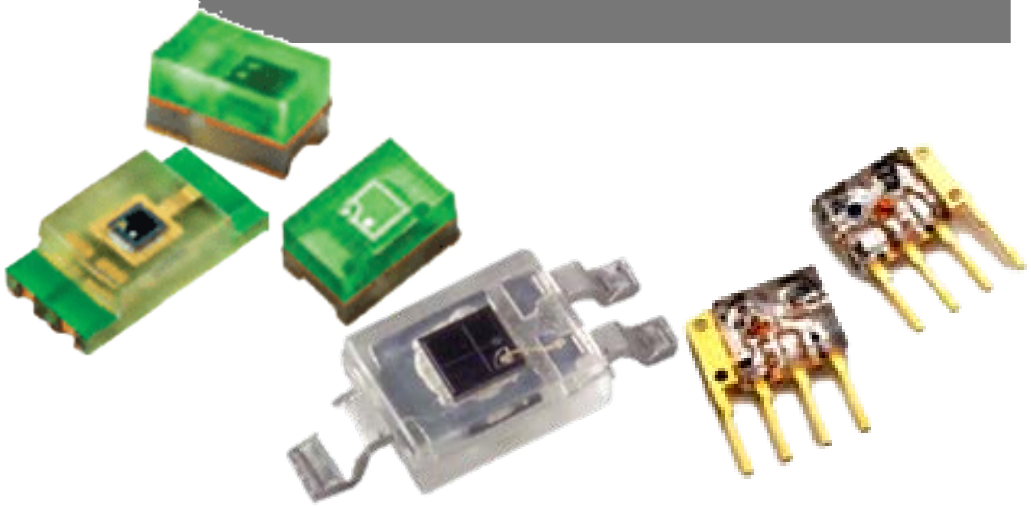
SOLEPOXY CLEAR ENCAPSULANT MATERIALS

Silicone & Optical Bandpass Filter Replacement & Outdoor RGB Display



SolEpoxy Clear Encapsulant Materials

Optically Clear OP1000, OC10-1, OG10-1 and OL10-1

sol epoxy

SolEpoxy Optically Clear Encapsulants

OP1000, OC10-1, OG10-1, OL10-1

PRODUCT LAUNCH OUTLINE

1. Overview: Summary of the product and target applications
2. Product Background: How it fits into our complete product offering
3. Markets Served
4. Key Features and Benefits
5. Process and Handling Conditions
6. Technical Data Sheet and Safety Data Sheet
7. Ordering Information

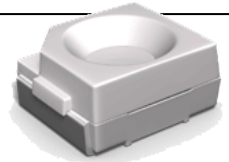
SolEpoxy Optoelectronics Product Portfolio

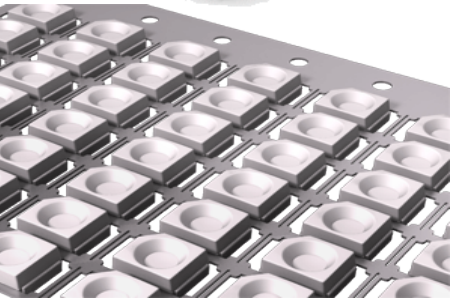
We offer "White Reflective" and "Optically Clear" Materials

White Reflective Mold Compounds

Coming Soon

NBXXXX-XX
Level 1 LED non-MAP leadframe





Clear Opto Epoxy Mold Compounds

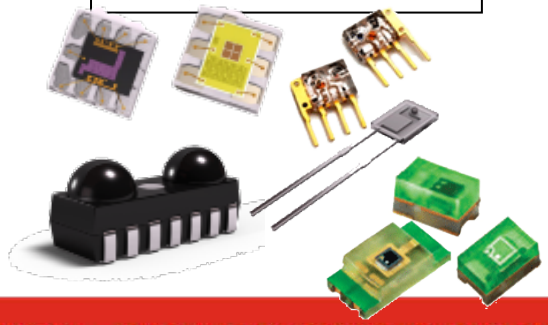
OP, C, G-Series

OP1000 Pellets
Outdoor Sign RGBs on SMT LED

OC10-1 Cast Pellets
Mid-Power LED, Outdoor RGB

OG10-1 Fine Powder
Fine Powder for Phosphor Blending

OP7001 / OP7200
Clear Opto for Data Transmission



Clear Opto Hybrid Liquid Compounds

OL-Series

OL10-1
Mid-Power LED SMT Liquid Encap

OL88-8
Outdoor RGB SMT Liquid Encap

Modular Capabilities Independent of Technologies

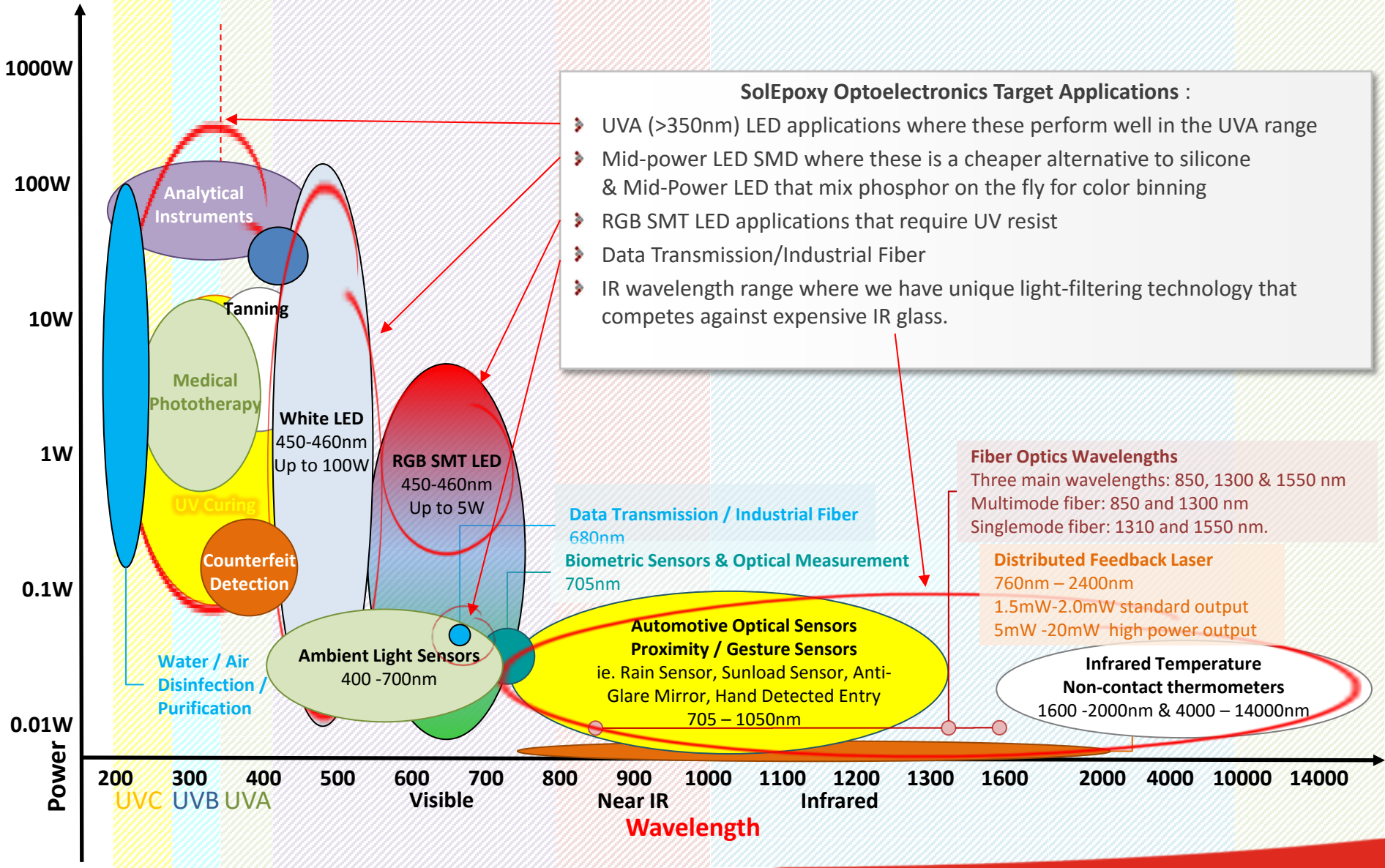
F is for Filter
OC10-1F820
Light blocking and/or light filtering ie. @ 820nm as above

Colors: Red, Blue, Green
Incredible color stability by adding colors to clear compounds

Ready for Diffusant or Phosphor
Phosphor Blending into Clear Opto Liquid is possible

Markets Served: Power vs. Wavelength

Target applications of SolEpoxy Clear Encapsulants



SolEpoxy Optoelectronics Target Applications :

- UVA (>350nm) LED applications where these perform well in the UVA range
- Mid-power LED SMD where these is a cheaper alternative to silicone & Mid-Power LED that mix phosphor on the fly for color binning
- RGB SMT LED applications that require UV resist
- Data Transmission/Industrial Fiber
- IR wavelength range where we have unique light-filtering technology that competes against expensive IR glass.

Lumen Requirement for Various Applications

A look at the devices each application demands

sol epoxy

Lumen Requirement

25000
10000
1000
800
500
100
50
10
1

Very Low-end LED Lamp potting

Target Applications

Focus: UV Resist Applications

RGB Billboard display
Through-hole RGB devices with higher lumen and higher reliability requirements. Outdoor also have UV resist requirement.

Critical Mass: Large Screen LCD Backlighting (BLU)
An entire industry and infrastructure was built from 2010 to support LCD backlighting. Overcapacity led to a 75% cost decrease in mid-power devices which made them viable (in larger numbers) for general lighting.
Link to article

General Lighting (450 – 2000 Lumen requirement)
There are many ways to achieve required lumens. Many mid-Power LED could be used, or fewer high-power LEDs.
Tradeoffs are cost vs. space vs. performance

LCD Backlighting
The smaller the device (ie. Smartphone), the fewer the total lumens needed. The higher the lumens per Watt (lm/W), the fewer number of SMD LED's needed.

Require Silicones

Industrial Baylights:
Infrastructure Lighting
2000 – 25,000 Lumens

Projectors:
Office projectors ~2000lm
Outdoor projectors up to 10,000 Lumens

Xenon/HID Headlights
1000-2,500 Lumens

RGB display	SMD Low Power (Keypad backlight)	SMD Mid Power (TV Backlighting/General Lighting)	SMD High Power (Baylights & Automotive Lighting)
<0.1 watts/~100°C	<0.1W/~80°C	<0.1-0.5W/~125°C	0.5-20W watts/~150°C

Interference Bandpass Filter

An interference filter or dichroic filter is an **optical filter** that reflects one or more spectral bands and **transmits** others, with near zero absorption for all wavelengths.

Polished Optical Glass Filter

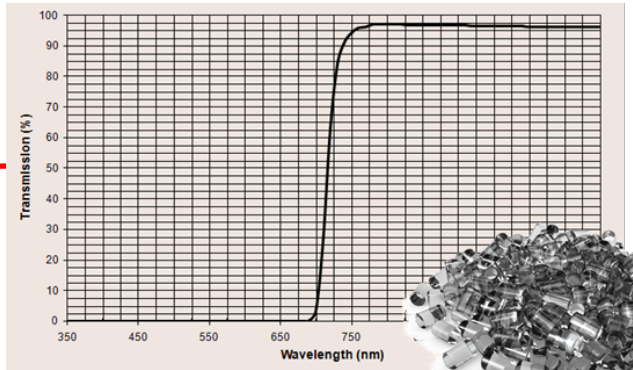
SCHOTT

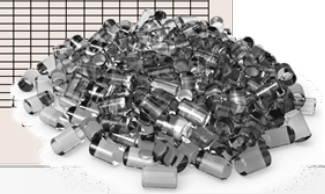
BG-36 Polished Optical Filter Glass 6 1/2 in. x 6 1/2 in., #POL-BG36-0-165x165

$899.00

... a proven but **expensive** process that can run up to **hundreds of dollars** per piece.

Use Epoxy with Filter Technology





... a **proven**, **cost-effective** and **flexible** alternative that uses filter technology.

Optical Interference Bandpass Filters

Where are the applications?

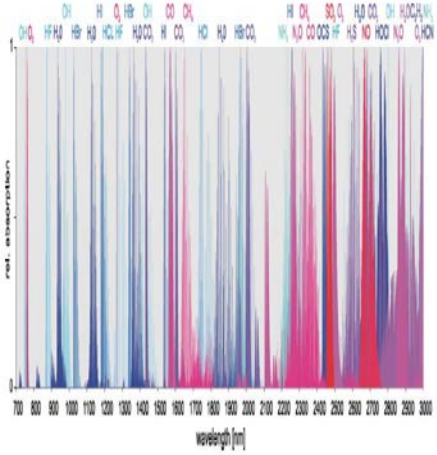
Anti-Glare, Self-Dimming Mirrors

Automotive Rain Sensors

Automotive Sunload Sensor

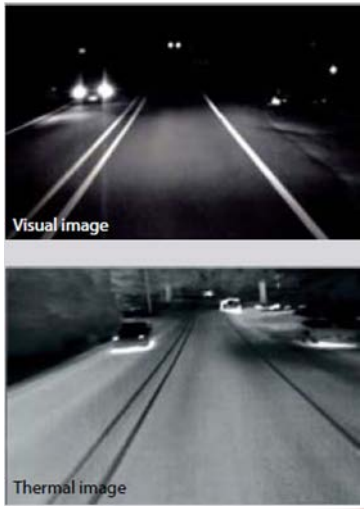
Human Machine Interface

Biometric Sensors



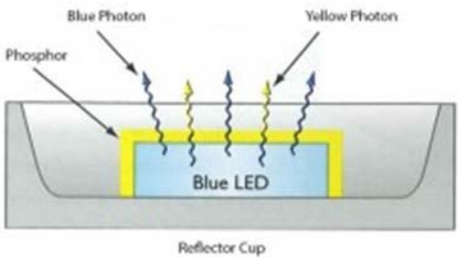
Driver recognition, Lane Departure Warning

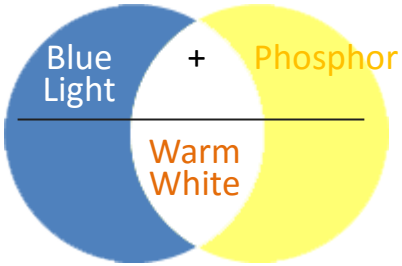
Automotive Night Vision Sensor

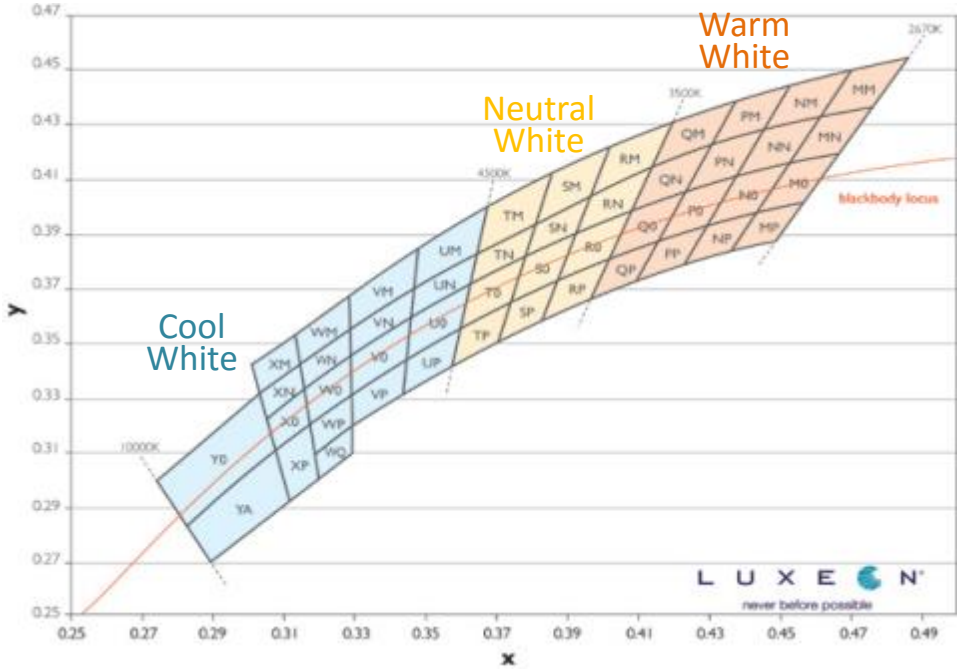


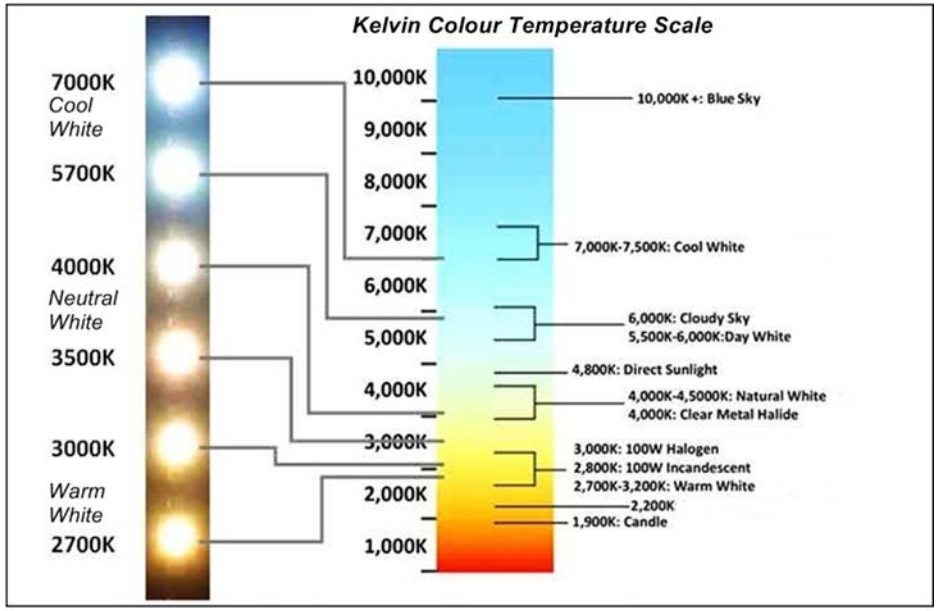
Consumer Gesture Control

Phosphor: From Cool to Warm White





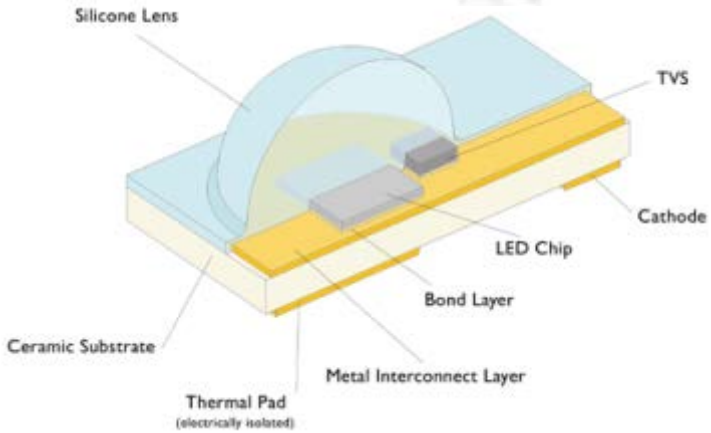




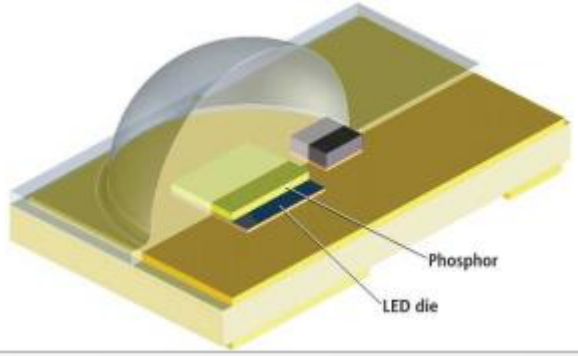
Remote Phosphor vs Direct Phosphor

Two approaches to achieve the same effect – warm white light!

Remote Phosphor Lamps



Phosphor Applied at Die Level



LED Lamp Retrofits

Both remote phosphor and phosphor applied at the die level lamps produce warm, white light. Remote phosphor lamps can use high-powered, les expensive die, but require more phosphor. Die-level applied phosphor lamps use less total phosphor, but use lower power and are less efficient.

SolEpoxy Optically Clear Encapsulants History

Pioneered Clear Epoxy Compound in 1980's

MG18

Lower moisture absorption
Higher MSL Performance

MG97

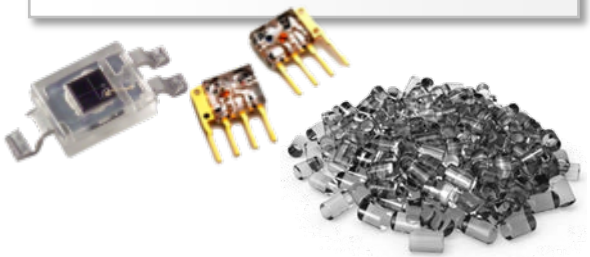
Silicone Replacement Hybrid Chemistry
Yields outstanding Clarity & Durability
Heat stable for >7500 hours @ 125°C

OP1000

Cast Pellet Version of OP1000
Heat stable for 1000's of hours @ 105°C
Cost Effective version of OP1000

SolEpoxy OC10-1

Shelf Stable for 6 months @ 10°C



Fine Grind Powder version of OP1000
Heat stable for 1000's of hours @ 105°C
Add your own Phosphor technology

SolEpoxy OG10-1

Shelf Stable for 6 months @ 10°C

Silicone Replacement Liquid
Liquid for high production flexibility
Heat stable for > 3000 hours @ 100°C

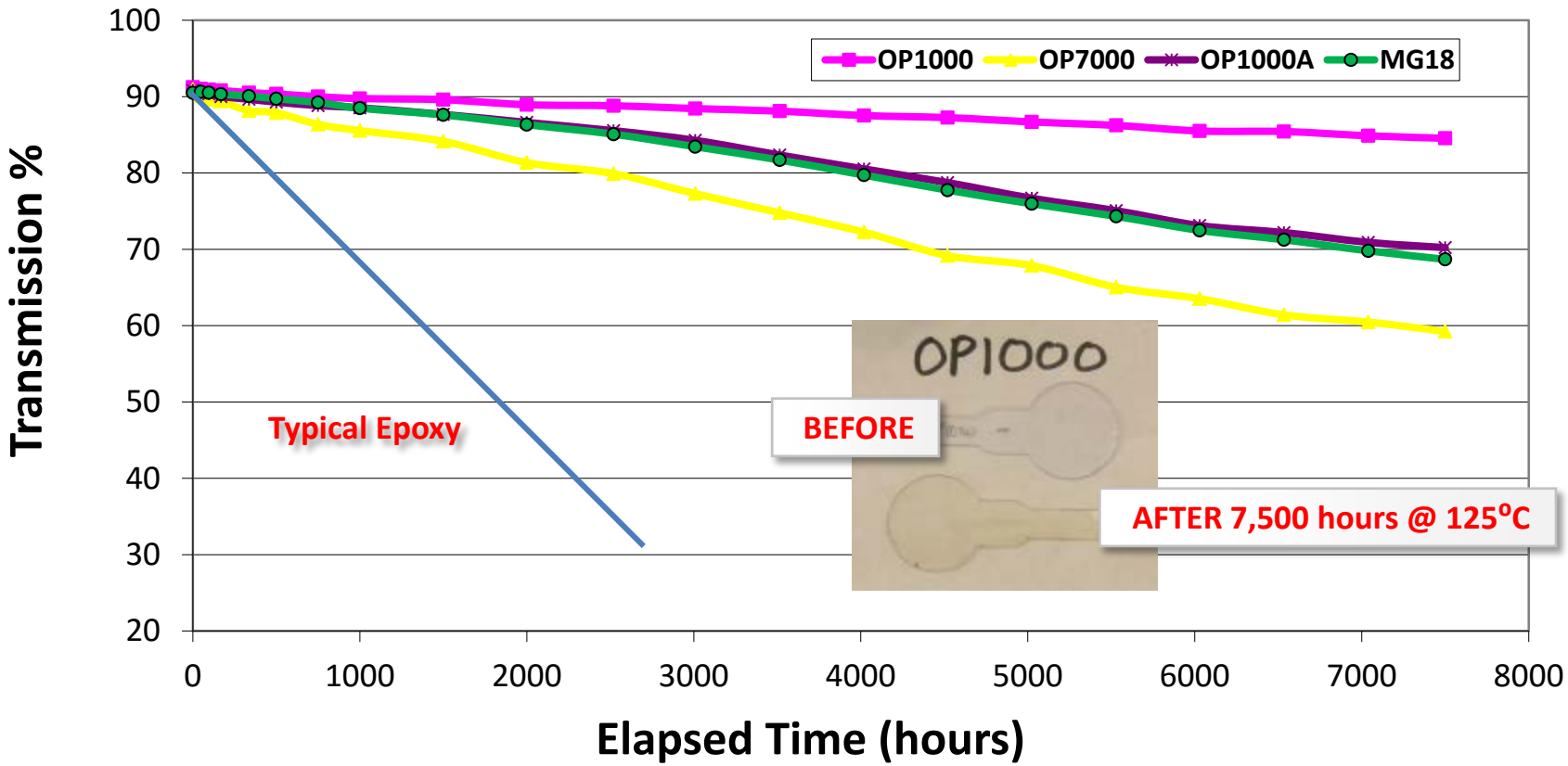
SolEpoxy OL10-1

Shelf Stable for 6 months @ -20°C

Clear LED Encapsulant- Transmittance after Heat Aging

Results for 1mm disk at 440nm wavelength

SolEpoxy™ OP1000 is very heat-stable @440nm, even after 7,500 hours @125°C

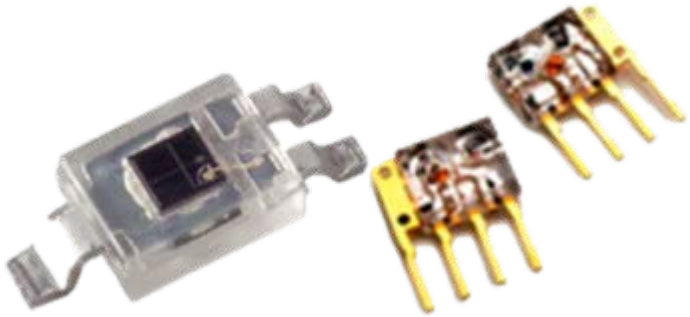


Data is similar for 460nm wavelength transmission

OC10-1: Silicone Replacement Hybrid Clear Pellet

Key Features, Benefits and Target Applications

SolEpoxy OC10-1



Product Features & Benefits:

- Cost Effective alternative to silicone for encapsulant of Mid Power LED
- Cost Effective alternative to even OP1000 with a draft angle
- High (>90%) transmission from 270nm – 14,000nm
- Non-yellowing after 1000's of hours at temperatures of 105°C
- Shelf-Life stability is >18mos @ 5°C

Target Applications:

- Mid-Power LED SMD that have a junction temperature (Tj) < 105°C
- Sensor applications, including:
  - Leadless MAP devices
  - IR sensors with unique light-filtering technology
  - UV sensors operating at >350nm

Other Potential Applications:

- UV LED applications that require high transmittance >350nm
- Outdoor RGB SMT LED applications that require UV Resist

OG10-1: Silicone Replacement Liquid

Key Features, Benefits and Target Applications

SolEpoxy OG10-1

Product Features & Benefits:

- Cheaper alternative to silicone for encapsulant of Mid Power LED
- High (>90%) transmission from 270nm – 14,000nm
- Non-yellowing after 1000's of hours at temperatures of 105°C
- Shelf-Life stability is >18mos @ 5°C

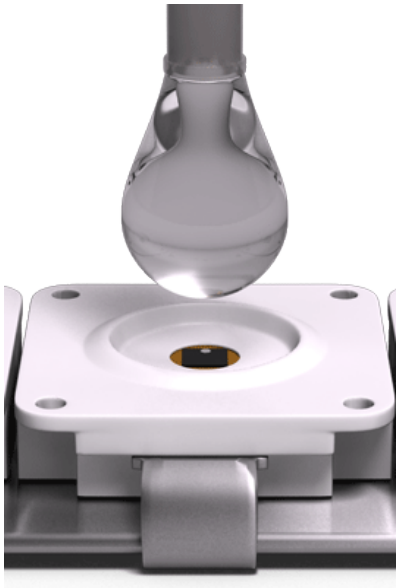
Target Applications:

- Mid-Power LED SMD that have a junction temperature (Tj) < 105°C
- Allows customers to add their own phosphor to be able to do their own color binning.

OL10-1: Silicone Replacement Liquid

Key Features, Benefits and Target Applications

SolEpoxy OL10-1



Product Benefits:

- Cost Effective alternative to silicone for encapsulant of Mid Power LED
- High (>90%) transmission from 270nm – 14,000nm
- Non-yellowing after 1000's of hours at temperatures of 105°C
- Shelf-Life stability is >6mos @ -20°C (compared to -40°C)
- Allows you to do your own color-binning using own phosphor
- Very high adhesion to various plastics (grim-death comparison ☺)
- Outstanding toughness and moisture resistance

Target Applications:

- Mid-Power LED SMD that have a junction temperature (Tj) < 105°C
- Applications that are still low volume and require high flexibility
- Sensor applications, including:
  - Leadless MAP devices
  - IR sensors with unique light-filtering technology
  - UV sensors operating at >350nm

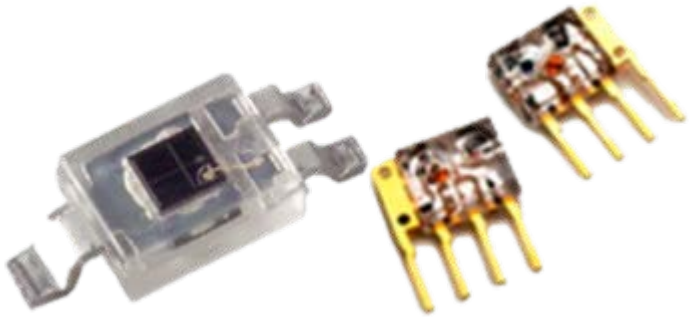
Other Potential Applications:

- UV LED applications that require high transmittance >350nm
- Mid-Power LED applications that require phosphor mixing

OC10-1: Silicone Replacement Cast Compound

Key Features and Benefits

SolEpoxy OC10-1



Product Benefits:

- Cost Effective alternative to silicone for encapsulant of Mid Power LED
- High (>90%) transmission from 270nm – 14,000nm
- Non-yellowing after 1000's of hours at temperatures of 105°C
- Shelf-Life stability is >18mos @ 5°C
- Allows you to do your own color-binning using own phosphor
- Very high adhesion to various plastics (grim-death comparison ☺)
- Outstanding toughness and moisture resistance

Target Applications:

- Mid-Power LED SMD that have a junction temperature (Tj) < 105°C
- Applications that do not yet use an auto-feed transfer mold equipment

Other Potential Applications:

- UV LED applications that require high transmittance >350nm
- Outdoor RGB SMT LED applications that require UV Resist
- Mid-Power LED applications that require phosphor mixing

Encapsulation Alternatives for Mid-Power LED

SolEpoxy Clear Encapsulants vs Alternatives

Property	SolEpoxy OC10-1 Hybrid Cast Clear Pellets	Alternatives			
		OL10-1 Hybrid Liquid CMC	OP1000 Hybrid CMC	Dimethyl Silicone	Phenyl Silicone
Transmission (Initial)	■■■■ >90% @ 270nm	■■■■ >90% @ 270nm	■■■■ >90% @ 270nm	■■□□ >90% @ 320nm	■■□□ >90% @ 320nm
Heat Resistance	■■■□ Tj < 125°C	■■□□ Tj < 105°C	■■■□ Tj < 125°C	■■■■ Tj < 170°C	■■■■ Tj < 150°C
UV Resistance	■■■□	■■■□	■■■□	■■■■	■■■□
Adhesion	■■■■ Epoxy/PPA/PCT/Ag	■■■■ Epoxy/PPA/PCT/Ag	■■■■ Epoxy/PPA/PCT/Ag	■□□□ OK to Silicone/PPA	■□□□ OK to Silicone/PPA
Gas Permeability (Sulphur)	■■■■	■■■■	■■■■	□□□□	■■□□
Rigidity (E Modulus)	■■■■	■■■■	■■■■	■□□□	■■□□
Refractive Index (Efficiency)	■■■□ 1.51	■■■□ 1.51	■■■□ 1.51	□□□□ 1.41	■■■■ 1.58
Production Flexibility	■□□□ Transfer Mold	■■■□ Dispense	■□□□ Transfer Mold	■■■■ Dispense/Compress	■■■■ Dispense/Compress
Production Efficiency	■■■■	■■□□	■■■■	■■■□	■■■□
Shelf Life	■■■■ 18 months @ 5°C	■□□□ 6 months@ -20°C	■■■■ 18 months @ 5°C	■■■■ 6 months @ 5°C	■■■■ 6 months @ 5°C
Material Cost	■■■□	■■■□	■■■□	■□□□	□□□□

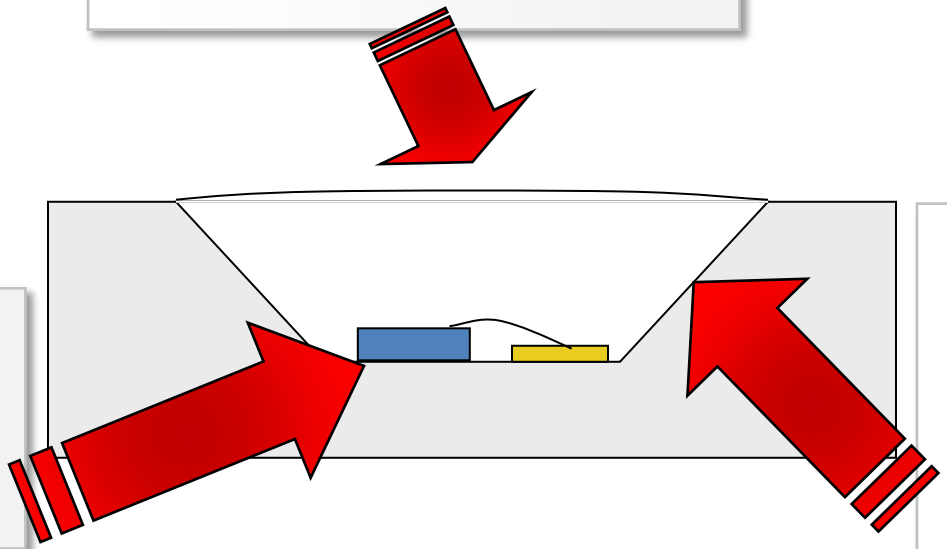
□□□□ Worst ■□□□ Poor ■■□□ Fair ■■■□ Good ■■■■ Best

Essentially, silicone is over-engineered for many of the applications that use it.

The 3+ Known Problems with Silicones

Silicone is non-yellowing but mechanical properties are poor

1. Soft & Sticky
Pressure on silicone can break wires. Dust on silicone will stick and reduce light output



2. Delamination
De-lamination at PPA/PCT interface with Silicone – creates “dark spots” – reduces reflectivity & light output

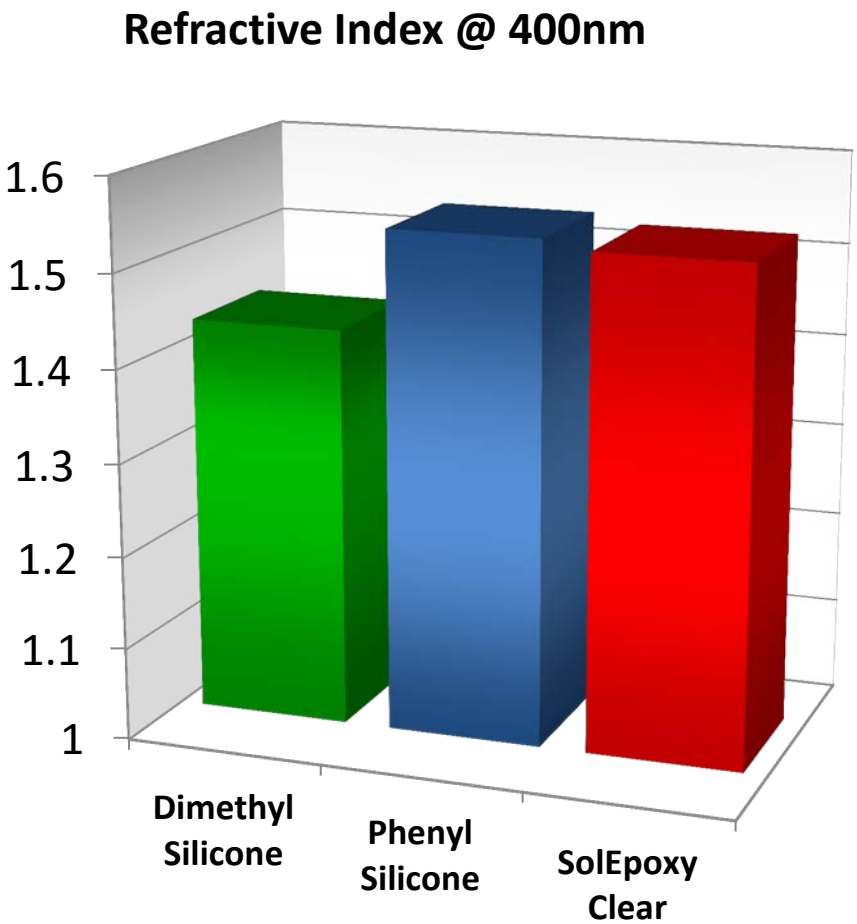
3. Porosity
Water and chemicals can penetrate and corrode silver to black – reducing reflectivity

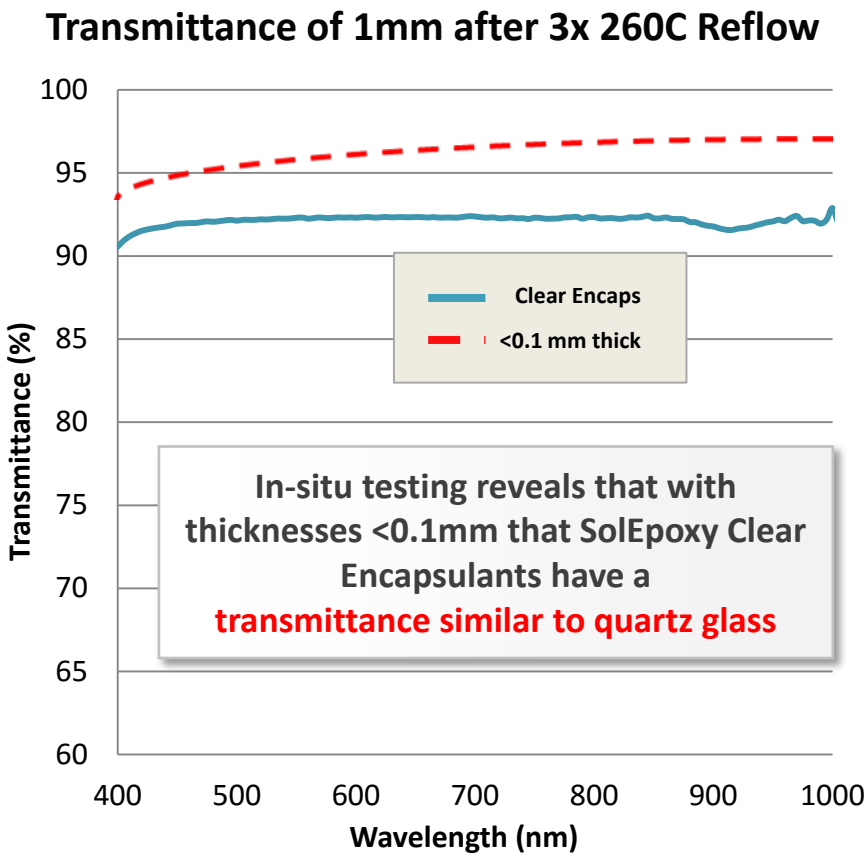
4. Cost
Water and chemicals can penetrate and corrode silver to black – reducing reflectivity

5. Rigidity
Water and chemicals can penetrate and corrode silver to black – reducing reflectivity

SolEpoxy Clear Encapsulants

Refractive Index and Reflow Resistance





High Refractive Index

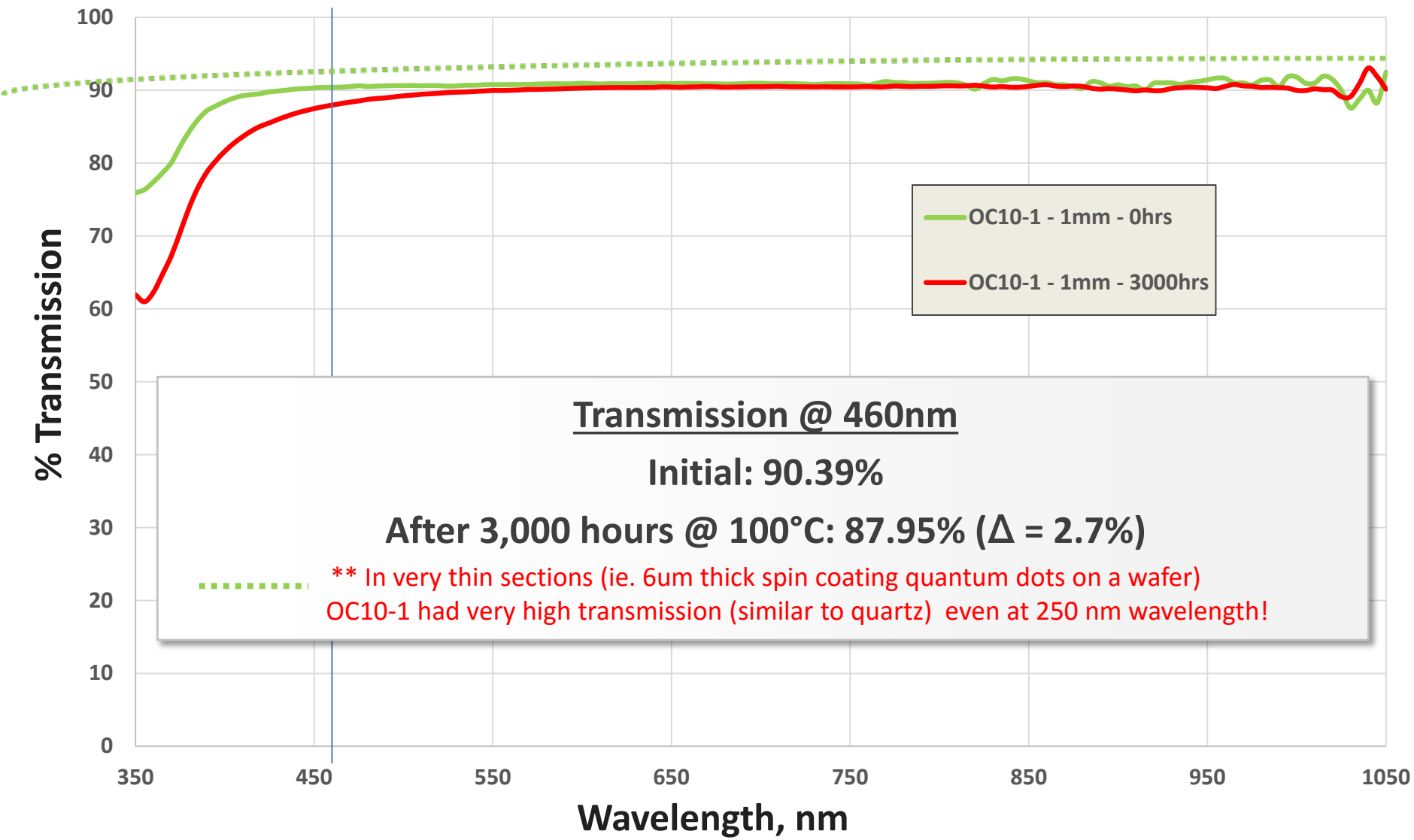
Higher RI translates to higher light output, and thus higher efficiency

Designed for SMT Reflow

Stable optical and mechanical properties even after 3x IR reflow at 260°C

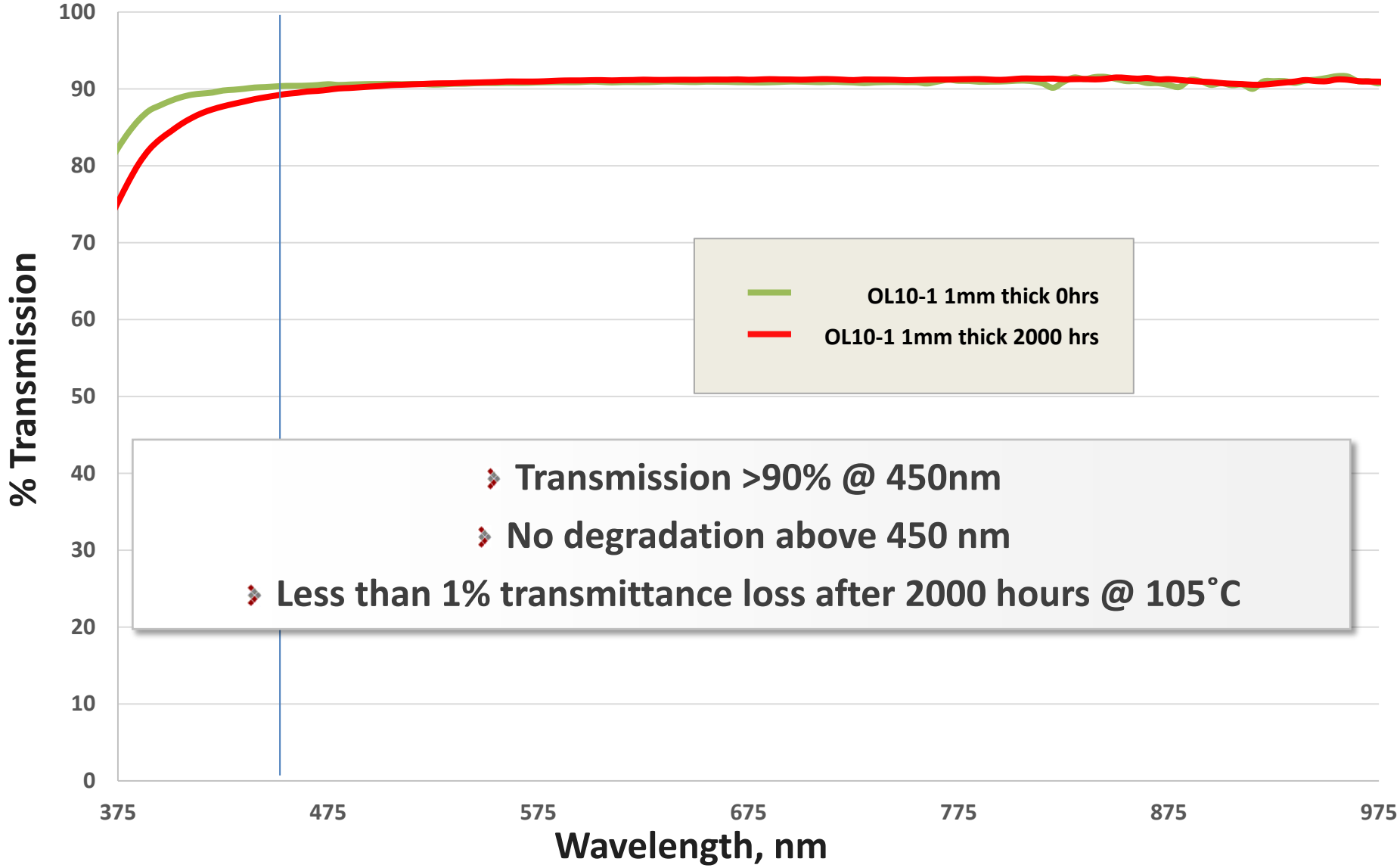
Optically Clear Encapsulants Initially & after Aging

Transmittance after Aging @ 100°C, 3000 hours, 1 mm thick



OL10-1 Initially & after Aging

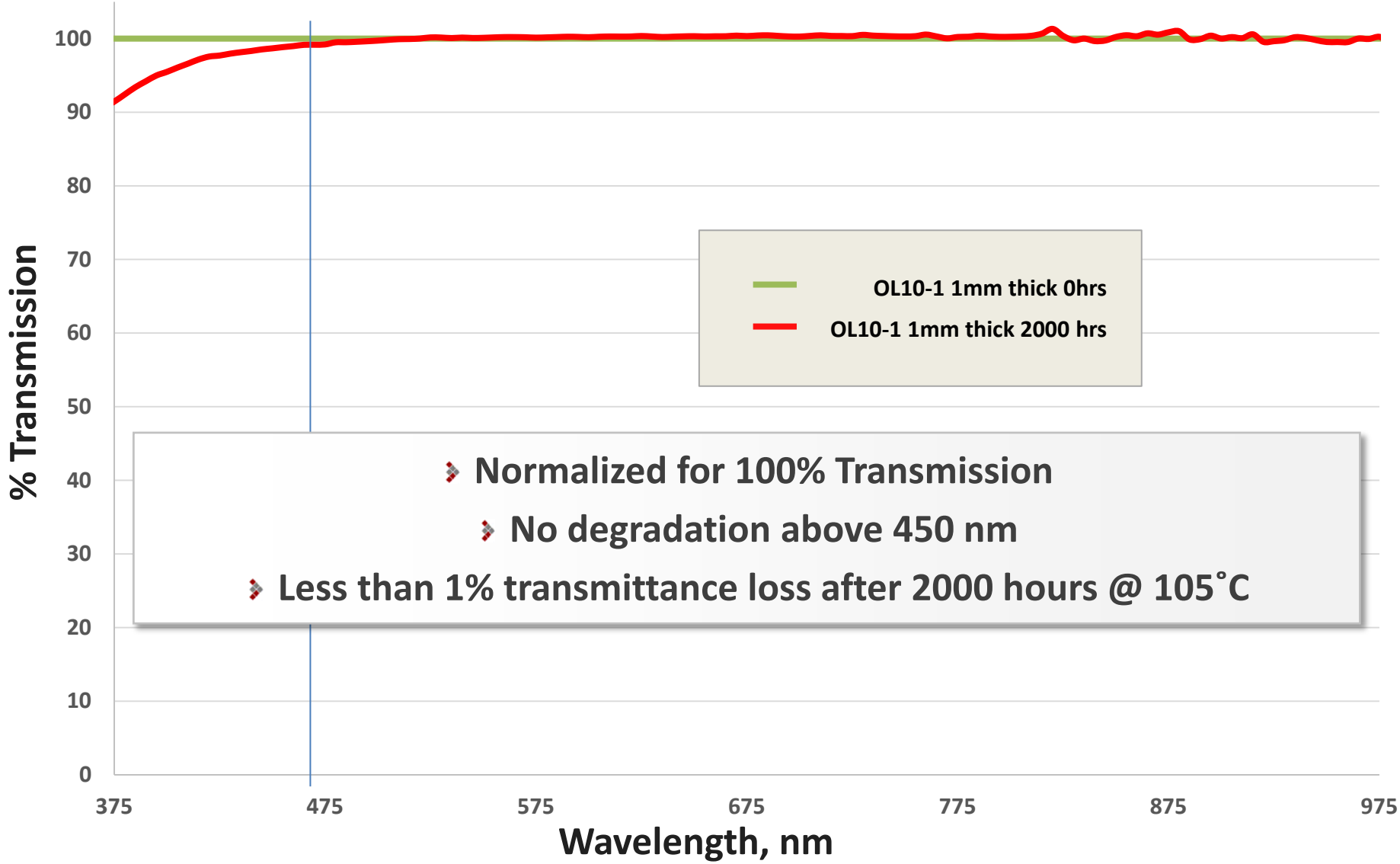
Transmittance after Aging @ 105°C, 2000 hours, 1 mm thick



- Transmission >90% @ 450nm
- No degradation above 450 nm
- Less than 1% transmittance loss after 2000 hours @ 105˚C

OL10-1 Initially & after Aging (Normalized)

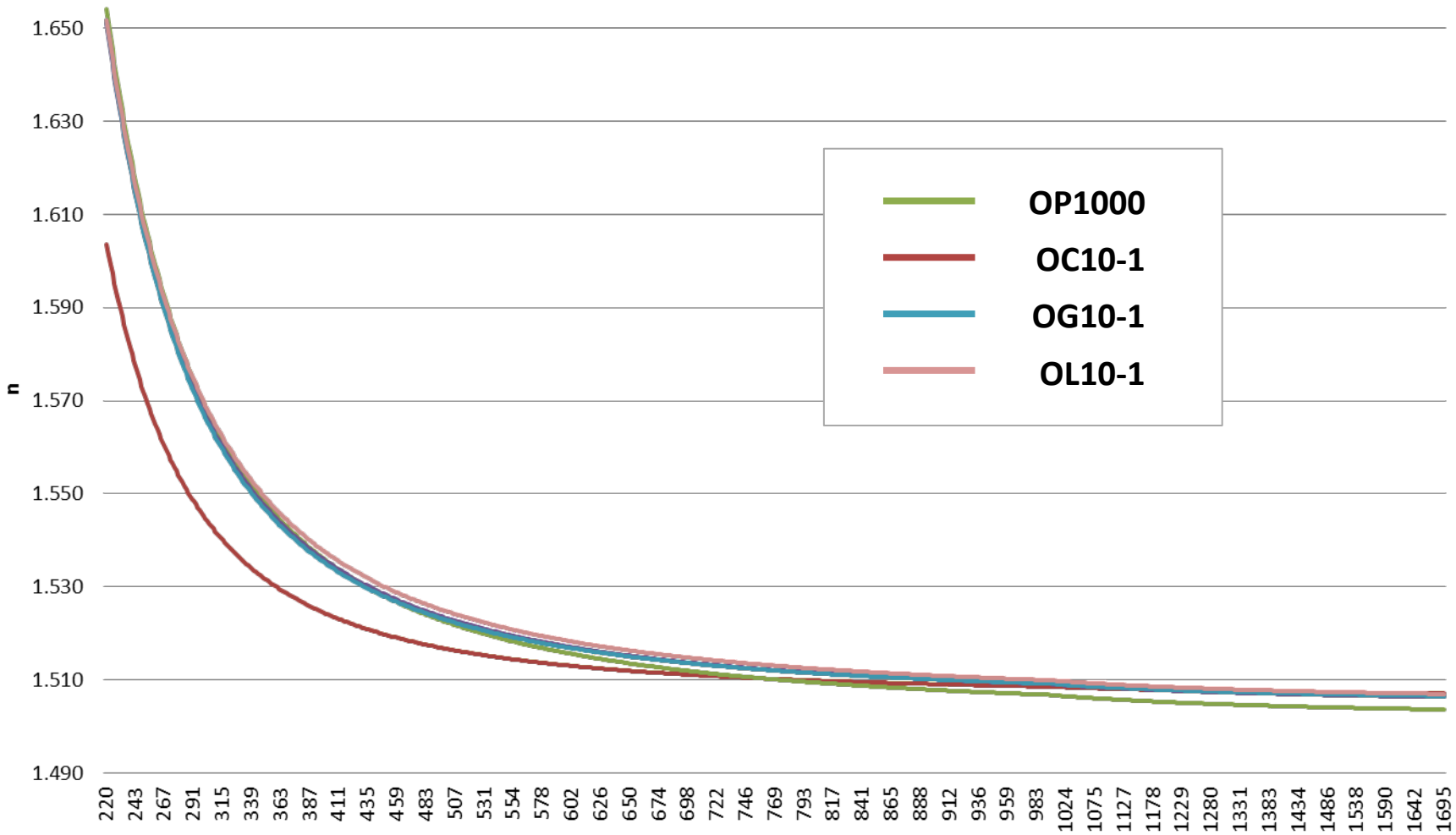
Transmittance after Aging @ 105°C, 2000 hours, 1 mm thick



- Normalized for 100% Transmission
- No degradation above 450 nm
- Less than 1% transmittance loss after 2000 hours @ 105˚C

Refractive Index Comparison

Comparison of SolEpoxy Clear Encapsulants

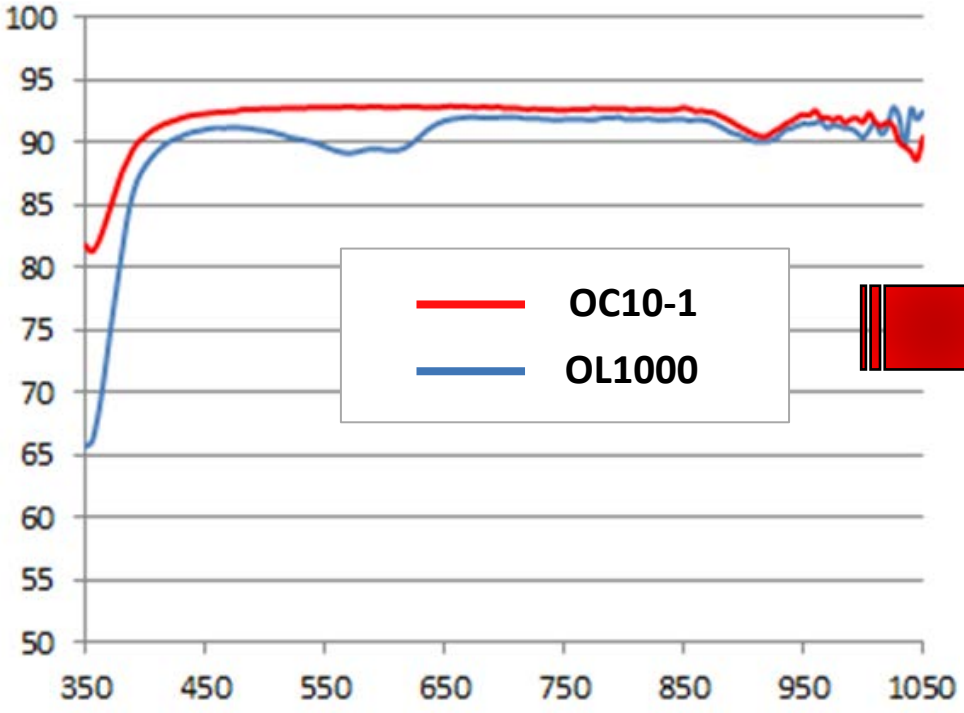


Samples prepared 10/2014, test data 11/2014 by J. A. Woollam Co. on a M-2000 Model: DI
Samples: 1 mm thickness Opto MC PB for 4 hr @ 150°C Opto Liquid PB for 2 hr @ 150°C

SolEpoxy Clear Encapsulants

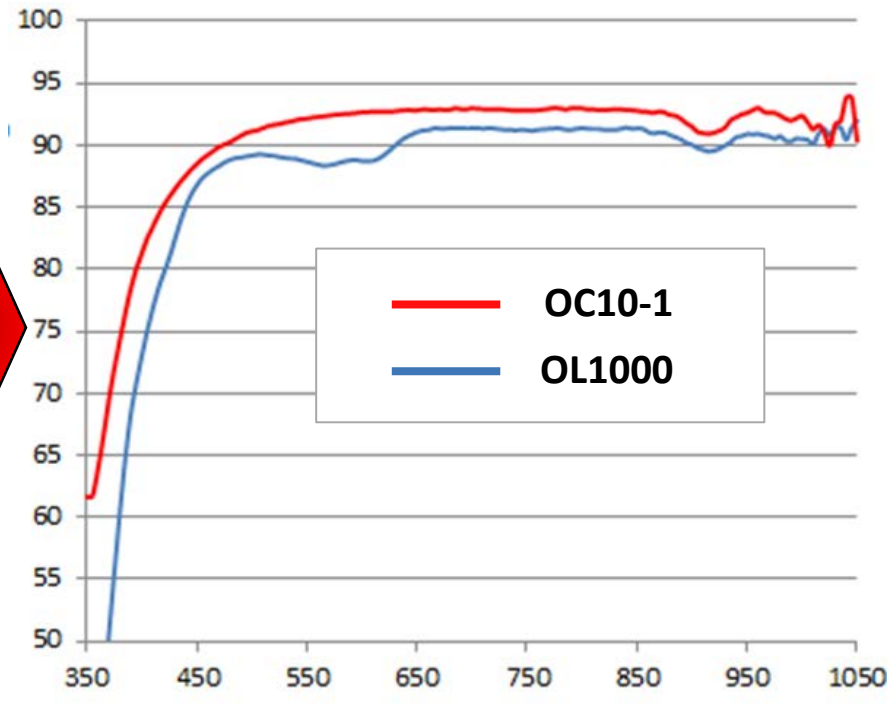
Transmission Data before and after heat exposure

OC10-1 has good transmission initially…



Transmission data at T=0

…and after 500 hours @ 125°C

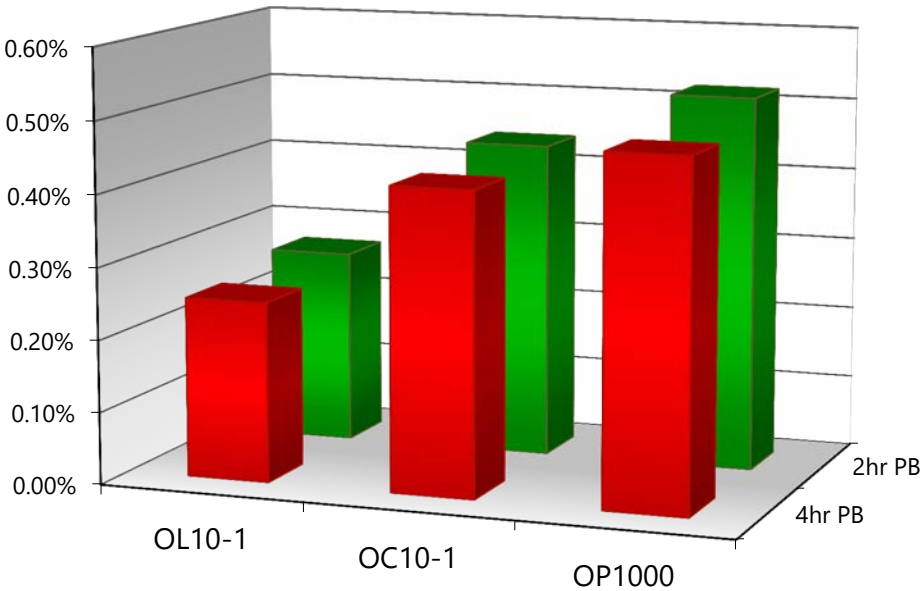


Transmission data at T= 500 hours

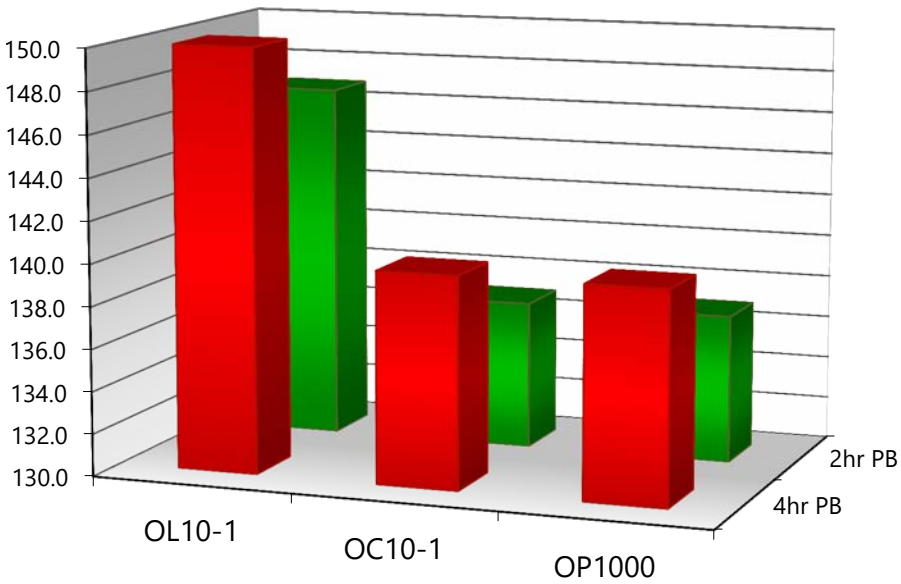
SolEpoxy Clear Encaps better MSL Performance

Designed with lower moisture absorption & higher Tg

Moisture Absorption, %
After 1 hour boil @ 100°C
With 2hr & 4hr Postbake @ 150°C



Glass Transition Temperature (Tg), °C
With 2hr & 4hr Postbake @ 150°C



Low Moisture Absorption

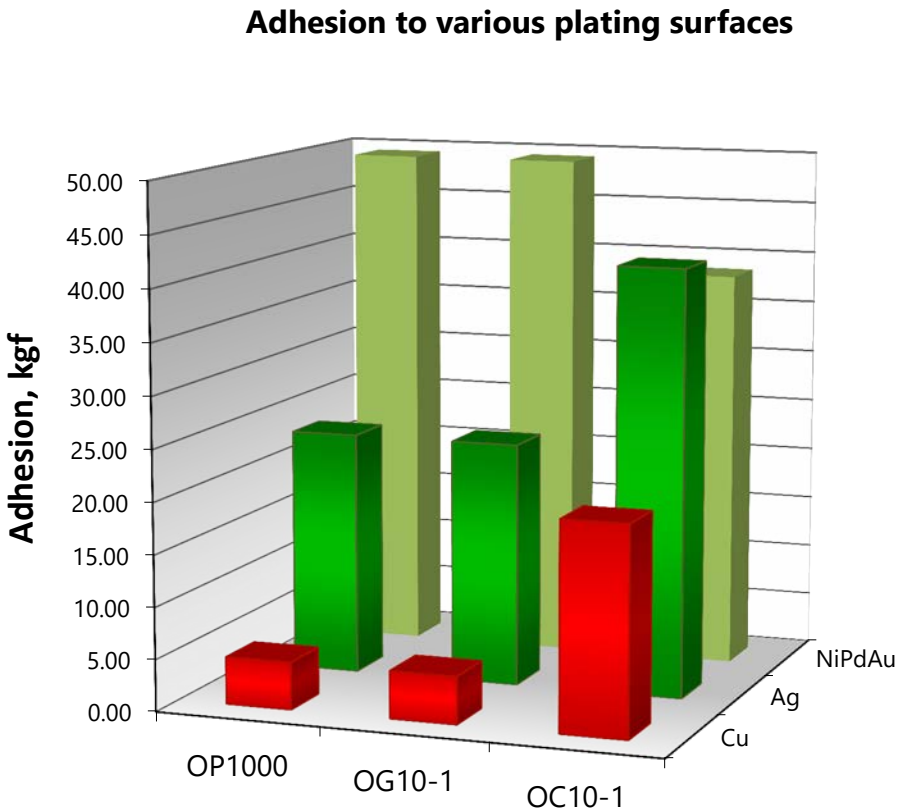
Means less pop-corning and better MSL performance

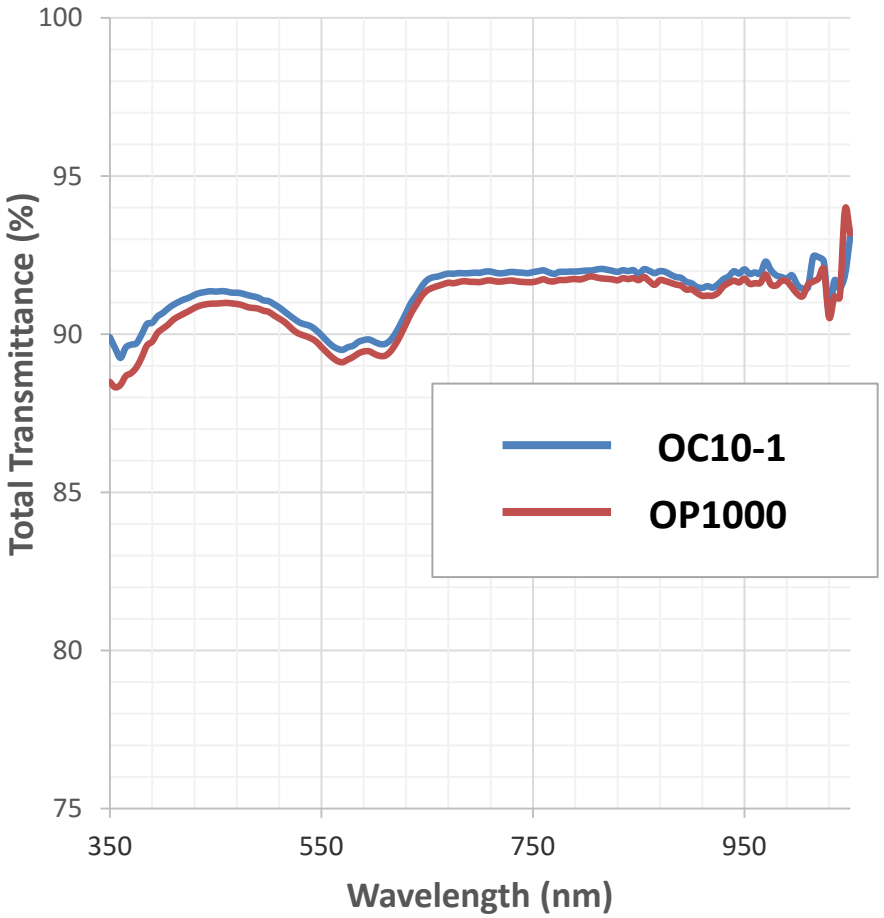
High Tg

High glass transition temperatures of SolEpoxy Clear Encapsulants

SolEpoxy Clear Encaps Adhesion Data

Designed for Copper, Silver and Preplated Leadframes





High Adhesion

Proven on Cu, Ag and NiPdAu leadframes

SolEpoxy Clear Encapsulants

Summary of Properties

Cured Properties* *After 4 hrs @ 150°C	**OP1000**	**OC10-1**	**OG10-1**	**OL10-1**
Sunshine Gel Time @ 125°C, min	N/A	N/A	N/A	24
Viscosity Initial, Cps After 7 hrs @ 25°C				 2800 3800
Transmittance @ 460nm Initial, %	-	-	-	91.85%
Refractive Index @ 460nm	1.52	1.52	1.52	1.52
Mold Shrinkage, %	TBD	TBD	TBD	1.07%
Glass Transition Temperature, °C	139	139	139	152
Coefficient of Thermal Expansion, ppm/°C Alpha 1 Alpha 2	 80 161	 80 161	 80 161	 67 171
Die Shear Adhesion, lbs (kg) Glass Epoxy, FR4 Copper, Cu	 TBD () TBD ()	 TBD () TBD ()	 TBD () TBD ()	 TBD () TBD ()
Water Absorption after 4hs@150°C, % Boiling Water, 1 hour	 0.48%	 0.44%	 0.48%	 0.25%
Flexural Properties after 4hrs @150°C Flexural Strength, MPa (psi) Flexural Modulus, GPa (Mpsi) Flexural Toughness, MPa (psi)	 110 MPa (16,830 psi) N/A N/A	 110 MPa (16,830 psi) N/A N/A	 110 MPa (16,830 psi) N/A N/A	 122 MPa (17,695 psi) 2.8 GPa (0.41 Mpsi) 2.51 MPa (363,000 psi)

Light Filtering Version for IR Devices

Transmission Data, 1mm, molded 2 hrs @ 150C