DOW CORNING Lighting Solutions

Illuminating Innovations ™

Silicone Solutions for LED Packaging

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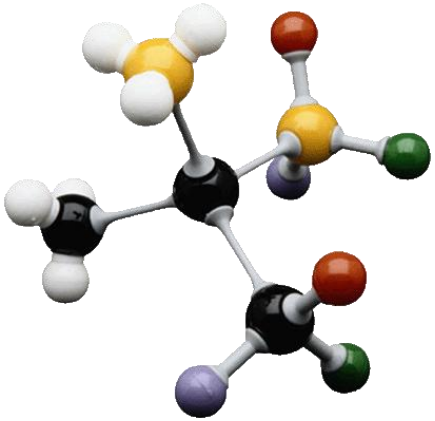
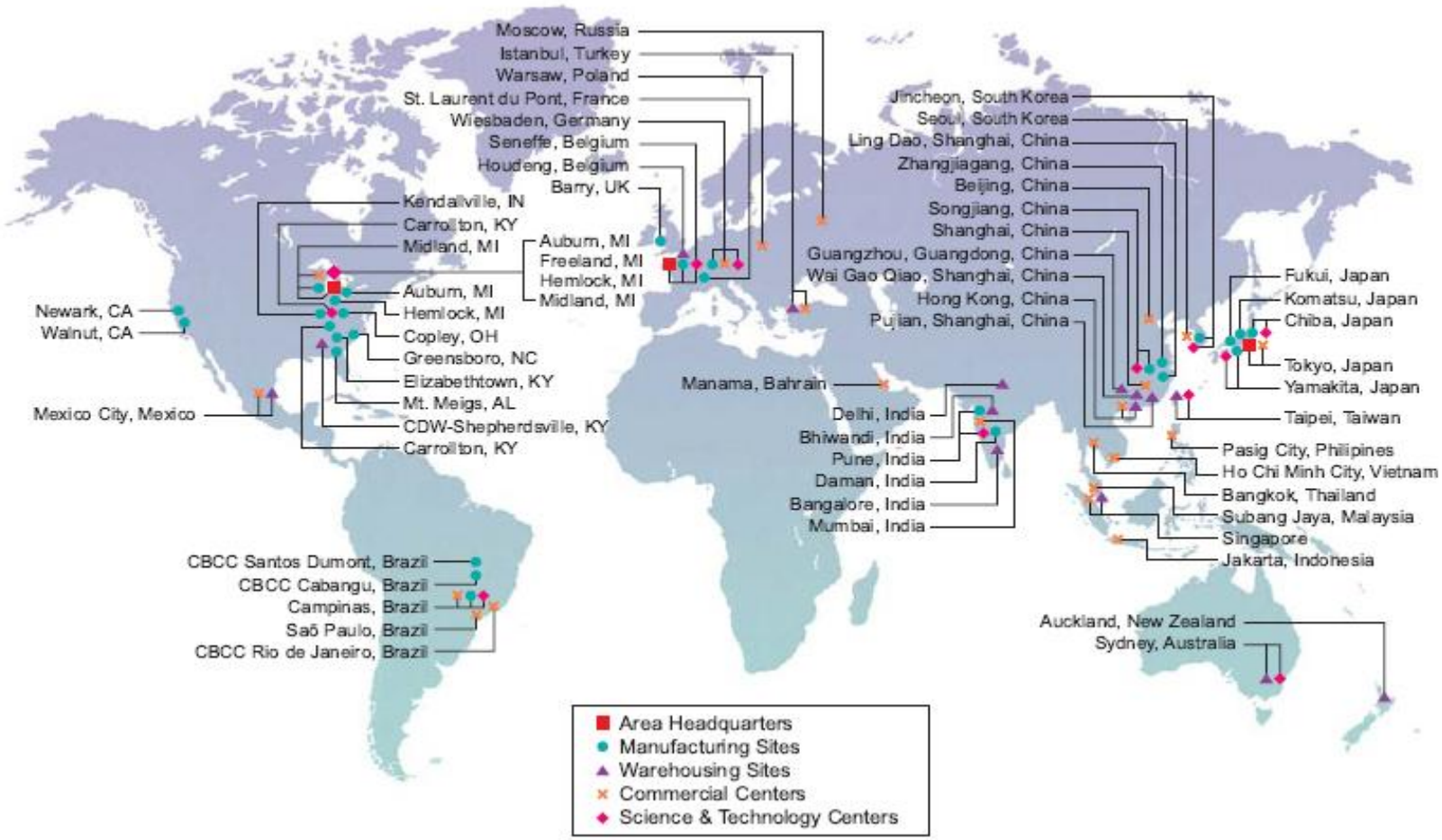
Dow Corning Introduction

Dow Corning is …

- Equally owned by The Dow Chemical Company and Corning Incorporated
- Organized to explore the potential of the silicon atom in 1943
- A global leader in silicone and high purity silicon
  - More than 7,000 products/services
  - Approx 25,000 customers
  - Approx 12,000 employees
  - Strong and healthy financially: $6.43 billion sales in 2011



Dow Corning Worldwide



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We help you invent the future.™

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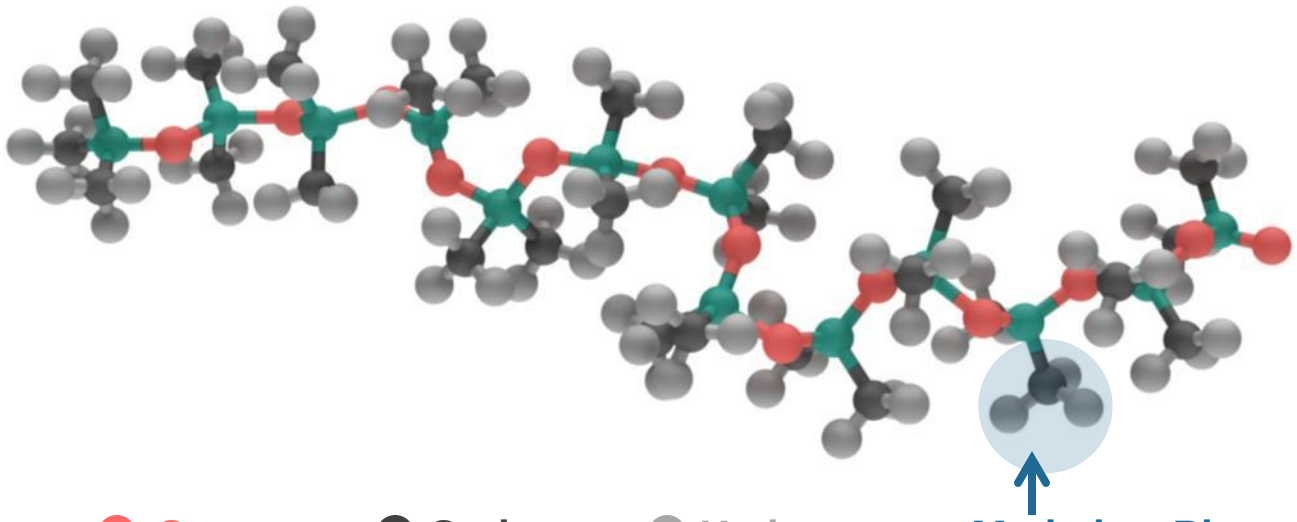
Silicones for LEDs

What is Silicone?

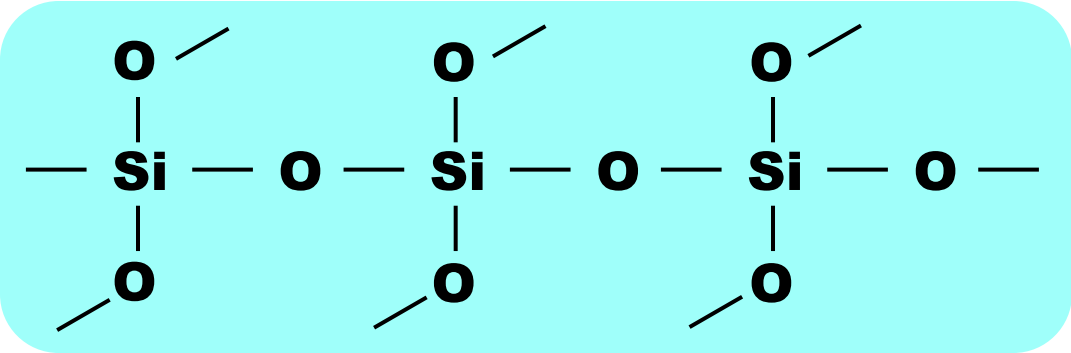
Silicones consist of an **inorganic** silicon-oxygen backbone with **organic** side groups attached to the silicon atoms.

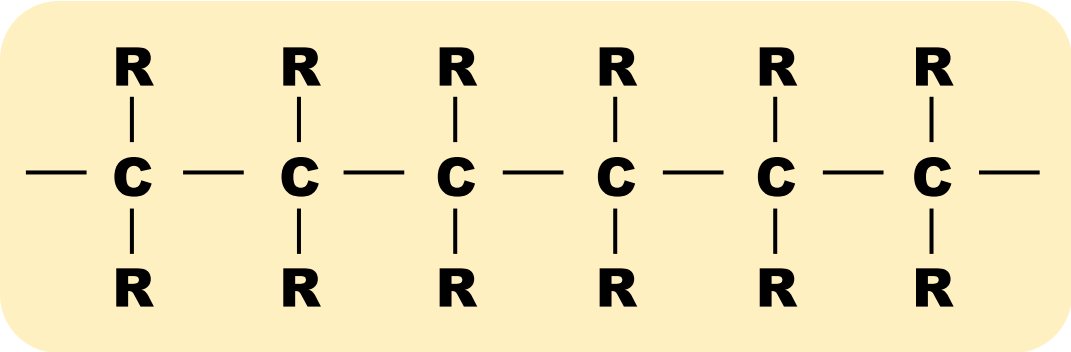


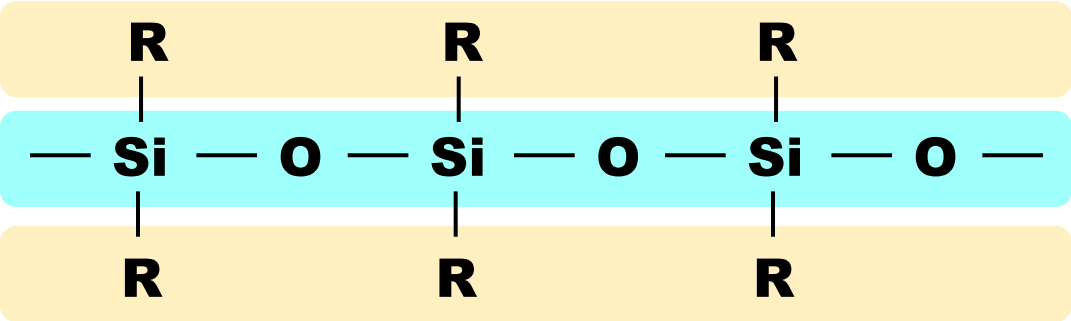
Silicon Oxygen Carbon Hydrogen Methyl or Phenyl Group

Combining the flexibility and strength of plastics (which are carbon-based) with the resistance of glass (which is silica-based), delivers the best qualities of both.

Defining Silicones







Glasses are:

- **Thermally stable**
- **Optically excellent**
- **Complex to process**

Organic polymers are:

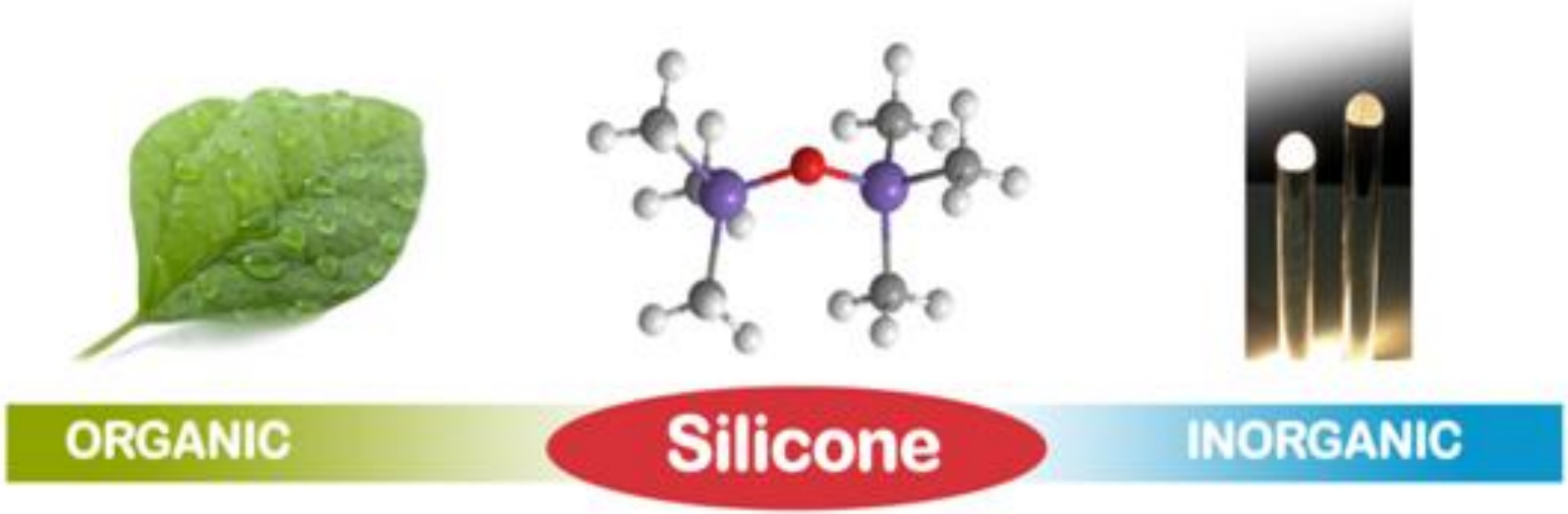
- **Easier to process**
- **Range of properties**
- **Less thermally stable**

Silicones have properties that combine glass and organic polymers

Fascinating Silicone™

The missing link

- Combining the characteristics of plastics and glass



Silicones Polymer Properties

Chemical Property	Physical Property	Application/ Design Properties
Long Si-O bond distance Wide bond angle	Facile bond rotation	Low modulus
High bond energy	Stable bonds	Heat resistance
Weak van der Waals' force	Low temperature dependence	Wide working range
	Low viscosity	Good workability
Organic exterior	Hydrophobicity	Low moisture absorption

This combination of properties is unique among polymeric materials

How Are Silicones Special?

High & low temp use

Material	High Temp	Flexible to
Silicones	**+150 to 200 C**	**-45 to -115 C**
Epoxies	+150 to 180 C	-
Urethanes	+115 to 125 C	-60 C
Acrylics	+85 to 125 C*	-

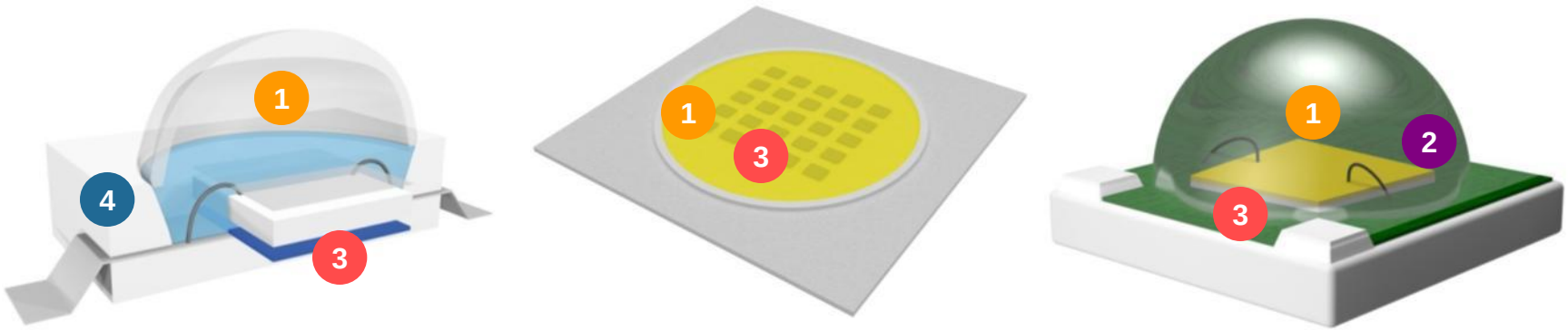
Silicones for LED Package

1 Optical Encapsulant

2 Chip Coating

3 Die Attach Adhesive

4 White Reflector



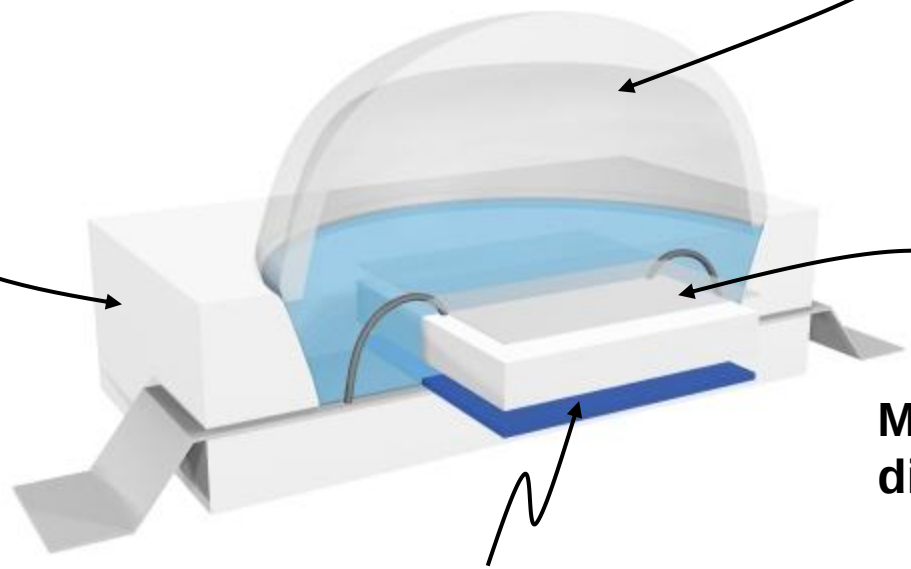
Proven reliability and efficiency across all lighting applications and processes:

- Seal
- Protect
- Adhere
- Cool
- Shape light

Material Needs in LED Components

Encapsulants requiring high heat and light flux stability

Improved white reflective materials for LED chip housing



Materials for phosphor dispersion and light control

Thermally conductive die attach materials to conduct heat from the LED chip

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Encapsulant

Dow Corning Silicone Product Line

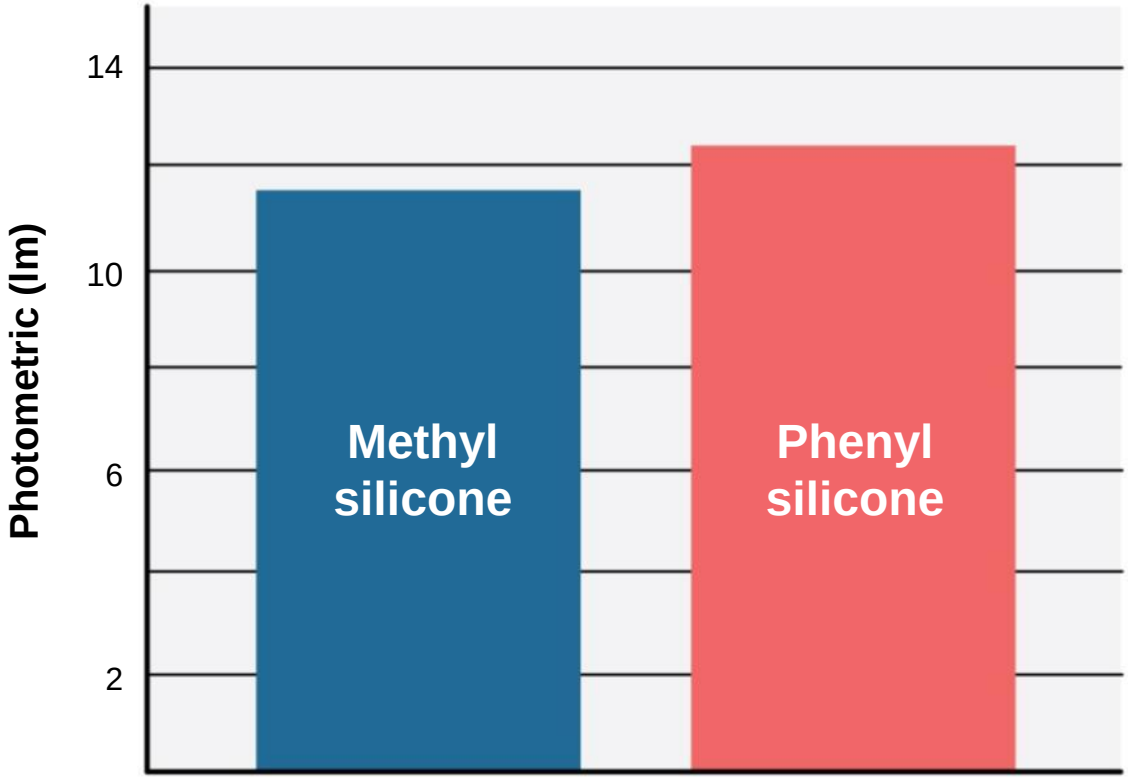
Silicone Encapsulant – Methyl or Phenyl

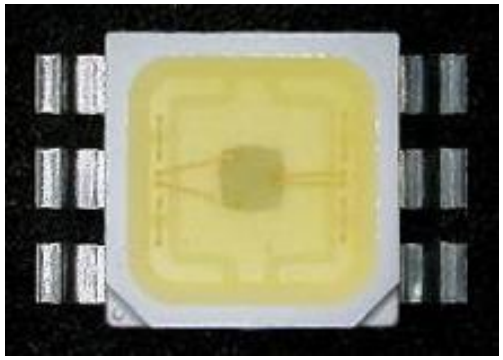
Two different types of silicone are commonly used as LED encapsulants: Methyl and Phenyl silicone. What is the difference?

	Methyl	**Phenyl**
Refractive Index (n_p)	1.41	1.53-1.54
Transmittance	Excellent	Excellent
Light Stability	Excellent	Very Good
Gas Barrier	Fair	Very Good

Phenyl encapsulants may enhance efficiency of light extraction of LEDs.

Methyl vs. Phenyl – Light Output

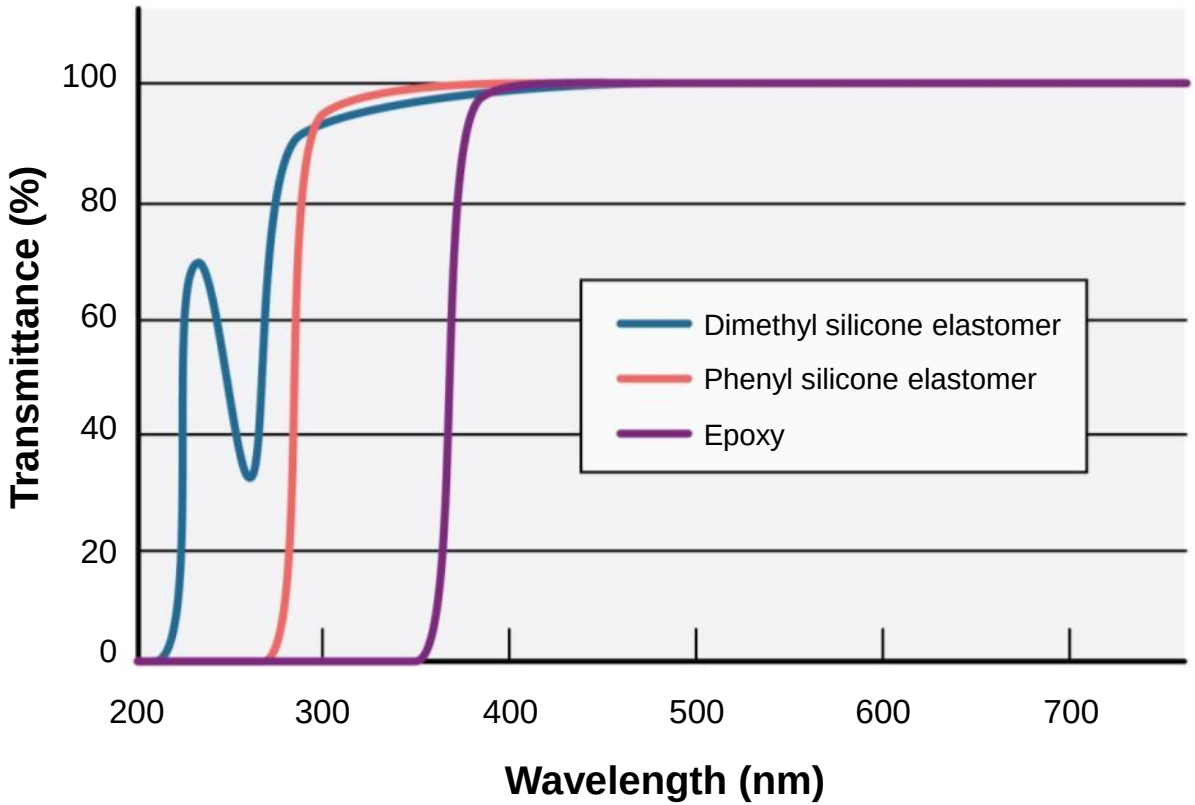




Blue LED with silicone encapsulants containing phosphor in 5050 package

Phenyl silicone can provide ~7% more light output compared to methyl silicone.

Methyl vs. Phenyl – Transmittance



Both show higher transmittance compared to organic material.

Thermal Stability of Silicone

200h thermal aging test (4mm thickness)

Methyl silicone

Phenyl silicone

Epoxy

Methyl vs. Phenyl – Gas Barrier

Gas Permeability

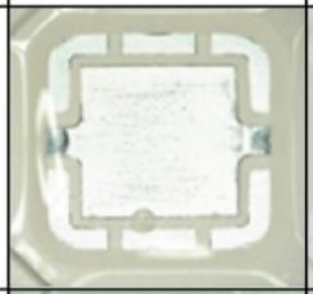
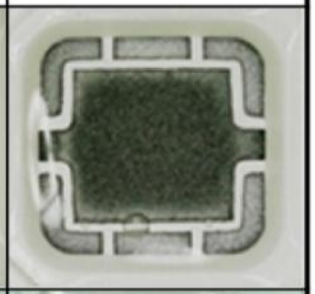
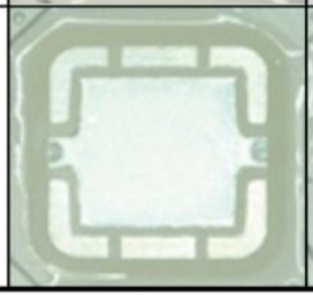
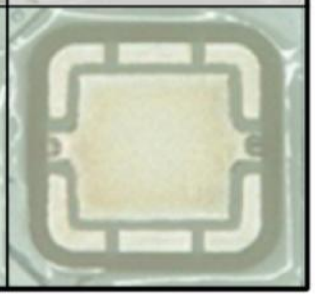
	Durometer Hardness	O_2 ($cm^3/m^2/24h/atm$)*	H_2O ($g/m^2/24h$)**
Phenyl Resin	Shore D 70	510	12
Phenyl Resin	Shore D 36	630	15
Phenyl Elastomer	Shore A 57	1120	19
Methyl Elastomer	Shore A 53	>20000	104

*JIS K 7126 (Detected by GC at 23˚C with the film thickness of 0.91mm)
**JIS Z 0208 (at 40˚C/90% RH with the film thickness of 0.91mm)

Phenyl silicone shows better gas barrier characteristics than Methyl silicone, which provides better protection of metals used in the LED package.

Methyl vs. Phenyl – Gas Barrier

Sulfur Corrosion

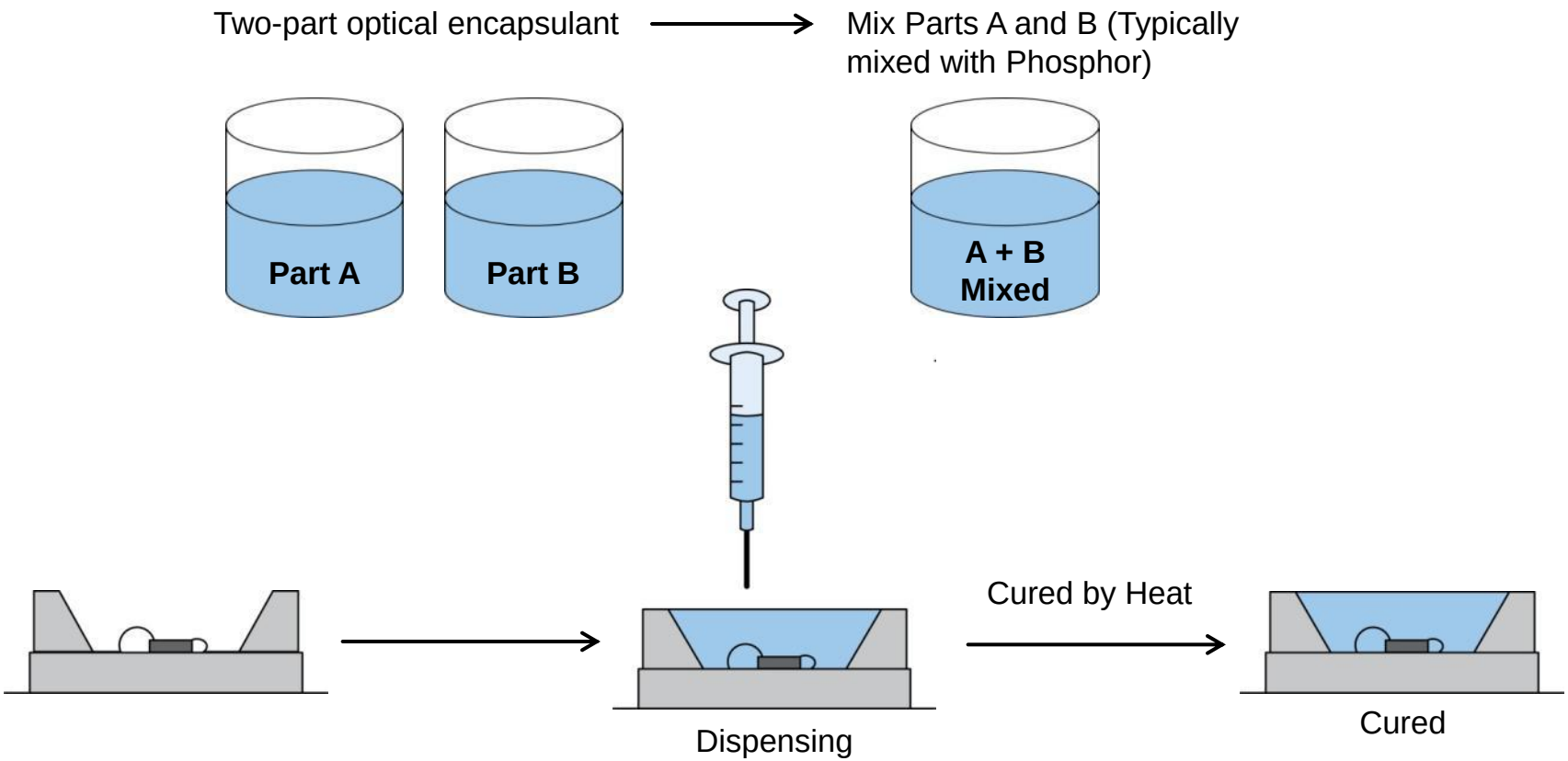
	Initial	20 hours
Methyl silicone		
Phenyl silicone		

Test condition

- 1.2 g of sulfur powder in a 450 ml bottle
- Aged at 80˚C for 20 hours
- 5050 PKG

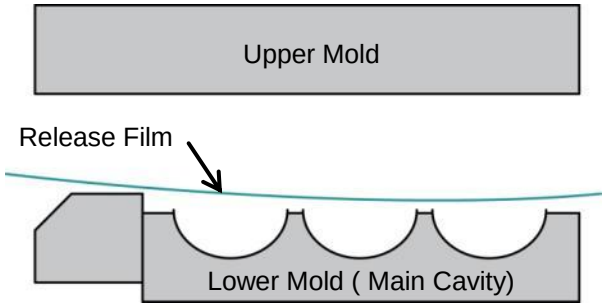
Phenyl silicone has a better gas barrier property and is more resistant to silver corrosion, which helps maintain light output.

Process – Dispensing

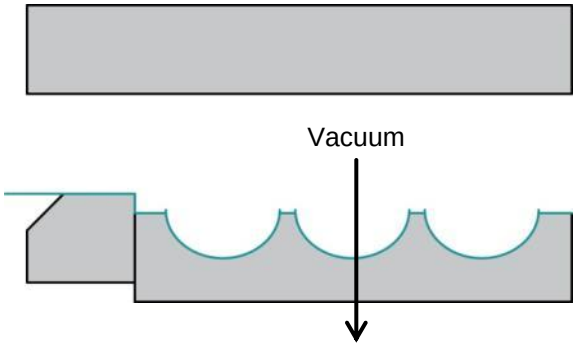


Process – Compression Molding

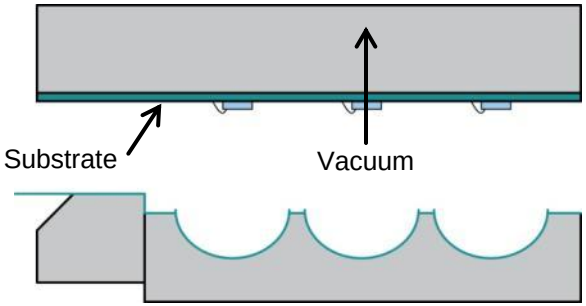
1. Release film loaded



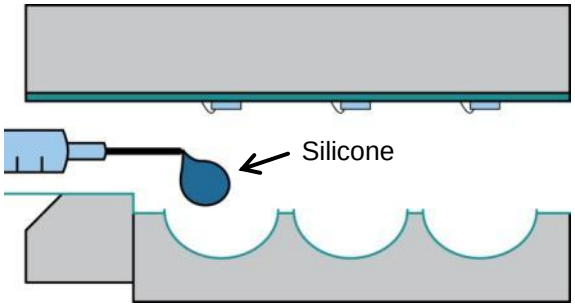
2. Film set on bottom by vacuum



3. Substrate placed on upper mold

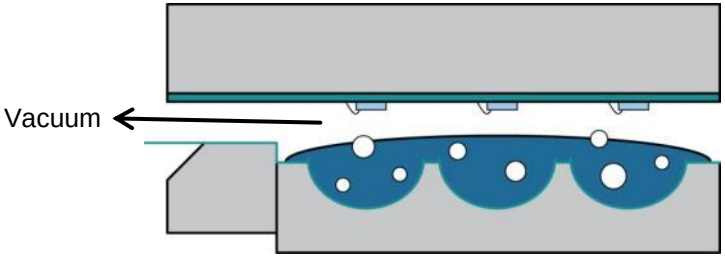


4. Silicone dispensed

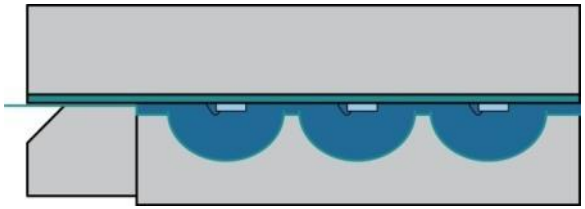


Process – Compression Molding

5. Pre-heated (Degassed)

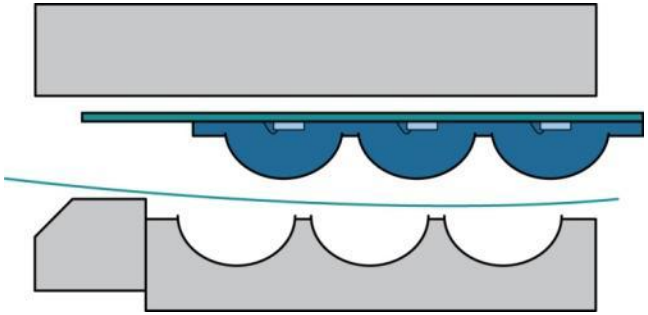


6. Mold clamped and silicone cured



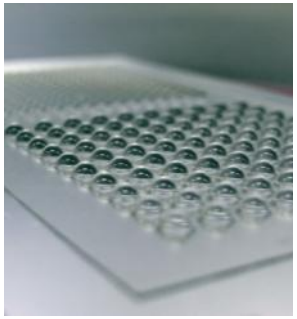
Full Clamp

7. Mold opened and finished



Compression Molding System

Lens Array



DOW CORNING Lighting Solutions

Silicone White Reflector

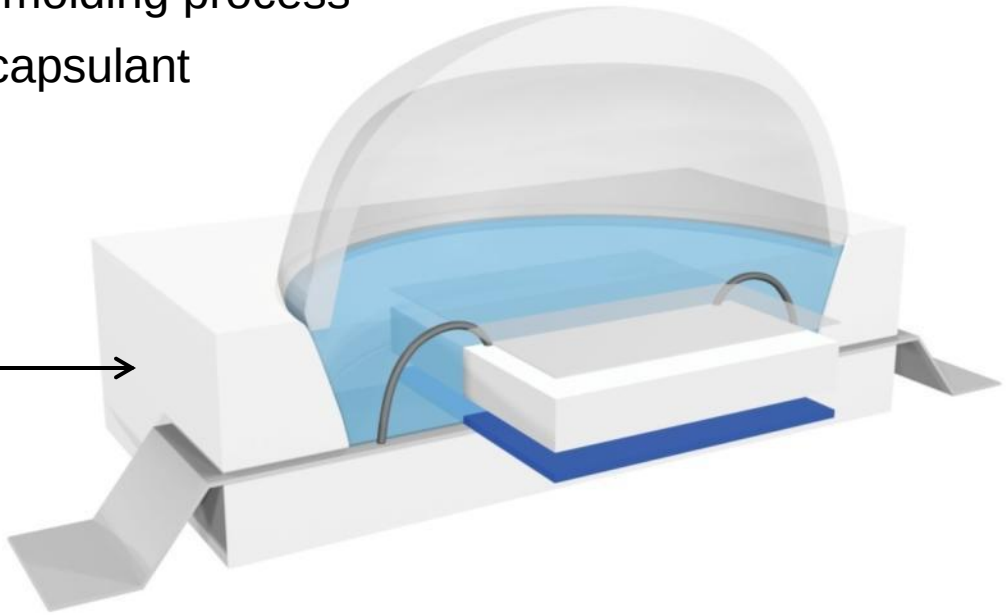
Dow Corning Silicone Product Line

Silicone White Reflector

Silicone-based Reflector for LED

- Superior thermal reliability
- High light reflectivity
- Fast cure for high throughput molding process
- Compatibility with silicone encapsulant

Reflector of LED Package →



Silicone White Reflector

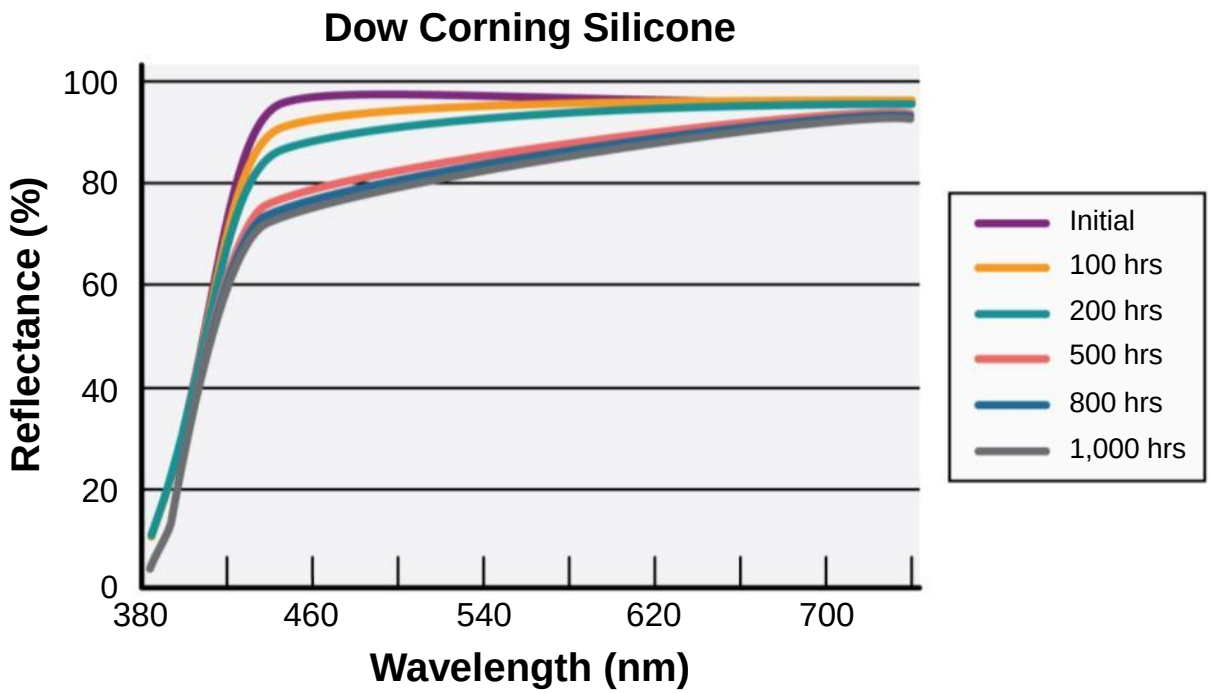
Thermal Stability of Silicone Reflector

Reflectance After 180˚C Aging				
	0 hours	**100 hours**	**500 hours**	**1000 hours**
Silicone				
Epoxy				
Liquid Crystal Polymer				
Nylon				

Silicone has superior thermal stability and resistance to yellowing.

Silicone White Reflector

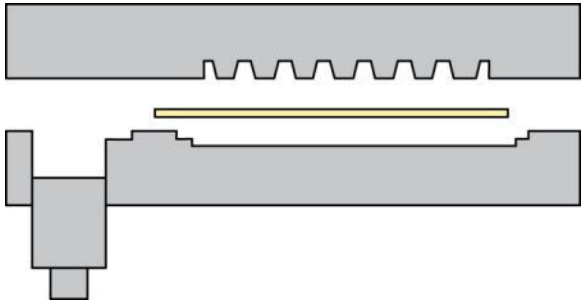
Reflectance decay at high temperature (180˚C)



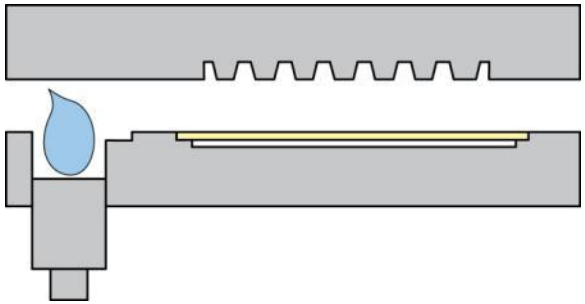
Silicone reflector shows stable reflectance at visible wavelength during aging at 180˚C.

Process – Transfer Molding

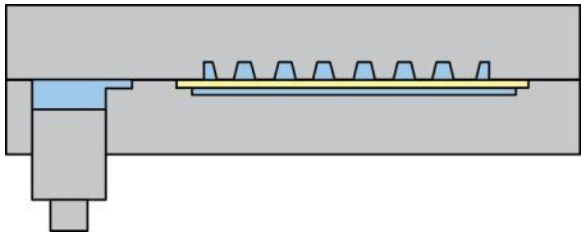
1. Spray releasing agent and place lead frame



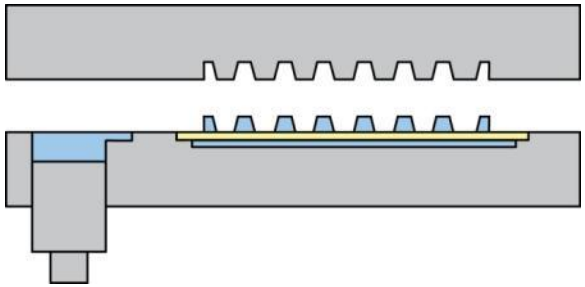
2. Dispense silicone



3. Mold close, plunger up and cure silicone



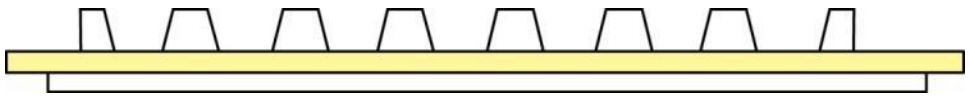
4. Mold open and finish



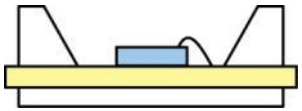
Process – PMC and Packaging

Post Molding Cure and Packaging

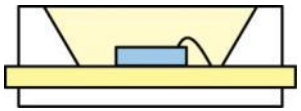
1. Post molding cure and deflash

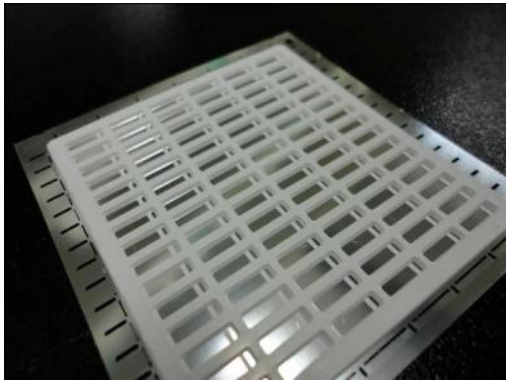


2. Chip bonding and wiring



3. Encapsulation and dicing



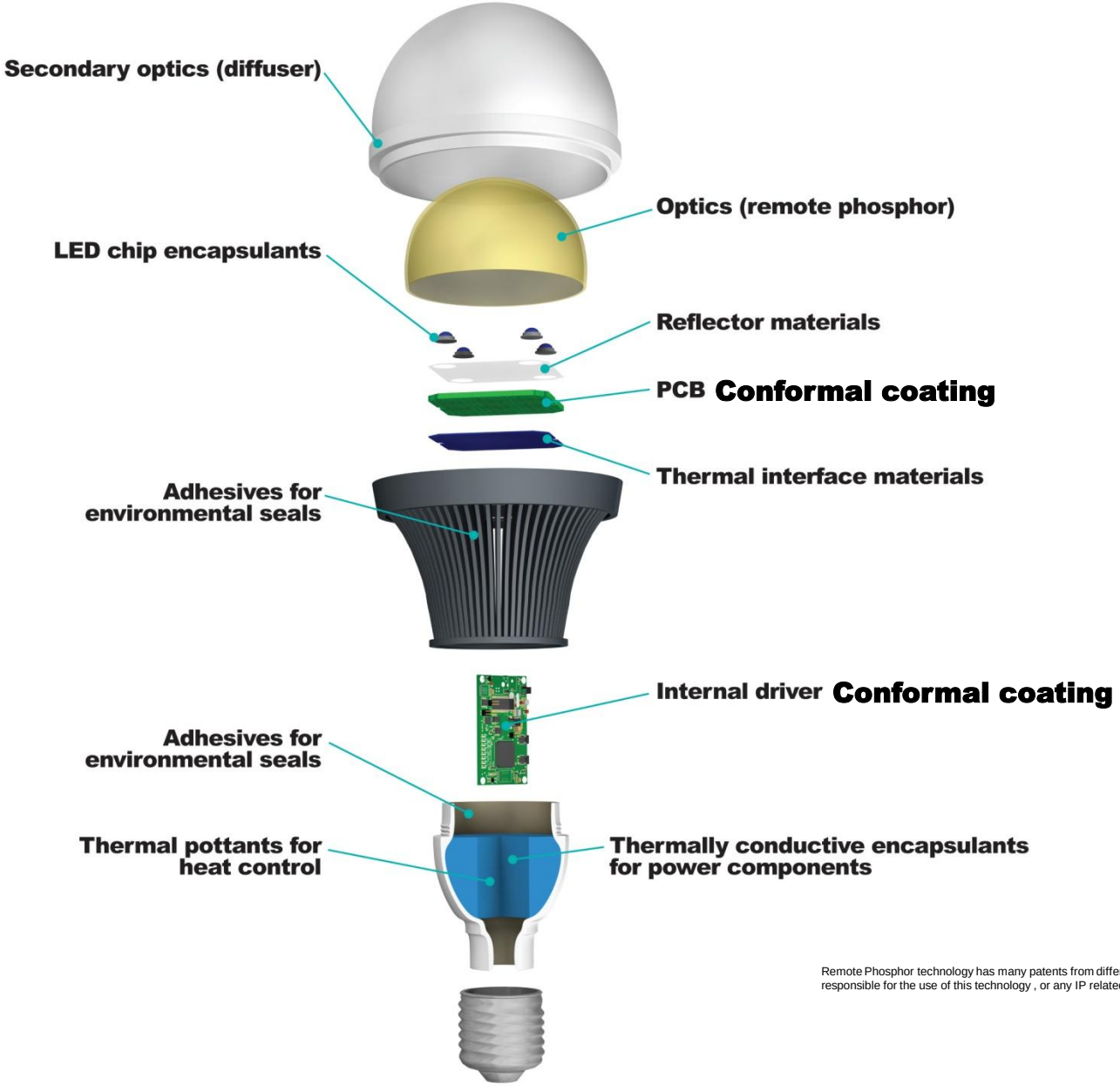


Molded Silicone Reflector

Test Conditions
- Molding: 130˚C/3 min
- Post cure: 150˚C/2 hrs
- Deflash: ED water jet

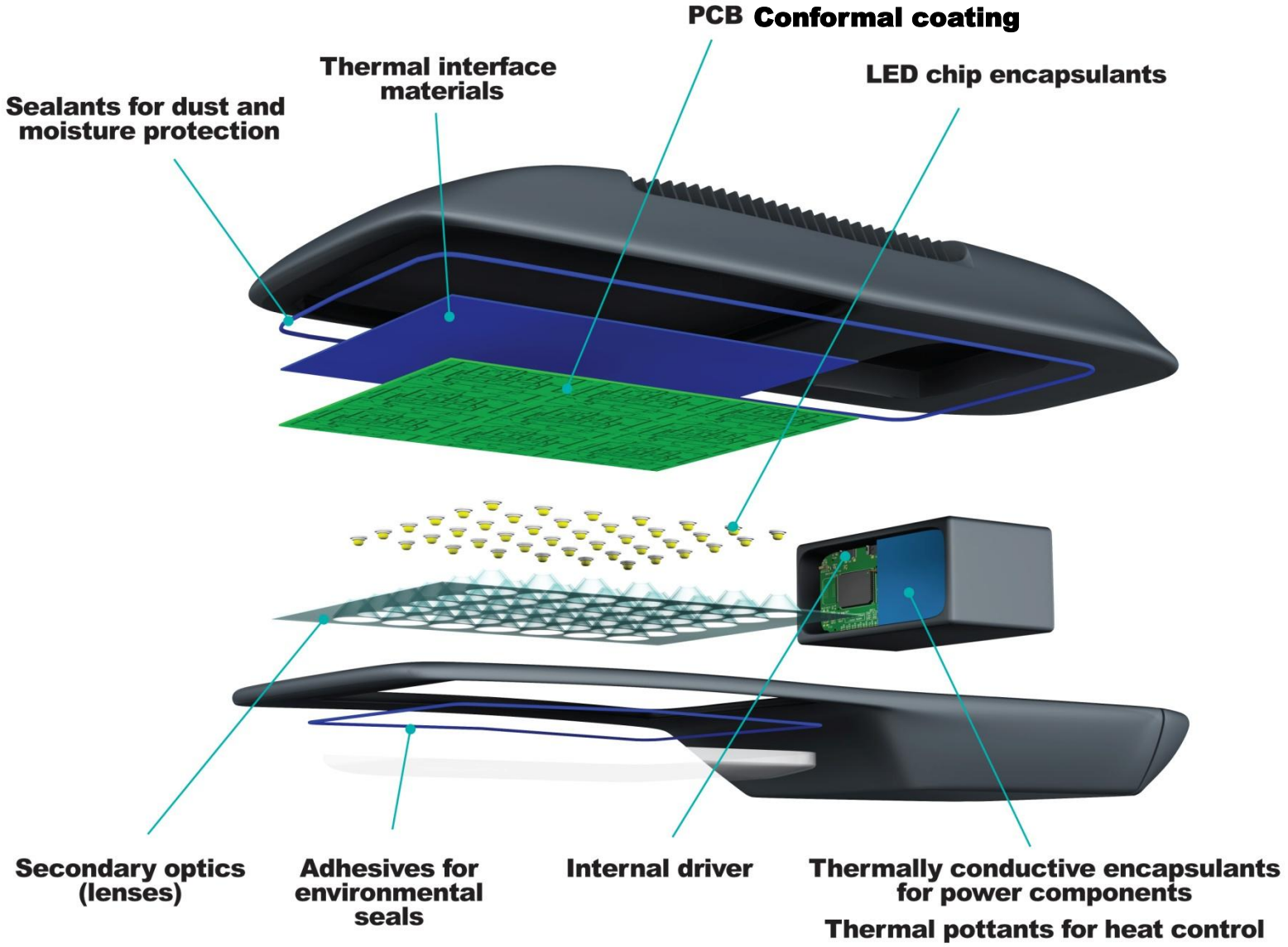
Silicone Applications in LED Lighting Assembly

Example of Applications(Lamps)



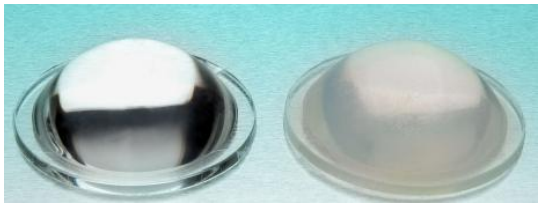
Remote Phosphor technology has many patents from different companies, Dow Corning is not responsible for the use of this technology , or any IP related subject.

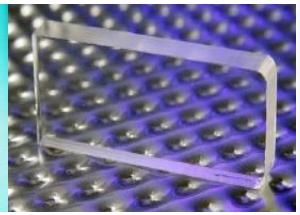
Example of Applications(LED Luminaires)



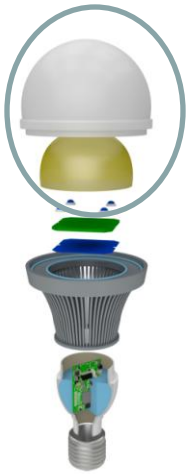
Optical Materials for Lamps and Luminaires

Moldable Optical lenses

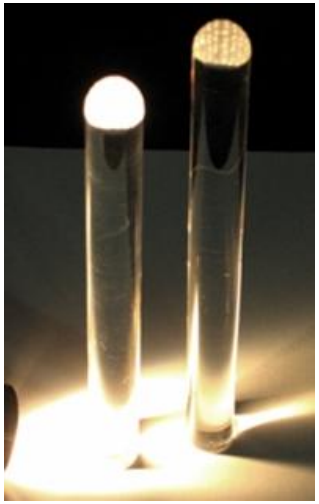




Remote Phosphor; Diffuser



Light Guides



White Reflector

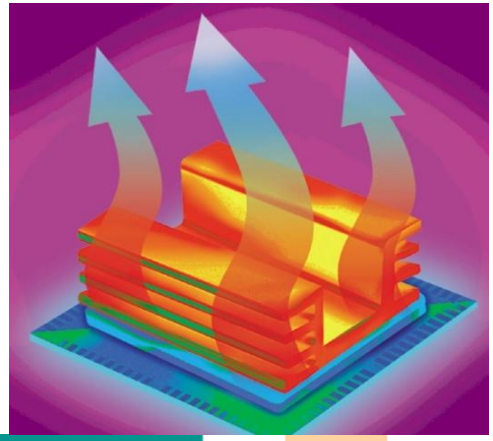
Silicones benefits across the entire lighting value chain

- Thermal stability
- Transparency
- Photo stability
- Enhanced light output efficiency
- Easy processability
- Lower cost of ownership
- Enhanced Protection
- Enhanced reliability and lifetime

Thermal Challenges for Materials in Lighting

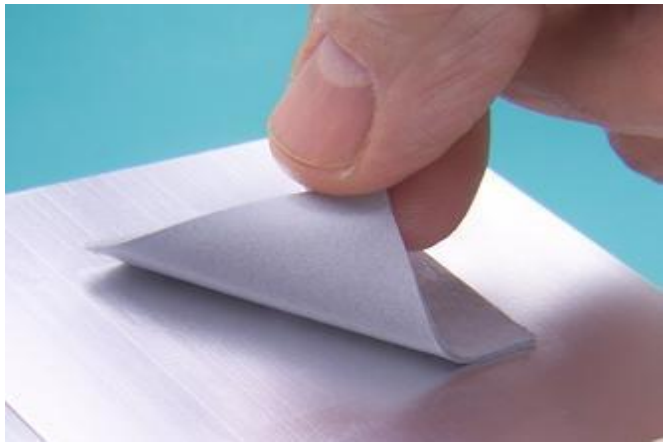
Energy		Incandescent (60 W)	Fluorescent (Typical linear CW)	Metal Halide	LED
Light	Visible Light	8%	21%	27%	20-30%
	IR	73%	37%	17%	~0%
	UV	0%	0%	19%	0%
Heat	Convection and Conduction	19%	42%	37%	70-80%
Total		100%	100%	100%	100%

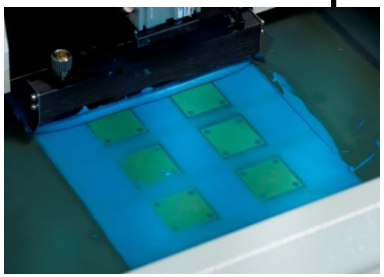
- **Adoption of LM-80 and LM-79 standards changing expectations for materials technology development**
- **Materials that are acceptable at t=0 may not be acceptable at t=6000 hours**

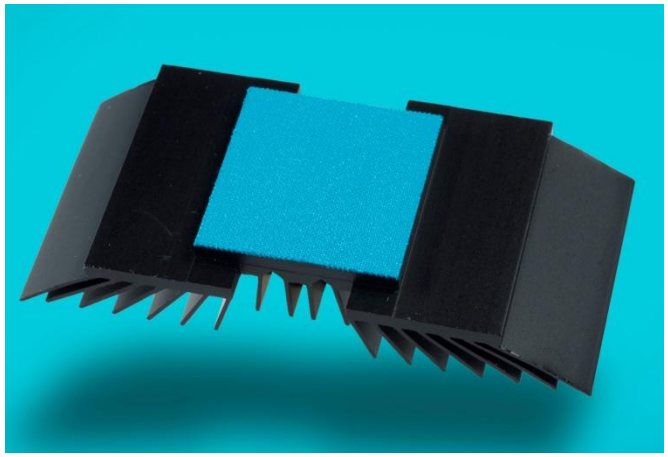


Dispensable / Printable Pad Concept

- A fabricated pad is one that is coated onto some kind of liner, cured and then cut into pieces for use such as a gap pad (below left).
- A dispensable pad is a pad that applied to the application substrate in it's wet state and cured in place (below right). Pad may be screen/stencil printed or dispensed.







Thank you