



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

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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

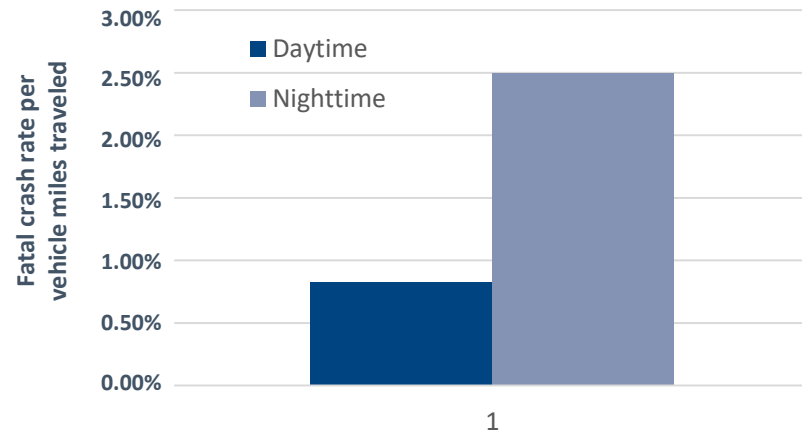


Figure 1: Fatal crash rates per VMT for Day and Night (2009 FARS and NHTS data)²

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	Limitations ¹
Increase roadway illumination	Glare and reflections, infrastructure needed
Increase high beam usage by drivers	Glare and concern for oncoming drivers
<i>Adaptative driving beam (ADB) implementation:</i> Long range visibility without causing discomfort, distraction or glare	



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

DOW + MOLDABLE SILICONES

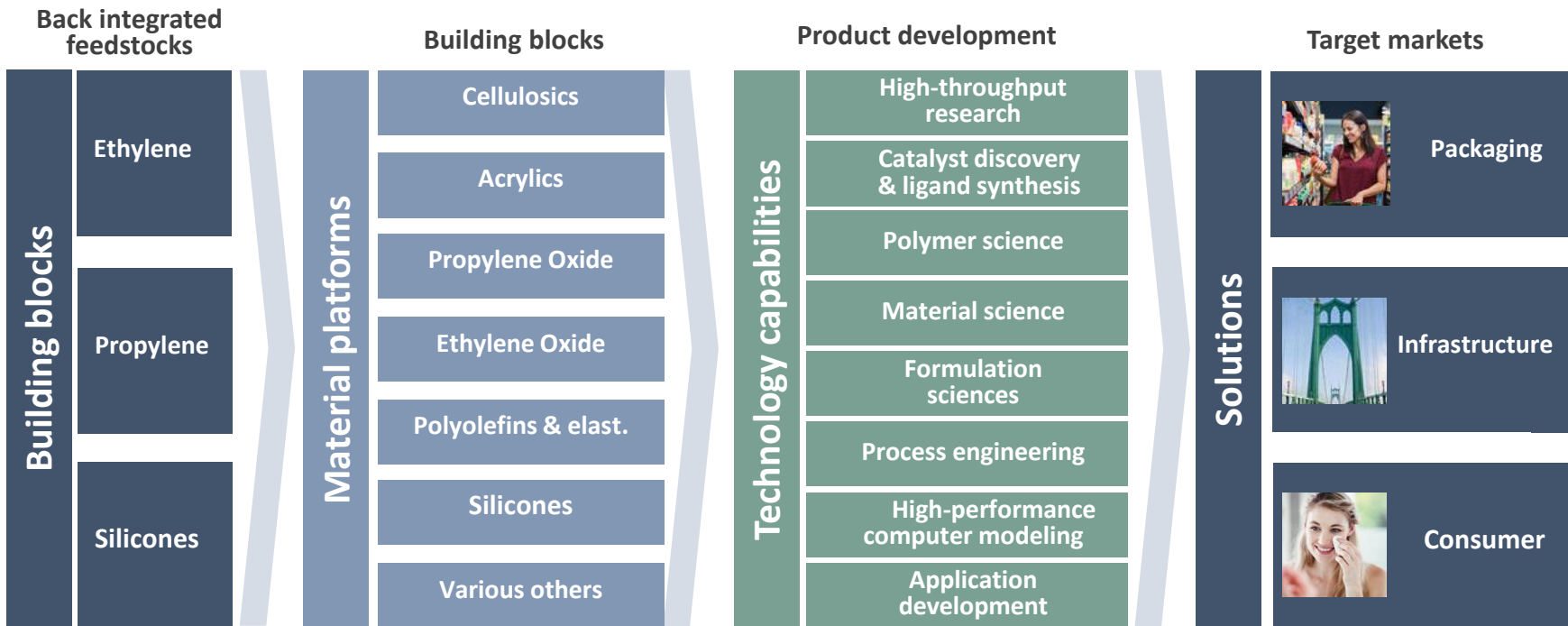
Dow is the world *leader* in Silicone technology with 10+ years of optical silicone experience and five years of use in production ADB systems.

Moldable silicones are high performance materials that provide:

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



THE NEW DOW



DOW SILICONES: FROM SAND TO FUNCTIONALITY



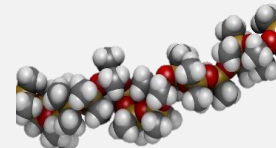
Sand (SiO_2)



Silicon (Si)

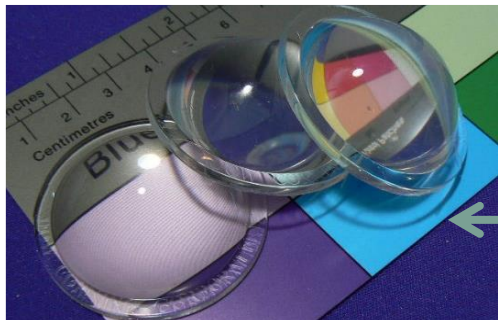


Methylchlorosilanes

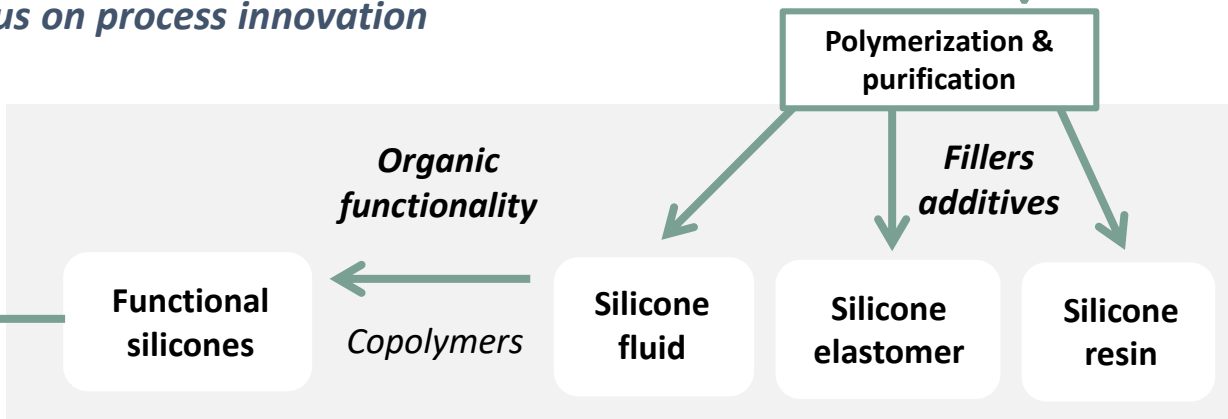


Silicones

Low cost integration and focus on process innovation



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

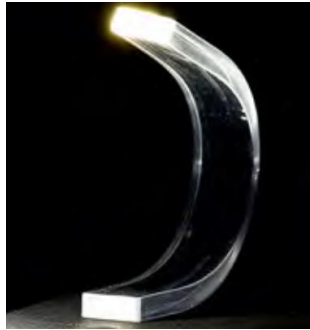
A NEW MATERIAL: MOLDABLE OPTICAL SILICONES

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

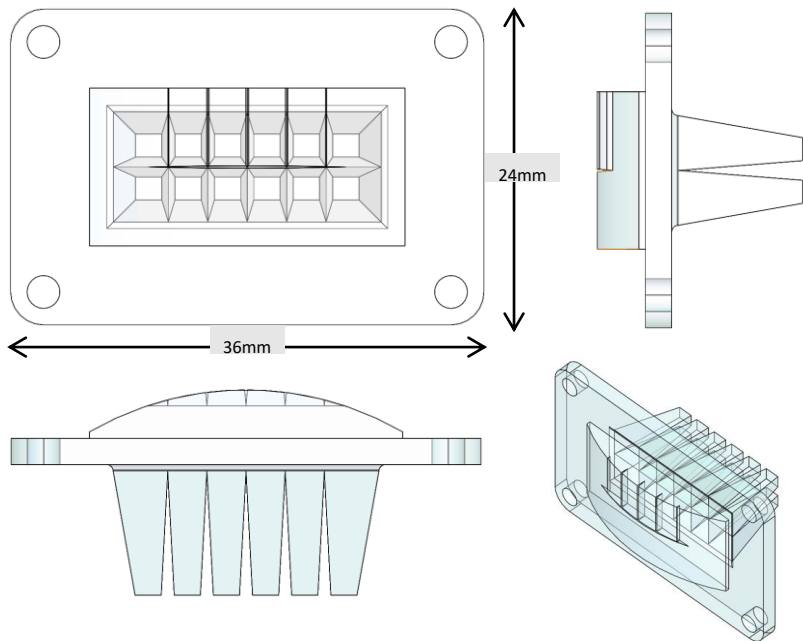
What unique capabilities do these properties *enable*?

	SILASTIC™ Moldable Silicone	PC	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
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

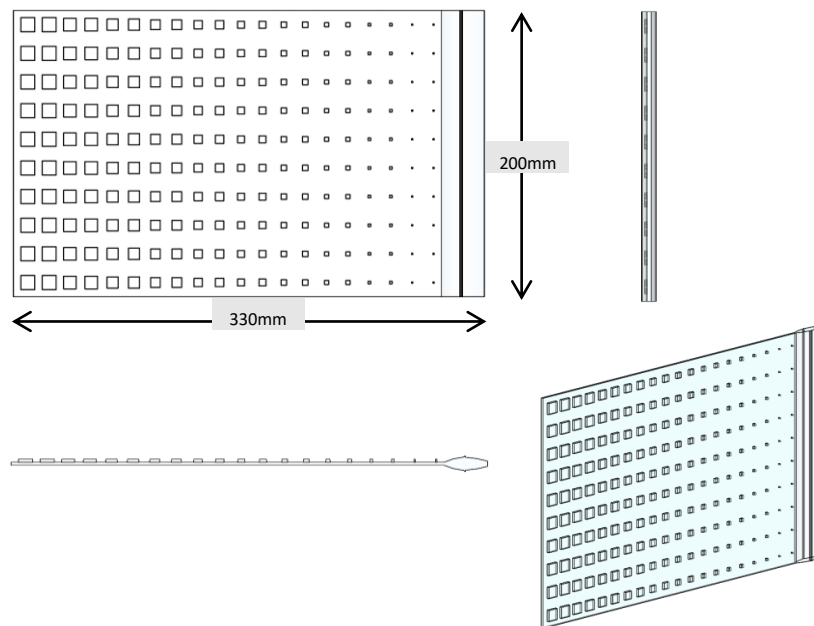


MOLDABLE SILICONE ENABLED DESIGN: REFERENCES

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

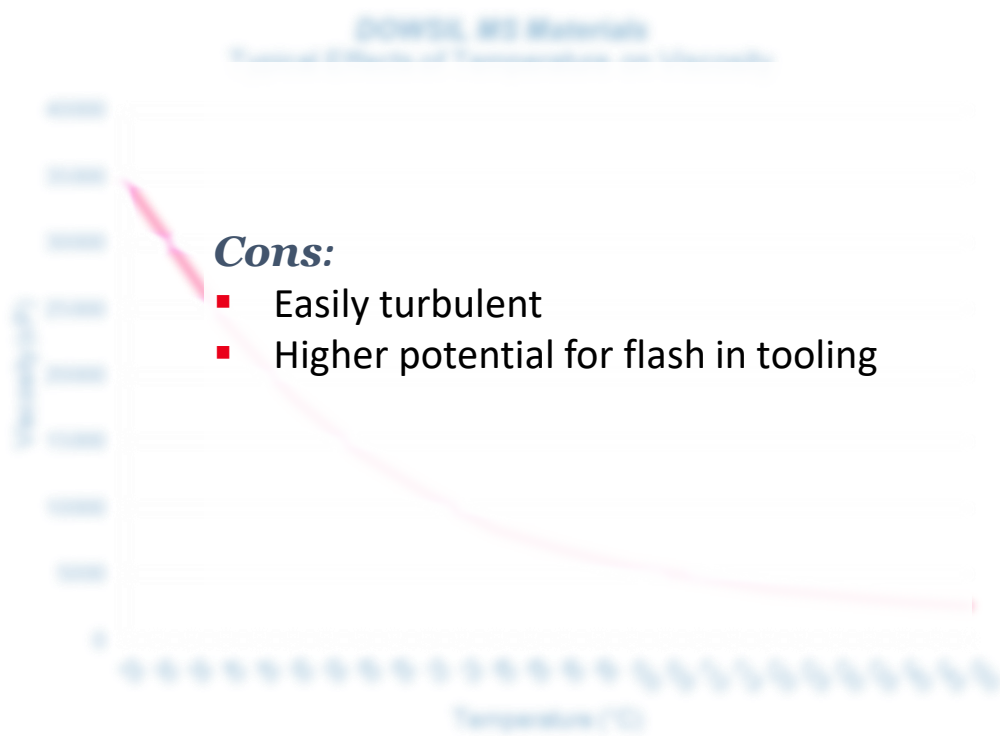
Heat influences viscosity of moldable silicone – very sensitive to temperature

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

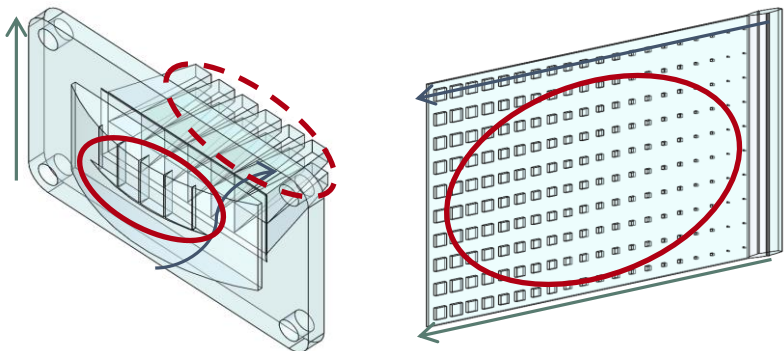
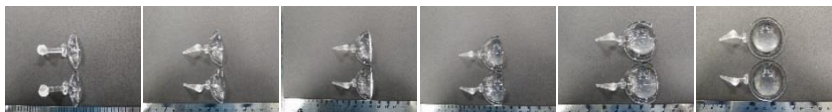


MATERIAL PERFORMANCE

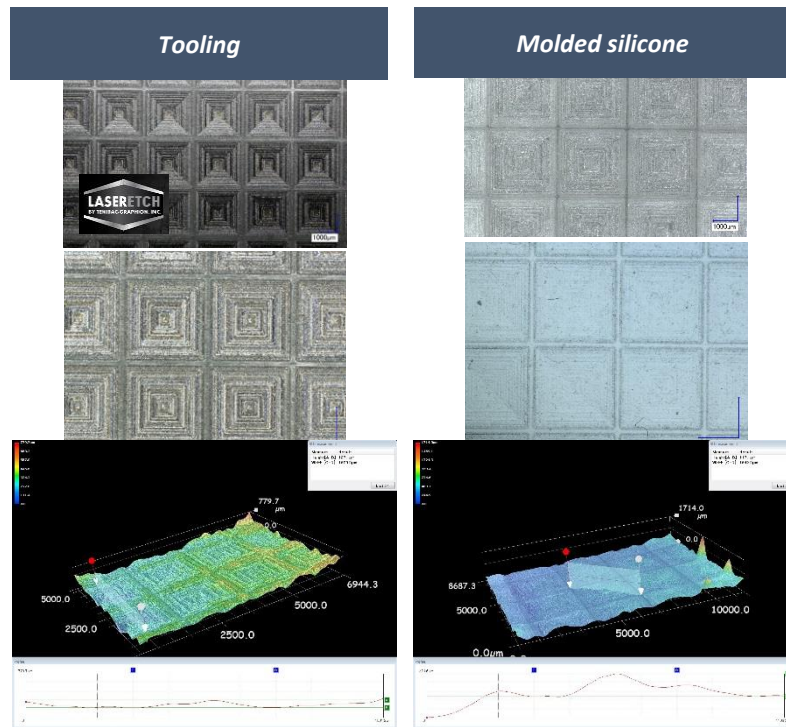
- Good flow in complex parts
- Cure profile allows for fill in liquid state



0% % fill 100%



- Excellent reproduction of mold features



**Moldable
optical
silicones:**
*Mechanical
and optical
performance*



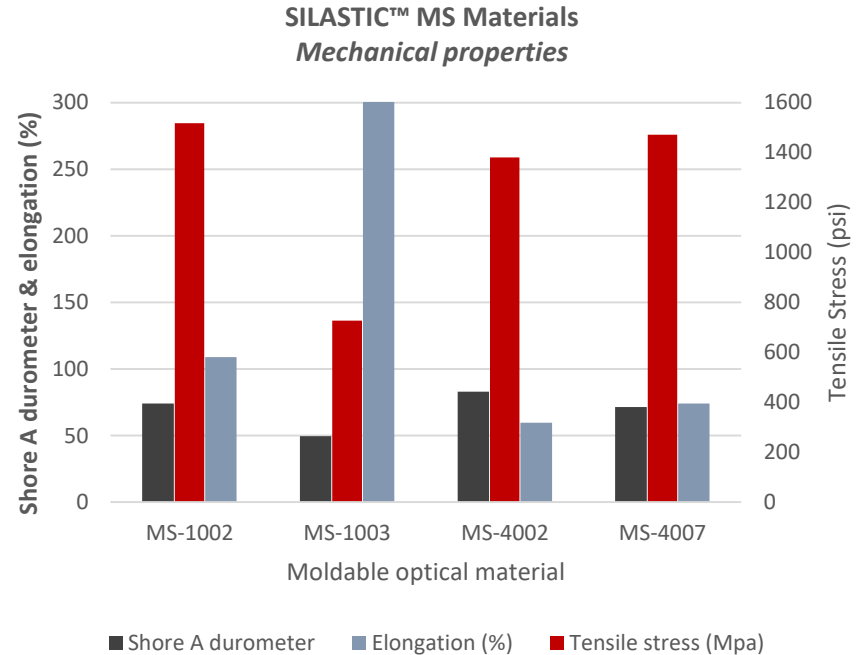
MOLDABLE SILICONES: MECHANICAL PROPERTIES

Soft & 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

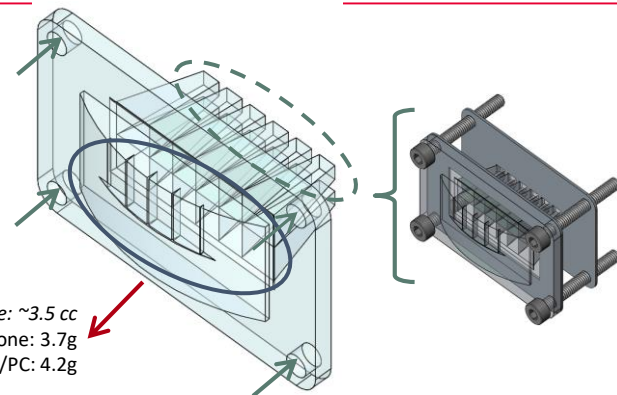
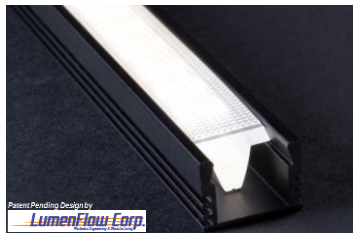


MECHANICAL PERFORMANCE

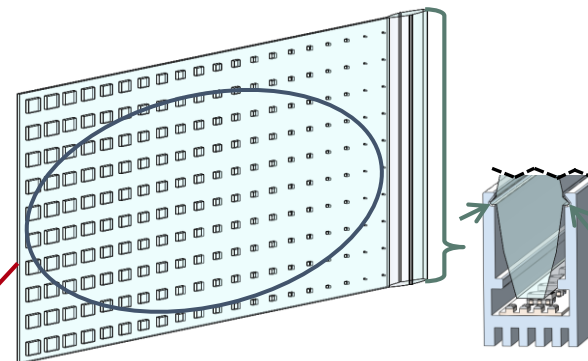
- Impact and scratch resistant
- Minimal compression set and accurate part fixation
- Optics lighter than with alternatives for a given volume



mPOWER™ Fascia Light from SoundOff Signal is the first extremely compact, tri-color line of lighting



Volume: ~3.5 cc
Silicone: 3.7g
PMMA/PC: 4.2g



Volume: ~173 cc
Silicone: 185g
PMMA/PC: 206g



MOLDABLE SILICONES: OPTICAL PROPERTIES

Excellent optical performance

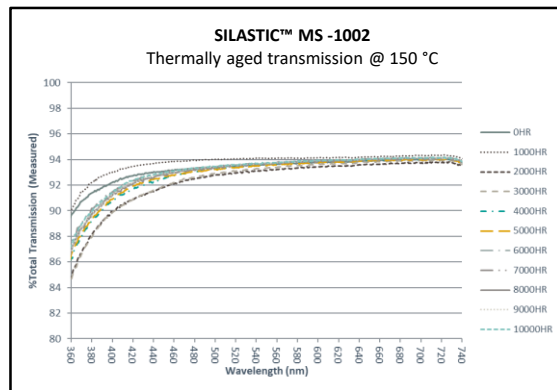
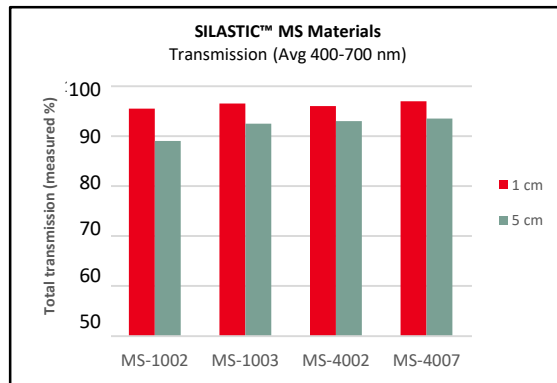
- High light transmittance
- Low haze and scatter

Reliable in extreme conditions

- Robust to thermal and hydrothermal aging

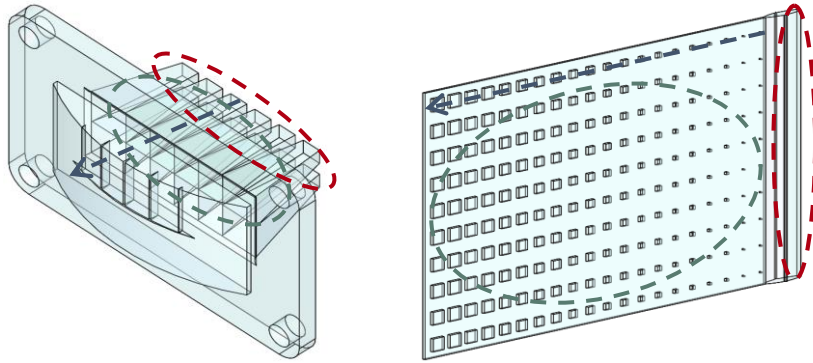
Optics for many applications

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



OPTICAL PERFORMANCE

- High light transmittance
- Low haze and scatter




- Robust thermal and hydrothermal aging

SILACTIC MS-1002	PC (*)	PMMA (*)	<i>Weathering conditions:</i>
			Initial non-aged lenses
			UV/65°C 6000 hrs
			130°C 6000 hrs
			85% rh/ 85°C 8 weeks

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



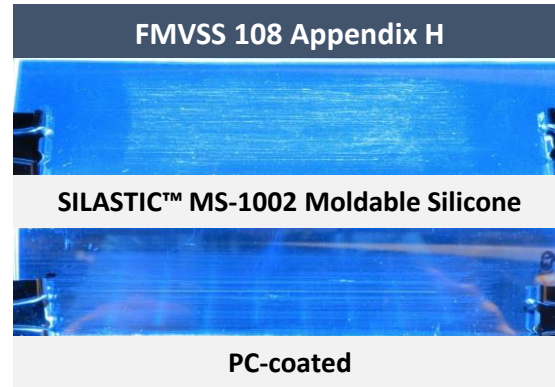
A close-up photograph of a car's headlight assembly. The headlight is illuminated, showing two bright red LED rings. The car's body is a dark, metallic color. The text is overlaid on the left side of the image.

**Moldable
optical
silicones:
*In-application
performance***

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

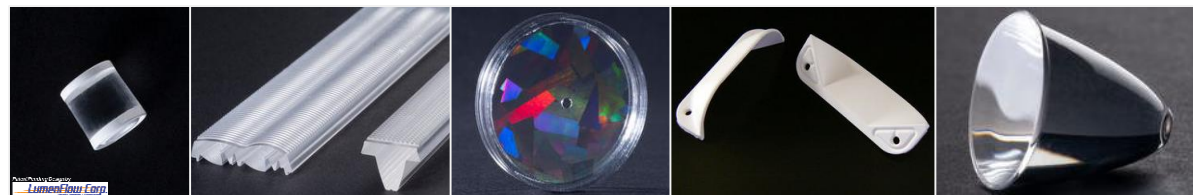
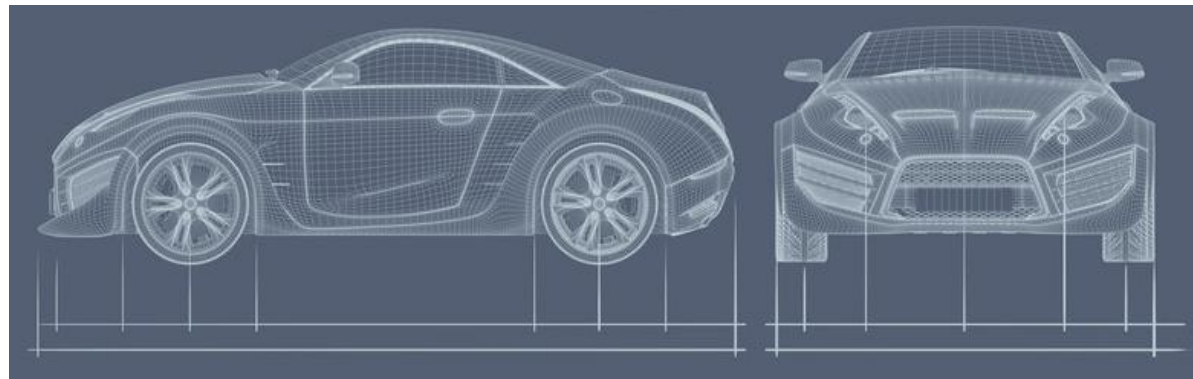
Image projection

Optical sensors

Color mixing (white reflector)

Co-molding

Over-molding

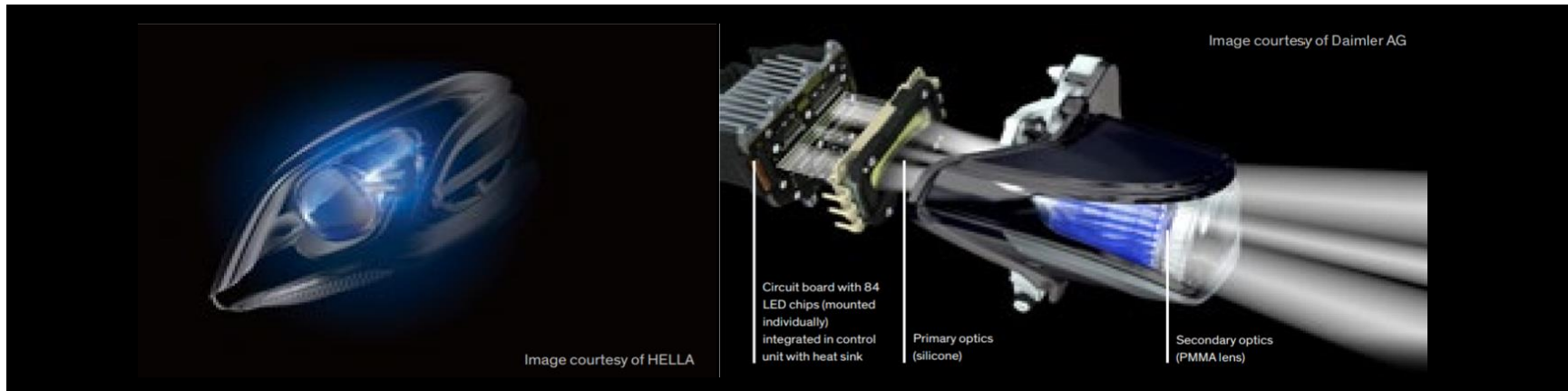


KEY TAKEAWAYS

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

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