SolEpoxy Clear Encapsulant Materials

Optically Clear OP1000, OC10-1, OG10-1 and OL10-1

Silicone & Optical Bandpass Filter Replacement & Outdoor RGB Display
SolEpoxy Optically Clear Encapsulants
OP1000, OC10-1, OG10-1, OL10-1

PRODUCT LAUNCH OUTLINE

1. Overview: Summary of the product and target applications
2. Product Background: How it fits into our complete product offering
3. Markets Served
4. Key Features and Benefits
5. Process and Handling Conditions
6. Technical Data Sheet and Safety Data Sheet
7. Ordering Information
SolEpoxy Optoelectronics Product Portfolio

We offer “White Reflective” and “Optically Clear” Materials

White Reflective Mold Compounds

Coming Soon

NBXXXX-XX
Level 1 LED non-MAP leadframe

Clear Opto Epoxy Mold Compounds

OP, C, G-Series

OP1000 Pellets
Outdoor Sign RGBs on SMT LED

OC10-1 Cast Pellets
Mid-Power LED, Outdoor RGB

OG10-1 Fine Powder
Fine Powder for Phosphor Blending

OP7001 / OP7200
Clear Opto for Data Transmission

Clear Opto Hybrid Liquid Compounds

OL-Series

OL10-1
Mid-Power LED SMT Liquid Encap

OL88-8
Outdoor RGB SMT Liquid Encap

Colors: Red, Blue, Green
Incredible color stability by adding colors to clear compounds

F is for Filter
OC10-1F820
Light blocking and/or light filtering ie. @ 820nm as above

Ready for Diffusant or Phosphor
Phosphor Blending into Clear Opto Liquid is possible

Modular Capabilities
Independent of Technologies

EPOXY INSULATING COATING POWDERS • DURABLE DIELECTRIC MOLDING COMPOUNDS • OPTOELECTRONIC COMPOUNDS

SOLEPOXY.COM
Markets Served: Power vs. Wavelength

Target applications of SolEpoxy Clear Encapsulants

**SolEpoxy Optoelectronics Target Applications**:
- UVA (>350nm) LED applications where these perform well in the UVA range
- Mid-power LED SMD where these is a cheaper alternative to silicone & Mid-Power LED that mix phosphor on the fly for color binning
- RGB SMT LED applications that require UV resist
- Data Transmission/Industrial Fiber
- IR wavelength range where we have unique light-filtering technology that competes against expensive IR glass.

**Fiber Optics Wavelengths**
- Three main wavelengths: 850, 1300 & 1550 nm
  - Multimode fiber: 850 and 1300 nm
  - Singlemode fiber: 1310 and 1550 nm.

**Distributed Feedback Laser**
- 760nm – 2400nm
- 1.5mW-2.0mW standard output
- 5mW -20mW high power output

**Infrared Temperature**
- Non-contact thermometers
  - 1600 -2000nm & 4000 – 14000nm

**Analytical Instruments**
- UV Curing
- Tanning
- Medical Phototherapy
- Ambient Light Sensors
  - 400 -700nm
- Counterfeit Detection
- Water / Air Disinfection / Purification
- White LED
  - 450-460nm
  - Up to 100W
- RGB SMT LED
  - 450-460nm
  - Up to 5W
- Ambient Light Sensors
  - 400 -700nm
- RGB SMT LED
  - 680nm
- Data Transmission / Industrial Fiber
  - 1600 -2000nm & 4000 – 14000nm
- Biometric Sensors & Optical Measurement
  - 705nm
- Automotive Optical Sensors
  - Proximity / Gesture Sensors
    - i.e. Rain Sensor, Sunload Sensor, Anti-Glare Mirror, Hand Detected Entry
    - 705 – 1050nm
Lumen Requirement for Various Applications

A look at the devices each application demands

**Focus: UV Resist Applications**

**RGB Billboard display**
Through-hole RGB devices with higher lumen and higher reliability requirements. Outdoor also have UV resist requirement.

**SMD Low Power**
(Keypad backlight)  
<0.1W/~80°C

**SMD Mid Power**
(TV Backlighting/General Lighting)  
<0.1-0.5W/~125°C

**SMD High Power**
(Baylights & Automotive Lighting)  
0.5-20W watts/~150°C

**Critical Mass: Large Screen LCD Backlighting (BLU)**
An entire industry and infrastructure was built from 2010 to support LCD backlighting. Overcapacity led to a 75% cost decrease in mid-power devices which made them viable (in larger numbers) for general lighting.  
[Link to article](#)

**General Lighting (450 – 2000 Lumen requirement)**
There are many ways to achieve required lumens. Many mid-Power LED could be used, or fewer high-power LEDs. Tradeoffs are cost vs. space vs. performance.

**Industrial Baylights:**
Infrastructure Lighting  
2000 – 25,000 Lumens

**RGB display**  
Through-hole RGB devices with higher lumen and higher reliability requirements. Outdoor also have UV resist requirement.

**Projectors:**
Office projectors ~2000lm  
Outdoor projectors up to 10,000 Lumens

**Xenon/HID Headlights**  
1000-2,500 Lumens

**Very Low-end LED Lamp potting**

**LCD Backlighting**
The smaller the device (ie. Smartphone), the fewer the total lumens needed. The higher the lumens per Watt (lm/W), the fewer number of SMD LED’s needed.
An interference filter or dichroic filter is an optical filter that reflects one or more spectral bands and transmits others, with near zero absorption for all wavelengths.

Use Epoxy with Filter Technology

... a proven, cost-effective and flexible alternative that uses filter technology.

Polished Optical Glass Filter

BG-36 Polished Optical Filter Glass 6 1/2 in. x 6 1/2 in., #POL-BG36-0-155x155 $899.00

... a proven but expensive process that can run up to hundreds of dollars per piece.
Optical Interference Bandpass Filters
Where are the applications?

- Anti-Glare, Self-Dimming Mirrors
- Automotive Rain Sensors
- Automotive Sunload Sensor
- Human Machine Interface
- Biometric Sensors
- Driver recognition, Lane Departure Warning
- Automotive Night Vision Sensor
- Consumer Gesture Control
Remote Phosphor vs Direct Phosphor
Two approaches to achieve the same effect – warm white light!

Remote Phosphor Lamps

Phosphor Applied at Die Level

LED Lamp Retrofits
Both remote phosphor and phosphor applied at the die level lamps produce warm, white light. Remote phosphor lamps can use high-powered, less expensive die, but require more phosphor. Die-level applied phosphor lamps use less total phosphor, but use lower power and are less efficient.
SolEpoxy Optically Clear Encapsulants History

Pioneered Clear Epoxy Compound in 1980’s

MG18

Lower moisture absorption
Higher MSL Performance

MG97

Silicone Replacement Hybrid Chemistry
Yields outstanding Clarity & Durability
Heat stable for >7500 hours @ 125°C

OP1000

Cast Pellet Version of OP1000
Heat stable for 1000’s of hours @ 105°C
Cost Effective version of OP1000

SolEpoxy OC10-1
Shelf Stable for 6 months @ 10°C

Fine Grind Powder version of OP1000
Heat stable for 1000’s of hours @ 105°C
Add your own Phosphor technology

SolEpoxy OG10-1
Shelf Stable for 6 months @ 10°C

Silicone Replacement Liquid
Liquid for high production flexibility
Heat stable for > 3000 hours @ 100°C

SolEpoxy OL10-1
Shelf Stable for 6 months @ -20°C
SolEpoxy™ OP1000 is **very heat-stable @440nm**, even after 7,500 hours @125°C.

Data is similar for 460nm wavelength transmission.
OC10-1: Silicone Replacement Hybrid Clear Pellet

SolEpoxy OC10-1

Product Features & Benefits:
- Cost Effective alternative to silicone for encapsulant of Mid Power LED
- Cost Effective alternative to even OP1000 with a draft angle
- High (>90%) transmission from 270nm – 14,000nm
- Non-yellowing after 1000’s of hours at temperatures of 105°C
- Shelf-Life stability is >18mos @ 5°C

Target Applications:
- Mid-Power LED SMD that have a junction temperature (Tj) < 105°C
- Sensor applications, including:
  - Leadless MAP devices
  - IR sensors with unique light-filtering technology
  - UV sensors operating at >350nm

Other Potential Applications:
- UV LED applications that require high transmittance >350nm
- Outdoor RGB SMT LED applications that require UV Resist
OG10-1: Silicone Replacement Liquid

Key Features, Benefits and Target Applications

SolEpoxy OG10-1

Product Features & Benefits:
- Cheaper alternative to silicone for encapsulant of Mid Power LED
- High (>90%) transmission from 270nm – 14,000nm
- Non-yellowing after 1000’s of hours at temperatures of 105°C
- Shelf-Life stability is >18mos @ 5°C

Target Applications:
- Mid-Power LED SMD that have a junction temperature (Tj) < 105°C
- Allows customers to add their own phosphor to be able to do their own color binning.
OL10-1: Silicone Replacement Liquid
Key Features, Benefits and Target Applications

SolEpoxy OL10-1

Product Benefits:
- Cost Effective alternative to silicone for encapsulant of Mid Power LED
- High (>90%) transmission from 270nm – 14,000nm
- Non-yellowing after 1000’s of hours at temperatures of 105°C
- Shelf-Life stability is >6mos @ -20°C (compared to -40°C)
- Allows you to do your own color-binning using own phosphor
- Very high adhesion to various plastics (grim-death comparison 😊)
- Outstanding toughness and moisture resistance

Target Applications:
- Mid-Power LED SMD that have a junction temperature (Tj) < 105°C
- Applications that are still low volume and require high flexibility
- Sensor applications, including:
  - Leadless MAP devices
  - IR sensors with unique light-filtering technology
  - UV sensors operating at >350nm

Other Potential Applications:
- UV LED applications that require high transmittance >350nm
- Mid-Power LED applications that require phosphor mixing
**OC10-1: Silicone Replacement Cast Compound**

**Key Features and Benefits**

**SolEpoxy OC10-1**

**Product Benefits:**
- Cost Effective alternative to silicone for encapsulant of Mid Power LED
- High (>90%) transmission from 270nm – 14,000nm
- Non-yellowing after 1000’s of hours at temperatures of 105°C
- Shelf-Life stability is >18mos @ 5°C
- Allows you to do your own color-binning using own phosphor
- Very high adhesion to various plastics (grim-death comparison 😊)
- Outstanding toughness and moisture resistance

**Target Applications:**
- Mid-Power LED SMD that have a junction temperature (Tj) < 105°C
- Applications that do not yet use an auto-feed transfer mold equipment

**Other Potential Applications:**
- UV LED applications that require high transmittance >350nm
- Outdoor RGB SMT LED applications that require UV Resist
- Mid-Power LED applications that require phosphor mixing
Encapsulation Alternatives for Mid-Power LED

SolEpoxy Clear Encapsulants vs Alternatives

<table>
<thead>
<tr>
<th>Property</th>
<th>SolEpoxy OC10-1 Hybrid Cast Clear Pellets</th>
<th>Alternatives</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OL10-1 Hybrid Liquid CMC</td>
<td>OP1000 Hybrid CMC</td>
</tr>
<tr>
<td>Transmission (Initial)</td>
<td>&gt;90% @ 270nm</td>
<td>&gt;90% @ 270nm</td>
</tr>
<tr>
<td>Heat Resistance</td>
<td>Tj &lt; 125°C</td>
<td>Tj &lt; 105°C</td>
</tr>
<tr>
<td>UV Resistance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adhesion</td>
<td>Epoxy/PPA/PCT/Ag</td>
<td>Epoxy/PPA/PCT/Ag</td>
</tr>
<tr>
<td>Gas Permeability (Sulphur)</td>
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<td></td>
</tr>
<tr>
<td>Rigidity (E Modulus)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refractive Index (Efficiency)</td>
<td>1.51</td>
<td>1.51</td>
</tr>
<tr>
<td>Production Flexibility</td>
<td>Transfer Mold</td>
<td>Dispense</td>
</tr>
<tr>
<td>Production Efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shelf Life</td>
<td>18 months @ 5°C</td>
<td>6 months @ -20°C</td>
</tr>
<tr>
<td>Material Cost</td>
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<td></td>
</tr>
</tbody>
</table>

Essentially, silicone is over-engineered for many of the applications that use it.
The 3+ Known Problems with Silicones

Silicone is non-yellowing but mechanical properties are poor

1. Soft & Sticky
   Pressure on silicone can break wires. Dust on silicone will stick and reduce light output

2. Delamination
   De-lamination at PPA/PCT interface with Silicone – creates “dark spots” – reduces reflectivity & light output

3. Porosity
   Water and chemicals can penetrate and corrode silver to black – reducing reflectivity

4. Cost
   Water and chemicals can penetrate and corrode silver to black – reducing reflectivity

5. Rigidity
   Water and chemicals can penetrate and corrode silver to black – reducing reflectivity
SolEpoxy Clear Encapsulants
Refractive Index and Reflow Resistance

High Refractive Index

Higher RI translates to higher light output, and thus higher efficiency

Designed for SMT Reflow

Stable optical and mechanical properties even after 3x IR reflow at 260°C

In-situ testing reveals that with thicknesses <0.1mm that SolEpoxy Clear Encapsulants have a transmittance similar to quartz glass.
Optically Clear Encapsulants Initially & after Aging

Transmittance after Aging @ 100°C, 3000 hours, 1 mm thick

% Transmission vs. Wavelength, nm

Transmission @ 460nm
Initial: 90.39%
After 3,000 hours @ 100°C: 87.95% ($\Delta = 2.7\%$)

** In very thin sections (ie. 6um thick spin coating quantum dots on a wafer)
OC10-1 had very high transmission (similar to quartz) even at 250 nm wavelength!
OL10-1 Initially & after Aging

Transmittance after Aging @ 105°C, 2000 hours, 1 mm thick

- Transmission >90% @ 450nm
- No degradation above 450 nm
- Less than 1% transmittance loss after 2000 hours @ 105°C
OL10-1 Initially & after Aging (Normalized)

Transmittance after Aging @ 105°C, 2000 hours, 1 mm thick

- Normalized for 100% Transmission
- No degradation above 450 nm
- Less than 1% transmittance loss after 2000 hours @ 105°C
Refractive Index Comparison

Comparison of SolEpoxy Clear Encapsulants

Samples: 1 mm thickness Opto MC PB for 4 hr @ 150°C  Opto Liquid PB for 2 hr @ 150°C
OC10-1 has good transmission initially...

Transmission data at T=0

...and after 500 hours @ 125°C

Transmission data at T= 500 hours
SolEpoxy Clear Encaps better MSL Performance

*Designed with lower moisture absorption & higher Tg*

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**Moisture Absorption, %**
After 1 hour boil @ 100°C
With 2hr & 4hr Postbake @ 150°C

**Glass Transition Temperature (Tg), °C**
With 2hr & 4hr Postbake @ 150°C

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**Low Moisture Absorption**
*Means less pop-corning and better MSL performance*

**High Tg**
*High glass transition temperatures of SolEpoxy Clear Encapsulants*
SolEpoxy Clear Encaps Adhesion Data

Designed for Copper, Silver and Preplated Leadframes

Adhesion to various plating surfaces

High Adhesion
Proven on Cu, Ag and NiPdAu leadframes
## SolEpoxy Clear Encapsulants

### Summary of Properties

#### Cured Properties*

<table>
<thead>
<tr>
<th>Property</th>
<th>OP1000</th>
<th>OC10-1</th>
<th>OG10-1</th>
<th>OL10-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunshine Gel Time @ 125°C, min</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>24</td>
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<tr>
<td>Viscosity</td>
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<tr>
<td>Initial, Cps</td>
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<tr>
<td>After 7 hrs @ 25°C</td>
<td></td>
<td></td>
<td></td>
<td>2800</td>
</tr>
<tr>
<td>Transmittance @ 460nm Initial, %</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>91.85%</td>
</tr>
<tr>
<td>Refractive Index @ 460nm</td>
<td>1.52</td>
<td>1.52</td>
<td>1.52</td>
<td>1.52</td>
</tr>
<tr>
<td>Mold Shrinkage, %</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
<td>1.07%</td>
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<tr>
<td>Glass Transition Temperature, °C</td>
<td>139</td>
<td>139</td>
<td>139</td>
<td>152</td>
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<tr>
<td>Coefficient of Thermal Expansion, ppm/°C</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alpha 1</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>67</td>
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<tr>
<td>Alpha 2</td>
<td>161</td>
<td>161</td>
<td>161</td>
<td>171</td>
</tr>
<tr>
<td>Die Shear Adhesion, lbs (kg)</td>
<td>TBD ()</td>
<td>TBD ()</td>
<td>TBD ()</td>
<td>TBD ()</td>
</tr>
<tr>
<td>Glass Epoxy, FR4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper, Cu</td>
<td>TBD ()</td>
<td>TBD ()</td>
<td>TBD ()</td>
<td>TBD ()</td>
</tr>
<tr>
<td>Water Absorption after 4hrs@150°C, %</td>
<td>0.48%</td>
<td>0.44%</td>
<td>0.48%</td>
<td>0.25%</td>
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<tr>
<td>Flexural Properties after 4hrs @150°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexural Strength, MPa (psi)</td>
<td>110 MPa (16,830 psi)</td>
<td>110 MPa (16,830 psi)</td>
<td>110 MPa (16,830 psi)</td>
<td>122 MPa (17,695 psi)</td>
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<tr>
<td>Flexural Modulus, GPa (Mpsi)</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>2.8 GPa (0.41 Mpsi)</td>
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<tr>
<td>Flexural Toughness, MPa (psi)</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>2.51 MPa (363,000 psi)</td>
</tr>
</tbody>
</table>
Light Filtering Version for IR Devices

Transmission Data, 1mm, molded 2 hrs @ 150°C

Cuts out all visible light.
Transmission below 800nm < 1%
Transmission @ 950nm > 85%