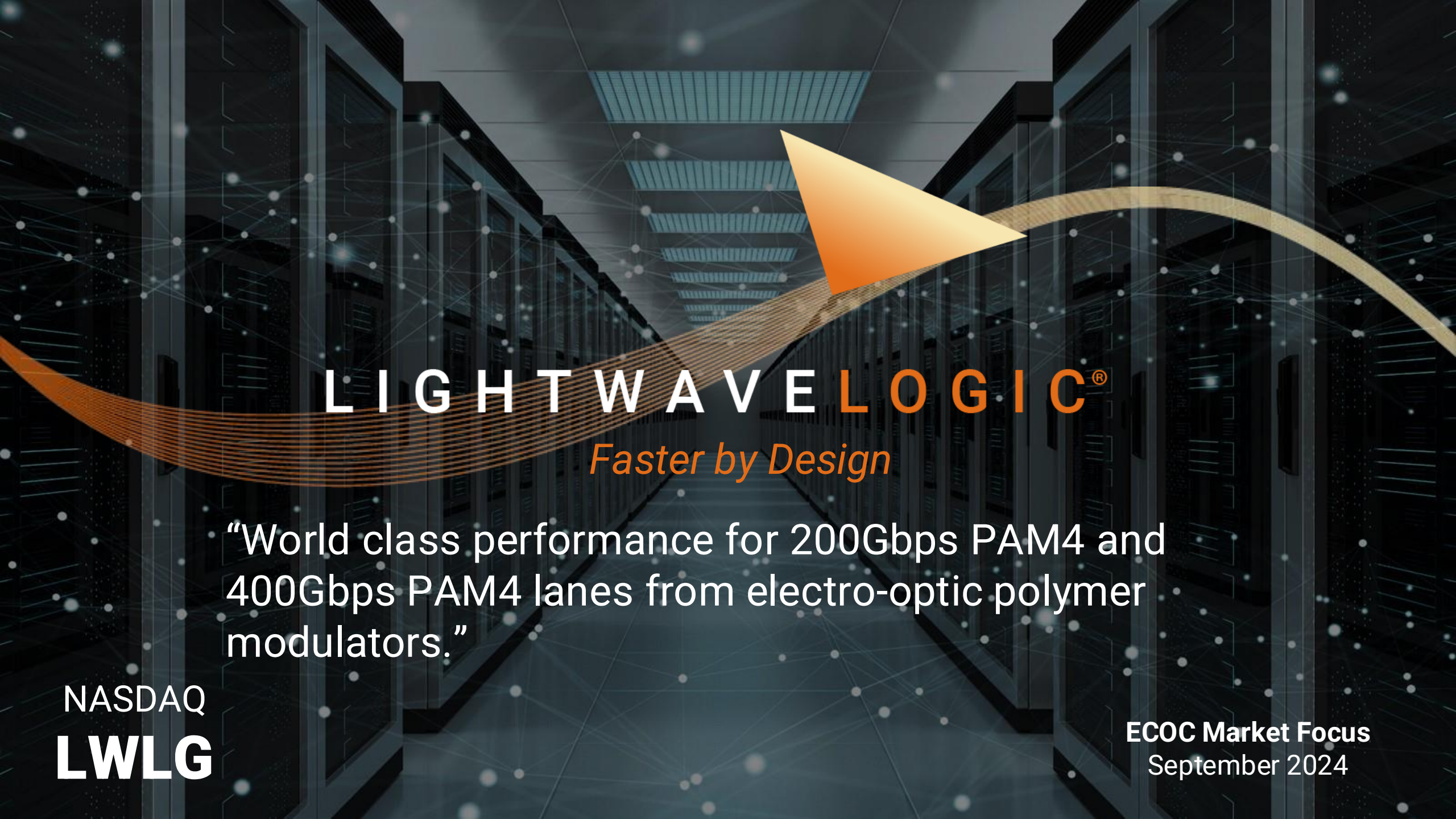

LIGHTWAVELOGIC®
Faster by Design
“World class performance for 200Gbps PAM4 and 400Gbps PAM4 lanes from electro-optic polymer modulators.”
NASDAQ
LWLG
ECOC Market Focus
September 2024

Safe Harbor

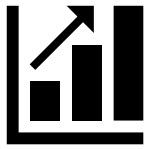
LIGHTWAVELOGIC®

The information in this presentation may contain forward-looking statements within the meaning of the Private Securities Litigation Reform Act of 1995. You can identify these statements by use of the words "may," "will," "should," "plans," "explores," "expects," "anticipates," "continue," "estimate," "project," "intend," and similar expressions. Forward-looking statements involve risks and uncertainties that could cause actual results to differ materially from those projected or anticipated. These risks and uncertainties include, but are not limited to, general economic and business conditions, effects of continued geopolitical unrest and regional conflicts, competition, changes in technology and methods of marketing, delays in completing various engineering and manufacturing programs, changes in customer order patterns, changes in product mix, continued success in technological advances and delivering technological innovations, shortages in components, production delays due to performance quality issues with outsourced components, and various other factors beyond the Company's control.


Who we are...

Corporate Overview

Lightwave Logic is positioned for growth by leveraging its proprietary electro-optic polymers to transmit data at higher speeds with less power and integration with silicon foundaries…

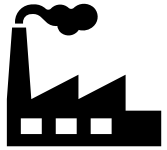


Large & Growing Overall Market

Market expected to grow to ~$100B by 2030 driven by data centers, comm & AI requirements

Proprietary EO Polymer Technology

Supports >3x faster data transmission speeds with ~10x lower power, relieving bottlenecks in internet infrastructure

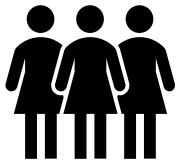


Commercialization Underway

Secured initial licensing agreement in May ’23

Robust Patent Portfolio

70+ patents and patents pending



Experienced Leadership:

Management, TAB, and Board are composed of technology & finance experts with 200+ years of combined experience

Robust Balance Sheet

$31M+ cash for growth
No debt

LIGHTWAVELOGIC®

NASDAQ
LWLG

Share Price[1]	$3.90
Market Cap[1]	$468.4M
Cash & Cash Equivalents[2]	$31.5M
Debt[1]	$0
Shares Outstanding[1]	120.1M
Headquarters	Englewood, CO

1) As of May 17, 2024
2) At Mar. 31, 2024


Polymer Opportunities…

Key EO Polymer Material & Modulator Markets

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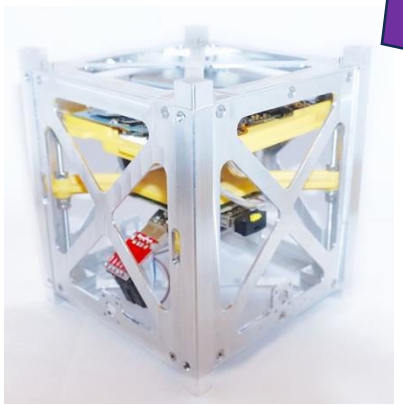
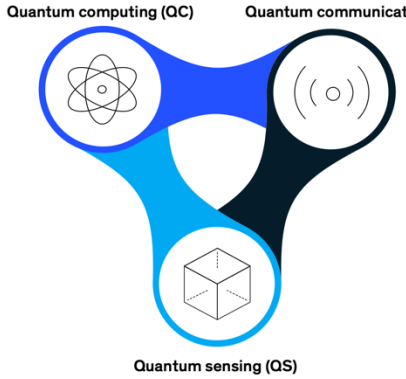


"SPACE"



"QUANTUM"

"STORAGE"

Near Term: Addressing Datacenter power and speed requirements Is Clear Application for EO Polymers

Source: LWLG, Google, Seagate

Reducing “Power” in data centers with minimum disruption will remain a top priority for the near future

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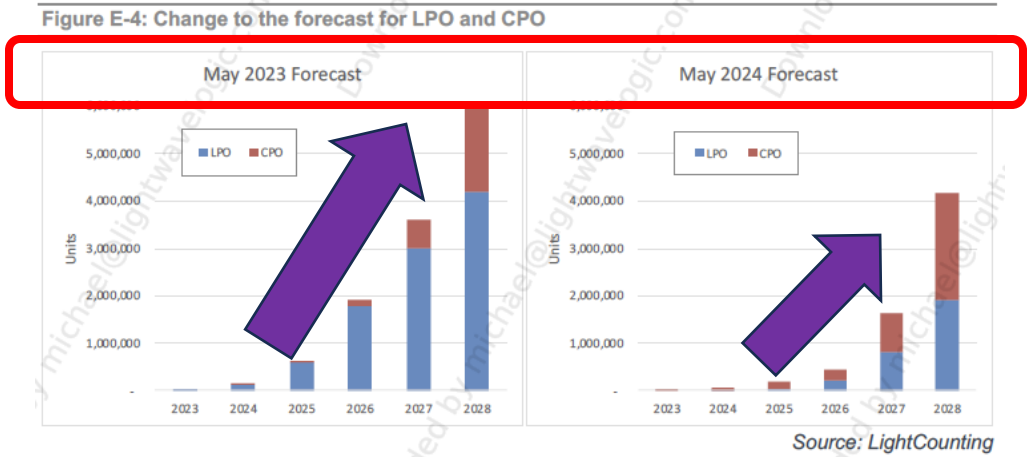
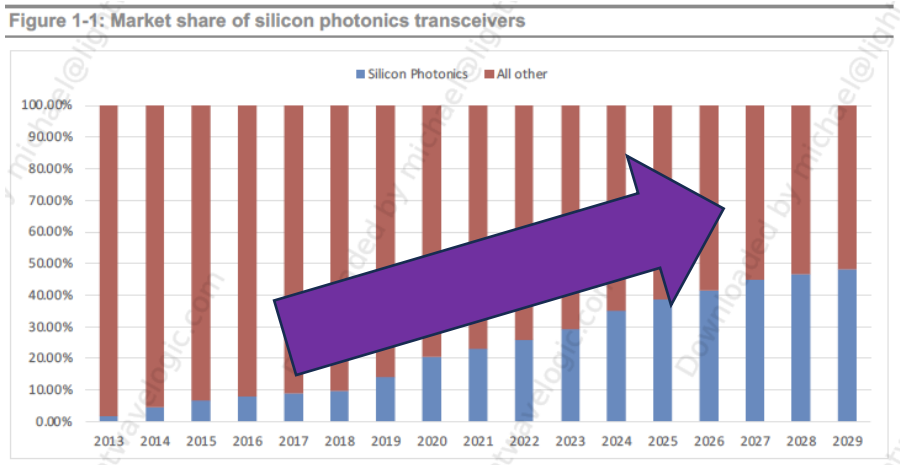
To reach pJ/Bit targets a “collective” effort is needed

- A key “vehicle” for this effort can be new, high-density modules enabled by “co-dependent” features like…
  - Lower power/”lite” DSPs (or no DSPs/LPO)
  - Next-gen modulators





For LPO, CPO & SiPH adoption will be gradual

Source: LWLG, Lightcounting, Arista, microsoft

Next Generation Interconnect Speed Will Require Scaling of Optical PMD

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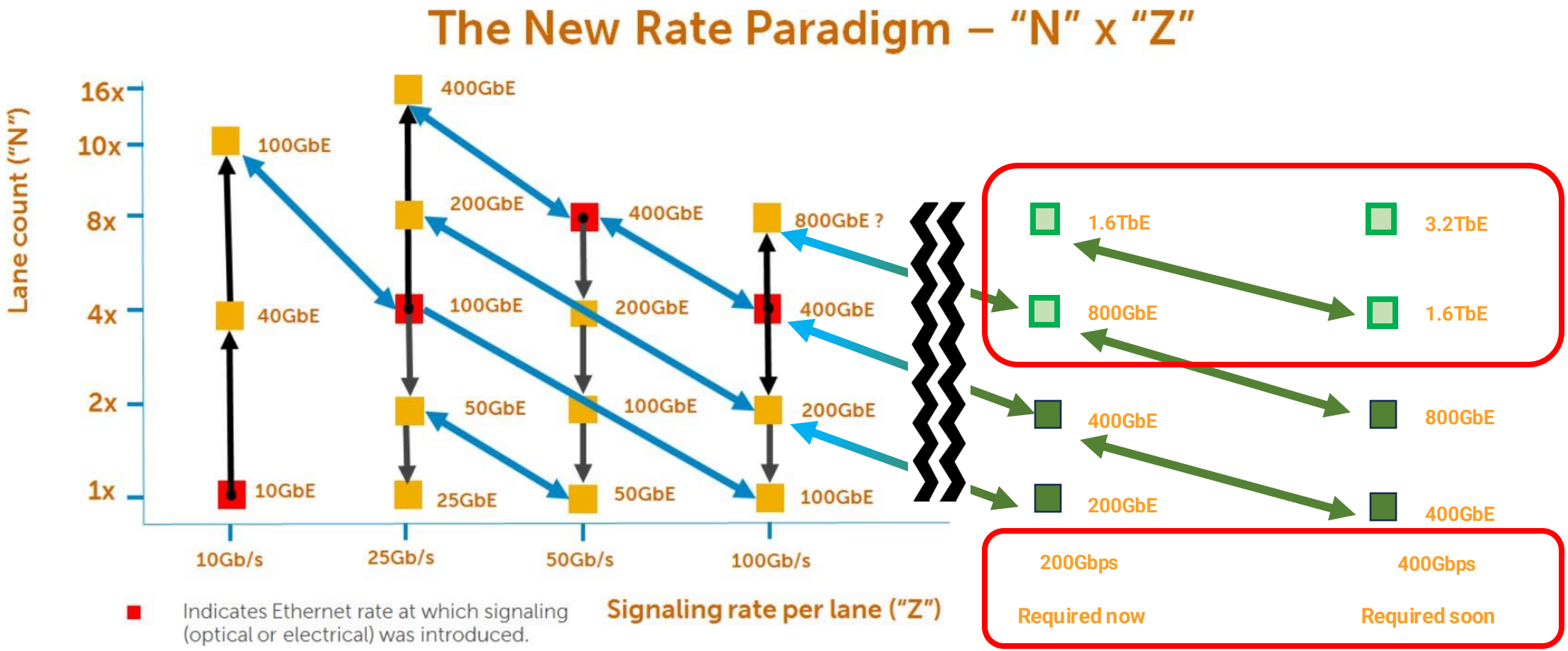

Indicates opportunities for EO polymers

Deploying Ethernet or Infiniband or proprietary protocols at speeds of 200Gbps/lane and beyond is becoming increasingly challenging

Source: John D'Ambrosia; annotated

4 Options to Scale Optical PMD

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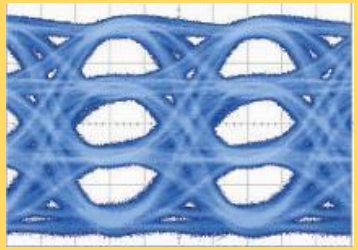
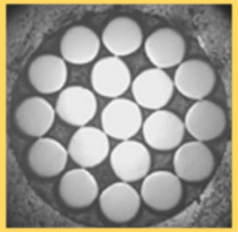
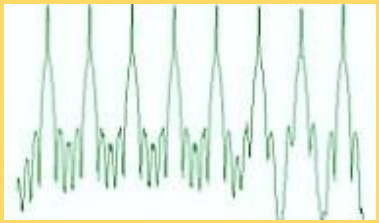
multi-level modulation



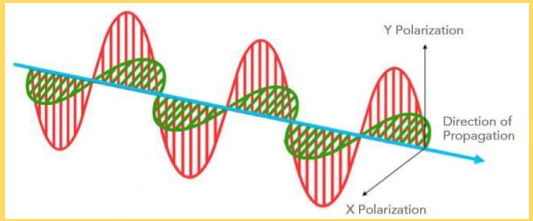
Space Division Multiplexing



Wavelength Division Multiplexing



Polarization Multiplexing



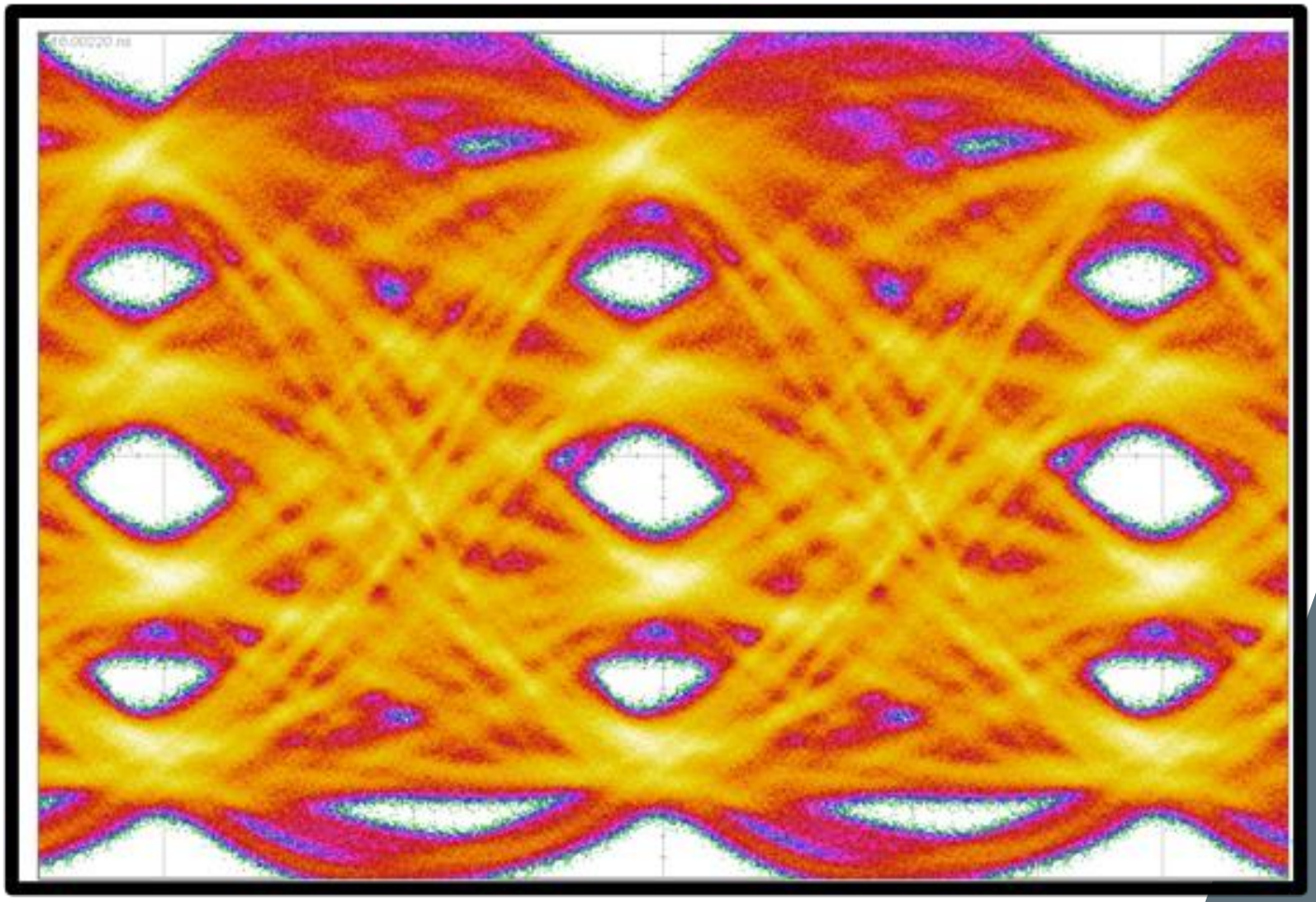
- It took **~7 years** for PAM4 mass adoption. It will need to be used until 3.2T
- SDM and WDM have ”run way” >3.2T but industry is going to have to learn – and scale - miniature fiber handling and “attach” techniques…***fast and cost effectively***
- The likelihood that coherent will be adopted by datacenters or datacom is **miniscule** until ~6.4T (see item 1 above)

Source: Adapted from Paraskevas Bakopoulos, Nivida, 10 September 2024

Polymer Performance To Address PMD Challenge

Internal Performance Results

100 Gbaud, 200 Gbit/s, V_{drive} < 1 V



Drive Voltage ~1V

Up to 100GBaud PAM4 (200Gbps)

Open eyes…

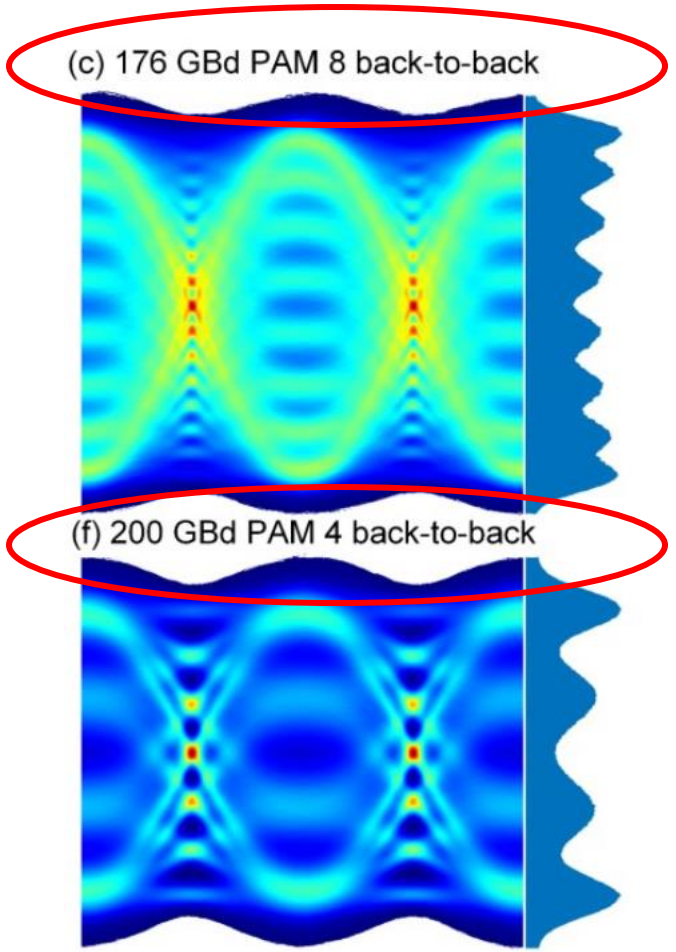
Ideal for low voltage 800Gbps 4 lane and 8 lane 1.6Tbps pluggable transceivers

Source: LWLG

3rd party use of Perkinamine® LWLG polymers

LIGHTWAVELOGIC®

- *World class performance EO polymers* used for *400G lanes*
- Next generation node for datacenters
- Potential to enable 4 lane pluggable transceiver at 1.6Tbps & 8 lane at 3.2Tbps



Sources: ETH Zurich, Kulmer et al, OFC 2024 (W4H.5), LWLG Perkinamine™ chromophore series 3 material

Positioning for 400Gbps per lane

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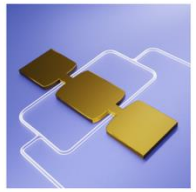
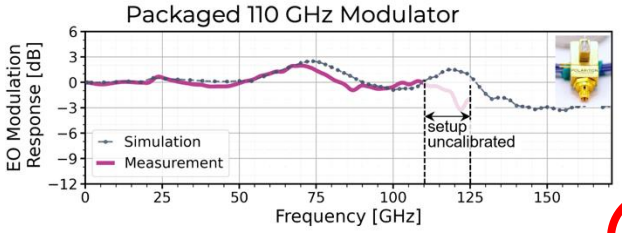
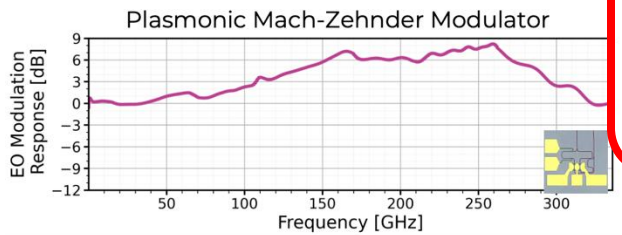
Plasmonic MZ with LWLG EOP

Mach-Zehnder







Small RC-constant & high-speed

→ Packaged modulator: >110 GHz (next-gen: 145 GHz)

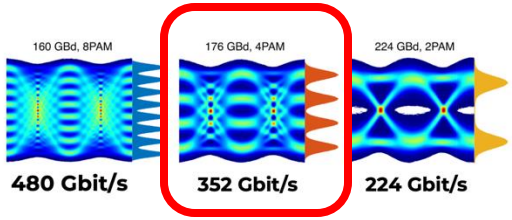
→ Chip-level >300 GHz

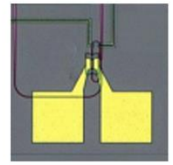
→ Chip-level *high-speed*[1] >500 GHz

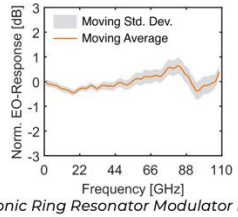
[1] Burla, Maurizio, et al. "500 GHz plasmonic Mach-Zehnder modulator enabling sub-THz microwave photonics." *Apl Photonics* 4.5 (2019).

Plasmonic RR with LWLG EOP

Beyond 400 G/λ: Plasmonic Ring Resonator Modulator







- Fiber-to-fiber loss: <6 dB
  1.6 dB device loss
- Extinction Ratio > 10 dB
- EO Bandwidth > 110 GHz
- 461 Gbit/s AIR

Blatter et al., *Plasmonic Ring Resonator Modulator Demonstrating IM/DD >400G per lane*, ECOC 2024, Tu1D.1

Polariton packaged products with Lightwave Logic EO polymer engine…

Sources: Polariton, LWLG & ETH Zurich

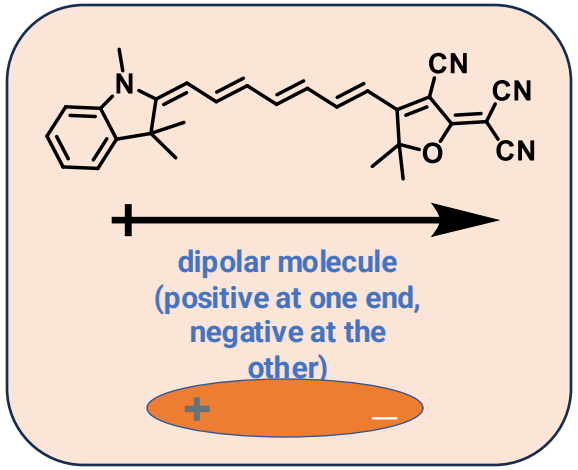

Chromophore production

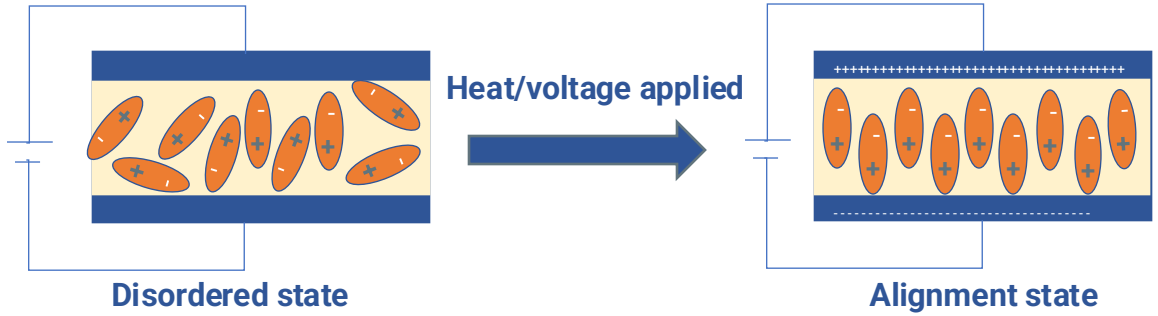
Perkinamine® Electro-Optic polymers

LIGHTWAVELOGIC®

Our polymers are world-class and proven by third parties

Electro-optic polymers can be used to fabricate optical modulators



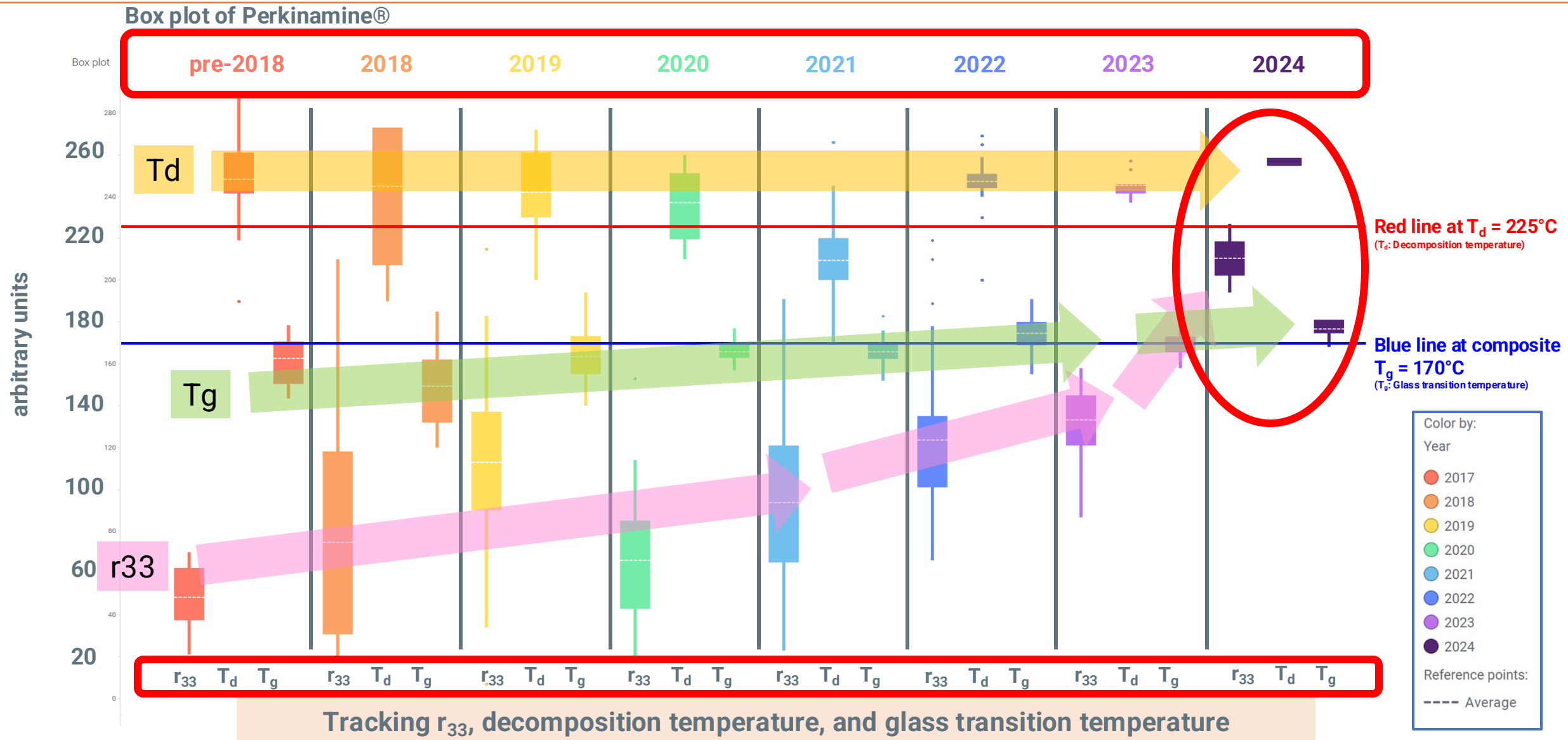


We create organic chromophores…

- Designed, simulated and modeled in Denver, Colorado
- Manufacturing chemistry facility that can scale volume
- Deep experience with material characterization, testing, lifetime, and reliability

LWLG EO polymer materials have significantly improved…

LIGHTWAVELOGIC®



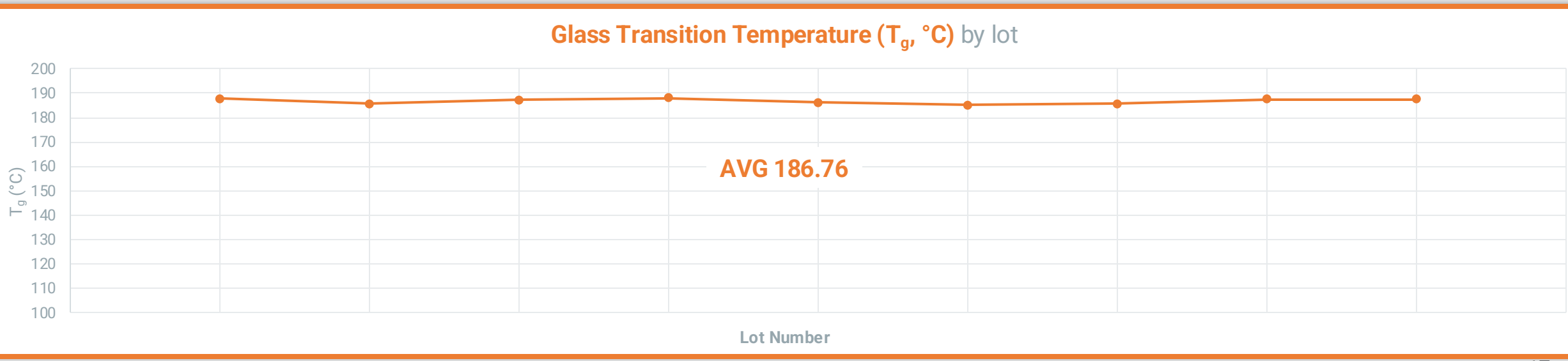
Tracking r_{33}, decomposition temperature, and glass transition temperature

A box plot or boxplot is a method for graphically demonstrating the locality, spread and skewness groups of numerical data through their quartiles

Source: LWLG

Lot Uniformity

LIGHTWAVELOGIC®



Source: LWLG

LWLG Electro-Optic Polymers: Ready for Commercialization

LIGHTWAVELOGIC®

World-class chemical synthesis lab

State-of-the-art equipment for process-scale synthesis of chromophores

Industry-standard purification techniques

State-of-the-art equipment for production of highly pure materials

Source: LWLG


Reliability

Material Parameters and Comparison

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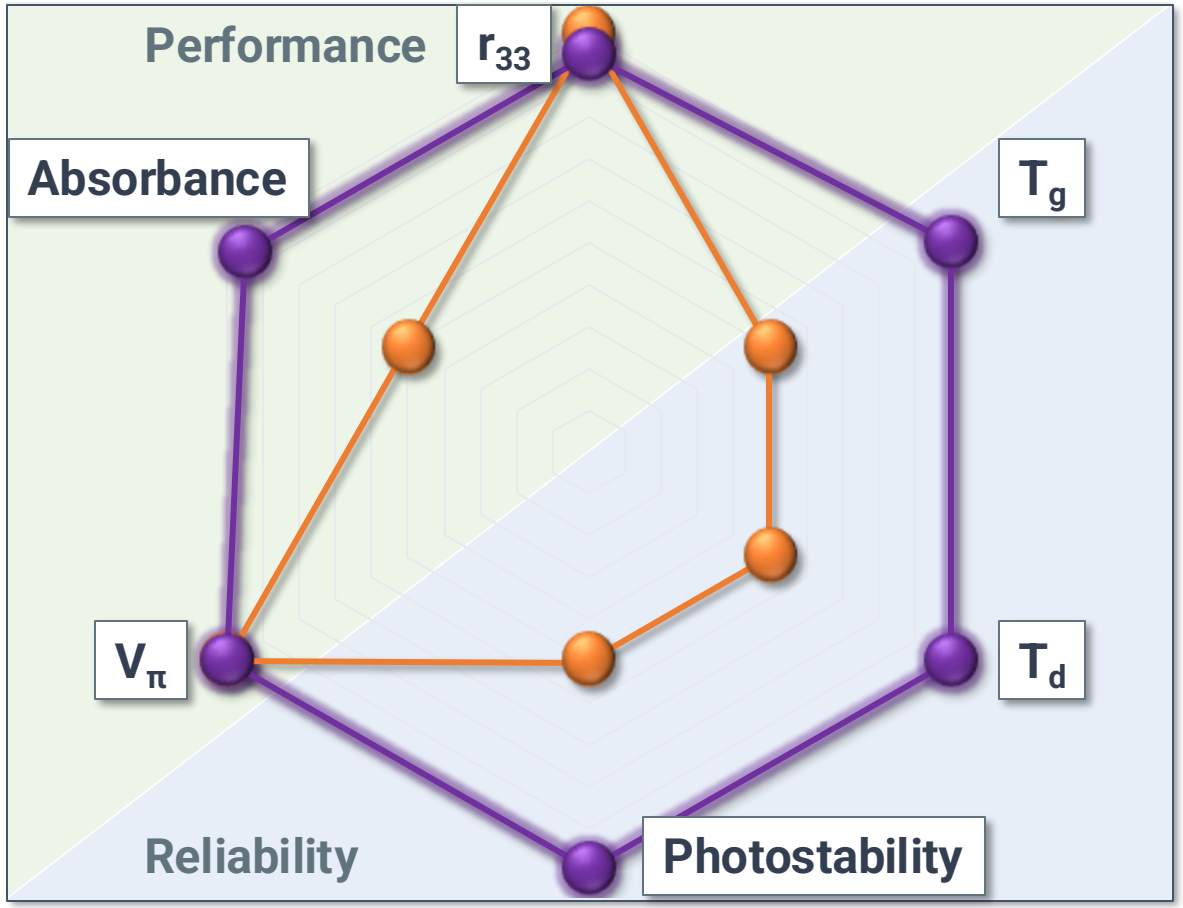
Material comparison: TFLN vs LWLG Polymers

Thin-Film $LiNbO_3$ (TFLN)	LWLG Electro-Optic Polymers
r_{33} (1310 nm) ~31 pm/V	r_{33} (1310 nm) > 200 pm/V
Fabrication and processing: *DIFFICULT & HIGH TEMP (>1000°C)*	Fabrication and processing: *EASY* (foundry compatible) *& LOW TEMP (<150°C)*
Relative Permittivity: 30 (poor velocity matching)	Relative Permittivity: 3-4 (good velocity matching)

Material comparison: LWLG Polymers vs Competition/Legacy Polymers



LWLG EO polymers are world-class in every parameter and designed for reliability.

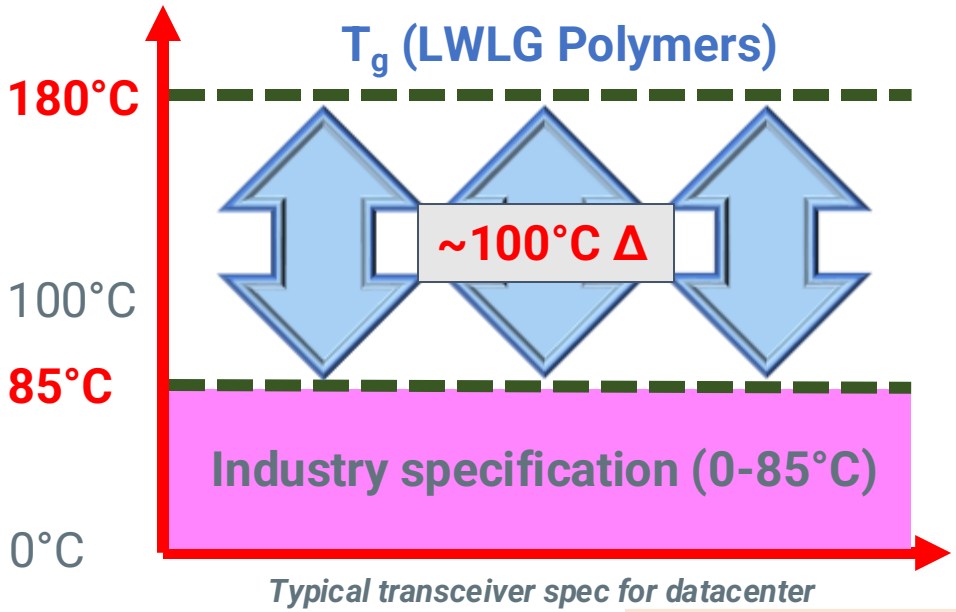
Source: LWLG

Temporal Stability – *Design for Reliability*

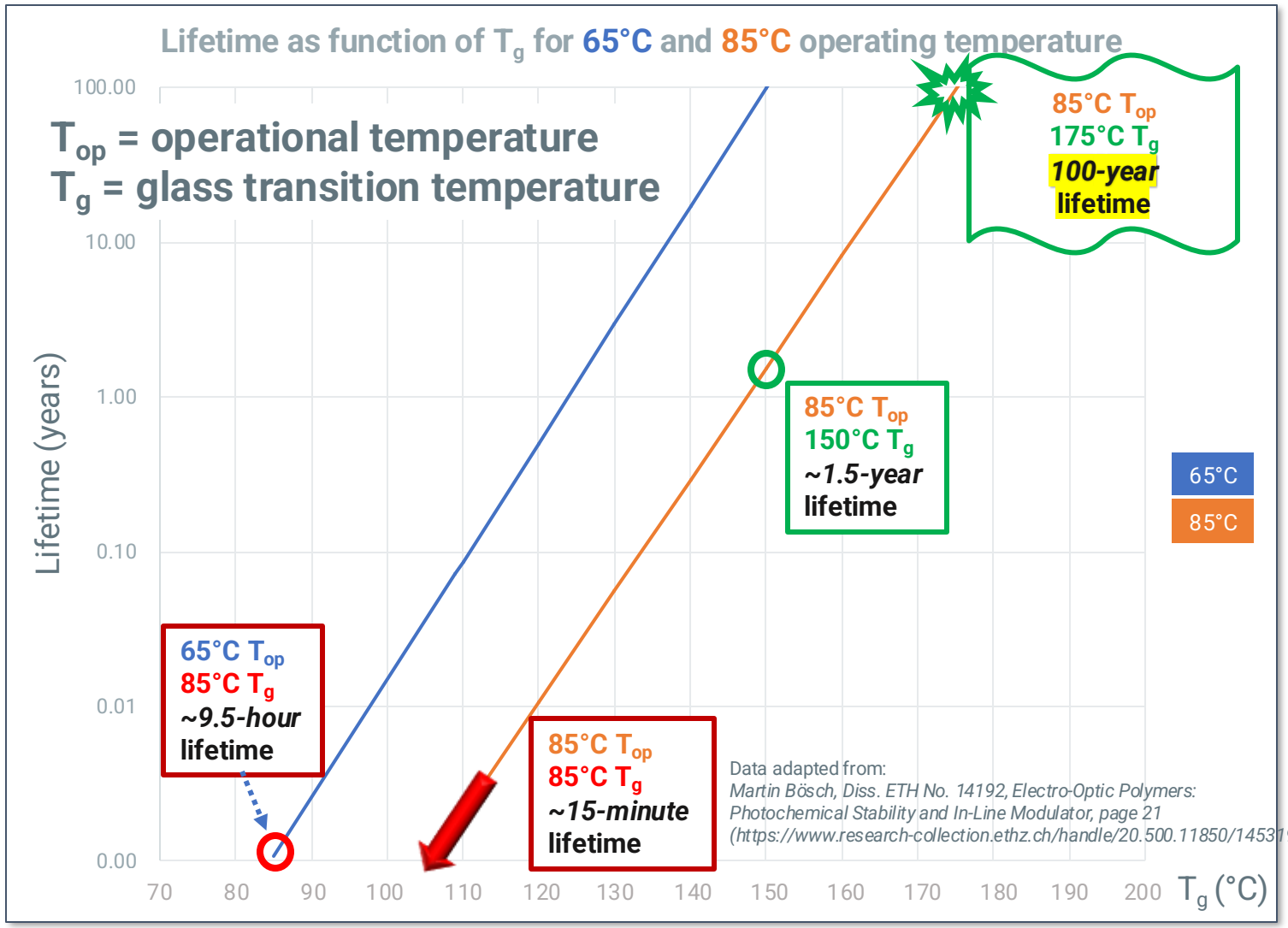
LIGHTWAVELOGIC®

Temporal Stability = Orientational Stability of Poled State

- Lifetime = 10% loss of poled state
- Increasing T_g of material increases lifetime (protects from loss of activity due to depoling)
- *LWLG materials designed for high T_g*



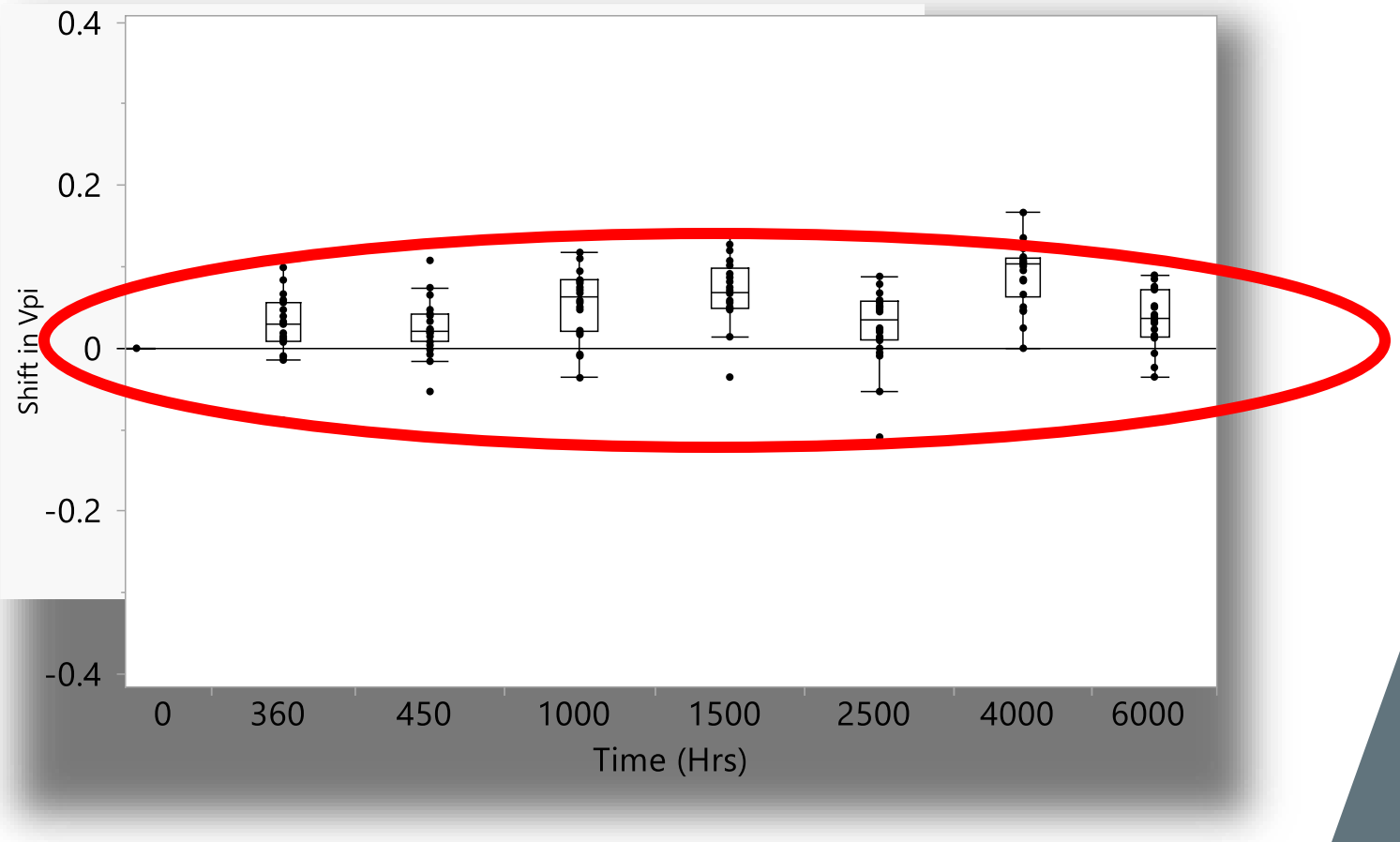
Typical transceiver spec for datacenter



LWLG EO polymers are uniquely resistant to de-poling due to high T_g.

Source: LWLG

Modulator Thermal Stability (TS)

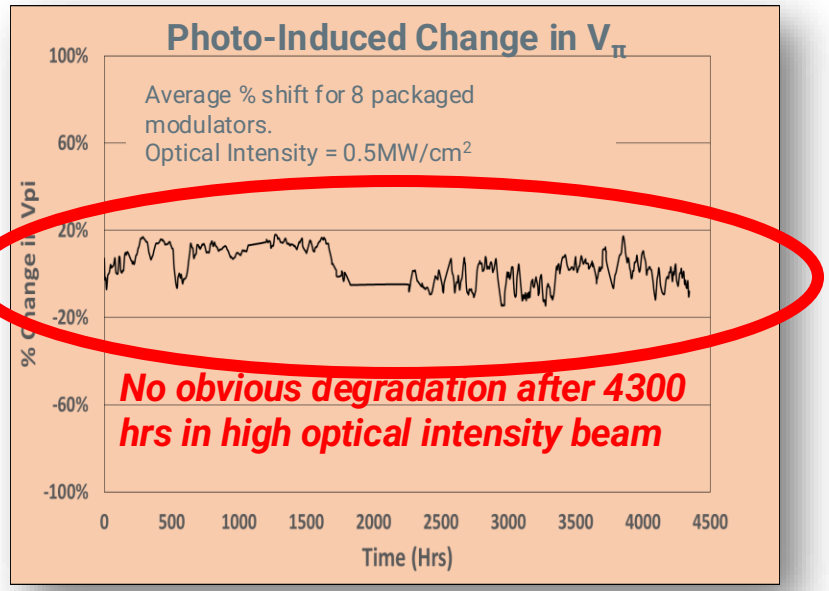


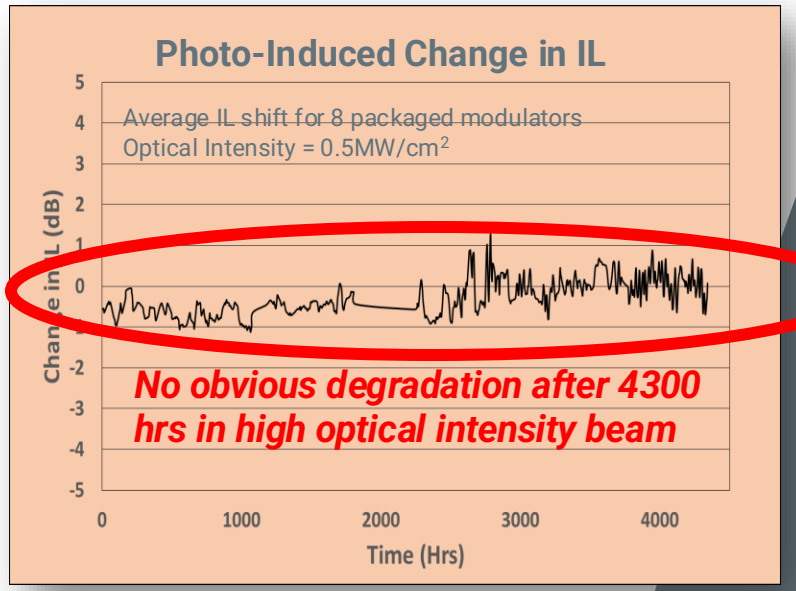
- The V_π on 20 modulators is stable over 6000hrs.
- The average shift over ~ 6000hours is 1.2% and it is within the margin of error of the test setup.

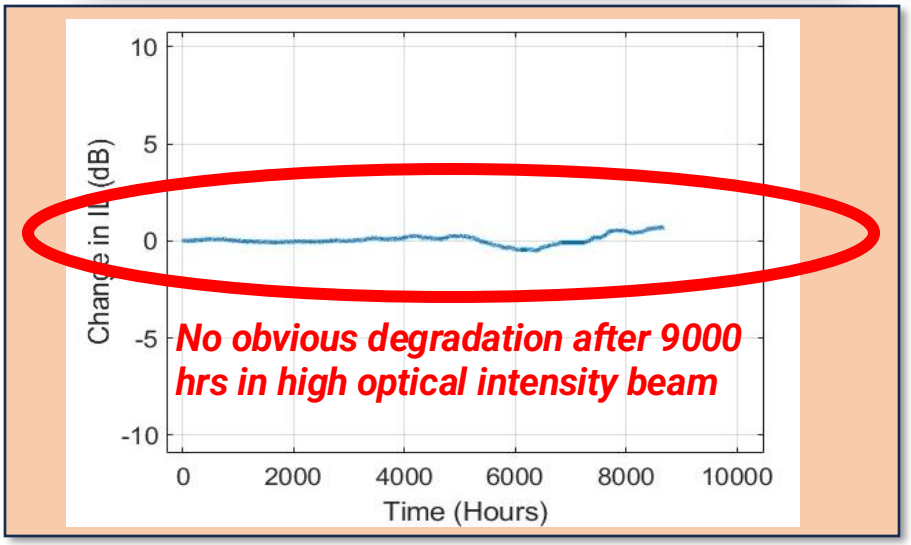
Modulator V_π stable after 6000 hrs

Source: LWLG

Photostability vs Voltage and Insertion Loss





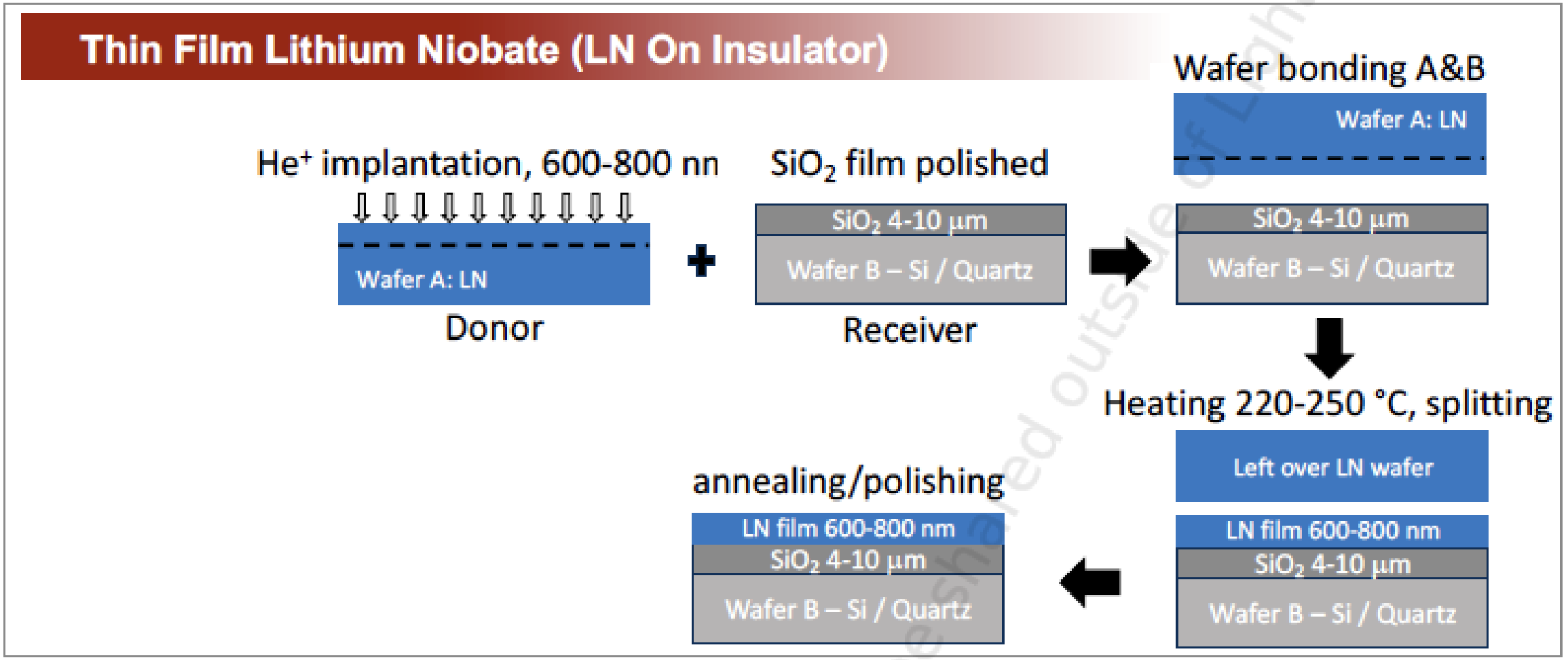


Source: LWLG

Long and short-term photostability *does not seem to be an issue* with LWLG EO chromophores when protected from O_2


Silicon foundry compatible...

”DFM” & Ability To Scale Will Be Important For Any New Modulator Technology



Source: AFR presentation at OFC 2024

Large incumbent fabs Need to Adapt if TFLN is Going To Scale

Source: LightCounting “SP, LDP & CPO” May 2024

Polymers are ideal for silicon foundries…

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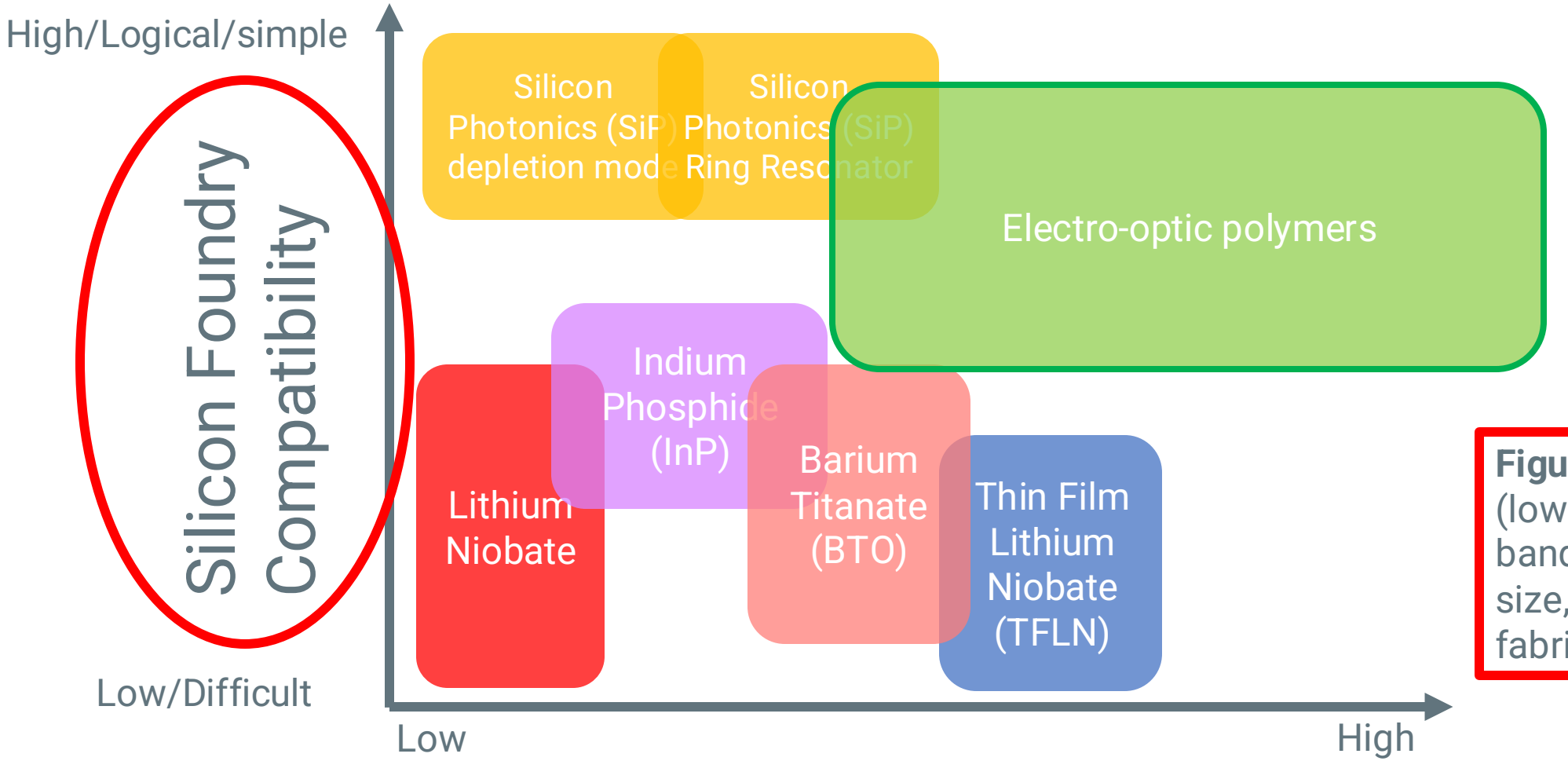


Figure of Merit (low V, high bandwidth, small size, ease of PDK, fabrication)

Polymer positioning for heterogeneous integration is aligns with silicon foundries very well

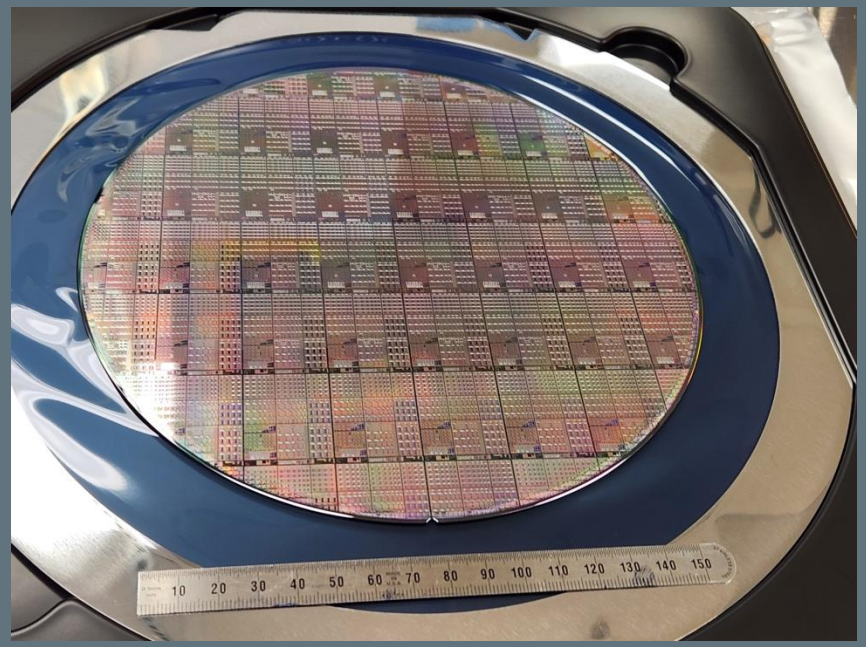
Source: LWLG

Leveraging silicon eco-system

- Polymers *can easily* fit into silicon foundries compared to legacy and new exotic materials
- Polymers *extend* silicon photonics performance
- Polymers *meet* the performance for datacenter applications

Commercial Foundry

200 mm Wafer



Source: LWLG

Modulators Produced at A Commercial Fab

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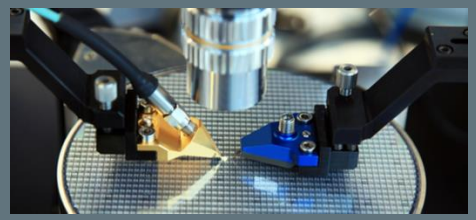
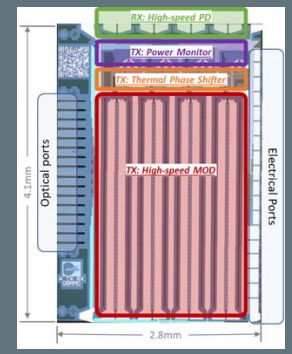
amf ADVANCED MICRO FOUNDRY

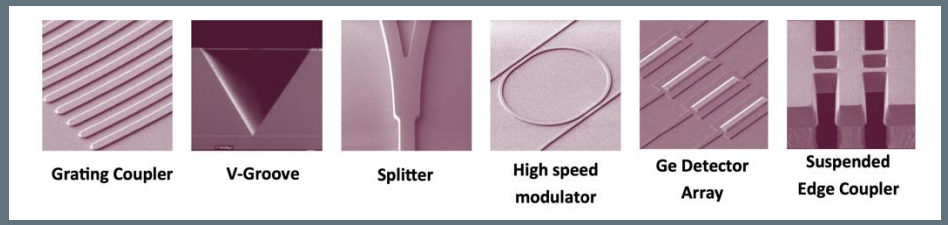
- Partnering with AMF to produce polymer slot modulators on 200mm silicon wafers

A High Mix specialty commercial foundry for integrated optics manufacturing





AMF Transceiver Reference Design



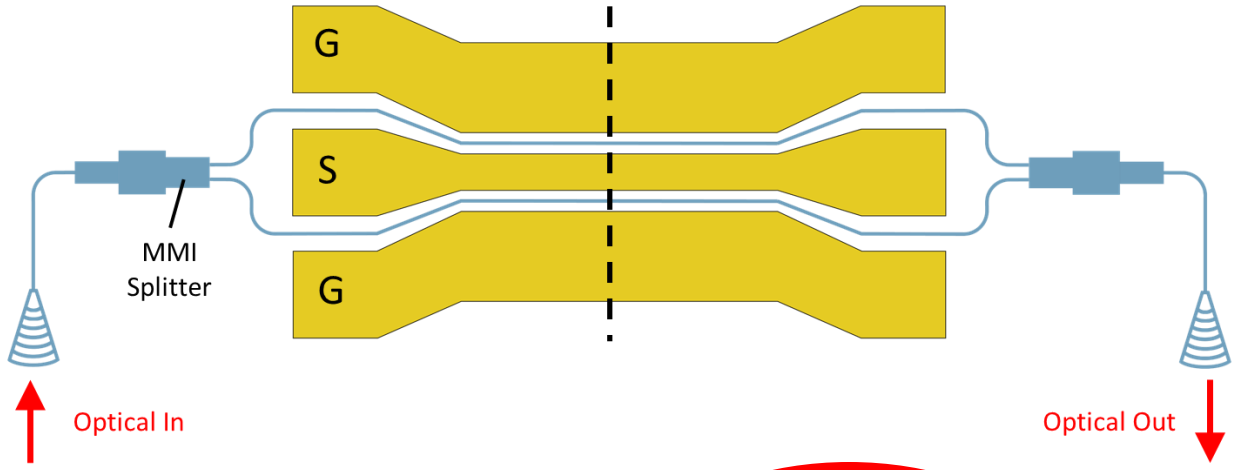
Comprehensive PDK

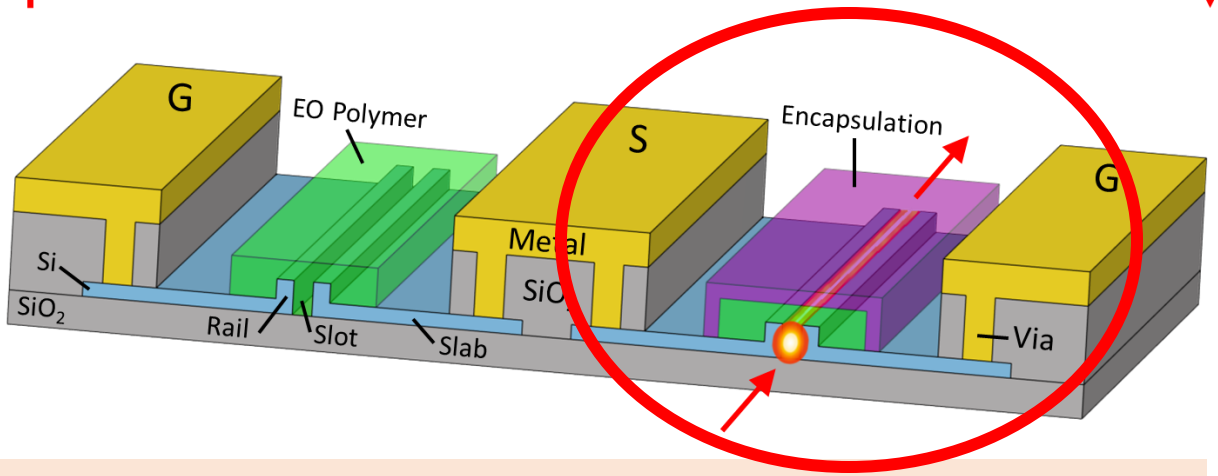
Source: AMF; https://www.advmf.com


Integration of polymers with silicon…

Polymer Slot Modulator

Our polymers are ***easily fabricated*** in silicon fabs → ideal for heterogenous integration





EO polymer integration onto silicon slots and wafers

- **Heterogeneous integration** of polymer on Silicon Photonics Platform
- Low drive voltage and small form factor for **low power consumption** and high density
- Very high bandwidth (**70-100GHz**)
- Fabricated onto **200mm** silicon wafers

Source: LWLG

Cross-section of fully etched slot waveguide

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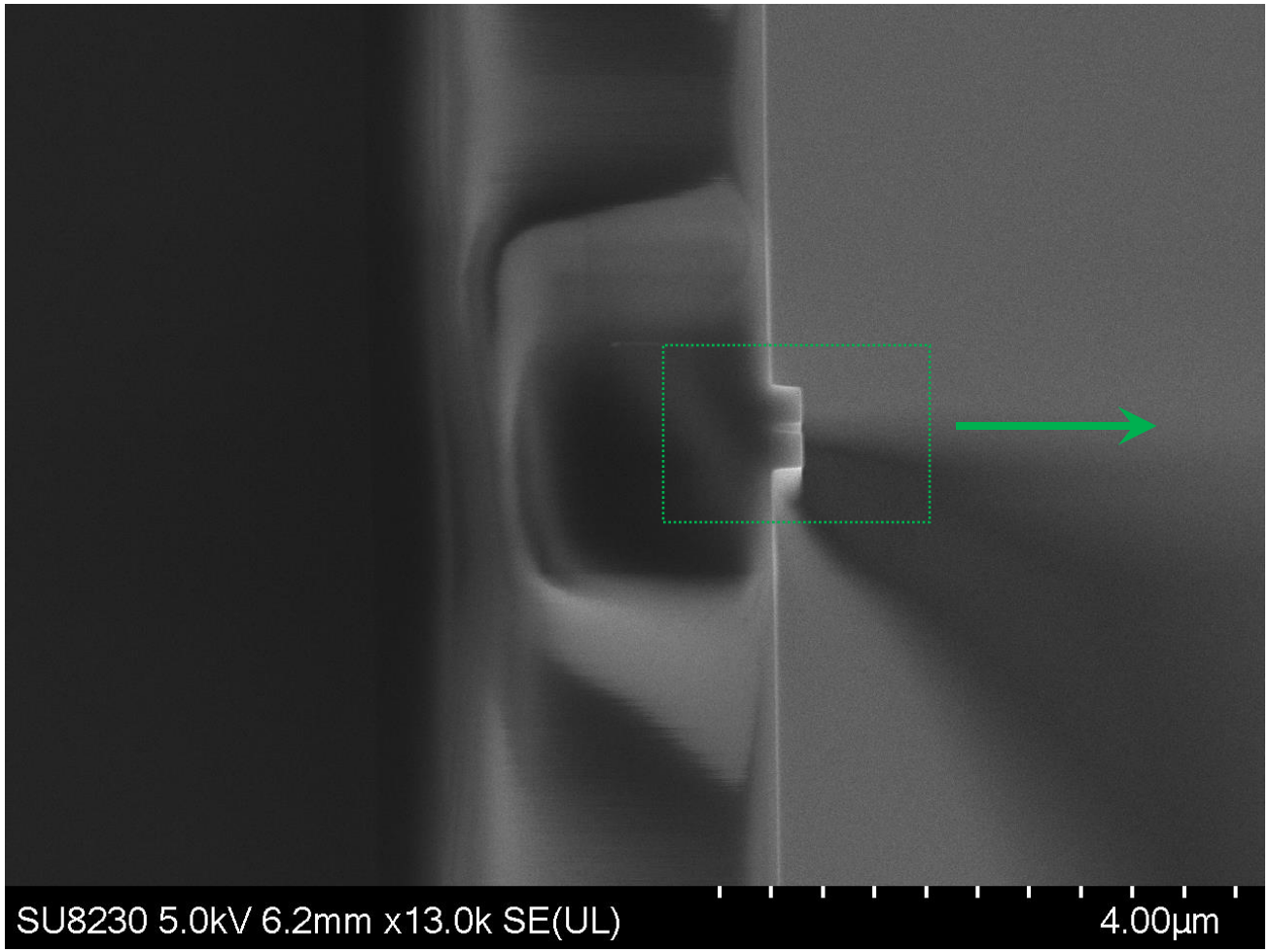

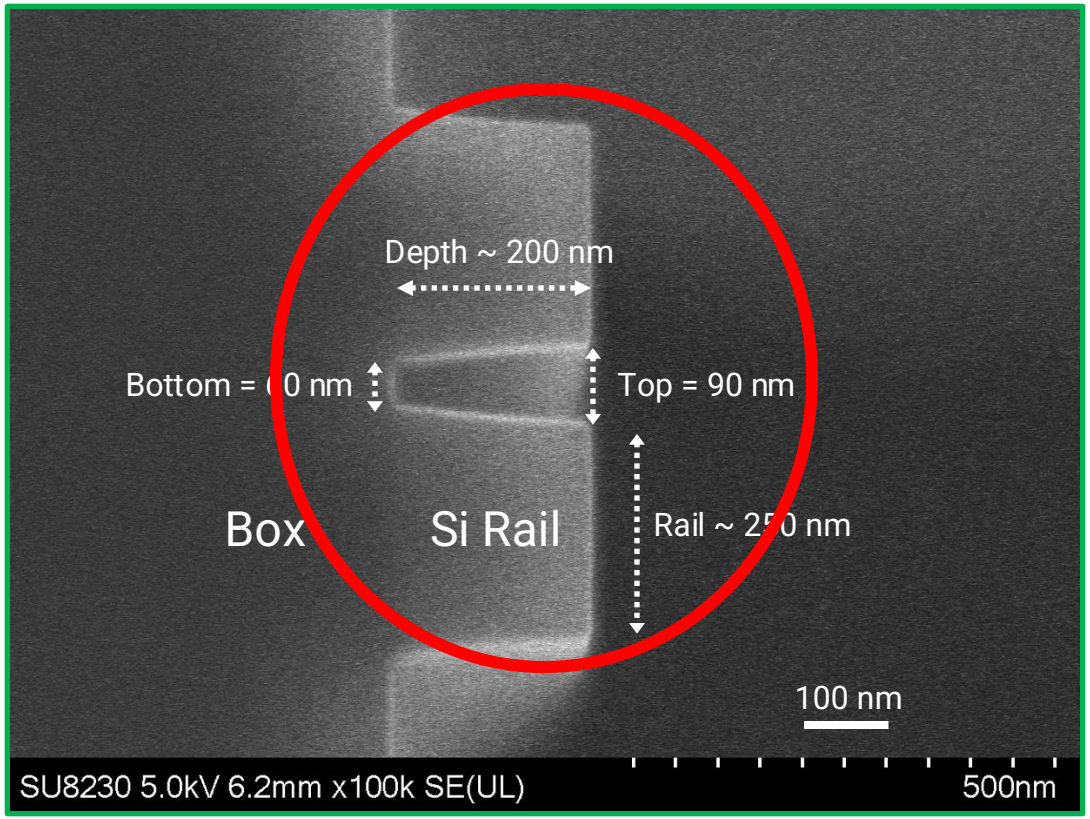

Clean, sharp silicon slots with width <100 nm, sidewall angle > 86°

Source: LWLG

Modeling EO polymers and silicon slots

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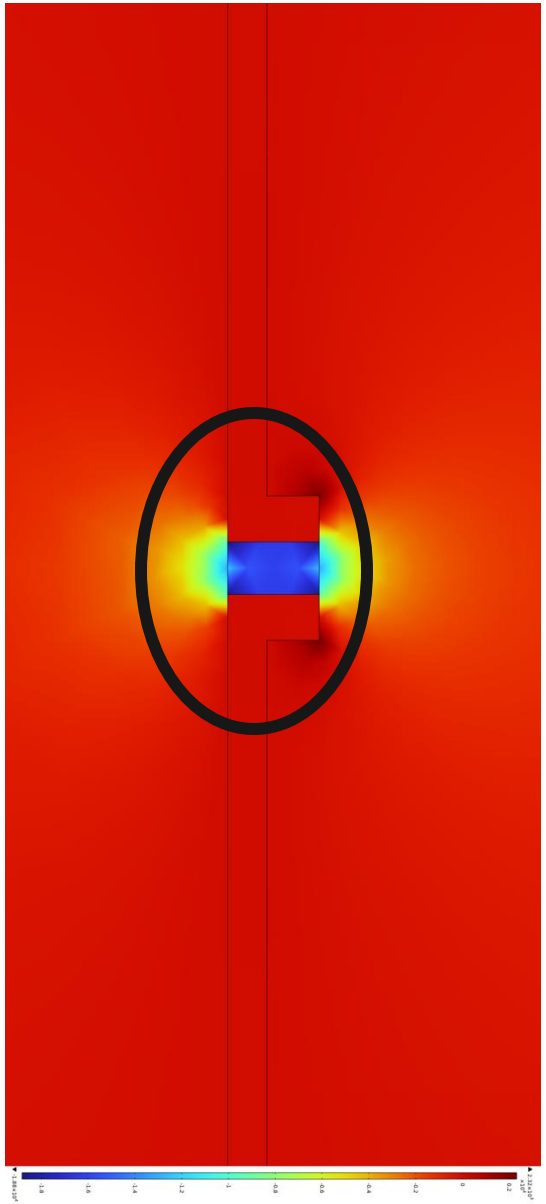
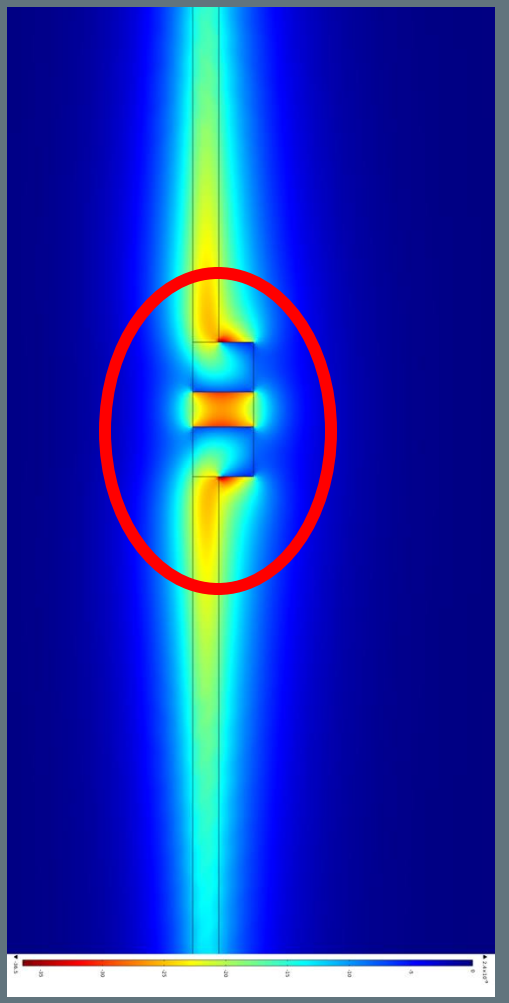
E-field simulation

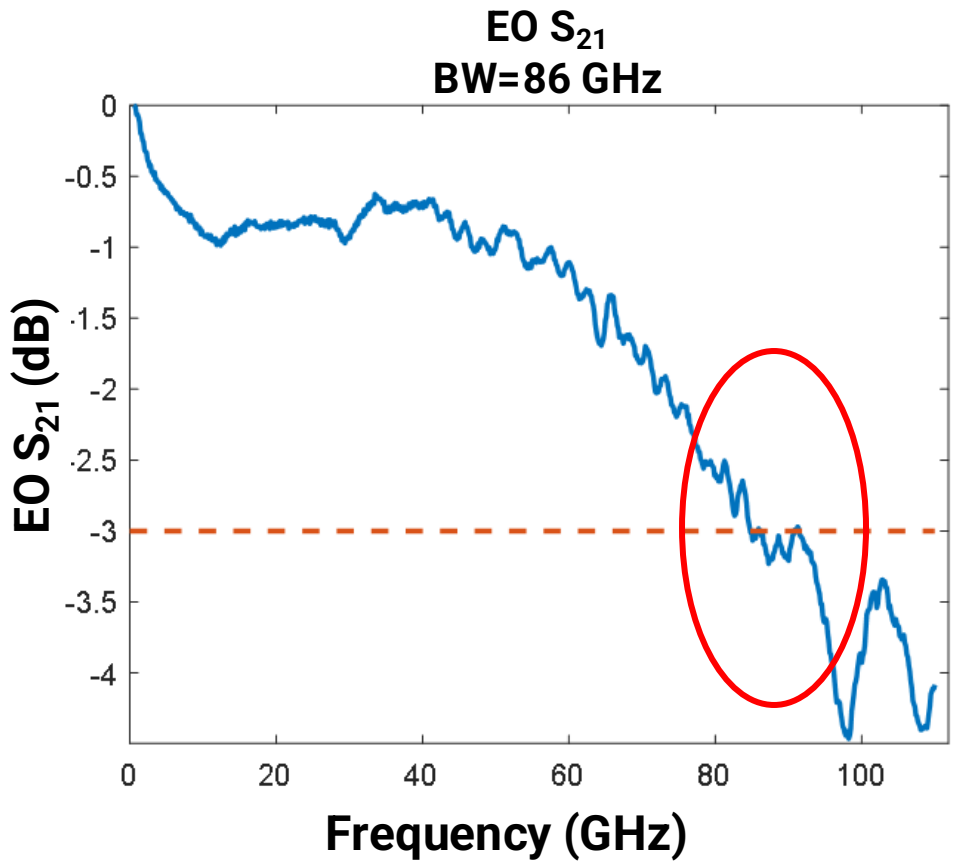




Optical mode simulation

Source: LWLG

High BW MZ Polymer Slot™ Modulator



EO Bandwidth=86 GHz

EE Bandwidth>110 GHz

Enables optical signaling for >200Gbps lanes

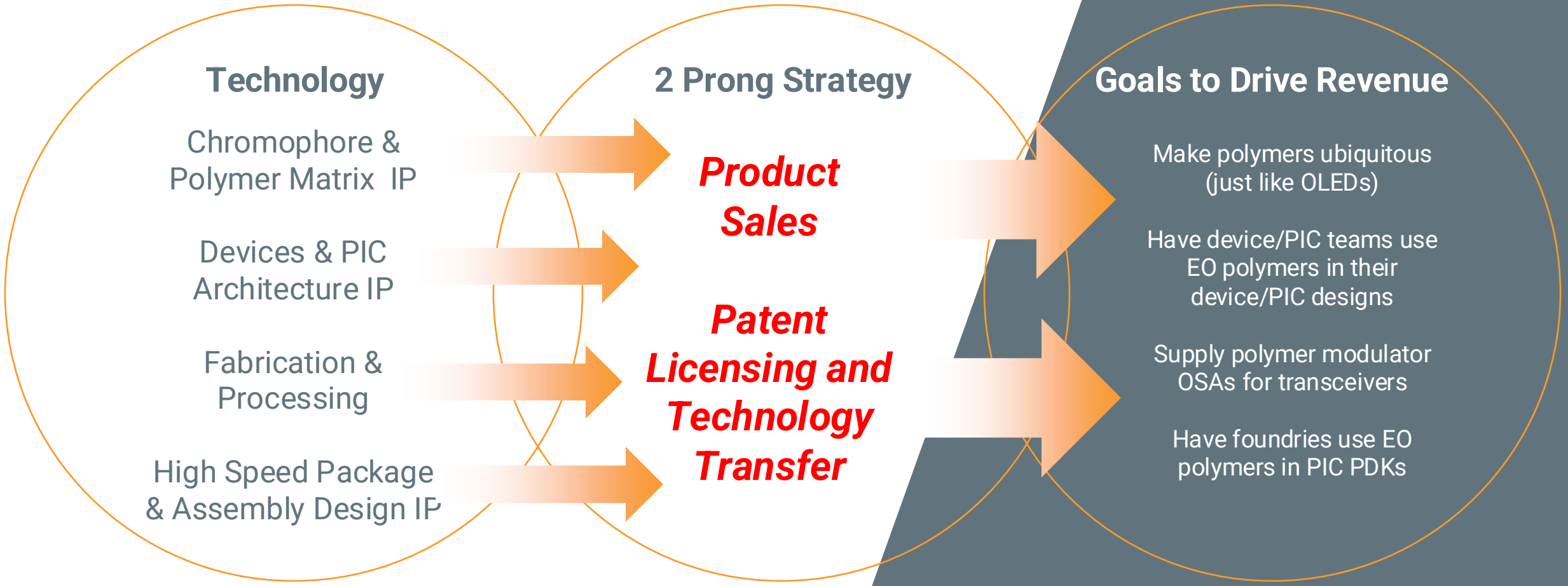
Source: LWLG


Our business model is innovative…

Implementing a New Technology Platform

LIGHTWAVELOGIC®

Licensing model provides inherent scalability



Patent licensing and product sales to drive revenue

Source: LWLG

Summary

- Our heterogeneous polymer/silicon platform is poised to *become ubiquitous* (just like OLED polymer material)
- We are open *to license our material,* do technology transfer, and to leverage your position in the market-place…
- EO polymers continue to show technical progress with *polymer reliability and stability…200G lanes* and performance head-room to go 400G lanes and more…

Source: LWLG

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LIGHTWAVELOGIC®
Faster by Design

Thank you for listening

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