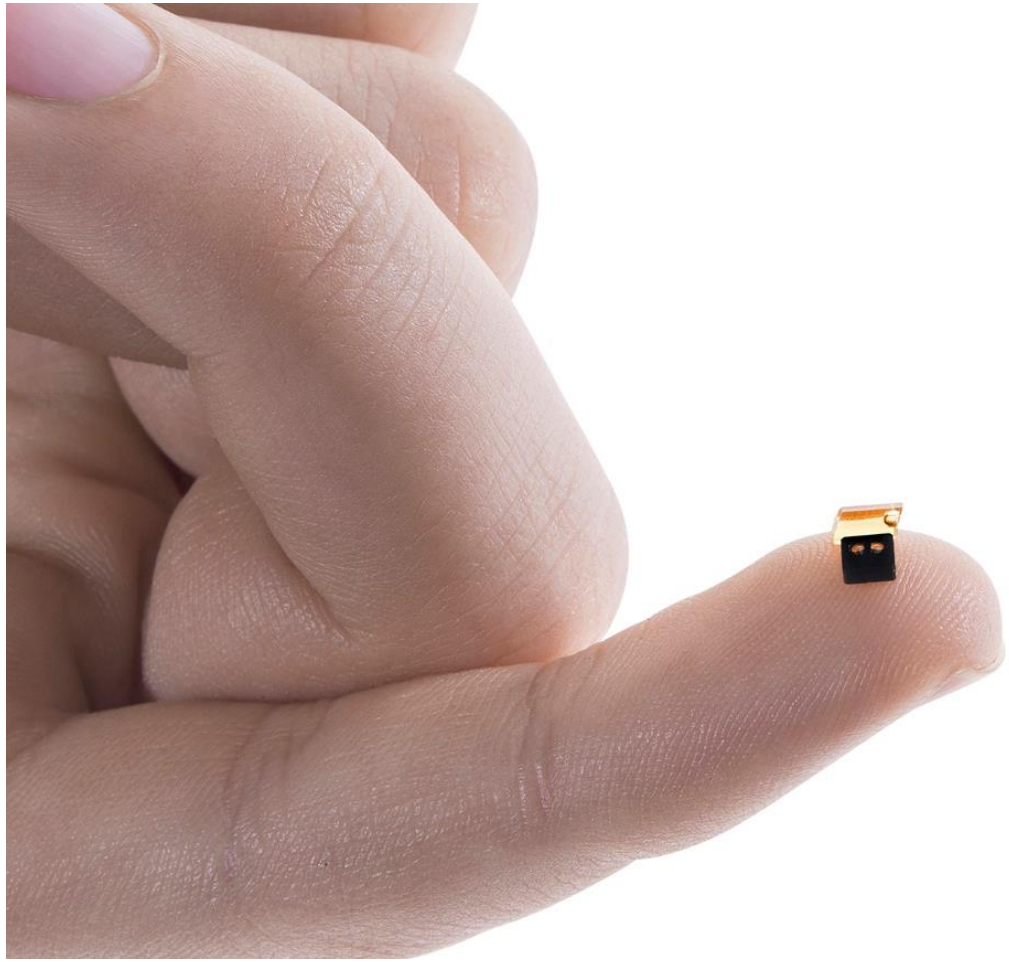
CHEMISTRY THAT MATTERS™

EXTEM™ RH1016UCL RESIN FOR FIBER OPTICAL COMPONENTS

SABIC'S SPECIALTIES BUSINESS
HIGH HEAT RESINS

March 2022

ADVANTAGES OF THERMOPLASTIC OPTICAL ELEMENTS



DESIGN FREEDOM & MINIATURIZATION

Thermoplastics can allow complex part designs that are potentially limited in alternative solutions like glass or thermoset resins. Examples are aspherical lenses or lens arrays.

INTEGRATION AND SIMPLIFICATION

Thermoplastics allow the integration of mechanical (such as fixtures) and optical features to simplify design and assembly for potential cost improvement.

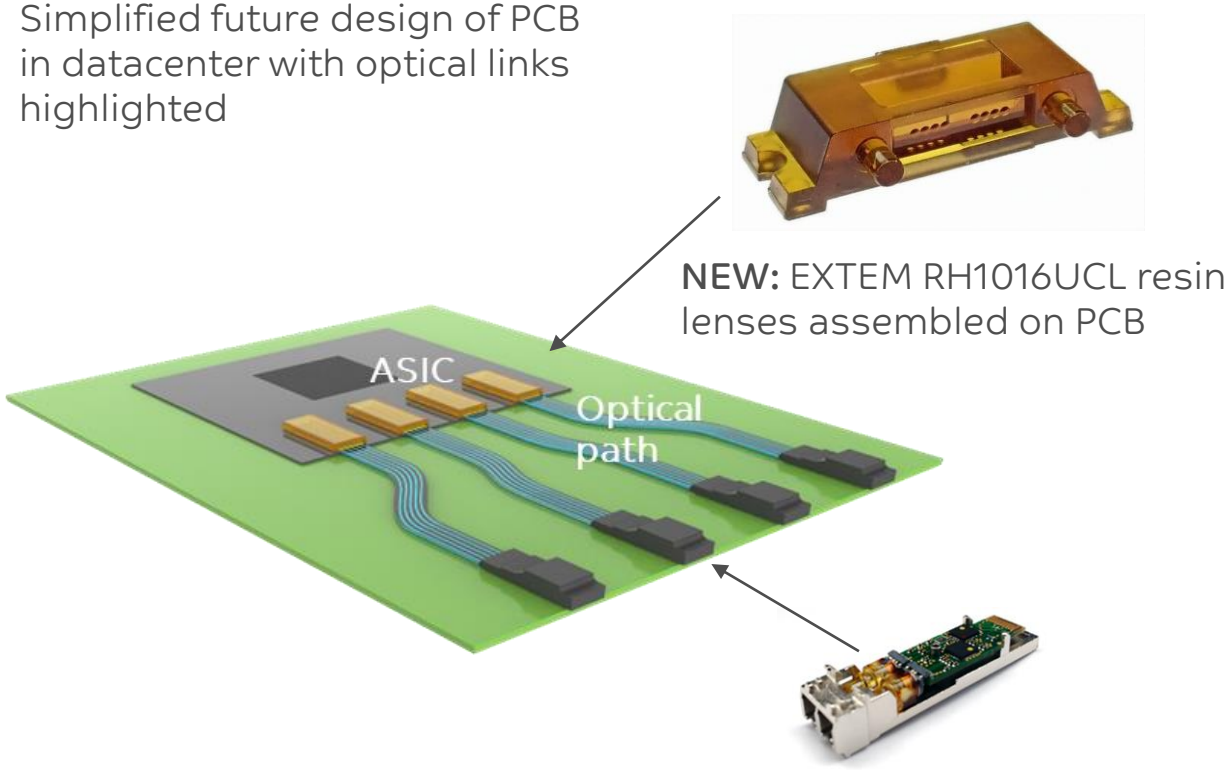
MASS PRODUCTION

Injection molding of thermoplastics enables high precision manufacturing of complex parts at large build numbers.

OPTICAL LENS (ARRAYS) WITH EXTEM™ RESIN RH1016UCL

OPTICS IN DATA COMMUNICATION

Simplified future design of PCB in datacenter with optical links highlighted



NEW: EXTEM RH1016UCL resin lenses assembled on PCB

CURRENT: ULTEM™ resin lenses in pluggable optical transceivers

Co-packaged Optics (CPO) designs from one single optical component can deliver integration opportunities of multiple design elements.

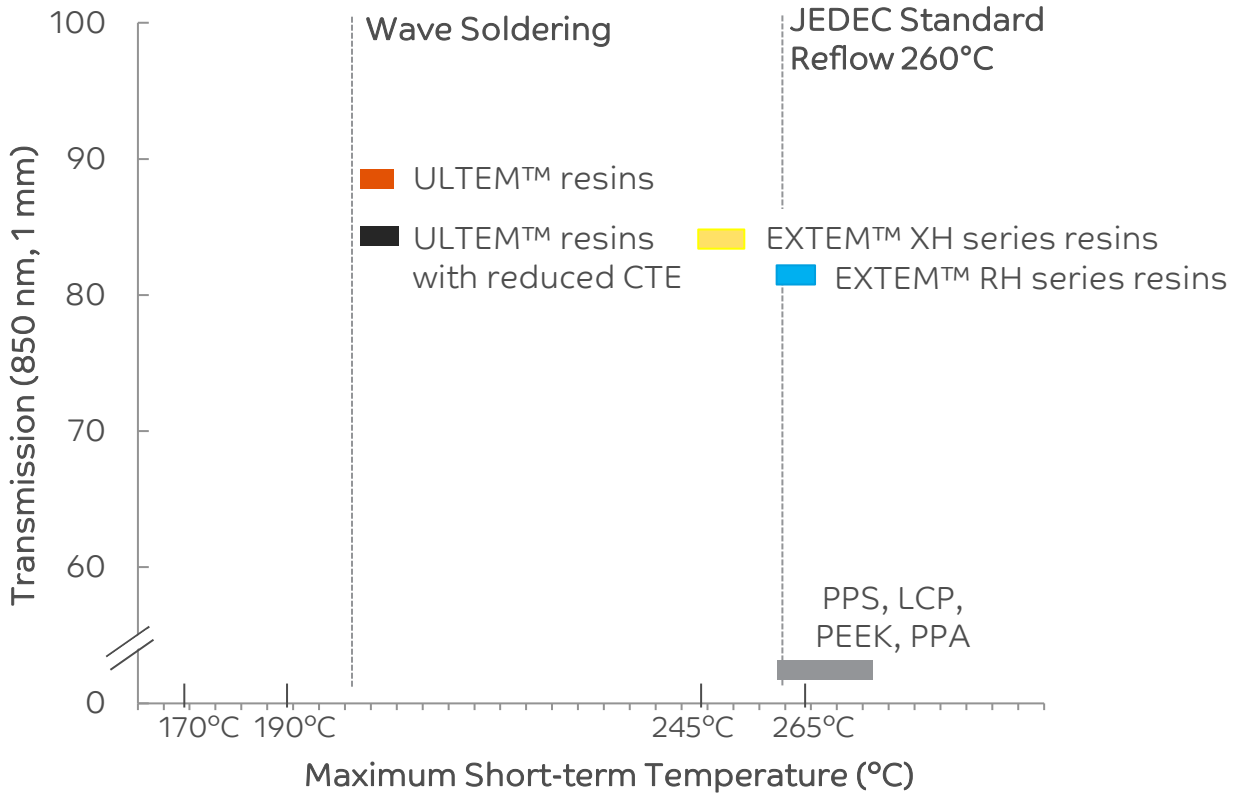
EXTEM resins can integrate multiple optical components within a single part to help eliminate complex assembly

- Freeform optics with complex surfaces and designs
- Retain signal integrity and low signal loss as EXTEM resin can maintain dimensional tolerances through reflow soldering according JEDEC standard lead free Reflow Profile (J-STD-020D)
- Retention of high near IR transmission and light alignment when tested vs. Telcordia standards (e.g. hydro aging)

*Optical interconnect lens designed and produced by Nalux Co., LTD. https://www.nalux.co.jp/en/index.html

THERMO OPTICAL PORTFOLIO FOR OPTICAL LENS APPLICATIONS

SABIC's thermo optical portfolio is supporting applications in the photonics sector, with a range of thermoplastics offering various levels of heat resistance and light transmission.



EXTEM resins maintain stiffness and dimensional stability for mounting of parts and modules in PCB assembly with SAC/SMT reflow solder (245 - 260°C)

- Based on ULTEM™ resin polyetherimide chemistry processes
- EXTEM™ RH1016UCL resin can provide dimensional stability through the lead-free solder reflow process according JEDEC J-STD-020A, with a peak temperature of 260 °C

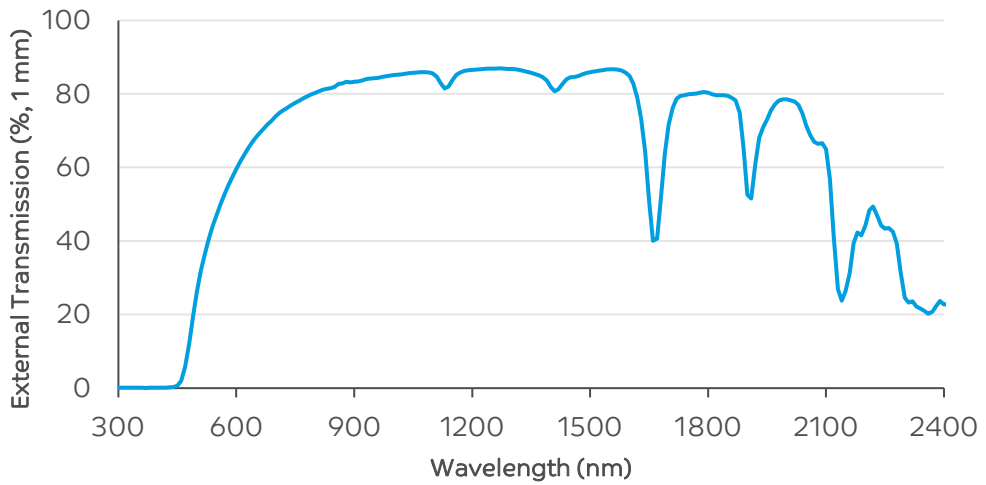
OPTICAL PROPERTIES OF EXTEM™ RH1016UCL RESIN

ULTEM™ AND EXTEM RESIN OPTICAL PARAMETERS*

Property	ULTEM™ 1010 resin	EXTEM™ XH1015UCL resin	EXTEM RH1016UCL resin
HDT, 0.455 MPa, 3.2 mm	200 °C	252 °C	262 °C
1 mm % T 850 nm	88	82	82
1 mm %T 1310 nm	89	87	87
850 nm Refractive Index	1.639	1.633	1.663
Abbe Number	21	18	18
Dn/dT (30 °C – 120 °C)	-9.8 x 10^{-5}/°C	-9.8 x 10^{-5} /°C	-9.8 x 10^{-5} /°C

* The data shown are typical properties and may vary from lot to lot

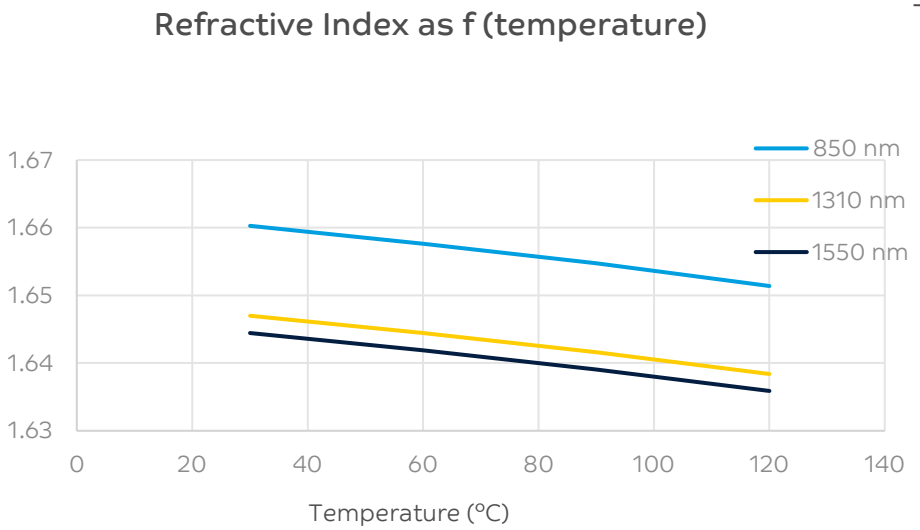
External transmission (%) at 1 mm, as a function of wavelength of EXTEM RH1016UCL resin

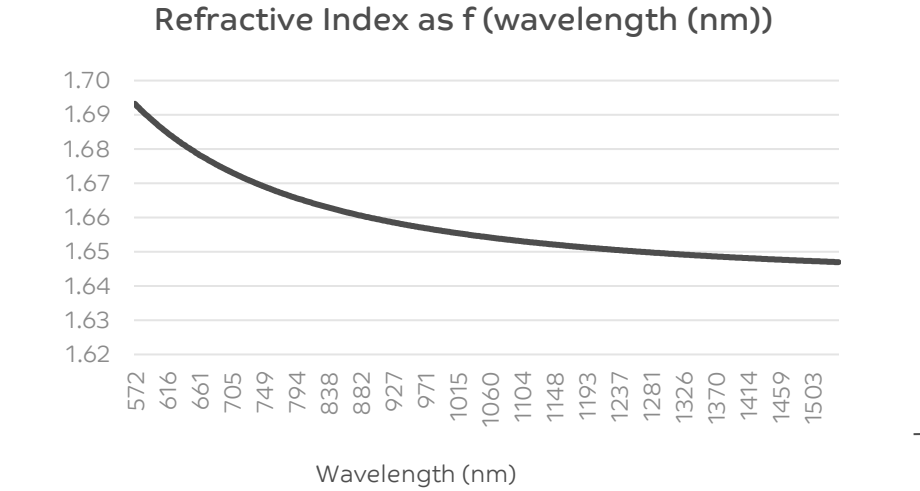


EXTEM™ RH1016UCL resin demonstrates excellent light transmission for near infrared optical communication

- 850nm for multi mode optics
- 1310nm/1550 nm for single mode optics

REFRACTIVE INDEX (TEMPERATURE, WAVELENGTH)





EXTEM RH1016UCL RESIN
Refractive index dependance with wavelength or temperature

Sellmeier Dispersion Equation for Refractive Index
$n^2 - 1 = \frac{B_1\lambda^2}{\lambda^2 - C_1} + \frac{B_2\lambda^2}{\lambda^2 - C_2} + \frac{B_3\lambda^2}{\lambda^2 - C_3}$

Constants of Sellmeier Dispersion# Formula	
B_1	0.56262
B_2	0.56145
B_3	0.56329
C_1	0.03324
C_2	0.03264
C_3	0.03307

Temperature Dependence of Refractive Index
$\Delta n_{abs} = \frac{n^2 - 1}{2n}\left[D_0\Delta T + D_1\Delta T^2 + D_2\Delta T^3 + \frac{E_0\Delta T + E_1\Delta T^2}{\lambda^2 - \lambda_{tk}^2}\right]$

Constants* of Dispersion dn/dT	
D_o	-1.78×10^{-4}
D_1	5.42×10^{-8}
D_2	2.89×10^{-10}
E_o	1.13×10^{-5}
E_1	-1.98×10^{-7}
λ_{tk}	0.00

Zemax OpticStudio® parameters are available for modeling design

REFLOW SOLDERING FOR ON-BOARD INTERCONNECTS

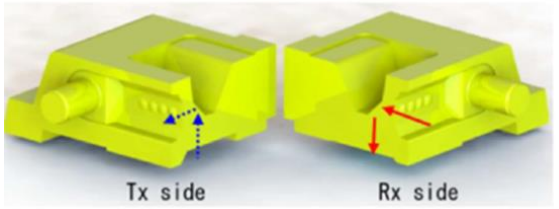
NALUX is a full-service micromolder of plastic precision optics including micro lens arrays, aspherical lenses, diffractive optics, etc. with in-house optical design capabilities.

SABIC and NALUX have collaborated on an optical interconnect lens array to demonstrate that EXTEM™ resins maintain stiffness and dimensional stability through lead-free solder conditions.

Molded by NALUX Japan for multi-mode on board optics/CPO*

Connector designed using EXTEM™ RH1016UCL resin

- 4 Rx and 4 Tx lens array on PCB side with 250 µm spacing
- 4 Rx and 4 Tx lens array on MPO side with 250 µm spacing
- 4.3 x 8.9 x 2.1 mm (W x L x H)



Transmit
laser to fiber

Receive
fiber to detector

*Optical interconnect lens designed and produced by Nalux Co., LTD. https://www.nalux.co.jp/en/index.html

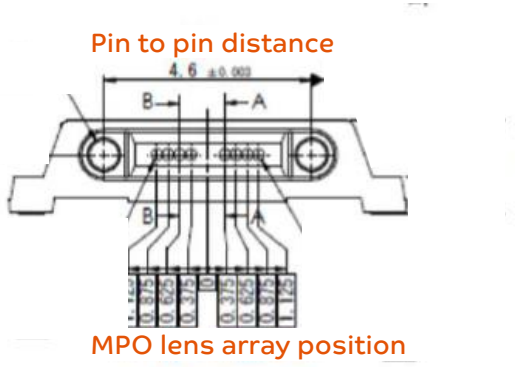
REPLICATION AND SPACING MAINTAINED AFTER REFLOW

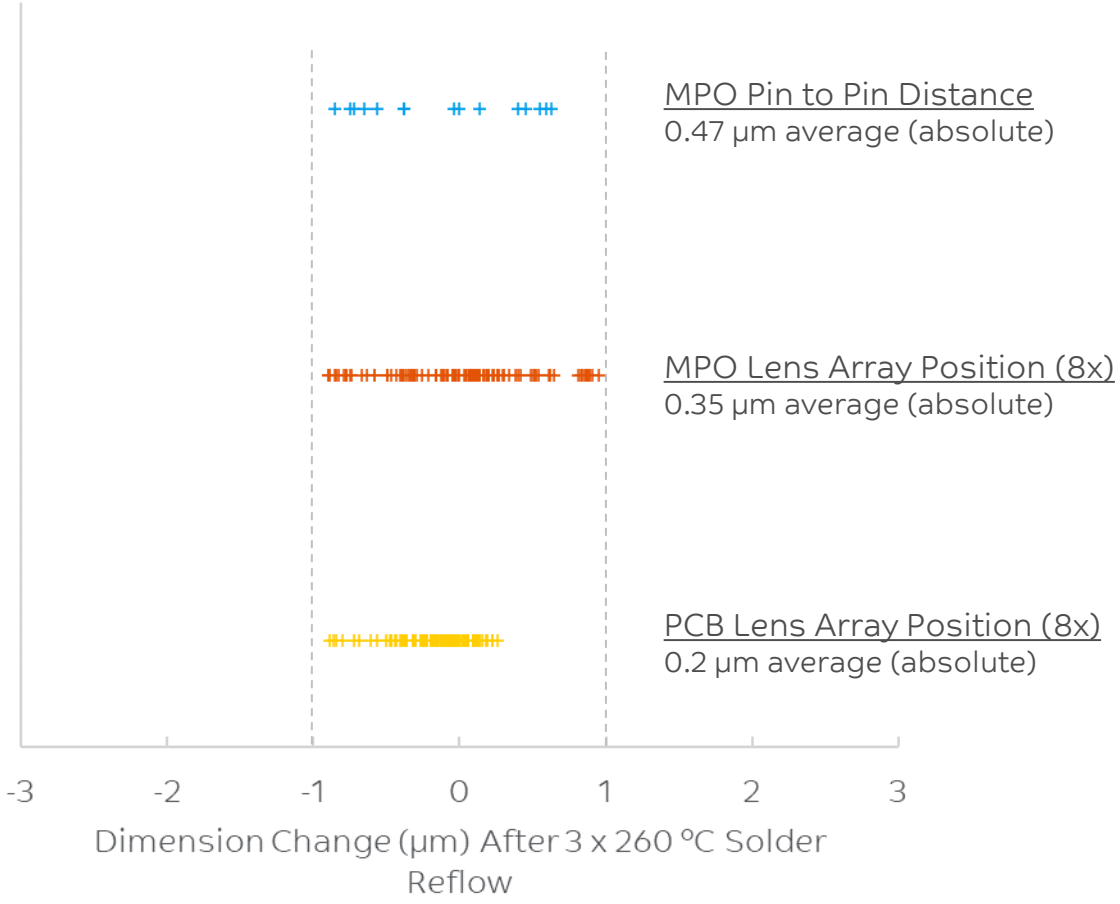
REFLOW SOLDER TESTING – ROBUST DIMENSIONAL STABILITY

Dimensional measurements on lenses and alignment spacing after reflow conditions have changed only by **sub-micrometer** distances

Three passes of 260°C peak temperature reflow cycles

- 15 samples over 3 lots
- MPO pin and lens array spacing measurements

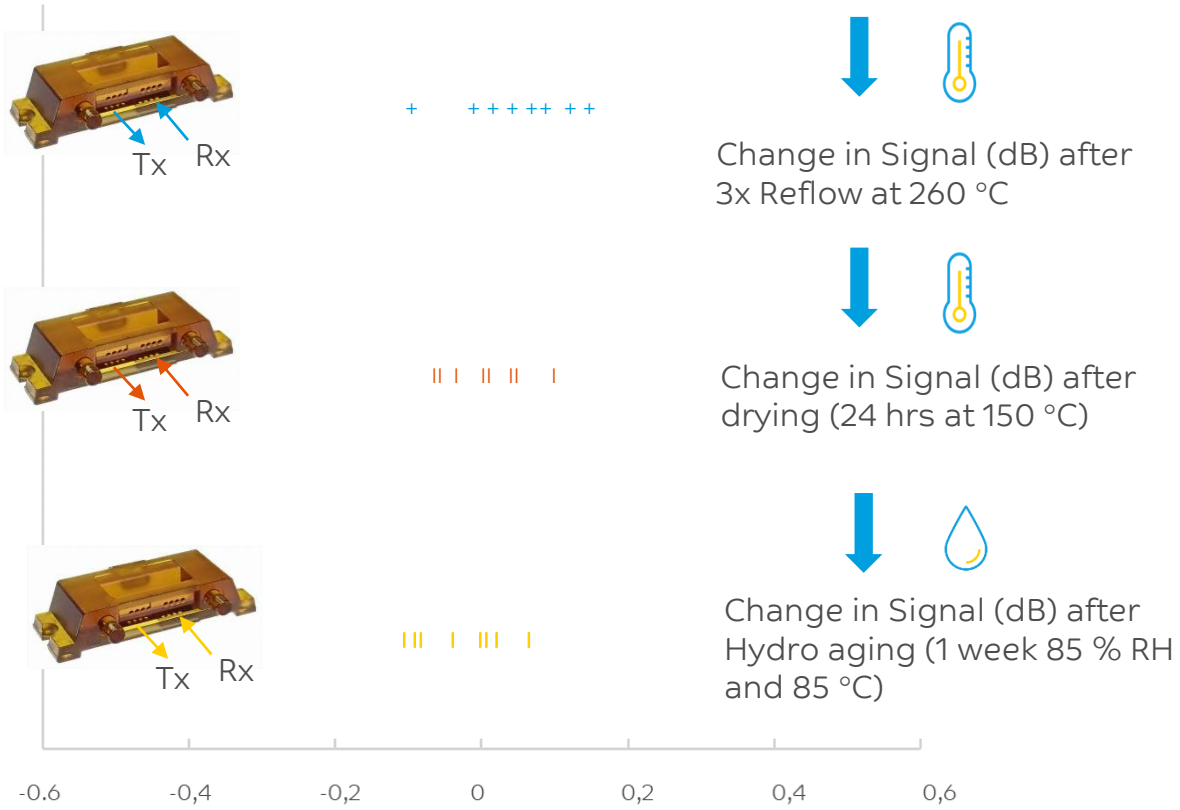




EXTEM™ RH1016UCL resin part design demonstrated resistance to solder reflow conditions according to JEDEC J-STD-020A

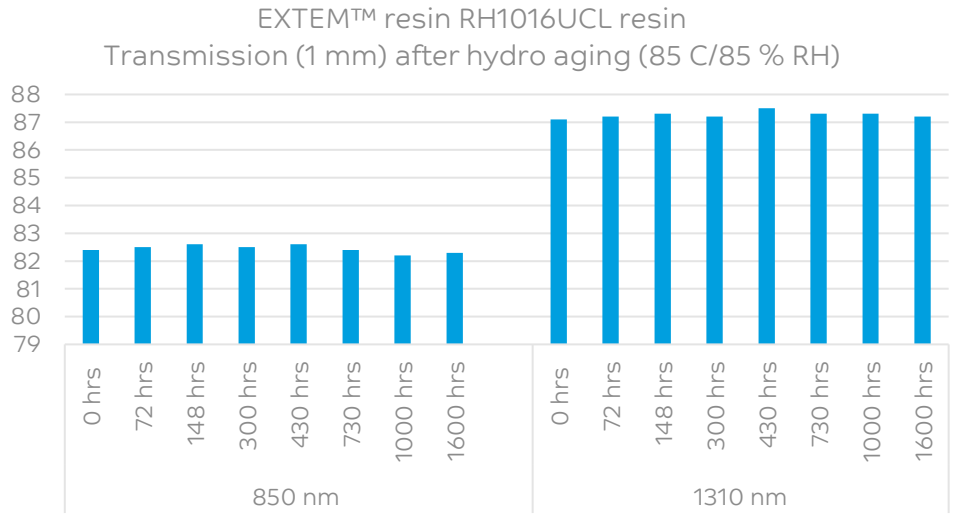
SIGNAL INTEGRITY MAINTAINED AFTER REFLOW AND (HYDRO) AGING

Signal loss (in dB) as measured in connector part at 850 nm



Signal Loss (dB) of Tx/Rx channels after Reflow and (Hydro) Aging

Signal loss (in % transmission) as measured in molded plaque



Based on current testing, EXTEM™ RH1016UCL resin shows little to no deviation in optical performance after hydro aging according to JEDEC standard. No significant change in near infrared light transmission or visual color change, haze, or void formation.

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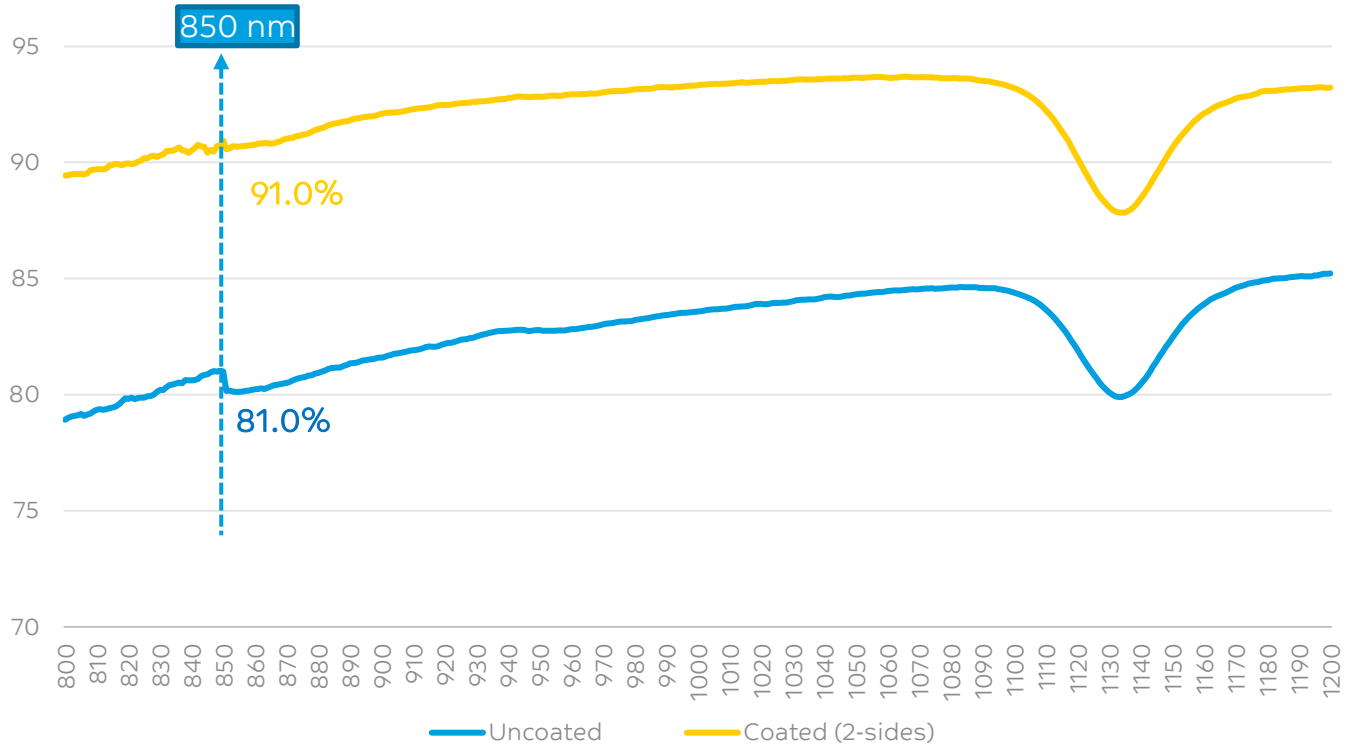
ANTI-REFLECTIVE COATINGS

Two-sided anti-reflective coating for near IR light transmission (1 mm thickness) for EXTEM™ RH1016UCL resin



External partners have demonstrated custom anti-reflection coatings for EXTEM™ resin substrate materials, designed for maximum %T increase in near infra red. Samples are available for testing.

ASSEMBLY OF COMPONENTS WITH MIXED MATERIALS

PCB ASSEMBLY TECHNIQUES

SABIC has worked with industrial adhesive suppliers and can assist in the selection of adhesives, with high bonding strength against several substrates

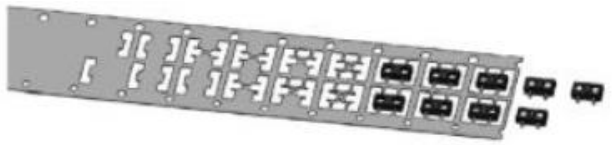
Adhesive	%T	Shear Test Before / After SMT	Dispensing
Epoxy A	■	● / ●	●
Epoxy B	●	▲ / ●	●
Epoxy C	●	● / ●	●
Silicone A	●	■ / ■	●

● Recommended ▲ Marginal ■ Not Recommended

OVERMOLDING

Integration of multiple components can be accomplished with two-shot injection over molding
Example: EXTEM™ resin lenses + opaque mounting; total assembly surviving reflow

ToF sensor lens
5 x 2.5 x 1.6 mm



Metal lead-frame overmolding
in 2 steps – reel to reel

Photo Source: Soprod SA

SABIC GLOBAL APPLICATION DEVELOPMENT CAPABILITIES

SABIC supports customers with:

- New product and application development for micro-molded components
- Troubleshooting and processing expertise to support industry adoption

MICRO MOLDING

Arburg 370A and Sumitomo SE30EV micro molding machines selected to match customer capabilities

Shot weight capabilities: 0.5 g to 9.5 g

PROTOTYPING TOOLS

Proof of concept for customer demonstrations and faster validation

- 0.3 - 1 mm thick parts with diffractive or refractive optics
- Designed for measurements of focal length, beam profile, signal loss

MEASUREMENT CAPABILITY

Resin Prototyping Data

- Optical parameters for resins
- Spectrophotometer (%T)
- Refractometer (refractive index)
- ZEMAX OpticStudio® (modeling)

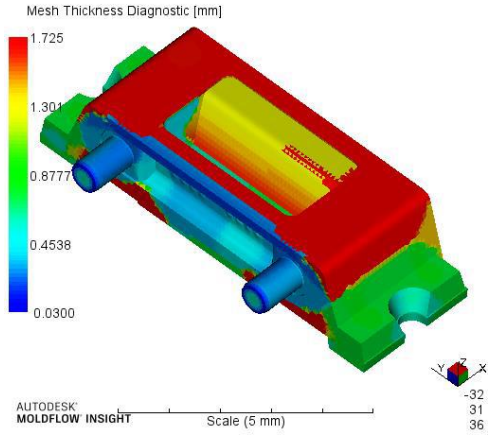
Part Validation

- Optical and confocal microscopes for sub-micron distance measurements
- JEDEC compliant solder reflow oven to validate assembly conditions

EXPANDING THERMOPLASTIC CONNECTOR DESIGN CAPABILITIES

NEW DESIGN CAPABILITIES:

- Increased design complexity are possible with diffractive optics, metallization, and overmolding
- Improved validation tools and multipoint datasets are available for reliability testing, simulation and mold flow analysis
- SABIC can assist with evaluating global micro molders with proven capabilities to micro-mold EXTEM™ resin components



NEW MATERIALS:

- New resins for thermoplastic optics can allow optical components to be assembled prior to lead-free solder reflow
- Materials with lower CTE for single-mode optics are being developed

*Optical interconnect lens designed and produced by Nalux Co., LTD. https://www.nalux.co.jp/en/index.html

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