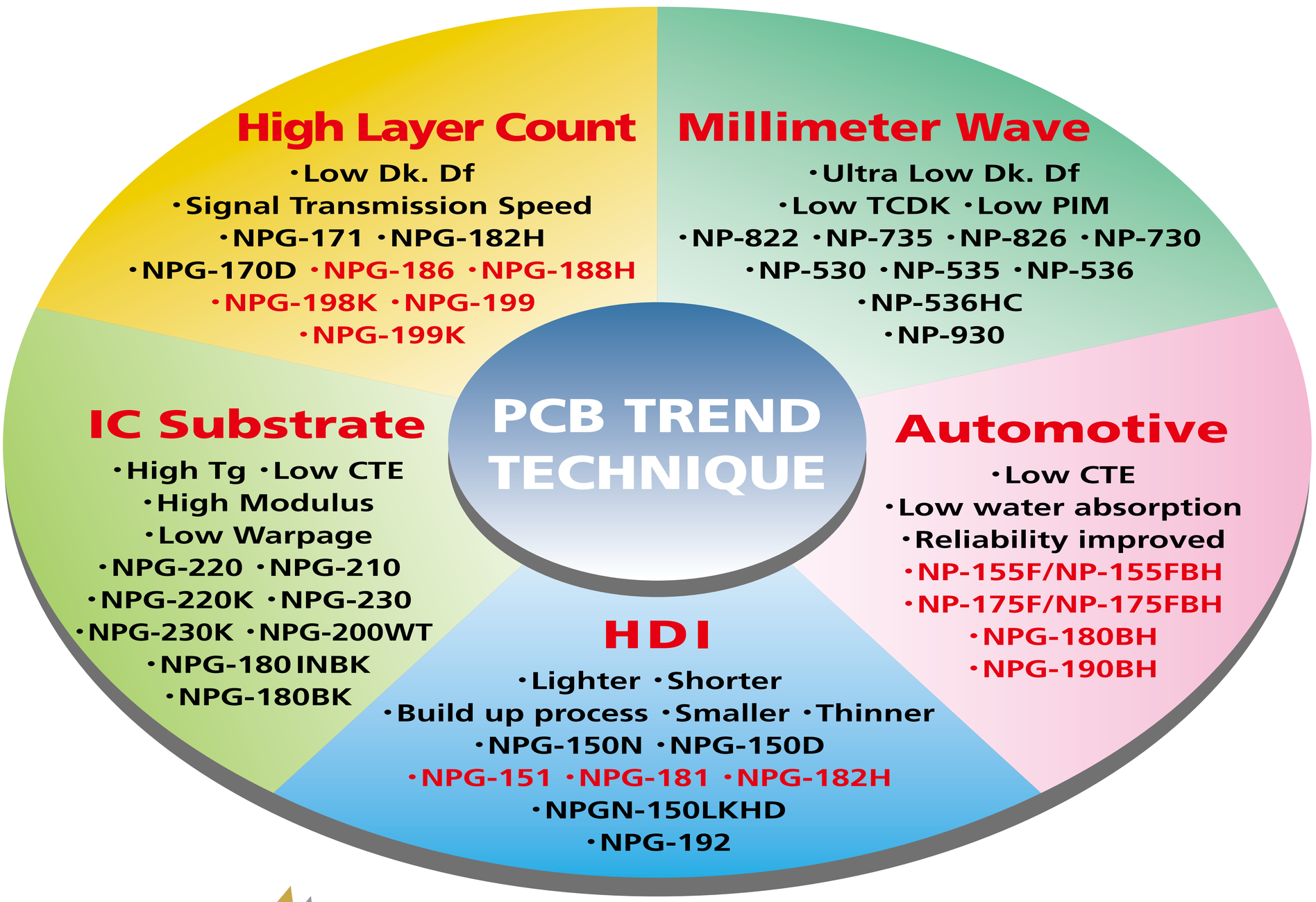
The CCL Material Trend
System Products of Nan Ya CCL



Millimeter Wave
- NP-735 NP-730 NP-826 NP-822 NP-930 PTFE
- NP-530 NP-535 NP-536 NP-536HC

Automotive
- NPG-181PY High Tg CIT600(Under development)
- NPG-180BH/NPG-190BH
- NPG-151
- NP-175FBH
- NP-155F/NP-155FBH

HDI
- High Tg Low Dk NPG-181
- High Tg Low Dk/Df NPG-182H, NPG-192
- NPG-150N, NPG-151, NPG-150D
- Low Dk NPGN-150LKHD

Low Dk/Df : High Layer Count
- NPG-199K Ultra Low Loss Level(II)
- NPG-198K Ultra Low Loss Level(II)
- NPG-199 Ultra Low Loss
- NPG-186K/NPG-186 Ultra Low Loss
- NPG-188H Ultra Low Loss
- NPG-182H Low Loss
- NPG-170D Low Loss
- NPG-171 Middle Loss

IC Substrate
- NPG-220K NPG-230 NPG-230K
- NPG-200WT, NPG-210, NPG-220
- NPG-180INBK, NPG-180BK

Traditional Product
- FR4 NP-140 Tg 140℃
- FR-4-11PY(CT1600)
- CEM-3-09HT, CEM-3-10(CTI600), CEM-3-01 HC(CTI600)
- CEM-1-97PM, CEM-1-97(CTI600)

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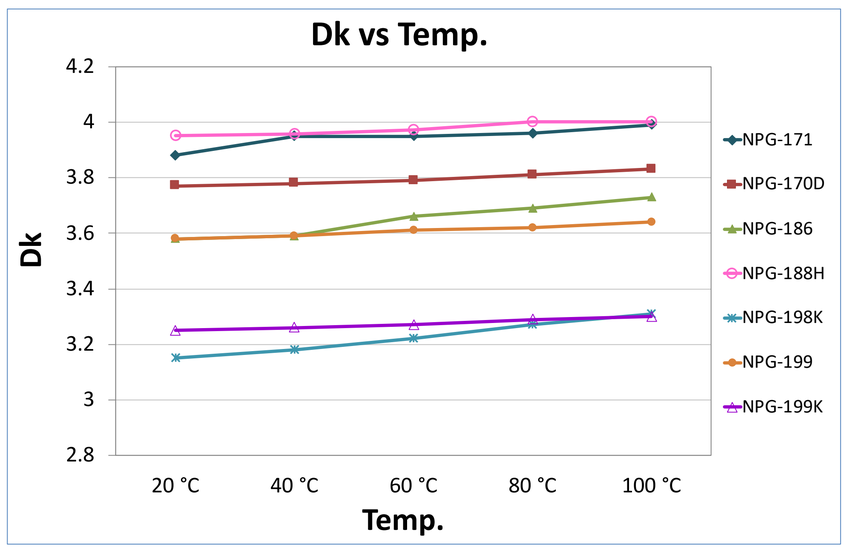
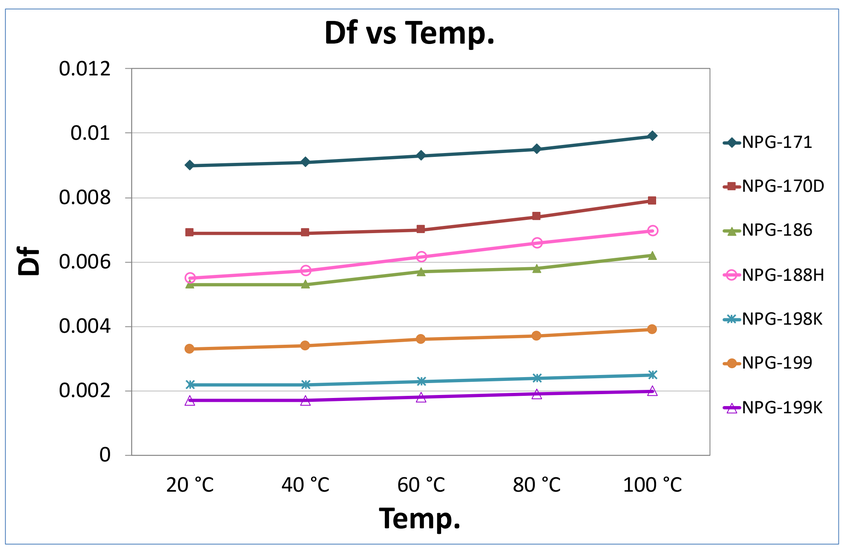
High Layer Count Material
Laminates Suited for High-Speed Applications

General Properties

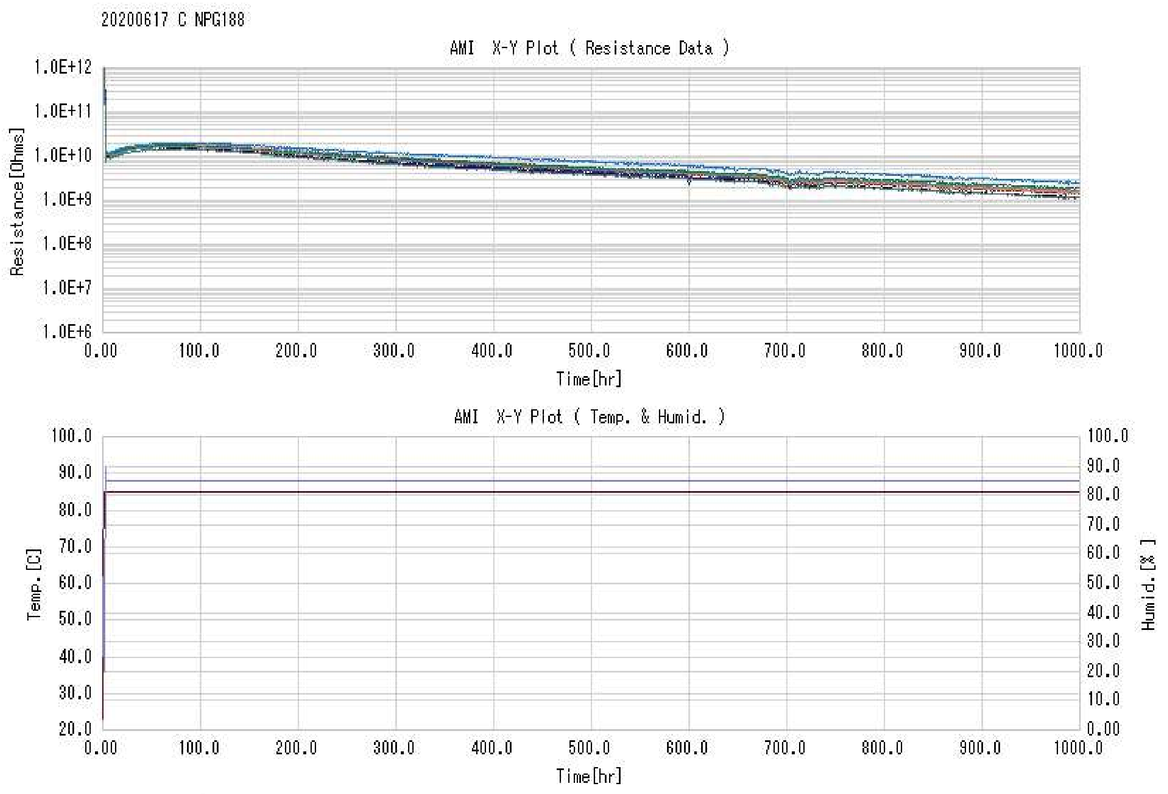
Item	Unit	NPG-171	NPG-170D	NPG-182H	NPG-188H	NPG-186	NPG-186K	NPG-198K	NPG-199	NPG-199K
Tg	℃	170	170	230 (TMA)	210 (TMA)	226 (DMA)	226 (DMA)	220 (DMA)	220 (DMA)	220 (DMA)
Z-axis CTE	α 1 (ppm/℃)	40	35	30	30	33	33	35	30	30
	α 2 (ppm/℃)	220	220	120	130	213	213	215	195	195
PCT 2 hr	Water Absorption %	0.2	0.18	0.10	0.15	0.12	0.12	0.1	0.1	0.1
	288℃ solder dipping	10'	10'	10'	10'	10'	10'	10'	10'	10'
T260	Min	>60'	>60'	>60'	>60'	>60'	>60'	>60'	>60'	>60'
Td 5%	℃	365	390	425	420	400	400	410	440	440
Dk(3GHz)	-	4.14	4.03	4.0	3.9	3.9 (10GHz)	3.5 (10GHz)	3.23 (10GHz)	4.0 (10GHz)	3.6 (10GHz)
Df(3GHz)	-	0.008	0.006	0.005	0.0043	0.005 (10GHz)	0.0035 (10GHz)	0.002 (10GHz)	0.003 (10GHz)	0.002 (10GHz)
Delta-L	dB/inch @8GHz	0.99	0.75	0.71	0.58	0.54	0.48	0.44	0.46	0.38
	dB/inch @16GHz	1.72	1.35	1.25	0.96	0.93	0.82	0.74	0.8	0.65

Stable Electrical Properties





CAF Resistance



- Material : NPG-188H 30LB
- Board thickness : 4.0 mm
- Hole size : 0.3mm, Pitch 0.6 /0.7/0.8 mm
- Precondition : IR Reflow 260℃ x 5 times
- Test Condition : 1000 hours, 85℃ /85%RH, DC 1000V
- Pass Criteria : Insulation resistance ≥1.0+E08Ω
- Result : PASS

Heat Resistance

NPG-188H 30LB

TH size : 0.25mm
TH pitch : 0.8mm
288℃ floating : 10sec x 6times

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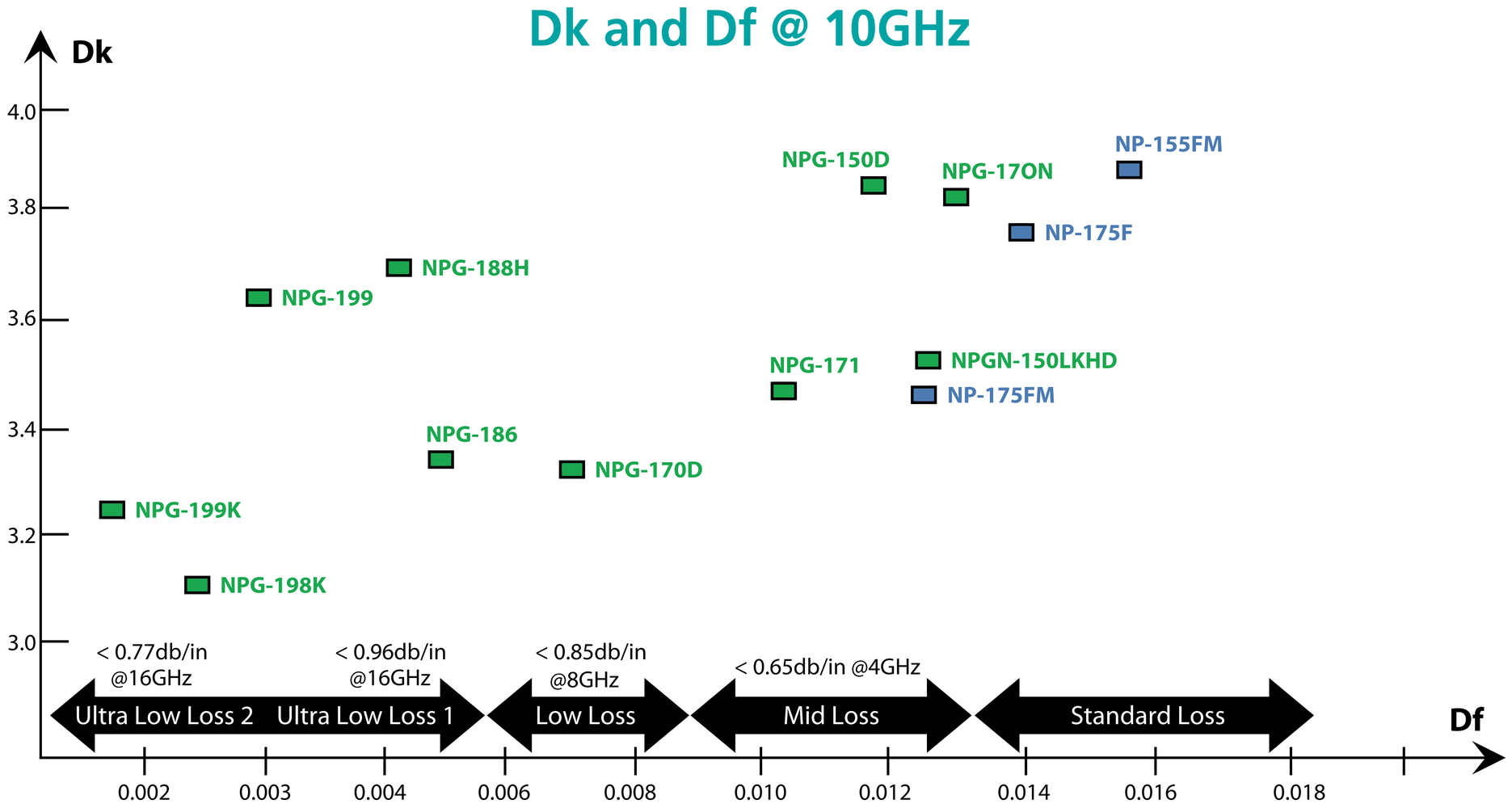
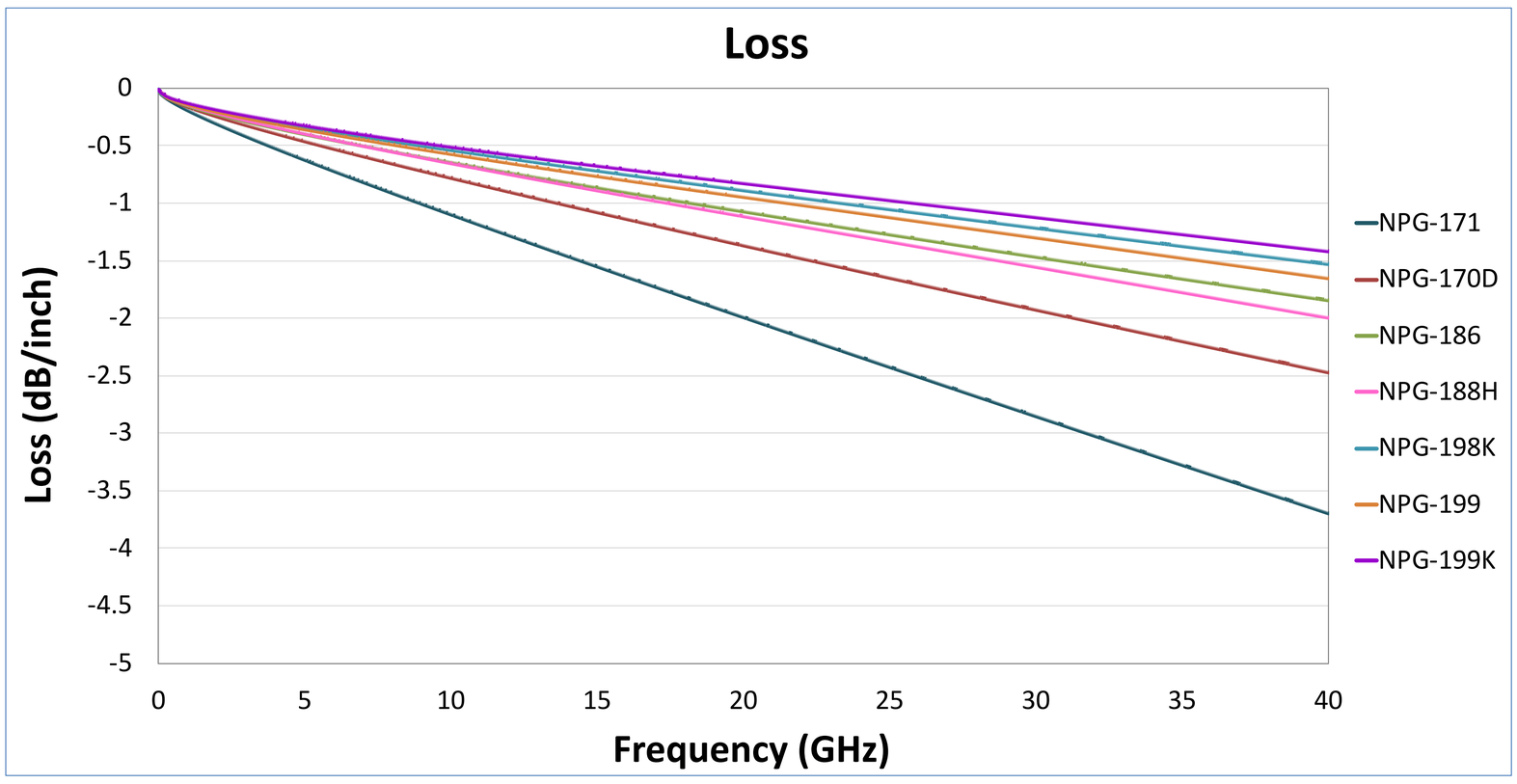
High Layer Count Material
Laminates Suited for High-Speed Applications

Dk and Df @ 10GHz





Nan Ya Materials Application

Nan Ya Products	Applications		
NPGN-150LKHD NPG-150D Series	Server Workstation		
NPG-170N NPG-171 Series	Networks Blade Server Backplanes		
NPG-170D NPG-186 NPG-188H NPG-198K NPG-199 NPG-199K	Server Storage Telecom		

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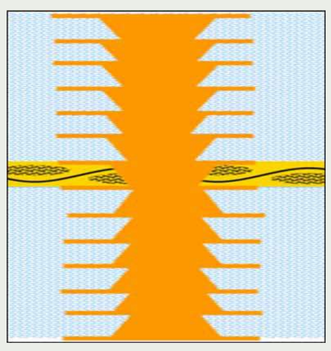
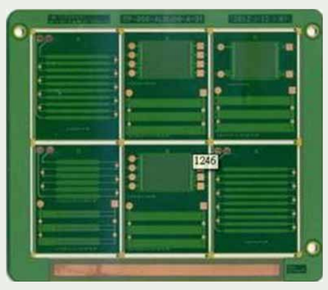
NAN YA PLASTICS CORPORATION

High Density Interconnect Material

General Properties

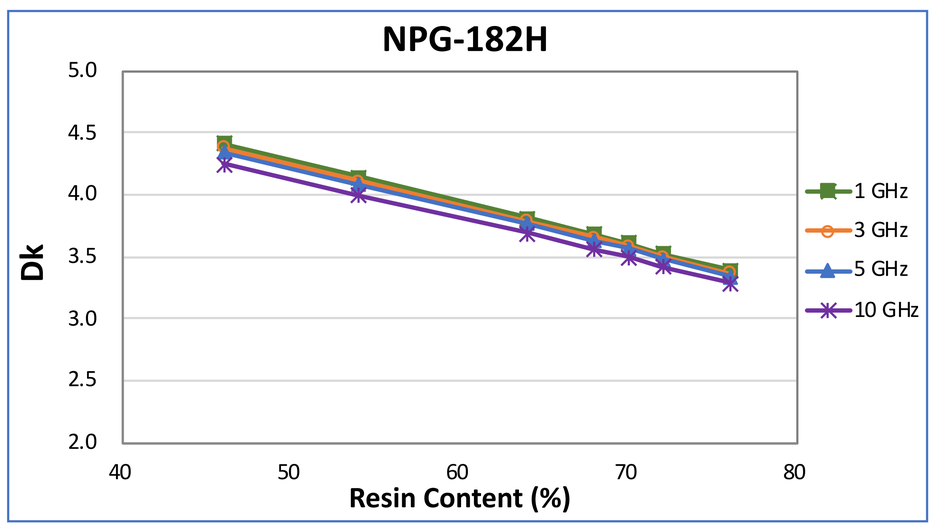
Item	Test Condition	NP-155F	NPGN-150 LKHD	NPG-150D	NPG-151	NPG-181	NPG-182H	NPG-192
Tg	℃	150	150	155(TMA)	155(TMA)	180	230(TMA)	230(TMA)
Z-axis CTE	α-1(ppm/℃)	40	30	30	30	30	30	30
	α-2(ppm/℃)	240	224	220	210	210	120	130
PCT 2 hr	Water Absorption %	0.19	0.17	0.15	0.16	0.15	0.15	0.10
	288℃ solder dipping	10'	10'	10'	10'	10'	10'	10'
T260	Min	>60'	>60'	>60'	>60'	>60'	>60'	>60'
Td 5%	℃	350	370	350	380	390	425	430
Dk(1GHz)	RC 74%	3.9	3.4	4.1	3.9	3.4	3.5	3.3 (RC70%@10GHz)
Df(1GHz)	RC 74%	0.013	0.012	0.009	0.013	0.008	0.005	0.004 (RC70%@10GHz)

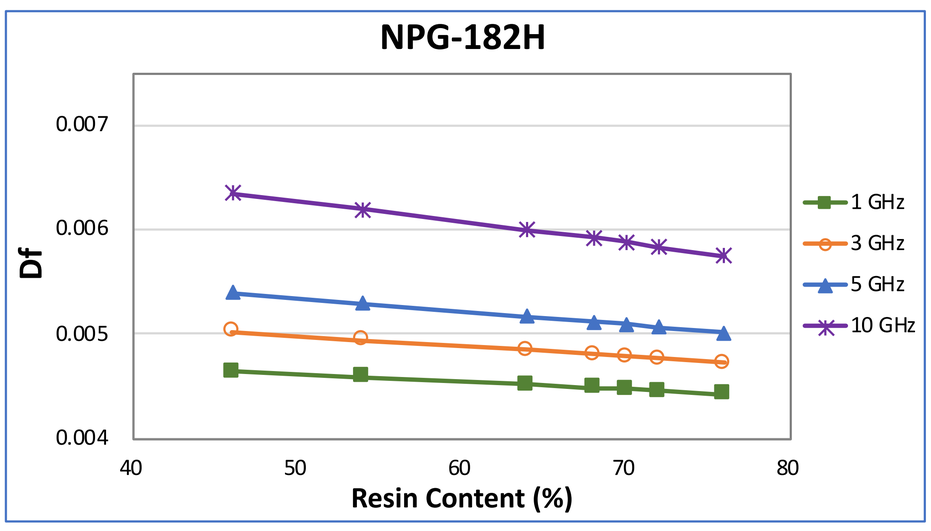
Thermal Reliability

Materials	Construction (7+2+7)	Test Pattern
NPG-182H Core thickness 60 μm (1078x1ply) Built-up prepreg 1078(RC70%)		

Test Item	Condition	Results
Reflow	Peak temp @260℃	> 15 cycles
Thermal Stability	Solder dipping 274℃	> 15 cycles
Hot Oil Test	25 ℃ x20"/260 ℃ x20"	> 20 cycles
TCT	-55x15min/ 10" /125℃ x15min	> 300 cycles

Dielectric Properties/Material: NPG-182H





Nan Ya Materials Application

Nanya Products	Applications
NP-155F & NPG-150D Series	1+N+1, 2+N+2, 3+N+3 HDI-process compatible Desktop Laptop Tablet Mobile Phone Hard Disk Game Console LCD TV
NPG-151 & NPG-150D Series	ELIC & any-layer HDI-process compatible Laptop Tablet Mobile Phone
NPG-181 / NPGN-150LKHD Series (Low Dk Material) NPG-182H / NPG-192	ELIC & any-layer HDI-process compatible Tablet Mobile Phone

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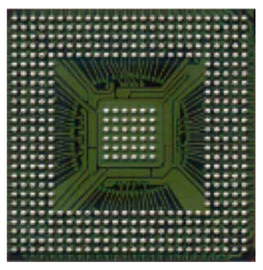
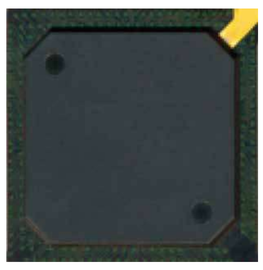
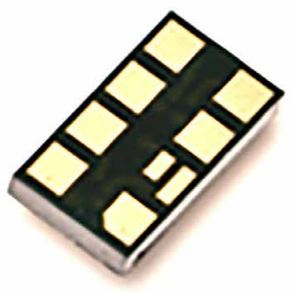
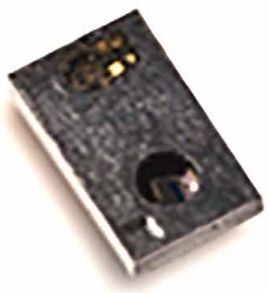
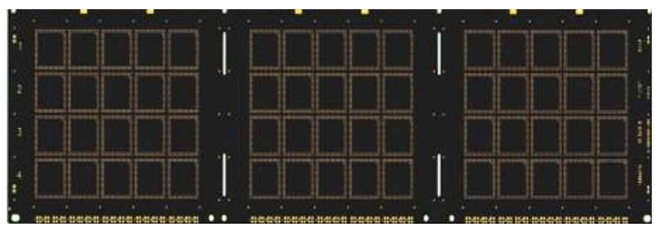
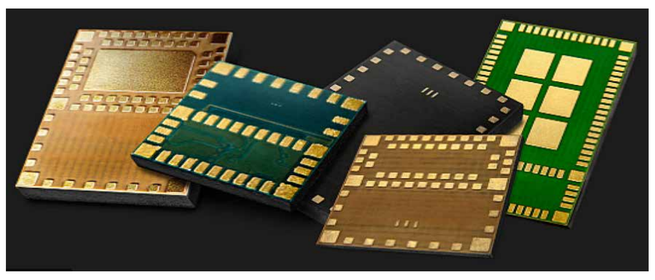
Halogen Free IC Substrate Materials

General Properties

Test Item	Unit	NPG-180INBK	NPG-180BK	NPG-210	NPG-220	NPG-220K	NPG-230	NPG-230K
Color		Black	Black	Black	Black	Black	NC	NC
Copper	oz	T	T	T	T	T	1(HVLP)	1(HVLP)
Peel strength	lb/in	4.9	4.9	4.0	4.5	4.5	3.5~4.0	3.5~4.0
Permittivity (1GHz)	-	4.48	4.72	4.2	4.1(10GHz)	3.75(10GHz)	4.0(10GHz)	3.6(10GHz)
Loss tangent (1GHz)	-	0.010	0.013	0.006	0.009(10GHz)	0.004(10GHz)	0.003(10GHz)	0.002(10GHz)
Tg by DMA	℃	240	240	310	270	270	220	220
Tg by TMA	℃	180	180	270	200	200	180	180
Storage Modulus at 50℃	GPa	22	22	25	23	23	15-16	15-16
Storage Modulus at 240℃	GPa	12	12	15	13	13	6-7	6-7
CTE-Z(α 1)	ppm/℃	30	30	20	28	28	30	30
CTE-Z(α 2)	ppm/℃	90	90	55	120	120	195	195
CTE-X,Y(α 1)	ppm/℃	12	12	6±1 (E glass) 4±1 (S glass)	10	10	10-13	10-13
W.A(D-23/24)	%	0.25	0.25	0.14	0.20	0.20	0.008	0.008
T288 Delamination with copper	min	>20'	>20'	>60'	>60'	>60'	>60'	>60'

Nan Ya Substrate Materials Applications

Nan Ya Products	Applications	
NPG-180IN NPG-180INBK	Memory card CSP DDR Ⅲ , DDR Ⅳ PBGA	 
NPG-180BK	Mini LED RGB Optical sensor	 
NPG-210 NPG-210 Type S	Ultra Low CTE FCCSP POP MCP	
NPG-220 NPG-220K NPG-230 NPG-230K	Antenna in package	

Nan Ya IC Substrate Materials Features

1. Excellent dimensional stability and through-hole reliability
2. Excellent thermal stability and long term reliability
3. Excellent insulation properties for CAF
4. Raw materials integration to ensure consistent and stable supply

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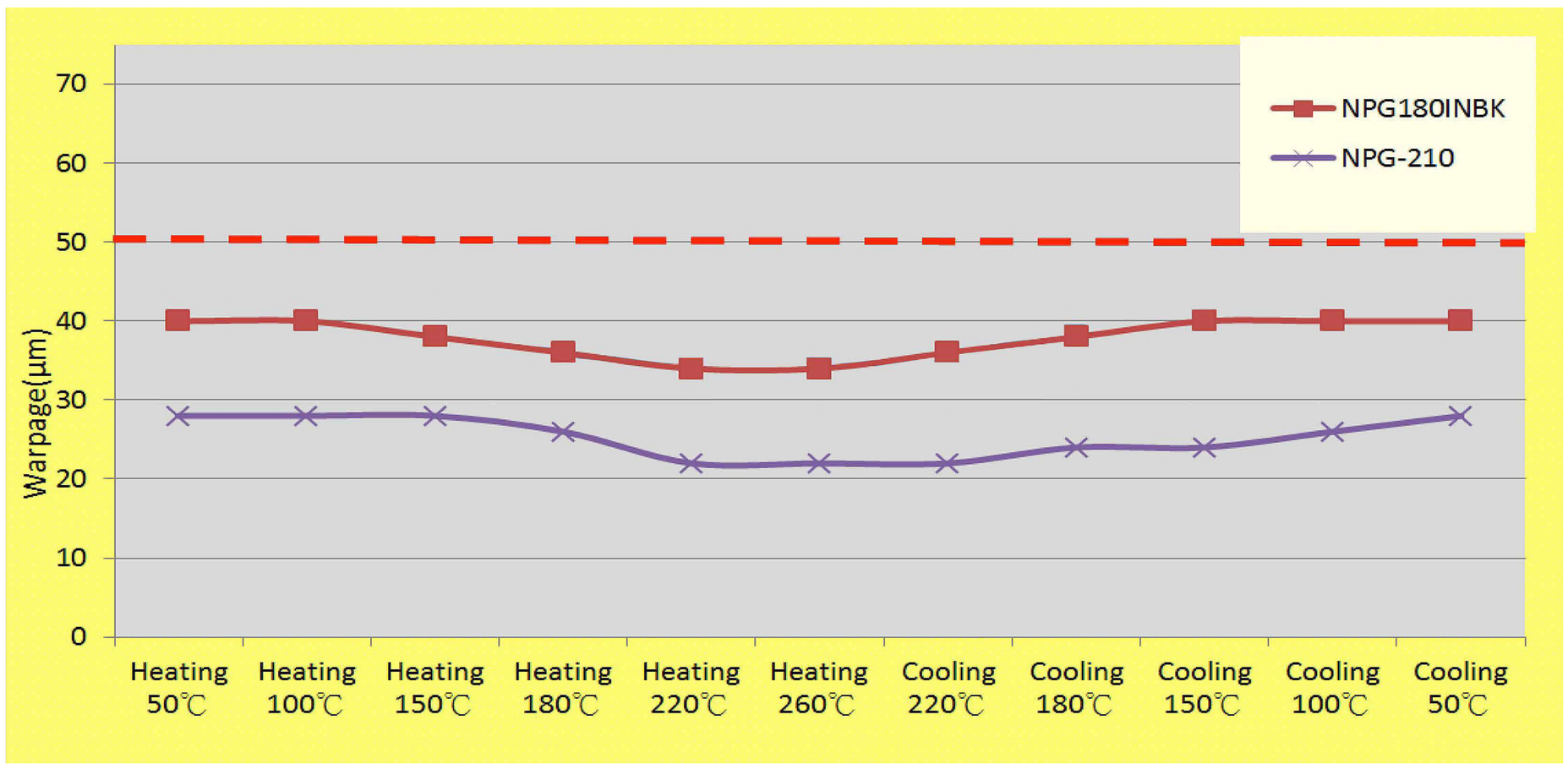
Halogen Free IC Substrate Materials
Warpage Test of Nan Ya Substrate Cores

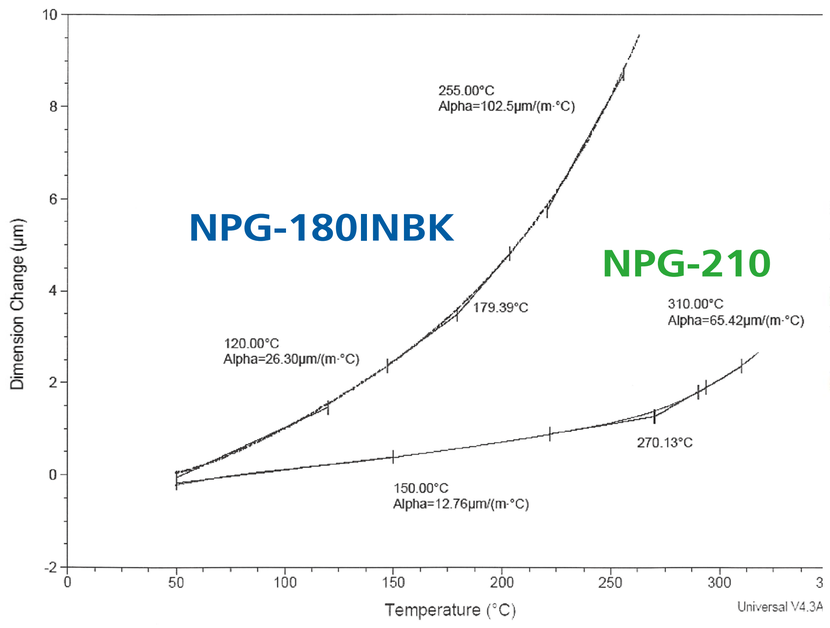
- **Features :**
  - Halogen and antimony free.
  - Flammability meets UL 94 V-0.
  - Excellent long term reliability.
  - UV blocking type.
  - Superior CAF-Resistance (Anti-migration).
  - Reactive type flame retardants.
  - High Tg (DMA)> 300℃ and ultra low C.T.E will provide excellent dimensional stability and through-hole reliability.



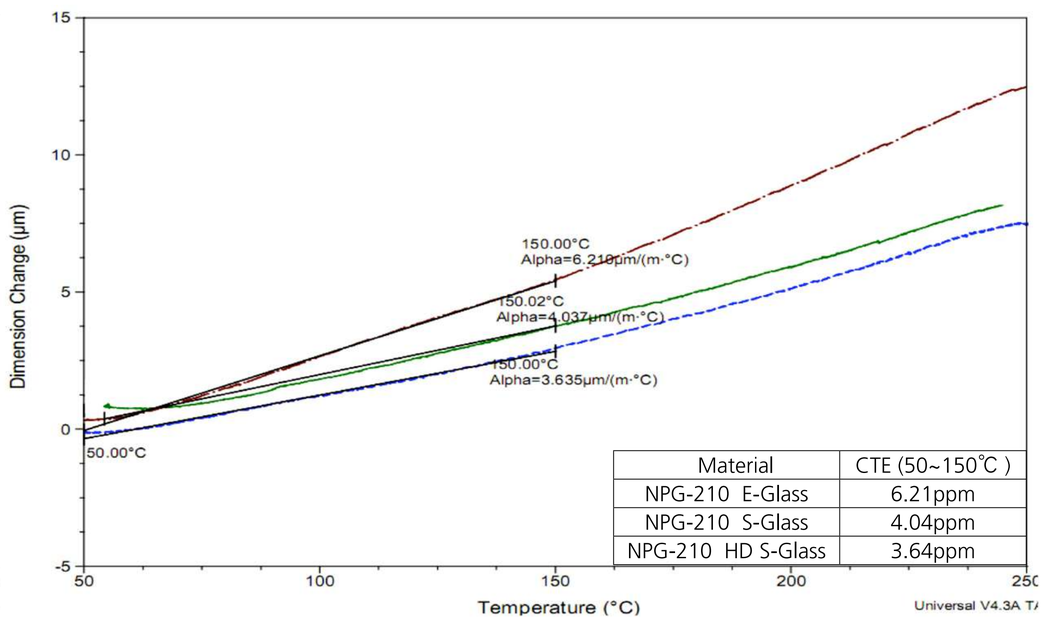
Nan Ya substrate cores with low warpage trend.

Nan Ya Low CTE Substrate Cores Comparison

Z AXIS CTE



X AXIS CTE



Material	CTE (50~150℃)
NPG-210 E-Glass	6.21ppm
NPG-210 S-Glass	4.04ppm
NPG-210 HD S-Glass	3.64ppm

NPG-180IN and NPG-210 are designed with high Tg, low C.T.E and high stiffness to provide excellent thermal reliability and dimensional stability.

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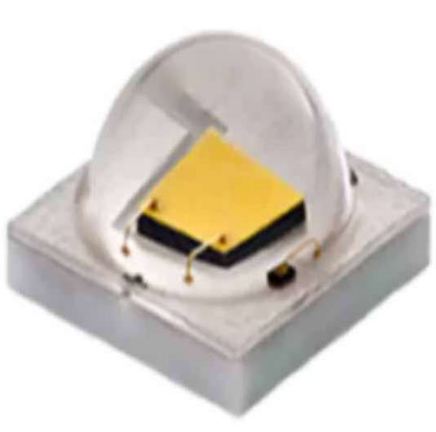
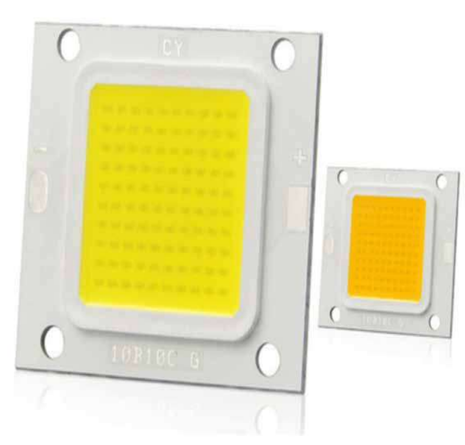
Substrate Materials for Mini-LED Application
NPG-200WT

• Applications




• Features

1. Excellent optical properties

* In the visible range (400nm ~ 450nm), having high reflectivity
* Excellent resistance to high temperature yellowing (antioxidant)
* Excellent resistance to UV yellowing

2. High Tg and high thermal reliability

* DMA Tg> 200 ℃
* High thermal stability
* Low coefficient of expansion

• Property Comparison

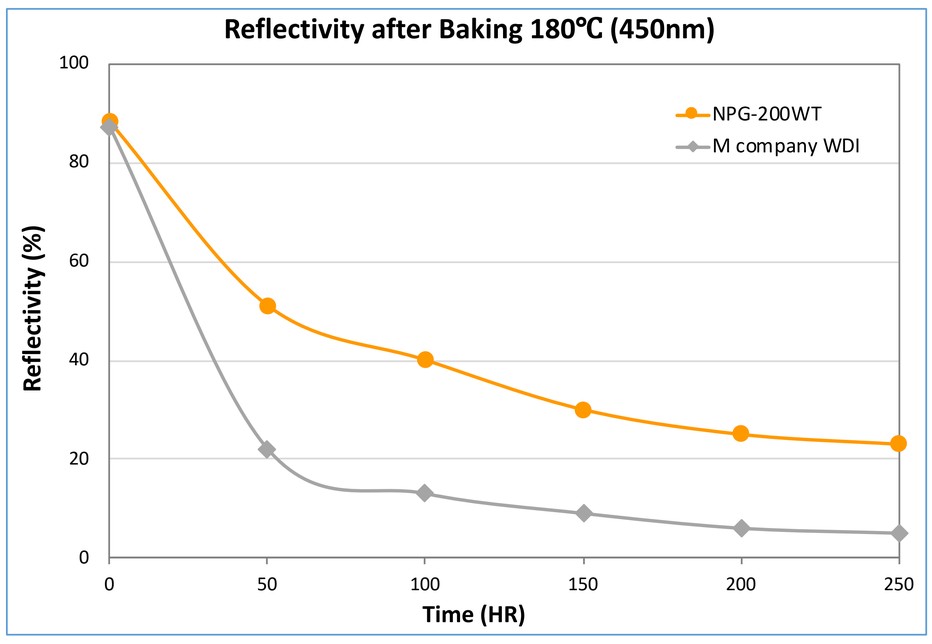
Test Item	Unit		Nan Ya NPG-200WT	M company
Color	-		White	White
Halogen-free compliance	-		Yes	N/A
DK(1GHz)	-		5.2	5.7
Df(1GHz)	-		0.018	0.020
Insulation resistance	C-96/20/65		$6*10^{14-15}$ Ω	$5*10^{13-15}$ Ω
Suface resistance	C-96/20/65		$6*10^{14-15}$ Ω	$5*10^{13-15}$ Ω
CTE(X,Y,Z)	X	<Tg (ppm/℃)	15	15
	Y		15	15
	Z		35	33
	Z	>Tg (ppm)	170	171
Tg(by DMA)	-		205℃	200℃
1/2hr PCT TEST	Water absorption		0.27%	0.29%
	288℃ dipping		>10’	>10’
Flame resistance	E-168/70		V-0	HB

Reflectivity comparison after 180℃ baking

Test Condition :

Temperature：180℃ *240hrs

Reflectivity Wave length：450nm



Substrate color comparison after 180℃ baking

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Automotive Application

FEATURES :

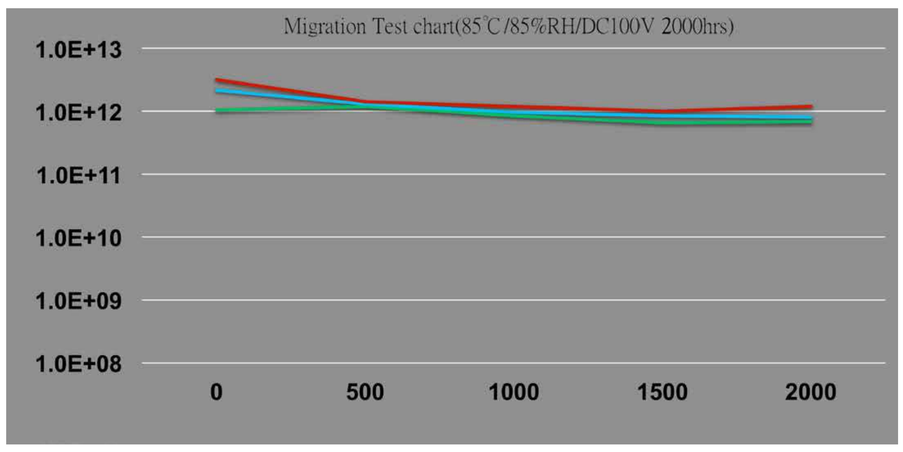
Excellent Thermal and Mechanical Properties
- Lead free compatible.
- Stable long time thermal storage.
- Low Z-CTE, high PTH reliability.

Excellent Insulation and CAF properties
Low Moisture Absorption

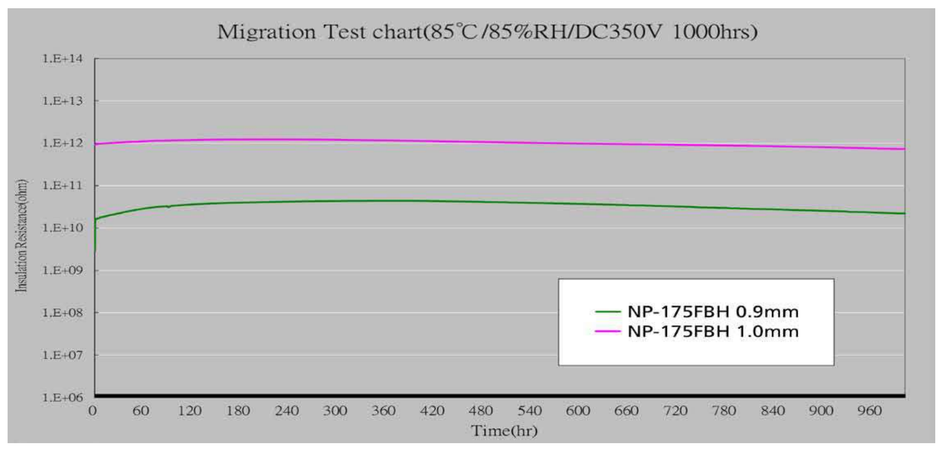
General Properties

Product Name	NP-155F	NP-155FBH	NP-175FBH	NPG-151	NPG-180BH	NPG-190BH
Properties	PN Mid TG	PN Mid TG	PN Hi TG	H/F	H/F, Hi TG Ultra Low CTE	H/F, Hi TG Low CTE
Tg (℃ , By DSC)	150	150	170	155(TMA)	185	230(TMA)
Td (℃)	350	350	350	380	395	430
Fillers	Yes	Yes	Yes	Yes	Yes	Yes
Flammability (UL 94)	V-0	V-0	V-0	V-0	V-0	V-0
Z-Axis alpha 1 max (ppm/℃)	40-50	35-45	30-40	30-40	25-40	20-25
Z-Axis alpha 2 max(ppm/℃)	230-250	220-240	210-230	210-230	125-145	120-130
Z-Axis % (50~260℃)	3.0	2.6	2.2	2.4	1.6	1.4
T-260 (min)	>60'	>60'	>60'	>60'	>60'	>60'
T-288 (min)	>20'	>20'	>30'	>30'	>30'	>30'
Anti CAF	Yes	Yes	Yes	Yes	Yes	Yes

CAF Resistance



Material : NP-175FBH 8LB
Board thickness : 1.6 mm
Hole size : 0.3mm , Pitch 0.8 /0.9/1.0mm
Precondition : IR Reflow 260℃ x 3 times
Test Condition : 2000 hours, 85°C/85% DC 100V
Pass Criteria : Insulation resistance ≥ 10^8 Ω
Result : PASS

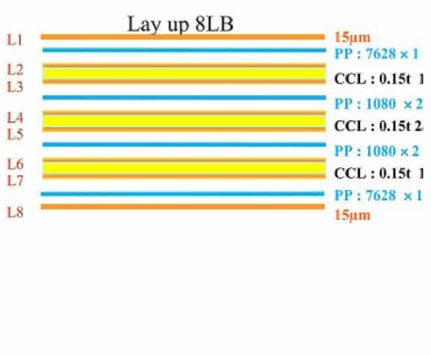


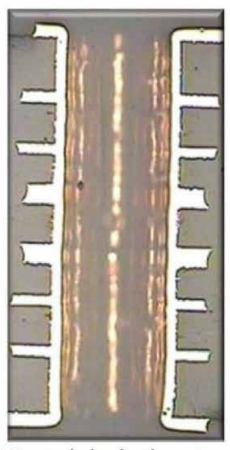
Material : NP-175FBH 8LB
Board thickness : 1.6 mm
Hole size : 0.3mm , Pitch 0.9/1.0mm
Precondition : IR Reflow 260℃ x 3 times
Test Condition : 1000 hours, 85°C/85% DC 350V
Pass Criteria : Insulation resistance ≥ 10^8 Ω
Result : PASS

TCT Evaluated (Air to Air)

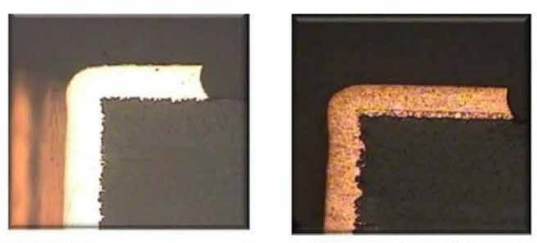
- **Material : NP-175F 8LB**
- Board thickness : 1.6mm
- Precondition: 3X reflow @ 260℃
- Pass Criteria :Resistance change < 10%
- Test Condition:**-40˚C /+145˚C** 30min / 10s / 30min **1000 cycle**
- Result: PASS

Hours		0	300	500	750	1000	Change Rate
1	1	0.8019	0.7928	0.81	0.8143	0.8238	2.73%
	2	0.7167	0.7067	0.706	0.7069	0.7354	2.61%
	3	0.7053	0.6985	0.693	0.6991	0.6855	-2.81%
	4	0.4966	0.4917	0.485	0.4259	0.5037	1.43%
	5	0.3929	0.387	0.418	0.4177	0.3942	0.33%
2	1	0.7938	0.7889	0.755	0.7652	0.7701	-2.99%
	2	0.7145	0.7066	0.701	0.8004	0.7401	3.58%
	3	0.7264	0.7119	0.717	0.7036	0.6956	-4.24%
	4	0.4957	0.4985	0.49	0.4888	0.4809	-2.99%
	5	0.3935	0.3871	0.41	0.4224	0.3963	0.71%
3	1	0.8511	0.8409	0.791	0.7991	0.832	-2.24%
	2	0.7544	0.7516	0.735	0.7354	0.747	-0.98%
	3	0.7585	0.7526	0.791	0.7916	0.748	-1.38%
	4	0.5393	0.533	0.537	0.5388	0.526	-2.47%
	5	0.4063	0.3991	0.421	0.4219	0.424	4.36%
4	1	0.7979	0.7909	0.7825	0.7898	0.7970	-0.11%
	2	0.7156	0.7067	0.7035	0.7537	0.7378	3.10%
	3	0.7159	0.7052	0.7050	0.7014	0.6906	-3.53%
	4	0.4962	0.4951	0.4875	0.4574	0.4923	-0.78%
	5	0.3932	0.3871	0.4140	0.4201	0.3953	0.52%
5	1	0.8225	0.8149	0.7730	0.7822	0.8011	-2.60%
	2	0.7345	0.7291	0.7180	0.7679	0.7436	1.24%
	3	0.7425	0.7323	0.7540	0.7476	0.7218	-2.78%
	4	0.5175	0.5158	0.5135	0.5138	0.5035	-2.71%
	5	0.3999	0.3931	0.4155	0.4222	0.4102	2.56%

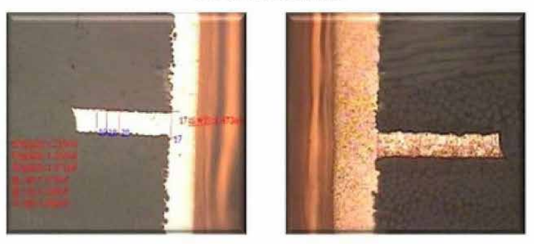




Check Item : de-lamination, separation of layers, measlings, laminate or prepreg voids, resin crack, pull away, resin recession, resin recession inner layer, Plating crack
No defect found



Check Item : Corner crack, pad lift, outer layer foil crack
No defect found



Check Item : Wedge Void, plating crack, inner layer foil crack
No defect found

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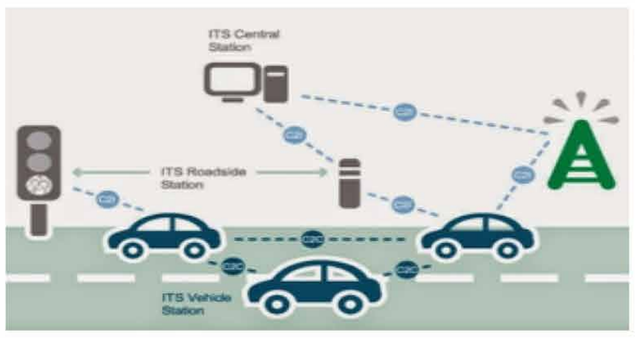
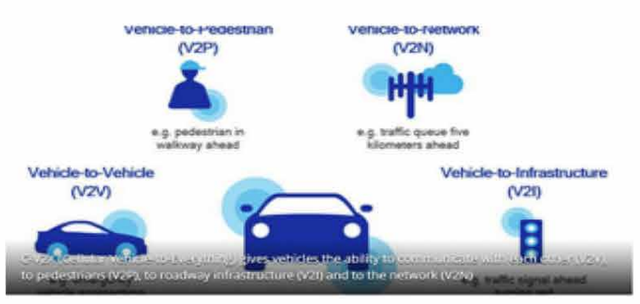
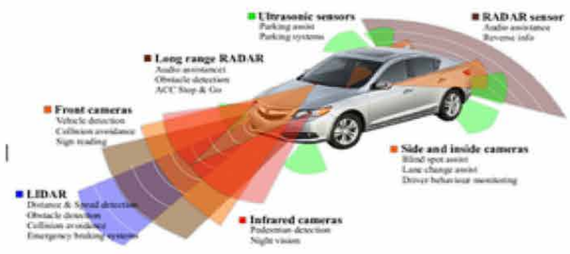
Automotive Electronic Material Trend

Internet of Vehicle

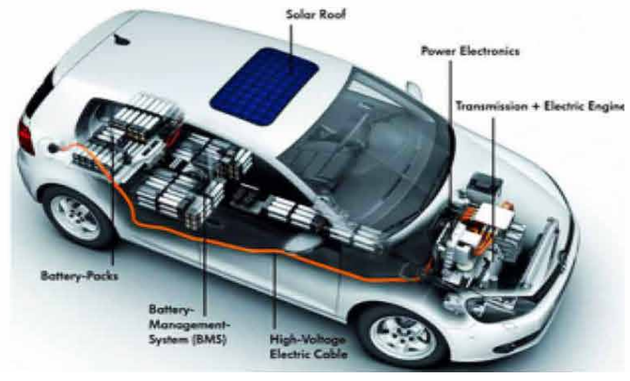




ADAS



New Energy



Automotive Product Update

Passenger Compartment Exterior Accessible to Splash, Etc In Car	Headliner Engine Compartment Remote From Engine	Ignition Surface Engine Compartment Close to Engine	On Engine Alternator Surface
～45℃	～105℃	～125℃	140℃～150℃ 160℃

NP-140

NP-155F

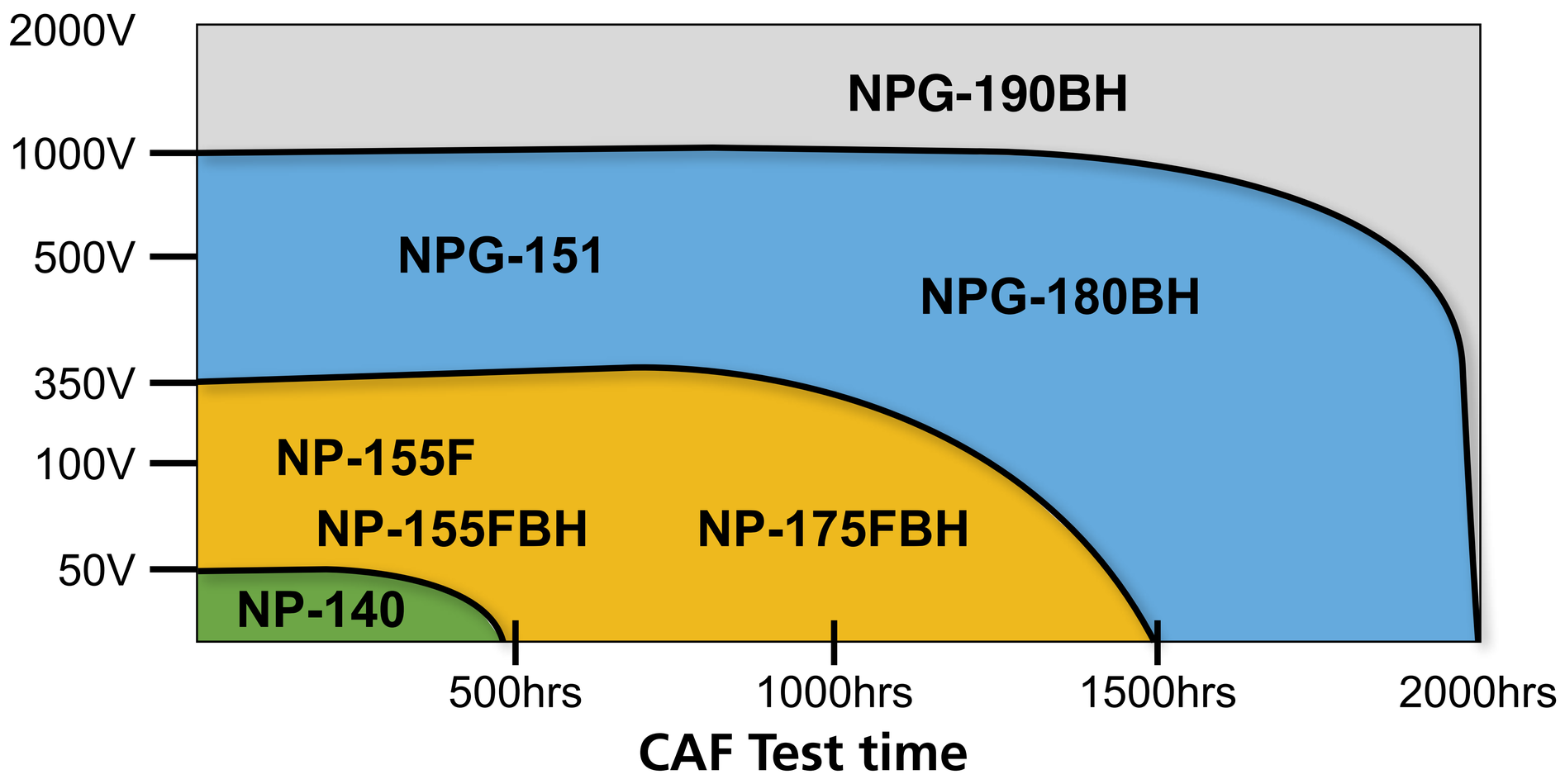
NP-155FBH/NPG-151

NPG-170N

NP-175FBH

NPG-180BH

NPG-190BH



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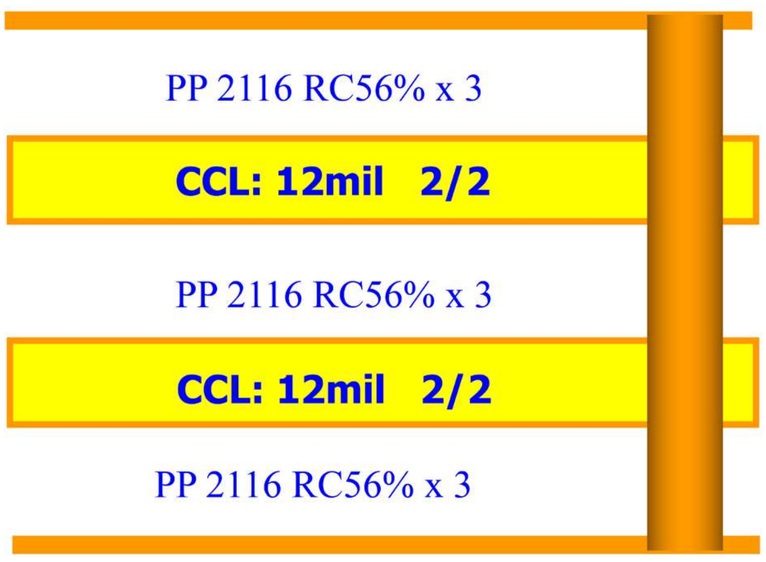
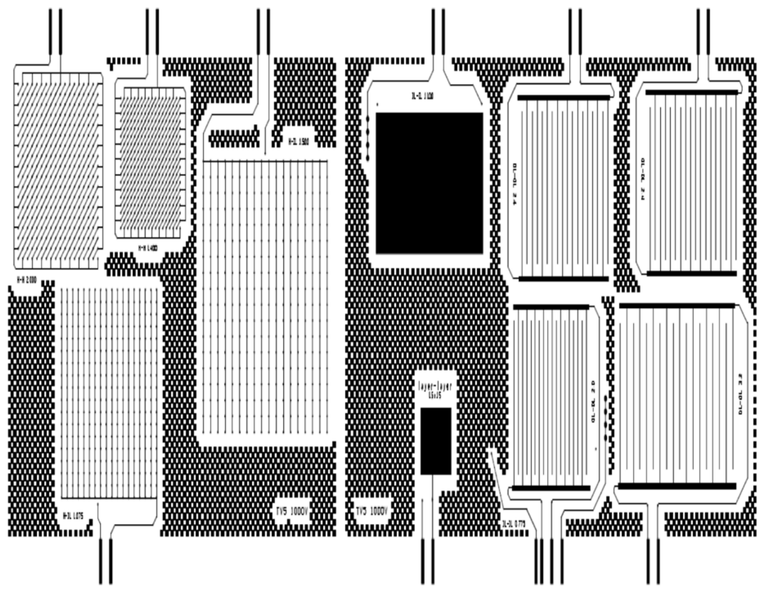
High Voltage & Heavy Copper CAF test

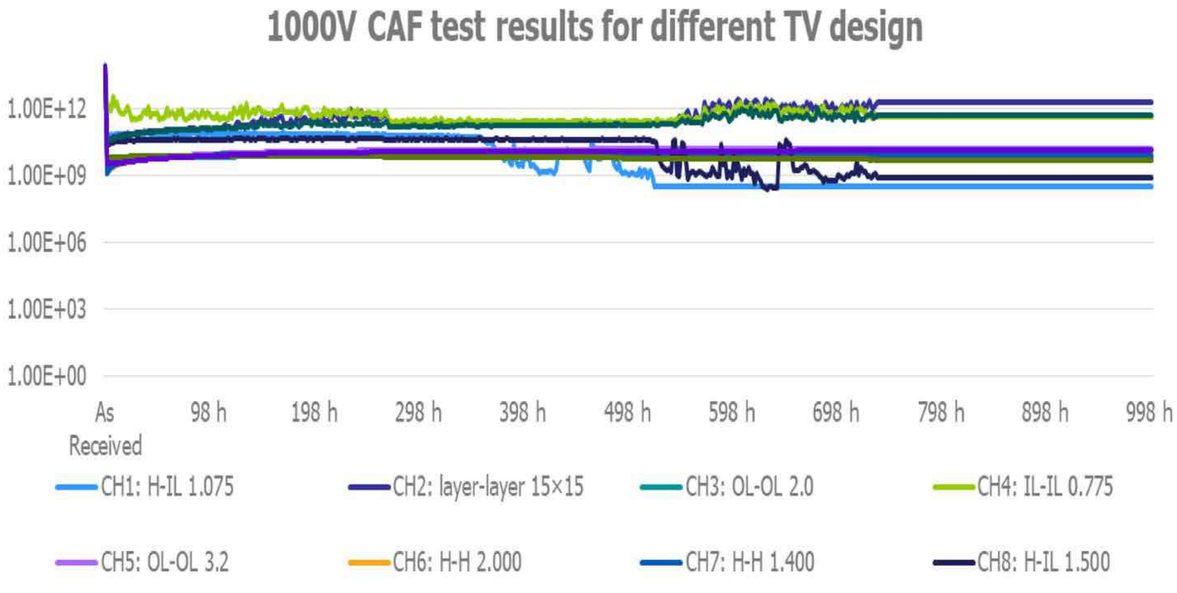
Test information

- Precondition: 3X lead free reflow at 260°C
- Test and bias voltage: 1000 V, 85 °C, 85% relative humidity, 1000hrs
- Test material: NP-175FBH
- Pass criteria: All insulation resistance are higher than 1.0E+08 ohms
- Test Patterns :



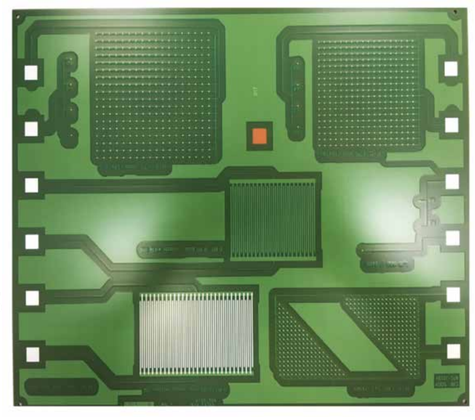


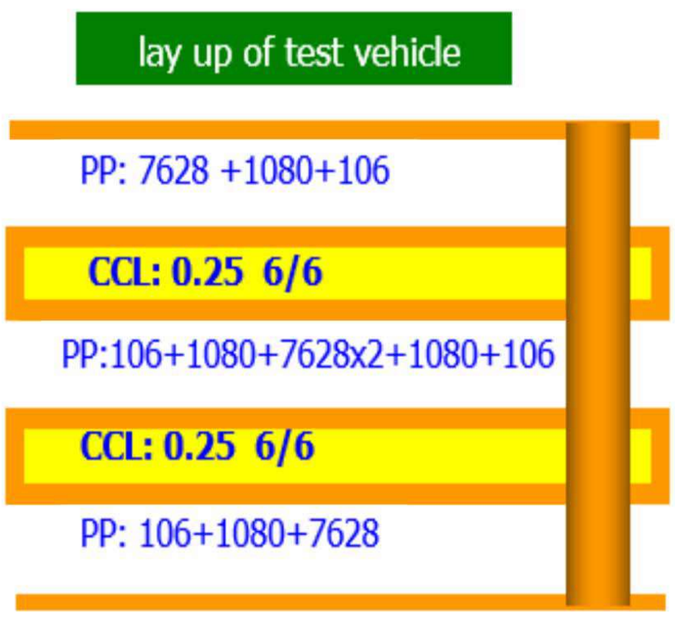
Test Sample	Test Pattern (mm)	Test Quantity (PC)	Test Result
NP-175FBH 6LB 2oz	H-H 1.400	10	Pass
	H-H 2.000	10	Pass
	H-IL 1.075	10	Pass
	H-IL 1.500	10	Pass
	IL-IL 0.775	10	Pass
	IL-IL 1.100	10	Pass
	OL-OL 2.0	10	Pass
	OL-OL 2.4	10	Pass
	OL-OL 3.2	10	Pass
	OL-OL 2.4 (Soldermask)	10	Pass
	layer-layer 15×15	10	Pass

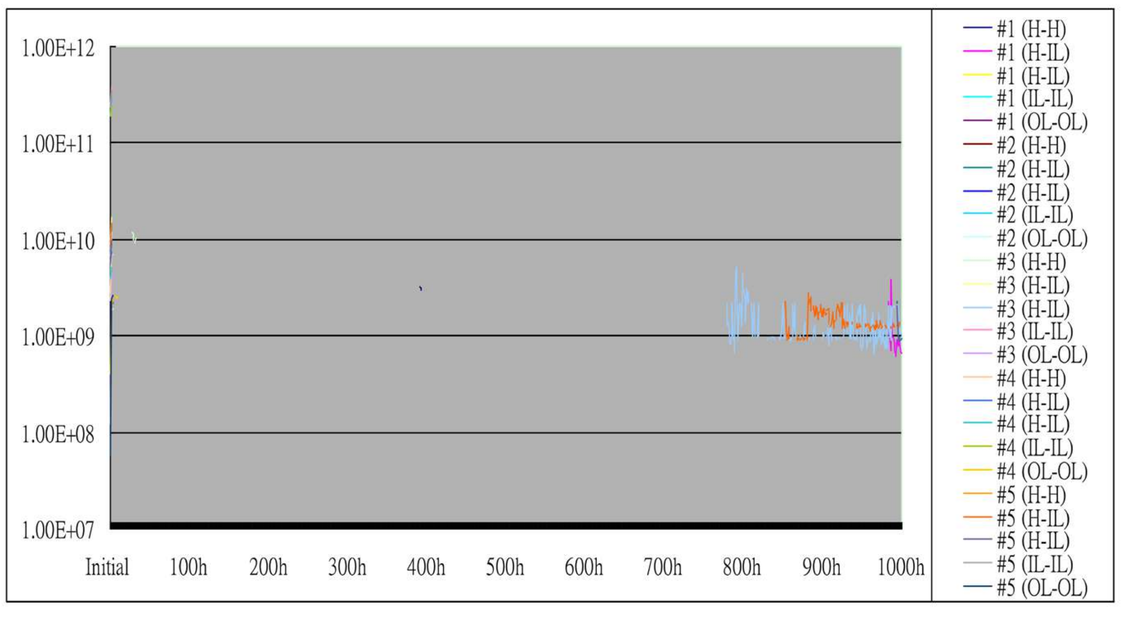


NPG-180BH 6LB with 6oz inner layer

- Precondition: 3X lead free reflow at 260C
- Test and bias voltage: 500 V
  85 +/- 2°C, 85 +3/-2% relative humidity, CAF 1000 hours
- Test Patterns : HW-HW 2.6mm, H-IL: 1.75mm; L/S:1.4mm
- Pass criteria: All insulation resistance are higher than 2.0E+07 ohms
- Result: Pass (All resistance high than 2.0E+07 ohms)







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5G Network Application Materials

FEATURES :

- High speed and high frequency application.
- Low Dk/Df, high Tg, high heat resistance and high reliability.
- Suitable for communication and network (Router, server, switch) equipment.
- Hydrocarbon bondply NP-535B have Low Dk/Df and good resin flow, suitable for multilayer application.

5G Network application

Small cell

Mobile phone

5G Home router

5G Base station

General Properties

Item	Unit	NP-930	NP-730	NP-826	NP-822	NP-530	NP-535	NP-536	NP-536HC	NP-535B Bondply	NPG-186	NPG-198K	NPG-199	NPG-199K
Resin System	-	PTFE				Hydrocarbon					PPE			
Flame retardant	-	Halogen Free	Halogen Free	Halogen Free	Halogen Free	Halogen	Halogen	Halogen	Halogen	Halogen	Halogen Free	Halogen Free	Halogen Free	Halogen Free
Dk (10GHz)	-	3.0	3.0	2.6	2.2	2.98	3.45	3.55	3.66	3.50	3.9	3.23	4.0	3.6
Df (10GHz)	-	0.0010	0.0022	0.0018	0.0009	0.0030	0.0033	0.0031	0.0030	0.0031	0.0050	0.0020	0.0030	0.0020
Peel Strength (1oz)	lb/in	10	10	10	10	6.0-7.0	6.0-7.0	6.0-7.0	6.0-7.0	6.0-7.0	6.0-6.5	5.0-6.0	5.0-6.0	5.0-6.0
T288	Min	>60'	>60'	>60'	>60'	>60′	>60′	>60′	>60′	>60′	>60′	>60′	>60′	>60′
Td 5%	℃	540	540	540	540	420	370	380	410	420	395	404	440	440
Flammability	UL-94	V-0	V-0	V-0	V-0	V-0	V-0	V-0	V-0	V-0	V-0	V-0	V-0	V-0
PIM	dBc	≦ -158	≦ -158	≦ -158	≦ -158	≦ -158	≦ -158	≦ -158	≦ -158	-	-	-	-	-
outgassing	-	pass	pass	pass	pass	-	-	pass	-	-	pass	pass	-	-

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High Frequency Millimeter Wave Materials

FEATURES :

- Low dielectric constant and low dissipation factor at high frequency range.
- Tightly controlled Dk tolerance enables more consistent performance.
- By choosing low roughness copper foil to reduce skin effect and signal loss.
- Excellent dimensional stability.
- Suit for Automotive Radar, 5G Infrastructure and Aerospace application.

Products	Electrical Properties (at 10GHz)	Composites	Applications
NP-930	Dk=3.0 Df=0.0010	PTFE Ceramic-filled Glass Fabric	Automotive Radar (77GHz)
NP-536HC	Dk=3.66 Df=0.0033	Hydrocarbon Ceramic-filled Glass Fabric	Automotive Radar (24GHz)
NP-730	Dk=3.0 Df=0.0028	PTFE Ceramic-filled Glass Fabric	5G Infrastructure Base Station Antenna Power Amplifier Low Noise Block RF Components Aerospace
NP-735	Dk=3.5 Df=0.0030 TC=0.75 W/m・k	PTFE Ceramic-filled Glass Fabric	
NP-826	Dk=2.6 Df=0.0025	PTFE Glass Fabric	
NP-822	Dk=2.2 Df=0.0014	PTFE Glass Fabric	
NP-536	Dk=3.55 Df=0.0036	Hydrocarbon Ceramic-filled Glass Fabric	5G Infrastructure Base Station Antenna Power Power Amplifier Low Noise Block Network station Switch Router Server V sat Aerospace
NP-535	Dk=3.45 Df=0.0033		
NP-530	Dk=2.98 Df=0.0036		
NP-535B (Bonding Material)	Dk=3.5 Df=0.0037		
NPG-186	Dk=3.9 Df=0.0050	Low Dk Resin Ceramic-filled Glass Fabric	
NPG-186B (Bonding Material)			
NPG-199K	Dk=3.6 Df=0.0020		
NPG-199KB (Bonding Material)			

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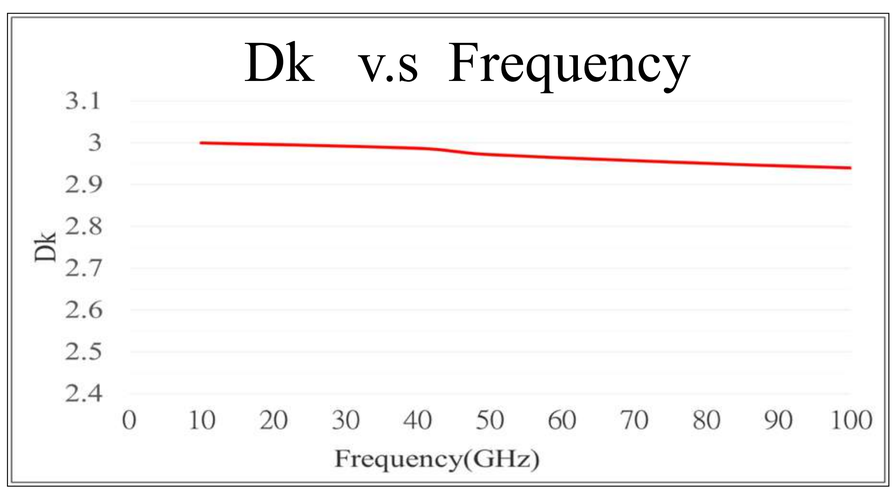
77GHz Automotive Radar
NP-930

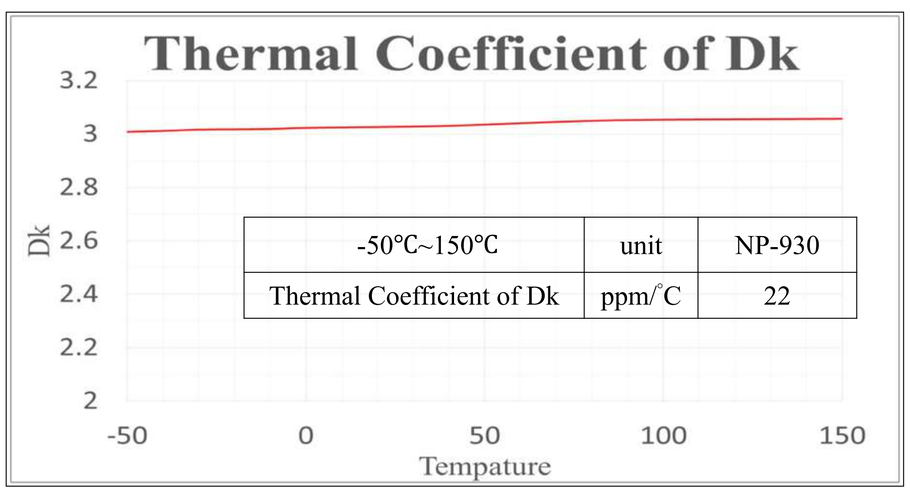
FEATURES :

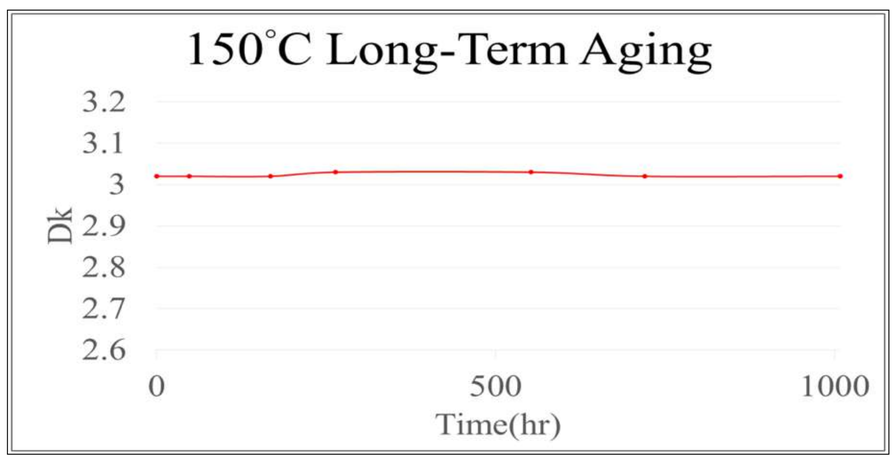
- Low Dk/Df enables more consistent performance and low loss
- Tightly controlled Dk tolerance ± 0.04
- Low TCDk can maintain stable electrical properties under severe environment
- Excellent peel strength and excellent dimension stability
- Suit for 77GHz Automotive Radar and high frequency application

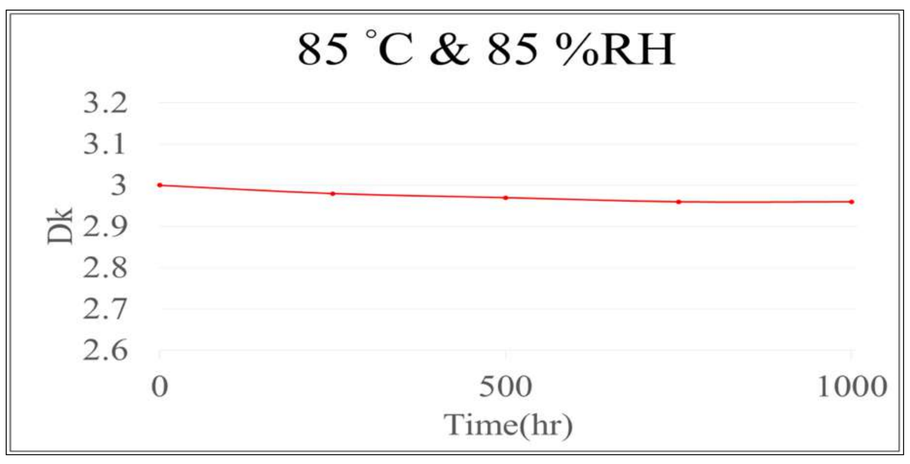
Item	Unit	Test Method	NP-930
Dk(10GHz)	-	IPC-TM-650 2.5.5.5	3.0
Df(10GHz)	-	IPC-TM-650 2.5.5.5	0.0010
Peel Strength(1oz)	lb/in	IPC-TM-650 2.4.8	10
Thermal Coefficient of Dk, TCDk	ppm/℃	IPC-TM-650 2.5.5.13	22
T288	Min	IPC-TM-650 2.4.24.1	>60'
Td 5%	℃	ASTM D3850	540
Moisture absorption	%	IPC-TM-650 2.6.2.1	0.05
Flammability	-	UL-94	V-0

Reliability Testing



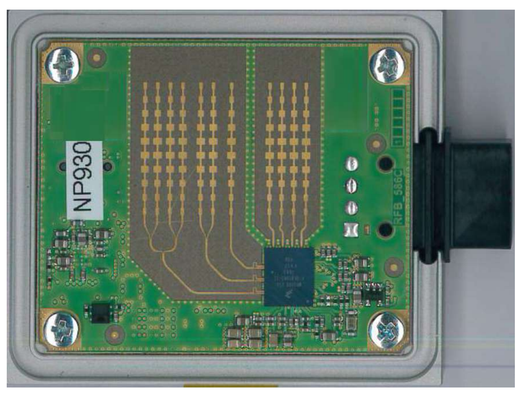




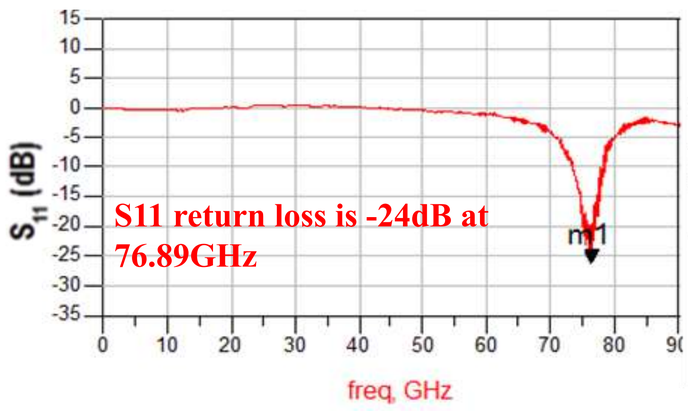


Return Loss & Insertion Loss Measurement

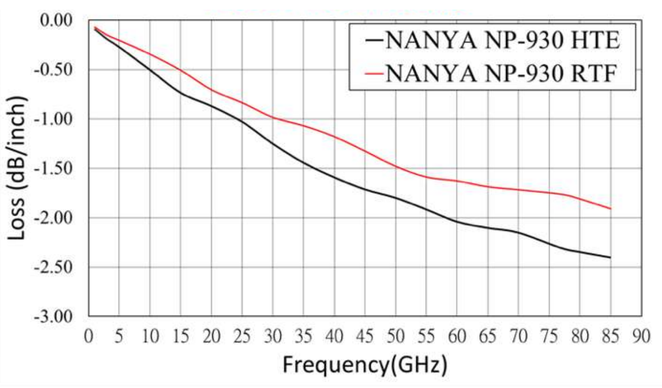
77GHz Radar



S11 Return Loss



Insertion Loss



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