



LIGHTWAVE LOGIC®

*Faster by Design*

**Commercializing electro-optic polymers**

Michael Lebby, CEO

NASDAQ  
**LWLG**

Photonics Enable Cloud Computing  
October 2023



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A digital illustration of a server room. Rows of dark server racks line a perspective view of a hallway. The ceiling has a series of glowing blue rectangular lights. A thick, wavy orange line, composed of many thin parallel lines, curves across the middle of the image. A network of white dots connected by thin lines is overlaid on the entire scene, giving it a digital or data-driven feel.

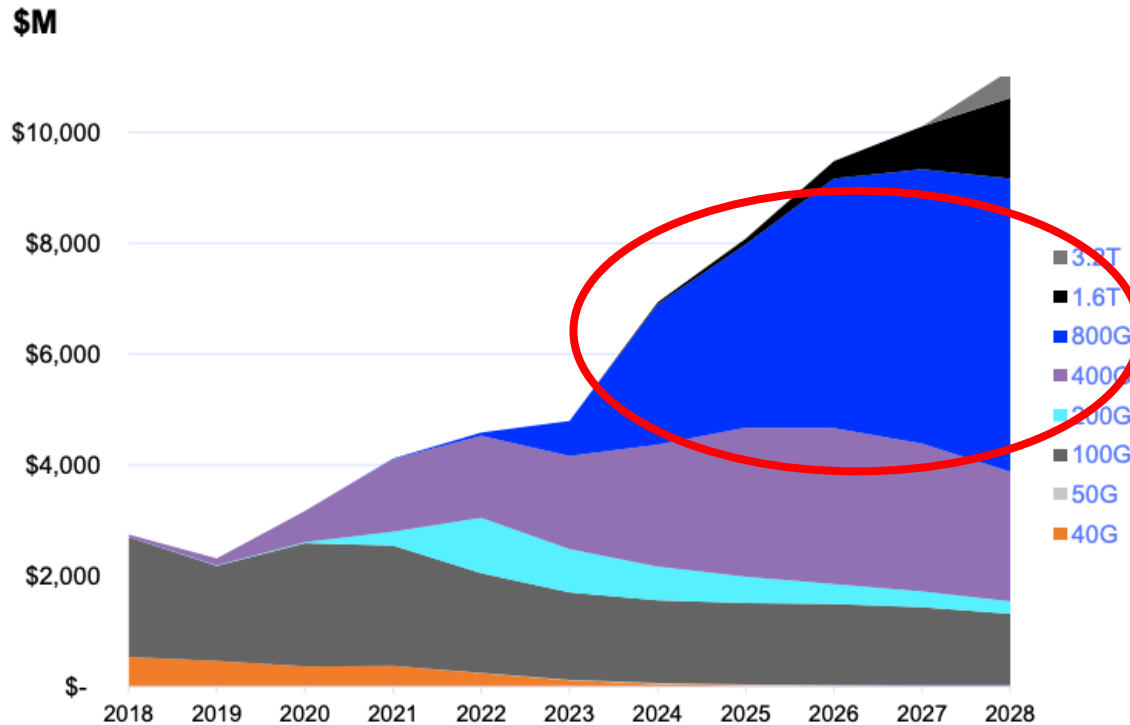
*Market Dynamics...*

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



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## DATAKOM TRANSCEIVER GLOBAL MARKET



Source: LightCounting, Internal Estimates

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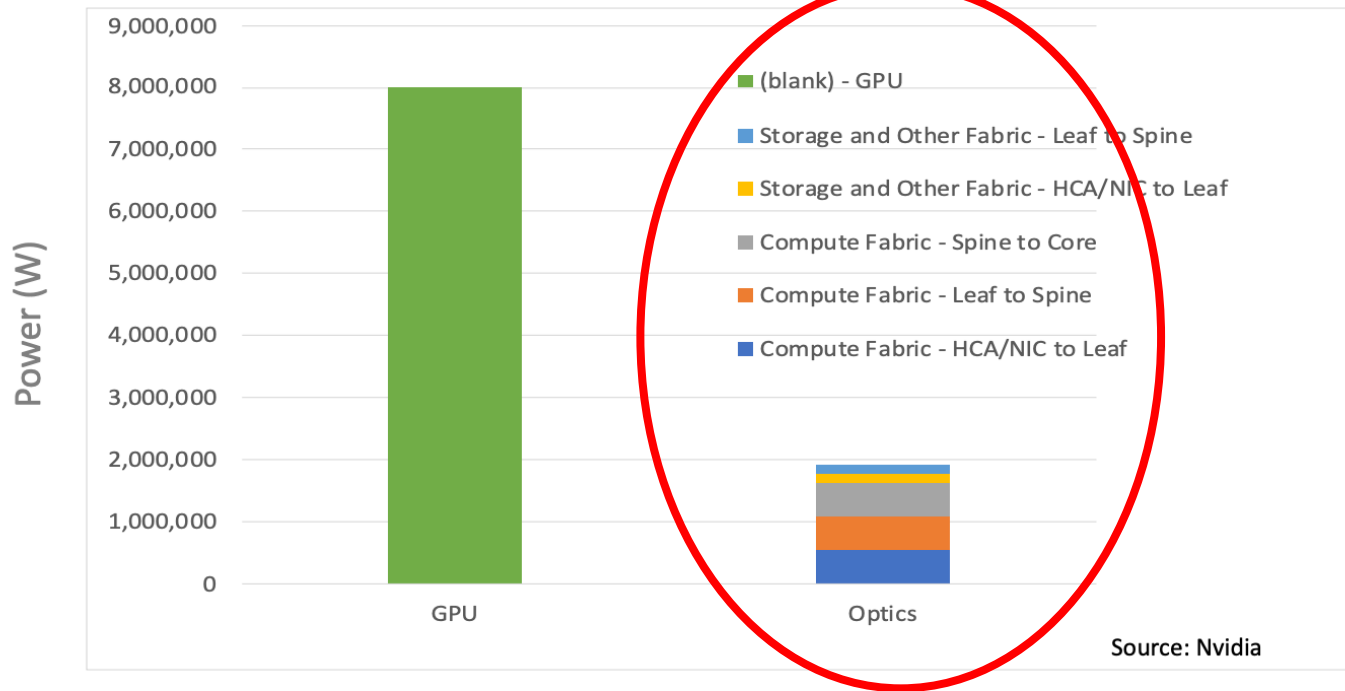
800G is expected to be a huge market in datacom and telecom

# Optics is No Longer A “Minor” Contributor to Datacenter G-AI Power Issues



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Power Dissipation for 16K GPU Clusters



Power dissipation  
for AI cluster  
optics showing  
optical network  
power dissipation  
share increasing...

Large language models requires large GPU clusters (ChatGPT 4 training requires ~25,000 GPUs)

For 16,000 GPU clusters, optics consume ~2MW (equivalent to 4000 GPUs) – source: Nvidia, CIOE, Song, 2023)



The background is a perspective view of a server room aisle. On both sides are rows of dark server racks. The floor is a light blue-grey. The ceiling has several rectangular light fixtures. Overlaid on the scene is a network of white dots connected by thin lines, and a thick, wavy orange line that spans across the aisle. 

*What we do...*

# Perkinamine® Electro-Optic polymers



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**Our polymers are world-class and proven by third parties**

Electro-optic polymers can be used to fabricate optical modulators which enable:



- 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**

Source: Lightwave Logic (LWLG)

## 3<sup>rd</sup> Party Use of Perkinamine®

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

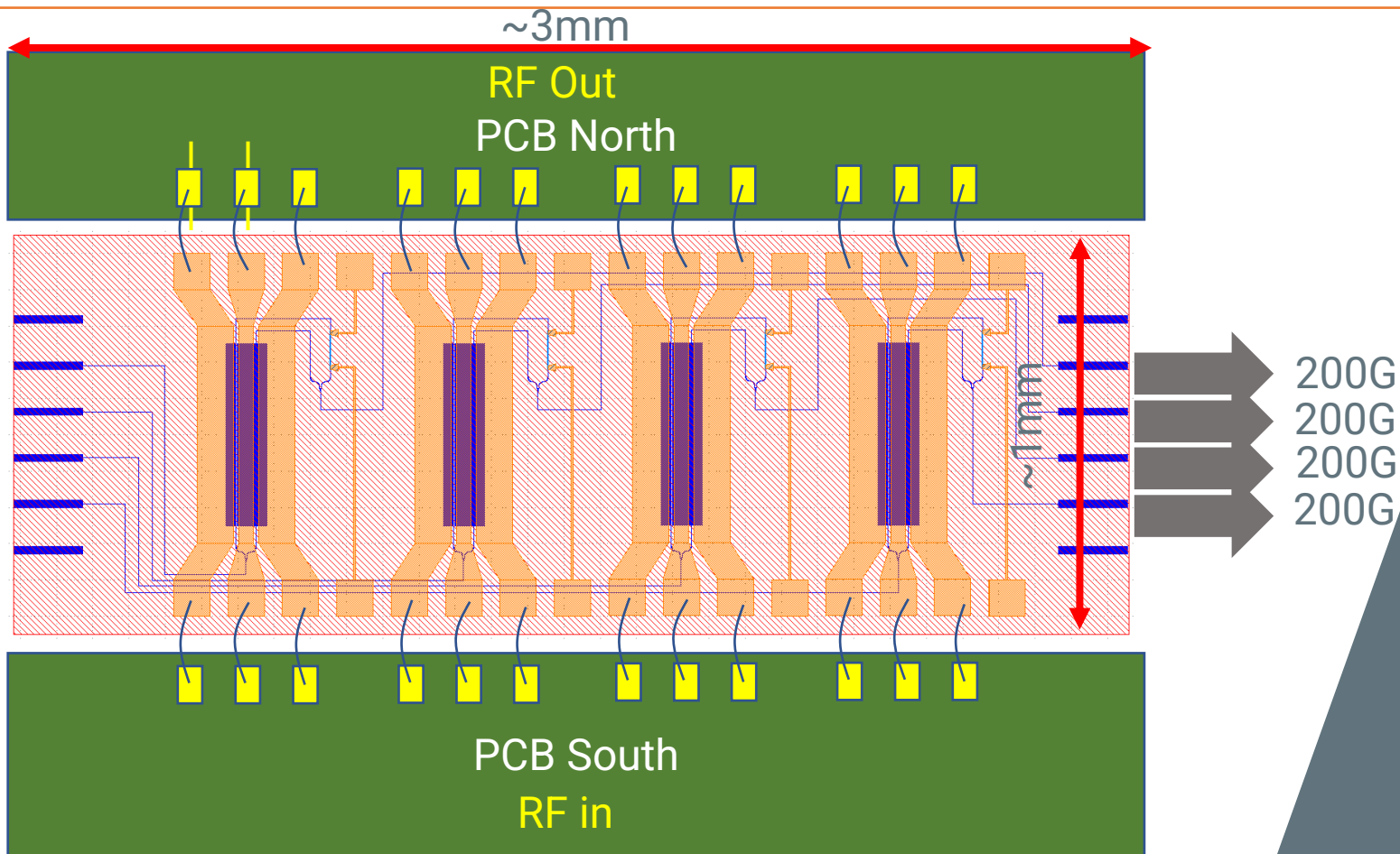
Sources\*: Nature Photonics: Resonant plasmonic micro-racetrack modulators with high bandwidth and high temperature tolerance (ETH Zurich, Polariton and LWLG EO polymer material)

Sources\*: KIT, SiOriX, EU Horizon 2020, ETH Zurich, Polariton, CAU University Kiel (post deadline paper published at ECOC2022 using LWLG EO polymers)

# 800G integrated polymer modulators



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In development → 4  
channel polymer PIC  
chip as part of our  
P<sup>2</sup>IC platform

Potential for 300G and  
even 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

\*Using EO S21 3dB bandwidths in excess of 150GHz, with the potential for >250GHz



The background is a perspective view of a server room aisle. On both sides are rows of dark server racks. The floor and ceiling are dark, with the ceiling having rectangular light panels. A network of glowing white nodes connected by thin lines is overlaid on the scene. A thick, wavy, orange-gold line curves across the middle of the image, starting from the left and ending on the right. 

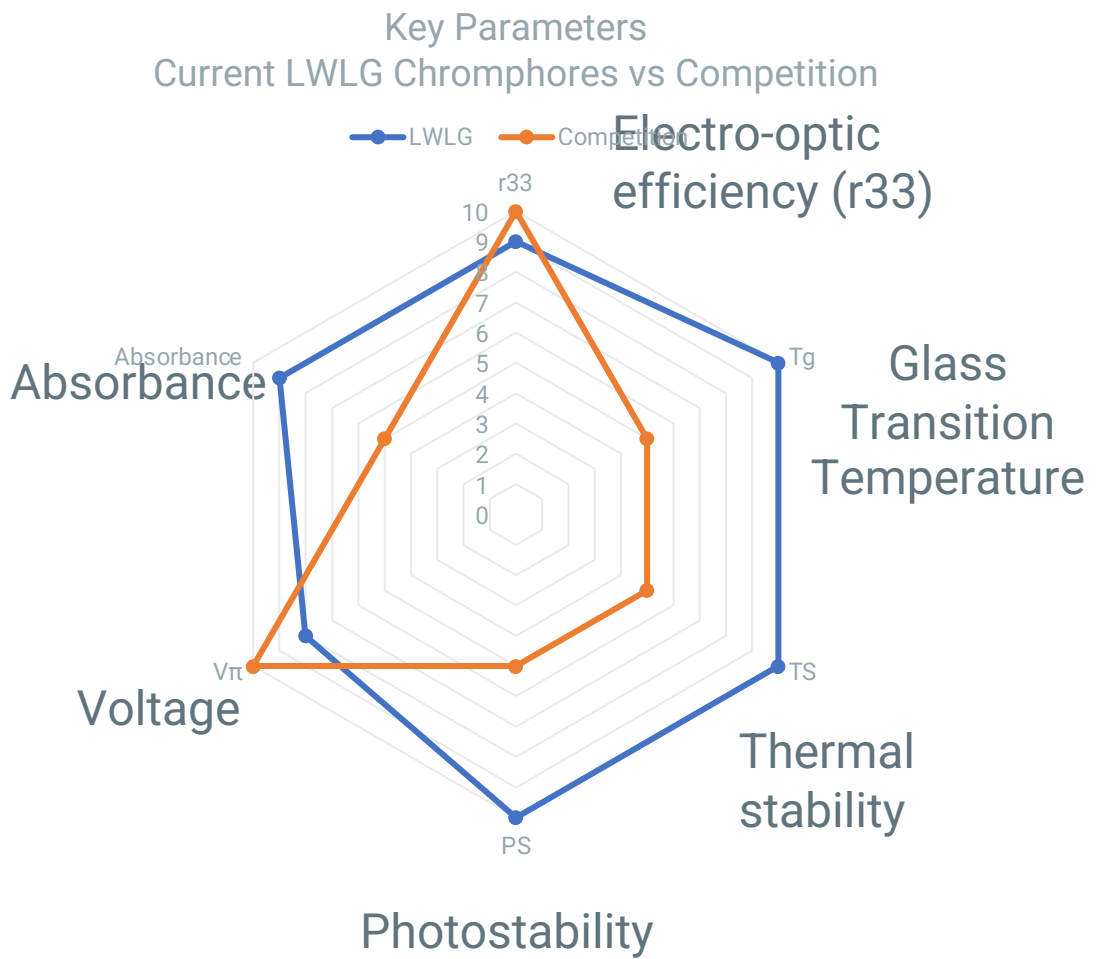
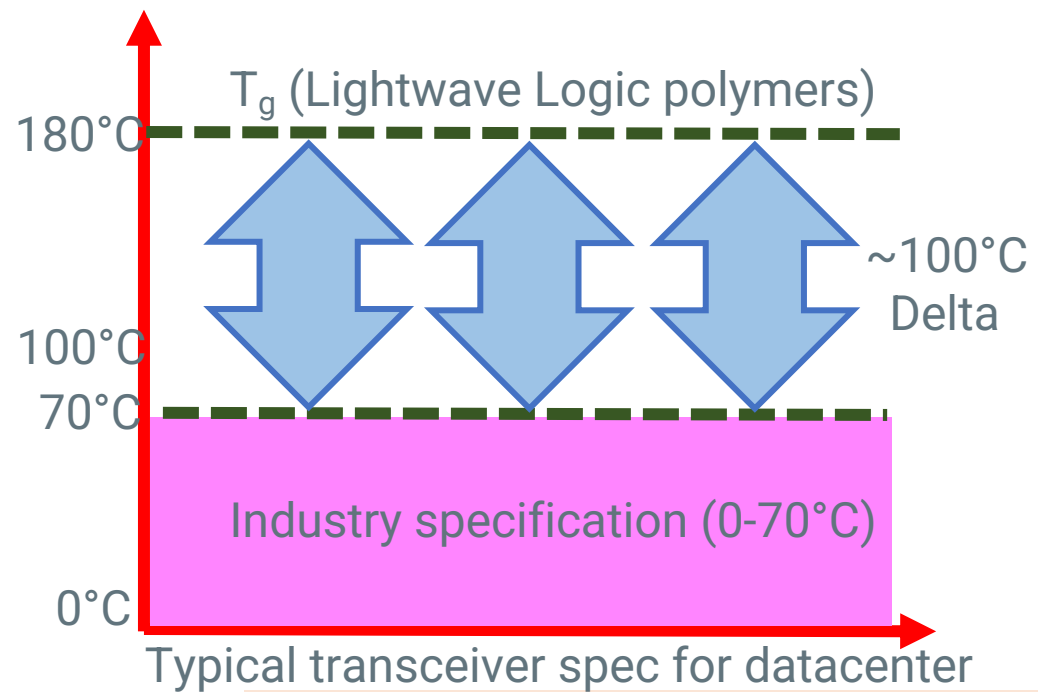
*Reliability and stability...*

# Optimized for reliability & stability



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- **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)



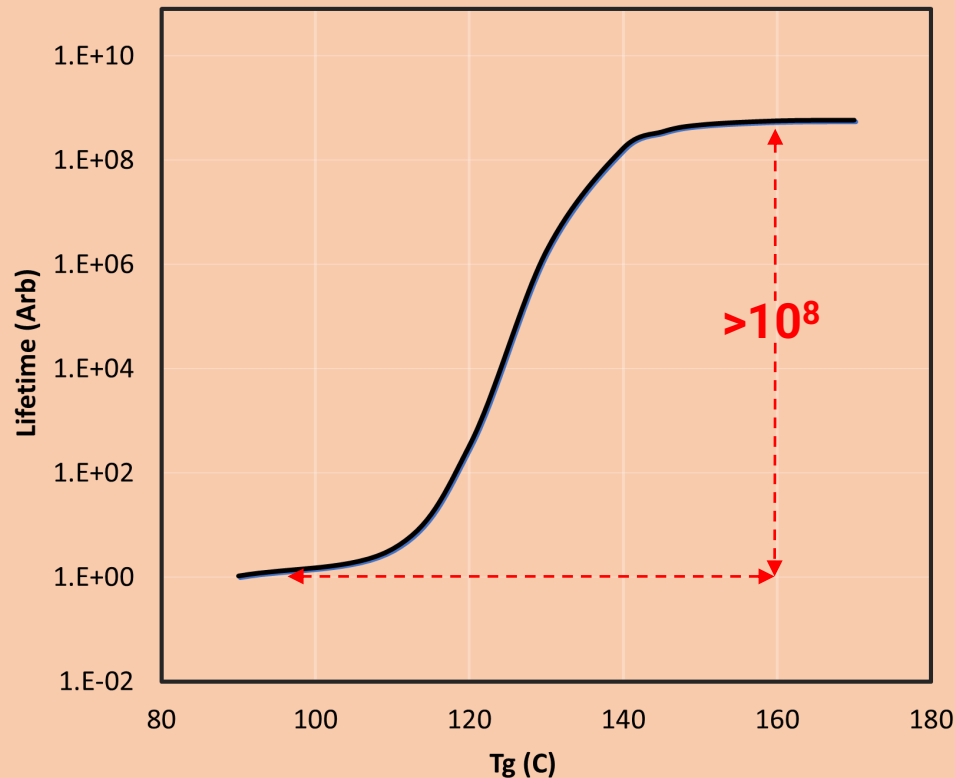
**Electro-optic material designed for reliability, stability, and overall operational performance**

# How important is glass transition temperature ( $T_g$ )?



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Lifetime at 85C vs  $T_g$



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<sup>8</sup> times greater** than the lifetime for a polymer with  $T_g = 90^\circ\text{C}$

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

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

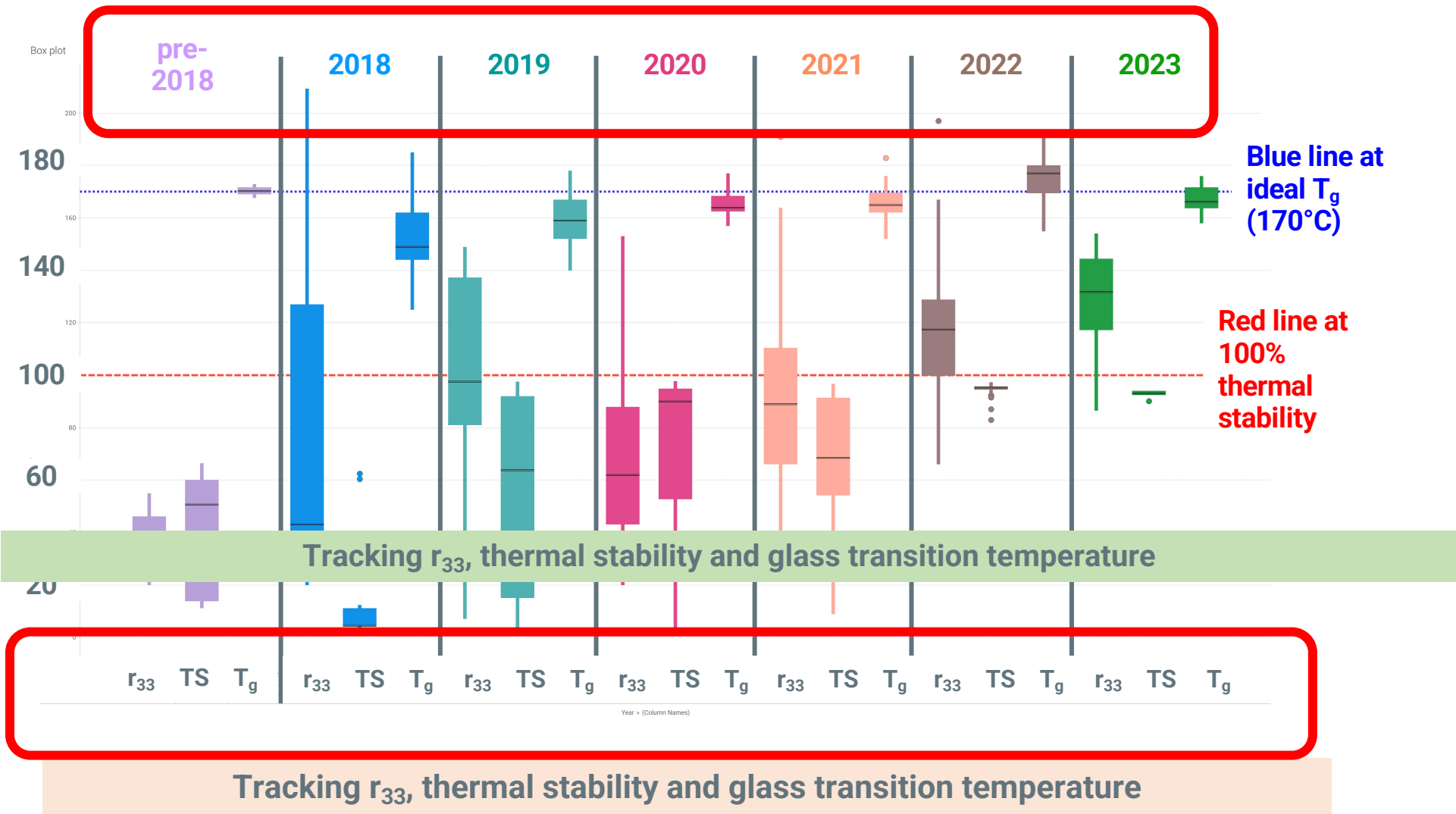
$$\ln(\tau/\tau_P) = E_R(1 + \tanh[(T_c - T)/D])/2RT + E_P/RT$$



# How have EO polymers improved over the last 6 years?



Box plot of Perkinamine®



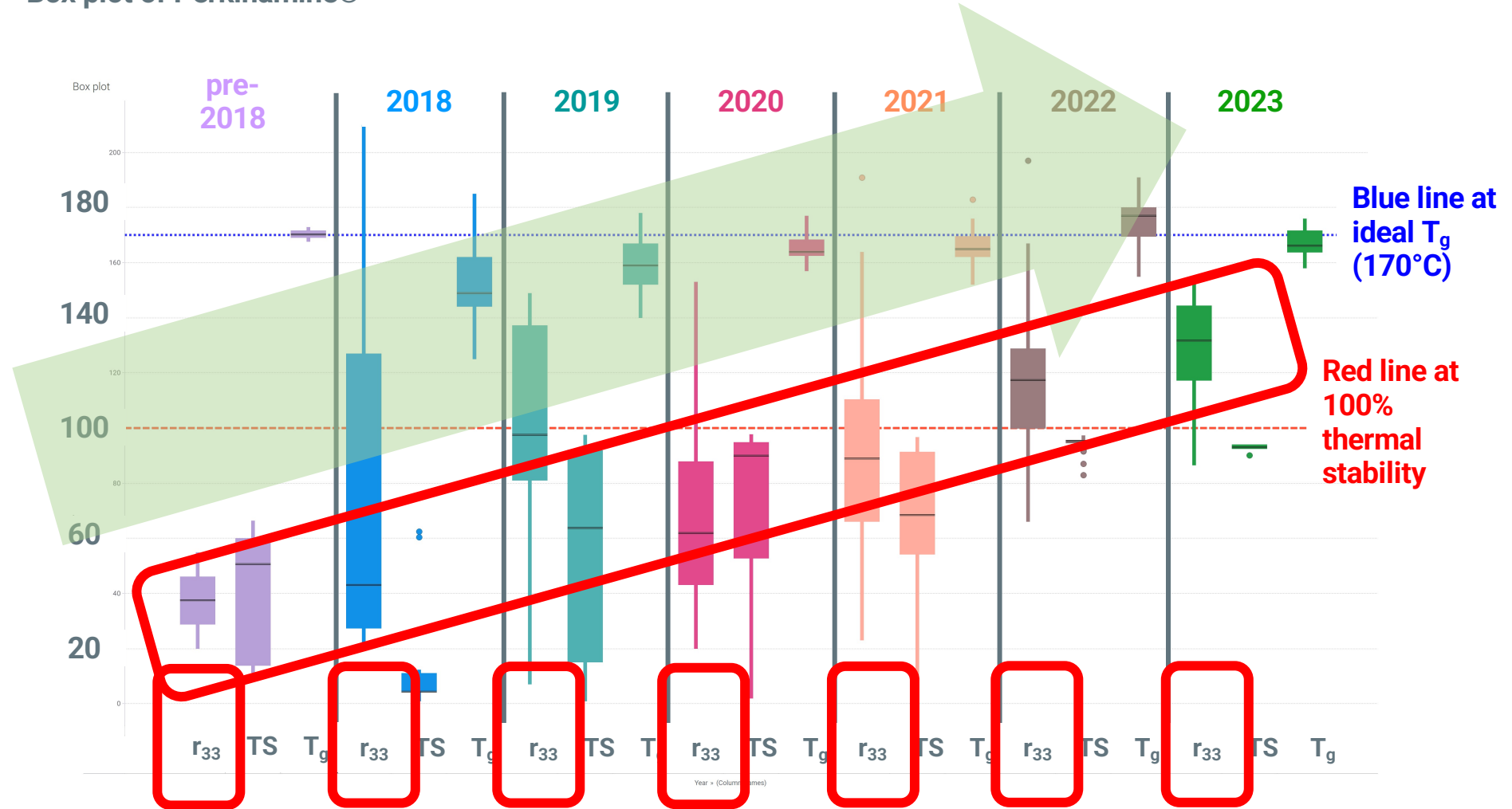
A box plot or boxplot is a method for graphically demonstrating the locality, spread and skewness groups of numerical data through their quartiles  
Source: Lightwave Logic (LWLG), \*best estimates;

# Tracking $r_{33}$ improvements



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Box plot of Perkinamine®

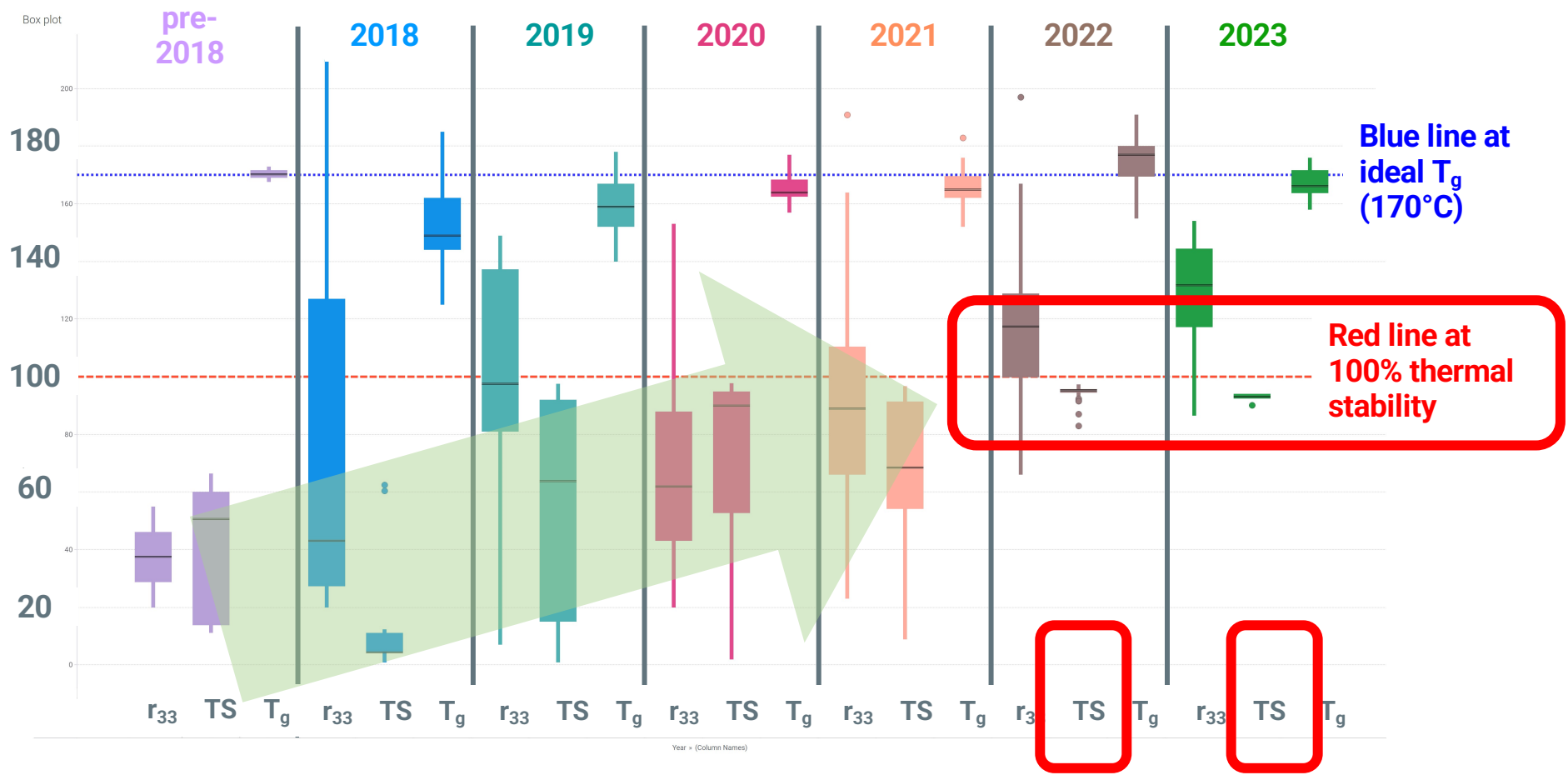


$r_{33}$  improved 5X over past 6 years; and now very stable in testing



# Tracking TS (Thermal Stability) improvements

Box plot of Perkinamine®



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

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

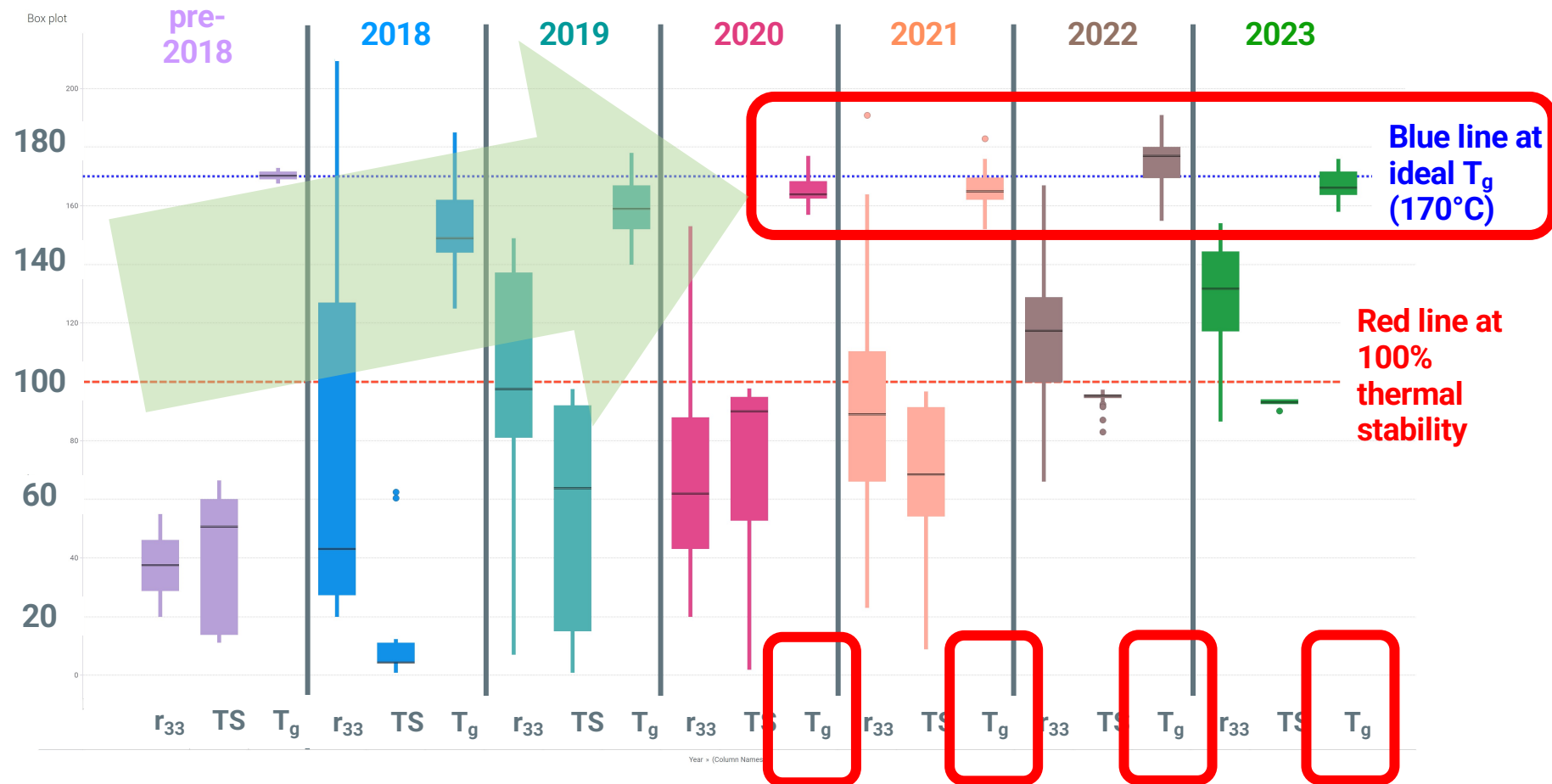


# Tracking glass transition temperature ( $T_g$ )



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Box plot of  
Perkinamine®



Tight control of materials with extremely high  $T_g$  at 170C

# Photostability vs Voltage and Insertion Loss



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Long and short-term photostability does not seem to be an issue with LWLG electro-optic chromophores

Photo-Induced Change in  $V_{\pi}$

Average % shift for 8 packaged modulators.  
Optical Intensity =  $0.5\text{MW}/\text{cm}^2$

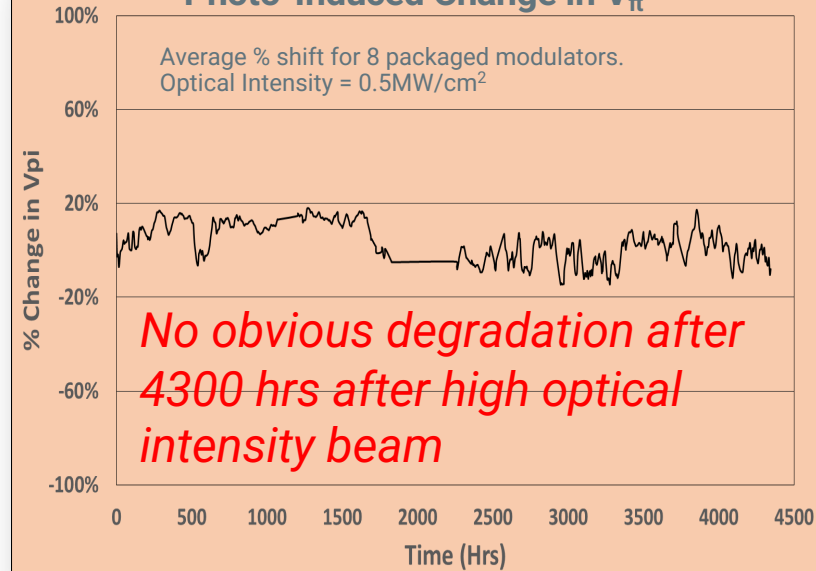
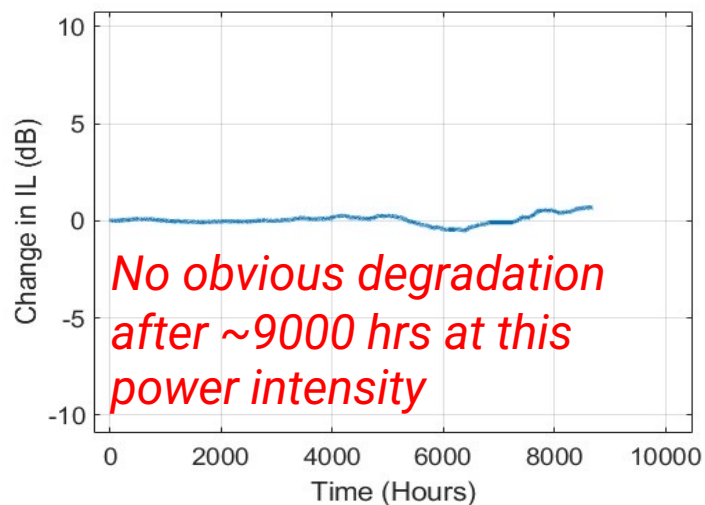
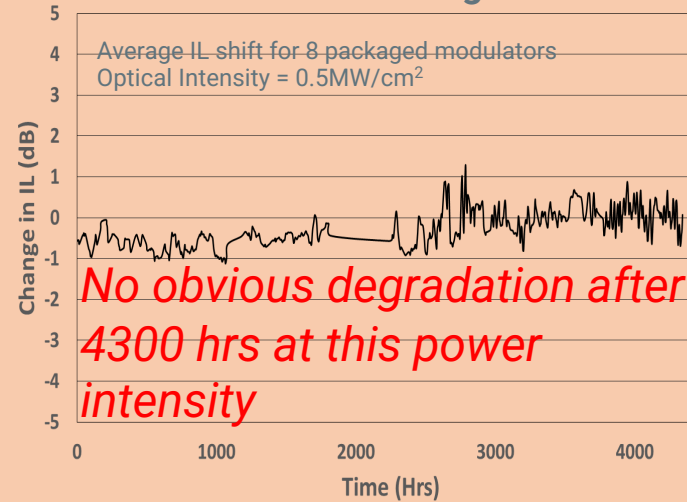


Photo-Induced Change in IL

Average IL shift for 8 packaged modulators  
Optical Intensity =  $0.5\text{MW}/\text{cm}^2$

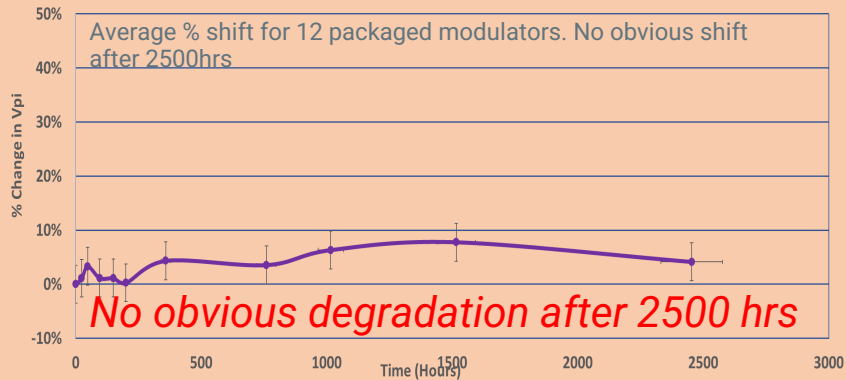


# Device Thermal Stability (TS) against change in voltage



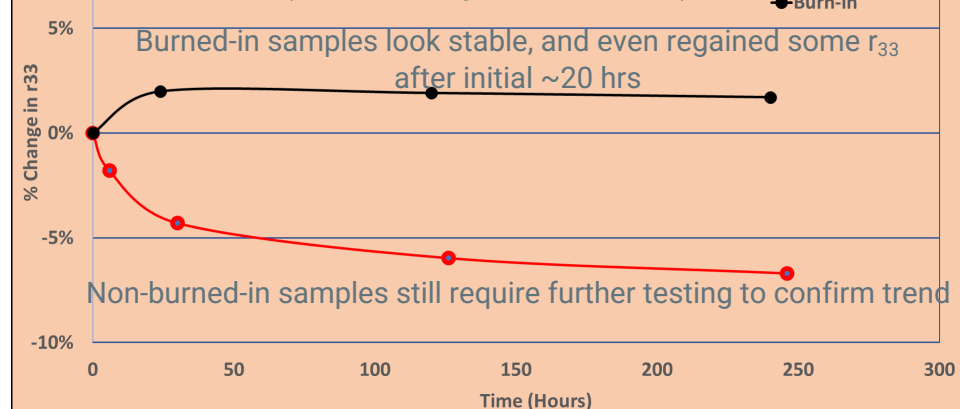
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Thermal test at 85°C on 12 packaged modulators



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

Thermal stability of thin films at 85°C with and without burn-in  
(burn-in temperature 120°C)



2 groups, each with 6 samples. Red = non-BI and Black = BI

Thermal stability does not seem to be an issue with LWLG packaged modulators or burn-in against change in  $r_{33}$



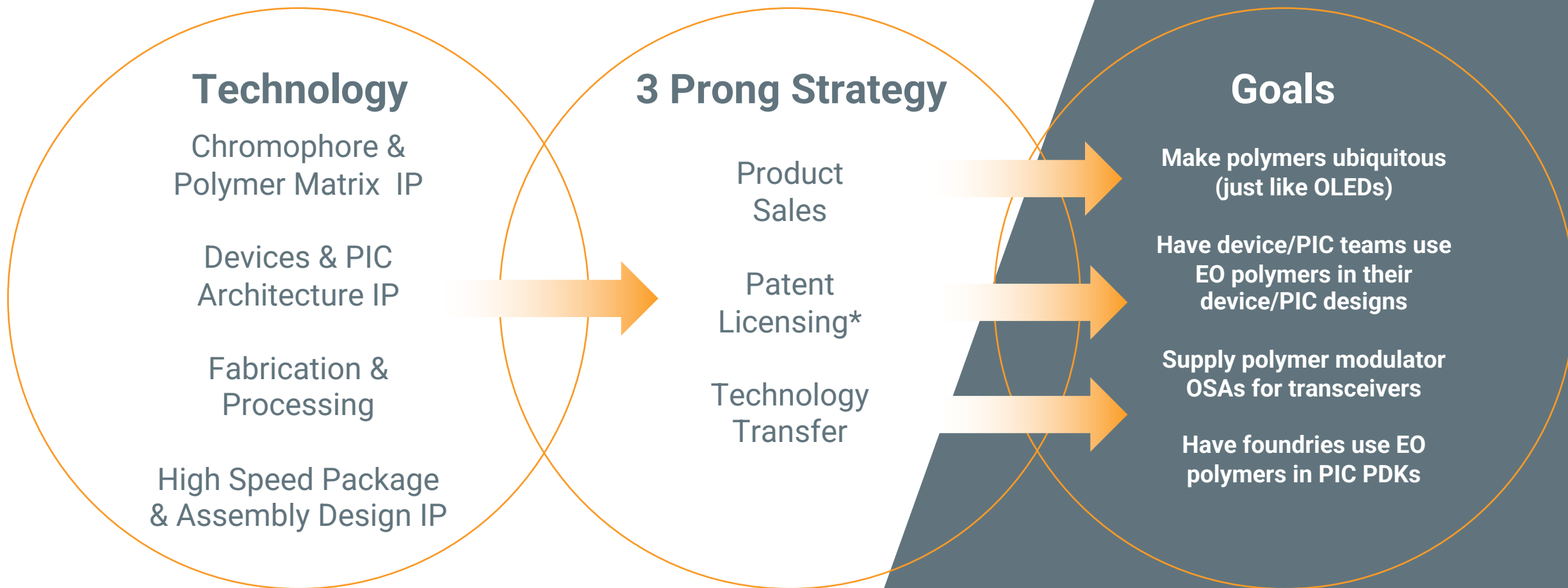
The background is a perspective view of a server room with rows of dark server racks on both sides. A glowing orange wave, composed of many thin lines, curves across the middle of the image. A network of white dots connected by thin lines is overlaid on the entire scene, giving it a digital or data-centric feel. The ceiling has a series of rectangular light fixtures.

*Trying electro-optic polymers...*

# Implementing a new technology platform...

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## Licensing model provides inherent scalability



\*1st commercial material supply license agreement 2Q23 → market acceptance



The background is a perspective view of a server room aisle. On both sides are rows of dark server racks. A series of glowing orange lines, representing data or network connections, curve from the left side towards the center of the aisle. The ceiling features a series of rectangular light fixtures. A faint, light-blue network diagram with nodes and connecting lines is overlaid on the entire scene. 

*Summary...*



# Takeaways

- Electro-optic polymers have *superior performance...*
- We continue to increase our *technical progress with reliability and stability...*
- We can scale polymer materials today, and are positioning to have *polymer modulators scale using foundries/OSATS...*
- We are developing prototypes for trial and reliability testing.





## Investor Relations Contact

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*Faster by Design*

*Thank you for listening*

[lightwavelogic.com](http://lightwavelogic.com)

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Englewood, CO 80112



The image depicts a perspective view down a long aisle in a server room. On both sides are rows of dark server racks. The floor and ceiling are dark, with the ceiling featuring a series of rectangular light fixtures. A complex network of thin, light-blue lines with small white nodes is overlaid on the scene, suggesting a data network. A thick, wavy, orange-gold line, composed of many fine parallel lines, curves across the middle of the image from left to right. At the bottom center, a dark gray horizontal bar contains the text "BACK-UP" in a white, italicized, sans-serif font.

*BACK-UP*

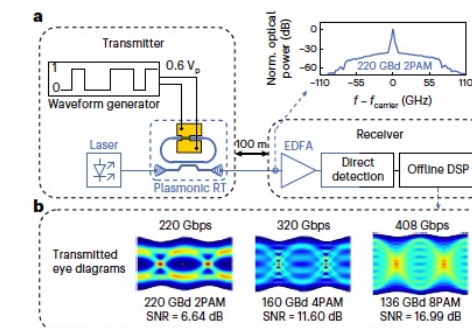
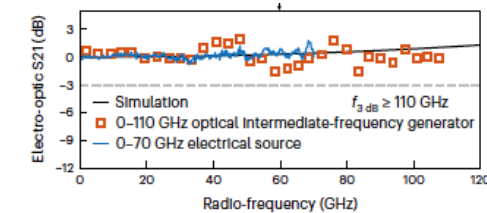
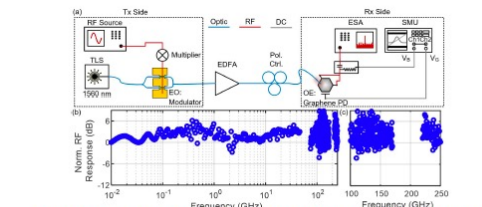
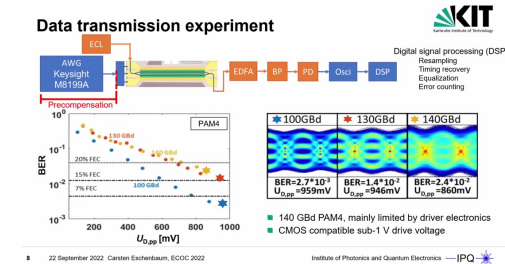


The background is a perspective view of a server room with rows of black server racks on both sides. A glowing orange wave, composed of many thin lines, curves across the middle of the image. A network of white dots connected by thin lines is overlaid on the entire scene, creating a digital or data network aesthetic. The ceiling has a series of rectangular light fixtures.

*3rd party verification...*

# 3<sup>rd</sup> party use of Perkinamine®

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





The background of the slide is a dark, atmospheric image of a server room. Rows of server racks stretch into the distance, illuminated by a cool blue light from the ceiling. Overlaid on this scene is a complex network of thin, glowing orange lines that connect various points, suggesting data flow or a global network. A thick, wavy orange band also curves across the middle of the image. In the lower portion, a semi-transparent dark grey rectangle contains the text.

*E0 polymers are competitive with  
semiconductor modulators...*

# Competitive polymer positioning



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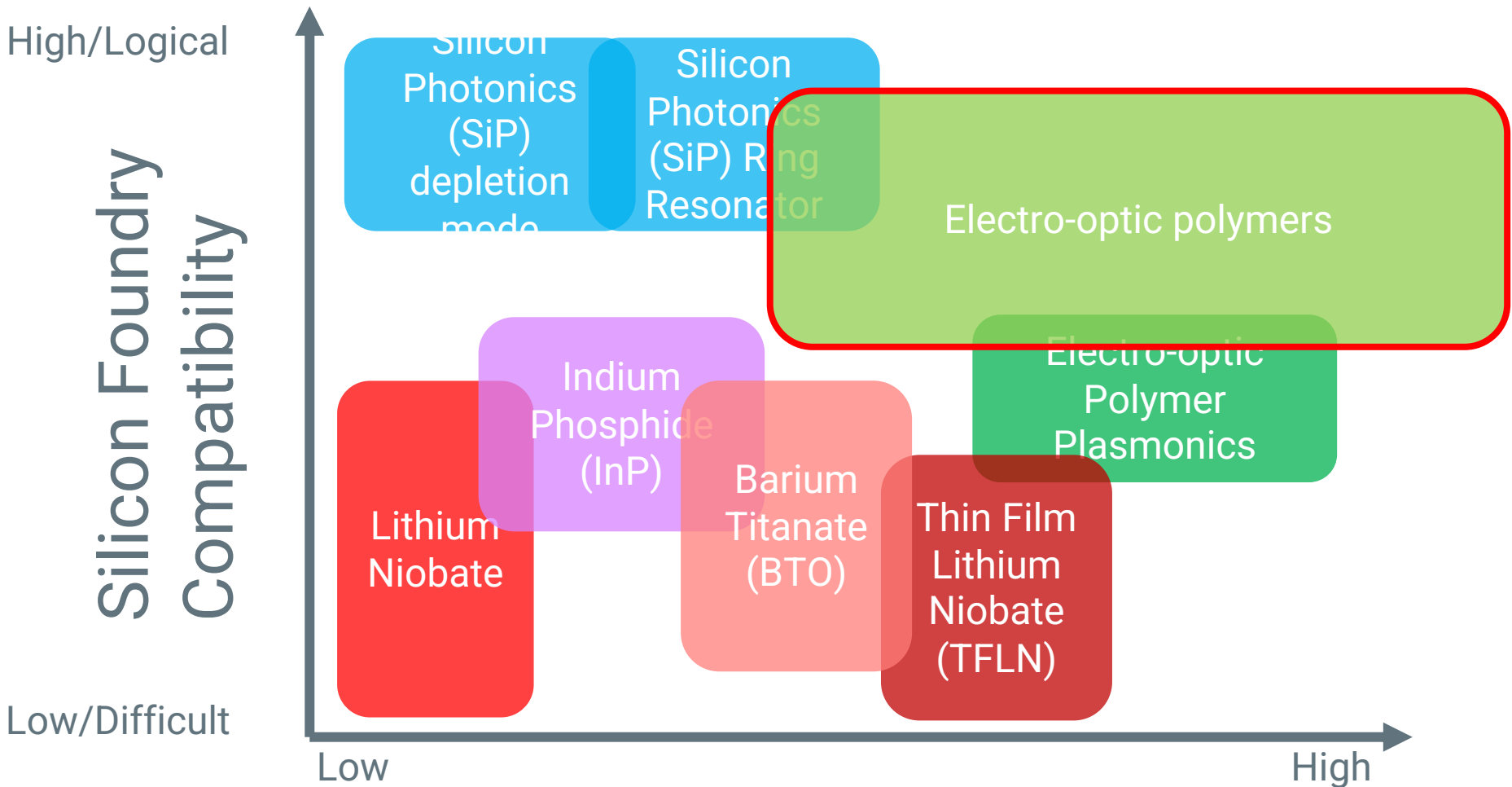


Figure of Merit (low V, high Bandwidth, small size)

Polymer modulators outperform competitive semiconductor technologies

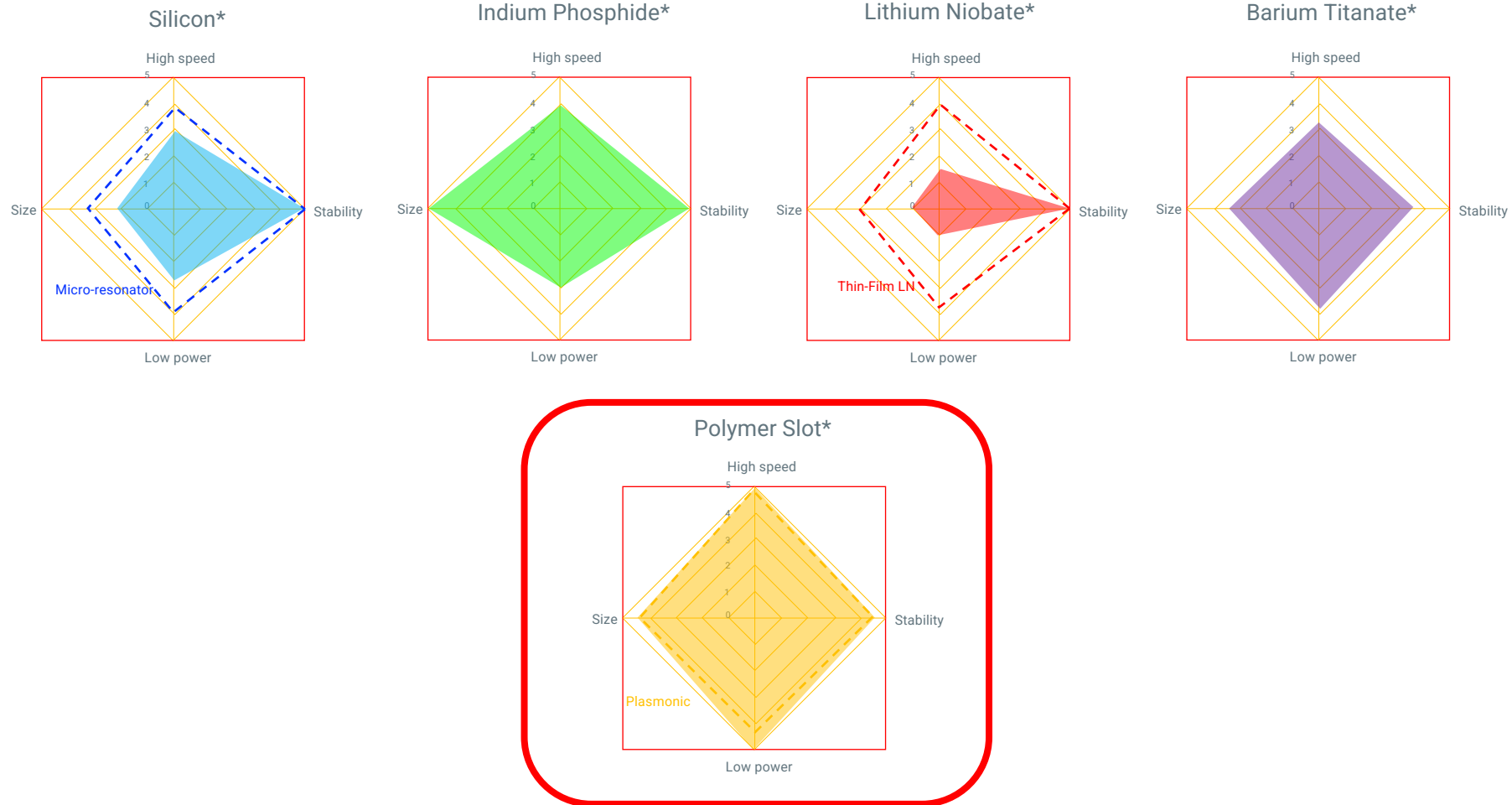
Source: Lightwave Logic (LWLG) research showing target metrics for polymers



# Polymer attributes are impressive...



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Technology spider chart → polymers have strong coverage → excellent performance

A digital illustration of a server room aisle. The perspective is looking down a long, narrow corridor lined with dark server racks on both sides. The floor is a light blue-grey color. The ceiling features a series of rectangular light fixtures. A prominent feature is a thick, wavy, orange-gold line that curves across the middle of the frame, composed of many thin, parallel lines. Overlaid on the entire scene is a network of white dots connected by thin, light blue lines, creating a web-like pattern. The overall color palette is dark and futuristic, with blue, grey, and orange-gold tones.

*END*