31st International Conference on Electronics Manufacturing and Technology - IEMT 2006
8-10 November 2006
Sunway Resort Hotel, Petaling Jaya, Malaysia

Wafer Bumping & Wafer Level Packaging for 300mm Wafer

Thomas Oppert, Elke Zakel, Thorsten Teutsch

www.pactech.de
Content

• Short company profile
• Electroless NiAu UBM – History
• Eless NiAu
  – Market share, Usage
  – Pac Tech Licenses
  – Pac Tech Asia (Penang)
  – Pac Tech Worldwide Bumping Capacity
  – Processes
  – Equipment
• Soldering
  – Paste Printing
  – Gang Ball Placement
Pac Tech Corporate Profile

- 1995 Pac Tech GmbH established, Berlin-Germany
- 1997 1st Bumping facility in Nauen, Germany
- 2000 2nd Bumping facility in Fukui, Japan (Alpha Bumping Technologies - ABT, JV with Nagase)
- 2002, 3rd Bumping facility PacTech USA Inc., CA, USA
- 2005, Customer Service Center Thailand
- 2006, Pac Tech Asia (Penang, Malaysia - planned Q4)

- PT Germany: 125 employees
- PT USA, Inc.: 20 employees
- Sales Turnover 2005: 14 Million Euro (PT Germany)
- Shareholder Structure: NAGASE & CO., Ltd. Founders

Certified DIN EN ISO 9001; TS 16949 conform
NAGASE PROFILE

- HISTORY: Founded 1832, Incorporated 1917
- SALES: 5 billion US$
- STOCK: Listed TSE-1, OSE-1
- TYPE: Trading & Manufacturing
- FIELDS: Industrial & Consumer
- ITEMS: Electronics, Chemicals, Plastics, Pharmaceuticals, Beauty Care,

Tokyo Head Office
Osaka Head Office

THE WORLD OF NAGASE
The Technology and Intelligence Oriented Company

NAGASE & CO., LTD.

www.nagase.co.jp
Certified DIN EN ISO 9001; TS 16949 conform

Locations Worldwide

- Italy
- Denmark
- Sweden
- Malaysia
- Singapore
- Taiwan
- Thailand
- Philippines
- France
- Finland
- Pac Tech GmbH, Nauen, Germany
- Boston
- Pac Tech USA Inc, Santa Clara, CA
- Tokyo
- Fukui
- Korea
- China
- Taiwan
- Pakistan
- Israel
- China
- Thailand
- Malaysia
- Singapore

- Pac Tech facilities
- Distributor/Sales Agent
Pac Tech Asia, Penang

Front View
Pac Tech Asia, Penang

- Process qualification orders June 2007
- Accept production orders October 2007
Electroless Ni/Au Bumping

History
1st Ni Bumps

Electroless Deposition of Bumps for TAB-Technology

J. Simon, E. Zakel and H. Reichl
Technische Universität Berlin
Sekr. TIB 4/2-1
Gustav-Meyer-Allee 25, D-1000 Berlin 85, Germany

Abstract
The technology to place on the contact surface of TAB structures is of great importance to TAB. The main aspects in this field are the following: (i) the possibility of placing the necessary bumps in order to provide adequate electrical connections, (ii) the possibility of placing the necessary bumps in order to provide adequate mechanical connections, and (iii) the possibility of placing the necessary bumps in order to provide adequate thermal connections. The paper presents an electroless deposition process which meets these requirements.

1st Ni Bumps

1990
Certified DIN EN ISO 9001; TS 16949 conform
II

Electroless Ni/Au Bumping

Market Share, Usage, Pac Tech Licenses & Worldwide Bumping Capacity
Worldwide use of electroless Ni & solder printing

- Memory
- RFID
- Pass. Comp./CSP's
- MOSFET
- Power MOS
- LCD Driver
- ASIC
- IGBT
- Mobile Phone
- Medical
<table>
<thead>
<tr>
<th>Year</th>
<th>Growth</th>
<th>Business Development – Installed Equipment for eless NiAu &amp; Technology Transfer/Licenses of Pac Tech</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>Japan (ABT) Subcon</td>
<td>Korea (STW) LCD-Drive USA Memory USA (PacTech) SubCon Philippines</td>
</tr>
<tr>
<td>2001</td>
<td>300 mm</td>
<td>USA 300 mm France Q4/06 Germany Q2/07 300 mm</td>
</tr>
<tr>
<td>2002</td>
<td>300 mm</td>
<td>USA 300 mm France Q4/06 Germany Q2/07 300 mm</td>
</tr>
<tr>
<td>2003</td>
<td>300 mm</td>
<td>USA 300 mm France Q4/06 Italy Q4/06 Germany Q3/07</td>
</tr>
<tr>
<td>2005</td>
<td>France</td>
<td>Germany Q3/07</td>
</tr>
<tr>
<td>2006</td>
<td>France Q4/06</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>France Q3/07</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Pac Tech Group Worldwide Wafer Bumping Capacity

<table>
<thead>
<tr>
<th>Year</th>
<th>&lt;4-8&quot; Wafer&gt;</th>
<th>&lt;12&quot; Wafer&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2006</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pac Tech GmbH</td>
<td>600k</td>
<td>100k</td>
</tr>
<tr>
<td>Pac Tech USA</td>
<td>600k</td>
<td>150k</td>
</tr>
<tr>
<td>ABT (&quot;Pac Tech Japan&quot;)</td>
<td>450k</td>
<td>-</td>
</tr>
<tr>
<td><strong>2007</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pac Tech GmbH</td>
<td>600k</td>
<td>100k</td>
</tr>
<tr>
<td>Pac Tech USA</td>
<td>600k</td>
<td>150k</td>
</tr>
<tr>
<td>ABT (&quot;Pac Tech Japan&quot;)</td>
<td>600k</td>
<td>-</td>
</tr>
<tr>
<td>Pac Tech Asia</td>
<td>300k</td>
<td>100k</td>
</tr>
<tr>
<td><strong>2008</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pac Tech GmbH</td>
<td>600k</td>
<td>100k</td>
</tr>
<tr>
<td>Pac Tech USA</td>
<td>600k</td>
<td>150k</td>
</tr>
<tr>
<td>ABT (&quot;Pac Tech Japan&quot;)</td>
<td>600k</td>
<td>-</td>
</tr>
<tr>
<td>Pac Tech Asia</td>
<td>600k</td>
<td>150k</td>
</tr>
</tbody>
</table>
III

Electroless Ni/Au Bumping

- eless NiAu on Al
- eless NiAu on Cu
- eless NiPdAu
Under Bump Metal Process

Electroless Plating of Ni/Au Bumps on Al pad 1/2

- Backside Coating
- Pad Cleaning
- Pad Activation
- Electroless Nickel
- Flash Gold
- Coating Removal
Under Bump Metal Process

Electroless Plating of Ni/Au Bumps on Al pad 2/2
Electroless Ni/Au on Copper Pad

Backside Coating
Pad Cleaning
Pd Treatment
Electroless Nickel
Flash Gold
Coating Removal
Electroless Ni/Pd/Au Bumping on Al

Backside Coating
Aluminum Cleaning
Zincate Pretreatment
Electroless Nickel
Electroless Palladium
Immersion Gold
Coating Removal
25µm Ni/Au UBM on RFID-Wafers 1/2

Customer A
Wafer Level RDL & Ni/Au-Bumping
Applications

RFID-Tag
Flip chip on coil for contactless smart cards
Flip Chip Modules for contactless Smart Cards

Substrate handling: reel to reel
Assembly: Laplace soldering Flip chip attach
IV
Equipment for Electroless Ni/Au UBM
Pacline 300 - A50

8 Plating Systems in the Field

300 mm
Pacline 300 - A50

- Capability for parallel processing of 3 carriers with 50 wafers 8" or 3 carriers with 26 wafers 12"
- UPH: max. 150 Wafers 8"/hour or max. 78 wafers 12"/hour (5µm Ni/Au UBM)
- Thick Au ability for wire bonding reliability
- Ni bath control with ConPac 2.0 (bath conditioner) and ConPac control set
- Central Computer Control Unit (CCCU)
- PLC with Profi Bus system
- Additional security tanks for each module and pump system
- Design will be adapted to customer's facility
- SECS GEM Interfacing
- The system fulfils the fire safety standard FM 4910
Advantages of PacLine 300 A50 & electroless Ni/Au UBM

1) **Low Capital Investment Cost**
   - ElectroPlating: 10-20 Mio US$
   - Electroless UBM + Solder Print/Ball: 3-5 Mio US$

2) **High Throughput**
   - 600,000 wafers per year 8"; 312,000 wafers 12" per year

3) **Maskless Process**
   - No tooling required

4) **Low Process Cost compared to Electroplating**
   - Low Cost Process (~20 US$ per wafer for high volume in house processing)

5) **Compatible for wafers from 4" to 12"**
   - no additional invest for different wafer sizes

6) **Proven Reliability**

8) **Compatibility with all FC-Assembly processes**
   - Soldering
   - ACF
   - NCP

9) **Suitable for Al and Cu pad metallization**

10) **Compatibility with Wire Bonding**
    - Revolution: *one pad metallization for wire bonding and Flip Chip*
V

Soldering (Paste Printing)
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

Certified DIN EN ISO 9001; TS 16949 conform
Stencil Solder Printing Process Flow

*SnPb37, Lead-free: SnAgCu*

Electroless Ni/Au Bumping

Solder Paste Printing

Reflow

Wafer Cleaning

Wafer Inspection

Pack & Ship
Solder Printing on 300mm Wafer
Solder Printing on 300mm Wafer

- 739,840 I/O's
- 680 I/O per chip
- 1,088 Chips per wafer
- 225µm pitch
- 100µm pad size
- 70µm solder height
VI

Soldering (Micro Gang Ball Placement)
Automatic Gang Ball Placer for Micro Ball Placement 1/2

- Cassette to Cassette robot handling f. wafer up to 12"
- Integrated rework capability
  - 100% yield
- 2x optical inspection
  - 1st after ball transfer
  - 2nd after repair
- min ball size 80µm
- pre-fluxing by printing/spraying
- UPH 5min/Wafer (8"

1st fully auto machine already installed in Japan

300 mm Capability!
Automatic Gang Ball Placer for Micro Ball Placement 2/2

- 8“ Wafer
- Pitch 200µm
- 400,000 I/O’s
- 100µm solder balls SnAgCu
Wafer Level CSP Application

- eutectic SnPb or lead-free
- pitches: 120µm or higher
- wafer sizes: 4” – 8”
- solder ball diameter: 80 - 500 µm
Semiautomatic Gang Solder Ball Placer GBP 200

- 4” - 8” Wafer
## Comparison

<table>
<thead>
<tr>
<th></th>
<th>Ball Drop Process</th>
<th>Solder Transfer by GBP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tooling (time)</strong></td>
<td>4 – 6 weeks</td>
<td>1 week</td>
</tr>
<tr>
<td><strong>Tooling (cost)</strong></td>
<td>~ 2,500 $</td>
<td>500 – 1,000 $</td>
</tr>
<tr>
<td><strong>Ball size</strong></td>
<td>≥ 300µm (250µm)</td>
<td>80 - 500µm</td>
</tr>
<tr>
<td><strong>Pitch</strong></td>
<td>≥ 500µm (400µm)</td>
<td>120µm or higher</td>
</tr>
<tr>
<td><strong>Accuracy</strong></td>
<td>± 10µm</td>
<td>± 10µm</td>
</tr>
<tr>
<td><strong>UPH</strong></td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td><strong>Yield</strong></td>
<td>≤ 30 missing balls @ 80k</td>
<td>≤ 5 missing balls @ 80k</td>
</tr>
<tr>
<td><strong>Techn. limits</strong></td>
<td>Pitch, Layout density, fluxing</td>
<td></td>
</tr>
<tr>
<td><strong>Capital cost</strong></td>
<td>~ 300k $</td>
<td>~ 275k $ + Fluxing (semiauto)</td>
</tr>
</tbody>
</table>

Certified DIN EN ISO 9001; TS 16949 conform
Contacts:

### Pac Tech GmbH

<table>
<thead>
<tr>
<th>Contact</th>
<th>Telephone</th>
<th>Fax</th>
<th>E-mail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Elke Zakel</td>
<td>+49-3321-4495-100</td>
<td>+49-3321-4495-110</td>
<td><a href="mailto:zakel@pactech.de">zakel@pactech.de</a></td>
</tr>
<tr>
<td>Thomas Oppert</td>
<td>+49-3321-4495-100</td>
<td>+49-3321-4495-110</td>
<td><a href="mailto:oppert@pactech.de">oppert@pactech.de</a></td>
</tr>
</tbody>
</table>

www.pactech.de

### Pac Tech USA Inc.

<table>
<thead>
<tr>
<th>Contact</th>
<th>Telephone</th>
<th>Fax</th>
<th>E-mail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Thorsten Teutsch</td>
<td>+1-408-588-1925</td>
<td>+1-408-588-1927</td>
<td><a href="mailto:teutsch@pactech-usa.com">teutsch@pactech-usa.com</a></td>
</tr>
</tbody>
</table>

www.pactech-usa.com