

CHEMISTRY THAT MATTERS™



AN INTRODUCTION OF LNP™ DIELECTRIC SOLUTION

SEP 2022



CONTENT

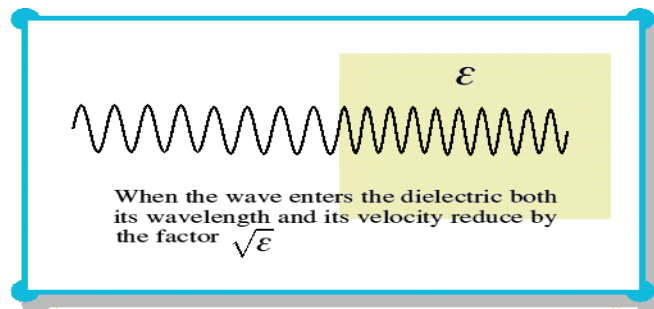
- DielectricPropertyBasicIntroduction
- LNP™ DielectricProductPortfolioIntroduction&ValueProposition
- TheIntroductionofNewlyCommercializedDielectricGrades
- Case Study

DIELECTRIC PROPERTY BASIC INTRODUCTION

Dielectric

A dielectric material is a substance that is a poor conductor of electricity, but an efficient supporter of electrostatic field. By utilizing tunable Dk (dielectric constant) and Df (dissipation factor) of substrate material, a smaller size of antenna and a thermoplastics injection molded phase shifter can be achieved and produced.

Dk - Dielectric Constant



Dielectric Constant (ϵ) is a number relating the ability of a material to carry alternating current to the ability of vacuum to carry alternating current.

Df - Dissipation Factor

- The simplest way to define dissipation factor (loss tangent) is the ratio of the energy dissipated to the energy stored in the dielectric material
- The more energy that is dissipated into the material. The less is going to make it to the final destination
- This dissipated energy typically turns into heat or is radiated as RF (Radio Frequencies) into the air

LNPT™ DIELECTRIC PRODUCT PORTFOLIO INTRODUCTION & VALUE PROPOSITION

LNP™ DIELECTRIC SOLUTION INTRODUCTION

RF Application Needs

Low Dissipation Factor (Df)

Stable Dielectric Constant (Dk)

High DK (Some Applications)

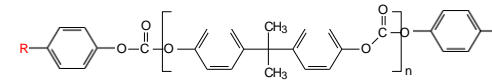
Low DK (Some Applications)

Process Ability

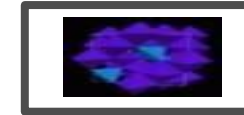
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LNP Dielectric Solution

Polymer



Dielectric additive/...



Where Dielectric Solution Plays?

- ☐ Base station antenna phase shifter
- ☐ RFID substrate
- ☐ Mobile device internal antenna
- ☐ IOT wireless substrate
- ☐ Automotive antenna
- ☐ Other applications needing dielectrics properties

Value Proposition For Customer

- ☐ High Dk helps smaller part size compared with normal DK
- ☐ Low Df to improved antenna signal gain / longer reading distance compared with normal Df
- ☐ Higher productivity compared with non-Thermoplastic
- ☐ Lower system Cost compared with non-Thermoplastic
- ☐ More design freedom compared with non-Thermoplastic

LNP Dielectric Solutions Can Help in Designs Having High RF Requirement

LNP™ THERMOCOMP™ DIELECTRIC PRODUCT PORTFOLIO

		Dk, 1.1GHz	Df, 1.1GHz	HDT, 0.45 MPa	Key Feature
LNP Dielectric portfolio	Z1C00XP	2.38	0.0007	120°C	Low Dk and Low Df
	Z1C00I	2.54	0.0008	160°C	Low warpage ,easy plating
	ZKC04	3.04	0.0009	174°C	Impact modified, high HDT
	ZKC06	3.7	0.0009	173°C	Impact modified, high HDT
	ZKC08	3.91	0.0009	173°C	Impact modified, High HDT
	ZKC09	4.55	0.001	170°C	Impact modified, High HDT
	ZKC0B	5.5	0.001	165°C	High modulus, High HDT
	ZKC0C	5.9	0.001	155°C	High Modulus
	ZKC0CXXQ	6.0	0.001	155°C	High Modulus, Impact Modified
	ZKC0CXXD	6.1	0.001	160°C	High Modulus, High HDT
	ZKC0CXXR	6.4	0.001	160°C	Impact modified, High HDT
	ZKC0DXXD	7.4	0.001	147°C	Impact modified, High Dk
	ZKC0E	7.9	0.001	135°C	Impact modified, High Dk

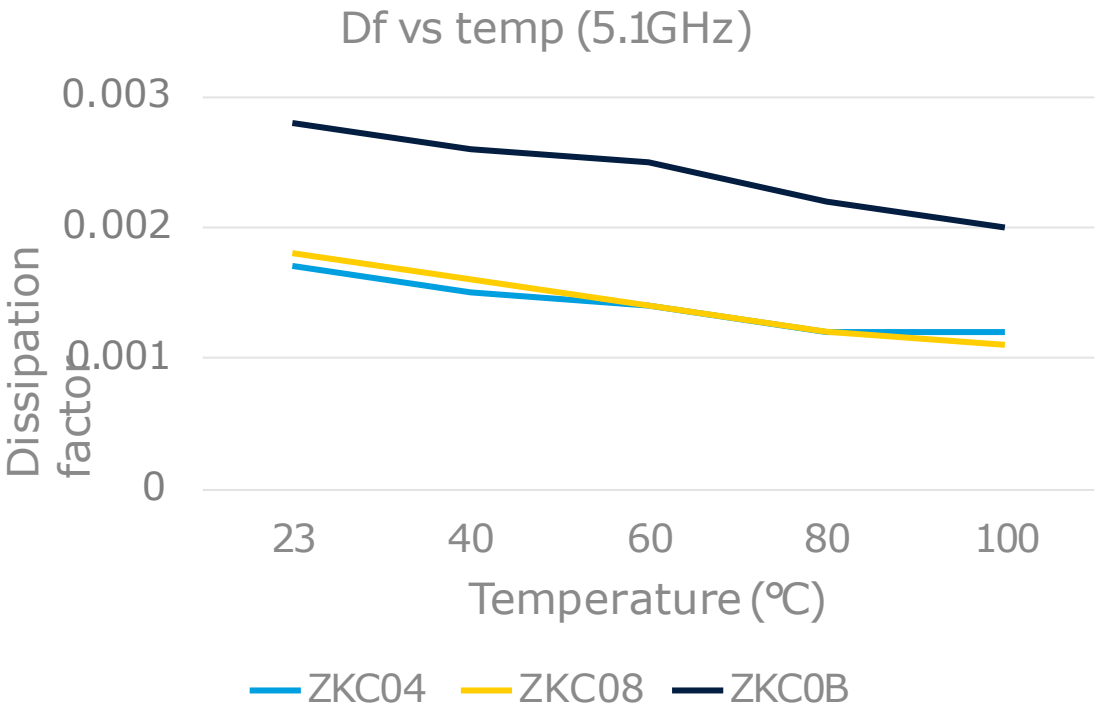
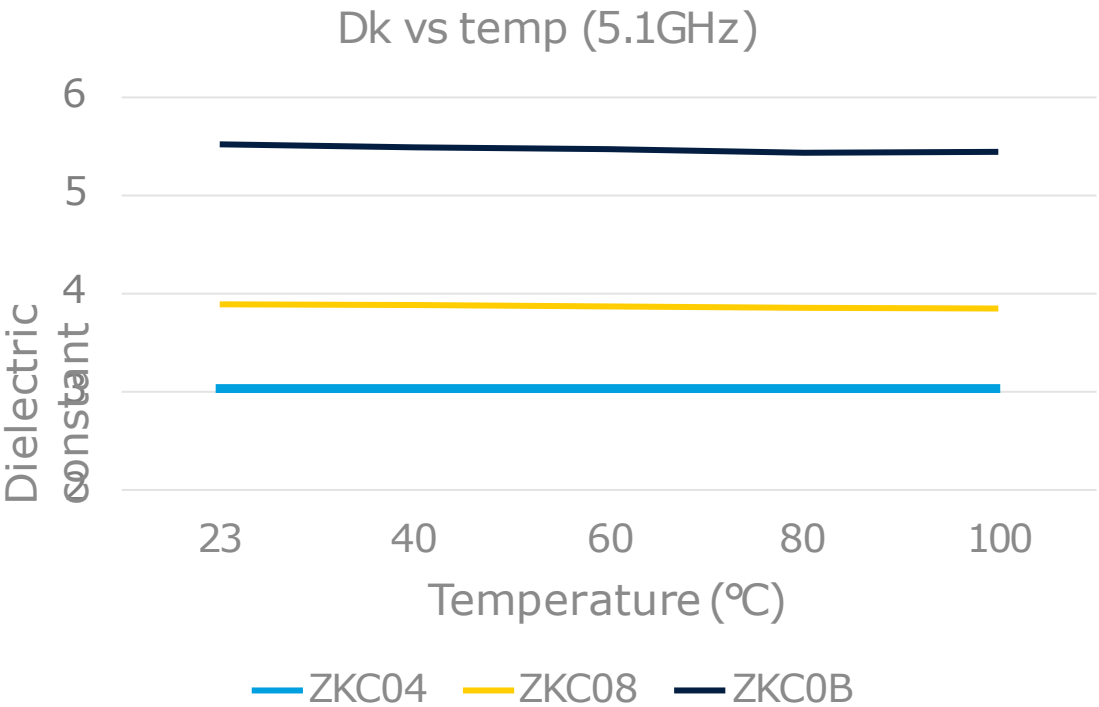
PPO
Resin

New

LNPTM THERMOCOMPTM DIELECTRIC PRODUCT PORTFOLIO - 2

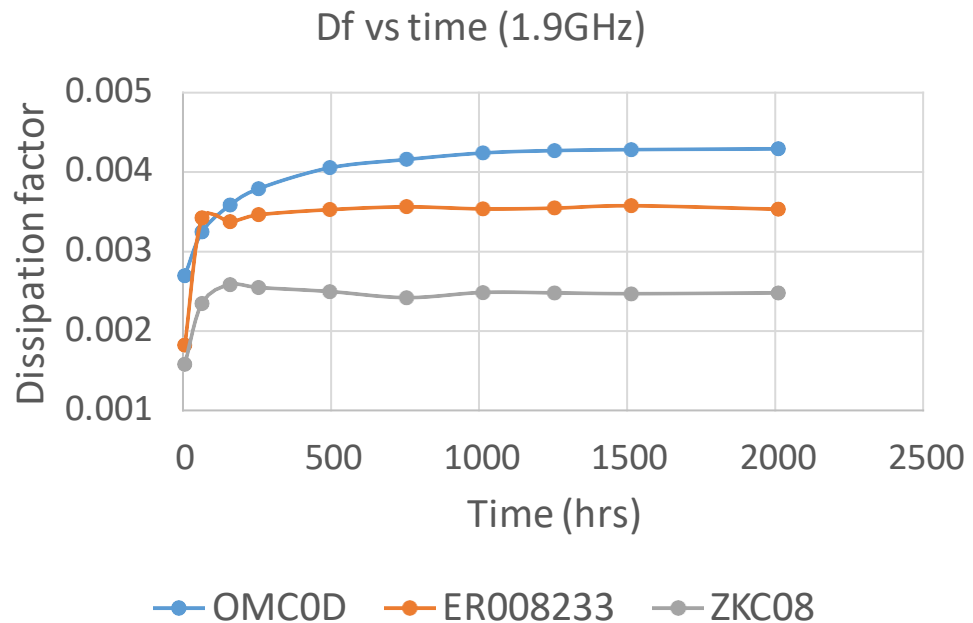
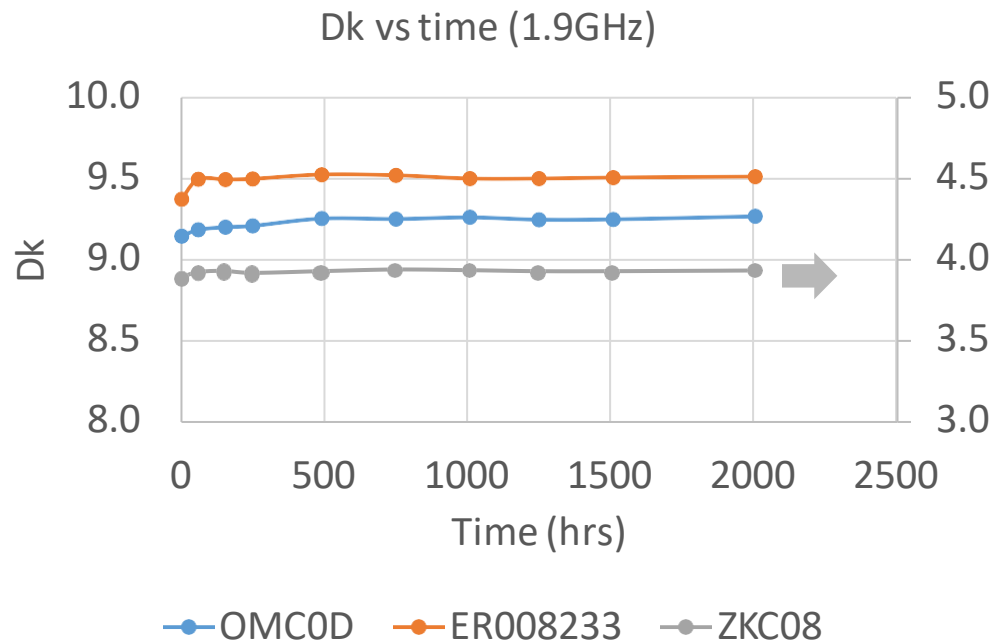
			Dk, 1.1GHz 1.9GHz*	Df, 1.1GHz 1.9GHz *	HDT 0.45MPa 1.82MPa *	Key feature
LNP Dielectric Portfolio	HDPE resin	FX10009	13.1	0.008	160°C	High Dk , Low Df
	PC resin	DX09309	8	0.01	97°C *	High Dk
	PPA resin	UX08319	6.2 *	0.015*	265°C *	LDS grade, SMT capable
	PBT resin	WFC06I	3.7	0.008	200°C	Low warpage, laser transmission
		WFC06IXP	3.5	0.008	193°C	Low warpage , laser absorption
	LCP resin	8FC05G	3.2	0.004	260°C	SMT capable, high flowability
	PPS resin	OMC0D	9.4	0.002	220°C	High Dk, High HDT
		OMC0E	11.0	0.002	220°C	High Dk, High HDT

LNPTM THERMOCOMP™ DIELECTRIC PRODUCT – TEMPERATURE DEPENDENCY



➤ Dielectric constant and dissipation factor shows slight change within temperature range of 23-100°C

LNPTM THERMOCOMP™ DIELECTRIC PRODUCT – DH85 MEASUREMENT



➤ Dk shows slight increasing under DH85 for both ER008233 (PPO base Dk9), ZKC08 and OMC0D . Df shows obvious increasing for all materials. PPS-based grade shows higher Df than PPO-based grades

LNPTM DIELECTRIC PRODUCT PORTFOLIO VALUE PROPOSITION

- Higher Productivity
- Potential Cost Reduction
- Better Design Space & Efficiency
- Easier to go to the market
- Quicker tailor made for small lot validation & pilot production

Vs. Non Thermoplastics high Dk low Df solution (such as special ceramic...)

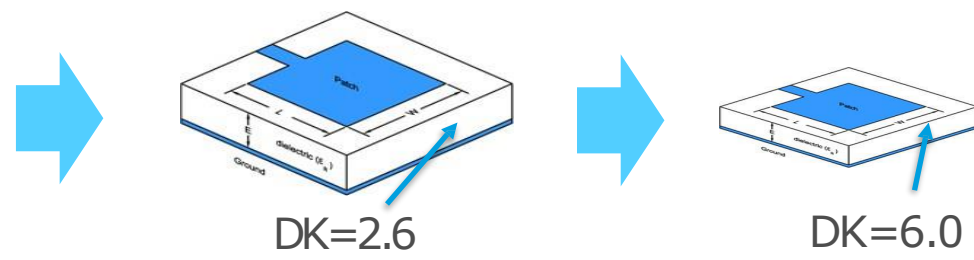
- More complete product portfolio covering from super low Dk/Df to super high Dk products
- More stable Dk DF values
- Better Mechanical Properties
- Multiple effects combination (Dielectric + LDS + SMT capable ...)

Vs. Other thermoplastics high Dk low Df solution

WHY LNP™ DIELECTRIC PRODUCT PORTFOLIO?

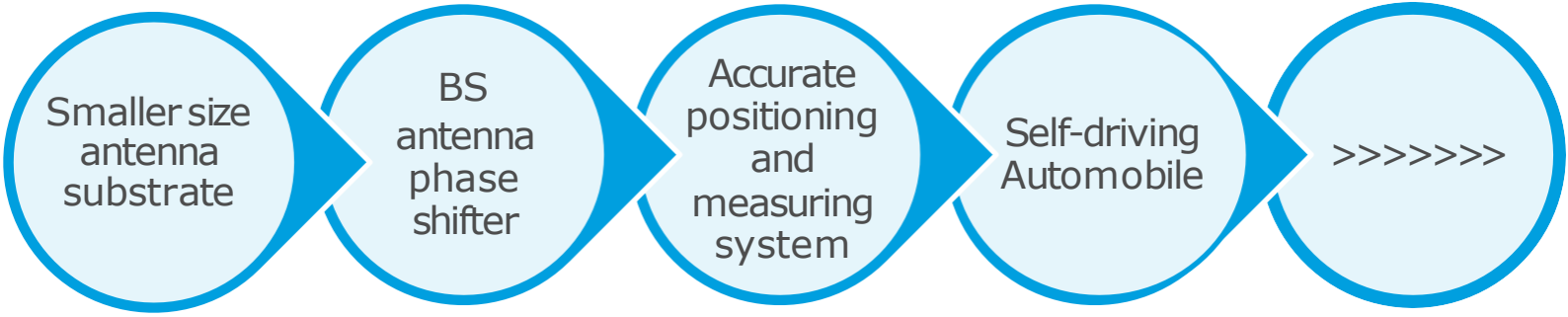
- Using high Dk low Df material as the substrate of an antenna can reduce the size of whole antenna. This is based on the principle of Maxwell's Electromagnetic Theory and Equation. The length of an antenna is inversely proportion of the square root of Dk value of its substrate
- Using high Dk low Df material as the phase shifter of a base station antenna can change the phase of electromagnetic wave and then change the coverage of the base station
- Using low Dk low Df material in the applications of dielectrics, the lose of energy of electromagnetic wave passing through this dielectrics is also low

Dielectric material thickness - 2.0mm Working frequency - 2.0Ghz	DK=2.6	DK=6.0
Width (mm)	55.9	40.1
Length (mm)	45.7	30.3



High Dk Low Df Product Is A good
Material Of Smaller Size Antenna Substrate

POTENTIAL MARKET & APPLICATION WITH DIELECTRIC MATERIAL



THE INTRODUCTION OF NEWLY COMMERCIALIZED DIELECTRIC GRADES

LNP™ THERMOCOMP™ ZKC0DXXD INTRODUCTION

LNP THERMOCOMP ZKC0DXXD is a high Dk (7.4 at 1.9 GHz) and low Df (0.001 at 1.9 GHz) PPO compound

New

Features:

- Stable Dk and Df value
- Good heat resistance
- Impact modified
- Good process-ability
- Higher productivity compared with non-Thermoplastic
- Better design freedom compared with non-Thermoplastic

Key Performance Data

	Unit	Value
Tensile Modulus	MPa	2800
Tensile Strength	MPa	48
Tensile strain, brk	%	3.6
Notched Izod	kJ/m ²	7.7
HDT(0.45MPa)	°C	147
Dk @ 1.9Ghz		7.4
Df @ 1.9Ghz		0.001

Potential Applications:

- Base station antenna phase shifter , Antenna substrate requiring high Dk low Df to make the size smaller, Other applications requiring High Dk low Df

LNP™ THERMOCOMP™ ZKC0CXXD INTRODUCTION

LNP THERMOCOMP ZKC0CXXD is a high Dk (6.1 at 1.1 GHz) and low Df (0.001 at 1.1 GHz) PPO compound

New

Features:

- Stable Dk and Df value
- High HDT
- High modulus
- Good process-ability
- Higher productivity compared with non-Thermoplastic
- Better design freedom compared with non-Thermoplastic

Key Performance Data

	Unit	Value
Tensile Modulus	MPa	5000
Tensile Strength	MPa	74
Tensile strain, brk	%	2.7
Notched Izod	kJ/m ²	6.1
HDT(0.45MPa)	°C	160
Dk @ 1.1Ghz		6.1
Df @ 1.1Ghz		0.001

Potential Applications:

- Base station antenna phase shifter , Antenna substrate requiring high Dk low Df to make the size smaller, Other applications requiring High Dk low Df

LNP™ THERMOCOMP™ ZKC0CXXP INTRODUCTION

LNP THERMOCOMP ZKC0CXXP is a high Dk (6.1 at 1.1 GHz) and low Df (0.001 at 1.1 GHz) PPO compound

Features:

- Stable Dk and Df value
- Good heat resistance
- Good mechanical properties
- Good process-ability
- Higher productivity compared with non-Thermoplastic
- Better design freedom compared with non-Thermoplastic

Potential Applications:

- Base station antenna phase shifter , Antenna substrate requiring high Dk low Df to make the size smaller, Other applications requiring High Dk low Df

LNP™ THERMOCOMP™ WFC06I(ER010945) INTRODUCTION

LNP THERMOCOMP™ WFC06I (ER010945) is a low Dk (3.5 at 1.9 GHz), Df (0.008 at 1.9 GHz), PBT based glass fiber 30% reinforced compound

Features:

- Low Dk and low Df with stable value control
- Ultra low warpage
- High ductility
- High laser transmission
- Good chemical resistance

Potential Applications:

- Mm wave radar front cover requiring laser welding process on laser transmission parts
 - Applications requiring laser welding process with low warpage control, low Dk and low Df with efficient signal transmission effect at high frequency working environment
-

LNP™ THERMOCOMP™ WFC06IXP(ER010946) INTRODUCTION

LNP THERMOCOMP™ WFC06IXP (ER010946) is a low Dk (3.5 at 1.9 GHz), Df (0.008 at 1.9 GHz), PBT based glass fiber 30% reinforced compound

Features:

- Low Dk and low Df with stable value control
- Super Low warpage
- High ductility
- Good chemical resistance

Potential Applications:

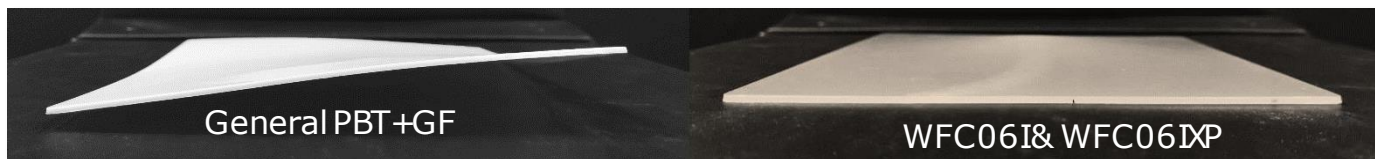
- Mm wave radar back cover requiring laser welding process as laser absorption parts
- Applications requiring super low warpage especially the current material is PBT glass fiber reinforced

LNPT™ WFC06I AND WFC06IXP INTRODUCTION

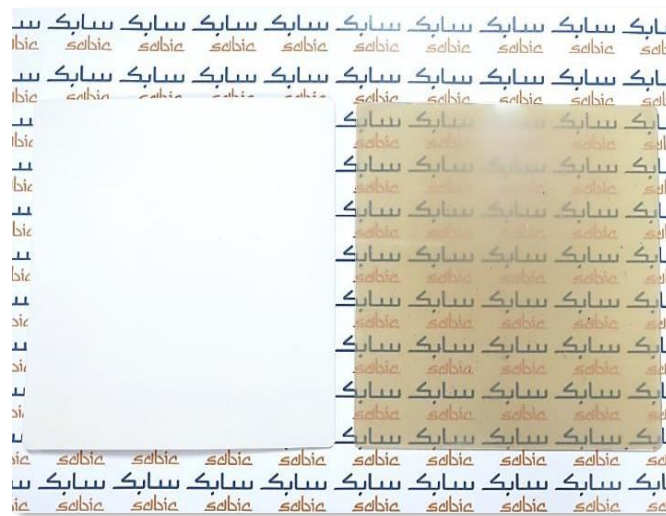
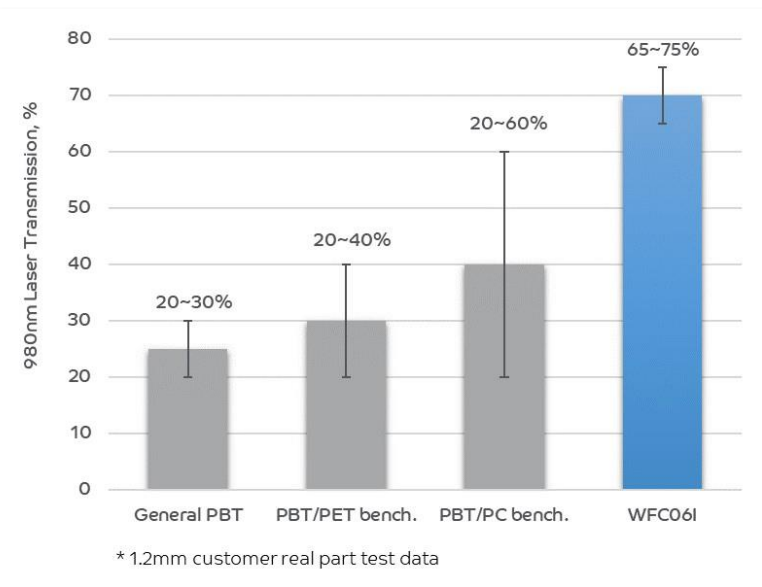
THERMOCOMP™ WFC06I, 30% glass reinforced PBT, super low warpage, low Df, laser transmission

THERMOCOMP™ WFC06IXP, 30% glass reinforced PBT, super low warpage, low Df

- Ultra low warpage

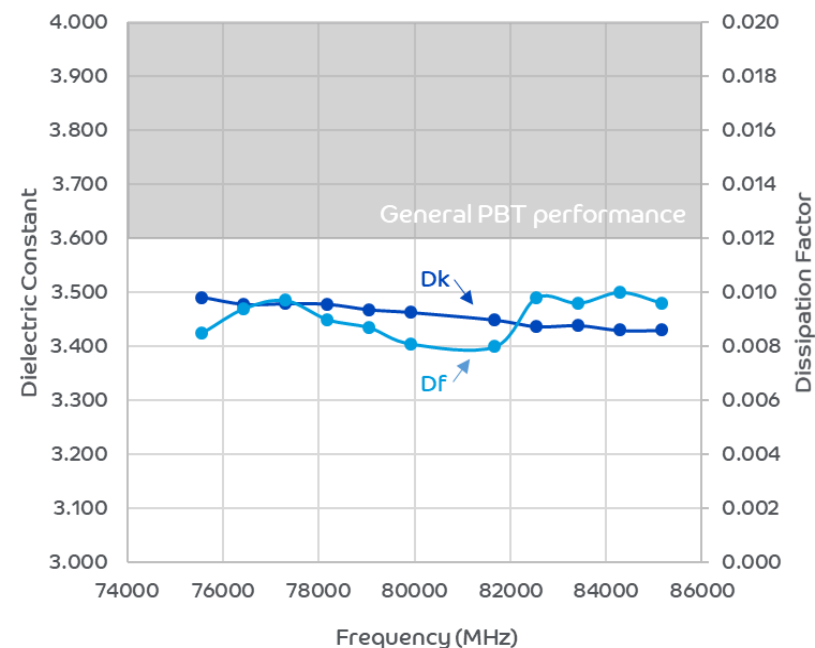


- High laser transmission (WFC06I)



- Low Df & Dielectric consistency across frequencies, along parts (WFC06I& WFC06IXP)

Dielectric Consistency Across Frequencies



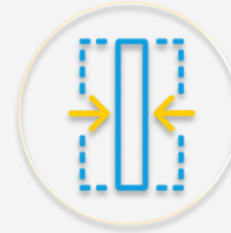
LNP™ WFC06I AND WFC06IXP VALUE PROPOSITION

- Much better ductility
- Better warpage control
- Better laser welding performance



Vs. LNP™ old generation materials

- Much better ductility
- Excellent warpage control
- Much better laser transmission
- Much lower Df
- Similar strength



Vs. PBT-based competitors

- Much better ductility
- Excellent strength
- Much higher laser transmission
- Similar warpage control
- Much higher Dk/Df



Vs. PPO-based materials

➤ Win with high ductility, super low warpage, laser welding capability and low Df

LNP™ THERMOCOMP™ 8FC05G (ER010636) INTRODUCTION

LNP THERMOCOMP 8FC05G (ER010636) is a super low Dk (3.1 at 1.9 GHz), Df (0.004 at 1.9 GHz) Liquid Crystalline Polymer (LCP) based compound

Features:

- High heat resistance for robust SMT processing
- Super low Dk and low Df
- Low warpage
- UL94V0
- Superior flowability

Potential Applications:

- 5G, telecom antenna , new generation connector requiring low Dk and low Df with efficient signal transmission effect at high frequency working environment.

LNP™ THERMOCOMP™ OMC0D (ER010642) INTRODUCTION

LNP THERMOCOMP OMC0D(ER010642) is a super high Dk (9.4 at 1.9 GHz), Df (0.002 at 1.9 GHz) PPS based compound

Features:

- Super high Dk
- Super low Df
- Excellent heat and chemical resistance
- Good dimensional stability
- UL94 V0

Potential Applications:

- GNSS(Global Navigation Satellite System) antenna
- GPS antenna
- Applications requiring high Dk for antenna miniaturization

LNP™ THERMOCOMP™ OMC0E (ER010643) INTRODUCTION

LNP THERMOCOMP OMC0E(ER010643) is a super high Dk (11.0 at 1.9 GHz), Df (0.002 at 1.9 GHz) PPS based compound

Features:

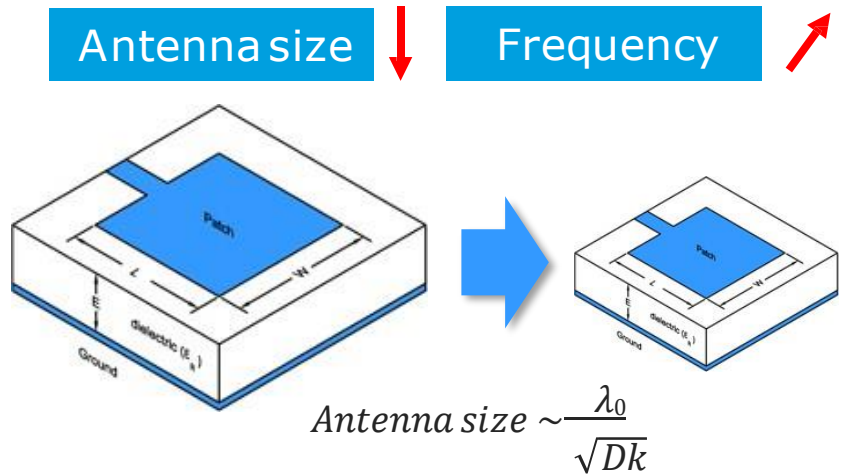
- Super high Dk
- Super low Df
- Excellent heat and chemical resistance
- Good dimensional stability
- UL94 V0

Potential Applications:

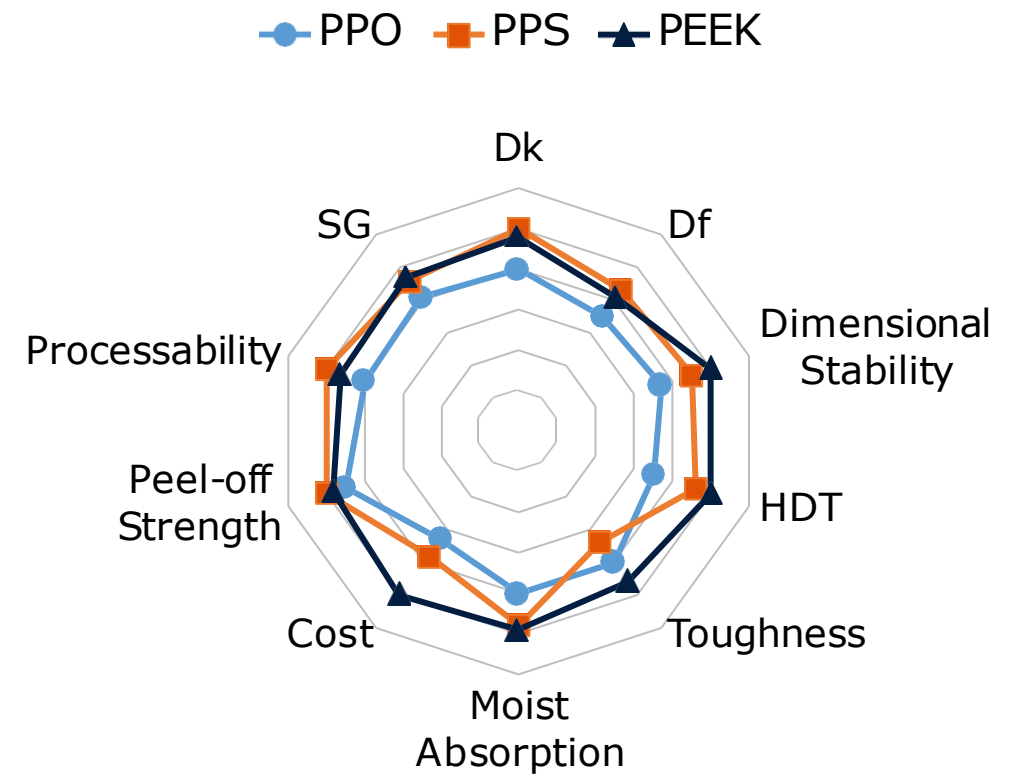
- GNSS(Global Navigation Satellite System) antenna
- GPS antenna
- Applications requiring high Dk for antenna miniaturization

LNPTM THERMOCOMP™ OMC0D/OMC0E — ULTRA HIGH DK PPS

- ❖ High Dk Low Df material for antenna miniaturization
- ❖ How to select high Dk compounds base resin?



Thickness 2.0mm Frequency 2.0Ghz	DK=2.6	DK=6.0
Width (mm)	55.9	40.1
Length (mm)	45.7	30.3



CASE STUDY

CASE STUDY - LNPTTM THERMOCOMPTM ZX08005 IN BASE STATION ANTENNA PHASE SHIFTER

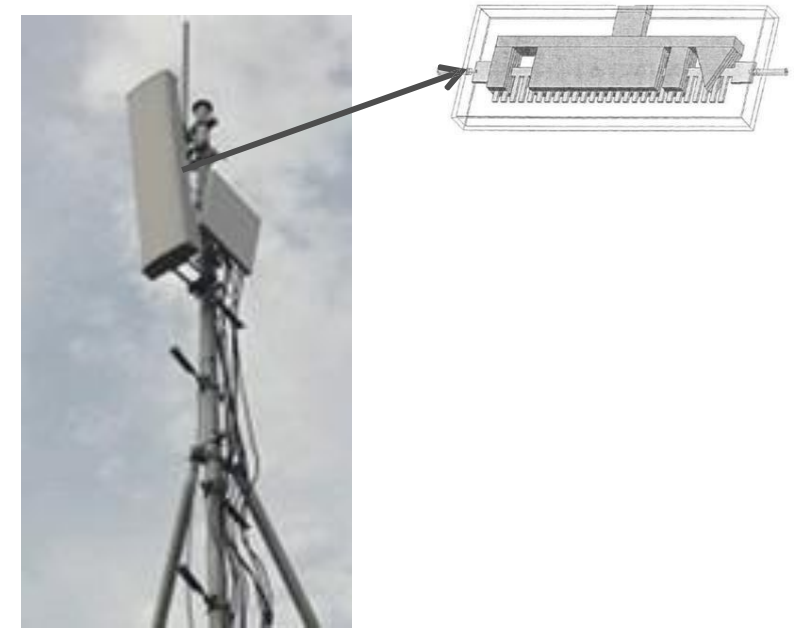
Application: Base station phase shifter

Application Requirements

- D_k @ 2Ghz > 4.5
- D_f @ 2Ghz 0.001-0.002
- Tight dimensional tolerances
- Good impact at low temperatures

Value Proposition By Using ZX08005

- Higher D_k helps for better design freedom
- Durability when antenna vibrates in storm
- Processing efficiency with lower cost
- Higher gain creating larger reach ("Signal Footprint")



CASE STUDY - LNPTTM THERMOCOMPTM ZKC0CXXD AND ZKC0DXXD IN AUTOMOTIVE ANTENNA

Application: Automotive GNSS Antenna

Application Requirements

- Dk within 6.0~6.5 and Dk7.0~7.5
- Df < 0.0015
- Stable electroplating feature
- -40°C~50°C product level reliable test
- 1.3mdrop test as produce level



Value Proposition By Using ZKC0CXXD and ZKC0DXXD

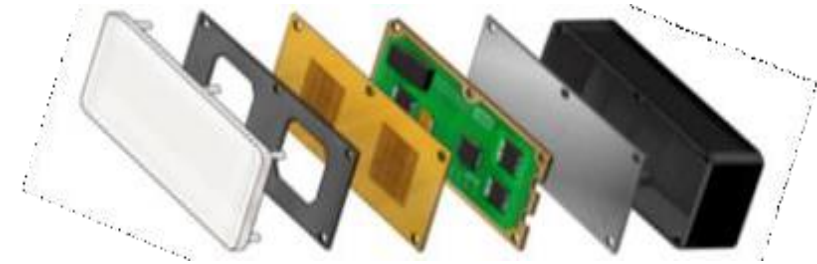
- High Dk leads to smaller space design
- Low Df maximize the signal gain
- Stable electroplating feature enhances the yield rate
- Plastics solution benefit for flexible antenna design

CASE STUDY - LNPTTM THERMOCOMPTM WFC06I AND WFC06IXP IN ADAS RADAR COVER

Application: ADAS RADAR COVER

Application Requirements

- Laser transmit and Laser absorb
- Ultra low warpage
- $Df < 0.01$
- Hydrolysis resistance (water boiling 90 for 30 days, no whitening and no chalking when cracked)
- Good impact strength



Value Proposition By Using WFC06I and WFC06IXP

- High laser transmission, improve yield rate and reduce the total cost
- Flatness and warpage control for large flat, increase the productivity
- Low Dk/Df improve mmWave transmission performance

PRESS AND VIDEO RELEASE

Press release:

- English: [SABIC - SABIC Launches New Lnp™ Thermocomp™ Compounds For Automotive...](#)
- English [SABIC - SABIC's LNP™ THERMOCOMP™ compounds for adas radar covers](#)
- Chinese: [SABIC - SABIC推出用于汽车GNSS天线的新型LNP™ THERMOCOMP™改性料，信号增益优于陶瓷](#)
- Chinese: [SABIC - SABIC推出全新LNP™ THERMOCOMP™改性料有助于改善ADAS雷达罩的信号传输](#)

Video release:

- English : <https://www.youtube.com/watch?v=fzG-3nQk-Zw>

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