

Enabling advanced automotive lighting applications with moldable optical silicones

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Dow Performance Silicones – Lighting

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Advanced lighting for automotive Presented: 31 May 2019

Transportation lighting

Dark or low-lighting conditions increase likelihood of a collision¹

- Dark driving 25% of automotive travel
 - > 52% of driver fatalities
 - > 71% of pedestrian deaths
- Largest contributing factors
 - Limited forward illumination efficacy of US compliant headlamps
 - Speed of travel low beam usage adequate for only 39-52 mph

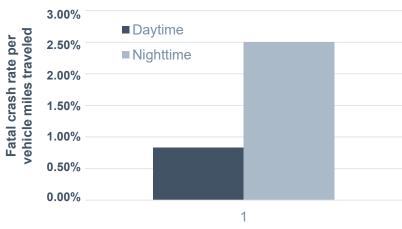
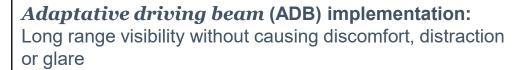


Figure 1: Fatal crash rates per VMT for Day and Night (2009 FARS and NHTS data)²

^{1.} AAA "Comparison of European and U.S. Specification Automotive Headlamp Performance" April 2019. 2. FHWA Lighting Handbook: https://safety.fhwa.dot.gov/roadway_dept/night_visib/lighting_handbook/#a1

Transportation lighting: potential solutions

Potential solution	Limitations¹
Increase roadway illumination	Glare and reflections, infrastructure needed
Increase high beam usage by drivers	Glare and concern for oncoming drivers









^{1.} AAA "Comparison of European and U.S. Specification Automotive Headlamp Performance" April 2019.

The new Dow

Back integrated feedstocks

Ethylene blocks Propylene Building Silicones

Building blocks

Cellulosics

Acrylics

Propylene Oxide

platforms

Material

Ethylene Oxide

Polyolefins & elast.

Silicones

Various others

Product development

High-throughput research capabilities

Catalyst discovery & ligand synthesis

Polymer science

Material science

Formulation sciences

Process engineering

High-performance computer modeling

> **Application** development

Target markets



Packaging

Solutions



Infrastructure

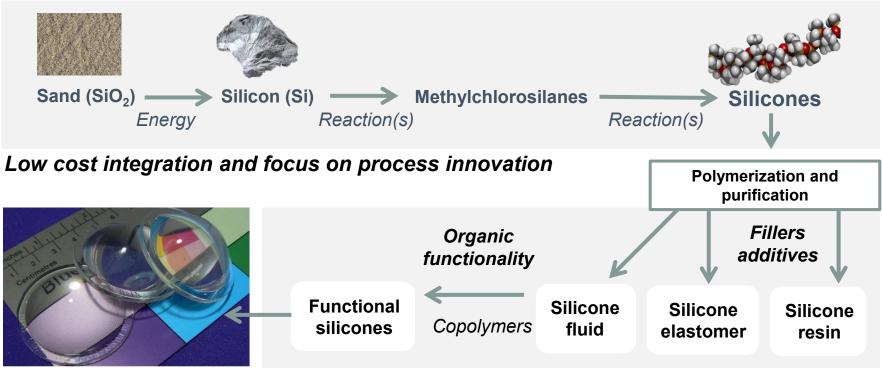


Consumer



Technology

Dow silicones: from sand to functionality



Materials for key applications

Focus on product and application innovation



A new material: moldable optical silicones

An enabling technology that is both *clear and tough*

Excellent environmental stability, optical performance and design flexibility

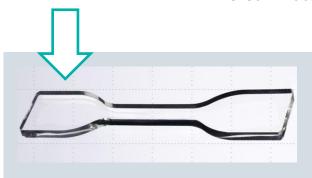
LIQUID SILICONE RUBBER (LSR):

Silica particle reinforced: hazy material



MOLDABLE OPTICAL SILICONES (MS):

Siloxane resin reinforced: clear material



- Molds like LSR
- Transmits light like glass



A new material: moldable optical silicones

Moldable silicones are:

 Injection moldable optical silicone materials for unique applications, including lenses, light guides, diffusers, reflectors, etc.

Moldable silicones can:

 Precisely control light, 'bend' light, replicate nano-scale optical features, uniformly diffuse or reflect light, be used in harsh environments/applications, and more...











How chemistry relates to end-use properties

What unique capabilities do these properties enable?

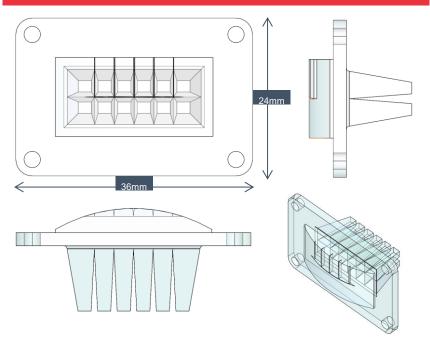
	SILASTIC™ Moldable Silicone	PC	РММА	Glass
Light transmission	94%	88-90%	93%	95%
Refractive index	1.42	1.58	1.49	1.52
UV resistance	High	Low	Medium	High
Chemical resistance	Medium	Medium	Low	High
Service temperature maximum (°C)	>150	120	90	>200
Yellowing*	Low	High	High	Low
Micro detail replication	High	Low	Medium	Low
Ability to mold large and thick parts	High	Low	Low	Medium
Maximum 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



Moldable silicone enabled design: references

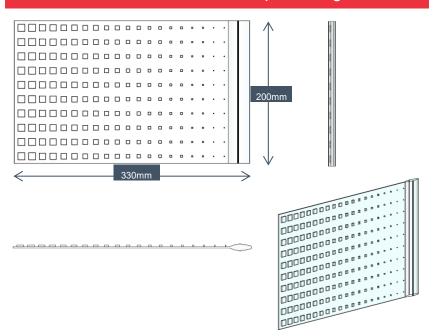
ADAPTIVE DRIVING BEAM: LIGHT ENGINE

high-power LED matrix w/silicone primary lens



REAR LAMP/INDICATOR: LIGHT GUIDE

LED linear w/silicone coupler and guide



^{*}Designs are for **reference only** and are not meant to duplicate or infringe on any other design



Moldable optical silicones: Material performance

Moldable silicones: viscosity

Heat influences viscosity of moldable silicone – very sensitive to temperature

Pros:

- Ease of fabrication through liquid injection molding
- Good flow allows for complex part geometry
- Excellent reproduction of mold features

Cons:

- Easily turbulent
- Higher potential for flash in tooling



Moldable silicones: cure

Cure properties *tuned* for optic and mold design

- Cure profile allows for fill of complex geometry in liquid state
- Reduced gelation period can reduce cycle time and defects
- Quick to cured and handle-able part





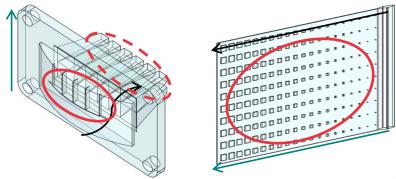
Material performance

- Good flow in complex parts
- Cure profile allows for fill in liquid state

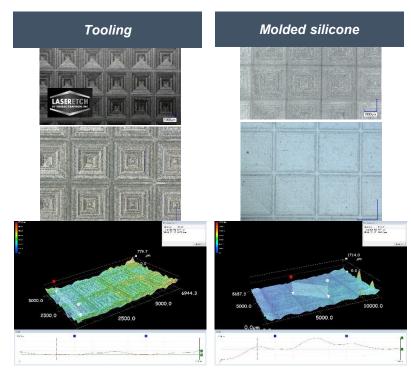


0% % fill 100%





Excellent reproduction of mold features





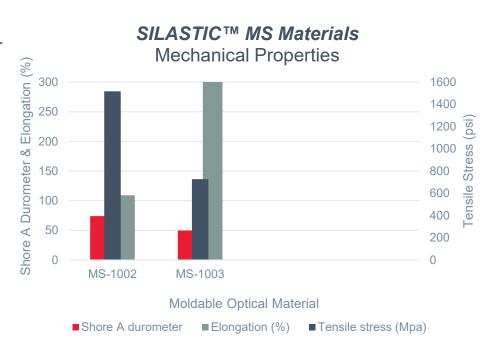
Moldable silicones: Mechanical properties

Soft and pliable or firm and tough

- High elongation and Shore A durometer
 → impact and scratch resistance
- Range of hardness' and material toughness → accurate part fixation, high IP rating

Light weight optics

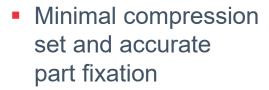
- Silicones are less dense than incumbent material → less weight in auto lighting
- Optics lighter than with alternatives for a given volume





Mechanical performance

Impact and scratch resistant

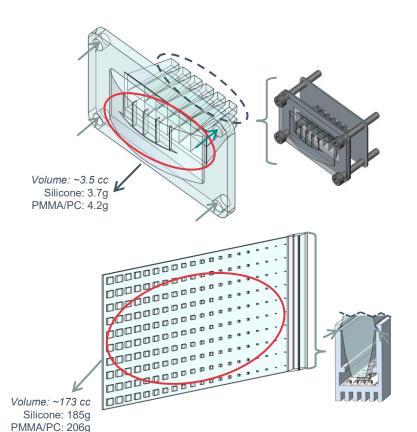


 Optics lighter than with alternatives for a given volume











Moldable silicones: optical properties

Excellent optical performance

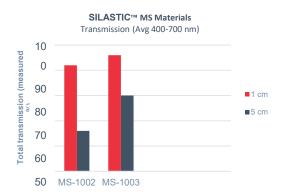
- High light transmittance
- Low haze and scatter

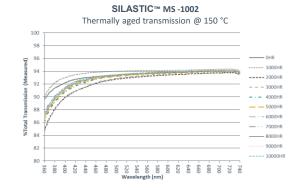
Reliable in extreme conditions

Robust to thermal and hydrothermal aging

Optics for many applications

 Freeform collimators; secondary lenses, micro-lens arrays; light guides



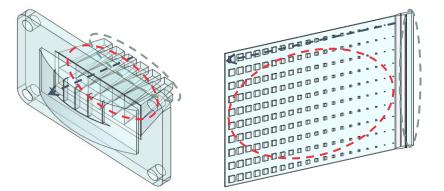




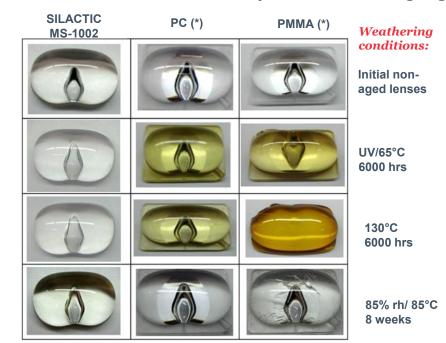
Optical performance

- High light transmittance
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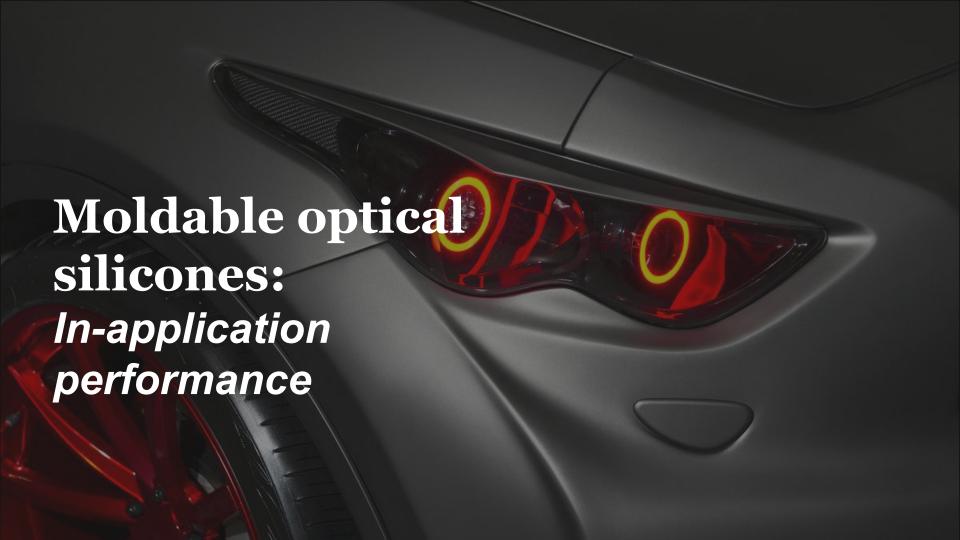


Robust thermal and hydrothermal aging



(*) PC and PMMA were NON-STABALIZED grades against UV





Moldable silicones: In application

Industry tested

- Weathering: FMVSS 108 Appendix H
 - > AMECA Certified Materials
- Impact: SAE J400
- Abrasion: FMVSS 108 Appendix J
- Chemical resistance: GMW 14334
- Flammability: FMVSS 302
- And more...







Moldable silicones: application examples

Interior: Light guides

Interior: Branding

Exterior: A-Side

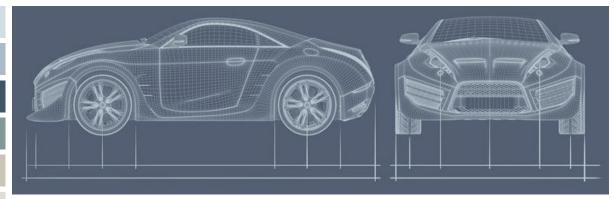
Image projection

Optical sensors

Color mixing (white reflector)

Co-molding

Over-molding













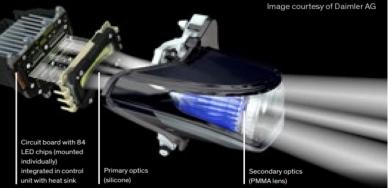
Key takeaways

Moldable silicones are high performance materials that provide:

- Improved design flexibility (form factor, undercuts, optical features)
- Strong optical performance
- Superior environmental stability

Dow is the world *leader* in silicone technology with 10+ years of optical silicone experience and 5 years of use in production ADB systems.







Thank you

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