Conductive Die Attach Film - CDAF

Higher Reliability Conductive Die Attach Films: Compatible with Si and GaAs Wafers

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Presented by Shashi Gupta
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Market Trends
Smaller, Faster, Higher Functionalities

- Higher density design
- Higher functionalities
- Faster signal speed
- Power Management
- Lower TCoO
- Reduce package thickness

Applications space covers consumer, mobile, computing, communication, health care, energy, industrial and automotive.
Market Trends
An Example – Source Prismark

1. Texas Instruments TWL5030 Power Manager
   • 256-CSP
2. TI/CICLON CSD25401 P-Channel NexFET Power MOSFET
   • QFN3.3x3.3
3. Fairchild FDMC510P P-Channel PowerTrench MOSFET
   • QFN 3x3mm
4. Fairchild FDMC7200 Power Trench MOSFET “non catalogue”
5. Alpha and Omega AON740130V P-Channel MOSFET
   • DFN 3x3mm
6. Intersil ISL9519 Highly Integrated Narrow VDC System Voltage
   Regulator and Battery Charger controller
   • QFP-28
7. Texas Instruments TPS63031 High Efficient Single Inductor
   Buck-Boost Converter w/1-A Switches
   • QFN-10
8. Texas Instruments PS63020 High Efficiency Single Inductor
   Buck-Boost Converter with 4A Switch
   • QFN-14
9. Texas Instruments TPD12SO15YFR HDMI Companion Chip
    with Step-up Converter, 12C Level Shifter, and High-speed ESD
    Clamps
    • WSCSP-28
Package Trends - Wirebonded
Higher Functionality & Efficiency

- Miniaturized packages (QFN, DFN, SOs)
  - Increased die-to-pad ratio
  - In some case D/P ratio close to 1.0

- Thinner packages (QFN, SO, QFP)
  - Packages <0.3mm
  - Thinner die <75um
  - Thinner DA bondline thickness <20um

- Higher density packages
  - Multi-dies packages
    - SiP – LGA/PBGA
Current Material Challenges on LFs
Conducting Die Attach Paste

- **Dispensing**: Optimize dispense patterns for various die sizes - 0.2 x0.2 mm to >10x10mm.
- **Fillet & Bleed**: Forces engineers to have a minimum keep out zone around die
- **Bondline Control**: Specially for smaller die BLT control is challenging and leads to die tilt
- **Kerf creep**: For thinner wafers uneven fillet height can lead to kerf creep
Future Material Needs
What does the market really need moving forward?

- Lower Cost
- Higher Reliability
- Zero Delamination
- Zero Bleed
- Minimal fillet
- Consistent BLT control
- Thin Wafer handling capability
- Low to no outgassing
- Drop in solution
New Materials – Conductive Die Attach Films

Controlled flow technology

Precut conductive die attach films offer a single step lamination to wafer back
Control Flow
Enables Miniaturization

- With Fillet
- Controlled Fillet

- Reduced footprint → Shorter interconnection → Faster signal speed
- Less Au wire, leadframe, EMC used → Lower TCoO
Control Flow
Thin Wafer Handling

- Thinner wafer handling enabled
- Consistent Thinner bondlines achieved
  - Eliminated Fillet
  - Eliminated bleed
Advantages of Control Flow

Package level

- Enables emerging packages:
  - Miniaturized
  - High density
  - Ultra thin

- Indirectly improves package performance:
  - Faster signal speed (shorter interconnection)
  - Better power management (low $R_{dsOn}$)
  - Better heat dissipation

- Indirectly reduces TCoO:
  - Cheaper design choice (SiP vs. SoC)
  - Less material used (high packaging density)
  - Improve yield

CDAF technology is well-aligned with emerging package trends
Henkel’s Solution to Control Flow

Product Space

- A4: Low warpage, ultra-high thermal, MSL1, <15um thick
- MSL2 on all LF finish
- MSL1 on all LF finish
- MSL2 on Laminates
- CDF 800P
- CDF 200P
- CDF 500P
- L QFN
- 2mmx2mm
- 4mmx4mm
- 6mmx6mm
- 8mmx8mm
Why CDAF has higher reliability
Paste and Film comparison

**Paste material**
- Low viscosity
- Thermoset monomer with lower molecular weight
- High cross-linking density
- Low toughness
- Lower adhesion
- Inferior MSL performance

**Film material**
- High viscosity
- Thermoset monomer with higher molecular weight (solid resins)
- Lower crosslinking density
- High toughness
- Better adhesion
- Better MSL performance
Material Benefits of cDAF
Potential for Zero Delam applications

- Conductive films do not bleed and do not have a fillet, so the adhesion of MC to LF is stronger – regardless of LF finish: smooth or rough.
- CDAF also has minimal out-gassing, which ensures clean WB bond pads & die top –
  - wirebonding or MC-die top delamination not observed
Thermal & Electrical for cDAF

Stable In-Package performance

- Thermal Conductivity [W/mK] is an intrinsic material property
- Thermal Resistance, $R_{th}$ [K/W], is a geometry dependant value that allows us to better compare materials in a functional package
  - 70 – 90% of the $R_{th}$ is due to the interfaces and is not captured in thermal conductivity values

Conductive films are designed to have optimal performance in the z-axis direction
# Portfolio of CDAF Products

Property table for film and paste

<table>
<thead>
<tr>
<th>Material Property</th>
<th>unit</th>
<th>CDF 200P</th>
<th>QMI519</th>
<th>84-1LMI SR4</th>
<th>8290</th>
<th>8008HT</th>
<th>CDF 800P</th>
<th>QMI529HT</th>
<th>CDF 500P</th>
<th>FS849-TI</th>
<th>CDF 600</th>
<th>2100A</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Volume Resistivity</strong></td>
<td>ohm-cm</td>
<td>0.0014</td>
<td>0.0001</td>
<td>0.0002</td>
<td>0.008</td>
<td>0.0006</td>
<td>0.0003</td>
<td>0.0004</td>
<td>0.0002</td>
<td>0.00002</td>
<td>0.0008</td>
<td>0.05</td>
</tr>
<tr>
<td><strong>Thermal conductivity</strong></td>
<td>W/mK</td>
<td>2</td>
<td>3.8</td>
<td>2.5</td>
<td>1.6</td>
<td>11</td>
<td>3.5</td>
<td>6.5</td>
<td>1 - 2</td>
<td>7.8</td>
<td>1</td>
<td>1.35</td>
</tr>
<tr>
<td><strong>CTE alpha 1</strong></td>
<td>ppm/C</td>
<td>48</td>
<td>40</td>
<td>40</td>
<td>81</td>
<td>37</td>
<td>40</td>
<td>53</td>
<td>60</td>
<td>44</td>
<td>75</td>
<td>65</td>
</tr>
<tr>
<td><strong>CTE alpha 2</strong></td>
<td>ppm/C</td>
<td>120</td>
<td>140</td>
<td>150</td>
<td>181</td>
<td>62</td>
<td>118</td>
<td>156</td>
<td>245</td>
<td>155</td>
<td>155</td>
<td>320</td>
</tr>
<tr>
<td><strong>Tg</strong></td>
<td>°C</td>
<td>15</td>
<td>75</td>
<td>120</td>
<td>38</td>
<td>264</td>
<td>11</td>
<td>3</td>
<td>10</td>
<td>211</td>
<td>-</td>
<td>60</td>
</tr>
<tr>
<td><strong>Modulus @ 25°C</strong></td>
<td>Mpa</td>
<td>5,400</td>
<td>5,300</td>
<td>3,930</td>
<td>3,034</td>
<td>6,659</td>
<td>7,100</td>
<td>3,300</td>
<td>11,300</td>
<td>7,800</td>
<td>3,000</td>
<td>3,200</td>
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<tr>
<td><strong>Performance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>HDSS (260°C) on Ag</strong></td>
<td>kg/mm²</td>
<td>1.3</td>
<td>0.8</td>
<td>0.2</td>
<td>0.6</td>
<td>0.7</td>
<td>1.0</td>
<td>0.5</td>
<td>0.7</td>
<td>0.5</td>
<td>0.7</td>
<td>0.4</td>
</tr>
<tr>
<td><strong>Room Temp DSS on PPF</strong></td>
<td>kg/mm²</td>
<td>2.14</td>
<td>4.9</td>
<td>3.0</td>
<td>5.0</td>
<td>-</td>
<td>&gt; 2.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Room Temp DSS on Ag</strong></td>
<td>kg/mm²</td>
<td>3.02</td>
<td>4.8</td>
<td>2.3</td>
<td>5.1</td>
<td>1.5</td>
<td>&gt; 2.0</td>
<td>2.2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Room Temp DSS on Cu</strong></td>
<td>kg/mm²</td>
<td>3.17</td>
<td>1.8</td>
<td>1.2</td>
<td>2.5</td>
<td>1.5</td>
<td>&gt; 2.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Failure Mode</strong></td>
<td></td>
<td>Cohesive</td>
<td>Cohesive</td>
<td>Cohesive</td>
<td>Cohesive</td>
<td>-</td>
<td>Cohesive</td>
<td>Cohesive</td>
<td>Cohesive</td>
<td>-</td>
<td>Cohesive</td>
<td>Cohesive</td>
</tr>
<tr>
<td><strong>Thermal Resistance, Rth</strong></td>
<td>K/W</td>
<td>1.5</td>
<td>1.3</td>
<td>0.83</td>
<td>1.8</td>
<td>1.5</td>
<td>0.81</td>
<td>0.77</td>
<td>1.5</td>
<td>0.72</td>
<td>2.1</td>
<td>2.3</td>
</tr>
<tr>
<td><strong>RDSon</strong></td>
<td>ohm</td>
<td>0.075</td>
<td>0.044</td>
<td>0.033</td>
<td>0.067</td>
<td>0.032</td>
<td>0.042</td>
<td>0.055</td>
<td>0.038</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>RDSon Shift (500 TC)</strong></td>
<td>%</td>
<td>2.2</td>
<td>n/a</td>
<td>10.0</td>
<td>n/a</td>
<td>5.7</td>
<td>42</td>
<td>n/a</td>
<td>28.0</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>RDSon Shift (1000 TC)</strong></td>
<td>%</td>
<td>6.6</td>
<td>15.6</td>
<td>16.0</td>
<td>n/a</td>
<td>6.4</td>
<td>42</td>
<td>n/a</td>
<td>28.8</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>JEDEC MSL 260°C (on 7x7mm PPF QFN with 2.5x2.5x0.33 die)</strong></td>
<td>MSL level</td>
<td>1</td>
<td>MSL1 capable for small die</td>
<td>3</td>
<td>MSL1 capable for small die</td>
<td>3</td>
<td>1</td>
<td>MSL1 capable for small die</td>
<td>1</td>
<td>MSL1 capable for small die</td>
<td>2 (PBGA)</td>
<td>2 (PBGA)</td>
</tr>
<tr>
<td><strong>JEDEC MSL 260°C (on 7x7mm PPF QFN with 5x5x0.36 die)</strong></td>
<td>MSL level</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>1</td>
<td>3</td>
<td>2 (PBGA)</td>
<td>2 (PBGA)</td>
</tr>
<tr>
<td><strong>Processing</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cure</strong></td>
<td>profile</td>
<td>30 min ramp to 200°C + 1hr soak @ 200°C</td>
<td>30 min ramp to 175C + 1hr soak @ 175C</td>
<td>30 min ramp to 175C + 15min soak @ 175C</td>
<td>20 seconds @ 280°C</td>
<td>30 min ramp to 200C + 1hr soak @ 280°C</td>
<td>30 min ramp to 185C + 30min soak @ 185C</td>
<td>30 min ramp to 200C + 1hr soak @ 200C</td>
<td>30 min ramp to 175C + 30min soak @ 175C</td>
<td>30 min ramp to 175C + 100C/30min + 30 min ramp + 170C/1hr</td>
<td>30 min ramp to 175C + 15min soak @ 175C</td>
<td></td>
</tr>
</tbody>
</table>
Thermal Resistance
Comparison of paste and film materials

2.5x2.5x0.36mm² Si-back die
QFN 7x7mm, PPF (pad 5.8x5.8mm)
30min RAMP + 200°C 1hr cure
RDS_{on}
In package performance

2.0x2.9x0.18\text{mm}; \text{TiNiAg-back die}
TO-220, Cu pad
## Conductive Die attach Film

### Laser Dicing

<table>
<thead>
<tr>
<th></th>
<th>Blade Dicing</th>
<th>Laser Dicing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Process method</strong></td>
<td>Mechanical cutting</td>
<td>Surface absorption laser process (melting, evaporation)</td>
</tr>
<tr>
<td><strong>Water (cooling / cleaning)</strong></td>
<td>Required</td>
<td>Required for cleaning only</td>
</tr>
<tr>
<td><strong>Chipping?</strong></td>
<td>Yes</td>
<td>Less chipping</td>
</tr>
<tr>
<td><strong>Debris generation?</strong></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>T-shape and round shape dicing</strong></td>
<td>Not possible</td>
<td>Possible in certain cases</td>
</tr>
<tr>
<td><strong>Ultra-thin wafer dicing possible?</strong></td>
<td>Limited</td>
<td>Possible</td>
</tr>
<tr>
<td><strong>Kerf Width</strong></td>
<td>15 to 25 µm</td>
<td>Less than 15µm</td>
</tr>
<tr>
<td><strong>Processing speed</strong></td>
<td>5 to 10 mm/s</td>
<td>225 mm/s</td>
</tr>
</tbody>
</table>

CDAF is compatible with both blade and laser dicing on Si or GaAs waders
Advantages of Control Flow

CDAF – Material Advantages

• **Thin wafer handling with precut format**
  - Excellent electrical conductivity, very low RDSon shift (<10%)
  - Thinner package and smaller footprint (higher density packaging)
  - Potentially eliminate wafer backside metallization
  - In multi-die packages allow shorter die-to-die wirebonds for faster speeds.

• **Consistent bondline thickness and controlled flow**
  - No die tilt,
  - Design flexibility from tight clearance between die and die pad

• **Clean dry process**
  - No dispensing, printing/B-staging necessary
  - No bleed (even on rough LFs), no fillet, uniform bondline, no kerf creep

• **Reliability performance**
  - Higher reliability performance (MSL1) on multiple substrates (PPF, Ag Spot, Cu) and various wafer back metallization (Si, Au, Ag)
  - Achieve better efficiency, reduce yield loss: Efficient and robust process

• **Cost Savings**
  - Higher density leadframes, shorter Au wires and less mold compound usage
Thank you!
Henkel Electronics Adhesives Headquarters
Irvine, California

Alan Syzdek
Corp Sr. Vice President
Serving our Customers Worldwide
Adhesive Electronics Global End to End Business

- Henkel has a global presence with a footprint in every geography.
- Globally aligned infrastructure to serve our customers locally.

Estimated Employees: 1,700