New Low Transmission Loss Material for Millimeter-wave Radar Module "AS-400HS"

Takao Tanigawa *Yuusuke Kondou* *Yuuichi Shimayama* *Tetsurou Irino*
Telecommunication Materials Development Center,
Tsukuba Research Laboratory,
New Business Development Headquarters

1 Abstract

Recently, the safety driving support system utilizing millimeter-wave radar has been spreading. Since the study of automatic driving is also active, then the market of the millimeter-wave radar for automobile is expected to increase rapidly in the future[1)~2)].

The newly developed low dielectric material, AS-400HS, has more excellent electric property and workability compared to conventional thermoplastic composite materials utilizing PTFE and LCP. Furthermore, it can propose the new design such as multilayer antenna for ultra-wide band by buildup.

2 Characteristics of the product

- It has excellent dielectric properties.
- It has a good workability such as applicability of laser via hole drilling and good in plating uniformity.
- It can be used for a multilayer antenna as it can be fabricated into a build-up multilayer printed board.

3 Background of the development

Significant manufacturing cost reduction of radar is needed for full-fledged applications for collision prevention radar for vehicle; therefore, switching from traditional metal antenna or ceramic material substrate based antenna to fluorine resin (PTFE) or liquid crystal polymer (LCP) substrate based antenna is now being studied. These thermoplastic resins, however, have certain workability issues including material processing by drilling/laser and plating uniformity, resulting in higher processing cost as a bottleneck in wide applications for collision prevention radar for vehicle.

Then, using new thermosetting resin deriving from our proprietary resin technology, we started development of new low transmission loss materials having dielectric property equal to and workability better than other PTFE or LCP based materials for substrate.

4 Details of the technology

1. Development concept of AS-400HS

We used thermosetting resin which we developed using our proprietary resin design technology and has superior dielectric properties. To satisfy both superior dielectric properties and better adhesive strength, a low profile copper foil can be selectable and still be able to provide excellent transmission performance. AS-400HS can be fabricated into buildup multilayered substrate for antenna because it is a film made from thermosetting resin, which is different story for PTFE or LCP based materials.

2. General properties of AS-400HS

General properties of AS-400HS are shown in **Table 1**. Its electrical properties include Dielectric Constant (Dk) of 3.0 and dielectric dissipation factor(Df) of 0.0023 at 10 GHz, and shows better values than those of traditional PTFE or LCP based substrates. As heat resistance parameter T-300 (per IPC TM-650) was 60 minutes or longer, and its thermal decomposition temperature was 460°C (5% weight loss), heat resistance of AS-400HS should be excellent. Its excellent workability including via formation by laser drilling, laser processing and easy electroplating was confirmed as shown in **Figure 1**. Furthermore, L1-L2 Laser IVH (via diameter: 0.10 mm, via pitch: 0.50 mm, insulation layer 100 µm, thermal cycle: at 65°C (15 min) ⇔125°C (15 min)) showed no drops in connection resistance value after 3,000 cycles, and had good reliability without no insulation deterioration after 2000 testing hours using a comb structure test pattern (line/space 65 µm/65 µm, 85°C/85%RH, 100 V).

3. Transmission characteristics of AS-400HS

Evaluation results of transmission characteristics (transmission loss) of microstrip line of AS-400HS are shown in **Figure 2**. It has a transmission line characteristics better than those of PTFE or LCP based materials even in millimeter wave band (transmission loss reduced by 34% at 76 GHz compared to PTFE based material substrate).

Table 1 Properties of AS-400HS

Item	Condition	Unit	***AS-400HS***	Material A[*2]	Material B[*2]
Resin system		—	**Thermosetting**	Thermoplastic LCP type	Thermoplastic PTFE type
Dk (10 GHz)[*1]	A	—	**3.0**	3.0[*3]	3.0[*3]
Df (10 GHz)[*1]	A	—	**0.0023**	0.0020[*3]	0.0013[*3]
CTE (XY-axis)	TMA (30-120℃)	ppm/℃	**80**	—	17
CTE (Z-axis)	TMA (30-120℃)		**36**	—	30
	TMA (250-300℃)		**53**	—	—
Tg	TMA	℃	**—**	—	30
	DMA		**190**	—	—
Elastic Modulus	DMA	GPa	**3.0**	3.4	1.2
Heat resistance	288℃/20 s dip	—	**PCT-5 h Pass**	—	—
	T-300	min	**> 60**	—	—
Td	TGA 5% loss	℃	**460**	—	—
Peel strength (RT)	Low profile	kN/m	**0.77 (VLP)**	0.70	—
	Profile free		**0.60**	—	—
Water absorption	D-23/24	%	**0.1**	0.05	—
Insulation reliabilities[*4]	85℃/85%RH, DC100 V	hr	**> 2000 (< 1%)**	—	—
IVH connection reliabilities[*5]	−65℃ (15 min) ⇔ 125℃ (15 min)	cycle	**> 3000 (> 1.0×10^{11} Ω)**	—	—

*1 Cavity resonator perturbation method *2 Catalog value *3 Strip-line resonator method
*4 Line/Space: 65 μm/65 μm, Precondition: Reflow x 6 (Max 265℃)
*5 L1-L2 Via: Φ0.10 mm, Pitch: 0.50 mm, Thickness: 0.10 mm, Precondition: C-168/85/85 + Reflow x 6 (Max 265℃)

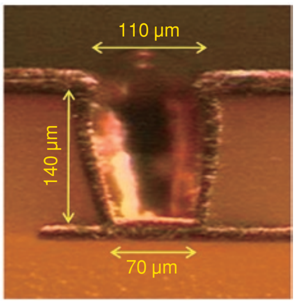

Figure 1 Cross section of laser via

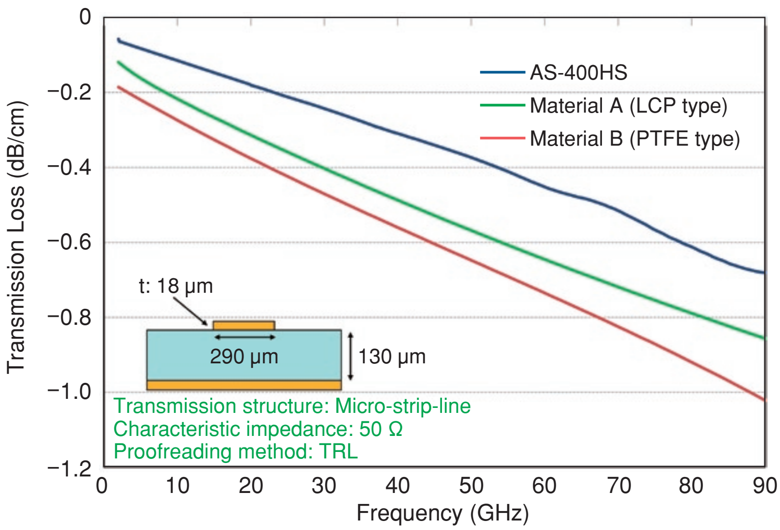

Figure 2 Transmission loss of AS-400HS

5 Future Business Development

・Development of new low transmission loss material for millimeter-wave radar

【References】

1) *Milimeter Wave Solution2007[Miri-Ha Soryu-shon 2007]*. Yano Research Institute Ltd. (2007)

2) *Market trend of Milimeter Wave Radar(2015) [Miri-Ha Re-da-Shijou Doukou (2015)]*. Japan Marketing Survey Co,. Ltd