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Advanced Insulating Film for Next-Generation Smartphone Performance Requirements

IEEE EPS Seminar(ECTC2019) May 30th, 2019

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Ajinomoto Co., Inc.

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1. Brief Company Introduction of Ajinomoto Co., Inc.

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   Low Dielectric Loss ABF for high frequency package
   Next Generation ABF for Thinner Application

3. Molding Film(ABF-LE)

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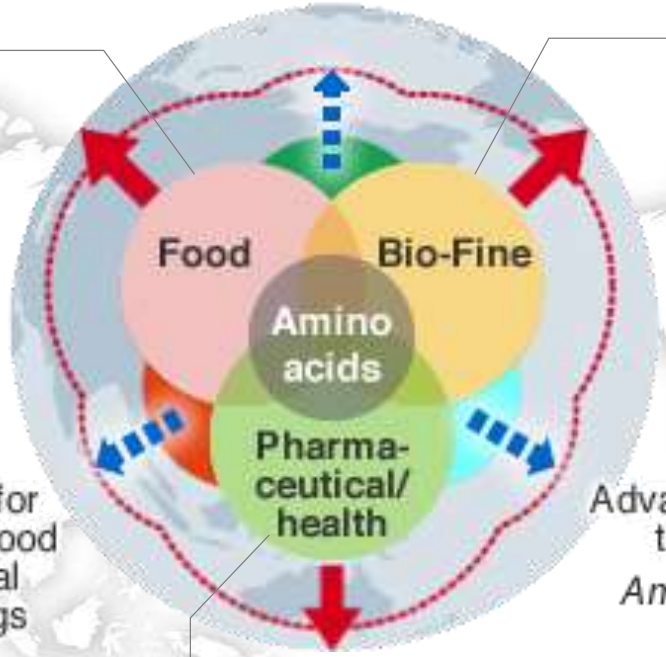
Over View of the Ajinomoto Group

Foundation	May 20, 1909	Paid-in Capital	JPY 79,863million
Number of employee	34,452	Net sales FY2017	JPY 1,150.2 billion

(as of March 31, 2017)

Lower resource fermentation technology
Nutrition for animals, plants, and marine creatures

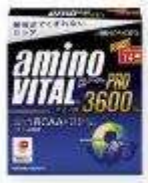
Foods

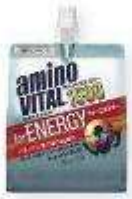


Amino Science

Materials for functional food
Functional seasonings

Advanced medical technology
Amino Index ®





Pharmaceuticals and Health

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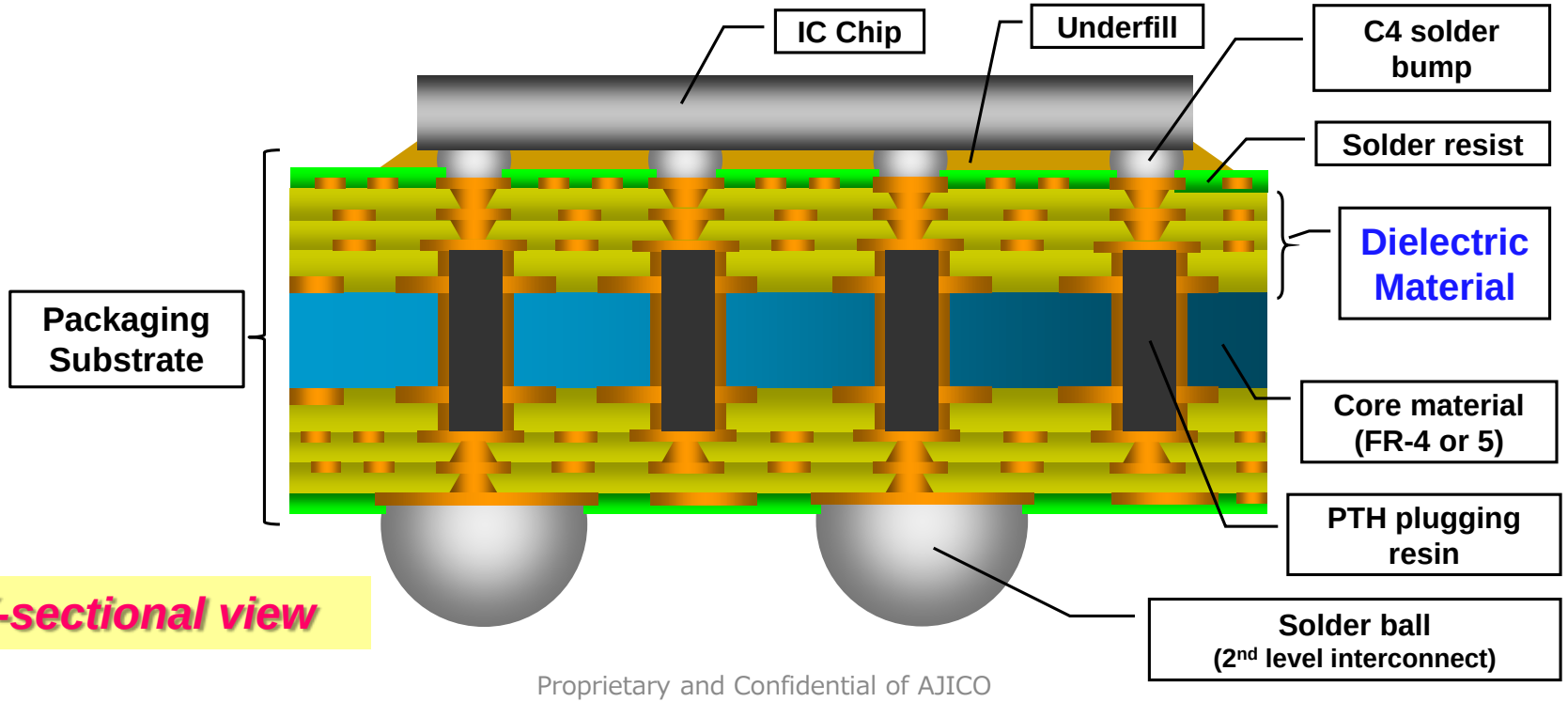
Insulation Build-up Materials;
Ajinomoto Build-up Film(ABF)

ABF Application

Electric Product

Print Circuit Board (PCB)

CPU Package



X-sectional view

Outline of Manufacturing Substrates using ABF

1; Preparation of core-boards

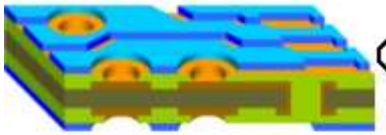
2 ; ABF vacuum lamination

3; Pre-curing

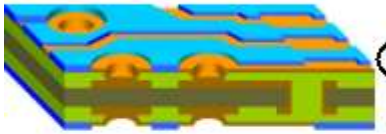
4 ; Laser Via formation & Desmear

5 ; Thin Cu plating

6 ; Photo Dry Film Resist lamination

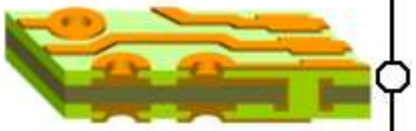


7 ; Patterning



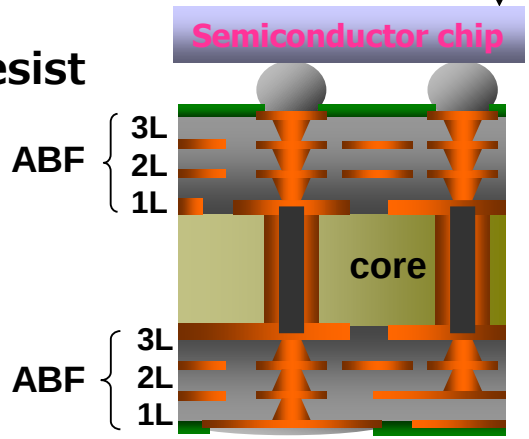
8 ; Electro Cu plating

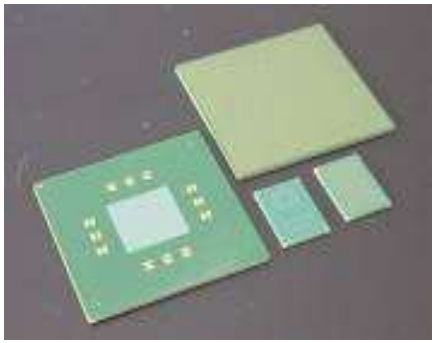
9; Dry Film removal



10; Thin Cu etching & Full-curing (180-200degC)

Repeat for multilayered Build-up





[Packaging substrates]

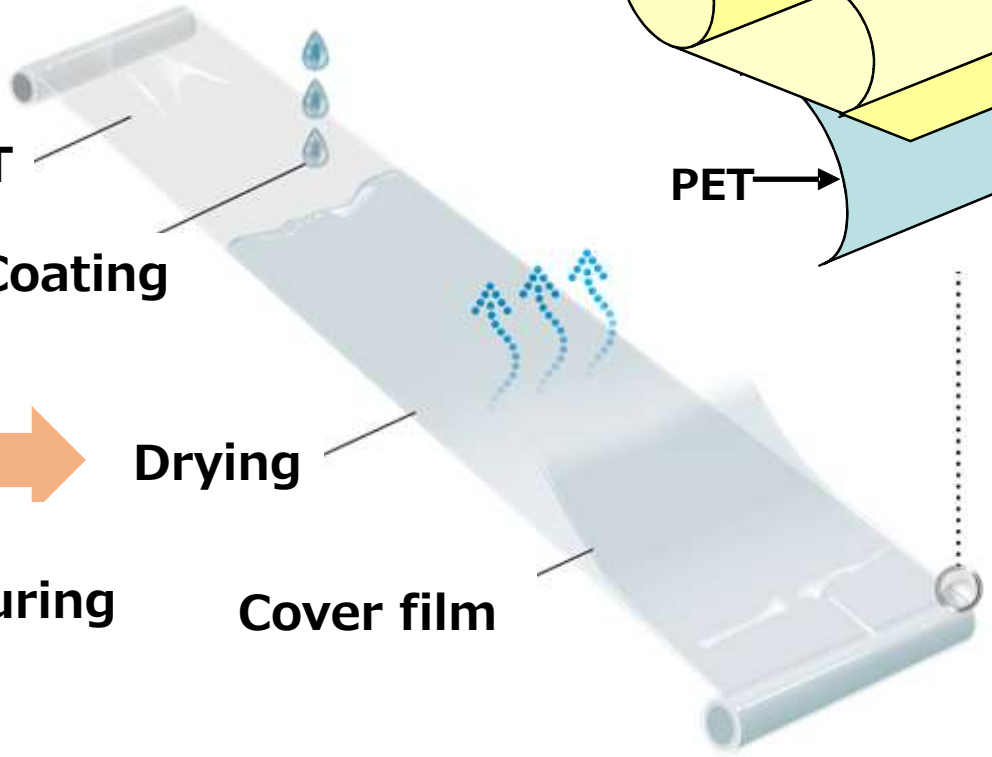
Manufacturing Process of ABF

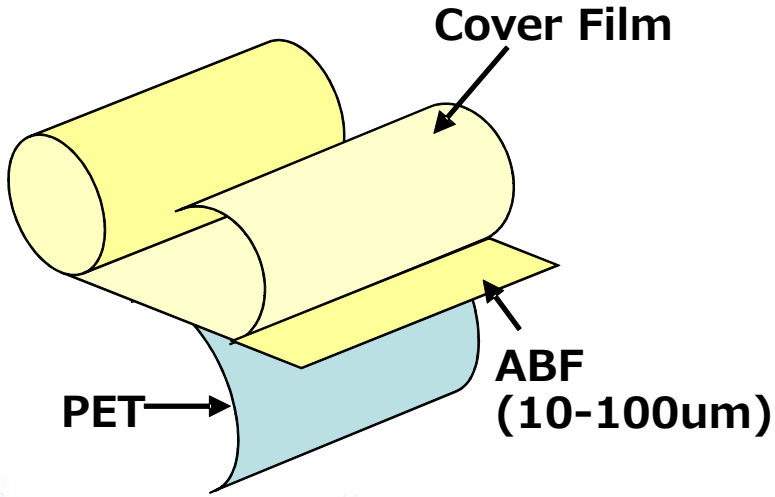
resin, filler

Mixing

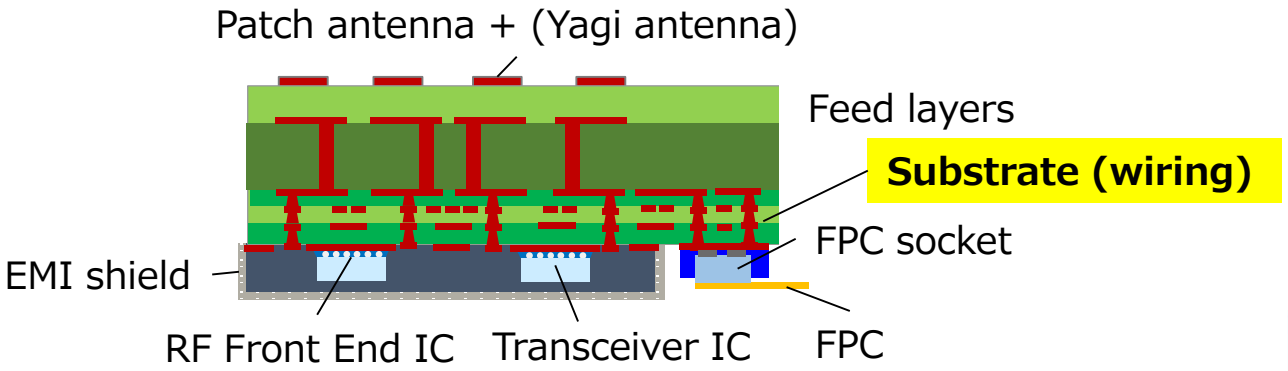
Varnish

Film manufacturing





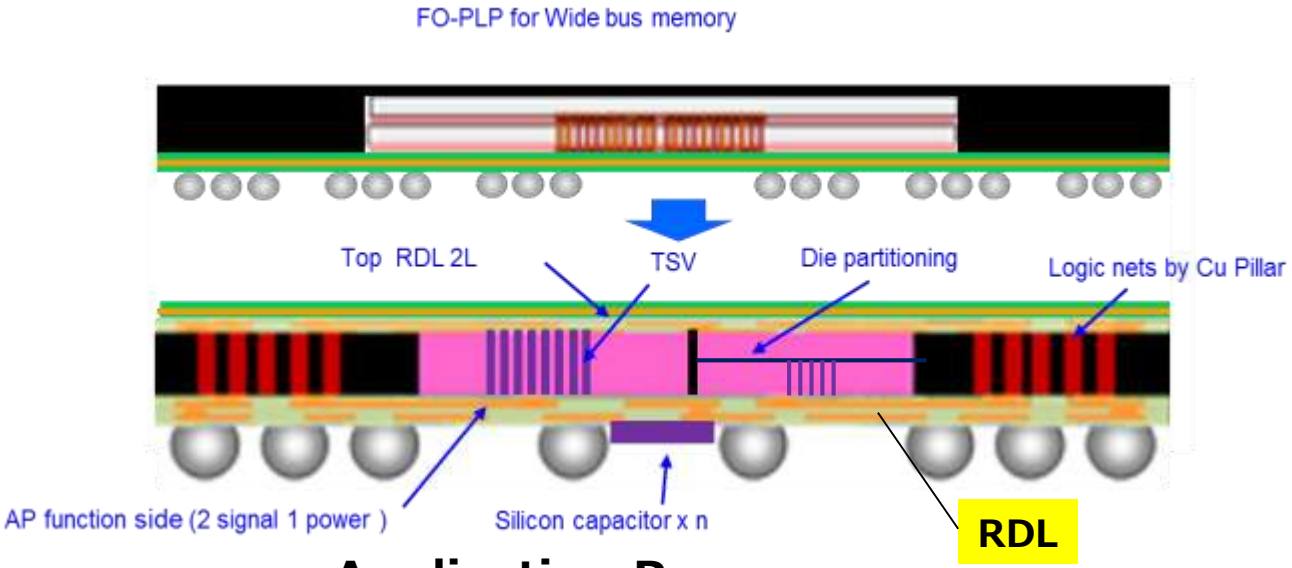
Smartphone PKG trend & ABF development trend



Antenna Substrate

High speed transmission

Low Dielectric Loss ABF



Application Processor

High density & Thin structure

Thinner ABF

Next Build-up Material for High Speed Application

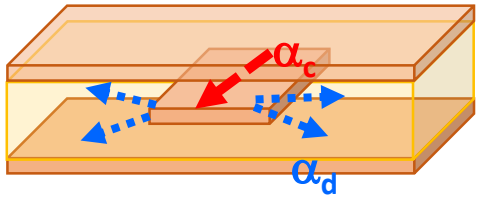
■ Requirement for Low Transmission Loss

Transmission loss (α)
= Dielectric loss(α_d)
+ Conductor loss(α_c)

$\alpha_d \propto \sqrt{\varepsilon} \times \tan\delta$

ε : Dielectric constant

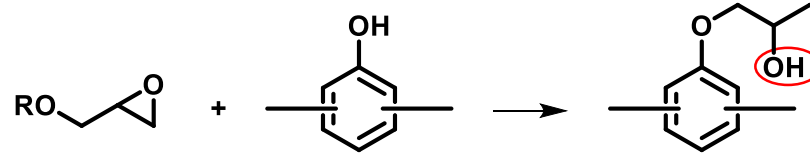
tanδ : Dielectric loss tangent



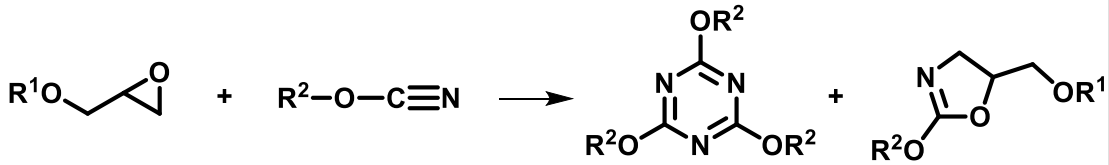
To reduce the transmission loss…
➔ *Low dielectric loss tangent (Df)*

■ ABF for High Speed Transmission

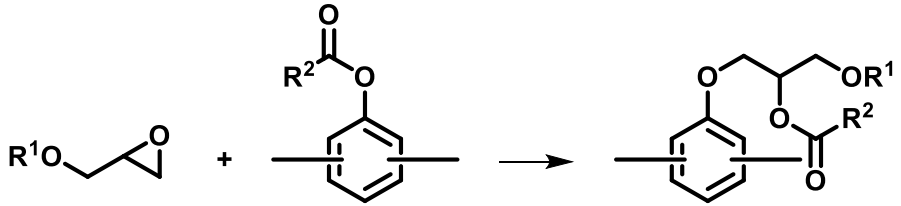
GX series (Epoxy and Phenol Hardener)



GZ series (Epoxy and Cyanate Ester)



GL series (Epoxy and Phenolic Ester Hardener)



Reduction of polar group

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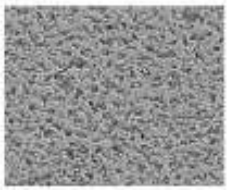
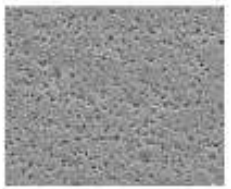
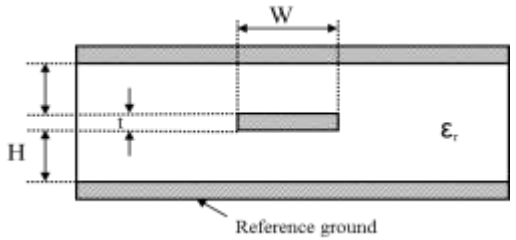
Outline of New ABF GL series

ABF	GX92	GX-T31	GZ41	NEW GL
CTE (ppm: 25-150degC)	39	23	20	20
Tg (degC, tensile TMA)	153	154	176	153
Dielectric constant (5.8GHz)	3.2	3.4	3.3	3.3
Loss tangent	0.018	0.014	0.0074	0.0044
ABF Surface after desmear (SEM, x3500)				

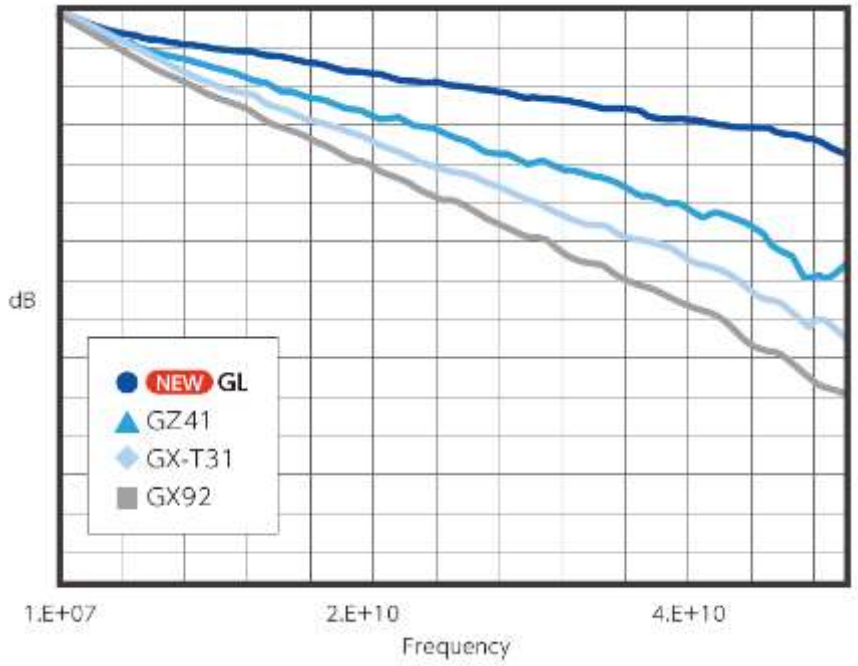
Evaluation of Transmission Loss

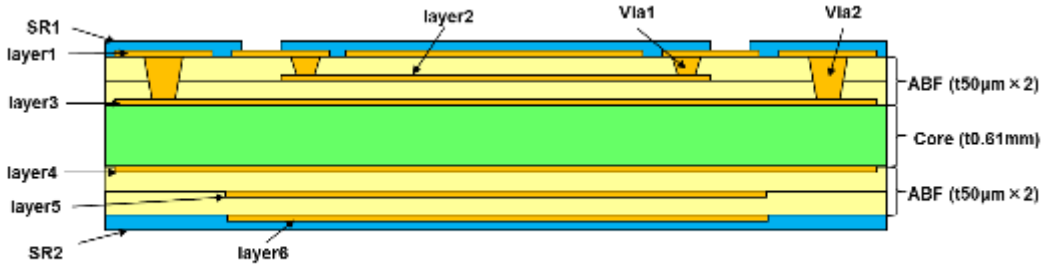
＊Formula of strip line impedance

$$Z_s = \frac{30\pi}{\sqrt{\varepsilon_r}}\left[\frac{(2H+t)}{(W+0.441(2H+t)}\right]$$



W **: 45-50um**
2*H* **: 80um**
t **: 13-23um**
Z_S : 50Ω





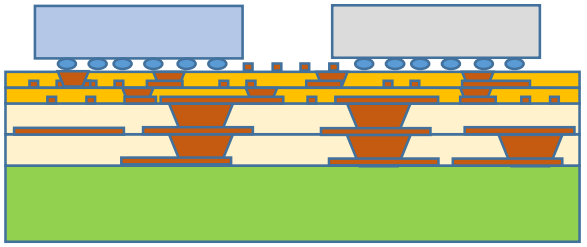
Cross sectional view image of PKG

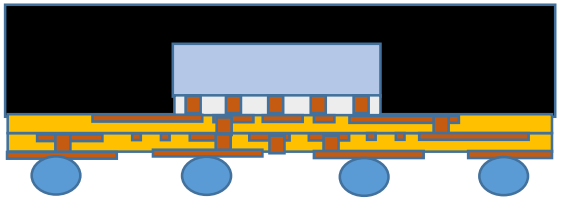
Transmission Loss:
GX92 >> GX-T31 > GZ41 > GL

Low Df material shows lower transmission loss.

Next Generation ABF for Thinner Application

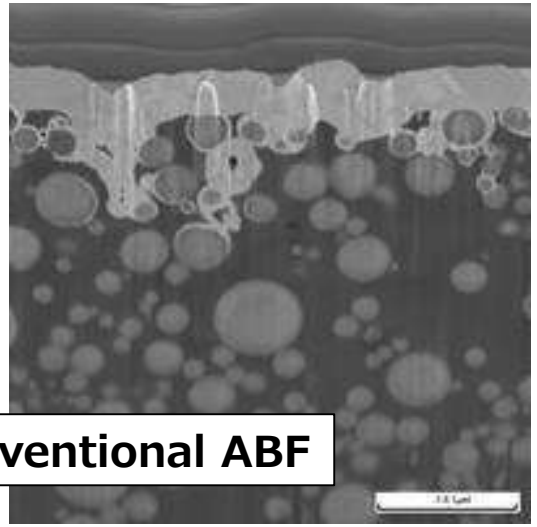
■ Redistribution layer of 2.1D / Fan-out package

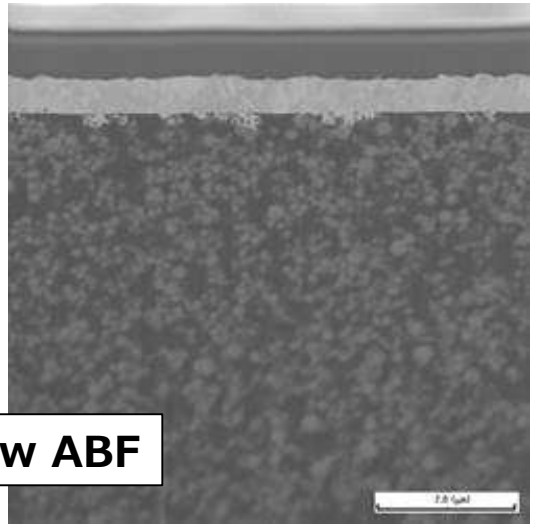




✓ **Thinner LtL, Smaller via, Finer Line & Space ➔ Using Smaller Silica**

■ Development of New ABF with smaller Silica





New ABF with smaller silica showed smooth surface after E-less Cu plating

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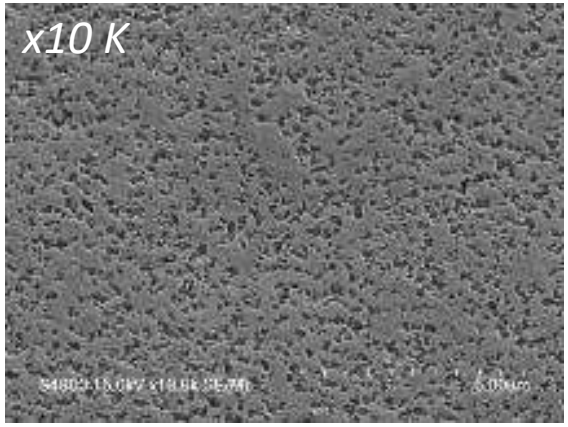
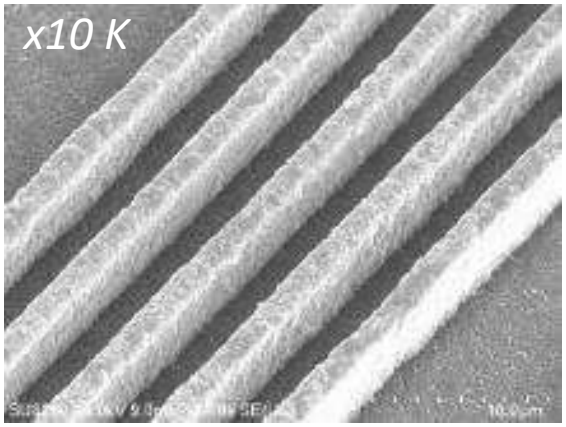
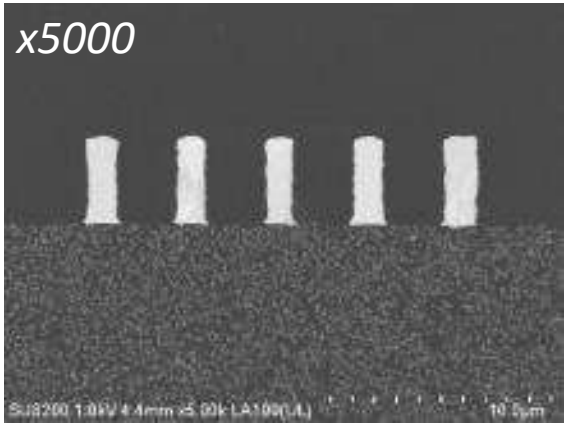
Fine Line & Fine Via Formation

After Wet desmear

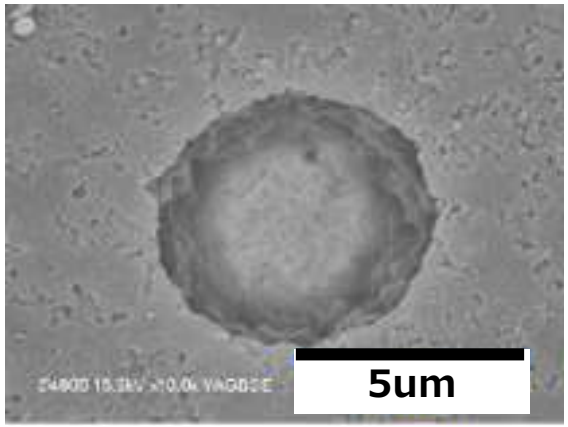


After Cu plating



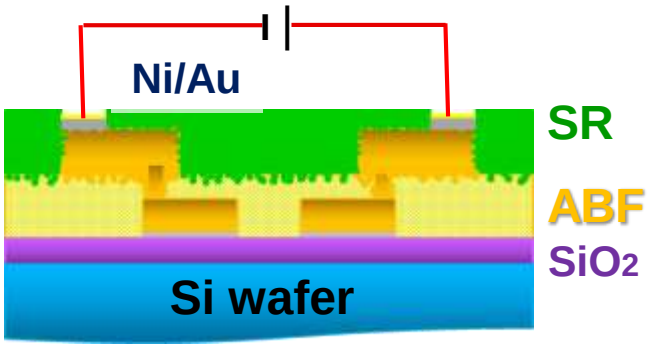


Smoother surface ➔ L/S = 2/2 by SAP



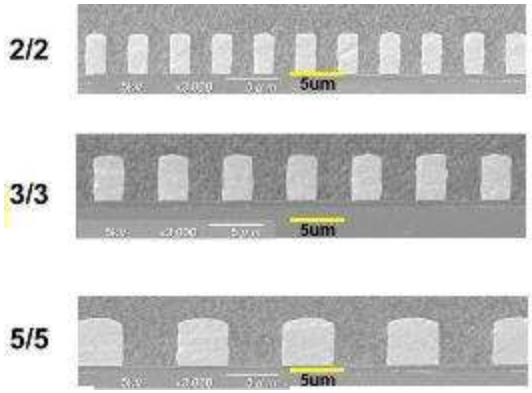
ϕ5um via by UV Laser

Insulation reliability (Line to Line)



■ **HAST condition**

130degC, 85%RH, 3.3V



ABF	L/S=2/2um	L/S=3/3um	L/S=5/5um
GX92	NG	150hrs pass	200hrs pass
GX-T31	NG	200hrs pass	200hrs pass
New ABF with smaller Silica	200hrs pass	200hrs pass	200hrs pass

New ABF with smaller silica keeps good insulation even L/S = 2um /2um.

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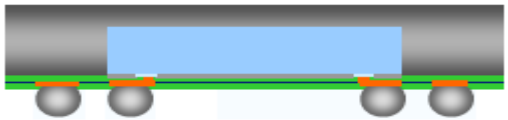
Molding Film

Background

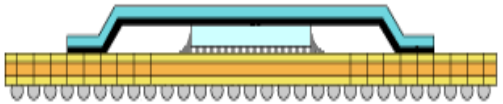
■ Market expectation for Fan-out WLCSP

Fan-in WLCSP

Fan-out WLCSP



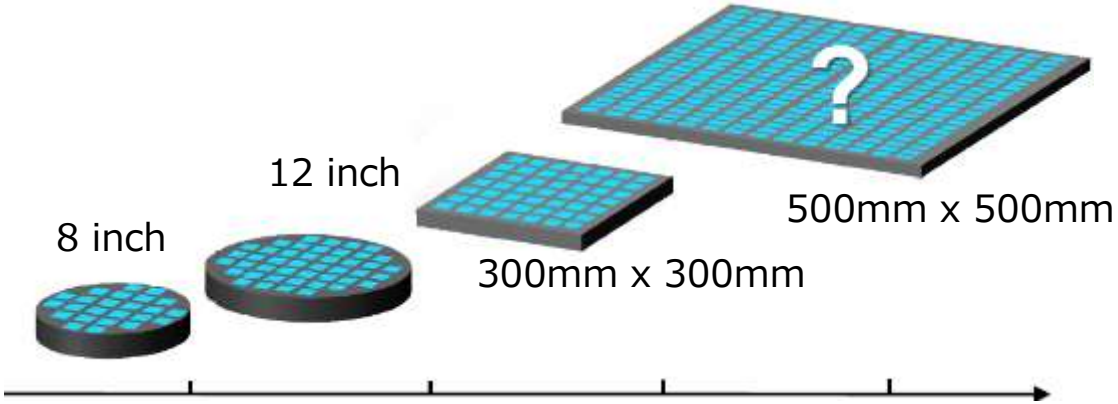
FC-BGA



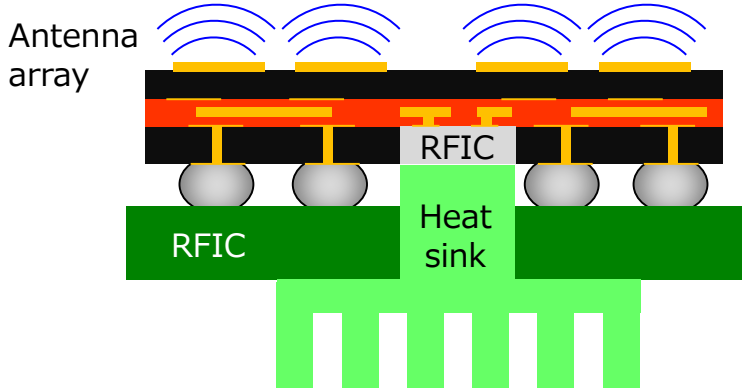
■ Advantages over fan-in WLCSP
- ✓ No pad pitch restriction due to fan-out area
- ✓ Only KGD is packaged!
- ✓ Potential SiP integration
- ✓ Lower thermal resistance

■ Advantages over FC-BGA
- ✓ Thinner
- ✓ Shorter inter connection due to substrate-less
- ✓ Future potential for SiP / 3D integration
- ✓ Lower thermal resistance

■ Wafer form to Panel form



■ Integrated antenna in FO-WLP



(*IME Industry Forum: High Density FOWLP Platform for Next Generation Mobile/2.5D/5G Systems, March 2016*)

Characteristics of Sheet Molding Compound

Material Name		LE
CTE (30-150degC)(ppm/K)	TMA	<15
CTE (50-150degC)(ppm/K)		<15
CTE (150-240degC)(ppm/K)		<25
Young's modulus (GPa)	Tensile mode	<15
Breaking strength (MPa)		50
Elongation (%)		>1.0
Dielectric constant (Dk)	Cavity Perturbation method @5.8GHz	3.2~3.3
Dissipation factor (Df)		<0.01
Peel strength (kgf/cm)	Cu Plating	0.4~0.5
x-y HAST L/S=15/15um	130degC, 85%, 3.3V	>200h

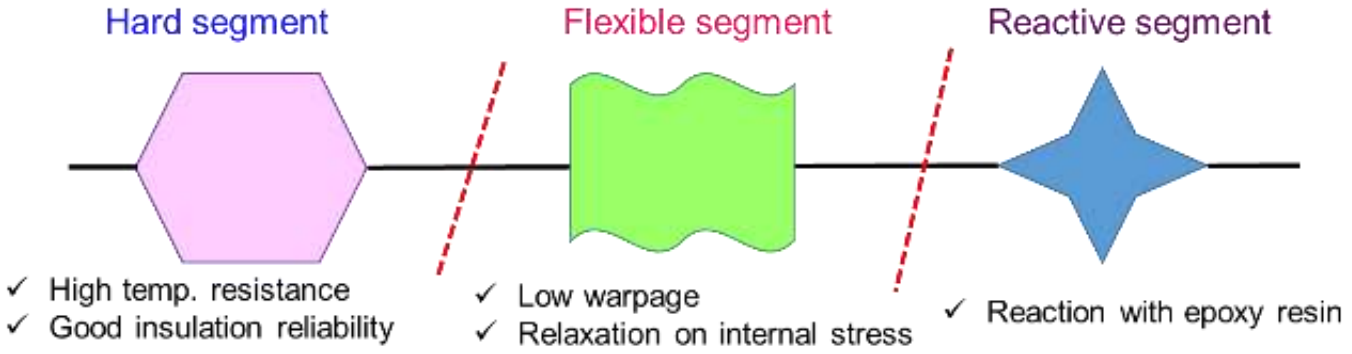
- ***Low CTE & Low Young's Modulus***
  ⇒ ***No warpage after the one-side resin curing***

LE: No warpage!

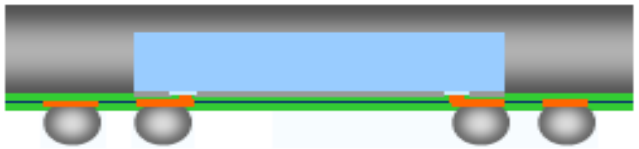
GX13:Big warpage!

(Laminated on 4 inches φ Si wafer)

- ***Low Df value***
- ***Good insulation reliability***



Suitable for Molding Material!



Summary

1. Advanced Build-up Materials; Next Generation ABF

- **Low Dielectric Loss ABF**

  Lower Df ABF showed lower transmission loss

  >> Applicable to high frequency packages

- **Next Generation Material for Thinner Application**

  Good Processability & Insulation Reliability

  >> Applicable to WLP/PLP redistribution layer and thinner packages

2. Molding Film (ABF-LE)

Low Warpage, Good HAST Reliability, and Low Loss Tangent

>> Suitable for FO-WLP/PLP

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Thank you very much for your attention!