New Non-Reinforced Substrates for use as Embedded Capacitors

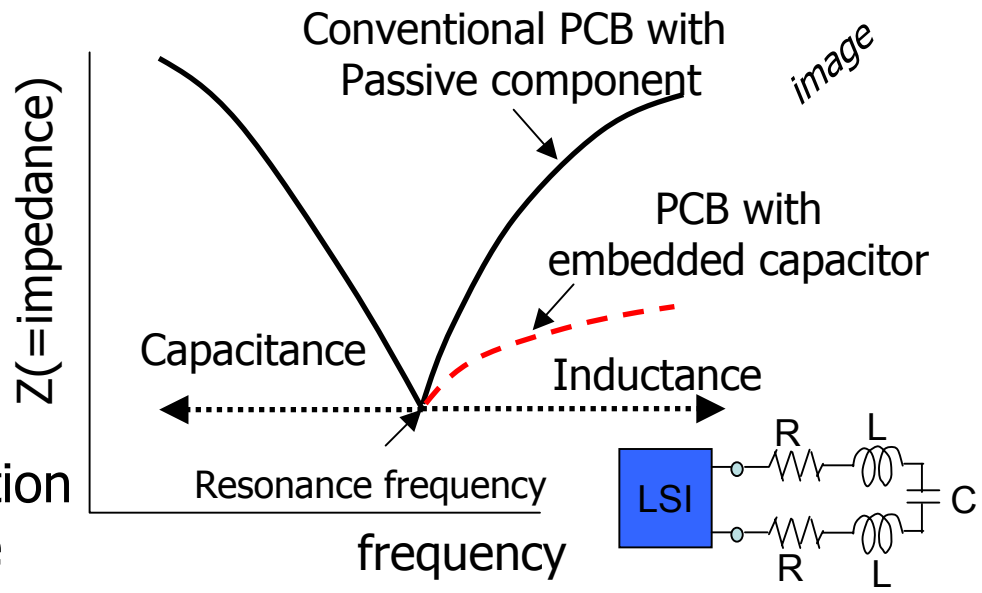
John Andresakis
Oak-Mitusi Inc.
T. Yamamoto,K. Yamazaki,F. Kuwako
Mitsui Mining & Smelting Co., Ltd

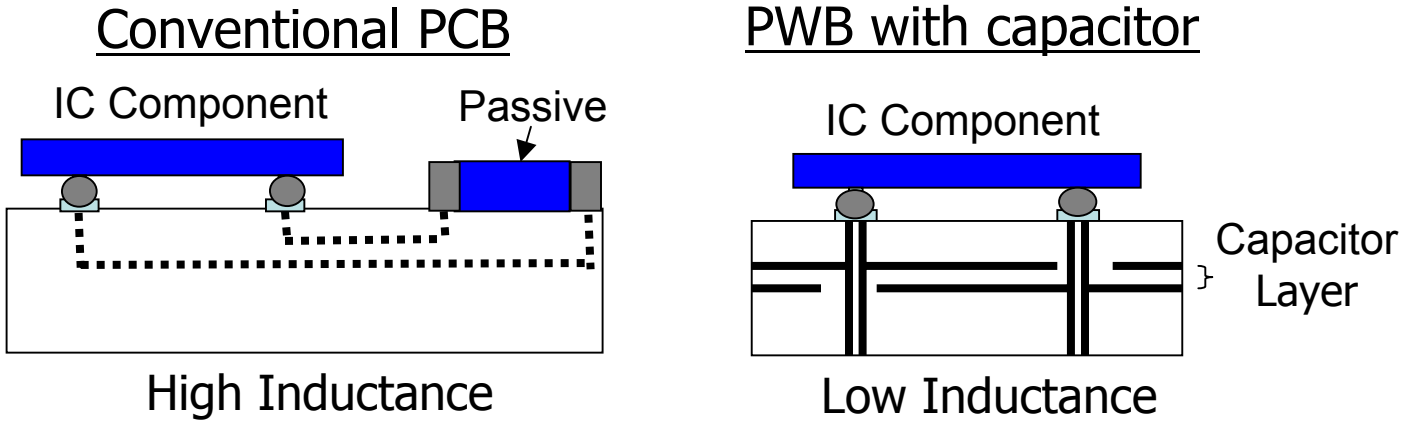
Background-1

Current application
with Embedded Capacitor

- Hi-end computers
- Network servers
- Network routers

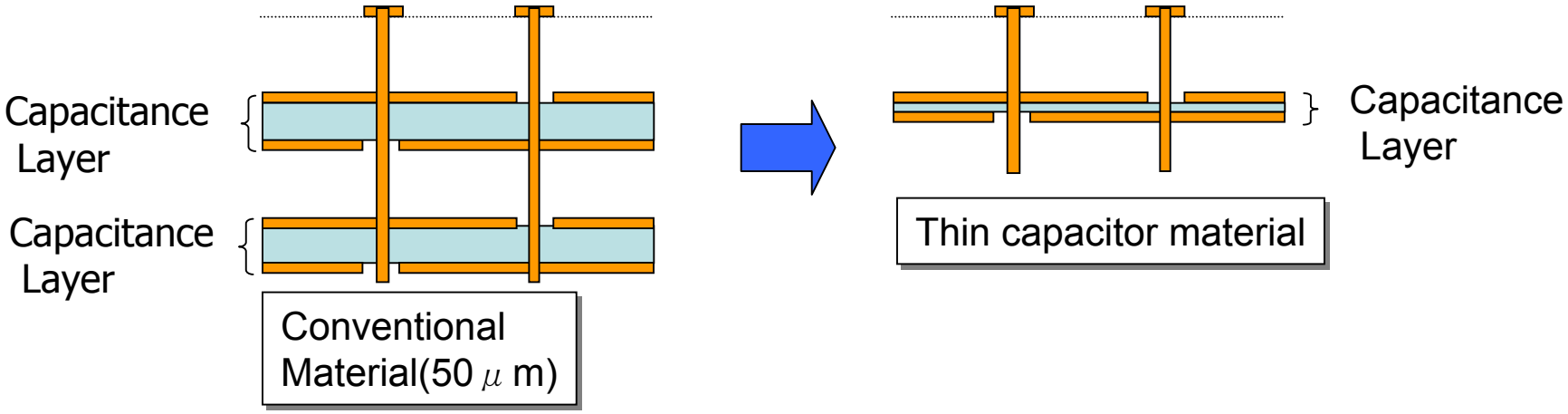
⇨ Demand for power distribution system with low impedance





Background-2

PWB with capacitor



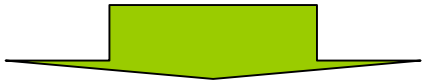
Demand for Thin(<25micron) Capacitor Material

Expectation by using Thin Capacitor Material

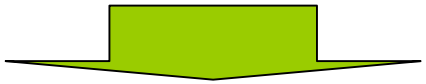
- Improvement in electrical performance
- Reduce cost
- Reduce thickness of the board

Development of Thin Capacitor & Investigations

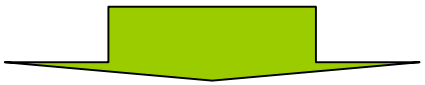
Material Selection to Construct Thin Capacitor
a) Copper Foil b) Dielectric Resin



Characterization of Thin Capacitor

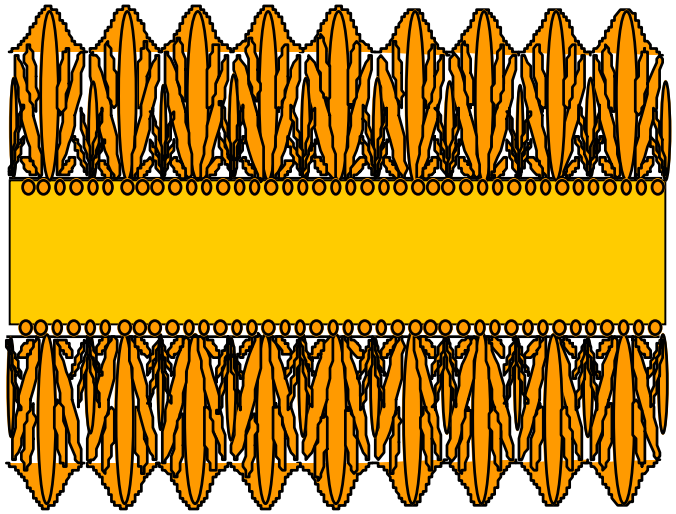


PWB Manufacturing Processing
of Thin Capacitor



Decoupling Performance of PWBs using
Thin Capacitor Material

Thin capacitor material



Copper Foil

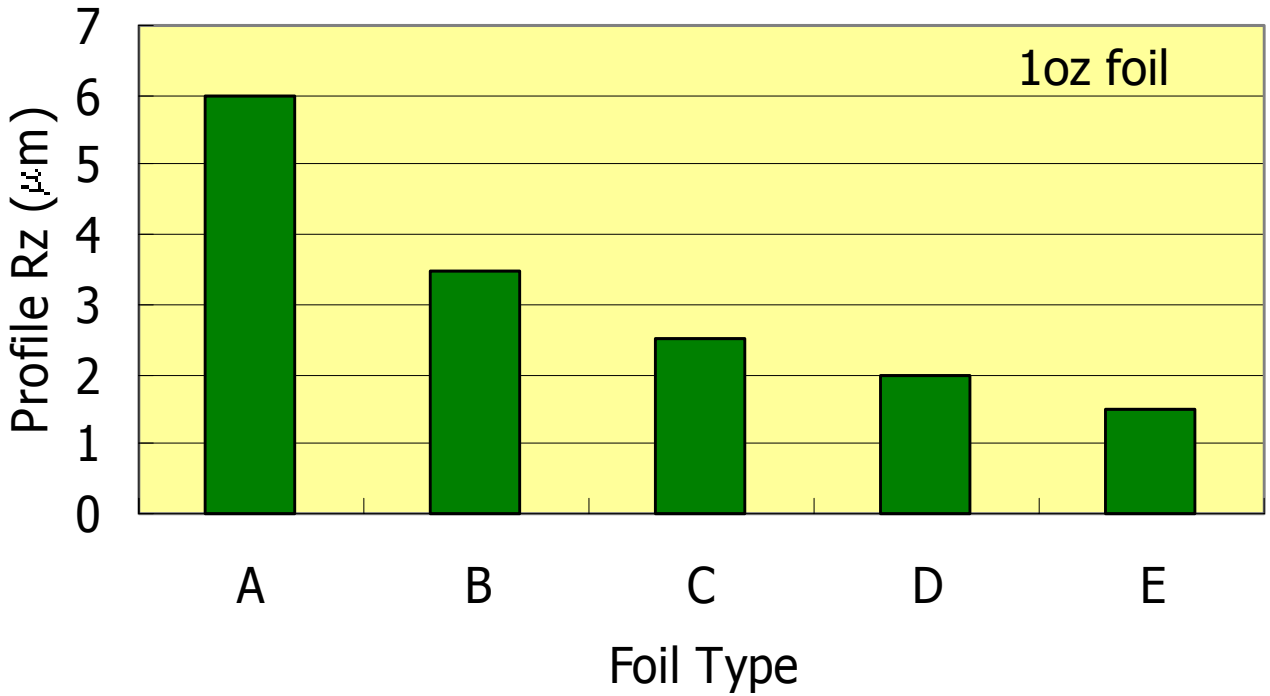
Peel Strength
Capacitance value

Dielectric Resin

Physical Properties
(Toughness, Flexibility)
Insulation Reliability

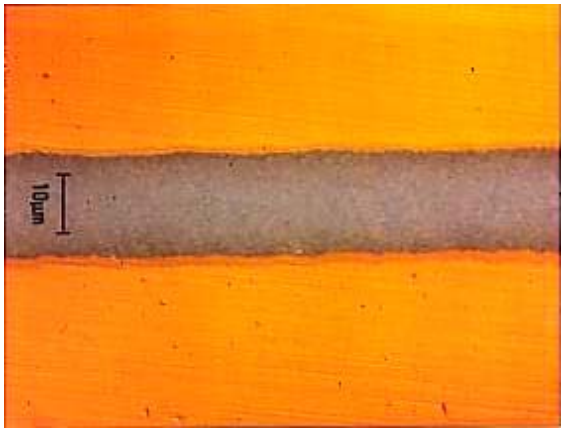
Copper Foil - Profile(1)

A) Standard HTE electro deposited (ED) copper foil
B) RTF(Reverse treated foil)
C) Super low profile ED foil
D) Ultra low profile ED foil
E) Wrought foil

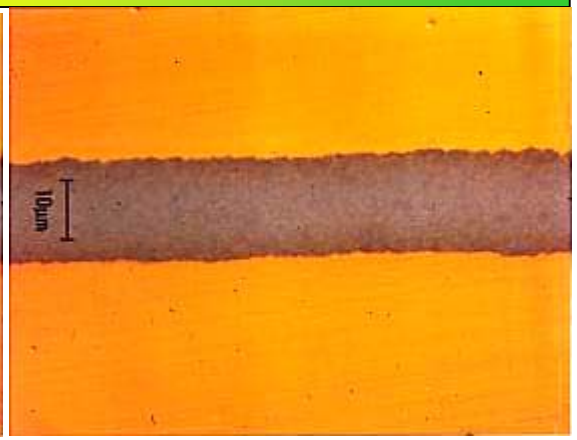


Copper Foil - Profile(2)

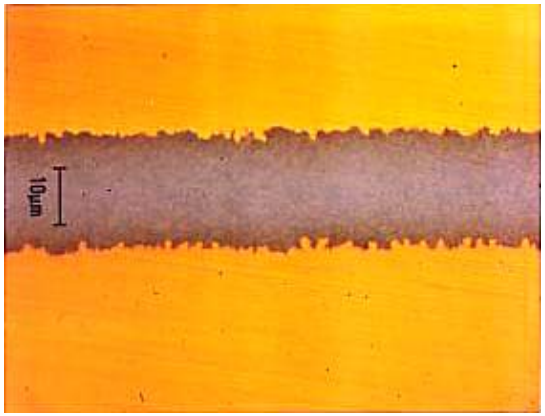
Foil E Rz=1.5 μm



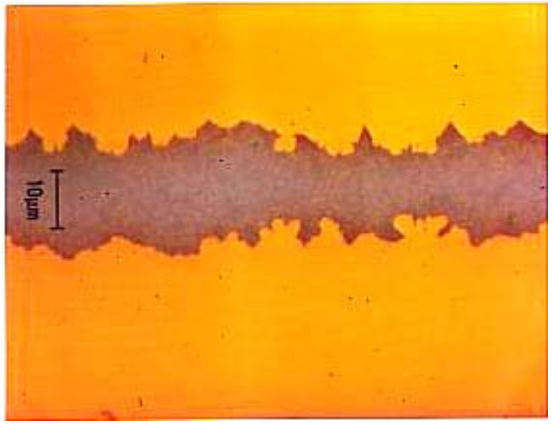
Foil D Rz=2.0 μm



Foil C Rz=2.5 μm



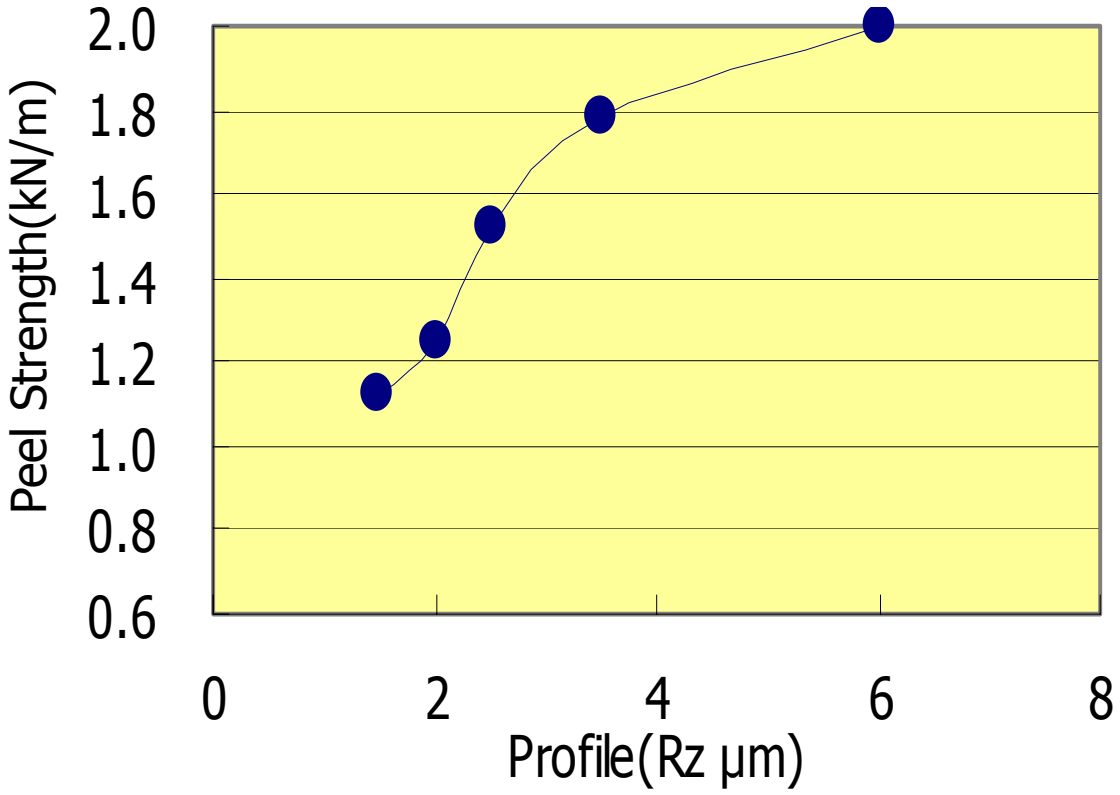
Foil B Rz=3.5 μm



Foil A Rz=6.0 μm

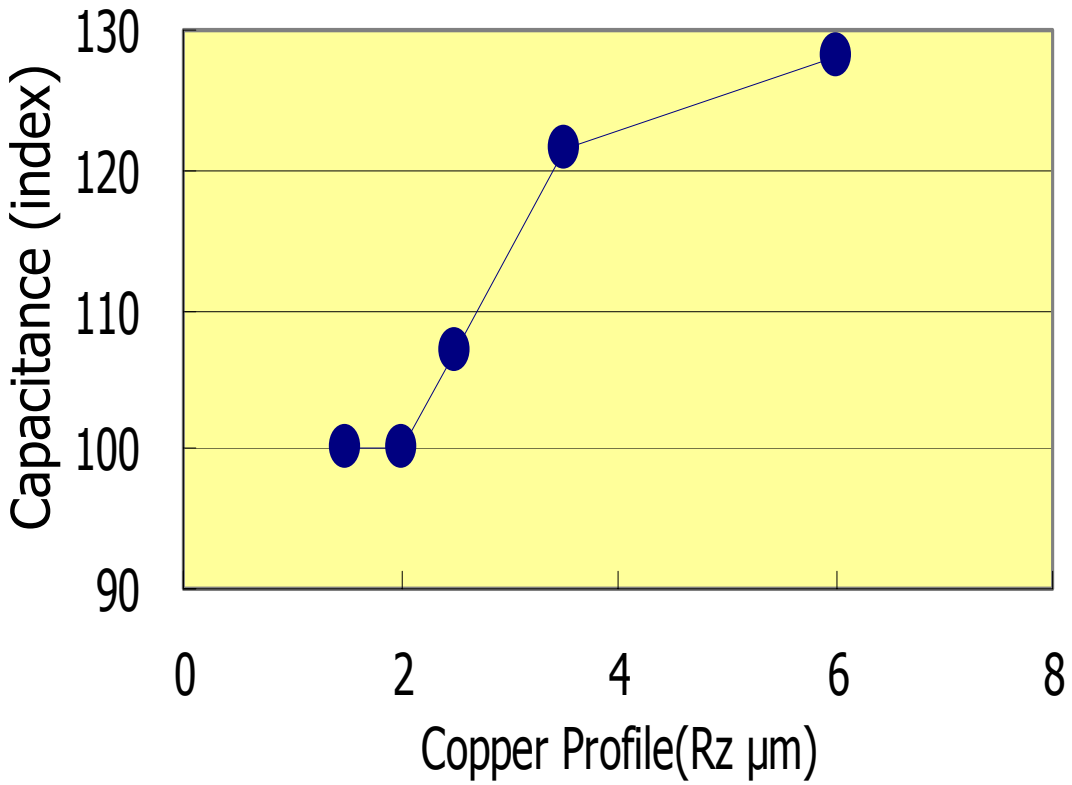
Capacitor were formed with 20micron dielectric thickness using various copper foils.

Copper Foil - Peel strength



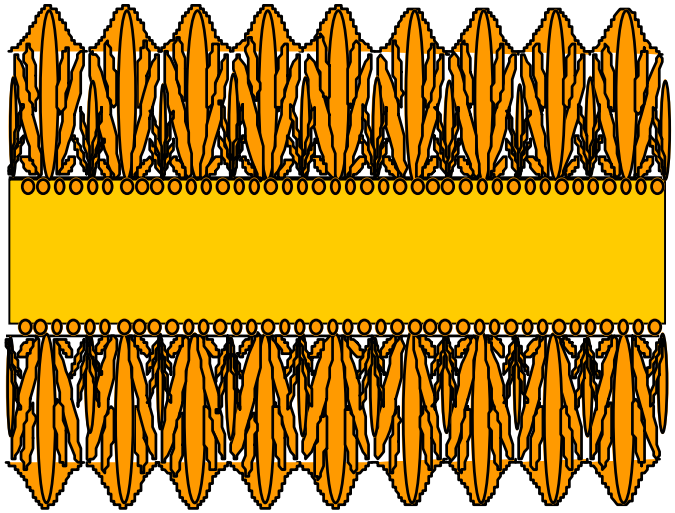
Measured on standard epoxy resin system.
1oz copper foil.

Copper Foil - Capacitance



Dielectric thickness 20micron.
Measured frequency 1MHz
Measured diameter 20mm

Thin capacitor material - Dielectric Resin



Dielectric Resin

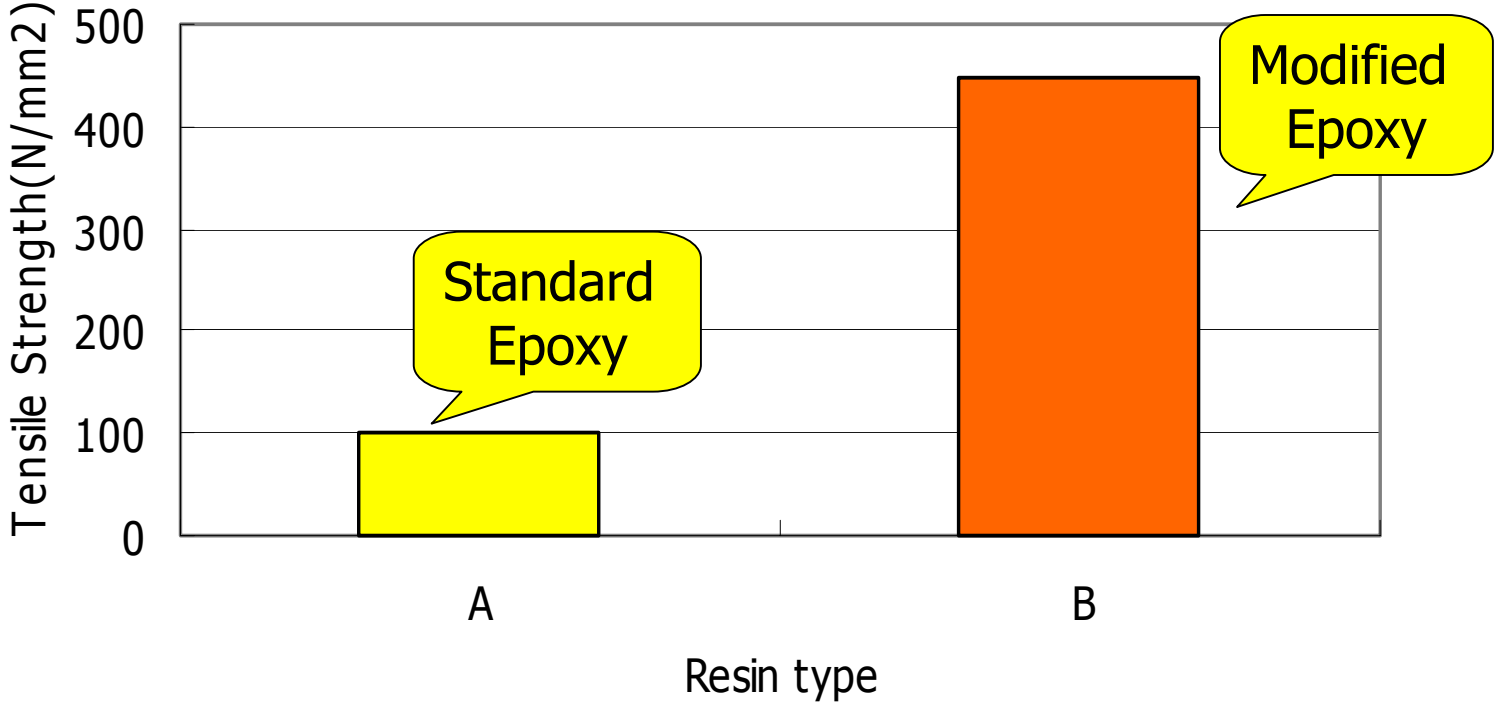
Physical Properties
(Toughness, Flexibility)
Insulation Reliability

Prepared dielectric for evaluation :

Type A : Standard Epoxy

Type B : Modified Epoxy

Dielectric Resin - Tensile Strength

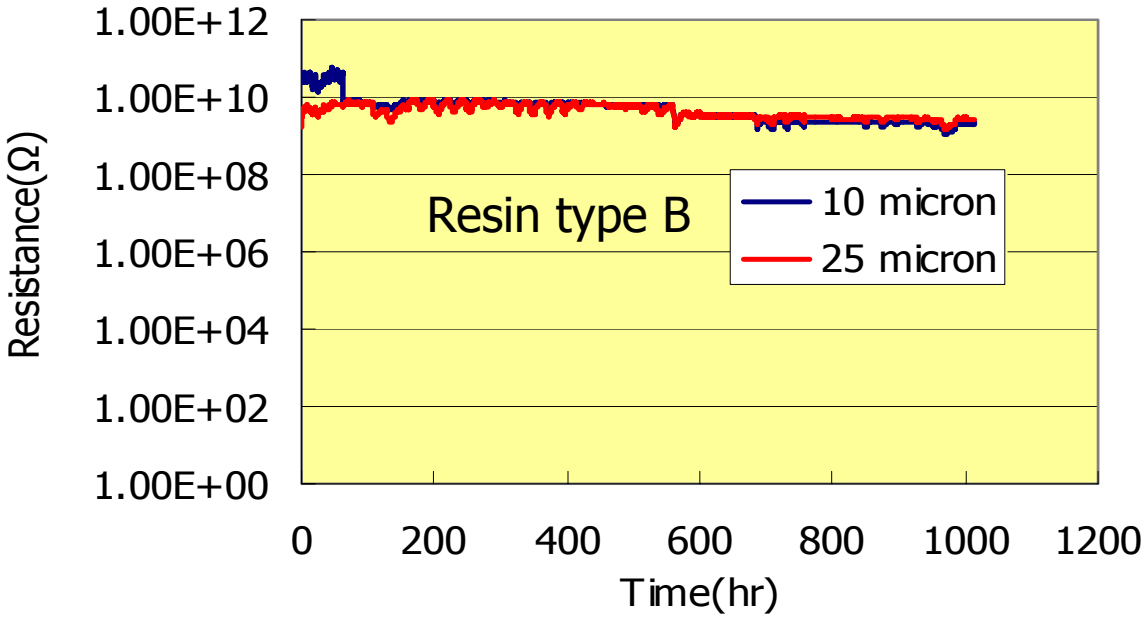


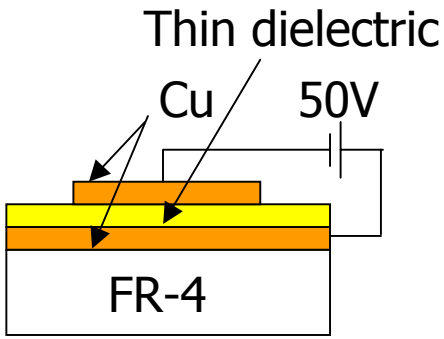
Resin Type	A	B
Tensile Strength* (N/mm2)	99	448

* Measured on 10μm thick resin

Dielectric Resin - Electro Migration

Test condition: 85C/85% 50V





Electro migration test

Resin type	Lasted hours		
	N=1	N=2	Avg.
A	658	706	682
B	>1000	>1000	>1000

Thin Capacitor Material Construction

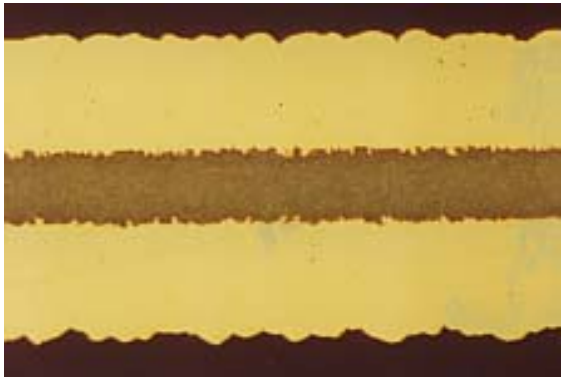
Selection of copper foil and dielectric resin

Consideration

Copper Foil
Peel strength
High pot test yield
Capacitance

Dielectric Resin
Electro Migration
Toughness/Flexibility

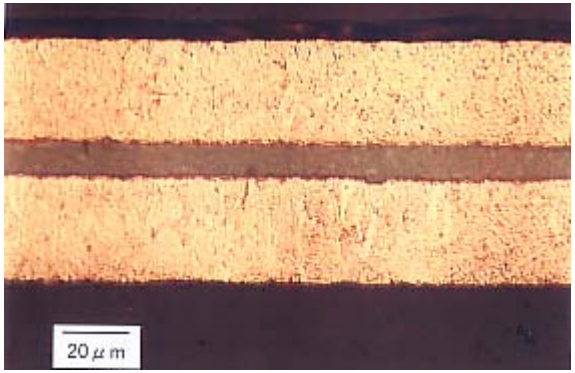
Dielectric thickness 25μm Capacitor



→ Copper Foil **TypeB**

→ Dielectric resin **TypeB**

Dielectric thickness 10μm Capacitor



→ Copper Foil **TypeC**

→ Dielectric resin **TypeB**

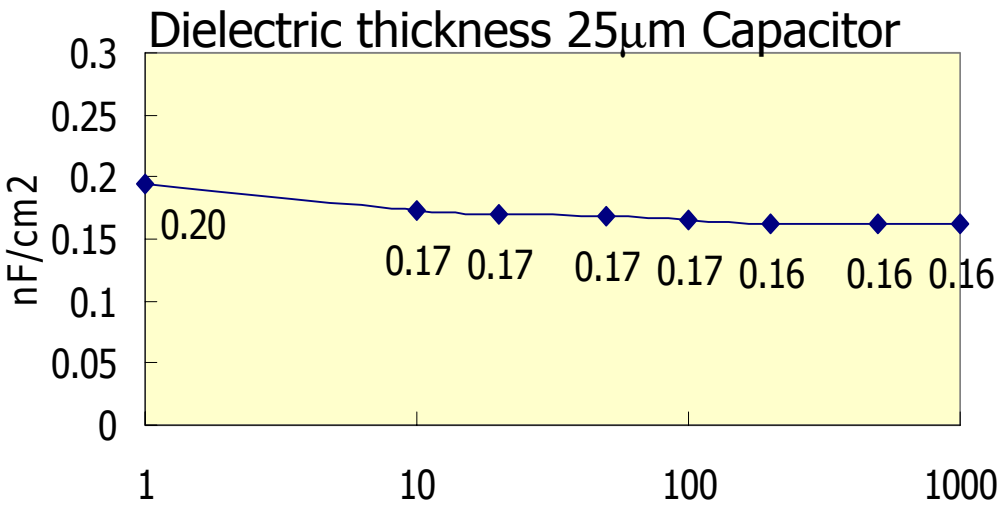
Thin Capacitor Material Characteristics

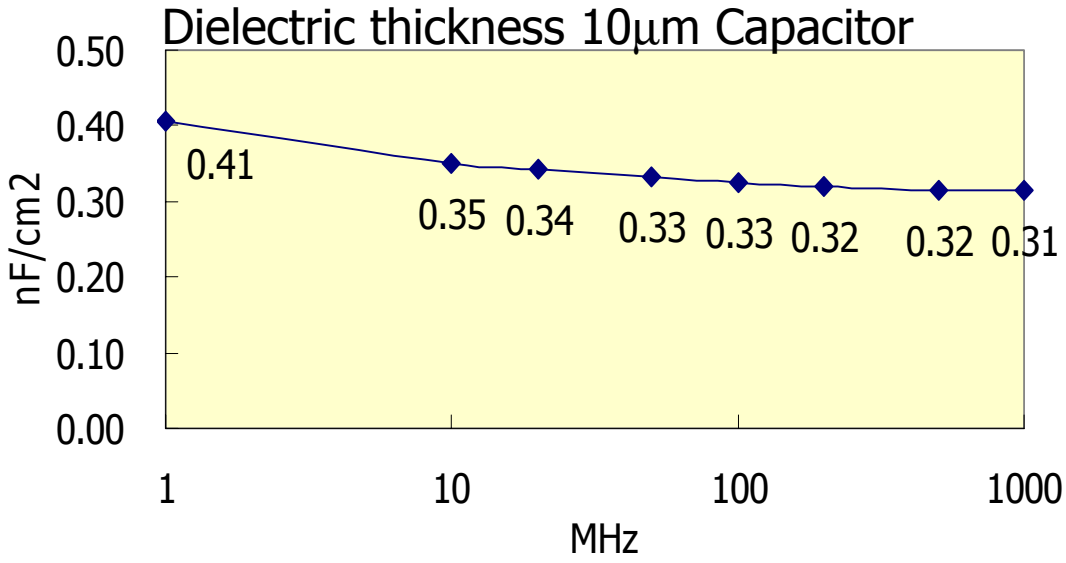
Thin capacitor characteristics

Properties	25μm Material	10μm Material
Copper foil type	B	C
Dielectric type	B	B
Copper weight (oz)	1	1
Peel strength (kN/m)	>1.0	>1.0
Dielectric thickness μm	25	10
Capacitance(nF/cm2)10MHz	0.16	0.35
Dk at 10MHz	4.0	4.0
Df at 10MHz	0.03	0.03
Dielectric breakdown V	>500	>500
Tg(DMA) Celsius	>220	>220
Electrical migration*(hrs)	>1000	>1000
Solder float (288Cx5times)	Passed	Passed

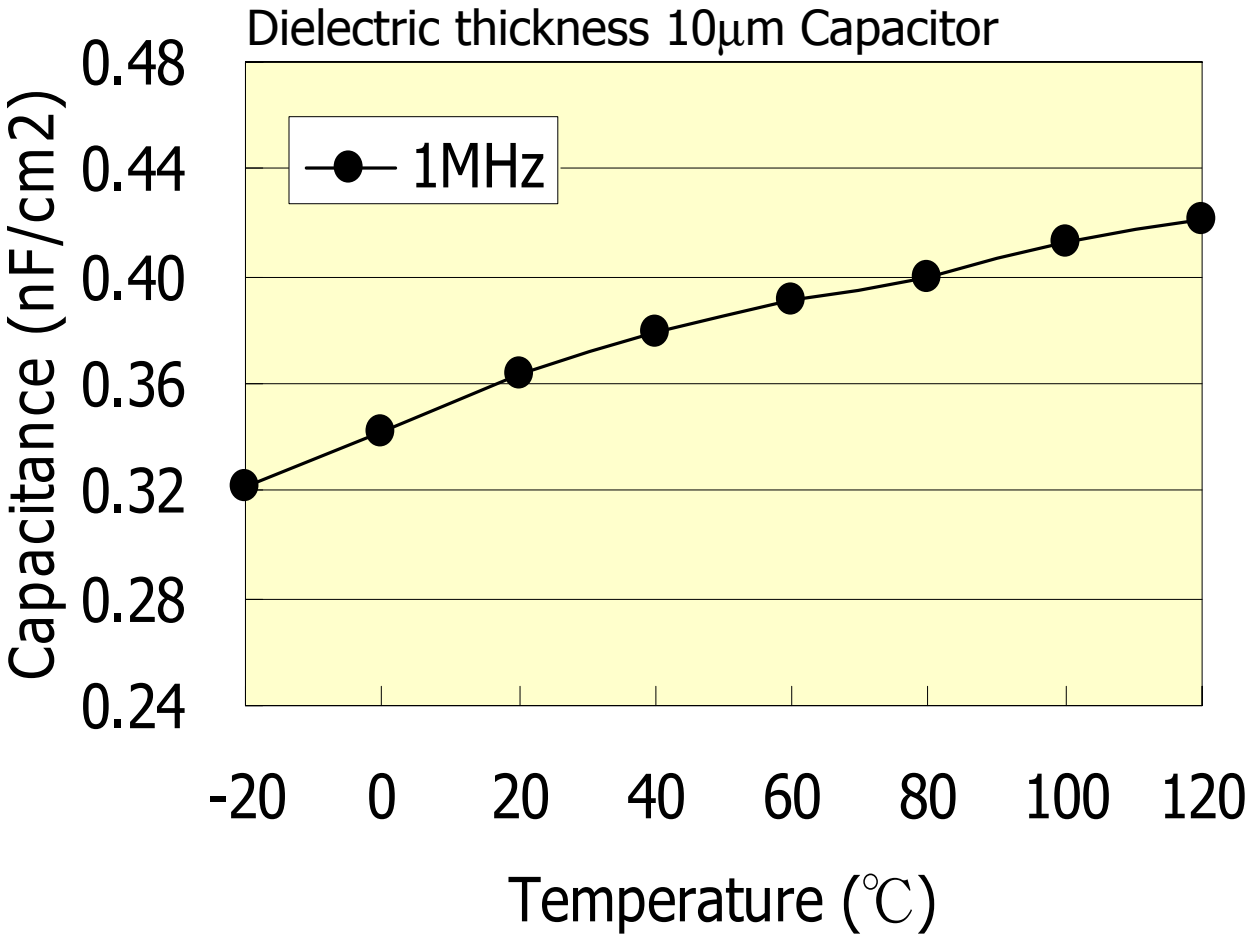
*RH85%/85C/50V

Frequency Characteristic - Capacitance



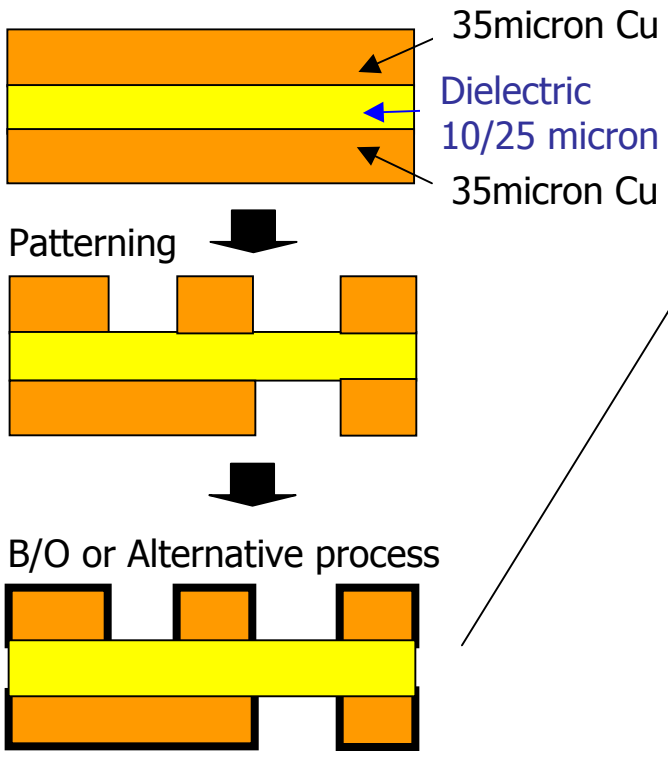


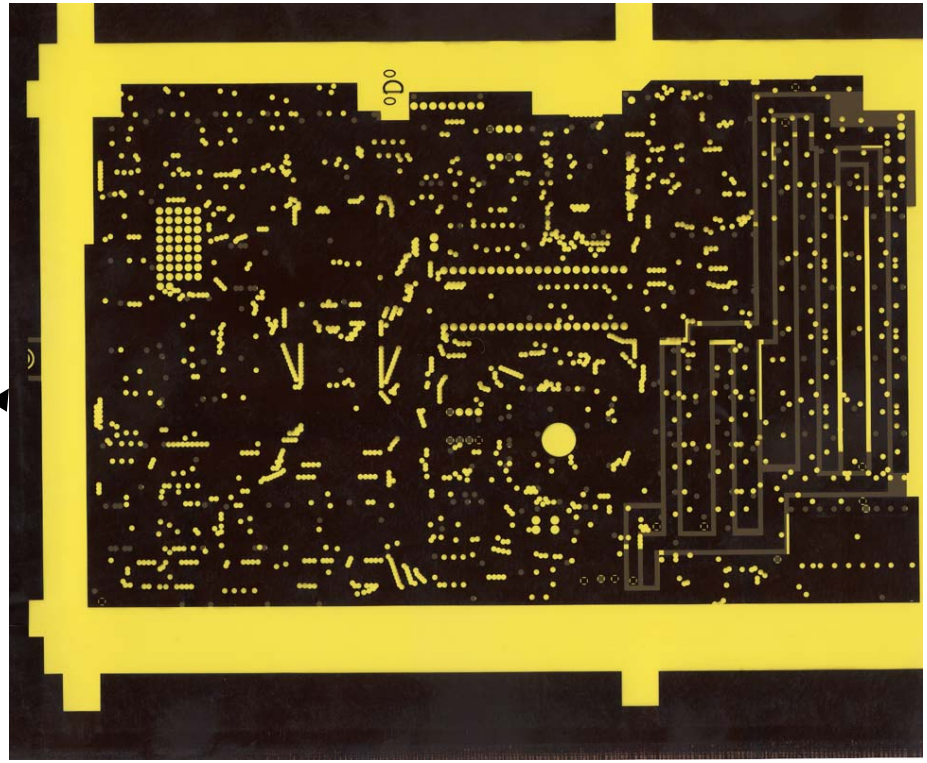
Temperature Characteristic - Capacitance



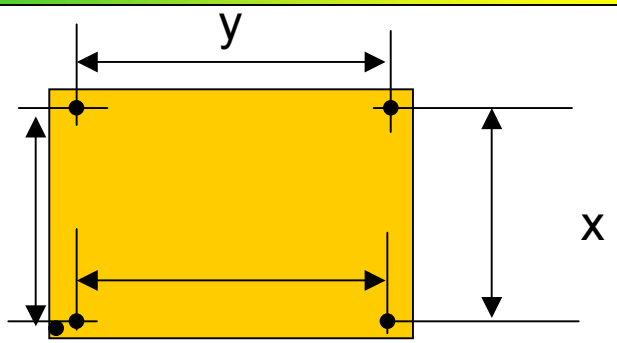
PWB Manufacturing Process

1. Chemical etching
2. Dry Film lamination
3. Image transfer
4. Pattern etching (Dual sides)
5. Black oxidizing

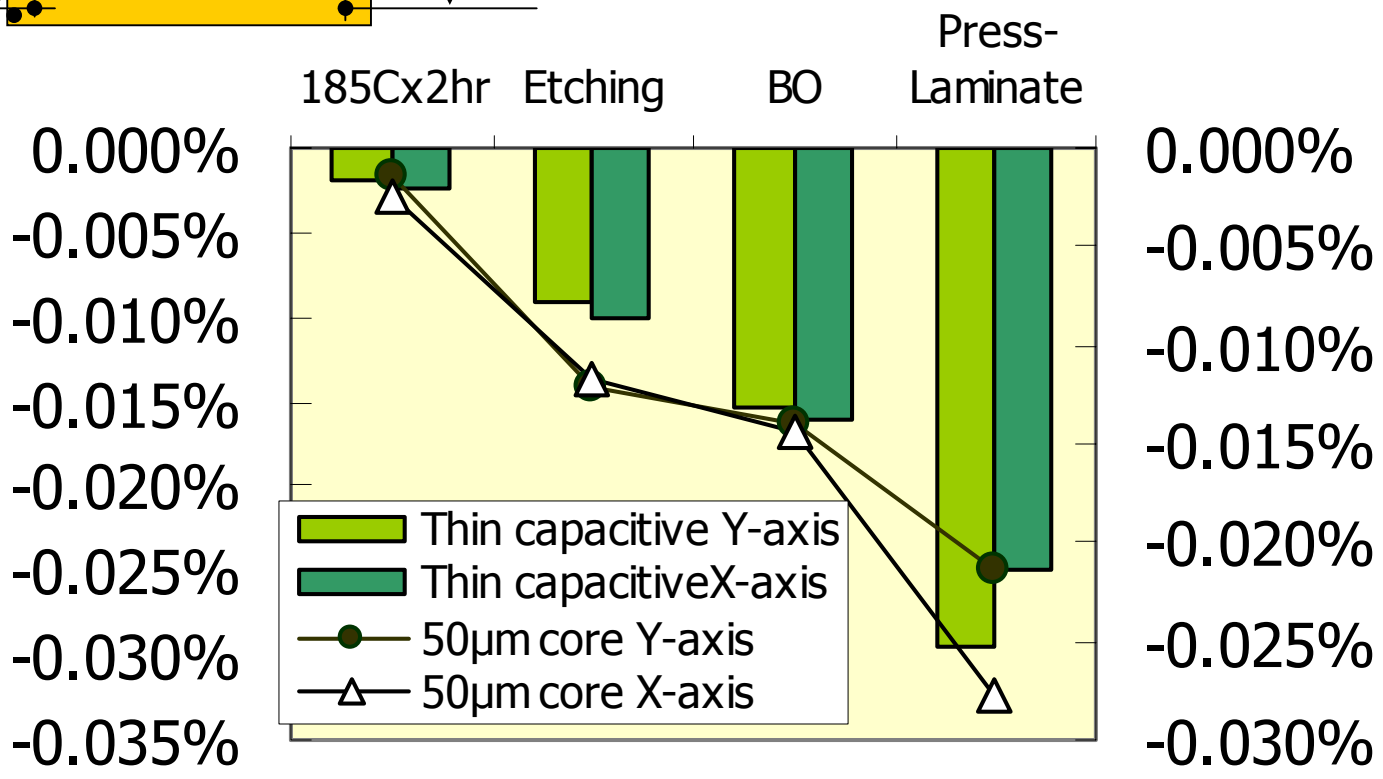




PWB Manufacturing Process - Scaling factor

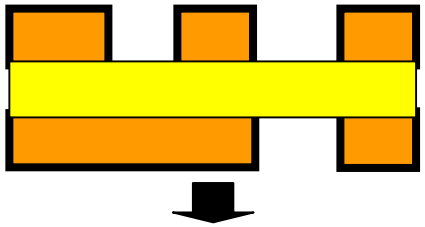


Dielectric thickness 10μm Capacitor

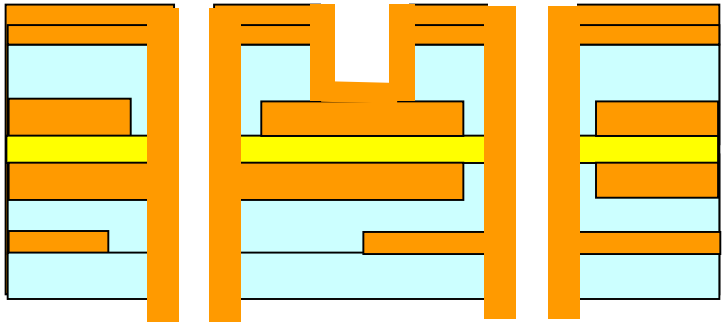


PWB Manufacturing Process - Lamination etc

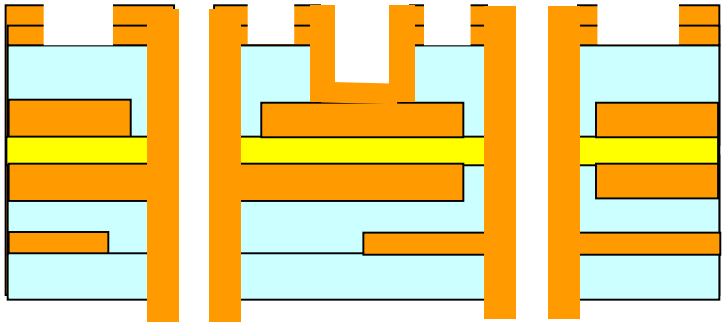
B/O or Alternative process



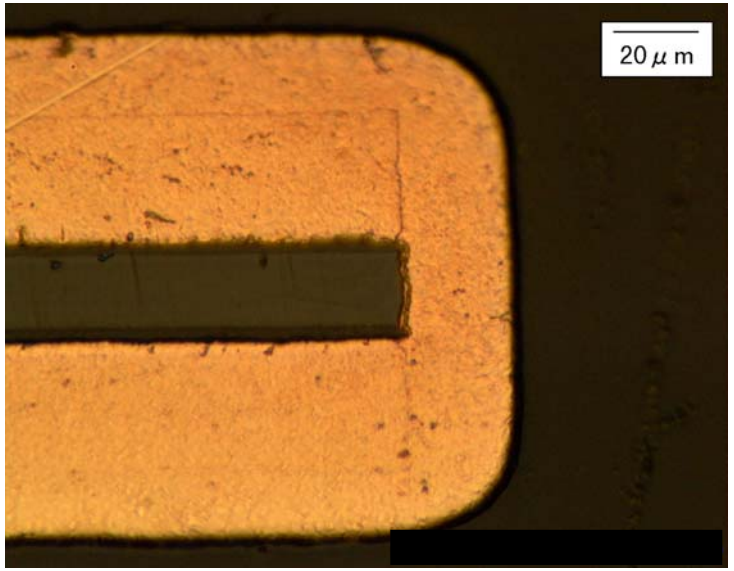
Through hole and Micro via formation



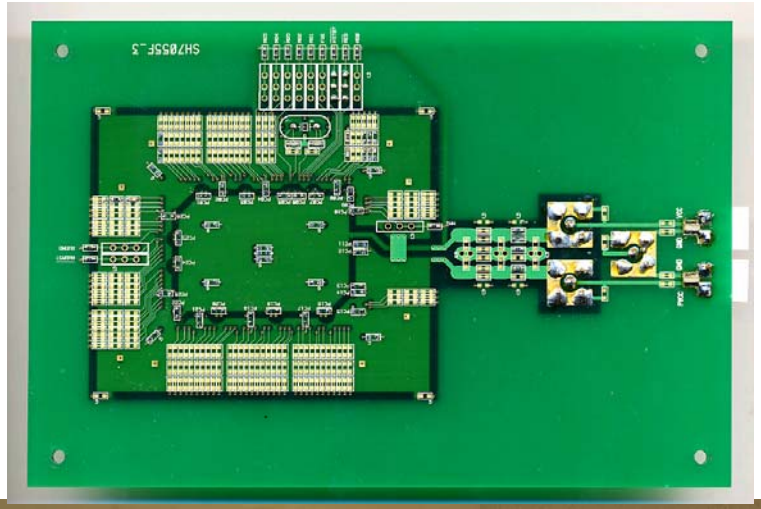
Patterning



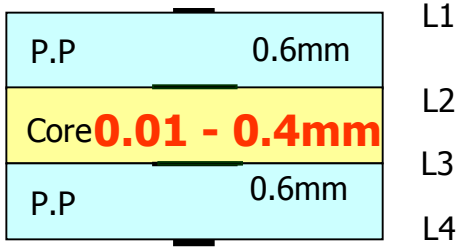
After Processing drilling,desmear and plating.

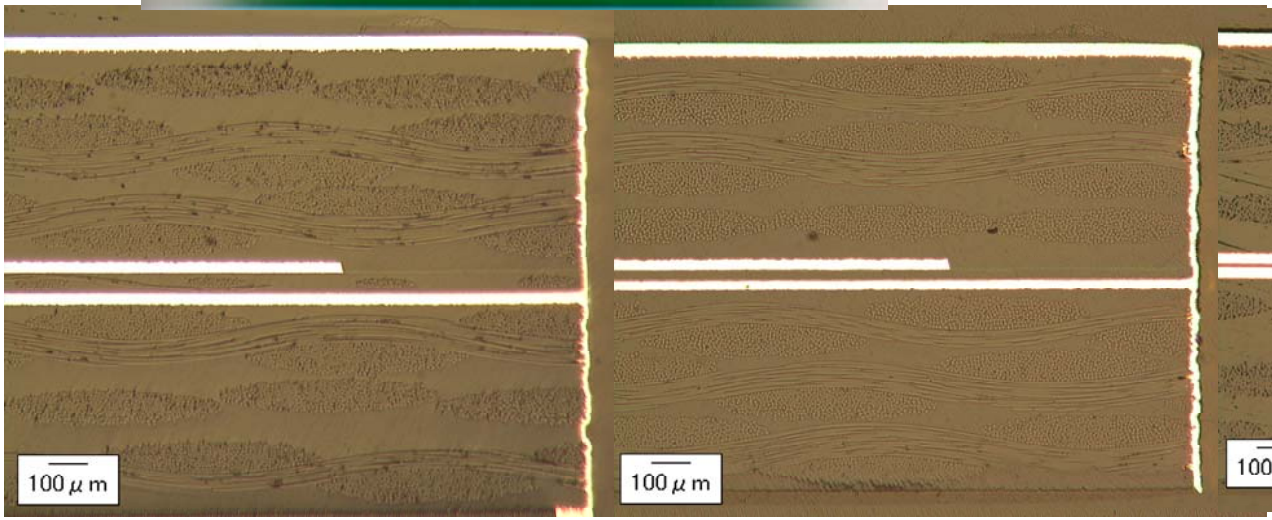


Comparison of PWB - Decoupling characteristics



4 layer board

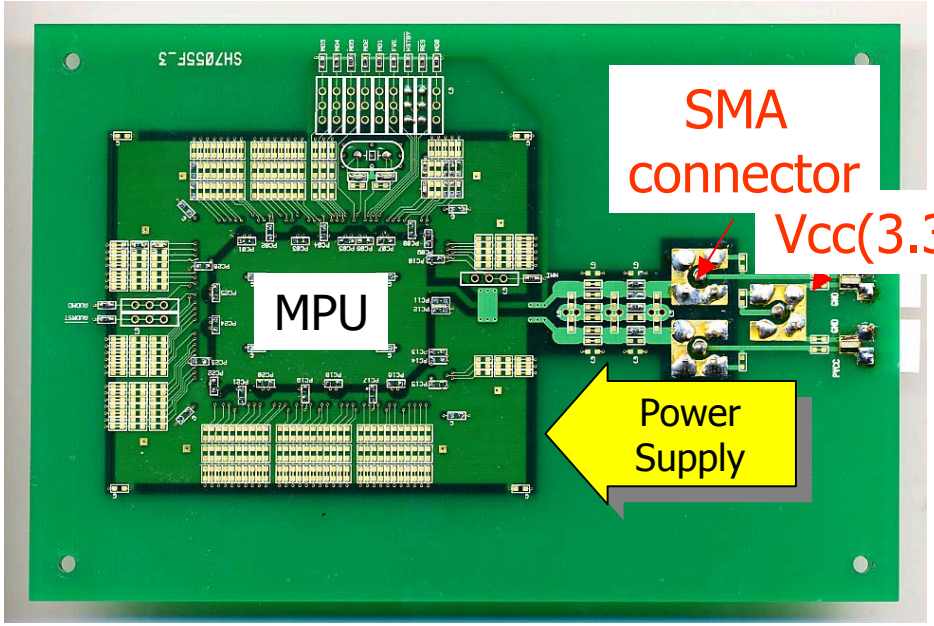




50μm core as a reference 25μm capacitor material 10μm capacitor material

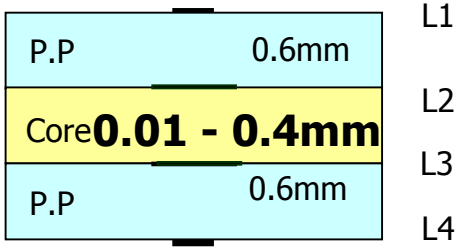
Noise Measurement

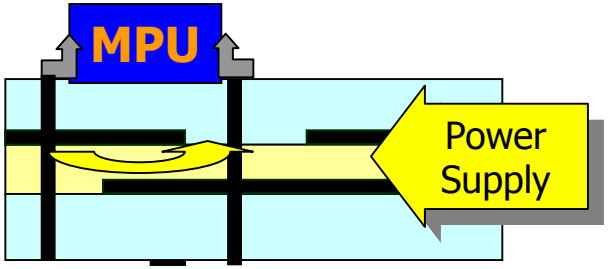
Conducted Emission measurement by VDE method



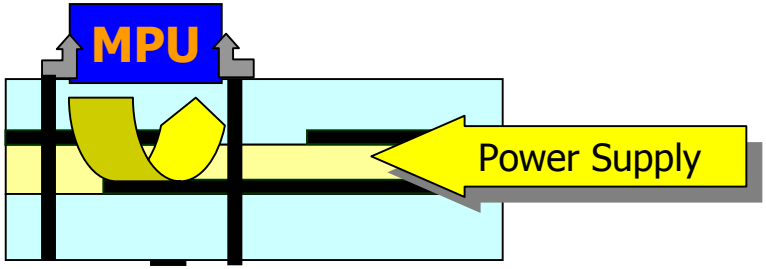
MPU(40MHz) is mounted on the other side of the board.

Construction



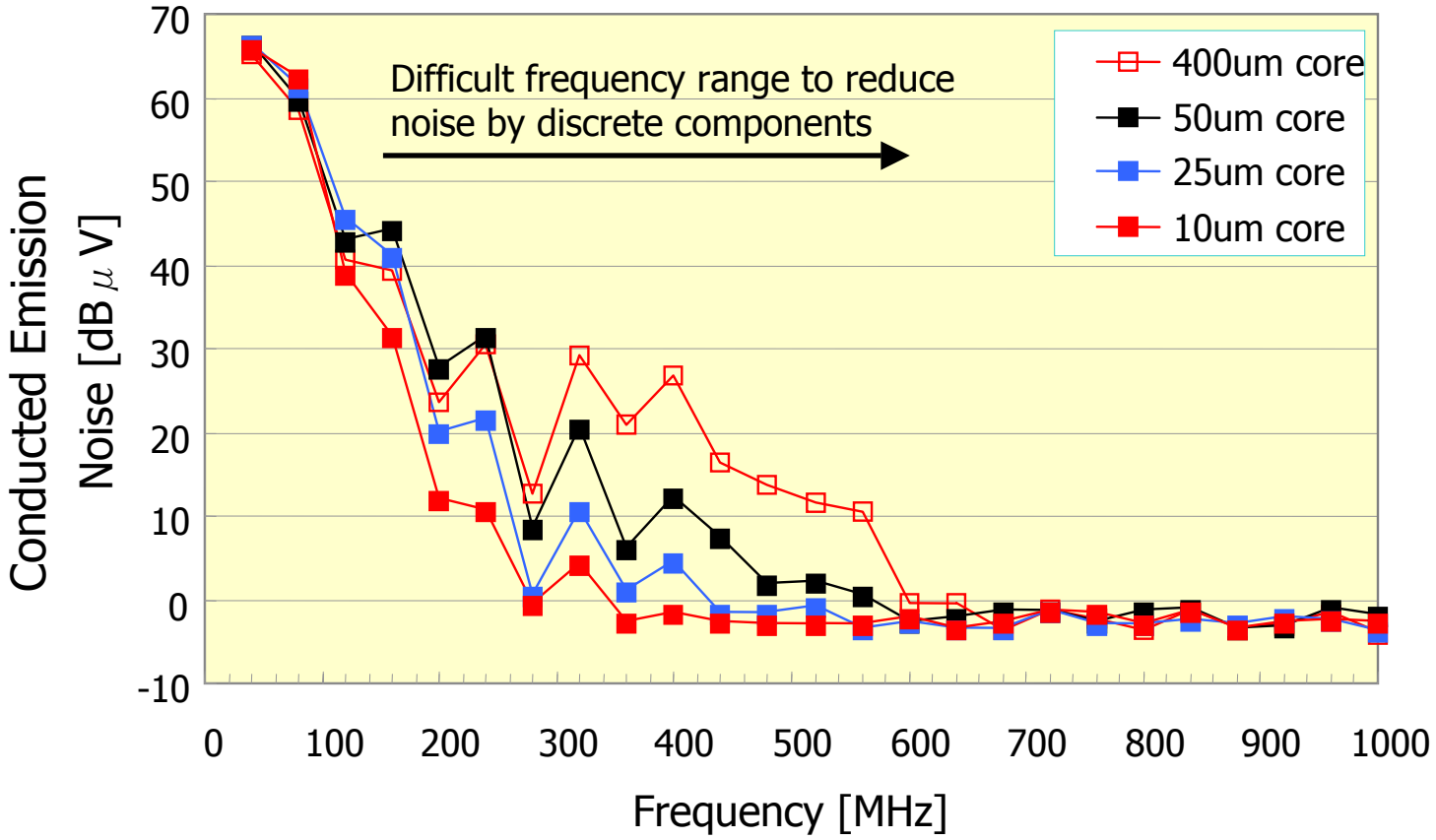


With poor decoupling characteristics



With good decoupling characteristics

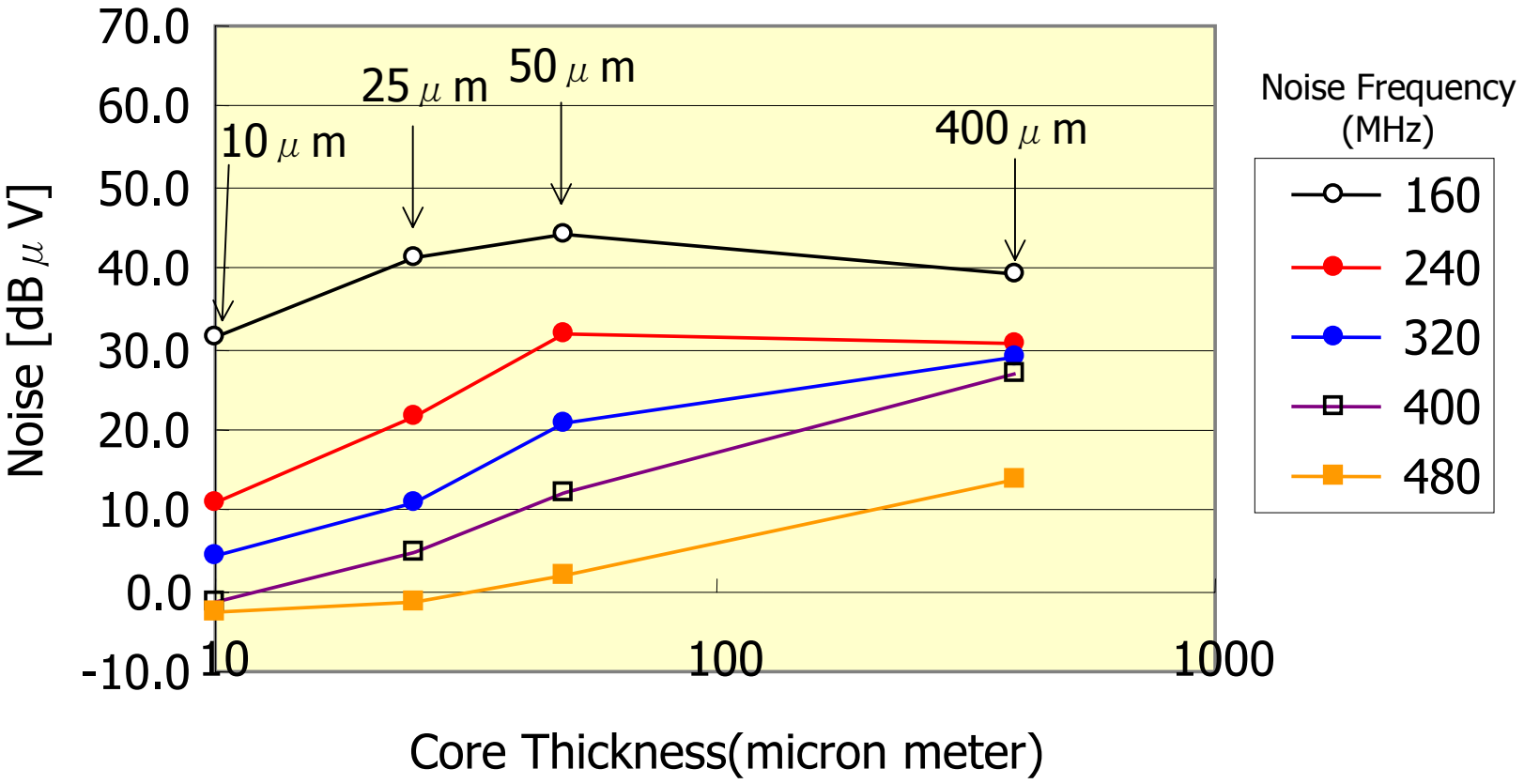
Noise Measurement



Significant noise reduction on PWBs using thin capacitor layer

*Courtesy of HITACHI LTD.

Noise Measurement



The thinner the capacitance layer
the more efficient the noise reduction

Conclusion

- Contribution of copper foil and dielectric resin properties has been investigated.
  Selection of copper and resin properties are important to construct Thin Capacitor material
- Characteristics of thin capacitor has been investigated.
  Characteristics of thin capacitor showed
- Thin capacitor was capable to process through conventional PCB manufacturing process.
- Improvements in performance as decoupling capacitor using thin capacitor material has been demonstrated.