



LIGHTWAVELOGIC®

Faster by Design

Commercializing reliable hybrid electro-optic polymer modulators

2nd October 2023

Michael Lebby
CEO, Lightwave Logic



Safe harbor

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.

- Electro-optic polymers are *competitively superior and unique*...
- We continue to increase our *technical progress with reliability and stability*...
- With our partners, we are positioned to have *polymers scale* for optical networking...
- We have the team, resources, and plans in place to *make polymers ubiquitous*...

- What we do...and why?
- Market dynamics
- Electro-optic polymers
- Licensing polymers & creating devices/PICs
- Summary



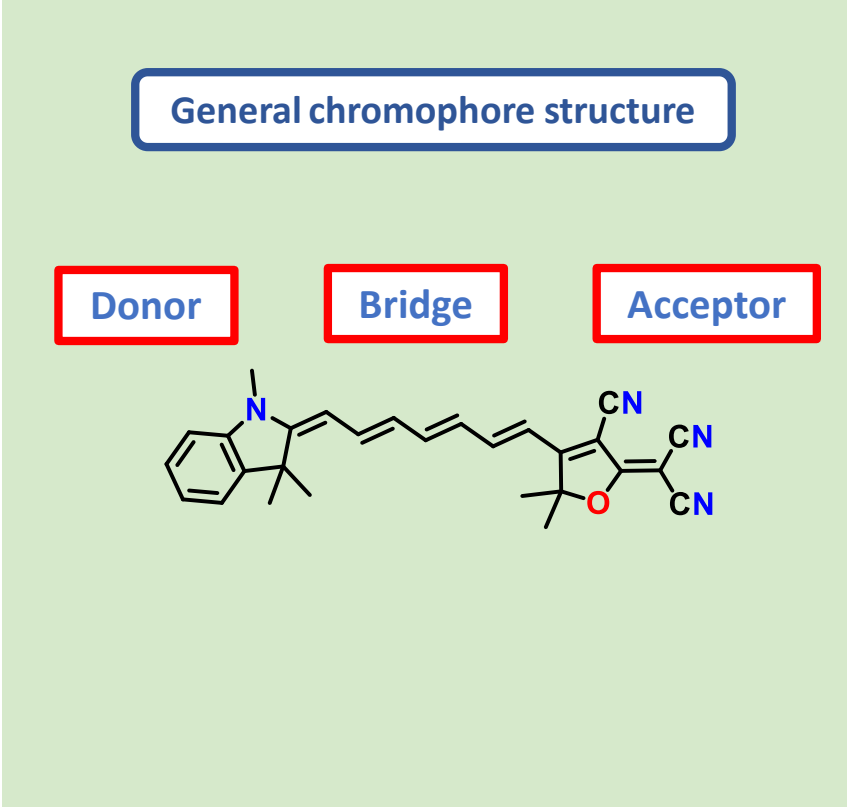
A server room with rows of black server racks. The scene is illuminated by vibrant, glowing light trails in shades of blue, orange, and purple that swirl and streak across the floor and racks, creating a sense of dynamic energy and data flow. The text "What we do..." is centered in the foreground in a clean, white, sans-serif font.

What we do...



We create electro-optic organic polymers

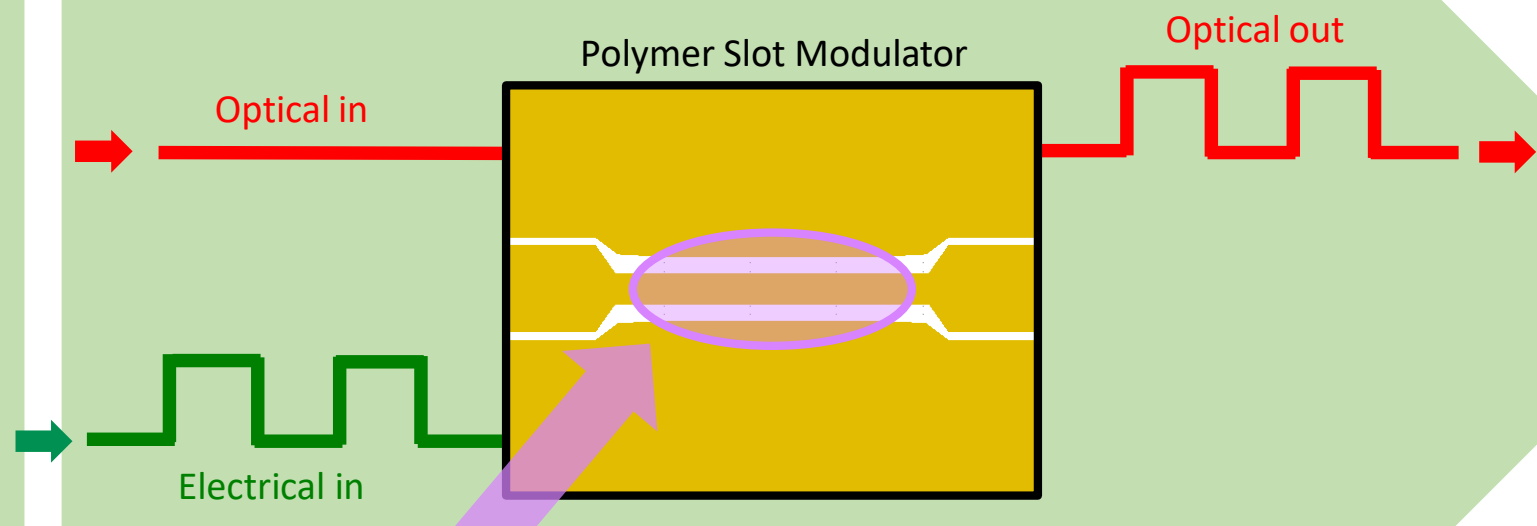
LIGHTWAVELOGIC®



Advanced modeling and simulation design for organic chromophores



Apply polymer to create modulators



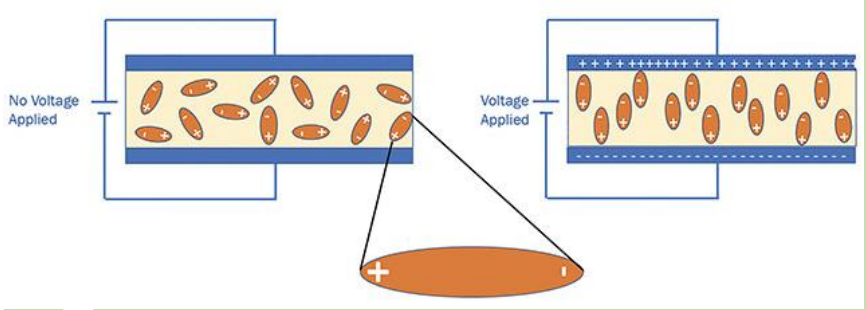
LWLG EO polymer

EO polymers → Fast, stable, reliable, low power consumption, and very small in size



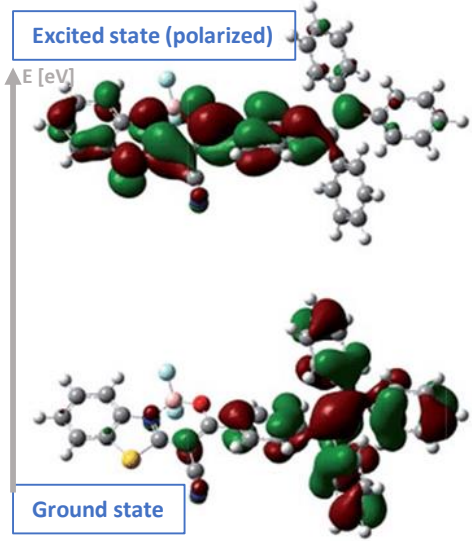
We pole the polymers for optical action

Poling process



Dipoles are aligned to make non-centrosymmetric material

Refractive index change



RSC Adv., 7, 1348-1356, 10.1039/C6RA25871A.

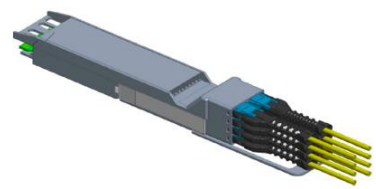
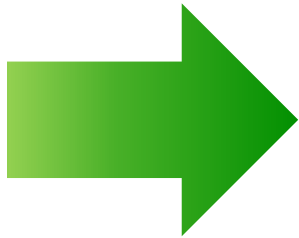
The electric field shifts the electron cloud to the excited-state molecular orbitals; this alters the refractive index of the electro-optic material, which in turn causes a phase change to any transiting optical signal

Electro-optic action is very fast and low voltage (→ low power)

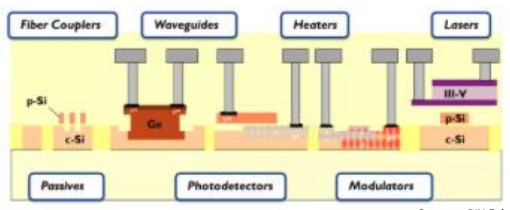
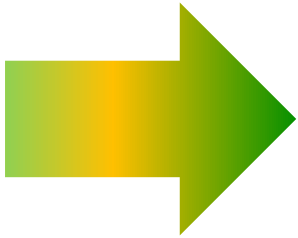


Immediate polymer opportunities

Electro-optic polymer modulators for transceivers suppliers

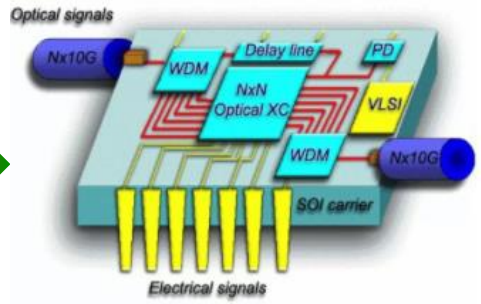
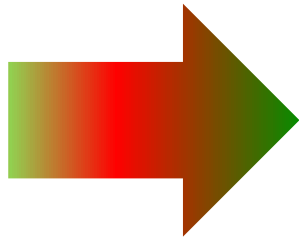


Electro-optic polymer modulators for Silicon Photonic platforms



Source: ePIX Fab

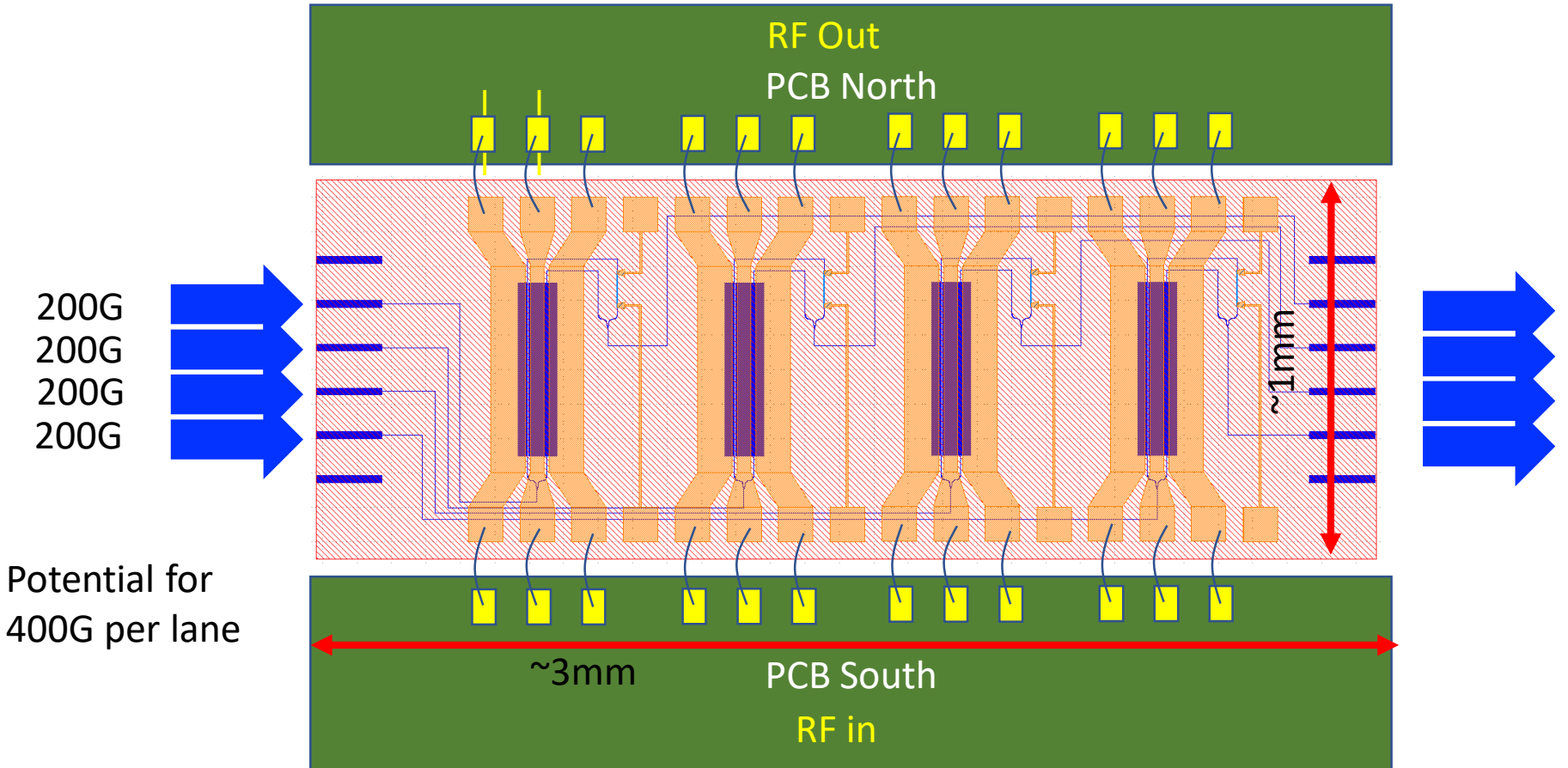
Electro-optic polymer modulators for "Other" platforms including optical/quantum computing, HPC, and RF applications



Electro-optic polymer engines for fiber optic communications



800G Integrated polymer modulators



200G
200G
200G
200G

Potential for 400G per lane

- Optical 4 channel Polymer PIC layout with Mach Zehnder Interferometers (MZI) arrays
- Fiber array to be connected on both East and West side using Edge couplers
- Electrical CPW transmission length ~1mm

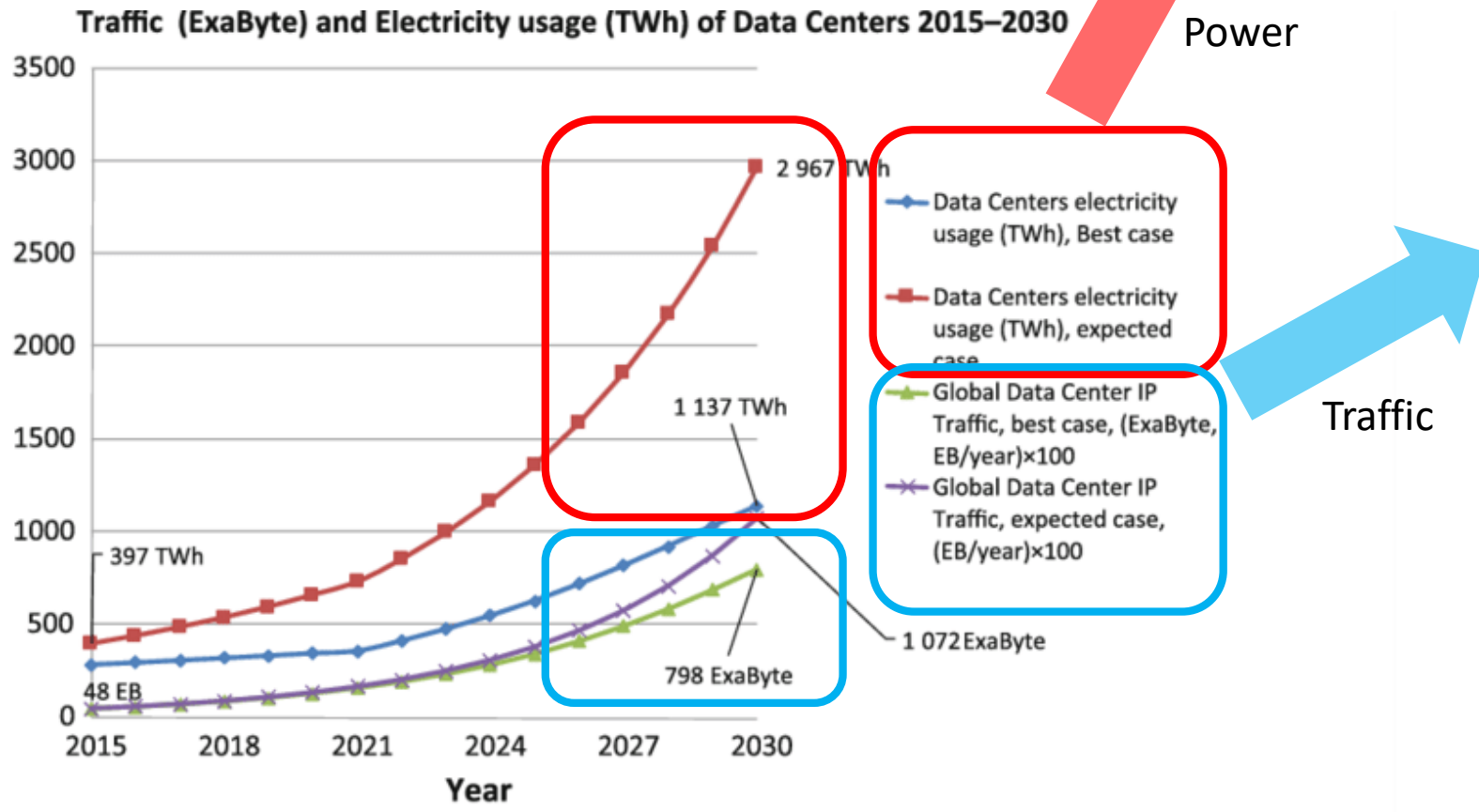
4 Channel polymer PIC chip as part of our P²IC™ platform

A digital illustration of a server room. The room is filled with rows of black server racks. The floor is a light gray, and the ceiling is a white grid. In the center, the word "Why?" is written in a large, white, sans-serif font. The scene is illuminated by vibrant, glowing light trails in shades of blue, orange, and purple, which appear to be moving through the server racks and across the floor, creating a sense of dynamic energy and data flow.

Why?



Industry Achilles Heel....



Major challenge for datacenters and service providers

Power is growing exponentially with increased traffic levels...it is the Achilles Heel...

Electro-optic polymers are competitively superior

LIGHTWAVELOGIC®

Perkinamine®
electro-optic
chromophore
material

Polymer
modulator
devices

High material-level
thermal and photostability

Long-term storage
and operational
durability

>3x faster modulation
than existing products

~10x lower power
than existing
products

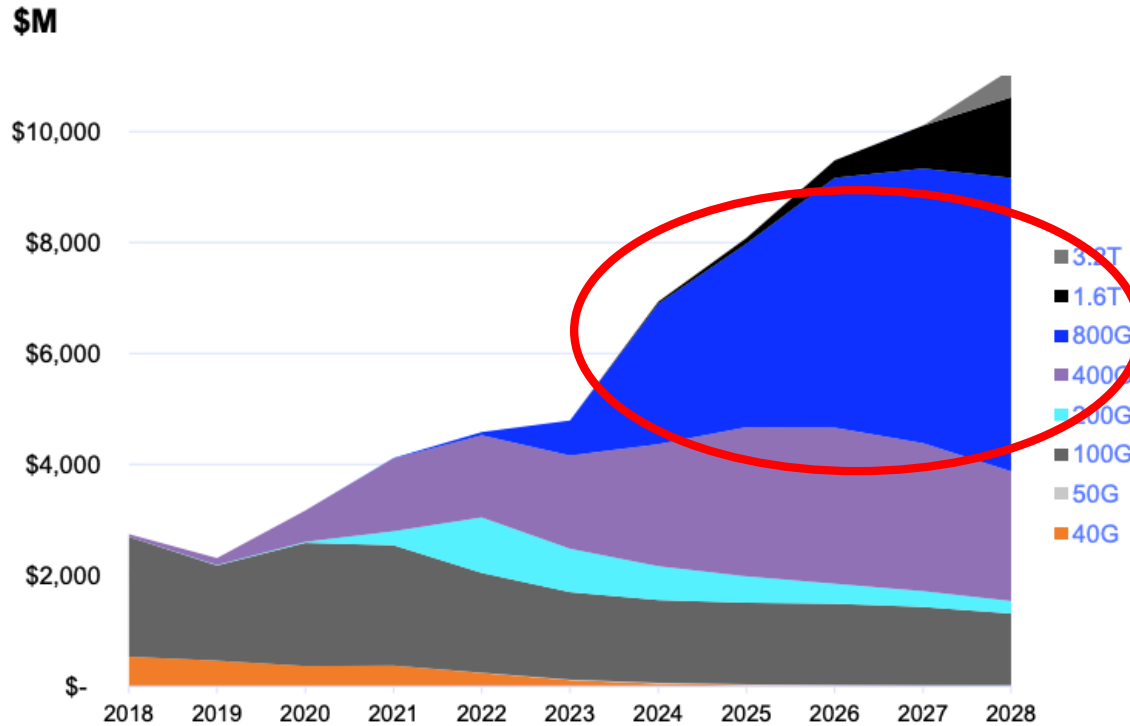
EO polymers → Fast, stable, reliable, low power consumption, and very small in size

A server room with rows of black server racks. The scene is illuminated by vibrant, glowing light trails in shades of blue, orange, and purple that swirl and streak across the floor and racks, creating a sense of dynamic energy and data flow. The text "Market dynamics and potential" is overlaid in the center in a bold, white, sans-serif font.

Market dynamics and potential

As anticipated, G-AI is driving rapid deployment of 800G+ solutions

DATAKOM TRANSCIEVER GLOBAL MARKET



Source: LightCounting, Internal Estimates



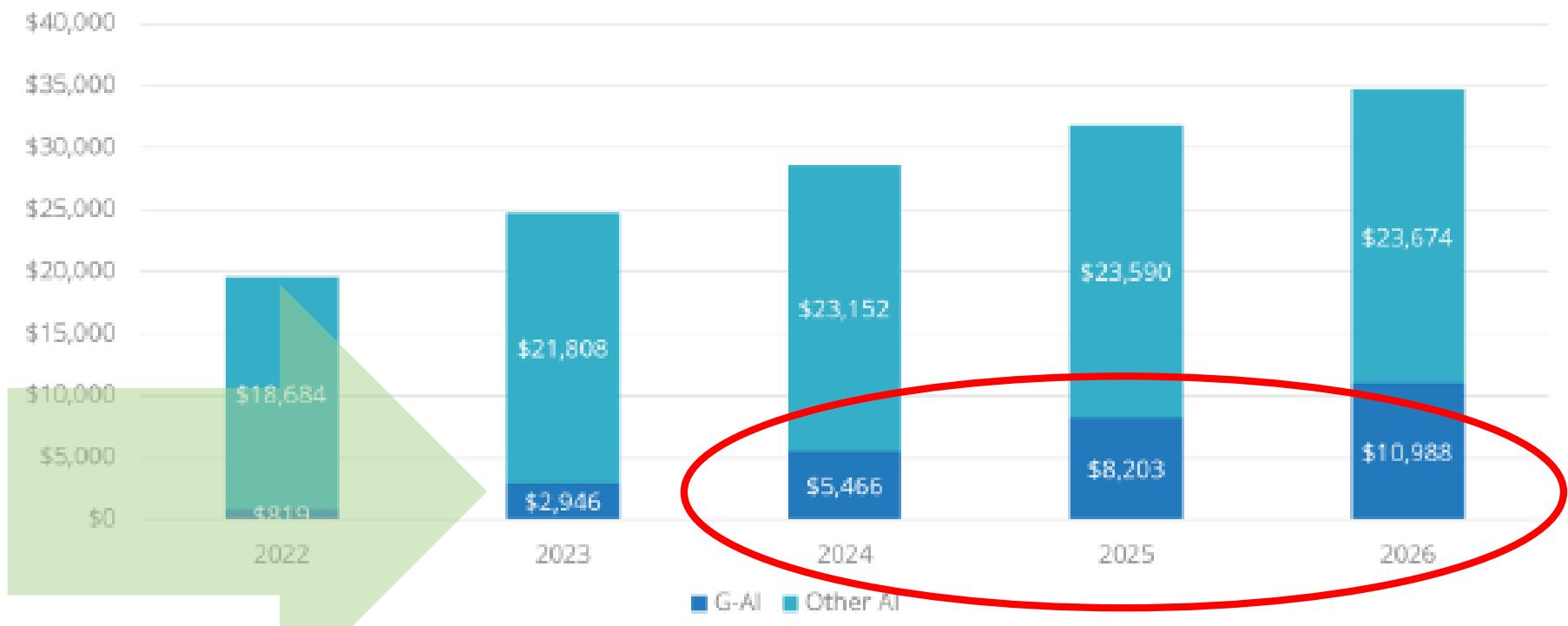
Copyright 2023, Coherent. All rights reserved.

800G is expected to be a huge market in datacom and telecom



G-AI market growing quickly...

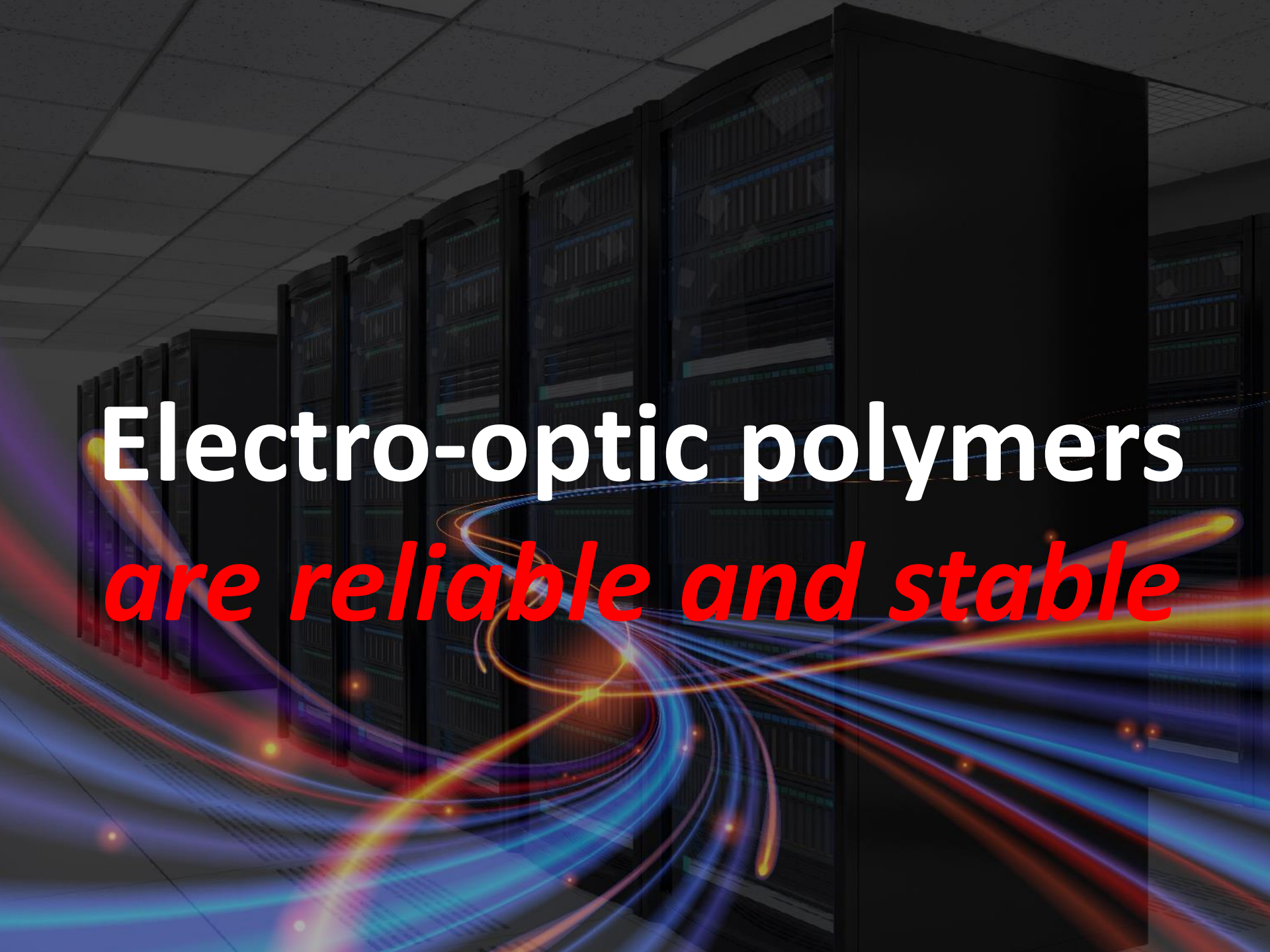
Worldwide G-AI and Non-G-AI Server Infrastructure Forecast (\$M)



Source: IDC

Estimated CAGR for "AI-Transceivers" alone is 44%

~20% of G-AI data center capex are expected to be 800G transceivers (\$3B in 2026)

A server room with rows of black server racks. The scene is illuminated with vibrant, glowing light trails in shades of blue and orange, creating a sense of motion and data flow. The text is overlaid on this background.

Electro-optic polymers
are reliable and stable



Electro-optic organic material is fast...

Types of electro-optic materials

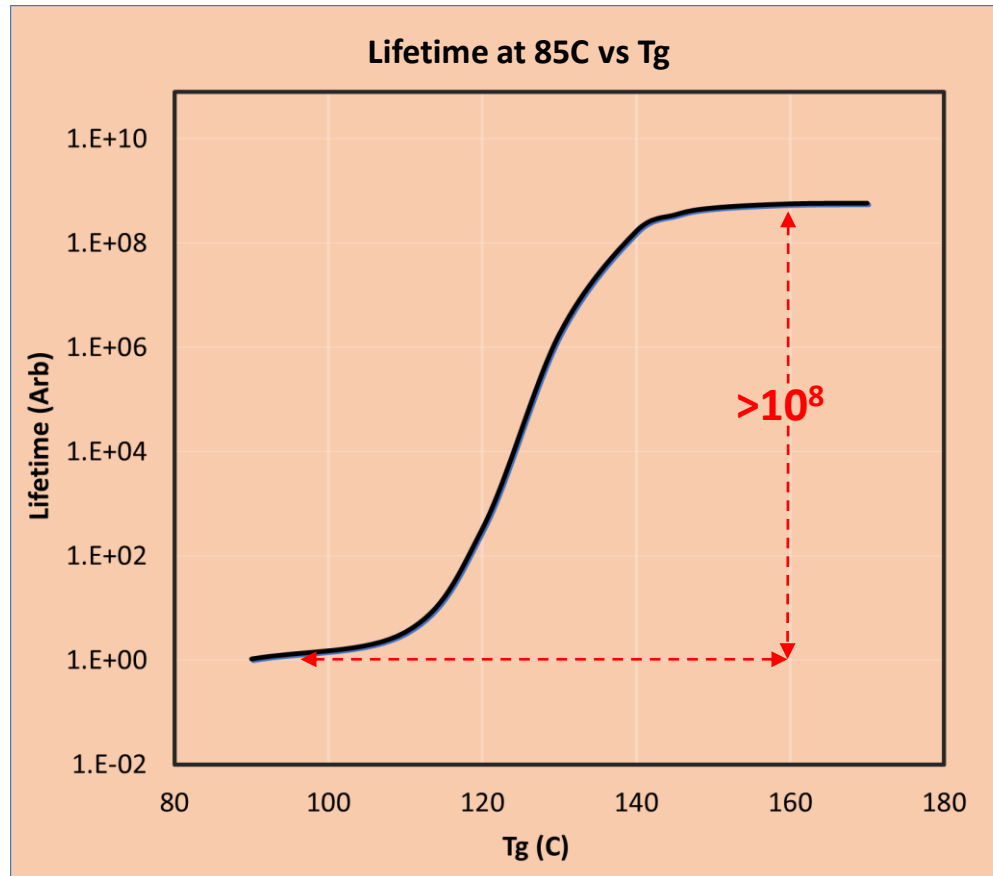
Electro-optic polymers with optical bandwidths >150GHz



Electro-optic polymers create modulators, and are fast in operation...

How important is glass transition temperature (T_g)?

The thermal lifetime of an EO-polymer material at 85C will **increase** with increasing T_g



The lifetime at 85°C for a polymer with $T_g = 160^\circ\text{C}$ is $>10^8$ times greater than the lifetime for a polymer with $T_g = 90^\circ\text{C}$

Using the widely quoted Lindsay's time constant formula which is found in *Polymer 48 (2007) 6605-6616*

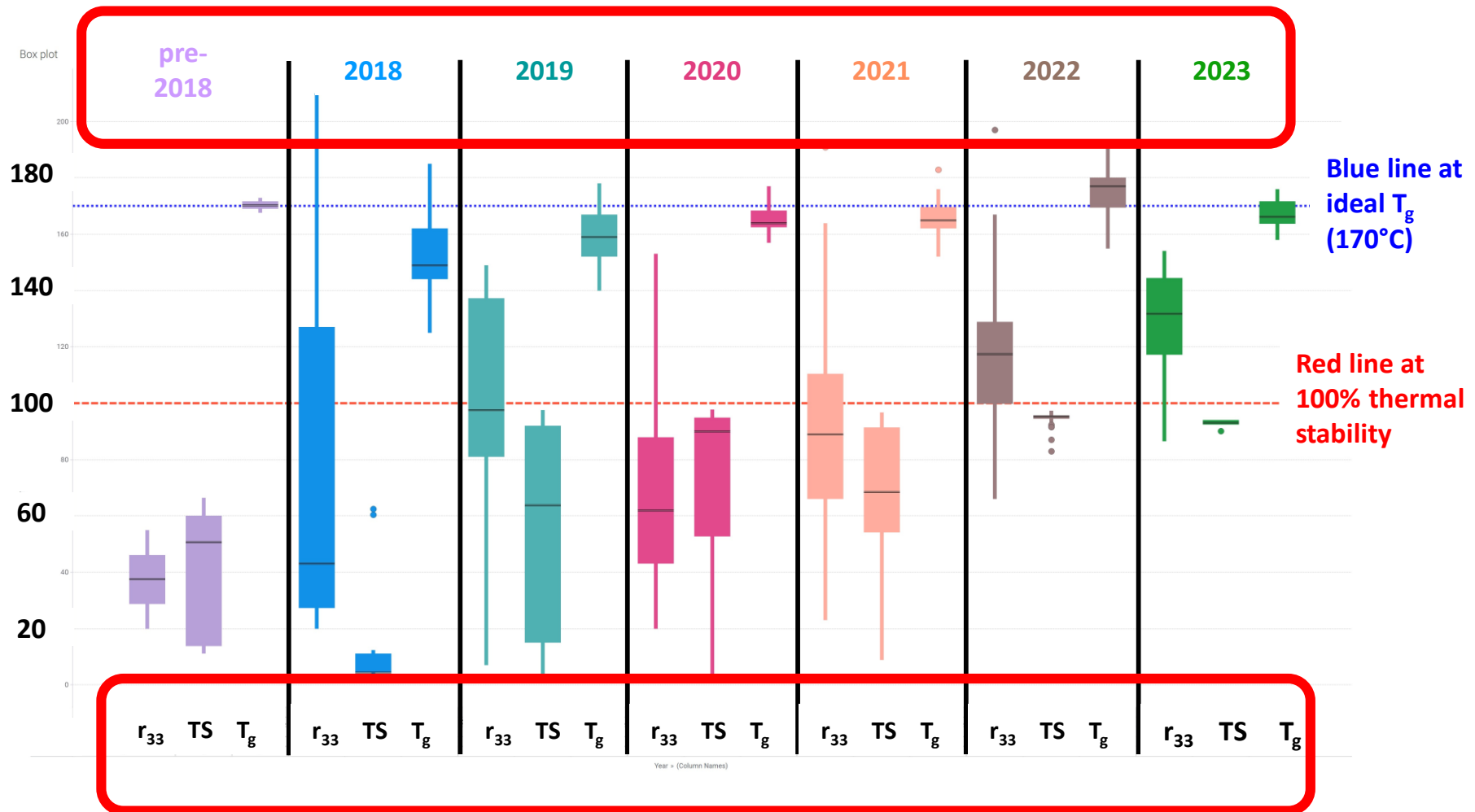
$$\ln(\tau/\tau_p) = E_R(1 + \tanh[(T_c - T)/D])/2RT + E_p/RT$$

Increasing $T_g \rightarrow$ means much higher lifetime in electro-optic polymer materials

How have EO polymers improved over the last 6 years?



Box plot of Perkinamine®



Tracking r_{33} , thermal stability and glass transition temperature

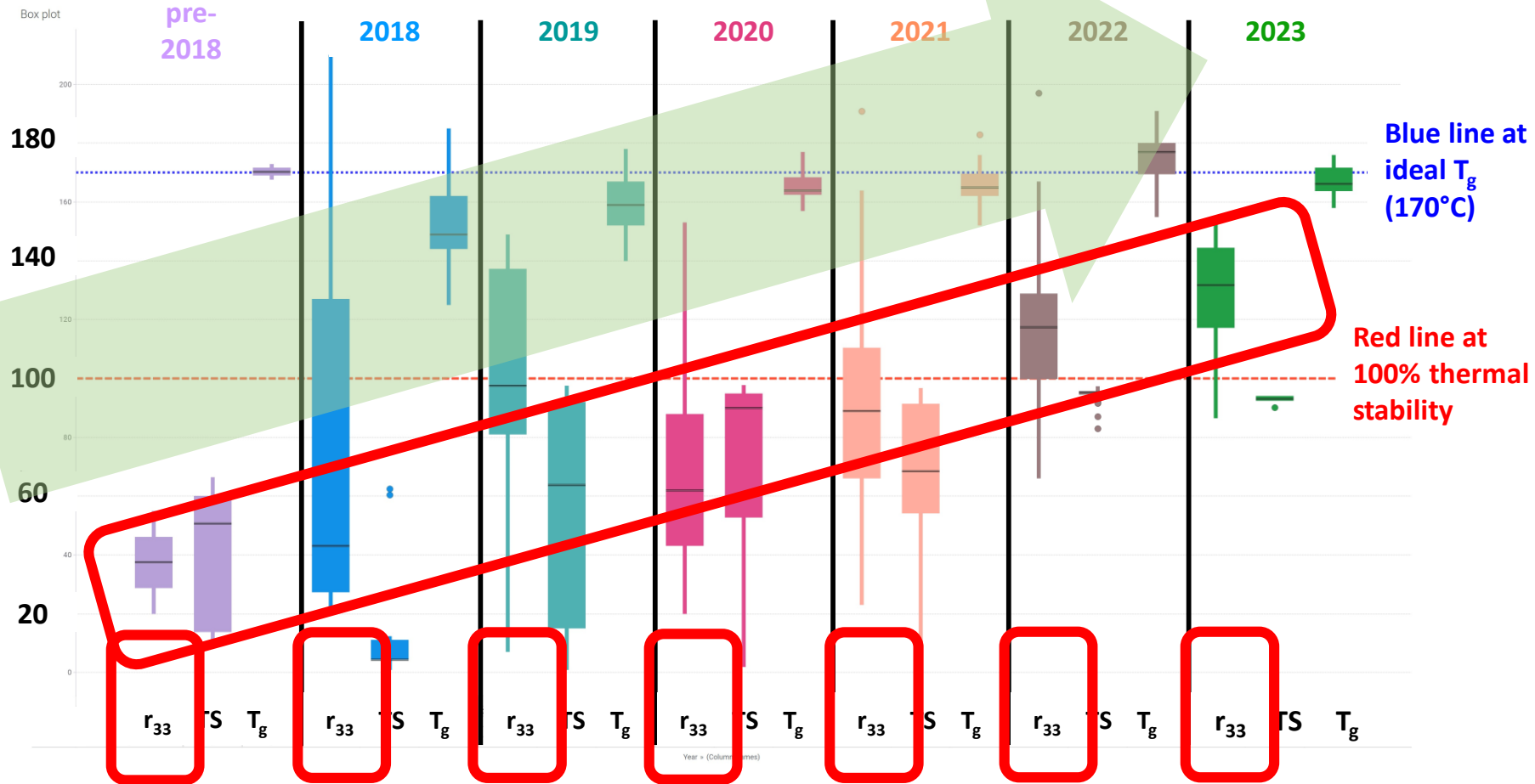
A box plot or boxplot is a method for graphically demonstrating the locality, spread and skewness groups of numerical data through their quartiles

Source: Lightwave Logic (LWLG), *best estimates;



Tracking r_{33} improvements

Box plot of Perkinamine®

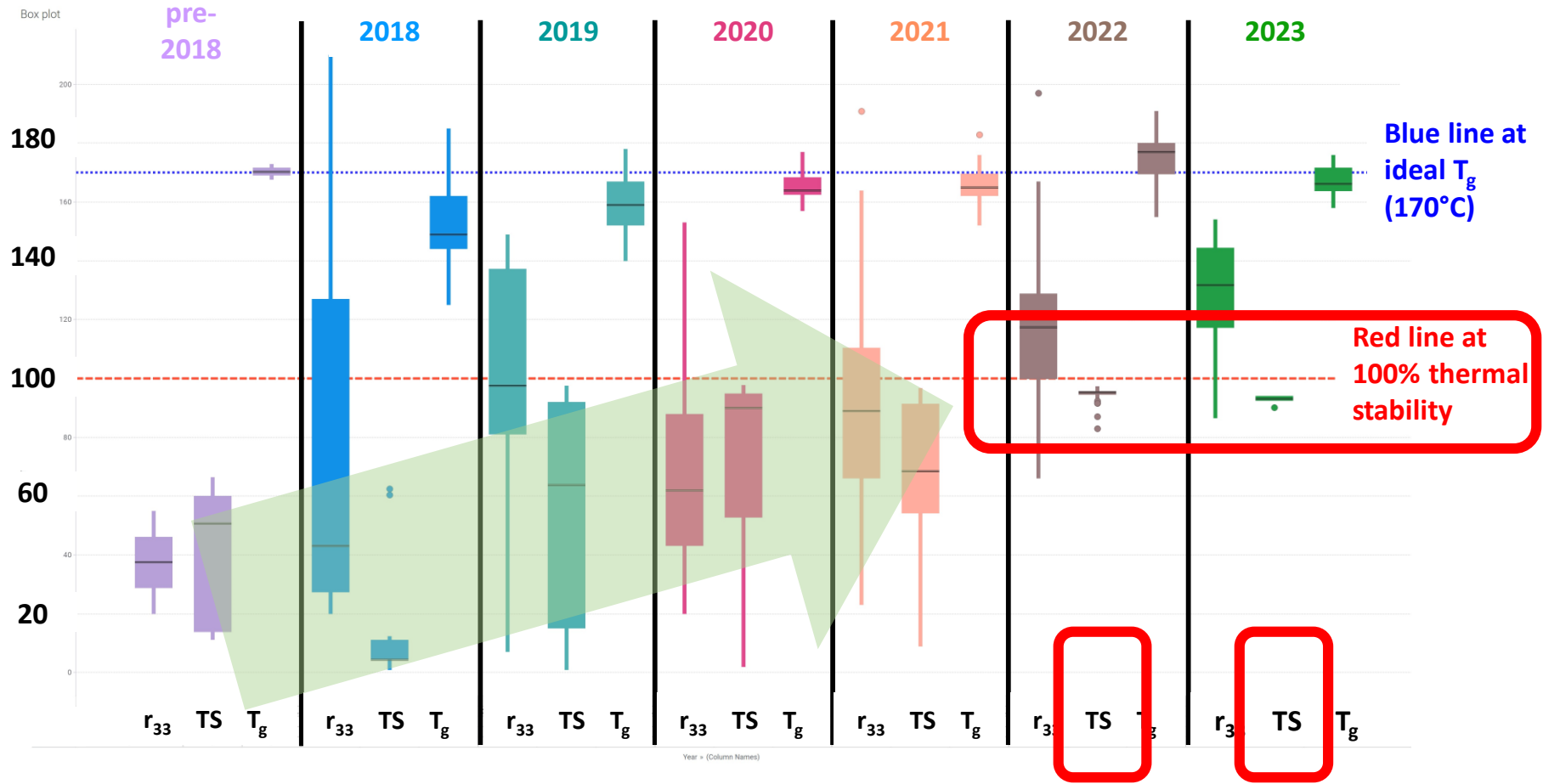


r_{33} improved 5X over past 6 years; and now very stable in testing



Tracking TS (thermal stability) improvements

Box plot of Perkinamine®

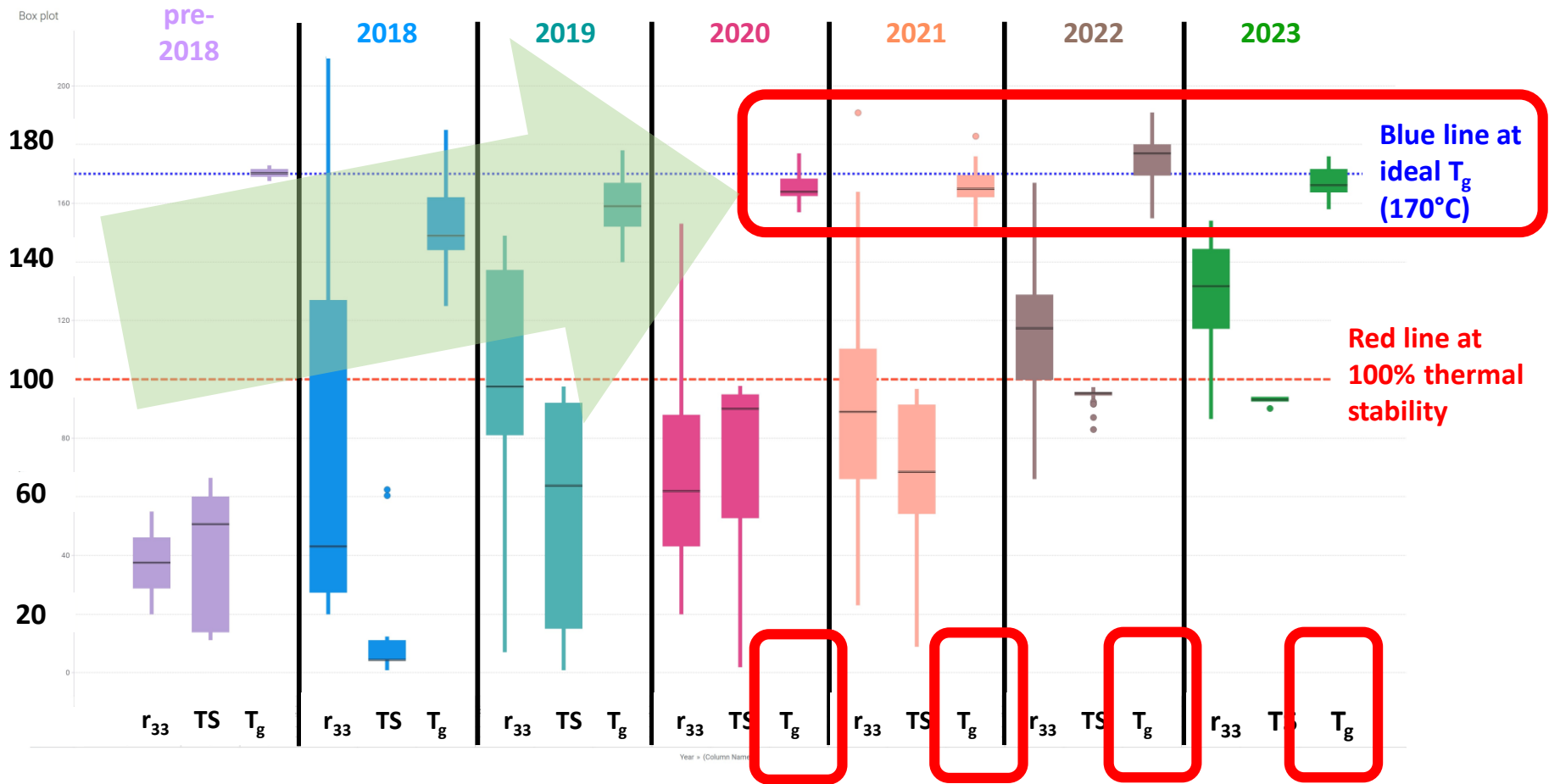


Super performance of material thermal stability in last 2 years (approaching 100%)

Tracking glass transition temperature (T_g)



Box plot of Perkinamine®



Tight control of materials with extremely high T_g at 170C

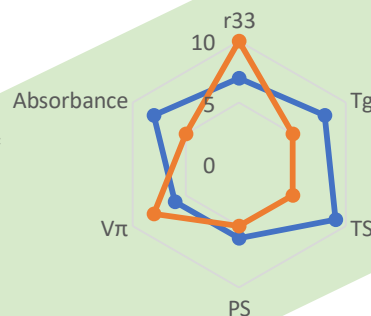
Creating world class electro-optic polymers

Balance of key parameters

- EO activity - r_{33} (pm/V)
- Drive voltage (V_{π})
- Photostability (PS)
- Thermal stability (TS)
- Glass transition temperature (T_g)
- Optical absorbance

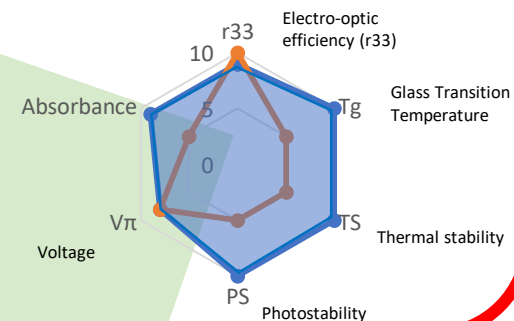
Intermediate LWLG Chromophores vs Competition*

— LWLG — Competition



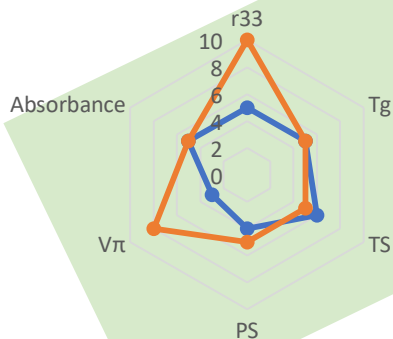
Key Parameters Current LWLG Chromophores vs Competition*

— LWLG — Competition



Initial LWLG Chromophores vs Competition*

— LWLG — Competition

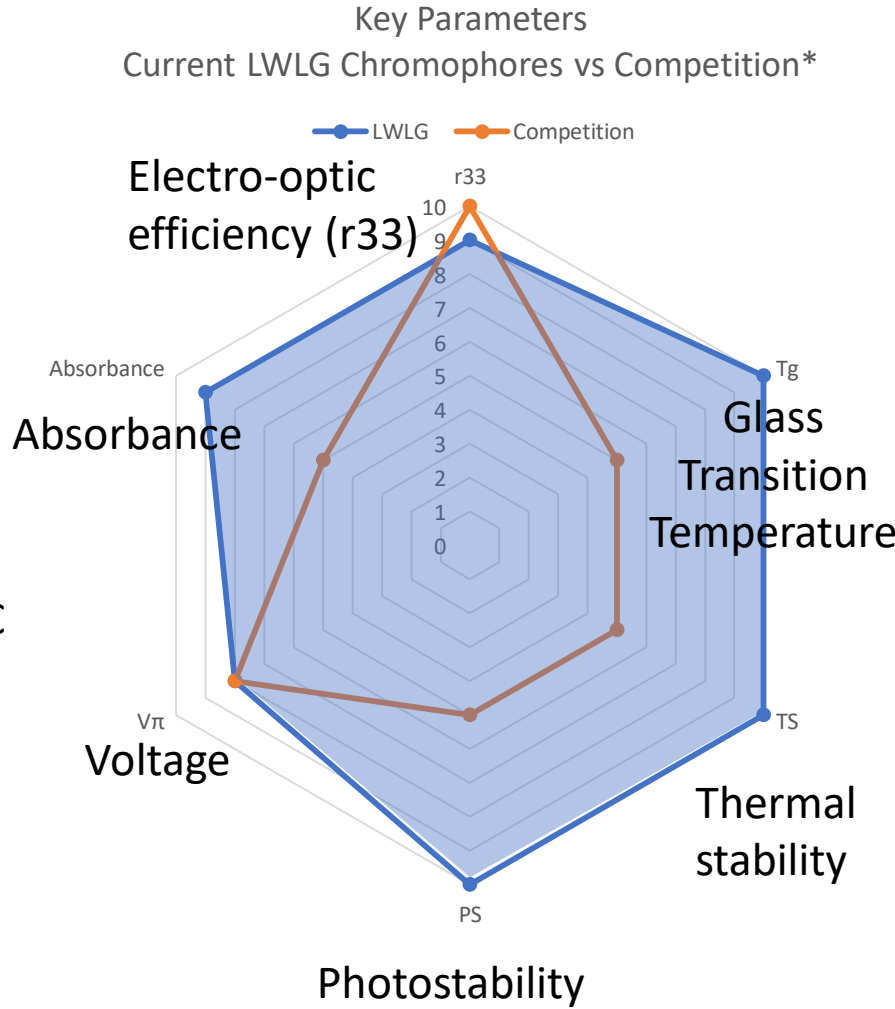
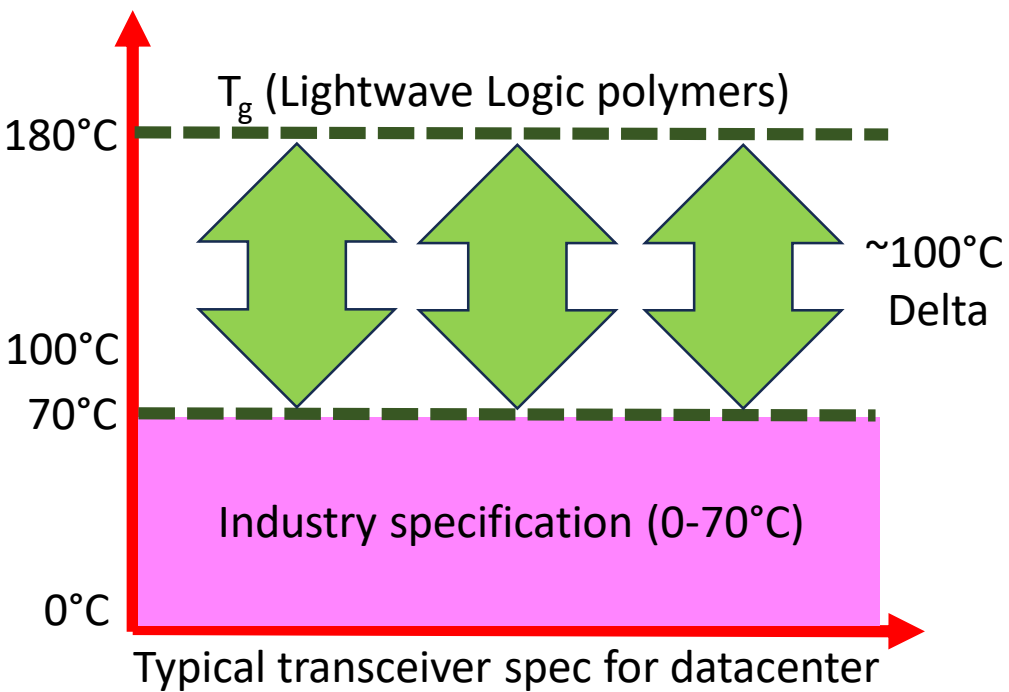


Steady increase in overall electro-optic material performance



Optimized for reliability and stability

- **World class chromophore design**
 - Very high glass transition temperature (T_g)
 - $\sim 100^\circ\text{C}$ delta between industry spec and T_g
 - Eliminates need for cross-linking
 - Protects material from de-poling (occurs when T_g is close to industry specification high limit)



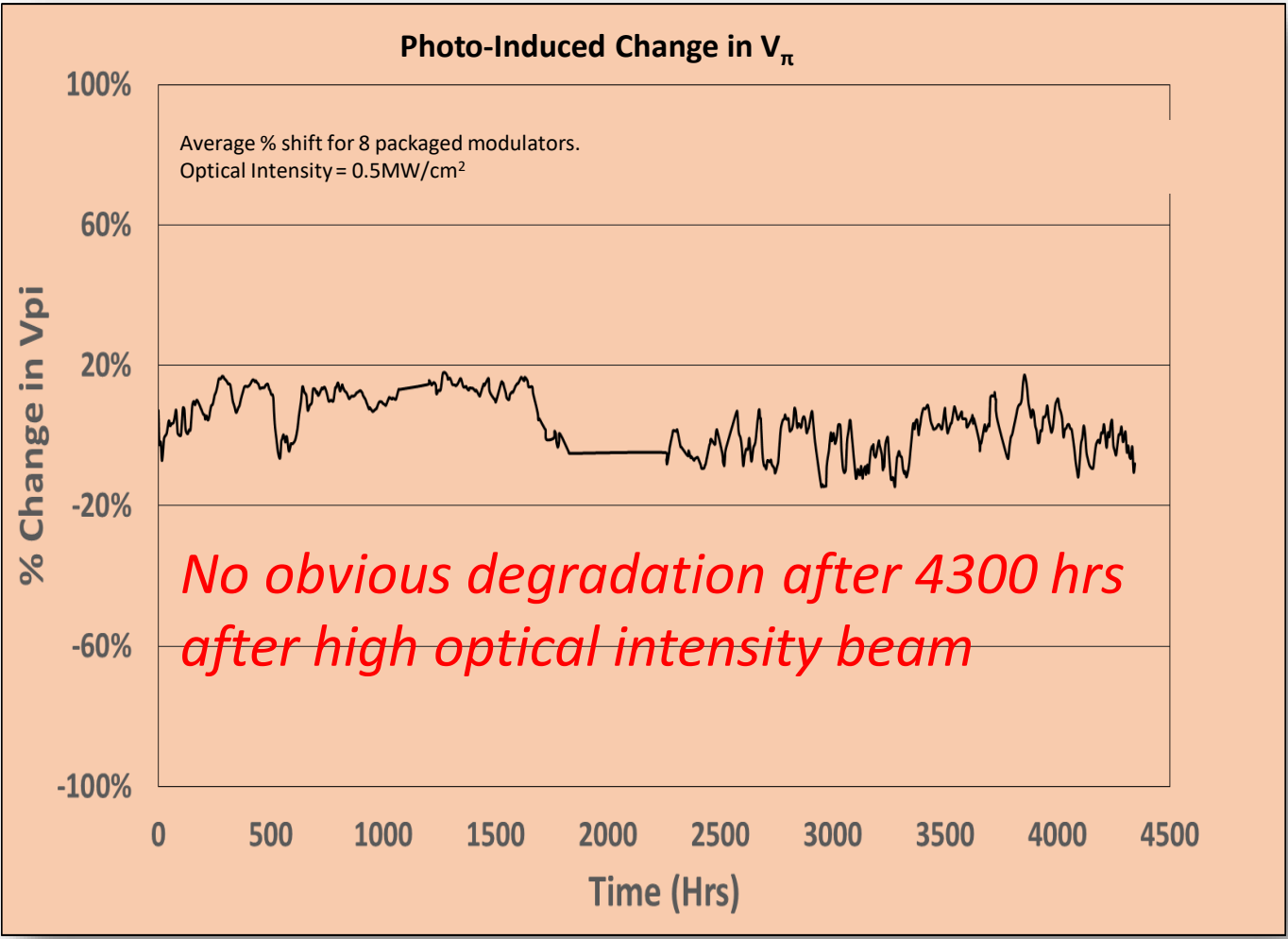
Electro-optic material designed for reliability, stability, and overall operational performance

NB: These are *qualitative* analyses only: i.e. on a scale of 1-10, how "good" is the material in terms of the particular parameter.

Source: Lightwave Logic (LWLG), *best estimates of public data

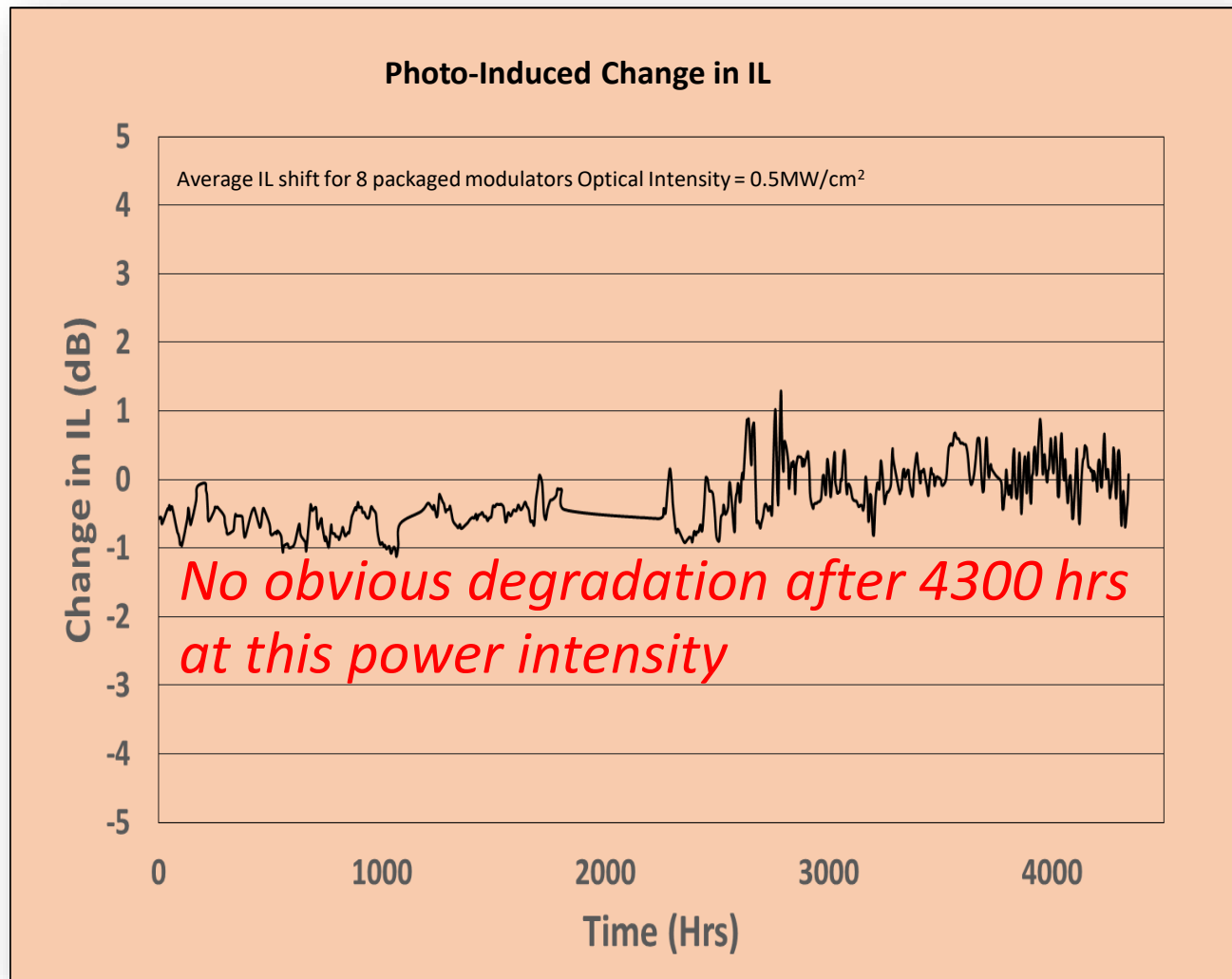


Photostability against change in voltage



Photostability is **NOT** an issue with Lightwave Logic electro-optic chromophores

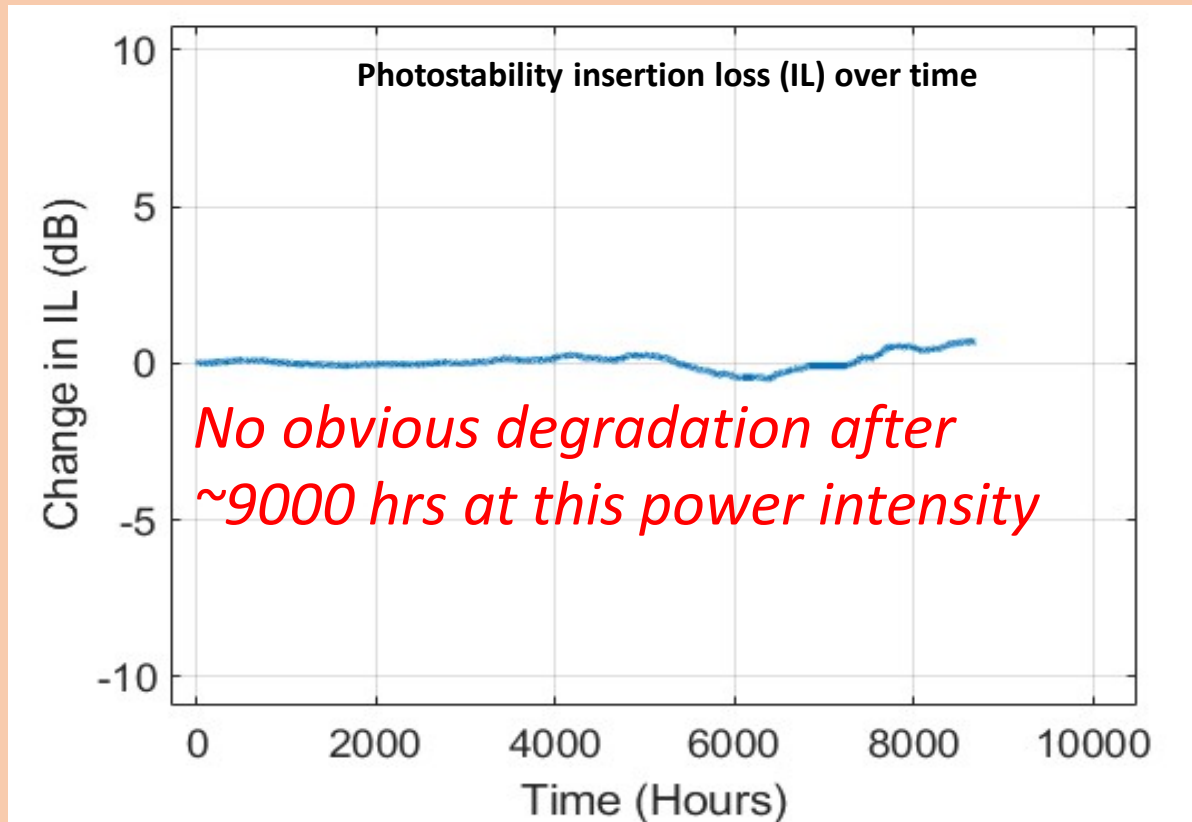
Photostability (PS) against change in optical loss



Photostability is **NOT** an issue with Lightwave Logic electro-optic chromophores



Long-term photostability



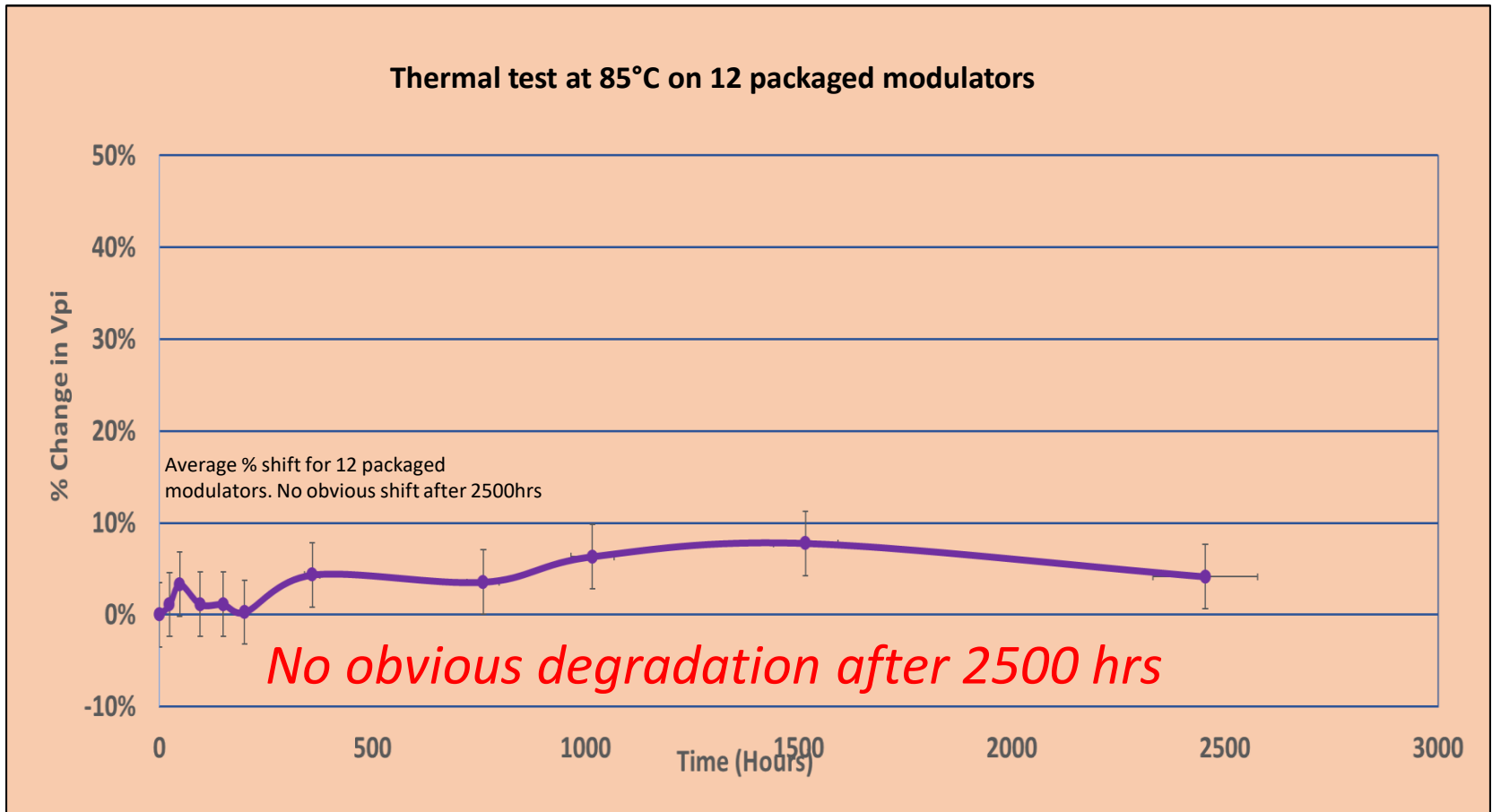
~9000 hrs test; wavelength=1550 nm; optical intensity = 500 kW/cm²

Minimum photodegradation (indicated by reduction in IL due to bleaching of chromophore)

Observed shift is within measurement error

Long-term photostability is **NOT** an issue with Lightwave Logic electro-optic chromophores

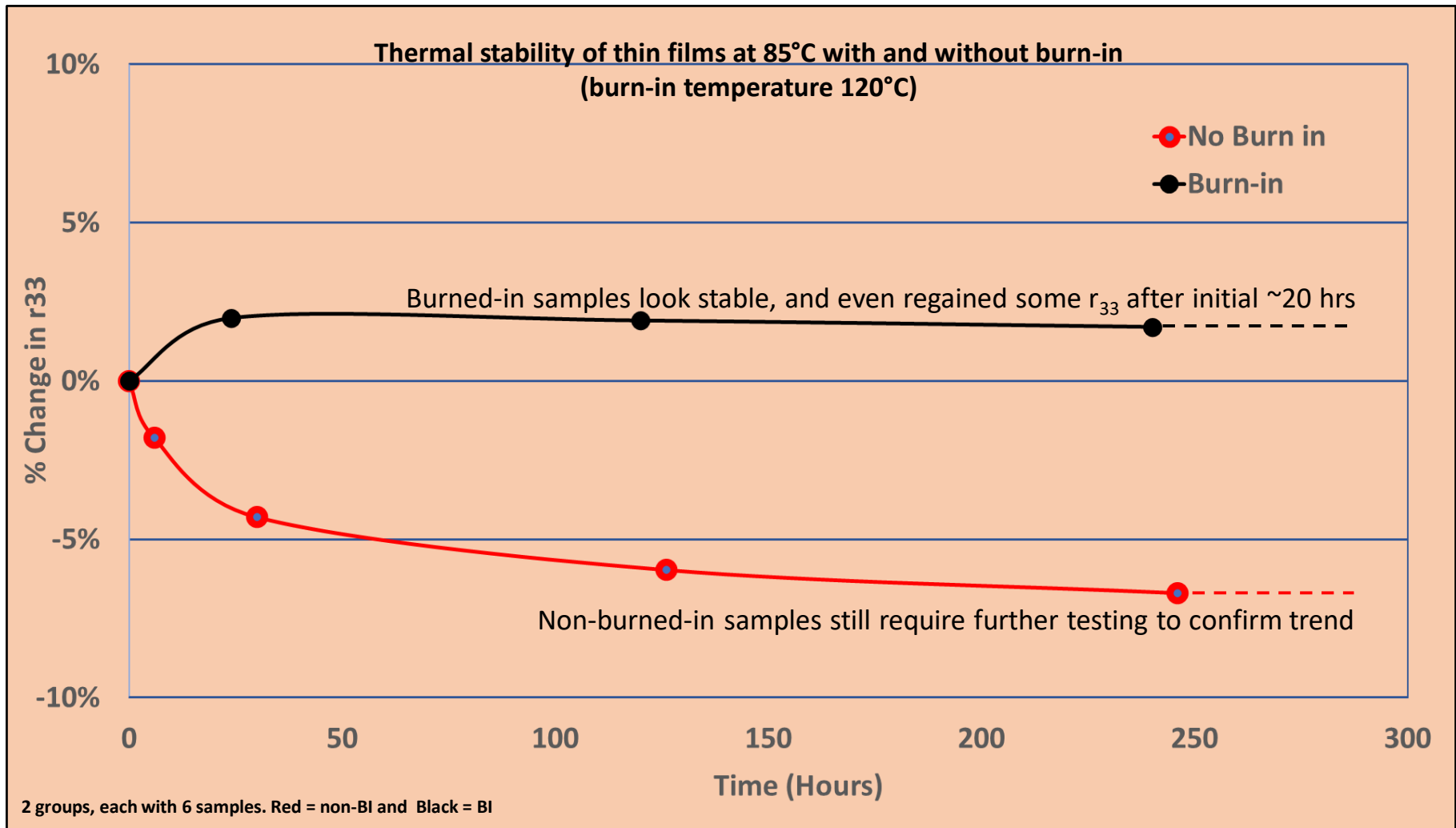
Device thermal stability (TS) against change in voltage



The 12 parts continue to show fluctuations and variations in the V_{π} readings, but there is no obvious trend.

Thermal stability is **NOT** an issue with Lightwave Logic packaged modulators

Thermal Stability with and without burn-in against change in r_{33}



Burn-in **stabilizes** r_{33} of Lightwave Logic thin film electro-optic chromophores

A server room with rows of black server racks. The scene is illuminated with vibrant, glowing light trails in shades of blue and orange, creating a sense of motion and data flow. The text is overlaid on this background.

**Electro-optic polymer
devices**

***are competitive with
semiconductors***



Competitive polymer positioning

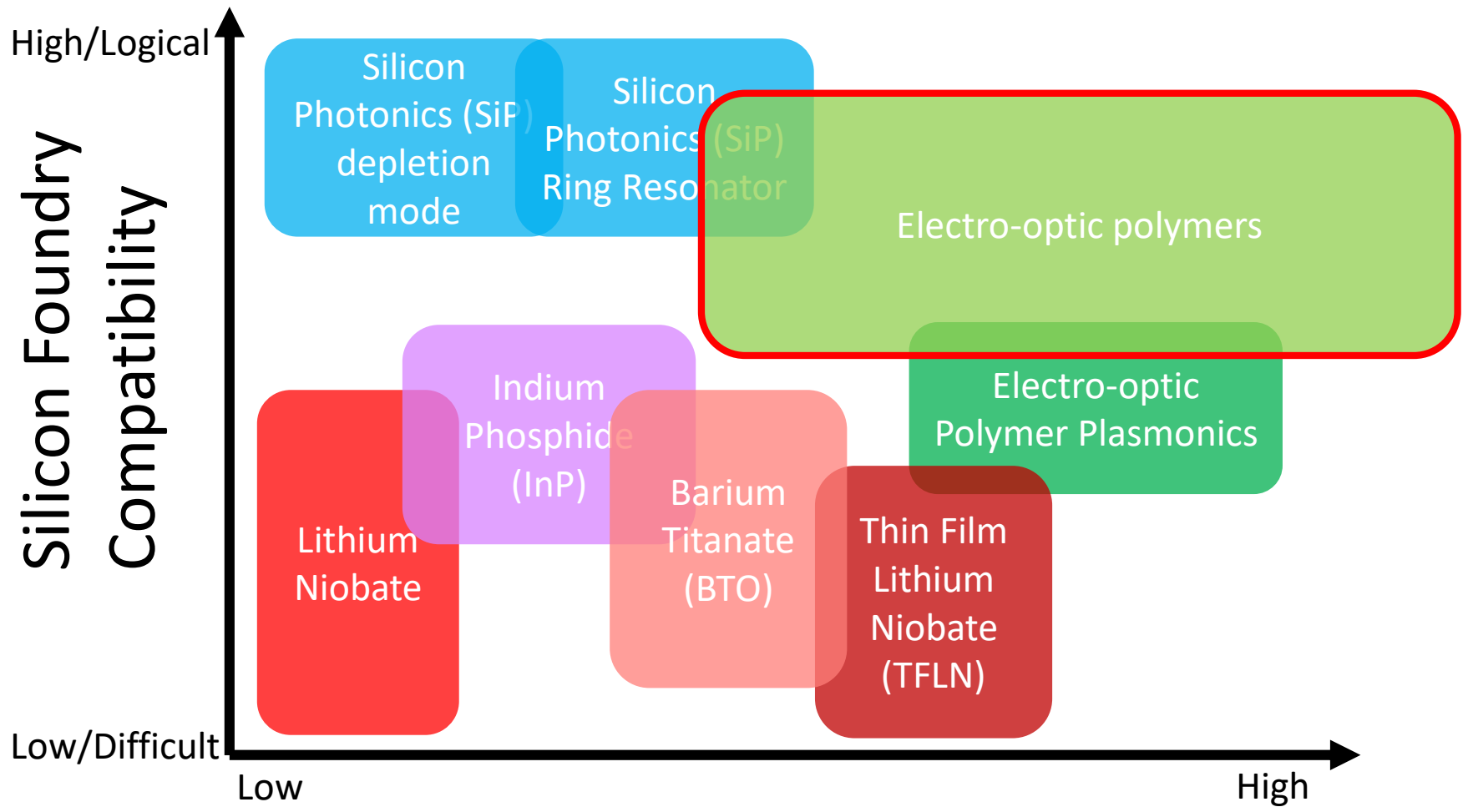
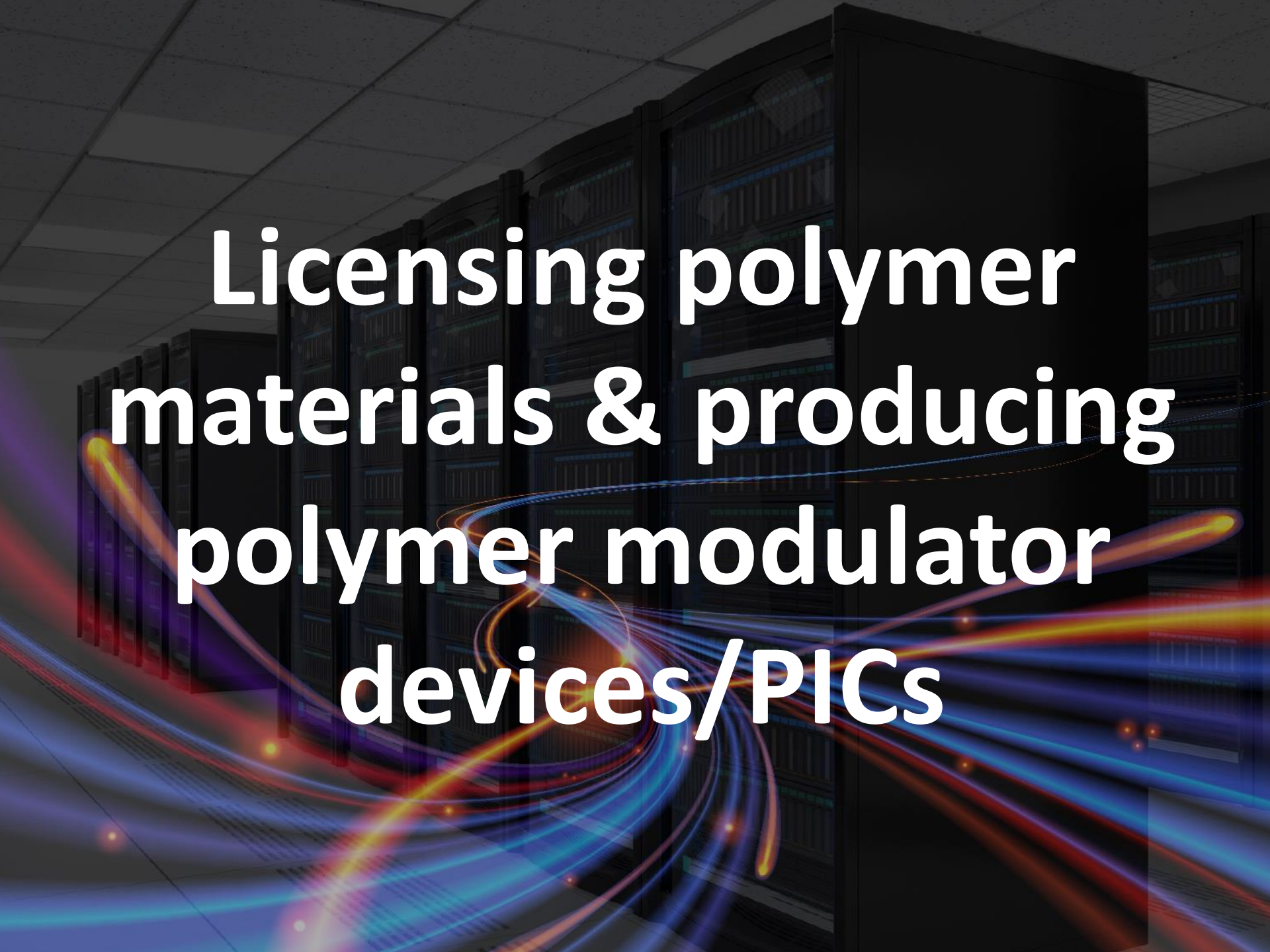


Figure of Merit (low V, high Bandwidth, small size)

Polymer modulators outperform competitive semiconductor technologies

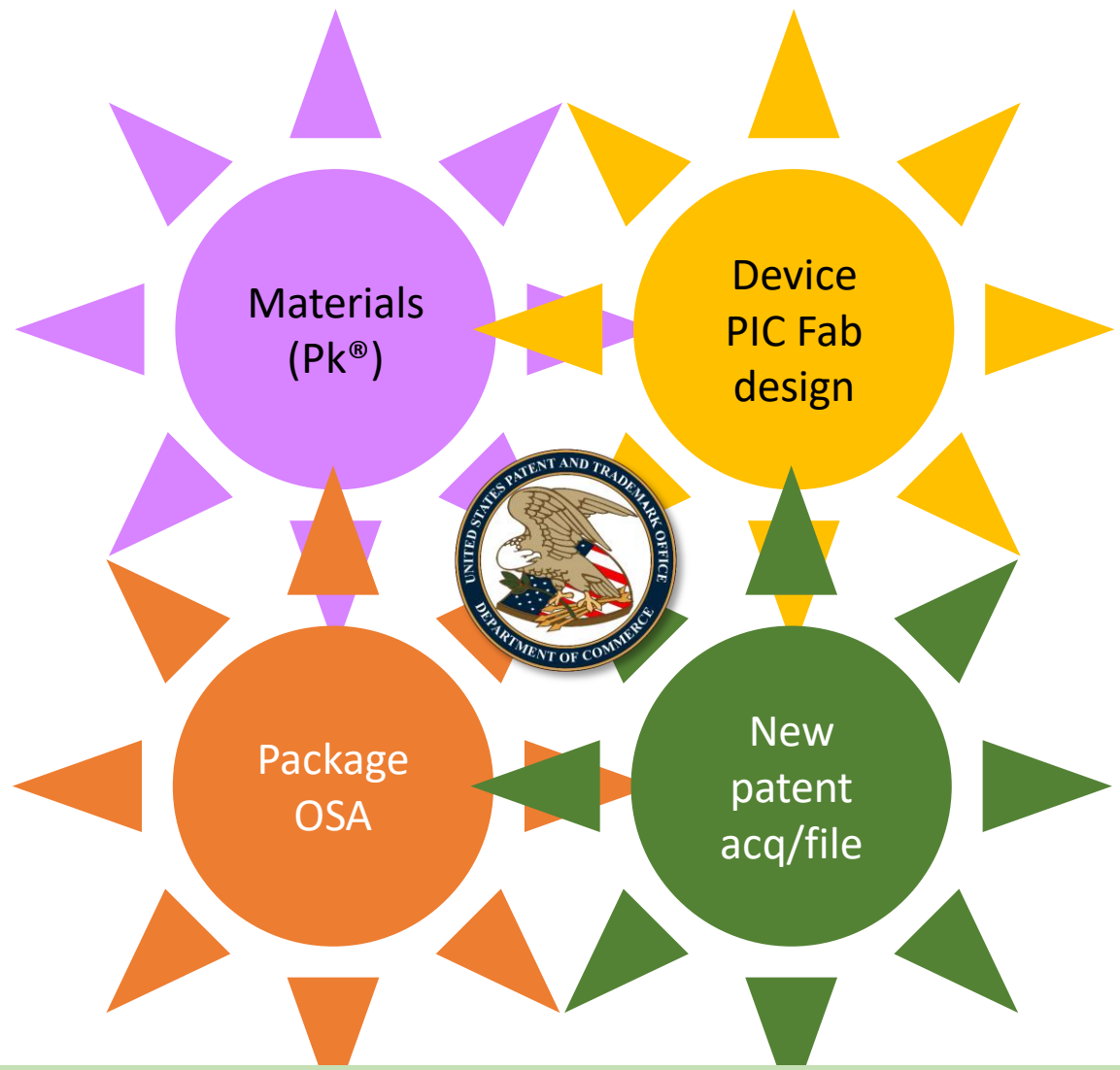
Source: Lightwave Logic (LWLG) research showing target metrics for

A server room with rows of black server racks. The scene is illuminated by vibrant, glowing light trails in shades of blue, orange, and purple, creating a sense of motion and data flow. The text is overlaid in the center in a bold, white, sans-serif font.

**Licensing polymer
materials & producing
polymer modulator
devices/PICs**



Patents drive licensing opportunities...

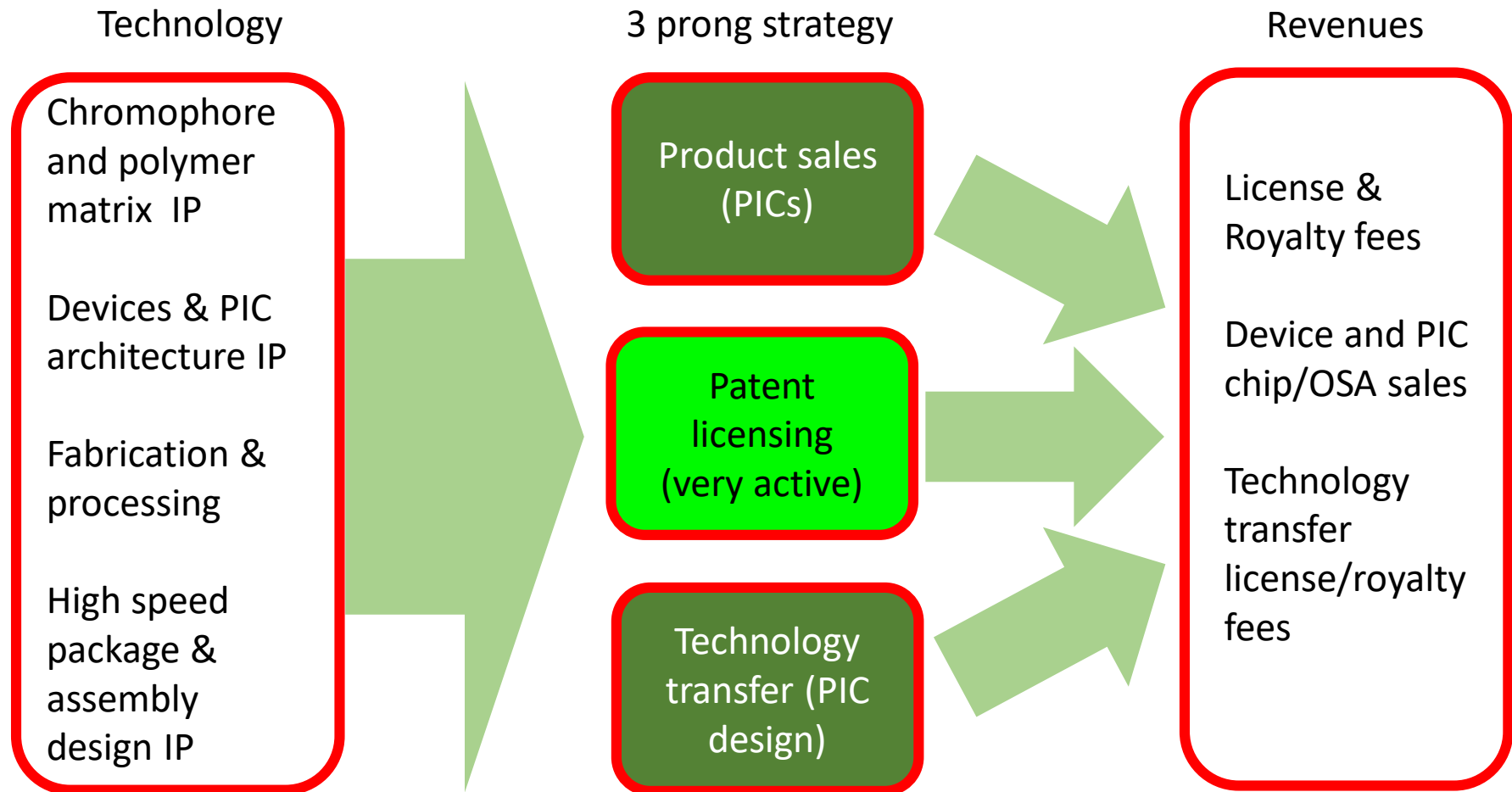


- We develop and *license* polymer-based technologies that are engines for the internet, optical networking, datacenters
- Our patent IP portfolio creates a *strong moat* and know-how to carve leadership in high speed, low power modulators
- *Unique polymers* that we design and create continually strengthen our patent moat to *over 70 patents* issued and pending

IP portfolio enables licensing & tech transfer for long term revenue generation

Source: LWLG, Perkinamine® Series Electro-optic polymers; Pk® = Perkinamine®; Perkinamine® is a registered trademark of Lightwave Logic Inc.

We are open to polymer material licensing...

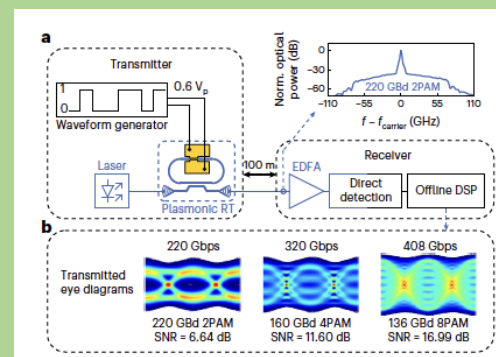
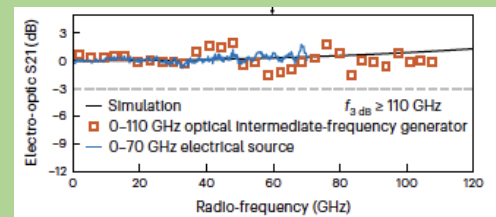
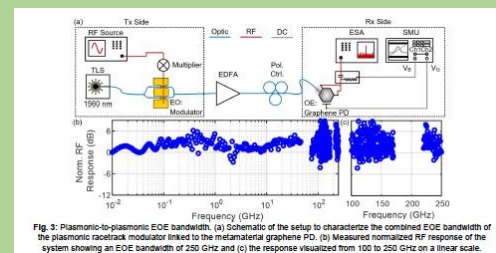
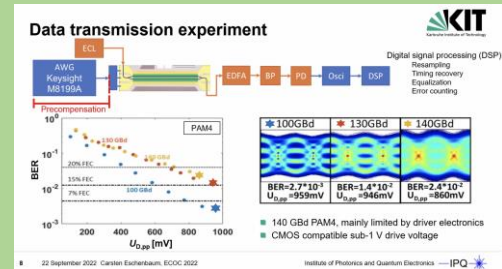


Our polymers fit into several modulator device designs – ring, plasmonic, slot, stack etc.

A server room with rows of black server racks. The scene is illuminated by vibrant, glowing light trails in shades of blue, orange, and purple that swirl and flow through the aisles, creating a sense of dynamic energy and data movement. The text "3rd party verification..." is overlaid in the center in a bold, white, sans-serif font.

3rd party verification...

- *EO polymer* used in different device designs
- Silicon slot, plasmonic slot, plasmonic ring resonator
- All produced *world class* results*
- Presentations at *industry* conferences



A digital illustration of a server room. The room is filled with rows of black server racks. The floor is a light gray, and the ceiling is a white grid. The scene is illuminated by vibrant, glowing light trails in shades of blue, orange, and purple that swirl and flow through the space, creating a sense of dynamic energy and data movement. The word "Summary" is prominently displayed in the center in a clean, white, sans-serif font.

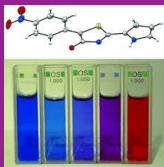
Summary

Summary...EO polymers enable modulators for next generation optical networking

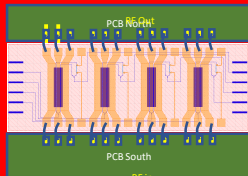


LIGHTWAVELOGIC®

Material Science



Polymer PIC design



High speed device design & packaging



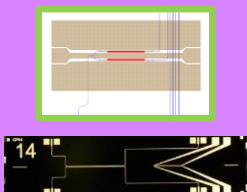
Powerful patent portfolio



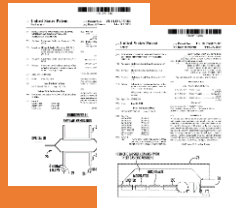
Huge \$B markets



Selling components



Licensing polymer materials



Partnering foundries (for scale)



Material & device data sheets

Polymer Star® O-Band Modulator

Lightwave Logic's O-Band Polymer Star® O-Band Modulator is a high speed device (carrier modulation rate of 200 Gbps) designed for high speed applications requiring high data transmission rates and low power consumption for energy efficient applications.

The high speed data rate and low power consumption are achieved by Lightwave Logic's proprietary high performance, high quality electro-optic chromophore.

Polymer Star® Modulators are targeted for use in high speed data center interconnects, used in 800G and 1.6T applications.

Applications:

- 800G and 1.6T applications
- High speed data center interconnects
- High speed data center interconnects

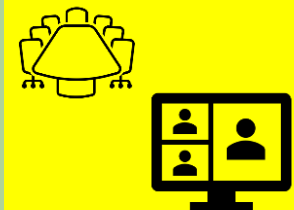
Product Highlights:

- High speed data center interconnects
- High speed data center interconnects
- High speed data center interconnects

Table 1. Polymer Star® O-Band Modulator Specifications

Parameter	Value	Unit
Carrier Wavelength	1270	nm
Modulation Rate	200	Gbps
Power Consumption	~10	mW
Insertion Loss	~1	dB
Extinction Ratio	~15	dB
Bandwidth	~10	nm
Temperature Range	-40 to 85	°C
Reliability	~10	years

World class BoD, TAB & IR/PR



- Electro-optic polymers are *competitively superior and unique*...
- We continue to increase our *technical progress with reliability and stability*...
- With our partners, we are positioned to have *polymers scale* for optical networking...
- We have the team, resources, and plans in place to *make polymers ubiquitous*...

Investor Relations Contact

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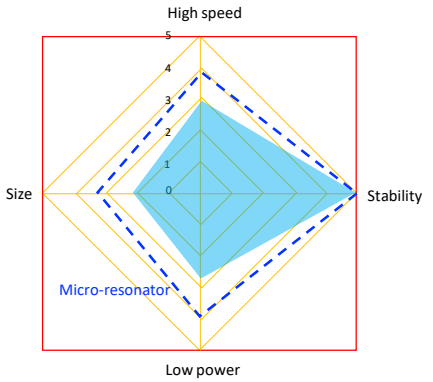
Thank you!



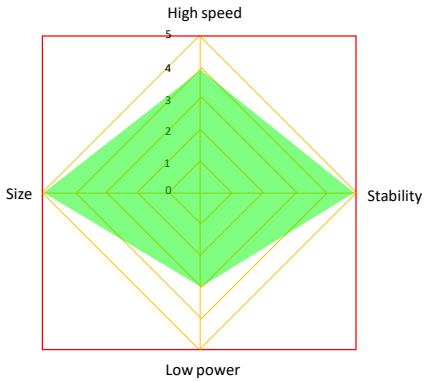


Polymer attributes are impressive...

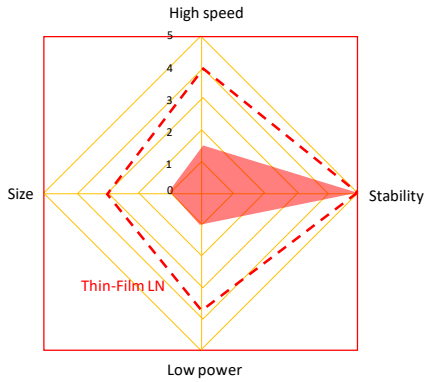
Silicon*



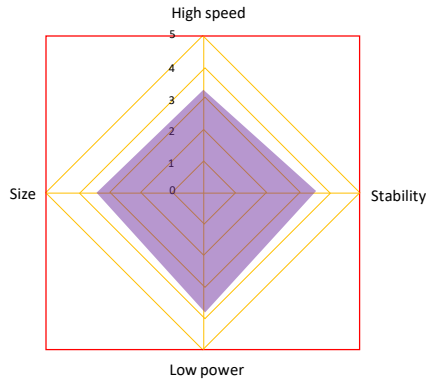
Indium Phosphide*



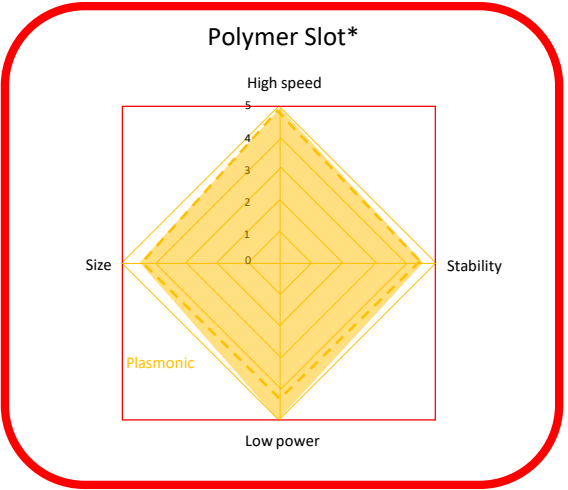
Lithium Niobate*



Barium Titanate*



Polymer Slot*



Technology spider chart → polymers have strong coverage → excellent performance

Source: Lightwave Logic (LWLG), *best estimates