# Durable
# Versatile
# Optically Clear

**Ultra Clear Liquid Silicone Rubber**

**Silopren* LSR 7000 Series**

MOMENTIVE™

## New Lighting Technologies Require Advanced Material Properties

Cutting-edge technologies that are being developed to advance high-power LEDs, automotive lighting and electronics pose new challenges. These technologies demand extremely long-term transmission retention for optimum optical performance and high flowability to enable a micro-structure design in a compact shape. However, these requirements are challenging for many transparent plastics. By providing optical clarity, durability and design freedom, the Ultra Clear Silopren* LSR 7000 liquid silicone rubber (LSR) series can serve as the alternate solution.

The series combines typical LSR properties such as high temperature stability and flowability with 94 percent transmission and excellent UV and blue light stability. With regards to processing, the series can help enable excellence in manufacturing complex and micro-structure optical lenses, even in large quantities, utilizing the injection and compression molding processes.

This brochure gives an overview of the unique combination of properties Silopren LSR provides and the optical applications for which it may be considered.

## Ultra Clear Silopren LSR 7000 Series

The Silopren LSR 7000 Series is an excellent solution to consider for applications that require high optical clarity in combination with long-term durability, if exposed to high temperatures and UV light. The series combines these features with the typical processing and productivity benefits of addition-cured, platinum-catalyzed LSRs and can enable high precision molding of complex geometries.

### Optical Clarity

LSR 7000 is a highly transparent material with excellent typical values in transmission, haze and dispersion as compared to those of plastics.

- 94% transmission
- <1% haze
- Abbe number of approximately 50
- Strong color stability

### Durability

High temperature and UV light resistance coupled with resistance to even the smallest cracks makes LSR 7000 a durable material. Its ability to retain good optical properties, even in challenging conditions, allows it to meet the demanding requirements of most innovative applications.

- High temperature resistance even above 150 °C
- UV light resistance
- Micro-crack resistance

### Design Freedom

The most innovative ideas can be realized with LSR 7000. Due to its high flowability, the material can help enable increased precision and the ability to design complex and micro-structure parts.

- Enhanced options for part integration
- Reduced weight in design

### Productivity

Reproduction of optical parts is clearly a critical factor in material selection. LSR 7000 can enable reliable mass production processes with minimized waste, high yield and easy manufacturing.

- Excellent processability for injection/compression moldability
- Material waste may be minimized in the coldrunner-based LSR injection process

# LSR 7000 can make the most innovative ideas possible.

## Industry and Potential Application Overview

The Silopren LSR 7000 Series can serve a wide range of industries and applications that have historically utilized amorphous engineering thermoplastics.

### Automotive Lighting

Lenses and light guides

### Electronics

Mobile phones, flash lenses, light guides and other optics

### Interior and Exterior Lighting

Lenses and other illumination optics

### Solar

Lenses and light guides

## Potential Application Examples

Since the introduction of the Silopren LSR 7000 series, engineers have been utilizing this innovative material for a wide array of unique applications. The series has evolved into a technology enabler where ideal design was unachievable with traditional materials due to limitations caused by its physical properties. Below are examples of existing and potential applications that demonstrate the specific properties of the Silopren LSR 7000 series and the benefits created that are not possible with traditional materials. Many more designs are currently in development across the globe as engineers begin to incorporate the series into even more innovative applications.

### Optical lenses

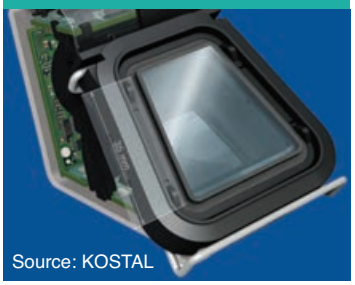
**Isotropic:** minimal to no stress even in complex and micro-structure designs

### Light guides

**Optical clarity:** uniform and efficient light distribution over a broad range of wavelengths

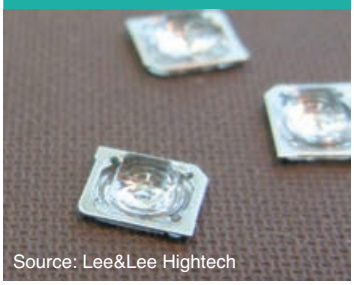
**Elastomeric:** flexible and noise/vibration dampening

### Adaptive optical interface




**Ultra-low modulus:** easy to adapt to different shapes, tolerances and surfaces

### Flash lenses of mobile phone cameras




**High heat resistance:** Surface-mounting-technology process compatibility

### Secondary lenses of outdoor lighting

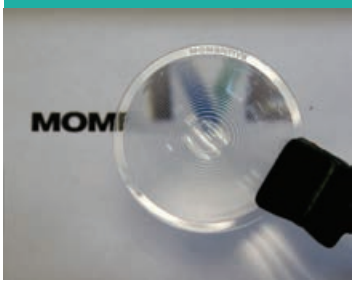
**High flowability:** Design freedom for complex and micro-structure optical parts

**High temperature and UV light stability:** long-term optical property retention

### Molded lenses for LED package


**Low viscosity availability:** excellent processibility for compression molding

### Concentrating optic with micro-structure



**High flowability:** easy implementation of micro-structure optical design like Fresnel lenses

## Comparison with Other Transparent Materials

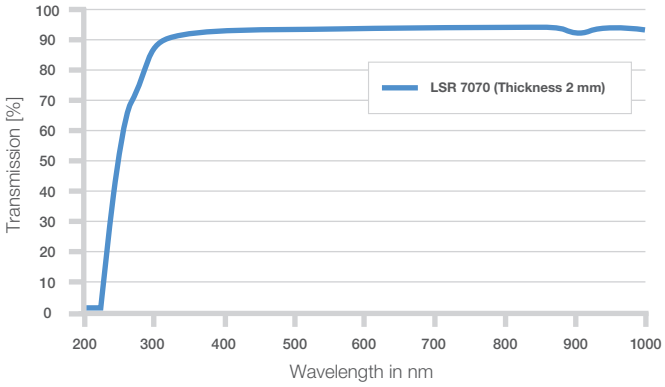
The inherent chemical properties of silicone make LSR a strong, durable material as compared to thermoplastics, such as polycarbonate (PC) and polymethylmethacrylate (PMMA). The bonding energy of the inorganic Si-O chain of a silicone is at 451kJ/mol, which is at least 30% higher than at the carbon C-C chain of an organic plastic material at 352 kJ/mol.

Also, while thermoplastics may be able to mass produce optical parts, the materials do not typically possess long-term durability to thermal or UV light exposure. Additional typical properties of the LSR 7000 series as compared to other transparent materials are detailed below.

| Category | Property | LSR 7000 | PC | PMMA | Glass |
|---|---|---|---|---|---|
| **Properties of Optical Clarity, 2 mm** | Transmission [%] | 94 | 86~89 | 89~92 | 92 |
| | Index of Refraction (RI) | 1.41 | 1.59 | 1.49 | 1.5~1.6 |
| | Haze % | <1 | 1-3 | 2-4 | - |
| | Abbe number | 50 | 34 | 57 | 39~59 |
| | Yellowness index | <1 | 1.0~3.0 | 1.0~3.0 | - |
| **Durability** | Heat resistance | Excellent | Poor | Poor | Excellent |
| | UV resistance | Excellent | Poor | Good | Excellent |
| **Design Freedom** | Complex/micro-design | Excellent | Good | Good | Poor |
| | Material flexibility | Excellent | Poor | Poor | Poor |
| | Light weight design | Excellent | Good | Good | Poor |

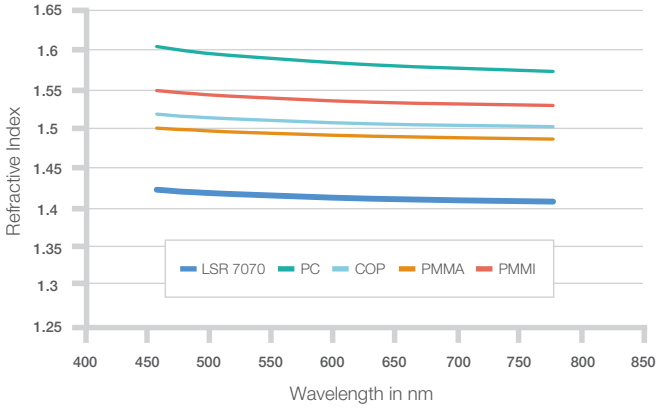
Figures may vary by specific grades. Typical product data values are averages and should not be used as specifications.

# Typical Optical Properties




## Transmission

The Silopren LSR 7000 series features a consistent transmission level of approximately 94 % at 2 mm over a wide range of wavelengths in both visible and non-visible light.




## Refractive Index

The Refractive Index (RI) is important for many optical applications. The RI is directly influenced by the thermal expansion of the molded part with RI decreasing as the temperature of the part increases. The LSR 7000 series typically has a lower RI than common thermoplastics; with an appropriate lens design, performance similar to thermoplastics can easily be exceeded.

| | LSR 7070 | PC | COP | PMMA | PMMI |
|---|---|---|---|---|---|
| *Abbe number (v) | 48.9 | 31.0 | 54.1 | 58.8 | 46.2 |

***v =(nD-1)/ (nF-nC), where (nD-1) = Refractivity, (nF-nC) = Principal Dispersion**

Typical product data values are averages and should not be used as specifications.

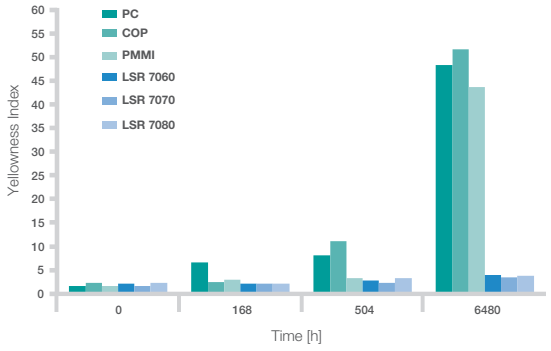
## Dispersion

Another important measurement for optical applications is the Abbe number, which relates to the tendency of a material to separate light into its components when passing through a lens. Optical parts made out of LSR 7000 typically are characterized by reduced chromatic aberration.

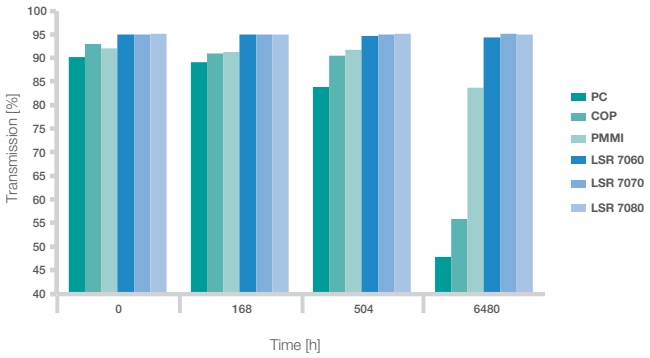
# Durability

The LSR 7000 series typically demonstrates good heat stability, even at higher temperatures, showing long-term optical performance with consistent transmission retention and a low yellowness index as compared to thermoplastics.

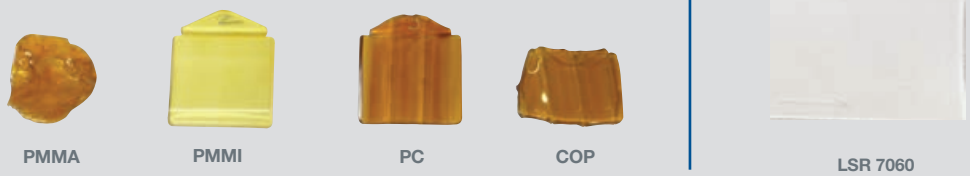
**Yellowness Index change over 6,480 h @ 150 °C**




**Transmission change over 6,480 h @ 150 °C**



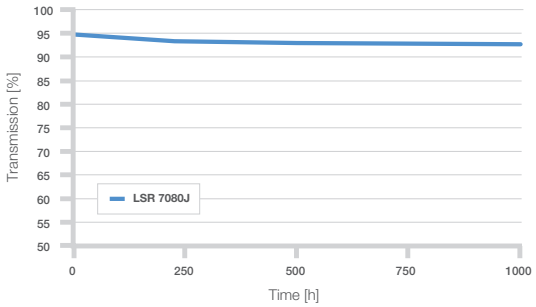

**Test results from Momentive demonstrating yellowing after 6,480 hours at 150 °C on a variety of transparent materials, including the LSR 7000 series.**



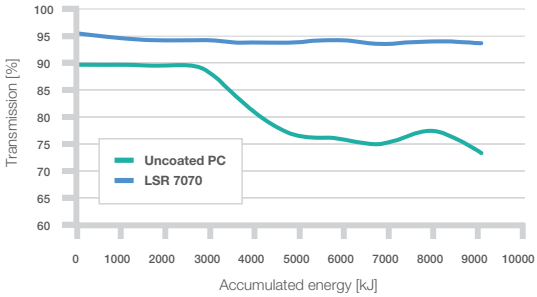

The test data below demonstrates LSR 7000's ability to retain optical properties even when exposed to heat and humidity.

When the Xeon acceleration test was combined with humidity over time, LSR 7000 still exhibited long-term stability of optical properties.

**Transmission at 85 °C / 85 % RH (relative humidity) aging test over 1,000 h**




**Durability according to SAE J2527 / Automotive**

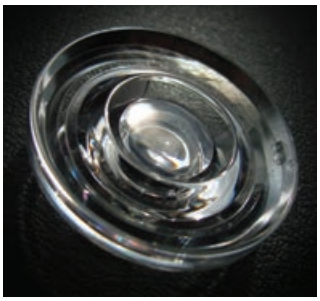



Typical product data values are averages and should not be used as specifications.
Note: Test data. Actual results may vary.

## Design Freedom

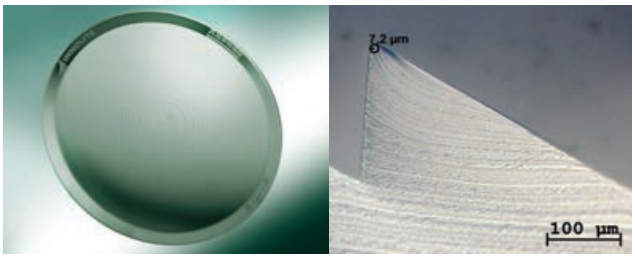
LSR can be fed and injected at room temperature into a hot mold at a temperature higher than 150 °C. LSR can fill the smallest areas and gaps of the cavity at a low injection pressure. In the cavity, it thermally expands from an injection temperature around 25 ˚C to a curing temperature higher than150 ˚C. Filling difficult areas and shaping highly precise surface structures can be realized through low viscosity and thermal expansion with a needle gate system that minimizes the holding pressure to a minimum and makes complex runner systems dispensable.

Along with its flexibility, the LSR injection molding process can enable true freedom of design in manufacturing during de-molding. Even with direct gating, cold runner and small gate sections, it is possible to generate complex parts and high precision microstructures with the LSR injection molding process.

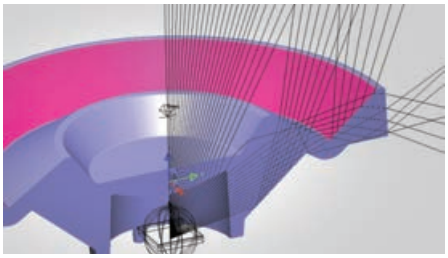


**LSR 7070**
(Source: KIMW, Germany, 2011)

## LSR process can allow implementation of microstructures




Example: Fresnel Lenses (Source: ARBURG, Germany)

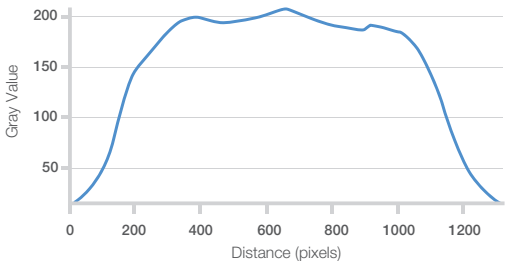


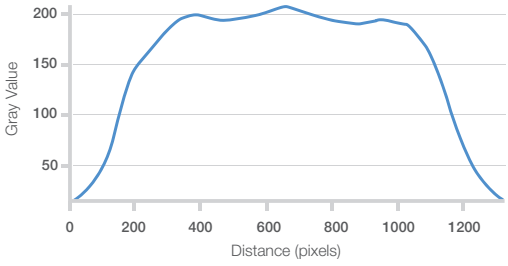
LSR can enable the filling of complex cavities with high precision even with varying dimensions in wall thickness. Example: multifunctional lenses (Source: Ingenieurbüro Dr. Thomas Abel, Germany)

## Light Distribution

Precise light projection of the multifunctional lens can be retained even when exposed to heat and humidity.

**Survived 700h at 85 °C / 85 % humidity**




Light distribution before test

Light distribution after test

(Source: KIMW, Germany, 2011)

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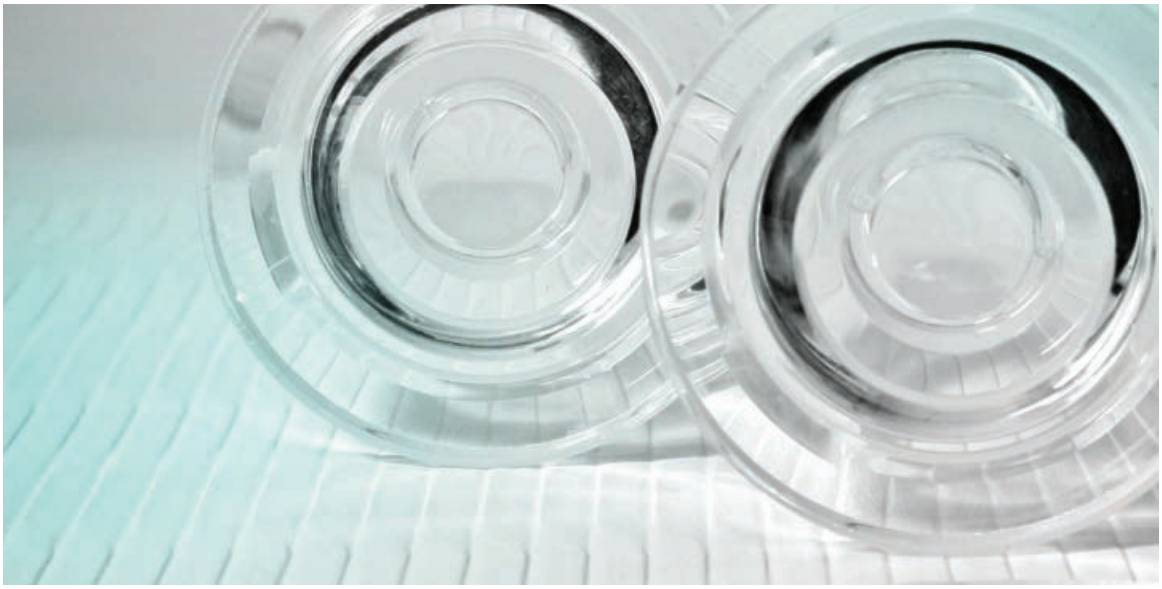
Note: Test data. Actual results may vary.



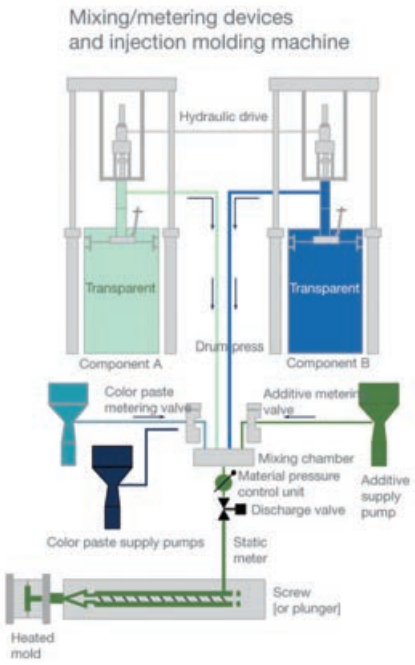
## Potential Productivity Advantages

The Ultra Clear Silopren LSR 7000 series is a hot-vulcanizing thermosetting rubber developed to be processed by the highly efficient liquid silicone rubber injection molding process.

By combining the advantages below, the injection molding process can enable safer and potentially cost-efficient manufacturing, especially of high-quality parts at high quantities.

- Very short cycle times through fast curing platinum catalyzed system
- Virtually by-product free curing through poly-addition system
- Fully automated process without sprue & runner waste through cold runner technology

The low viscosity in the range of 20 - 500 Pa·s (at shear rate 10 $s^{-1}$ at 20 °C) can conserve mold and machinery equipment; enable overmolding of mechanically sensitive inserts; and easily fill highly complex parts and long flow paths through minimized gates.




# LSR injection molding process can enable true freedom of design in manufacturing.

## Wide Range of Product Options

A broader portfolio of Ultra Clear LSR grades is available to meet specific application requirements. The product is designed to be used in a 1:1 mix ratio and typically cures rapidly to a crosslinked elastomer by heating in various molding equipment such as injection and compression molding technologies.

## Silopren LSR 7000 Series – Typical Physical Properties

| | | | LSR 7005 | LSR 7030 | LSR 7060 | LSR 7070FC | LSR 7080J | LSR 7090 |
|---|---|---|---|---|---|---|---|---|
| Appearance | | | Optical Clarity | Optical Clarity | Optical Clarity | Optical Clarity | Optical Clarity | Optical Clarity |
| Mix ratio by weight | | | 1:1 | 1:1 | 1:1 | 1:1 | 1:1 | 1:1 |
| Viscosity (mixed) @ 23 °C | Pa·s | | 53 | 38 | 46 | 20 | 120 | 42 |
| Cured Properties (Press cure 15 min@130°C for all except LSR 7090 15 min@130°C, 1hr@150°C) | | | | | | | | |
| Basic | | | | | | | | |
| Density | JIS K 6249 | $g/cm^3$ | 0.98 | 1.01 | 1.03 | 1.05 | 1.06 | 1.08 |
| Shore A hardness | JIS K 6249 | - | 5 | 30 | 60 | 70 | 80 | 90 |
| Shore D hardness | - | - | - | - | 18 | 23 | 30 | 42 |
| Tensile strength | JIS K 6249 | $N/mm^2$ | 0.3 | 3.5 | 6.5 | 8.5 | 10 | 8.0 |
| Elongation at break | JIS K 6249 | % | 210 | 250 | 340 | 145 | 90 | 50 |
| Tear strength | JIS K 6249 | N/mm | - | 3 | 11 | 7 | 7 | 8 |
| Optical | | | | | | | | |
| Transmission (2 mm) | 400nm | % | 93 | 93 | 93 | 93 | 93 | 93 |
| | 700nm | | 94 | 94 | 94 | 94 | 94 | 94 |
| Refractive Index | ($n_D$25) | | 1.41 | 1.41 | 1.41 | 1.41 | 1.41 | 1.42 |
| Haze | D 1003 | % | <1 | <1 | <1 | <1 | <1 | <1 |
| Dispersion | Abbe number | % | 50 | 50 | 50 | 49 | 51 | 51 |
| Thermal | | | | | | | | |
| CTE linear (40-90°C) | - | ppm/°C | 330 | 345 | 290 | 270 | 265 | 250 |
| Linear Shrinkage | JIS K 6249 | % | 2.2 | 2.2 | 2.1 | 2.1 | 2.1 | 2.0 |
| Others | | | | | | | | |
| Water absorption | D 570 | % | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Curing Data | 10'@ 110 °C | T60 [min] | 0.5 | 0.4 | 1.1 | 1.4 | 1.4 | 1.7 |
| Potential Applications | | | | | | | | |
| Primary lenses | | | | | ● | ● | | |
| Secondary lenses | | | | | | | ● | ● |
| Light guides | | | | ● | ● | | | |
| Flexible optics | | | ● | ● | | | | |

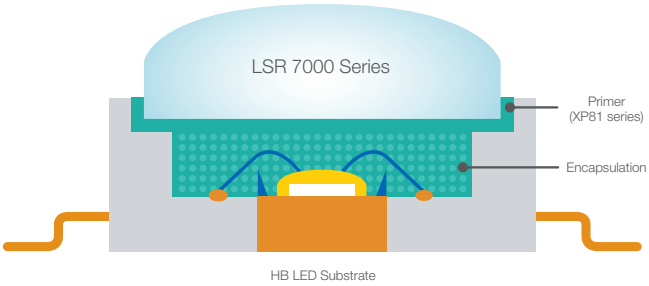
Custom grades are available by request.

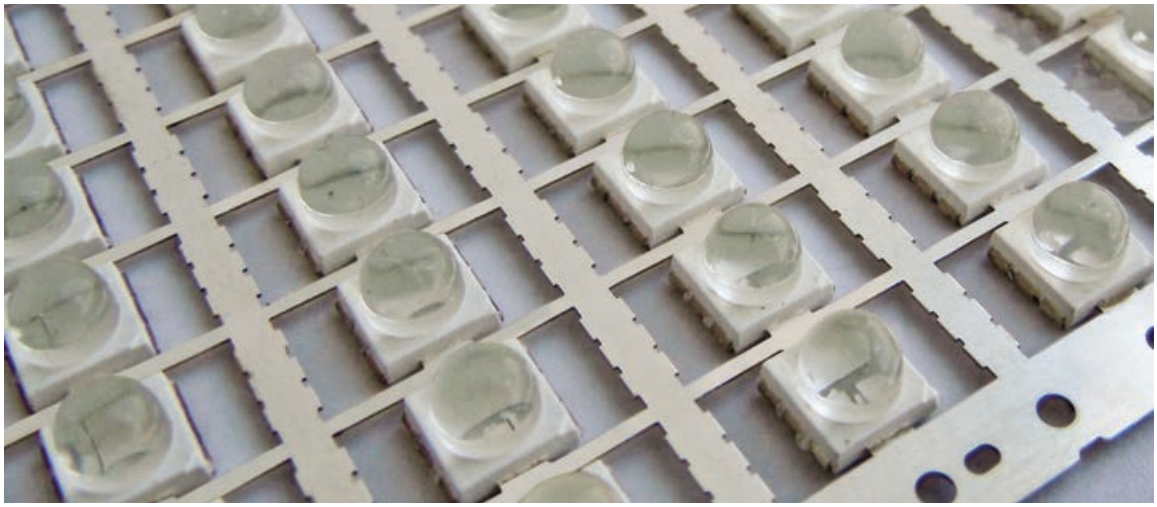
Typical product data values are averages and should not be used as specifications.

## Primer for LSR 7000 based optical applications

Momentive Performance Materials has developed two primers for use with LSR 7000 for optical applications: XP81-C5262 and XP81-C0431.

Detailed information is available upon request from the Momentive sales contact.



## Pioneer in LSR Technology

Momentive Performance Materials is a pioneer of LSR technology and brings a blended heritage of more than 70 years of silicone innovation and market firsts. Across the globe, Momentive's silicone elastomers have been shown to provide outstanding properties to a wide range of industries from healthcare to electronics to personal care and automotive. As a pioneer of many of the applications for these industries, Momentive continues to serve its customers with leading innovations and creative ideas.

## Technical Support Partner

Momentive Performance Materials has an Application Development Center that provides state-of-the-art technical and managerial support. From the selection of material to choosing the optimum design to molding and processing setup, the Momentive team supports customers from project initiation through production.

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**Patent Status**

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**Product Safety, Handling and Storage**

Customers should review the latest Material safety Data Sheet (MSDS) and label for product safety information, handling instructions, personal protective equipment if necessary, and any special storage conditions required. MSDS are available at www.momentive.com or, upon request, from any Momentive Performance Materials representative. For product storage and handling procedures to maintain the product quality within our stated specifications, please review Certificates of Analysis, which are available in the Order Center. Use of other materials in conjunction with Momentive Performance Materials products may require additional precautions. Please review and follow the safety information provided by the manufacturer of such other materials.

**Limitations**

Customers must evaluate Momentive Performance Materials products and make their own determination as to fitness of use in their particular applications.



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