Electromagnetic Noise Shielding Film for FPC Applications

Our company has developed and commercialized the SF-PC1000 of ultra-thin electromagnetic shielding film especially intended for flexible printed circuit applications (hereafter referred to as FPC), which can give shielding performance without degrading flexibility intrinsic to FPCs. The SF-PC1000, featuring thinness and high flexibility, is more and more widely used in mobile equipment that is required to be downsized and more functional, such as cellular phones, notebook PCs and digital cameras.

As electronic equipment becomes smaller and lighter, FPCs, which are wiring material with a high degree of freedom in design and excellent flexibility, are in greater demand.

In addition, such electronic equipment becomes more functional and operates at a higher speed, as well as becoming smaller and lighter. Therefore, it is now essential to take proper measures against electromagnetic noise. In such a situation, demand for electromagnetic noise suppression of FPCs incorporated into electronic equipment is also growing rapidly. Up to the present, for electromagnetic noise suppression, FPCs have been shielded by laminating copper foil or conductive paste. Or, components such as a rectangular ferrite core or EMI filter have been installed to FPCs. However, it is difficult to apply the shielding method using a lamination structure to the drive section on FPCs because this method degrades the flexibility of FPCs. Also, the shielding method installing noise suppression components is a problem from the viewpoint of the mounting space because mobile equipment is being downsized rapidly.

Photo 1 SF-PC1000 shielding film for FPC applications

Our company has developed and commercialized the SF-PC1000 **(Photo 1)** of ultra-thin electromagnetic noise shielding film that can give shielding performance without degrading the flexibility intrinsic to FPCs. This article introduces the structure and characteristics of the SF-PC1000 and its most frequently used applications.

Structure and Features

The cross-sectional structure of the SF-PC1000 is shown in **Fig. 1**. With the main body of the SF-PC1000, highly heat-resistant PPS film 9 μm in thickness is used as the base film. A metallic deposition layer 0.1 to 0.15 μm in thickness is formed on this base film and then a thermosetting conductive adhesive layer is formed on the metallic deposition layer. As described above, the SF-PC1000 has a three-layer structure.

Taking into consideration the working efficiency and processability during the bonding process to an FPC, a reinforcement film is laminated to the base film side, and a mold release film for protection is laminated to the adhesive side. These films are removed while processing the FPC, and finally the three-layer structure (base film/metallic deposition/conductive adhesive) is only added to the FPC, as

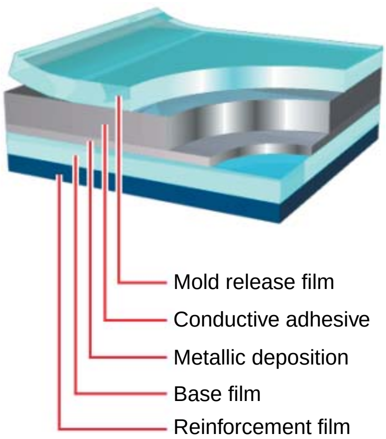

Fig. 1   Cross-sectional structure of the SF-PC1000

shown in **Fig. 2**. The metallic deposition layer is joined with the ground circuit of the FPC through the conductive adhesive and works as a shielding layer. Electrical insulation between the metallic deposition layer and the outside is achieved with the base film. The specifications and functions of each layer are shown in **Table 1**. Moreover, the SF-PC1000 can be applied to both sides of an FPC. In this case, the front and rear metallic deposition layers are electrically joined with each other through the conductive adhesive, allowing both sides of the FPC to be shielded, as shown in **Fig.3**.

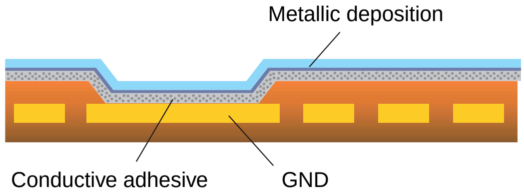

Fig. 2 Shielded FPC (Single-sided shielding)

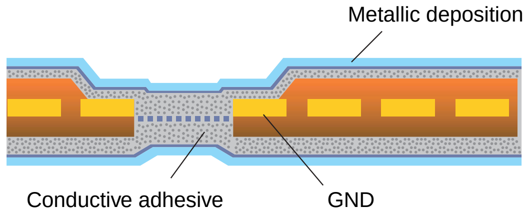

Fig. 3 Shielded FPC (Double-sided shielding)

The features of the SF-PC1000 are shown below.

- Thin and lightweight despite its three-layer structure. The total thickness is 32 μm.
- Provides excellent adaptability, flexibility, and suppleness.
- Provides excellent shielding characteristics in a wide band range.
- Reflow-soldering is applicable. (Lead-free soldering is also applicable.)
- Can be pressed simultaneously with a cover-lay film.

Table 1 Specifications and functions of each layer

Item		Specifications [1]	Functions
Mold release film (with adhesive) Removed during the production process.		PET with adhesive (#25) Thickness: 62 μm	Protects the conductive adhesive layer and prevents its contamination during the transportation and production process
Shielding film	**Base film**	Heat-resistant engineering plastic: PPS Thickness: 9 μm	Ensures electrical insulation between the metallic deposition layer and the outside. Can be reflow-soldered due to high heat resistance.
	Metallic deposition	Surface resistance: 100 mΩ/☐ or less Thickness: 1.000 to 1.500 Å (Reference value)	Works as a conductive layer to provide shielding performance. Keeps shielding characteristics of 60 dB or more in a wide band range.
	Conductive adhesive	Thermosetting conductive adhesive Thickness: 23 μm Adhesion strength: 3.0 N or more [2]	Works as a conductive layer to electrically join the metallic deposition layer (shielding layer) with the ground circuit of the FPC, and as an adhesive layer to bond the SF-PC1000 to the FPC body.
Reinforcement film (with adhesive) Removed during production process. [1]		PET with adhesive (#50) Thickness: 48 μm	Improves ease of handling and ease of punching during the production process.

1. The values described in the specifications columns are typical values.
2. The adhesion strength of adhesive layer against polyimide (Kapton 100 H, 25˚C x 40 to 60%RH)

Typical Characteristics

Bending endurance (Flexural endurance)

The result of the MIT flexural endurance test shown in **Fig. 4** is shown in **Fig. 5**. Although the flexural endurance of an FPC shielded by the SF-PC1000 is shorter than that of an FPC only, the endurance (number of bends) exceeds 10 thousand times when the radius of curvature is 0.8 mm. Thus, the SF-PC1000 has achieved a level where it can be practically used as the shielding material for a drive section. The test conditions are shown in **Table 2**.

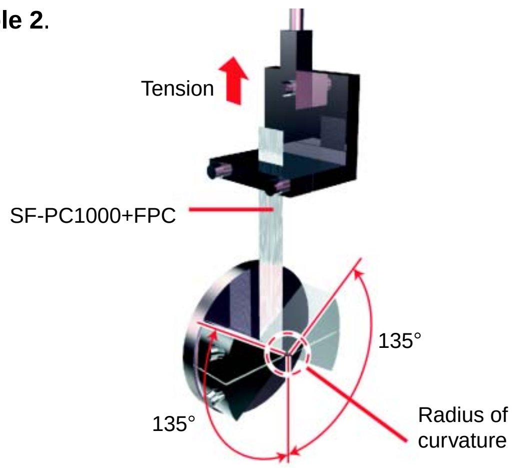

Fig. 4 MIT flexural endurance test

Table 2 MIT flexural endurance test conditions

Item	Conditions
Speed	175 times/min.
Tension	5 N
Test atmosphere	Room temperature (25˚C)
Test Patarn	12 mm width, L/S = 0.12/0.1

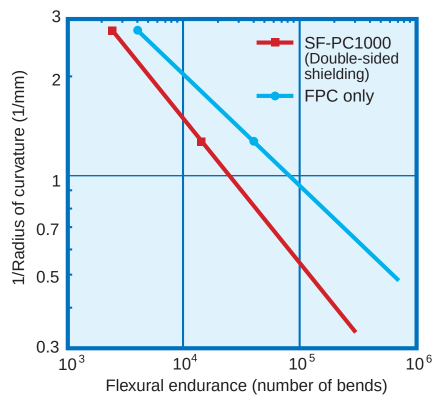

Fig. 5 MIT flexural endurance characteristics

Shielding characteristics

The shielding characteristics measured by the KEC method are shown in **Fig. 6**. The shielding characteristics are even more excellent in the order of copper foil, shielding copper paste for FPCs (NF2000 of DD paste offered by our company), and the SF-PC1000 according to the difference in electrical characteristics. However, in high-frequency bands of several hundred MHz or more, the difference in shielding characteristics between these three shielding materials is minimal, and there is not a great difference between the SF-PC1000 and the shielding copper paste for FPCs. The required level of the shielding characteristics varies depending on the equipment to which the FPC is installed. However, since the SF-PC1000 keeps shielding characteristics of 60 dB or more in the frequency range of up to 1 GHz, it can be said that the SF-PC1000 displays the shielding effects in a wide variety of equipment.

Ground join resistance

In order to allow the SF-PC1000 to display its shielding characteristics fully, it is necessary to stably join the metallic deposition layer, which is the shielding layer, with the ground circuit of the FPC. The joint resistance between the metallic deposition layer and ground circuit varies depending on the number and diameter of connection holes made in the ground circuit of the FPC. The relationship between the diameter of connection holes and joint resistance is shown in **Fig. 7** and **8**. By using the largest area possible to join the metallic deposition layer with the ground circuit of the FPC, a stable joint can be made. When a large area cannot be used for design convenience, joint stability can be improved by joining them at multiple points. As well, it is desirable that the copper foil on the FPC connected should be a gold-plated one that is electrically stable.

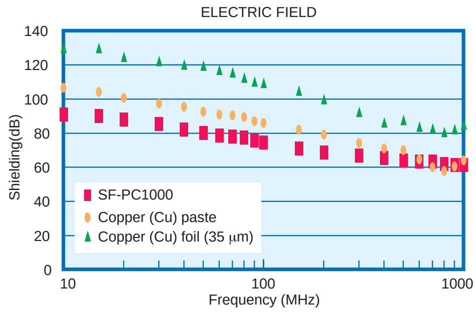

Fig. 6 Shielding characteristics (KEC method)

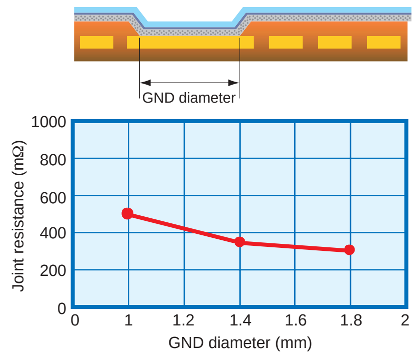

Fig. 7 Ground joint resistance (Single-sided shielding)

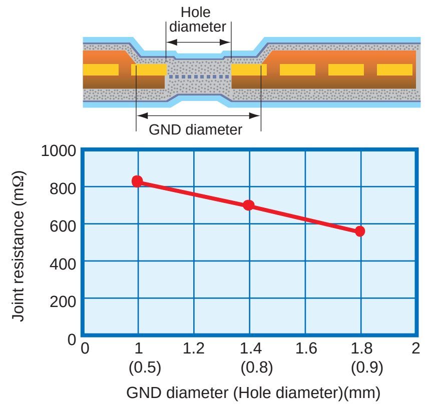

Fig. 8 Ground joint resistance (Double-sided shielding)

Processing Process

The example of the standard processing process for the SF-PC1000 is shown in **Fig. 9**.

1. Punching

Punch or half-cut the SF-PC1000 according to the shape of the FPC and remove the mold release film on the adhesive surface.

2. Pre-fixing

Fix the SF-PC1000 to the FPC at a temperature of 120 to 130˚C.

3. Thermal pressing

Bond the SF-PC1000 to the FPC by thermal pressing. The standard pressing conditions are shown in **Table 3**. Since the pressing conditions for the SF-PC1000 are the same as the standard pressing conditions used during the production process of FPCs, the SF-PC1000 can be bonded to the FPC without using special equipment or conditions. Moreover, it can also be pressed together with a cover-lay film. This increases productivity.

4. Removing reinforcement film

5. Processing the outward form of the FPC

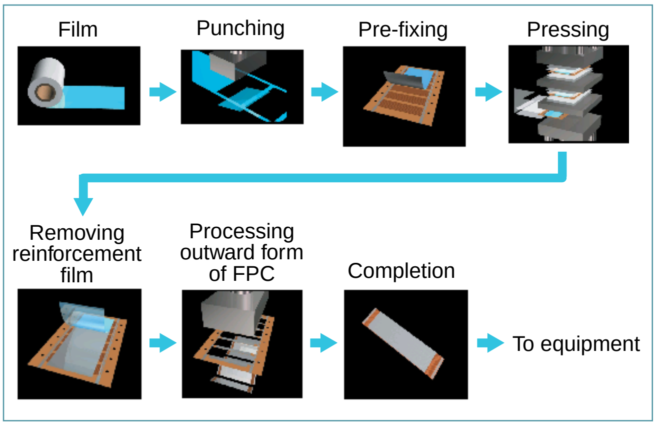

Fig. 9 Example of processing process for SF-PC1000

Table 3 Standard pressing conditions

Item	Conditions [1]
Temperature	160 to 170°C
Pressure	2 to 3 MPa
Time	30 min.

1. Conditions vary depending on the composition of the cushion material and the specifications of the pressing machine.

Application Examples

The SF-PC1000 is being more widely applied, mainly to mobile equipment such as cellular phones, digital video cameras, and notebook PCs. The purposes of electromagnetic noise suppression are diversified. The SF-PC1000 is being employed increasingly not only to satisfy the noise standards in various countries such as VCCI and CC, but also to suppress in-equipment noise and immunize the equipment against noise. The application examples are introduced below.

Cellular phone (Photo 2)

Cellular phones, which are required to be more functional and continually downsized, are an example of equipment in which the features of the SF-PC1000 are used to the full. Particularly, a lot of FPCs are used as wiring material for the liquid crystal display and keypad of two-fold type cellular phones that are coming to main products of cellular phones. With this type of cellular phone, the liquid crystal display is enlarged and colored to improve the display function, whereas these phones have more problems with electromagnetic noise interference due to an increased speed of transmitted signals. Electromagnetic noise enters these phones through their antenna, decreasing the receiving sensitivity (signal-to-noise ratio). Thus, the number of cellular phones that use the SF-PC1000 to suppress in-equipment noise is increasing.

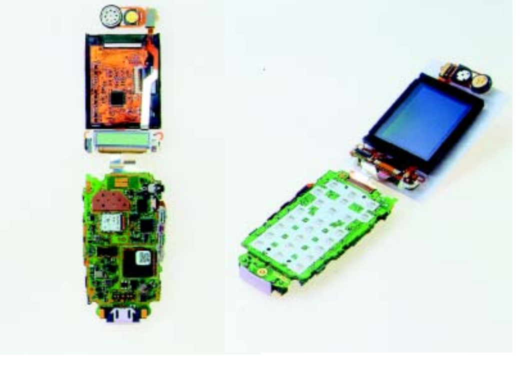

Photo 2 **Cellular phones**
(offered by Sanyo Electric Co., Ltd.)

Digital video camera (Photo 3)

The cylinder head (used to record images into the magnetic tape) of digital video cameras handles faint signals. Therefore, it is susceptible to the influence of electromagnetic noise entering from the outside. This results in degrading the performance of the digital video camera itself, such as image quality deterioration. Accordingly, it is essential to shield the FPC used for the cylinder head. Until now, FPCs shielded with conductive copper paste have been employed frequently. However, these shielded FPCs have problems with working efficiency during mounting because of their hardness. Since the shielding characteristics and high adaptability of the SF-PC1000 have been highly evaluated, it has been used in digital video cameras for immunization against noise.

Photo 3 **Digital Handycam**
(offered by Sony Corporation)

Future Prospects

As equipment becomes more functional and operates at increasingly and higher speeds, the necessity of electromagnetic noise suppression becomes crucial. In addition, with the development of networking, mobilization of electronic equipment is accelerated. In such a situation, the shielding materials are required not only to provide excellent shielding characteristics but also to be "thin" and "lightweight" in order to satisfy the requirements of mobile equipment. Therefore, we expect that demand for the SF-PC1000 is steadily increasing. When functional material is made to a film-type product, generally it is difficult to supply the product in a small lot and in a short delivery period. The more globalized electronic equipment industry strongly requires a decrease in stock articles and reduction in lead-time. Our company is working on developing new products by extending the development concept of the SF-PC1000 and is making full efforts to establish a supply system that enables frequent, small-lot production.

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