Singi™ Low Dk/Df Siloxane PCB Resin/Film For Microwave Electronic

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Singi™ Low Dk/Df Siloxane PCB Resin/Film

Singi ™ is the low dielectric constant(Dk)/dissipation factor(Df) thermosetting resin and glass-fabric reinforced pre-preg film based on the siloxane chemical. They can apply to high frequency (microwave) applications such as 5G/6G communication, RADAR sensor in automobiles, large-capacity high-speed electronic substrates, and bonding/build-up film semiconductor packaging. The fabricated Cu Clad Lamination (CCL) is used for 5G/6G communication PCB and antenna.

Features

- Low dielectric constant(Dk=2.92 @10 GHz)/dissipation factor(Df=0.0016 @10 GHz)
- High heat/humid stability No change in dielectric properties
- Direct lamination and good adhesion with Cu foil
- No halogen (fluorine) content and low carbon content
- Quartz-fabric Reinforced Pre-preg (QFRP) film
  - Dk=3.2, Df=0.0014 @10 GHz
  - CTE : ~10 ppm/°C

Singi™ G Low Dk/Df Siloxane PCB Resin

Singi™ G is the base siloxane formulation with lowest Dk/Df

Curing Condition

- 200 °C – 250 °C in inert atmosphere for > 2hrs

Dielectric Properties

- Dk = 2.92, Df = 0.0016 @ 10 GHz

	2.5 GHz	5 GHz	10 GHz	20 GHz	30 GHz	40 GHz	50 GHz
Dk	2.92	2.92	2.92	2.91	2.91	2.91	2.9
Df	0.0011	0.0013	0.0016	0.0019	0.0022	0.0024	0.0025

Thermo-mechanical Properties

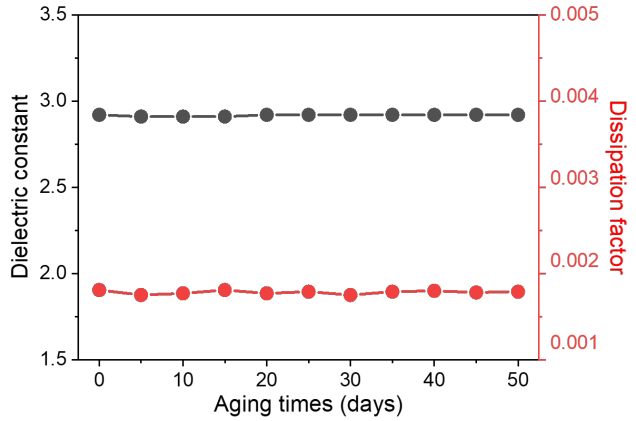
- CTE : ~80ppm/°C (25°C~250°C), No glass transition
- Tensile strength : 29 MPa, Elastic modulus : 1.4GPa, Elastic strain : ~2%

Singi™G Stability and Temperature Dependence

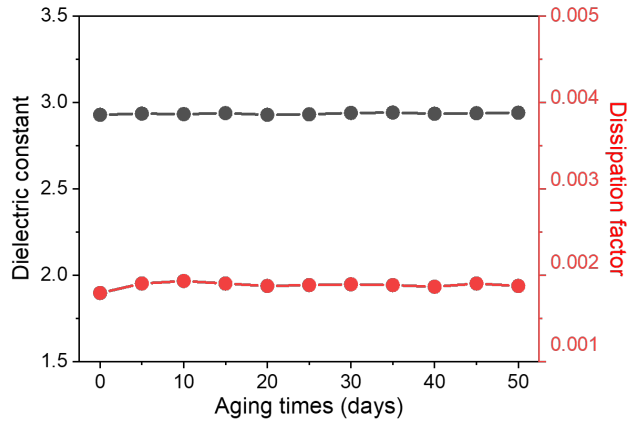
Long-Term Thermal & Humid Stability

- No change in Dk and Df at 25 °C/100 RH% 85 °C/85 RH% & 120 °C for 50 days

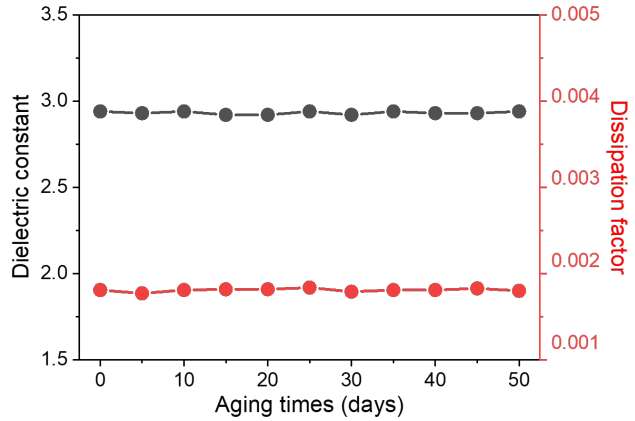
25 ℃/100 RH %



85 ℃ /85 RH%

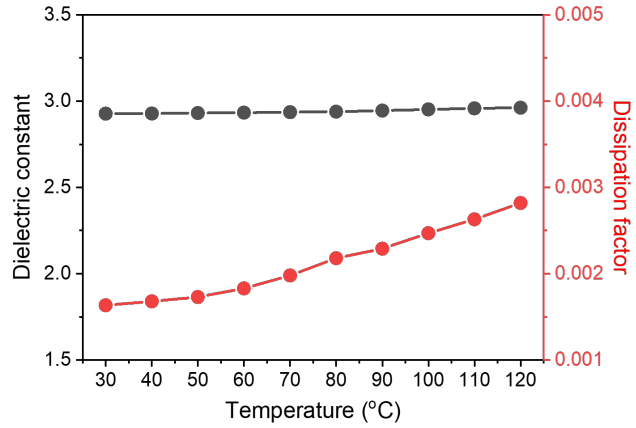


120 ℃



Temperature Dependence

- Change in Dk and Df (@10 GHz) with increasing temperature



Singi™G Low Dk/Df Siloxane Prepreg Fim

Quartz-Fabric Reinforced Prepreg (QFRP) Fim

- Quartz-fabric (Shinetsu SQ, 30μm), ~50% resin content

	2.5 GHz	5 GHz	10 GHz	20 GHz	30 GHz	40 GHz	50 GHz
Dk	3.2	3.2	3.2	3.19	3.19	3.18	3.18
Df	0.0009	0.0011	0.0014	0.0016	0.0018	0.002	0.0022

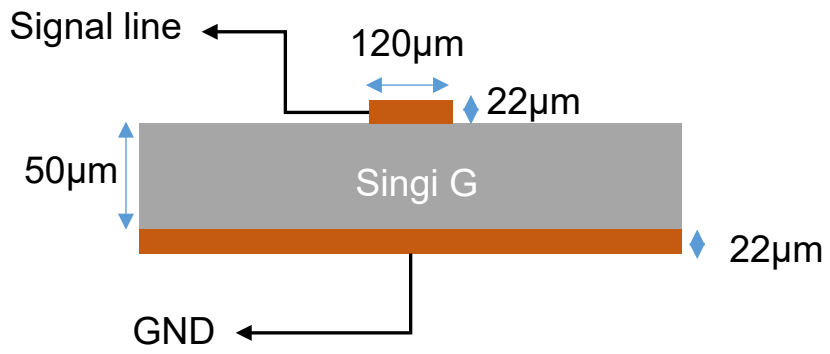
Glass-Fabric Reinforced Prepreg (GFRP) Fim

- NE glass-fabric (Nittobo, NEA #1035 25μm), 50% resin content

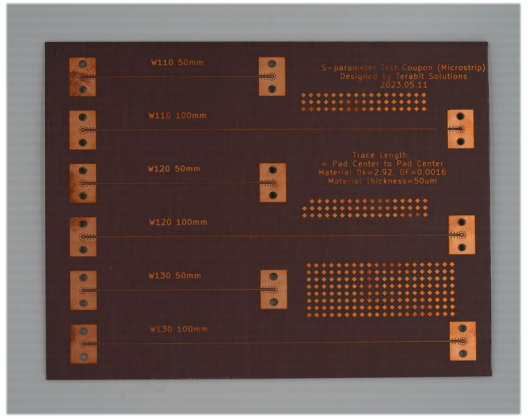
	2.5 GHz	5 GHz	10 GHz	20 GHz	30 GHz	40 GHz	50 GHz
Dk	3.43	3.43	3.43	-	-	-	-
Df	0.0016	0.0019	0.0022	-	-	-	-

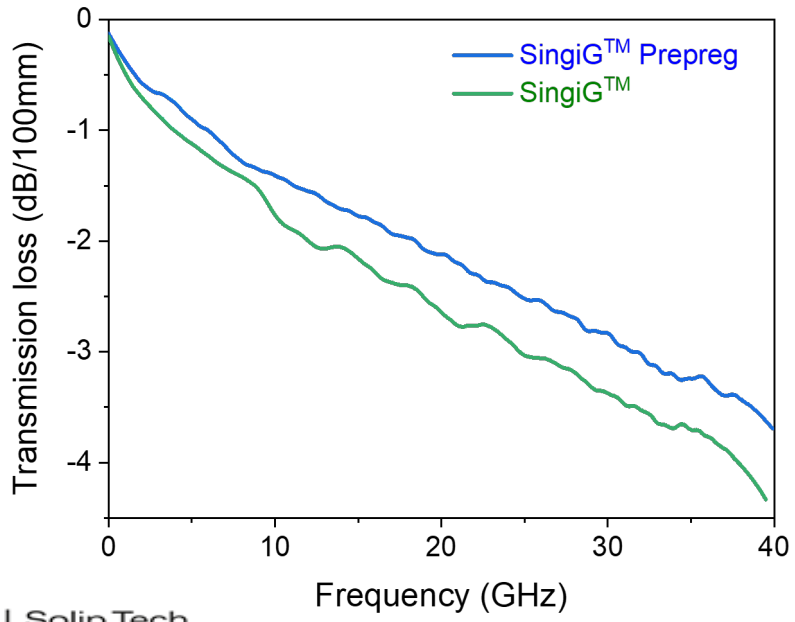
Singi™G Transmission Characteristics

Measurement of transmission loss (S_{21})



Test Coupon (Microstrip Line)





Transmission loss (dB/100mm)

Frequency	Singi G Prepreg Film	Singi G Resin	LCP (Kuraray)
10 GHz	-1.41	-1.77	-2.47
20 GHz	-2.12	-2.67	-3.76
30 GHz	-2.83	-3.43	-5.02
40 GHz	-3.69	-4.22	-6.34

- LCP data from Kuraray VECSTAR™ Brochure

Singi™C Low Dk/Df Siloxane PCB Resin

Singi™ C is the high-viscosity siloxane formulation suitable for manufacturing B-stage prepreg film

Curing Condition

- 200 °C – 250 °C in inert atmosphere for > 2hrs

Dielectric Properties

- Dk = 3.00, Df = 0.003 @ 10 GHz

Quartz-fabric Reinforced Prepreg (QFRP) Film

- Dk = 3.3, Df = 0.0027 @ 10 GHz

	2.5 GHz	5 GHz	10 GHz	20 GHz	30 GHz	40 GHz	50 GHz
Dk	3.52	3.48	3.44	3.42	3.38	3.36	3.35
Df	0.002	0.0025	0.003	0.0036	0.004	0.0042	0.0045

- CTE : ~15 ppm/°C (25°C~250°C), No glass transition
- Tensile strength : 142.9 MPa, Elastic modulus : 5.3 GPa, Elastic strain : ~2.5 %

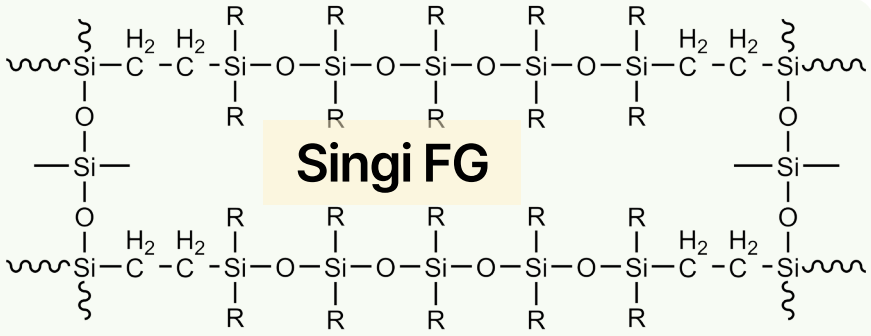
Singi™ F Stretchable Low Dk/Df Siloxane Elastomer

Singi™ F is the highly elastic, stretchable low Dk/Df siloxane formulation suitable for use in foldable FPCB or semiconductor packaging substrates/films

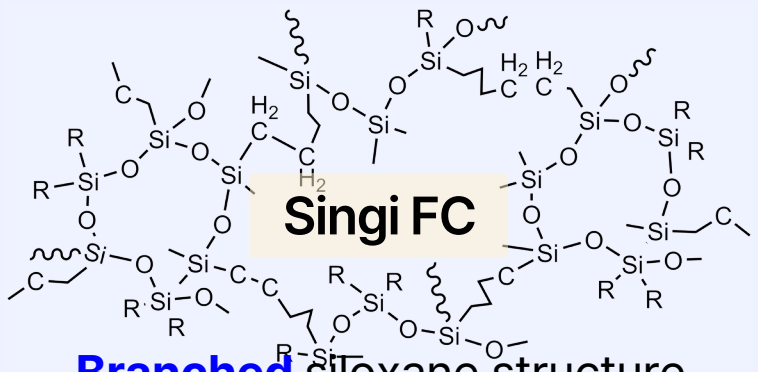
Features

- Low modulus and high elastic strain (stretchable/flexible)
- Low Dk/Df in the microwave frequency region
- Zero/tunable CTE glass-fabric reinforced prepreg (GFRP) film for applications to PCB and semiconductor packaging substrates/films
- Bonding characteristics of prepreg film and siloxane resin for simpler multi-layer PCB production and build-up film
- Application to highly foldable FPCB and advanced stress–free semiconductor packaging

Singi™ FG/FC Low Dk/Df Siloxane Elastomer

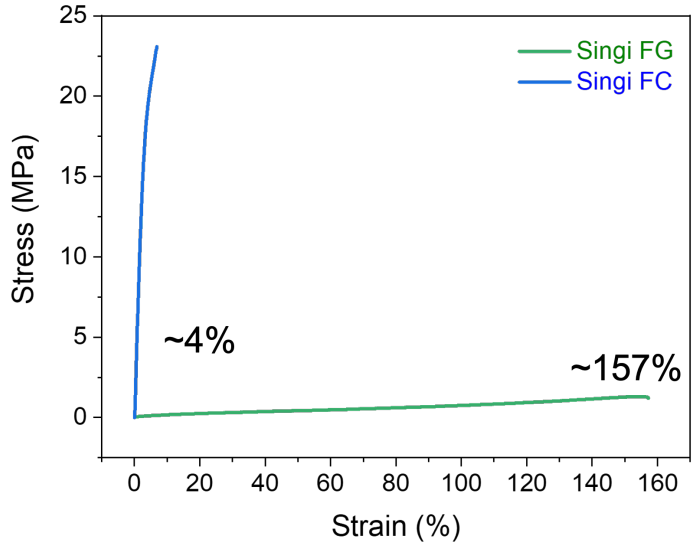


Crosslinked linear siloxane structure



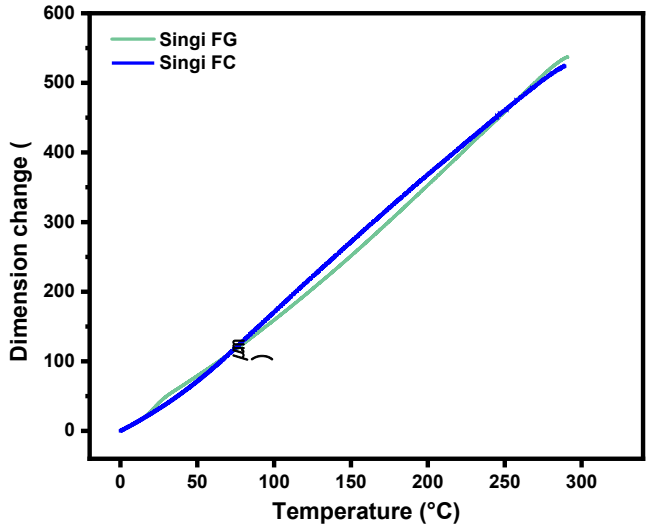
Branched siloxane structure

Glass-Rubber transition at 20°C



Tensile Test

Glass-Rubber transition at 70°C



Thermal Expansion (TMA)

Singi™ FG/FC Low Dk/Df Siloxane Elastomer

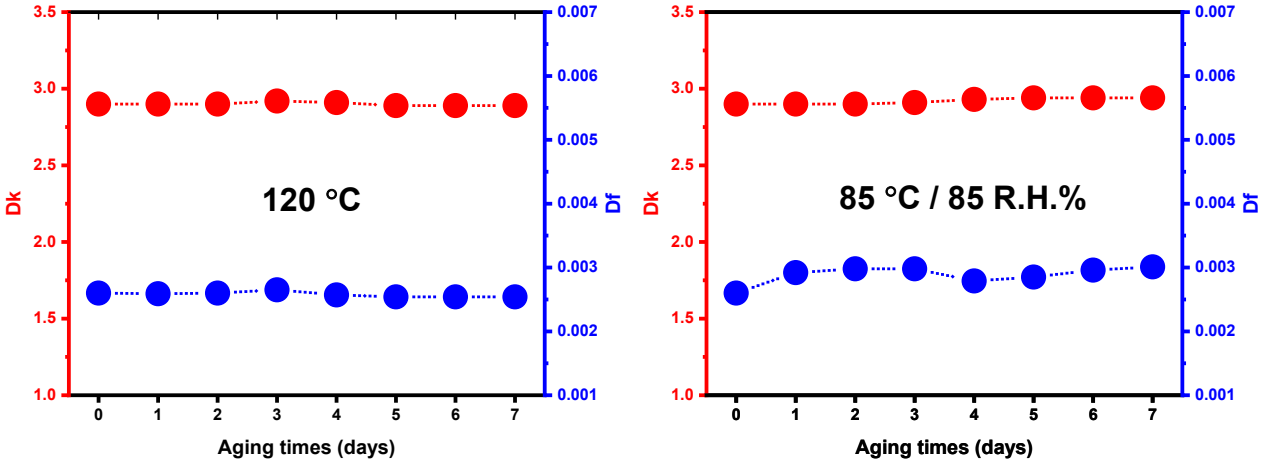
Curing Condition

- 200 °C in air for > 2hrs
- Lower temperature curing in air

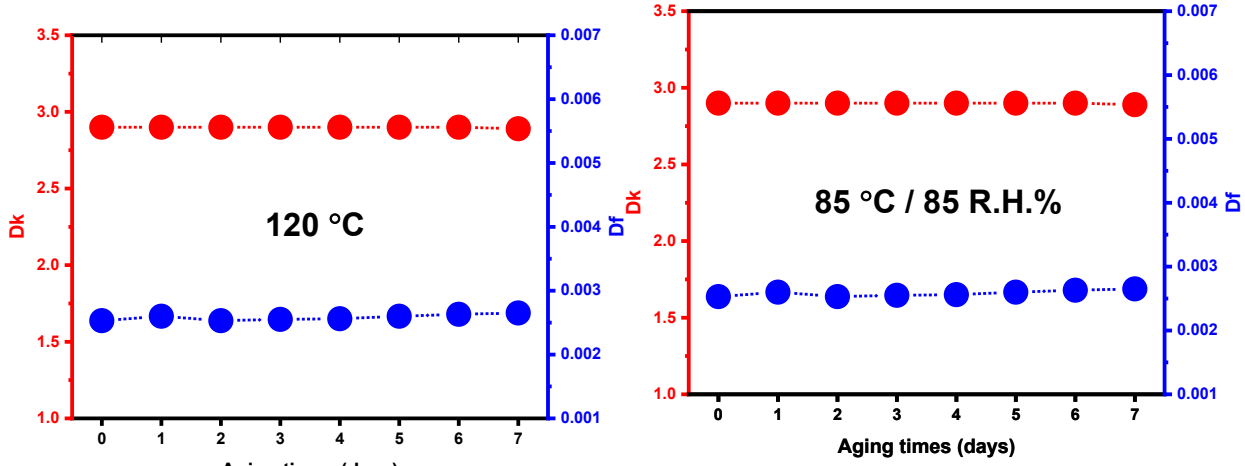
Dielectric Properties

- Singi™ FG : Dk = 2.90, Df = 0.0022 @ 10 GHz
- Singi™ FC : Dk = 2.92, Df = 0.0025 @ 10 GHz

Singi™ FG



Singi™ FC



Singi™ FG Low Dk/Df Siloxane Prepreg Film

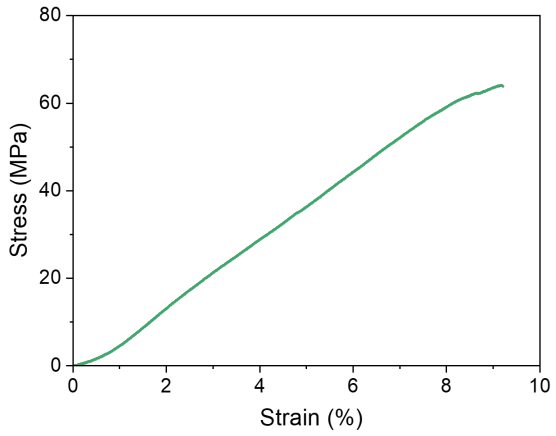
Quartz-fabric Reinforced Prepreg (QFRP) Film

- ~40μm film with quartz-fabric (Shinetsu SQ, 30μm), ~50% resin content

	2.5 GHz	5 GHz	10 GHz	20 GHz	30 GHz	40 GHz	50 GHz
Dk	3.2	3.2	3.2	3.19	3.19	3.18	3.18
Df	0.0009	0.0011	0.0014	0.0016	0.0018	0.002	0.0022

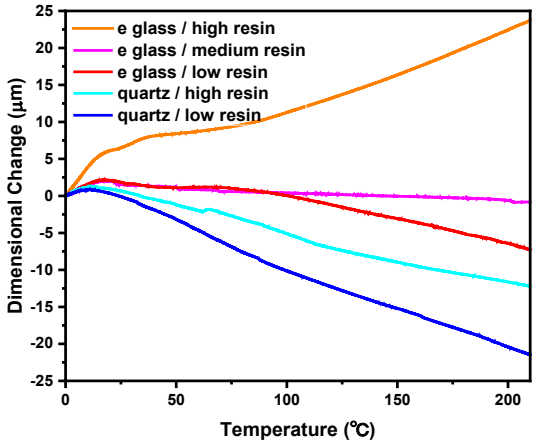
Tensile Test

- Tensile strength : 58.5 MPa
- Elastic modulus : 923 MPa
- **Elastic strain : ~10 %**



Thermal Expansion

- **CTE : -10 ~ 10 ppm/°C**
- Depends on glass-fabric and resin content



Singi™ FC Low Dk/Df Siloxane Prepreg Film

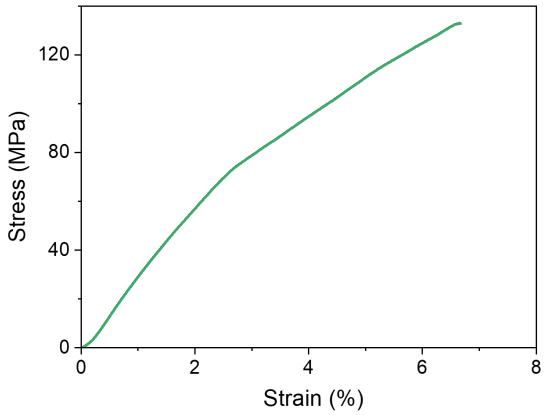
Quartz-fabric Reinforced Prepreg (QFRP) Film

- ~40μm film with quartz-fabric (Shinetsu SQ, 30μm), ~50% resin content

	2.5 GHz	5 GHz	10 GHz	20 GHz	30 GHz	40 GHz	50 GHz
Dk	3.04	3.03	3.02	3.02	3.02	3.01	3.01
Df	0.0019	0.0023	0.0025	0.003	0.0034	0.0036	0.0038

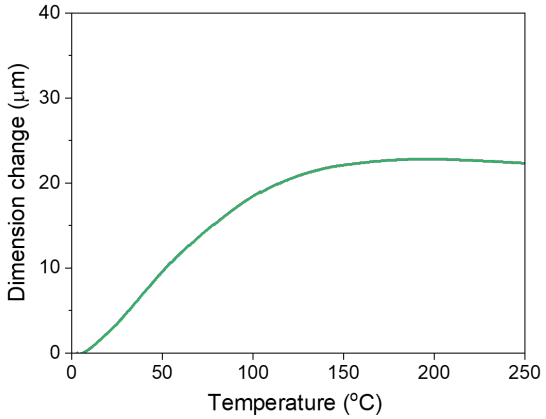
Tensile Test

- Tensile strength : 133 MPa
- Elastic modulus : 1.6 GPa
- **Elastic strain : ~7 %**



Thermal Expansion

- **CTE : 18 ppm/°C (<150°C)**
  CTE : 2ppm/°C (>150°C)
- Transition at 80°C~150°C



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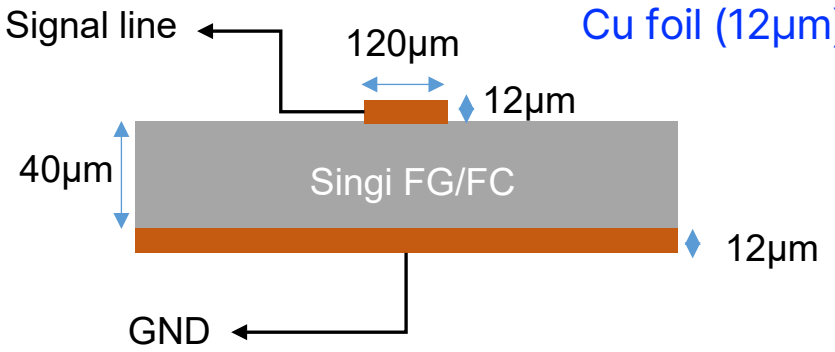
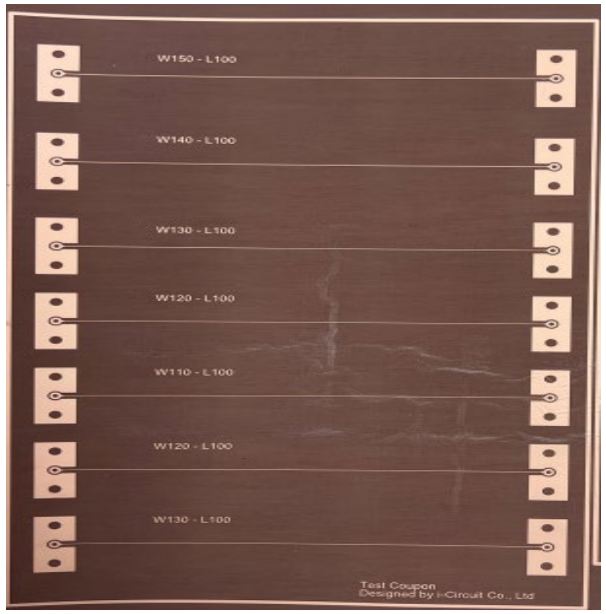
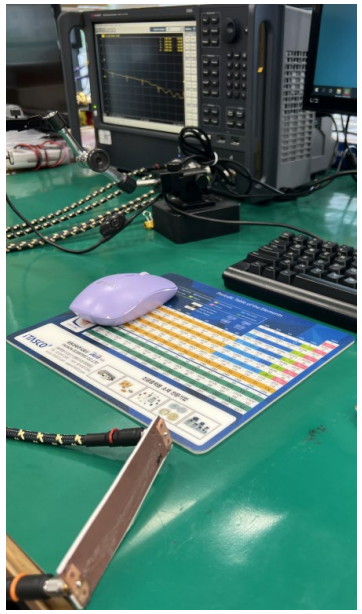
Singi™ FG/FC Low Dk/Df Siloxane Prepreg Film

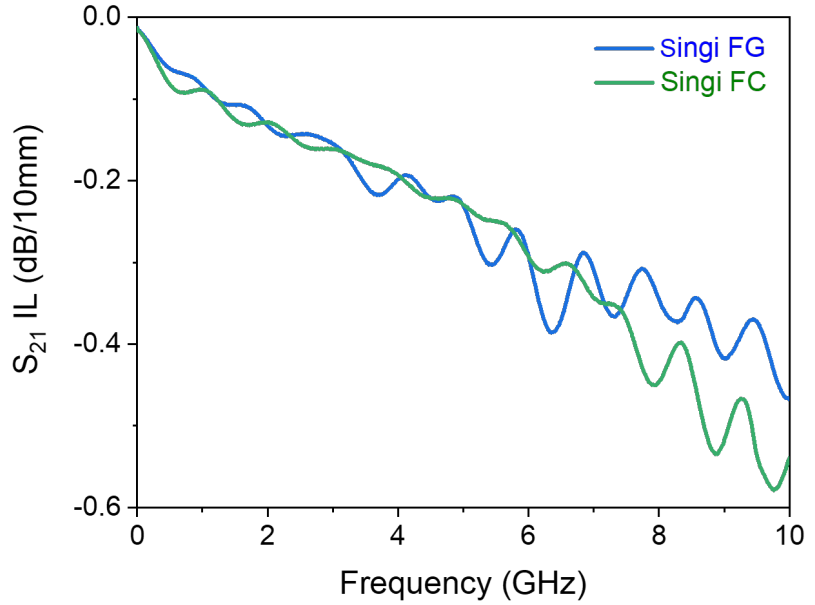
- **Test Coupon Microstrip Line**

Quartz-fabric (30μm): Shinetsu
Cu foil (12μm) : Iljin (Korea)







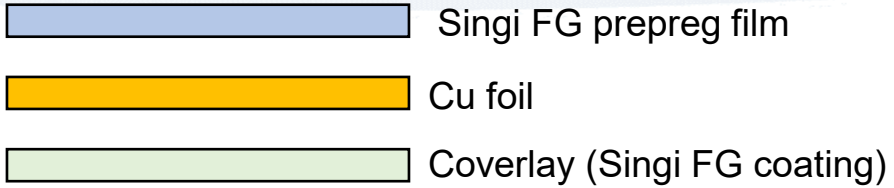


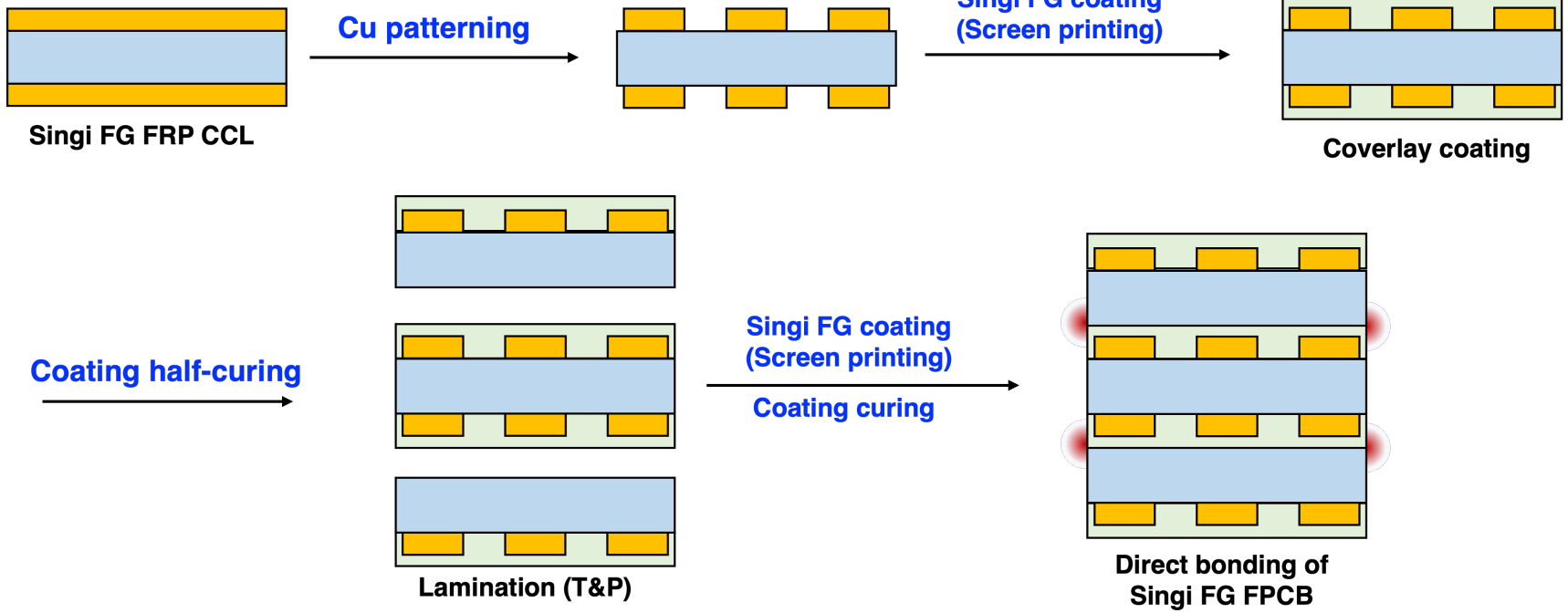
S_{21} Transmission loss (dB/10mm)

Frequency	1GHz	2.4GHz	3.5GHz	6GHz	8GHz
Singi FG	-0.08	-0.14	-0.2	-0.29	-0.34
Singi FC	-0.09	-0.15	-0.18	-0.29	-0.44

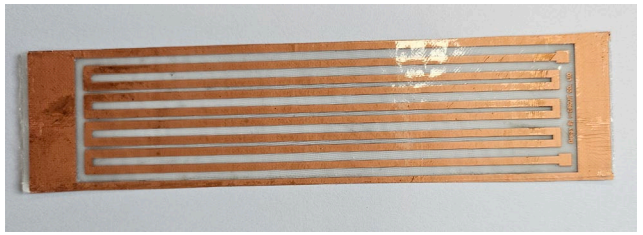
Singi™ FG Manufacturing of Multi-Layer FPCB

- Direct Coverlay coating (Screen printing) of Singi FG resin
- Direct bonding without use of the bonding sheet





Coverlay coated patterned FPCB



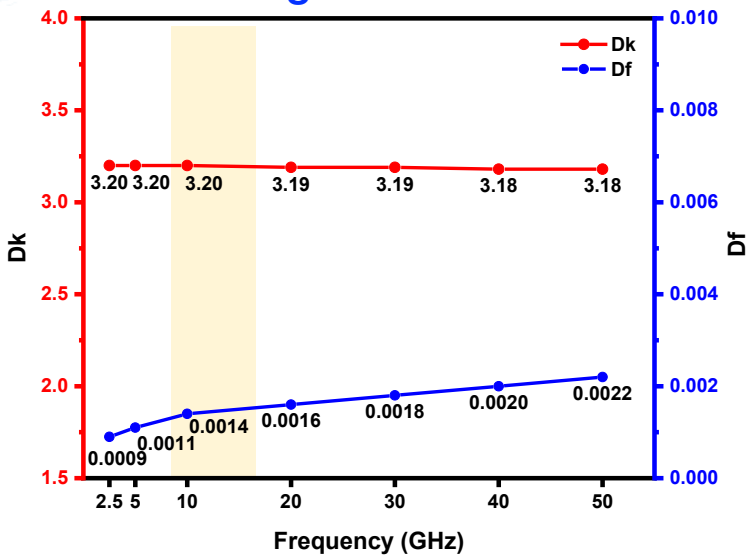
4-layers patterned FPCB

Singi™ Summary of Low Dk/Df Siloxane Prepreg Film

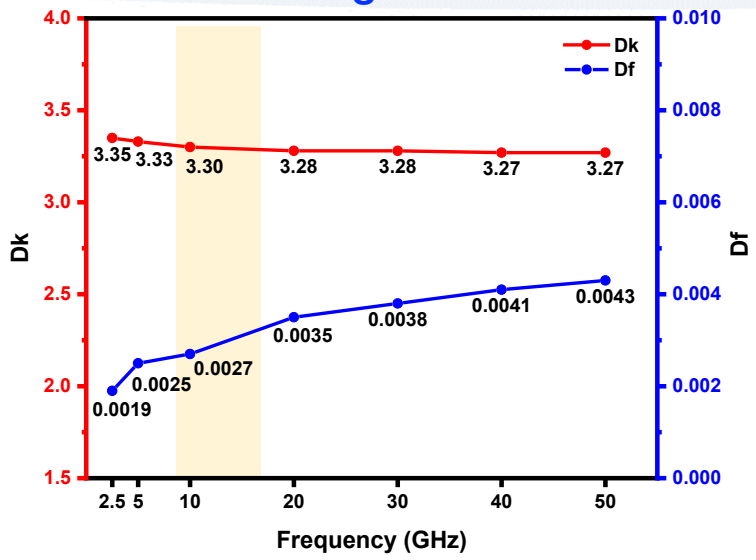
Properties			Unit	Singi G QFRP Film	Singi C QFRP Film	Singi FG QFRP Film	Singi FC QFRP Film	Test Method
Siloxane Composition				Base	High Viscosity	Stretchable	Flexible	
Mechanical	Tensile Strength		MPa	214	143	58.5	133	ASTM D882
	Elastic Modulus		GPa	8.85	5.3	0.92	1.6	ASTM D882
Thermal	CTE (0 - 250 °C, x axis)		ppm/°C	10	16	-10~0	2~18	ASTM E831
	Tg		°C	**Almost Tg-less @ >RT**				
Chemical	Water Absorption		%	**< 0.05**				ASTM D570
Electrical	Dk (@10 GHz)		-	3.2	3.3	3.08	3.02	Split Post Dielectric Resonator (SPDR)
	Df (@10 GHz)			**0.0014**	**0.0027**	**0.0021**	**0.0025**	
Stability	ΔDk / Df after 30 Days Aging	25°C /100 % RH	-	**0 (No change)**				
		120 °C						

Singi™ Summary of Low Dk/Df Siloxane Prepreg Film

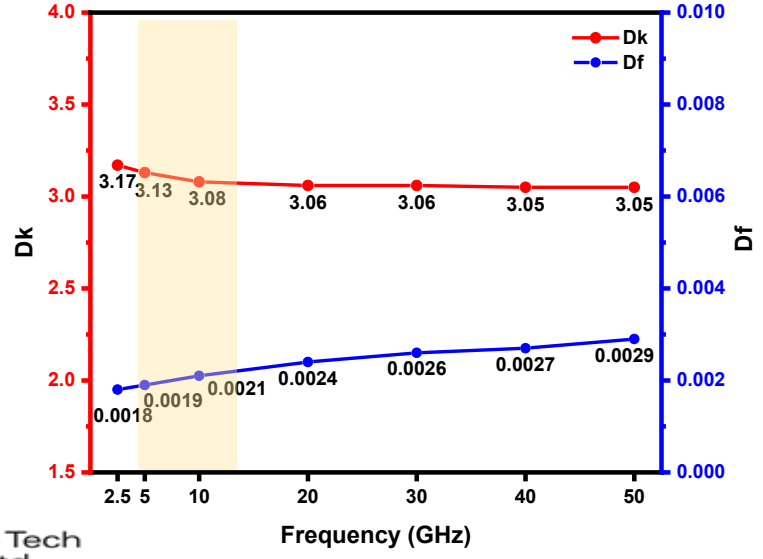
Singi G QFRP



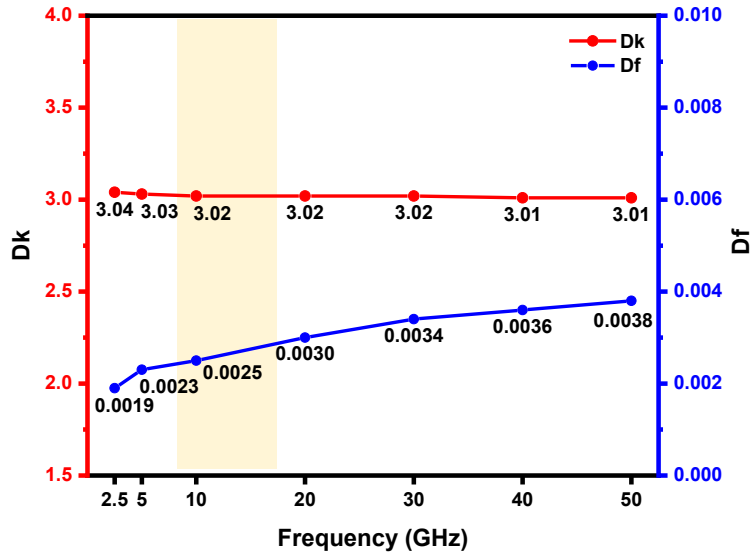
Singi C QFRP



Singi FG QFRP



Singi FC QFRP



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