Henkel Enabling Materials for Semiconductor and Sensor Assembly

TechLOUNGE, 14 November 2017
Content

- Brief HENKEL Introduction and ELECTRONICS Focus Areas

- Innovative Semiconductor and Sensor Assembly Solutions
  - Package level EMI shielding solutions
  - Advanced semiconductor packaging materials
  - High conductivity semi sintering die attach adhesive
  - Ultra-low and stable modulus materials for MEMS sensors
  - Low outgassing and low temperature cure materials for CMOS image and biometric sensor packaging
Who We Are
Globally Leading in Consumer and Industrial Businesses

- Headquartered in Düsseldorf (DE)
- Preferred stocks since 1985, family owns >59% of ordinary stocks
- Henkel products and technologies available worldwide
- 170 manufacturing and 21 major R&D sites around the world
- Employees from 125 nations

More than 50,000 employees

Around €18.7 bn sales, +3.1% OSG
Henkel Adhesive Technologies
Five Strategic Business Areas

- **Global adhesive market leader** with app. 25,000 employees and €9 billion sales
### Henkel Adhesive Electronics
Assembly Solutions vs Market Needs

#### Henkel Solutions

<table>
<thead>
<tr>
<th>Market Needs</th>
<th>Manufacturing Efficiency (uph)</th>
<th>High Reliability</th>
<th>Miniaturization</th>
<th>Sustainability</th>
</tr>
</thead>
</table>

#### EMI Shielding, Pastes, Coatings

- Die Attach Adhesives
- EMI Shielding, Pastes, Coatings

#### Underfills, Pastes, Films & Liquids

- Underfills & Encapsulants
- Inks & Coatings

#### Liquid Encapsulants, Thermal & UV Cure, Compression Molding

- Solder Materials

#### Die Attach Adhesives, Pastes, Films & B-Stage

- Thermal Materials

- Electrically Conductive Adhesives and Inks, Solder Pastes
Henkel Adhesive *Electronics*
By Acquisition and Brands

- **1997**: LOCTITE
  - PCB Assembly
  - Adhesive & Coating

- **2000**: Hysol
  - PCB Assembly
  - Soldering
  - Semiconductor & PCB Encapsulation

- **2008**: Emerson Cuming
  - PCB Assembly
  - Adhesive & Potting
  - Printed Electronics

  - Acheson
    - Semiconductor
    - Die Attach

- **2014**: Beroquist
  - Thermal Interface

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**Our Manufacturer Brand**

**Our Technology Brands**

- LOCTITE
- BONDERITE
- TECHNO MELT
- TEROSON
- AQUENCE
Henkel Adhesive Electronics
Fostering Technology Leadership with Strong Innovations

Conductive Die Attach Film
- Technology leading solution for thin wafer, small die and multi-chip devices
- Design enabling innovation

EMI Shielding Materials
- Innovative electromagnetic interference (EMI) shielding solutions
- For in-package compartment and surface shielding

Room Temperature Stable Solder
- Industry leading performance with resistance to harsh environments
- Sustainability by improved logistics

Thermal Interface Gap Filler
- Leading supplier of liquid dispensed Gap Filler technology
- Sustainability by reduced waste versus Gap Pads
Semiconductor & Sensor Assembly Focus Areas
Applications & Product Technologies

Wirebond Semiconductor
- Wirebond & Discretes
- Power, RF, Embedding

Sensors & Modules (System in Package)
- MEMS & Sensors
- Finger Print Sensors
- CMOS Image Sensors
- EMI Shielding

Advanced Semiconductor
- Wafer Level Packaging
- Flip Chip, TSV (3D IC)

Die Attach (Conductive, Non-Conductive, Paste, B-Stage, Film, Ag Sintering)

Liquid & Film Encapsulants, Conductive Coatings (EMI Shielding), First Level Underfill (ACP, CUF, NCP, WAUF)

Focus on Specialized Adhesives, Encapsulants and Coatings in Liquid, B-Stage or Film Format for Semiconductor and Sensor Assembly
Package Level EMI Shielding Solutions
Compartment Shielding using Jet Dispense Process

- **LOCTITE ABLESTIK ABP 2821** – Highly conductive trench filling adhesive designed for compartment EMI shielding in SiP’s used in Mobile and Wearable Devices
  - Unique high aspect ratio trench filing product down to 120um wide and >1mm deep
  - Compatible with all methods of conformal shielding

![Image of LOCTITE ABLESTIK ABP 2821](image)

- Aspect Ratio = 10:1
- Void Free

![Diagram of EMI Shielding](image)
Package Level EMI Shielding Solutions
Conformal Shielding using Ultrasonic Spray Process

- **LOCTITE ABLESTIK EMI 8880S** –
  Highly conductive and **spray-able coating**
  - Excellent adhesion on untreated mold compound
  - **Uniform sidewall and top coating thickness within 3-10um by adjusting flow rate and spray speed**

Mount devices on chosen carrier (singulated, panel, strip, etc.)
Load carrier or chosen vehicle into spray chamber
Specialized spray with optimized parameters
Oven cure 60 minutes at 175°C (batch mode)
Pick up components

No treatment, in-air spray!
Advanced Semiconductor Packaging
Henkel Product Offering

Advanced Packaging

Flip Chip
- CSP
  - CUF
  - NCP
  - NCF
- BGA
  - CUF
  - Lid Attach
  - TIM1 (BQ)
- PoP
  - Gap Filling
  - IP Attach (WIA)

Wafer Level
- Fan-In
  - BSP (Back Side Prot.)
  - FSP (5 Side Prot.)
- UV WBC
- Fan-Out
  - DAF (Face Up)
  - LCM (Liquid Molding)

Memory 3D TSV
- NCF (WAUF)
Liquid Compression Molding (LCM) Standard Fan-Out WLP Process (eWLB)

Thermal Release Tape on Carrier → Die P&P on Carrier → Dispensing on Die → Compression Molding & Post Mold Cure (PMC)

Remove Carrier → Back Grinding → Redistribution Layer (RDL) → Ball Mount & Simulation

Join today’s Advance Packaging Conference paper at 5:15pm “Ultra-Low Warpage LCM Development for Advanced WLP”
Liquid Compression Molding (LCM)

“Trench Filling” Process for 5/6-Side WLCSP Protection

- Wafer from Foundry
- Copper Pillar Pad
- Trench Dicing (half cut)
- Back Side Grinding
- Top Side Grinding for Pad Exposure
- Trench Filling by Liquid Compression Molding
- Film or Print to Back Side for 6 Side Protection
- Dicing to Single Units
- Protected WLCSP
- Excellent filling 40um width, 400um depth without voiding
Innovative Underfill Solutions

- **C4 Process**
  - Pitch: >75um
  - Steps: Dispense Underfill, Capillary Flow, Cure

- **Cu Pillar Process**
  - Pitch: >30um
  - Steps: Dispense, Cure

- **NCF Process**
  - Pitch: >15um
  - Steps: Film Lamination, Wafer Dicing, Cure

**TC Bonding = One Process**

**NCP & NCF Technology enabling Reliable Fine Pitch Flip Chip Cu Pillar and TSV Die Stacking using Thermal Compression (TC) Bonding**
Non Conductive Paste (NCP)
Best in Class Adhesive for Cu Pillar

- **LOCTITE ECCOBOND NCP 5209** – Fast curing hybrid adhesive designed for Thermal Compression Bonding (TCB) of *very fine pitch Cu Pillar* Flip Chip devices
  - NCP high volume runner with long staging time (>60 min 70°C)
  - Typical TCB cure within 2-4 seconds @ 240-280°C
  - High Tg of 180°C and low ionics (<5ppm)

### Application Process

![Application Process Diagram]

**Advantages**
- Flux embedded in NCP thus offers simple process
- Bump protection right after TC bonding
- Offers best design flexibility for Cu pillar device

**Disadvantages**
- Require TC bonder investment
- Filler entrapment risk

5209 on CuOSP

(Semicon Europa 14-17 Nov 2017 Munich Germany)

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## Non Conductive Film (NCF)

**LOCTITE ABLESTIK NCF 220 for 3D Memory**

<table>
<thead>
<tr>
<th>(20um adhesive layer)</th>
<th>Unit</th>
<th>NCF 220</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filler loading</td>
<td>%</td>
<td>40</td>
</tr>
<tr>
<td>Transmittance @555nm</td>
<td>%</td>
<td>85</td>
</tr>
<tr>
<td>Melt Viscosity (lowest point)</td>
<td>Pa·s</td>
<td>1727</td>
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<tr>
<td>Lowest MV temperature</td>
<td>°C</td>
<td>138</td>
</tr>
<tr>
<td>DSC onset / peak temp</td>
<td>°C</td>
<td>162 / 169</td>
</tr>
<tr>
<td>B-stage TGA @150°C / @250°C</td>
<td>%</td>
<td>0.57 / 1.09</td>
</tr>
<tr>
<td>Tg by post mold cure TMA 10°/min</td>
<td>°C</td>
<td>120</td>
</tr>
<tr>
<td>CTE 1 / CTE 2</td>
<td>ppm/°C</td>
<td>31 / 147</td>
</tr>
<tr>
<td>Tg by post mold cure DMA 5°/min, tanδ</td>
<td>°C</td>
<td>163</td>
</tr>
<tr>
<td>Storage Modulus @25°C / @250°C</td>
<td>GPa</td>
<td>8.9 / 0.13</td>
</tr>
<tr>
<td>Post mold cure Ionics Na+ / K+ / Cl-</td>
<td>ppm</td>
<td>5 / 1 / 3</td>
</tr>
</tbody>
</table>

### Option 1 (In Production)

Bond each die in the stack individually (recommended)

### Option 2 (Collective Bond)

Tack each die in place at lower temp then press with hot bond head
UV B-stage Wafer Backside Coating (UV WBC) Transparent “Liquid DAF”

- **LOCTITE ABLESTIK WBC 8901UV** – Non Conductive UV Curable Wafer Backside Coating offering **Lower Total Cost of Ownership than Dicing Die Attach Film (DDF)**

  - Adjustable **adhesive thickness below 10um** by spin coating or spray control
  - Compatible with most common UV dicing tapes in market (excellent pickup >0.2mm)
  - Passing MSL2 @ 260ºC preconditioning up to 11x11mm die size
  - Alternative bonding solution for “ultra thin, ultra small die” using **Dicing Before Grinding (DBG)** process

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**Diagram:**
- 2 mil, 200 micron wafer with a 10 micron thickness coating of Ablestik WBC-8901UV
- Spray coat of wet adhesive
- B-staged film by UV irradiation
UV B-stage Wafer Backside Coating (UV WBC)
“DBG + Liquid DAF” Process Overview

- Spray & UV B-stage 10-25um Adhesive Layer on Die
- Mount on Dicing Tape, Remove BG Tape and Move to Die Pick-up & Die Bonding
UV B-stage Wafer Backside Coating (UV WBC)
LOCTITE ABLESTIK WBC 8901UV Bonded Die Images

- Cross sections after die bonding and cure showing uniform bond line thickness (BLT)

- 0.2x0.2mm Die with 2um BLT
- 0.3x0.3mm Die with 3um BLT
- 0.5x0.5mm Die with 6um BLT
- 1.0x1.0mm Die with 8um BLT
High Conductivity *Semi Sintering* Die Attach Adhesive
LOCTITE ABLESTIK ABP 8068TA Structure & Toughness

- Polymer hybrid system with relatively high 5% elongation @ break vs pure Ag sintering and Ag filled adhesive
High Conductivity *Semi Sintering* Die Attach Adhesive

In-Package Thermal Resistance (Rth)

- **LOCTITE ABLESTIK ABP 8068TA proving**
  - Much lower Rth compared to Ag adhesives like Loctite Ablestik QMI 529HT
  - Rth of 0.5 K/W comparable to soft solder (0.45 K/W)
  - Same Rth level on multiple lead frames *incl. copper*

![In-package thermal comparison with ABP8068TA and QMI529HT](chart)

**SEMICON EUROPA**

Henkel Enabling Materials for Semiconductor & Sensor Assembly

November 20, 2017
High Conductivity *Semi Sintering* Die Attach Adhesive
Dispensing, Fillet Height, Coverage & (No) Voiding

- Dispensing and processing like standard conductive die attach materials in use
- App. 65~70% fillet height (30um BLT), 100% coverage and *no voiding* (by X-Ray)
High Conductivity *Semi Sintering* Die Attach Adhesive

**Moisture Sensitivity Level**

- LOCTITE ABLESTIK ABP 8068TA passing MSL1 on 5x5mm Ag BSM die on PPF lead frame

<table>
<thead>
<tr>
<th>T-SCAN Before MSL1</th>
<th>DA</th>
<th>DP</th>
<th>DT</th>
<th>DA &amp; DP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0/24</td>
<td>0/24</td>
<td>0/24</td>
<td>0/24</td>
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</table>

<table>
<thead>
<tr>
<th>T-SCAN After MSL1</th>
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</thead>
</table>

<table>
<thead>
<tr>
<th>C-SCAN After MSL1</th>
</tr>
</thead>
</table>
High Conductivity *Semi Sintering* Die Attach Adhesive

### High Temperature Storage

- **LOCTITE ABLESTIK ABP 8068TA** showing increased Hot Die Shear Strength (HDSS) @ 260°C after 500hrs @ 200°C storage

  Measured on 3x3mm Au BSM die on Ag L/F, 20min ramp to 130°C, hold 30min + 15min ramp to 200°C, hold 1hr, N2 atmosphere

Join today's Advance Packaging Conference paper at 4:00pm “Effect of 200°C and Chemical Base on Conductive Die Attach”
Adhesives for MEMS & Sensors
Technology Drivers

- **Low temperature** processing
  - Temperature sensitive SiP’s such as CIS, FPS and MEMS going through multiple thermal cycles
  - Target processing at 80°C or below

- **Low stress, low warpage** materials
  - Accurate and stable sensor performance over full functional temperature range
  - Low and constant modulus needed for MEMS
  - Requirement for low warpage often related with low stress and low temperature conditions

*Henkel Providing a Broad Portfolio of Low Temperature, UV, and Dual Cure Adhesives*
Adhesives for MEMS & Sensors

Typical Applications Running in High Volume

Microphone, Pressure Sensors

- Lid / Cap Attach
- ASIC Attach
- Glob Top
- MEMS Attach

Optical Sensors

- LCP Lid
- ASIC Die
- LED Die

Accelerometers, Gyroscope, Magnetometers

- ASIC Attach
- MEMS Attach
Adhesives for MEMS & Sensors
Henkel Product Offering

MEMS Sensors

- Value added:
  - Low temperature cure down to 80°C
  - Ultra-low, stable & customized modulus
  - High adhesion on LCP & metal finishes
  - Low outgassing

Driving modulus further down below 1 MPa from -25°C up to 300°C for very stress sensitive MEMS applications
CMOS Image Sensor Technology
Camera Module Adhesive Applications

5 | Instant bonding of Lens Barrel
4 | Fixture of Lens Barrel
3 | Bonding of IR filter to Lens holder
2 | Bonding of Lens holder to substrate
1a | Die Attachment
1b | Underfill
Adhesives for MEMS & Sensors
Henkel Product Offering

CMOS Image Sensors

- Value added:
  - Fast (UV) and or low temperature cure
  - High adhesion and low warpage on engineering plastics (like LCP) & metals
  - Low outgassing

Low Temperature Cure Down to 60°C
Please Visit Us in Hall B1, Booth 1567

Many Thanks for Your Attention!

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