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Innovative Development,
Imagination for the Dream,
Identity & Diversity

Feature article

Prestressing Steel

Supports Infrastructure Around the World

SUMITOMO ELECTRIC GROUP

Projects id Formidable Social Challenges

Develop Infrastructure for the Realization of a Sustainable Society

Supporting the construction of the Shin-Meishin Expressway and the reconstruction of the Tohoku Region, as well as overseas projects

Road networks are a foundation for economic activities and social life. Japan rapidly developed expressways during the high economic growth period.

Now, while it is necessary to repair the roads that have degraded with age, demand for the development of new roads as sustainable infrastructure is also increasing.

Expressways in Japan inevitably need bridges as they pass through mountainous areas and over rivers, and the construction of bridges currently involves a wide range of social issues. In addition to safety, there are also plenty of issues that were not considered in the past infrastructure development, such as productivity improvement through energy and labor saving and the shortening of construction periods, as well as the extension of service life and the reduction of environmental impact.

Sumitomo Electric is proactively addressing these issues in the construction of bridges. It is the supply of high-performance prestressing steel and related products featuring high strength and durability.

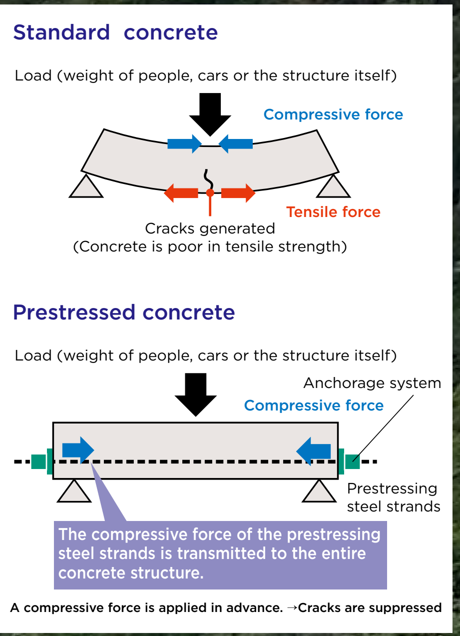
Construction of the Shin-Meishin Expressway is in progress (Youbaizan Viaduct)
The simultaneous operations of 32 form travelers indicate that there is no time to lose in the construction. (Photo courtesy of Sumitomo Mitsui Construction)

Prestressing Steel Supports Infrastructure Around the World

Unknown power of prestressing steel which are indispensable for the construction of long concrete bridges

The prestressing steel is high-strength steel strand that features high tensile strength and excellent toughness (tenacity of the material). Standard concrete is resistant to compressive forces but weak in tensile strength. A very effective solution to this problem is prestressing steel strand, which has five to seven times higher strength than reinforcing steel. Prestressed concrete is currently used in the construction of most long concrete bridges.

In prestressed concrete structures, a tensile force is applied to prestressing steel strand with a hydraulic jack and the compressive force is transmitted to the concrete to inhibit cracks and maintain the strength and soundness of the structures.



Prestressing Steel Technology Supported the Shin-Meishin Project

Mukogawa Bridge, Aigawa Bridge and Youbaizan Viaduct

The super-high-tention system reduced the weight of bridges

Creation of a "double network" linking the Kansai and Chubu Regions

One of the main arteries that connect major cities in the eastern and western parts of Japan is the Meishin Expressway between Nagoya and Kobe. This important transportation infrastructure underpins the economic activities and everyday life of Japanese people but has suffered chronic traffic congestion due to the growing traffic volume and there has always been a risk that the only trunk line could be cut off in case of disasters and other emergencies. To solve these issues, a new major road was planned, namely the Shin-Meishin Expressway, which will be 174 km long. This big project duplicates the expressway and creates a "double network" connecting the Kansai and Chubu Regions to reduce traffic congestion and serve as an alternative route in emergencies, which will secure smooth transportation. It can also shorten the traveling time to improve economic efficiency and contribute to local communities.

The world's strongest prestressing steel strand and the anchorage system

The project to construct the Shin-Meishin Expressway has used a large number of prestressing steel and related products supplied by Sumitomo (SEI) Steel Wire Corp.[*1] (hereinafter referred to as "Sumitomo Electric" collectively). Sumitomo Electric obtained a license for long-span prestressed concrete bridge construction technologies from Dyckerhoff & Widmann AG (Dywidag) of Germany to introduce them to Japan in the late 1950s and developed a business related to prestressing steel and related products during the period of rapid economic growth. Then, the Company worked to further improve the strength and created the world's strongest prestressing steel strand with approximately 20% higher strength than conventional JIS (Japanese Industrial Standards)-compliant types[*2]. A key point was that the strength of the prestressing steel strand was enhanced while the diameter was almost the same with that of conventional ones. Their functions were also improved. An example was the development of highly durable (corrosion-resistant) prestressing steel and related products, which are coated with epoxy resin and polyethylene (PE) resin at a factory in advance to dramatically enhance the long-term reliability.

The anchoring process is also important, in which tensioned prestressing steel and related products that efficiently transmit the compressive force to concrete are anchored to a bridge. It is a great advantage of Sumitomo Electric that it can offer a total solution from prestressing steel strands to the anchorage system (a group of parts for the anchoring).

*1 Sumitomo (SEI) Steel Wire Corp. was separated and became independent from Sumitomo Electric Industries, Ltd., in October 2002 to start operation as a comprehensive manufacturer of specialty steel wire products. While Sumitomo Electric sells the products outside of Japan, Sumitomo (SEI) Steel Wire is in charge of manufacturing, development and domestic sales.
*2 JIS-compliant prestressing steel strand has the strength of 1,860 MPa, which is equivalent to the strength of a prestressing steel strand of 15.2 mm in diameter to withstand the weight of about 25 passenger cars. The world's strongest prestressing steel strand has the strength of 2,230 MPa, which can be manufactured by only several companies worldwide.

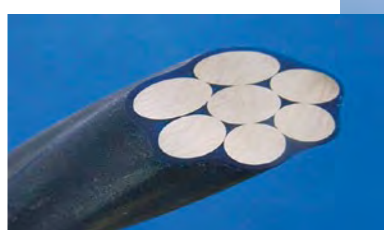
The Super-high-tension system strongly supported the solution of challenges

For this project, Sumitomo Electric provided a super-high-tension system, which consists of the world's strongest prestressing steel strand and the anchorage system mentioned above. Since the prestressing steel strand has a similar diameter to that of ordinary ones but has higher strength, the number of the cables, which are made by stranding the prestressing steel strands, can be reduced and the anchorage system can also be deployed properly in a limited space. In addition, epoxy resin coatings and other highly durable rust prevention treatments are applied to the prestressing steel strands.

This super-high-tension system has been adopted in the construction of Mukogawa Bridge, Aigawa Bridge and Youbaizan Viaduct of the Shin-Meishin Expressway. It has been highly valued for the construction of the long span bridges and greatly helped save labor and reduce the bridge weight.

Mukogawa Bridge

Epoxy coated and filled (ECF) strands



Dywidag™ anchorage system

Pre-grouted prestressing steel strand

Anchorage zone of stay cables at pylon

Mr. Katsuhiko Mizuno
Sumitomo Mitsui Construction

Mukogawa Bridge needed to reduce its weight and have high earthquake resistance

One of the features of Mukogawa Bridge is the combination of the butterfly web structure[*3] in the main girder with the extradosed structure[*4], which was the first attempt in the world. Mr. Katsuhiko Mizuno from Sumitomo Mitsui Construction Co., Ltd. was in charge of the design and construction.

"We had to thoroughly reduce the weight and improve the earthquake resistance. The amount of concrete and steel used in a bridge can be reduced with the butterfly web structure due to its shape as well as with the extradosed structure, which uses shorter main towers (girder height of 4 m). A lighter bridge girder leads to higher earthquake resistance and can also slim down the foundation and piers, which can eventually improve the economic efficiency and reduce the environmental impact. We needed the high-strength prestressing steel strands to meet these requirements. "

As a result of reducing the weight of the main girder, we decreased the total number of the blocks in free cantilever construction (bridge erection method to extend the bridge body from each pier to both directions; the width of a block is usually 3 to 4 m). It helped reduce the construction work as a whole, shorten the construction period and thereby lower the environmental impact.

"The bridge would not have been achieved without the high-strength prestressing strand and the anchorage system. Sumitomo Electric did not only supply prestressing steel strand and the anchorage system but also responded to various technical issues on the construction site. They are a reliable partner."

*3 Structure with butterfly-shaped thin panels
*4 Bridge structure where diagonal cables anchored to the main towers support the bridge girder

Aigawa Bridge (Photo courtesy of Sumitomo Mitsui Construction)

Mr. Naoki Nagamoto
Sumitomo Mitsui Construction

Young engineers of Sumitomo Electric who supported the Shin-Meishin Expressway bridge project

Aigawa Bridge - an attempt to achieve one of the world's longest span with world's deepest girder height.

For Aigawa Bridge, the prestressing steel strand had to have higher strength. The span length of the bridge (span between the piers) is 179 m for the inbound lane and 170 m for the outbound lane and the maximum girder height of the piers is 11.5 m. It is the world's top corrugated steel-plate web girder bridge in terms of both span length and girder height. To establish the structure of Aigawa Bridge, the reduction of the weight was a major challenge. Mr. Naoki Nagamoto from Sumitomo Mitsui Construction, who was in charge of the design and construction, also mentioned it.

"The reduction of the weight is always a major proposition for bridge engineers like us. How we can reduce the amount of concrete is a theme we have tackled as a pioneer of concrete bridges for many years. In the case of Aigawa Bridge, it was difficult to arrange prestressing steel cables because a very large number of prestressing steel cables were needed to support the dead weight of the bridge with a very long span. Then, we adopted the super-high-tension system to reduce the number of cables by about 20% and were able to establish the world's longest structure."

Extraordinarily large construction work with simultaneous operations of 32 form travelers

Youbaizan Viaduct is a long bridge with both inbound lane and outbound lane exceeding 1,100 m long. While the free cantilever method was applied to the bridge as in the cases of Aigawa Bridge and Mukogawa Bridge, there was a major challenge unique to Youbaizan Viaduct that was not relevant to the other two bridges. Mr. Kenichi Kata from Sumitomo Mitsui Construction was in charge of the design and construction.

"The construction work of this bridge was so huge that 32 form travelers were used simultaneously at the busiest time while around 10 form travelers are used in ordinary work. No trouble was allowed in such simultaneous operations because the suspension of work on any of the sites could affect the whole process. The construction abilities were put to the test in the project. In addition, the timely and prompt supply of prestressing steel strand was essential to proceed with the work."

Delivering high-strength prestressing steel strands to the construction site on a just-in-time basis

While the proper and prompt supply of steel strands was an absolute mission, the mega Youbaizan Viaduct required about 1,000 tons of high-strength prestressing steel strands. The fact that the total quantity of the high-strength prestressing steel

Youbaizan Viaduct (Photo courtesy of Sumitomo Mitsui Construction Co., Ltd.)

Supply 1,000 tons of high-strengh prestressing steel strand in a timely manner

strand shipped by Sumitomo Electric over 10 years was about 3,000 tons indicates the large scale of the project. In addition, it was not enough to just produce and transport the strands. It was necessary to supply only the needed volume of the strands only when they were needed because the construction site had no space to store such a large amount of materials. We were required to supply them literally in a just-in-time manner. To meet the demand, we carefully made a production and delivery plan even in consideration of unexpected circumstances in the land transportation and controlled the delivery while examining the progress of the construction work.

"Sumitomo Electric responded to the demand perfectly. I feel that it is a result of the trust relationship that has been developed between the two companies. A future challenge is the downsizing and weight saving of the equipment used at the construction site. When the scale of construction work becomes larger, the total volume of materials increases. Downsized equipment will accelerate the improvement of productivity on construction sites. We would like to generate innovations that change the construction sites drastically together with Sumitomo Electric." (Mr. Kata).

Mr. Kenichi Kata
Sumitomo Mitsui Construction

Yuka Kishimoto
"I was involved in the development of new technology for high-strength prestressing steel strand. I will continue to work for innovations in the production technology and the development of new products."

Shinji Nakaue
"I was in charge of the design and development of the anchorage system. My goal is to create a new technology that contributes to advanced prestressed concrete construction work."

Hisashi Nakatani
"I was responsible for sales and product delivery for Youbaizan Viaduct. I have a special attachment to the project because I have been involved in it since the completion of the bridge piers."

Shuichi Tanaka
"I was in charge of production technology and mass production of high-strength prestressing steel strand. I feel rewarded as an engineer that I was able to contribute to the widespread use of the products."

Recovery from damage of the Great East Japan Earthquake The transportation infrastructure development is in progress

The Great East Japan Earthquake in March 2011 caused devastating damage. While the damage affected a wide range of fields, the disruption of the rail, road and other transportation networks particularly had a major impact on the local communities. Roads are actually indispensable channels for emergency transportation of support staff and relief supplies, reminding us of the importance of connecting the affected areas and the inland region. A leading project for quick recovery from damage of the earthquake was the Tohoku-Chuo Expressway Soma-Fukushima Road and Sumitomo Electric supplied prestressing steel and related products for the construction of the Tsukidate Viaduct on the road.

Challenges to salt and freezing damage Efforts to extend the life of the bridge

Tsukidate Viaduct is 462 m long and one of the longest prestressed concrete bridges on Soma-Fukushima Road. The person in charge of the construction management was Mr. Yukihiko Morita from Kajima Corporation.

"One of the features required for the bridge was a long life. The location is exposed to high risks of salt and freezing damage so high durability was needed to reduce the lifecycle cost

Tsukidate Viaduct (Photo courtesy of Kajima Corporation)

Optical Fibers Observe the Soundness of the Bridge

Tsukidate Viaduct on a road to support the post-earth quake recovery

from a long-term perspective. Along with the quality of the concrete, highly durable prestressing steel strands were essential."

In response to such demand, Sumitomo Electric supplied high-corrosion-resistant prestressing steel strand that has PE coating in addition to the ordinary corrosion-resistant coating. The anchorage system supplied for the project also had specifications to prevent salt damage such as coating with epoxy film.

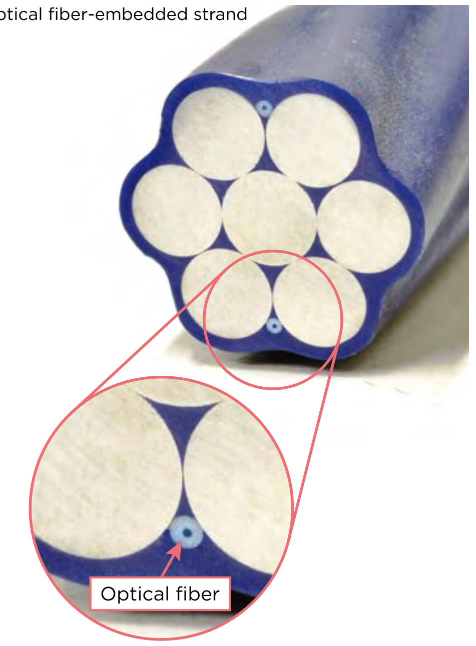
Mr. Yukihiko Morita
Kajima Corporation

Monitoring of the tensile strength of prestressing steel cable

Sumitomo Electric also introduced a groundbreaking technology into the construction work, namely "optical fiber-embedded strand" in which optical fibers are incorporated into a prestressing steel and related product. This enables the measurement of the strain created on the optical fibers to assess the distribution of tension over the entire length of the prestressing steel cable, which was difficult to achieve by conventional technologies. Coated with epoxy resin, the optical fibers have no risk of being damaged during the construction work and can be used for measurement over a long term. This product was created through joint development between the three companies of Kajima Corporation, Hien Electric Industries, Ltd. and Sumitomo Electric. Mr. Naoki Sogabe from Kajima Corporation was one of the members who led the development.

Measurement work (Photo courtesy of Kajima Corporation)

Optical fiber-embedded strand



"For the construction and maintenance/management of a prestressed concrete bridge like Tsukidate Viaduct, it was necessary to control the tensile strength of prestressing steel cables. To this end, we planned to realize the idea to use optical fibers for the measurement of the tensile strength, which Kajima Corporation had considered for a long time. To overcome the challenge of integrating prestressing steel strands with optical fibers, the technology of Sumitomo Electric, an expert of prestressing steel and related products, was indispensable."

Integration of prestressing steel strands with optical fibers A problem occurred on the construction site

The person in charge of the development in Sumitomo Electric was Masashi Oikawa.

"We developed a technology to incorporate optical fibers into epoxy resin and completely integrate them so that a long-life sensor function can be added while the high durability of prestressing steel strands are maintained. On the other hand, the firm coating made it extremely difficult to take out the optical fibers to be connected to measuring equipment from prestressing steel strand. At first, the coating was cut manually to take out the fibers, which took so much time that it affected the progress of the construction work."

Masashi Oikawa

Mr. Naoki Sogabe
Kajima Corporation

Oikawa and other staff concentrated their knowledge accumulated through the past technological development on the solution to the problem. As a result of repetitive consideration of tools and methods, they successfully reduced the time to remove the coating and take out the optical fibers, allowing the practical use of the product.

"The management of tensile strength with optical fiber sensors is fairly groundbreaking. A future task is to make effective use of the monitoring data. We would like to work for the sophistication of the maintenance and management technology from a comprehensive perspective in cooperation with staff from Sumitomo Electric." (Mr. Sogabe).

Furthermore, SmART Cell™ has also been applied to Tsukidate Viaduct, which is a magnetic tension sensor developed by Sumitomo Electric to measure the tensile force with pinpoint accuracy. In addition to the development and supply of prestressing steel strand and the anchorage system, an extensive line of related system products helps improve the reliability of the prestressed concrete technology.

SmART Cell™


Cantilever construction at sea


Corrosion-resistant prestressing steel cable installed inside a bridge beam (Photo courtesy of Sumitomo Mitsui Construction Co., Ltd.)

Lach Huyen Bridge
(Photo courtesy of Sumitomo Mitsui Construction)

Prestressing Steel
Supports Infrastructure Around the World

Our High-Performance Prestressing Steel Cables Crossed the Sea to Build a Long Offshore Bridge
Lach Huyen Bridge in Vietnam

Offshore bridge supporting the Vietnamese economy Demand for high corrosion resistance and a shorter construction period

Vietnam is one of the countries maintaining especially high GDP growth every year among the emerging economies in Asia. Many foreign firms have advanced to the northern part of Hanoi, its capital, in recent years. In response to the economic development, a project to construct an international deep-water port was launched in the Lach Huyen district of Hai Phong City, funded by the Japan International Cooperation Agency (JICA). The project also involved the construction of Lach Huyen Bridge as part of the access road. We interviewed Mr. Kazuhiro Nishimura from Sumitomo Mitsui Construction, who was responsible for the construction together with a local construction company.

"Lach Huyen Bridge is the longest offshore bridge in Vietnam with a bridge span of over 5.4 km. The prestressing steel strand used for the bridge had to have high corrosion resistance because it was located at sea. The demand was satisfied by the corrosion-resistant prestressing steel strand of Sumitomo Electric. With corrosion resistance and robustness provided by double coating, the strands greatly helped reduce the construction period and save labor with no need to inject grout (rust prevention materials such as cement milk and resin) or connect PE pipes on site."

Nevertheless, there was a major problem to be solved before their transportation to the actual site and introduction of the technology.

A challenge of cable processing on site Patient and persistent efforts led to the solution

When prestressing steel strands are delivered to construction sites in Japan, the steel material manufacturer cuts them to a certain length and bundles multiple strands to create a cable at plant. However, the cost efficiency of this method is very poor when the products are transported to Vietnam. After repeated examinations, we adopted a method of delivering uncut products to Vietnam and then cutting and processing them locally. Shiyouji Kusano from Sumitomo Electric went to Vietnam and trained the local staff.

"A challenge was the prevention of damage to the surface of PE and epoxy coated and filled steel strands at the stages from processing to install into the girder. A cable wound around a wooden drum was cut into 60 m pieces and then bundled to create 19 cables on site. In fact, the operators in Vietnam had no experience of bundling corrosion-resistant PE and epoxy coated and filled steel strands and then installing them. I trained them persistently to help them understand the need to prevent the cables from being damaged with a corner of concrete. We also made various efforts to secure facilities and equipment for processing 60 m cables on site."


Mr. Kazuhiro Nishimura
Sumitomo Mitsui Construction

These patient manual efforts supported the creation of a new artery for the Vietnamese economy.

Future prospect of the prestressed concrete technology Disseminate the high-performance prestressing steel strand developed in Japan around the world

In addition to bridges, the prestressed concrete technology has been used for large LNG tanks, water and sewage treatment tanks, railroad concrete sleepers, ground anchors, etc. Since the technology can provide pillar-free large space, it is also used for gymnasiums, halls and other buildings, as well as for shafts for wind power generators, these days.

Masato Yamada, who supervises the entire prestressing steel business in Sumitomo Electric, said:

"Improving the soundness of the infrastructure constructed in the past and extending its life, based on the latest technologies, is our social mission. To this end, we will work to enhance the functions and value of prestressing steel and related products and also package related technologies to provide a total solution, while promoting the development of other uses."

We are promoting overseas activities at the same time.

"Infrastructure in developed countries is becoming increasingly degraded while demand for development is soaring in developing countries. In response, we have been promoting global development through such activities as the establishment of manufacturing facilities in three US locations and Indonesia. While claiming that high-performance prestressing steel strands can help extend the life of infrastructure, we also promote the strategy to establish the high-strength and high-corrosion-resistance prestressing steel strand, optical fiber sensors, etc. created with the technological development capabilities of Sumitomo Electric as global standards."

Sumitomo Electric aims to spread highly functional prestressing steel products developed in Japan to the world and is confident that the efforts will support the development of infrastructure worldwide and thereby help people in the world live an affluent life.


Masato Yamada

Sumitomo Electric
The Professionals

"When I encounter something unknown or a new phenomenon, I will think it our thoroughly to clarify it however hard it is. The light at the end of it will illuminate a new horizon."

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Featured person

Tetsuya Hayashi

Assistant Manager, Information Transmission Department
Optical Communications Laboratory

2006: Entered Sumitomo Electric Industries, Ltd. Assigned to Optical Communications Laboratory and has been consistently engaged in the research and development of optical fibers up to the present.

2009: Started research on multi-core optical fibers.

2013: Received a Ph.D. for research on multi-core optical fibers.

2016: Became the third winner of the Tingye Li Innovation Prize* in OFC from the Optical Society (OSA) for his work on a coupled multi-core optical fiber suitable for ultra-long-haul transmission.

* The Tingye Li Innovation Prize is awarded each year to a young professional at the age of 39 or younger who has demonstrated the most innovative ideas during the Optical Fiber Communication Conference (OFC), the world's largest international conference on optical communication, and at the Conference on Lasers and Electro-Optics (CLEO), one of the largest international conferences on lasers and optical electronics in the world.

An optical fiber for communication usually emits no visible light because it uses near-infrared light. But the optical fiber in this photo was illuminated with the integrated unit of RGB-One™, a full-color laser module of Sumitomo Electric, as the light source to make the fiber more visible.

Suspect Accepted Theories and Think Thoroughly by Yourself

Environment where I can grow as a researcher

I was engaged in research on optical fiber sensors at graduate school. An optical sensor detects changes in reflection components of light propagating in an optical fiber to measure continuous distribution of data along the fiber, such as temperature and tensile strain, accurately in a real-time basis. I studied the subject because I found the properties of the lightwave scientifically interesting. Having completed the Master's program, I chose a path to become a researcher in the private sector, like most Japanese researchers and engineers do so, with an idea that research activities in a field outside of academia would foster my growth.

While I was engaged in the research and development of optical fiber sensors after joining Sumitomo Electric, which was an extension of my research at graduate school, I sometimes felt unsatisfied with the development activities with predictable results. I had a desire for something unknown and new to me. Just then, I was assigned to research optical fibers themselves. I worked in research and development for the improvement of the performance of existing optical fibers for communication, which led to research on a multi-core optical fiber (MCF), the subject to which I am still committed.

Challenge of expanding transmission capacity

An optical fiber is a very thin line to transmit optical signals. The optical fiber dramatically improved the speed and capacity of data transmission, underpinning the sophisticated information society in the modern world as represented by the Internet. Nevertheless, with the introduction of various network services such as smartphones and video distribution services, the volume of data flowing through the network has been growing each year. While continuous improvements have been made to expand the transmission capacity based on wavelength division multiplexing* and other innovative technologies, the transmission capacity of the conventional single mode optical fiber (SMF) is getting close to the limit.

In the SMF, the central part called the "core" is covered with a layer called "cladding" concentrically and light is confined in and transmitted through the only one mode (path for light) that exists in the core. To overcome the limits of the SMF, research on space division multiplexing was started to add more paths for light in an optical fiber. In this research trend, I focused on the MCF in my research and development activities. While a conventional optical fiber has a core in the cladding, the MCF has multiple cores in a cladding and is expected to dramatically increase the transmission capacity. On the other hand, there is a concern that the existence of multiple cores causes characteristic degradation that does not occur in the SMF, and the suppression of the degradation was a major challenge for practical use.

To think thoroughly and be persistent is my professional style

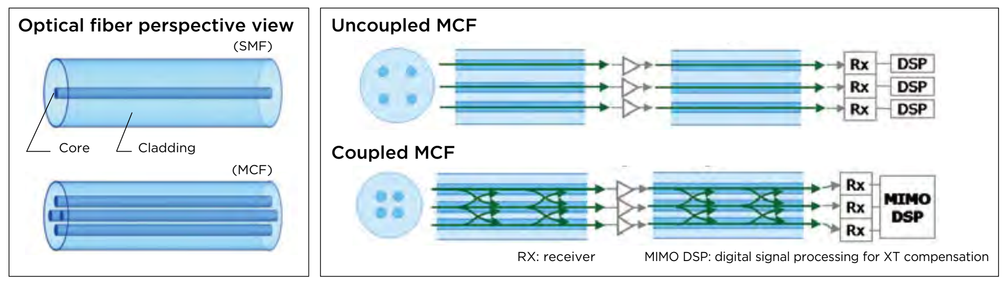
One of the problems was the core-to-core crosstalk (XT), which is mutual interference of signals between cores that degrades the quality of communication. Through experiments, I found that much larger XT than predicted based on the conventional theory could be generated, and discovered and demonstrated that it was attributed to a phase matching in the light between cores caused by bending the fiber. I then developed a method to suppress XT by conversely using the fiber bends to induce the phase mismatch in light, and we realized an ultra-low-XT MCF which still has the lowest XT record as MCFs applicable to long-haul transmission, to the best of our knowledge. Using the ultra-low-XT MCF, the first transmission experiment achieving more than 100 Tb/s/fiber—regarded as the SMF capacity limit—was demonstrated in collaboration with the National Institute of Information and Communications Technology and others in 2011. Recently, in collaboration with KDDI Research, Inc., the transmission experiment with an ultra-high capacity of more than 10 Pb/s—100 times larger than the SMF capacity limit (100 Tb/s)—over a few-mode MCF was successfully demonstrated, by increasing the number of modes in each core to realize mode division multiplexing in addition to suppressing the core-to-core XT.

We have also collaborated with Bell Laboratories (now Nokia Bell Labs) to establish an approach that allows XT and recovers the data at the receiver. The allowance of XT enables cores to be located closer to each other, which has an advantage of transmitting a larger volume through a fiber of the same diameter with that of a conventional standard optical fiber. On the other hand, arrival time differences between the signals (modal dispersion) were a major challenge because they have a large impact on the calculation complexity for recovering the information. Then, we fabricated a coupled MCF in a new original design and significantly suppressed the modal dispersion, which is low enough for practical ultra-long-haul transmissions. As the coupled MCF design was compatible with the manufacturing process of the ultra-low-loss optical fiber, where Sumitomo Electric excels, the transmission loss has also been reduced to the level equivalent to that in a high-quality ultra-low-loss SMF thanks to the efforts of our manufacturing engineer.

Thus, a coupled multi-core optical fiber suitable for ultra-long-haul transmission with excellent optical properties was realized with a standard cladding diameter of 125 µm. I believe that I won the prize from the Optical Society because our development demonstrated a practical and realistic solution to support future growth of communication traffic. This was a milestone for me as a researcher and I am now working to realize the practical use and mass production of those research outcomes.

I always keep it in mind as a researcher that when I encounter a new phenomenon or challenge, I will review the relevant accepted theories, papers, and books to find any oversight or omission in them and think it out until I can understand it and become convinced.

Research involves constant encounters with something unknown or new and clarification of it. You may face a huge barrier. To overcome it, you have to think thoroughly and care about things in a persistent manner. This is my style as a researcher. Sticking to the professional style, I hope to grow to be a researcher who can promote technological progress, and create technologies and products that widely support society.



*Technology to transmit multiple signals with light of respectively different wavelengths in order to increase the transmission capacity of an optical fiber

QUARTERLY

id Topics from the future-shaping Sumitomo Electric Group

The new plant established in Moldova has started full-scale operation

Prime Minister H.E. Mr. Pavel Filip (right) and Tomoyuki Miyake, President of Sumitomo Electric Bordnetze at the plant opening ceremony

The Republic of Moldova is an inland European country located between Romania and Ukraine with a population of about 3.5 million.

Sumitomo Electric Bordnetze SE, a German subsidiary of Sumitomo Electric operating an automotive wiring harness business, constructed the main plant of its subsidiary S.R.L. SE Bordnetze in Orhei, a central district of Moldova, and held the opening ceremony in October 2017.

The automotive industry is at a stage of major innovations and we are also working to establish a stable production and delivery system to further enhance our competitive position in Europe.

While S.R.L. SE Bordnetze is currently operated with approximately 470 workers, we plan to increase the number to about 2,500 in 2019. H.E. Mr. Pavel Filip, Prime Minister of the Republic of Moldova, attended the opening ceremony of the plant and said that "2,500 Moldovan people can work in their home country. That means the full-scale operation of S.R.L. SE Bordnetze will make 2,500 families in Moldova happy." The opening ceremony was also featured in the local news, which indicated the high expectations of local people for the plant.

We will endeavor to ensure that S.R.L. SE Bordnetze can grow smoothly and meet customer needs to contribute to employment promotion and industrial development in Moldova and other European countries.

Mitsuo Nishida, Vice President of Sumitomo Electric (5th from left), H.E. Mr. Pavel Filip, Prime Minister of the Republic of Moldova (6th), H.E. Mr. Masanobu Yoshii, Ambassador of Japan to the Republic of Moldova (8th), Fumiyoshi Kawai, President of Sumitomo Wiring Systems, Ltd. (9th) and related parties of S.R.L. SE Bordnetze

Employees of S.R.L. SE Bordnetze at the opening ceremony

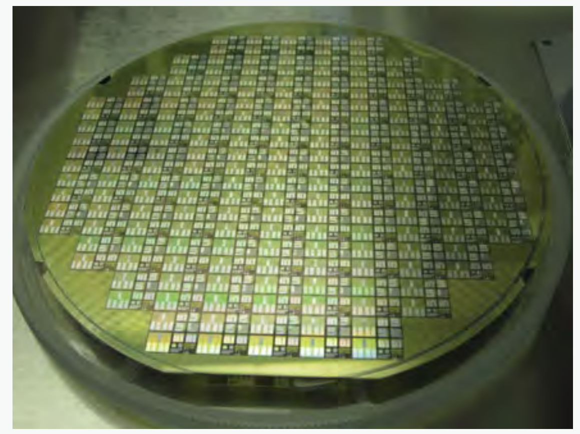
We contribute to an energy-efficient society by developing next-generation materials and original technologies

SiC epitaxial substrate "EpiEra™"

Electric equipment is basically equipped with power devices, or semiconductor devices for voltage, frequency and AC-DC conversion. It is anticipated that global energy consumption will further increase in the future with population growth and economic development in emerging countries. In the meantime, energy loss due to heat radiation from power devices is estimated to approximately 5% of the total energy consumed in the world. To reduce the loss, efficient conversion of a large amount of power is needed as a major key to an energy-efficient society.

Power devices are usually produced by laminating epitaxial layers on a wafer (epitaxial substrate) and applying fine machining to them. While a single material "silicon (Si)" has been used conventionally, a compound "silicon carbide (SiC)" now attracts attention as a next-generation material. With a nature between that of a diamond and that of silicon, SiC has high hardness, heat resistance, chemical stability and ability to withstand high voltage. This material is expected to help reduce energy loss and downsize products. On the other hand, it has been technically difficult to produce a defect-free epitaxial substrate with SiC.

Nevertheless, Sumitomo Electric has succeeded in the mass production of the high-quality and reliable SiC epitaxial substrate "EpiEra™" using its original growth technology (MPZ™) based on high-accuracy simulation in addition to the compound semiconductor technologies accumulated over many years in the Company. It has achieved an industry-leading 99% defect-free area (DFA), which represents the usable area with no surface defect, on the wafer surface. Sumitomo Electric further aims to achieve a completely defect-free epitaxial substrate, which will help realize an energy-efficient society.

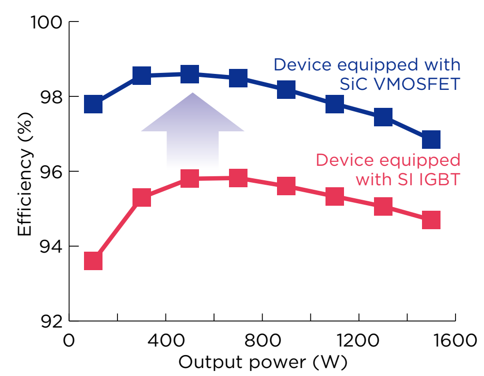


Device formed on a 6 inch EpiEra™

SiC Efficiency improvement achieved by using SiC

Sumitomo Electric's power storage system for household use "POWER DEPO™ Ⅱ" is experimentally equipped with SiC power devices. It has improved the efficiency by more than 2 points across the power range in comparison with that with Si power devices. SiC power devices are expected to be used in the automotive field, in which an increasing number of electric vehicles are introduced; the railroad and other transportation fields, in which the energy efficiency and weight reduction of vehicles are required; the energy field, in which power plants are involved in a large amount of energy loss; and the information and communication field, in which stable power supply and space saving in data centers and other facilities are required. If efficiency was improved in all of the motors used in Japan, the power of approximately 11 billion kWh could be saved, which is equivalent to the electricity used in 3 million households.

Power efficiency (discharge)
Comparison of devices with an input voltage of DC 100V and an output voltage of AC 100V



Power storage system for households "POWER DEPO™ Ⅱ"

Input: 100V 1kW
Output: 100V 1kW
Frequency: 20kHz

A Picture of Sumitomo Electric in Those Days

1922

Installation of the World's Longest Submarine Power Transmission Line

An end of the cable pulled up to Shisakajima

Overcoming Many Troubles

–Our Technology Connected Niihama City, Ehime, and Shisakajima

In 1922, Sumitomo Electric Wire & Cable Works (present Sumitomo Electric Industries, Ltd.) successfully completed a project that was considered to be impossible with the technology of that time, namely the installation of a 21 km submarine cable from Niihama City, Ehime to an offshore island called Shisakajima.

A refinery was relocated to the uninhabited island of Shisakajima to avoid smoke hazards in 1905. After that, the cost of transporting coal for fuel to the coal-fired power plant in the island became a problem. There was a large hydropower plant on the opposite shore in Niihama and power transmission from it to the island would reduce the cost to one fifth. However, the world's longest submarine cable in those days, which was in San Francisco, was only 6.7 km long. There was no technology to install a submarine cable exceeding three times its length anywhere in the world.

Just then, the coal-fired power plant was damaged. It was decided to install a power transmission line from Niihama to the island and the whole project ranging from the design and production of the cable to the installation was delegated to Sumitomo Electric Wire & Cable Works. The company thoroughly studied submarine cables in the United States and Europe and concentrated the experience and knowledge to complete a high-performance cable full of originality and ingenuity. Overcoming a series of problems, such as suspension of the work due to rainstorms and malfunction of the cable, underwater installation work was carried out over 20 days to successfully install the world's longest submarine cable of that time. This experience dramatically improved the submarine cable technology of Sumitomo Electric Wire & Cable Works.

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

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