

High-Frequency Substrate FLUOROCUIT

1. Overview

The high-frequency bands used for millimeter-wave radar and data communication originally designed for vehicle collision avoidance and distance control are expected to see expanded use in order to support the high-precision sensing and high-speed communication required to improve safety and accelerate the popularization of software-defined vehicles (SDVs). Existing substrate materials for high-frequency antennas exhibit significant transmission loss above 20 GHz, driving a growing demand for next-generation materials optimized for high-frequency signal transmission and reception.

Sumitomo Electric Printed Circuits, Inc. and Sumitomo Electric Industries, Ltd. have developed FLUOROCUIT, an advanced high-frequency substrate that leverages the low-dielectric properties of fluororesin—a low-dielectric-constant material—as its substrate material. Figure 1 shows an example of an antenna substrate using this material. As illustrated in Fig. 2, applications are expected in high-performance vehicle collision avoidance sensors, high-speed communication antennas, vital sensors, vital signs sensor, and more.



Fig. 1. Example of high-frequency antenna substrate

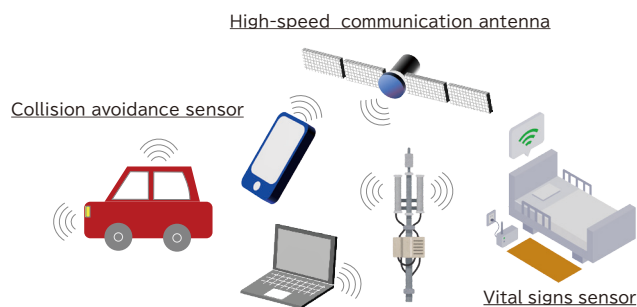


Fig. 2. Application examples of high-frequency antenna substrates

2. Materials

2-1 Fluororesin substrate material

In high-frequency transmission, transmission loss increases as frequency rises. Transmission loss improves as the dielectric constant and dissipation factor of the resin layer decrease. We have developed substrate materials

using fluororesin, which has the lowest dielectric constant and dissipation factor among resins (Fig. 3). The composition of the fluororesin substrate materials is shown in Fig. 4. For high-frequency transmission, we have developed two types of substrate materials: FAL, a glass-cloth composite, and FFL, which contains inorganic fillers for high-frequency antenna substrates. Both materials reduce transmission loss at frequencies above 20 GHz by bonding fluororesin with smooth-surfaced copper foil. In this study, we fabricated an antenna substrate using the FFL substrate and evaluated its characteristics.

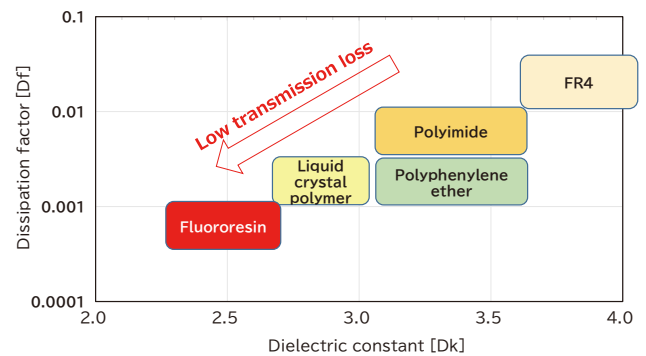


Fig. 3. Dielectric properties of fluororesin

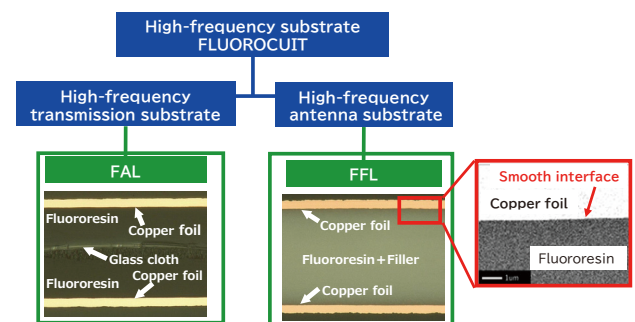


Fig. 4. Composition of fluororesin substrate materials

2-2 Features of FLUOROCUIT

(1) Low transmission loss

As shown in Fig. 5, FLUOROCUIT exhibits significantly lower transmission loss in the high-frequency band above 20 GHz compared to existing high-frequency substrates, enabling high-gain antenna characteristics.

(2) Stable dielectric properties against temperature changes

As shown in Fig. 6, FLUOROCUIT's dielectric constant varies by less than 0.1% within the temperature range of 30–100°C. Its transmission loss changes by 0.5 dB or less, ensuring stable antenna characteristics.

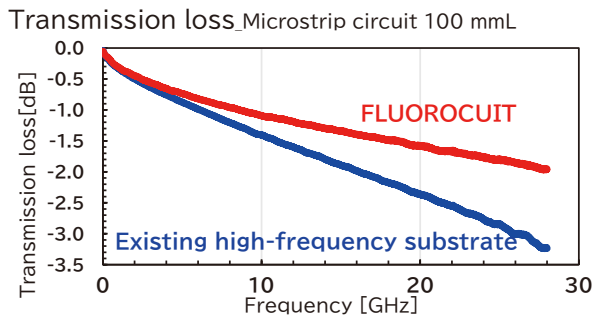


Fig. 5. Transmission loss of fluororesin substrate

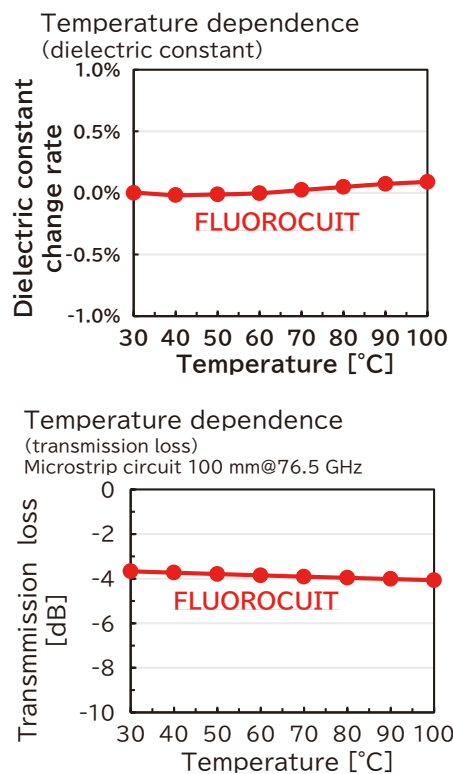


Fig. 6. Temperature dependence of dielectric constant and transmission loss of FLUOROCUIT

3. Evaluation of Antenna Characteristics Using FLUOROCUIT

3-1 Antenna design

We compared antenna characteristics between antennas fabricated with commonly used polyphenylene ether (PPE)-based high-frequency antenna substrates and those using FLUOROCUIT. The antennas were designed for an operating frequency of 28 GHz, targeting 5G communication networks. The antenna configuration consisted of a 16-element array arranged in a 4×4 patch antenna element grid. The element spacing (8.4 mm) and substrate shape were identical for both antenna designs, while the individual element geometries were optimized individually to match each material's properties. The external appearance of the designed antenna is shown in Fig. 7, and the substrate materials' characteristics used for the antenna design are listed in Table 1.

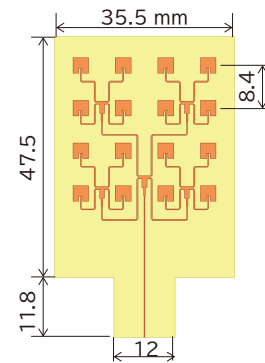


Fig. 7. Antenna element for evaluation

Table 1. Substrate material (dielectric thickness: 100 μm , copper foil: 12 μm)

	FLUOROCUIT (FFL)	Existing high-frequency substrate
Dielectric constant	3.0	3.2
Dissipation factor	0.0005	0.002

3-2 Comparison results of antenna characteristics

The substrate of the fabricated antennas was evaluated using the measurement system shown in Fig. 8. A reference radio wave transmitted from the measurement equipment was received by the antenna under test mounted on a rotary stage. By measuring the received power at various angles, antenna directivity was determined. The measured data are presented in Fig. 9.

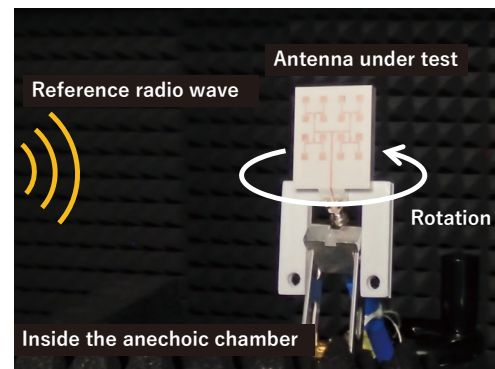


Fig. 8. Measurement system for antenna characteristics

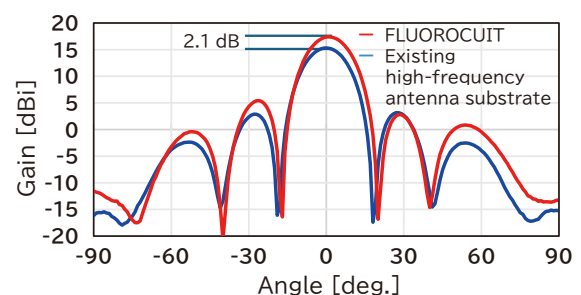


Fig. 9. Antenna directivity

The antenna substrate using FLUOROCUIT achieved a gain 2.1 dB higher than the antenna fabricated with existing materials, demonstrating superior antenna characteristics. As shown in Table 2, the high gain enables radio waves to reach farther distances. Thus, at the same transmission power, the coverage area radius is expected to increase by a factor of 1.27, potentially reducing the number of base stations. Additionally, for the same coverage area radius, transmission power is reduced to 62% of that required by existing substrate, thereby contributing to lower power consumption.

Table 2. Antenna characteristics comparison

	FLUOROCUIT High-frequency antenna substrate	Existing high-frequency antenna substrate
Gain [dBi]	17.4	15.3
Area radius at the same transmission power (radio wave coverage distance)	127 ※ Area radius of existing substrate set as 100	100
Required transmission power for the same area coverage	62 ※ Required transmission power of existing substrate set as 100	100

4. Summary

We have developed FLUOROCUIT, a high-frequency substrate using fluororesin as the substrate material. Evaluation of prototype patch antenna arrays confirmed that FLUOROCUIT achieves higher gain than the conventional substrates. FLUOROCUIT is expected to be applied in millimeter-wave sensors, radar, and high-speed communication antennas.

• FLUOROCUIT is a trademark or registered trademark of Sumitomo Electric Industries, Ltd.