Imagine enhanced readability, increased visibility and improved reliability

Optical bonding materials selection guide
Why choose Dow Performance Silicones?

Dow Performance Silicones has been a global leader in silicone-based technology for more than 70 years. Headquartered in Michigan, USA, we maintain manufacturing sites, sales and customer service offices, and research and development labs in every major geographic market worldwide to ensure you receive fast, reliable support for your processing and application development needs.

**Unique product technology**
Our substantial silicone legacy – showcased though the DOWSIL™ and SILASTIC™ brand names that encompass more than 7,000 silicone products and services – offers a portfolio with breadth and proven performance that few companies can match.

**Extensive know-how**
We multiply our product value with deep in-house expertise and an extended network of industry resources.

**Collaborative culture**
We work closely with you to help reduce time and cost at every stage of your new-product development.

**Stability**
For more than seven decades, we have been a global leader, investing in manufacturing and quality to help fuel your innovations, through a consistent supply of proven silicone products.
DOWSIL™ VE Series silicone optical bonding for displays

Applications for optical bonding

- Cover window (glass or plastic)
- Touch sensor
- Display cell/panel

Benefits of optical bonding

- Improved viewing experience and readability
- Increased display ruggedness
- Extended display product life

Unlike most displays, those used in automotive interiors endure harsh environmental conditions, including extreme temperatures, high humidity, and prolonged UV exposure. They consequently demand more robust adhesive materials that still support simple, cost-effective processing.

The DOWSIL™ VE Series offers UV cure, UV/thermal dual-cure and thermal-cure systems. These solutions are silicone-based optically clear resins that reliably bond a variety of cover window materials – including glass, PMMA, and PC – to automotive LCD display modules. Their excellent optical properties help displays deliver superb performance properties, such as high transmittance, low haze, minimal yellowing, and superior reliability under common automotive environment test conditions.

These silicone OCR solutions adapt easily to incumbent optical bonding processes and deliver superior photothermal stability, mechanical properties, and optical performance for optimized processing and performance of your next automotive display design.

Key characteristics of DOWSIL™ VE Series silicone optical bonding materials

We’ve tailored DOWSIL™ VE Series silicone optical bonding materials to meet your needs for cost, packaging, and a wide range of attributes – many of which are specific to optically clear resin (OCR) applications.

- High optical transparency
- High thermal stability
- Stable to UV degradation

Our DOWSIL™ VE Series bonding materials – which offer the inherent benefits of silicone – are available with a broad range of viscosities and mechanical properties. These materials provide:

- Good yellowing resistance under use conditions
- Good elongation
- Aging reliability
- Low modulus (to eliminate the mura effect)
- Choices for adhesion, hardness, viscosity, and refractive index
- A range of cure times and cure technologies

Potential uses and applications

- Automotive displays
- Consumer displays requiring reliability in harsh conditions, such as micro/mini LED displays

Why silicone optical bonding materials from Dow?

The inherent versatility of silicone chemistry can help expand your design freedom, increase your processing options, and enhance the performance and reliability of your device. As a class of materials, silicones generally offer demonstrable benefits over organic-based solutions.

Dow builds on silicone’s inherent potential by combining it with industry-leading materials knowledge, application expertise, customer collaboration, and a global footprint.

We’ve designed this guide to help you quickly narrow your search for a bonding solution that will meet your specific application demands.
DOWSIL™ VE Series optical bonding materials – UV-cure technology

<table>
<thead>
<tr>
<th>Form factor</th>
<th>DOWSIL™ VE-6001 UV Optical Bonding Material</th>
<th>DOWSIL™ VE-2003 UV Optical Bonding Material</th>
<th>DOWSIL™ VE-3004 UH Optical Bonding Material</th>
<th>DOWSIL™ VE-3050 UH Optical Bonding Material</th>
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</thead>
<tbody>
<tr>
<td>Mix ratio, A:B</td>
<td>1-part</td>
<td>1-part</td>
<td>2-part</td>
<td>2-part</td>
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<tr>
<td>Viscosity, Part A, mPa·s</td>
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<td>—</td>
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<td>1:1</td>
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<tr>
<td>Viscosity, Part B, mPa·s</td>
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<td>—</td>
<td>4,100</td>
<td>4,100</td>
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<tr>
<td>Viscosity, Mixed, mPa·s</td>
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<td>3,600</td>
<td>4,100</td>
<td>4,100</td>
</tr>
<tr>
<td>Pot life @ RT, min</td>
<td>3 months without UV exposure</td>
<td>3 months without UV exposure</td>
<td>&gt;1 week under dark</td>
<td>&gt;1 week under dark</td>
</tr>
</tbody>
</table>

Cure conditions

- DOWSIL™ VE-2003 UV Optical Bonding Material
  - >4,000 mJ/cm² metal halide UV LED at 365, 395, 405 nm
  - >2,000 mJ/cm² at 365 nm + 1 hr @ 25°C
- DOWSIL™ VE-3004 UH Optical Bonding Material
  - >2,000 mJ/cm² at 365 nm + 1 hr @ 25°C

Product properties, cured

- Hardness
  - 49 Shore OO
  - 54 Shore OO
  - 40 Penetration
  - 20 Penetration
- Volume shrinkage, %
  - <1.0
  - <1.0
  - <1.0
  - <1.0
- Lap shear strength(1), kgf/cm²
  - 8.9
  - 8.3
  - 5.8
  - 8.3
- Transmittance, %
  - >99
  - >99
  - >99
  - >99
- Refractive index
  - 1.53
  - 1.53
  - 1.41
  - 1.41
- Yellowness index(1)
  - 0.3
  - 0.32
  - 0.28
  - 0.28

Optical properties after 1,000 hours at 85°C/85% RH

- Yellowness index(1)
  - 1.1
  - 1.1
  - 0.52
  - 0.6

(1) Silicone thickness: 200 µm, glass/glass. | (2) Developmental material. | Specification writers: These values are not intended for use in preparing specifications. Please contact your local Dow representative or sales office before writing specifications on these products.

DOWSIL™ VE-2003 UV Optical Bonding Material

Optical properties after reliability test

Sandwiched glass with 200 µm thickness, metal halide D bulb at 4,000 mJ/cm²

Transmittance at 550 nm

![Graph showing transmittance at 550 nm over time](image)

b*

![Graph showing b* over time](image)

Yellowness

![Graph showing yellowness over time](image)
DOWSIL™ VE Series optical bonding materials – thermal-cure technology

<table>
<thead>
<tr>
<th></th>
<th>DOWSIL™ VE-5002 H</th>
<th>DOWSIL™ VE-1204 Quick Cure Optical Bonding Material</th>
<th>DOWSIL™ VE-1204 H Optical Bonding Material(2)</th>
<th>DOWSIL™ VE-1303 H Optical Bonding Material(2)</th>
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<td>2-part</td>
<td>2-part</td>
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<tr>
<td>Product properties, uncured</td>
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<tr>
<td>Mix ratio, A:B</td>
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<td>1:1</td>
<td>1:1</td>
<td>1:1</td>
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<tr>
<td>Viscosity, Part A, mPa·s</td>
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<td>Viscosity, Part B, mPa·s</td>
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<td>2,800</td>
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<td>Viscosity, Mixed, mPa·s</td>
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<td>Pot life @ RT, min</td>
<td>&lt;360</td>
<td>3.5</td>
<td>&lt;60</td>
<td>3.0</td>
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<tr>
<td>Cure conditions</td>
<td>1 hr @ 60°C</td>
<td>1 hr @ 25°C</td>
<td>1 hr @ 60°C</td>
<td>0.5 hr @ 40°C</td>
</tr>
<tr>
<td>Product properties, cured</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardness</td>
<td>21 Shore OO</td>
<td>40 Penetration</td>
<td>40 Penetration</td>
<td>45 Penetration</td>
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<tr>
<td>Volume shrinkage, %</td>
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<td>&lt;1.0</td>
<td>&lt;1.0</td>
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<td>Lap shear strength[1], kgf/cm²</td>
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<td>5.7</td>
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<td>3.6</td>
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<td>Transmittance, %</td>
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<td>&gt;99</td>
<td>&gt;99</td>
<td>&gt;99</td>
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<tr>
<td>Refractive index</td>
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<td>1.54</td>
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<tr>
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<tr>
<td>Optical properties after 1,000 hours at 85°C/85% RH</td>
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<td></td>
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</tr>
<tr>
<td>Yellowness index[1]</td>
<td>0.5</td>
<td>0.5</td>
<td>0.6</td>
<td>0.5</td>
</tr>
</tbody>
</table>


DOWSIL™ VE-1204 Quick Cure Optical Bonding Material

Optical properties after reliability test

Sandwiched glass with 200 µm thickness, 1 hr @ 25°C
Selecting an optical bonding material

- **Large-size display (~20”)**
  - Slit-coating process
    - Using precure process
      - With dam process
        - Fill material: Large process window for precure condition
        - Dam material: Same as fill material with spot-cure system
  - Screen-printing process
    - For thicker layer (~400 µm)
      - High-thixotropy OCR products
    - For thinner layer (~350 µm)
      - High-viscosity OCR products
  - Injection process
    - With dam process
      - Low-viscosity product for fill material
      - High-viscosity with thixotropic product for dam material

- **Typical-size display (~6” to ~13”)**
  - Slit-coating process
    - Using precure process
      - With dam process
        - Fill material: Large process window for precure condition
        - Dam material: Same as fill material with spot-cure system
  - Dam and fill process
    - Dam cure process window
      - Large precure process window material
      - For 10”+ size filling
        - Flowable-viscosity OCR products
  - Pattern design
    - Pattern design
      - Proper-wettability OCR products
      - Flowable-viscosity OCR products
  - Screen-printing process
    - For thicker layer (~400 µm)
      - High-thixotropy OCR products
    - For thinner layer (~350 µm)
      - High-viscosity OCR products

- **Specific-design display - Curved display - 3D auto display**
  - Slit-coating process
    - Using precure process
      - With dam process
        - Fill material: Large process window for precure condition
        - Dam material: Same as fill material with spot-cure system
  - Screen-printing process
    - For thicker layer (~400 µm)
      - High-thixotropy OCR products
    - For thinner layer (~350 µm)
      - High-viscosity OCR products
Optical bonding with silicones

- Cover glass
- OCR
- Touch sensor
- OCR
- LCM
Typical processes for optical bonding

Liquid optical bonding technology was introduced in late 1970s in the liquid crystal display (LCD) industry and has been in use ever since. In the 2010s, optical bonding technology was being used widely due to the low total cost of ownership compared with the dry-bonding process.

The liquid optical bonding process can use either one-part UV-cure materials or two-part thermal-cure materials. The one-part materials, known as UV cure OCR or LOCA, are compatible with most bonding equipment and have faster cure times and easier handling than two-part materials, making them the material of choice for many optical bonding companies.

There are three different liquid optical bonding processes: the dam and fill process, patterning, and the slit-coating process. In 2015, screen (stencil) printing processes and dam and injecting processes had been newly proposed for specific display designs, such as curved displays, 3D design displays, notch-design displays, and others. DOWSIL™ VE Series optical bonding materials are proven to be processable with a wide range of optical bonding processes. Five representative liquid optical bonding processes are illustrated on the next page.

Materials requirements for various process options

<table>
<thead>
<tr>
<th>Storage modulus, Pa</th>
<th>Injection material</th>
<th>Dam material</th>
<th>Screen-printing material</th>
</tr>
</thead>
<tbody>
<tr>
<td>10^3</td>
<td>10^4</td>
<td>10^5</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Viscosity, mPa·s</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
</tr>
<tr>
<td>1,000</td>
</tr>
<tr>
<td>10,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Large-size display (~20&quot;)</th>
<th>Display (~6&quot; to ~13&quot;)</th>
<th>Specific-design display</th>
</tr>
</thead>
<tbody>
<tr>
<td>Especially for digital information displays</td>
<td>Typical auto display application</td>
<td>Curved or 3D auto display application</td>
</tr>
</tbody>
</table>
Representative optical bonding processes

1. Dam and fill
   - Dispense OCR on module and precure it for DAM
   - Dispense OCR on cover window and laminate cover glass
   - Laminate glass and precure the material
   - Full cure

2. Patterning
   - Dispense OCR on cover window
   - Laminate cover window on LCD
   - Materials spread
   - Full cure (side cure added if needed)

3. Slit-coating
   - Slit-coat OCR on cover window
   - UV precure
   - Laminate cover window and precure the material
   - Full cure

4. Screen printing
   - Dispense OCR on mask frame to coat specific area
   - Print OCR with squeegee blade
   - Laminate cover window and LCD
   - Full cure

5. Dam and injecting
   - Dispense dam material on LCD module
   - Laminate cover glass on LCD
   - Inject OCR into laminated LCD with cover window
   - Full cure (side cure added if needed)
Environmental reliability test conditions in the automotive industry have become more challenging in recent years, with even more stringent conditions proposed in 2016. Consider the newly proposed reliability test conditions:

- 105°C for the high-temperature degradation test
- 85% RH or 90% RH at 85°C for the humid heat constant test
- -40 to ~95°C for the thermal shock test and QUV or QSUN tests

To meet these exacting standards, increasingly reliable OCR materials are required for automotive displays. Acrylic OCR materials and other organic-film materials have demonstrated weaknesses in their ability to meet these proposed reliability requirements.

During the reliability tests based on the newly proposed conditions, various failure modes could be generated in optical bonding layers and films. Key factors to prevent failures include changing the bonding process and/or changing the OCR and film materials.

**Typical failure modes**

- **Bubbles**: Generated by the lamination process and outgassing
- **Polarizer discoloration**: Generated by the chemical reaction in PVA
- **Delamination**: Caused by volume shrinkage and adhesion change
- **Black matrix**: Typical chemical reliability issue in the optical material industry
- **Display and touch-sensing area**: Caused by mechanical stress changes and bonding material color changes
- **Flexible PCB for display and touch-sensing**
Reworkability methods for optical coupling resins (OCR)

Chemical method

1. Use wire to debond touch sensor and LCD module.
2. Spray solvent (IPA or MICSOL 1620) on residual adhesives, or cloth wipe covering residual adhesives.
3. Wait five minutes until residual adhesives soften.
4. Rub with plastic blade to remove residual adhesives.
5. Spray with solvent and clean with cloth wipe.

Mechanical method

1. Use wire to debond touch sensor and LCD module.
2. Store substrate with residual adhesives below -25°C for 30 minutes.
3. Rub with plastic blade to remove residual adhesives.
4. Spray with solvent (IPA or MICSOL 1620) and clean with cloth wipe.
Learn more

We bring more than just an industry-leading portfolio of advanced silicone-based materials. As your dedicated innovation leader, we bring proven process and application expertise, a network of technical experts, a reliable global supply base, and world-class customer service.

To find out how we can support your applications, visit consumer.dow.com/pcb.

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