BONDABILITY RELATED TO PROBING

« WHEN PROBING AND BONDING ARE NOT GOOD FRIENDS ! »

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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
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 m²
Established: 1993 (Founded 1970)
Wire bonding (thermosonic) on the bond pad
- Ball bonding sequence

1. Gold wire
2. Capillary
3. EFO wand
4. Bond pad
5. Chip

Successful ball bonding on pad
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
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

\[ 48.4 \times 15.5 = 750.2 \, \mu m^2 \]

% of probe area vs bond pad opening

\[ \frac{750.2}{(72 \times 72)} = \frac{750.2}{5184} = 14.5\% \]

**Exposed Oxide measurement**

Exposed oxide area

\[ (3.14 \times 6.68 \times 6.68) / 4 = 35.03 \, \mu m^2 \]

% of exposed oxide area vs bond pad opening

\[ \frac{35.03}{(72 \times 72)} = \frac{35.03}{5184} = 0.68\% \]

**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.
Instruments used for non-destructive (dimensioning) and destructive tests (ball shear)
What is the impact of Ball Shear and % of Lifted Ball Bond on bond pads with big/multiple probe marks?

Graph of Ball Shear and % of Lifted Ball Bond rejects vs increasing Probe Mark Area

Ball Shear (% of Lifted Ball Bond rejects) vs increasing Probe Mark Area
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?
- 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

POSITIVE FOR TESTING

- Remove alu oxide
- Decrease CRs
- Improve Yield
- Allow Prober to operate needle to pad alignment
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 Retest*: J971 SRAM
- Analog Test: Group B Visual Inspection
- Analog Retest*: BSG
- 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

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San Diego SWTW
HOW CAN EXPOSED OXIDE HAPPENED?

⇒ PROBE-CARD REASONS:
  ➢ Tip size, tip shape
  ➢ Needles planarity, PC warping (temperature)
  ➢ Needle gram force
  ➢ Scrub length (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
## CANTILEVER PC IMPROVEMENTS

**PAD PITCH 60um  PAD SIZE 52x95um**

<table>
<thead>
<tr>
<th>Layer</th>
<th>Needle Diameter ((\phi))</th>
<th>Angle</th>
<th>O/D ((\mu m))</th>
<th>Tip Length ((\mu m))</th>
<th>Beam</th>
<th>Knee</th>
<th>Taper</th>
<th>Contact Force (g)</th>
<th>Scrub amount ((\mu m))</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.15</td>
<td>5</td>
<td>100</td>
<td>170</td>
<td>2763</td>
<td>0.050</td>
<td>1.5</td>
<td>9.37</td>
<td>13.96</td>
<td>28.96</td>
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<tr>
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<td>0.15</td>
<td>7</td>
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<td>250</td>
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<td>0.050</td>
<td>1.5</td>
<td>9.37</td>
<td>20.35</td>
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<tr>
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<td>9</td>
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<td>0.15</td>
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<td>0.060</td>
<td>1.5</td>
<td>9.98</td>
<td>34.78</td>
<td>49.78</td>
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ALTIS Semiconductor
An IBM INFINEON Company

CANTILEVER PC IMPROVEMENTS

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## CANTILEVER PC IMPROVEMENTS

### Needle Tip Contact Scrub

<table>
<thead>
<tr>
<th>Layer</th>
<th>Needle Diameter (( \phi ))</th>
<th>Angle</th>
<th>O/D (( \mu m ))</th>
<th>Tip Length (( \mu m ))</th>
<th>Beam</th>
<th>Knee</th>
<th>Taper</th>
<th>Contact Force (g)</th>
<th>Scrub amount (( \mu m ))</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
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<td>6</td>
<td>70</td>
<td>230</td>
<td>1749</td>
<td>0.44</td>
<td>1.134</td>
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<td>290</td>
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<td>1.088</td>
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<tr>
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<td>0.1</td>
<td>10</td>
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<td>350</td>
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<td>1.042</td>
<td>5.6</td>
<td>21.91</td>
<td>36.91</td>
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</tbody>
</table>

![Image of needle tip contact scrub](image-url)
Fine Pitch Probing Critical Factor: Probe Tip Size

- 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

- 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

- 641 MicroSprings measured on API PRVX2
- Touchdowns performed at 75μm overtravel
Fine Pitch Probing Critical Factor
Pad Damage

- Scrub Depth – 500nm @ 40µm overtravel
- 10-15µm 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…
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