ALTIS Semiconductor

An IBM INFINEON Company

BONDABILITY RELATED TO PROBING

« WHEN PROBING AND BONDING ARE NOT GOOD FRIENDS ! »

By Eugene LIM
and Dominique LANGLOIS
with Patrick BUFFEL

AGENDA

Part 1/4 Impact of probing on wire bonding

- Introduction of Infineon plants
- Ball bonding sequence and failure mode
- Data collection and analysis

Part 2/4 Probing process

- Altis Semiconductor presentation
- Final sort process flow
- Why several touch downs…
- Probe marks size, build-up height, exposed-oxide mechanisms

Part 3/4 Probe-card improvements

- How to improve Cantilever (APS/MJC)
- Low pitch micro-spring PC for tomorrow (FFI)

Part 4/4 Conclusion

- Bonding concerns
- What could be the solutions…

Infineon (Corporate Back End - CBE)

Overview

Assembly & Test:	**Logic & Power Ics / Discretes / Optocoupler / High frequency Components & Sensors**
Employees:	**7510**
Area:	**111 400 m²**

Munich
Headquarter

Regensburg
Advanced Backend Technology Pilotlines*

Penang
Opto Components*

Malacca
Discretes, Power ICs, Opto Components, DRAM

Batam
Logic ICs

Singapore
Logic ICs

Wuxi
Opto Components

* Part of Osram OS

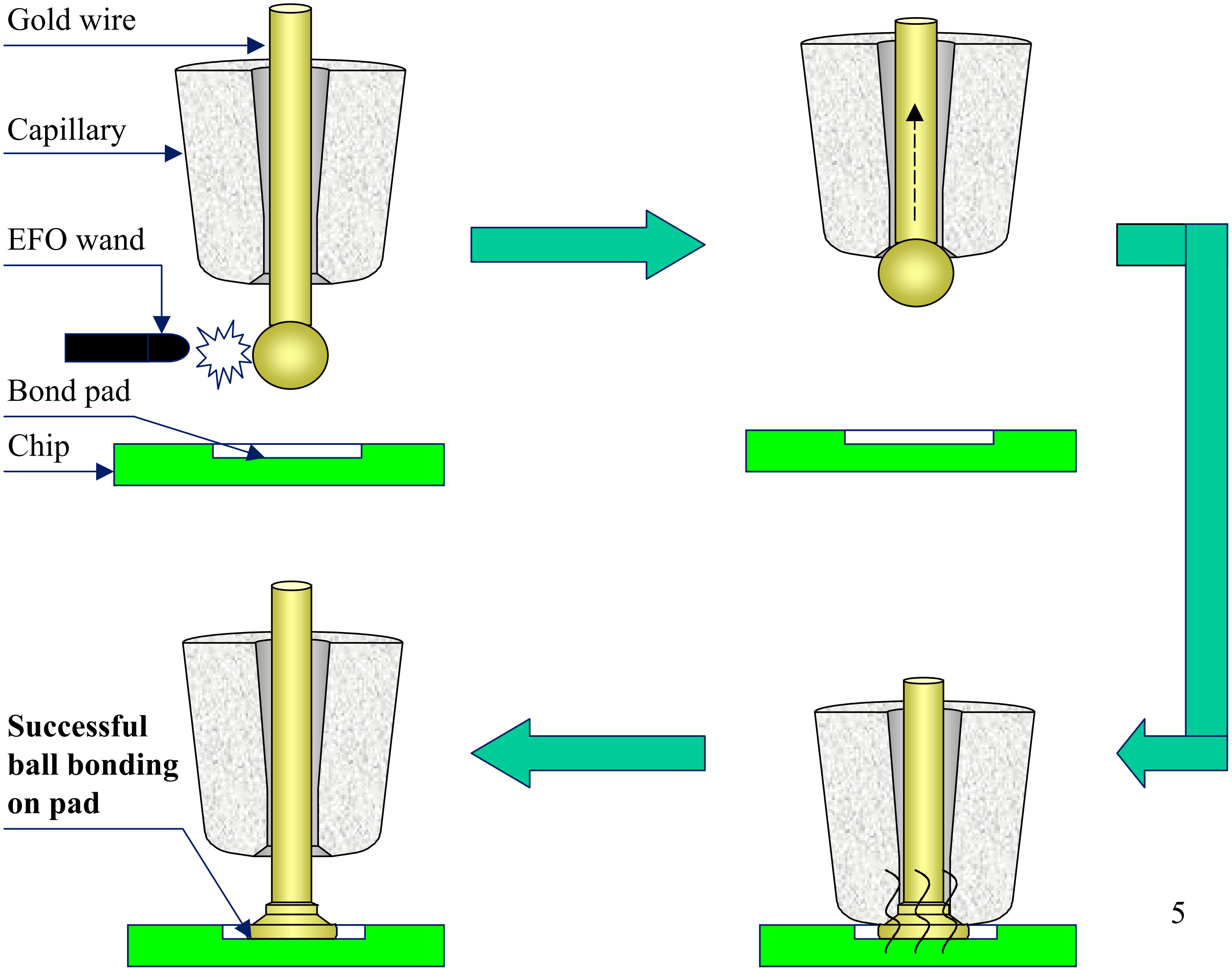
Lim Hock Chuan
Eugene
June 2001

Singapore - Assembly & Final Test of Logic ICs

Country:	Singapore
Products:	Applications Specific ICs Microcontrollers Power ICs High Frequency ICs
Packages:	P - TSSOP P - MQFP P - TQFP P - LFBGA P - VQFN
Testers:	Logic, Analog & Mixed Signal
Production* :	583' (pieces 00/01)
Employees:	2000 (without Sales,DC,EZM & AIT)
Floor space:	31410 m^2
Established:	1993 (Founded 1970)

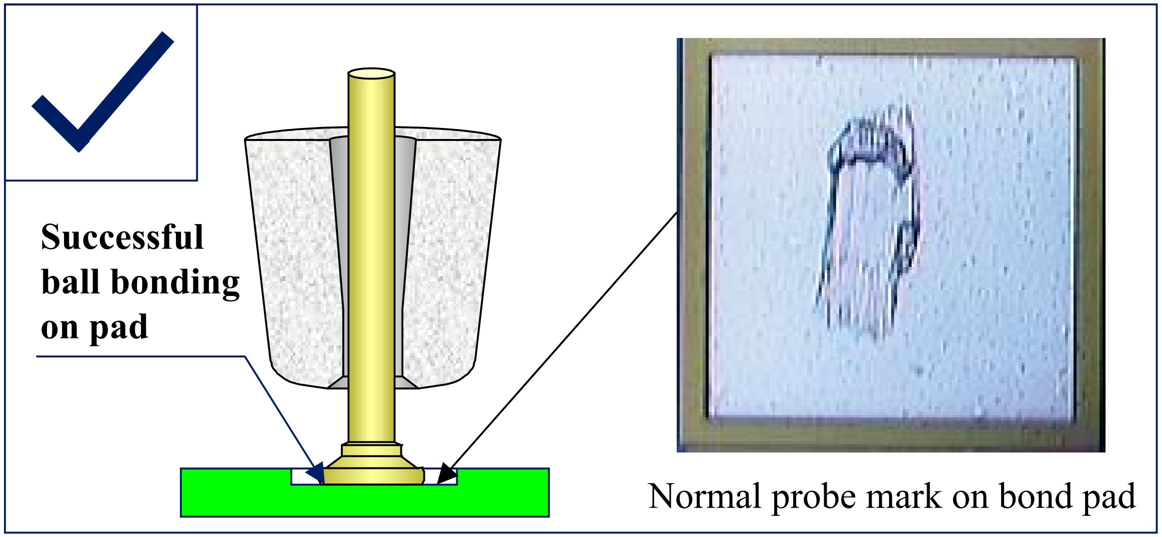
Lim Hock Chuan
Eugene
June 2001

Wire bonding (thermosonic) on the bond pad - Ball bonding sequence



Lim Hock Chuan Eugene
June 2001

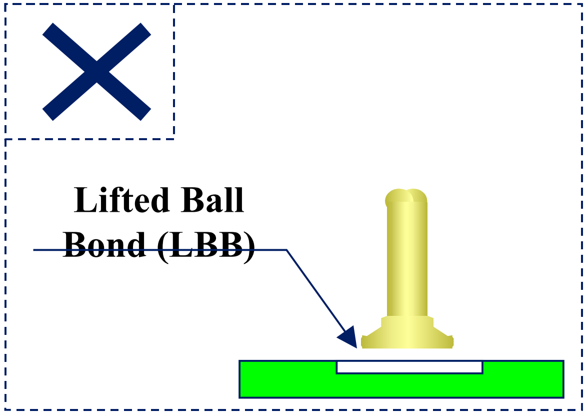
What is Lifted Ball Bond (LBB) & Non Stick On Pad (NSOP)?



✓

Successful ball bonding on pad

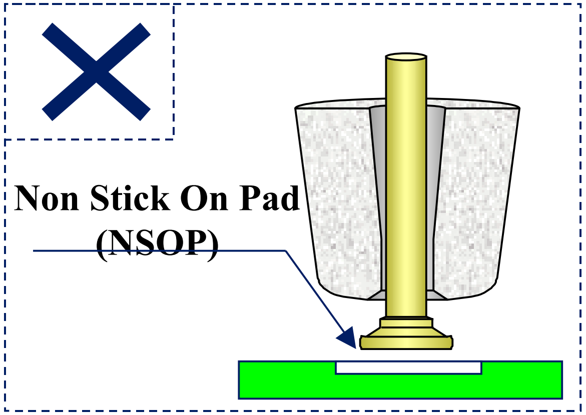
Normal probe mark on bond pad



✗

Lifted Ball Bond (LBB)

Ball bond is lifted after wire bonding



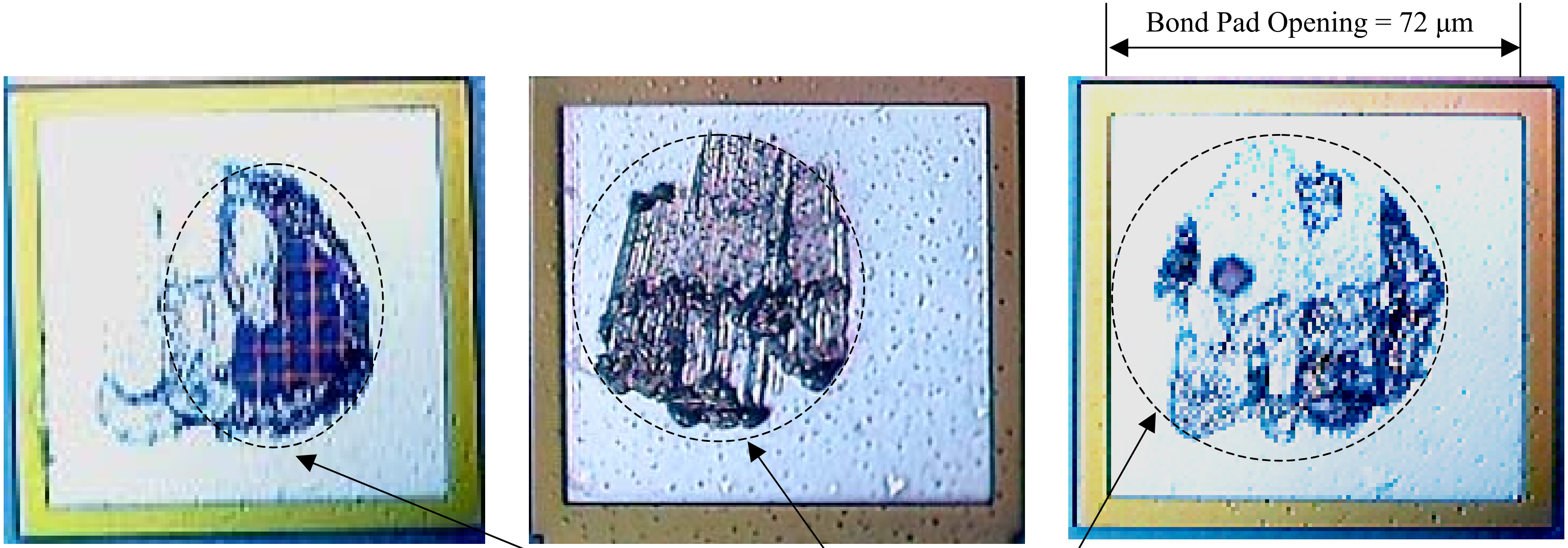
✗

Non Stick On Pad (NSOP)

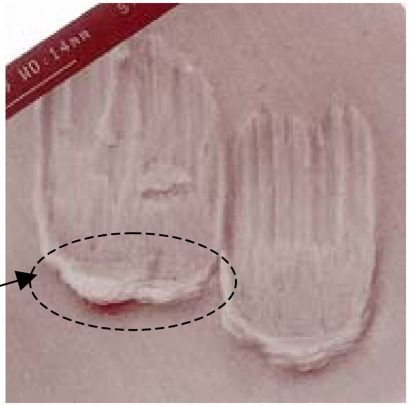
Ball bond is lifted during wire bonding

Lim Hock Chuan Eugene
June 2001

What can cause Lifted Ball Bond (LBB) & Non Stick On Pad (NSOP)?

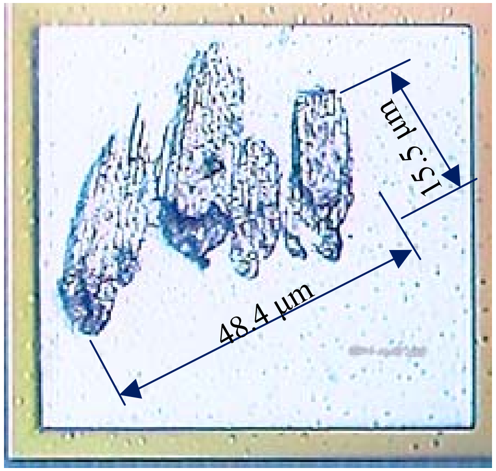


1. **Exposed Oxide**
2. **Big/Multiple probe marks**
3. **Aluminum build-up**



Classification of exposed oxide, big probe marks, and Aluminum build-up

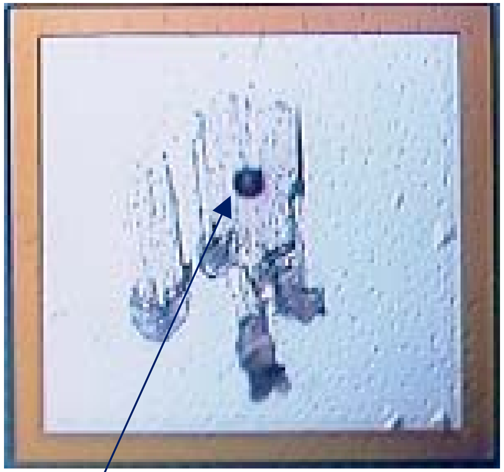
Probe Mark measurement



Probe mark area
= 48.4 x 15.5
= 750.2 µm^2

% of probe area vs bond pad opening
= 750.2 / (72 x 72)
= 750.2 / 5184
= 14.5%

Exposed Oxide measurement

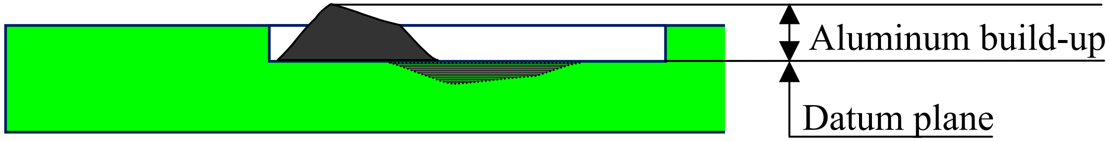


Diameter = 6.68µm

Exposed oxide area
= (3.14 x 6.68 x 6.68) / 4
= 35.03 µm^2

% of exposed oxide area vs bond pad opening
= 35.03 / (72 x 72)
= 35.03 / 5184
= 0.68%

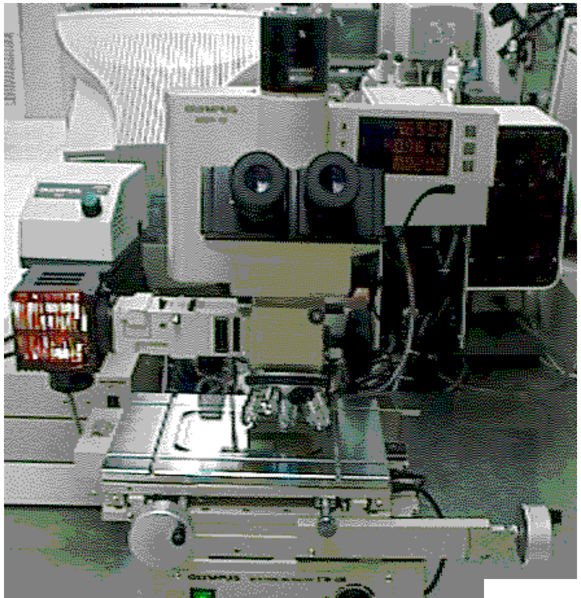
Aluminum Build-Up measurement



1. Focus is done on the selected bond pad, making it the datum plane.
2. Move the scope vertically in the z-axis to focus on the tip of the build-up.
3. This vertical displacement is the height of the Aluminum build-up.

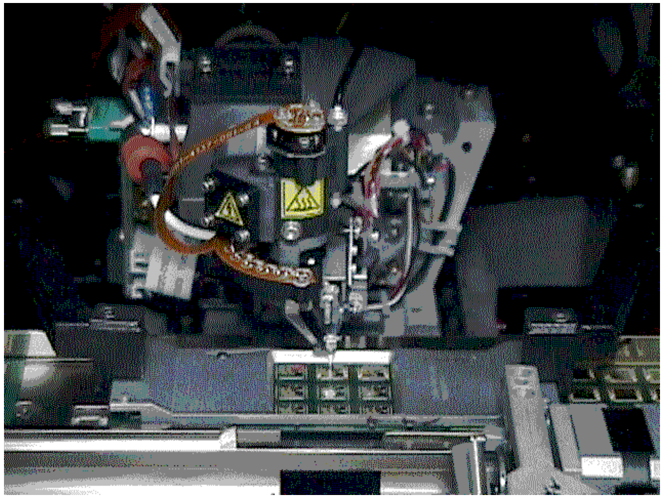
Lim Hock Chuan Eugene
June 2001

Instruments used for non-destructive (dimensioning) and destructive tests (ball shear)



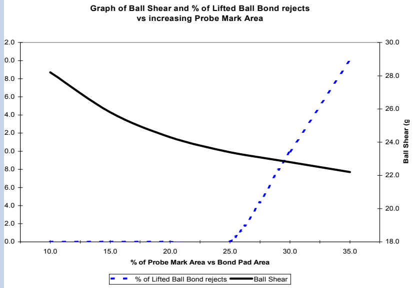
Microscope

Ball shearing machine

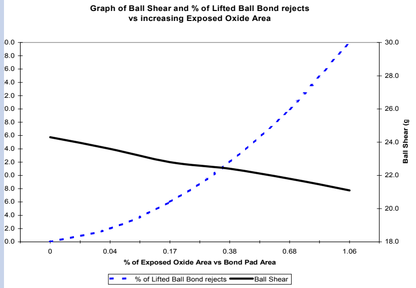


Wire bonding machine

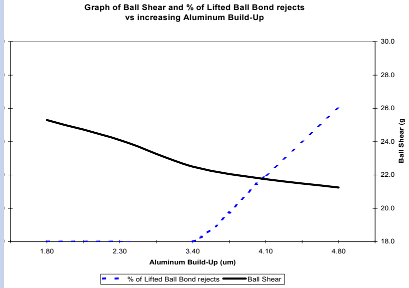
What is the impact of Ball Shear and % of Lifted Ball Bond on bond pads with big/multiple probe marks?



What is the impact of Ball Shear and % of Lifted Ball Bond on bond pads with exposed oxide?



What is the impact of Ball Shear and % of Lifted Ball Bond on bond pads with Aluminum build-up?



An IBM INFINEON Company

- **A Company built from the IBM Microelectronics Corbeil-Essonnes site**
- **50 / 50 IBM / Infineon Joint Venture (07 / 99)**
- **A conversion from DRAM centric focused product mix to Logic centrix focused mix**
  - ✓ LOGIC : 0.35µ / 0.25µ Aluminium / 0.18µ Copper / 0.13µ Copper Low K
  - ✓ Embedded MEMORY: DRAM 0.35µ / 0.20µ / 0.17 µ
- **World class customers leaders in Telecoms and Computer peripherals**
- **Shared management IBM / Infineon**
- **Capacity sharing 50 / 50 based on normalized capacity**
- **Investment plan : about 1 Billion Euro in the years 2000/2001**

WHEN PROBING AND BONDING ARE NOT GOOD FRIENDS !

SCRUB MARK EFFECTS

−

NEGATIVE FOR BONDING

Decrease Bonding Performance

- ➢ Remove alu oxide
- ➢ Decrease CRs
- ➢ Improve Yield

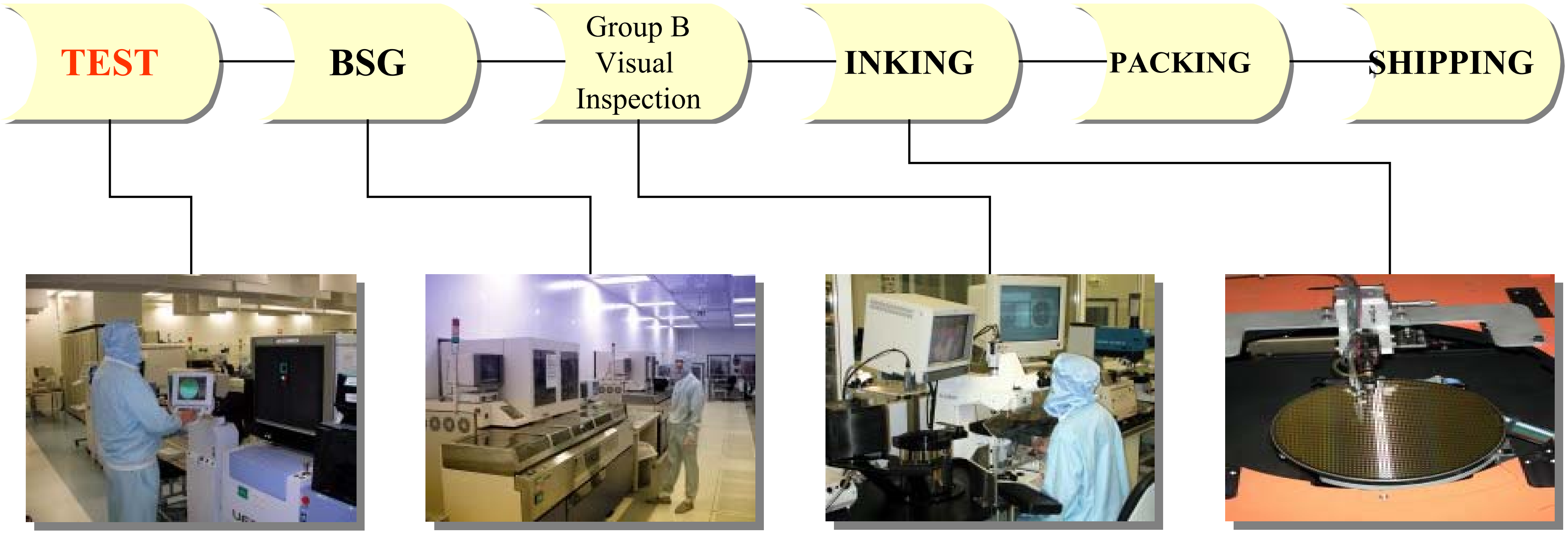
- ➢ Allow Prober to operate needle to pad alignement

+

POSITIVE FOR TESTING

FINAL SORT : FROM SHORT TO LONG PATH…

Exemple 1 : The short way…



TEST

BSG

Group B Visual Inspection

INKING

PACKING

SHIPPING

WAFER SORT : FROM SHORT TO LONG PATH…

Exemple 2 : A long way to go…(logic product with EDRAM, SRAM, CPU)

- **Prefuse Test** J995 EDRAM
- **Prefuse Retest*** J995 EDRAM
- **FUSE** EDRAM
- **Postfuse/ Prefuse Test** J971 EDRAM, SRAM, CPU
- **Postfuse/ Prefuse Retest*** J971 EDRAM, SRAM, CPU
- **FUSE** SRAM
- **Postfuse Test** J971 SRAM
- **Postfuse Restest*** J971 SRAM
- **Analog Test**
- **Analog Retest***
- **BSG**
- Group B Visual Inspection
- **INKING**
- **PACKING**
- **SHIPPING**

* If more than 5 % retest gain

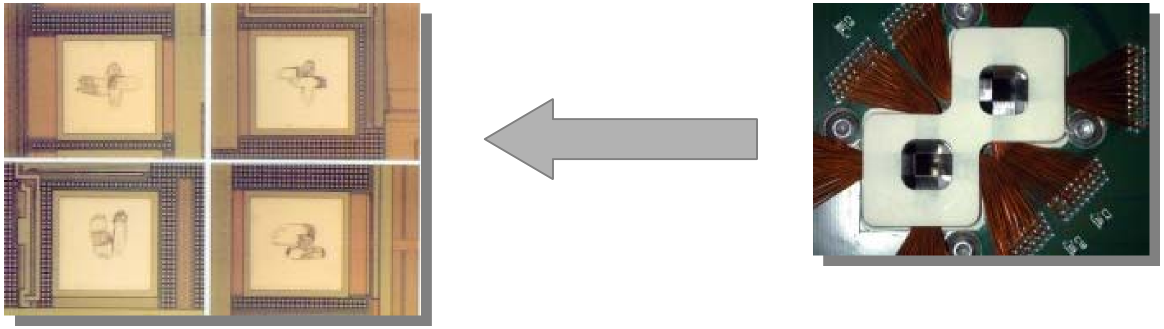
WHY SEVERAL PROBE MARKS…

⇨ PROCESS REASONS :

- Different tests (Prefuse, Postfuse, Analog)
- Restest (contact problems, yield issues)…

⇨ PROBE-CARD REASONS :

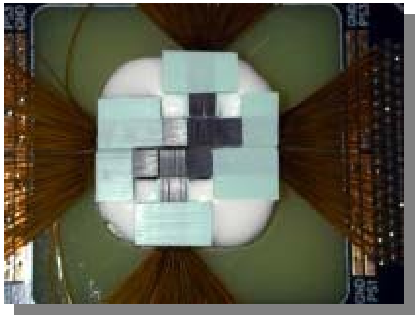
- Over probing due to probe-card (Dut layout)



WHAT MAKES THE SIZE OF A PROBE-MARK…

⇨ PROBE-CARD REASONS :

- Tip size, tip shape
- Needles planarity, PC warping (temperature)
- Needle gram force



⇨ PROBER REASONS :

- Z height detection, profiler precision
- Chuck, prober table planarity
- Test head docking influence

⇨ PRODUCT REASONS :

- Pad material hardness

⇨ HUMAN REASONS :

- Overtravel set by operator

HOW CAN EXPOSED OXIDE HAPPENED ?

⇨ PROBE-CARD REASONS :

- Tip size, tip shape
- Needles planarity, PC warping (temperature)
- Needle gram force
- Scrub lenght (beam angle, needle layer related)

⇨ PRODUCT REASONS :

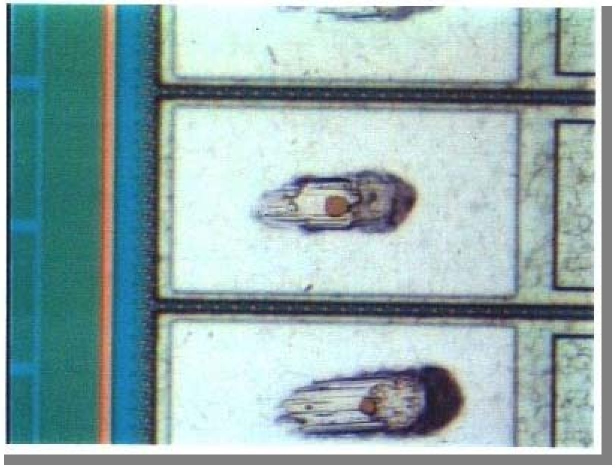
- Pad thickness (technology dependant)
- Pad material hardness
- Pad structure

⇨ PROBER REASONS :

- (same as page 18)
- Double Zup
- Z chuck speed

⇨ HUMAN REASONS :

- Excessive overtravel set by operator



AND WHAT ABOUT THE SCRUB MARK BUILD-UP HEIGHT !

A VERY DIFFICULT AND NEW PARAMETER TO CONTROL AND UNDERSTAND

(SO FAR NO PROBE-CARD SPECIFICATIONS LINK TO THIS PARAMETER..)

⇨ PROBE-CARD REASONS :

- ➢ Needle shape (flat, radius, semi-radius, beam angle)
- ➢ Needles planarity, PC warping (temperature)
- ➢ Needle gram force
- ➢Beam, knee, taper angle

⇨ PROBER REASONS :

- ➢ (same as on previous pages)

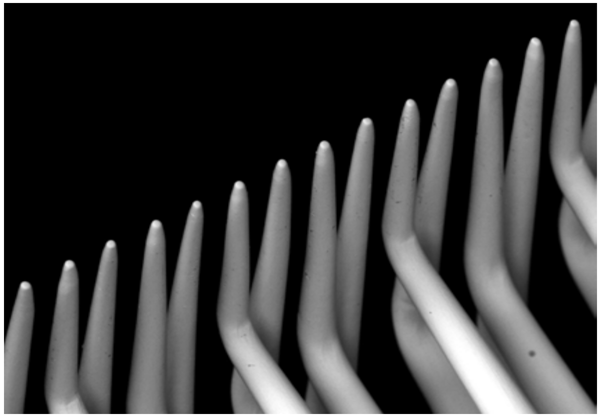
⇨ PRODUCT REASONS :

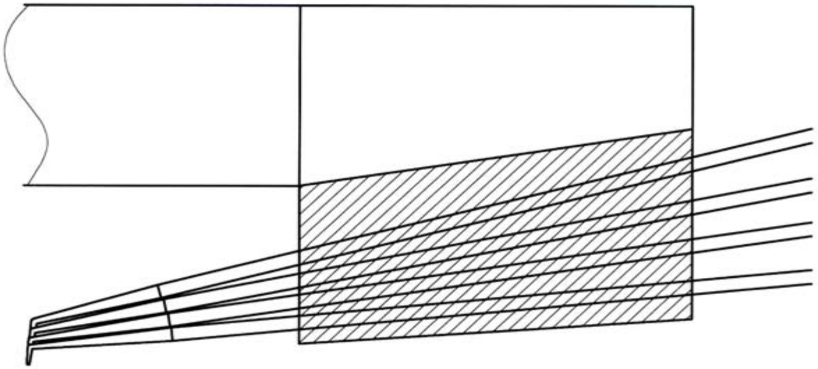
- ➢Pad material hardness

⇨ HUMAN REASONS :

- ➢Overtravel set by operator

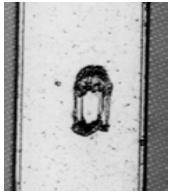
PAD PITCH 60um PAD SIZE 52x95um





Layer	Needle Diameter (φ)	Angle	O/D (μm)	Tip Length (μm)	Beam	Knee	Taper	Contact Force (g)	Scrub amount (μm)	Remark
1	0.15	5	100	170	2763	0.050	1.5	9.37	13.96	28.96
2	0.15	7	100	250	2763	0.050	1.5	9.37	20.35	35.35
3	0.15	9	100	350	2763	0.055	1.5	9.69	27.55	42.55
4	0.15	11	100	450	2763	0.060	1.5	9.98	34.78	49.78

1


3


2


4


1

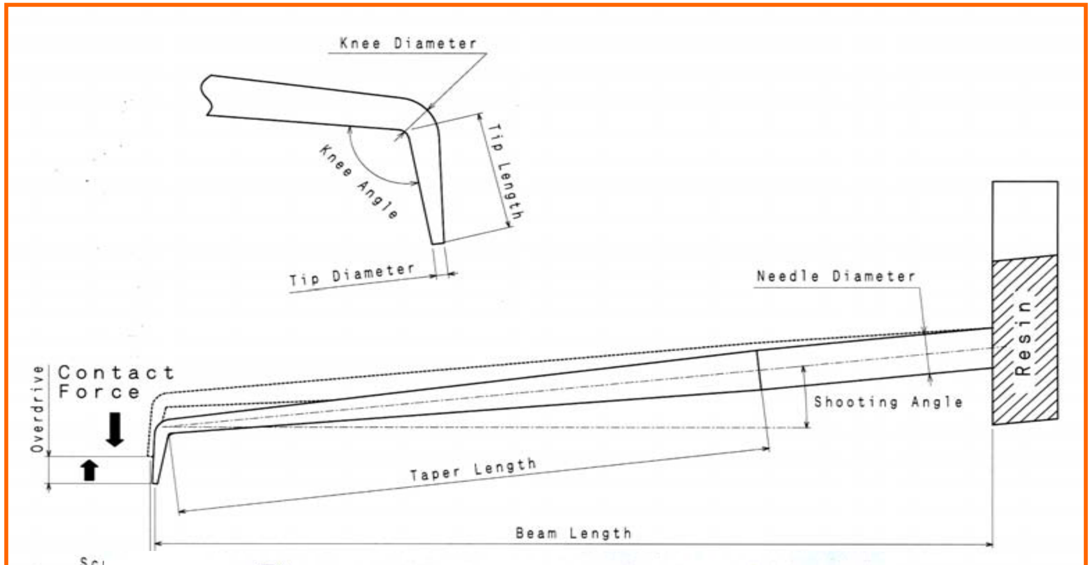

3

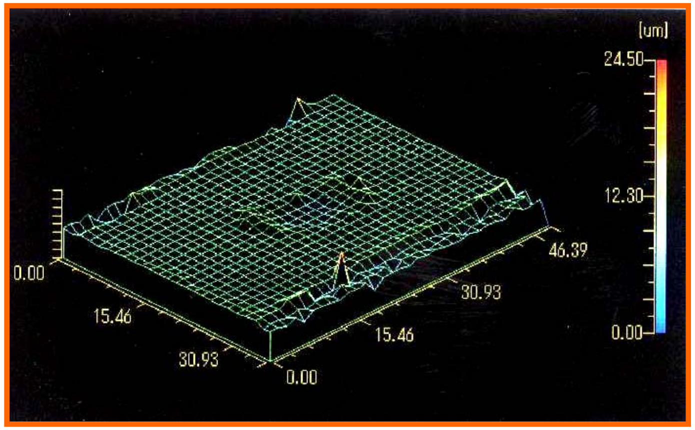

2

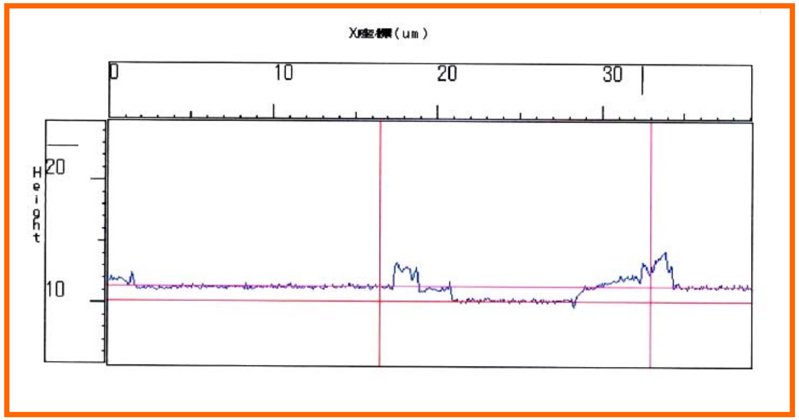

4


CANTILEVER PC IMPROVEMENTS

MJC aps

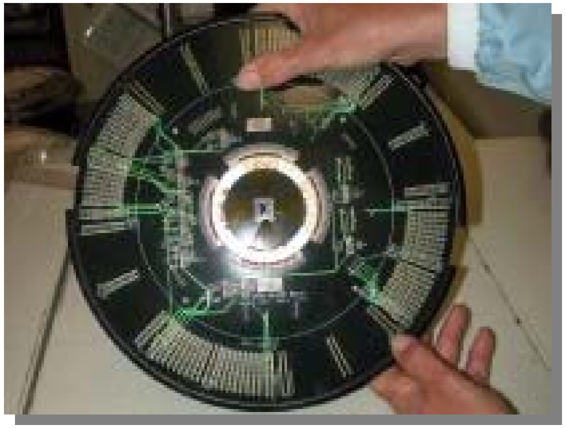


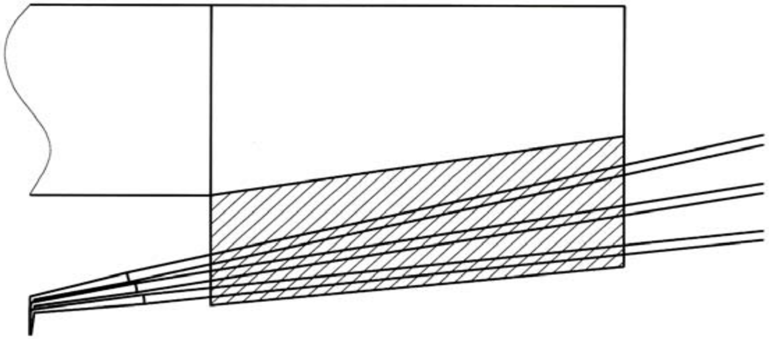




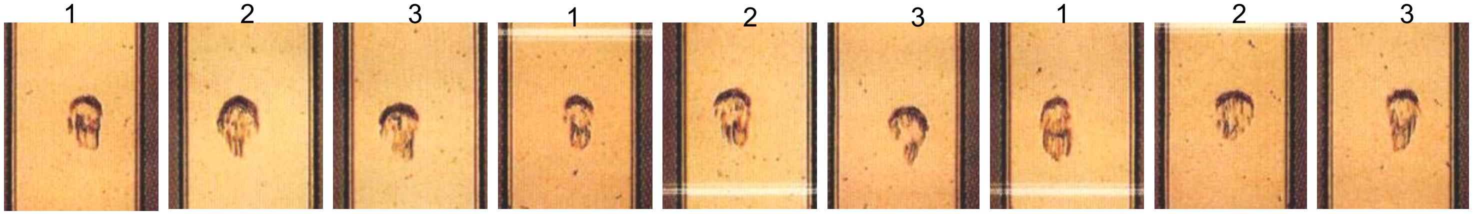
CANTILEVER PC IMPROVEMENTS

MJC aps

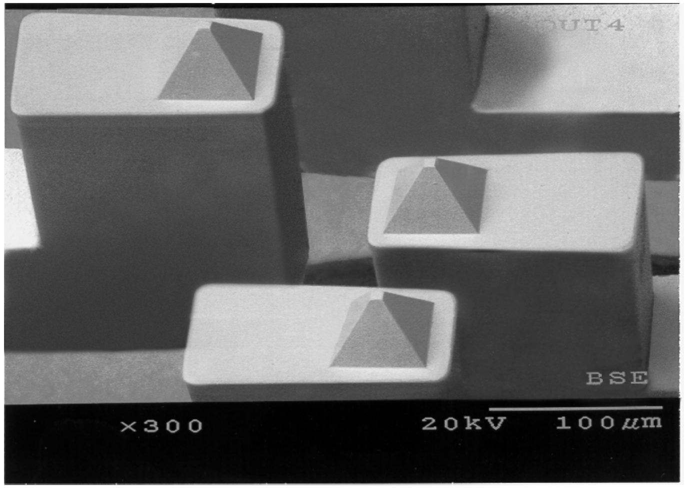


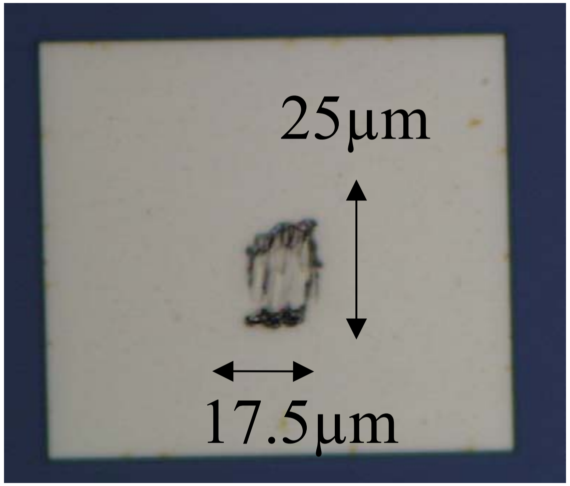


Layer	Needle Diameter (φ)	Angle	O/D (μm)	Tip Length (μm)	Beam	Knee	Taper	Contact Force (g)	Scrub amount (μm)	Remark
1	0.1	6	70	230	1749	0.044	1.134	5.01	13.57	28.57
2	0.1	8	70	290	1749	0.048	1.088	5.35	18.79	33.79
3	0.1	10	70	350	1749	0.051	1.042	5.6	21.91	36.91



Fine Pitch Probing Critical Factor Probe Tip Size



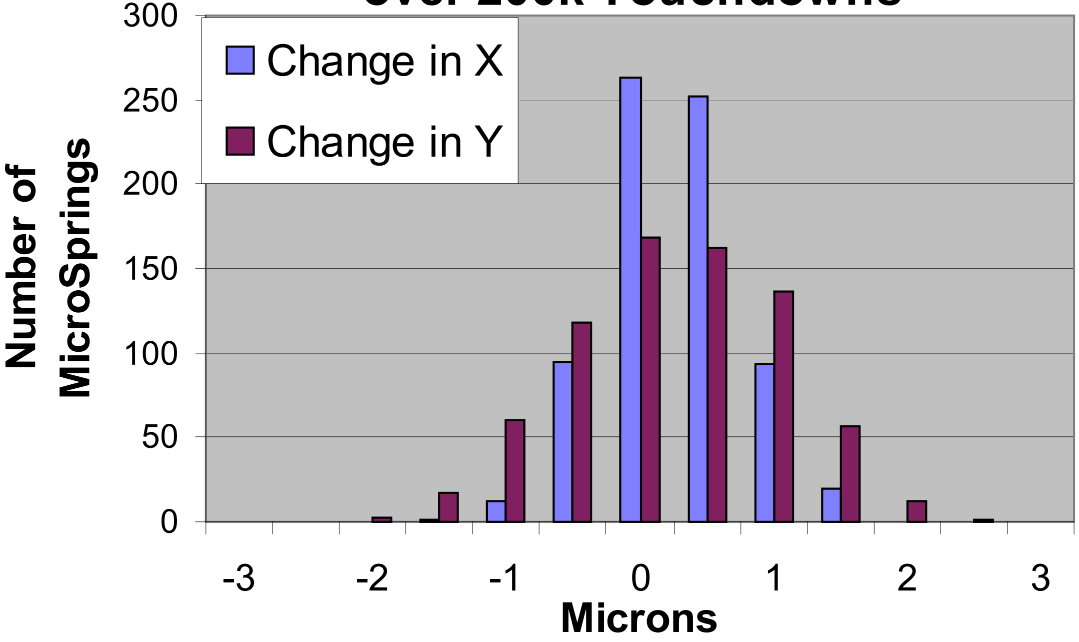


100µm pad

80µm OT

- Controlling the probe tip size is critical for maintaining scrub mark size
- Fine pitch/Small pad probing may require < 10µm probe tips

Fine Pitch Probing Critical Factor Alignment Repeatability

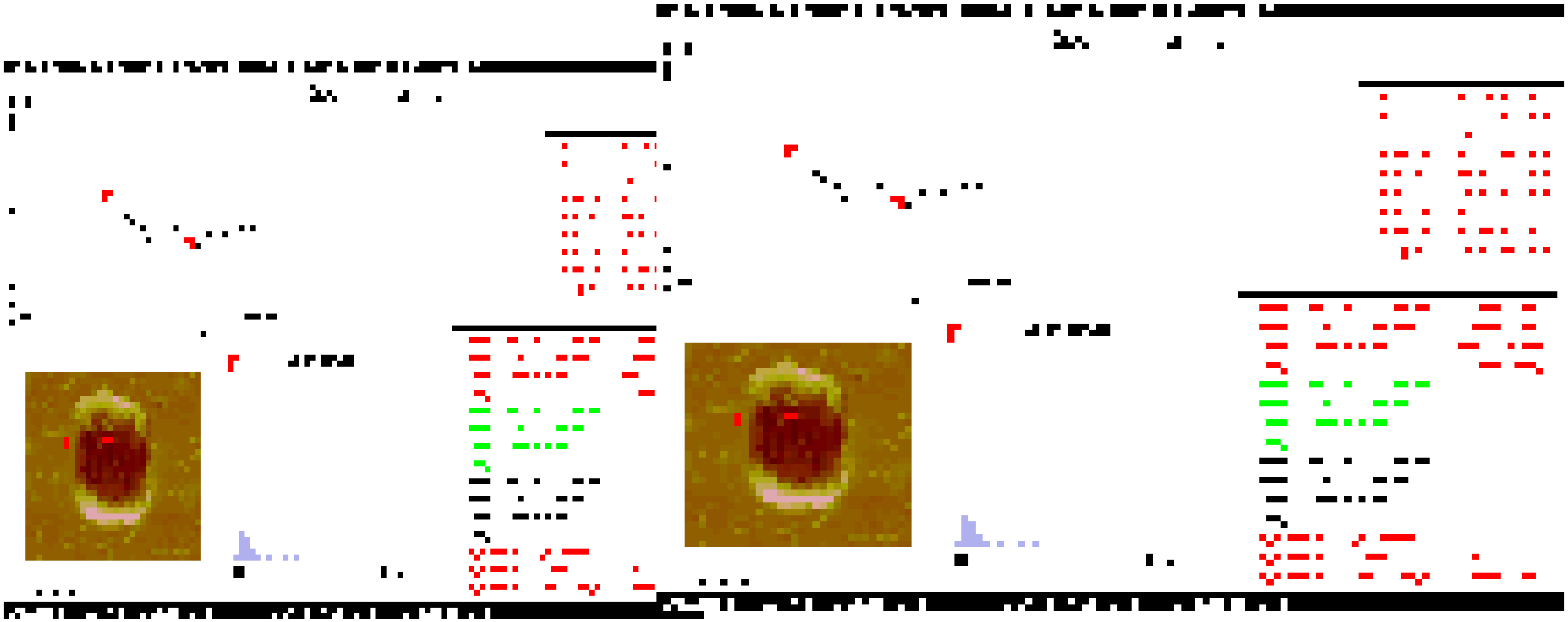


Change in MicroSpring Alignment over 200k Touchdowns

- 641 MicroSprings measured on API PRVX2
- Touchdowns performed at 75µm overtravel

- Alignment variation leads to:
  - Passivation damage
  - Increased Maintenance
  - Yield loss
- Hitting the center of the pad is more critical for tighter pad pitch and smaller pads
- Alignment repeatability = PRODUCTIVITY

Fine Pitch Probing Critical Factor
Pad Damage



- Scrub Depth – 500nm @ 40µm overtravel
- 10-15um probe tip with 1.5gm/mil probe force

CONCLUSION PART 1

1. The presence of big/multiple probe marks, exposed oxide & Aluminum build-up will cause:
    1.1 Ball shear readings to decrease.
    1.2 % of lifted ball bond rejects to increase.

2. Probe mark area > 25% will increase lifted ball bond rejects.

3. The presence of exposed oxide is already a reject, and it will exhibit lifted ball bond rejects.

4. Aluminum build-up > 3.40um will increase lifted ball bond rejects.

* The simulation of probe mark defect modelling in this area will help to represent a more universal impact of wire bondability due to probing (the 3 elements covered).

CONCLUSION PART 2

SHORT TERM SOLUTIONS

- OPTIMIZE WAFER MAP INDEX (TO AVOID OVER PROBING)
- REDUCE PROBE-CARD SPECIFICATIONS
- PROBER IMPROVEMENTS :
  - IMPROVE PRECISION (calibration, preventive maintenance)
  - USE ALL POSSIBLE OPTIONS (soak time, double profiler, etc…)
  - REDUCE OVERTRAVEL LIMIT

- USE A PROBER / TESTER INTERACTIVE LOOP CONTACT
- USE WAFERWORX (API) TO OPTIMIZE PC SETUP
- CHARACTERIZE PROBING WITH WAFERS IN REAL PRODUCTION CONDITION

CONCLUSION PART 3

LONG TERM SOLUTIONS

- HAVING UNIVERSAL TESTERS (memory, analog and logic test)
- USE VERTICAL PROBING (to avoid scrubbing)
- FUSE DURING TEST (electrical fuse)
- WAFER SORT AFTER BONDING (exemple : WOW from FFI)
- PACKAGE TEST ONLY (using electrical fuse if needed)
- DEDICATED PAD FOR BONDING…
- ETC…

ACKNOWLEDGEMENTS

THANKS TO ALL PEOPLE INVOLVED IN THIS PRESENTATION

- Patrick BUFFEL (Altis Semiconductor)
- Roland BLASS and Thomas GÜNZEL (APS/MJC)
- Bob MARTIN (FORM FACTOR)

Contact : Dominique LANGLOIS
Altis Semiconductor
224, Bd John Kennedy
91105 Corbeil-Essonnes Cedex France
Tel : (33) 1.60.88.69.33
Email : dominique.langlois@altissemiconductor.com

Contact : Lim Hock Chuan Eugene
Infineon Technologies
168, Kallang Way
Singapore 349253
Tel : (65) 8400457
Email : eugene.lim@infineon.com