Taiyo's Photo Imageable Dielectric for High Density Substrate Applications

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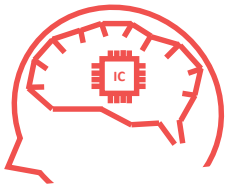
Agenda

- Motivation for High Density RDL
- Taiyo's Material Portfolio
- Why and What is PID?
- PID Performance
- High Density RDL Demo
- Summary

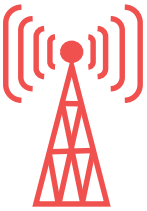
New Applications: Large Data Bandwidth Monsters



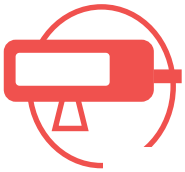
AI

Cloud computing

Autonomous car



5G



VR/AR

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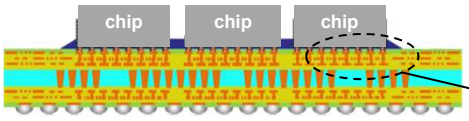
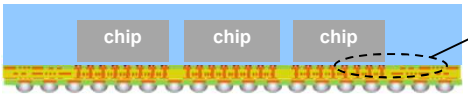
Need in High-Density RDL for Advanced IC Packaging

Substrates/Interposers

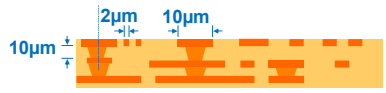


High density Fan-out

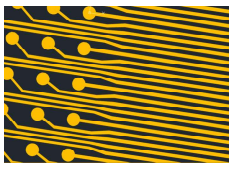


High density RDL

Cross section



Top view



Dielectric material capable of
- 10 μm small micro-via formation
- 2 μm L/S fine Cu wiring patterning

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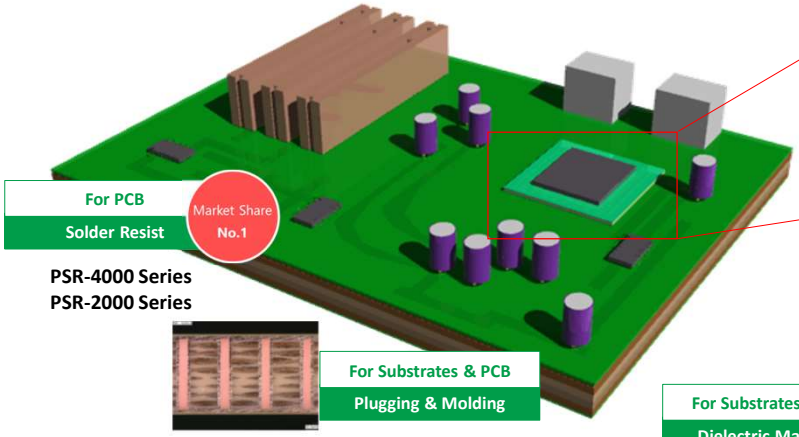
Taiyo's Portfolio for IC Packaging Substrate and PCB



For PCB
Solder Resist
Market Share No.1

PSR-4000 Series
PSR-2000 Series

For Substrates & PCB
Plugging & Molding

- THP Series:(Non-solv. Plugging Paste)
- Cellfill Series:(Sheet type Mold)

For Package Substrates
Solder Resist
Market Share No.1

Liquid type: PSR-4000 AUS series
Dry film type: PSR-800 AUS series

For Substrates & PCB
Dielectric Materials

- PVI Series: (Photo imageable for High Density)
- Zaristo Series:(Non-Photo for Low Loss)

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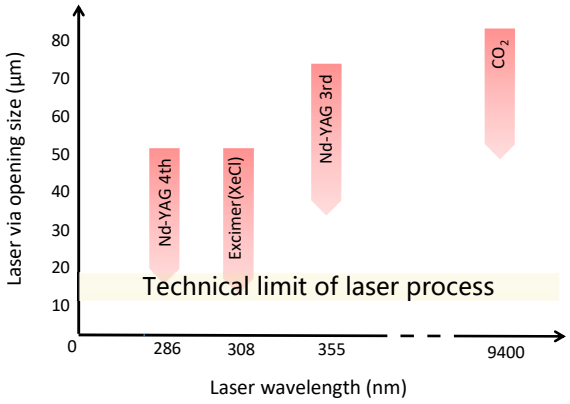
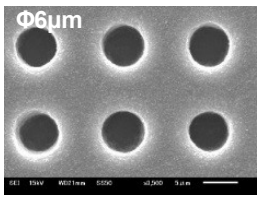
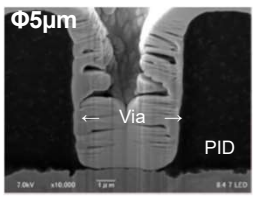
Why PID (Photo Imageable Dielectric)? – Micro-via Size

Non-photo dielectric + Laser
→ Technical Limit below 10 µm



PID can form < 10µm micro-vias





PID can form ultra-small via <10 µm easily

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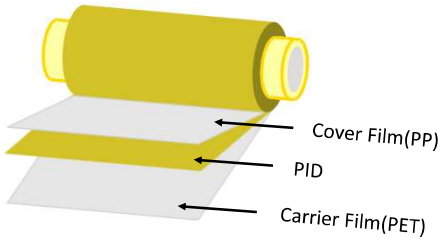
Taiyo's PID: Dry-Film Type



Dry Film Benefits

✓ Surface Flatness
- Multi-layer RDL formation
- Fine L/S formation

✓ Large Area Scalable
- Large panel production
- Process uniformity

✓ Low Emission – No solvent drying
- Process reduction
- Environment friendly

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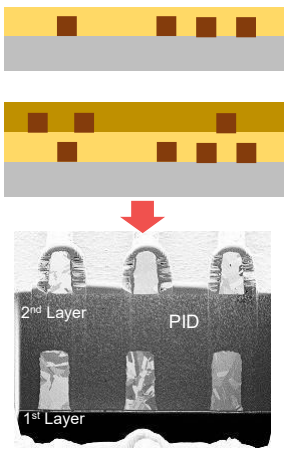
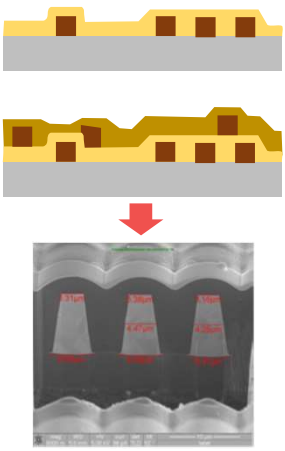
Surface Flatness of Dry-Film PID

Dry film Type



Liquid Type



Source of photo:
"An introduction for novel multi-layer thin film substrates applied in space transformers"
C. K. Yang
SW Test Workshop 2018

High surface planarity
→ Beneficial for multi-layer RDL

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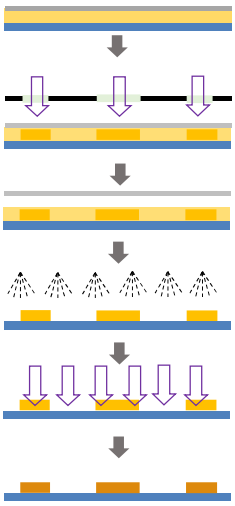
PID Process Flow: Photolithography



Vacuum Lamination	
Exposure	Projection Exposure, DI Exposure i-Line(365nm)
PET Film Peel off	
Development	1wt%Na_2CO_3 or 2.38wt%TMAH
UV Curing	High-pressure Mercury Vapor Lamp
Thermal Curing	Box oven, 180deg.C

Non-solvent development & low temp. curing

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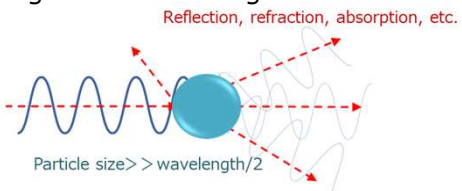
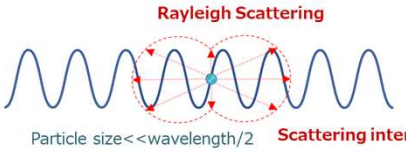
PID Resolution – Effect of Filler Size

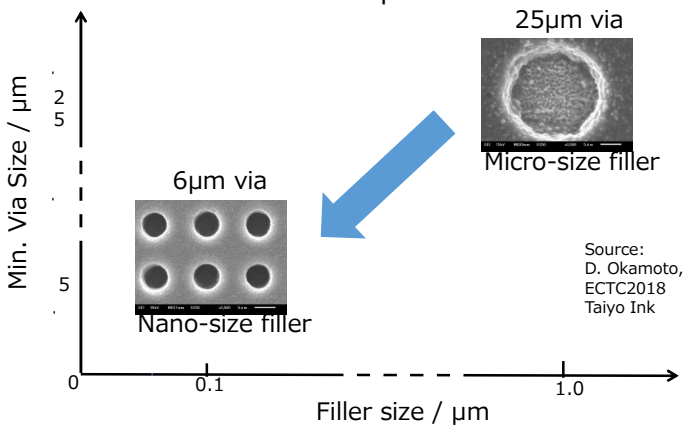
Large filler scatter light



Small filler minimize scattering



PID thickness :10μm



PID with nano-size filler enabled
- Ultra-small vias below 10μm
- Low CTE (40-50ppm/ °C)

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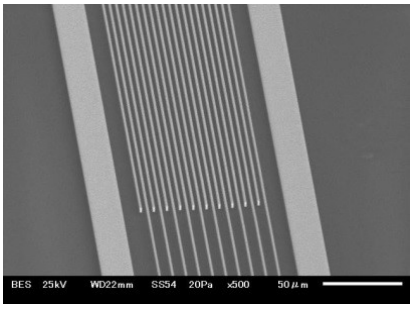
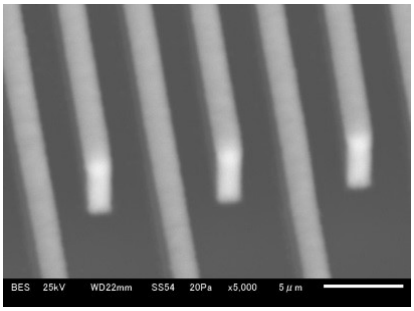
Semi-Additive Process (SAP) Compatibility

2µm Line/Space Cu Wiring on PID



SEM image (x500)



SEM image (x5000)

Process Steps:
1. PID curing
2. Ti/Cu sputtering
3. Resist patterning
4. Electro Cu plating
5. Resist stripping
6. Seed etching

Courtesy: Mitsui Mining & Smelting Co., Ltd.

Fine RDL formation compatible

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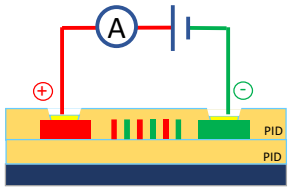
Insulation Reliability of PID: Biased-HAST (B-HAST) Test

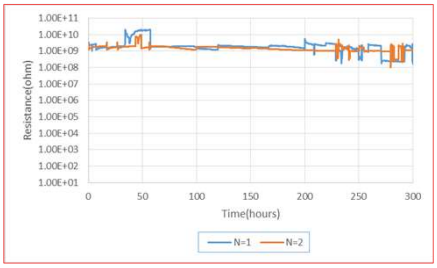
B-HAST configuration



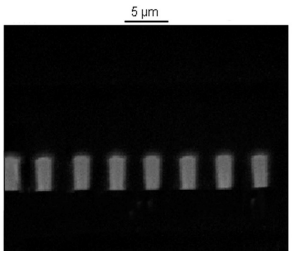
Preconditioning
- 125deg.C/24h
- 85deg.C/60%/168h
- Reflow:260deg.C/3times

BHAST
- 130deg.C/85%/5V
(Failure criteria:1.0E+6 ohm)

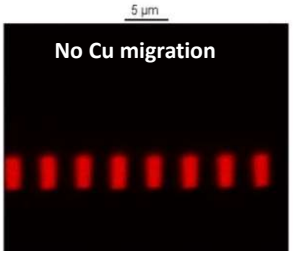
In-situ Resistance



2µm L/S after 300h of B-HAST



SEM image



EDX Cu mapping

High reliability over 300 hours insulation

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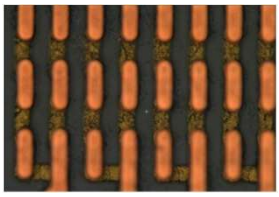
Mechanical Reliability of PID: TCT Test

TCT configuration

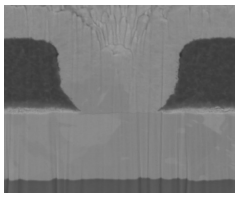
Preconditioning
- 125deg.C/24h
- 60deg.C/60%/150h
- Reflow:260deg.C/3times

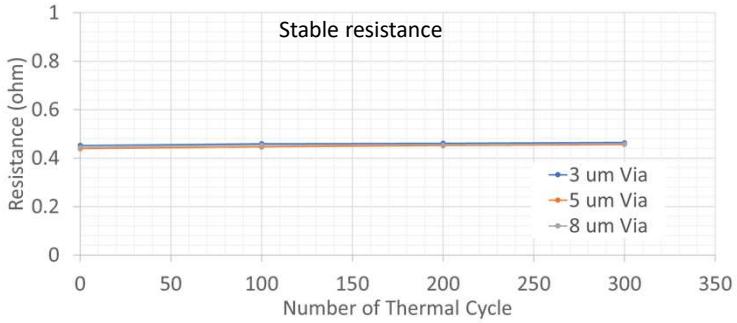
TCT
- 125℃ ↔ -55℃

Daisy-chain Top view



3µm via X-SEM





No failure up to 300 cycles

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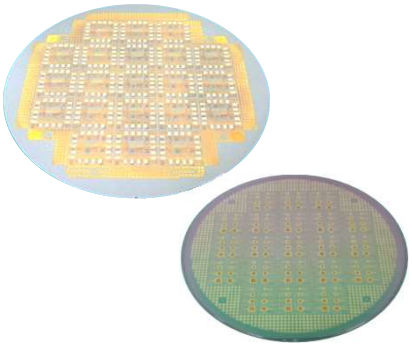
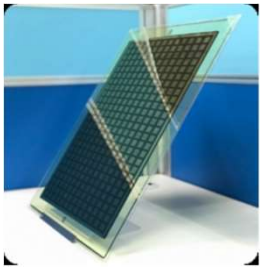
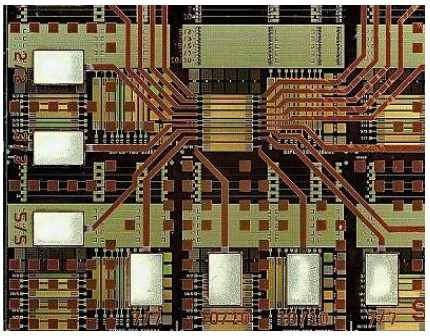
Multi-layer RDL with PID on Glass Demo

Glass Test Vehicles Top View





Multi-RDL on Glass



Courtesy: Research Center for Three-Dimensional Semiconductors (Japan), ITRI (Taiwan)

Multi-layer RDL with 2µm L/S wiring + 10µm via demonstrated

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PID Material Properties

Properties	Unit	Taiyo's PID	Ref: standard type Non-photo A	Method
Tg (@TMA)	deg.C	150-155	165-175	Instrument : Q-400 Fulcrum distance 16 mm, t = 30 µm Force : 0.05 N, Mass flow : 100.0 mL -40.00 to 300 deg.C (10 deg.C/min)
CTE alpha 1	ppm	40 – 45	25-30	
Elastic Modulus	GPa	3.5-4.0	6.0-6.5	Instrument : RSA-G2 Temp. : 25 deg.C Constant linear Rate : 2.0e-3 mm/s Duration : 1000 s
Tensile Strength	MPa	100-105	100-110	
Elongation	%	5-7	2-3	
Residual Stress	MPa	20.0-25.0	No data	Instrument : SE700, t = 20 µm
Dk (10 GHz)		3.0-3.1	3.4	SPDR method, t = 30 µm
Df (10 GHz)		0.021-0.023	0.015-0.017	
Water Absorption	%	1.2	1.2	D-1/100, t = 30 µm
Curing Temp.	deg.C	180	190	Box oven

Comparable material properties to standard non-photo dielectric

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Summary

Taiyo's PID material is beneficial for advanced packaging:

1. High density RDL formation with 2µm L/S & below 10µm micro-via
2. Dry-film type for surface planarity and scalability
3. Excellent material reliability & properties

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