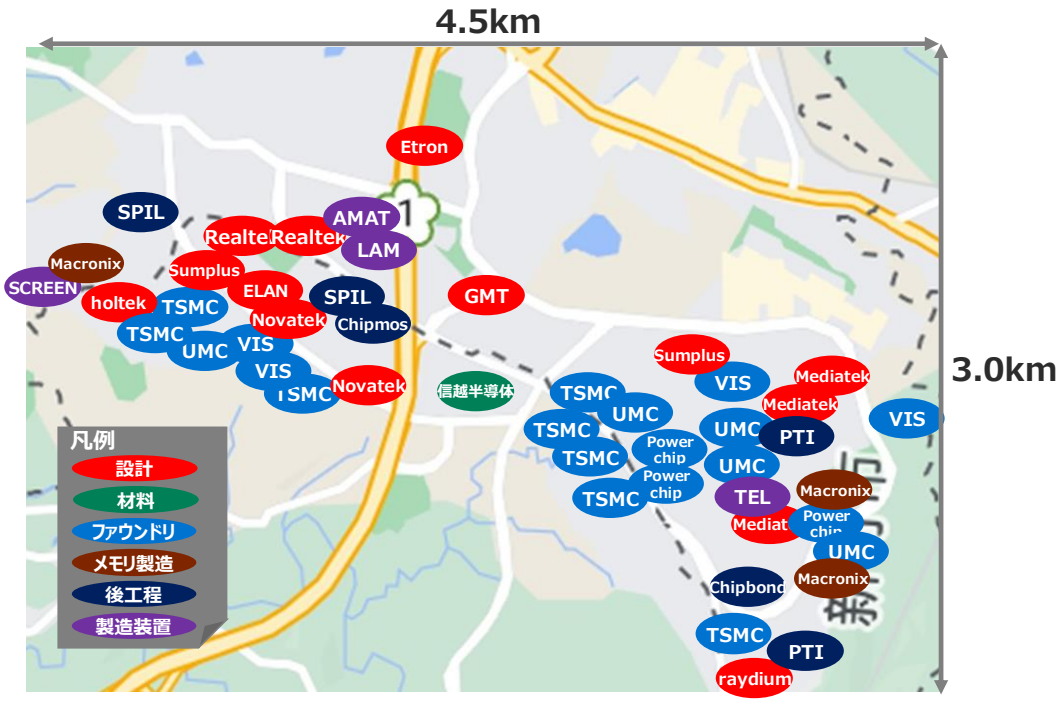


Figure 7: Accumulation at Hsinchu Science Park

Source: Map data © 2023 Based on Google and various publicly available information

- Industrial Cluster in South Korea

With a target of 50% domestic production of materials, parts, and equipment by 2030, the South Korean government announced in May 2021 a plan to develop new design, materials, post-process, and manufacturing equipment bases to cover the existing semiconductor plants in the southern suburbs of Seoul (K semiconductor strategy, construction of K semiconductor belt, etc.). Major investments by domestic companies such as Samsung Electronics and SK Hynix are expected to be the centerpiece of the plan.

The "K Semiconductor Strategy" aims to establish the world's largest semiconductor supply network in South Korea by 2030 and plans to establish four new locations around the existing semiconductor industry cluster.

・An industrial park specializing in materials, parts, and equipment
・Advanced packaging platforms
・An industrial complex of high-tech equipment companies
・Fabless Valley, which specializes in design

To achieve these goals, the government provides support from the perspectives of tax credit, human resource development, infrastructure development, and legislation.

・Tax credit up to 40% - 50% of R&D investment and up to 10% - 20% of facility investment.
・Developing 36,000 human resources for the semiconductor industry over the next ten years
・Securing water and power supplies to the semiconductor industry
・Enacting the Special Act on Semiconductors (grounds for exceptional deregulation, infrastructure, and tax support)"

- Industrial Cluster in the United States

In response to supply shortages and disruptions caused during the new coronavirus in the United States, the U.S. government focused on increasing domestic semiconductor production capacity. In August 2022, the CHIPS Act (formal name: CHIPS and Science Act) was passed to promote the domestic semiconductor industry. The CHIPS Act includes plans to spend about USD 52.7 billion to boost U.S. competitiveness and national security, particularly to boost investment in semiconductor manufacturing capabilities. For semiconductor manufacturing, research and development, and workforce development, approximately USD 24 billion is allocated to semiconductor manufacturing. A framework has been under consideration since the spring of 2020, which has stimulated semiconductor-related investment, and more than 40 semiconductor-related investments have been planned since 2020 (major companies that has investment plan as follows).

・Semiconductor manufacturing: TSMC, Intel, Samsung, SK Hynix, Micron, etc.
・Manufacturing equipment: ASML, Edwards, EMD Electronics, etc.
・Materials: Sumitomo Chemical, JX Metals, Mitsubishi Gas, Corning, etc.

For example, in Arizona, TSMC is planning a large plant totaling USD 40 billion at request of the U.S. government. It is the largest foreign direct investment in the United States. The TSMC is also working to attract Taiwanese partners to build these plants, and a semiconductor supply chain similar to Taiwan's is planned in Arizona.

- Industrial Cluster in India

In December 2021, the Semiconductor Mission in India (ISM) was announced, launching a grand plan to turn India into a major production center for semiconductors and electronics. In response to the government's move, the state of Gujarat announced its "Semiconductor Policy for 2022 to 2027" in July 2022, aiming to establish a semiconductor city to serve as a dedicated manufacturing base for semiconductors and displays.

- Summary of the states of industrial cluster in each country

Summarizing the states of industrial cluster in the semiconductor supply chain in Taiwan, South Korea, the United States, and India, a particular focus on integration related to device manufacturing (design, materials, pre-processing, and post-processing) is observed.

As the risk of supply chain disruption increases owing to natural disasters, new coronavirus, trade friction, and other factors, the competition among countries to secure an important production base for semiconductors will accelerate from the standpoint of economic security.

Table 1 Targets for strengthening supply chains in each country

Classification	Supply chain	Taiwan	Korea	United States	India
Device	Design	●	● Fabres	***	● Semiconductor designer
	Materials	● Strategy for semiconductor chemical materials Supply chain construction	● Mainly focusing on materials, parts and equipment	● Subjects of the CHIPS Act (research)	***
	Pre-process	● Foundry memory	● Foundry memory	● Subject to the CHIPS Act (Investments)	● Semiconductors and compound semiconductors ·display plant
	Post process	● Packaging and IC Inspection	● Packaging	● Subject to the CHIPS Act (Investments)	● Semiconductor package
	Products	***	***	***	***
Manufacturing equipment	Manufacturing equipment manufacturers	△ Part of the supply chain	△ Some materials, parts and equipment	***	***
	Parts and processing (manufacturing equipment subcontract)	***	***	***	***
Others	Dispatch and outsourcing	***	***	***	***

Source: Based on various publicly available information

3.1.2 Conditions for the location of semiconductor companies

In recent years, companies in the semiconductor supply chain (Pre-process, post-process, materials, manufacturing equipment) have made decisions to establish plants, and the reasons for these decisions are summarized in Table 2 Infrastructure Conditions Pertaining to the Location of Semiconductor-related Companies. A variety of factors, such as supply chain, human resource acquisition, water and power supply, policy support, and natural conditions, are the reasons for investment decisions to build a semiconductor manufacturing (pre-process) plant, but one characteristic is that there is no awareness of the existence of customers.

However, the presence of customers (pre-process companies) is considered a major reason for investment decisions in plant construction by manufacturers of post-process, equipment, and materials.

Table 2 Infrastructure requirements for the location of semiconductor-related companies

Classification	Case study		Reason						
	Companies, factories and areas	Timing	Customer	Supply chain	Recruitment	Water and power supply	policy support	natural conditions	Other
Pre-process	**Intel**	• Began in 2021	***	***	✓	✓	✓	✓	***
	Intel	• Construction started after 2022	***	***	✓	✓	***	***	***
	Samsung Electronics Co., Ltd.	• Announced in 2021	***	✓	***	✓	✓	***	• Existence of existing factories
	TSMC (Arizona, USA)	• Started in 2024	***	***	***	***	✓	***	• Geopolitical factors
	TSMC (Nanjing, China)	• Announced in 2015	***	✓	✓	***	✓	***	***
	Micron Technology Co., Ltd.	• Started in 2024	***	✓	***	***	***	***	• Taiwan Strait Risk
Post process	**ASE (Taoyuan, Taiwan)**	• Announced in 2022	***	***	***	***	***	***	• Existence of existing factories
	ASE (Kaohsiung, Taiwan)	• Announced in 2018	***	***	***	***	✓	***	***
	ASE (Penang, Malaysia)	• Construction started in 2020	***	***	***	***	***	***	• Existence of factories
	Amkor (Haknin Province, Vietnam)	• Completed in 2023	***	***	✓	***	✓	***	***
	SPIL (Yunlin, Taiwan)	• Announced in 2022	✓	***	***	***	***	***	***
	SPIL (Changhua, Taiwan)	• Announced in 2021	✓	***	***	***	***	***	***
	PTI (Hsinchu, Taiwan)	• Started in 2020	✓	***	***	***	***	***	***
Equipment	**AMAT (Texas, USA)**	• Reviewed in 2022	✓	***	***	***	***	***	***
	Lam Research (Penang, Malaysia)	• Opened in 2021	✓	***	***	***	***	***	***
Materials	**SUMCO (Imari City, Saga Prefecture)**	• The 2021 Year Plan	***	***	***	***	***	✓	• Existence of existing factories
	Tokyo Ohka Kogyo Co., Ltd.	• Opened in 2014	✓	✓	***	***	***	***	***
	Sumitomo Chemical Co., Ltd.	• The 2021 Year Plan	✓	***	***	***	***	***	***
	Sumitomo Chemical Co., Ltd. (Jiangsu, China)	• Opened in 2019	✓	***	***	***	***	***	***

Source: Prepared based on various publicly available information

Specific reasons for each condition include:

A) Supply Chain

- The existence of a complete semiconductor supply chain in which the semiconductor industry is accumulated.
- Easy collaboration between academia and suppliers

B) Recruitment

- Development of technical human resources to support advanced industries
- The ability to acquire talent from universities
- A rich pool of engineers

C) Water and Power Supply

- Stable electricity supply and abundant groundwater (the need for pre-process companies for water).
- High level of infrastructure

D) Policy support

- Availability of local government support and tax benefits
- The central and local governments cooperate in corporate activities and are willing to support relevant companies.

E) Natural conditions

- Low humidity and low risk of natural disasters

F) Customers

- Potentially closer to customers in Asia

- Expected start of rush to build semiconductor plants
- Each semiconductor manufacturer plans to boost its lines

3.2 Trends in Human Resource Recruitment and Development in the World

As the semiconductor market is expected to grow and semiconductor-related companies are stepping up factory investments to capture the market, the problem of shortage of semiconductor professionals and human resources is becoming more apparent in Taiwan, South Korea, China, and the United States.

The ratio of active job offers to jobseekers in the semiconductor industry in Taiwan increased from 2.3 times in December 2019 to 3.7 times in December 2021, indicating a serious shortage of human resources. In particular, the demand for human resources in the sciences has been increasing annually due to increased investment by semiconductor and other electronics-related companies, while the number of graduates in higher education has been decreasing and competition for getting human resources in the sciences has intensified. In addition, according to the Korea Semiconductor Industry Association, the massive expansion of production facilities by semiconductor manufacturers has resulted in an annual shortage of 3,000 workers in South Korea. The Semiconductor Display Technology Society of Korea emphasizes that "Only about 1,400 out of the 10,000 human resources hired annually by domestic semiconductor companies are semiconductor majors, and the capacity of university semiconductor related departments should be expanded, and semiconductor related graduate schools should be strengthened to produce more master's and doctoral students."

According to China's IC Industry Human Resource Development Report, China will face a shortage of approximately 200,000 semiconductor professionals by 2022. In addition, the latest massive shortage has become severe, with a new report published by the China Institute of Education Finance at Peking University stating that "The shortfall reached about 300,000 in 2019, more than doubling from 150,000 in 2015."

In the United States, the CHIPS Act has led to a planned investment of USD 13.2 billion in R&D and human resource development, indicating a high sense of urgency to secure and develop human resources.

Table 3 Shortages of Semiconductor Human Resources and Response Status

Country	Situation of talent shortage	Responding to the shortage of human resources
Taiwan	**Intensified competition and the ratio of active job offers to job offers was at the highest level of 3.7 (Shortfall of 24000)**	**◆Launched a platform for advanced semiconductor talent in 2021 ◆Develop more than 950 highly skilled human resources from Taiwan and abroad (target)**
Korea	**Shortage of about 30,000 in next 10 years**	**◆Semiconductor-related human resources development plan unveiled, declaring 150,000 semiconductor workers to be trained by 2030**
China	**Lack of more than 200,000 professionals by 2022**	**◆Plans to train a total of more than 200,000 field engineers (excluding semiconductors) by 2025 under the "Special Training for Field Engineers in Vocational Education" plan**
United States	(No clear mention found)	**◆With the CHIPS Act, we will continue to expand our R & D and human resource development, an investment of $13.2 billion (about 2 trillion yen)**

Source: Based on various publicly available information

As the shortage of human resources becomes severe, national efforts to develop human resources from short to long-term perspectives are being implemented. From a short-term perspective, each country is launching short-term intensive education programmes at universities, offering work-ready programmes at vocational high schools and colleges, providing interns capable to recruitment, and opening educational and training facilities. From medium to long-term perspectives, measures are being taken to increase the number of university students, establish new departments, build networks for the development of semiconductor human resources, and provide semiconductor education programs for elementary and secondary schools.

Table 4 Measures for human resource development in each country

Viewpoint	Overview	Details
Short term	**short-term intensive education program**	◆Korea launches new short-term intensive education program for students majoring in other fields ◆US: Bootcamp for semiconductor engineers to quickly learn skills needed in two weeks
	Vocational high school and vocational college Immediate Workforce Development	◆Korea: Vocational high schools and colleges offer programs tailored to corporate needs More work-study programs
	Direct-to-hire Intern implementation	◆(South Korea) Semiconductor-maker engineers participate as lecturers in semiconductor job training Providing internship opportunities (with pay) and opportunities for successful graduates to switch to permanent positions
	Ready-to-work development Education and training facilities	◆Taiwan: Equipment maker opens training center to train engineers in cutting-edge technology
Mid-term	**Increase in the number of students allowed in universities**	◆Taiwan: Raising quotas for undergraduate, master's and doctoral programs and easing the number of students per teacher ◆(Korea) Increase the number of students in advanced fields. In addition, standards for university administration regulations and requirements for concurrent and invited faculty in advanced fields were relaxed.
	Establishment of new departments	◆TAIWAN - The University has signed agreements with some of Taiwan's largest memory semiconductor companies for industry-university cooperation. Established a master's program in memory with the aim of providing exceptional human resources to the industry
	Development of semiconductor human resources network construction	◆12 universities and community colleges in the Midwest states of Ohio, Michigan and Indiana jointly train semiconductor talent by forming Midwestern Regional Network for semiconductors
Long-term	**Elementary and middle school Program delivery**	◆Japan: Introduces semiconductor companies and industries through company tours and delivery courses for elementary, junior high and high school students

Source: Based on various publicly available information

On the other hand, measures to secure human resources have been implemented at national and corporate levels.

At the national level, for example, Taiwan has enacted the “Overseas Professional Manpower Act”, a law designed to attract international professionals, and has implemented measures such as allowing people to freely look for jobs and change jobs at home, tax breaks, and relaxing the criteria for the right of residence for spouses and children.

At the corporate level, competition for human resources has intensified by headhunting and retention (prevention of outflow) through high salaries and favorable treatment, such as generous benefits, as well as strengthening collaboration between industry and academia.

Table 5 Measures to secure human resources in each country

Viewpoint	Overview	Details
Country Level	**A legal system to attract overseas talent Foreign Professional Personnel Act**	◆Taiwan: Offers preferential treatment to talented professionals ➢ Providing a work gold card that allows people to freely search for jobs and change jobs ➢ Income tax benefits, less restrictions on buying health insurance, more coverage related to mandatory retirement ➢ Relaxation of provisions on permanent residency applications for spouses and children, and work permits for adult children ◆Taiwan: Support for procedures and job search (Establishment of a one-stop application platform, disclosure of information through a recruitment portal, and provision of consulting services by professional staff)
	United States significant reduction in entry standards for professionals	◆Significantly lowered entry standards for semiconductors and AI professionals
corporate enterprise Level	**Favorable treatment drawing and securing (Prevention of personnel outflow)**	◆China: High salaries, generous benefits and the promise of high positions within the company ◆South Korea: Chipmakers race to improve treatment to retain workers (In 2021, both will eventually offer special bonuses of 4 to 5 times their base salary)
	Building relationships with universities	◆US: Chipmaker builds close relationship with Arizona State University Positioning as the best place to work for engineering students ◆U.S.: Major foundries frequently consult with universities and community colleges to build supply routes
	Deep involvement in educational programs	◆Major foundries collaborate with universities on both sides of a wide range of training programs ◆TAIWAN - The University has signed agreements with some of Taiwan's largest memory semiconductor companies for industry-university cooperation. Established a master's program in memory with the aim of providing exceptional human resources to the industry

Source: Based on various publicly available information

3.3 Trends in Semiconductor Innovation Ecosystem Construction

The world's major semiconductor manufacturers are pursuing research into cutting-edge technologies that require huge investments, such as miniaturization, collaboration among semiconductor manufacturers through the joint development of SoCs[9], and active collaboration with semiconductor-related industries (design tool providers, material manufacturers, equipment manufacturers, etc.).

In addition, with the expansion of semiconductor applications such as IoT, data centers, 5G infrastructure, robotics, autonomous vehicles, and smart cities, there are many examples of collaboration with downstream industries, such as information and communications and the automotive industry. In recent years, some cases have indicated large fabless companies who have

[9] Abbreviation for System on a chip. A circuit is wired on a single IC chip, making the system operable on a single chip.

built their own consortia and technology platforms to create an ecosystem for making most of their semiconductors.

Table 6 Trends in joint research organizations and alliances of semiconductor manufacturers

Categories	Company Name	Overview of external collaboration trends	Examples of cooperation with semiconductor companies	Examples of cooperation with semiconductor-related industries	Examples of collaboration with downstream operators		
					Information Communications	Automobile	Other
Overseas IDMs	**Intel**	• As a leader, we work with semiconductor vendors on standards development (UCIe Conso) and collaborate with downstream industries.	UCIe console	material system (Imec, etc.)	NTT, etc.	AECC Conso (Toyota, Denso, etc.)	Health care (GE Healthcare)
	Samsung	• Collaborative research with downstream companies, but may be completed within the group partly due to the aspect of manufacturers of mobile phones, communications equipment, home appliances, etc.	UCIe console, IBM (Transistor Research)	*** (Is it in a group?)	*** (Is it in a group?)	Tesla	OCF (Dell, Cisco, Electrolux, etc.)
	Micron	• Collaborate with other companies in the same industry (SoC development) and downstream providers on the basis of the company's state-of-the-art memory solutions	Nvidia (for GPUs), Qualcomm (for SoCs)	***	IoT related (Tata Communications)	Machine Learning Related (Continental)	Physical experiment (CERN, etc.)
Fabres	**Qualcomm**	• Expanded use of areas other than mobile to expand sales of Snapdragon SoC and other products	UCIe Conso, U.S. government project (SoC development)	U.S. government projects (AMAT, Siemens EDA, etc.)	Many collaborations and demonstrations Example:Ericsson, Thales (satellite 5G)	5GAA (More than 130 companies, including Audi and Daimler) *Early Members	OCF (Dell, Cisco, Electrolux, etc.) *central role
	Nvidia	• Actively building an ecosystem with downstream companies and simulation vendors based on commercial products such as autonomous driving and virtual space development platforms	***	NVIDIA DRIVE Partners (many simulation/tool vendors)	5G virtualization, gaming servers, data centers (Softbank, etc.)	NVIDIA DRIVE Partners (OEM, Tier 1 majority)	***
Domestic IDMs	**Kioxia**	• Research cutting-edge technologies with WD, with which we have a close relationship, and collaboration with domestic semiconductor manufacturing equipment and universities	Years of joint development with Western Digital	Refinement by NIL (DNP, Canon)	***	***	Academia (Telecommunications, Waseda)
	Renesas	• Active collaboration with solution vendors in the automotive industry and automotive application development	***	Semiconductors, embedded software design environment (Fixsters, etc.)	Software for IoT and in-vehicle services (Cyberon, etc.)	Many collaborations and demonstrations (Tata, etc.)	***
	Sony	• Collaborative development of AI cameras and other sensing solutions and promotion of collaboration on their development environments	Qualcomm (Joint Lab)	***	AI Camera Solutions (Microsoft, Uhuru, etc.)	*Honda and EV Development Establish New Company	Space (Device Evaluation)

Source: Based on companies' web pages, etc.

In addition to the collaboration between industries, there is active collaboration between companies and academic institutions. Intel, for example, has sponsored various science and technology centers at universities worldwide to promote collaboration and community development between Intel and academia. The research subjects range from machine learning[10] to deep learning[11], hardware design, automated driving, Internet of Everything (IoE)[12], intelligent systems[13], security, and cross-disciplinary topics, not limited to semiconductor manufacturing.

[10] A technique that allows artificial intelligence to learn things autonomously without using explicit instructions. A computer reads data and automatically finds rules and patterns, and uses the results to classify and predict.
[11] A type of machine learning that learns the structure of rules and patterns in multiple layers, allowing for more complex classifications and predictions.
[12] A concept that refers to the development of the Internet of Things (IoT), in which various things are connected to the Internet, and the connection of not only things but also people and services to the Internet.
[13] Any system that incorporates automatic control by electronic circuits and advanced software control by built-in computers.

In Europe, there are examples of public institutions taking a central position in promoting the innovation ecosystem. The Fraunhofer Institute in Germany provides meticulous research and development services and acts as bridge between industry and academia to small and medium-sized companies, provides the technological foundation for growth into a global niche top company[14], and plays an important role in the development of new products by large companies.

[14] A dominant player in a small niche market.

4 Current status of the semiconductor industry in Kumamoto

4.1 Current status and issues of the semiconductor supply chain in Kumamoto Prefecture

In the 1960s, when Mitsubishi Electric Corporation and NEC Kyushu Corporation built an integrated semiconductor manufacturing plant, Kumamoto Prefecture became one of the largest semiconductor manufacturing centers in Japan.

In the 1960s, the geographical advantages of the Kumamoto region, such as the lack of earthquakes and lightning strikes, the availability of good quality and abundant underground water, and the vast plains, were major factors in the location of companies.

In 1982, the Kumamoto Technopolis Basic Plan was formulated, aiming to create a town where industry, academia, and housing are integrated, with the advanced technology industry at its core. In 2000, the semiconductor field (recognized as a new manufacturing technology) was clearly positioned as one of the strategic areas in the "Kumamoto Prefecture Industry Promotion Vision," a guideline for medium to long-term industrial promotion measures in Kumamoto Prefecture, which has successfully attracted a large number of companies by actively promoting business attraction, technological development through industry-academia-government collaboration, and support for new businesses.

The “Kumamoto Semiconductor Forest Concept” formulated in 2005 proposed a five-pronged strategy centered on research and development: human resource development, university revitalization, strategic enterprise attraction, and support for new industry creation, further strengthening the semiconductor manufacturing base.

Since 2011, based on the “Kumamoto Prefecture Industrial Promotion Vision”, Kumamoto prefecture government has supported the promotion and growth of the manufacturing industry in Kumamoto Prefecture through industry-government-academia concerted efforts aimed at fostering leading industries, promoting industries that take advantage of the region’s characteristics, and integrating collaboration to create new industries.

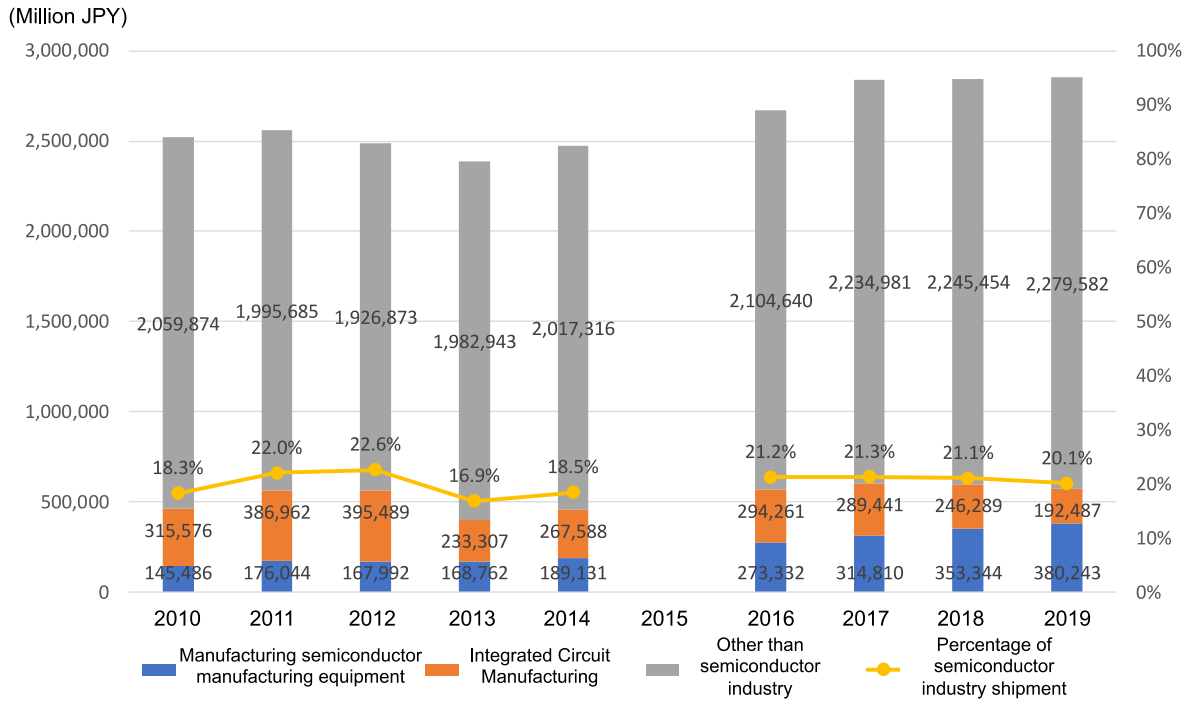
Since 2021, based on the “Kumamoto Prefecture Industrial Growth Vision”, Kumamoto prefecture government has been trying to create a new industry unique to Kumamoto Prefecture by continuing to create and nurture businesses by building an ecosystem that generates innovation sustainably in response to growing social and economic uncertainty.

Under these policies, Kumamoto has played a role in Silicon Island Kyushu by strengthening supply chains through corporate accumulation and semiconductor research and education in academic institutions. As countries globally strengthen their semiconductor supply chains aiming at economic security, the central government and Kumamoto Prefecture also need to strengthen their supply chains and accumulate further.

- Quantitative analysis

The semiconductor industry (semiconductor manufacturing equipment and integrated circuit manufacturing) accounts for a large portion of the total value of all manufacturing industry shipments in Kumamoto Prefecture, about 20% of the total. By contrast, the semiconductor industry

accounts for approximately 2% of all manufacturing industry shipments in Japan, making it an important industry to support the Kumamoto economy.



*Semiconductor Industry: Total of "Semiconductor Manufacturing Equipment" and "Integrated Circuit Manufacturing"

* Other related industries excluded.

Figure 8: Shipments of the semiconductor industry in Kumamoto Prefecture and their share of the total manufacturing industry

Source: Ministry of Economy, Trade, and Industry Industrial Statistics Survey and Economic census

● Qualitative analysis

In Kumamoto Prefecture, a series of supply chains are concentrated around major semiconductor device manufacturers that manufacture in-vehicle semiconductors, CMOS sensors, power semiconductors, coaters/developers, and large semiconductor manufacturing equipment manufacturers that manufacture coaters/developers, transfer equipment, etc., in addition to material manufacturers, contract companies for the post-processing of semiconductor devices, companies that process and provide components for manufacturing equipment, and staffing, outsourcing, and maintenance companies that support these companies.

In the supply chain in the device field, in addition to the presence of major companies in the " pre-processing " field in Japan, the construction of new large-scale plants is planned. In line with this, we expect further strengthening in the materials area, with plans for new plant construction and expansion. On the other hand, the areas of design and post-process were relatively weak. In addition to the point of view of finalizing supply chains in close areas and inducing innovation through close cooperation between companies, the design area is less competitive in Japan as a

whole, so it has the potential to become a niche top, and the post-process area needs to be strengthened in the future because it generates a large number of jobs.

In the supply chain of the manufacturing equipment field, there are several companies, mainly manufacturers of equipment, that process and provide parts and materials, making this a substantial value chain. However, companies that process and provide parts and materials need to implement new initiatives by themselves, such as technology development and business development, to respond to the ups and downs of the market.

Table 7 Results of hearings on the semiconductor supply chain to related companies and

Classification	Supply chain	Structure of the supply chain	requests for agglomeration and strengthening
Device	**Design**	• **Japanese design firms have almost no market share and are in crisis** • The design is concentrated in Fukuoka, and **Kumamoto is very weak**	• Kumamoto is becoming a pre-process (manufacturing), the post-process is Oita (testing), **Design and development is in Fukuoka,** So, **it is better to look at Kyushu** • **Design and development is pretty weak, and should be strengthened.**
	Materials	• **Materials companies have a great advantage in developing, producing, and selling under their customers.**	• **Chemical supply chain needs strengthening**
	Pre-process	• **In Kumamoto, the previous process (manufacturing)**, the later process is Oita (testing)), and the design and development are conducted in Fukuoka, so it is better to look at the whole of Kyushu • **There are many big strong companies.**	• No special mention
	Post process	• **The post-process is weak, and if it continues as it is, it will go abroad.** • **There are few companies involved in the post-process, which do not have the technology.** • **Few companies test**	• **There is an opportunity for growth by attracting the post-process.** • **There is an opportunity in the process of fusion as the division between the previous process and the latter process is disappearing.** • **Local companies can only enter the post-process**
Manufacturing equipment	**Manufacturing equipment manufacturers**	• Many strong semiconductor giants. • **There are many equipment related to the previous process.**	• No special mention
	Parts and processing (Manufacturing equipment subcontract)	• To date, **suppliers have grown up and have established relationships with equipment manufacturers, and the quality has improved to meet the expectations of equipment manufacturers, and the impression is that companies and personnel have been built.** • I'm busy making money at my current job, so I don't have time to do anything else • **Few companies take the initiative in strategic development or strategic marketing** with a strong air of passivity awaiting work	• **Concentrating in a nearby area** has the benefit **of being able to respond immediately to customer emergencies.** • **Small businesses need to be subcontracted and reactive** but **self-directed**

Source: Interviews with semiconductor companies (total of 40 semiconductor companies and organizations).

● Issues such as congestion, housing and environmental impact

It is also important to enhance infrastructure for semiconductor supply chain integration.

With further accumulation expected in the future, semiconductor companies in Kumamoto Prefecture will need to address concerns such as securing adequate housing for the rapidly increasing employees, improving the educational environment, the occurrence of commuting congestion due to the unipolar concentration of factories, and reduction of groundwater due to heavy use of water in the semiconductor pre-process.

In recent years, as part of the SDGs and environmental initiatives, increasing number of companies now select and coordinate business partners based on the evaluation of their environmental initiatives, and the standards have become more stringent every year. To carry out

and continue to conduct partnerships and transactions with global companies in the future, Kumamoto prefecture government will need to take actions for local companies to maintain and improve their scores by conducting environmental activities in accordance with globally standardized evaluation indicators.

4.2 Current status and issues of securing and developing semiconductor human resources in Kumamoto Prefecture

● Quantitative analysis

The ratio of job offers to job seekers in Kumamoto (from July 2021 to July 2022) was 1.38, higher than the national average (1.20) and the highest in the Kyushu region, indicating a relative shortage of human resources. In addition, the ratio of IT engineers to the total workforce is as low as 0.7%, indicating a shortage of engineers to drive digitalization and DX promotion.

Table 8 Current Situation of Human Resources Supply in Kumamoto Prefecture

Item	Data	Overview
Level of the job-offers-to-applicants ratio in Kumamoto (July 2021 to July 2022)	Job offer ratio: 1.38 • 18th in the nation's prefectures • No. 1 in the Kyushu region	• The ratio of job offers to job offers in Kumamoto is higher than the national average (ranked in the top 20 or so in the country). • The ratio of job offers to job offers in Kumamoto is the highest in the Kyushu region
Total employment to IT technician ratio (2015)	Percentage of IT engineers: 0.7% • It ranks about 30th in all prefectures.	• The ratio of IT engineers to total employment in Kumamoto Prefecture is about 0.7%, which is not high.
Indicators for promoting DX (2020)	DX Index: • Kumamoto's rating is relatively small in the Kyushu region. • Low evaluation on human resource development	• Evaluation scores for training DX-related personnel in Kumamoto Prefecture * is not expensive. *The Local Government DX White Paper Editorial Committee compiled data on each prefecture's DX initiatives and scored them by mechanical judgment

Source: Based on various publicly available information

● Qualitative analysis

Semiconductor-related companies in Kumamoto Prefecture have stated a general shortage of human resources in all areas with the growing semiconductor market. In recent years, young people interested in the manufacturing industry has been decreasing. In particular, 24-hour manufacturing in the semiconductor industry has been shunned, making it more difficult to recruit human resources. Competition for human resources is expected to intensify in the future and wages are expected to rise as large-scale plant construction and operations are scheduled to begin. Small and medium-sized enterprises (SMEs) are experiencing a shortage of human resources and are expected to face a human-resources-crunch in the future.

When it is difficult to secure and develop human resources, it is important to promote the semiconductor industry so that it can attract interest not only from students, but also from those around it, such as parents.

In addition, there have been cases in which small- and medium-sized companies have been able to acquire the human resources they seek as a result of actively accepting internships. Therefore,

companies and educational institutions working together is important for developing human resources.

Source: Based on interviews with semiconductor companies

Table 9: Results of interviews on "Securing and developing semiconductor human resources" for related companies and organizations

Classification	Supply chain	Situation of talent shortage	Human resources needed
Device	Design	• Recruitment of new graduates becomes more competitive • Small and medium enterprises will find it even more difficult to secure human resources, which is difficult to improve treatment. • Inadequate recruitment for past five or six years. Semiconductor industry unpopular at job fair	• Challenges abound for small businesses. However, there is a significant shortage of personnel who can handle it. • People who understand test specifications and can be replaced by programs
	Materials	• People still come in compared to other peers	• No special mention
	Pre-process	• Hire hundreds every year, but it looks like things are going to get tight • We are concerned that people may not gather when we need them. • It is unclear if people can be hired in the long run	• Almost all areas of technology are lacking • Engineers and maintenance workers are hard to find • Both technicians and workers are needed
	Post process	• High wage recruitment is a threat to local businesses • In the past few years, only a few new graduates have entered the semiconductor industry • We want people, but we do not have sufficient applicants to select them.	• Need an operator to work at the edge of the shop floor
Manufacturing equipment	Manufacturing equipment manufacturers	• It's especially hard to hire software engineers. • Absolute numbers of female engineers are low • There will be fewer people who can touch the equipment and understand the semiconductor manufacturing process.	• Especially controlling software developers • Embedded hardware designers
	Parts and processing (Manufacturing equipment subcontract)	• Overall, there are fewer new graduates interested in manufacturing • I hear the temp agency is locking up people. • I think that Kumamoto Prefecture alone is too short of people	• We have no choice but to rely on the foreign labor force.
Others	Dispatch ・Outsourcing	• Night shifts and 24 hour shifts make it difficult for people to hire • We expect competition for talent to get tougher in the future.	• Worker operator required • A person of professional consciousness

(total of 40 semiconductor companies and organizations).

4.3 Current Status and Challenges of the Semiconductor Innovation Ecosystem in Kumamoto Prefecture

- Quantitative analysis

Among the universities and other research institutions in Kumamoto Prefecture, the number of joint research projects, patent applications based on research with private companies, and university-initiated ventures that have been produced at Kumamoto University is approximately ranked middle (around 20th) in Japan. Although it ranks high in the Kyushu area, it is inexperienced nationally.

In addition, the rate of increase in the number of university ventures in Kumamoto was lower than the national average.

Table 10 State of university-industry collaboration among universities in Kumamoto Prefecture

Classification	Item	Rank of cases		Other features and remarks
		National ranking	Rank of the Kyushu area	
Research activities	**Implementation of joint research (Kumamoto University)**	21st	2nd *However, the number of cases of top ranked Kyushu University is about 50%	Receipts per case are small Co-operation with small and medium-sized enterprises in the prefecture accounts for a high percentage (Comparison with the average of the top 30 universities)
	Implementation of commissioned research (Kumamoto University)	92nd	11th	Consignment from companies in the prefecture accounts for a low percentage (Comparison with the average of the top 30 universities)
Intellectual property	**Number of patent applications based on joint and commissioned research with private companies (Kumamoto University)**	19th	2nd *However, the number of cases of top ranked Kyushu University is about 40%	The percentage of patent applications based on joint research with private companies is at a level comparable to that of the top 30 universities (about 50%)
Startup	**State of the production of venture companies from universities (Kumamoto University)**	20th	2nd *However, the number of cases of top ranked Kyushu University is about 25%	In the 5 years since the 2016 academic year, the number of university-initiated ventures has been 11, all established by transfer of patented technology However, Exit has not been achieved yet.
	Number of locations of ventures originating from universities (Kumamoto)	20th	3rd *However, the number of cases is about 20% of that in leading Fukuoka Prefecture. *Second place: Kagoshima	A venture from a university located in Kumamoto. There has been a slight increase since fiscal 2019, but the ranking among all prefectures has declined. (The rate of increase is lower than the national average.)

Source: Based on various publicly available information

- Qualitative analysis

University-industry collaborations are currently being conducted not only in the semiconductor field, but also in the medical field, mainly by large companies and universities. In the case of small- and medium-sized companies, there are still few examples of such collaborations that take advantage of their unique strengths and characteristics overall, so they need to be strengthened in the future.

On the other hand, to accelerate industry-academia collaboration and industrial collaboration, functions to match needs with seeds, such as support by coordinators who understand the semiconductor industry and holding seminars, are required.

In particular, Kumamoto Prefecture has a rich natural environment, a solid medical system, research and development in academic institutions, and other strengths in the life sciences field; therefore, there are good opportunities for innovation in merging these areas.

In addition, when conducting business collaborations, it is necessary to consider collaborations not only within Kumamoto Prefecture but also throughout Kyushu region and within Japan, and furthermore, to broaden the scope to include overseas companies, human resources, and channels for necessary collaborations.

Table 11: Results of interviews on the "Semiconductor Innovation Ecosystem" to related companies and organizations

Classification	Supply chain	State of industry-academia collaboration	Demand for intra-industry collaboration
Device	Design	• **We worked with Kyushu Institute of Technology for practical use of technology.**	• Oita and Fukuoka stand out and focus on the semiconductor industry, so new information comes in at seminars and other events. **I would be very grateful if you could do it in Kumamoto. Fukuoka is good at matching seeds with needs.**
	Materials	• **It is** affiliated **with both Kumamoto University and Kyushu University.** • As for the collaboration between industry and academia, **we will conduct it with a university that has an authority in an industry that we are interested in.**	• **Messages on our company's HP** Sites where you can send **academic societies and exhibitions** Opportunities to get to know each other
	Pre-process	• **Internships for high school and college students are also accepted**	• **It would be great to have a player who knows all the skills and can give me a blind date.** We are also looking for the status quo.
	Post process	• No special mention	• **We have limited information and would like to request a seminar for small businesses or a match.**
Manufacturing equipment	Manufacturing equipment manufacturers	• **Talking to a teacher who came to Kumamoto University** • We continue **to collaborate with Kumamoto Technical College on five or six themes.**	• No special mention
	Parts and processing (Manufacturing equipment subcontract)	• **Collaborate with Kumamoto University School of Medicine** • Our company **is taking advantage of its positioning to communicate with major corporations and universities.**	• **Nobody has a grasp of the entire semiconductor market.** Someone drew up a vision and said, **I want someone who can organize the whole thing.** • **It is very effective when there is information dissemination. It's good for engineers to interact with each other and for companies to connect with each other**

Source: Interviews with semiconductor companies (total of 40 semiconductor companies and organizations).

5 Future challenges

5.1 Strengthening the semiconductor supply chain

- Integrated and strengthened supply chains across the prefecture

As countries strive to strengthen their semiconductor supply chains aiming for economic security, Japan and Kumamoto Prefecture also need to strengthen and further consolidate their supply chains.

The semiconductor industry in Kumamoto Prefecture is home to many of the world's largest semiconductor-related companies and small- and medium-sized enterprises that support them. However, each company is engaged in business activities that are close to each supply chain, and thus far, efforts throughout the entire semiconductor industry have not been sufficient. In addition, while semiconductor-related industries are active, research on semiconductor-related issues and industry-university collaborations by regional universities is limited to a few number of initiatives.

The technology required for semiconductor-related industries is becoming more extensive and advanced, and technological innovation will become increasingly difficult for individual companies. In addition, the entry of TSMC will prompt small and medium-sized enterprises in the prefecture to respond to the "intensified competition from companies outside the prefecture" which are new entrants and the "ultra-sophistication of required technologies", and those enterprises will also need to pay attention to the silicon cycle.

To strengthen the semiconductor supply chain in the future, establishing a stable semiconductor supply system is urgent after addressing the above issues, and it is also necessary to further strengthen the competitiveness of companies in the prefecture.

Moreover, the semiconductor supply chain consists of a global network, and it is difficult for Kumamoto Prefecture to build a robust semiconductor supply chain that supports Japan's economic security, which requires wide-area coordinated efforts throughout Kyushu and even Japan. In addition, it will be essential to meet the requirements of global standards, including those related to sustainable procurement and other SDGs.

Example: Measures needed to strengthen the semiconductor supply chain

- Further strengthening the competitiveness of previous processes and semiconductor manufacturing equipment (strengthening the competitiveness of existing technologies).
- Conducting research and development to create a three-dimensional stacked packaging industry (research and development of new technologies and strengthening industry-academia collaboration)
- Build a strong seamless semiconductor supply chain (BCP measures).

- BCP measures associated with climate change risks and cybersecurity

According to the World Economic Forum's[15] “Global Risk Report 2022[16]”, the most severe global risk over the next ten years is the failure to adapt (or respond) to climate change. On the other hand, despite the experience of large-scale disasters such as the 2016 Kumamoto earthquake and heavy rains in July 2020, the percentage of companies in Kumamoto that have formulated BCPs and business continuity enhancement plans remains low (BCP planning rate of small and medium enterprises in the prefecture is 13.6%, source: Kumamoto Small and Medium Enterprises Association, 2022). To prevent future supply chain vulnerabilities, the challenge is to improve the rate at which companies develop BCPs.

In addition, with the recent development of the Internet, "cyber-attacks" have become increasingly complex and sophisticated, and the methods of "industrial espionage" have also become more sophisticated. In particular, in recent years, an increasing number of regions worldwide have been at risk of global attacks by cybercriminals. In some cases, Japanese companies with overseas offices are attacked in their home countries where their headquarters are located through overseas offices with weak cybersecurity, and companies in prefectures with international offices also need to take measures from the perspective of BCP.

- Resolution of infrastructure problems such as transportation

The southern area of Kikuchi, including Semi-Contech Park and the city of Kumamoto, still suffers from chronic congestion. Assuming the future development of corporate accumulation in the region, promoting initiatives to alleviate congestion is an important issue for Kumamoto Prefecture, not only to ensure a smooth semiconductor supply chain, but also to ensure the quality of life of workers and residents.

Currently, the timeliness and speed of access between downtown Kumamoto City, the southern Kikuchi area, and airports are not sufficiently ensured, and the development of safe, secure, and smooth transportation infrastructure is required.

- Reducing environmental impact

In response to reducing the environmental impact on local governments and businesses, there is an urgent need to conserve energy and shift energy in the industrial and commercial sectors, which account for approximately 50% of the greenhouse gas emissions in Kumamoto Prefecture. Furthermore, the semiconductor supply chain is likely to require higher level of initiatives, such as virtually zero CO2 emissions, and further actions are required.

In addition, the semiconductor industry, which uses a large amount of water in the pre-process of semiconductor manufacturing, must work on reducing its environmental impact through groundwater recharge, reducing the use of groundwater through water reuse and waste recycling

[15] An independent, nonprofit organization dedicated to promoting exchanges among leaders in political, economic, academic and other fields in order to address global and regional economic issues.
[16] An annual report published by the World Economic Forum that analyzes global risks. The main risks are analyzed based on a survey of global risk awareness among the world's leading experts. https://jp.weforum.org/reports/global-risks-report-2022/

and recycling waste.

5.2 Secure and develop stable semiconductor human resources

As the shortage of human resources is forecasted globally, governments and semiconductor companies are scrambling to acquire and develop human resources, and further shortages are expected in the future. Kumamoto Prefecture needs to secure and develop human resources.

As people who has scientific expertise increasingly leaves the semiconductor industry, many companies in Kumamoto Prefecture have stated that there is a shortage of human resources in all areas, not only those with expertise in semiconductors but also operators and those dealing with digitalization. The elimination of the shortage of human resources is a major issue for the sustainable development of the semiconductor industry in the short to medium to long term.

To solve the shortage of human resources, it is necessary to develop and secure the necessary human resources, not only in semiconductors but also in the digital domain, after improving labor productivity, including digitalization, to create maximum results with a small number of people. In terms of human resource development, not only short-term but also medium and long-term initiatives will be implemented, and to secure human resources, developing the infrastructure and promoting migration e will be necessary, as well as to make active use of new manpower such as senior and foreign personnel.

Example: Measures needed to secure and develop human resources

- Increase labor productivity by promoting DX
- Enhancing practical human resource development programs through reskilling and corporate interns
- Expanding semiconductor education opportunities for prefecture residents
- Enhancing semiconductor education programs through collaboration among universities, technical colleges, companies, etc.
- Support for securing human resources through promotion of migration and settlement measures
- Support for unified branding of the prefecture and clarification of the required semiconductor talent profile

The “Kyushu Semiconductor Human Resource Development Consortium[17]”, which consists of related organizations of industry, government, and academia in each prefecture of Kyushu, has identified the following as the "3 Aims of Kyushu for 2030" and will work to develop semiconductor human resources in all Kyushu areas.

[17] A consortium of industry, academia and government organizations established in March 2022 by the Kyushu Bureau of Economy, Trade and Industry with the aim of strengthening Japan's semiconductor industry base. Three main initiatives will be promoted: the development and retention of human resources for semiconductors, the strengthening of business-to-business transactions and supply chains, and the promotion of industrial exchanges with foreign countries.

① Kyushu, where everyone understands the value of semiconductors as core of social infrastructure
② Kyushu, where everyone shares the joy of learning about semiconductors
③ Kyushu feels pride and a sense of worth in the semiconductor industry

5.3 Building a semiconductor innovation ecosystem

An aim of state-led semiconductor supply chain integration is to make it easier to collaborate upstream, midstream, and downstream at various stages and to create new products and technologies that lead to competitiveness. Similarly, major semiconductor manufacturers are attempting to increase their competitiveness by implementing industrial and academic collaborations, including both domestic and foreign companies.

On the other hand, industrial and academic-industrial cooperation in Kumamoto Prefecture has advanced in some large companies, but overall, it is insufficient. In addition, there are few opportunities for coordination and matching to encourage industrial and academic collaboration. In other words, for Kumamoto Prefecture to be able to revitalize and stabilize its semiconductor industry in the long term, the challenge is that the foundation of the “Semiconductor Innovation Ecosystem” is insufficient. To achieve this, it is necessary to build the following foundations:

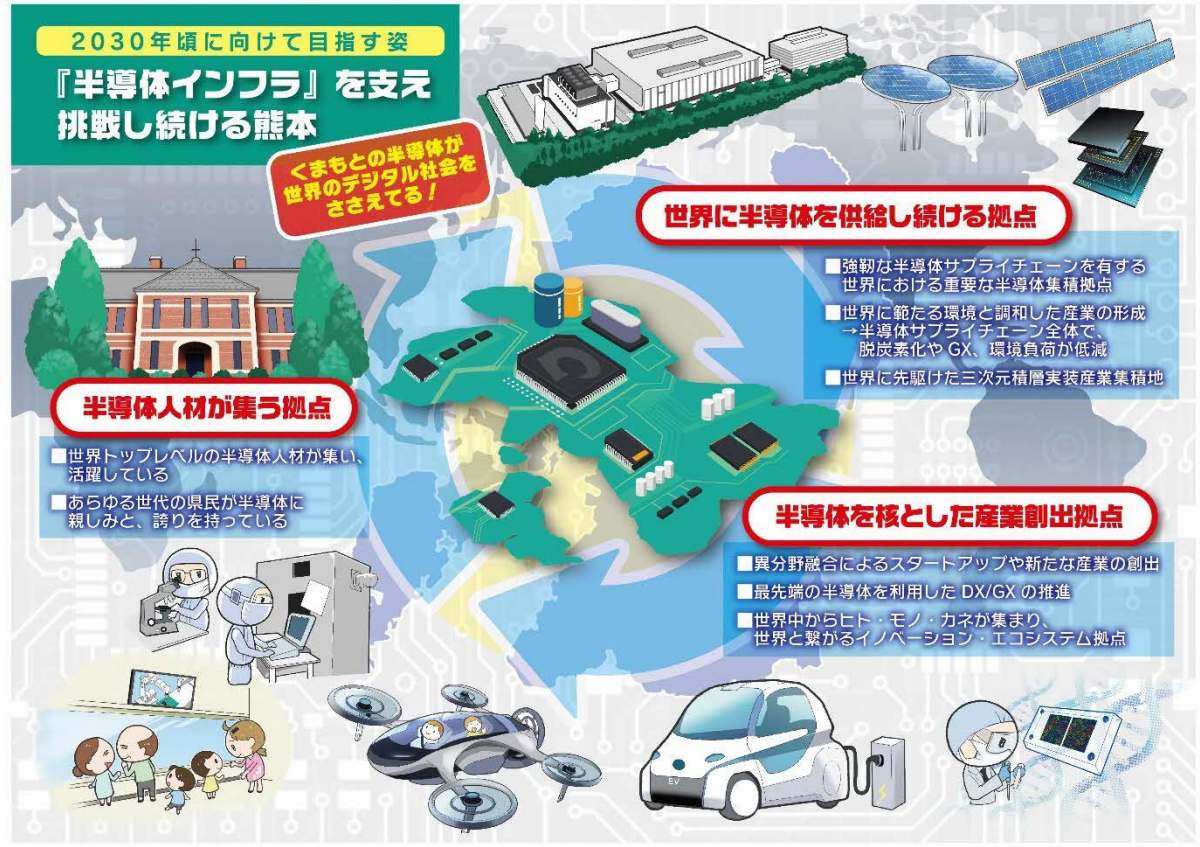
Example: Measures needed to create a foundation for the semiconductor innovation ecosystem

- Establishing a framework for strengthening cooperation among industry, academia, and other industries
- Developing a mechanism to link users with industrial and corporate R&D centers.
- Developing a system to attract and create the next generation of venture startups.
- Developing mechanisms to enhance competitiveness by incorporating advanced technologies (for example digital technology
- Developing a mechanism to create innovation through collaboration with different industries
- Developing a mechanism for international cooperation

Chapter III Aim for around 2030

Kumamoto, a region that continues to support and challenge semiconductor infrastructure

This chapter show a vision for the semiconductor industry that Kumamoto Prefecture aims for around 2030.



1. Kumamoto, a center that continues to supply semiconductors to the world

- It has become an important semiconductor hub worldwide, creating a robust semiconductor supply chain that can respond to diverse risks.
- The establishment of a collaboration system among industry, academia, government, and money has led to the continuous creation of new technologies, and the city has become the world's first industrial cluster of three-dimensional stacked packaging.
- The entire semiconductor supply chain has achieved decarbonization, GX, and a reduced environmental impact, creating an environmentally harmonious semiconductor industry that is a model for the world.

2. Kumamoto, a hub of professionals for the semiconductor industry

- Some of the world's top semiconductor professionals are attracted to the semiconductor industry and the educational and living environment in Kumamoto and are gathering and working there.
- Residents of all generations, from young to old, are familiar with semiconductors and take pride in Kumamoto's semiconductor industry.
- In addition to their extensive knowledge and experience in semiconductors, Kumamoto has developed robust human resources with connections to diverse industries, and the ability to solve various social issues.

3. Kumamoto, a center for creating new businesses with semiconductors at its core

- The technologies and resources cultivated in semiconductor-related industries have merged with other industries, creating new venture startups and industries that drive the prefecture's economy.
- With the introduction of AI and IoT technologies, and the spread of EVs, DX/GX initiatives using cutting-edge semiconductors are accelerating in all industries.
- With semiconductor-related industries at its core, it has become an innovation ecosystem hub that attracts people, goods, and money from around the world and connects with the rest of the world.

Chapter IV Three strategies and initiatives to Realize the Ideal Model

1 Strategy 1 Semiconductor supply chain resilience

- Kumamoto prefecture government aims to further enhance its competitiveness of its front-end process and semiconductor manufacturing equipment, and to build a robust supply chain that is seamlessly linked from "upstream" materials and design to "downstream" back-end processes.
- In addition, Kumamoto prefecture government will promote research and development of innovative cutting-edge technologies to strengthen the international competitiveness of Japan's semiconductor supply chain in the mid to long term.

Key Initiatives

We provide seamless technical and financial support at each stage, from R&D to business expansion, to increase companies' international competitiveness.

1.1 Further enhancing the competitiveness of pre-processes and semiconductor manufacturing equipment (enhancing the competitiveness of existing technologies)

① Kumamoto prefecture government will support initiatives aimed at strengthening competitiveness, such as the research and development of semiconductor pre-processing and manufacturing equipment, which are strengths within the prefecture, and the promotion of innovation.

- For companies in the prefecture that are actively working to improve labor productivity and added value, Kumamoto prefecture government will provide across-the-board support, such as bridging to effective support in collaboration with industrial support agencies and support for commercialization.
- Subsidies will be provided for capital investment, R&D, product development, and other initiatives undertaken by companies in the prefecture.
- Kumamoto prefecture government provide support for bridging business transactions and technology linkages between large companies and companies in the prefecture, as well as for testing technologies and prototypes that are essential for their realization.
- In addition to establishing an analytical instrument infrastructure for ultra-advanced semiconductor technology at the Industrial Technology Center, Kumamoto prefecture government will strengthen core engineers at regional companies and provide technical support for R&D.

1.2 Conducting R&D to create a three-dimensional stacked packaging industry (R&D of new technologies)

① Gaining advantage of the large number of semiconductor-related companies

concentrated in the prefecture, Kumamoto prefecture government will work together with industry, academia, government, and money for the mass production of a new industry, three-dimensional staked packaging technology, with the aim of making Kumamoto an industrial hub for three-dimensional staked packaging.

- By utilizing the Cabinet Office's "Grants for Regional Universities and Regional Industrial Revitalization [18] ," Kumamoto prefecture government will support the research and development of process and design technologies related to three-dimensional staked implementation, as well as the strengthening of the foundation of the preceding process, which is a collaborative effort between Kumamoto University and companies in the prefecture.
- For R&D of new technologies, Kumamoto prefecture government will form a forum for collaboration between universities and semiconductor companies in the prefecture to match the needs of semiconductor user companies with the seeds of universities and related companies and promote strategic commercialization.

1.3 Build a strong, seamless semiconductor supply chain

① Kumamoto prefecture government will strive for industrial cluster across the supply chain of the semiconductor industry.

- The “Semiconductor Industry Integration Promotion Headquarters” will continue to work across the prefecture to resolve issues related to the locations of related companies in the prefecture.
- Kumamoto prefecture government will conduct complex and effective corporate attraction activities, such as actively encouraging suppliers of companies located in the prefecture and holding exhibitions and seminars to promote the semiconductor industry in the prefecture, both domestically and internationally, to attract strategic companies and to concentrate related companies.
- To facilitate the rapid accumulation of semiconductor-related companies, the relevant departments and agencies will cooperate with municipalities to integrate and guide companies and ensure smooth land-use coordination.

② Kumamoto prefecture government will help companies responsible for materials, design, and post-processing to become more competitive.

- For companies in the prefecture that are actively working to improve labor productivity and added value, Kumamoto prefecture government will provide across-the-board support, such as bridging to effective support in collaboration with industrial support agencies and support for commercialization.
- Subsidies will be provided for capital investment, R&D, product development, and other initiatives undertaken by companies in the prefecture.

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[18] In February 2023 (2023), it was decided that the proposal of Kumamoto Prefecture was adopted as the main application frame for the 2023 Regional Universities and Regional Industrial Revitalization Grants.
https://www.chisou.go.jp/sousei/about/daigaku_kouhukin/pdf/050203_hyoukakekka_honshinsei.pdf

③ Kumamoto prefecture government will work to further strengthen the supply chain throughout Kyushu by strengthening cooperation with the semiconductor industry in each prefecture and building a mutually complementary structure.

- Within the Kyushu Semiconductor Human Resource Development Consortium, information will be shared as needed with semiconductor-related companies and related organizations, and human resource development methods will be discussed, as well as efficient logistics systems based on the results of a survey of the actual distribution environment, to strengthen transactions between companies and promote industrial exchanges with overseas countries.

④ Kumamoto prefecture government will establish a network with Taiwan and other global industry organizations.

- Kumamoto prefecture government will share information and strengthen cooperation with relevant organizations such as the Taiwan-Japan Industrial Cooperation Promotion Office (TJPO) and JETRO, with which we have concluded partnership agreements, and will accelerate transactions and industrial partnerships between semiconductor companies in the prefecture and overseas companies in Taiwan and elsewhere through business meetings, seminars, site visits, and participation in Semi-Con Taiwan.

⑤ Kumamoto prefecture government will minimize the risks to the semiconductor supply chain by preventing technical information leaks, strengthening cybersecurity measures, and supporting BCP measures in preparation for large-scale disasters.

- To effectively promote "outreach activities" and provide information on methods and effective countermeasures for the leakage of advanced technology information, the “Kumamoto Prefecture Network for the Prevention of Leakage of Technology Information[19]” will conduct information sharing and public awareness activities related to cybersecurity measures to prevent the leakage of advanced technology information held by companies through collaboration among industry, government, and academia.
- In accordance with the Agreement on Supporting the Preparation of the Kumamoto Prefecture Business Continuity Plan (BCP), Kumamoto prefecture government will work with related organizations to raise awareness and promote the preparation of BCPs by companies in the prefecture.

1.4 Build a smooth semiconductor supply chain by developing transportation infrastructure such as roads and railways and utilizing transportation

[19] A public-private partnership network that allows relevant organizations and groups in Kumamoto Prefecture to get together and exchange ideas. Established by the Kumamoto Prefectural Police on September 1, 2022 (2022) to effectively promote outreach activities.

infrastructure technology

① By developing transportation infrastructure, such as roads and railways, and improving the convenience of public transportation, Kumamoto prefecture government will ensure smooth transportation from both soft and hard aspects.

- In collaboration with transportation companies, Kumamoto prefecture government will reduce congestion around the Semi-Con Techno Park by increasing the number of semi-Con commuter buses and promoting the use of existing public transportation.
- To meet the new demand for roads arising from the concentration of related companies in the vicinity of Semi-Contech Park, Kumamoto prefecture government will improve surrounding roads.
- Consideration for early construction of an airport access railway, and infrastructure development in the area around Aso, Kumamoto Airport for the accumulation of semiconductor-related industries and other businesses.

② Through the development of traffic safety facilities and the use of transportation infrastructure technology, Kumamoto prefecture government will optimize human flow and logistics, and build a smooth supply chain.

- Traffic lights and other traffic safety facilities will be installed where necessary, and optimal traffic light control will be implemented using advanced analysis technologies to ensure traffic safety and minimal congestion.

1.5 Reducing Environmental Impact in the Semiconductor Supply Chain

① Kumamoto prefecture government strive to reduce the environmental impact of our production processes by conserving and reusing water resources, reducing CO2 emissions, and implementing the 3Rs for waste.

- For collecting groundwater, the impact on the surrounding area will be checked when obtaining a permit from the prefecture based on the Groundwater Conservation Ordinance and will strive to conserve groundwater by asking companies not only to reuse water and reduce the amount of groundwater collected, but also to recharge the necessary groundwater.
- Considering the growing demand for industrial water, we will possibly utilize surface water (river water) and implement other measures to ensure a stable supply of water and conserve groundwater.
- To promote waste reduction and recycling in companies, we will provide information, certify recycled products, and support facilities.

② Kumamoto prefecture government will promote energy conservation in facilities and use of renewable energy to promote decarbonization and GX throughout the semiconductor supply chain.

- To ensure that businesses are aware of the issues they need to address to reduce CO2

emissions, Kumamoto prefecture government will review the business activity plan system based on the Global Warming Prevention Ordinance, including the visualization of the amount of emissions for each facility and the time of renewal, and promote the renewal of energy-saving equipment.

- Kumamoto prefecture government will work with companies in the prefecture to discuss measures to reduce greenhouse gas emissions and inform other companies of effective measures to promote measures to combat global warming throughout the prefecture.
- To increase the possibility of new participation in environmentally friendly supply chains and ESG investment[20], Kumamoto prefecture government will support companies in the prefecture in obtaining the Renewable Energy 100 Declaration (RE Action)[21].
- To achieve both decarbonization and business BCP measures, Kumamoto prefecture government will support the introduction of distributed energy systems, such as solar power generation facilities, storage batteries, and cogeneration, and long-term stable power sources by business operators, as well as study the construction of an RE 100[22] industrial area around the airport.
- To promote the identification of suitable sites for community-based renewable energy facilities that consider the natural environment and landscape, Kumamoto prefecture government will support the zoning of onshore wind and ground-based solar power facilities and the establishment of "(renewable energy) promotion areas[23]" based on the revised Act on Promotion of Measures to Cope with Global Warming of municipalities.

[20] Investment that focuses on and selects companies that have environmental, social, and corporate governance (ESG) considerations in order to encourage continued consideration of ESG issues in the portfolio.
[21] A new framework to promote the use of 100% renewable energy by companies, local governments, educational institutions, medical institutions and other organizations showing their willingness and action to switch their electricity use to 100% renewable energy. https://saiene.jp/
[22] An international initiative that aims for companies to use 100% renewable energy to power their operations.
[23] The term refers to "areas subject to local decarbonization promotion projects" that municipalities shall endeavor to establish as prescribed in Article 21, Paragraph 5 of the Warm and Warm Countermeasures Act.

2 Strategy 2 Ensuring a stable semiconductor professionals and human resource development

Kumamoto prefecture government works to develop and accumulate global human resources with broad knowledge of semiconductors and the digital domain, who can play an active role in various industrial fields, and to promote DX, including local small and medium-sized enterprises.

Key Initiatives

In addition to helping companies improve labor productivity through DX and develop practical human resources through reskilling, we aim to eliminate the shortage of human resources and provide semiconductor education for a wide range of generations.

<Securing and Developing Human Resources in Short Term>

2.1 Enhance practical human resource development programs through reskilling, and corporate interns

① In collaboration with companies in various supply chains in the prefecture, Kumamoto prefecture government will implement reskilling programs and recurrent education aimed at the advancement of semiconductor human resources and supporting practical human resource development through internships.

- In collaboration with technical schools and other institutions in the prefecture, Kumamoto prefecture government will identify the IT human resource needs of companies and support the development of educational programs to acquire knowledge and skills in the semiconductor field and the relevant fields, and reskill and establish recurrent educational programs to enhance skills.
- To promote understanding and interest in the semiconductor industry among high school students, Kumamoto prefecture government will work with semiconductor companies in the

prefecture to further enhance internships for high school students, and deploy career supporters and job coordinators to support employment at semiconductor companies in the prefecture.

- Develop and implement educational programs on IoT and DX to help companies reskill their employees.

2.2 Support for unified branding of the prefectures and clarification of the required image of semiconductor talent

① In addition to actively promoting and branding semiconductor companies in the prefecture to increase the attractiveness of the semiconductor industry in Kumamoto, Kumamoto prefecture government will support companies in hiring the human resources they seek and disseminate information both in Japan and overseas to secure the right people in the right place.

- Kumamoto prefecture government will create PR tools to introduce the initiatives of semiconductor-related companies in the prefecture and hold exchange meetings between companies and students to promote branding of the entire semiconductor-related industry in the prefecture.
- For companies suffering from labor shortages, Kumamoto prefecture government will provide across-the-board support such as preparing recruitment plans based on the actual situation of each company, finding and disseminating information on appeal points of interest to job seekers, and digitizing recruitment tools.

2.3 Support for securing human resources through the promotion of migration and settlement measures

① To secure a diverse range of human resources, including highly specialized personnel, Kumamoto prefecture government will improve living and educational environments, strengthen measures for migration, settlement, and “UIJ” turn, and establish a system for receiving international residents.

- By utilizing various public relations tools such as SNS and developing promotions with the Kumamon CPO as a hook, Kumamoto prefecture government will increase the awareness of Kumamoto both in Japan and abroad, leading to the accumulation of human resources and companies.
- Kumamoto prefecture government will work with municipalities to promote migration and settlement in the prefecture by disseminating information through SNS and portal sites, holding migration consultation meetings, providing financial support for employment at companies in the prefecture, and promoting UIJ turns.
- Collaborating with recruitment agencies, financial institutions, and other related organizations, Kumamoto prefecture government will support the acquisition of highly specialized human resources, including semiconductor digital personnel, needed by small and medium-sized

enterprises in the prefecture.

- To ensure that children of foreign nationalities can enjoy learning in Kumamoto with peace of mind, Kumamoto prefecture government will work with each educational institution to develop an acceptance system for international schools and other institutions and provide meticulous support for the lives of those assigned to these schools and their families.

2.4 Increase labor productivity by promoting DX

① To resolve the shortage of human resources, we will promote the DX transformation of production sites, including the introduction of IoT and AI technologies, to reduce manpower and improve labor productivity.

- To promote DX, which leads to higher labor productivity and operational efficiency for companies in the prefecture, Kumamoto prefecture government will support initiatives that actively utilize digital technology and advanced capital investments that will have a high ripple effect on the local economy.
- For companies in the prefecture that are actively working to improve labor productivity and added value through the promotion of DX, Kumamoto prefecture government will provide across-the-board support, such as bridging to effective support in collaboration with industrial support agencies, and support for commercialization.
- The “Kumamoto DX Promotion Consortium[24]” will conduct events and seminars, and promote business matching to promote DX for all industries in the prefecture.

Securing and developing human resources in mid to long-term

2.5 Expanding semiconductor education opportunities for residents

① Through school education, including compulsory education and courses for working adults, Kumamoto prefecture government will promote the acquisition of accurate basic knowledge in the semiconductor industry and understanding of the semiconductor industry among the residents of the prefecture, thereby securing opportunities for the creation of advanced semiconductor-related personnel in the future.

- Delivery classes and industrial lectures for elementary and junior high school students will be held to increase the interest in and understanding semiconductors among the younger generation.
- Kumamoto prefecture government will distribute textbooks of semiconductor to high schools in the prefecture, provide on-site lectures by semiconductor engineers, conduct factory tours and hands-on learning at semiconductor-related companies, conduct tours of universities and other institutions that focus on semiconductor education, and provide training for high school

[24] A system and framework (platform) in which industry, academia, and government work together as a place of "co-creation" to realize the vision outlined in the "Kumamoto DX Grand Design" formulated in fiscal 2021 (fiscal 2021). https://kumamotodx.jp/

teachers and staffs to increase students' interest in and understanding of the semiconductor industry.

2.6 Enhancing semiconductor education programs through collaboration among universities, technical colleges, and companies

① In times of uncertainty and difficulty in predicting, Kumamoto prefecture government will enhance educational programs to develop semiconductor specialists who can play an active role in society.

- In collaboration with three universities in the prefecture, including Kumamoto University, Kumamoto prefecture government will develop global human resources with a spirit of challenge through DX, and semiconductor education through cross-disciplinary degree programs, entrepreneurship education, and data science education.
- This program supports the development of practical semiconductor human resources with basic knowledge of the entire process, from design to post-process, in the newly established semiconductor-specific curriculum at Kumamoto University.
- In addition to establishing a new department related to semiconductors at the Kumamoto Prefectural College of Technology, Kumamoto prefecture government will use the revised Special Zone Law for Structural Reform to enable students to transfer to Kumamoto University, thereby developing practical electronic and mechanical engineers with skills and technologies related to semiconductors and semiconductor manufacturing equipment.
- Through industry-academia-government collaboration, Kumamoto prefecture government will develop the next generation of regional industrial human resources who can respond to DX, etc., by conducting Team Teaching (TT) classes by industrial practitioner teachers, professional corporate training using corporate facilities, and professional delivery classes by companies and universities.

② In collaboration with the Kyushu Semiconductor Human Resource Development Consortium, Kumamoto prefecture government will promote human resource development by utilizing various educational resources in each Kyushu prefecture.

- Kumamoto prefecture government will work on human resource development on a broad scale by examining human resource development training programs through networks including the "Kumamoto Semiconductor Human Resource Development Council[25]" and the " Kyushu Semiconductor Human Resource Development Consortium" and through individual cooperation with the efforts of each prefecture in Kyushu.

③ Kumamoto prefecture government will strengthen our global human resources

[25] A conference established by the prefecture in fiscal year 2021 (fiscal year 2021) to create a regular forum for direct dialogue between industry, academia, and the government in order to develop and secure human resources at semiconductor companies in the prefecture, and to examine the image of human resources required by industry and educational programs for human resource development.

development function by establishing R&D centers in collaboration with universities, research institutes, etc., to attract researchers from Japan and abroad.

- With the help of the Cabinet Office's “Subsidy for Regional Universities and Regional Industry Creation”, the newly established “Institute for Semiconductor and Digital Research and Education at Kumamoto University” will invite numerous top-level semiconductor researchers and establish a system to promote collaboration with universities, companies, and research institutes in Japan and abroad to help strengthen global human resource development.

3 Strategy 3 Building a semiconductor innovation ecosystem

With cooperation and collaboration with diversified user companies, Kumamoto prefecture government will build an innovation ecosystem that creates a chain of new business creation by collaborating with various fields, such as the biotechnology and life science industries, based on the technologies and resources accumulated in semiconductor-related industries.

Key Initiatives

In collaboration with the UX Project, we will promote open innovation in different fields of industry, government, academia, and gold fields with semiconductor industry at its core, and provide matching and commercialization support for the creation of venture startups and new industries that will play a key role in the future of the Kumamoto Prefecture economy.

3.1 Ensuring matching opportunities with semiconductor exit industries

① Through personnel exchanges and deployment of coordinators across the industry, government, academia, and gold fields, Kumamoto prefecture government will match the needs of semiconductor user companies in each prefecture of Kyushu with the seeds of semiconductor-related companies.

- For R&D of new technologies, Kumamoto prefecture government will form a forum for collaboration between universities and semiconductor companies in the prefecture to match the needs of semiconductor user companies with the seeds of universities and related companies and promote strategic commercialization.

3.2 Supporting semiconductor industry-related venture startups

① By enhancing accelerator programs[26] related to semiconductors, Kumamoto prefecture government will attract and create venture startups related to the semiconductor industry in areas such as software design, edge AI[27], semiconductor materials, and factory automation (FA)[28].

- To commercialize the technology seeds held by companies, universities, and research institutes in and outside the prefecture and to lead to the creation of new growth industries, Kumamoto prefecture government will create an environment in which new businesses can be born and bred continuously through a system that is consistently supported by industry, academia, and government money, and provide support according to the stages of discovery, research, and commercialization of startups.

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[26] A program in which the backers of startup companies, called accelerators, help startup companies grow their businesses by matching them with partners and investors.
[27] A technology that uses artificial intelligence (AI) on the terminal to learn and reason without uploading data collected by the terminal to the cloud.
[28] A general term for systems that automate production processes in factories.

3.3 Strengthening Support Systems for Building an Innovation Ecosystem

① Kumamoto prefecture government will strengthen our support system for the commercialization of seeds in the prefecture.

- To promote the commercialization of semiconductors and other hard technology fields[29], Kumamoto prefecture government will strengthen our support system for the commercialization of seeds in the prefecture, taking inspiration from the efforts of Fraunhofer, Germany, and other countries, and proceed with studies for collaboration and attraction with players outside the prefecture and abroad.

3.4 Promoting DX through the use of semiconductors

① In collaboration with the Kumamoto DX Promotion Consortium and other organizations, Kumamoto prefecture government will promote DX in the prefecture by introducing advanced technologies utilizing semiconductors, such as IoT, and robots in the manufacturing industry, agriculture, tourism, and medical fields.

- To promote DX, which leads to higher labor productivity and operational efficiency for companies in the prefecture, Kumamoto prefecture government will support initiatives that actively utilize digital technology and advanced capital investments that will have a high ripple effect on the local economy.
- For companies in the prefecture that are actively working to improve labor productivity and added value through the promotion of DX, Kumamoto prefecture government will provide across-the-board support, such as bridging to effective support in collaboration with industrial support agencies, and support for commercialization.
- The “Kumamoto DX Promotion Consortium” will conduct events and seminars, and promote business matching to promote DX for all industries in the prefecture.

3.5 Promote open innovation programs in collaboration with other industries

① Collaborating with UX projects, Kumamoto prefecture government will promote open innovation programs that create new industries by merging with other fields, such as biotechnology and life sciences.

- Kumamoto prefecture government will promote open innovation between the life sciences and semiconductor industries through the integration of diverse players in UX projects[30], building an environment for the utilization of medical data, development of an innovation hub that generates human and technological exchanges, and utilization of semiconductor technology.
- A UX Innovation Hub will be established at the Techno Research Park to promote human and technological exchanges between the life sciences and semiconductor industries.

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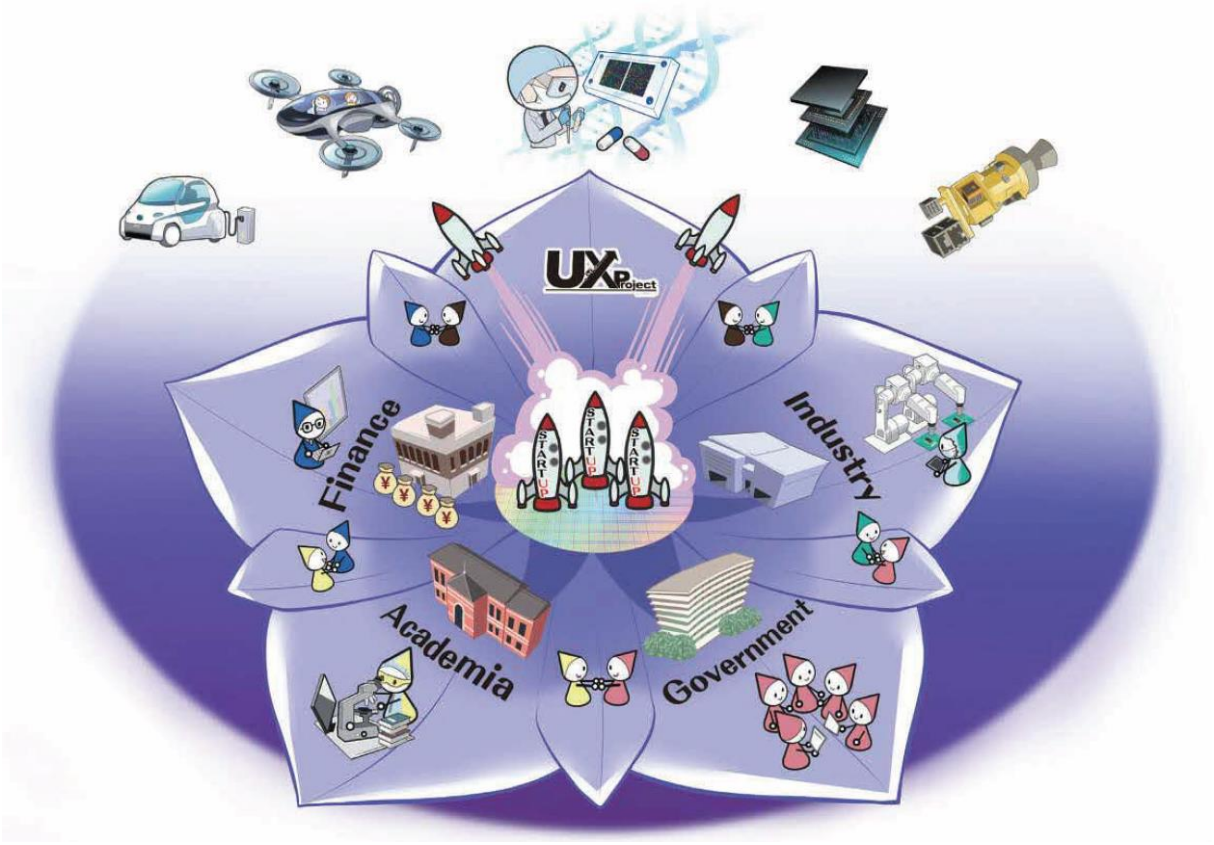
[29] A technical field that combines digital and physical technologies.

[30] This is an initiative centered on the life sciences industry to gather people, things, technology and information and to accumulate new knowledge that is organically linked. https://ux-project.jp/

3.6 Promoting International Cooperation

① Kumamoto prefecture government will establish a network with Taiwan and other global industry organizations.

・ Kumamoto prefecture government will share information and strengthen cooperation with relevant organizations such as the Taiwan-Japan Industrial Cooperation Promotion Office (TJPO) and JETRO, with which we have concluded partnership agreements, and will accelerate transactions and industrial partnerships between semiconductor companies in the prefecture and overseas companies in Taiwan and elsewhere through business meetings, seminars, site visits, and participation in Semi-Con Taiwan.



Chapter V Promoting the Vision

1 Progress management and promotion structure

In order to effectively promote policies based on the three strategies in the "Kumamoto Semiconductor Industry Promotion Vision," Kumamoto prefecture government will work in close cooperation with industry, universities, educational and research institutions, support organizations, the financial community, and the central government. Kumamoto prefecture government will also evaluate the progress made in realizing our vision.

2 Setting targets

Kumamoto prefecture government sets targets to evaluate progress on the vision and priority initiatives and to clarify the direction of actions to be taken based on that evaluation. The target will be reviewed as appropriate according to changes in the social situation, given the increasing uncertainty caused by the impact of the new coronavirus and increasing tension in international relations.

Indicators	Target Level	At Present
Production value of semiconductor-related industries	JPY 1,931.5 billion in 2032 (USD 262,162.5 billion)	JPY 829 billion in 2019 (USD 112,520.2 billion)
Number of new semiconductor-related companies (cumulative)	130 (FY 2032)	13 ＊ Average of the last 10 years
Number of employees in semiconductor related industries	25,490 (2032)	21,275 (2019)
Number of graduates from universities, technical colleges, and high schools in the prefecture employed by semiconductor-related companies e	More than 255 ＊ To be revised upward in the future based on each institution’s progress	171 (FY 2021)
Number of semiconductor-related startups created and moved (cumulative)	10 startups (FY 2032)	― (FY2021)
Number of business meetings with overseas semiconductor companies at venues provided by the prefecture and related organizations (cumulative)	2,500 (FY 2032)	54 (FY 2021)

* USD 1 = JPY 135.73 (12:00 on March 6th 2023)