

# Space transformer & Ultra fine pitch PCB Solution

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## PCB Market Overview

### Global PCB Market Overview

- Market Size: Approximately \$70 billion as of 2023
  - South Korea Market Size: Approximately \$10 billion as of 2023
- Growth Rate: Expected CAGR of 3~5%
- Applications
  - Consumer Electronics, Telecommunications, Automotive Electronics, Medical Devices, Aerospace and Military, Industrial Equipment, etc.

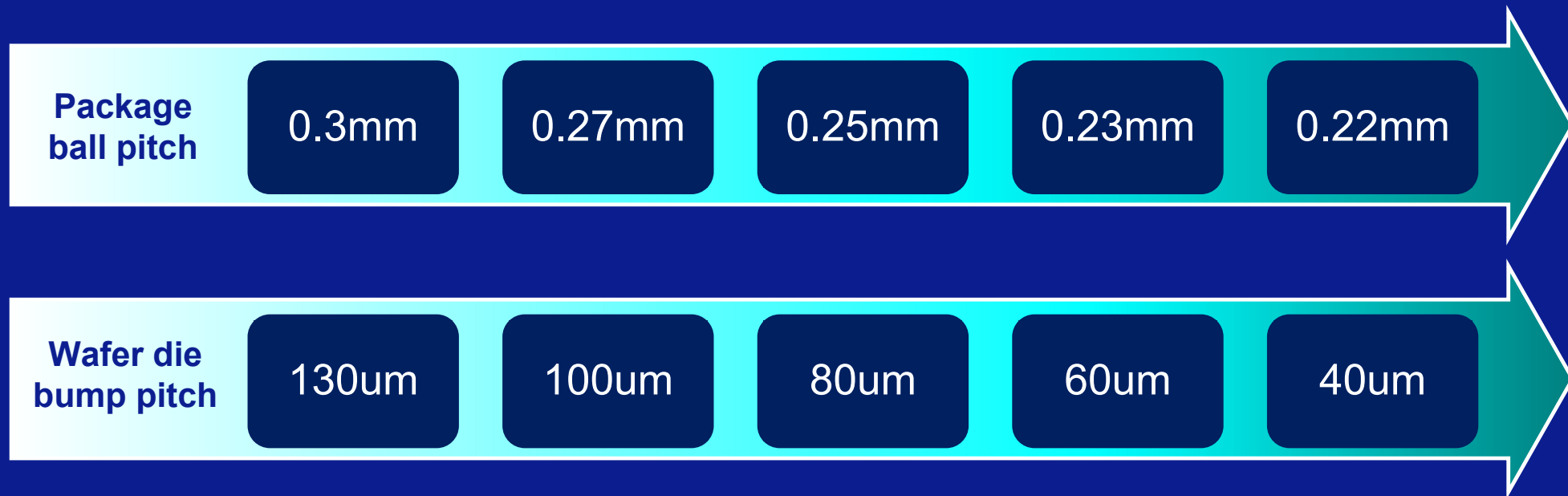
## Trends in semiconductor technology

### Technological changes in semiconductor testing

-  Ultra-fine Pitch
-  High Speed IO
-  Low Power & High Current
-  Extreme Temperature

## Trends in ultra-fine pitch

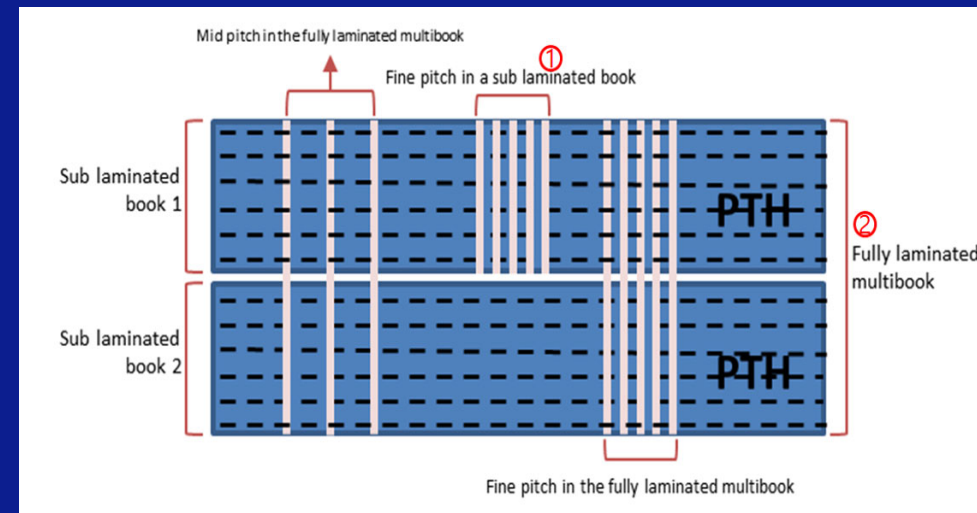
### Fine-pitching of wafer die bumps and package balls



## Challenges for fine pitch PCBs

### Fine-pitch solutions up to 0.27mm pitch

- MLB(Multi-layer board)
  - Precision etching process
  - Uniform plating thickness
  - Small machining drill process
  - Thermal expansion of materials
  - Multibook process

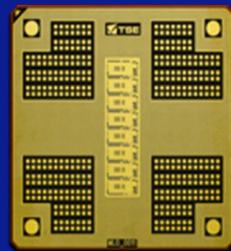


- PCB Thickness : 7.6mmT
  - PTH (Plated Through Hole) : 3.8mmT

## Challenges for fine pitch PCBs

### Fine-pitch solutions up to 40um pitch

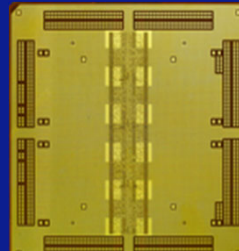
- STO-ML(Space Transformer Organic-Multi Layer)
  - Space transformer PCB between PLB and Probe Head (or Socket)
  - STO-ML is the exclusive TSE brand of MLO



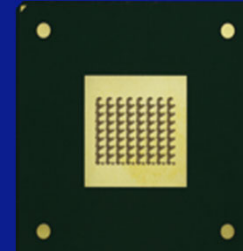
50um



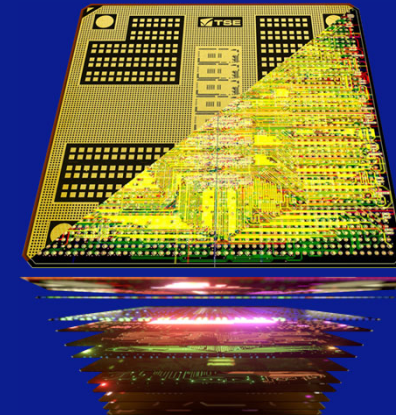
60um



90um

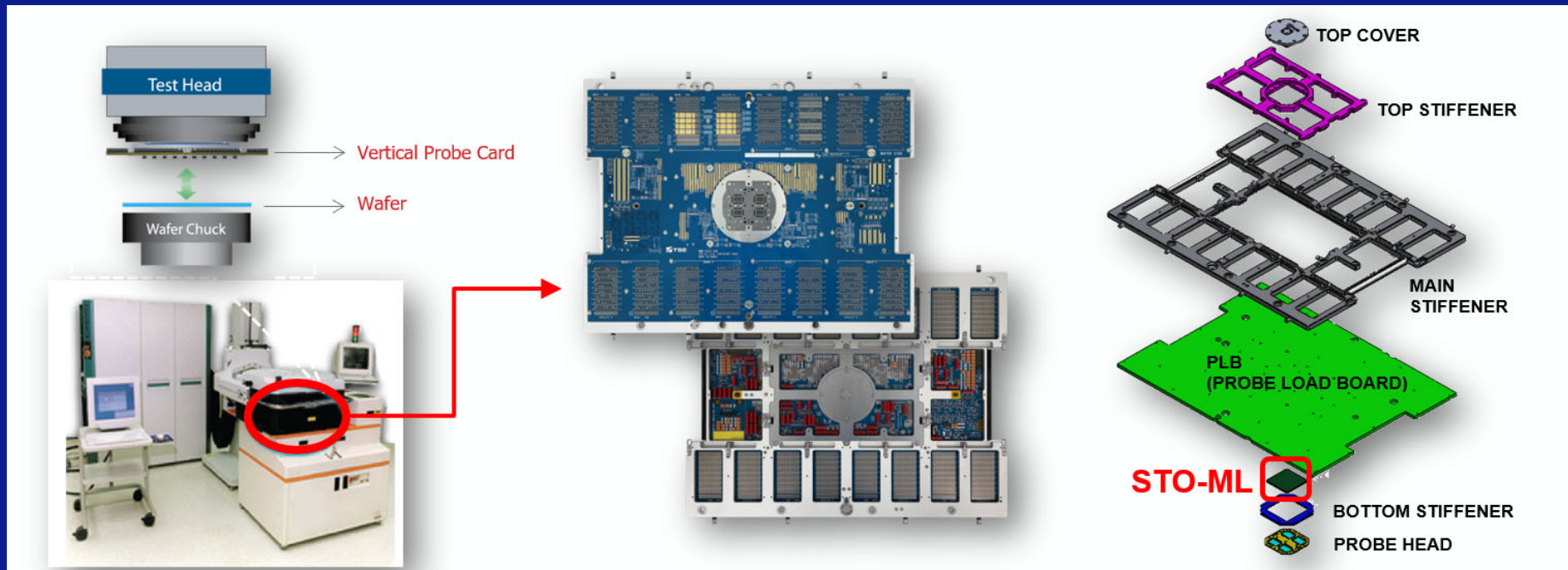


110um



## Application of Vertical Probe Card

### Structure Overview

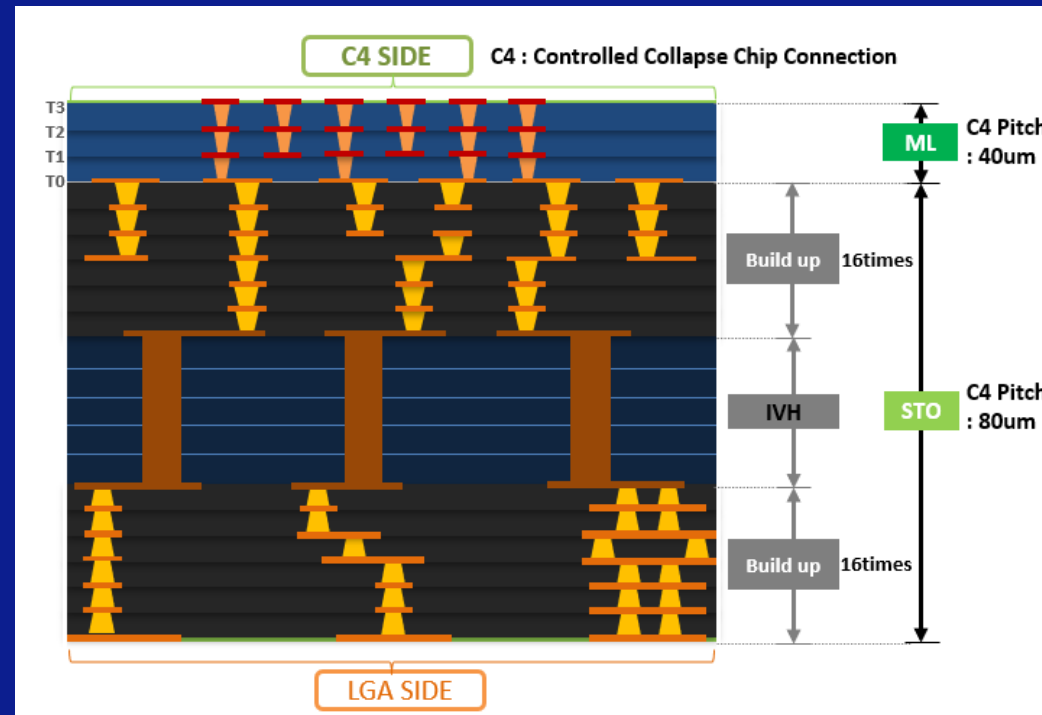




## Space Transformer Organic-Multi Layer

### Fabrication Capability

- STO
  - Pitch : Up to 80um
  - Stack Up : 16-n-16
  - Micro Via : 30um
  - C4 Pad Size : 60um
- STO-ML
  - Pitch : Up to 40um
  - Stack Up : 3(ML)-16-n-16
  - Micro Via : 18um
  - C4 Pad Size : 30um



## Space Transformer Organic-Multi Layer

### Material Overview

- Low Dielectric Constant (Dk)
  - STO : 3.19@10GHz / ML : 3.1@10GHz
- Low Dissipation Factor (Df)
  - STO : 0.008@10GHz / ML : 0.018@10GHz
- Thermal characteristics
  - High Tg (TMA Thermomechanical Analysis : STO 230°C / ML 155°C)
  - Low CTE Coefficient of Thermal Expansion : 9~10ppm/°C



## Space Transformer Organic-Multi Layer

### Key Process Technologies

- Build Up Layer Lamination
  - The alignment and adhesion between layers are crucial
- Fine Patterning and Etching
  - Ensuring high-frequency characteristics through impedance matching
- Via fill Plating and Stacked via Alignment
  - Via plating should be free of voids and cracks, and alignment is critical
- Testing and Quality Control

## Space Transformer Organic-Multi Layer

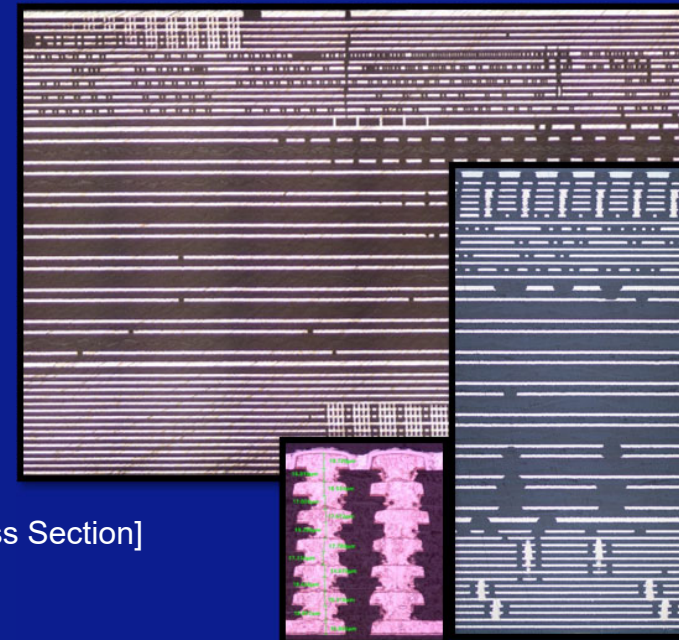
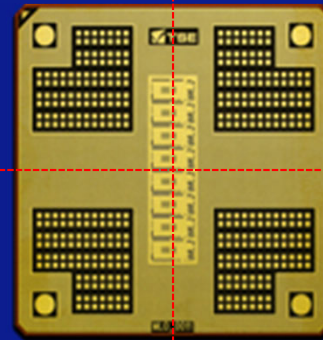
### Reliability Management

- Reliability Test
  - Solder Floating (288°C @ 10sec)
  - Thermal Shock Cycling Test (125°C↔-55°C @ 100Cycles)
  - Constant Thermal & Humidity Test (40°C @ 90%)
- Test Verification (IPC-6012D)
  - BBT (Electrical Check)
  - Cross Section (Mechanical Check)

## Space Transformer Organic-Multi Layer

### Reliability Management

- Cross Section
  - Delamination
  - Crack
  - Void
  - Via fill plating
  - Stacked via alignment
  - etc.



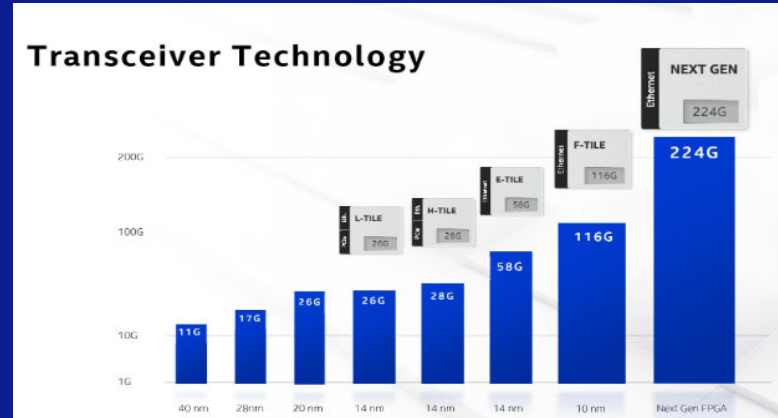
[Cross Section]

## Space Transformer Organic-Multi Layer

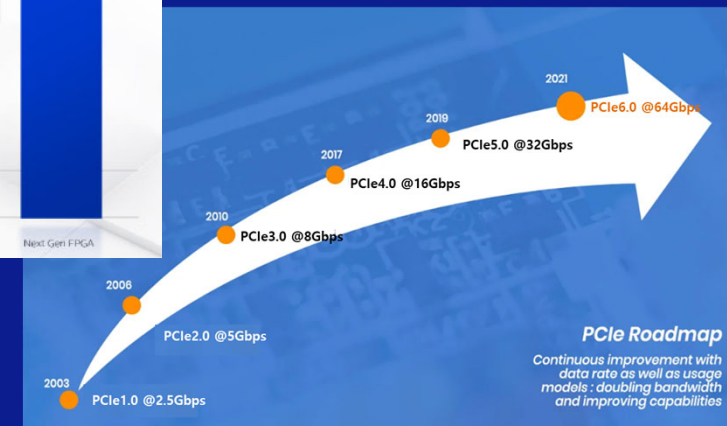
### Signal Integrity of High Speed IO

CPU, GPU, Chipset, AP, Microcontroller, ASIC, FPGA, etc.

- High Speed IO
  - PCI Express
  - MIPI
  - USB
  - DP
  - etc.



Source : Intel

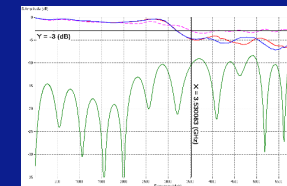


## Space Transformer Organic-Multi Layer

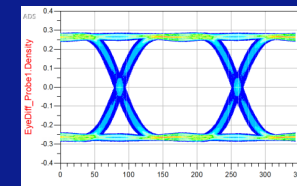
### Simulation based PCB Design

- Simulation
  - S-Parameter analysis for signal integration
  - Z-Parameter analysis for power integration

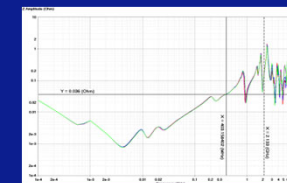
TYPE	Software	Maker
EM Tool	PowerSI	Cadence
	SIwave	ANSYS
	PowerDC	Cadence
	HFSS	ANSYS
Circuit Tool	ADS	Keysight
	Designer SI	ANSYS



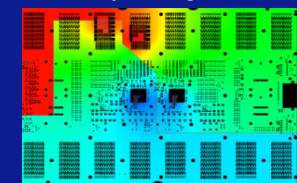
S-Parameter



Eye Diagram



Power Impedance



IR Drop

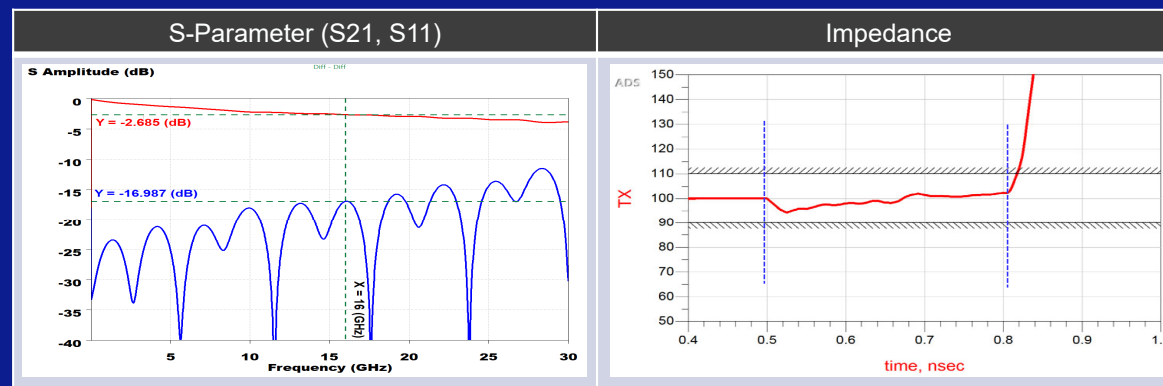
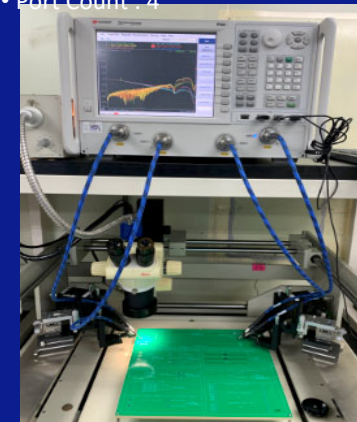
## Space Transformer Organic-Multi Layer

### Signal Integrity of STO-ML

- PCIe Gen5 32Gbps
  - Tx ↔ Rx: Trace length 30mm & AC Coupling Capacitor
  - Insertion Loss: less than -3dB / Return Loss : more than -15dB
  - Impedance: Differential pair 100Ω ±10%

#### VNA (Vector Network Analyzer)

- Maker : Keysight
- Model: N5224A
- Bandwidth :10MHz ~ 43.5GHz
- Probe Spec : 50GHz RF probe
- Port Count : 4



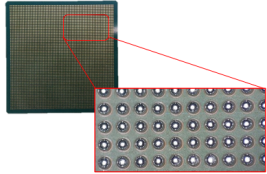
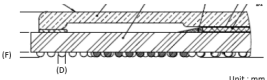


## Space Transformer Organic-Multi Layer

### SMT (Surface Mount Technology)

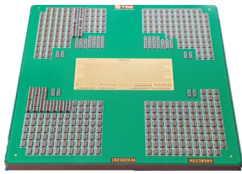
- Selection of solder balls considering pitch and pad size
- Application of a jig for PCB alignment and maintaining flatness
- Management of SMT profiles for each product to ensure solder joint quality

**Ball mount [Bottom Side]**

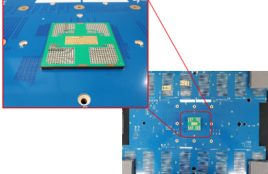
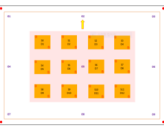
Unit : mm		
A	Pitch	1.0mmP / 0.8mmP
B	LGA Pad Size	0.55±0.05 / 0.45±0.05
C	Solder Ball Size	φ0.55±0.05 / φ0.45±0.1
D	Ball Diameter Spec.	0.6±0.06 / 0.5±0.06
E	Ball Height Spec.	0.46±0.06 / 0.38±0.06
F	Height (Ball mount)	2.3~2.8 / 0.19~0.24

**Capacitor Assembly [Top Side]**



Parameters	STO-ML Capacitor	
Capacitor value	0.1uF, 1.0uF, 2.2uF	0.1uF, 1.0uF (MLCC), 2.2uF (Terminals)
Capacitor Size	1.0 x 0.5mm / 1.6 x 0.8mm	0402, 0603 (inch)
Capacitor Thickness	< 1mm	K02 (Probe Head)
Operating Temperature Range	-55 ~ 125°C	X5R, X7R, X7S

**PLB & STO-ML Assembly**

- Measurement
- ✓ C4 Coplanarity
- ✓ Bow & Twist



[SMT Line]

## Summary

### Challenges for fine-pitch PCBs

- High layer fine-pitch support through multi-book process
- Ultra fine-pitch support through space transformer process

### Simulation based PCB Design

- Ensuring signal integrity and power integrity characteristics

### Surface mount technology for fine-pitch PCBs

- Optimal temperature profile, solder ball selection and flatness control

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