4 Array Resistor의 TC 신뢰성에 영향을 미치는 Factor에 관한 연구

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Study on Factors to affect TC Reliability of 4 array Resistor

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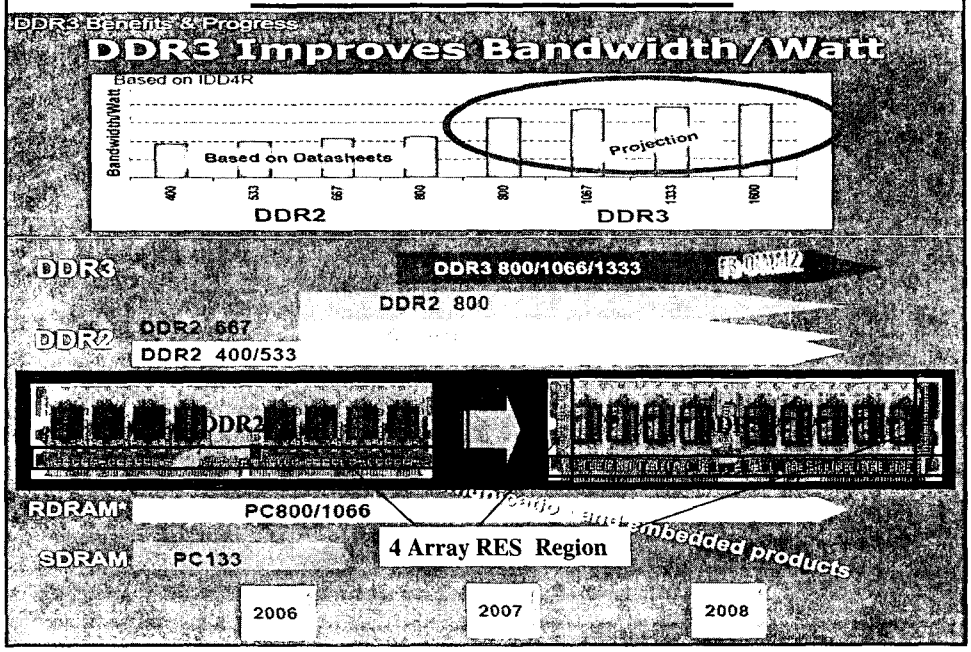
2007. 04. 04

Device Packaging 2 Team
Samsung Electronics

Contents

Internal Use Only

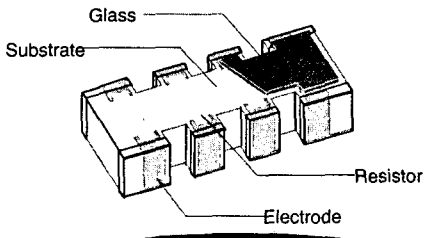
Roadmap



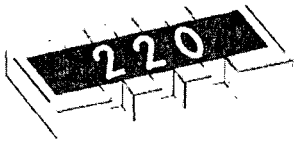
Internal Use Only

Passives

Resistor

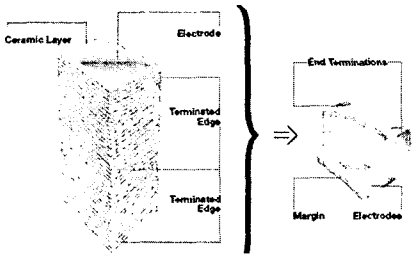


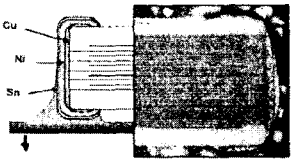
Resistor is More Critical



Signal Noise Elimination

Capacitor





Power Noise Elimination

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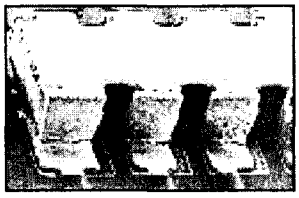
Background

- ▶ RIMM TC 600 Cycle Fail
- ▶ SODIMM TC 1000 Cycle Fail
  → Development Delay, Reliability Margin Insufficient

SODIMM TC 1000 cycle



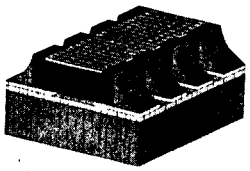
Top View

Section View

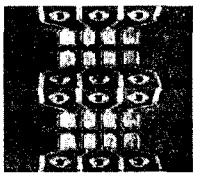
Failure Mode : Solder Joint Crack

Objectives

Simulation



Daisy Chain Board



- ▶ Understanding of Failure Mechanism
- ▶ The Effect of Characteristics against Factors
- ▶ Design Parameter Optimization

TC Reliability Increase!

Factors

- Board Layers

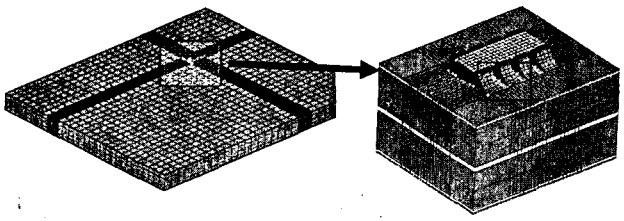
  4, 6, 8 Layers for 1.27mm Thick, 12 Layers for 2.09mm Thick
- Pad Design (4 Types)
- Pad to Stencil Opening Ratio (1:0.8 vs 1:1)
- Solder Composition (63Sn37Pb vs Sn3.0Ag0.5Cu)
- Resistor Size (3216 vs 2010)
- Via Hole Size (250um, 300um)

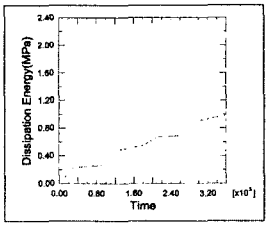
Experiments

<Simulation>

- TC Condition (-25℃ ~ 125℃)

  1Cycle/30min, Ramping Time(5min), Dwell Time(10min)
- ¼ Symmetric Modeling
- Visco – Plastic 3D Analysis Considering Creep
- Accumulated Strain Energy Density Prediction (Up to 2 cycles)





Internal Use Only

Experiments

<Daisy Chain Board>

- TC Condition (-25℃ ~ 125℃) up to 3000 cycles
- Measure Resistance Change at Every 500cycle
- Via hole Size *Pad Design (18 matrix/Board)
- Board Layer * Solder Composition * Metal Finish (16 Board matrix)

<Mechanism Examination>

- DMA (Dynamic Mechanical Analysis)
- TMA (Thermo-Mechanical Analysis)
- SEM, EDX

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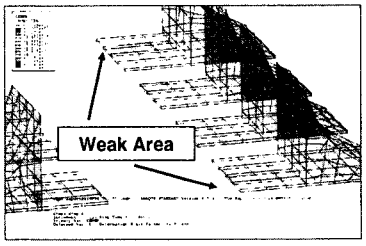
Failure Mechanism

Simulation Results



$$\gamma \propto \frac{DNP\ \Delta T\ \Delta\alpha}{h}$$

γ : Shear Strain

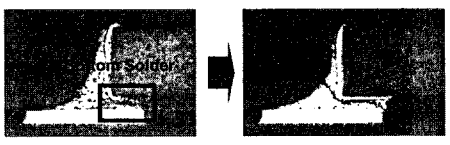
DNP : Distance from Neutron Position

Δ T : Temperature Difference

Δα: CTE Difference bet RES and Board

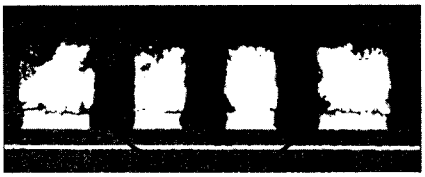
h : Bottom Solder Height

Bottom Solder Height Effect



Crack Initiation　　Crack propagation

DNP Effect



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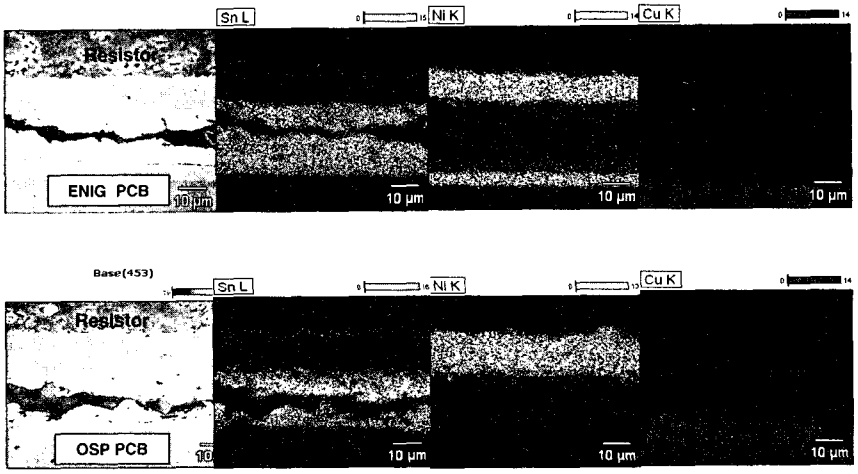
Failure Mode



Solder Bulk Crack !

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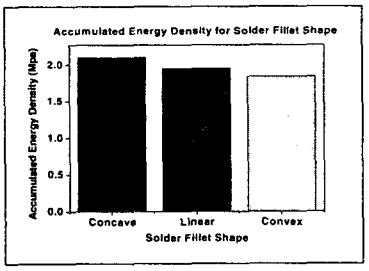
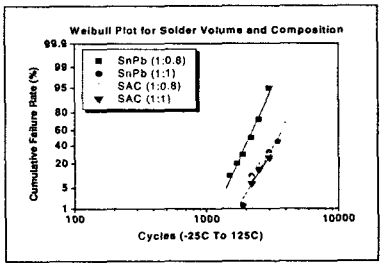
Fillet Shape

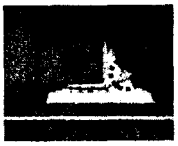
Simulation Data for Fillet Shape



Weibull Plot for Fillet Shape

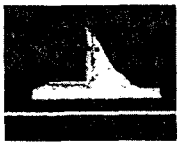


Concave Fillet



Pad : Opening = 1 : 0.8

Convex Fillet



Pad : Opening = 1 : 1

- **Convex Fillet has higher Reliability than Concave Fillet**
- **Crack Propagation is different as Fillet Shape**

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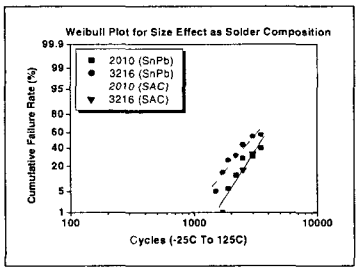
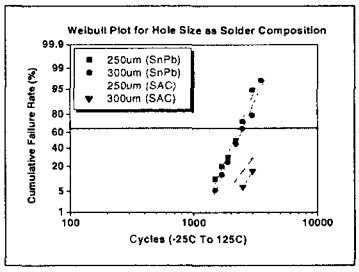
RES / Hole Size

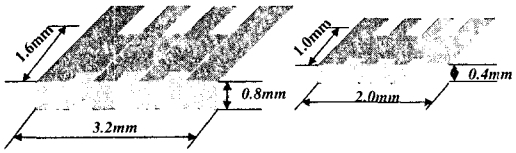
Weibull Plot for RES Size

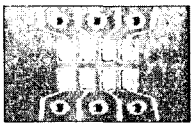


Weibull Plot for Hole Size



3216 RES **2010 RES**





DNP Effect is Dominant !

Bigger Hole can be release Board Stress !

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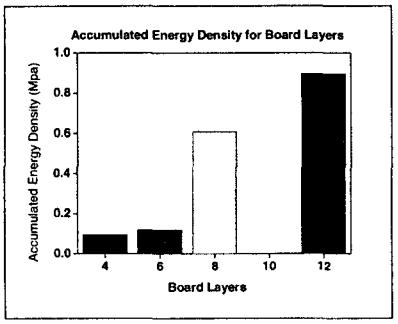
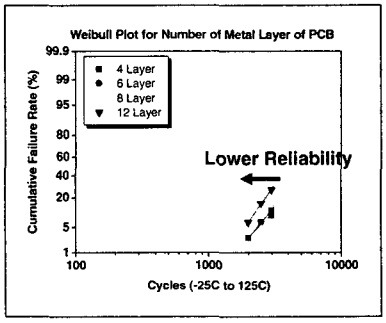
Board Layers

Simulation data for Board Layers



Weibull Plot for Board Layers



As Number of Board Layer is increased,

Why reliability is decreased?

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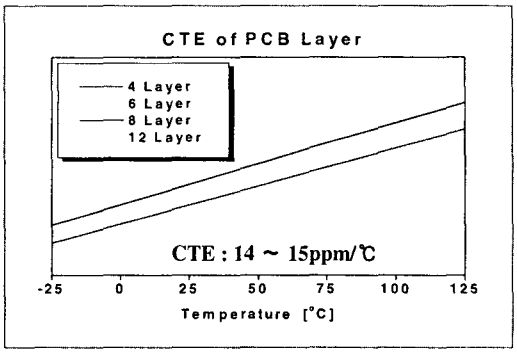
CTE Effect ?

TMA data for Board Layers



CTE is not Dominant Factor

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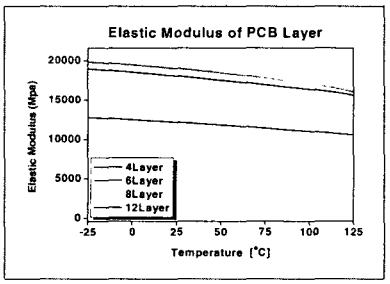
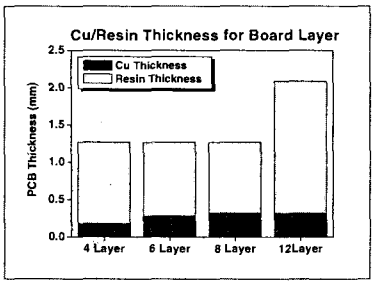
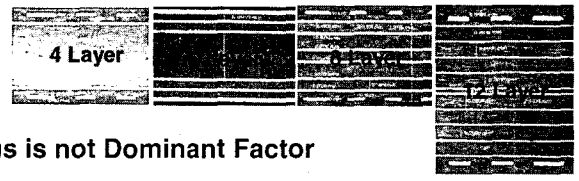
Modulus Effect ?

DMA data for Board Layers



Cu/Resin Thickness for Board Layer





Modulus is not Dominant Factor

Another Factor?

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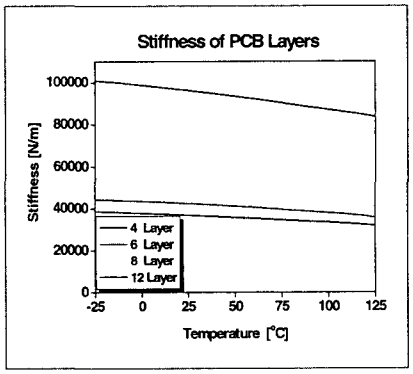
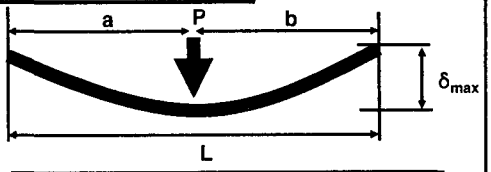
Stiffness Effect?

Stiffness for Board Layers





$P = K\delta$

$\delta max = \dfrac{Pb(L^2 - b^2)^{3/2}}{9\sqrt{3}LEI}$

$I = bt^3/12$

P : Force
K : Stiffness
δ : Displacement
E : Modulus
t : Thickness
L : Length

$K \propto Et^3/L^2$

As Board Layer is increased (Cray RIMM),

Reliability is decreased Because of Stiffness

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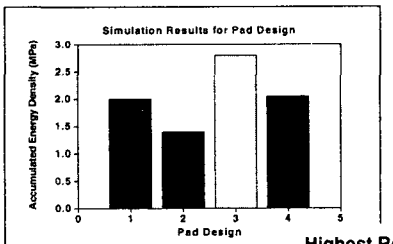
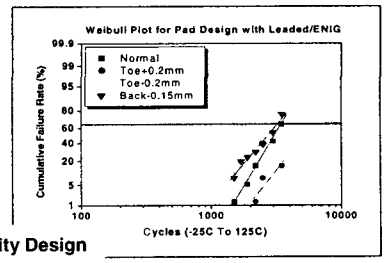
Pad Design

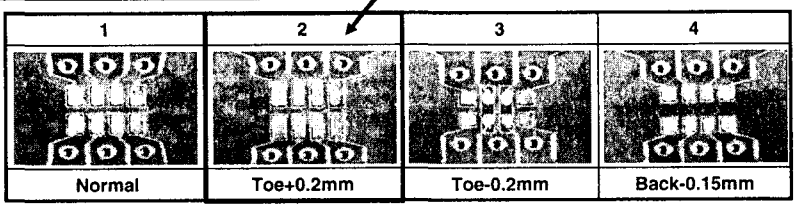
Simulation Data for Pad Design



Weibull Plot for Pad Design



Highest Reliability Design



Toe Length is more Dominant Factor than Back Length

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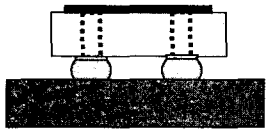
Suggestion

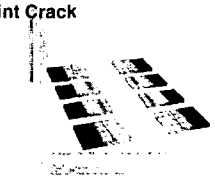
Crack Initiation : Bottom Solder → Bottom Solder Height Control?

Solder Joint Crack

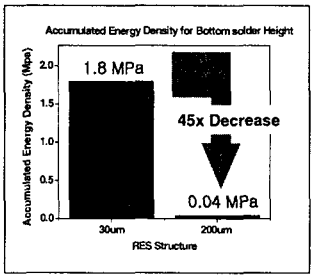
Stand –off Height : 30um



Stand –off Height : 200um



Simulation Data for Stand-off Height



‡ BGA Type RES is Patented

BGA Type RES : Solder Joint Reliability Increase!

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Design Parameter Optimization

To Increase TC Reliability of 4 Array RES

Parameters	Best Case	Worst Case	Remarks
Pad Design	#2 (Long Toe)	#3 (Short Toe)	
Board Layer	4	12	
Solder Volume	1:1	1:08	
RES Size	2010	3216	
Via Hole Size	300um	250um	
Reliability Level	3000 Cycles	1000 Cycles	One Side Board
RES Type	BGA	Leadless	

‡ **The Reliability of Both Side Board May be half of that of One Side**

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Summary

- Various Factors to affect TC Reliability of 4 array RES has been Investigated through Simulation Tool and Daisy Chain Board Test
- Solder Joint Crack Mechanism of 4 array RES has been Examined Also, It has been Examined Thoroughly What Influence Each Factors gives to TC Reliability and Why Those Factors gives an Influence to it
- BGA Type RES is Suggested to Improve TC Reliability (Patented)
- Through this Study, Best Design Parameter has been Optimized to Increase TC Reliability of 4 Array RES

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