Stick to the Clear Advantage

NEW DOWSIL™ EI-2888 Primerless Silicone Encapsulant



Product Launch Presentation

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February 21, 2019

consumer.dow.com/lighting

Agenda

- **Lighting Market and its Challenges**
  - Growth and impact on the planet
  - Adressing the needs of professional lighting
  - Focus on high level of protection
- **Protective Materials Over LEDs**
  - Protection options
  - Optical influence
  - Material comparison



- **Innovate with DOWSIL™ EI-2888 Primerless Silicone Encapsulant**
  - Key features and benefits
  - Product details and performance in use

Global LED Lighting Market Growth / Impact on Planet

Global LED lighting market to reach $100B in the upcoming decade

- This corresponds to 12%+ CAGR in value and **20%+ CAGR in volume**



Lighting related energy consumption is expected to drop by 40% in 2030, thanks to LED penetration into general illumination.

Imagine

Addressing the Needs - Professional Lighting Market

The professional LED lighting market is expected to surpass $35B by 2022.

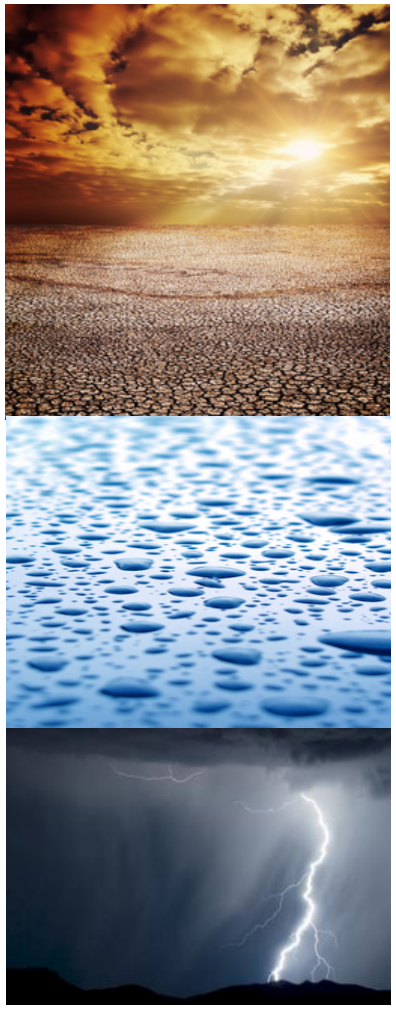
- This includes **industrial**, **commercial**, **outdoor,** and **architectural** applications

Main growth drivers are linked to the expectations of

- **High efficiency**
- **Reliability and robustness**
- **High brightness**
- **Condensed size and customized shapes**
- **Low power consumption**



The Need for High Ingress Protection



- **Flexible and Rigid LED Strips**
- **Outdoor LED Displays**
- **Explosion Proof Lighting**
  - Linear: Tube and string/strip
  - Spot, flood and general-area
  - Small portable-type: Flashlights, wearable headlamp
  - Specialty and panel

Protective Materials

DOWSIL™

Conformal Coating

- **Minimally effects luminous flux and CCT**

  — Challenge: Provides the least amount of protection above bare components

Optical Encapsulant

- **Provides the highest degree of protection and ease of use**

  — Challenge: Impact on CCT

Molded Lens

- **Best optical management**

  — Challenge: Lower degree of protection (air gap) and more complex impacting price

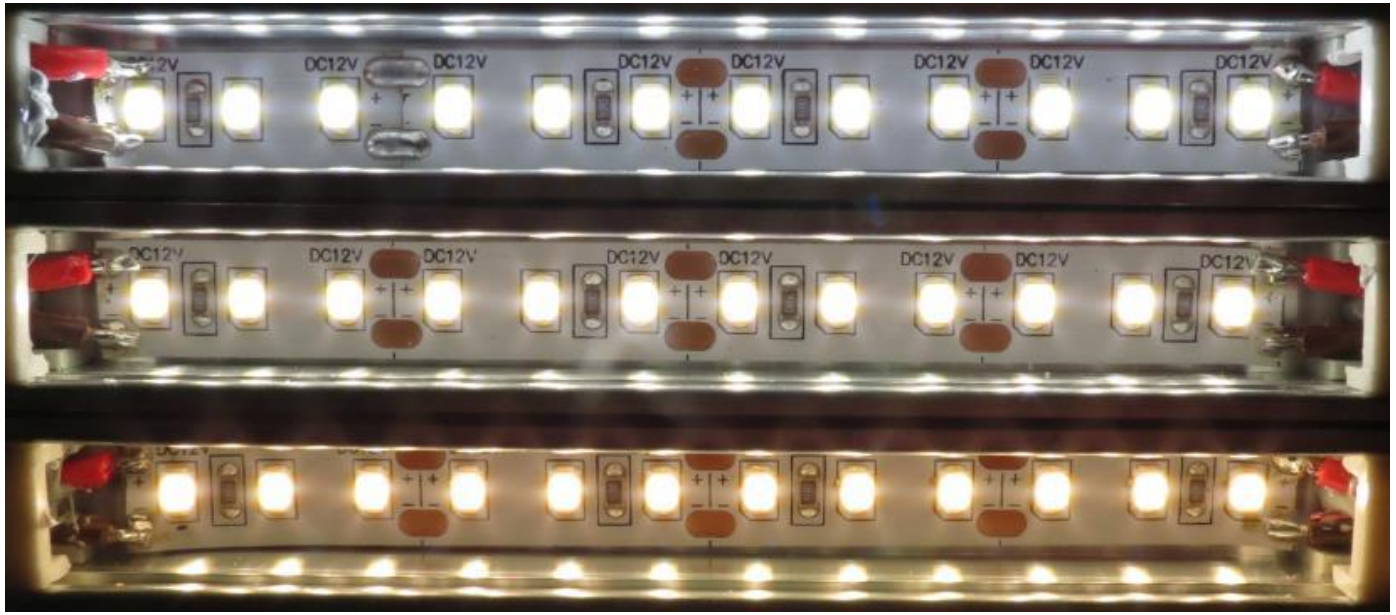
Encapsulation is best suited for harsh environments, such as explosion proof or high IP rated luminaires.

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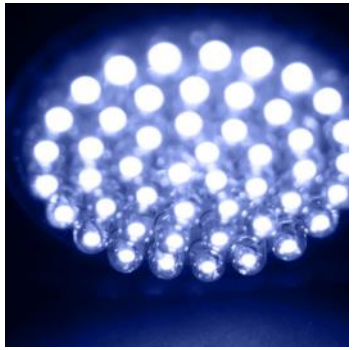
Protection and Performance

DOWSIL™

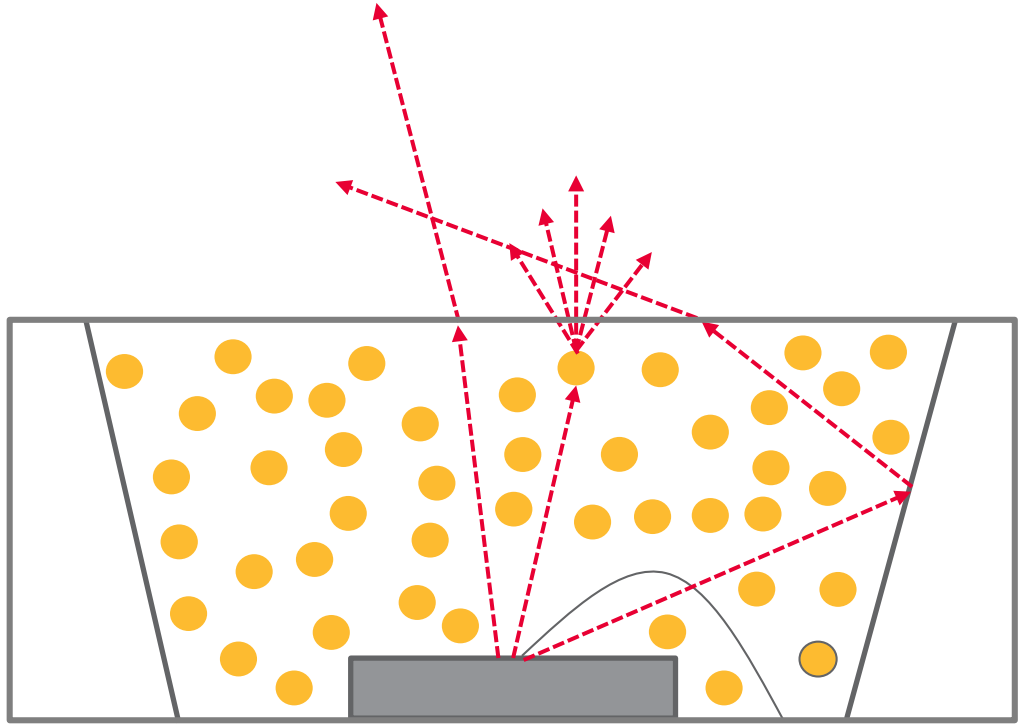
DOWSIL™ EI-2888 Encapsulant versus other solutions



Protective Materials Over LEDs
and Associated Optical Effects

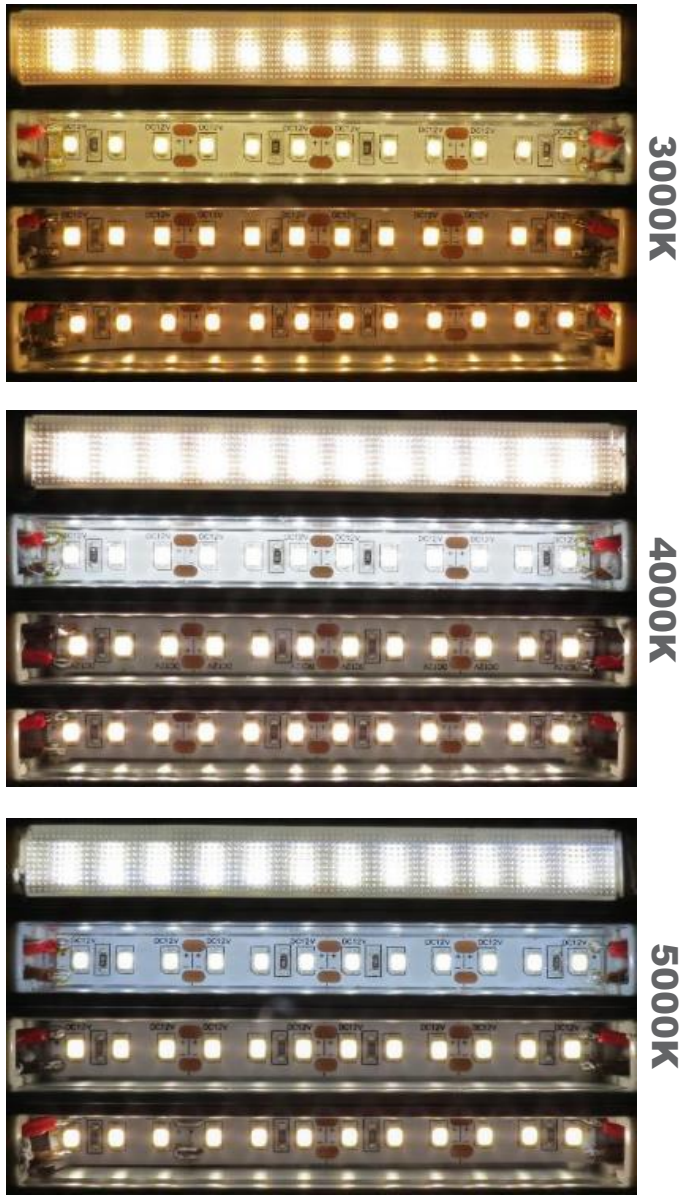




Optical Influence



Protective material can

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



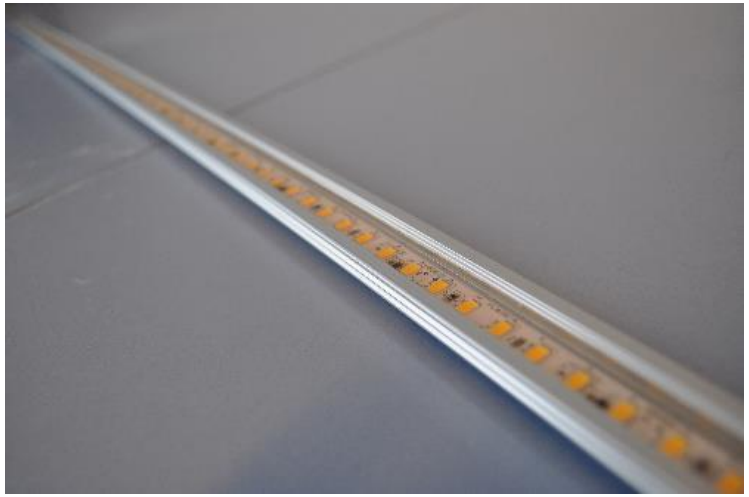
Existing Encapsulation Materials

	Advantages	Limitations
Epoxy	• Hard – best mechanical protection • Good adhesion to many substrates • Lowest price	• Weak photo resistance • Shrinkage during cure • Health concern
Urethane	• Tunable hardness – soft to hard • Conditional adhesion to substrate • Medium price	• Shrinkage during cure ➡ stress • Sensitive to moisture during cure ➡ bubbles • Health concern: isocyanates
Silicone	• Highest thermal stability and photo resistance • Good moisture and humidity resistance • No exotherm and no shrinkage	• No adhesion, need of primer • Higher price • Cure inhibition

Existing Encapsulation Materials

	Epoxy	Urethane	Silicone
Light Transmission			
Aging Resistance			
Processing			
Rapid RT Cure			
Self Adhesion			
Health Concern			
Shrinkage / Exotherm			
Cure Robustness			
Cost			

NEW DOWSIL™ EI-2888 Primerless Silicone Encapsulant









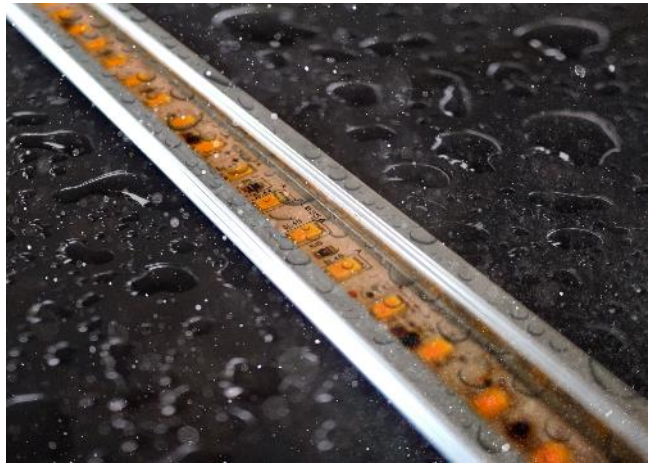
Innovative Technology from Dow

NEW DOWSIL™ EI-2888 Primerless Silicone Encapsulant

DOWSIL™ EI-2888 Encapsulant	
Light Transmission	
Aging Resistance	
Low Viscosity	
Rapid RT Cure	
Self Adhesion	
Health Concern	
Shrinkage/Exotherm	
Cure Robustness	
Cost	

- Patented technology
- 100% silicone product





Self Adhesive

DOWSIL™

Reliable adhesion on:

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

Even after 2000 hours exposed to:

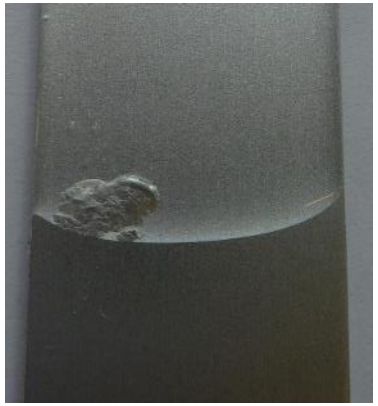
- 150ºC
- 85ºC / 85% RH
- -40 / +150ºC thermal shock
- Sunlight UV

Limitation: PMMA, die-cast aluminum







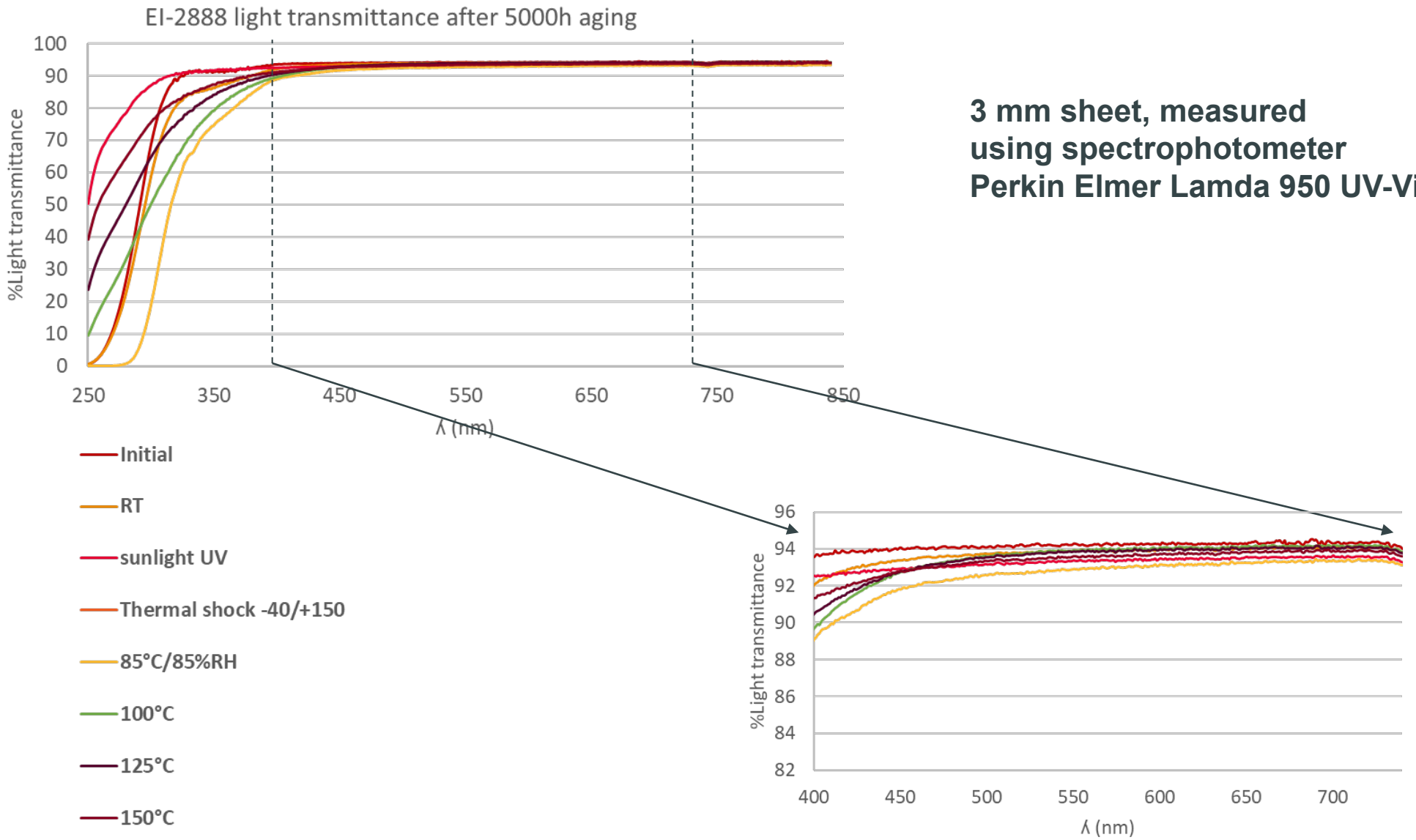


DOW

Optically Clear Under Harsh Environment

	DOWSIL™ EI-2888 Encapsulant (2,000 hrs)	DOWSIL™ EI-2888 Encapsulant (5,000 hrs)	Optical-grade PU (168 hrs)	Optical-grade PU (1,400 hrs)	Optical-grade PU (10,000 hrs)
Room temperature					
100ºC					
125ºC					
150ºC					
UV					
- 40ºC / +150ºC					
85/85					

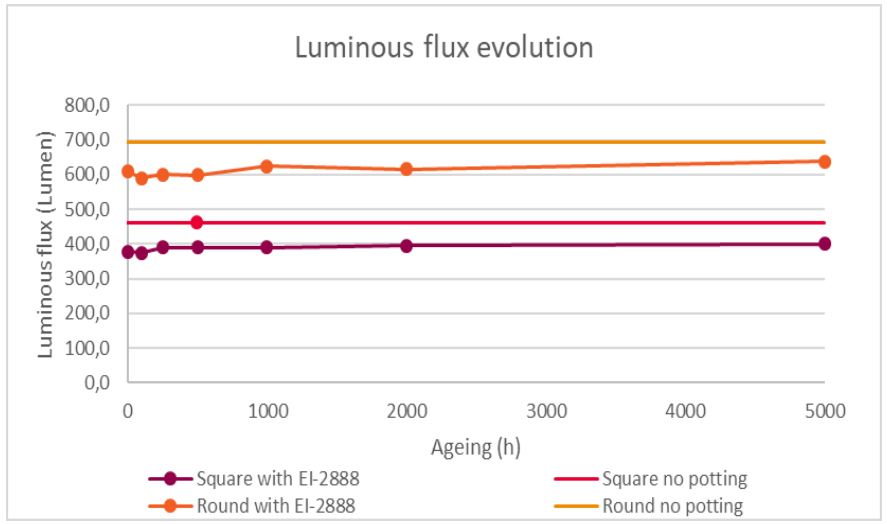
Optically Stable Beyond Visible Range and Under Aging



3 mm sheet, measured using spectrophotometer Perkin Elmer Lamda 950 UV-Vis

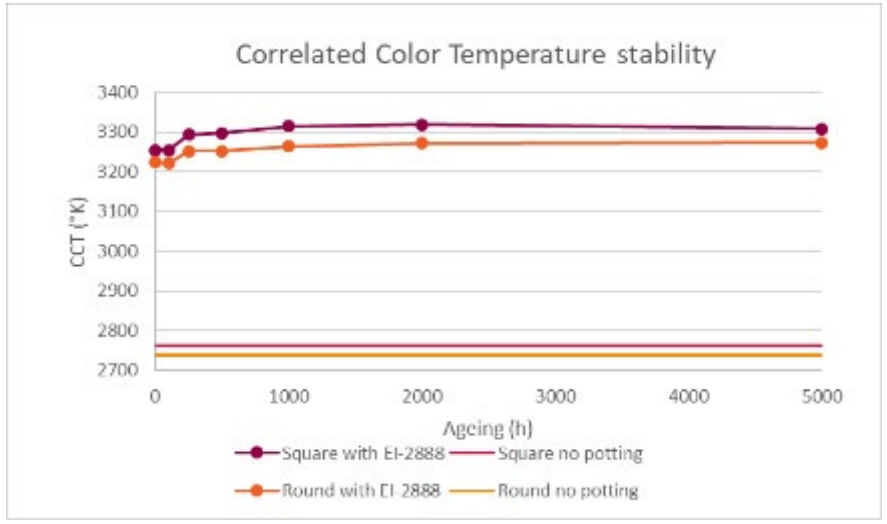
Proven Results

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









Driven 12V 1.42A up to 5000 hrs

Cure Robustness

- **Not subjected to cure poisoning**
  - Common issue with silicone-based encapsulants
- **Not sensitive to moisture during cure ≠ urethane**
  - No need for control atmosphere
- **Lower cleaning requirement**

Potential cost saving





Ease of Processing

Ease of De-gassing





t = 0



t = 15 min



t = 1 hr

Low Viscosity

Part A	2,000 mPa.s
Part B	2,300 mPa.s
Mixed	2,700 mPa.s

1:1 Mix ratio

- **Suitable with various mixing techniques, such as hand stirring, static mixing, dynamic mixing, and by centrifuge**
- **No need for vacuum after application**

Flexible and Robust



Durometer	Value
Shore 00	7 @ 22ºC, 28 @ 50ºC (after 1 day) 35 (after 3 days) 45 (after 7 days) 60 (after 21 days)
Shore A	10 (after 21 days)



Cure Time / Hardness to Design Your Process

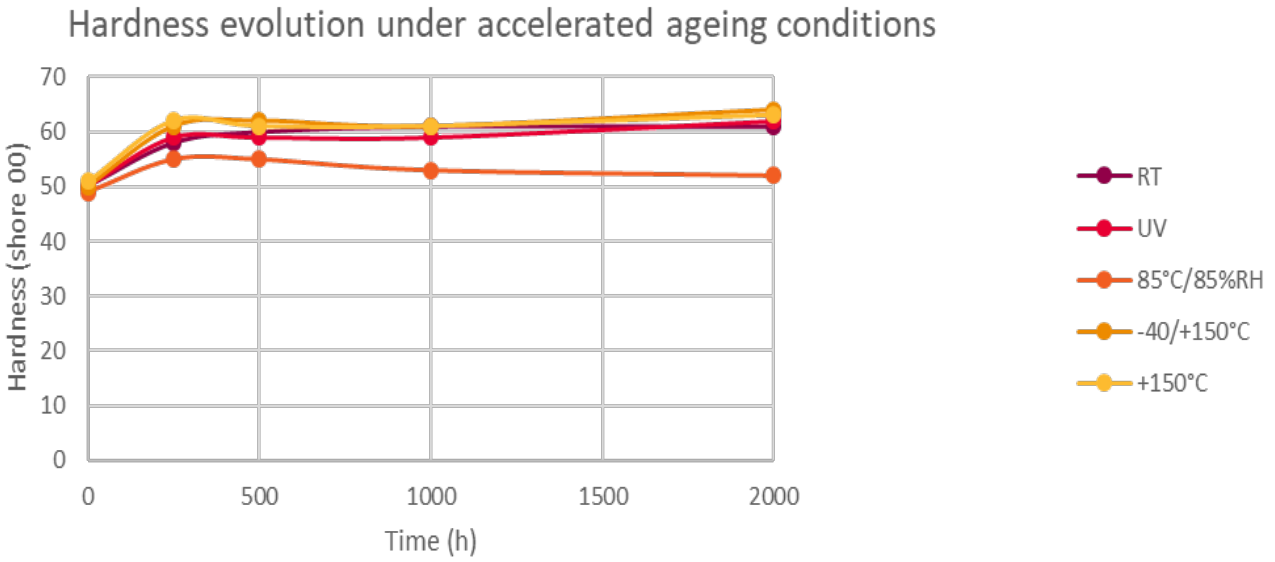


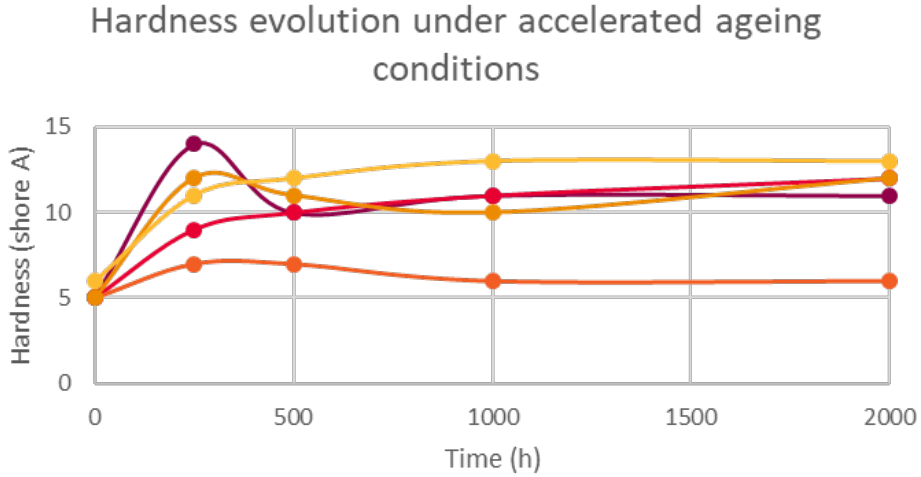






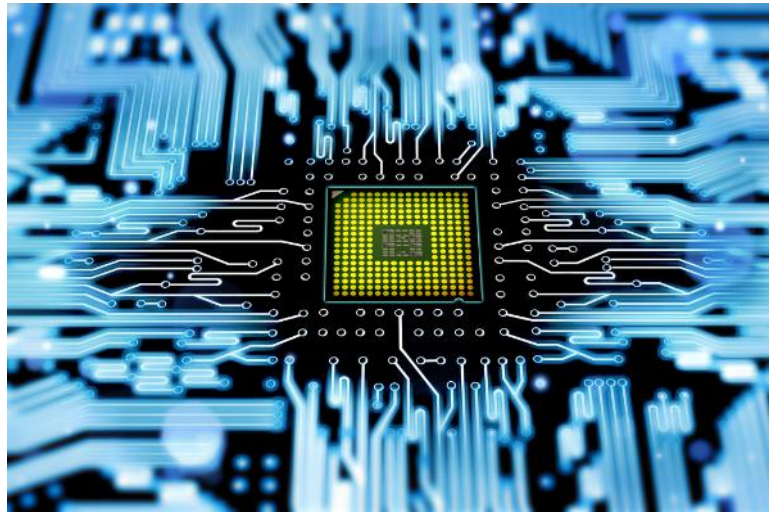
Stable Under Aging





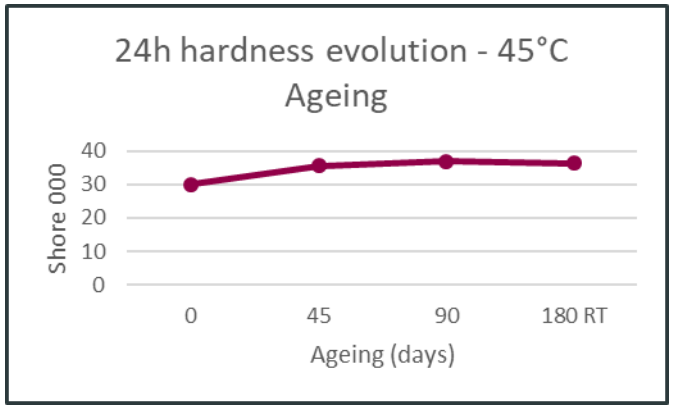
Good Dielectrical Properties

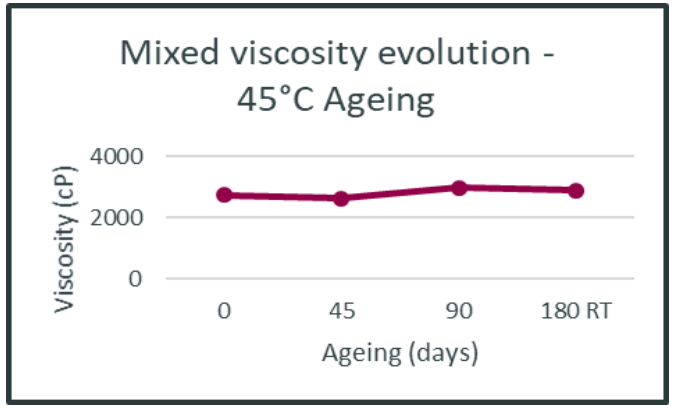
Property	Value
Dielectric strength	19kV/mm
Volume resistivity	1^{E}+16 Ω.cm
Surface resistivity	$2,6^{E}$+14 Ω •

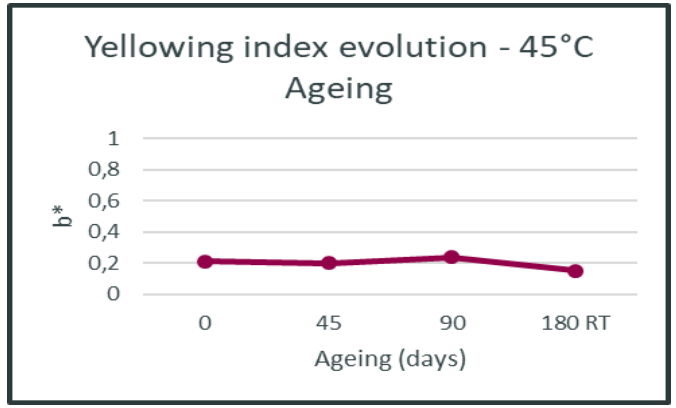


Long Usable Life

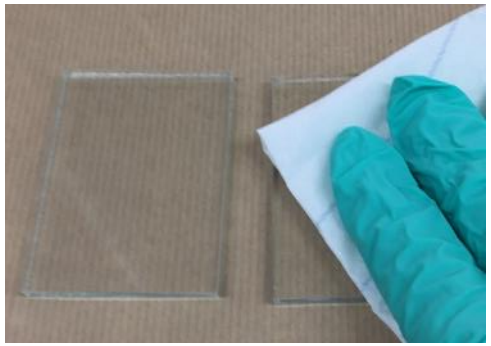
- One-year stability expected
- Keep packaging closed – avoid moisture
- Moisture contamination will decrease cure speed

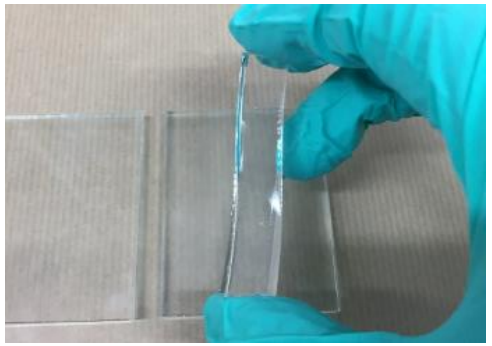


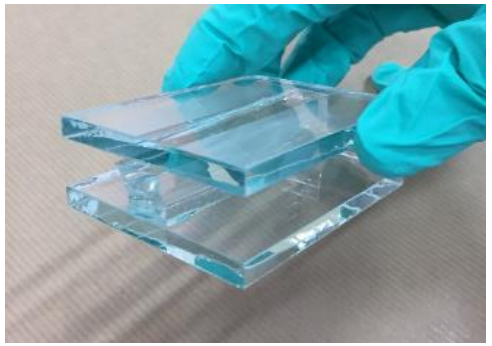




Additional Unique Feature







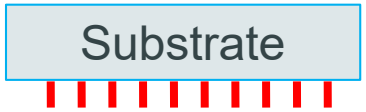
Prime Substrate

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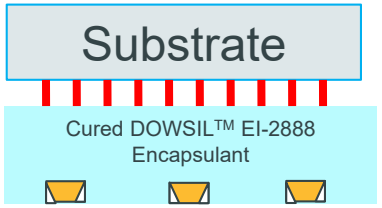
Apply cured **DOWSIL™ EI-2888 Encapsulant**

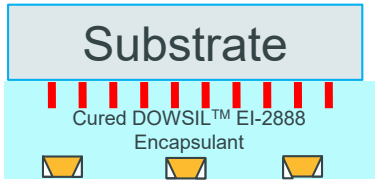
<5 min

Bonded Assembly



Primer has to react with substrate first





Durable chemical adhesion

Final Comparison / Recap

	Epoxy	Urethane	Silicone		
			SYLGARD™ 184 Elastomer	DOWSIL™ EI-1184 Encapsulant	DOWSIL™ EI-2888 Encapsulant
Light Transmission					
Aging Resistance					
Processing					
Rapid RT Cure					
Self Adhesion					
Health Concern					
Shrinkage / Exotherm					
Cure Robustness					
Cost					

Price Positioning

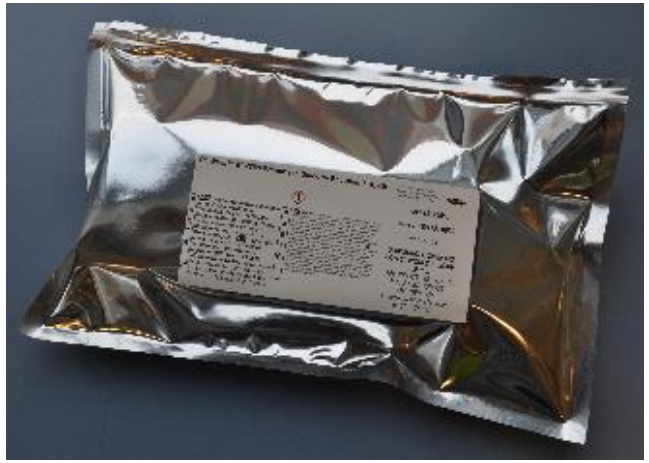
	Epoxy	Urethane	Silicone		
			SYLGARD™ 184 Elastomer	DOWSIL™ EI-1184 Encapsulant	DOWSIL™ EI-2888 Encapsulant
Light Transmission					
Aging Resistance					
Processing					
Rapid RT Cure					
Self Adhesion					
Health Concern					
Shrinkage / Exotherm					
Cure Robustness					
Cost					

Packaging

Sample

- 400 ml side-by-side CRT





Material number:
400 ml A/B kit: 99124556

Standard

- 2 x 19 kg Jerry can
- 2 x 200 kg drum





Material number:
19kg: 99120811 (Part A) 99117550 (Part B)
200kg: 99120810 (Part A) 99117489 (Part B)

Technical and Safety Data Sheets Available

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Technical Data Sheet

DOWSIL™ EI-2888 Primerless Silicone Encapsulant

Optically clear, 2-part 1:1 mix ratio, low viscosity, self priming silicone encapsulant

Features & Benefits

- Room temperature cure with optional heat acceleration
- Low viscosity – ease of processing
- Self priming – no primer needed
- 100% silicone (PDMS)
- UL 94 recognized

Applications

DOWSIL™ EI-2888 Primerless Silicone Encapsulant is particularly suitable for encapsulating rigid and flexible circuit boards for indoor and outdoor LED Lighting, explosion proof and high ingress protection rated luminaire as well as outdoor displays applications.

Typical Properties

Specification Writers: These values are not intended for use in preparing specifications.

Test[1]	Property	Unit	Result
	One or two-part		Two
	Mix ratio		1:1
CTM 0176B	Appearance		Clear
CTM 0050	Viscosity Part A	mPa-Sec	2000
CTM 0050	Viscosity Part B	mPa-Sec	2300
CTM 0050	Viscosity mixed	mPa-Sec	2700
	Gel time (G'=G") at 22°C[2]	hrs	8
CTM 0055	Pot life at 22°C[2]	min	130
CTM 0099	Durometer after 24 hrs	Shore 00	7 (22°C) – 28 (50°C)
CTM 0099	Durometer after 3 days at 22°C	Shore 00	35
CTM 0099	Durometer after 7 days at 22°C	Shore 00	45
CTM 0099	Durometer after 21 days at 22°C	Shore 00	60
		Shore A	10
ASTM D 412	Tensile strength	MPa	0.2

1. CTM: Corporate Test Method, copies of CTM's are available on request. ASTM: American Society for Testing and Materials.
2. Can vary due to environmental condition (humidity, mixing method)

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Typical Properties (Cont.)

Test	Property	Unit	Result
ASTM D 412	Elongation	%	190
CTM 0043	Unprimed lap shear (AL)	MPa	0.17
CTM 0114	Dielectric strength	kV/mm	19
CTM 0249	Volume resistivity	Ohm*cm	1E + 15
ASTM D 1003	Light transmission @ 380 nm, 5 mm	%	91
ASTM D 1003	Light transmission @ 450 nm, 5 mm	%	94
ASTM D 1003	Light transmission @ 760 nm, 5 mm	%	95
	Shelf life at 22°C	months	12

Description

DOWSIL™ EI-2888 Primerless Encapsulant is supplied as two-part liquid component. When liquid components are thoroughly mixed either by weight or volume, the mixture cures at room temperature or with mild heat to a flexible elastomer, which is well suited for the protection of rigid and flexible circuit boards for indoor or outdoor LED Lighting, explosion proof and high ingress protection rated luminaire as well as outdoor displays.

Dow silicone encapsulants cure without exotherm at a constant rate regardless of sectional thickness or degree of confinement. This encapsulant contains its own source of moisture, so cure progresses evenly throughout the material and deep-section or confined space cures are possible.

Self priming encapsulant develop reliable adhesion to a wide range of substrates at room temperature or with mild heat, without the need of primer. Only good cleaning may be needed.

Unlike other silicone chemistries, this product is unsensitive to phenomena like Platinum catalyst inhibition when exposed to contaminant, or material reversion when exposed to high temperature in a confined environment.

Dow silicone elastomers require no post cure and can be placed in service immediately following the completion of the cure schedule.

Dow silicone elastomers retain their original physical and electrical properties over a broad range of operating conditions which enhance the reliability of and service life of devices.

Application Methods

- Automated static or dynamic metered mixing
- Manual mixing
- Flow, pour, or needle dispense

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