V STACK ASET

Superfine Flip-Chip Interconnections in 20-μm-pitch

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Contents

- Introduction
  - Background and abstract of our development
- Performance of 20-μm-pitch bonding
  - Reliability of flip-chip Au-Au bonding
- Low temperature interconnection
  - Ultrasonic flip-chip bonding
  - Cu bump bonding
- Summary

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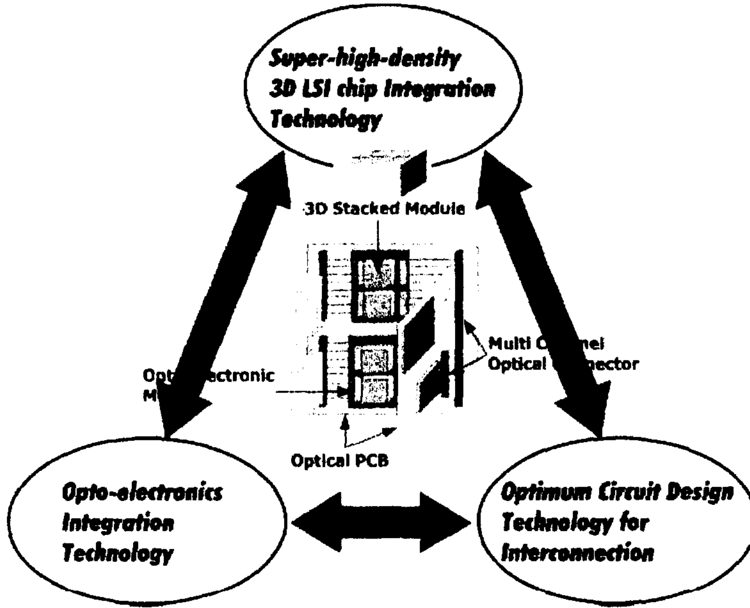
E-SI Research Scheme



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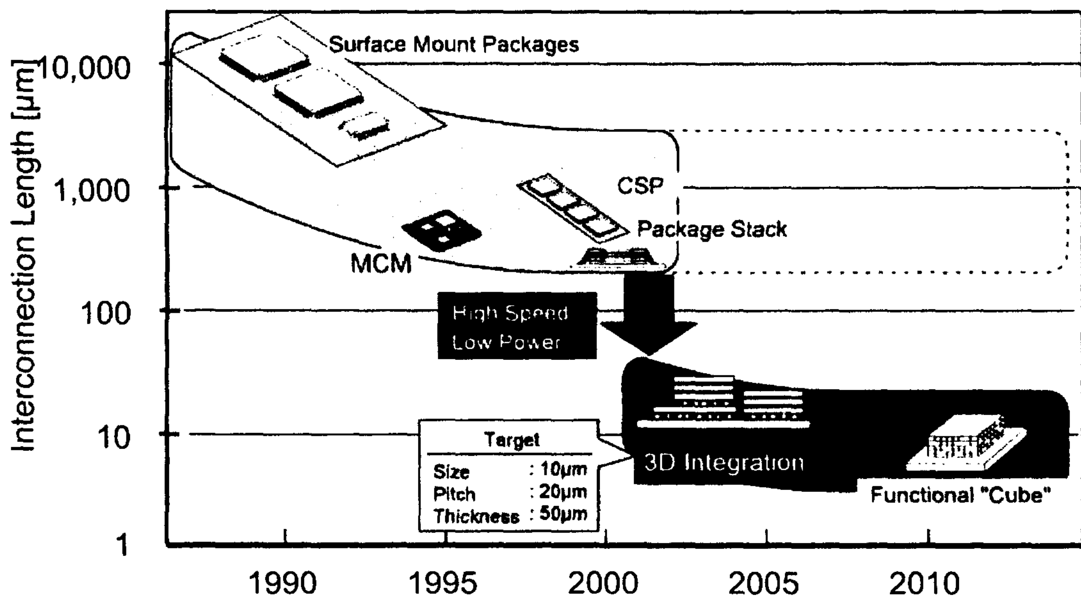
Packaging Trend



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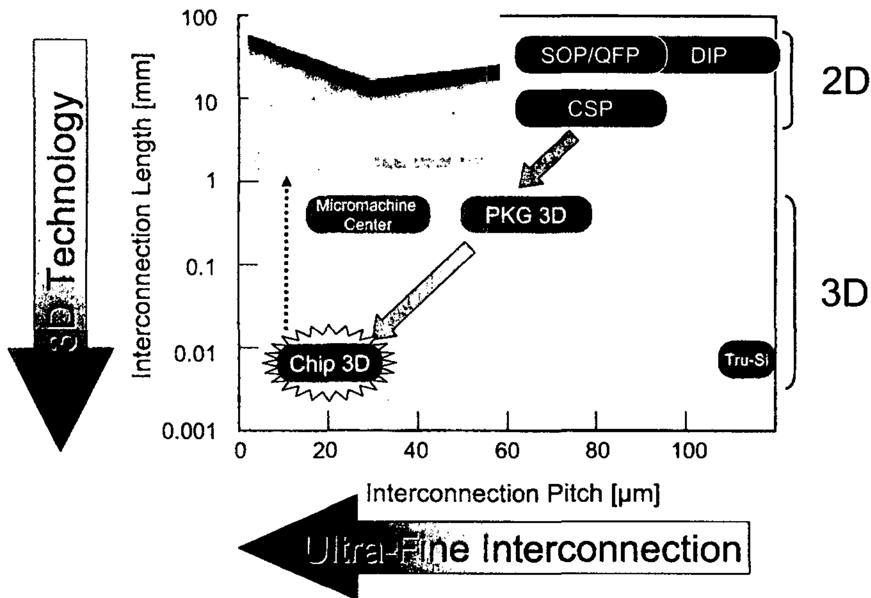
Important Factors



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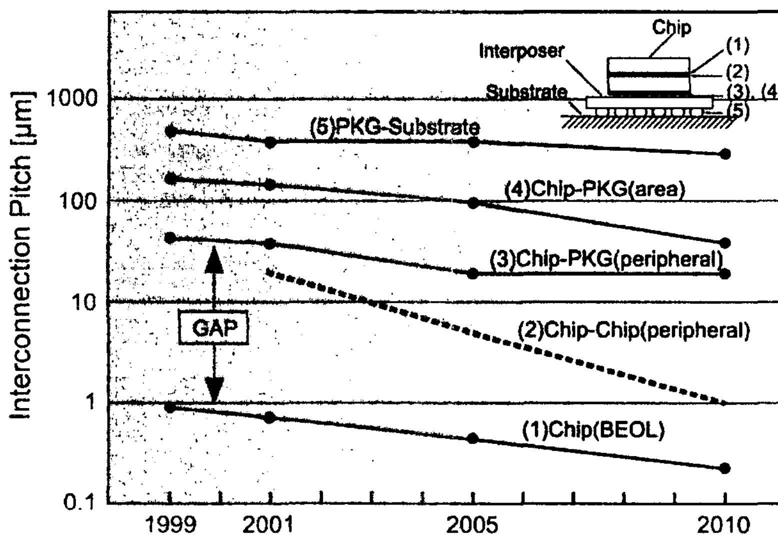
Hierarchy of Design Rules of Interconnection

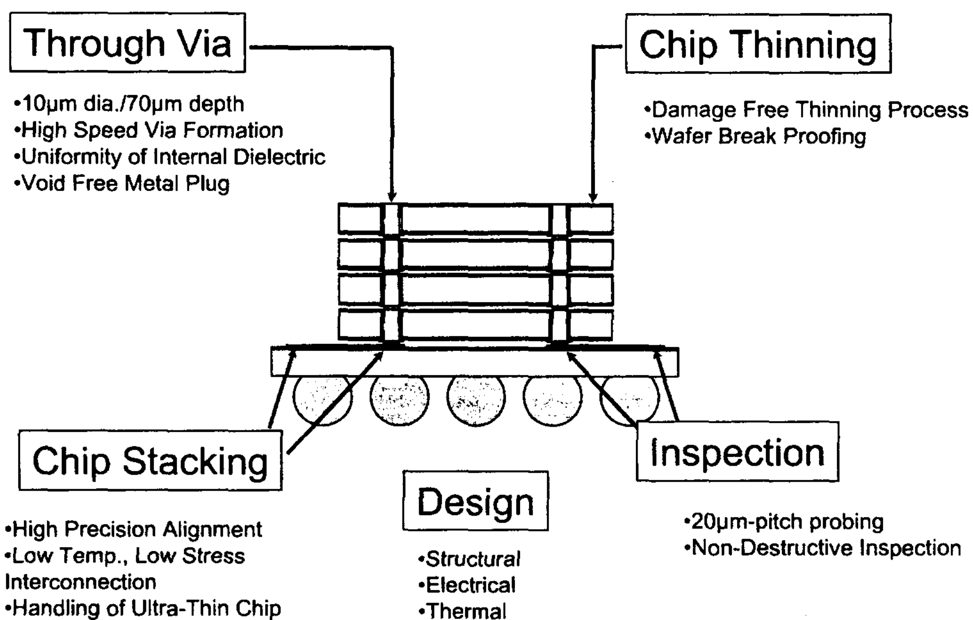


Development Schedule

(FY)

1999	2000	2001	2002	2003
Structure/Process Development		Brush Up	3D-OE Development	Total Integration
Defining 3D Structure and Process Flow		Sample Build & Performance Check	Unit Technology & Interface	Integration & Brush Up
	Application Images of 3D Technologies	High Speed Memory Module		
			System on Package (SoP)	
			Ultra-High Density Interposer	

Technology Map



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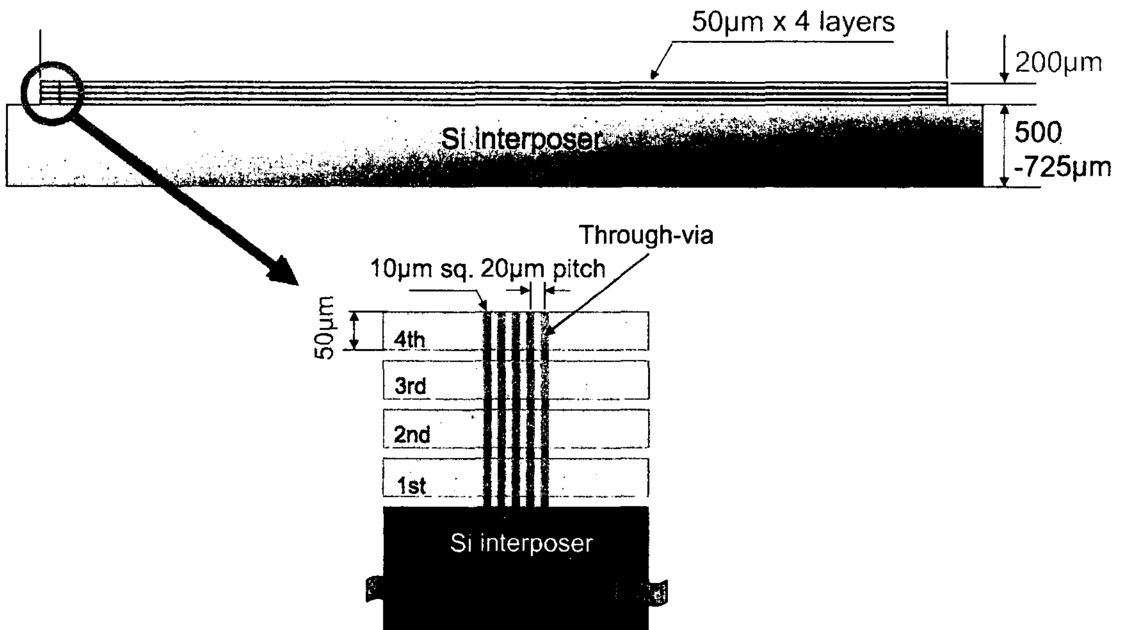
Structure of the 3D Module



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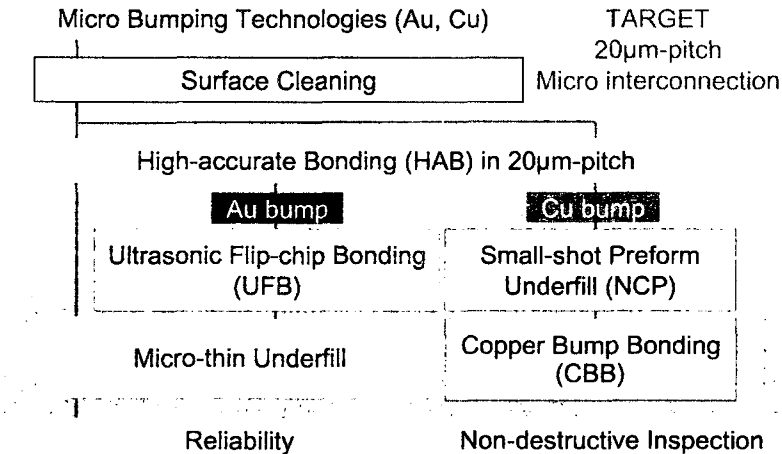
Chip Stacking Technology Map



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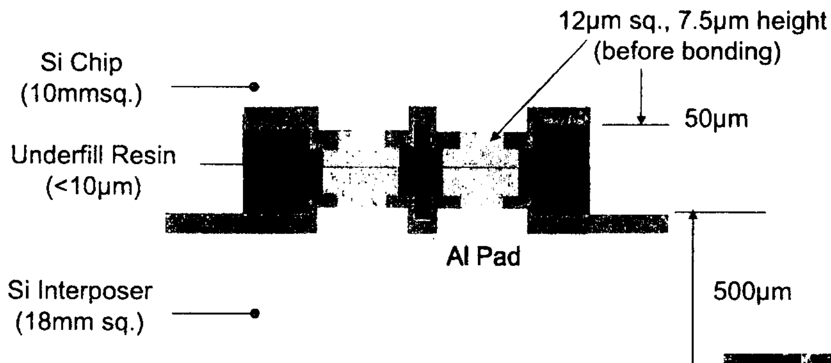
Reliability of flip-chip Au-Au bonding

- Purpose
  - Interconnection reliability of 20-μm-pitch flip-chip bonding.
  - Effect of CTE of underfill resin.
- Methods
  - Chip-on-chip (COC) structure.
  - Three kinds of filler content.
  - -40°C to 125°C, up to 1500 cycles. Electrical tests of daisy-chain circuits.
  - Failure analysis and simulation.

Experimental model

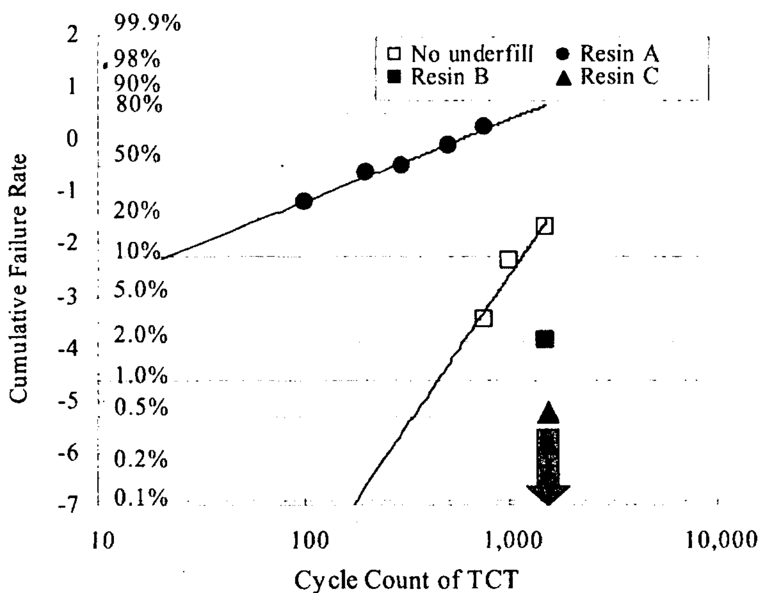


Bonding Condition: 24.5 N, 7 s, 350 °C
Underfill Cure Temp.: 80 °C

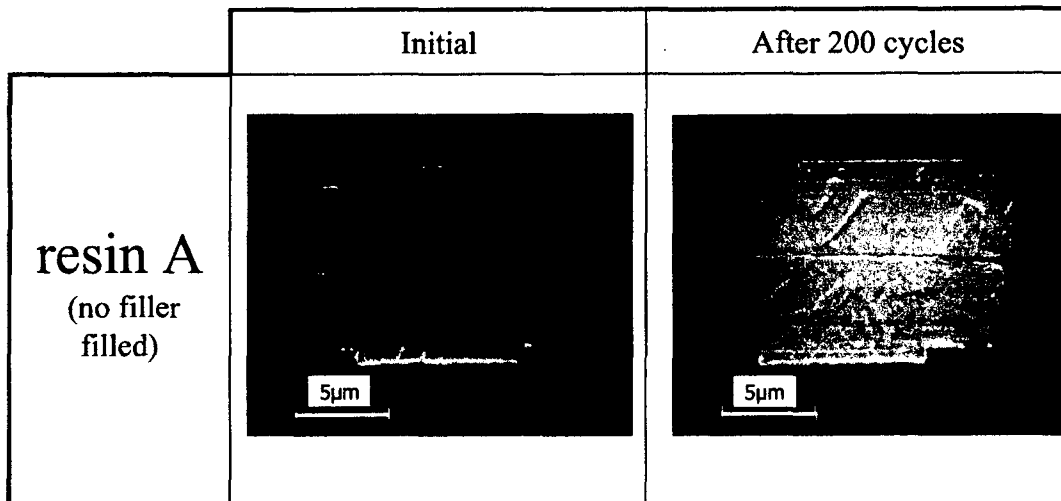
Material Properties of Underfill Resin

	Unit	Resin A	Resin B	Resin C
Filler Contents	wt %	0	50	60
Elastic Modulus	GPa	3.2	6.0	8.5
Tg	°C	136	136	134
CTE (<Tg)	ppm/°C	71	41	33
CTE (>Tg)	ppm/°C	192	103	106

Reliability Test Results

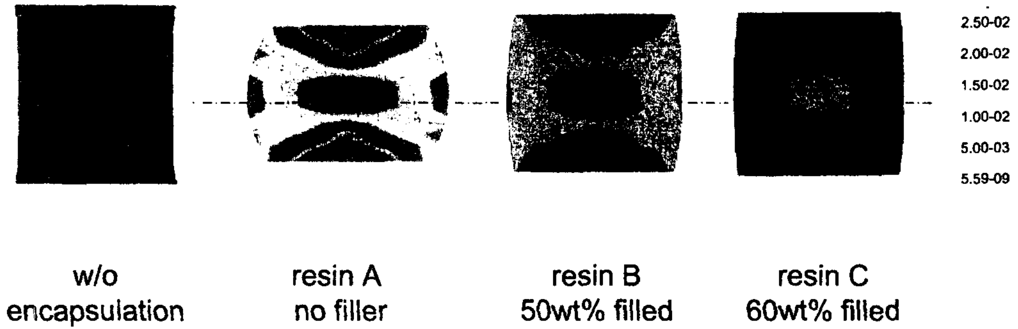


Failure Analysis Results



Results of FEM Analysis

Maximum Plastic Equivalent Strain



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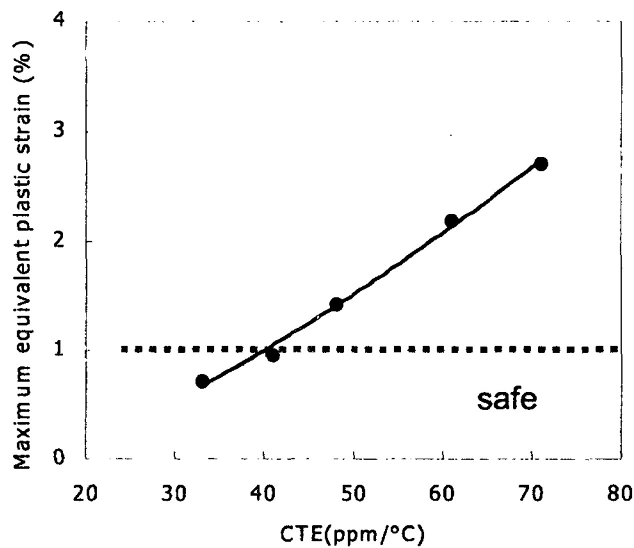
Maximum Plastic Equivalent Strain



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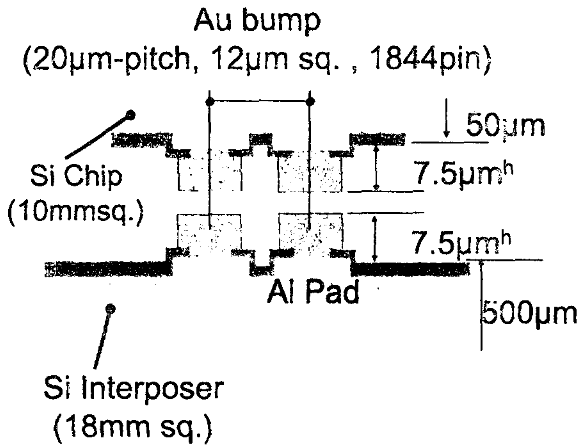
Ultrasonic Flip-chip Bonding

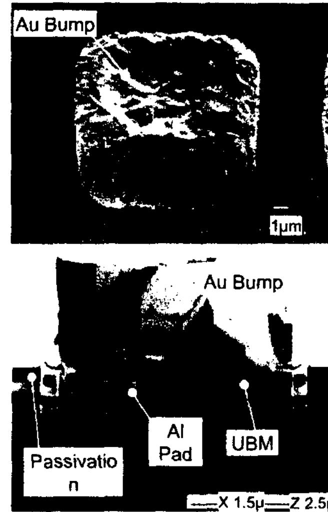
- Purpose
  - Basic evaluation of ultrasonic flip-chip bonding (UFB) of 20-μm-pitch bumps.
- Methods
  - Chip-on-chip structure.
  - Positional accuracy.
  - Electrical test with daisy chain circuits.
  - Chip damage check.
  - Micro-analysis of bonding interface.

COC Structure for 20µm-pitch Interconnections

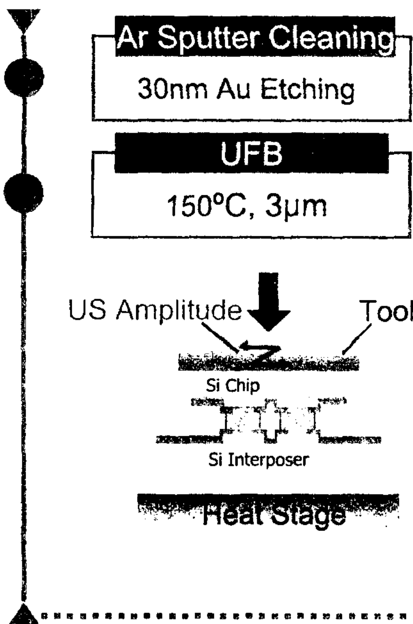
■COC Structure



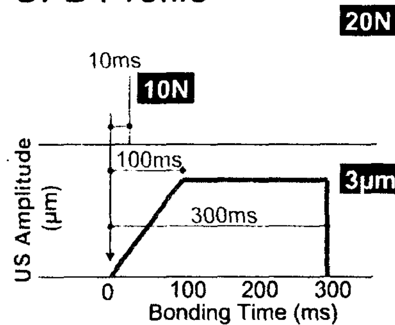
■20µm-pitch Au Bump



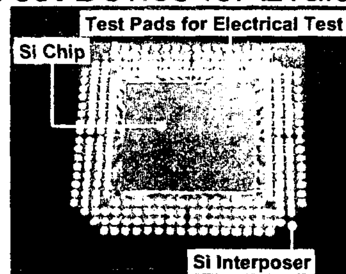
UFB Conditions



■UFB Profile

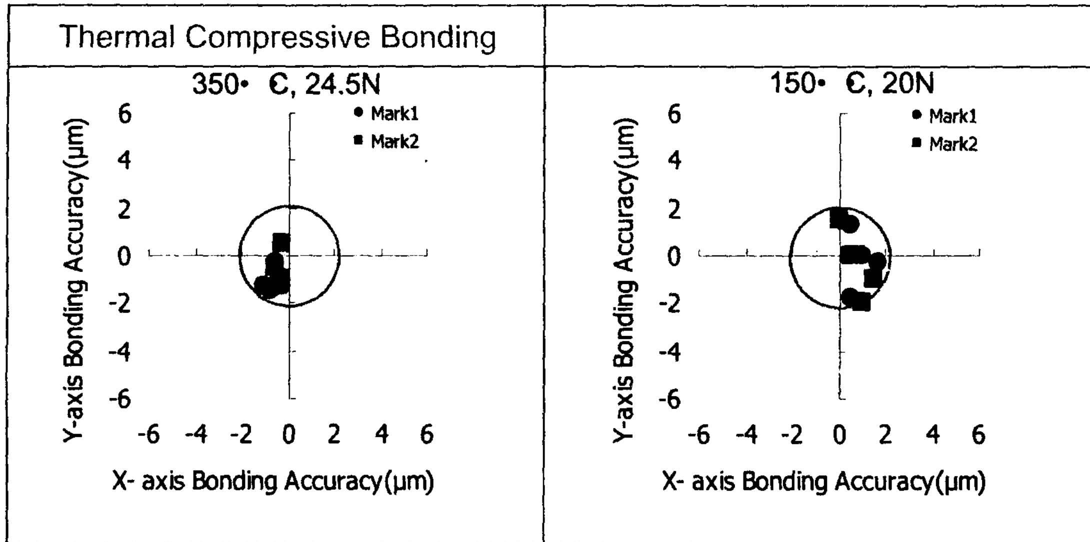


■Test Device for Evaluation



UFB Bonding Accuracy

■Positional Tolerance Data



✦UFB bonding accuracy was confirmed within • 2μm.

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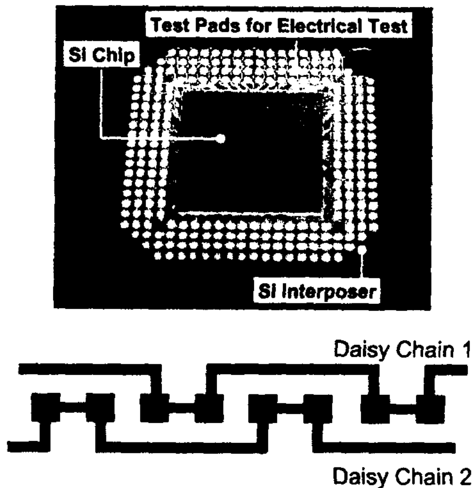
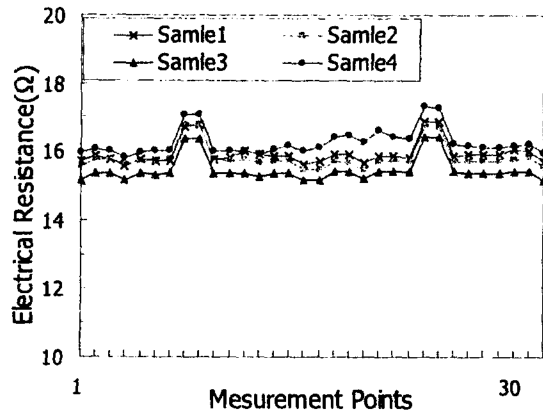
UFB Connection Resistance

■Daisy chain Pattern

■Electrical Resistance Data

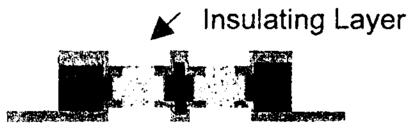


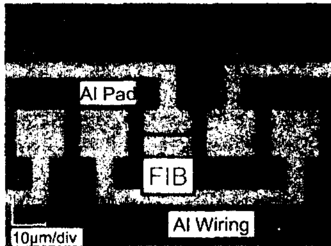


✦UFB connection resistance was stable.

UFB Damage & Bondability

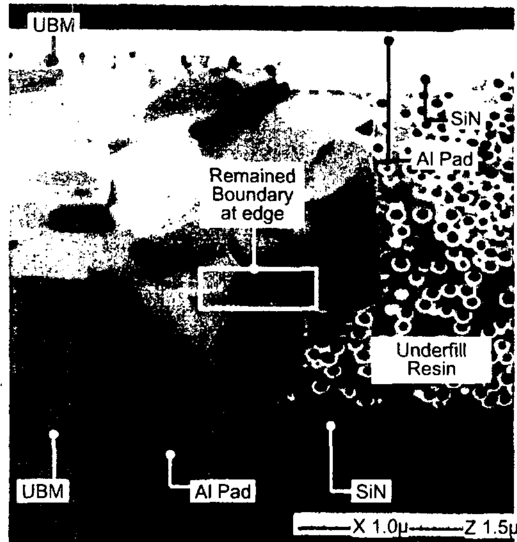
■After Si Etching





Back Side of Al Pad

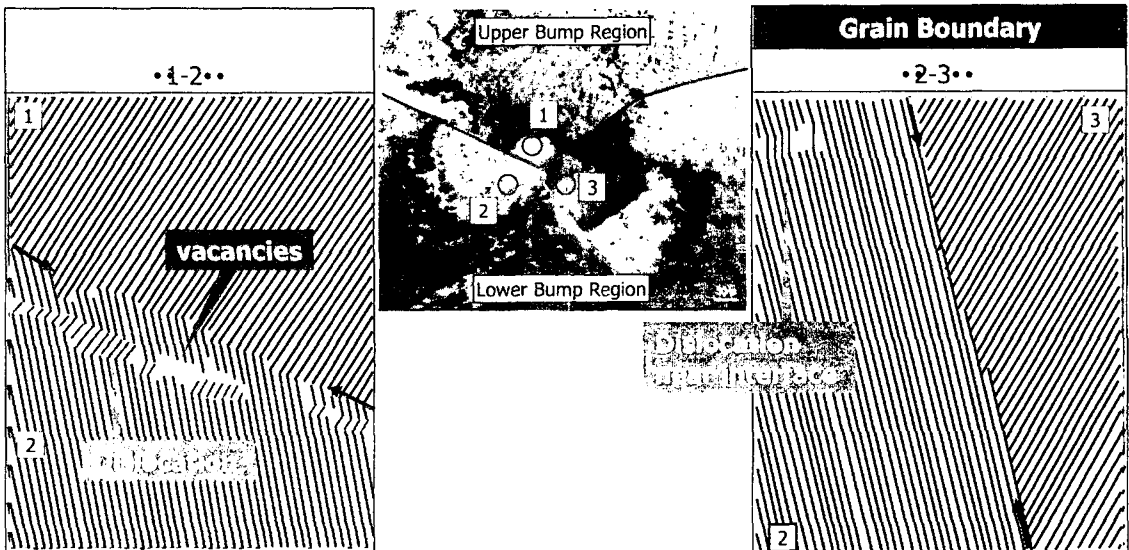
■FIB Analysis



Cross section of interconnection

↓No remarkable damage by UFB was observed.

TEM Image & Lattice Pattern



↓The solid phase bonding interface was discontinuous boundary with some dislocations and vacancies.

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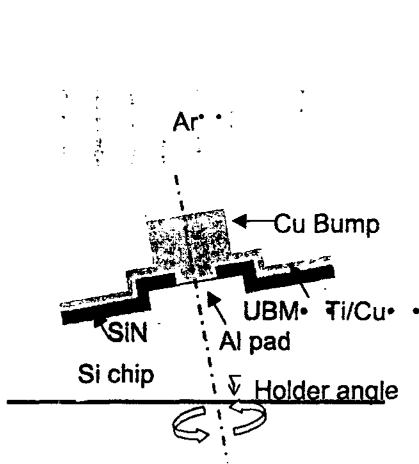
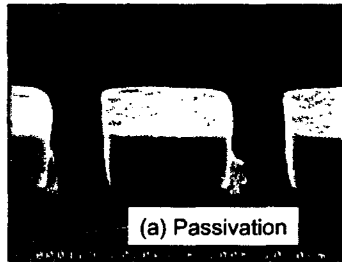
Copper Bump Bonding

- Purpose
  - Basic evaluation of dry process applicability to under bump metallurgy (UBM) removal.
- Methods
  - Application of ion milling.
  - Analysis of residues around bumps.

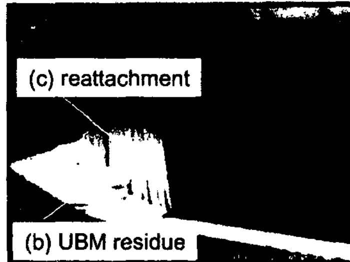
Dry Processes Applied to UBM Removal

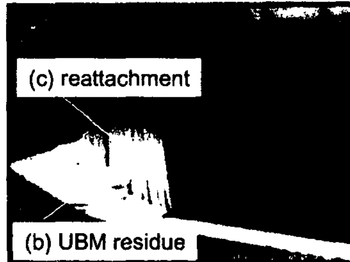


Ion Milling to Bumped Wafer



Si & N were detected.

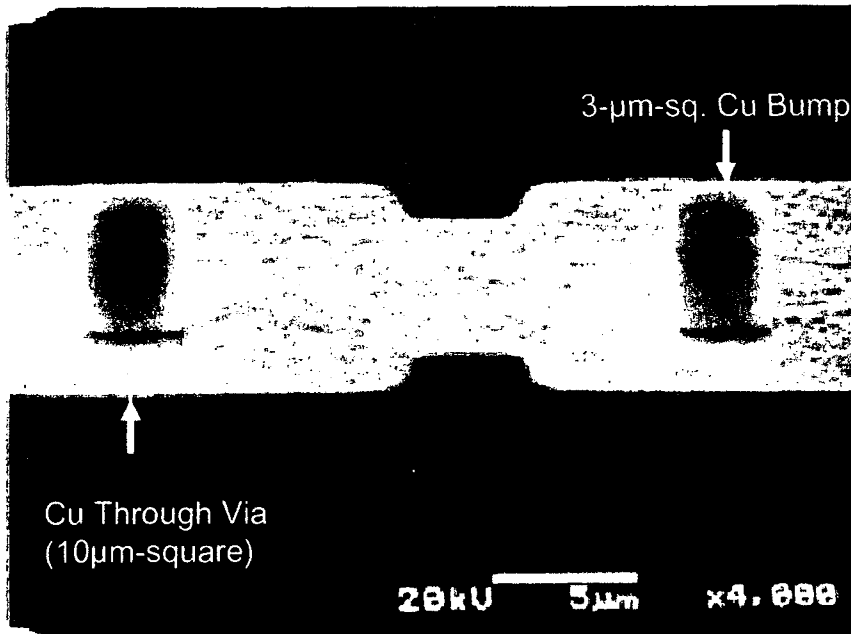




Ti was detected. (small amount)

Ti was detected.

SEM Micrograph of Cu Bumps



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Summary

- Reliability
  - The reliability strongly depended on the CTE of underfill resin.
  - The fractured portion was identical with the maximum plastic equivalent strain.
  - 1% or less value of the maximum plastic equivalent strain certified more than 1000 cycle of TCT life.
- UFB
  - Bonding accuracy was confirmed within • 2μm.
  - The fundamental bondability of UFB was confirmed with no damage around aluminum pads.
  - Some dislocations and vacancies were observed at the interface, however, the atomic level bonding was confirmed.
- CBB
  - Dry process was applied to UBM removal.

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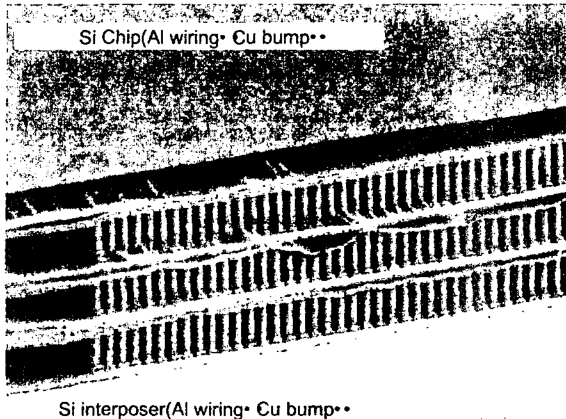
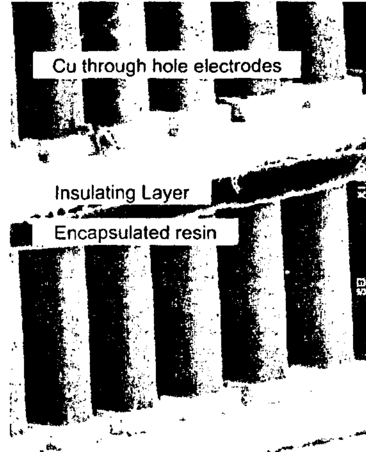
Four Layer Stacked Structure with 20μm-pitch





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Acknowledgement

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