Display Optical Bonding
Product Selector Guide & Technology Road Map

2012.Dec
MOMENTIVE performance materials.
Electronics_Display and Commercial
Momentive’s family of Optical clear silicone series feature outstanding optical bonding process and makes displays more readable in direct sunlight or in bright ambient lighting conditions. Our silicones deliver high light transmittance and display component protection to effectively reduce surface reflection and increase display reliability.
Function of Optical Clear Silicone

- Less transmittance loss
- Preventing glaring
- Better mechanical design
- Improve shock resistance
- Extending display life
General display module structure

Touch-less screen

- Cover glass
- Adhesive
  - PF
  - CF glass
  - LC
  - TFT glass

Touch screen

- Cover glass
- Adhesive
  - Touch module
- Adhesive
  - PF
  - CF glass
  - LC
  - TFT glass

New Touch system

- Cover glass
- Adhesive
  - PF
- CF glass
- LC
- TFT glass
Various applications with touch screen structure

<table>
<thead>
<tr>
<th>GFF</th>
<th>GG</th>
<th>G1F/GF2</th>
<th>G2/G1</th>
<th>In-cell/On-cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cover Window (Glass/PMMA)</td>
<td>Cover Window (Glass/PMMA)</td>
<td>Cover Window (Glass/PMMA)</td>
<td>Cover Window (Glass/PMMA)</td>
<td>Cover Window (Glass/PMMA)</td>
</tr>
<tr>
<td>OCA/LOCA</td>
<td>OCA/LOCA</td>
<td>OCA/LOCA</td>
<td>OCA/LOCA</td>
<td>OCA/LOCA</td>
</tr>
<tr>
<td>ITO Film</td>
<td>ITO Glass</td>
<td>ITO Film</td>
<td>ITO Film</td>
<td>Display</td>
</tr>
<tr>
<td>OCA/LOCA</td>
<td>OCA/LOCA</td>
<td>OCA/LOCA</td>
<td>OCA/LOCA</td>
<td>Display</td>
</tr>
<tr>
<td>Display</td>
<td>Display</td>
<td>Display</td>
<td>Display</td>
<td>Display</td>
</tr>
</tbody>
</table>

*Note) GFF: Glass Film Film, GG: Glass Glass, G1F/GF2:Glass 1way sensor Film/Glass Film 2way sensor, G2/G1:Glass 2way sensor/Glass 1way sensor

With air gap case

- GFF
- GG
- G1F/GF2
- G2/G1

No air gap case

- In-cell/On-cell

<Source: IHS Displaybank, Touch Trend & Perspective>
Trend of Touch structure by application

- **Smartphone**
  - High-end: In-cell, On-cell
  - Mid-end: GG, GFF
  - Low-end: G1, P1

- **Tablet PC**
  - High-end: GG, G2 (Cell), GFF
  - Mid-end: G2 (sheet), G1F, GF2
  - Low-end: PFF, P1

- **Notebook PC**
  - High-end: G2 (sheet), G1F, GF2
  - Mid-end: G1F, GF2
  - Low-end: GFF

- **AIO PC**
  - High-end: GG, G2

**Sources:** IHS Displaybank, Touch Trend & Perspective

---

<Source: IHS Displaybank, Touch Trend & Perspective>
### Why improved visibility is valuable to end users?

<table>
<thead>
<tr>
<th>Category</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle</td>
<td>No loss of time looking at unclear picture, decrease of change accidents when looking on navigation screen</td>
</tr>
<tr>
<td>Mobile communication devices</td>
<td>Better details in environment with high ambient light levels</td>
</tr>
<tr>
<td>3D Display</td>
<td>Better viewing angle in 3 dimensional way</td>
</tr>
<tr>
<td>Ship Navigation</td>
<td>Details on sea maps better visible with improved visibility</td>
</tr>
<tr>
<td>Outdoor</td>
<td>Better detail of tracks visible</td>
</tr>
<tr>
<td>Aviation</td>
<td>Clear picture on screens giving information on system status</td>
</tr>
</tbody>
</table>

**Copyright 2012 Momentive Performance Materials Inc. All rights reserved. CONFIDENTIAL**
Key techniques to improve visibility

External reflective surface

Anti Reflective

- Protective coating on the top of surface, touch screen
- Cancels reflections
- Best not used in screen often touched, touch screens easily smudges, difficult to clean and multiple cleaning session destroy the coating.

Anti Glare

- Etching of the surface of protective surface
- Light is scattered in many directions. Perception of the eye is less glare and picture enhancement
- Better to clean and more durable than AR

Internal reflective surface

Optical bonding

- Close air gap between TFT LCD and protective cover
- Reduce reflections due to reduction of internal reflective surfaces
Liquid optical bonding process

**2P Thermal cure type**

- Dispense 
- Flip bonding 
- Screen 
- Module 
- 70degC*30min Cure 
- Bonding 
- Curing 
- inspection 

**UV cure type**

- Syringe 
- Flip bonding 
- Screen 
- Module 
- 3000mJ/cm²@320~400nm Cure 
- Full curing 
- Re work 

Copyright 2012 Momentive Performance Materials Inc. All rights reserved. CONFIDENTIAL
The kind of method for liquid optical bonding

1. Triaxial Robot dispenser & Flip bonder
   - For small size
   - Drawing by robot
   - Possible to bond under atmosphere pressure

2. Screen print & Vacuum bonder
   - For large size
   - Coating whole area

3. Slot die coater & Vacuum bonder
   - For ultra large size
   - Coating whole area
   - Variable coating thickness
   - High accuracy
Why Silicone is needed?

- Great intermolecular distances
- Low intermolecular forces
- Excellent cold resistance
- High compressibility
- High gas permeability
- Small mechanical strength

- Stable Si-O bond
- Stable aC-H bond
- Excellent thermal stability
- Excellent UV stability
- Excellent weatherability
- Excellent Ozone Resistance

Flexible Bonding
Small Rotation Barrier

Large Bonding Energy:
- (C-C: 356kJ)
- (C-O; 339kJ)

Large Ionic Character

Copyright 2012 Momentive Performance Materials Inc. All rights reserved. CONFIDENTIAL
UV-Vis-IR spectra of dimethysilicone and methylphenylsilicone

Transparency of silicone polymers

- Transparent in visible region
- Transparent to around 340nm

<table>
<thead>
<tr>
<th>Wavelength (nm)</th>
<th>Transmittance (a.b.u)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td></td>
</tr>
<tr>
<td>400</td>
<td></td>
</tr>
<tr>
<td>600</td>
<td></td>
</tr>
<tr>
<td>800</td>
<td></td>
</tr>
<tr>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>1,200</td>
<td></td>
</tr>
</tbody>
</table>

- dimethysilicone
- methylphenylsilicone
Transparency trend, 60 °C, 90%RH 168hrs

UV-Vis spectra of Silicone vs Acrylic

- Glass/Air/Glass
- Acrylic resin _Initial
- Acrylic resin _60C/90%RH _168hrs
- Silicone _initial
- Silicone _60C/90%RH _168hrs

Wavelength (nm) vs Transmittance (%)

Soda-lime Glass T=1.0mm
Adhesive T=150μ
Soda-lime glass T=1.0mm

Copyright 2012 Momentive Performance Materials Inc. All rights reserved. CONFIDENTIAL
Transparency trend, 85 °C 500hrs

UV-Vis spectra of Silicone vs Acrylic

Transmittance(%) vs Wavelength(nm)

- Glass/Air/Glass
- Acrylic resin_Initial
- Acrylic resin_85C 504hrs
- Silicone_initial
- Silicone_85C_504hrs

Copyright 2012 Momentive Performance Materials Inc. All rights reserved. CONFIDENTIAL
Typical trend of silicone
Good wettability

Young’s formula

\[ \cos \theta = \frac{\gamma_l - \gamma_{sl}}{\gamma_l} \]

- \( \gamma_l \) : surface energy (liquid)
- \( \gamma_s \) : surface energy (substrate)
- \( \gamma_{sl} \) : surface energy (substrate/liquid)

Lower contact angle will be larger \( \cos \theta \)

- Larger surface energy of substrate
- Lower surface energy of liquid

Copyright 2012 Momentive Performance Materials Inc. All rights reserved. CONFIDENTIAL
Good wettability_Surface tension

Low surface energy → good wettability
Concept of InviSil OP series

- Clarity (High transmittance >95%, Colorless)
- Refractive index (>1.4)
- Good reliability (non yellowing after aging test)
- Non solvent low surface energy solution
- Non bubble generation
- Mild cure condition
- Low shrinkage during curing
- No corrosive (No acid, Low ionic agent)
- Electric insulating (Volume resistivity $10^{13}$ Ω · m)
- Good shock absorption (Stable of dynamic modulus)
# Requirements and material properties

<table>
<thead>
<tr>
<th>Process</th>
<th>Customer requirements</th>
<th>Competitors Acrylic (UV)</th>
<th>Momentive Silicone</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>OPXX1X Series</td>
<td>OPXX3X Series</td>
</tr>
<tr>
<td>Product</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dispensing</td>
<td>Stable Viscosity on Various temp.</td>
<td>Fair</td>
<td>Excellent</td>
</tr>
<tr>
<td></td>
<td>Pot life</td>
<td>Good</td>
<td>Fair</td>
</tr>
<tr>
<td></td>
<td>Component</td>
<td>1P</td>
<td>2P</td>
</tr>
<tr>
<td></td>
<td>Bubble less</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Bonding</td>
<td>Wet ability</td>
<td>Good</td>
<td>Excellent</td>
</tr>
<tr>
<td></td>
<td>Bubble less</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Curing</td>
<td>Fast cure</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Property</td>
<td>Adhesion</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Glass</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td></td>
<td>Plastics</td>
<td>Fair</td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>Non Shrinkage</td>
<td>Fair</td>
<td>Excellent</td>
</tr>
</tbody>
</table>
**Product Migration**

**Current**

**OP2131**
- 250~350nm: 2000 mJ/cm²
- Vis: 3.0 Pa.s
- Hardness: TYPE E 25
- Adhesive: Glass

**OP2012**
- 1hr at 60°C cure
- Vis: 0.8 Pa.s
- Hardness: TYPE E 25
- Adhesive: Glass, PMMA

**OP1012P**
- 1hr at 60°C cure
- Vis: 0.8 Pa.s
- Hardness: Gel
- Adhesive: Glass

**New!**

**OP2131D**
- 330~430nm: 2000 mJ/cm²
- Vis: 3.0 Pa.s
- Hardness: TYPE E 25
- Adhesive: Glass

**OP2131S**
- 250~350nm: 2000 mJ/cm²
- Vis: 3.0 Pa.s
- Hardness: TYPE E 5
- Adhesive: Glass, PMMA, PC

**OP2131SD**
- 330~430nm: 2000 mJ/cm²
- Vis: 3.0 Pa.s
- Hardness: TYPE E 7
- Adhesive: Glass, PMMA, PC

**Next Generation**

**OP2012L**
- 1hr at 60°C cure
- Vis: 0.1 Pa.s
- Hardness: TYPE E 25
- Adhesive: Glass

**OP2012S**
- 1hr at 60°C cure
- Vis: 0.8 Pa.s
- Hardness: TYPE E 25
- Adhesive: Glass, PMMA, PC

**OP2112S**
- 1hr at 60°C cure
- Vis: 2.0 Pa.s
- Hardness: TYPE E 25
- Adhesive: Glass, PMMA, PC

**SC**
- 1min at RT cure (no using UV)
- Vis: 5Pa.s
- Hardness: TYPE E 25
- Adhesive: Glass, PMMA, PC

**UV cure platform**

**Thermal cure platform**
Cure Shrinkage

Low shrinkage
Yellowing trend@85degC*85%RH

![Graph showing the yellowing index over time for OP2131 and Acrylic materials.]
Haze trend@85degC*85%RH

- **OP2131**
- **Acrylic**

Less Haze
Modulus trend by temperature

Silicone is the stable modulus In various temperatures
Vacuum bonding is an alternative solution for joining material offering versatility, consistency. This method based on a concept that the use of a vacuum helps prevent air bubbles. During Vacuum condition, some of ingredient having low boiling point can be boiled and generate weigh loss. It affect consistency of bonding performance.

*Rotary pump : 360L/ min, Chamber φ 500mmx300mm

Provided by Piezo Parts Co., Ltd
## Impact resistance_Drop ball test

<table>
<thead>
<tr>
<th>Drop ball test(23℃)</th>
<th>OP1012</th>
<th>OP2012</th>
<th>OP2131</th>
<th>Acrylic</th>
<th>Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>50cm</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>60cm</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Broken</td>
</tr>
<tr>
<td>100cm</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>120cm</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>130cm</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Broken</td>
<td></td>
</tr>
<tr>
<td>150cm</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Broken</td>
<td></td>
</tr>
<tr>
<td>180cm</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Drop ball test(-40℃)</th>
<th>OP1012</th>
<th>OP2012</th>
<th>OP2131</th>
<th>Acrylic</th>
<th>Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>100cm</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>110cm</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Broken</td>
</tr>
<tr>
<td>120cm</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>130cm</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Broken</td>
<td></td>
</tr>
<tr>
<td>150cm</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>180cm</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Steel ball 16g (D=16mm)
Glass thickness t=0.8mm
Adhesive thickness t=0.1mm
RA test (PMMA), 85 °C, 85%RH 500hrs

<table>
<thead>
<tr>
<th>Layer</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMMA</td>
<td>T=1.8mm</td>
</tr>
<tr>
<td>Adhesive</td>
<td>T=100μ</td>
</tr>
<tr>
<td>Soda-lime glass</td>
<td>T=0.8mm</td>
</tr>
</tbody>
</table>

Good reliability

Bubble failure

After 200hrs

Cracked UV Acryl resin
RA test (PMMA), -55 ~ 125 °C 100cycle

OP2131

OP2012

Acrylic

Good reliability

PMMA
T=1.8mm
Adhesive
T=100μ
Soda-lime glass
T=0.8mm

Adhesive Crack  Failure

Cracked UV Acryl resin
# Product Selector Guide_Silicone

<table>
<thead>
<tr>
<th>Product</th>
<th>Type</th>
<th>System</th>
<th>Ratio (w/w)</th>
<th>Cure Condition</th>
<th>Viscosity (Pa.s)</th>
<th>Hardness (-)</th>
<th>Yellow index</th>
<th>Shrinkage (%)</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>OP2131</td>
<td>Rubber</td>
<td>UV, 1P</td>
<td>n.a</td>
<td>3000mJ@350nm</td>
<td>3.0</td>
<td>21 (Type E)</td>
<td>0.3</td>
<td>0.20</td>
<td>Standard</td>
</tr>
<tr>
<td>OP2131D</td>
<td>Rubber</td>
<td>UV, 1P</td>
<td>n.a</td>
<td>3000mJ@365nm</td>
<td>3.0</td>
<td>21 (Type E)</td>
<td>0.47</td>
<td>0.22</td>
<td>Longer wavelength cure</td>
</tr>
<tr>
<td>OP2131S</td>
<td>Rubber</td>
<td>UV, 1P</td>
<td>n.a</td>
<td>3000mJ@350nm</td>
<td>3.0</td>
<td>5 (Type E)</td>
<td>0.42</td>
<td>0.17</td>
<td>Good plastic (PC, PMMA) adhesion</td>
</tr>
<tr>
<td>OP2131SD</td>
<td>Rubber</td>
<td>UV, 1P</td>
<td>n.a</td>
<td>3000mJ@365nm</td>
<td>3.0</td>
<td>5 (Type E)</td>
<td>0.43</td>
<td>0.19</td>
<td>Longer wavelength cure, good plastic (PC, PMMA) adhesion</td>
</tr>
<tr>
<td>OP2831D</td>
<td>Rubber</td>
<td>UV, 1P</td>
<td>n.a</td>
<td>3000mJ@365nm</td>
<td>30</td>
<td>10 (Type E)</td>
<td>0.42</td>
<td>0.13</td>
<td>High viscosity</td>
</tr>
<tr>
<td>OP1012</td>
<td>Gel</td>
<td>AC, 2P</td>
<td>1:1</td>
<td>70degC*30min</td>
<td>0.8</td>
<td>Gel</td>
<td>0.18</td>
<td>0.28</td>
<td>Standard Gel type</td>
</tr>
<tr>
<td>OP2012</td>
<td>Rubber</td>
<td>AC, 2P</td>
<td>1:1</td>
<td>70degC*30min</td>
<td>1.0</td>
<td>25 (Type E)</td>
<td>0.21</td>
<td>0.35</td>
<td>Standard Adhesive type</td>
</tr>
<tr>
<td>OP2012S</td>
<td>Rubber</td>
<td>AC, 2P</td>
<td>1:1</td>
<td>70degC*30min</td>
<td>1.0</td>
<td>25 (Type E)</td>
<td>0.11</td>
<td>0.40</td>
<td>Good plastic (PC, PMMA) adhesion</td>
</tr>
<tr>
<td>OP2012L</td>
<td>Rubber</td>
<td>AC, 2P</td>
<td>1:1</td>
<td>70degC*30min</td>
<td>0.1</td>
<td>5 (Type E)</td>
<td>0.20</td>
<td>0.38</td>
<td>Lower viscosity</td>
</tr>
</tbody>
</table>

1 UV = UV cure, AC = Addition Cure
## InviSil OPA series (selected grades only, please contact us for material selection support)

<table>
<thead>
<tr>
<th>Product</th>
<th>Type</th>
<th>System&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Ratio (w/w)</th>
<th>Cure Condition</th>
<th>Viscosity (Pa.s)</th>
<th>Adhesion strength (Mpa)</th>
<th>Yellow index</th>
<th>Shrinkage (%)</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCS-100</td>
<td>Rubber</td>
<td>UV, 1P</td>
<td>n.a</td>
<td>2000mJ@365nm</td>
<td>3.2</td>
<td>0.40</td>
<td>0.90</td>
<td>1.20</td>
<td>Standard</td>
</tr>
<tr>
<td>OCS-200</td>
<td>Rubber</td>
<td>UV, 1P</td>
<td>n.a</td>
<td>2000mJ@365nm</td>
<td>1.0</td>
<td>0.40</td>
<td>0.80</td>
<td>1.30</td>
<td>Lower viscosity</td>
</tr>
<tr>
<td>OCS-300</td>
<td>Rubber</td>
<td>UV, 1P</td>
<td>n.a</td>
<td>2000mJ@365nm</td>
<td>3.3</td>
<td>0.40</td>
<td>0.80</td>
<td>1.30</td>
<td>High elongation</td>
</tr>
<tr>
<td>OCS-400L</td>
<td>Rubber</td>
<td>UV, 1P</td>
<td>n.a</td>
<td>2500mJ@365nm</td>
<td>25.0</td>
<td>0.43</td>
<td>0.92</td>
<td>1.20</td>
<td>High Viscosity (Dam)</td>
</tr>
<tr>
<td>OCS-400H</td>
<td>Rubber</td>
<td>UV, 1P</td>
<td>n.a</td>
<td>2500mJ@365nm</td>
<td>50.0</td>
<td>0.45</td>
<td>0.96</td>
<td>1.10</td>
<td>High viscosity (Dam)</td>
</tr>
<tr>
<td>OCS-500</td>
<td>Rubber</td>
<td>UV, 1P</td>
<td>n.a</td>
<td>2000mJ@365nm</td>
<td>3.5</td>
<td>0.40</td>
<td>1.05</td>
<td>1.40</td>
<td>longer wave length cure</td>
</tr>
</tbody>
</table>

<sup>1</sup> UV = UV cure
**OP2131S**

System: 1-P UV cure

**Silicone features**
- High Transparent
- Fast cure
- viscosity 3.0 Pa.s
- Low Shrinkage
- Cohesive adhesion

**Application benefits**
- Functions in general display temperature range
- Good plastic and film adhesion
- Process flexibility
- Absorbs shock and protects display module from external stress
- Less bubble generation
OP2131SD

System: 1-P UV cure

Silicone features
- High Transparent
- Longer wavelenth curable (>365nm)
- viscosity 3.0 Pa.s
- Soft
- Low Shrinkage
- Cohesive adhesion

Application benefits
- Functions in general display temperature range
- Good plastic and film adhesion
- Design flexibility
- Absorbs shock and protects display module from external stress
- Less bubble generation

UV absorbance on PMMA

Stress/Strain Curve by Temperature
OP2012S

System: 2-P addition cure

Silicone features
• High Transparent
• Low temp. cure
• Viscosity 0.8 Pa.s
• Low Shrinkage
• Cohesive adhesion

Application benefits
> Functions in general display temperature range
> Good plastic and film adhesion
> Excellent optical properties
> Shadow portion curable
> Absorbs shock and protects display module from external stress
> Design flexibility

Curing curve by Temperature

Representative Product

Yellow Index

Copyright 2012 Momentive Performance Materials Inc. All rights reserved. CONFIDENTIAL
Black Ink for Display_HRB-100

Momentive HRB-100 Black Ink is environmentally friendly products with non solvent solution. It is applied to cover lenses, touch screens and displays as a black matrix area. It provides excellent heat resistance, chemical resistance and wetting properties of glass and plastics.

Material Features

- High heat resistance black ink, at 300 °C
- Excellent adhesion
- Good uniformity
- Good leveling & wetting properties
- Low temp curable

Product Information

<table>
<thead>
<tr>
<th>Product Information</th>
<th>HRB-100</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product name</strong></td>
<td>HRB-100</td>
</tr>
<tr>
<td><strong>Color</strong></td>
<td>Black</td>
</tr>
<tr>
<td><strong>Form</strong></td>
<td>1-Component</td>
</tr>
<tr>
<td><strong>Heat resistance temperature</strong></td>
<td>300 °C</td>
</tr>
<tr>
<td><strong>Optical Density</strong></td>
<td>&gt; 2.0</td>
</tr>
<tr>
<td><strong>Surface resistance (Ω/□)</strong></td>
<td>1x10¹³</td>
</tr>
<tr>
<td><strong>Solid content (%)</strong></td>
<td>70 (Controllable)</td>
</tr>
<tr>
<td><strong>Viscosity (at 25°C)</strong></td>
<td>20,000 ± 5,000</td>
</tr>
<tr>
<td><strong>Density</strong></td>
<td>1.1 ± 0.1</td>
</tr>
<tr>
<td><strong>Storage condition (at 25°C)</strong></td>
<td>0 ~ 15 °C</td>
</tr>
<tr>
<td><strong>Shelf life</strong></td>
<td>6 month</td>
</tr>
</tbody>
</table>

Copyright 2012 Momentive Performance Materials Inc. All rights reserved. CONFIDENTIAL
### Road Map of UV Curable

#### Current
- **UVA2500**
  * UV activated addition cure
  Two part 10:1 mixing
  Vis : 0.25Pa.s
  Hardness : 25(Type 00)
  Ad. strength : Gel type

- **OP2131**
  Vis : 3.0Pa.s
  Hardness : 21(Type E)
  Ad. Strength : 0.5MPa

- **OP2131D**
  * 365nm curable
  Vis : 3.0Pa.s
  Hardness : 21(Type E)
  Ad. Strength : 0.5MPa

#### New
- **OP2131S**
  Cohesive adhesion
  Onto plastic
  Vis : 3.0Pa.s
  Hardness : 5(Type E)
  Ad. Strength : 0.2MPa

- **OP2131SD**
  365nm curable
  Adhesion to plastic
  Vis : 3.0Pa.s
  Hardness : 5(Type E)
  Ad. Strength : 0.2MPa

- **OP2831D**
  365nm curable
  Adhesion to plastic
  Vis : 30Pa.s
  Hardness : 10(Type E)
  Ad. Strength : 0.5MPa

#### Next Generation
- **OP2131D**
  * 365nm curable

- **OP2831D**
  * 365nm curable

- **Anti Yellowish and Haze(<0.5%)**
- **Curable under BM**
- **Good plastic/film adhesion**
- **Hybrid Cure(UV/Low temp) and adhesive**

- **New adhesion promoter for high plastic and pol. film adhesion**

- **Hybrid polymer for UV/low temperature hybrid cure**

**Platform technology**
- Adhesion promoter to pol. film/glass
- Polymer/resin design
- Photo initiator system

---

Copyright 2012 Momentive Performance Materials Inc. All rights reserved. CONFIDENTIAL
Road Map of Thermal Curable

**Current**

**OP1012**
- Two part
- 30min @70degC
- Vis : 0.8Pa.s
- Hardness : Gel

**OP2012**
- Two part
- 30min @70degC
- Vis : 0.8Pa.s
- Hardness : 25(Type E)
- Ad.Strength : 0.1MPa

**New**

**OP2012L**
- Two part
- 30min @70degC, Vis : 0.1Pa.s
- Hardness : 5(Type E)
- Ad.Strength : 0.3MPa (t=0.1mm)

**OP2012S**
- Two part
- 30min @70degC, Vis : 0.8Pa.s
- Hardness : 25(Type E)
- Ad.Strength : 0.1MPa

**OP2012FC**
- Two part
- 10min @70degC, Vis : 0.8Pa.s
- Hardness : 25(Type E)
- Ad.Strength : 0.1MPa

**Next Generation**

- Anti Yellowish and Haze
- Good plastic/film adhesion
- Fast cure within 5min @23degC

- One part preferable
- Fast cure with longer pot life
- Excellent adhesion to plastic/film
- Hybrid curable(UV+Thermal)
- High R.I

- New adhesion promoter for high plastic and pol.film
- New polymer and resin design

Platform technology
- Adhesion promoter to pol.film/glass
- Polymer / resin design
- Pt/Inhibitor system

* Not commercialized
Product In Development

ALOC (“Advanced Liquid Optical Bonding system”)

1. coating

2. Flip

3. Bonding

Snap curable by addition cure system

Finish cure process

Available Q4.2012
DISCLAIMER: THE MATERIALS, PRODUCTS AND SERVICES OF MOMENTIVE PERFORMANCE MATERIALS INC., MOMENTIVE PERFORMANCE MATERIALS USA INC., MOMENTIVE PERFORMANCE MATERIALS ASIA PACIFIC PTE. LTD., MOMENTIVE PERFORMANCE MATERIALS WORLDWIDE INC., MOMENTIVE PERFORMANCE MATERIALS GmbH, THEIR SUBSIDIARIES AND AFFILIATES DOING BUSINESS IN LOCAL JURISDICTIONS (collectively "SUPPLIERS"), ARE SOLD BY THE RESPECTIVE LEGAL ENTITY OF THE SUPPLIER SUBJECT TO SUPPLIERS’ STANDARD CONDITIONS OF SALE, WHICH ARE INCLUDED IN THE APPLICABLE DISTRIBUTOR OR OTHER SALES AGREEMENT, PRINTED ON THE BACK OF ORDER ACKNOWLEDGMENTS AND INVOICES, AND AVAILABLE UPON REQUEST. ALTHOUGH ANY INFORMATION, RECOMMENDATIONS, OR ADVICE CONTAINED HEREIN IS GIVEN IN GOOD FAITH, SUPPLIERS MAKE NO WARRANTY OR GUARANTEE, EXPRESS OR IMPLIED, (i) THAT THE RESULTS DESCRIBED HEREIN WILL BE OBTAINED UNDER END-USE CONDITIONS, OR (ii) AS TO THE EFFECTIVENESS OR SAFETY OF ANY DESIGN INCORPORATING SUPPLIERS’ PRODUCTS, MATERIALS, SERVICES, RECOMMENDATIONS OR ADVICE. AFOREMENTIONED EXCLUSIONS OR LIMITATION OF LIABILITY ARE NOT APPLICABLE TO THE EXTENT THAT THE END-USE CONDITIONS AND/OR INCORPORATION CONDITIONS CORRESPOND TO THE RECOMMENDED CONDITIONS OF USE AND/OR OF INCORPORATION AS DESCRIBED BY SUPPLIER IN ITS PRODUCT DATA SHEET AND/OR PRODUCT SPECIFICATIONS. EXCEPT AS PROVIDED IN SUPPLIERS’ STANDARD CONDITIONS OF SALE, SUPPLIERS AND THEIR REPRESENTATIVES SHALL IN NO EVENT BE RESPONSIBLE FOR ANY LOSS RESULTING FROM ANY USE OF ITS MATERIALS, PRODUCTS OR SERVICES DESCRIBED HEREIN. EACH USER BEARS FULL RESPONSIBILITY FOR MAKING ITS OWN DETERMINATION AS TO THE SUITABILITY OF SUPPLIERS’ MATERIALS, SERVICES, RECOMMENDATIONS, OR ADVICE FOR ITS OWN PARTICULAR USE. EACH USER MUST IDENTIFY AND PERFORM ALL TESTS AND ANALYSES NECESSARY TO ASSURE THAT ITS FINISHED PARTS INCORPORATING SUPPLIERS’ PRODUCTS, MATERIALS, OR SERVICES WILL BE SAFE AND SUITABLE FOR USE UNDER END-USE CONDITIONS. NOTHING IN THIS OR ANY OTHER DOCUMENT, NOR ANY ORAL RECOMMENDATION OR ADVICE, SHALL BE DEEMED TO ALTER, VARY, SUPERSEDE, OR WAIVE ANY PROVISION OF SUPPLIERS’ STANDARD CONDITIONS OF SALE OR THIS DISCLAIMER, UNLESS ANY SUCH MODIFICATION IS SPECIFICALLY AGREED TO IN A WRITING SIGNED BY SUPPLIERS. NO STATEMENT CONTAINED HEREIN CONCERNING A POSSIBLE OR SUGGESTED USE OF ANY MATERIAL, PRODUCT, SERVICE OR DESIGN IS INTENDED, OR SHOULD BE CONSTRUED, TO GRANT ANY LICENSE UNDER ANY PATENT OR OTHER INTELLECTUAL PROPERTY RIGHT OF SUPPLIERS OR ANY OF ITS SUBSIDIARIES OR AFFILIATES COVERING SUCH USE OR DESIGN, OR AS A RECOMMENDATION FOR THE USE OF SUCH MATERIAL, PRODUCT, SERVICE OR DESIGN IN THE INFRINGEMENT OF ANY PATENT OR OTHER INTELLECTUAL PROPERTY RIGHT.

Momentive, the M-design logo and ‘the science behind the solutions’ are trademarks of Momentive Performance Materials Inc.