TECHNICAL POSTER RESEARCH WORK OPTIMIZING BASE MATERIALS FOR HIGH-SPEED, HIGH-FREQUENCY PCBS

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ABSTRACT

The development of 5G, AI, data centers and wired/wireless connections necessitates the design of high-speed, high-frequency PCBs with exceptional performance and reliability. A critical factor in achieving this lies in the judicious selection of base materials. This paper analyzes key factors (Dk, Df, CTE, Cu peel strength, etc.), addressing discrepancies between datasheet values and actual measured properties. This work aims to assist engineers in selecting optimal materials for achieving the best balance of performance, cost, and manufacturability.

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METHODOLOGY

Advanced materials can be selected for specific applications by carefully examining each component of the system: carrier, copper foil, and the resin system. The proper combination determines the overall performance and cost effectiveness.

❑ Material features

Performance Attributes: Halogenated or halogen-free, 6x 288°C solder float capable, CAF resistant, Tg>190°C, Low moisture absorption, Low CTE, High thermal stability

Processability: Multiple lamination cycles, HDI technology compatible, FR-4 process compatible, Good fill and flow

❑ Material availability

Standard material: Prepreg and laminate

Copper foil type: HVLP 1-4, ½-3 oz

Glass fabric: E, NE, NER, quartz

❑ Testing method

Table 1. Standard test methods for laminate characterization

Item	Test method
Tg	IPC-TM-650 2.4.24; 2.4.25
CTE	IPC-TM-650 2.4.24.5; 2.4.24
Td	IPC-TM-650 2.4.24.6
T288	IPC-TM-650 2.4.24.1
Thermal conductivity	ASTM D5470
Dk/Df	split post dielectric resonator (SPDR)
Peel strength	IPC-TM-650 2.4.8
Flexural Strength	IPC-TM-650 2.4.4
Water absorption	IPC-TM-650 2.6.2.1
Flame retardancy	UL-94

❑ Test vehicle

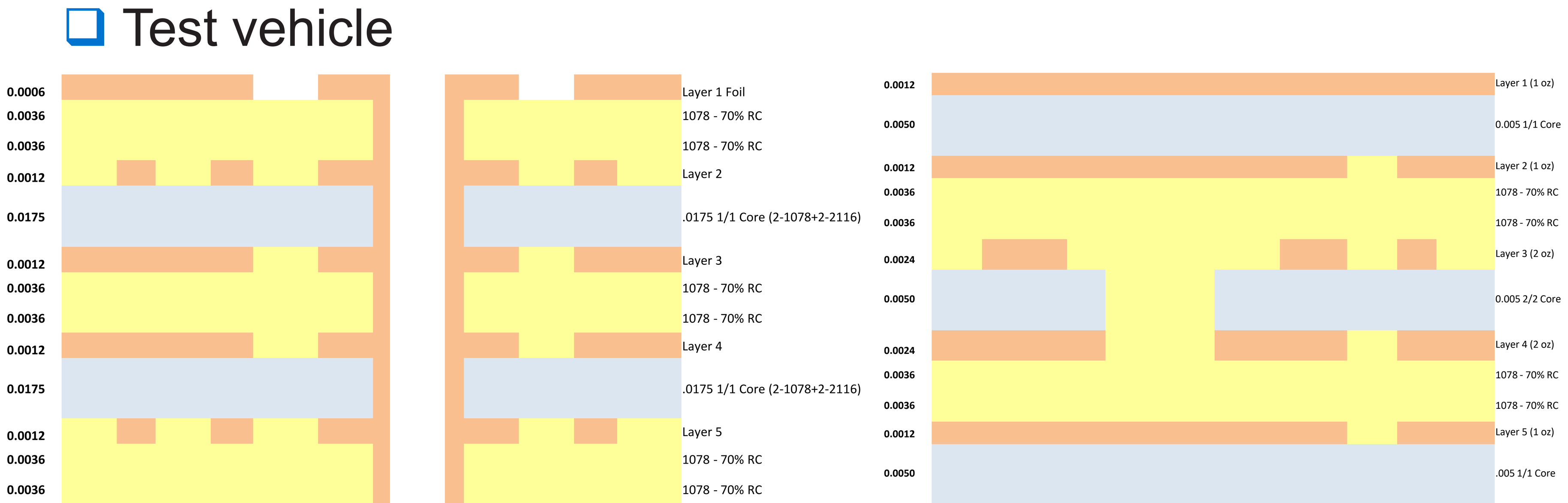

Figure 1. TV1 and TV2 stack-up for PCB reliability test

RESULTS

❑ Resin composition

Resin change impacts laminate properties, not fully captured in the specification of typical data sheets.

Table 2. Effect of resin component change on properties of laminate

Properties		A	B	C	D
TMA CTE	(%, 260 °C)	2.7	2.7	2.1*	2.7
	(ppm/°C)	57	46	43	42
DMA Tg	(°C, tan&)	195	195	193	198
Cu Peel	1 oz HS2-M2-VSP	3.8	3.5	2.8	3.7
ILBS	WG / XG	1.8/1.6	2.9/2.9	2.3/1.6	2.8/2.6
2x1078SI 10 GHz	Dk [AB]	3.1	3.2	3.2	3.2
	Dk [IPC]	3.1	3.2	3.2	3.2
	Df [AB]	0.00138	0.00145	0.00142	0.00125
	Df [IPC]	0.00140	0.00153	0.00154	0.00135

Above typical values are tested under specified constructions. IPC data were collected following 24h storage at room temperature and 50% humidity. *Group C data were collected at 53RC% due to excessive resin flow, while other data were collected at 57RC%.

❑ Aging stability

Data sheets often lack information on aging stability, a critical factor that can degrade performance over time. This can manifest as signal loss, crosstalk, timing skew, and ultimately, circuit failure.

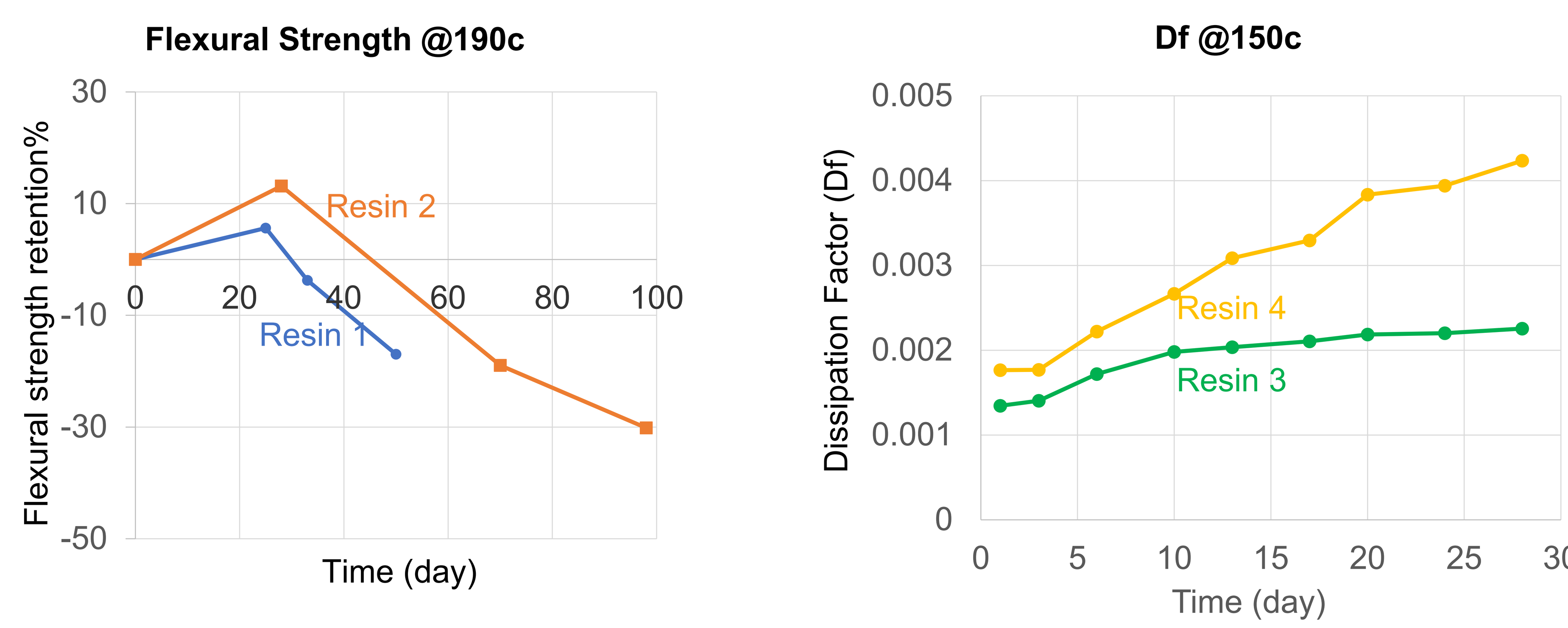

Figure 2. Long Term Thermal Aging (LTTA) stability of different resins

❑ Performance, reliability and processability

A suitable combination of carrier, copper foil, and resin system must meet performance requirements, demonstrate good fill and flow, exhibit excellent dimensional stability and registration, successfully pass a 1000-cycle IST, and exhibit no CAF failures after 1000h.

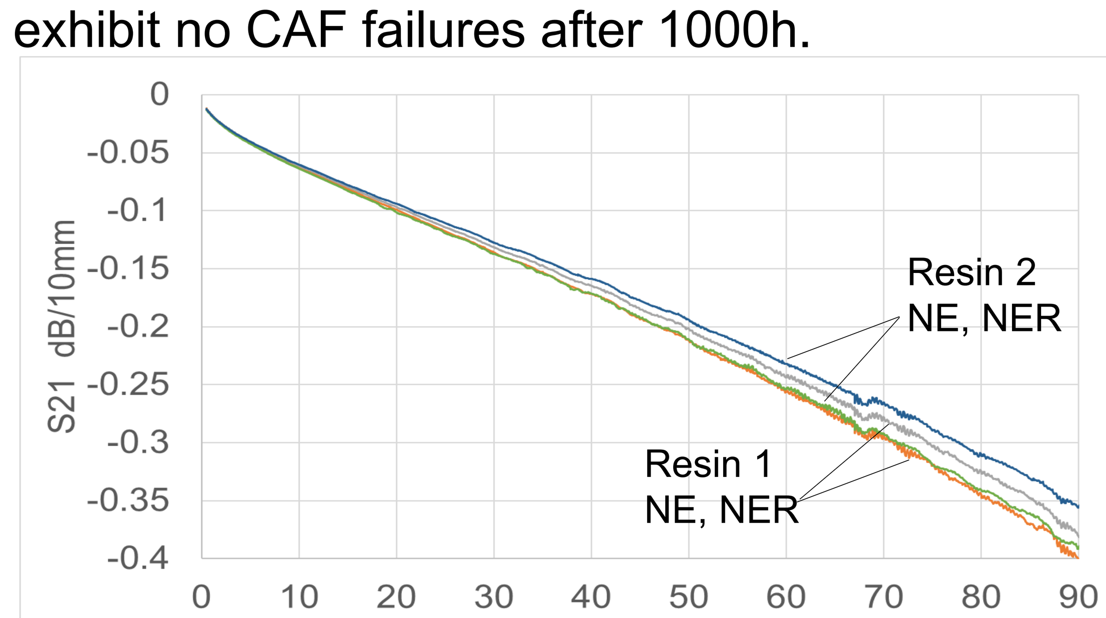

Figure 3. SI performance by Resin/Carrier

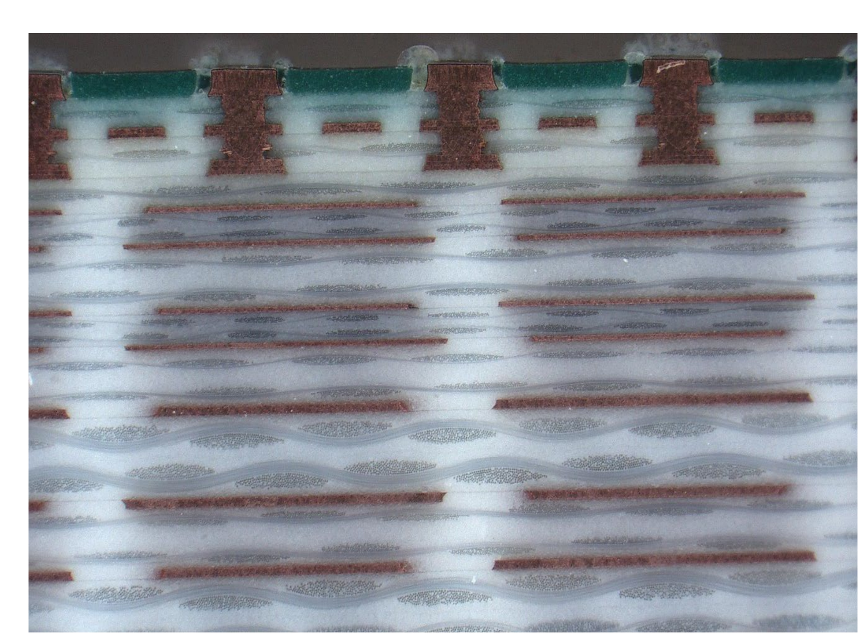

Figure 4. x-sectional view of 20-layer PCB

CONCLUSIONS

Optimizing advanced materials selection for specific applications necessitates a careful evaluation of each system component: carrier, copper foil, and resin system. The optimal combination of these elements dictates performance, reliability and cost-effectiveness of the final product.

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