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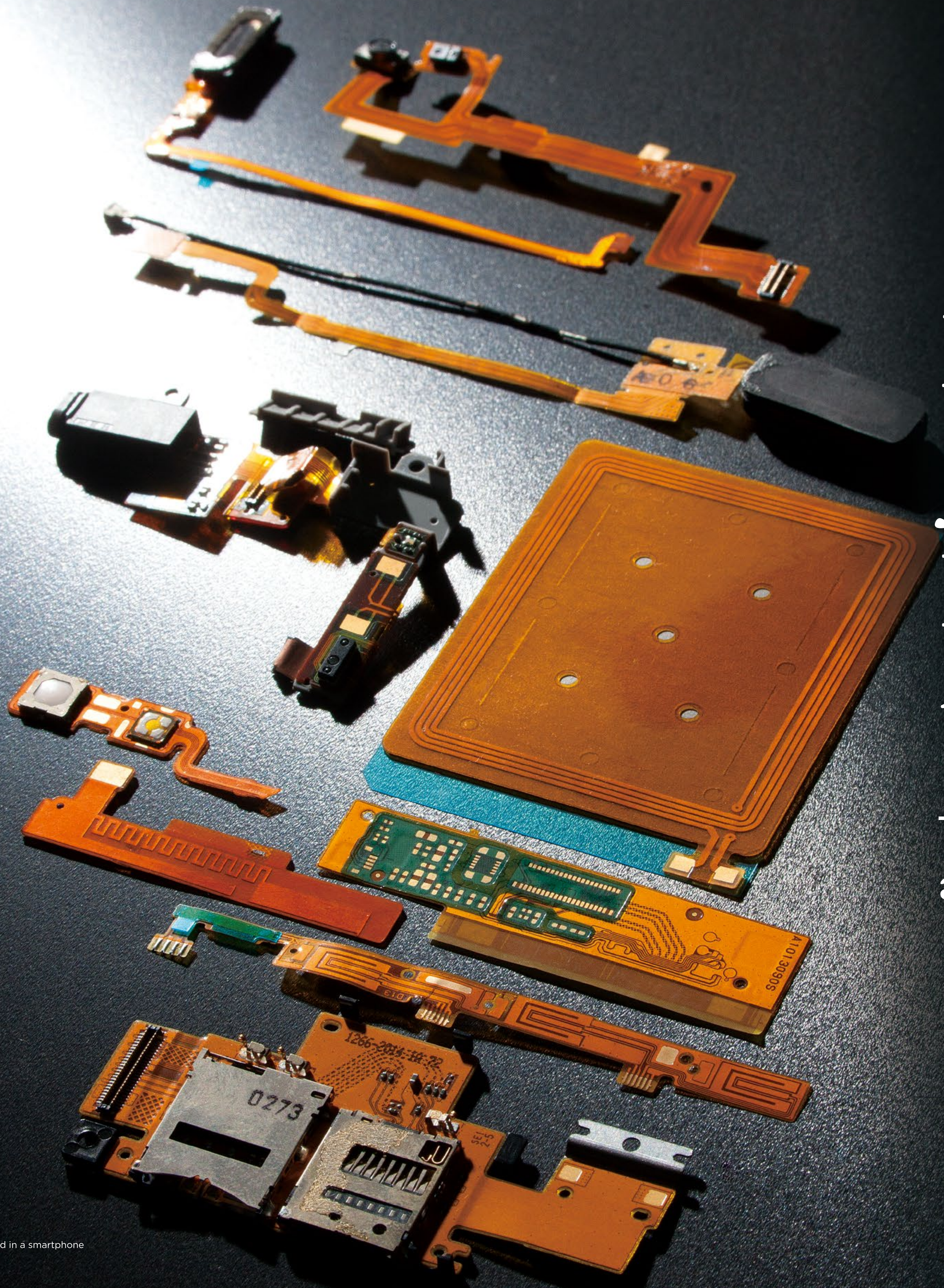
Innovative Development, Imagination for the Dream, Identity & Diversity

Feature

Half-Century History of FPCs

Ultra-Fine Circuits and Material Technologies Creating the Future

SUMITOMO ELECTRIC GROUP



FPC products used in a smartphone

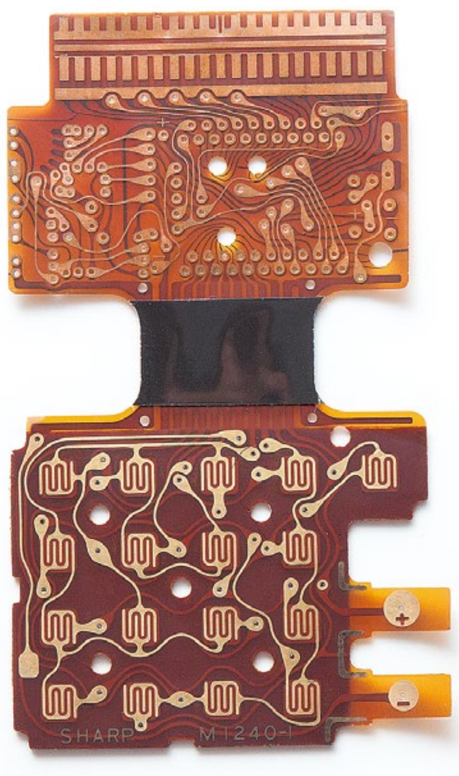
FPCs Supporting Japan's Electronics Industry Behind the Scenes

– Meeting the Needs of the Times and Looking Ahead to the Future –

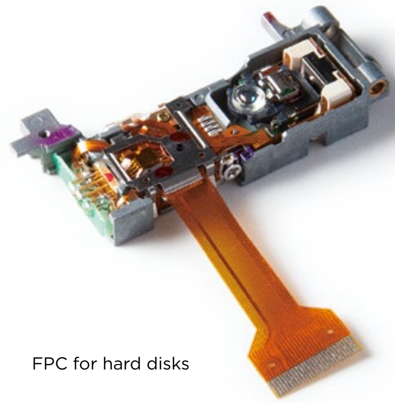
As the name implies, a flexible printed circuit (FPC*) is a flexible circuit wiring material that can be freely bent and deformed. Its characteristics of lightness, thinness, and flexibility have greatly contributed to the development of smaller, lighter, and thinner electronic devices. Since FPCs have excellent heat resistance, it is possible to mount electronic components on them by reflow soldering, and due to their resistance to repeated bending, they are an indispensable wiring material for the moving parts of electronic equipment. FPCs also contribute to increasing design flexibility and functionality because they occupy less space inside the device. Taking advantage of these features, FPCs are used for a broad range of applications, such as wiring in smartphones and digital cameras, as well as wiring for the moving parts of optical drives. FPCs are one of the key products that have been supporting the evolution of electronic devices and the growth of the Japanese economy.

The Sumitomo Electric Group began research and development of FPCs in the mid-1960s ahead of other companies in Japan, and started its FPC business in 1969. Since then, the group has been providing products that meet the market needs of the times, and in the 2000s, in response to the need for lighter, thinner, shorter, smaller, and more sophisticated electronic devices, it developed fine pitch FPCs, or ultra-fine circuits, which accelerated the evolution of FPCs. And now, the FPC business is at another major turning point: the shift from wiring materials to functional parts. Now, more than half a century after the start of the business, the Sumitomo Electric Group has started to develop a new generation of FPCs.

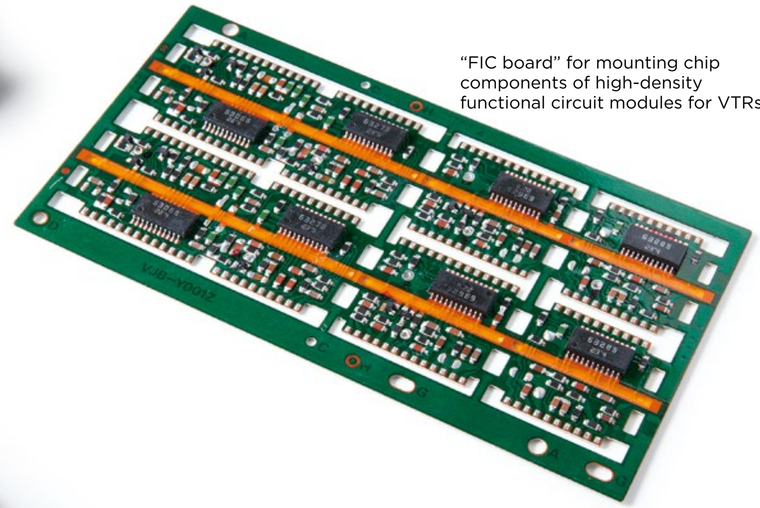
* A wiring material made by forming electric circuits of copper foil on an ultra-thin insulating film



FPC for folding calculators



FPC for hard disks



"FIC board" for mounting chip components of high-density functional circuit modules for VTRs

FPC for folding mobile phones

Challenge to Develop Japan's First FPC

– Half-Century History of Sumitomo Electric's Efforts and Achievements –

Starting from scratch without any guide

The development of FPCs began in the early 1960s in the United States as a wiring material to reduce the weight and size of mainly aerospace equipment. In 1965, the Sumitomo Electric Group began research on tape wires as a new equipment wiring material, and also started research on FPCs earlier than other companies to explore the FPC's potential as the ultimate form of wiring. However, at that time, there was little reference literature or written technical information, so they had to start basic research from scratch without any guide.

At the dawn of the FPC business, Ken Okazaki, who belonged to the Parts and Materials Development Office of the Osaka Research Department, was assigned to the FPC development team. When he joined the company, he devoted himself to the research and development of fluororesins because he wanted to do something new. His efforts resulted in Sumiflon® coating, which was widely adopted for cooking appliances. Okazaki started research and development of FPCs several years after the start of the FPC business, and at that time, FPCs were far from commercialization although a measuring instrument manufacturer adopted some products.

"I thought it was an interesting technology, but I didn't know what application was possible. At the same time, FPCs require customized design, so I was also worried whether it could fit our company's business style or not," says Okazaki.

Okazaki had an idea when he participated in a training program held in the United States. "In fact, Japan is leading the development of transistors and ICs (integrated circuits) for consumer use, which were developed in the United States. FPCs may be able to open up a similar path." As an engineer, Okazaki had realized a growing need for "lighter, thinner, shorter, and smaller" electronic equipment. After repeated prototyping, FPCs began to be used in the flat keys of calculators, and then they were mass-produced as a monolithic circuit board for folding calculators. This was the first turning point for their FPC business and an opportunity for FPCs to attract the attention of society. This was in the middle of 1975.

Accumulated know-how is the greatest strength

After that, full-scale market development began. The use of FPCs in cameras, CB radio transceivers, car stereos, and other equipment rapidly increased, and Sumitomo Electric succeeded in receiving an exclusive order for FPCs for car phones, of which service started in 1979. Furthermore, the advent of the "era of disks" such as CDs and floppy disks increased the presence of FPCs. Then, the base of the FPC business was moved to the Nagoya Works from the research building of the Osaka Works, which became too small due to the expansion of the relevant organization, and orders increased steadily thereafter. Another major factor for the increase in sales was the development and mass production of FIC boards,* which were launched in 1982 as FPCs for portable VTRs. FIC boards were adopted by major home appliance manufacturers, which solidified the presence of the Sumitomo Electric Group in the industry.

"If we had any advantage over our competitors, it was our 'history of failure.' We had accumulated knowledge and know-how of FPCs through repeated failures in prototyping. So, when we faced a problem, we were able to quickly identify the cause and take appropriate measures. I think that helped to secure the trust of customers," says Okazaki.

In 1990, a production subsidiary, Sumiden Circuits, Inc. was established in Konan City, Shiga Prefecture. (In 2000, the head office of the subsidiary and the facilities of the FPC business in Nagoya were consolidated to Koka City, Shiga Prefecture, and the company name was changed to Sumitomo Electric Printed Circuits, Inc.) Amid a rapid increase in FPC demand, the advent of smartphones following mobile phones further boosted demand for FPCs as an indispensable component for them.

* FIC board: FPC with a metal stiffener

Sumitomo Electric's corporate culture behind its success in FPC business

While Okazaki launched the Sumitomo Electric Group's FPC business, the person who put it on track for growth was Toshihide Kimura. After joining the company, Kimura was assigned to the Parts and Materials Development Office and engaged in the development of FPC adhesives. He devoted himself to the development of FPCs with rigorous guidance from Okazaki, who was assigned to the same department. After that, he moved to Nagoya due to the expansion of the business organization and continued to be involved in the development and manufacture of FPCs there. In 1990, he moved to Shiga in line with the establishment of a production subsidiary there. He worked hard to stabilize the business while also working on technical development.

"Printed circuit demand fluctuates wildly. If a customer's products do not sell well, they will quickly stop placing orders. So, I always gathered the latest information from customers and made efforts to shorten the lead time to avoid having extra stock. I spent days of trial and error," says Kimura.

Thanks to these efforts, the FPC business finally began to generate stable profits. In 1996, the Flexible Printed Circuits Division was established, and Kimura was appointed division manager. Riding a wave at the time, FPCs were adopted for camera-equipped mobile phones and supplied to overseas mobile phone manufacturers, which contributed greatly to the growth of the business. Furthermore, Kimura looked overseas to establish the foundation of the business. Looking at lower labor costs and availability of a diligent workforce, he promoted the establishment of manufacturing bases in Shenzhen, China, as well as in the Philippines, laying the foundation for the current global supply chain.

We asked Kimura, who led the FPC business for a long time, about the most important factor for the success of the business.

Toshihide Kimura, Former Advisor, Sumitomo Electric Industries Co., Ltd.

Ken Okazaki, Former Deputy Manager, Electronic Wire Division, Sumitomo Electric Industries Co., Ltd.

Hideo Aramaki, Former Senior Assistant General Manager, Electronics Business Unit, Sumitomo Electric Industries Co., Ltd.

"Sumitomo Electric's corporate culture helped us a lot. When I suggested drawing up an ambitious plan, my supervisor said, 'Do it. I will support you,' instead of saying "No." If there had not been such an environment, the FPC business would have been closed at the time when it was unprofitable. I was really grateful for Sumitomo Electric's corporate culture," says Kimura.

Pursuit of the optimal production method and design

Hideo Aramaki was in charge of FPC production engineering for a long time as a subordinate of Okazaki and Kimura.

"There were various issues in each production process, and I worked hard to solve them every day. Since there were few manuals, I struggled to find solutions, such as how to properly control the adhesive that bonds copper foil and polyimide and how to stabilize dimensional changes in the etching and heating processes, pursuing the optimal FPC production method. An impressive job was the establishment of continuous screen-printing technology, which realized drastic cost reduction. The launch of a new factory in Shenzhen, China is also unforgettable. While feeling pressure and tension, we accomplished setting it up in a short period of time with the cooperation of related departments in the company," says Aramaki.

Tsutomu Muramoto joined the company one year after Aramaki. As a design engineer, Muramoto handled technical discussions and negotiations with customers.

"I was in charge of matching the design of our FPCs with the needs of customers by interviewing them about their applications while making them aware of the advantages of FPCs. The key was how I could design optimal FPCs for customers' products by taking advantages of FPCs' flexibility. The advent of mobile phones and smartphones was significant. At that time, I was thrilled to realize that our business was steadily growing," says Muramoto.

According to Okazaki, the members involved in the FPC business at that time were comrades and family members. They had an exceptional team spirit. We asked Okazaki, the founder of the Sumitomo Electric Group's FPC business, to talk about the past 50 years and the next 50 years.

"At first, I did not expect the business to grow to this extent. I would like to say to my juniors that they did well. However, I do not think the next 50 years will be an extension of the past 50 years. I hope that they will brush up their sensitivity to information, foresight, and creativity to develop a new world of FPCs," says Okazaki.

Kimura also sends cheers to his juniors.

"It's okay to fail. The important thing is what they get from the failure. So, failure is also very important. Even if they fail as a result of their bold efforts, they can make good use of the experience next time. I hope they will continue to challenge themselves without being afraid of failure," says Kimura.

Tsutomu Muramoto, Purchasing Group, Former Minakuchi Office, Sumitomo Electric Printed Circuits, Inc. (Photo taken when he belonged to the company)

Group photo with colleagues at the Osaka Works. Okazaki is the third from the right in the front row. Kimura has his arms folded in the middle of the back row.

Micron-level fine circuits "fine pitch FPCs"

Mobile phones have exploded in popularity since the 1990s, which spurred the adoption of FPCs. Meanwhile, FPCs were required to meet a new market need. This was "fine pitch," namely, fine circuits, or high-density circuits. A circuit pitch is usually indicated in the form of L/S (line and space). For example, in the 1980s, the L/S was about 100 µm/100 µm, which means a circuit width (line) of 100 µm and a circuit interval (space) of 100 µm (100 µm = 0.1 mm). Then, in the early 2000s, an L/S of 50 µm/50 µm was realized (50 µm = 0.05 mm). FPCs with such a fine pitch pattern were developed to meet the market need for more compact and functional electronic devices. Fine pitch FPCs were indispensable to realize thinner, lighter, and more functional electronic devices. However, there was no end to this need.

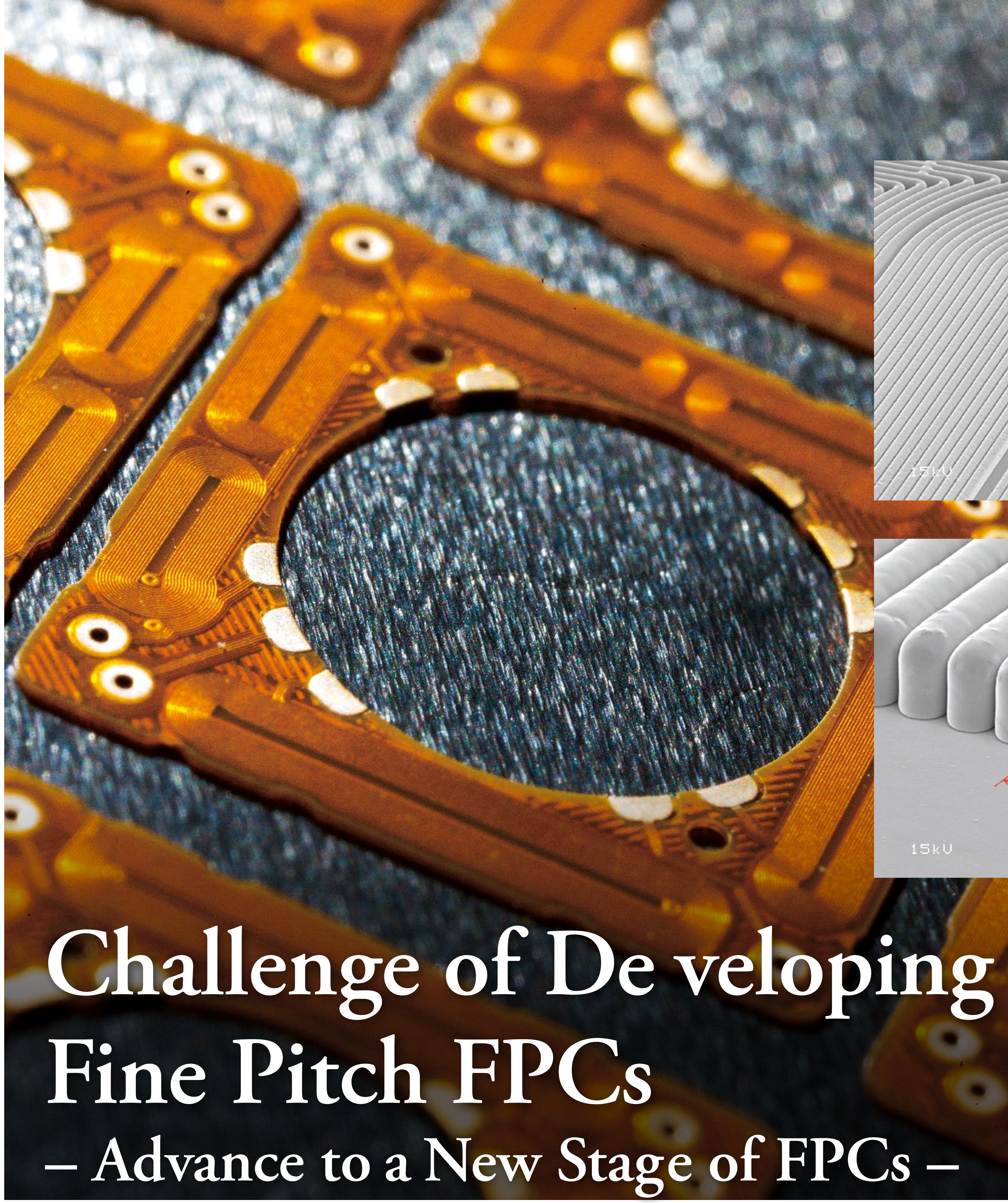
Shift from "copper etching method" to "copper plating method"

The market needed FPCs with finer pitch patterns, namely, ultrafine circuits. However, the conventional production method "copper etching," which uses photosensitivity phenomenon, had reached its limit. To overcome this challenge, the development staff started research on a new production method. As a result, the "copper plating method" has been developed. It is also known as the "semi-additive method" and is characterized by its use of electrolytic copper plating. Ko Noguchi was directly involved in this development. Noguchi had been involved in launching the mass production of fine pitch products as a member of the Engineering Department since joining the company, and he currently belongs to Sumitomo Electric U.S.A., Inc.

Ko Noguchi, Sumitomo Electric U.S.A., Inc.
(Photo taken when he belonged to the Engineering Department of Sumitomo Electric Printed Circuits, Inc.)

Shingo Ueda, First Sumiden Circuits, Inc.
(Photo taken when he was the General Manager of Technical Development Department, Flexible Printed Circuits Division, Sumitomo Electric Industries, Ltd.)

Challenge of Developing Fine Pitch FPCs
– Advance to a New Stage of FPCs –



Actuator coil used in a smartphone's built-in camera to prevent camera shake

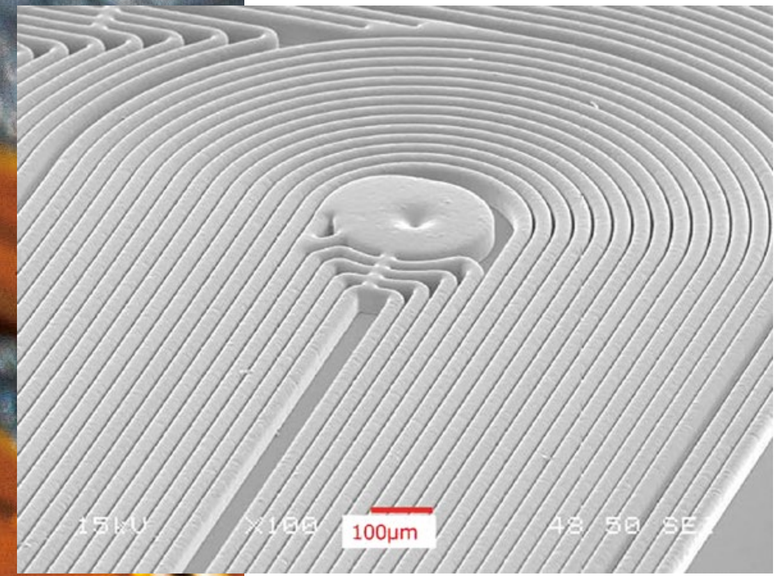
"The principle of this method is to build up a circuit pattern by electrolytic copper plating. Unless a substrate is plated evenly, the circuit pattern will not be built evenly either. Since consistency in the height of a circuit cross section must be ensured, it is necessary to accurately control the supply of ions, which determines the thickness of the plated layer. We gradually established a production method while finding the optimal conditions through trial and error," says Noguchi.

Use in actuators became a great turning point

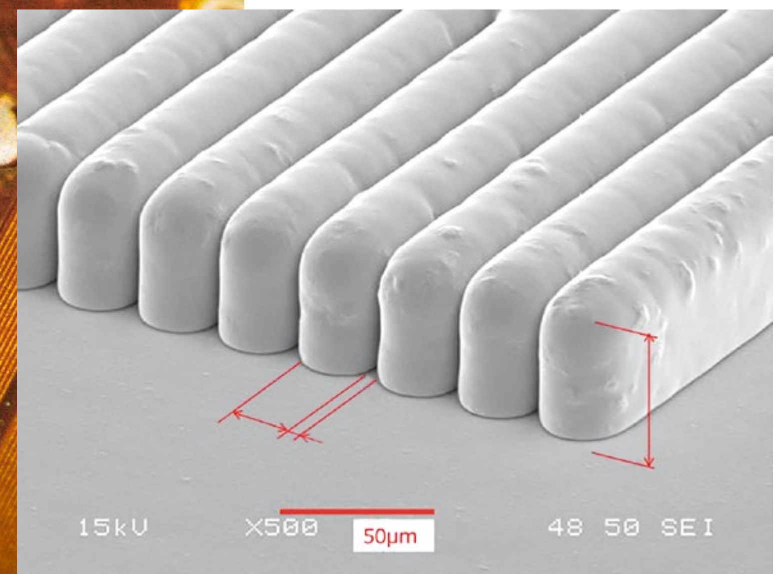
Currently, some competitors in Japan also adopt the semi-additive method, but at that time it was an innovative production method that paved the way for ultra-fine circuits. This method made it possible to break through the "wall of 50 µm" and realize 25 to 20 µm. It is no exaggeration to say that this is when the "era of fine pitch" began. Actuator coils for smartphones' built-in cameras, which were initially developed for hard disk applications, are still mass-produced even now in response to great market demand. The use of FPCs in camera actuators realized by the development of fine pitch technology became a great turning point for the role of FPCs. Shingo Ueda, an engineer who has worked on FPCs for about 30 years since joining the company, points out that it means FPCs' development from wiring materials into functional parts.

"We have conventionally provided FPCs as wiring materials, but their use in actuators has paved the way for them to develop into functional parts. The reason why FPCs became to be used in camera actuators is because fine pitch FPCs make it possible to form coils to generate magnetic force that act as the source of the camera shake prevention function. The purpose and role of FPCs have changed significantly from mere wiring materials," says Ueda.

In addition to the copper plating method, another new technology has been adopted to produce fine pitch FPCs. While the key technology is connection between double-sided conductor layers, which have been introduced to meet the need for more functional FPCs, they have developed an innovative interlayer connection method using nano-conductive paste, which also led to the development of an ultra-compact, thin wireless power supply module that can supply power to electronic devices without connecting a power cable.



Scanning electron microscope image of an actuator coil



Enlarged image of the circuit section

"My current mission is to research new electronic devices that can make use of the functions of these fine pitch FPCs and expand their applications. For example, taking advantage of their lightness, thinness, and compactness, we try to identify new uses ourselves, such as applications for wearable devices and medical devices," says Ueda.

Evolution of FPCs driven by Sumitomo Electric's comprehensive technologies

There are three FPC production bases in Japan and overseas, including Sumitomo Electric Printed Circuits, Inc., which is headquartered in Shiga Prefecture, but fine pitch products are produced only in Japan. Hiroshi Tatsuta, the president of the company, says that the reason is to secure their uniqueness.

"The production method of fine pitch FPCs is the product of various unique technologies and know-how. New 5G-compatible FPCs also use unique material technologies. If these products are produced globally, it is undeniable that other companies will follow or imitate. In order to secure and foster our unique and outstanding technologies, we produce new products only in Japan. These technologies have not been developed by our company alone but are the result of the combination of the comprehensive technologies of the Sumitomo Electric Group, and I believe that is one of the strengths of our FPCs," says Tatsuta.

The next chapter describes how Sumitomo Electric operates its global FPC production system.

Hiroshi Tatsuta, President of Sumitomo Electric Printed Circuits, Inc.

“Supply Sumitomo Electric FPCs to the World!”

– Future Strategy of Vietnam Factory Boasting the Largest Production –

Rigorous quality check performed by local employees

SEEV's integrated production system that can handle all the processes from the upper process to the lower process. Component mounting is one of their strengths.

Three production bases in Japan and overseas

The overseas production of FPCs started at a comparatively early time. In 1988, production started in Singapore, where a sales base had been established. In response to the growth of FPC demand, in 1994, consignment production by Songgang Electronics Wire Factory started in China, and in 1996, First Sumiden Circuits, Inc. (FSCT) was established in the Philippines as an FPC production company. In 2010, Sumitomo Electric Interconnect Products (Shenzhen) Ltd. (SEPG) was established in Shenzhen, China and took over production from Songgang Electronics Wire Factory. Furthermore, in 2012, SEI Electronic Components (Vietnam), Ltd. (SEEV) was established in Hanoi, Vietnam. Currently, the Sumitomo Electric Group has three FPC production bases: Sumitomo Electric Printed Circuits, Inc. in Koka City, Shiga Prefecture, which is positioned as the mother factory, FSCT in the Philippines, and SEEV in Hanoi, Vietnam. (Production at SEPG ended in April 2021.)

The roles of domestic and overseas production bases greatly differ from each other. Sumitomo Electric Printed Circuits, Inc. in Japan produces new products, including fine pitch FPCs, and also plays the role of a research and development center that works in cooperation with various sections within the Sumitomo Electric Group. On the other hand, overseas production bases are positioned as mass production bases that handle labor-intensive processes, such as processing and mounting. In recent years, FSCT is responsible for the final processing of fine pitch products (actuator coils for cameras) produced in Japan in addition to the production of conventional FPCs. So, how is SEEV in Vietnam, the Group's largest FPC production base, operated?

Production base of FPCs for smartphones

In Hanoi, the capital of Vietnam, SEEV is located in the Thang Long Industrial Park, which is about 20km from Hanoi Airport. More than 90% of its tenants are Japanese companies. In 2012, SEEV started to be fully involved in the FPC business, which was transferred from another company in the Sumitomo Group. Currently, it has five factories F1 to F5 on a site area of about 120,000 m^2 and employs about 6,800 people, making it the largest FPC production base in the Group. SEEV produces FPCs for cameras and displays built in smartphones, which are now favored by many users around the world. Kimihiko Ohara, who had been involved in the governance and management of the factories as Vice President since the establishment of SEEV and is currently the President of Sumitomo Electric Interconnect Products (Shanghai), Ltd., explains the characteristics of production at SEEV as follows.

“Characteristically, the intentions and ideas of smartphone manufacturers, namely our customers, have a considerable impact on our production system. For example, from 2015 to 2016, we made a large-scale investment to build an integrated production system that can handle all the processes from the upper process to the lower process and component mounting. It was a request from customers who want to ensure the quality and traceability of components. Since our products are used in smartphones, of which the production volume per model is large, customer's eyes on their quality are extremely severe. Therefore, ensuring and improving quality is a never-ending theme that we should always pursue. Quality is our strength and lifeline,” says Ohara.

Kimihiko Ohara, President of Sumitomo Electric Interconnect Products (Shanghai), Ltd.
(Photo taken when he was the Vice President of SEEV)

Pham Ngoc Hiep supervises production at the forefront as the general manager. He has been involved in the production of FPCs as an engineer for about 20 years. His mission is to ensure quality and on-time delivery and realize cost reduction, which are common objectives in manufacturing industries, based on the main premise of “safety first.”

Pham Ngoc Hiep, General Manager supervising SEEV's production

“The most important thing in ensuring quality is that individual employees observe the rules of the manufacturing site. To ensure that, we should not only ask them to observe the rules, but also should have them understand the purpose of the rules. We focus on training and OJT for this purpose. In addition, it is also important that individual employees set their goals and we create an environment that helps them achieve the goals as a team, regardless of whether they are related to quality, on-time delivery, or cost reduction. I think it is important to have them feel a sense of accomplishment and transform it to their motivation,” says Hiep.

Strategies to maintain presence

Currently, production at SEEV is going well, but there are many issues. One of them is that they cannot expect significant sales growth in the future due to the maturity of the smartphone market, which has grown explosively. Also, in order to continue the production of products for smartphones, which frequently upgrade their versions, it is necessary to meet requests from customers as much as possible, such as changing designs and quality plans as well as improving production facilities, while ensuring the high quality of the products. In response to our question about his future outlook, Katsumi Nanbu, who was appointed President of SEEV in 2018, says that SEEV needs to become a “strong factory.”

“We need to improve our manufacturing expertise to become a stronger factory. To that end, we need to appropriately and consistently manage SEQCDD (safety, environment, quality, cost, delivery, and development), which are used as fundamental indexes of Sumitomo Electric's management. To do this, human resources are important. We will implement human resource development programs, such as training and improvement of employees' motivation, at a high level. We are also considering automating part of our factory in order to address changes in necessary manpower due to seasonal fluctuations in the business. Although we cannot expect significant growth of production volume in the future, it is certain that smartphones themselves will continue to develop. We will demonstrate our unique technologies that support next-generation smartphones so that we can meet customer expectations and secure stable profits,” says Nanbu.

It is often pointed out that the FPC industry itself is leveling off. SEEV has established its mass production system for FPCs with a boost from increased demand for smartphones and its technological flexibility to meet customer needs. As the largest FPC production base in the Group, how will SEEV differentiate itself and develop? The company faces a crucial phase.

Katsumi Nanbu, President of SEEV

FPC Division's New Challenge toward the Future

– Shift from Wiring Materials to Functional Parts –

Tetsuro Kimura, General Manager, Flexible Printed Circuits & Components Sales Department

Hiroki Kawanishi, Senior Manager, Flexible Printed Circuits & Components Sales Department

Creating new demand with new technologies

The sales department promotes the FPC business at the front line. Currently, most of FPCs provided by the Sumitomo Electric Group are destined for overseas markets. The sales and marketing of those products are carried out by the staff of sales subsidiaries in the United States, Europe, and China. The roles of the domestic sales department include supporting global sales and coordinating production and delivery schedules, as well as dealing with domestic customers. Tetsuro Kimura leads the FPC sales team as the General Manager of the Flexible Printed Circuits & Components Sales Department.

"In the more than half-century history of our FPC business, breakthroughs have always happened when a new technology was established through innovation. For example, the use of electronic-component-mounted modules in hard disks and mobile phones led to the development of multi-layer boards and other new technologies. We need to continue to capture market needs through dialogue with customers and create new products and new businesses that suit the new era. I believe that opportunities are hidden in changes in the world and society," says Kimura.

Hiroki Kawanishi, the former Manager of the Market Development Group and the current Senior Manager, used to carry out the task of cultivating new domestic demand for fine pitch FPCs and automotive FPCs.

"The use of fine pitch FPCs as actuator coils started from my talks with a customer during promoting fine pitch FPCs as a new technology, during which the customer suggested that fine pitch FPCs would be effective for their product. Since they were still in the development stage, the production was not stable, and it was not easy to establish a mass production system. So when we successfully launched the fine pitch FPCs on the market, I felt a sense of achievement. But we are still at the starting point. What is most important now is how we can go about creating new demand. I would like to open up new perspective by exploring the needs for the next-generation FPCs," says Kawanishi.

FPC distributors as business partners living in the same age

In promoting the sales of FPCs, distributors play an indispensable role. They work closely with Sumitomo Electric to quickly respond to customer needs. Elematec Corporation is an electronics trading company that has been involved in the sales of Sumitomo Electric FPCs as one of the distributors of the products for many years. The company boasts an exceptional track record in promoting the sales of FPCs for mobile displays. Mr. Ryo Takanohashi and Mr. Kentaro Shiga of the company were in charge of Sumitomo Electric FPCs in 2005, when the products were adopted as components of mobile displays.

"The trigger was liquid crystal displays. That was when it became popular to take pictures with mobile phones and the shift from mobile phones to smartphones began," says Mr. Shiga.

What were the strengths of Sumitomo Electric FPCs that contributed to the growth of the business?

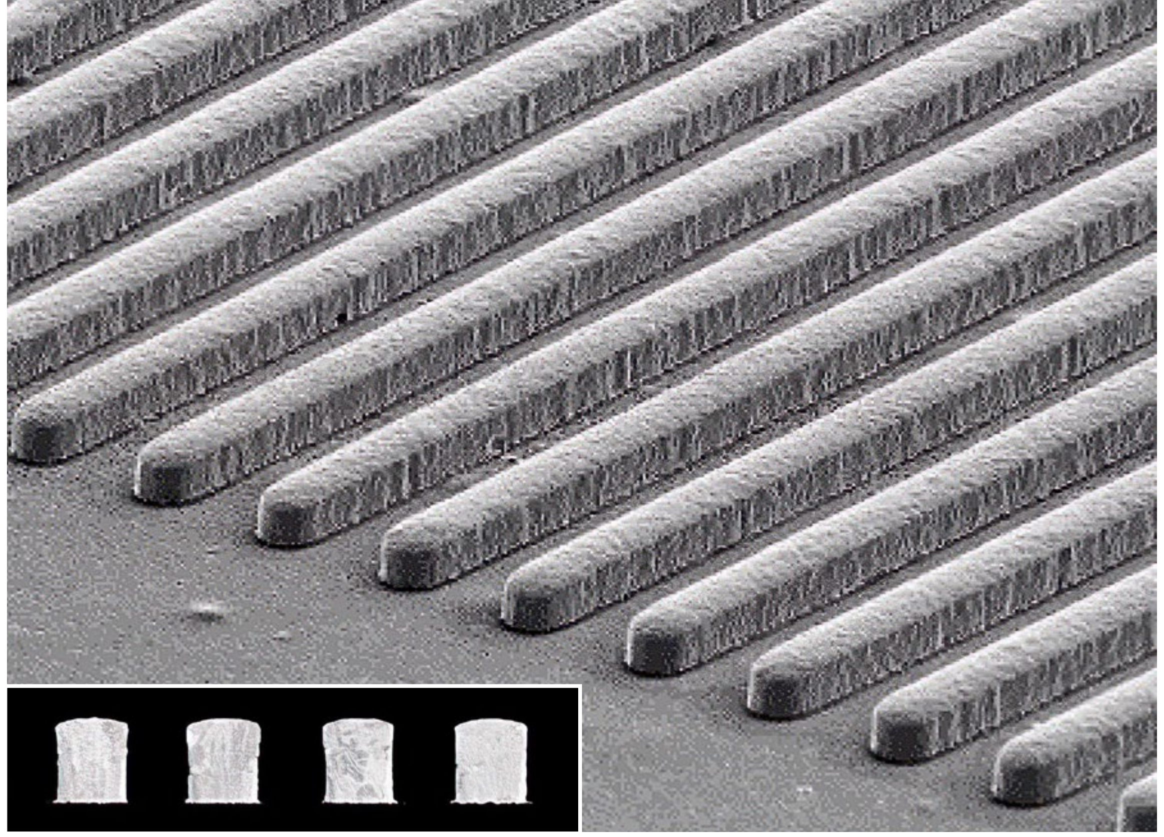
"At that time, FPC manufacturers concentrated on producing FPCs, and the mounting of electronic components on FPCs was carried out by other companies. However, Sumitomo Electric was the first to build a mounting line at its own factory and provide component mounted FPCs. In addition, I think Sumitomo Electric was also the first to apply a reinforcing material (liquid polyimide) to FPCs, which is a difficult process as it requires preventing warpage in order to retain their shape. The speed at which Sumitomo Electric was able to respond to customer needs and develop innovative materials left a strong impression on me," says Mr. Takanohashi.

They also have memories of working hard to address the situation in which FPC production struggled to meet the rising demand whilst customer expectations were also increasing. While Mr. Shiga flew around the world to visit customers' factories as a mass production coordinator, Mr. Takanohashi spent many days at Sumitomo Electric's factory in the Philippines and the expanded factory in Shenzhen, China as a development coordinator. They miss the days when they worked together tirelessly with the staff of Sumitomo Electric.

"Because we are a trading company, we did not know much about manufacturing. We learned many things through close communication with Sumitomo Electric's staff at the manufacturing sites. I really think that what we are now is the result of Sumitomo Electric's cooperation," says Mr. Takanohashi.

Mr. Kentaro Shiga, General Manager of Head Office Sales Group IV and General Manager of Chiba Branch, Elematec Corporation

Mr. Ryo Takanohashi, General Manager of Head Office Sales Group III, Elematec Corporation



Cross section

Enlarged image of fine pitch FPC (L/S = 7μm/7μm, Copper layer thickness = 8μm)

A development team that takes on the challenge of developing new products based on information on market needs from the Sales Department

What, then, do they expect from Sumitomo Electric in the future?

"There is a growing need for environmentally conscious products, so I expect them to meet such demand through new products. I am also looking forward to the development of new technologies that support smaller electronic products," says Mr. Shiga.

"I hope for products that have an absolute advantage in technology. It would be easier for us to make proposals if Sumitomo Electric's products have advantages beyond the reach of competitors," says Mr. Takanohashi.

Expectations for Sumitomo Electric's technologies from distributors are growing increasingly.

Fine pitch FPCs and high frequency FPCs

The Sumitomo Electric Group is conducting research to develop FPCs with finer pitch patterns as a key product for further growth of their FPC business. In 2021, the Energy and Electronics Materials Laboratory is approaching the achievement of an L/S of 7 μm/7 μm (a circuit width of 7 μm/a circuit interval of 7 μm, 7 μm = 0.007 mm), which is expected to expand the applications of FPCs. Also, in preparation for the spread of 5G wireless communication and the development of 6G technology, new low transmission loss materials using fluororesin are required.

The Sumitomo Electric Group has a long history of working on fluororesin processing and developing a variety of products (started by the aforementioned Okazaki). Due to its accumulated knowledge, Sumitomo Electric fluororesin substrates demonstrate their superiority even in low transmission loss characteristics.

The new type of FPCs using these fluororesin substrates are expected to be used in 5G-compatible smartphones and antennas installed in base stations. Another promising application is millimeter-wave antennas, typically for automotive use. It is certain that the number of millimeter-wave radars installed in each vehicle will increase in the future because, in addition to the current purpose of collision prevention and inter-vehicle distance control, due to the development of autonomous driving technology, it will become necessary to detect vehicles and pedestrians in all directions. There are great expectations for the commercialization of FPCs using low transmission loss fluororesin substrates provided by the Sumitomo Electric Group.

Beginning of a new history of FPCs

In 2019, the Sumitomo Electric Group's FPC business celebrated its 50th anniversary. Takafumi Uemiya has been involved in the management of the FPC business for many years as a former general manager of the Flexible Printed Circuits Division and the current Deputy General Manager of the Electric Conductor & Functional Products Business Unit. Uemiya emphasizes that it is the time for their FPC business to shift from half a century of conventional stage to a new stage.

"In the last 50 years, the FPC market has matured, and as wiring materials, FPCs are becoming more generalized and standardized. We want to shift from the market occupied by these general-purpose products to a market where our uniqueness can be made use of. That is the market of fine pitch FPCs and high frequency FPCs. Fine pitch FPCs have developed from mere wiring materials into functional parts that generate magnetic force, and furthermore, they are expected to develop into components that have a sensor function in response to the advent of the IoT era. High frequency FPCs are also promising components in the era of 5G communication and autonomous driving vehicles, which must handle a huge amount of information. Since we have strong relationships with telecommunications carriers and automobile manufacturers through our business, we are familiar with the market. By making the most of this advantage, we will demonstrate our comprehensive strength and competitiveness," says Uemiya.

Hiroshi Hayami was appointed General Manager of the Flexible Printed Circuits Division in 2020 as the successor to Uemiya. He has been involved in the FPC business as a materials researcher at the Research and Development Unit for many years and is one of the staff who has supported the development of fine pitch FPCs. Even now, he is also the Deputy General Manager of the Research and Development Unit. With the appointment of Hayami as the general manager of the division, Sumitomo Electric's FPC business is putting more focus on research and development than ever before.

Takafumi Uemiya, Executive Officer, Deputy General Manager of Electric Conductor & Functional Products Business Unit
(Photo taken when he was the General Manager of the Flexible Printed Circuits Division)

"Our basic policy is to increase the added value of FPCs themselves. During our rapid growth period, we promoted the mass production of assembly products with many electronic components mounted, but now, other FPC manufacturers can do the same. From now on, it is important to increase the added value of FPCs. This means that we must develop technologies that can be called "This is Sumitomo Electric!" which our competitors cannot catch up with," says Hayami.

Also, Hayami describes their three key business strategies as follows:

"The first strategy is to further develop existing FPC products to improve the competitiveness of quality, cost, and delivery. The second is actuator coils. It means manufacturing coils as our new products by using our fine circuit formation technology for FPCs. The third is the development of products that support high frequencies, including products related to CASE.* Fluororesin FPCs are also positioned here. We will expand our business with these three key strategies."

Hayami says that actuator coils are already becoming a major profit source.

Half a century after its launch, Sumitomo Electric's FPC business has entered a new stage in an undeveloped field with an R&D-oriented organization structure. Although it is not an easy road, there is no doubt that their bold challenge will promote the evolution of FPCs and open up a new frontier.

* CASE: An acronym for "Connected," "Autonomous," "Shared/Service," and "Electric," which are terms describing trends in the automobile industry

Hiroshi Hayami, Managing Executive Officer, General Manager of the Flexible Printed Circuits Division

Sumitomo Electric
The Professionals

Professing My Commitment to Goals and Making Constant Efforts

Pursuing Operational Improvement as a Team

"I am willing to take on any difficult challenge because I have pride as a professional in manufacturing."

id
Featured person

Toshihiro Fujinaga

Advanced Material Section, Itami Plant, Manufacturing Department, Sumiden Semiconductor Materials Co., Ltd.

1990: Joined Sumitomo Electric Industries, Ltd. Assigned to the Slice Section, Semiconductor Plant No. 2, Manufacturing Department, Compound Semiconductor Materials Division

2001: Leader of the Optical Slice Group, InP Section, Semiconductor Plant, Manufacturing Department, Compound Semiconductor Materials Division

2006: Deputy Chief, Optical Processing Section, Itami Plant, Manufacturing Department, Sumiden Semiconductor Materials Co., Ltd.

2012: Chief, Processing Section, Itami Plant, Manufacturing Department, Sumiden Semiconductor Materials Co., Ltd.

2014: Advanced Material Production Engineering Section, Engineering Department, Sumiden Semiconductor Materials Co., Ltd.

2015: Certified as an expert (Slicing and outer surface processing of InP substrates and new materials): Still valid

2018: Chief, Advanced Material Section, Itami Plant, Manufacturing Department, Sumiden Semiconductor Materials Co., Ltd.

Many of the improvements I made are the result of teamwork

"It is certain that the era of optical communication using next-generation InP (indium phosphide) semiconductors will come. It will be absolutely interesting to work on this new technology because it is not yet on the market."

This is advice I received from my older brother who conducted research on InP when he was in university. Convinced by this advice, I joined Sumitomo Electric and requested to be assigned to a department involved in InP, a compound semiconductor, and was assigned to the Compound Semiconductor Materials Division. Compound semiconductors, which are used in a wide variety of products from familiar smartphones and automobiles to industrial machines, are indispensable to our daily lives. A wafer, which is a substrate of compound semiconductors, is made by thinly slicing a cylindrical mass (ingot) formed by growing a crystal of the material. Since joining Sumitomo Electric Industries, I have been involved in slicing, including the setting up of new cutting equipment and the development of slicing processes for special products.

Since compounds handled in the slicing process are expensive, it is important to minimize losses and stably obtain as many wafers (substrates) as possible from a mass of material. When I was young, I worked with the help of my supervisors, seniors, and technical staff, and when purchasing wires, I negotiated with suppliers' engineers as well as their sales staff to collect as much information as possible. Then, while using the information obtained in this way as reference, I processed many samples, analyzed data, and repeated the PDCA* cycle to master the characteristics of equipment and materials.

There was an unforgettable event when we were required to improve the accuracy of the InP slicing angle. The equipment we were using at that time could not achieve the desired accuracy. So, I devised a solution that could be realized by introducing new equipment and improving the process, and strongly requested the plant manager to let me implement it. Although my plan required a very large investment, the plant manager called the manufacturer of the necessary equipment the next day and decided to introduce it.

At first, I struggled alone because I was not able to achieve the accuracy I expected, but as a result of sharing the ideal work process with my team members and making improvements by thoroughly resolving the causes of problems one by one, I finally achieved the desired accuracy. This experience made me realize that cooperation with colleagues is a key to success in everything I do. It convinced me that we could improve our operation and maintain our high product quality by creating an environment where we can work hard as a team while closely communicating with each other.

Unforgettable words of my supervisor when I made a big mistake

The conditions and equipment for cutting compound semiconductors differ depending on the target product. We sometimes use a wire saw, a cutting device using a wire, which is required to be able to cut the material quickly, accurately, and stably according to the characteristics of the product. So, I informed a wire manufacturer of detailed wire requirements, thereby accomplishing the development of a technology to cut a new material with a thin wire, which had not yet been successful at that time. I also succeeded in developing a new slicing technology using the latest cutting equipment. Since these developments were highly evaluated for their contribution to the reduction of material loss and cost, in 2015, I was certified as an expert having important skills.

Above: Team members
Below: Frequent guidance given to younger staff

However, not all has been smooth sailing for me. I tried many developments to improve operations, and there were some failures. One of the most unforgettable failures was when I placed a special crystalline material on a cutting machine in the wrong way, which resulted in a large loss of valuable material that I had never made before. It was a mistake made by doing other work in parallel. I felt down and was fully expecting to be blamed by my supervisor, but he unexpectedly said: "I do not blame you for any mistakes that you make as a result of making proactive efforts. It would be rather a greater loss for the company if employees lose their willingness to make improvements because they are afraid of making a mistake. Continue to try to make improvements without being afraid of making a mistake."

I still clearly remember these words and always keep them in mind when giving guidance to younger employees as an expert.

Professional pride and high goals

Partly because of these words of my supervisor, I do not blame younger employees when giving guidance to them. Even if they cannot do their tasks well, I thoroughly discuss with them until they find the causes and resolve them one by one. At that time, they need to share information in real time not only with site workers but also with other related persons, including engineering staff. When I see the process in which younger employees master a skill to such a degree that they can teach the skill to other employees and acquire professionalism, I feel a sense of accomplishment. Since each person has a different personality, it is important to understand it and give guidance in a way that suits the person. In this sense, I am being trained every day as an instructor.

Currently, I am involved in production, development for operational improvement, and the development of younger employees. The source of my energy is my willingness to accept challenges and my pride as a manufacturing professional. My motto is to profess my commitment to goals to motivate myself and make constant efforts to achieve them in cooperation with colleagues. Manufacturing cannot be done by an individual, but rather as a team, so relationships with colleagues are important. After preparing a suitable environment, I will continue to try to push the technical limits while flexibly responding to innovations that will take place across the world. I may face many obstacles in this process, but they will give me opportunities to improve my skills, so they are even kind of fun.

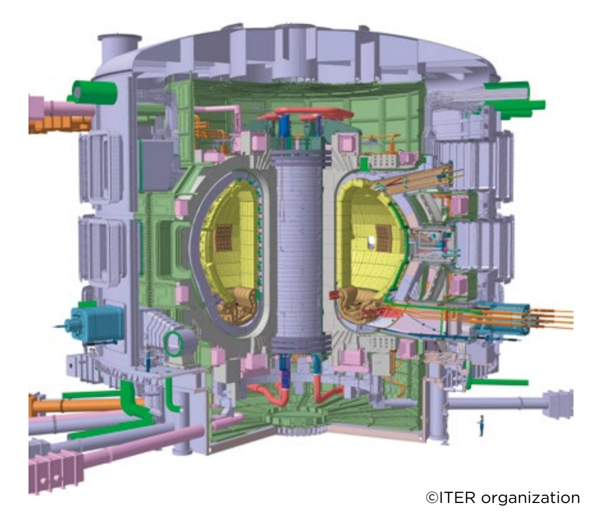
I am now working on the development of a new technology, which is expected to reduce our production cost and improve productivity. I believe that the accumulation of such improvements will lead to the development of our manufacturing sites.

* PDCA: An acronym for "plan," "do," "check," and "act," which represents a method to continuously improve management by repeating the cycle of these four steps.

A.L.M.T. Corp. Wins a Contract to Supply a Component Developed for the Fusion Experimental Reactor ITER

– International Project Attracting Attention as a Solution to Energy and Environmental Problems –

As global momentum to realize a carbon-free society is growing, “fusion power generation” is attracting attention as a fundamental solution to energy and environmental problems. Nuclear fusion is a reaction in which light nuclei combine to form a heavy nucleus, and the sun produces energy through this phenomenon. With the aim of producing fusion energy on the ground and using it for power generation, research and development of fusion power generation is underway. Unlike nuclear power generation, which uses fission reactions, fusion power generation does not generate high-level radioactive waste and the fusion reaction can be stopped easily. Due to these safety characteristics, its realization is highly anticipated.



External view of the ITER main unit. The ITER is a device for demonstrating that power generation using fusion energy, which has been called the “sun on the ground,” is technically and scientifically viable. The core of the device is a donut-shaped part where ultra-high temperature plasma is generated, and fusion reactions take place in the plasma.

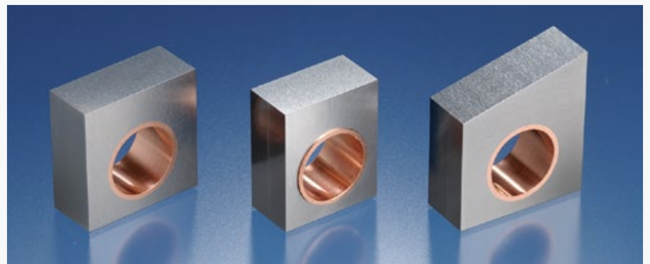
Under such circumstances, the construction of the fusion experimental reactor ITER is underway in France with international cooperation among six countries and one region (Japan, the EU, the United States, Russia, India, China, and South Korea). Recently, the tungsten monoblock developed and manufactured by A.L.M.T. Corp., a Sumitomo Electric Group company, has been adopted as an important component of the divertor,* a key device in the ITER.

In the process of fusion power generation, nuclear fusion reactions, which act as the energy source, take place in a plasma exceeding 100 million degrees Celsius confined in a magnetic field. Since the surface temperature of the divertor reaches a maximum of 2,300 degrees Celsius, the materials of the fusion reactor are required to have extremely high heat resistance. The tungsten monoblock developed and manufactured by A.L.M.T. Corp. has been confirmed to have characteristics that suit the fusion reactor, withstanding a thermal load of more than 2,000 degrees Celsius and remaining unbreakable even for a period of more than three times the number of operation cycles required in the specifications of the ITER, which led to the award of the contract this time.

As there is growing need for the stable supply of environmentally friendly clean energy, the “unbreakable tungsten” developed by the Sumitomo Electric Group is expected to contribute to the realization of fusion power generation.

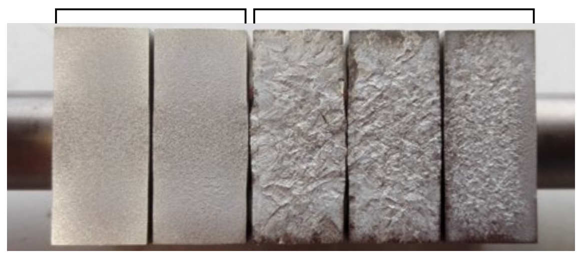
The Sumitomo Electric Group will continue to contribute to solving social issues through its innovative products and technologies.

* Divertor: A device for receiving high heat flow and particle flow generated by plasma and discharging and removing impurities unnecessary for maintaining plasma.
The procurement of the outer target, the inner target and the dome were assigned to Japan, the EU and Russia, respectively.


Tungsten monoblock: A product with a size of approximately 30 mm x 30 mm x 10 mm, which is made by bonding tungsten material suitable for fusion reactors and oxygen-free copper by using a special bonding method. This is skewered by a copper alloy cooling pipe to form a unit.

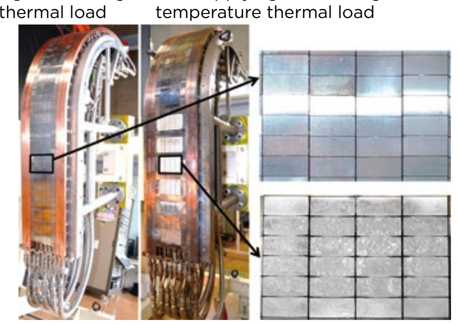
QUARTERLY id

Results of evaluation by the National Institutes for Quantum and Radiological Science and Technology (QST)



It was confirmed that the developed tungsten material has excellent thermal stability since it exhibited no remarkable elevation of the surface due to deformation, unlike the conventional tungsten material.

Results of prototype evaluation by the ITER Organization



The prototype exhibited excellent thermal shock resistance since no cracks were observed even for an evaluation period of more than three times the number of operation cycles required in the specifications of the ITER.

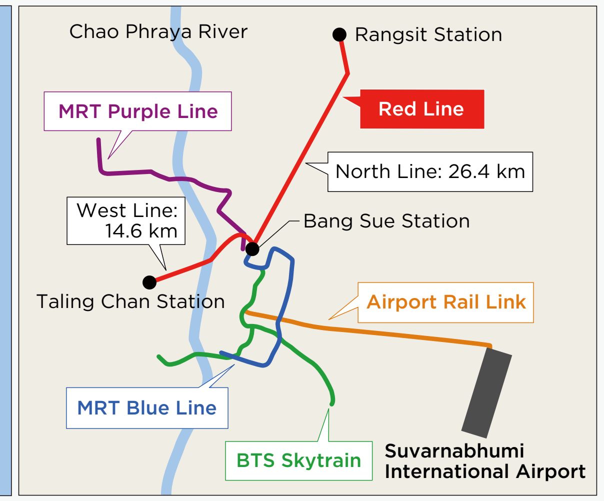
Source: National Institutes for Quantum and Radiological Science and Technology

Sumitomo Electric Delivers Power/Communication Cables for the Thai Commuter Railway Red Line Construction Project

Sumitomo Electric Industries, Ltd. received an order from Mitsubishi Heavy Industries, Ltd. and shipped an assortment of cables (an approximate total of 2,800 km) for the Red Line Construction Project, a plan involving the building of a new commuter railway route in the Kingdom of Thailand.

In the Kingdom of Thailand, the government is promoting the Bangkok Mass Transit System Project to alleviate traffic congestion, improve air pollution, and respond to increasing transportation demand in the Bangkok metropolitan area.

The Red Line Construction Project is part of this project and features the building of an all-elevated railway line starting from Bang Sue Station in the center of Bangkok, extending 26.4 km north (North Line) and 14.6 km west (West Line). The North Line was constructed using Japanese government funding while the West Line was constructed by using the Thai government’s own funding. The entire line started operation in August 2021.



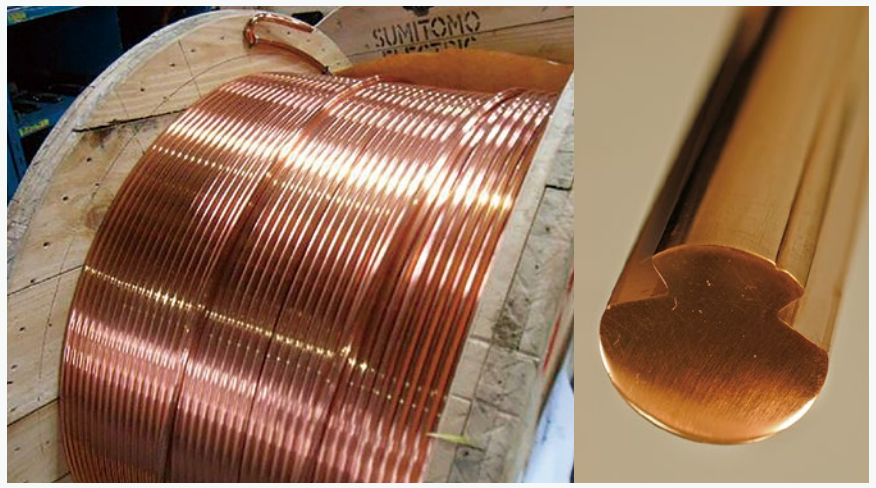
The Sumitomo Electric Group’s strength is that it can collectively provide a variety of products indispensable for railway construction, ranging from contact wires that supply power to railway vehicles through pantographs to power cables and signal cables.

Taking advantage of this strength, the group delivered the widest variety of products among the railway construction projects it has ever participated in, including contact wires, stranded hard-drawn copper wires, and various cables for medium- and low-voltage power, signals, and communications, to Mitsubishi Heavy Industries, which is a member of the consortium that was awarded the contract for this project.

Since it began manufacturing and selling contact wires in 1914, the Sumitomo Electric Group has been providing products and services that are indispensable for the railway network construction business around the world for more than 100 years. In particular, Asian countries are proactively promoting railway infrastructure development projects to deal with growing traffic demand, increasing economic activities in rural areas, growing environmental impact, global warming, and so on, and such projects are expected to further increase in the future. The group has been providing products and services to various projects, including the Dedicated Freight Corridor Construction Project in India, for which the group has received the largest-ever order for contact wires and delivery is underway. The Sumitomo Electric Group will continue to contribute to the construction of high-quality infrastructure with a wide range of products and services, making use of the experience it has accumulated so far.

■ List of products delivered for this project

Products	Quantity	Production site
Contact wires	About 180 km	Osaka Works
Stranded hard-drawn copper wires	About 170 km	Sumi Indo Kable, a Sumitomo Electric Group Company in Indonesia
Aluminum conductor steel reinforced (ACSR)	About 230 km	
Stranded hard-drawn aluminum wires	About 200 km	
Medium- and low-voltage power cables (600 V to 25 kV)	About 1,670 km	
Signal/communication cables	About 360 km	


Contact wire


Medium- and low-voltage power cables and other products manufactured by Sumi Indo Kabel

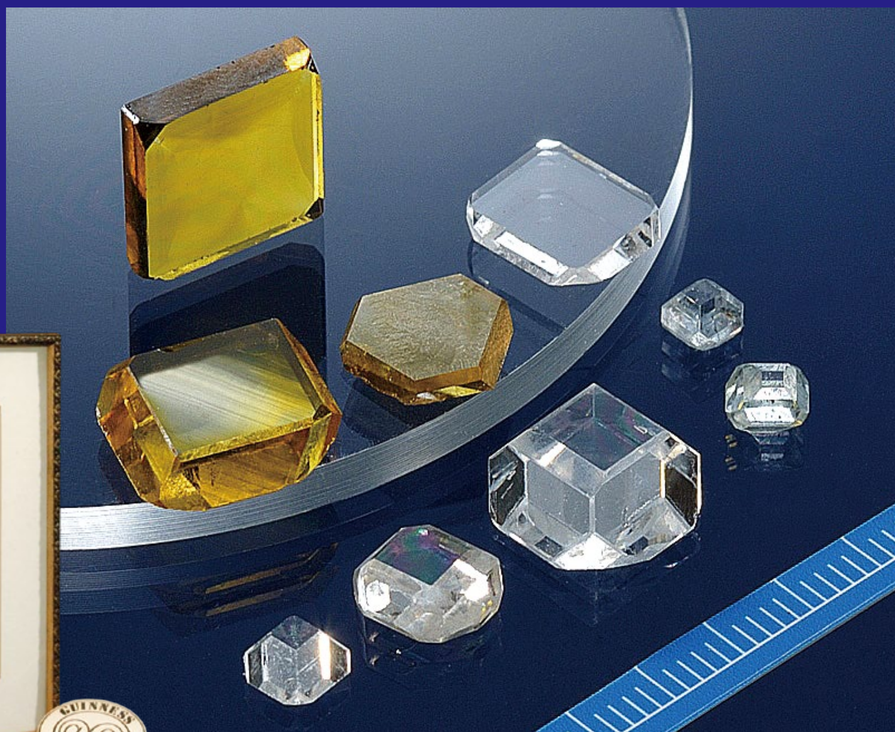
■ Reference (Sumitomo Electric website):
Website introducing contact wires
https://sumitomoelectric.com/products/railway

Sumitomo Electric Group e-magazine “id”
“Delivery of Contact Wires for the Dedicated Freight Corridor Construction Project in India”
https://global-sei.com/id/2018/12/quarterly/file001.html

A Picture of Sumitomo Electric in Those Days

1982

Success in Synthesizing the World's Largest Single Crystal Diamond



Large high-purity diamond crystals with a diameter of over 12 mm and a weight of over 10 carats

Certificate for entry in the 1984 Guinness Book of World Records

An Artificial Diamond Certified as the World's Largest by the Guinness Book of World Records

In the process of manufacturing electric wires, the main products of Sumitomo Electric Industries, a tool called a "wire drawing die" was used to size products according to the specified diameter. Around 1970, Sumitomo Electric came up with using diamond as the material of wire drawing dies in place of cemented carbide. This was the beginning of the history of Sumitomo Electric's synthetic diamond development.

At that time, an American company had succeeded in synthesizing artificial diamonds with a diameter of about 4 to 5 mm (0.75 carat or less), and it was thought impossible to synthesize diamonds without using any patented technology. Sumitomo Electric conducted research to develop new synthesis technologies, and in 1982, it succeeded in synthesizing a single crystal diamond with a diameter of about 6 mm (1.2 carats), which was one of the largest at that time and listed in the 1984 Guinness Book of World Records as "the world's largest synthetic diamond." Also, in 1989, Sumitomo Electric realized the mass production of large single crystal synthetic diamonds with a diameter of about 1 cm. The crystals at that time had a yellow color due to the presence of impurities, however, thanks to the passion and tenacious efforts of researchers who desired to develop larger, more colorless and transparent high-purity crystals to expand the scope of application and contribute to the development of industrial technology, high-purity, colorless, transparent, and high-quality large crystals with a diameter of 11 to 12 mm (about 10 carats) are now available.

Today, single-crystal synthetic diamonds are used not only for conventional tool applications, but also for non-tool applications, such as optical components, window materials, and spectroscopic devices.

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https://global-sei.com/id/

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