

Optical silicones in transportation

Intelligent automotive lighting 2019

Mainz, February 20-22, 2019

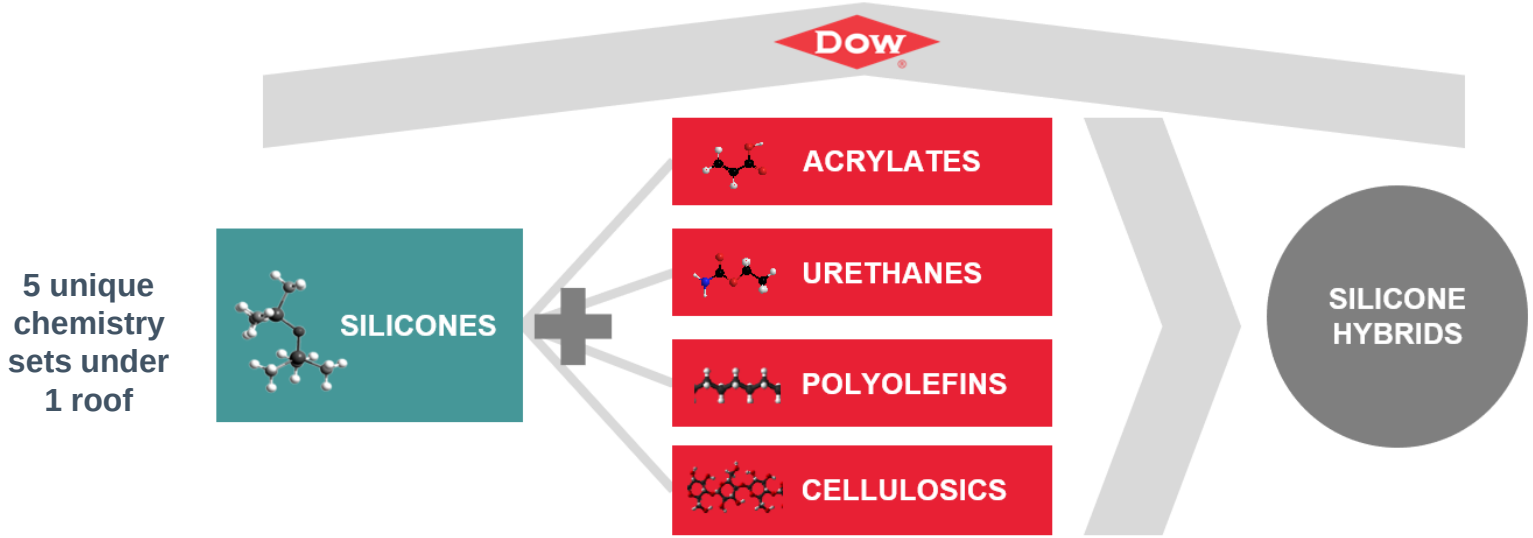
Dr. François de Buyl - Principal TS&D Scientist
Tobias Kleinmann - Sales & Business Development

Dow Performance Silicones – Silicone Elastomers – Lighting

Co-authors:
Kevin Van Tiggelen, Martijn Beukema, Jake Steinbrecher, Michelle Cummings, Nathalie Gérard

Dow innovation engine

Combining 75 years of silicones expertise with exceptional innovation to deliver new offerings to the market



Silicone hybrids provide improved material properties such as enhanced thermal stability, adhesion, sealing, and durability that reduce processing time and increase speed to finished product

Dow Consumer Solutions: at a glance



Building & Infrastructure



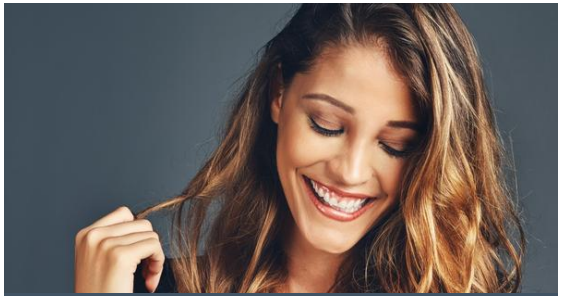
Mobility & Transportation



Consumer & Electronics



Industrial & Chemical Processing



Personal Care

Transportation solutions

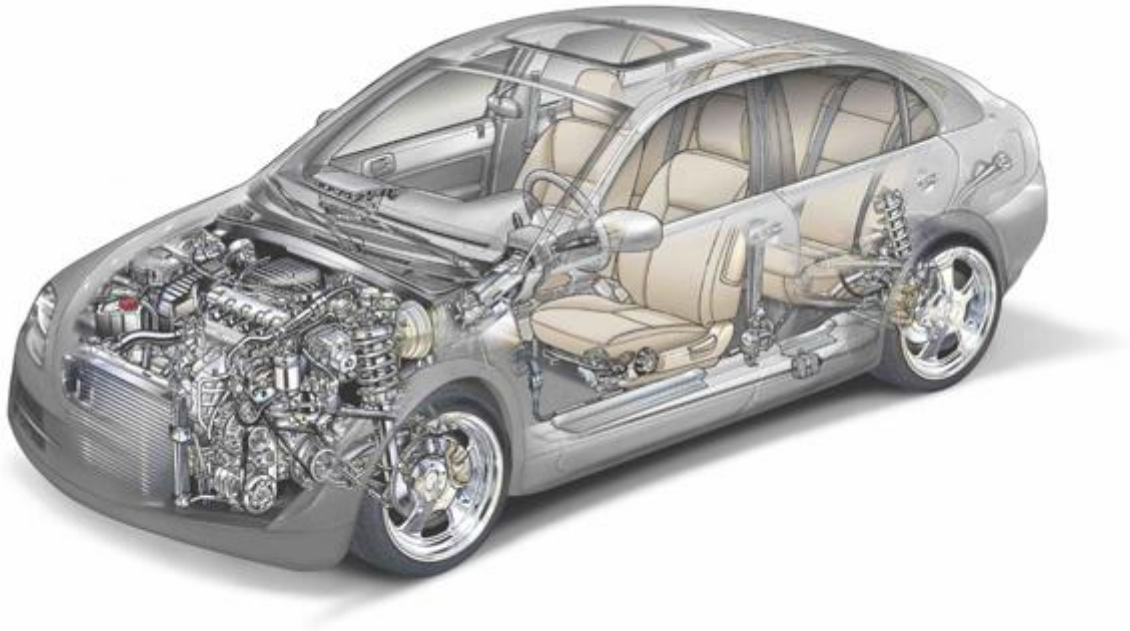
- Adhesives and sealants
- Conformal coatings
- Encapsulants
- Dielectric gels
- Thermally conductive
- Electrically conductive
- Optical moldable silicones



- Bonding
- Sealing
- Protection
- Stress relief
- Heat dissipation
- Processing
- Lighting

Transportation applications

- Battery pack assembly
- Under-the-hood gasketing
- Boards and assemblies
- Sensors
- Displays
- Housings
- Head / rear lamps



Why silicone for optics?



Flexible and soft material

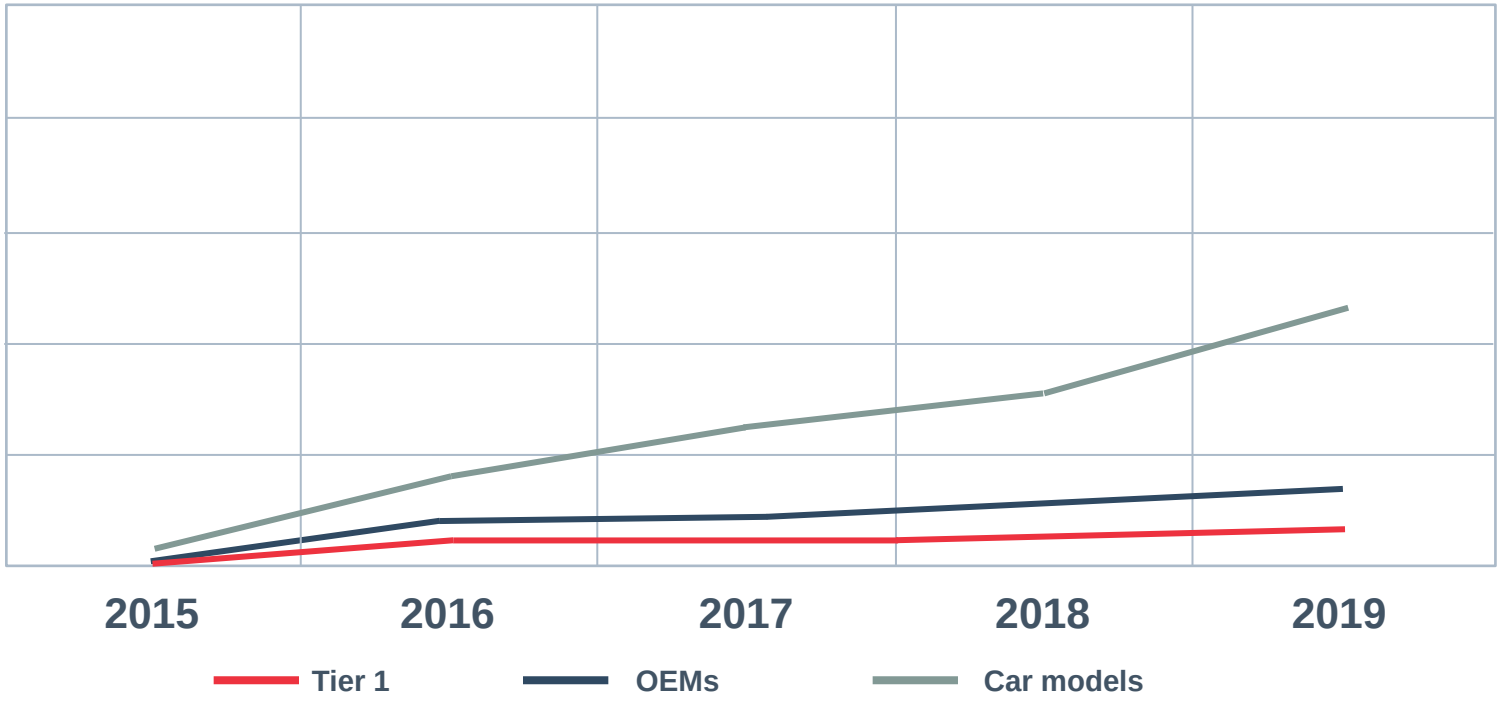


High precision and heat stability



Bendable light guides

European adoption of moldable optical silicones in automotive lighting



Moldable Optical Silicones from Dow



HELLA KGAA Hueck and Co.

Adaptive headlamps

High complexity headlamp module

- Silicone light guides
- Acrylic lens’



DOW

LIGHTING

CASE STUDY: HELLA KGAA HUECK & CO.

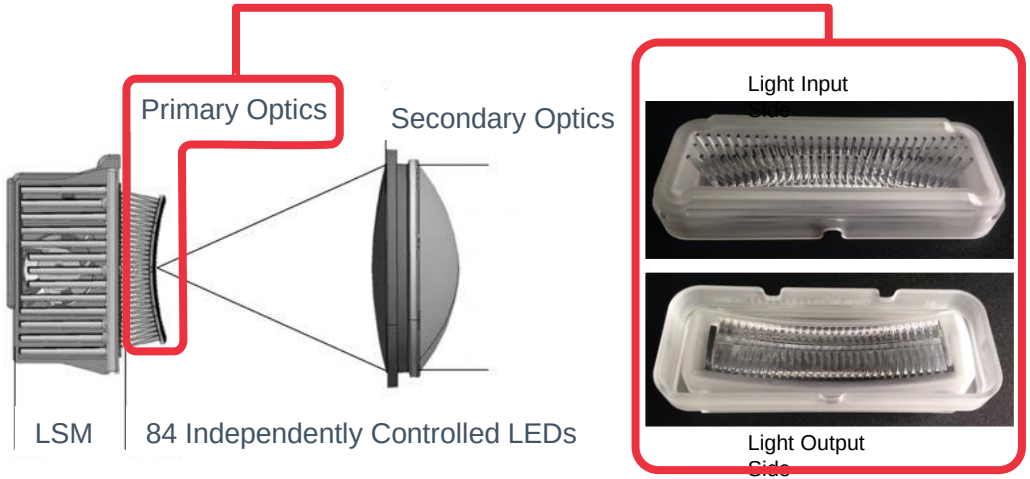
SILASTIC™ moldable optical silicones help pave the way to a groundbreaking LED headlamp design from Hella KGaA Hueck & Co.

The challenge

HELLA

Benefits of SILASTIC™ MS-1002 Moldable Optical Silicone

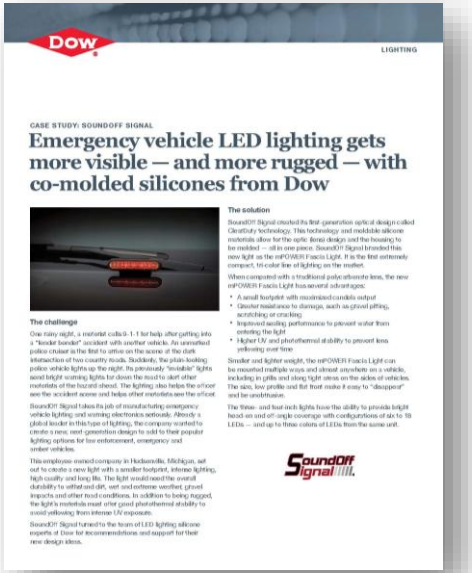
- Highly flexible material allows demolding with undercuts
- Stable mechanical and optical properties against high power LEDs



SoundOff signal – Emergency vehicle light

Benefits of SILASTIC™ MS-1002 Moldable Optical Silicone

- Over-molding SILASTIC™ MS-1002 with SILASTIC™ MS-0002
- Fewer parts for ease of assembly
- Small footprint with maximized candela output
- Improved sealing performance to prevent water ingress
- Greater resistance to gravel pitting, scratching, or cracking
- Higher UV and photo-thermal stability to prevent lens yellowing


DOW

LIGHTING

CASE STUDY: SOUNDOFF SIGNAL

Emergency vehicle LED lighting gets more visible — and more rugged — with co-molded silicones from Dow

The challenge

The solution

SoundOff Signal



Video courtesy of SoundOff Signal

SILASTIC™ Moldable Optical Silicones portfolio

Designed for many applications

- Freeform collimators
- Secondary lenses
- Micro-lens arrays
- Light guides

Expanded material properties

- Hardness
- Viscosity

Enhanced optical performance

- High light transmittance
- Accurate control of surface light scattering



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

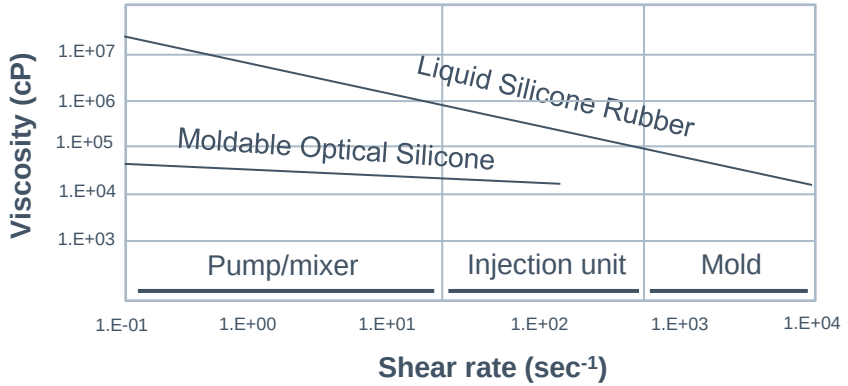
Moldable and mechanical properties

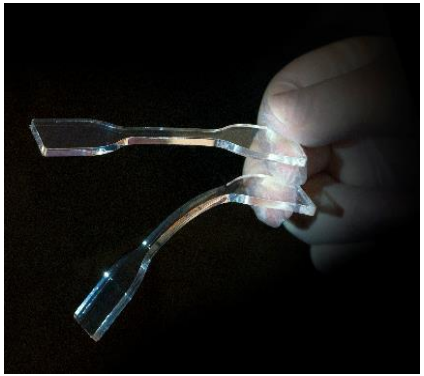
Efficient injection molding

- Ease of fabrication by liquid injection molding
- No secondary polishing of molded optics required

Soft and pliable, or firm and tough

- Impact and scratch resistant when hit or dropped
- High IP and IK ratings luminaries

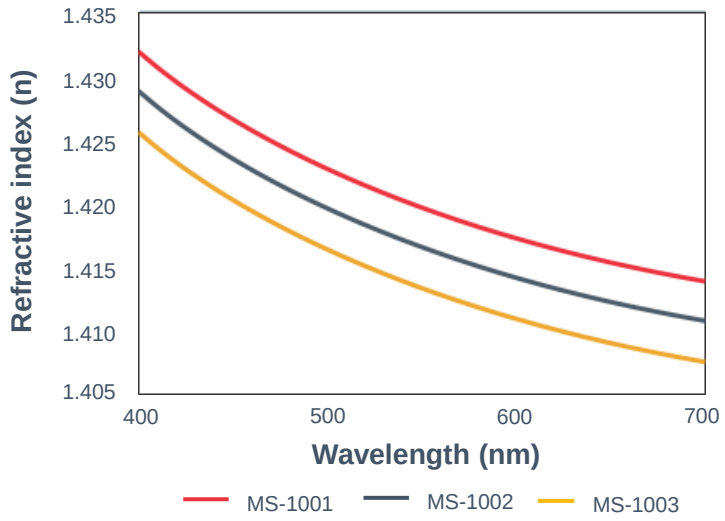






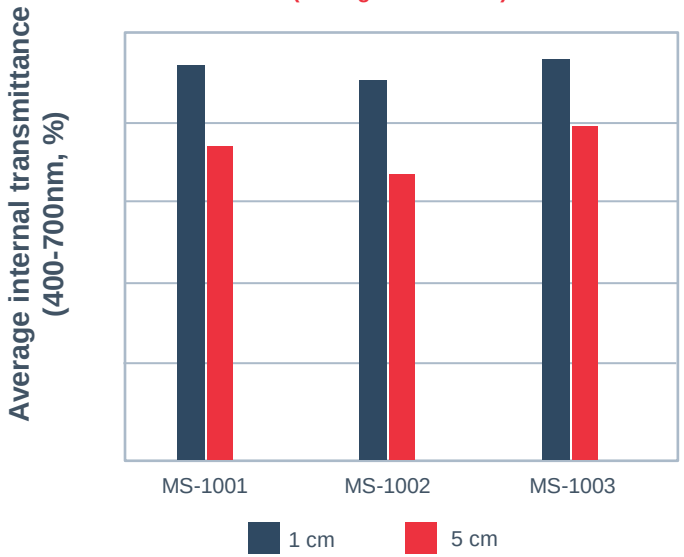
Optical properties

Refractive index vs. wavelength



Internal transmittance

(Average 400-700nm)



Property	SILASTIC™ MS-1001 Silicone	SILASTIC™ MS-1002 Silicone	SILASTIC™ MS-1003 Silicone
Refractive Index (633 nm)	1.42	1.41	1.41
Abbe Number	48.7	50.4	50.1

Silicone optic: long light path

D65 white light source

- Significant color shift
  Δ(u'v') = 0.007
  (average on 400-800 nm)
- Light loss <5% up to 10 cm path length

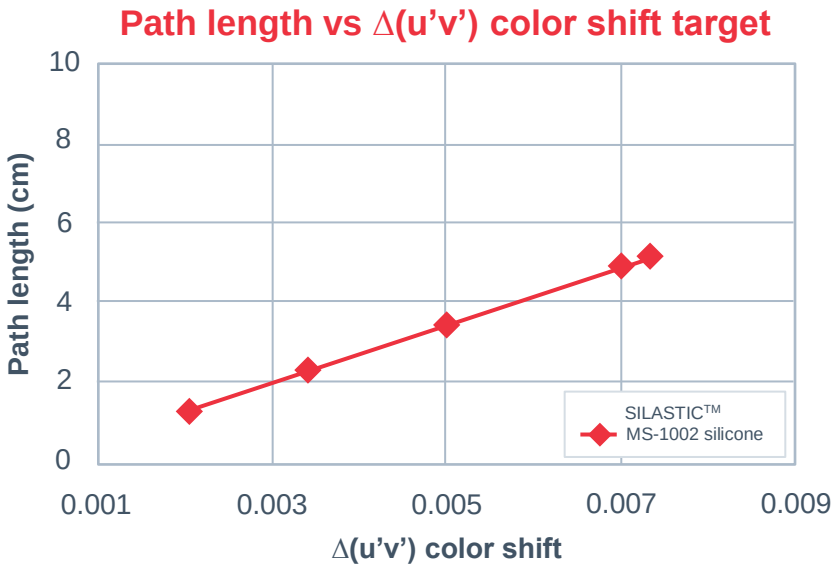
Monochromatic light source

- No color shift concern
- Light loss dependent on wavelength



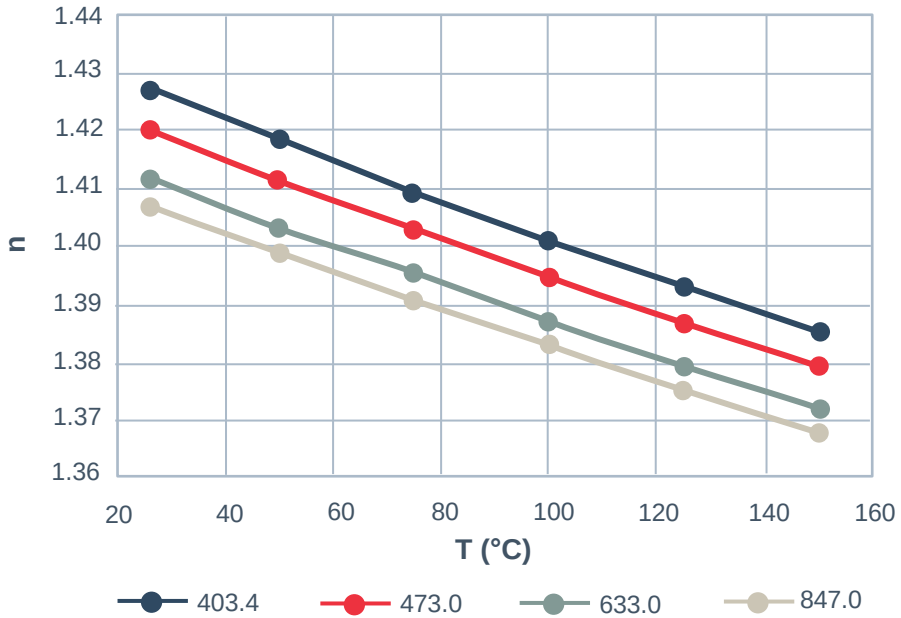






Thermal effects in silicone optics

Change of RI (n) as function of temperature



Refractive index measured with Metricon 2010/M Prism Coupler at four laser wavelengths, from room temperature up to 150ºC.

Material	CTE (ppm)	TOC (10^{-4}) dn/dT
Silicone	275	-3.2
PMMA	72	-1.1
PC	65	-1.07

CTE = Coefficient of Thermal Expansion
TOC = Thermo-Optical Coefficient

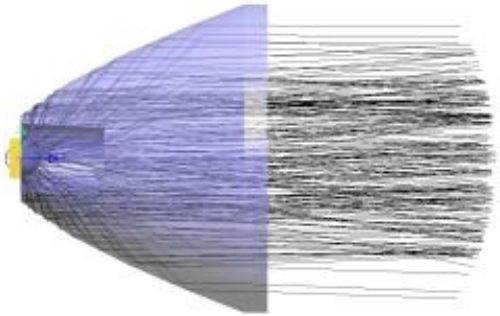
Silicone optic: narrow bean angle collimator

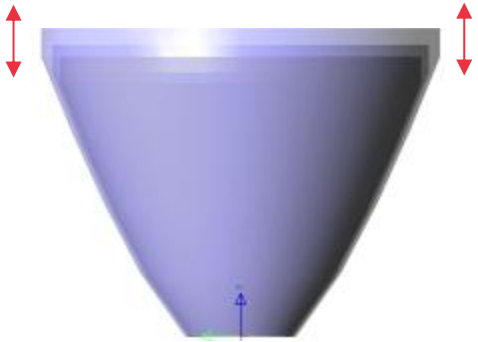
Simulation parameters

- Light source: CREE XPG-2 LED
- Narrow beam angle collimator: 9°
- Volume increase due to CTE effect – from 25°C up to 150°C
- Collimator un-constraint

Temperature	Volume (cm^3) Narrow collimator
25ºC	5.58
75ºC	5.81
150ºC	6.18





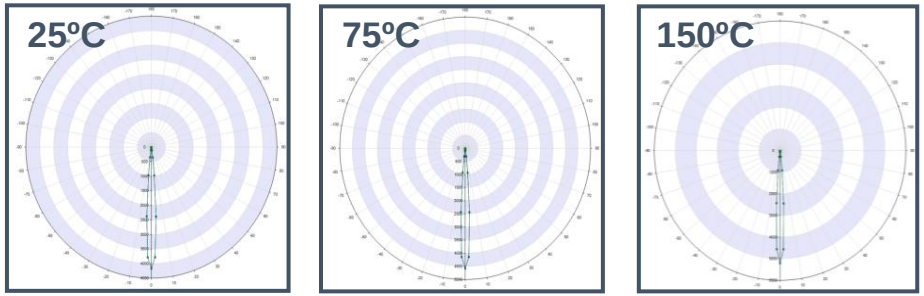


Silicone optic: narrow beam angle collimator

Simulation results

- Optical efficiency and light intensity at the center of the light beam increasing
- Light distribution slightly more narrow

Temperature of Lens	Optical Efficiency	Δ	CBCP (cd)	Δ	Beam Angle / FWHM	Δ
25ºC	90.70%	-	4,179	-	8.9°	-
75ºC	91.07%	**↑0.4%**	4,336	**↑3.8%**	8.6°	**↓0.3°**
150ºC	91.54%	**↑0.9%**	4,540	**↑8.6%**	8.3°	**↓0.6°**



Protective material over LEDS
and associated optical effects



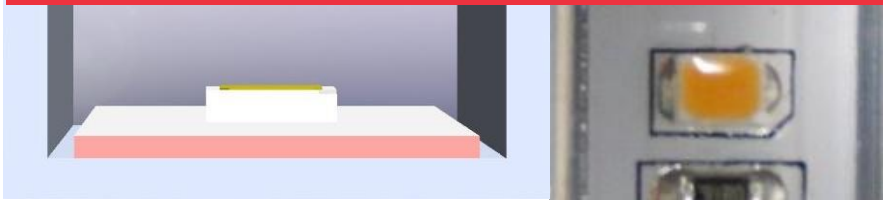




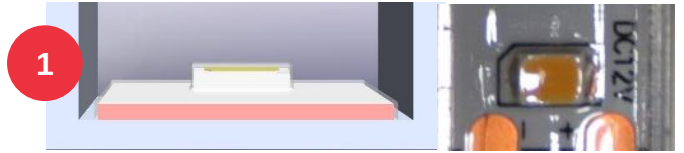
Protection options

- **Conformal coating:** Silicone, acrylic, urethane
  - ➢ Thin layer provides little impact on light quality
- **Encapsulant:** Silicone, acrylic, urethane
  - ➢ Impact protection in challenging environments
- **Molded lens:** Silicone, PC, PMMA
  - ❖ Impact protection with little impact on light quality

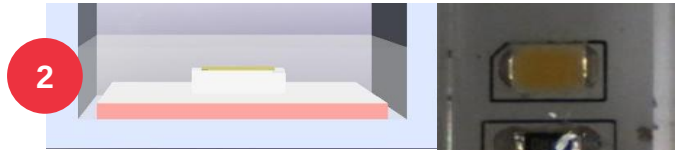
4000K Test part, no material (Optical simulation)



4000K Test part with DOWSIL™ 1-2577 Low VOC Conformal Coating



4000K Test part with DOWSIL™ EI-1184 Optical Encapsulant



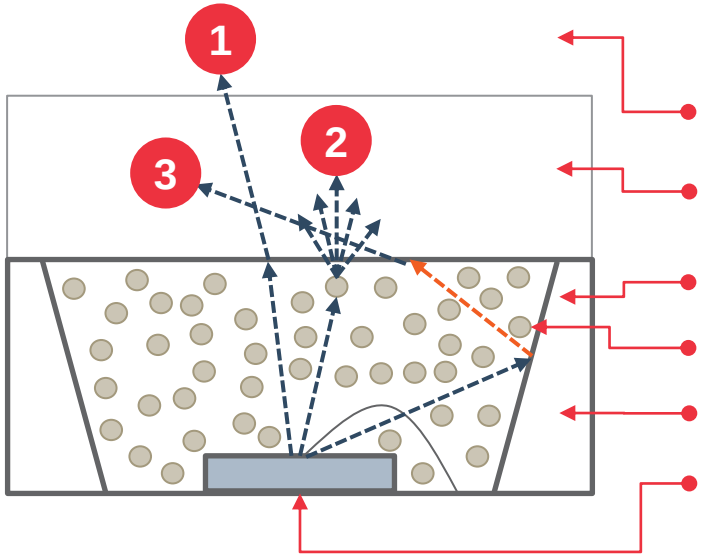
4000K Test part with SILASTIC™ MS-1002 Moldable Optical Silicone



Lens design courtesy of: LumenFlow Corp. Photonics Engineering & Manufacturing

Optical influence

Lumen output? Color temperature?



Air (n = 1.00)

Silicone protective material (n = 1.41 – 1.47)

Silicone encapsulant (n = 1.53)

Phosphor particles

Reflector cup

LED Chip



SILASTIC™ MS-1002 Moldable Silicone

DOWSIL™ EI-1184 Encapsulant

DOWSIL™ 1-2577 Low VOC Conformal Coating

No Protection

Protective material can

- Change Fresnel reflection
- Change color converted light
- Change total internal reflection

Innovative technology from Dow

New DOWSIL™ EI-2888 primerless silicone encapsulant

- Patented technology
- 100% silicone product

DOWSIL™ EI-2888 Encapsulant	
Light transmission	
Aging resistance	
Low viscosity	
Rapid RT cure	
Self adhesion	
Health concern	
Shrinkage/Exotherm	
Cure robustness	
Cost	





DOWSIL™ EI-2888 encapsulant: self adhesive

Cohesive failure on

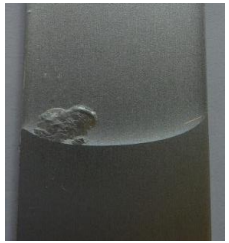
- Anodized aluminum
- Glass
- FR4
- Stainless steel
- Steel
- Polycarbonate
- PBT
- Copper

Reliable adhesion after 2000 hours

- 150°C
- 85°C/85% RH
- -40/+150°C thermal shock
- Sunlight UV

Limitation: PMMA, die-cast aluminum

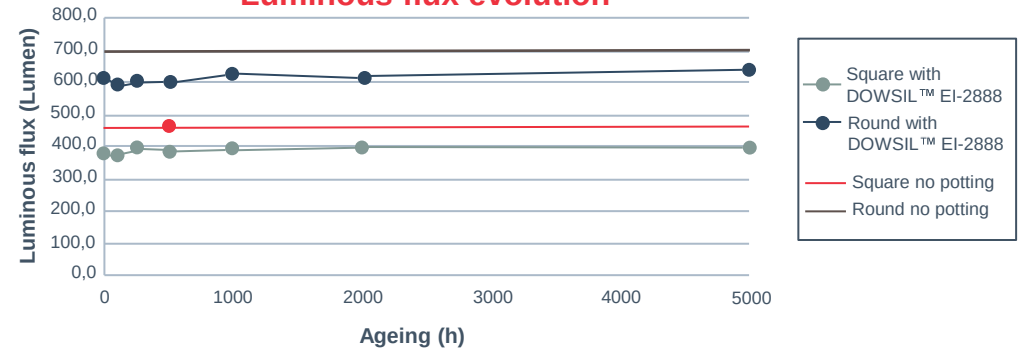


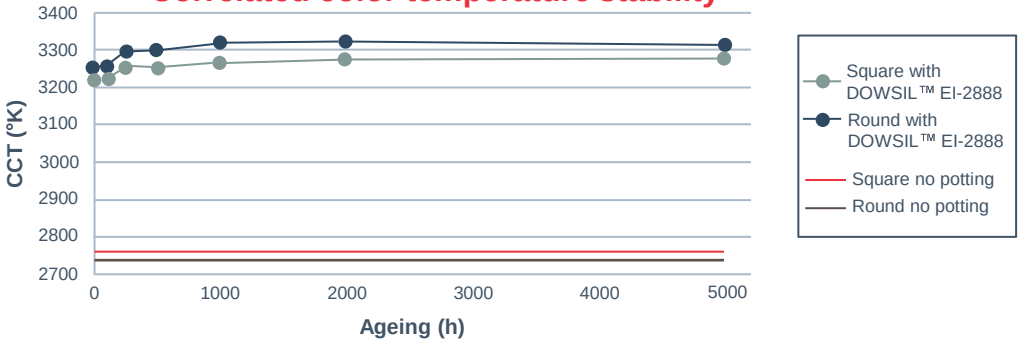
DOWSIL™ EI-2888 encapsulant: proven results

Two rigid, high-power LED modules using DOWSIL™ EI-2888 encapsulant

Luminous flux evolution



Correlated color temperature stability





Round & square cross section design



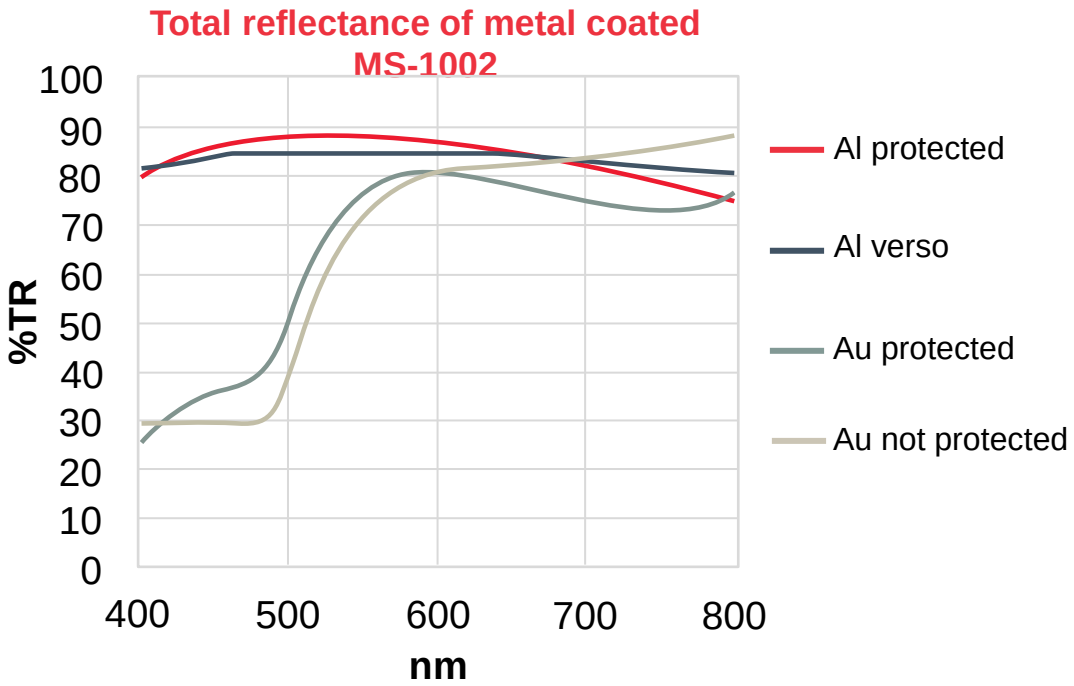
Driven 12V, 1.42A up to 5000 hrs

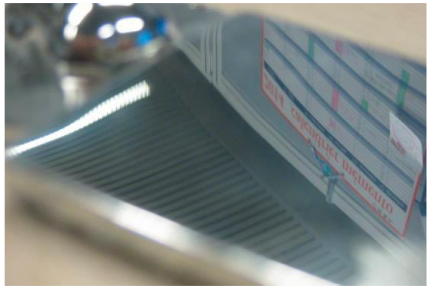
All details on the market release and technical performances available from LEDs Magazine webinar of February 21, 2019 on «***Stick to the clear advantage: new patented DOWSIL™ EI-2888 PrimerlessSilicone Encapsulant for LED Lighting***»
by Julien Renaud, Thierry Cooremans, Konstantin Sobolev

Reflective materials

SPECULAR VS. LAMVERTIAN

Metal coating on SILASTIC™ MS-1002 moldable silicone

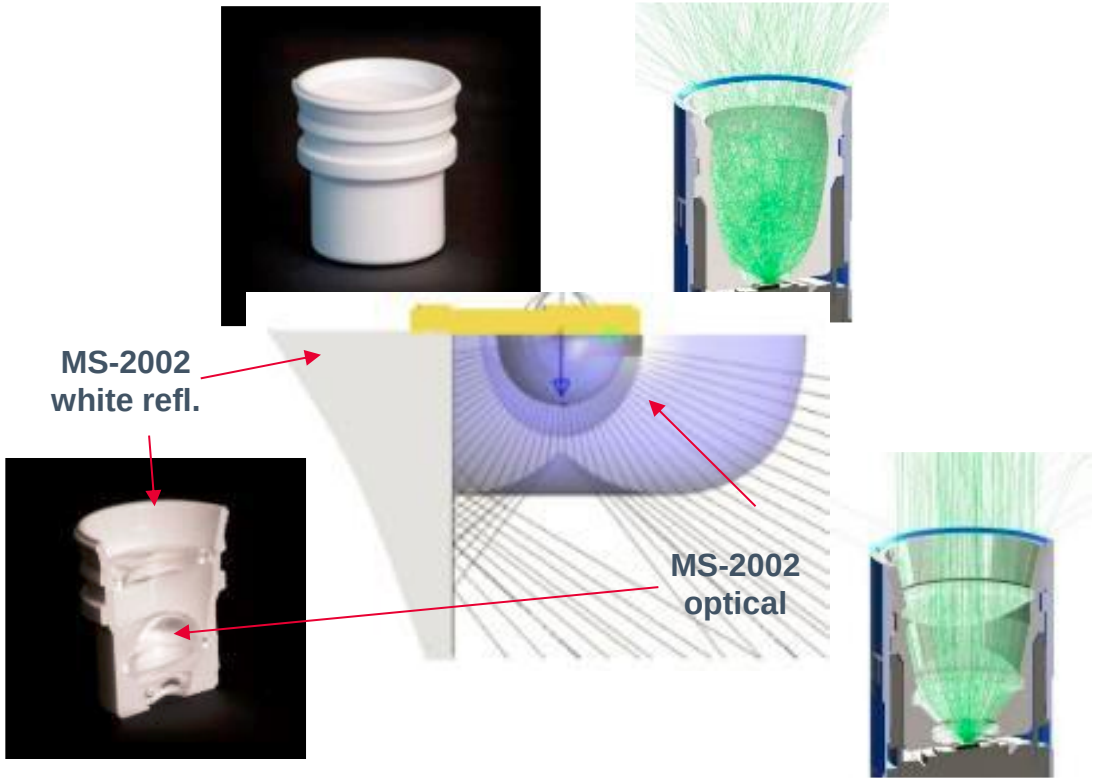




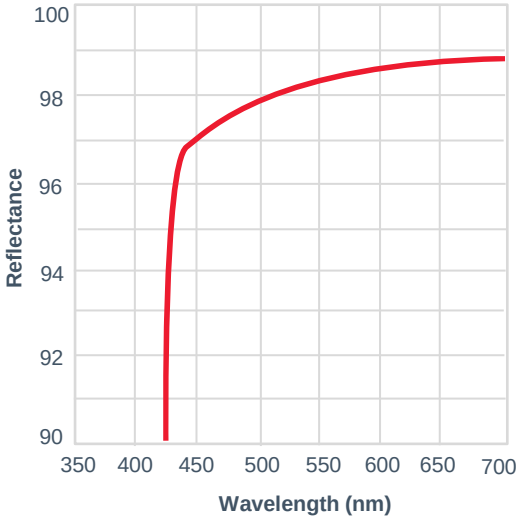


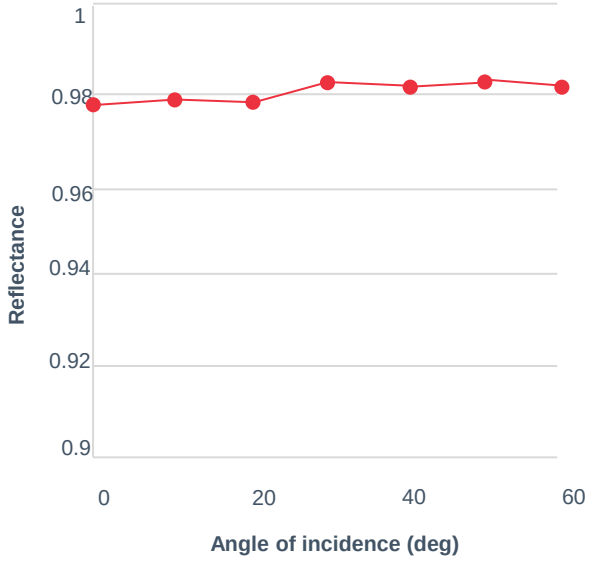
- **PE-CVD deposition of SiO2 layer + magnetron sputtering of metal layer (Al, Au) -**Surcotec, Geneva, Switzerland
- **Total reflectance** of Al and Au coating on optical moldable silicone are quite closely matching pure metal spectra

SILASTIC™ MS-2002 white reflection moldable silicone



SILASTIC™ MS-2002 white reflection moldable silicone (cont.)





SILASTIC™ MS-2002	
Mixing ratio	1:1
Viscosity mix A+B (1 sec^{-1} ; 25°C, mPa*s)	650,000
SG (g/ml)	1.44
Refractive index (@633 nm)	NA
Abbe number	NA
Light reflectance (thick.=3mm)	97%R (450 nm) 99%R (630 nm)
Hardness (Shore A)	**84**
Tensile strength (Mpa)	8.6
Elongation (%)	86
CTE (ppm/°C)	210
Pot life (hrs, 2X viscosity @25°C)	48

Conclusion

- Moldable optical silicones and optical encapsulants from Dow continue to enable innovation in exterior and interior automotive lighting
- A dedicated multi-expertise's technical and commercial team continue to serve customers in the field
- Your new design ideas are continuously welcome to challenge our curiosity and leadership in developing new solutions

Thank you

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Seek

Together™