Atmospheric Plasma
Applications in Electronic Packaging
Surface treatment tool
The PlasmaPen™ is an atmospheric gas plasma system used to clean and modify the surface properties of a material.

The PlasmaPen™ is ideally suited for in situ precision cleaning and activation of materials during manufacturing assembly and packaging.
Industrial Applications | Corona

Plasma Pen™ schematic

- Cooling gas
- Process gas
- Quartz tube
- High Voltage, 3.5kV (1.2-0.9kV/<100mA)
- Dielectric Barrier Discharge channel
- Plasma Plume

5 to 7 mm
Treatment are regimes
PlasmaPen™ technology niche

- **Micro point**
  Diam. = (sub-mm)

- **Spot**
  Diam. = (10 – 20 mm)

- **Spot Array**
  (30 – 100 mm) x (10 – 20 mm)

- **Linear**
  (100 – 2000 mm) x (10-20)

- **Planar**
  Diam. = (100 – 2000 mm) x (100 – 2000)
Treatment are regimes
PlasmaPen™ technology niche
Control Features and Options
Hardware - RoboPen
Applications
Atmospheric Plasma Applications in Device Packaging

Plasma pre-wirebonding

**Plasma Pre-Wirebonding**

- Maximizes bond strengths
- Minimizes non-sticks
- Minimizes bonding power for delicate dies
Atmospheric Plasma Applications in Device Packaging

Plasma pre-wirebonding - Wire Pull strengths

Wire Pull Strength Improvement after MW Plasma Treatment

![Graph showing wire pull strength improvement before and after plasma treatment.](image)
Wire bond pull strength distributions are shown for before and after plasma treatment. Component distributions for lead lifts and heel breaks are also shown under each main curve. The insert shows a graphic for the increased percentage wire break after plasma treatment.
Applications
Treatment prior to thin die wirebonding

Pull Strength versus Power
Aluminum Bond Pads

Bond Lifts
- Untreated
- After plasma

Pull Strength / gram force
Non-Sticks / %
Bonding Power / arb. units

Line graph
Bar graph
Graph legend:
- Non-stick plasma
- Non-stick untreated
- Without plasma bond pull
- Plasma bond pull
Applications
Treatment prior to thin die wirebonding

Wire Bonding Performance on Aluminum

<table>
<thead>
<tr>
<th>Power = 35</th>
<th>Power = 40</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% non-sticks</td>
<td>0% non-sticks</td>
</tr>
<tr>
<td>26% lifts</td>
<td>20% non-sticks</td>
</tr>
<tr>
<td>35% lifts</td>
<td>100% lifts</td>
</tr>
</tbody>
</table>

Untreated Al bond pads achieved 0% lifts at power > 55

Pull Strength / gf

Plasma
Untreated

Low Bonding Parameters (Zero non-stick)
High Bonding Parameters (Zero lifts)
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Plasma pre-wirebonding - Ball shear strengths

Ball Bond Strength Improvement after MW Plasma Treatment

<table>
<thead>
<tr>
<th>Ball Shear / gf</th>
</tr>
</thead>
<tbody>
<tr>
<td>34</td>
</tr>
</tbody>
</table>

- No Plasma
- After Plasma

- Range
- 5th/95th percentile
- Average
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Plasma pre-wirebonding - Non stick elimination

Elimination of non-stick after MW plasma

- 7 non sticks (NSOL) before MW plasma
- 0 non sticks (NSOL) after MW plasma

Ball shear / gf

Reference O2 plasma

CPK value

PBGA
GigaBatch 690
Applications
Die attach
Applications

Die attach

90% Adhesive-adhesive failure mode

10% Au-adhesive failure mode

Namics U844314 cured at 150° C for 1 hr.
Taiyo solder mask
Dage die shear system

Die attach / shear strengths

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>LP Plasma</td>
<td>40</td>
<td>5</td>
</tr>
<tr>
<td>Atm. Plasma</td>
<td>50</td>
<td>5</td>
</tr>
</tbody>
</table>

Post shear
Applications

Die attach

K. 1x1 Kovar coupon substrate without PlasmaPen™

Die size, 193x185x4

C1. 1x1 Kovar coupon substrate with PlasmaPen™
Applications

Reduction of oxides on copper and nickel
B-IV. Plasma Applications in Device Packaging

Plasma pre-underfill

Underfill wicking speed improvement with plasma treatment

Die size = 19.73 x 19.65 mm
Underfill dispensed at 85°C

Fillet height:
No Plasma = 25%
With plasma = >75%

Wicking Speed - mm/s

<table>
<thead>
<tr>
<th>No Plasma</th>
<th>After Plasma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voids observed</td>
<td>No Voids</td>
</tr>
</tbody>
</table>

UF CSAM
How does plasma improve potting?

Plasma treatment increases wettablility of polymers to potting compounds by chemically adding polar functional groups to the surface. The result is no skips, voids, blisters, or bleeding caused by incomplete wetting of the encapsulant.

For other materials, (glass, ceramics, metals *etc*) a more wettable surface results primarily because oily surface residues are removed by the plasma.
Aircraft cable repair

Aircraft and other heavy cable insulation can be repaired *in situ* using the PlasmaPen™. The damage can be overmolded or encapsulated successfully by the adhesion promotion properties of the plasma.
PlasmaPen™ modes of operation

Modes of operation

- Hand Held
- Robotic arm / Cartesian table
- Inline
- On-board
Evolution of plasma surface treatment in manufacturing

1. Low pressure batch processing
2. Low pressure in-line processing
3. Atmospheric in-line processing
4. Atmospheric in-situ / on-board processing
Market Applications
High potential for OEM partnerships

Dispensers
- Adhesive
- Inking / marking
- Potting
- Encapsulation
- Flip chip under-fill
- Patterning circuitry
- Assay / reservoir fill

Bonders
- Mounting
- Welding
- Soldering
- Wire bonding
Advantages of in-situ treatment

- Easy integration either in-line or on-board
- No substrate staging means faster production flow
- Plasma applied locally
- Subsequent processes performed immediately after treatment
- No voltage or current in plasma plume means no damage to electronic devices
- Low operating costs – compressed air
- Low capital cost compared to vacuum plasma
Reactant gas: Compressed air (6 Bar, (88 psi), 1000 liters/hour (15 f³/h))
Other gases: N₂, N₂/H₂, O₂, CO₂, He

Treatment width: 8-10 mm at 10 mm distance

No voltage or current in plasma plume

Lifetime of the electrode tip: >1500 hours

Standard umbilical length: 9 feet

Electricity: 115 VAC, 1 phase, 60 Hz or 230 VAC, 1 phase, 50 Hz

CE Certified
Standards and Compliances

- NFPA79, NFPA70
- CE
  - Directives:
    - 2006/95/EC, Low Voltage Directive
    - Standard IEC EN 61010
    - 2004/108/EC Electromagnetic Compatibility
    - Standard IEC EN 61326
    - CISPR 55011

- ISO
  - ISO9001: 2000
Thank you for listening