Moldable Optical Silicones: Material Enabled Performance for LED Lighting and Optical Applications

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LSR 2018

Outline

- **Introduction to Moldable Optical Silicones**
  - *What are moldable optical silicones?*
- **Material chemistry**
  - *How chemistry relates to end-use properties*
- **Material properties**
  - *Material performance in molding*
- **Tooling for Optical Silicones**
  - *Performance in tooling*
- **Molded parts & assemblies**
  - *Enabling end use*

SILASTIC™ silicone elastomers by DOW

What are moldable optical silicones?

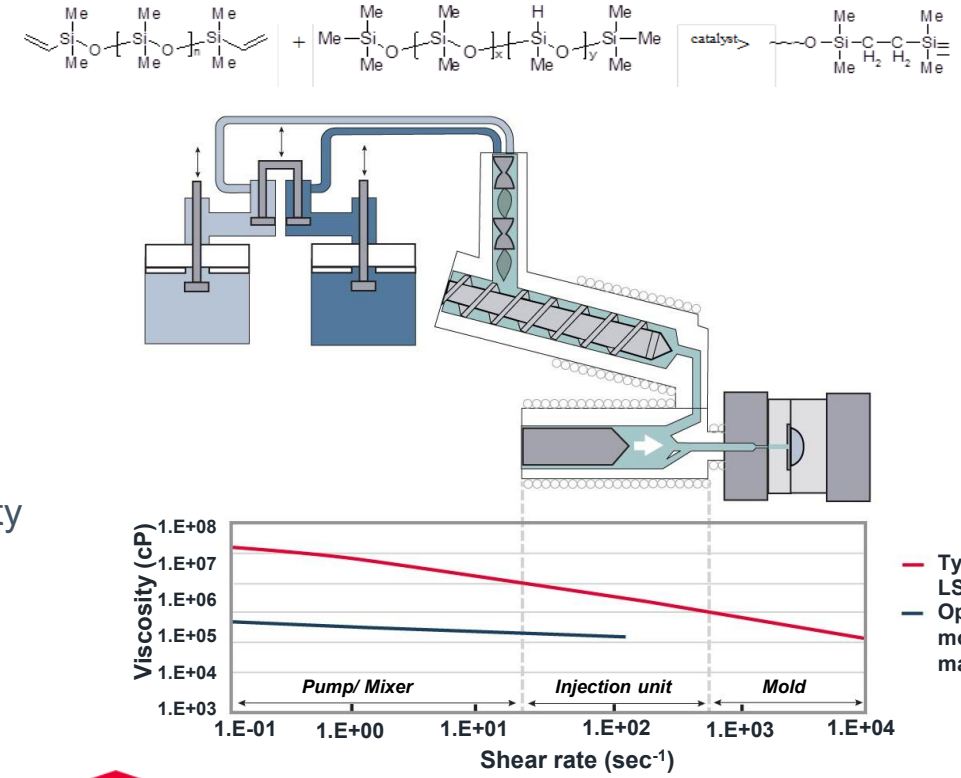
- **Moldable silicones ARE:**
  - Injection moldable optical silicone materials for unique applications, including lenses, light guides, diffusers, reflectors, etc.
- **Moldable silicones are NOT:**
  - Direct replacements for working plastic parts, perfect for every application. If alternate materials are working fine, silicone may not have a value proposition.

- A different kind of Liquid Silicone Rubber (LSR)
- Optically transparent, highly reflective, and translucent

Material chemistry

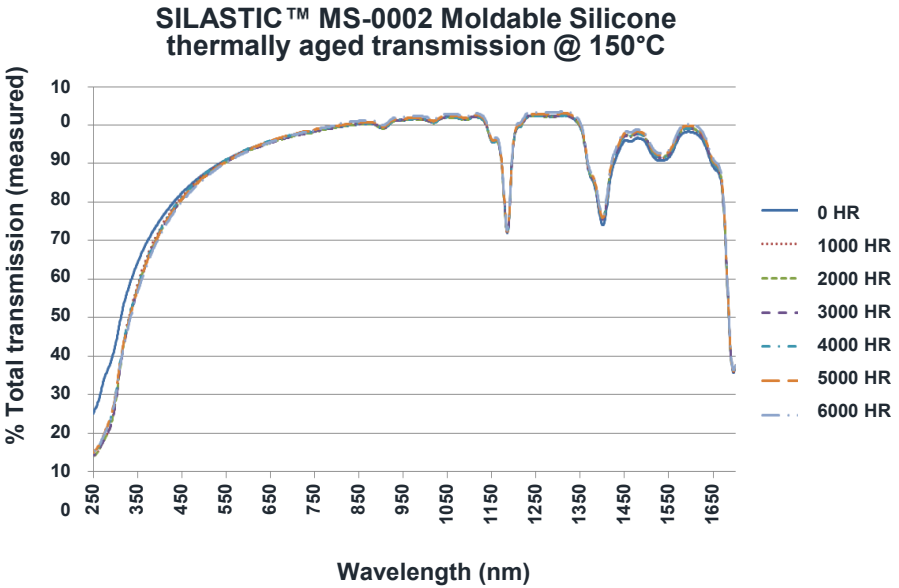
How chemistry relates to end-use properties

- **Traditional LSR**
  - Silica and/or other fillers impart strength and stability
- **Moldable optical silicones**
  - Silicone resins impart strength and stability
  - **Benefits of resin/polymer molecular backbone**
    - ✓ Moisture resistance & thermal stability
    - ✓ Physical property variations
    - ✓ High purity & clarity
    - ✓ Injection molding properties

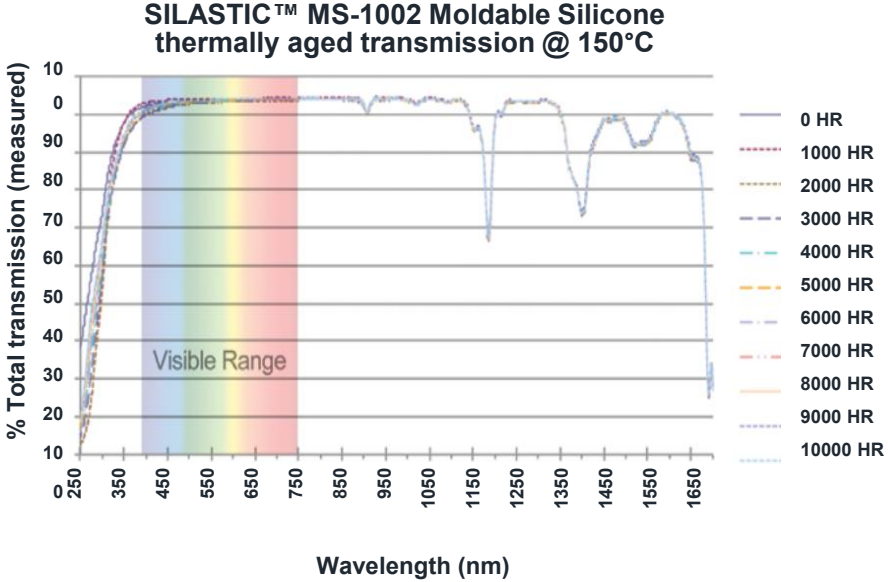


How chemistry relates to end-use properties

Traditional LSR



Moldable optical silicones



How chemistry relates to end-use properties

As compared to other optical materials

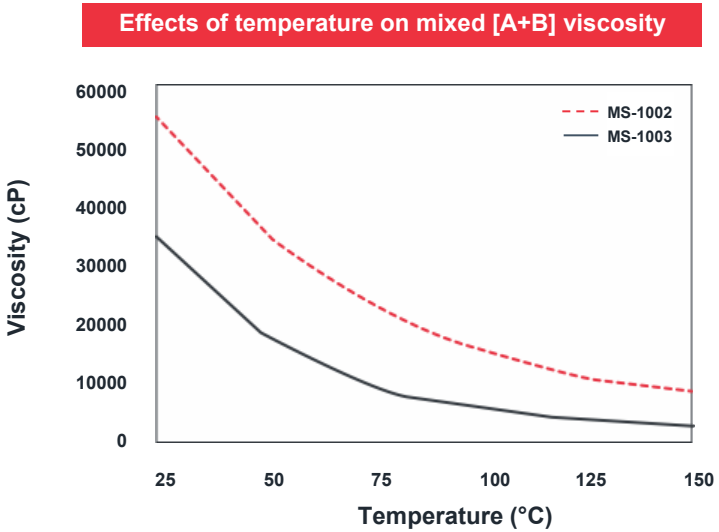
	SILASTIC™ Moldable Silicone	PC	PMMA	Glass
Light transmission	94%	88-90%	93%	95%
Refractive index	1.42	1.58	1.49	1.52
UV resistance	High	Low	Medium	High
Chemical resistance	Medium	Medium	Low	High
Service temperature maximum (°C)	>150	120	90	>200
Yellowing*	Low	High	High	Low
Micro detail replication	High	Low	Medium	Low
Ability to mold large and thick parts	High	Low	Low	Medium
Minimum thickness**	<0.5 mm	2 mm	2 mm	–
Draft angle manufacturing**	<0°	1 to 2°	1 to 2°	–
Weight	Low	Medium	Medium	High
Flexible material − Integration	High	Low	Low	Low

** Yellowing due to high temperature, high lumen density, or UV exposure*
*** Injection molding process*

Uncured material properties

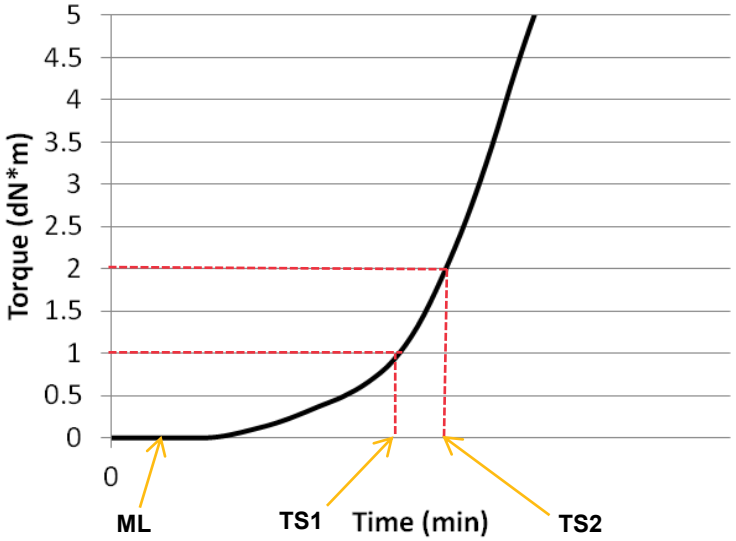
Material performance: viscosity

- **Heat influences silicone resin materials – very sensitive to temperature**
  - ***Pros**: Lower injection pressures, good flow, excellent reproduction of mold features*
  - ***Cons:** Potential for screw cavitation, slip by seals or check valve, easily turbulent*



Material performance: cure

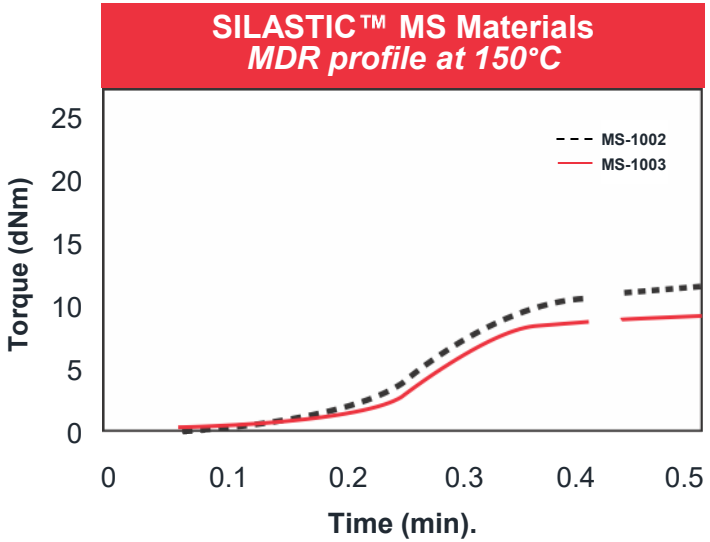
- **Cure properties tuned for mold/optic design**
- **Characterized via MDR***
  - **ML**: torque min set-up time – flow in mold cavity
  - **TS1**: time to raise one torque above min = scorch – gelation/ mid-cure
  - **TS2**: time to raise two torque units above min – ‘cured’/ handle-able



* *MDR does not correlate directly to injection molding, but helps immensely in evaluating formulations and materials*

Material performance: cure

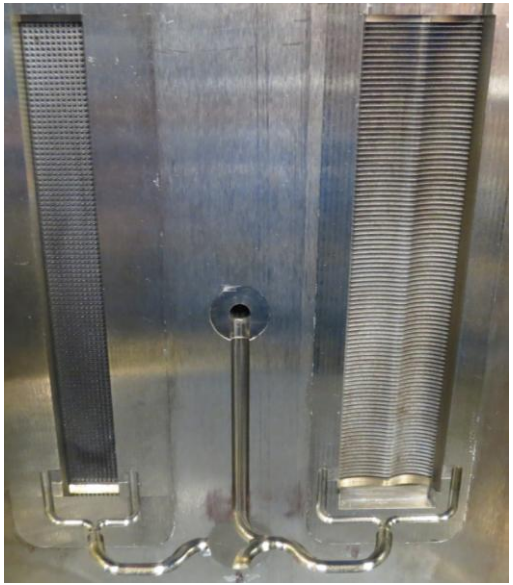
- **Cure properties tuned for mold/optic design**
  - Lag allows for fill in liquid state
  - Reduced gelation period
  - Quick to cured/handle-able part
- **Moldflow analysis in place to help better understand and predict material behavior**



Tooling for optical silicones

Performance in tooling

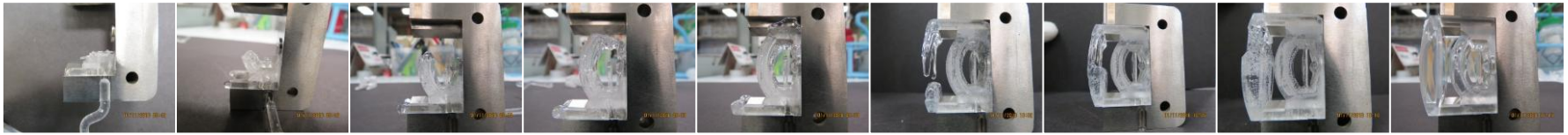
- **Low viscosity and good surface wetting**
  - Aids in flow through part cavity
  - Wet out of optical and surface features
- **Fills ‘like water’**



Patent Pending Design by

LumenFlow Corp.
Photonics Engineering & Manufacturing

Performance in tooling



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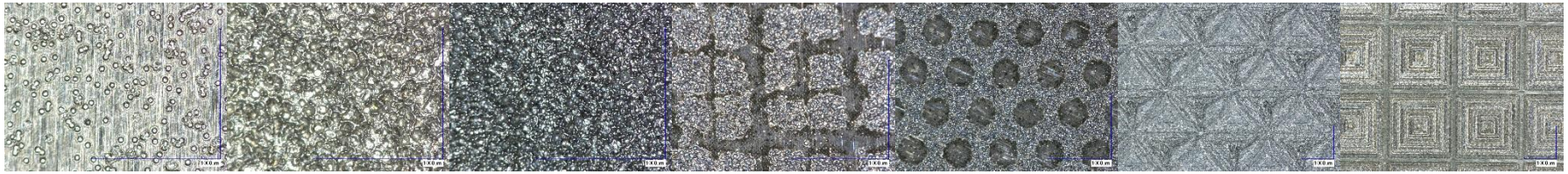


LASERETCH
BY TENIBAC-GRAPHION, INC.

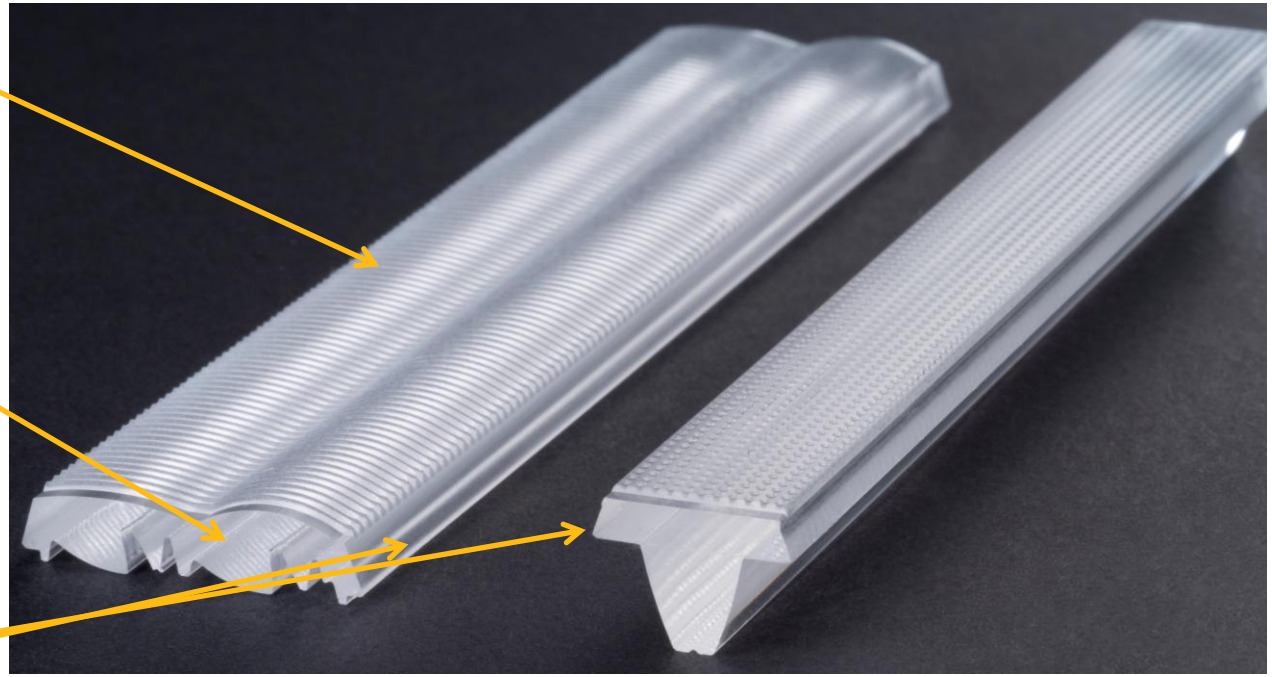
Molded parts and assemblies

Enabling end use

Unique textures

Asymmetric undercut

Sealing and fixturing features



Patent Pending Design by

LumenFlow Corp.
Photonics Engineering & Manufacturing

Enabling end use

UV and weathering resistant

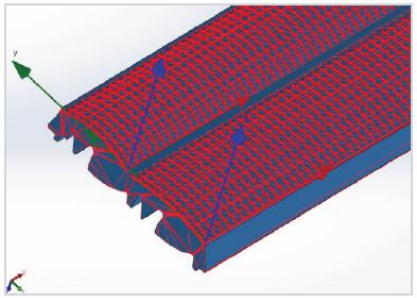
Integrated optic and seal

Close proximity to LEDs

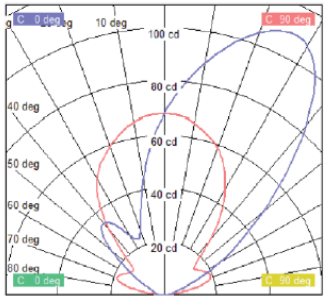
Patent Pending Design by

LumenFlow Corp.
Photonics Engineering & Manufacturing

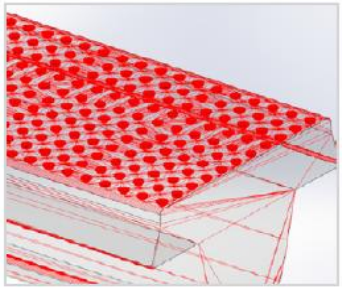
Enabling end use



Unique surface texture designed by LumenFlow Corp.



Output pattern, measured for eight (8) LED single optic section''



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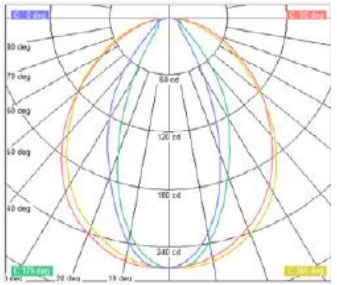

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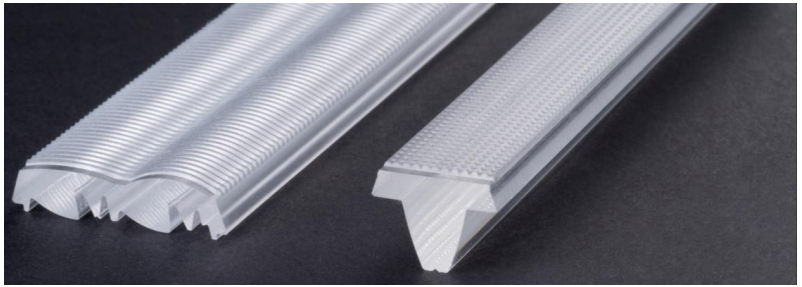
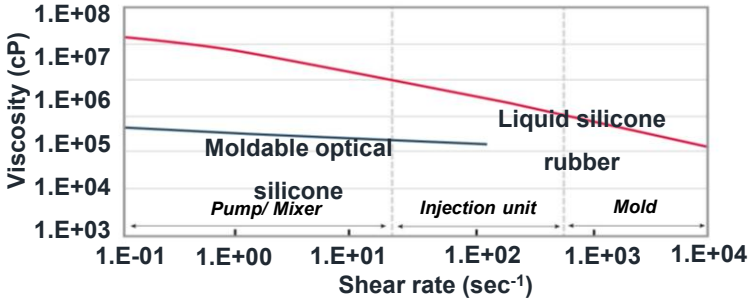
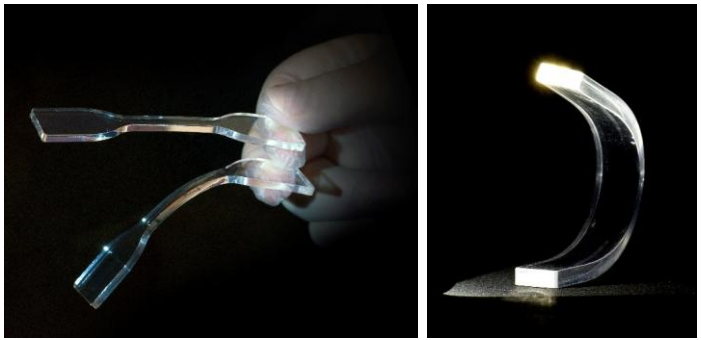


Moldable optical silicones

Moldable optical silicones: molding and mechanical properties

- **Efficient injection molding**
  - Ease of fabrication by liquid injection molding
  - No secondary polishing of molded optics required
- **Lightweight optics**
  - Low density of silicones → less weight for auto lighting applications
  - Optics lighter than with alternative materials for a given volume
- **Soft & pliable OR firm & tough**
  - Impact and scratch resistant when hit or dropped
  - Minimal compression set → high IP ratings luminaires

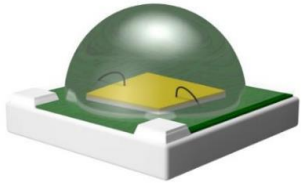




Moldable optical silicones: trends and opportunities

Incandescent
ca. 1900-2000 AD

A lighting revolution



Modern LED
ca. 2000-today

Performance silicones opportunities

Market trends

- High Power, High Efficiency
- LED Roadway Lighting
- Adaptive Headlights

Product trends

- High Photo/Thermal Stability
- Environmental Stability
- Design Flexibility

Specialty Applications
PHILIPS Deep UV
Disinfection

Outdoor Lighting
VS Lighting M-Class
Outdoor Lighting Module

Headlamp Assembly
HELLA KGaA Hueck &
Co. Matrix LED Module

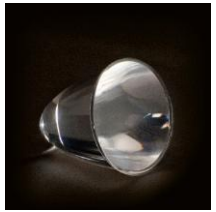
Moldable optical silicones: portfolio of solutions

- **Designed for many applications**
  - Freeform collimators
  - Secondary lenses
  - Micro-lens arrays
  - Light guides
- **Expanded material properties**
  - Hardness
  - Viscosity
- **Enhanced optical performance**
  - High light transmittance
  - Low haze and scatter

Diverse properties enable unique designs

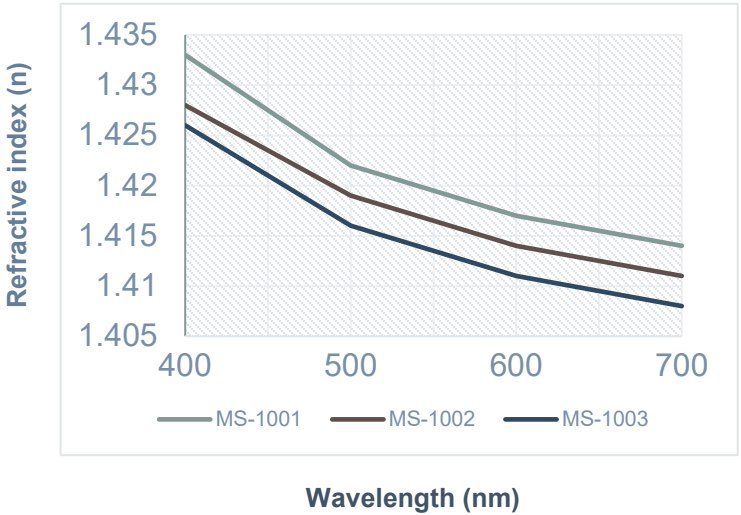
Property	SILASTIC™ MS-1003 Silicone	SILASTIC™ MS-1002 Silicone
Viscosity, Part A (Pa-sec)	52	40
Viscosity, Part B (Pa-sec)	37.5	18
Viscosity, mixed (pa-sec)	42.3	26.3
Specific gravity	1.05	1.07
Durometer (shore A)	51	72
Tensile strength (mpa)	5.5	11.2
Elongation at break (%)	325	80
Linear CTE (by TMA) (ppm/°C)	325	275

For complete data sheet, visit dow.com

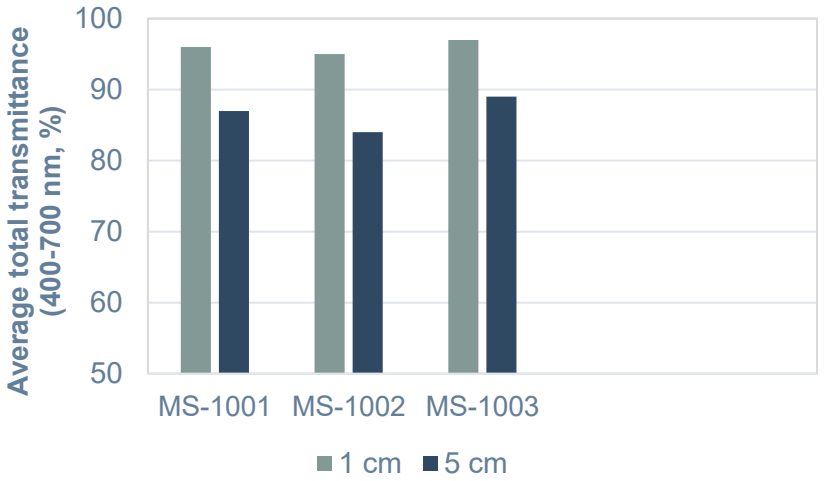


Moldable optical silicones: optical properties

Refractive index vs. wavelength



Internal transmittance (Average 400-700 nm)



Property	SILASTIC™ MS-1001	SILASTIC™ MS-1002	SILASTIC™ MS-1003
Refractive index (589.3 nm)	1.418	1.413	1.409
Abbe number	48	52	51

Moldable optical silicones

Product family

Moldable optical silicones from Dow

SILASTIC™ MS-1002
Moldable Silicone

Flexible and resilient optic

Shore A 72
Transmittance >93%
Elongation 80%

Moldable optical silicones from Dow

SILASTIC™ MS-1002
Moldable Silicone

Flexible and resilient optic

Shore A 72
Transmittance >93%
Elongation 80%

SILASTIC™ MS-1003
Moldable Silicone

Softer material for complex designs

Shore A 51
Transmittance ~92%
Elongation 325%

Moldable optical silicones from Dow

Moldable optical silicones from Dow

Application examples

Diffusers, protective covers

TIR, Fresnel, free-form lenses, engineered diffusers

Light guides

White reflectors, mixing chambers

SILASTIC™ MS-0002

SILASTIC™ MS-100X

SILASTIC™ MS-2002

Thank you

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