

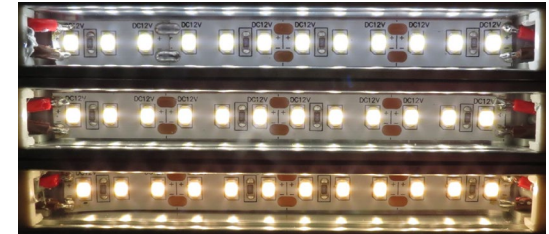


# Protective Materials Over LEDs – and Associated Optical Effects



Presented by Jake Steinbrecher • Dow Performance Silicones  
Strategies In Light, February 13, 2018

# Why Can't We Just Have "White" Light?

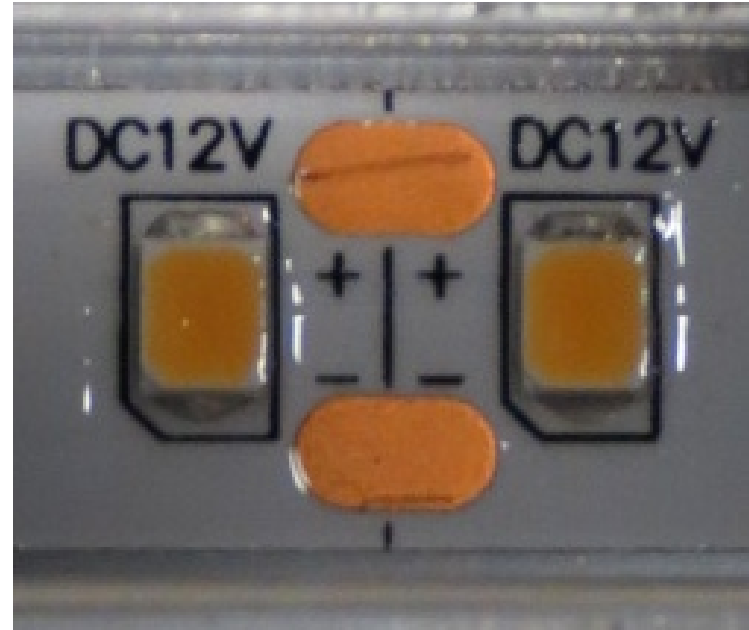


Paul Andreau  
Photo: © 2008 Artists Rights Society (ARS), New York / ADAGP, Paris

# Benefits of Protective Materials - Conformal Coatings

## Silicone, Acrylic, Urethane

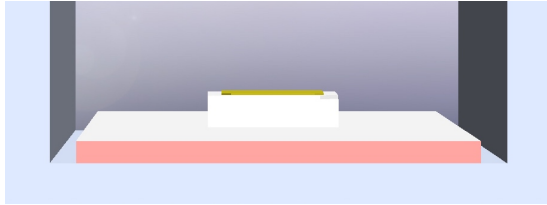
- Protect against environmental ingress, corrosion, etc.
- Thin layer provides little impact on light quality



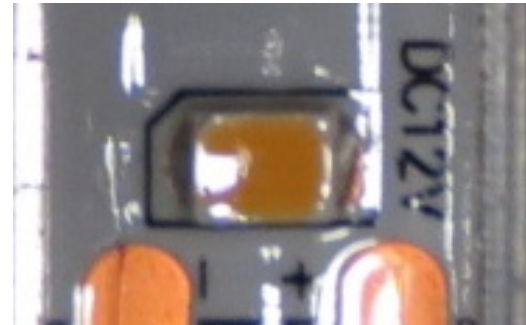
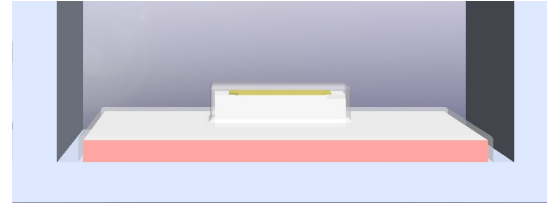
4000K test part with DOWSIL™ 1-2577 Low VOC Conformal Coating

# Protective Materials – Conformal Coatings

4000K Test Part, No Material



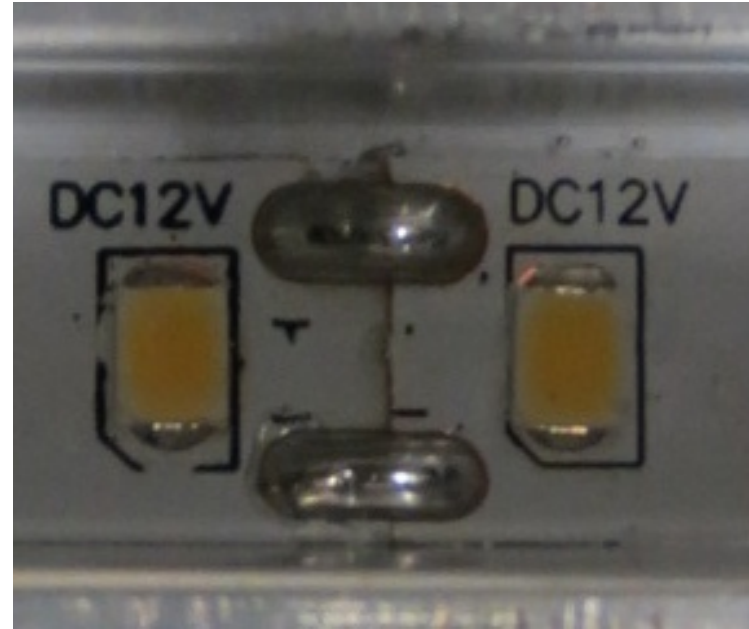
4000K Test Part with DOWSIL™ 1-2577  
Low VOC Conformal Coating



# Benefits of Protective Materials - Encapsulants

## Silicone, Acrylic, Urethane

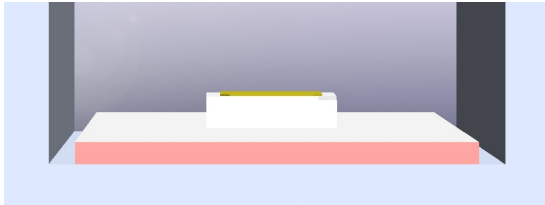
- Protect against environmental ingress, corrosion, etc.
- Impact protection



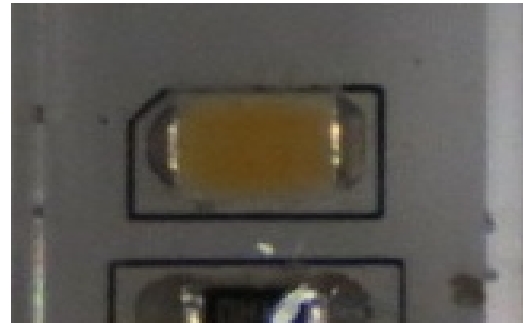
4000K test part with DOWSIL™ EI-1184 Encapsulant

# Protective Materials - Encapsulants

4000K Test Part, No Material



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



# Benefits of Protective Materials - Molded Lens

## Silicone, PC, PMMA

- Protect against environmental ingress (when sealed)
- Impact protection
- Little impact on light quality



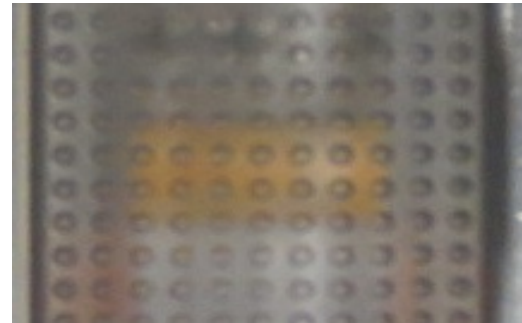
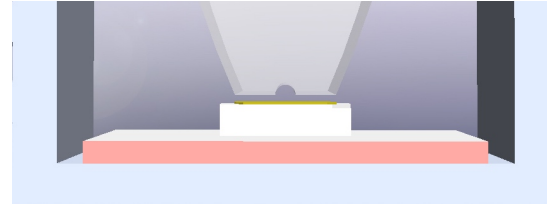
4000K test part with DOWSIL™ MS-1002  
Moldable Silicone

# Protective Materials - Molded Lens

4000K Test Part, No Material



4000K Test Part with DOWSIL™  
MS-1002 Moldable Silicone



Lens design courtesy of:

**LumenFlow Corp.**  
Photonics Engineering & Manufacturing

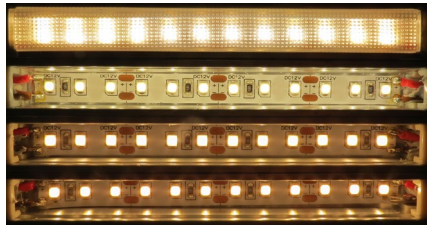


# Disadvantages of Protective Materials

## Effects on Light Quality

- Color shift
- Lumen depreciation

## Cost



3000K



4000K



5000K

Test parts, using **DOWSIL™ 1-2577 Low VOC Conformal Coating**, **DOWSIL™ EI-1184 Encapsulant**, and **DOWSIL™ MS-1002 Moldable Silicone**



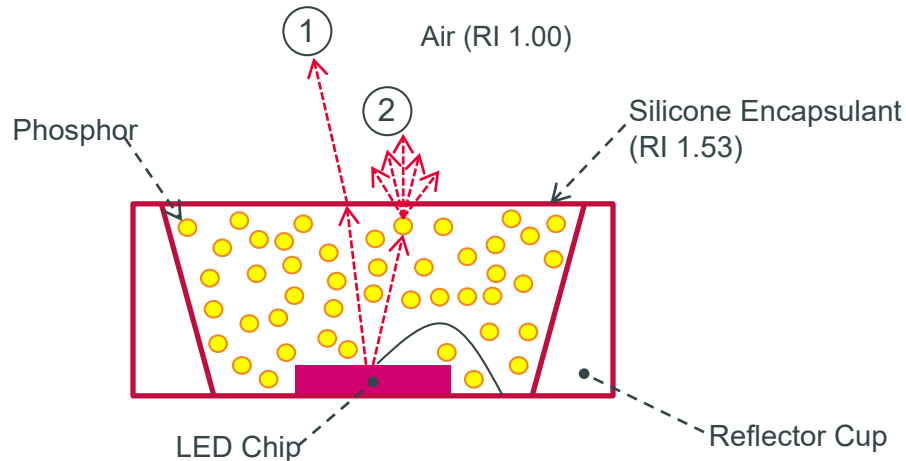
HOK International, Photo: Farid Khayrulin

# Protective Materials – Effects on Light Quality

## Typical LED Package

**Blue rays from the LED chip will:**

- 1) Go to air through silicone encapsulant material (RI 1.53)
- 2) Hit phosphor particles and emit rays with other spectrum (e.g. yellow, red)

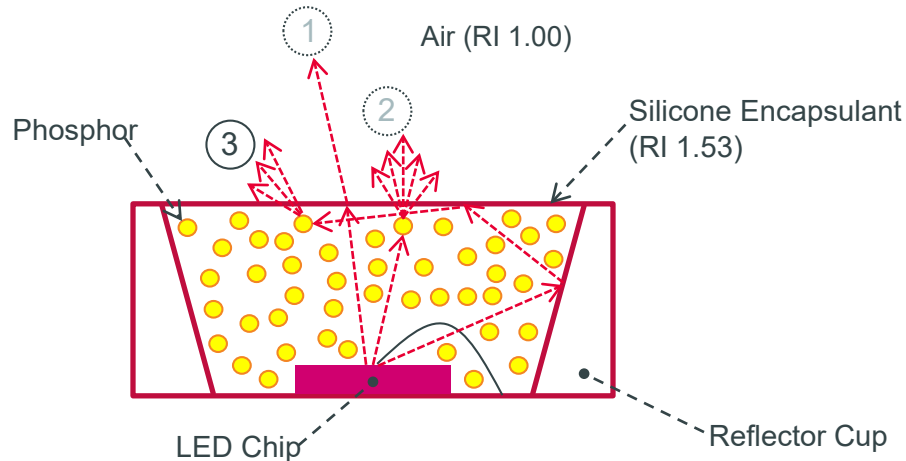


# Protective Materials – Effects on Light Quality

## Typical LED Package

Blue rays from the LED chip may:

3. Reflect at the interface of silicone encapsulant and air, due to Total Internal Reflection (TIR). In this example, the critical angle  $\theta_1$  is equal to  $\sin^{-1}(1/1.53)$ , which is 40.8 degrees. Any rays that hit this interface with an angle bigger than 40.8 degrees will be reflected, and may interact further with phosphor particles.

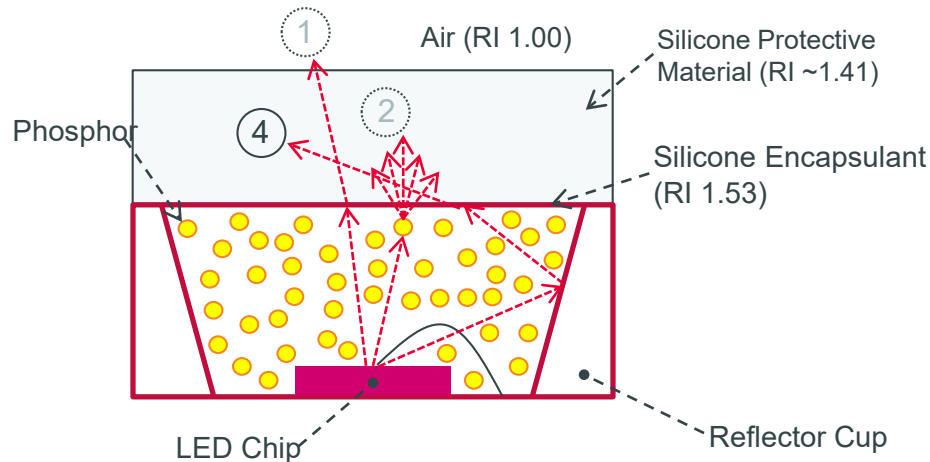


# Protective Materials – Effects on Light Quality

## Typical LED Package + Protective Material(s)

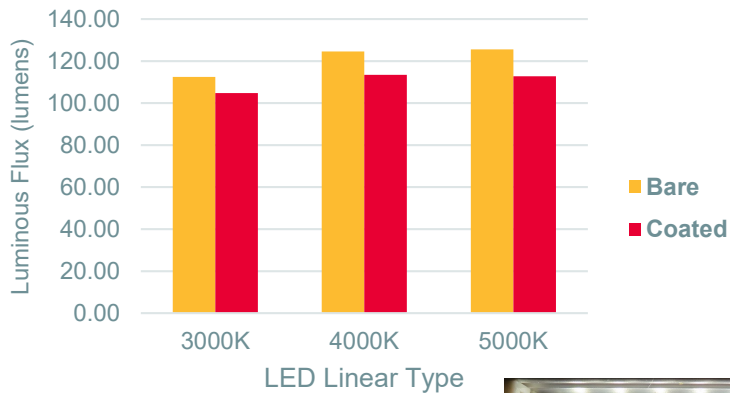
**Blue rays from the LED chip may:**

4. Have a better chance of escaping at the interface of silicone encapsulant and protective material due to TIR. In this example, the critical angle  $\theta_1$  is equal to  $\sin^{-1}(1.41/1.53)$ , which is 67 degrees. This leads to more blue light rays escaping and less interaction with phosphor, leading to increased color temperature.

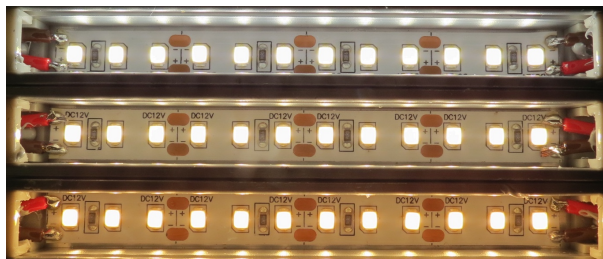
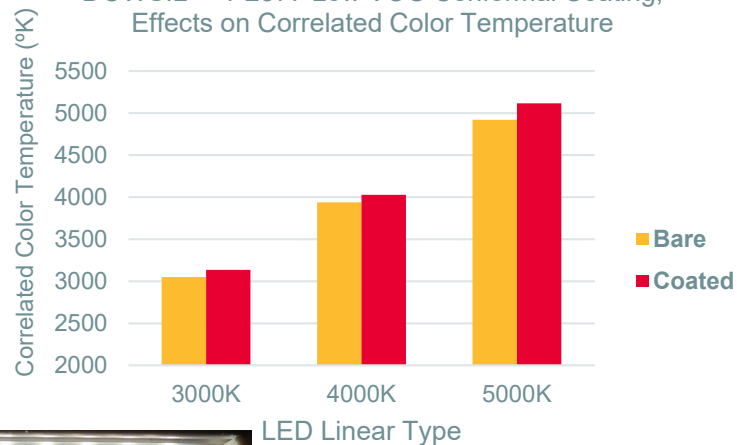


# Protective Materials – DOWSIL™ 1-2577 Low VOC Conformal Coating

DOWSIL™ 1-2577 Low VOC Conformal Coating,  
Effects on Luminous Flux

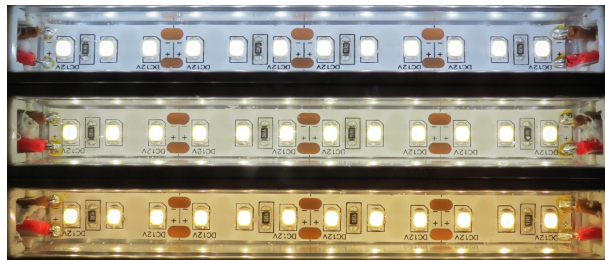
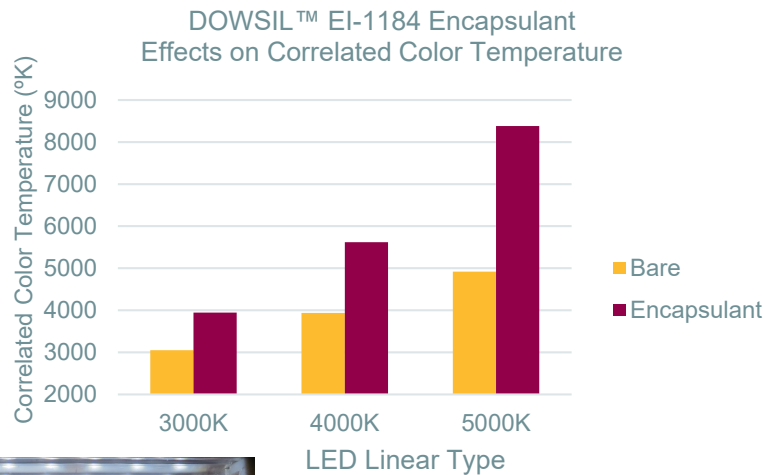
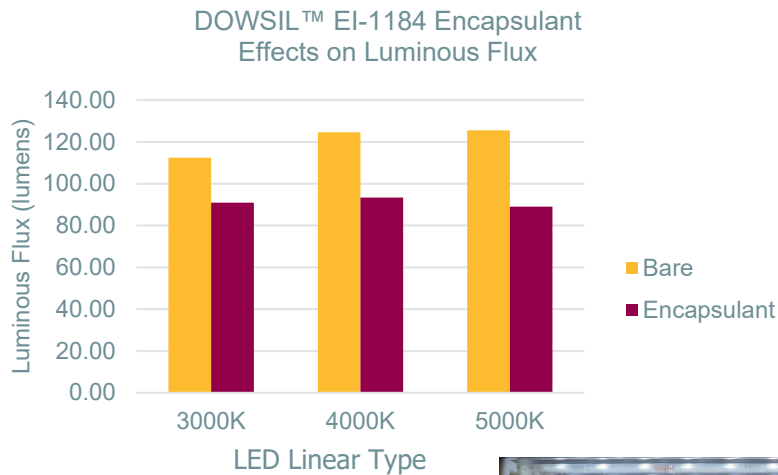


DOWSIL™ 1-2577 Low VOC Conformal Coating,  
Effects on Correlated Color Temperature



3000K, 4000K , and 5000K test parts with  
DOWSIL™ 1-2577 Low VOC Conformal Coating

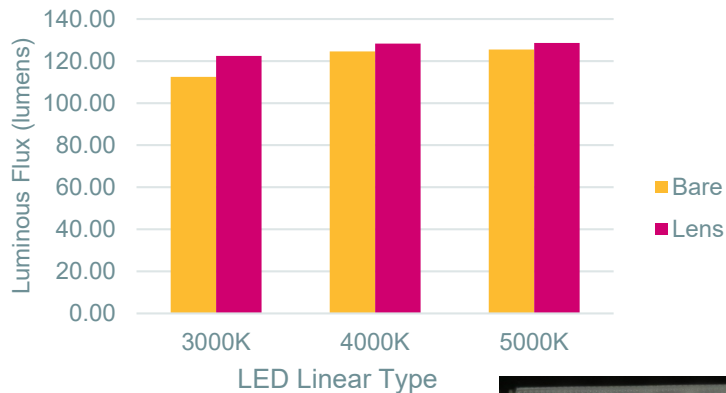
# Protective Materials – DOWSIL™ EI-1184 Optical Encapsulant



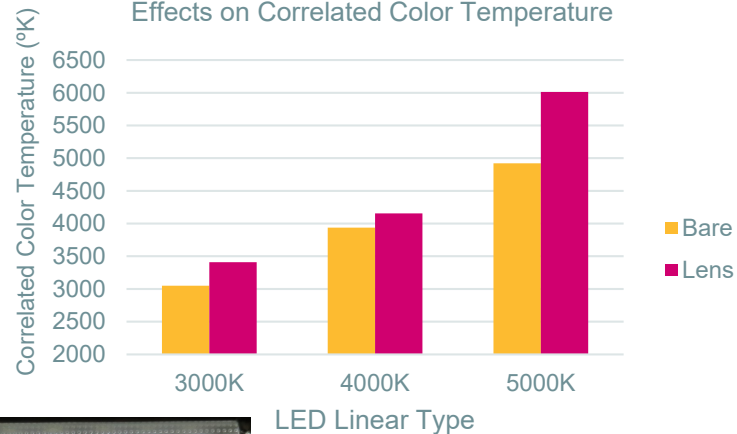
3000K, 4000K, and 5000K test parts with  
DOWSIL™ EI-1184 Optical Encapsulant

# Protective Materials – DOWSIL™ MS-1002 Moldable Silicone

DOWSIL™ MS-1002 Moldable Silicone  
Effects on Luminous Flux

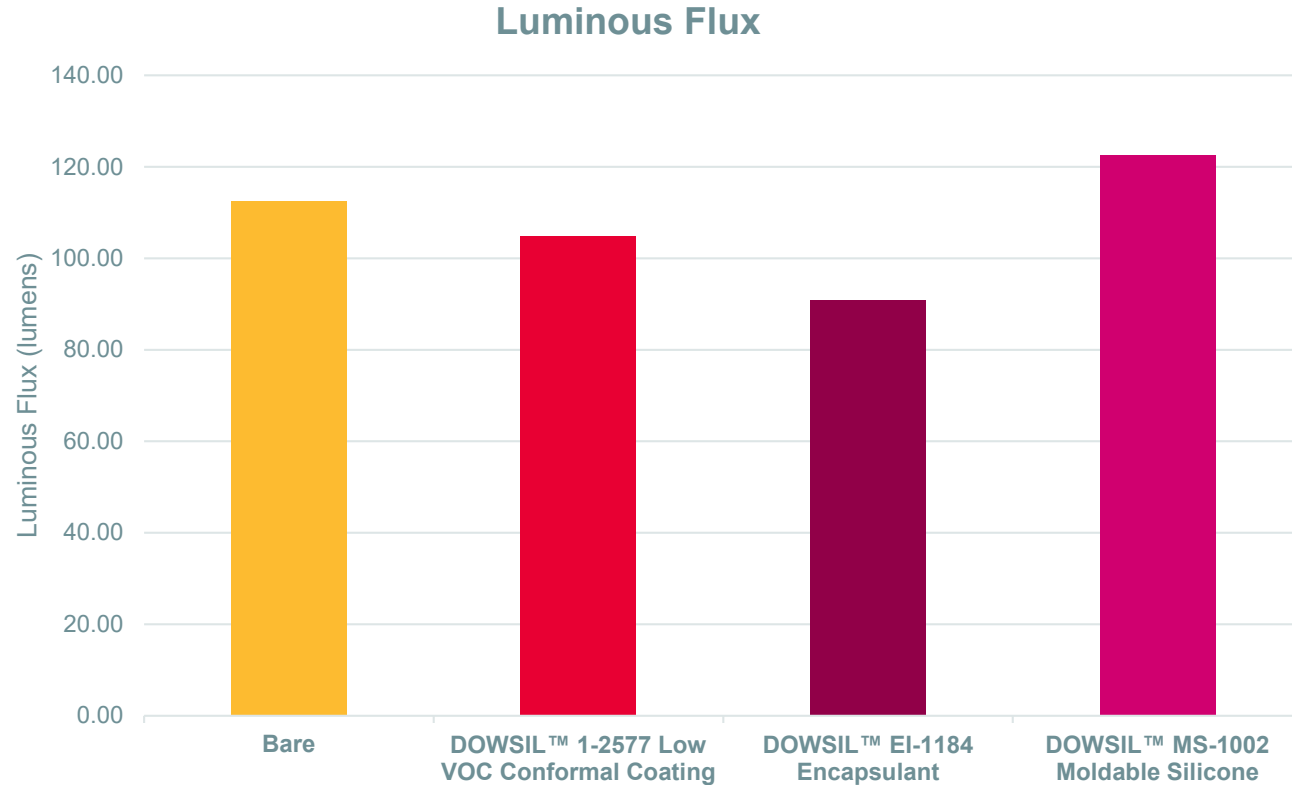


DOWSIL™ MS-1002 Moldable Silicone  
Effects on Correlated Color Temperature



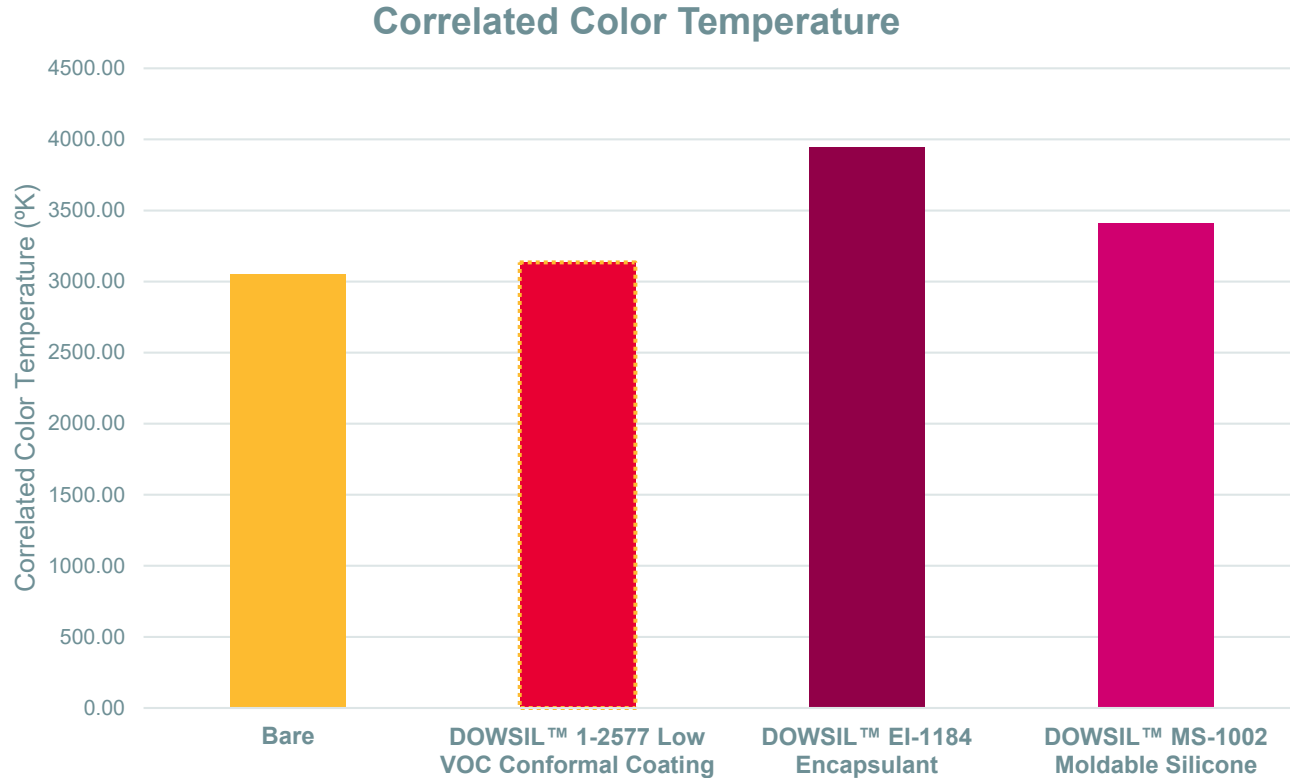
3000K, 4000K, and 5000K test parts with  
DOWSIL™ MS-1002 Moldable Silicone

# DOWSIL™ Protective Materials – Effects at 3000K

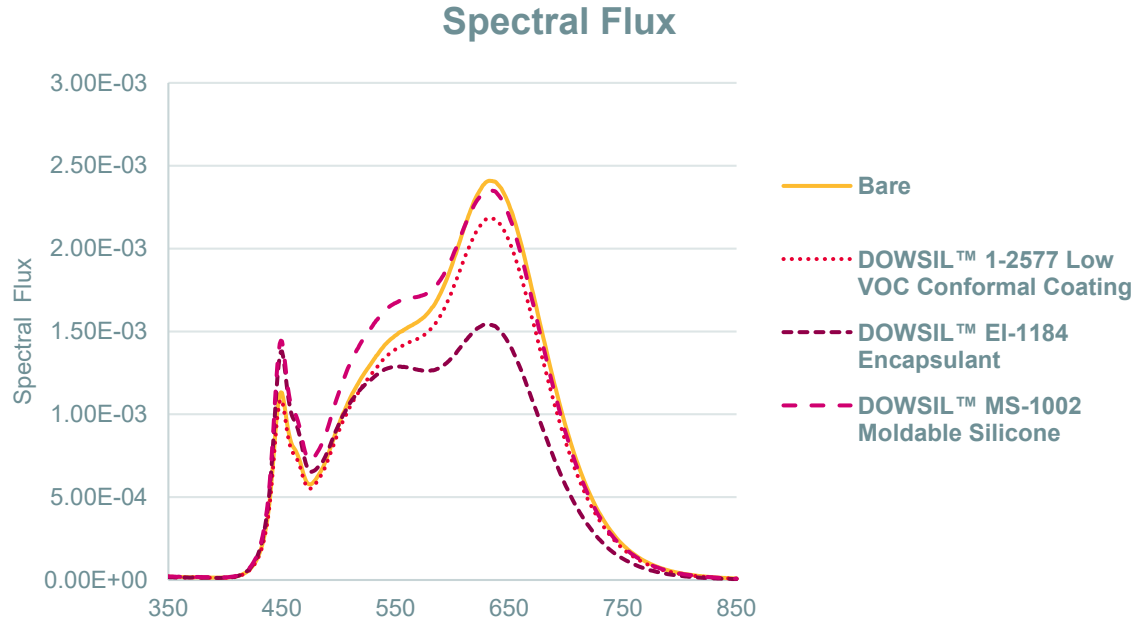




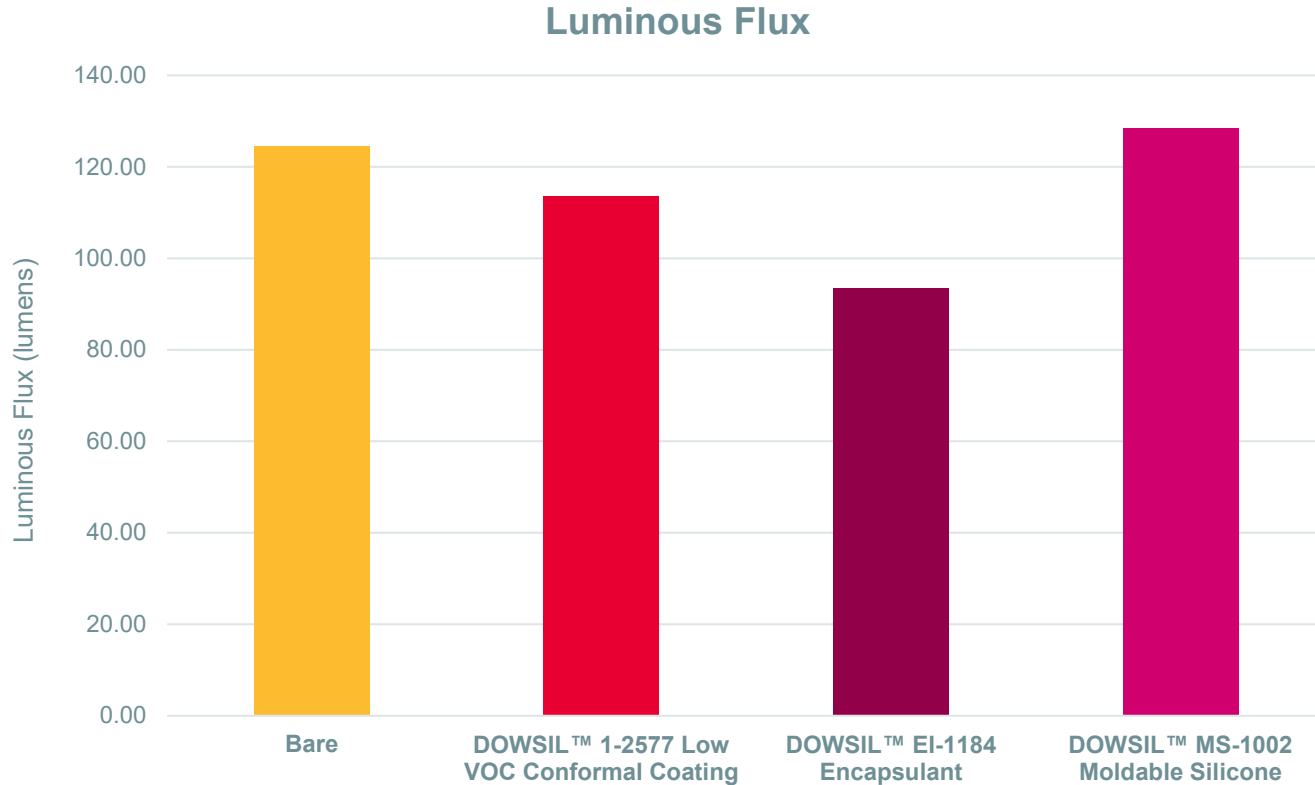
# DOWSIL™ Protective Materials – Effects at 3000K



# DOWSIL™ Protective Materials – Effects at 3000K

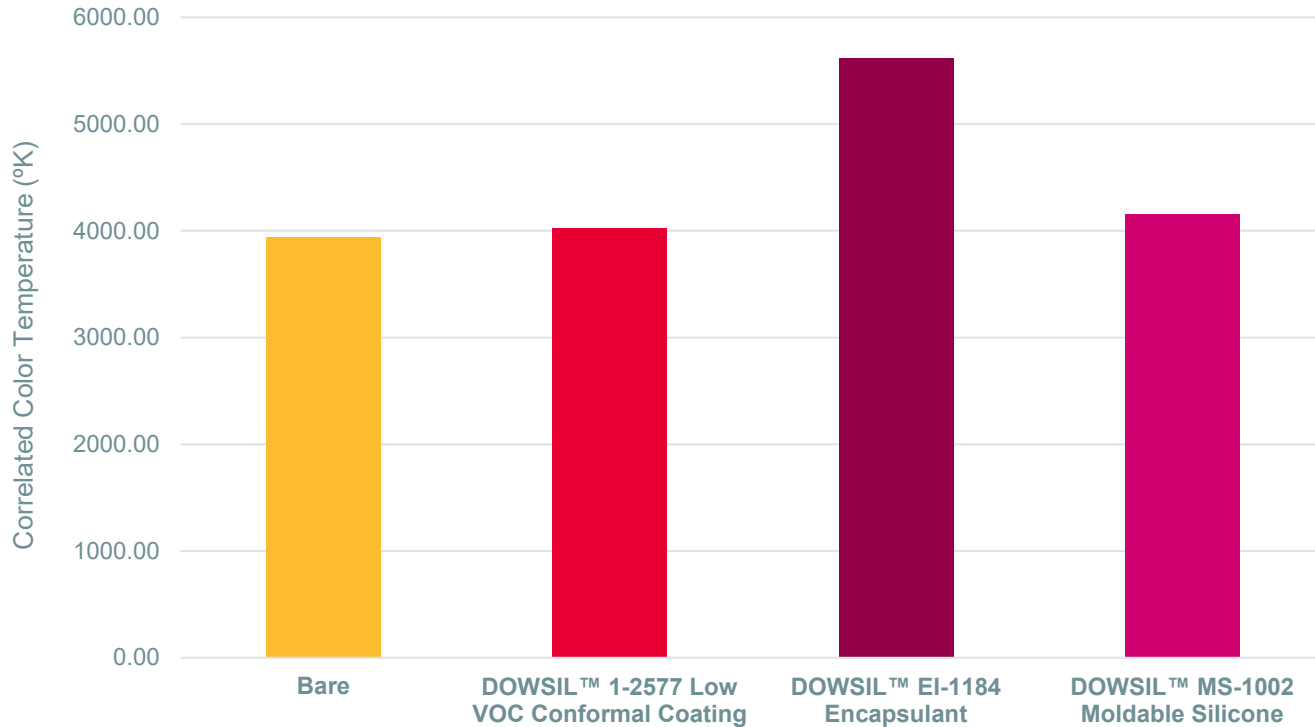


# DOWSIL™ Protective Materials – Effects at 4000K



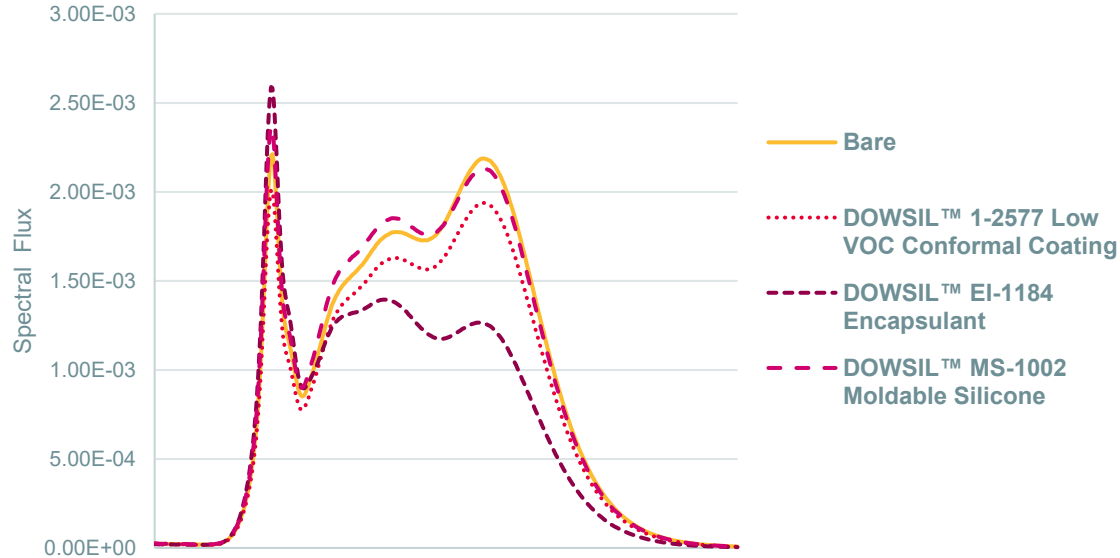
# DOWSIL™ Protective Materials – Effects at 4000K

Correlated Color Temperature

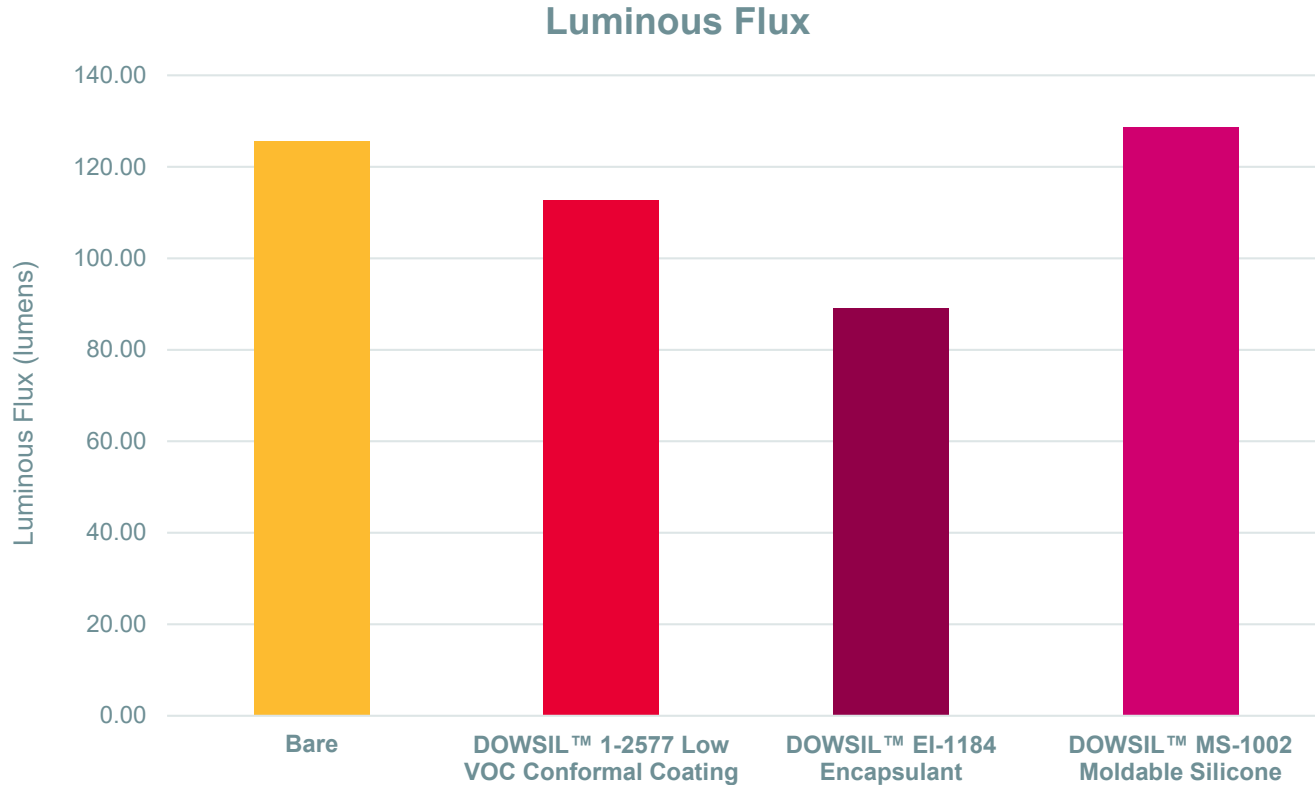


# DOWSIL™ Protective Materials – Effects at 4000K

Spectral Flux

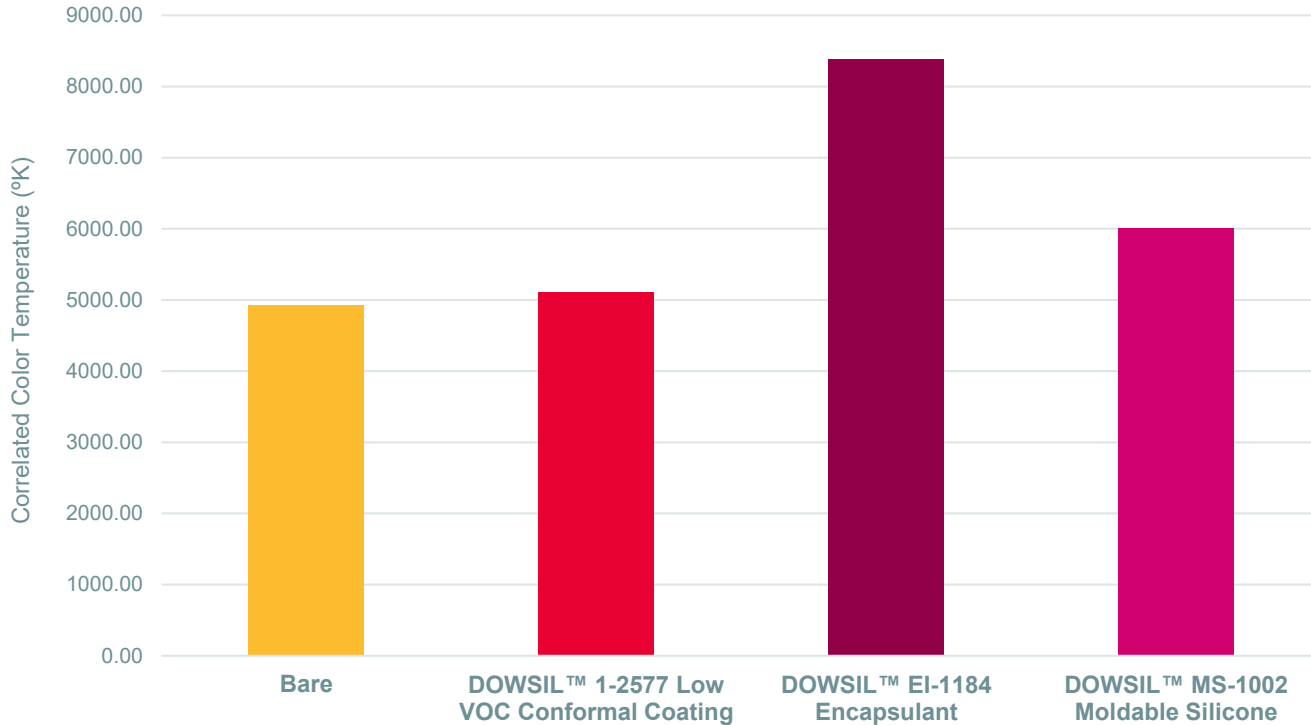


# DOWSIL™ Protective Materials – Effects at 5000K

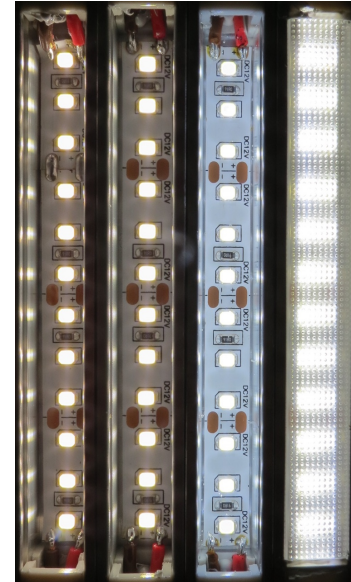
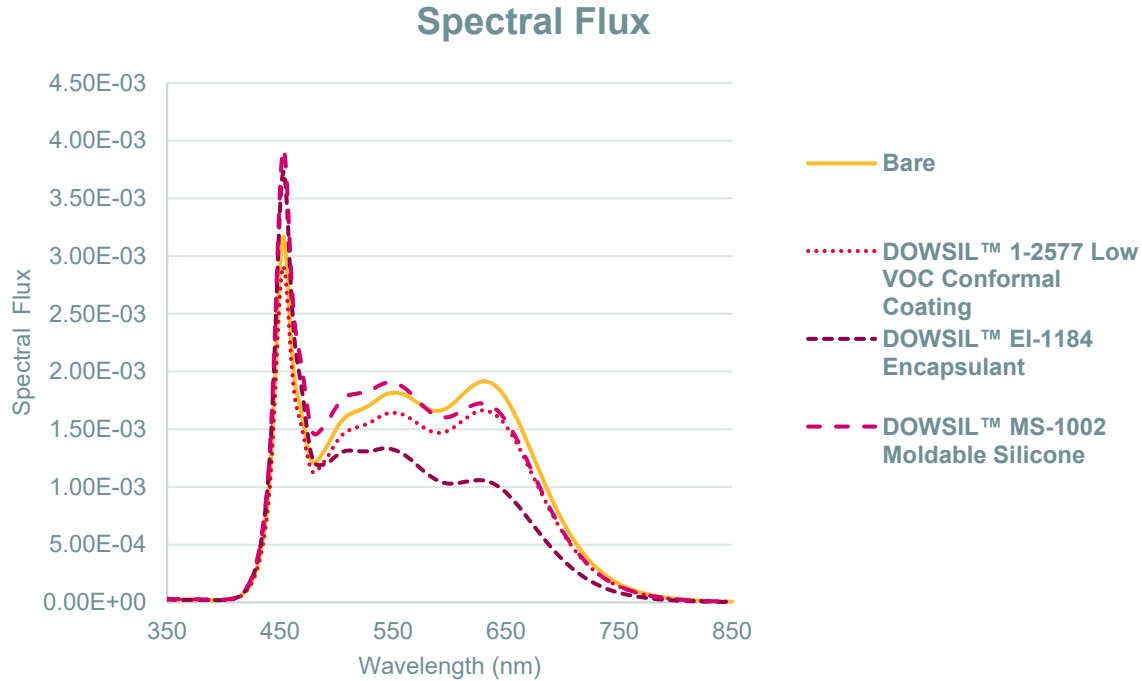


# DOWSIL™ Protective Materials – Effects at 5000K

Correlated Color Temperature



# DOWSIL™ Protective Materials – Effects at 5000K





# DOWSIL™ Protective Materials

## DOWSIL™ 1-2577 Low VOC Conformal Coating

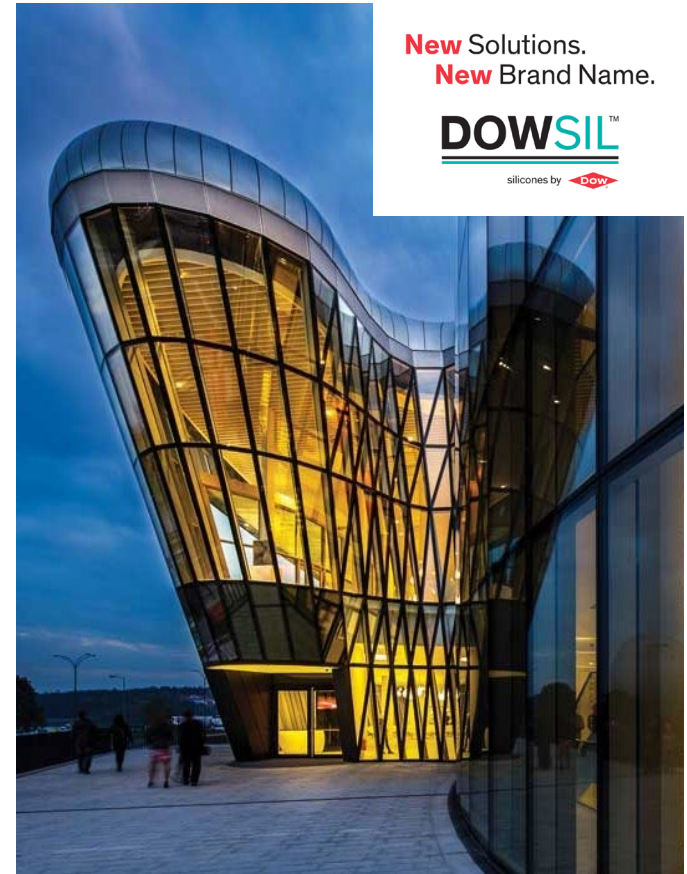
- **Minimally effects Luminous Flux and CCT**
  - *But, provides the least amount of protection above bare components*

## DOWSIL™ EI-1184 Optical Encapsulant

- **Provides significant protection above bare components**
  - *But, reduces Luminous Flux and increases CCT*

## DOWSIL™ MS-1002 Moldable Silicone

- **Slightly increases Luminous Flux and CCT**
  - *And, provides significant protection above bare components*



New Solutions.  
New Brand Name.

**DOWSIL™**  
silicones by 

Ingarden & Ewy Architekci; Arata Isozaki & Associates  
Photo: Wojciech Wandzel



# - Thank You

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