Development of Sumitomo Electric's Flexible Printed Circuit Business

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Sumitomo Electric is a comprehensive wiring material manufacturer who was among the first to start developing flexible printed circuit (FPC) in Japan about forty years ago. It was only in the latter half of the 1970s that FPC began to be used in consumer products and the FPC market has been steadily growing year after year since the 1980s. Since the full-scale spread of mobile phones in 2000, the FPC market has been expanding rapidly. During this time, Sumitomo Electric has been actively engaged in developing new products, new materials and new technologies (connection technology, etc.) by fully utilizing its integrative capability as a comprehensive wiring material manufacturer. The Company faced a harsh business environment during Japan's prolonged recession after the collapse of bubble economy in the early 1990s, but was able to over come business difficulties by conducting business actively. The FPC business of Sumitomo Electric has grown much larger as the Company utilized its flexibility, creativity and extensive technological capabilities in contributing to size and weight reduction as well as to function and performance improvement of electronic equipment. This paper describes the expansion of Sumitomo Electric's FPC business.

1. Overview of FPC

1-1 FPC features and applications

Flexible printed circuits (FPC) is, as the name suggests, a circuit wiring material that has flexibility. Since they are thin and lightweight, they have contributed greatly to making devices more compact, lighter and thinner. In addition, their excellent heat resistance makes mounting parts by reflow soldering (heated solder treatment) possible. Furthermore, their excellent durability in repeated bending makes them indispensable as wiring materials in the moveable parts of devices. They have been used extensively to take advantage of these features, including in the internal wiring of mobile telephones and digital cameras, the moveable parts wiring of hard disk drives (HDD), optical disks and other devices. (**Photo 1** shows a HDD and mobile telephone.)

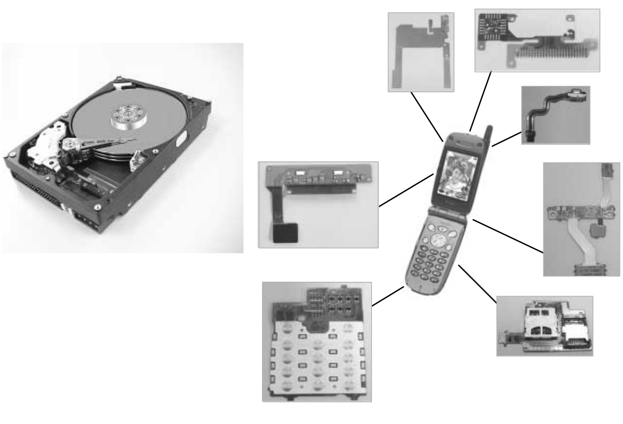

Photo 1. HDD and mobile telephone

1-2 Basic structure

Figure 1 shows the cross-sectional structures of single-sided, double-sided and multilayer FPCs.

In single-sided FPCs, etching of the core copper layer forms the circuit. Polyimide (PI) film insulation layers are attached with a thermosetting type adhesive above and below this circuit layer to protect the circuit from external stress. Coverlay openings are made selectively by punching with a die or other means to expose the copper layer in order to mount parts, attach connectors and so on. The surface of the exposed copper layer is nickel/gold plated, solder plated or anti-oxidation treated, for example. In recent years, in response to needs for improved heat-resistance and thinner materials, adhesiveless basematerial (two-layer material) has also been used widely. Furthermore, since FPC itself is thin and flexible, in many cases, stiffener is applied to the areas where connectors are attached or parts are mounted.

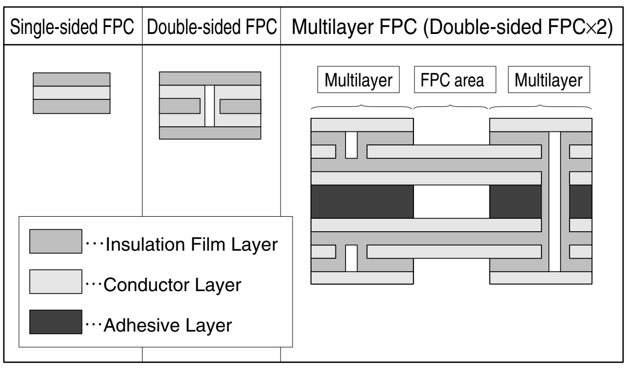

Fig. 1. Cross-sectional structural diagram

In double-sided FPC, a copper layer is on both sides of core PI film, and conduction is normally achieved through the copper plating of holes that pass through the core layer between the copper layers. This method is called plated-through-hole (PTH). The formation of insulation layers and the application of stiffeners is the same as that for single-sided FPC.

Since a multilayer FPC is, as the name suggests, fundamentally multiple layers of single-sided or double-sided FPC, conduction between circuit layers is achieved by PTH. Other connection methods also exist, such as blind-via-hole (BVH) for the purpose of high-density wiring and the use of conductive paste.

1-3 Materials

For the FPC insulation layer, PI film is normally used because it has excellent heat-resistance and a thermal expansion coefficient that is close to that of the copper foil. If the need for heat-resistance is low, polyester (PET) film is sometimes used. Furthermore, when high frequency characteristics are emphasized, liquid crystal polymer (LCP) is sometimes used. The main thicknesses of PI films are 25 μm (1 mil) and 12.5 μm (1/2 mil). Recently, photosensitive covercoats have been used frequently to handle high-density mounting. Covercoats that have epoxy resin or polyimide resin as main components have excellent heat-resistance and flexibility.

The two types of copper foil used are electrolytic copper and rolled copper. Electrolytic copper is relatively inexpensive, but when folding endurance is desired, rolled copper is used. Recently, electrolytic copper with improved folding endurance has been chosen when it meets desired specifications. Typical copper foil thicknesses are 35 μm (1 oz), 18 μm (1/2 oz), and 12 μm (1/3 oz).

1-4 Design

In FPC design, there is product design, which includes product structure, materials selection, outline shape and wiring patterns, and production design, which includes design of the manufacturing process, dies and fixtures.

FPCs are designed and order-made to the individual specifications required by customers, which include electronic and mechanical characteristics and so on. Furthermore, in product design, in order to prevent trouble during customer mounting and assembly processes, it is crucial that the design is done in consideration of quality and cost based on a clear understanding of the applications. Since these details are not often included in diagrams and other specification documents, regular consultation with the customer at the design stage is necessary.

For visual appearance standards, in particular, setting criteria that do not influence performance in advance is important considering the effective utilization of resources and the reduction of costs.

On the other hand, in production design, the design of the manufacturing process is conducted in consideration of cost and yield while fulfilling the required product specifications. In particular, in a fixed material area, since the number of units greatly influences the cost, coordination with outline shape design in product design is important.

1-5 Manufacturing process

Figure 2 shows a typical manufacturing flow chart for double-sided FPC. After (1) basematerial cutting, (2) NC drilling, and (3) PTH, the process is fundamentally the same as with single-sided FPC.

Circuit formation, insulation treatment, plating and other surface treatment steps are called the front-end process or the upper process, and manufacturing is implemented in the form of rolls or fixed-sized sheets (worksheets). Circuit formation is conducted using a photosensitive resin (etching resist) called "dry film" (DF) in a process of exposure, developing and etching. Insulation treatment is conducted by heat lamination with thermosetting adhesive on PI film where holes have been selectively opened as coverlay openings with a die or other device. The photosensitive covercoat is formed through a process of exposure and developing that is the same as for circuit formation, followed by heat treatment and UV exposure. Nickel/gold, solder, or other material plating is applied to the exposed copper depending on the electroplating or electroless plating method. Anti-oxidation treatment is sometimes used instead of plating.

In the front-end process or lower process, worksheets are divided into sizes that are easy to treat. Usually, after the application of stiffener and double-sided tape, the product form is finished by punching using a die. When the stiffener requires heat-resistance, heat lamination is done with a thermosetting type adhesive. When heat-resistance is unnecessary, attachment is done with double-sided tape. Inspection is usually conducted on every piece and includes electrical inspection to detect if circuits are open or have shorts and visual inspection to check other things. Recently, it has become common to do every step up to parts mounting, so more sophisticated inspection techniques are required.

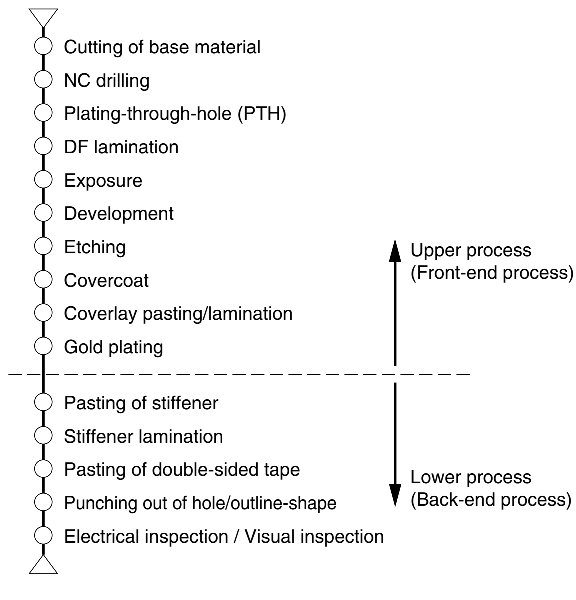

Fig. 2. Manufacturing process for double-sided FPC

2. Changes in FPC market and expansion of Sumitomo Electric's FPC business

Flexible printed circuits was born around 1960 by using polyimide film developed by DuPont in the USA. As the name suggests, FPCs are printed circuit boards in the form of film that have outstanding flexibility and bendability. At first, they were used in aerospace industry and other applications that required high reliability. At the beginning of the 1970s, this technology was brought to Japan and it achieved great growth, mostly in consumer applications. As shown in **Fig. 3**, in the 1970s, a large amount began to be used with the advent of electronic cameras and to make more compact calculators. In the 1980s, great numbers were used in home video recorders, car audio/video systems and other consumer electronic devices. In the 1990s, inclusion in video cameras, CD players and other mobile devices became common. In addition, application in HDDs, DVD drives, flat panel displays and other computer peripherals increased. Since 2000, mobile telephones and digital cameras have taken off, and a sudden increase in demand caused an FPC supply shortage in 2003, causing difficulty for customers and increasing awareness of the importance of FPCs.

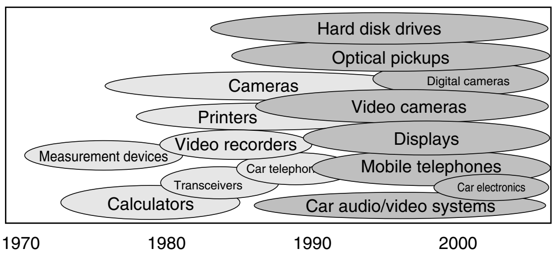

Fig. 3. FPC market change

Sumitomo Electric started FPC development in 1965 at its Osaka Works R&D. In 1969, the Company started business as the Development Section for Component Materials. In 1974, the Company incorporated manufacturing technologies from the US company Teledyne Electro-Mechanism, Inc. and began large-scale production of FPCs for calculators and cameras. When car telephone service was begun in 1979, Sumitomo Electric succeeded in monopolizing related orders. Furthermore, in expectation of increased orders for video recorders and printer applications as well, it was decided that this business be moved to the Nagoya Works to expand business. Also, an etching line and other equipment that were the most advanced at that time were installed to double the equipment capacity and reduce costs. Also installed at the same time was a computer system that handled the process from receiving orders to delivery of products in order to increase work efficiency. This development in Nagoya was a large undertaking that had many difficulties, but it was also the beginning of business expansion that followed. The Development Section for Component Materials was incorporated into the Electronic Wire Division in 1975, and it became the Electronic Wire Division Flexible Printed Circuit Department in 1983 along with business expansion. At Kanto Works a screen-printing line for consumer applications was installed in the following year, and a photo-printing line for computer peripherals was installed in 1985. Meanwhile, in the Nagoya area, Nagoya Sumiden Electronic Wire, Inc., which had been responsible for electronic wire manufacturing, started FPC lower process production in 1988. The following year, its name was changed to Sumiden Circuit, Inc. (SECT) in order to make it a subsidiary for FPC production in the future. Then, in response to increased orders for parts for video recorders and other consumer devices, the SECT Shiga Plant was opened and integrated production of FPC started in 1990.

The Flexible Printed Circuit Department became independent from the Electronic Wire Division in 1992. However, with the collapse of Japan's economic bubble, demand became stagnant, so Sumitomo Electric shut the Kanto Plant and reformed its FPC business structure, centering it on SECT. In the following year, after the Company's continuous structural reform efforts, the Flexible Printed Circuit Department was transformed into a division.

During this period, the FPC business environment became more difficult each year. One cause was the lowering of the market price and another was the sudden shift by customers to overseas production. In response to the former problem, a fine pitch streamlined line began operation at SECT in 1996. In response to the latter problem, FPC lower process production began from 1994 at Songgang Electronics Wire Factory (SGEW) in Shenzhen, China. In addition, First Sumiden Circuits, Inc. (FSCT) was established in the Philippines as a joint venture with the local Lopez Group in 1996 and began integrated production of single-sided FPCs which were supplied to Southeast Asia the following year.

After this, in order to further promote the strengthening of the organization and implement structural reform, Sumitomo Electric Printed Circuits, Inc. (SECT) was established in 2000. Sumitomo Electric also established its new Minakuchi Plant and built a streamlined line for double-sided FPCs. The Nagoya Plant was closed at that time and the design, prototyping and development functions were gathered to the Minakuchi Works. At this point, SECT became a complete FPC production company. Since 2000, the demand for double-sided FPCs and multilayer FPCs for mobile telephones has increased rapidly. To respond to this increase in orders, more lines for double-sided FPCs and multilayer FPCs have been steadily built at the Minakuchi Works. As Sumitomo Electric expanded the production capacities and capabilities of its overseas bases, it also enhanced its parts mounting line that had begun operation in 1999. The Company began new lower process production and parts mounting at Suzhou (SESZ) in 2005, and started lower process production at its new Vietnam Plant in the second half of 2007. Furthermore, in order to respond to orders from European and American users, which have been increasing recently, Sumitomo Electric is also in the process of enhancing its FPC production globally including parts mounting as shown in **Fig. 4**.

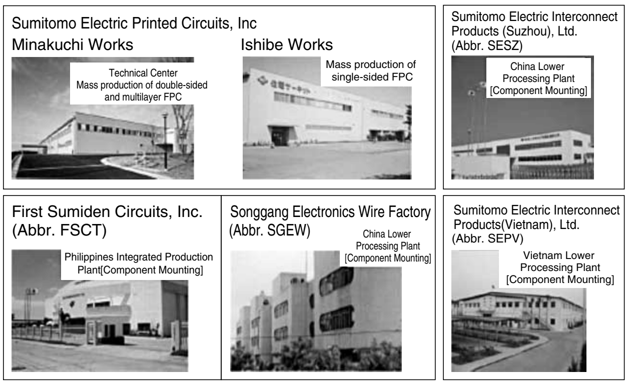

Fig. 4. FPC global production structure

3. Technology trends

This section discusses technology trends from 1970 to the present.

3-1 1970s

In 1975, highly bendable double-sided FPCs were first used in personal calculators. When Sumitomo Electric received information about the development of a revolutionary compact calculator from a major consumer electronics manufacturer, the Company also received a request to develop a double-sided FPC that could be bent repeatedly. The required specifications were for an FPC that could be bent more than 30,000 times at 180˚. Until then, bendable parts of double-sided structures were known to only be able to withstand bending of 50 to 60 times before connection would be broken. Sumitomo Electric conducted evaluation of prototype structures where the bendable part was single-sided and the rest was double-sided FPC, but all of them failed in 1000 or fewer repetitions. As a result of analyzing these results, the Company adopted a single-sided structure for the part that was to be bent repeatedly and used a plating-through-hole (PTH) process that did not put copper plating on the circuit. This structure cleared 50,000 repetitions in bending tests, exceeding the required specifications of 30,000 times. Sumitomo Electric also patented the structure. **Photo 2** shows an application example.

This first application of an FPC in a compact calculator inspired the expanded application of FPCs in low-profile calculators and other items that made use of the thinness and other features of FPCs.

In 1977, use of FPCs in on-board transceivers, car audio/videos and other consumer devices began to become increasingly common. Along with the trend toward compact, lightweight, on-board devices with advanced functions, Sumitomo Electric received requests from their manufacturers to seriously investigate the use of FPCs. At that time, the engineers at device manufacturers had little knowledge about FPC design, but by working with Sumitomo Electric designers on FPC design and cost investigations, they were able to use FPCs for the first time.

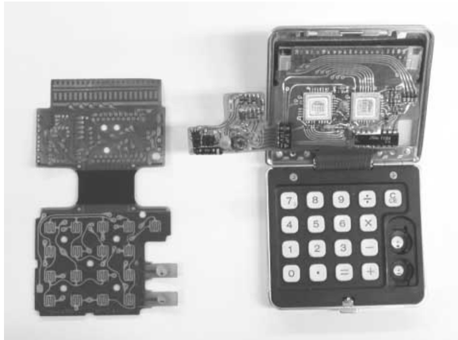

Photo 2. Compact electronic calculator

As a result of the second oil shock in 1978, procurement of the paper phenol board that had been used as an FPC stiffener became unstable. In order to provide users with a stable supply, Sumitomo Electric developed a new stiffener of nonwoven polyester, which could be procured steadily that was impregnated with epoxy (in-house name: K II B) as a substitute material. This stiffener had good processing characteristics, and the Company used it as a standard material until the 1990s.

As FPC began to be used widely in consumer applications, Sumitomo Electric also developed a screen print-type coverlay, which was named Screen Print Overlay (SPOL), stiffener adhesives and other materials using its comprehensive capabilities.

In 1979, Nippon Telegraph and Telephone Corporation (NTT) began the first service for car telephones (shown in **Photo 3**) in Japan using Sumitomo Electric's FPCs. Since car telephone wireless equipment was carried in car trunks, compact size and light weight was needed, so double-sided FPCs with connector mountings were used for internal wiring materials. Another benefit that the Company offered was that by providing FPC units with

Photo 3. Car telephone

connectors, users were allowed to connect the wiring inside the equipment easily by themselves. Through communication equipment manufacturers, Sumitomo Electric's FPCs were used by NTT for the first time.

3-2 1980s

In 1980, home video recorders (VCR/VTR) started to become common around the world. In 1982, function IC (FIC) boards (FPC with a metal stiffener) for video recorders were developed and began to be used as a standard part. Major electronics manufacturers sought to reduce hybrid IC costs in order to produce video recorders that were more compact, lighter and cheaper and they worked with Sumitomo Electric on the development of FIC boards. The features of FIC boards are that (1) FPC with a metal stiffener has a heat radiation function and the automatic mounting of electronic parts on it is possible, and (2) mounting density can be increased by bending FPCs and vertically mounting them to rigid printed circuit boards (RPC). Sumitomo Electric (1) developed an adhesive to attach metal stiffener to FPC and (2) established punching technologies for FPC with metal stiffener attached and other mass production processes. An automated line for FIC board production was added at the Kanto Plant, contributing to cost reduction. At that time, all the video recorders of the customers of Sumitomo Electric used FIC boards as standard parts, achieving reduced price, size and weight for VCRs.

An application example is shown in **Photo 4**.

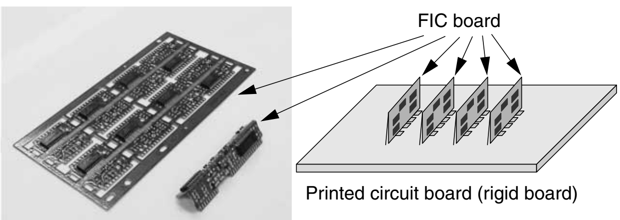

Photo 4. FIC board and mounting diagram

By establishing design and manufacturing technologies for FPCs with metal stiffeners, the Company was able to develop FPCs for various motors, optical pickups and other products.

At around the same time, use of FPCs in cameras and plasma displays (PDP) also began to become widespread, and Sumitomo Electric developed FPCs that were heat-resistant and possess anti-migration properties.

In order to popularize still cameras among ordinary consumers, electronic cameras that were more compact and lighter, but also had features such as autofocus and electronic shutters had been developed. FPC received sudden attention as a wiring material in the small spaces of these cameras. Sumitomo Electric developed coverlay adhesive that responded to technological demands for FPCs that compact chip parts can be mounted and the adhesive can withstand reflow temperatures. Furthermore, the Company also established mass production technologies to fulfill demands for FPC flatness, high dimensional stability and other high precision requirements. As shown in **Photo5**, many kinds of FPCs were used for cameras. Plasma display panels (PDP) started to become popular as personal computer display equipment. As FPCs were investigated for use as PDP connection leads, there were requirements related to (1) anti-migration properties due to the high voltage of PDPs, (2) circuit pitch dimension stability for connection with the PDP, and other technological issues. In order to satisfy these specifications, Sumitomo Electric developed basematerials, adhesives and other materials. **Photo 6** shows application examples.

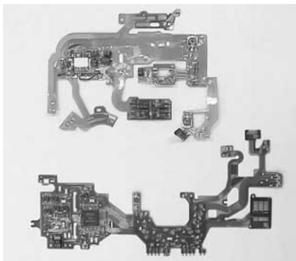

Photo 5. FPC for camera use

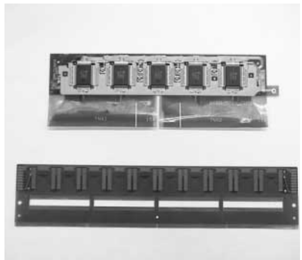

Photo 6. FPC for PDP use

Around the middle of the 1980s, there was demand for the development of domestic FPCs for applications in floppy disk drives (FDD) and hard disk drives (HDD), which were using US-made FPCs, so Sumitomo Electric worked on the development of flexible, highly bendable basematerials.

In the USA, flexible FPCs that had no coverlay were used for personal computer FDD heads. Japanese FDD manufacturers were importing US-made FPCs, but as disk drives became more popular, Sumitomo Electric received a request to develop FPCs that were only 1/3 the price of the US-made FPCs for the drives. Considering the anticipated expansion of the floppy disk drive market, the Company developed FPCs with flexible substrates. **Photo 7** shows examples.

At that time, US-made Winchester-type FPCs with high bending endurance were used in the heads of hard disk drive (HDD) computer storage devices. As the HDD industry grew in Japan, Sumitomo Electric received requests from HDD manufacturers to develop FPCs with the equivalent structure as U.S made FPCs and with high flexing performance of 100,000,000 repetitions or more. The Company was able to achieve this through development of a new basematerial and the establishment of manufacturing processes and bending evaluation procedures using specialized bending testing apparatus. **Photo 8** shows a Winchester-type FPC for HDD. Even now, as the demand for HDDs for personal computers and digital consumer electronics continues to grow, the demand for FPCs for HDDs also grows.

Photo 7. FPC for FDD use

Photo 8. Winchester-type FPC for HDD use

Sumitomo Electric also worked to develop multilayer flex/rigid wiring boards for aerospace industry applications. The equipment used by the Japanese aerospace industry had been mostly developed in the USA and imported. As domestic manufacture of these devices began, multilayer flex/rigid wiring boards (multilayer F/R) were used for internal wiring in devices, so Sumitomo Electric received requests to develop multilayer F/Rs with equivalent structures. Judging that the demand for multilayer F/R would grow in the future as the functions of equipment became more advanced, the Company undertook active development. Overcoming issues with FPC lamination materials and processing technologies, through-hole reliability and other technological issues, Sumitomo Electric established multilayer F/R (3-6 layers) technology and began mass production. **Photo 9** shows application examples. The foundations for the multilayer FPCs used in mobile telephones and other consumer applications have been built at present.

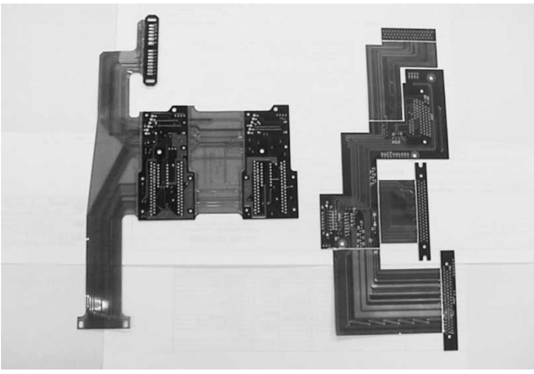

Photo 9. Multilayer F/R

In the second half of the 1980s, Sumitomo Electric developed the new connection technologies in response to FPC market expansion. At that time, there were no technologies for easily connecting FPCs and rigid printed circuit board (RPC) with high reliability, creating an obstacle to the expansion of the FPC market. The Company developed Pin-Attached Flex and Terminal Flex to provide users with new FPC connection technologies that would overcome this obstacle. Pin-Attached Flex, in which pins are attached to FPC tips at a fixed pitch, allows direct soldering to RPC boards along with other electronic parts, making connection easy. The demand for pin-attached flex in portable video and 8-mm video cameras, CD players and other compact, lightweight consumer devices has grown. **Photo 10** shows examples. Terminal Flex allows high-density connection to meet requirements for even more compact size, lighter weight and more advanced functionality. With Terminal Flex, the connection terminal part is a comb shaped double-sided structure, and the tip has a structure that is cut at the center of the through-hole. In other words, the connection terminal part is stiff enough and direct soldering to the RPC is possible. Terminal Flex has been evaluated highly by its users, and even now, it is being used for compact size and light weight, particularly in tight spaces. It can also be used for surface mounting.

Photo 11 shows utilization examples.

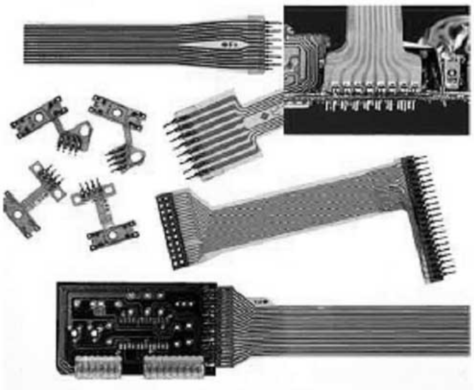

Photo 10. Pin-Attached Flex

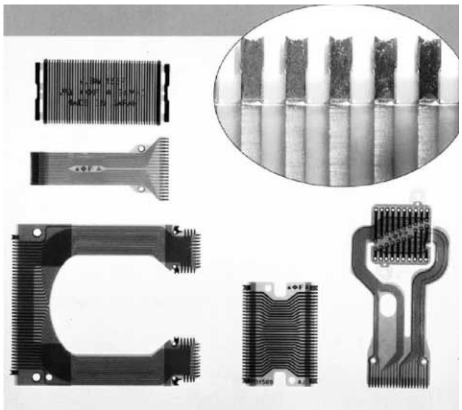

Photo 11. Terminal Flex

3-3 1990s

The miniaturization and increased functionality of electronic devices progressed steadily, and demand for the development of higher function fine-pitch FPC products increased along with the advancement of digitalization.

In the first half of the 1990s, development of early mobile telephones (NTT's Mova series) began, and a major manufacturer asked Sumitomo Electric to develop hinge wiring for the first foldable mobile telephones in the world. In order to achieve a folding endurance of 100,000 repetitions, the Company immediately adopted two-layer basematerial (base film and copper foil without adhesive), which was at the development stage at material manufacturers then. Even though they were double-sided FPCs, they were made thinner using a process without copper plating for the bending part, greatly improving their folding endurance. These technologies formed the foundation for recent mobile telephone FPC technologies. **Photo 12** shows an example

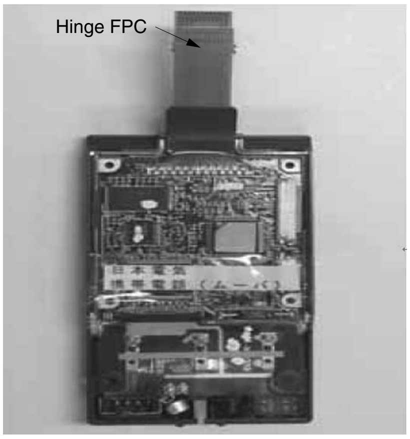

Photo 12. FPC for world's first folding mobile telephone

In the middle of the 1990s, to reduce the profile of the magnetic recording (MR) heads used in HDDs, Sumitomo Electric received requests from major Japanese manufacturers to develop FPCs with bumps for connection with MR heads. The Company made small diameter openings in the polyimide film by introducing laser-processing technologies, and developed FPCs with bump formations by applying copper core plating and solder plating to that part. As a result of this, narrow pitch connections to MR heads with high reliability became possible, earning high evaluations from customers. In addition, the Company achieved high quantity orders from American users, and this became one of its new products with high added value. **Photo 13** shows an application example.

In the second half of the 1990s, to raise HDD signal access speed, the pre-amp ICs mounted on FPC connectors needed to be brought closer to the MR heads in a narrow space. To do this, Sumitomo Electric developed a flip-chip mounting technology using bump connections in place of conventional wire bonding connections. To achieve quality assurance at the same time, the Company also introduced X-ray analysis inspection equipment. This technology has been indispensable for HDD performance improvement, and Sumitomo Electric is currently providing large supplies to three major HDD makers. **Figure 5** shows an application example.

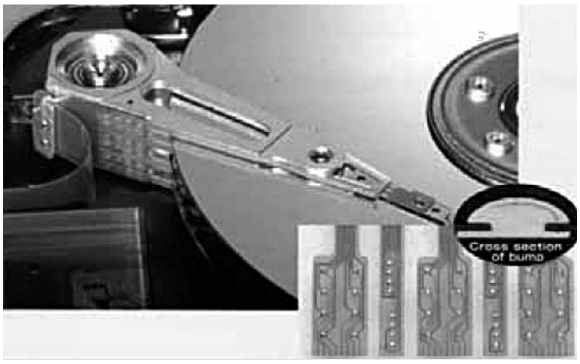

Photo 13. FPC with bumps

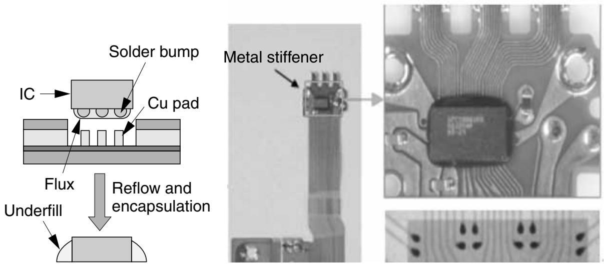

Fig.5. FPC with flip-chip mounting

Around the same time, the transmission signal speed of mobile telephones was increasing and, in particular, the need for highly bendable, shielded FPCs for hinge wiring increased. Sumitomo Electric had already developed shielded FPCs with copper paste applied for video recorders and other applications through cooperation with Tatsuta Electric Wire & Cable Co., Ltd. Now, however, the Company developed shielded FPCs with greatly improved bendability by using a deposited silver layer and conductive adhesive in the shield layer. The Company applied for a patent at this time and acquired domestic rights in 2004. Now this technology is used in mobile telephones around the world. **Photo 14** shows an example.

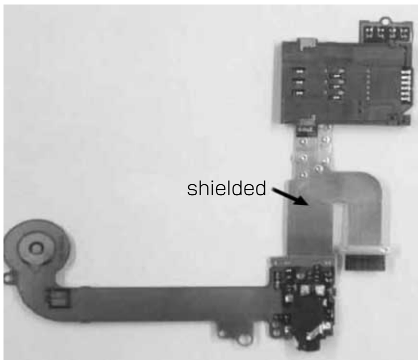

Photo 14. Highly bendable, shielded FPC

3-4 Since 2000

Mobile telephones have become increasingly common, and with the appearance of clamshell-type foldable models, the number of FPCs used, especially in the hinge wiring, has grown rapidly in Japan since 2000. Furthermore, the amount of information handled by mobile telephones and their need for high-speed transmission has increased with the addition of cameras and larger liquid crystal displays that are also in color. In order to respond to these changes, Sumitomo Electric promptly developed multilayer FPCs as shown in **Photo 15**. In multilayer structures with parts on 2-6 layers, bendability is increased by using a hollow structure called an "air gap" for the bending part. As a result, the application of multilayer FPCs increased rapidly, and the Company could not keep up with demand around 2002-2003, so it proposed the alternative design shown in **Fig. 6** to meet customer needs. In this design, rigid multilayer boards and FPC are manufactured separately and later connected by anisotropic conductive film (ACF), which also results in cost reduction.

In addition, as a countermeasure for electromagnetic interference (EMI) in order to support high-speed transmission, the Company developed a low-profile shield film with excellent bendability and heat-resistance, which is now used widely in hinges and other parts. Sometimes silver paste is applied instead of shield film, and this option can be selected to meet the required specifications. Furthermore, Sumitomo Electric has an array of simulation technologies and various measurement technologies for impedance-controlled circuit designs to handle high frequencies.

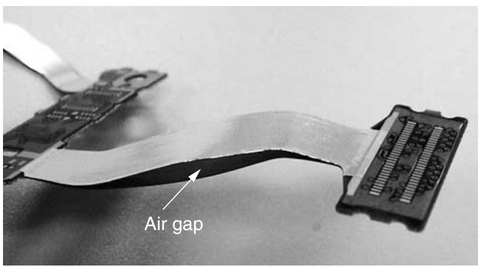

Photo 15. Multilayer FPC

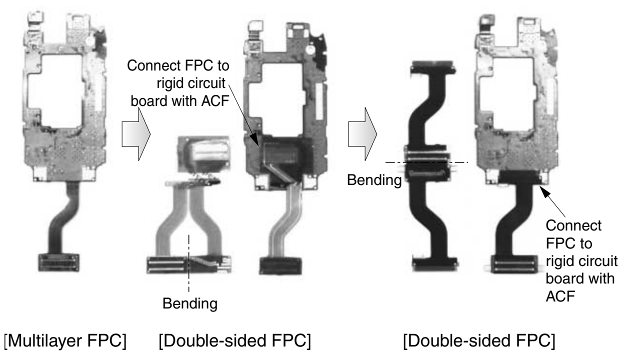

Fig. 6. Multilayer FPC alternative design example

For high-density mounting requirements, Sumitomo Electric began mass production of BVH double-sided FPCs as shown in **Fig. 7** and applied it in the world's first mobile telephones with built-in cameras. With this, the Company has made full-grid chip-size package (CSP) mounting possible even for double-sided FPCs.

Furthermore, along with the slimming of mobile telephones and the shrinking of digital camera sizes, liquid crystal modules have also become thinner, making requirements for improved FPC flexibility even higher. In liquid crystal modules, the glass panel and the main board are connected by the FPC, which is frequently folded and stored in an extremely narrow space. For this reason, along with flexibility, the need for FPCs with low spring-back has grown. Sumitomo Electric has developed a liquid-type polyimide (PI) covercoat that has low rebounding characteristic compared to conventional films, and the Company made this into a product in 2004 (**Fig. 8**). To respond to slimmer designs, Sumitomo Electric is developing an FPC product that puts our original high-conductivity silver paste on a single-sided FPC to form a jumper circuit (**Fig. 9**). While their function is equivalent to double-sided FPCs, the Company has reduced thickness by 40% and cut costs.

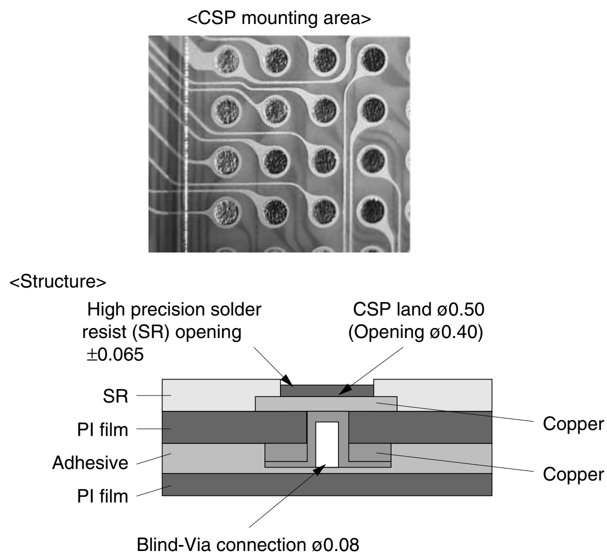

Fig. 7. BVH double-sided FPC

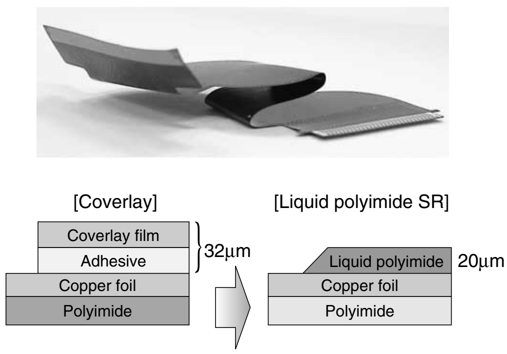

Fig. 8. Covercoat in liquid state

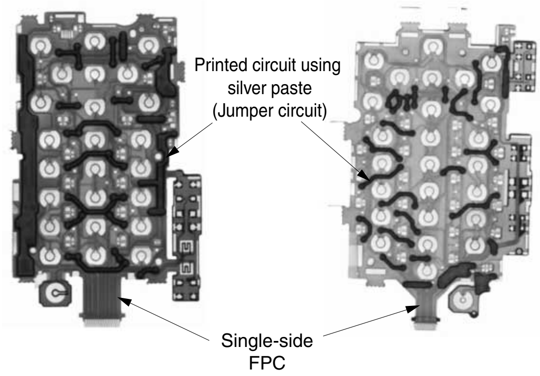

Fig. 9. FPC with jumper circuit

One issue has been that surface mounting technology (SMT) is the usual method for attaching parts to FPCs, but the number of parts is low and the amount of irregular parts is high compared to rigid printed circuit boards. As a result, the mass production lines of electronic equipment set manufacturers have poor efficiency, and the demand for mounting by FPC manufacturers is growing. In response to this demand, Sumitomo Electric has incorporated a mounting line to handle irregular parts and have begun to provide mounting services for its customers. The Company handles every part of the process in an integrated manner from the procurement of electronic parts to quality assurance after parts mounting. By doing this, interim inspections can be cut, production lead-time can be shortened and distribution costs can be reduced. The merits for customers, including reducing the difficulties of parts procurement, are great.

Implementation of parts mounting is advantageous to Sumitomo Electric as a FPC manufacturer, because the Company can accumulate design expertise to prevent troubles in parts mounting processes and design the layouts to suit its own parts mounting needs. Sumitomo Electric intends to actively meet customer requests by continuously conducting parts mounting.

4. Future prospects

4-1 Technology trends

FPC can be expected to continue to be advanced as a wiring material for various electronic devices by taking advantage of its features as have been described thus far. Demand can also be expected for chip-on-film (COF) and other high-density wiring applications that require a conductor pitch of 30 μm or less. In addition, circuit formation technologies that use the additive approach, which has been implemented for some products, will become necessary. Furthermore, multilayering will advance from 4-6 layers, which is common now, to 8-10 layers, and build-up multilayer FPCs can be expected to become necessary in order to mount CSPs with a pitch of 0.3-0.4 mm. Sumitomo Electric is working to develop these technologies and can already manufacture them at the sample level. The company has now begun investigating how to improve yield and reduce cost in preparation for mass production.

Moreover, utilizing its original technologies for generation and growth control of nano-particles, Sumitomo Electric has succeeded in making high-conductivity paste and ink and ACF into products, and intends to propose new wiring and connection technologies. In addition, the Company is also producing superfine coaxial cables and flexible flat cables (FFC). Through the development of products that combine these with FPCs, for example, Sumitomo Electric hopes to provide various solutions as a comprehensive wiring manufacturer to its customers.

In response to the RoHS directive and other environmental considerations, Sumitomo Electric started to produce halogen-free, flame retardant (UL standards compliant) adhesive in-house production in 2003. Furthermore, the Company created a halogen-free, flame retardant (UL standards compliant) photosensitive covercoat product in 2005. Based on these technologies, the Company is now working on devloping products with levels of flexibility and bendability that have been improved even further.

4-2 Responding to globalization

Sumitomo Electric began significant overseas production in the middle of the 1990s, and it is currently undertaking manufacturing at five bases in China, the Philippines, Thailand and Vietnam. In the future, the Company will meet the needs of its Japanese customers who are expanding their efforts overseas and the growing demand of its foreign customers by continuing to build its global production structure and service organization.

Although competition from overseas FPC manufacturers is also becoming increasingly fierce, expectations about the reliable quality and the technological development capabilities of Japanese FPC manufacturers including Sumitomo Electric remain high. In the future, as Japanese manufacturers maintain the lead in the most advanced technologies, Sumitomo Electric will seek to utilize its comprehensive capabilities to advance its business in partnership with its customers.

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