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Critical to the future, the rebirth of Japan's chip industry is being driven by strong public-private support

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BUILDING WITH ALLIES

Microchip reset crucial for a secure future: Amari

In an electronic society, semiconductors will be key to securing Japan's defense and economy, LDP heavyweight says

Then-Lower House lawmaker Akira Amari (second from left), Taiwan Semiconductor Manufacturing Co. founder Morris Chang (center) and TSMC Chairman Mark Liu (third from right) pose with other officials at the opening ceremony for its first chip factory in Japan, in the town of Kikuyo, Kumamoto Prefecture, in February. JIJI

As countries around the world continue to invest extensively in the semiconductor sector, Japan is accelerating the revival of its own chip industry, aiming not just to catch up with its peers, but to become a major chipmaker that can contribute to ensuring the stable supply of chips for the global market.

The Japan Times interviewed Akira Amari, former secretary-general of the ruling Liberal Democratic Party and the founder and honorary chairperson of the party's semiconductor strategy promotion league. He was one of the first to advocate that semiconductors would change international power relations and to push the need for a strategic revival of the domestic chip industry.

In the late 1980s, Japan was a major maker of semiconductors and home appliances. "Back then, semiconductors were made by a section in electronics manufacturers merely as a part of their products," Amari said. However, over time they evolved into a crucial component that is now so essential that entire social systems depend on them to function.

'Creating a supply chain among allies from the perspective of both economic and military security is important.'

"Chips today don't just operate vacuum cleaners and televisions. They are turning the world into an electronically controlled society. With this change, semiconductor sections became independent from electrical appliance makers and other manufacturers in the rest of the world," he said. Companies dedicated to making semiconductors began to flourish in various countries.

In fact, it became increasingly uncommon for companies in those countries to possess the in-house capabilities required to manufacture every part of a product. Rather than a single entity making the entire product, each component, such as a semiconductor, was produced by a dedicated supplier and then assembled piece by piece into the finished product.

Japan lagged in this shift. Amari noted that Japan is now at a make-or-break point, in that it can either become an independent semiconductor supplier or a country dependent on others for what is essentially running society.

Amari worked together with other like-minded lawmakers to persuade the government into again becoming a major maker of microchips. In 2021, they launched an LDP group dedicated to promoting semiconductor strategies and positioning microchips as a national strategic material.

"Today's cutting-edge semiconductors are nothing like those of decades ago. We are talking about single-digit nanometer-sized circuit lines," he said. A nanometer is a billionth of a meter.

Becoming a receiver rather than a maker of semiconductors would mean leaving Japan's digital infrastructure almost entirely dependent on other countries' technologies.

Many advanced technologies, including autonomous driving, quantum computing and artificial intelligence, also rely on microchips.

"The credibility of semiconductors is the credibility of society. Semiconductors are the foundation for nearly all aspects of social security in the modern world. That is why creating a supply chain among allies from the perspective of both economic and military security is important," Amari said. "More than 90% of high-end logic semiconductors are shipped worldwide through the Taiwan Strait. How much impact would the world suffer if a naval blockade were enforced in the area for some reason?"

Akira Amari

In the midst of this revival plan, IBM approached the government about the possibility of mass-producing IBM-designed chips in Japan.

"IBM wants to be a user, not a manufacturer, because their business is shifting toward providing computing services using those semiconductors. At the same time, they are aware of Japan's strong manufacturing technology and capability," Amari said.

However, existing Japanese companies were reluctant to try.

"What IBM was asking for was state-of-the-art chips" for which no one knew whether mass production was even possible, he said, implying the companies were not to blame.

Rapidus, a Japanese chip manufacturer supported by the government, decided to headhunt the nation's best semiconductor engineers to respond to IBM's request.

"From a list of the top 100 engineers' names and affiliations, we contacted each one of them and asked if they wanted to participate in the game to get back on top in semiconductors. Most of them joined Rapidus," Amari said, noting his satisfaction with the result. "We encouraged the team by saying that the future of the entire nation depends on them, and they will make history if they succeed in doing this."

The engineers have been training at IBM's research center in the U.S. to acquire the skills necessary for mass producing its new semiconductors.

"They have proven to be extremely efficient and capable, which has impressed IBM," he said.

But what are the chances that Japan, with so many years absent from this field, will be successful and lead the world again?

"If we were to build a new technology on top of the existing one, we wouldn't stand a chance of catching up. But the 2-nanometer chip technology is something almost entirely different from conventional semiconductor technology." Amari replied.

Indeed, the evolution of semiconductors is not just about keeping up with the latest technologies, such as artificial intelligence. Reducing their energy consumption, for example, has become a must. Since every sector of our lives, from our consumption and infrastructure to administrative, medical and education services relies on advanced microchips, a critical power shortage would bring our lives to a halt.

Given the vast amounts of electricity being used by data centers, the risk of chronic power shortages already haunts many countries, Amari explained.

"That is why we need to accelerate the miniaturization of semiconductors and increase their speed. One-tenth of the current size is not enough. We are looking at one one-hundredth or one two-hundredth. One of the technologies that is expected to make it possible is the optical semiconductor, a field where NTT, Japan's telecommunications giant, takes the lead," he said.

He also touched on the importance of maintaining the capability to make legacy chips.

"In recent years, we saw the U.S. imposing export controls on high-end chips and chip-making equipment to China. I instantly knew that it would lead to China's move to dominate the supply chain of the legacy chips as revenge. As we all know now, this is what happened, and we need both advanced and legacy chips for today's society to function," he said.

Another complication is that semiconductors are diversifying, Amari noted. "For example, various kinds of semiconductors are involved in sensor technology." He explained that sensors play the role of our five senses to capture information, and different kinds of semiconductors take it from there.

"Image sensors, in which Sony excels, convert visual information into digital data and send it as a signal to memory, where memory chips are at work. Logic semiconductors process data accumulated in memory together with newly incoming data. Solutions are then created, which are implemented and run by power semiconductors," he said.

However, he is not suggesting that Japan should try to be a supplier of every product that plays a significant role in the entire semiconductor supply chain.

"What is necessary is that we create a supply chain network among the countries that we trust," he said. "That way, we can win an even higher degree of trust from those countries. For instance, Japanese materials and manufacturing equipment play a crucial role in supporting the semiconductor industries of allied and friendly nations," he said.

This strategy is the basis of the support the government has been providing to persuade companies from both Japan and its allies to bring their production to this country. "And it makes sense for these companies to choose Japan. Take Taiwan Semiconductor Manufacturing Co.'s Kumamoto fabs as an example: No other country can build such large, high-precision fabs as quickly as Japanese companies," he said of the fabrication plants at the heart of the industry.

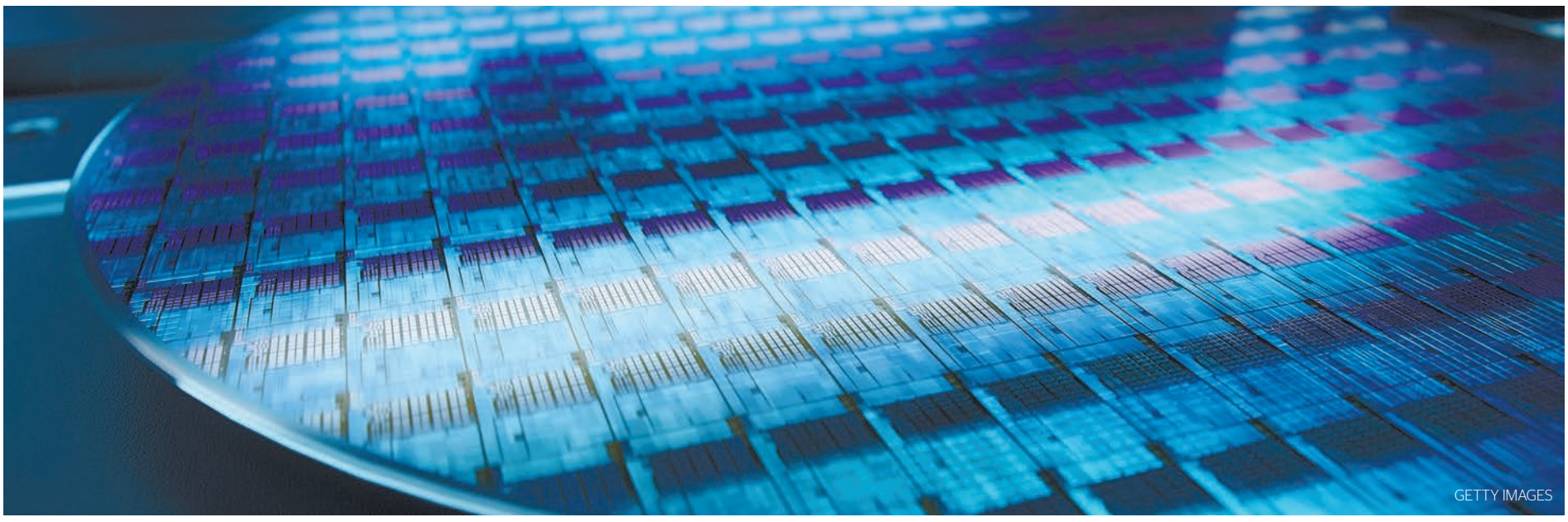
Amari stressed that it is of utmost importance for Japan to secure this position to support all other democratic nations, and for semiconductor suppliers to have a shared, universal perspective on freedom, democracy and human rights.

"A digitalized society where everything can be electronically controlled has an exceptionally high affinity with an autocratic nation and dictatorship," he warned, emphasizing the risk of technology destroying rather than contributing to society.

He concluded by saying that democratic countries should be the ones that establish international standards for semiconductors to ensure the security and prosperity of humanity.

This article was originally published in the Kyushu Semiconductor Special on Sept. 25.

LEVERAGING OUR STRENGTHS



GETTY IMAGES

TSMC tapped in reboot of Japan's chip industry

¥1 trillion investment in alliance with Taiwanese titan aimed at reversing nation's fall in strategic semiconductor market

The Japanese semiconductor industry is on the cusp of a revival, with major national backing for players including Taiwan Semiconductor Manufacturing Co., a world-leading chipmaker that is setting up plants in Japan, and Rapidus, a new cutting-edge domestic chipmaker.

The Japan Times interviewed University of Tokyo professor Tadahiro Kuroda about why Japan's once respected semiconductor industry has declined and how Japan aims to achieve a turnaround and position semiconductors as a national strategic commodity.

Kuroda, who holds a Ph.D. in electrical engineering, stated that the Japanese semiconductor industry has undergone three phases over the past nearly half-century.

"The first stage was the 1980s, when Japan accounted for over half of global semiconductor production. Japan's dominance in the memory chip market was particularly pronounced until around 1995, right before the rapid proliferation of computers started," he said.

The second phase was marked by an intensification of trade friction with the United States. "Semiconductor technology was originally developed in the United States, but Japan worked assiduously to gain a competitive advantage. U.S. discontent with this situation led to it becoming a political issue, which in turn resulted in the 1986 U.S.-Japan Semiconductor Agreement. This agreement included antidumping measures and numerical targets designed to protect the semiconductor industry in the United States.

"The trade friction was a trigger but not the ultimate cause of the decline of the Japanese semiconductor industry. As the semiconductor industry grew, the amount of investment required increased from billions (of yen) to tens of billions and hundreds of billions, beyond the resources of Japanese electronics manufacturers," he said.

Kuroda also highlighted Japan's relative weakness in developing business models for virtual spaces, noting that the country's strength lies in manufacturing products that ensure consumers' comfort in physical environments.

By the time China replaced Japan as the target of U.S. trade ire, Japan was no longer considered an enemy of the United States. "In addition to the improvement of the Japan-U.S. relationship, Japan's semiconductor industry began to receive government support from the perspective of national security, marking the third phase of the industry's history. Japan remains one of the top countries in the world in terms of gross domestic product, although there has been a decline in recent years. If the nation were to concentrate investment in this field, we could still make a difference," Kuroda explained.

The kind of semiconductor chip most needed in this era is one that can be used in technologies that integrate the real world and virtual space. Kuroda suggested that Japan could make various contributions in this field.

"Sony boasts the biggest share of the global market for image sensors and Japan also excels in manufacturing the power electronics used in motor drives," he said.

"Japan is still good at making things used in the real world. But it loses to the U.S. in making artificial intelligence calculate at a breakneck speed in a virtual space. The two countries bringing their strengths together for the development of today's semiconductors is where I see the hope for Japan's resurgence in this field," he said.

He stressed that this kind of bilateral and multilateral collaboration is indispensable not only for the success of Japan's semiconductor industry, but also for securing a stable supply of chips for the international community.

> Japan's microchip industry started to receive the blessing of the government from the perspective of national security.

"The major setback that the industry experienced in the past is largely attributable to the strategy to become the only winner in the global market. We should focus not on how to sell more than anyone else, but on how to continue providing a stable supply of semiconductors that are now used in everything from household electronics that we use every day to high-tech machines, as well as on producing what other countries have difficulty making," he said.

He also said that the complexity of today's semiconductor technology and the size of the industry make it unlikely that a single entity will monopolize the market. This is driving the need for global collaboration.

The substantial subsidy of over ¥1.2 trillion ($8.2 billion) provided by the Japanese government to TSMC represents an example of such an international collaboration. It demonstrates the company's commitment to investing in its facilities and business within Japan.

"This kind of investment requires a stronger commitment than joint research or joint development because it is more difficult to withdraw from," Kuroda said. He also highlighted the importance of having domestic production capacity within the extensive network aimed at supplying semiconductor chips to Japan.

On the other hand, the government is also investing in Japanese enterprises. Kuroda assured critics that supporting both TSMC and Rapidus at the same time is not contradictory.

University of Tokyo professor Tadahiro Kuroda

"TSMC in Kumamoto will specialize in the technology intended for making chips for products that make up the largest market segment, such as cars, home electronics and other items that are necessary for people's daily lives," he said, noting that these are the kinds of semiconductors that are needed now and in abundance from the perspective of economic security.

The most advanced ones are for data centers and AI. "That is where research and development is most needed because of the vertiginous speed of the technology's advancement. Rapidus is designed to play this part," Kuroda said.

It takes enormous energy to draw out the semiconductor performance required to run state-of-the-art AI operations.

"Considering the situation where electricity consumption is already increasing rapidly with the use of advanced technology and the necessity of cooling servers and other equipment, we need to increase the efficiency of semiconductors. That will allow more calculation to be done using the same amount of energy, or less energy to be consumed to do the same amount of calculation," he said, stressing that doing business in greener ways is essential to win the trust of the global market.

Kuroda thinks that Japan still has a chance in this part of the semiconductor market despite the period of over two decades of no investment and no progress in the industry.

"Why? It is because of the typical conventional personnel system of Japanese companies that does not lay off workers easily," he said.

He explained that some semiconductor experts who remained in companies such as electronics manufacturers continued attending academic conferences and learning from the latest research on semiconductors even after their companies withdrew from the business. "Those are the people who gathered to Rapidus," he said.

"In addition to the existing experts, we need to educate the young talent that will be the next-generation leaders in this field. That is why the University of Tokyo formed an alliance with TSMC and signed an agreement with Kumamoto University," he said.

For those engineers diverted by Japan's two-decade slump, the Fukuoka Semiconductor Reskilling Center, headed by Kuroda, opened in Fukuoka last year to help them relearn their skills.

"Working remotely is an option for some of the positions that could only be covered by employees working three shifts on site in the past. This helps achieve greater diversity in human resources that today's chip industry needs," Kuroda said. This need for diversification of human resources is what prompted him to accept the position of chancellor of the Prefectural University of Kumamoto this spring.

"The focus of the university, which does not have a faculty of engineering, is to nurture people with good international communication skills," which are necessary for an industry involving increasing international collaboration. He also said that the university's Faculty of Environmental and Symbiotic Sciences will provide a unique strength at a time when the industry needs to address water and other environmental issues.

As the AI era unfolds, Kuroda stated that the coevolution of AI and semiconductors occurring with no human in the loop is becoming a realistic prospect, whereby AI will begin to design the chips that drive it.

"It is our human ingenuity that drives the creation of new services and technologies using semiconductors to enhance the quality of life and ensure societal stability," he pointed out. Noting that new ideas emerge when diverse people gather and converse, he said: "That is what universities are for, and they need to continue their effort to attract brains at home and from abroad."

The revival of Japan's semiconductor industry depends on a long-term and comprehensive effort including human resource development, international collaboration and continuous government support.

This article was originally published in the Kyushu Semiconductor Special on Sept. 25.

SOCIAL IMPACT

Japan needs to regain share of global chip market

Although a leader in image sensors, there is a crucial need to further develop other aspects of chip manufacturing

Top: Construction of the Rapidus semiconductor factory is ongoing in Chitose, Hokkaido. Right: Tokyo University of Science professor Hideki Wakabayashi

There is no doubt about the fact that digital technologies will continue to play a central role in making society work as far into the future as one can imagine. But how to effectively use digital technologies has always been a major concern.

Hideki Wakabayashi, a professor of the Graduate School of Management at the Tokyo University of Science, wrote the 2022 book "Dejitaru Retto Shinkaron" ("Theory of Digital Japan Archipelago Evolution"), which discussed how Japan can solve mounting social issues and maintain its national strength by utilizing digital technologies and promoting the growth and prosperity of the industry.

In a recent interview with The Japan Times, Wakabayashi gave some concrete examples of how digital technologies have contributed and will continue to contribute to the lives and security of people, and the importance and progress of the domestic production of semiconductors that support these technologies.

Mitigating rural depopulation

"Attracting technology companies to rural areas has so far proven to be an effective solution to create new jobs and mitigate rural depopulation," Wakabayashi said. He added that a good example is the city of Inzai, Chiba Prefecture, which has attracted data centers including those of global tech giants. He also suggested that the effect that semiconductor plants such as those built in Kumamoto Prefecture by Taiwan Semiconductor Manufacturing Co. can have on their locations may even be much greater than that of data centers.

The latest technologies can also contribute greatly to prefectural infrastructure.

"For example, what is necessary to create a hazard map based on an accurate simulation to each area's vulnerability to disasters such as floods and earthquakes is artificial intelligence and a data center that can run it," Wakabayashi said.

Due to the increasing severity of natural disasters in Japan, the security of people, including civil servants and those in position to protect the lives of citizens — such as emergency service workers — has been a major challenge. Wakabayashi pointed out that artificial intelligence can contribute to preventing people from risking their lives to save others by giving accurate and timely evacuation warnings based on constant learning.

Accidents resulting from human error may also be reduced by using new technologies. Wakabayashi explained that autonomous driving managed by the infrastructure side based on maps with road surface information and weather conditions could help reduce traffic accidents.

Sustainable data centers key

At the same time, Wakabayashi stressed the importance of digital infrastructure that can ensure the stable use of technologies. He said that a lack of capacity at data centers or stability of signals and information network when conducting activities such as remote surgery could result in risking people's lives.

Data centers constitute a significant part of digital infrastructure. Wakabayashi said that the government has already decided on the plan to establish new bases for large data centers in Kyushu and Hokkaido in addition to the current ones in Tokyo and Osaka. However, he said the plan may not be enough.

Quoting a report by Keio University professor Jun Murai, Wakabayashi said data centers "should ideally be established in one or two locations in each prefecture, and ultimately in every municipality nationwide," and explained that the argument is based on the fact that today's data centers deal with artificial intelligence inference and learning, which consumes a vast amount of electricity, making it difficult to rely only on data centers in big cities. The key to producing and maintaining the efficiency and stability of data centers is semiconductors. But there is another concern about these items.

"I have been particularly concerned about Japan's trade deficit in digital technologies. To mitigate the deficit, we need to nurture Japan's competitiveness in manufacturing and rely less on imports," he said. "Japan used to have half of the global market share of semiconductors in 1989. In the same year, eight companies in the world's top 10 DRAM manufacturers were Japanese companies. One of the reasons why Japan was not able to maintain its position was Japan-U.S. trade friction," Wakabayashi said.

> 'Japan is also still strong in analog power chips, producing about a fourth of total production worldwide.'

However, in terms of logic semiconductors, Japan had never been strong. "In 1995, Japan's share in the global production of logic semiconductors was only ¥1 trillion out of ¥7 trillion," Wakabayashi pointed out. The global market for logic semiconductors grew rapidly since then, and it was the fabless and foundry model that brought about more efficiency and less cost in chip production in the world. Wakabayashi said that Japan continued its own old-school manufacturing, which involves the in-house production of everything either because it was ignorant of this major shift in the business model or it was too optimistic and did not take the change seriously.

"One of the areas where Japan has continued to lead the world is image sensors, in which Sony excels. The company has almost half of the global market. Japan is also still strong in analog power semiconductors, producing about one-fourth of the total production worldwide. This is the area that will attract increasing attention with the rise of electric vehicles," Wakabayashi said. He went on to say that certain kinds of memory chips are also promising, namely NAND-type flash memory used in generative AI. "In terms of NAND flash memory, the partnership between Kioxia and Western Digital is securing about 30% of the global market.

He also pointed out that Japan has continued to be one of the major manufacturing countries in terms of chip manufacturing equipment and materials. Tokyo Electron Ltd. and Screen Holdings specialize in manufacturing equipment, while Shin-Etsu Chemical, Sumco and Resonac produce materials.

Focus on chiplet technology

But how can Japan join the race to produce cutting-edge logic semiconductors, an area where it has had almost no presence?

"That is what Rapidus is focusing on, to try creating smaller than two-nanometer-size chips. With the new EUV (extreme ultraviolet) exposure equipment installed soon, the company will accelerate preparations to start the mass production of logic semiconductors in 2027," Wakabayashi said.

But mass production at Rapidus will be much smaller than at companies like TSMC. The strength of Rapidus is its ability to produce diverse kinds of chips in small lots in short periods of time. He pointed out that companies like Rapidus can increase their profits by going beyond nanoscale, shortening the turnaround time.

The technology he takes particular note of as a means to achieve higher efficiency and profitability is chiplet technology, which is what Rapidus is incorporating as well. A chiplet is a silicon die optimized for a specific function or task, and it can be easily assembled into a package with other chiplets to operate as a larger and more complex system. This is more efficient and cost effective than building a large monolithic die designed to perform multiple functions; these are facing limitations in yield rate as chips shrink.

In addition to chiplet technology, Rapidus has another strong advantage, which is global expectations as concern grows over China's disturbing moves. "In that regard, the project of Rapidus is actually a contribution to the international community," he said.

Viable supply a must

He went on to say that the next challenge for Japan would be to gain the capacity to produce SiC (silicon carbide) wafers domestically. This material is mostly used in 5G communications equipment, smart grids, electric vehicles and other advanced technologies.

"There is an ongoing project funded by the Green Innovation Fund, which was established by the New Energy and Industrial Technology Development Organization to develop new ways to make SiC wafers," he said. He explained that the project is trying various approaches such as those using the solution growth method or high-temperature gas, which could prove more stable than the current sublimation method. "It is looking promising with some achievements being made in these approaches," he said.

For society to continuously receive the benefit of digital technologies, stable supply and accelerated advancement of semiconductors is a must, but it has never been free from geopolitical concerns.

Wakabayashi's insights suggest that Japan can and should play a key role in the global semiconductor market while aiming to achieve higher self-sufficiency in digital technologies to solve its own social issues.

RIX

(Sponsored content)

High-tech tools that meet the needs of chipmakers

Rix aims to utilize its strengths, expertise and alliances to further explore new potential in IC manufacturing

Rix is a manufacturing and trading company headquartered in the city of Fukuoka, with about 40 branches and 10 subsidiaries in Japan and 12 subsidiaries overseas. In a recent interview with The Japan Times, three Rix executives spoke about the company's strengths, areas of specialization and efforts to collaborate with other manufacturers to explore new potential in the industry.

"The company started in 1907 as a distributor of *tabi* (Japanese split-toe socks), so we have a long history of working with the industrial sector. Through their daily communication with customers, the workers learned what their customers' problems and needs were, and started looking for products and solutions, which was the beginning of our history as a trading company," said Representative Director, President and Executive Officer Takashi Yasui.

The company's lines of business expanded as it sought suppliers in Japan and abroad and asked manufacturers to produce new items based on its customers' needs. "In our current trading section, we have about 3,000 items, mostly industrial products and parts such as pumps, valves, seals and filters from more than 3,000 suppliers," Yasui said.

In 1967, Rix began manufacturing high-pressure hydraulic pumps, the result of its commitment to meeting customer needs. Since then, the company has gradually expanded its role as a manufacturer while maintaining its capability as a trading company.

"Our manufacturing division has three pillars: high-pressure hydraulic technology, precision cleaning technology and sealing technology. Among the devices and machines we manufacture is a flux cleaning system that we developed to clean the space between the substrate and the motherboard of a chip," said Fluid Device Engineering Department Manager Hiroyuki Okamoto.

On the other hand, chiplet technology is becoming mainstream in the semiconductor industry, creating a new demand for cleaning. This technology involves multiple small chips being placed on an intermediate substrate called an interposer and fitted into a single package. These require more flux cleaning in narrow gaps than conventional chip mountings.

Okamoto explained that Rix is developing a new flux cleaning machine to clean these very narrow gaps based on its existing technology.

Rix President Takashi Yasui

He also said that a micro-ice-jet precision cleaning nozzle developed by Rix is attracting attention from the semiconductor industry. When compressed air and water enter the nozzle, its special shape accelerates the water to supersonic speeds, causing adiabatic expansion that instantly turns the mix into ice particles so small they can clean chip wafers and semiconductor devices.

"Using this nozzle has been proven to strongly reduce nanoscale contamination on the surface of wafers. We are constantly updating the technology through joint research with semiconductor device manufacturers to improve performance while minimizing damage to the wafers by controlling the size and speed of the ice particles, so that the nozzle can be used to clean the most advanced wafers that must be handled with the utmost care and precision," Okamoto said.

Rotary joints, one of Rix's flagship products, are also used in semiconductor manufacturing, among other industries. Performance requirements vary by application, but cleanliness is the most important element in semiconductor production. "We have to make sure that the joints do not generate even microscopic dust when they rotate," Okamoto said.

To expand its product line, Rix is seeking opportunities to collaborate with domestic and international manufacturers who possess unique technologies and has set up a new research lab just for that purpose. "To provide the space and equipment necessary for such collaborations, we opened a new research facility near Fukuoka Airport in November," Yasui said. The facility called the Cooperative Creation Center includes a clean room.

"This is going to be a center for co-creation, and it plays the role of sowing the seeds for the future," Yasui said.

Rix offers a variety of products used in making microchips, including micro ice jets (top left), water jet deflashing systems (top right), flux cleaning systems (bottom left) and rotary joints. RIX

Rix's Cooperative Creation Center opened in Fukuoka in November. RIX

Kensaku Ida, manager of the Electronics and Semiconductor Industry Professionals Promoting Department

Hiroyuki Okamoto, manager of the Fluid Device Engineering Department

Especially in semiconductors, where technology evolves at a rapid pace, it would be too slow to create an environment for research and development only when customer needs arise. Yasui said some of the company's research projects are being carried out on a prospective basis, with no assurance that they will meet future customer needs, and highly valued this trend instead of showing concerns.

> 'This is going to be a center for co-creation, and it plays the role of sowing the seeds for the future.'

"Our focus has long been on adding high value to our main products. So there weren't many ideas that strayed from that focus. Now we have this place where new ideas are welcome," Yasui said.

Kensaku Ida, manager of Electronics and Semiconductor Industry Professionals Promoting Department of the Global Sales Headquarters, said the company has already achieved a lot by introducing unique global products to Japan as a trading company and by meeting customer needs by manufacturing products using technologies the company excels in. Now it aims to invigorate the Japanese market by creating unique products of its own. To achieve this, it is not enough to simply install new equipment and use cutting-edge technologies at the center. "We want to establish partnerships with various suppliers and customers around the world to come up with new ideas," Ida said.

At the same time, Rix's strength as a trading company is growing. The range of products available in various fields, including semiconductors, is also expanding, and the company can now offer comprehensive solutions, such as repair and remanufacturing services, as well as products that are a combination of its own products and those of other companies.

Ida also said the goals behind procurement are changing on the customer side, especially in semiconductors. "Customers have always been concerned about how much cost reduction can be achieved through procurement," he said. "But now there is demand for rare parts and parts that are no longer manufactured."

In such cases, Rix can provide tailored support, made possible by the network of manufacturers and suppliers it has built up over the years. "For example, we have worked with manufacturers that have experience in other areas, such as the automotive industry, to handle items requested by our semiconductor customers," he said.

Rix can also provide repair and maintenance services. "We used to outsource the repair work to manufacturers and partners, which is a typical role at a trading company, but now we work with them to repair and recycle various items such as pumps, power supplies and heaters, incorporating them into our own company as a manufacturer," he said.

In fact, some of the items Rix repairs are products that were originally made by other manufacturers. Sometimes neither Rix nor other companies in Japan have the capability to repair a particular item. In such cases, Rix not only finds an overseas company that can repair the product, but a company that it can form a partnership with to bring the technology to Japan and handle domestic repair services, allowing it to provide timely support to customers.

The repair and recycling service is where Rix can take advantage of its close links with manufacturers and customers around the world as a trading company and its knowledge and experience as a manufacturer.

For overseas manufacturers and suppliers, Rix is a reliable partner with a wide variety of perspectives and capabilities, from sales and promotion to repair, recycling, research and development. It also boasts customers in a wide range of industries including steel, paper, semiconductors, machine tools, shipbuilding, automobiles, food, medicine and more. It already has accounts with many companies and their subsidiaries in Japan, helping to shorten what would otherwise be a long and tedious sales process.

"We can also suggest potential cross-industry cooperation among the companies we have connections with. And we know how and where to effectively promote new products," he explained.

Yasui said he is looking forward to engaging multiple partners to not only serve its customers, but also stimulate the Japanese market.

This page is sponsored by Rix.

SCREEN SEMICONDUCTOR SOLUTIONS (Sponsored content)

Long history of excellence in surface processing

Kyoto-based Screen is a global maker of microchip equipment that puts priority on sustainability

Headquartered in Kyoto, Screen Semiconductor Solutions Co. Ltd., which is celebrating over 80 years in business this year, holds the biggest global market share in semiconductor wafer cleaning systems, its core product. In a recent interview with The Japan Times, Representative Director and President Akihiko Okamoto and Cleaning Elemental Technology Development Department Head Hiroaki Takahashi spoke about the strengths of their wafer cleaning systems and their commitment to sustainability.

The company is part of Screen Holdings, which was formerly a printing company established in Japan in 1868. The Screen Group possesses three core technologies: surface processing, direct imaging and image processing. Each contains its component technologies that have been applied to the semiconductor, printing, display, printed circuit board and other markets.

Screen Semiconductor Solution's wafer cleaning systems boast the top global market share in various categories.

Ensuring cleanliness

Among the core technologies, Screen specializes in surface processing, which is mainly used in equipment for cleaning semiconductors.

"In semiconductor manufacturing, cleaning the surface of semiconductor wafers is required at the completion of each process. If this cleaning is inadequate or insufficient, microscopic dust and dirt can interfere with the next process and affect the quality of the product, resulting in a lower yield rate," Okamoto explained.

> Screen customizes and optimizes its wafer cleaning systems to cater to each unique case.

Screen's ultra-clean, fluid control and drying technologies support the surface treatment process.

"We are particularly focusing on our ultra-clean technology. The cleaning process varies widely and in complexity, depending on the type of semiconductor device and the process used to make it. This technology is designed to satisfy all needs while ensuring that all impurities are removed without fail," Takahashi said.

In addressing the complexity of the process, Takahashi explained that several chemicals are used separately in some cases and mixed in others, while temperature also varies according to each case.

"For example, when it is necessary to use multiple chemicals separately at high temperature, we need to ensure that the chemicals in their liquid form won't mix together. But the real challenge lies in how to prevent the chemicals that evaporate at high temperature from reacting with each other or coming into contact with other chemical solutions inside the equipment, creating unwanted results. Another issue is how to maintain the route for supplying the chemicals clean," he said.

Screen customizes and optimizes its wafer cleaning systems to cater to each unique case, making sure that any potential problems are addressed. Their wafer cleaning systems can be categorized into two basic types, one for logic semiconductors — the smallest and most sophisticated ones made for high-level computing mainly in smartphones and computers — and the other for legacy chips that are commonly found in automobiles, appliances and consumer electronics.

"But even within these two categories, there is great diversity in the processes for manufacturing chips, and the levels and functions required of wafer cleaning systems are different as well," Takahashi said.

Support from R&D

The Screen Research and Development Department comprises four areas: basic research, component technology development, product development and equipment evaluation, with each group communicating closely with the corresponding team at each customer.

The company collaborates on high-level, time-consuming basic research with schools such as Shiga University and Mie University, as well as national research institutes. The achievements of the basic research are used in the development of element technologies where the company engages in joint R&D with front-line consortiums, such as the Inter-university Microelectronics Centre (IMEC) in Belgium and the Alternative Energies and Atomic Energy Commission collaboration with the Electronics and Information Technology Laboratory in France.

In the areas of product development and equipment evaluation, new technologies and equipment are developed and evaluated through collaboration mainly with other companies.

Representative Director and President of Screen Semiconductor Solutions Akihiko Okamoto

"It is important that we work with other companies in the long and complex semiconductor supply chain, including our suppliers, such as manufacturers of valves, filters and chemicals," Takahashi said. New technologies and equipment are then further assessed at customer production sites before they are finally installed on the production lines at the sites.

Takahashi said the company employs science-based methods in all steps in its research and development process, even where the intuition and experience of engineers have conventionally been depended on. "We want to pursue science-backed optimal solutions to further improve the sophistication of our technology development," he said.

One example of such efforts is the use of computer simulation. "Take computer fluid dynamics as an example. It's a technology used to find the best way to cover wafers with liquid by simulating how liquid will spread when it is poured onto the horizontally rotating surfaces of wafers in the wafer cleaning systems," Takahashi said.

Another example is related to the drying technology used in the equipment. "Just like a woolen sweater shrinks when it is washed without adequate care, the structure of semiconductors is also affected by drying. Instead of making assumptions about how exactly this nanometer structure is influenced, we are trying to visualize the impact based on calculation and modeling as part of our joint research with a Japanese university at the moment," Takahashi said.

Pursuing sustainability

It is not just the area of cleaning technology that requires joint R&D with stakeholders. Basic conservation is an issue as well. "Throughout the long process of making chips, vast amounts of electricity and pure water are required. It is a big challenge for all in the supply chain to reduce their consumption," Okamoto said.

> 'In making chips, vast amounts of electricity and pure water are required. It is a big challenge for all in the supply chain to reduce their consumption.'

During the past several years since returning from Singapore in 2021 after heading Screen's local branch for 5 1/2 years and becoming president of Screen Semiconductor Solutions in April, Okamoto has felt rising interest in sustainability emerge among the company's customers. Takahashi said the trend cannot be ignored.

"We have been conducting regular technical meetings dedicated to issues of sustainability with some of our customers since about three years ago. Requests from customers related to sustainability have become increasingly specific and concrete," Takahashi said.

Okamoto said that he considers this trend an opportunity for the company to enhance its value and that the company will continue to focus on its efforts to increase environmental sustainability in the semiconductor industry.

The company's plant in Hikone, Shiga

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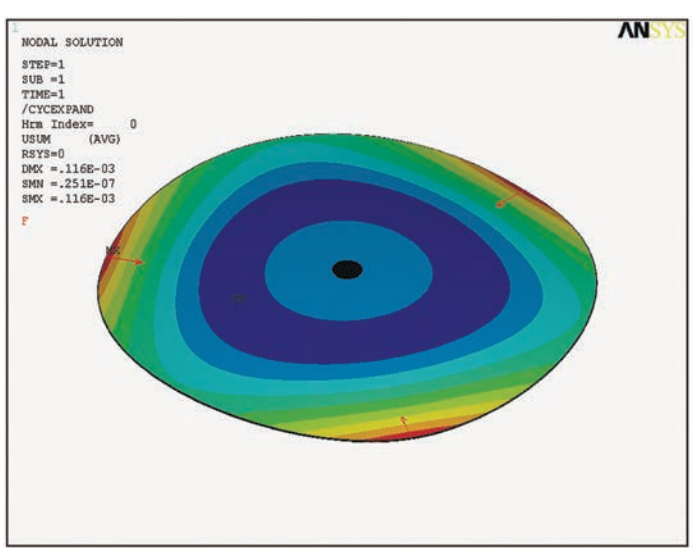

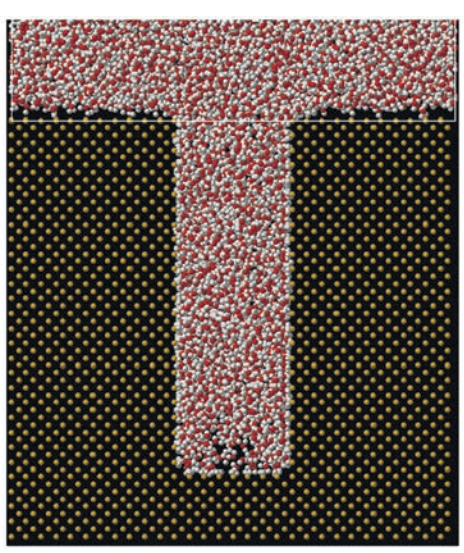

Screen proactively uses digital simulations in its research and development. Far left: A simulation of wafer deformation on a wafer chuck; Left: Wetting phenomena visualized on a nanometer scale

SCREEN SEMICONDUCTOR SOLUTIONS

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The S3-5 factory commenced operation in January at the company's Hikone Site.

→ *Continued from page B6*

Prefecture, uses electricity from renewable energy sources and facilities that consume less electricity than conventional ones. For the products the company manufactures, there is a set of evaluation standards established for the purpose of promoting products that are environmentally friendly both in the manufacturing process and when used. Products that meet the standards are certified as "green products." Efforts to make products greener include curbing their electricity consumption and carbon emissions, reducing the amounts of chemicals used, or looking for less harmful materials to use. "This way, we ensure that all our newly released products are labeled as green products," Takahashi said.

> It is increasingly important engineers come up with ideas about what society needs and the kinds of technology that can be useful.

Okamoto revealed that there are also demands to improve the efficiency of electricity and water use for its existing equipment.

"Our wafer cleaning systems use heated ultrapure water to clean the insides of itself. This water had conventionally been single use, but we developed a system that allows the water to be circulated and reused. Our customers are very satisfied with it, and we are aiming to deploy it worldwide," he said.

Okamoto pointed out that progress is being made to improve the cleaning process for semiconductors because it requires a significant amount of pure water.

"We started using a water management application to track and visualize how much water we are using and to analyze how we can reduce it. Now that we have gathered enough figures by using this application, we are starting to work on reducing our water usage," he said.

However, the amount was not the only problem. The company's research on its carbon emissions begun two years ago has revealed that using ultrapure water results in the greatest amount of carbon dioxide emissions among all other equipment at the company.

Takahashi explained this was because the conventional water heating unit was working even when water was not needed. This was to prevent the water temperature from dropping and the water flow inside the cleaning unit from becoming inconsistent.

Hiroaki Takahashi, head of the Cleaning Elemental Technology Development Department

A new water heater the company developed can heat it and supply it to the equipment only when needed, based on the concept of "smart use."

"Thanks to this new system, we have managed to reduce not only the amount of ultrapure water, but also the electricity consumption related to the water by 85%, resulting in lower emissions," Takahashi said.

Okamoto noted that each country has its own priorities when it comes to sustainability. The highest priority, whether it be water, electricity or something else, depends on various factors, including the country's environmental, social, economic and political situations. Screen is committed to customizing its efforts to customers in each country.

On the other hand, he emphasized that the carbon emissions issue needs to be addressed collectively by the entire semiconductor supply chain. As a member of the Semiconductor Climate Consortium (SCC) within Semiconductor Equipment and Materials International, a global association of more than 3,000 members from the industry, the company aims to take the initiative in conducting advanced carbon emission analysis of the supply chain and sharing effective practices with other members of the SCC. One of the projects the company engages in within the SCC involves the use of Zeroboard, a cloud-based tool that enables the calculation and visualization of greenhouse gas data.

"We use it to analyze where specifically in our supply chain environmental stress is significant so that we can better understand how to effectively minimize it," Okamoto said.

He added that the company is also collaborating with IMEC and other stakeholders both in Japan and abroad, which has expanded the technical boundaries of the supply chain in environmental sustainability. "However, as a result, we are faced with mounting costs," he said, stressing that in addition to a collective effort in covering the costs, it is important to call for support from the government to not hamper the industry's progress in becoming greener.

Global benefit of semiconductors

More than 80% of Screen Semiconductor Solutions' customers are companies in countries and regions such as Taiwan, South Korea, the United States, Europe and China. Takahashi said the company aims to give its customers the value of time wherever they are.

"To shorten the time at all stages of manufacturing and operating our equipment including the time for product development, installation, downtime and recovery, enabling the world to continuously receive the benefit of the most up-to-date semiconductors, we need to improve the intelligence of our equipment," he said.

Beyond that is the application of technologies to develop a "digital twin," a virtual model created and constantly updated in real time based on data gathered in the real world, that would allow them to create products based on accurate analysis of how exactly they should be designed, backed by science and theory, naturally resulting in shorter delivery times and higher reliability, he said.

But changes in manufacturing also mean changes in what is expected of engineers.

"It is increasingly important for engineers to have the ability to come up with ideas about what society needs and what kind of technology can be useful, and the communication skills to engage our customers and other stakeholders to realize the ideas," Takahashi said.

Okamoto said that he encourages all employees of the company, not just engineers, to feel confident their work has a social value in both direct and indirect ways.

"Our equipment and our environmental efforts directly contribute to society, while semiconductors, which cannot be produced without our cleaning technology, contribute to solving social issues around the world," he said.

This article is sponsored by Screen Semiconductor Solutions Co. Ltd.

Screen's long history goes back to Ishida Kyokuzan Printing Works, founded in 1868.

SONY SEMICONDUCTOR SOLUTIONS (Sponsored content)

Advancing sensors to pioneer a 'sensing society'

Sony's imaging and sensing technologies have inspired AI, smartphone, automotive and other growing areas

The Sony Semiconductor Solutions Group holds the largest share in the rapidly growing imaging sensor market in terms of revenue. It focuses on advanced technologies and excellent quality, aiming to accelerate the further expansion of social implementation through technological advancement.

Image sensors: A growing market

Image sensors are semiconductors that are also called "electronic eyes." Most of the current applications are for smartphone cameras; however, image sensors have also become essential for autonomous driving technology, factory automation, artificial intelligence integration and edge computing. Between fiscal years 2023 and 2030, the image sensor market is expected to have a compound annual growth rate of 9%.

'Sensor performance is key for high-quality still images and video and significantly influences camera performance.'

An independent subsidiary of the Sony Group since 2016, Sony Semiconductor Solutions has a long history in image sensor development. In the 1970s, the company succeeded in mass producing the world's first charge-coupled device image sensors. Although having established a dominant market position with CCDs, the company made the decision in 2004 to halt investment in CCDs and shift its development resources to something known as a complementary metal-oxide-semiconductor image sensor. CMOS sensors at that time had issues with image quality compared with CCDs; however, forecasting demand for significantly improved image quality for video recording and the use of mobile devices in the near future, the company decided to turn its full attention to developing a high-performance version of CMOS.

CMOS image sensors are essential creation technology. GETTY IMAGES

In the more than 20 years since, Sony Semiconductor Solutions has launched a number of world-first technologies that have led the company's CMOS image sensor to significantly exceed CCD performance, producing new trends and markets with its excellent image quality as well as unique features to function as the eyes of various electronics. According to its research, in fiscal 2023, it achieved an astonishing 53% market share in value, well ahead of its competitors.

"I feel that this number reflects the market's recognition of our high-performance products with exceptional and consistent quality that satisfy customer needs," said Terushi Shimizu, the company's representative director, president and CEO.

'Creation technology'

Sony Group has outlined the company's strategic direction as "Creation Shift," which means that Sony is shifting its focus towards creation side in each business layers to create *kando* (emotion) together with creators. The company's image sensors are essential creation technology for the growth of the group as it strives to achieve this forward-looking shift. Image sensors are mounted on mirrorless interchangeable-lens cameras and digital cinema cameras used in film production, contributing greatly to creation efforts. Furthermore, cameras installed in smartphones are now indispensable tools used every day to make every user a creator.

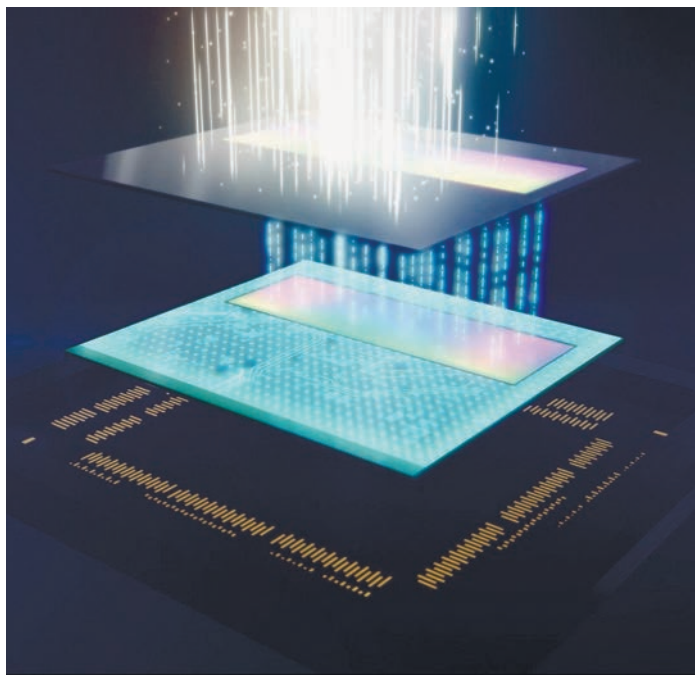

Image sensors convert light photons into electrical signals.

Terushi Shimizu, representative director, president and CEO, Sony Semiconductor Solutions Corp.

"Smartphone manufacturers consider cameras to be important elements in differentiating their products from others and strive to develop high-performance camera systems, especially for high-end models. Sensor performance is a key factor for achieving high-quality still images and video taken under a wide variety of conditions, and it significantly influences total camera performance," Shimizu said.

'Such comprehensive sensing technology capabilities are a major strength that differentiates us from our competitors.'

In addition to a larger sensor format that increases the light-receiving area, Sony Semiconductor Solutions is working on improving the key characteristics that determine image quality and continues to make steady progress on the long-term development road map.

Given the unstoppable growth of the image sensor market, the company has steadily increased capital investment to enhance production capacity, committing a total of ¥930 billion over the three years from fiscal 2021 to 2023. The company also has funded the expansion of its Nagasaki Technology Center's new Fab 5 and continues improving the facilities, while recently acquiring land in Kumamoto Prefecture next to its existing Technology Center to build a new fab primarily for image sensors.

Furthermore, Sony Semiconductor Solutions has invested in Japan Advanced Semiconductor Manufacturing, which was established as a subsidiary of Taiwan Semiconductor Manufacturing Co., the world's largest semiconductor foundry, also in Kumamoto. Through this strategic investment in JASM, Sony Semiconductor Solutions aims to reinforce its partnership with TSMC, while aiming for stable procurement of logic wafers used for the company's stacked CMOS image sensors.

"With globally expanding semiconductor demand, JASM is expected to contribute to the stable supply of logic wafers not only for Sony Semiconductor Solutions, but for the entire semiconductor industry as well. For the Japanese semiconductor industry, the establishment of JASM will stimulate the business initiatives of corporations involved in semiconductor manufacturing, leading to a revitalization of the overall industry," Shimizu said.

The company, which has broadened its customer base and achieved a high market share, is expanding its sensing capabilities and services for utilizing image information by incorporating various technologies into its image sensors. These chips are already being implemented in society for wide range of applications in various sectors, including automotive, machinery, industrial and the Internet of Things.

"Sony Semiconductor Solutions has provided sensors not only for smartphones and digital cameras, but also for a wide range of applications and has accumulated a variety of technologies over many years. Such comprehensive sensing technology capabilities in

Continued on page B9 →

Sony Semiconductor Solution's image sensors create unprecedented values.

Nagasaki Technology Center

SONY SEMICONDUCTOR SOLUTIONS

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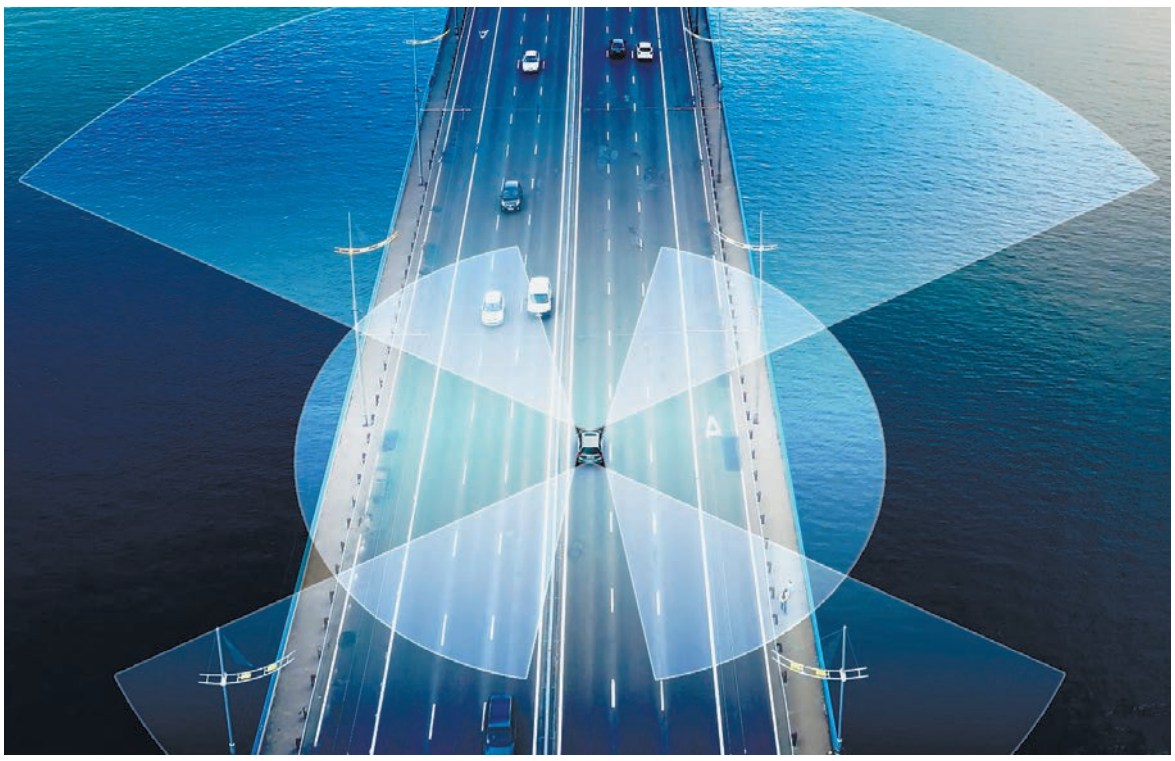

Left: Working toward ensuring safety and security in mobility; Right: Pursue the ideal environmental performance in the industry.

→ *Continued from page B8*

image sensor technology are one of the strengths that differentiates us from our competitors, and we aim to strengthen our business by further diversifying our products and customers," Shimizu said.

'We hope to use sensing technology to create new value by linking it to more affluence and convenience in daily life.'

With increased attention gathering around advanced driver-assistance systems and autonomous vehicles, the company has increased engagement with global original equipment manufacturers and other partners. According to Sony's research, this will allow the company to grow its share of automotive image sensors in value from 32% in fiscal 2023 to a projected 43% in fiscal 2026.

As the "eyes of vehicles," image sensors require high-precision object recognition capability even under unfavorable conditions such as darkness, backlight or bad weather. The company aims to promote safe, secure and comfortable transportation spaces by enabling both internal and 360-degree external monitoring around vehicles via sensing technologies that exceed human eyesight.

Industrial markets are another focus area as the company faces a new challenge in the solutions business, which is centered on its core image sensor technologies. In this area, the company is forging ahead of others to address the heavier cloud and environmental loads caused by the increase of IoT devices. The demand for vision sensing via cameras has been climbing significantly in the IoT era. However, given the vast amount of data processed via cloud computing, a large number of issues ranging from increased network loads and power consumption to privacy risks, have also become apparent.

To address these issues, Sony Semiconductor Solutions launched its edge AI sensing platform Aitrios, a one-stop environment for various solution builders to efficiently and reliably develop products that rely on image sensors. Aitrios is making great progress, and the results re already becoming visible in the retail, logistics and factory markets.

Realizing a 'sensing society'

All of the company's technological efforts are being accelerated by its commitment to contribute to building a sensing society.

"We strive to improve technology and corporate value to open the door to an efficient and affluent future. To do so, it is essential for us to increase our presence in society, gain the understanding and cooperation of a wide range of stakeholders, including partner companies and local communities, and to work together to create social value. We hope to use our sensing technology to create new economic value by linking it to a more affluent society and to convenience in daily life," Shimizu said.

'Since its foundation, Sony has kept true to its spirit of challenging itself to achieve what others have not.'

The greatest challenge for a regionally rooted semiconductor business is the substantial water and electricity required for manufacturing. Based on the Road to Zero, the Sony Group's long-term environmental plan, Sony Semiconductor Solutions has enhanced its approaches to reducing greenhouse gas emissions at each office and plant as its responsibility for the environment.

These approaches include the implementation of cutting-edge energy-saving technologies, the promotion of energy circulation and the adoption of renewable energy sources by combining solar panels with the purchase of Renewable Energy Certificates. As an integral part of its water resource preservation, the company also collects and reuses the majority of its wastewater.

Shimizu added: "Since its foundation, Sony has kept true to its spirit of challenging itself to achieve what others have not. Such activities motivate employees to explore new fields, resulting in the development of remarkable technologies. In addition, our company continues to identify the kind of added value that customers and partner companies around the world expect through close communication with them. Our drive to learn from the world, enthusiasm to create a positive future with our technology, and creativity that defies conventional wisdom have become the motivating power behind Sony Semiconductor Solutions' development of image sensors that satisfy customers. To realize a safe, secure and affluent sensing society, we continue seeking improvements that have a significant impact."

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TOPPAN

(Sponsored content)

Advancing semiconductor progress with substrates

Toppan's shift in focus to high-speed data transmission anticipates needs of generative AI and network devices

In October 2023, 123 years after Toppan Printing was founded in Tokyo in 1900, the group was reorganized into a holding company structure with Toppan Inc. as the core operating company. Based on a wide variety of technologies accumulated through its printing business, Toppan has established information and communication, living and industry, and electronics as its three major business segments. The electronics business achieved ¥266.5 billion in net sales for fiscal 2023, accounting for 16% of its total consolidated sales.

"You may wonder why a printing company is now involved in the electronics business; but we've actually been expanding our interests in electronics through our proprietary technology for more than 60 years since we started applying our photographic engraving technology in the manufacture of filters for sugar production," said Kazunori Katsumura, an executive officer and deputy head of the electronics division. Regarding the semiconductor business, Toppan has advanced technological capabilities for the high-end flip chip ball grid array (FC-BGA) substrates, next-generation semiconductor packages and photomasks for semiconductors, and has been involved as a substrate manufacturer in the TSMC 3DFabric Alliance. These business activities have been highly regarded in markets around the globe.

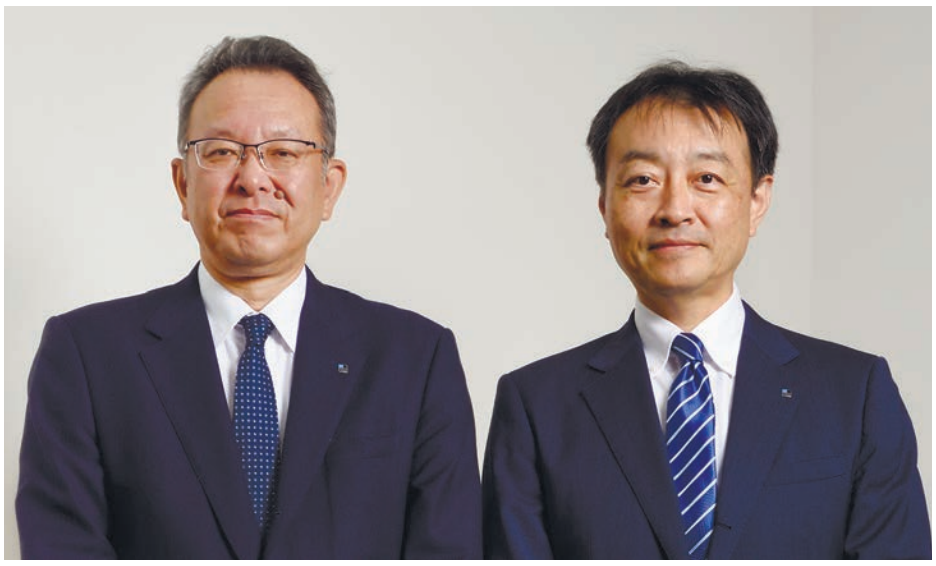
> Toppan is proud of its more than 20-year history in the mass production of substrates.

Substrates for blazing data speeds

Toppan is proud of its more than 20-year history in the mass production of FC-BGA substrates. Initially, its focus was on FC-BGA substrates used for game consoles; however, Toppan reached a turning point in 2007.

Akihiko Furuya, Toppan's executive officer and head of semiconductor business in the electronics division, proudly said: "With the appearance of iPhones, data communication quantity rose dramatically to 10 times that of previous levels. Based on the assumption that the quantity of data communication at mobile phone base stations would also increase, Toppan shifted its core semiconductor substrates to those used for network devices at base stations, and then expanded to semiconductor substrates for data centers. We continued seeking the most ideal semiconductor substrates that would correspond to high-speed transmissions, and we are quite confident in the formation of high-speed transmission lines and the quality of the signals."

While competitors have developed technologies for personal computers and other consumer products, Toppan focused on network switches, high-frequency devices and other industrial-use products to achieve superiority, which built confidence in its semiconductor substrate production. Large-scale substrates (98 millimeters × 95 mm and 90 mm × 90 mm) will be exhibited at Semicon Japan 2024.



Toppan executive officers Kazunori Katsumura (left) and Akihiko Furuya speak with The Japan Times on Oct. 1 at Toppan office in Minato-ku, Tokyo. TOPPAN

Toppan has responded flexibly to technological requirements such as increased substrate sizes and layers, and high-speed transmissions focusing on the development of large and multilayered FC-BGA substrates targeting server processers, network devices, home-use game devices, central processing units and graphics processing units.

> To further strengthen productivity and support business continuity for the Niigata Plant, construction is ongoing at the Singapore Plant.

"We have specialized in technology that forms high-speed transmission lines corresponding to a rate of 224 gigabits per second per line with four-level pulse amplitude modulation, and have achieved high-volume production of FC-BGA substrates. Recently, artificial intelligence accelerators employ extremely high-speed GPUs, and switches connecting accelerators also require high-speed transmission capability. This is where our FC-BGA substrates, which are capable of high-speed transmission, exert real strength. We have also produced a high-volume of large, multilayered 100-mm-square 9-2-9 build-up substrates for the market," Furuya added.

The Niigata Plant is producing high volumes of FC-BGA substrates, and the Phase 3 expansion production line is scheduled to start operation in 2026. To further strengthen productivity and support business continuity for the Niigata Plant, construction is ongoing at the Singapore Plant with plans to start operations at the end of 2026.

In the FC-BGA substrate business, Toppan is working on the development of substrates corresponding to photonics-electronics convergence technology represented by NTT's Innovative Optical and Wireless Network 2.0, which requires further high-speed transmission.

"We are working jointly with a customer to develop FC-BGA substrates corresponding to copackaging which mounts photoelectric conversion elements onto the substrate, and we are about ready for market launch," Furuya said.

This technology corresponds to ultra-high-speed switching at 102.4 terabits per second. Toppan is enhancing research and development considering optical transmission inside FC-BGA substrates (optical interconnections between chips) and intrachip optical interconnection as the next stage of optical connection between boards.

Primed for generative AI

Toppan promotes technological development not only for conventional FC-BGA substrates, but also for next-generation semiconductor packages for generative AI. According to Furuya: "Next-generation semiconductor packages will not eliminate FC-BGA substrates, but will develop a chiplet structure, which has multiple semiconductor chips mounted in an interposer installed onto an FC-BGA substrate. In response to this trend, Toppan is planning to enter the interposer market while maintaining its presence in the conventional FC-BGA substrate market."

Toppan focuses on the development of high-productivity interposers for next-generation semiconductor substrates using glass and other organic materials. Different from silicon interposers that can be created only from circular wafers, glass and other organic materials will make it possible to manufacture interposers from rectangular panels. As a part of this technological development, Toppan established the Advanced Semiconductor Packaging Development Center in April.

"We have a wide variety of specialists on the development team with extensive experience in important areas, including design engineers for design and microfabrication processing in semiconductor front-end process, photomask engineers for microfabrication processing, and liquid crystal display color filter engineers for glass processing and transferring technology. The development of organic redistribution layer (RDL) interposers requires the ability to design the semiconductor front-end process, an area in which Toppan can exert its strength in semiconductor design services. Toppan has prepared research and development along with technological development structures by gathering knowledge from throughout the group."

For generative AI, Toppan develops substrates for chiplet packaging combining FC-BGA and silicon interposers as it advances technological development of next-generation package substrates with glass cores, glass interposers and organic RDL interposers using glass carriers considering the potential for future popularization of chiplets. These technologies, which have attracted increasing attention, will be exhibited at Semicon Japan 2024.

Glass substrates

Toppan utilized glass processing technology that it has accumulated over the years to develop glass substrates having through glass vias (TGVs) with cavities of different depths for mounting in components. Toppan also succeeded in simultaneously processing TGVs and cavities. This can be applied to glass-core FC-BGA substrates and glass interposers. While there was concern about breakage in glass-core substrates caused by stress, Toppan was successful in preventing this problem. Toppan is exhibiting a sample at Semicon Japan 2024 that forms cavities and TGVs on a 510 mm × 515 mm glass panel without metallization.

RDLs by damascene processing

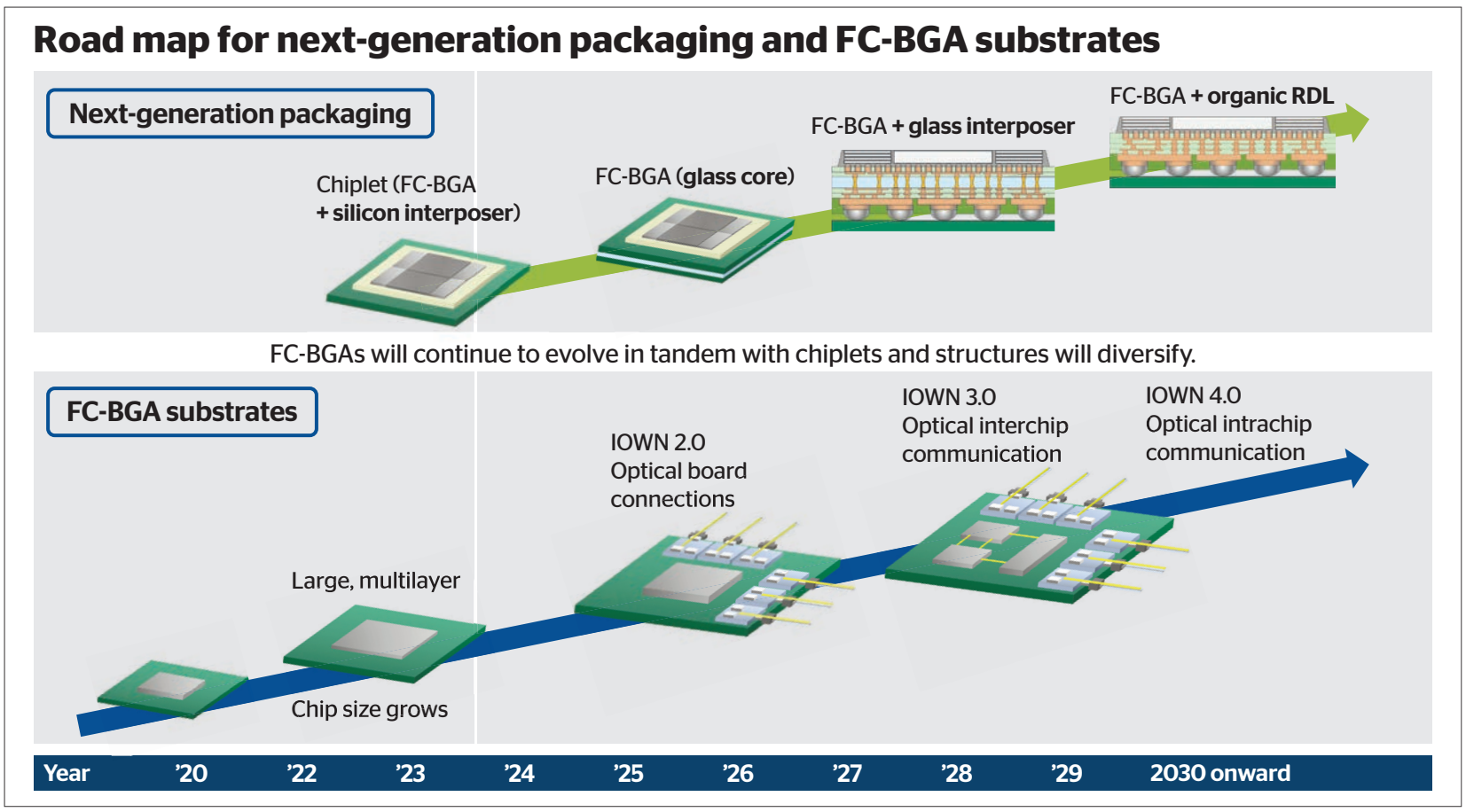
In addition to microfabrication technology nurtured in its FC-BGA business, Toppan utilizes a new damascene wiring formation developed from the semiconductor front-end process for chip-last type organic RDLs. After mounting an RDL (wiring layer) with glass car-

Continued on page B11 →

Akihiko Furuya notes that Toppan is confident in the formation of high-speed transmission lines and the quality of the signals. TOPPAN

Toppan's Niigata Plant has been mass producing FC-BGA substrates since 2014 and is preparing to add another production line in 2026. TOPPAN

Toppan's new Ishikawa Plant will have a line for the development and mass production of next-generation semiconductor packages. TOPPAN



IOWN = INNOVATIVE OPTICAL AND WIRELESS NETWORK, BY NTT CORP. TOPPAN GRAPHIC

Toppan envisions a future in which its substrate technology evolves to keep pace with advances in microchip packaging. TOPPAN

→ *Continued from page B10*

rier onto an FC-BGA substrate, the glass carrier is removed and chips are mounted. Toppan is exhibiting a sample at Semicon Japan 2024 that forms micro wiring (line/space = 2/2 micrometers) on a 510 mm × 515 mm glass panel with damascene processing method.

Coreless organic interposers

Toppan has developed a coreless organic interposer, the Toppan RDL Embedded Coreless Substrate, an example of innovative technology for packaging that increases the functionality of semiconductors. Interposers have three requirements to ensure the reliability of connection: low coefficient of thermal expansion (CTE) to approach the CTE of chips; fine pitch interconnections corresponding to the increase in input and output; and increased size corresponding to increases in the number of mounted chips. Coreless organic interposers capable of heterogeneous integration meet these requirements.

First, this new coreless organic interposer reduces CTE mismatches between chips and the FC-BGA substrate with a low-CTE material, adding structural rigidity to make it possible for the first time in the world to enable standalone electrical inspection without any carrier. And since these can then be delivered as a known-good-RDL, it improves mounting reliability and yield, making it possible to reduce loss due to chip disposal resulting from interposer defects.

Second, this new interposer can be made in sizes exceeding 100-mm-square. Toppan is exhibiting a sample of four interposers as a unit at Semicon Japan 2024 that enables the largest increase in the manufacturing process currently possible in the industry (512 mm × 612 mm).

Toppan is developing new-generation semiconductor packages by combining these new technologies with FC-BGA at its Advanced Semiconductor Packaging Development Center, aiming to start mass production in fiscal 2028 at the Ishikawa Plant, which is now under construction. Toppan is also exerting unique technological capabilities in the next-generation semiconductor packaging business, and has undertaken the development of TSMC 2.5D packaging substrates. This is seen in its participation as a substrate manufacturer in the TSMC 3DFabric Alliance. Toppan is highly regarded for the quality and consistent supply of substrates it delivers for 2.5D packaging.

Photomasks gain top share

Toppan's strength in the semiconductor business is not limited to FC-BGA substrates and next-generation semiconductor packaging.

Kazunori Katsumura looks forward to speaking with visitors from a range of industries at Semicon Japan 2024. TOPPAN

Toppan's Singapore Plant aims to ensure a stable supply of FC-BGA substrates when completed at the end of 2026. TOPPAN

Katsumura noted: "Toppan has gained the top market share in the external sales market for photomasks, which are essential components in semiconductor manufacturing. Our products cover a wide range of processes, from the conventional to cutting-edge innovations, and sales of our photomasks have expanded to global markets."

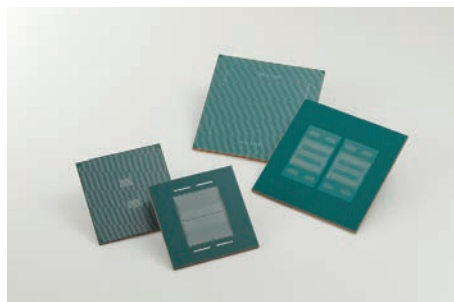
> 'Toppan has gained the top market share in the external sales market for photomasks, which are essential components in semiconductor manufacturing.'

The development and manufacture of Toppan's photomasks are handled by Toppan Group company Tekscend Photomask Corp. (rebranded from Toppan Photomask Co. Ltd. to Tekscend Photomask Corp. on Nov. 1). "Having eight manufacturing bases around the world, Toppan's global reach in the photomask business is impressive. This coverage means that even when product demand is concentrated at one plant, Toppan has the backup structure to support manufacturing at other plants. We can leverage cooperation among our bases to effectively respond to short-term delivery," Katsumura said.

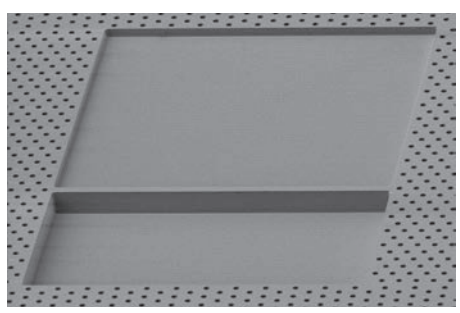
Toppan develops different types of photomasks, including binary masks, phase-shift masks, and extreme ultraviolet photomasks, the top choice for next-generation photolithography. In February, Toppan signed an agreement with IBM for joint research and development of EUV photomasks, supporting microfabrication of semiconductors through the manufacture of cutting-edge photomasks. Toppan also plans to exhibit its EUV photomask at Semicon Japan 2024.

Katsumura speaks enthusiastically about Toppan's participation in Semicon Japan 2024, "As the semiconductor business is attracting increasing attention both here in Japan and around the globe, we are pleased to have this opportunity to meet and speak with visitors in a wide range of industries at Semicon Japan 2024. I am looking forward to showcasing Toppan's impressive strength in the semiconductor business to the world."

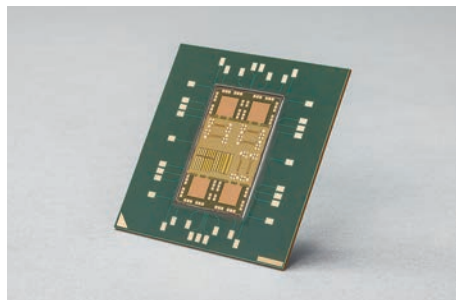
This article is sponsored by Toppan Inc.



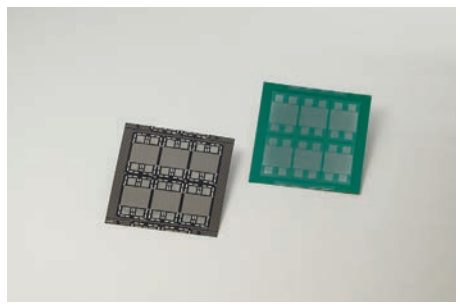
Toppan's FC-BGA substrates create distinct superiority in high-speed transmission lines. TOPPAN



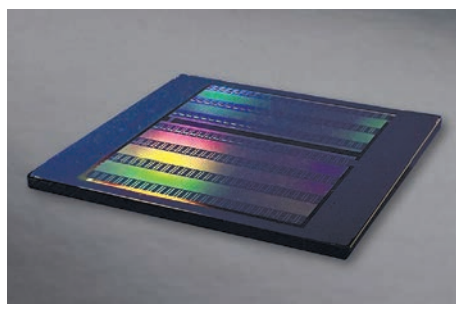
Toppan is capable of developing glass substrates that have through glass vias with cavities of different depths. TOPPAN



Chip-last type organic redistribution layers made by utilizing damascene wiring formation TOPPAN



The Toppan RDL Embedded Coreless Substrate is a coreless organic interposer capable of assuring standalone electrical inspection. TOPPAN



Extreme ultraviolet photomasks are a No. 1 candidate for next-generation lithography. TOPPAN

PUBLIC-PRIVATE COLLABORATION

With labor short, chip ecosystem key to engaging AI

Satoshi Nohara
DIRECTOR-GENERAL, COMMERCE AND INFORMATION POLICY BUREAU, MINISTRY OF ECONOMY, TRADE AND INDUSTRY

Japan is facing a structural labor shortage due to population decline and thus needs to utilize digital technologies such as generative artificial intelligence and robots across all industries to maintain people's standard of living and enhance productivity and industrial competitiveness. Moreover, generative AI is expected to contribute to the creation of innovative products and services.

However, Japan lags behind other countries in its scale of digital investment and the digital deficit is expanding. It is critical for us to establish robust development and utilization platforms for generative AI domestically. Competitiveness in generative AI relies not only on computational processing capabilities, but also on low power consumption to curb electricity demand. To achieve these aspects simultaneously, it is urgent to create an ecosystem in which hardware (such as semiconductors and data centers) and software (such as AI programs) function smoothly together.

Semiconductors are a technology critical for achieving digitalization and decarbonization. Furthermore, from the standpoint of economic security, they are strategic materials that influence Japan's overall industrial competitiveness, and it is essential for Japan to capture the significantly increasing global demand for these products. Particularly with the emergence and rapid advancement of generative AI, the presence or absence of a robust industrial base for advanced, next-generation microchips will greatly impact the overall competitiveness of industries.

Governments around the world are taking large-scale measures to secure chip manufacturing capacity. Likewise, the Japanese government has been swiftly implementing legal reforms and considerable financial support to aid the semiconductor industry. Over the past three fiscal years, it has secured a budget of about ¥4 trillion (roughly $26 billion).

Based on this budget, construction of the first facility of Japan Advanced Semiconductor Manufacturing, a joint venture in Kumamoto between Taiwan Semiconductor Manufacturing Co. and several Japanese companies the government decided to support two years ago, is progressing at an astonishing pace. It is expected to begin shipping by the end of the year, with a second facility set to break ground soon.

> Chips are strategic materials that affect Japan's competitiveness and it is essential to capture the growing demand.

The Rapidus project, which aims to mass produce next-generation logic semiconductors, is also progressing smoothly with research and development, and preparations are steadily advancing toward mass production in 2027, including the opening of a business office on the West Coast of the United States this spring.

As a result of these various kinds of support for the industry, significant spillover effects are already beginning to appear. For example, a private estimate suggests the JASM projects are expected to increase employee compensation by ¥380,000 per capita annually in Kumamoto Prefecture.

Additionally, the growth rate of investment in facilities in Kyushu reached an all-time high last fiscal year, and there is a positive cycle of investment and wage increases, with numerous investment projects being announced and executed, including those by small- and medium-sized enterprises. The semiconductor industry is expected to serve as a catalyst for the revitalization of many of Japan's industries. Moreover, since semiconductor production facilities are often built in regional areas, they contribute to the regional revitalization promoted by the administration of Prime Minister Shigeru Ishiba.

Minister of Economy, Trade and Industry Yoshiharu Muto holds a news conference after visiting a construction site of Rapidus Corp. in Chitose, Hokkaido, on Oct. 24. JIJI

Therefore, the government has decided to implement a policy to induce investment with heightened predictability rather than use sequential policy input to develop the AI and semiconductor sectors. Specifically, it aims to support technology development and capital investment plans for AI and semiconductors over the next seven years until fiscal 2030, triggering over ¥50 trillion in public and private investment over the next 10 years, and to achieve an economic ripple effect of approximately ¥160 trillion associated with semiconductor production and other activities.

Since this requires enhancing the predictability of private-sector entities and ensuring necessary funding across multiple years, the government decided to provide over ¥10 trillion in public support through subsidies, commissions, financial assistance and legal measures under the AI and Semiconductor Industry Base Strengthening Framework. As part of this framework, we will develop domestic production bases and support research and development for advanced and next-generation semiconductors, consider legal measures needed to mass produce next-generation semiconductors, and submit draft legislation to the next ordinary Diet session.

Based on such a financial framework, we will continue to support research and development and funding procurement for mass production of next-generation chips, support design and development of application-specific integrated circuits, also known as ASICs, for the generative AI era, and support capital investment and research and development for advanced and conventional semiconductors and their components.

Japan's semiconductor policy is at a critical juncture. We will continue to make every effort to revive it and to subsequently promote and utilize the AI industry starting from there, strengthening the international competitiveness of the entire Japanese economy and ensuring economic security through the resilience of supply chains.

Japan's microchip reset an open invite to collaborate

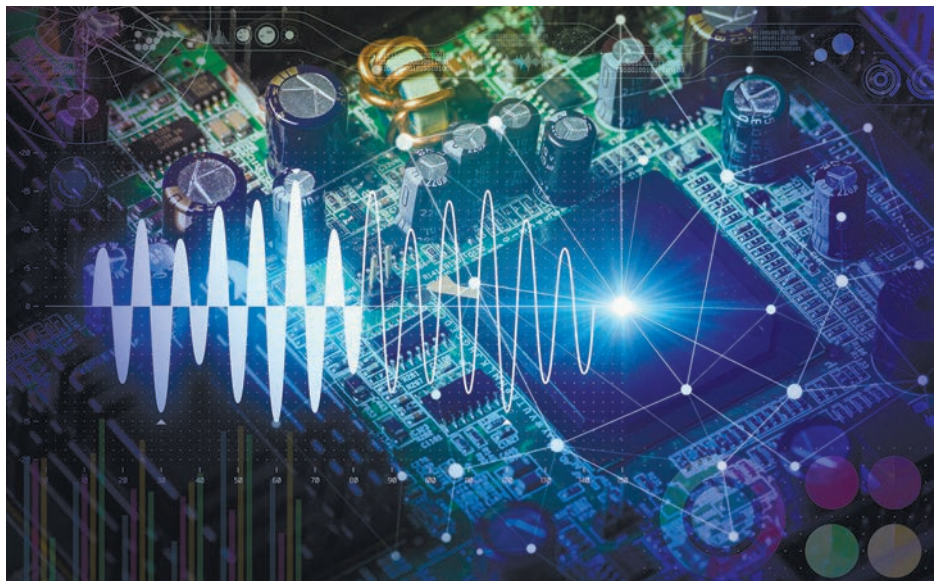
Joseph Bodenheimer
CEO, FOUNDER OF SHODAI VENTURES

Across the vast archipelago of Japan there is a trend that is clearly growing in scale and scope. This is the semiconductor and deep tech series of international exhibitions.

While Japan has had an impressive footprint in semiconductor design and manufacturing since the 1980s, the recent collaboration that ties government entities, private corporations and universities together underscores a massive national effort. Of course, these shows are also a core venue for thought leaders to exchange ideas in this new semiconductor ecosystem. This well-coordinated effort started during the pandemic, in May 2021 to be specific, when 100 members of the Diet came together as a working group to build a foundation designed to usher in a new age of semiconductor leadership. The group, led by the ruling party's then-Secretary-General Akira Amari, platformed ideas that became what we now know as the Strategy for Semiconductors and the Digital Industry. This government group, working hand in hand with the Ministry of Economy, Trade and Industry, has laid out a framework for Japan's next step in leadership into the ever-changing world of semiconductors and related technologies.

Thought leaders and ideas

The Semicon Japan 2024 exhibition to be held in Tokyo from Dec. 11 to 13, will bring together thought leaders in the manufacturing supply chain for the latest ideas and insights. This event will showcase new trends and innovations as the semiconductor industry drives advances in medicine, manufacturing, robotics and the Internet of Things. Speakers from the Japanese government, global private-sector firms and even universities will be presenting. It is worth noting that a cultural strength that Japan has always exhibited is educational investment in the future. These events have a component for high-school and college-level programs that involve students — very Japanese.



GETTY IMAGES

"In the semiconductor industry there are more and more Ph.D.'s or doctorate degree graduates from top universities who are attracted to the opportunities offered by corporations and startup positions in Japan," said Hiroshi Kawarada, a professor of Waseda University's Department of Nano Science and Engineering.

Japan and new alliances

While there are many new paths of success that are related to artificial intelligence, we must keep in mind that Japan has strong deep-tech roots in place across the country. Auto manufacturing and robotics firms are well placed from Honshu to Kyushu, many of them near major cities. In some areas of the country, there are semiconductor manufacturing facilities, extant for decades, right near auto assembly lines — a system that at this level is unique to Japan. And it is this unique strength in manufacturing that has attracted European and U.S. market leaders to work with Japan as the new supply chain takes form.

"Given that the 2020 pandemic disrupted and reshaped global supply chains, especially in the semiconductor industry, countries like Switzerland and Japan should definitely explore diverse forms of cooperation across all areas of research, including quantum science, artificial intelligence, robotics, materials science and space exploration," said Tom Clausen of IVP Global Capital. "However, this collaboration shouldn't be limited to research alone; it must also extend to practical applications, with a focus on driving innovation through partnerships between established companies and also carried out by dynamic startups powered by entrepreneurial energy."

Striving for leadership

As Japan moves toward a new age of technological leadership, it has become transparently obvious that as a nation, it sticks to its core strengths.

These strengths include basic materials, self-driving cars, robotics, image sensors and electric components. Combine Japan's core strengths with global collaboration and we clearly see new synergies appearing in the semiconductor space. Japan, Taiwan, the United States and Europe are building alliances and collaborating while each presents to the group very unique strengths.

"Semiconductor manufacturing is a global business and the partnership between Switzerland and Japan could benefit Japanese OEMs (original equipment manufacturers) significantly, especially in the metrology and inspection area," according to Hans Priem, vice president of business development at the VDL Enabling Technologies Group. "This Swiss-Japan coordination could benefit Japan, given the potential for enabling technologies that Swiss institutions possess."

While many of us know Japan's core strengths, events like Semicon Japan 2024 play an important role in showcasing and amplifying new discoveries from Japanese technology leaders. These events seem to grow in scale as the U.S., Europe and other countries in Asia recognize Japan's willingness to collaborate on, and in some cases, lead, the development of the next generation of semiconductors and related services.

KUMAMOTO UNIVERSITY

(Sponsored content)

School aims to support students, grow research

A future built on new facilities as well as ties with businesses and other schools both at home and abroad

Kumamoto University in Kyushu's Kumamoto Prefecture has a long history of providing talented human resources to and conducting joint research with semiconductor-related companies such as Sony Semiconductor Manufacturing Corp. and Tokyo Electron Ltd.

With the expansion of Taiwan Semiconductor Manufacturing Co. to Japan in fall 2021, demand for human resources in this field has been booming. In response, KU established a semiconductor research and education center in April 2022.

The center was developed into the current Research and Education Institute for Semiconductors and Informatics (REISI) in 2023. The organization is made up of a total of 42 researchers, 10 of whom are researchers in semiconductor-related fields that KU already had in various departments and were brought together to form the institute, along with new researchers that KU recruited from the University of Tokyo and other universities, companies and the National Institute of Advanced Industrial Science and Technology.

"The institute aims to support human resource development in the semiconductor field at all levels, from undergraduate to Ph.D., while advancing research in the field," said President Hisao Ogawa in a recent interview with The Japan Times.

This year, KU established the School of Informatics, offering the data science general course and data science semiconductor course, which provides basic knowledge ranging from semiconductor design, manufacturing processes and quality control to data science, artificial intelligence and other information sciences. Students are then trained to become engineers who can utilize their expertise to engage in quality control of each process of semiconductor device manufacturing and maximizing plant functions through optimization of the manufacturing process.

The School of Informatics is characterized by its diverse faculty. Faculty from various departments, including not only engineering, but also law and the School of Medicine, offer classes. To ensure student diversity, there are multiple options in the admissions process and efforts are made to increase the number of female students.

The Semiconductor Device Program in the Faculty of Engineering was also established this year. With a stronger focus on manufacturing, the program extracts semiconductor-related elements from various disciplines traditionally included in the engineering faculty.

"We aim to facilitate the use of various specialties, including materials engineering and mechanical engineering, in the manufacture of semiconductors," said Hiroshi Nakashima, a distinguished professor at REISI.

Kumamoto University President Hisao Ogawa

In 2025, a new department dedicated to the study of semiconductors and information mathematics will be established in the Graduate School of Science and Technology. The program's main purpose is to accept students who will graduate from the School of Informatics and the Semiconductor Device Program in four years with the intention of furthering their expertise. "But it was established earlier in light of the rapid shortage of semiconductor personnel so that we can start accepting students graduating from other undergraduate majors or from outside the university," Ogawa said.

"According to a report compiled by the Kyushu Bureau of Economy, Trade and Industry, the semiconductor industry is expected to face a shortage of 1,000 workers each year for the next 10 years," Nakashima said. KU thus aims to cultivate human resources engaged in chip manufacturing and quality control, as well as researchers and top engineers in the field. Collaboration between KU and the industry is also deepening.

"We have conducted joint research with Sony Semiconductor Solutions Corp. on the evaluation of image sensors in which the company has the largest global market share," Ogawa said. Since March this year, KU has entered a cooperation agreement with TSMC on research and human resource development. It also cooperates with Japan Advanced Semiconductor Manufacturing Corp., a subsidiary of TSMC.

KU has also maintained a close relationship with Kyushu Institute of Technology, a university strong in the front-end processing of semiconductor manufacturing. Meanwhile, KU excels at the back-end process after the wafers are made.

"The University of Tokyo established its branch at KU last year, and Tohoku University is expected to follow next year. We are also working with various universities and technical colleges in Kyushu to provide human resources for the industry. Otherwise, there's simply not enough," Ogawa said.

Students conduct experiments in a clean room at Kumamoto University's Research and Education Institute for Semiconductors and Informatics. KUMAMOTO UNIVERSITY

He also said that KU signed an agreement last year with four universities in Taiwan that are leaders in semiconductor research and human resource development. "We held a symposium on our campus in July this year to mark the beginning of our collaboration. Some joint research projects have already started, and we also plan to increase student exchanges between the universities," he said.

The university is constructing a new five-story research center, to be completed next year, to serve as a hub for open innovation. "Taking advantage of the regional characteristic of being home to many semiconductor-related companies, we will invite companies and other universities to the center and promote joint research, especially to advance three-dimensional integration of semiconductors," Ogawa said.

> 'The institute aims to support human resource development in the semiconductor field at all levels from undergraduate to Ph.D., while advancing research in the field.'

Three-dimensional integration is a new technology that allows different chips to be vertically stacked in one package and is expected to address the limit of semiconductor miniaturization.

To accelerate research in this area, KU, with the cooperation of the Kumamoto Prefectural Government, obtained a government subsidy in 2023 and established a consortium as part of this initiative.

"We are conducting a survey among the 130 or so companies that are members of the consortium to decide what kinds of machines to install in our research center to maximize the benefits for the members," Nakashima said.

"There are already nine ongoing collaborative research projects within the consortium, including some that are getting closer to commercialization," Ogawa said. One is led by Masahiro Aoyagi, a distinguished professor at KU, that involves through-silicon via technology used to electrically connect vertically stacked chips by drilling small holes in wafers and filling them with metal. "What we will achieve through this consortium will also benefit companies that use semiconductors, thus contributing to the growth of all industries that rely on semiconductors. The consortium also aims to create an ecosystem that combines research and business, which have existed separately until now," Ogawa said.

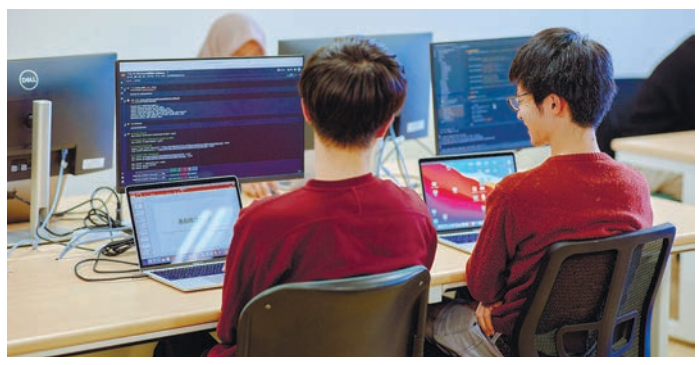
Research and Education Institute for Semiconductors and Informatics distinguished professor Hiroshi Nakashima

KU is also taking environmental impact into consideration. "Semiconductor manufacturing uses a large amount of groundwater. There is ongoing research by a professor in the Faculty of Science on the impact of semiconductor plants on groundwater and groundwater conservation based on data he has collected over the years," Ogawa said.

Both industry and academia have high expectations for KU's wide-ranging education and research activities aimed at not only advancing semiconductor technology, but also making it sustainable.

This page is sponsored by Kumamoto University.

The university's REISI facility boasts state-of-the-art technology. KUMAMOTO UNIVERSITY



Students can conduct cutting-edge research at the university's REISI facility. KUMAMOTO UNIVERSITY

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KYUSHU UNIVERSITY

(Sponsored content)

School broadens chip courses to diversify talent pool

New curricula focuses on future needs and university partnerships as pressure builds to corner microchip market

Kyushu University President Tatsuro Ishibashi

Kyushu University Senior Vice President Masaharu Shiratani

Kyushu University's effort in training human resources as well as conducting research and development in the field of semiconductors transcends academic boundaries and national borders.

The Japan Times interviewed President Tatsuro Ishibashi and Senior Vice President and Dean of the Institute for Advanced Study Masaharu Shiratani about the opportunities the university offers both students and the world of academia to accelerate innovations in microchip technologies.

Kyushu University's Education Center for Semiconductors and Value Creation, established in June, carries out research aimed at improving the performance of semiconductors and fosters talent that can create new value in this field. The center intends to train three different categories of people who can contribute to society through the development and use of these technologies from three standpoints.

"The three types of human resources are those who are specialists in the materials, design and manufacturing of semiconductors and integrated circuits, those who understand the semiconductors and integrated circuits required for social change, and those who can reflect this in the design and manufacture of future products," Ishibashi explained.

Shiratani noted that the conventional university education in Japan has taught students how to make chips and research these technologies from an engineering perspective.

"But what today's society expects from academia is to train people who can create new value and services using semiconductors in addition to fostering technological experts. The center aims to do exactly that," he said.

In other words, Japan's semiconductor industry lacks people with varied backgrounds, capabilities and expertise in other fields. "Such talents will be able to envisage how best to use chips, for example, in developing new businesses related to artificial intelligence and contribute to improving society," Shiratani said.

Thus, the center encourages humanities and social science majors as well as students from other universities and working adults to enroll. The center currently offers five undergraduate and six graduate classes. One class is attended by about 60 Kyushu U students and twice as many from other universities, on average. The working adults who participate include businesspeople, public officials and bankers who are facing a growing need for financing in the semiconductor sector.

The center also offers internship opportunities for students to gain hands-on experience that will prepare them for a career in the chip industry. In addition to internship programs provided by companies such as Taiwan Semiconductor Manufacturing Co., Micron Technology Inc. and Tokyo Electron Ltd., some students participate in a summer internship program at Rochester Institute of Technology in the United States, one of the world's leading universities in this field.

"Internship programs offered by Japanese companies are normally short-term but many of the programs we offer through the partnerships with companies and academia are long-term, lasting more than a month. This helps with the acquisition of practical skills. There is also a program exclusively for female students to promote diversity in the chip industry," Shiratani said.

The partnership agreement signed between Kyushu U and TSMC in April covers much more than human resources development. It promises a broad collaboration extending to scholarships and special lectures, as well as joint research.

Kyushu University has also been promoting partnerships with universities in Japan and abroad. "Kyushu Okinawa Open University, composed of 11 national universities in the Kyushu and Okinawa regions, was launched in March 2023 to cooperate on improving the research skills of researchers and students, sharing facilities and equipment and so on," Ishibashi said.

KOOU signed an agreement in April with the University Academic Alliance in Taiwan, a platform of 12 universities, to promote international collaboration in fields including engineering, life sciences, humanities and social sciences.

One field in which these partnerships are expected to create positive effects is semiconductors.

"There are also further collaboration possibilities with individual universities within the networks. For example, our university and National Yang Ming Chiao Tung University in Taiwan, one of the universities that belong to the UAAT, signed an agreement in June to establish a joint laboratory in both campuses and have already started the exchange of human resources and joint research," Ishibashi said.

> 'It makes sense for Japan's human resources to build relationships abroad for future potential partnership.'

Shiratani explained that today's semiconductor industry cannot depend on or be dominated by just one country. Even major players in the market are not entirely self-sustainable because they need to procure materials and equipment from other countries to make their technologies work. "It makes sense for Japan's human resources to build relationships abroad for future potential partnership," he said.

Kyushu University is also strengthening ties with the industry by addressing the urgent need for the extreme ultraviolet light irradiation and analysis services that are indispensable for advanced semiconductor manufacturing and the development of new materials. EUV Photon, a company funded 100% by the university, was established in July to serve this purpose.

"Japan is still strong in materials, holding approximately 50% of the market share for semiconductor materials, including a 90% share of photoresist. But Japanese companies rely on a research body in Europe for testing, which is mandatory prior to sales, which incurs the risk of technology outflows, expensive testing fees, and potential delays due to the high demands of testing," Shiratani explained.

Having domestic testing capability will greatly contribute to the security, competitiveness and speed of Japan-made technologies and products. However, it is not just about owning a testing facility. The data generated by the facility needs to be analyzed and evaluated with a high degree of expertise — something that the abundant talent pool of Kyushu University's faculty boasts.

Shiratani is confident that the semiconductor industry will continue growing at a high rate.

"Semiconductors are at the heart of new technologies that have brought about social change, such as smartphones and generative AI," Shiratani said, highlighting that semiconductors that used to be considered merely a component of electronic products have acquired a value that now endows humanity with new cultures and civilizations.

"We hope that more and more talented youths in Japan will participate in this field and make an impact on the world. That way, we can shape the new era when Japan can be the creator of new values and systems of society to share with the rest of the world," Shiratani said.

This page is sponsored by Kyushu University. This article was originally published in the Kyushu Semiconductor Special on Sept. 25.

Kyushu University's Ito Campus covers a vast expanse in the hills overlooking Hakata Bay off Fukuoka.

Kyushu U students walk past Shiiki Hall at the university's Ito Campus.

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TOYOHASHI UNIVERSITY OF TECHNOLOGY (Sponsored content)

Complete training in the basics of chip production

Aichi-based TUT boasts a full fabrication line that lets students design and manufacture large-scale integrated circuits

Founded in 1976 in Aichi Prefecture, Toyohashi University of Technology has been a home for research on integrated circuits, the foundational component for semiconductors, since 1979.

According to the university's charter, the mission of TUT is to "provide education and research in technological science and further technological innovation by exploring the science behind the technology."

In further pursuit of that mission, and to leverage the university's strengths in integrated circuit and semiconductor research, TUT in May 2023 reorganized one of its research bodies to establish the Institute for Research on Next-generation Semiconductor and Sensing Science, dubbed "IRES2."

The goal, according to IRES2 Director Kazuaki Sawada, was to create an interdisciplinary institution where researchers working on circuits and semiconductors, as well as researchers working in such areas as agriculture, mobility and life sciences, could operate under the same roof to facilitate cross-pollination between their respective fields of study.

According to TUT interim President Akihiro Wakahara, one way in which IRES2 stands apart from other domestic research institutions is that it is equipped with a complete fabrication line for producing large-scale integrated circuits and uses the results to create semiconductors, sensing devices and so forth.

Having this on-campus LSI factory means students and researchers can work under one roof at every stage of the integrated circuit fabrication process, including not only design and processing, but also installation and evaluation, Wakahara explained.

Additionally, with the facilities to accomplish all the work present on site — including the brainstorming on the designing and processing stages as well as installation and evaluation, "They can combine the semiconductors and sensors (that they have made) into a complete package themselves," rather than having to outsource their creations to a foundry, he said.

Sawada added: "There are several other university laboratories around Japan where they can produce transistors (for creating integrated circuits). However, one point that sets our institute apart from those institutions is that here we can make integrated circuits that have 10,000 to 100,000 transistors (LSIs). Of course, at the top level (in the commercial industry) they are making LSIs with 100 million or more, but we are the only university where 100,000-transistor circuits can be made and put to use as part of a system."

Toyohashi University of Technology interim President Akihiro Wakahara

Creating chip systems is one of the two reasons why IRES2 has such a factory on its premises in the first place. As an educational institution, it is crucial to provide opportunities to gain experience in creating systems such as semiconductors and sensor technologies that will nurture the human resources needed to further development in those areas, Sawada said.

However, the chip factory's other purpose is to provide the opportunity to create actual semiconductor packages. Sawada, who also serves as leader of the Research Department's Actuation and Sensing Group, offers his own work as an example.

"The institute is a laboratory that is capable of fusion research and cross-disciplinary research and development," he said.

His team focuses on combining their ever-more-refined integrated circuits with sensors, and thanks to the IRES2 facilities they can manifest their findings into an actual "proof of concept" end product. Put another way, he said they can not only discover the fundamental technological "seeds," but also use them to develop systems that fulfill the "needs" as well.

Fulfilling such needs is the raison d'etre for IRES2's interdisciplinary makeup. In addition to the LSI factory, IRES2 comprises two other departments. These are the Advanced Technology Research Division, which develops cutting-edge research areas, and the Social Application and Development Department, which works up applications both for the research and the factory's output.

The Advanced Technology Research Division includes four fields. These are innovative sensing technology creation, innovative sensing technology development, advanced environmental sensing and advanced life science.

The Social Application and Development Department, meanwhile, covers the fields of next-generation mobility society, safety and security technology, advanced agritech and human-robot symbiosis. In all of these fields, the aim is to promote collaborative, interdisciplinary research that makes use of the sensor technologies being created by the students.

The IRES2 facility offers hands-on chip design. TOYOHASHI UNIVERSITY OF TECHNOLOGY

Examples of projects being pursued in these departments include work being done in the Actuation and Sensing Group to develop a sensor capable of detecting some 400 scents — on par with the human nose, Sawada said — that could potentially have safety applications. Additionally, experiments being carried out in the Life Science Laboratory are looking to improve our understanding of the neural basis of sensory-driven behaviors. A project in the Future Mobility and Society Group would apply new sensor and sensing technologies to help researchers and companies plan and develop secure and safe transportation systems for the future.

> 'We are the only university where 100,000-transistor circuits can be made and put to use as part of a system.'

"Other universities around Japan may teach students how to make integrated circuits, semiconductors and so forth, but their students do not have the chance to put what they learned into practice," Wakahara said, referring to IRES2's LSI factory. An additional benefit to Toyohashi students, he said, is that when they graduate and go out into the workforce, they can tell potential employers that they already have firsthand experience with the integrated circuit fabrication process and actual use of the production equipment.

IRES2 has also welcomed students from abroad for training, Sawada said. Hailing from countries such as Malaysia and South Korea, students come primarily to learn how to make semiconductors and take that experience and knowledge back to their home countries. But international interest in TUT's offerings is not just limited to Asia. Sawada explained that a new program will be launched with the European Union that will promote exchanges of university students that will allow them to earn credits. The program will also include internships at Japanese companies and research institutions.

IRES2 Director Kazuaki Sawada

Furthermore, Japanese companies and the Japanese subsidiaries of foreign companies have also sent employees to receive training at IRES2. According to Wakahara, some 177 companies thus far have had their employees come to the institute to, for example, gain experience working on the fabrication line in the LSI factory.

"Here, we can create the 'seeds' of new technologies, and then work with companies to help them develop new products," Sawada said. "Sensors could, for example, be combined with artificial intelligence to better analyze human health or environmental conditions."

The hope, he added, is that through the fruits of the research performed and the training received at IRES2, researchers and students will be able to utilize both digital and analog semiconductors and sensors to innovate new technologies that can make our society healthier, safer and more sustainable for future generations.

This page is sponsored by Toyohashi University of Technology.

Researchers can prototype fusion devices with materials such as compound semiconductors, silicon and carbon nanomaterials in a clean room at the IRES2 facility. TOYOHASHI UNIVERSITY OF TECHNOLOGY

Toyohashi University of Technology operates on a modern campus in Aichi Prefecture. TOYOHASHI UNIVERSITY OF TECHNOLOGY

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WASEDA UNIVERSITY

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Top-tier school revamps outlook for global impact

New facilities, courses and study abroad in focus as university gears up for 150th anniversary

With its 150th anniversary on the horizon, the Waseda University mission statement issued on its 30th anniversary by founder Okuma Shigenobu looms over everything the university does as the institution looks toward the future, said President Aiji Tanaka.

"In his 1913 statement, Okuma urged that independence of scholarship be preserved, and that the research undertaken will make some social contribution. He also urged (students and scholars) not to stop at being satisfied with the results of their research, but to also find practical uses for it," Tanaka said. Okuma's ultimate goal, he explained, was to encourage Waseda to produce "model citizens" who can make contributions to better conditions around the world.

This thinking has provided a framework for the efforts Waseda is pursuing guided by the basic question of, "What kind of university should Waseda be after 2032?" Hence, Tanaka said, the emphasis is not just on education and research, but also on thinking carefully about how Waseda can contribute to society.

Centers to coordinate global impact

Founded in 1882, Waseda — then known as Tokyo Senmon Gakko (Tokyo Vocational School) — has grown from an institution with 80 students and three departments to one with more than 47,000 students studying in 13 undergraduate and 20 graduate schools.

Waseda is also Japan's top university for sending students abroad, and similarly has long welcomed large numbers of foreign students and scholars to its campuses around Tokyo and elsewhere. Accordingly, with becoming a "Waseda that shines on the global stage" by 2050 presenting an underlying theme for the university's 150th anniversary projects, internationalization has been a particular emphasis.

Toward that end, Tanaka said, rather than creating new departments or programs, Waseda has for some time now been reassessing its existing offerings and reorganizing them into three new centers to reflect these long-term goals. The university opened its Global Education Center in 2013, and followed it this past April with its Global Research Center.

The buildings were completed with the opening in April of the Global Citizenship Center. The GCC's purpose, said Tanaka, is to provide coordinated systemic support to, for example, student volunteer activities, such as by offering courses on leadership. The goal here, he said, is for Waseda to provide an "international interface" for facilitating students' and scholars' activities overseas and bringing their foreign counterparts to Waseda. Moreover, in the future, he said, Waseda hopes to provide the opportunity for all its undergraduates to spend at least part — if not all — of one year studying abroad.

Waseda University President Aiji Tanaka
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> 'In his 1913 statement, Okuma urged that independence of scholarship be preserved, and that the research undertaken will make some social contribution.'

Additionally, Tanaka added, Waseda already provides extensive educational opportunities in English, with a significant percentage of faculty able to provide instruction and conduct their own research in both Japanese and English. By way of example, nearly half of the teaching staff in Tanaka's own Faculty of Political Science and Economics obtained their doctorates at universities overseas and roughly 80% can teach in either language.

Crossing disciplinary boundaries

Waseda also continues to encourage interdisciplinary research, Tanaka said, especially work that combines studies in engineering or natural sciences with studies in the humanities or social sciences. One goal, for example, is for students and scholars of engineering working on, say, robotics or climate science, to also acquire knowledge in another field that helps them to understand the social implications of their work. In the opposite direction, courses on data science for students in the humanities and social sciences are also available and have proven to be popular, Tanaka said.

An image of the new Building 9 that Waseda University plans to open in 2027 at its central campus in Shinjuku Ward.
WASEDA UNIVERSITY

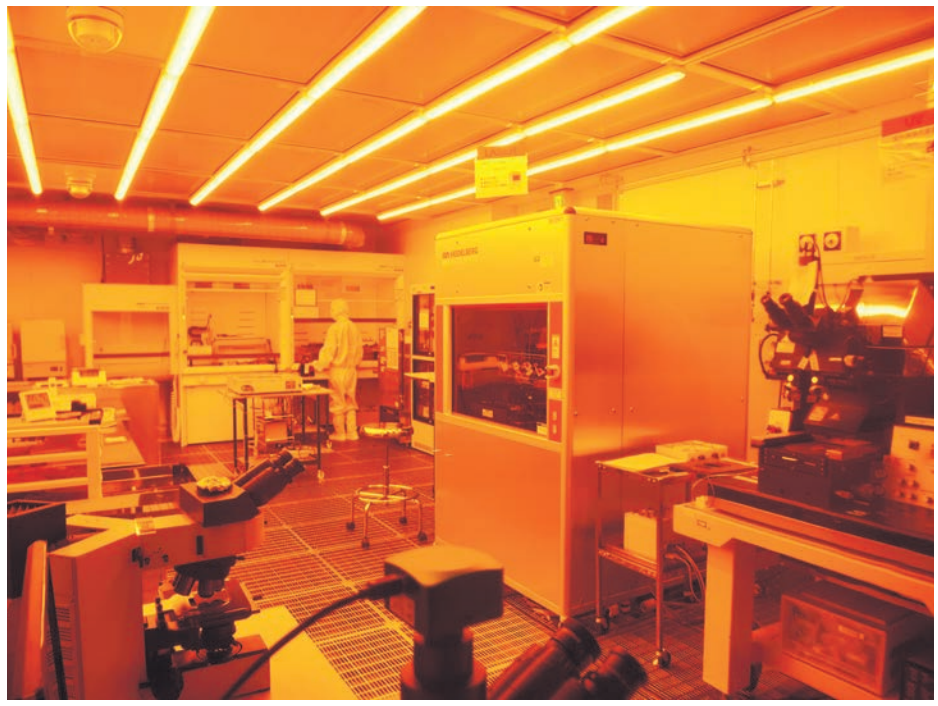
To further support such research, Waseda also needs to provide facilities that are equal to the task, Tanaka noted. One project with that aim is the renovation of the student learning center at the center of campus, which will be modified to include "learning commons." These spaces, he says, will have, for example, large screens onto which students and researchers can project their work in small group settings. The Wi-Fi network has also been extended to all buildings.

On a larger scale, he added, the university will build new facilities on its nearby Nishiwaseda Campus, which is home to departments in engineering and the sciences. Several buildings have been torn down and the new buildings, to be completed by November 2032, will contain up-to-date facilities and be designed to be more environmentally friendly.

Additionally, back on the Waseda Campus, the school is constructing a new Building 9. Its purpose, according to the university, is to create "an environment with state-of-the-art learning spaces and an area that promotes open innovation." It will serve as home to the Faculty of Education and Integrated Arts and Sciences, and is being designed with crossing disciplinary boundaries in mind.

Finally, Tanaka added, recalling Okuma's call for independence of scholarship, Waseda continues to encourage not only "top-down" research but also "bottom-up" research. He cites as examples the work being done on diamond-based power systems by professor Hiroshi Kawarada (see accompanying article) and an effort led by professor Takao Aoki to develop a gate-type quantum computer.

Left: Students mingle at a student lounge on the Waseda Campus. Right: Students study in a classroom on the Waseda Campus. WASEDA UNIVERSITY



Left: Devices for making diamond semiconductors are shown at the Hiroshi Kawarada Laboratory. Right: The clean room at the Nishiwaseda Campus ARK COMMUNICATIONS CO.

Diamonds open path to power-efficient microchips

Diamonds are commonly referred to as the hardest naturally occurring substance known to humankind. The chemical composition is extremely simple — carbon atoms, and nothing more. But the arrangement of those atoms in a particular lattice structure is what gives the substance its unique properties.

To date, silicon has been the primary raw material for making semiconductors owing to its stable structure. However, as professor Hiroshi Kawarada of the School of Fundamental Science and Engineering at Waseda University points out, diamond — whether natural or manmade — has the same structure as silicon but with superior electric properties.

"Diamond is an even better insulator," he said. "We can control thermal conductivity much better, making it ideal for semiconducting and superconducting applications," he said.

Easy to make

Diamond, along with carbon nanotubes, can be used to develop ultra-high-speed, high-power transistors, supersensitive nano biosensors and superconducting devices. As Kawarada explains it, this is because these materials have strong bonds and can withstand high electric fields and temperatures, while also having a high affinity for biomolecules and other substances.

"Heat dissipation in transistors is very, very important," Kawarada said. "Heat is generated when conducting electricity, and getting good thermal conductivity is difficult, so this makes diamond a very good material to use."

This characteristic, he argues, makes semiconductors with diamond-based circuits very useful for electric vehicle applications, where their ability to also tolerate high voltages gives them an added advantage. Moreover, the heat dissipation performance also would

Waseda University School of Fundamental Science and Engineering professor Hiroshi Kawarada
ARK COMMUNICATIONS CO.

make such semiconductors useful for graphics processing units. GPUs, he pointed out, are frequently used in the training of artificial intelligence models. They generate quite a lot of heat with the work they have to do, and so a diamond-based semiconductor could help to keep the heat under control.

Thanks to their thermal conductivity and insulating performance, diamond-based semiconductors can also have applications in the fields of personal computers and smartphones, he noted.

With respect to smartphones in particular, it is not just in the phones themselves but also in base stations through which signals are transmitted. Base stations need to withstand a wide range of environmental conditions, from hot temperatures in summer to cold in winter. Ideally, he explained, base stations should be installed in an air-conditioned space to keep them at a constant temperature, but this may be overlooked by some carriers due to the additional expense. Moreover, they also want base stations to be as small as possible. Given the heat generated within such small spaces and fluctuating temperatures in the external environment, diamond-based semiconductors again have an edge, Kawarada emphasized.

Tangentially, diamond also has an environmental benefit in terms of how it is made, Kawarada added. Diamond can be made by taking two greenhouse gases out of the atmosphere, methane and carbon dioxide. When the manufacturing process is complete, the result is diamond and the waste product is simple water. Compared with silicon, diamond is quite simple to make, he said. It is very good for semiconducting once it is combined with metals, and the result can be used to make semiconductors. The ease of this process has an educational benefit, he added, in that "it makes it very easy to teach to our advanced undergraduates how to make a transistor. It is very good to help our students learn how semiconducting devices work."

Into the future

These materials and the notion of diamond-based semiconductors are being further explored through a start-up venture Kawarada co-founded at Waseda in August 2022 — Power Diamond Systems. This start-up, which also maintains a research and development center in Kitakyushu, is a research-driven operation that aims to "realize the social implementation of diamond semiconductor power and high-frequency devices."

"It is true that there are two dozen other diamond-substrate companies like ours around the world, including at least two or three others here in Japan. One thing that I believe sets us apart is that we are working to make transistors that are based on substrates, and these transistors can then be used in other applications," he said.

> 'Heat is generated when conducting electricity and getting good thermal conductivity is difficult, so this makes diamond a very good material to use.'

PDS develops these prototype devices, but does not sell them by itself, he hastened to add, saying, "To actually develop and produce commercial devices ourselves would take a lot more time, and require more resources." PDS is focused on doing the kind of exploratory research and development work that a major company might want to do, but perhaps does not have the time or expert staff. The most important potential application for the transistors that PDS is working on is power electronics, he explained.

Traditionally, silicon carbide has been used for high-voltage power devices, such as the inverters that control electric vehicle motors. What is needed, he said, are transistors that can carry high voltages and are very efficient, and PDS believes that diamond will take power devices to the next level.

These articles are sponsored by Waseda University.

The Nishiwaseda Campus, which is being renovated, will add three new buildings to house the School of Fundamental Science and Engineering as shown in this artist's image. WASEDA UNIVERSITY

The Nishiwaseda Campus is in Shinjuku Ward's Okubo district.
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YOKOHAMA NATIONAL UNIVERSITY

(Sponsored content)

Nurturing experts for chip, quantum tech future

YNU helps to promote interdisciplinary studies that integrate science and humanities to build well-rounded students

Yokohama National University is strengthening its focus on developing human resources in the fields of semiconductors and quantum technology. In line with that, the university aims to create an ecosystem with stakeholders from industry, academia and the government to leverage its strengths in science and technology, as well as its convenient location in the Tokyo metropolitan area.

In a recent interview with The Japan Times, YNU's president and two professors spoke about their efforts and goals in those high-tech fields.

As there is a shortage of specialists in both fields, YNU President Izuru Umehara said there is an urgent need to train skilled personnel.

According to a report published by the Japan Electronics and Information Technology Industries Association last year, there will be a shortage of more than 40,000 workers in the semiconductor industry in the next decade, and 12,000 of those will be needed in the Kanto region.

This is also why YNU has been focusing on enrichment of related curricula in the College of Engineering Science. YNU also established the Interfaculty Graduate School of Innovative and Practical Studies, which aims to nurture interdisciplinary perspectives that integrate humanities and science. The IFGS links the university's four graduate schools of international social sciences; urban innovation; environment and information sciences; and engineering science. Its purpose is to offer a framework that allows students with nonscience and nonengineering backgrounds to study semiconductor-related fields.

The university has also established the Semiconductor and Quantum Integrated Electronics Research Center as one of the five academic centers under the Institute for Multidisciplinary Sciences. The other four are the Center for Creation of Symbiosis Society with Risk; the Typhoon Science and Technology Research Center; the Research Center for Sustainability, Resilience and Well-being; and the Research Center for Next-Generation Health Technology. The SQIE serves as a base for interdisciplinary collaborations among researchers of diverse fields to accelerate research and social implementation of the technologies.

"These fields need to be studied not just for the sake of advancement in research, but for the swift implementation in society, which requires knowledge of humanities," Umehara said.

Developing human resources

Fumihiro Inoue, vice director of SQIE, has been playing a central role in bringing about these changes in YNU to accelerate the advancement of the university's semiconductor sector.

Tomoyuki Horikiri, head of the Quantum Internet Laboratory at the Semiconductor and Quantum Integrated Electronics Research Center
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tion for the past few years. He has engaged in research and development of the 3D packaging process of semiconductor manufacturing for about 10 years at the Interuniversity Microelectronics Centre (IMEC), an internationally acclaimed research and development hub for nanoelectronics in Belgium. The back-end process involves the interconnection, packaging and testing of semiconductors after each chip is manufactured. Upon receiving an offer from the university, Inoue, who had a strong sense of mission to nurture semiconductor-related human resources in Japan to strengthen the country, returned to Japan in 2021.

> Quantum technology is still in a much earlier stage than semiconductors. ... More time is needed before it is implemented.'

Tomoyuki Horikiri, head of the Quantum Internet Laboratory at SQIE and former researcher at the Japan Society for the Promotion of Science, the National Institute of Informatics and Stanford University, leads education and research in the field of quantum technology.

How did researchers from two different fields end up at the same research center? Umehara said that quantum computing technology requires various kinds of integrated circuits that are essentially semiconductors.

"For the future of both fields, it makes sense to put these together. Universities must try to solve urgent issues, but they also need to make decisions based on the imagination of what society will be like several decades from now," he said.

"In the context of quantum information and quantum communication, it is important to learn various concepts of semiconductors, including chiplet technology," Horikiri said. Chiplets are small chips with diverse functions designed to be assembled on an interposer. He explained that quantum technology shares the same challenge with the field of semiconductors when it comes to social implementation, which is the continuous pursuit of more efficient integration technology.

YNU President Izuru Umehara
ARK COMMUNICATIONS CO.

Inoue said the limits of chip miniaturization are already becoming apparent, which is why the importance of advancing the packaging process has been increasing because it offers alternative solutions to achieve desired chip sizes, speeds and functions. "But there are also limits to what the packaging process can do," he said, explaining that the research of quantum computing is important in improving speed even if chips themselves stop evolving.

Major hub in Kanto

With those new curricula and institutes in place, Inoue said he wants to make YNU a major hub for semiconductor workforce development and 3D packaging research in the Kanto region. There are many chip-related companies in Yokohama, the capital of Kanagawa Prefecture. For example, Ulvac, a former vacuum device maker now operating in the semiconductor sector, is in Chigasaki. Samsung meanwhile has established a new research institute dedicated to packaging processes in Minato Mirai, Yokohama's coastal district. And semiconductor material company Resonac has a similar research center in Kawasaki.

"This is a welcome trend and as a national university in the area, we have every reason to support them," Inoue said.

But he also pointed out the problem of corporate research centers working individually.

"The key to the success of IMEC was its concept of open innovation. It is clear that there are limits to what one company can do independently; we need an ecosystem composed of multiple stakeholders to bring about innovations," he said, emphasizing that such an ecosystem should be led by a university that can be a fair and neutral party whose interests are dedicated to society.

Some of the ongoing joint research projects already involve multiple companies that are among the 70 members of the 3D Heterogeneous Integration Alliance, a consortium headed by Inoue that aims to revitalize the semiconductor industry.

Fumihiro Inoue, vice director of the Semiconductor and Quantum Integrated Electronics Research Center
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Various collaborations are also taking place in the field of quantum technology, including quantum computers and quantum communication, which the government is starting to push. Horikiri said it is indispensable to engage various companies to accelerate research, development and experiments. That is why Lquom Inc. was founded in 2020 with support from the university to develop quantum communication systems and other related technologies. Horikiri, a founding member of the company, said Lquom has made it easier and faster to collaborate with other companies.

> 'Universities have to try to solve urgent issues, but they also need to make decisions based on what the future will be like.'

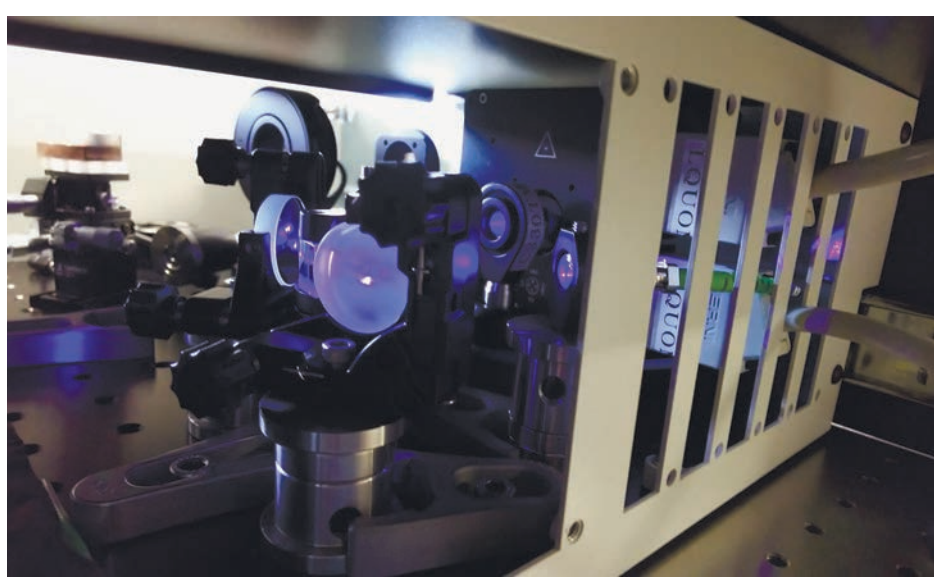
The company is also contributing to the development of human resources in the field. In the 2010s, quantum researchers received little public funding due to shrinking expectations, Horikiri explained. This led to a dearth of young specialists who would have been playing leading roles in the field today.

Lquom is promoting the full-time employment of doctoral students and providing an environment where they can build their careers while engaging in research and development. The CEO is a YNU alumnus who completed a doctorate in 2022.

Umehara said YNU graduates at Lquom are equipped with not only technical knowledge, but also entrepreneurship. "Now that we have a place for both business and research, I believe that more students will choose to proceed to doctoral courses," he said.

Behind the idea of fostering motivated young researchers was what happened 10 years ago between Umehara, who was a professor at the time, and Horikiri, who was a

Continued on page B19 →



Left: The Institute of Advanced Sciences houses YNU's Semiconductor and Quantum Integrated Electronics Research Center. Right: The interior of Lquom, a startup that was born at the university's Horikiri Laboratory.
YOKOHAMA NATIONAL UNIVERSITY

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Students prepare for a presentation at Yokohama National University's Tokiwadai Campus. YOKOHAMA NATIONAL UNIVERSITY

→ ***Continued from page B18***

young and talented researcher. "He gave me his own laboratory," Horikiri said.

"It was a 100-square-meter laboratory. I was confident that he would be a leading researcher of quantum technologies in Japan," Umehara said.

Horikiri recalled that this was a turning point for him, and that recognizing and fostering young researchers and creating an environment where they can maximize their abilities has always been one of his most important missions ever since.

Support from other sectors

In recent years, the business community has been showing interest in Lquom as well as how YNU is linking the fields of quantum computers with semiconductor technologies to promote their mutual growth.

For example, Macnica, a Yokohama-based semiconductor company, is an investor in Lquom. "This is a sign that there are companies that see the future supported by the deeper connection between quantum technologies and semiconductors," Horikiri said.

Public support and funding for quantum research that almost died out a decade ago is also coming back. Currently, Lquom is subsidized by the governmental New Energy and Industrial Technology Development Organization under the Deep-Tech Startups Support Program.

"The field of quantum technology is still in a much earlier stage than the semiconductor field, where we need to improve the performance of each element. More time is needed before it is implemented in society. That is why I think there is a possibility for Japan to lead the world in this field if we focus on it now," Horikiri said.

The next phase will involve international collaboration. Horikiri touched on the importance of field experiments in areas where fibers are installed. "There are experimental sites in various parts of the world, and we are starting to communicate with players near those sites, which are mainly in Europe," he said.

In semiconductors, YNU is preparing to sign a dual degree agreement with KU Leuven in Belgium. KU Leuven, a university with a history of almost six centuries, has a close relationship with IMEC, which is in the same city. Currently, two students who belong to Inoue's lab are staying at IMEC through a study abroad program called Tobitate provided by the education ministry.

"We are aiming to further enhance such international collaborations in the future," Inoue said.

This article is sponsored by Yokohama National University.

Students listen to a presentation on computer frameworks at the Tokiwadai Campus. YOKOHAMA NATIONAL UNIVERSITY

Above: The sign at the main gate of Yokohama National University, which occupies one of the city's largest and greenest tracts of land at the Tokiwadai Campus (left). YOKOHAMA NATIONAL UNIVERSITY

Yokohama National University

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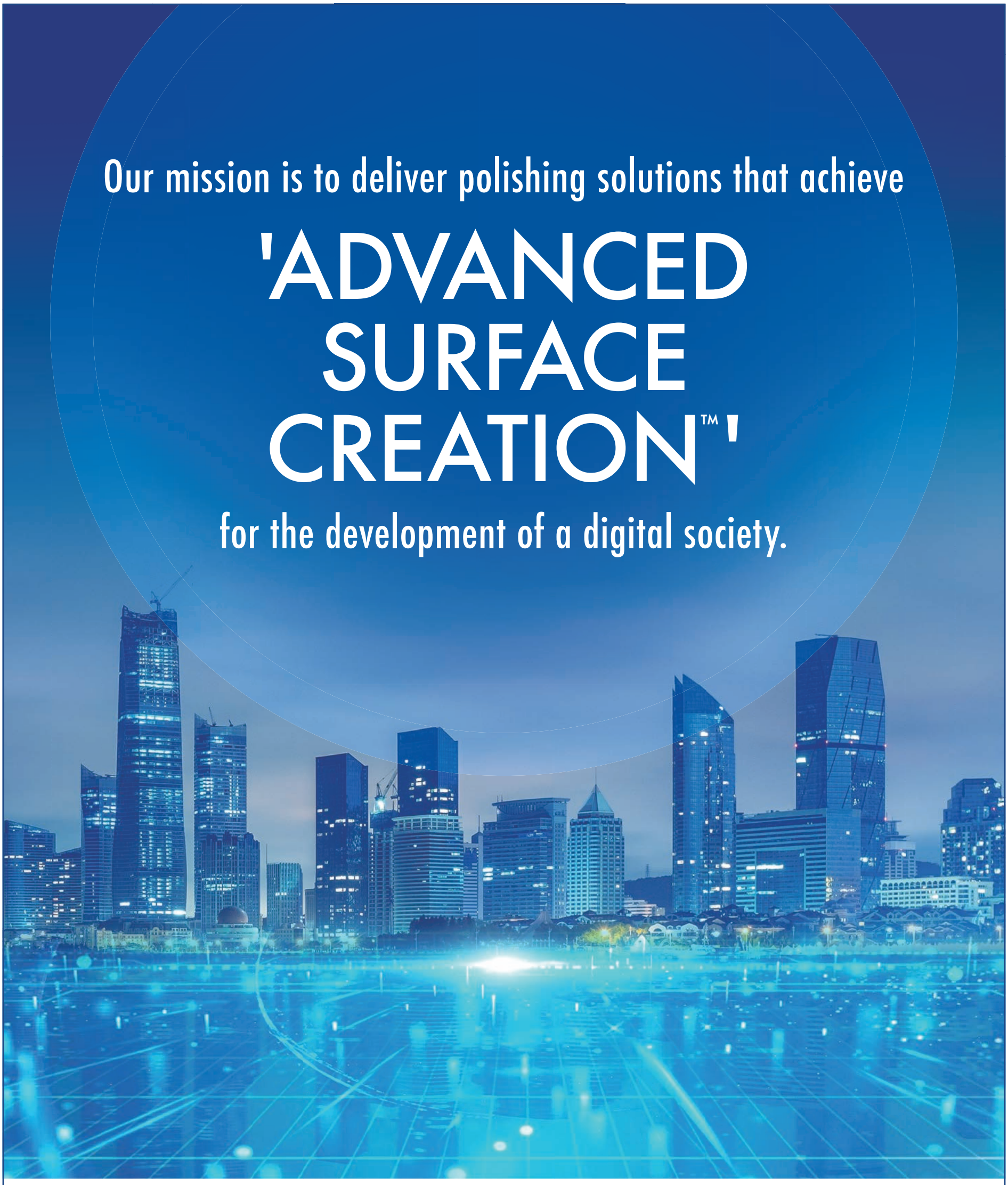

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