CHEMISTRY THAT MATTERS™

MICRO LENSES FOR OPTICAL INTERCONNECTS MOLDED IN A NEW REFLOW RESISTANT EXTEM™ RESIN (TPI)

MICRO-OPTICS SUMMIT & EXPO

Young Joon Choi, SABIC's Specialties Business
December 3, 2024

SABIC AT A GLANCE

As the ‘home of unique offerings’ within SABIC, the Specialties business is focused on challenging technology endeavors that deliver fundamental progress to the way the world travels, communicates, works and lives. Leveraging global application technology centers and deep materials processing expertise, Specialties’ solutions are provided to a wide range of industries and include engineering thermoplastic resins and compounds, composites, sheets, fluids, thermosets and additives.

The branded portfolio includes **thermoplastics** like ULTEM™ resins, LNP ™ compounds, NORYL™ resins, LEXAN ™ copolymers and EXTEM ™ resins.

Top 2
Chemical Brand Value*

29,000
Employees around the world

140
Countries served

63
World -class plants worldwide

37,7
US$ bn
Annual revenue

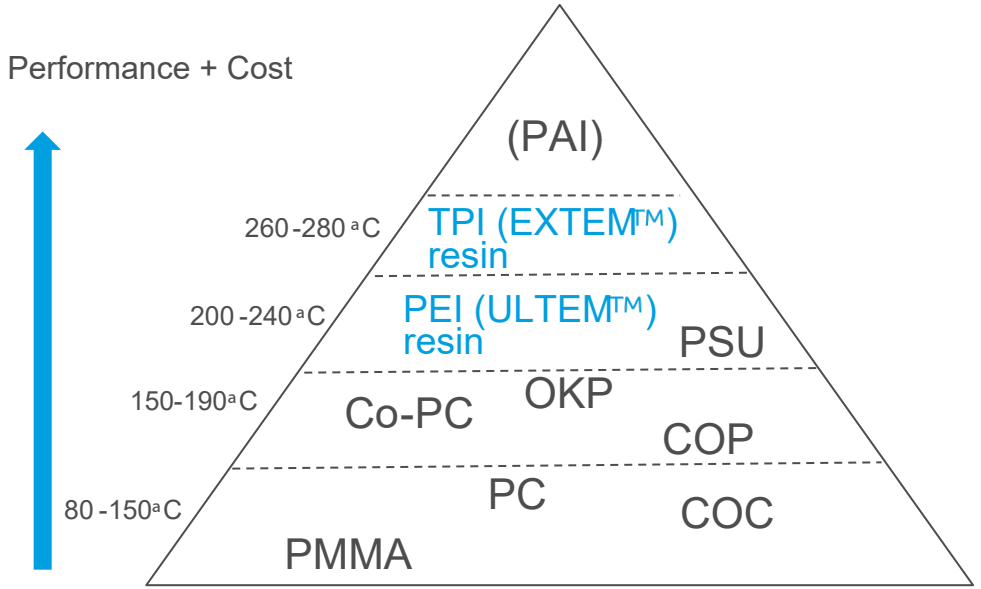
~11.000
Global patents and pending applications

* Brand Finance, 2024

HIGH PERFORMANCE SPECIALTIES PORTFOLIO

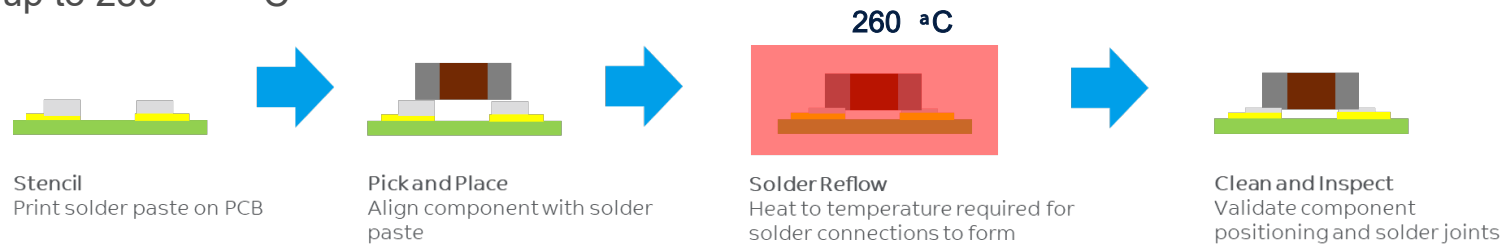
ULTEM™ resins

- Polyetherimide (PEI)
- Near-IR transparency while blocking lower light spectrums
- Strength and modulus, even at high temperatures
- Dimensional stability / tight tolerances
- Long-term high heat stability
- Inherent flame resistance with low smoke evolution & toxicity
- Hydrolytic and chemical stability
- Injection moldable , melt processible



EXTEM™ resins

- Similar performance to ULTEM ™ resin, as listed above
- Thermoplastic Polyimides (TPI) with exceptional high heat resistance with glass transition temperature of up to 280 ᵃC that can survive reflow solder processes

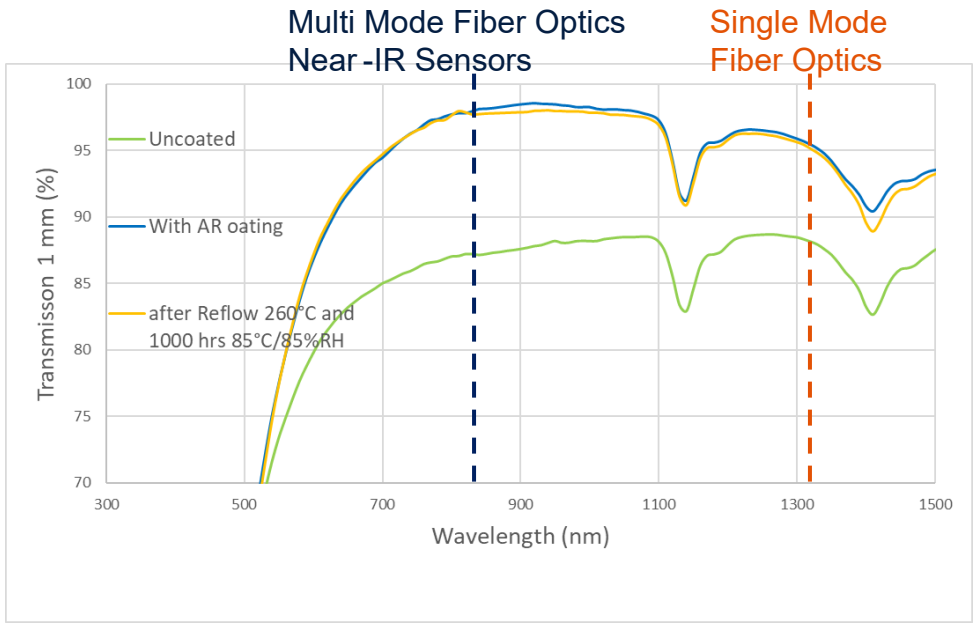


THERMOPLASTIC EXTEM™ RESIN

EXTEM™ resin optical parameters*

Property	EXTEM™ RH series resin
Glass Transition Temperature	281 °C
1 mm % T 850 nm	87
1 mm %T 1310 nm	88
850 nm Refractive Index**	1.639
Abbe Number	18
Dn/dT (30 °C – 120 °C)	-9.8 x 10^{-5} /°C

Optical transmission at 1 mm of EXTEM ™ resin



- Reflow (3x 260 °C)
- 1000 hrs 85°C/85%RH

New EXTEM ™ RH1017UCL resin

- High near-IR transparency for typical VCSEL wavelengths (sensors, fiber optics, etc.)
- Anti reflection coating remains intact after Reflow and after 1000 hrs 85 °C /85 % RH: no cracking, no haze or polymer hydrolysis
- Target commercialization date Q4 – 2024

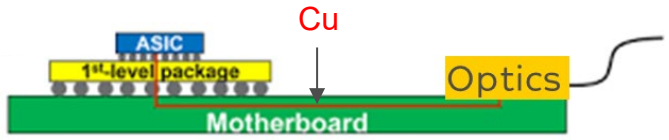
EXTEM™ resin offering near -IR transparency and high Tg for 260 °C reflow, can be used as lens material

* The data shown are typical properties and may vary from lot to lot
** Optical constants available in ANSYS ZEMAX

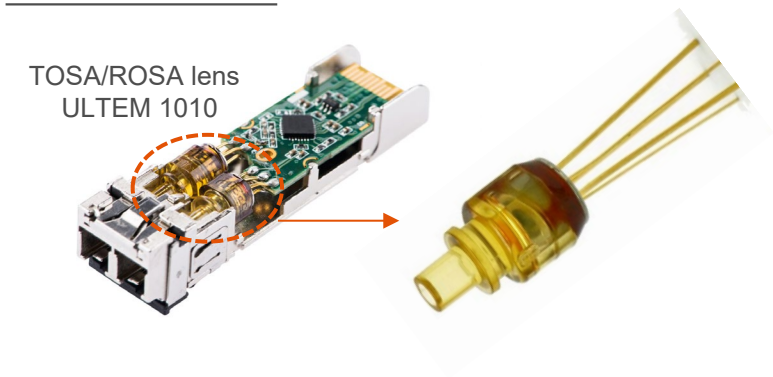
OPTICS SHIFTING FROM FACEPLATE TO THE CHIP ON THE BOARD

CURRENT: pluggable optical transceivers

Datacenter :



SABIC Solution :



ULTEM™ transceivers

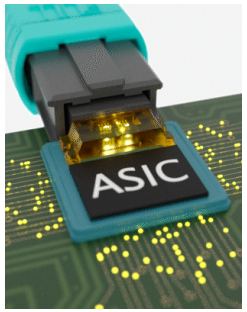
- injection molded optical lens and housing to cover laser module or photodiode
- provide the conversion of electrical signal to optical signal and vice versa.

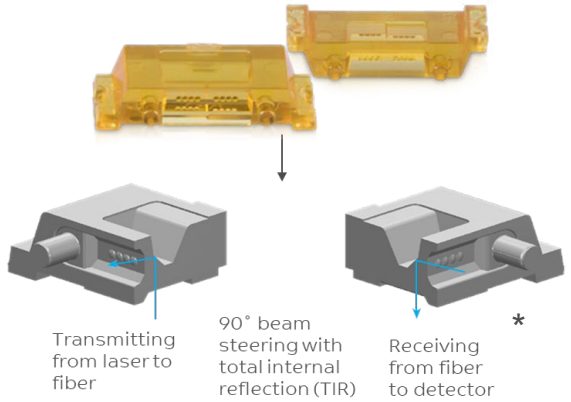
Future: Co-packaged optics (CPO) assembled on PCB

New Datacenter infrastructures :

- Faster data transmission with bandwidth increased > Å5
- Power consumption reduced to < 1/4

SABIC Solution :





EXTEM™ enables moving optics on board

- Complex shaped lens arrays, only possible with thermoplastics
- Expanded beam for higher alignment tolerance
- Reflow @260°C capable, requiring less assembly and lower costs

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

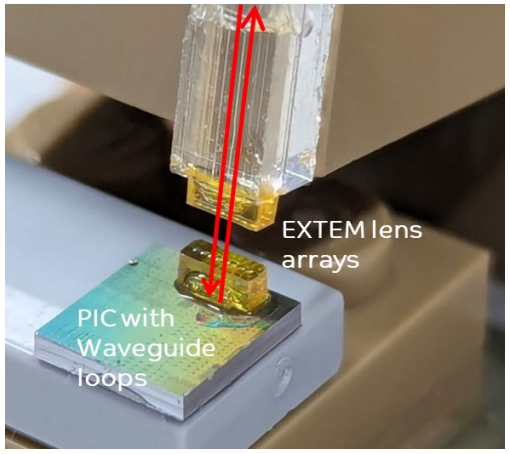
SINGLE MODE CO-PACKAGED OPTICS (CPO) DEMONSTRATOR

Micro -Lens Array (MLA) Connector

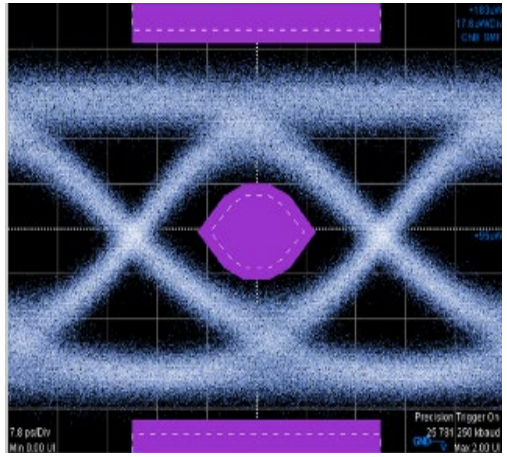
Pluggable Expanded Beam (EB) connection over free space between Photonic Integrated Circuit (PIC) and Fiber Array Unit (FAU)

- Relaxation of alignment tolerance
- Multiple break -and -make cycles

- Lens to lens distance: 250 µm
- 5nm Ra surface roughness
- Radius of curvature: 400 µm



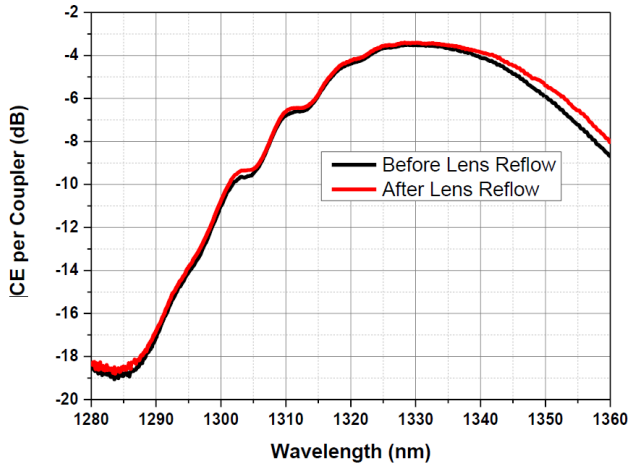
Expanded Beam grating coupler via MLA



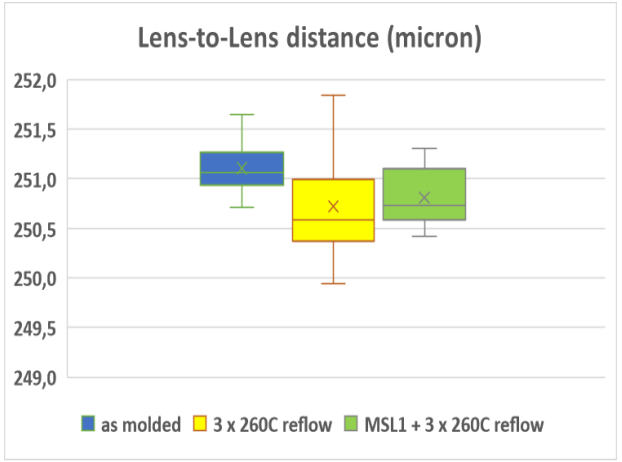
Eye diagram of the signal, fully compliant with the mask standard

Stable Coupling Efficiency after Solder Reflow

- Signal integrity / coupling efficiency remains intact before and after reflow process
- Variations of less than 1 µm in lens spacing, lens height and lens diameter



Coupling efficiency after Reflow

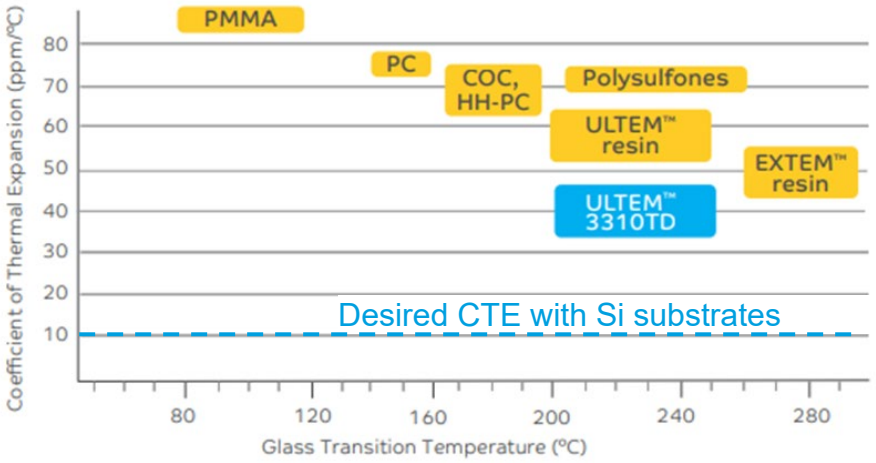


Dimensional stability

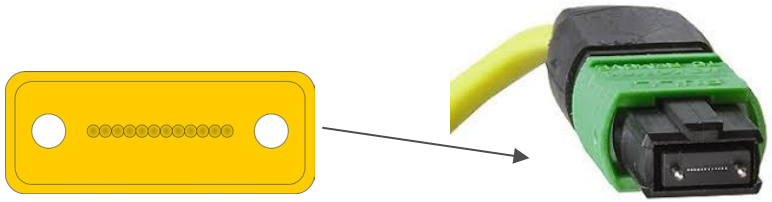
First ever Thermoplastic resin for Single Mode Co-packaged Optics demonstrator developed with Tyndall Institute

DIMENSIONAL STABILITY OF EXTEM™ RESIN FOR RETAINING SIGNAL INTEGRITY

CTE for different optical resins



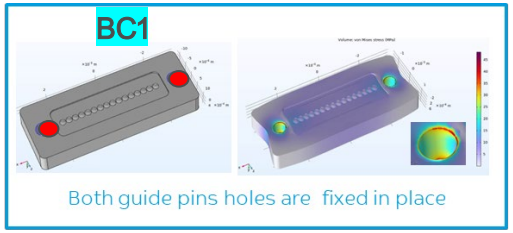
Design features can help bridge this CTE gap. E.g., alignment pins in MPO connector can act as fixation points via mating

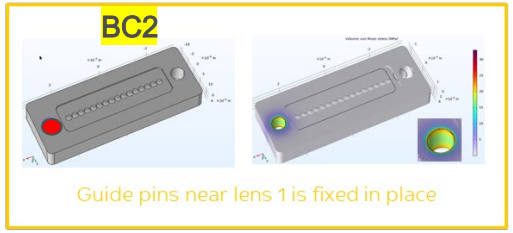


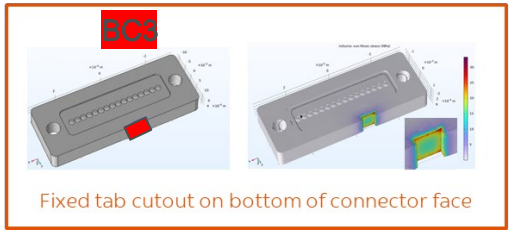
Expanded Beam MPO connector via MLA's

Simulation Strategy

- Test setup: expanded beam MPO optical connector female -male, with 3 different **fixation** boundary conditions (BC)
- Simulate lens -to-lens distance change with temperature 23 to 80 °C
- Simulate Coupling Efficiency (SM) for EXTEM resin (CTE of 50 ppm/ °C) vs Si substrate (CTE of 10 ppm/ °C)







	Maximum Misalignment lens -lens (micron)	Coupling Efficiency (dB loss)
BC1	0.2	0.03
BC2	14	40.4
BC3	8	14.5

Conclusion: using fixation points on thermoplastic MLA's can help to retain critical alignment tolerances

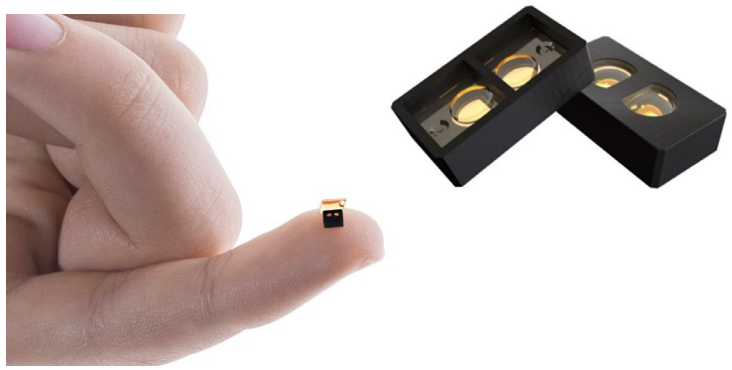
SUMMARY AND APPLICATION EXAMPLES

- Micro lenses play a key role in optical data communication, proximity sensors, 3D sensing, biometric monitoring devices.
- Increased sensor functionality and complexity do require complex part designs (e.g. free form optics, fixtures, etc.), for both refractive and diffractive lenses, which can be obtained by (micro-) injection molding of thermoplastic resins.
- Their build number will increase exponentially, requiring economy of scale and cost-efficient production.
- Compatibility with industry standard reflow soldering as offered by EXTEM™ resin is essential.
- Stable global supply: non-export controlled, non-hazardous

Co-packaged Optics for on board packaging*

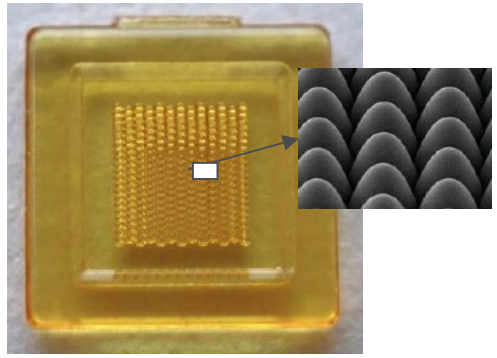
Detachable MPO/MT Connector
8.9 x 4.3 x 2.1 mm

Time-of-Flight Proximity Sensor lens



ToF sensor lens
5 x 2.5 x 1.6 mm

Super-wide-angle Diffuser for sensors*



Angle of diffusion: 170˚
Pitch size ~100 µm
Lens height 130 µm

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

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