Electroless Bumping for 300mm Wafers

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Internepcon 2006
Tokyo Big Sight, Japan
Outline

- Short Company Profile
- Electroless Ni/Au Under Bump Metallization UBM for Copper Devices
- Solder Bumping: Stencil Printing & Ball Placement
- Wafer Level RDL
- Interface for Wirebonding Application
- Outlook: Stacking, Via Filling, Micro Ball Placement
- Summary
## Corporate Profile

### PacTech GmbH & PacTech-USA Inc.

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<tr>
<th>Berlin (D)</th>
<th>Nauen (D)</th>
<th>Santa Clara, CA (USA)</th>
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<tbody>
<tr>
<td>Dept. Equipment Development &amp; Production</td>
<td>Dept. Bumping &amp; Redistribution Service</td>
<td>Bumping Service &amp; Equipment Sales Center</td>
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<tr>
<td>- Solder Ball Bumper: SB²-Jet, SB²-SM</td>
<td>- Electroless Ni/Au Bump</td>
<td>Equipment Sales &amp; Service</td>
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<tr>
<td>- Flip Chip Placer: LAPLACE, MAPLACE</td>
<td>- Solder Stencil Printing</td>
<td>- Laser Microassembly &amp; Equipment Demo Center</td>
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<td>- Electroless Bumping Line PacLine 2000</td>
<td>- Solder Ball Placement</td>
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<td>- Laser Wafer Marking System: LS²</td>
<td>- Wafer Sawing &amp; Scribing</td>
<td>Wafer Bumping Service</td>
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<td>- Wafer Level RDL &amp; CSP</td>
<td>- Electroless Ni/Au</td>
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<td>- Solder Stencil Printing</td>
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<td>- Solder Ball Placement</td>
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<td>- FC-Assembly</td>
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Pac Tech Germany Nauen - Cleanroom
PacTech-USA

- Bumping & Technology Services
- Equipment Sales: SB², Pacline, etc.
- Process Licensing & Technology Transfer
- Training & Support

- 10,000 ft² floorspace
- 2,000 ft² cleanroom
- class 10,000

328 Martin Avenue
Santa Clara, CA 95050
Phone: 408-588-1925
www.pactech-usa.com
Under Bump Metallization for 300mm

Challenges: Copper Pad Metallization, Organic Passivation, Homogeneity

Process: Electroless Ni/Au UBM
Worldwide Use of Electroless Ni & Solder bumping

Distribution

- USA (30%)
- Europe (40%)
- Asia (30%)

Applications

- Memory 12.5%
- RFID 20%
- Pass. Comp./CSP's 20%
- MOSFET 10%
- LCD Driver 2.5%
- ASIC 22.5%
- Medical 12.5%
Under Bump Metal Process

Electroless Plating of Ni/Au Bumps

Backside Coating

Copper Cleaning (Oxides, CMP)

Paladium Pretreatment

Electroless Nickel

Immersion Gold

Coating Removal
Electroless UBM Advantages

- Maskless Process
- No Sputtering
- Low Initial Capital Investment
- Quality/Reliable/Proven Chemistries
- Suitable for Solder Bumping & Adhesives
- Wire bondable Interface
- Less cost than Electrolytic Plating
- Fastest and Most Cost Effective Method

• 150 Wafers / hour
• 4“ – 12“ Capability
• SECS GEM
• 300mm Handling
• SPC Sofware
Ni/Au Bump height measurements on a 12” Wafer

UBM Height Measurements:
21 Areas
Samples/Area 10
Sample Size: 210
Mean Value (µm): 9.71
3 Sigma (µm) ±0.49

Shear Force Values:
21 Areas
Samples/Area 20
Sample Size: 420
Mean Value (g): 124
Sigma (g): ±15

300mm Wafer Production Lot
Distribution of Ni bump height on a 12” Wafer

Mean Value: 9.71 µm
3 Sigma: 0.49 µm

Fraction [%]

Height Variation [%]
Fully automated 300mm Equipment Concept

PacLine 300 A50

- High Throughput: 150 wafers/h 8” & 75 wafers/h 12”
- Automated Cassette to Cassette Wafer Handling
- Wafer Drying
- SECS GEM
- Improved Wafer DI Water Rinse by US Activation
- High Speed Profibus Internal Communication
Pacline 300 - A50

8 Bumping Systems in the Field
Solder Bumping

Challenges:
- Low Alpha
- Lead-Free
- High I/0 Count

Process:
- Stencil Printing
- Solder Ball Ball Placement
Comparison of Solder Bumping Technologies

- Evaporated Solder Bump
- Sputtered UBM + Plating
- Sputtered UBM + Print (FCT)
- Electroless UBM (+)
  - Print or Ball Attach

C4 Solder
Solder
Solder
Solder

Au
Ni/Au
Solder Bump Material Requirements

• Lead-Free Solders
  – Ternary & Quaternary Alloy Systems
    => stencil printing or ball placement
  – Type 6 & 7 solder paste
  – Design & Assembly
  – Reflow & Flux Cleaning

• (Ultra) Low Alpha
  – Availability
  – Price
  – Qualification / Certification

SnAgCu Bumps
Stencil Solder Printing or Gang Solder Ball Placement

Process Flow

Electroless Ni/Au Bumping

Solder Paste (Flux) Printing

(Solder Ball Attach)

Reflow

Wafer Cleaning

Wafer Inspection

Pack & Ship

300 mm Capability!
PbSn 63/37 vs. Lead-free Solders
A Feasibility Study under Production Conditions

### Bump Yield (8” Wafer)

<table>
<thead>
<tr>
<th>Bump Yield Loss [ppm]</th>
<th>SnAg4Cu0.5</th>
<th>Sn37Pb63</th>
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<tbody>
<tr>
<td>Wafer Type I</td>
<td>0 - 55</td>
<td>0 - 110</td>
</tr>
<tr>
<td>250µm Pitch</td>
<td></td>
<td></td>
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<tr>
<td>I/O count: 30,000</td>
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<tr>
<td>Wafer Type II</td>
<td>120 - 150</td>
<td>95 - 120</td>
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<tr>
<td>225µm Pitch</td>
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<tr>
<td>I/O count: 30,000</td>
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### Bump Height Distribution:

- typ. +/- 10µm @ 3 Sigma
- slightly better for lead-free
Solder Bumping Roadmap

Main Challenge: High Pad Count / Pad Density

• **Stencil Printing**
  - Paste Material
  - Stencil Technology
  - Printer Accuracy
  - Stencil Cleaning
  - Solder Paste Transfer
  - Yield

• **Gang Ball Placement**
  - Micro Ball Placement
  - Cost
  - Equipment Availability
  - Yield / Repair
  - Inspection
Wafer Level Redistribution

Challenges:
- Low-K Dielectric Layer
- Throughput / Speed
- Tooling
- => Low Cost

Processes:
- (BCB) / Al / BCB
- Epoxy / Electroless Cu/ Epoxy
- Electroless Ni/Au UBM
Process Flow Overview - ElastoPAC

Epoxy / Cu / Epoxy

1. Spinning of Dielectric Layer
2. Photo Imaging: Opening of Ni/Au Bond Pads
3. Formation of Seed Layer
4. Full Area Copper Deposition
5. Resist Spinning and Photo Structuring
6. Copper Etching
7. Solder Mask Spinning and Photo Imaging
8. Ni/Au - Bumping of Redistributed Pads
9. Solder Stencil Printing or Ball Placement

- Ni/Au - Bumping of Bond Pads
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Certified DIN EN ISO 9001:2000
Internepcon 2006
Tokyo, Japan
Cu Wire Bonding

Challenges:
Wire Bondability of Copper Pad

Other Solutions:
Cu Wire Bonding
  => feasibility, reliability
Al sputtering on Cu Pad
  => Cost

Best Solution:
Wire Bondable Low Cost Interface
  => Electroless Ni/Au
Au Wire Bonding on Electroless Ni/Au Layer

- **Surface Treatment**
  - Ni/Au UBM
  - Ar Plasma Cleaning/Activation
  - Lowest Cost
  - Acceptable Bond Window
  - Process has to be optimized for thin Au layer

- **Thick Au Finish**
  - Ni/Au UBM
  - High Chemistry Cost
  - Chemistry Performance
  - Longer Processing Time
  - Broad Bond Window
  - Good Reliability

- **Pd Layer**
  - Ni/Pd/Au UBM
  - Broad Bond Window
  - Reasonable Cost / Reliability Ratio
  - Prototyping Status on Wafer-level
Thick Au Finish

Shear modes of Au Stud Bumps

Au: 0.1µm - 0.2µm

Bond Parameter:

- US-Time: 140 ms
- US-Power: 150 mW
- Bond Force: 30 cN
- Stage Temperature: 100 °C
Outlook

New Applications: e.g. Die Stacking

Requirements:
• Electroless Ni/Au UBM for Via Filling
  => Na free, low Phosphorous
  => Small Structure Plating Capability
Summary

300mm Capability
already in production,
cost effective bumping process & equipment
Excellent UBM Quality (height distribution)

Copper Pad Metalization
low cost process, no tooling, easy transferable (Al)

Bumping Process for low K
UBM and Solder (stencil printing or ball placement)

Redistribution
low cost, less tooling

Wire Bonding
cost, flexibility