Low Cost Adhesives for Temporary Substrate Support During Thinning and Backside Processing

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Daetec, LLC
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Daetec Business Model

• **What We Do:** Product development and consulting

• **How We Do it:** Use commercially available ingredients, formulate, apply to a process

• **Primary Experience:** Coatings & cleaning products

• **Deliverables:** New product or ancillary

• **Clients:** Materials & equipment suppliers, end-users (manufacturing)
Product & Process Development

Eng. Curves, Adhesion

Cure Conditions - Analytical

Equipment Applications & Diagnostics

Cleans & Stability Tests

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Concept to Commercialization

Daetec

Demo → Proof of Concept → Prototype

Daetec

Client

Mass Production ← Commercial Scale-Up ← Technology Transfer

Daetec

Client

Timing, Demo – Tech Transfer ~6mos

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Daetec Working Relationship

Supporting Market Leaders

• The staff at Daetec have developed products, patented, written papers, or presented work with a wide number of leaders in the industry. Our work spans temporary adhesives used in 3DIC to PR and residue removal processes.
Typical Thin Wafer Support

- Tape
- Vacuum Chuck
- Carrier & Adhesive
## Thin Wafer support

<table>
<thead>
<tr>
<th>Thin Wafer Handling</th>
<th>Thickness Min (um)</th>
<th>Chem &amp; Therm Resistant</th>
<th>Single Wafer or Batch</th>
<th>Backside Processing Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tape</td>
<td>&gt;50</td>
<td>No</td>
<td>Both</td>
<td>No</td>
</tr>
<tr>
<td>Vacuum Chuck</td>
<td>&gt;50</td>
<td>No</td>
<td>Single</td>
<td>No</td>
</tr>
<tr>
<td>Adhesive Bonded Carrier</td>
<td>&lt;25</td>
<td>Yes</td>
<td>Both</td>
<td>Yes</td>
</tr>
</tbody>
</table>

- Thinner is Better
- Must be Resistant
- Versatility Is Best
- Must do Backside Processing

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Two ACTIVE steps occur with Temporary Bonding Technologies. The “BOND” step appears similar between popular practices. Primary differences occur during “DE-BOND”.

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Rubber, olefinic & high MW hydrocarbon polymers, blends

Acrylic, styrenic, and blends

Polyimide & silicone
Roadmap to Dicing

Film Attachment
Carrier Demount

Wafer Cleans
Safe for Tape

Dicing
## Cleaning on Film Frame

<table>
<thead>
<tr>
<th>Adhesive Type</th>
<th>Cleaning</th>
<th>Tape Compatibility</th>
<th>Cleans Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rubber, Olefinic Polymer</td>
<td>Non-polar solvent</td>
<td>Yes, RT limited time</td>
<td>Short time, cleans?</td>
</tr>
<tr>
<td>Acrylic</td>
<td>Polar solvents</td>
<td>Limited (most)</td>
<td>Cleans?</td>
</tr>
<tr>
<td>Polyimide</td>
<td>Polar solvents</td>
<td>Limited (most)</td>
<td>Cleans?</td>
</tr>
<tr>
<td>Silicone</td>
<td>Specialty blends</td>
<td>Limited, attacked</td>
<td>Unknown</td>
</tr>
</tbody>
</table>
Adhesive Governs the Process

- Process performance, compatibility
- Choice in debonding Tool, corresponding throughput & yield
- Cleaning chemistry
- Tape/Film type
- Process tuning between film & cleaning results
Low-Cost Adhesive Example #1
Semiconductor

- Thermal resistant (tunable) >200C
- Applied by spin-coating, spray, roll-coat, pipet
- Low temp cure, <150C in minutes
- Resistant to process chemistries, acids, DIW
- Low outgas at ULV (can be >150C)
- Aqueous soluble adhesive, detergent in DIW
- Comparable COO <<50%, process dependent
Washable Coating Solution Viscosities
Thickness vs. Spin-speed

- V=2577 cSt
- V=760 cSt
- V=440 cSt

Formula A-112 Spin-Coat data
Low Outgas Product (e.g. CVD)

Targets for successful CVD processing:

• Low permeability coating
• High Tg
• If amorphous, high softening/melting point
• Softening/melt pt is > process temp
• Design cure program as > process temp
Process Overlay

SP – softening point

Temperature

CVD

Cure Program

SP

De-Bond
## Polymer Gas Permeability

Gas permeability: cm³-mm/m²-day

<table>
<thead>
<tr>
<th>Polymer</th>
<th>N₂</th>
<th>O₂</th>
<th>CO₂</th>
<th>H₂</th>
<th>H₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parylene N</td>
<td>1.7</td>
<td>39</td>
<td>214</td>
<td>540</td>
<td>1.5</td>
</tr>
<tr>
<td>Parylene C</td>
<td>1</td>
<td>7.2</td>
<td>7.7</td>
<td>110</td>
<td>0.2</td>
</tr>
<tr>
<td>Parylene D</td>
<td>4.5</td>
<td>32</td>
<td>13</td>
<td>240</td>
<td>0.2</td>
</tr>
<tr>
<td>Epoxies</td>
<td>4</td>
<td>5-10</td>
<td>8</td>
<td>110</td>
<td>1.8-2.4</td>
</tr>
<tr>
<td>Silicones</td>
<td>-</td>
<td>50,000</td>
<td>300,000</td>
<td>45,000</td>
<td>4.4-7.9</td>
</tr>
<tr>
<td>Urethanes</td>
<td>80</td>
<td>200</td>
<td>3,000</td>
<td>-</td>
<td>2.4-8.7</td>
</tr>
</tbody>
</table>

Parylene conformal coating systems, www.scscookson.com
Volatile Component vs. Temperature Exposure

HB 180  HT 210  Outgas 180

Coat ==> SB ==> HB ==> HT ==> Outgas

110C  180C  210C  180C

Cure

Barrier Level (%)

Measured Volatile Components (%)

0%  1%  2%  3%  4%  5%  6%
Checklist for Low-Cost Adhesive

- Early design includes COO
- Select according to the process (i.e. CVD)
- Able to achieve minimum thickness
- Chemical resistance
- Use of permeability data
- Clean-up and compatibility
Low-Cost Adhesive Example #2
Solar Cell Manufacturer

• Thin, fragile wafer, <10um
• Scale-up phase
• Transfer to factories w/tool-set
• Shift from liquid to film adhesive
• Review existing products or toll as new product
• Confirm COO for transition
Spin-Coated Liquid Adhesive

Thin wafer & Carriers → Spin Coating → Cure & Bonding → Cell Build → Single-Wafer De-bonding → Dirty wafer & Carriers → Clean wafer & Carriers
Laminated Film Adhesive

Thin Wafer & Carrier Wafers

Cure & Bonding

Cell Build

Single-Wafer De-bonding

Dirty Wafer & Carriers

Clean Wafer & Carriers

Film Adhesive
Film Lamination

- Recycle
- Substrate Fixture
- Film Adhesive lamination
- TPU Film
- Adhesive Coated Substrates

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Application Comparison

Liquid Spin-Coat

Thin wafer & Carriers

Spin Coating

Cure & Bonding

Cell Build

Single-Wafer De-bonding

Dirty wafer & Carriers

Clean wafer & Carriers

Film Lamination

Thin wafer & Carriers

Cure & Bonding

Cell Build

Single-Wafer De-bonding

Dirty wafer & Carriers

Clean wafer & Carriers
2. COO Comparison

- SEMI Std E35
- Conduct screening comparison as a ratio between COO₂ (new) and COO₁ (current)
- Assumptions: similar yield, internal costs, scrap, life, maintenance, etc.
- Tool costs, service, support, etc., identified as a factor of material costs
COO Defined

\[ \text{COO} = \frac{F$+R$+Y$}{L \times T \times Y \times U} = \frac{\text{Costs}}{\text{Product}} \]

<table>
<thead>
<tr>
<th>Item</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>F$</td>
<td>Fixed Costs</td>
</tr>
<tr>
<td>R$</td>
<td>Recurring Costs</td>
</tr>
<tr>
<td>Y$</td>
<td>Yield Cost (scrap)</td>
</tr>
<tr>
<td>L</td>
<td>Equipment Life</td>
</tr>
<tr>
<td>T</td>
<td>Throughput</td>
</tr>
<tr>
<td>Y</td>
<td>Composite Yield</td>
</tr>
<tr>
<td>U</td>
<td>Utilization</td>
</tr>
</tbody>
</table>

\[ \frac{\text{COO}_2}{\text{COO}_1} = \frac{\text{Film Adhesive}}{\text{Liquid Adhesive}} \]
Application COO Comparison

Adhesive Liquid + Spin-Coat Process

Adhesive Film + lamination Process

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# Materials & Throughput

<table>
<thead>
<tr>
<th>Adhesive Form</th>
<th>Materials Cost Estimate ($/wafer)</th>
<th>Throughput Estimate (wafers/day)</th>
<th>Tool Cost estimate * (yr 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid, spin-coating + cure</td>
<td>$0.1850</td>
<td>288 single 864 shared</td>
<td>$0.087 \times R$_1$</td>
</tr>
<tr>
<td>Film, roll + thermal stamp</td>
<td>$0.0125</td>
<td>28,800</td>
<td>$0.38 \times R$_2$</td>
</tr>
</tbody>
</table>

* Relative to materials cost (yr 1)
## COO Comparison

\[
\frac{\text{COO}_2}{\text{COO}_1} = \frac{\text{Film Adhesive}}{\text{Liquid Adhesive}}
\]

<table>
<thead>
<tr>
<th>Item</th>
<th>Definition</th>
<th>COO$_2$ vs. COO$_1$</th>
<th>Explanation</th>
</tr>
</thead>
</table>
| F$       | Fixed Costs                       | $F$_2 = 0.38 \times R$_2$
          | $F$_1 = 0.087 \times R$_1$
          | $\$Roll = 38\% film
          | $\$Coaters = 8.7\% liquid         |
| R$       | Recurring Costs                   | $R$_2 = 0.07R$_1$   | $\$Film = 0.07 \times \$Liq                  |
| Y$       | Yield Cost (scrap)                | $Y$_2 = Y$_1 = 0    | Polysilicon, low cost                           |
| L        | Equipment Life                    | $L$_2 = L$_1        | Same life                                        |
| T        | Throughput                        | $T$_2 = 33T$_1      | 1 Roll = 33 coaters                             |
| Y        | Composite Yield                   | $Y$_2 = Y$_1        | Same yield                                       |
| U        | Utilization                       | $U$_2 = U$_1        | Same maintenance                                |
COO Calculations

\[
\frac{\text{COO}_2}{\text{COO}_1} = \left[ \frac{F$2 + R$2 + 0}{L \times 33T_2 \times Y \times U} \right] \times \left[ \frac{L \times T \times Y \times U}{F$1 + R$1 + 0} \right]
\]

\[
\frac{\text{COO}_2}{\text{COO}_1} = \frac{(0.38R$2 + R$2)}{33(0.087R$1 + R$1)} = \frac{0.038R$2}{R$1} = 0.0027
\]

The COO for integrating a film adhesive is 0.3% of the COO for a liquid representative.
Summary

• Low-cost adhesives are available
• Process tuning is common
• Must consider ownership options
• Include experts on your team
• COO reduction to <50% is common, <10% is a meaningful target depending upon usage
Contact for More Information

• DAETEC provides development, consulting, and technical training/support to solve manufacturing problems and introduce new options of doing business.

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