

LaserLight-LiFi for ultra-high-speed sharing of LiDAR data

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KYOCERA SLD Laser, Inc.

Goleta, CA, United States



SLDLASER

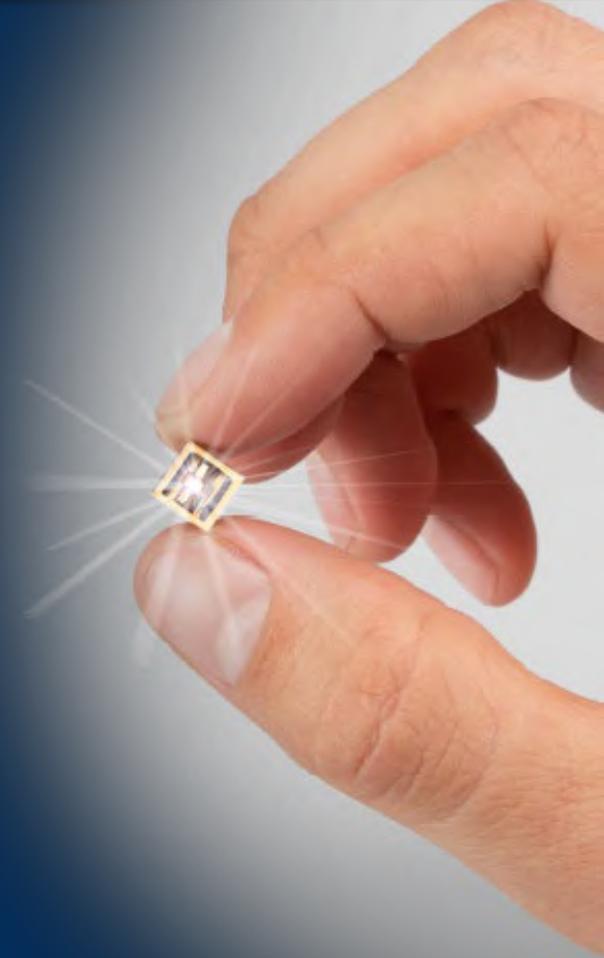
Key Messages



- Laser-based white light “LaserLight™” offers unique benefits over LED
10-100X the brightness, 10X the range, dynamic beam shaping, fiber delivery, sensing, LiDAR and LiFi.
- LaserLight-LiFi overcomes conventional RF wireless challenges/limits and enables 50-100X the data rate of LED based LiFi.
- We will demonstrate the application potential of KSLD’s LaserLight™ SMD as a LiFi transmitter.
- In this presentation we will focus on **LiFi as the carrier for real-time LiDAR data and Video.**
- LaserLight-LiFi has an exciting future for a wide range of communication applications not only for Mobility; also, for Smart Cities, Factories, Healthcare and ultimately Homes.



- Kyocera SLD Laser introduction
- LaserLight[™] -SMD: the Source for LiFi
- Why LaserLight-LiFi?
- LaserLight: Use case AD > Car2Car and Car2X comm.
- LaserLight: Use Cases in other Mobility areas



KSLD Laser : Business entity within Kyocera



SLDLASER

- Founded in 2013, Acquired 2021
- Auto and Lighting DNA
- Auto certified, IEC safety certs



LaserLight SMD
1000 lumen
Dual White/IR
Fremont, CA
4" GaN laser chip factory



KSLD Laser: Company intro & Portfolio



Semipolar GaN Laser Diode + Phosphor = LaserLight



History

- SLD spun out of Soraa (LED) in 2013
- ~215 employees with DNA from Auto, SSL, laser industries
- GaN pioneers @ UCSB Prof's Nakamura and DenBaars
- Acquisition in January 2021 by Kyocera Group

Operations

- HQ and Epi in Santa Barbara, CA
- Device engineering & Production fab in Si Valley, CA
- Module product design in Tucson, AZ
- Assembly in Asia

Technology

- Unique Laser Diodes, based on Semipolar GaN
- LaserLight™ Fiber & SMDs with 100x brightness of LEDs
- >500 patents covering materials to applications

Commercialization

- In series production for Auto since 2019
- Beyond Lighting: Sensing and LiFi commercialization since 2021
- IATF 16949 and ISO certified; UL and IEC safety certified

KSLD Laser Worldwide presence



California

Epi growth and
Wafer fab



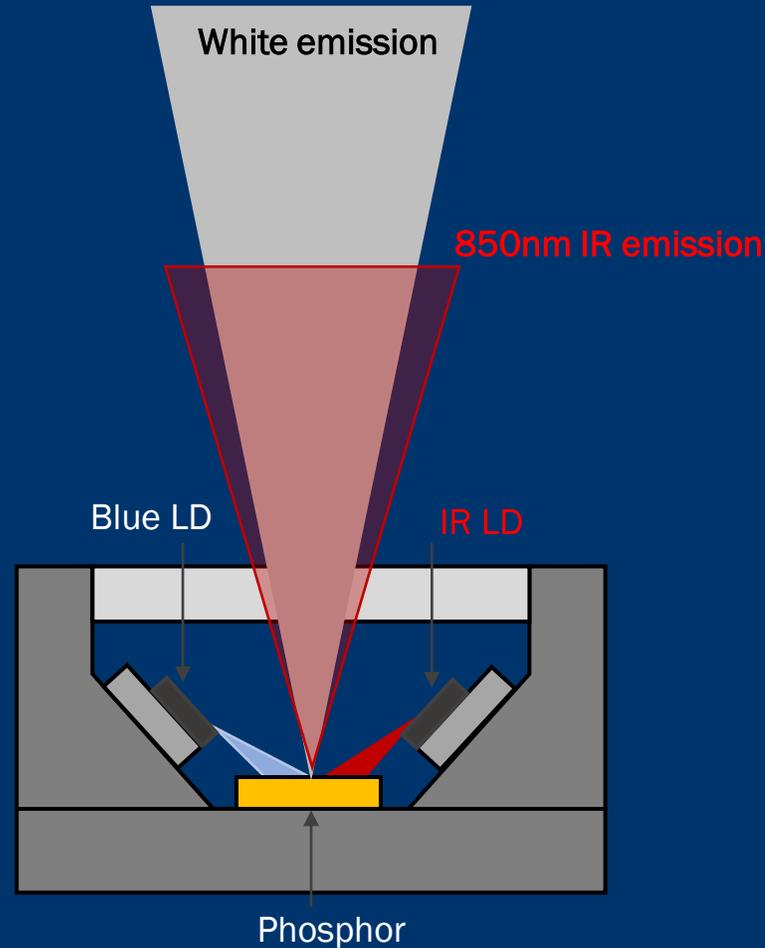
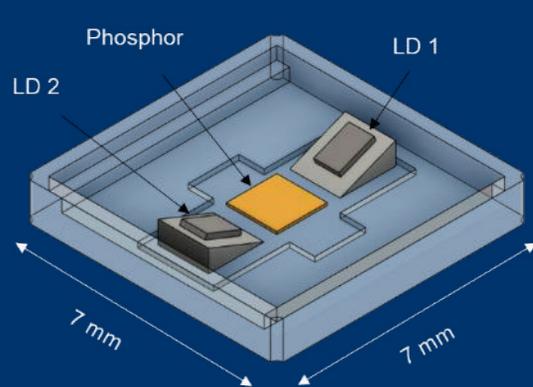
Asia

Assembly
and Test

Santa Barbara HQ, EPI, Advanced Development
Silicon Valley EPI, Wafer Fab, Product Development
Los Angeles Product Showroom
Tucson Product Design Center
Los Angeles, Detroit Marketing, Sales & Support

Munich Marketing, Sales & Support
Tokyo Marketing, Sales & Support
Shanghai Marketing, Sales & Support
Shenzhen Marketing, Sales & Support
Thailand, Philippines Assembly & Testing

Single Chip White + IR LaserLight SMD



THE NEW VALUE FRONTIER

LASERLIGHT SMD LASERLIGHT Blue+IR SMD



PRODUCT SPECIFICATIONS SUMMARY

PRODUCT CHARACTERISTICS

Parameter	Units	Typical Value
White Light Channel		
Luminous Output	lm	450
Emitting Region (dia.)	mm	0.35
Luminance	Mcd/m ²	1000
Color Temperature (CCT)	K	6000
Color Rendering Index	CRI	70
Forward Current	A	2.3
Forward Voltage	V	5.0

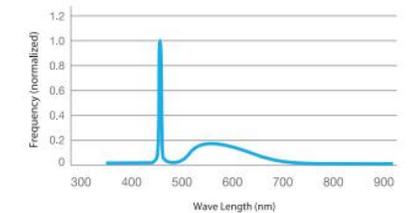
Infrared Channel

Dominant wavelength	nm	850, 905, 940
Output Power	mW	250
Emitting Region (dia.)	mm	0.5
Forward Current	A	1.0
Forward Voltage	V	1.8

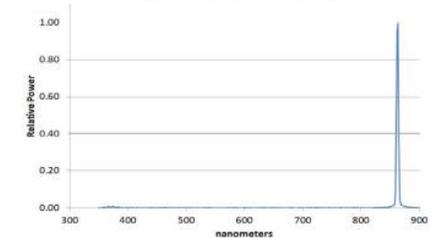
Mechanical Characteristics

Package Dimensions	mm	7.0 sq x 2.6
Max oper. temp. (case)	°C	50
Viewing Angle	deg.	120

SPECTRAL POWER DISTRIBUTIONS



Device may be switched between spectra or both simultaneous



Why “LaserLight” Laser Diode Based LiFi?



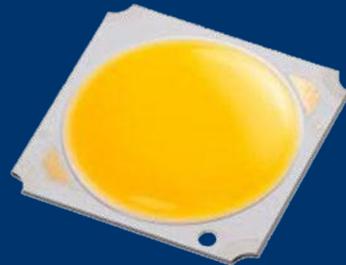
Legacy WiFi:

- RF, mm-wave
- Short range
- Limited speed
- Poor efficiency
- Limited available spectrum
- Not secure



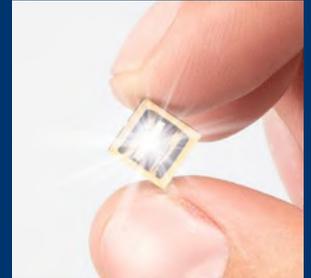
LED LiFi:

- High Efficiency
- High Reliability
- Not bright enough for long range
- Not capable of fast comm or sensing
- Low spectral efficiency



Laser LiFi:

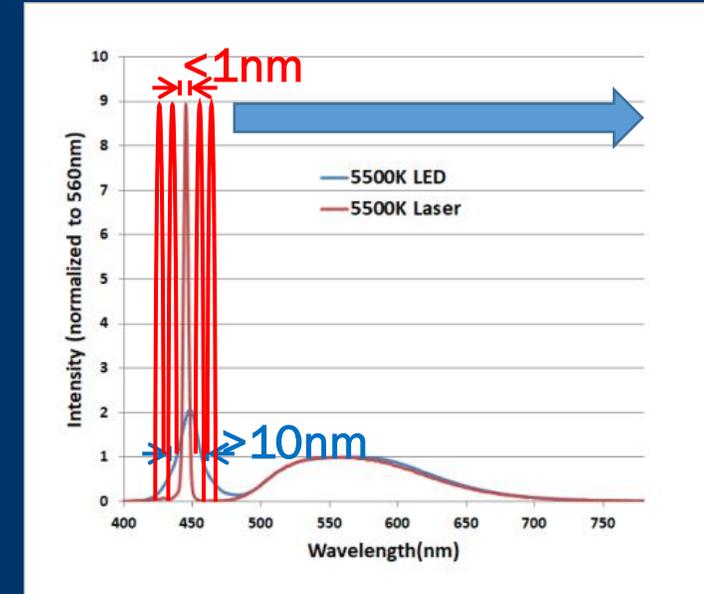
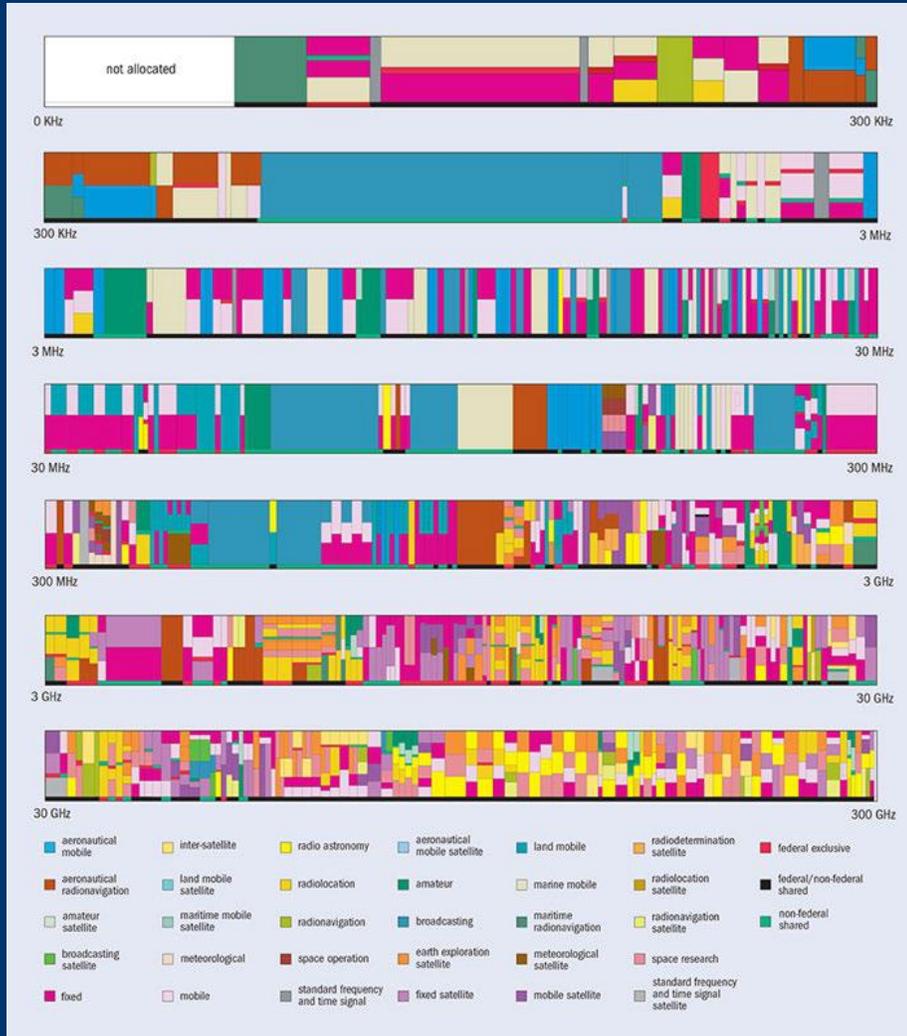
- High Efficiency
- High Reliability
- 100 times Brighter than LEDs
- 1/50th the Size & 1/20th the Weight
- 5-10X further range (1km distance)
- High spectral efficiency
- 100x faster communication and sensing:
>10GHz Laser vs. 100MHz LED
- Sharp patterns for precise control
- Spotlighting for directional and outdoor
- No RF/EMC issues



Why “LaserLight” LiFi?: Abundant Spectrum



RF spectral usage



- RF is highly regulated and available spectrum is full
- Congestion by multi-use of same frequency causes interruption and reliability issues
- Sub-nm linewidth of laser offers higher spectral efficiency than LED
- N×Channels in visible spectrum without congestion are available

100 Gbps Demonstration: CES 2022



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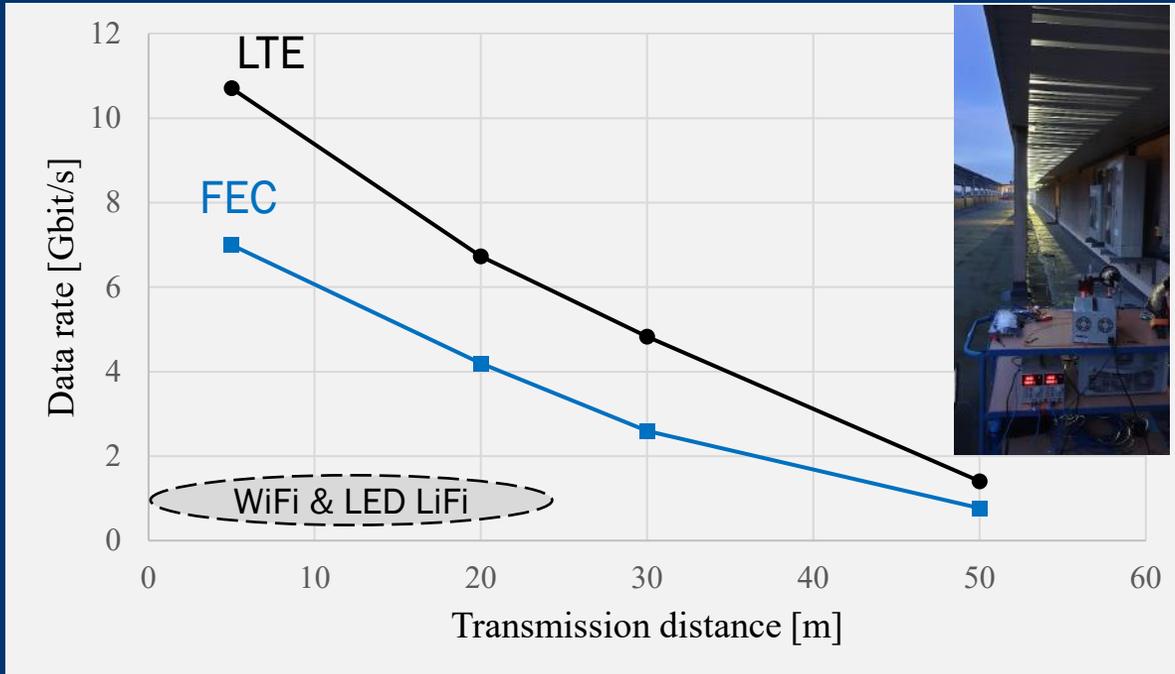
KYOCERA SLD Laser Achieves World Record LiFi Communications Data Rate 100 times faster than 5G

Company to Demonstrate Award-Winning >90 Gbps DataLight LiFi Innovation and for Automotive and Consumer Applications at the Consumer Electronics Show, January 5 - 7, 2022 in Las Vegas, NV

January 05, 2022 05:19 PM Eastern Standard Time



LaserLight SMD LiFi: 10 Gbit/s per channel



- High data rate up to **>10 Gbit/s** at **5 m**
- Maintained **>1 Gbit/s** data rate up to **50 m**

- 5 m demo covers **interior** situation
- 50 m demo covers **Car2X** cases

*LTE target is based on the staircase FEC code
(LTE: 5.6×10^{-2} and FEC: 3.8×10^{-3})

LaserLight LiFi: up to 20 Gbps per SMD

KSLD LiFi transmitter modules

✓

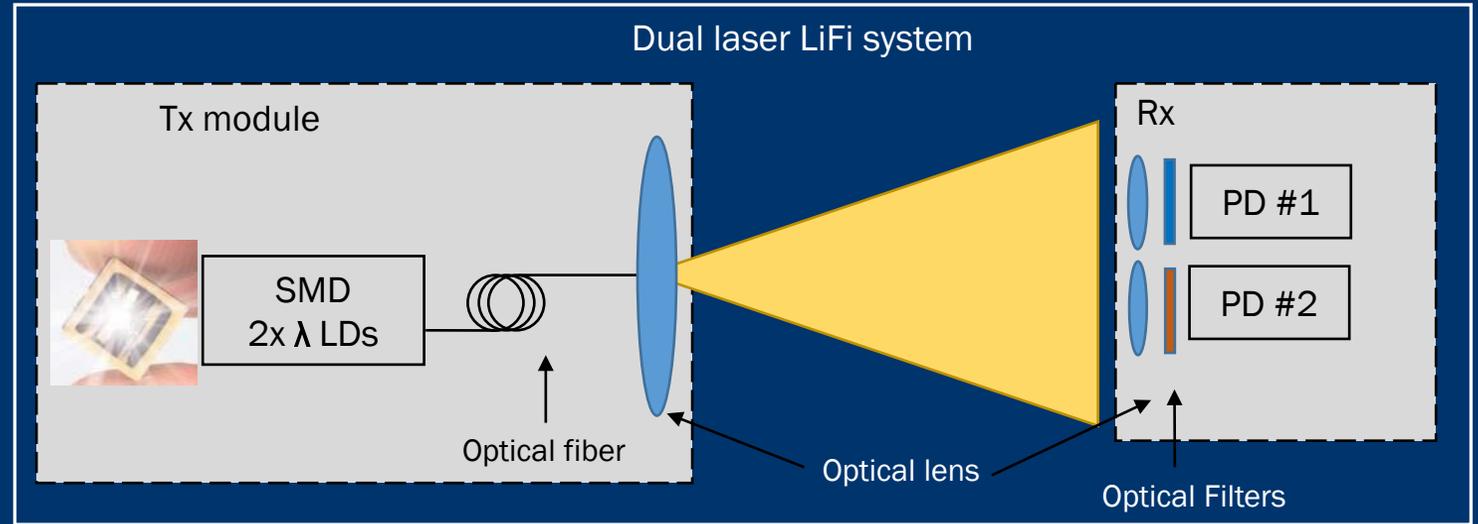


Micro-spot module

✓



Fiber-coupled module



Modulation/signal processing scheme

- ✓ QAM (Quadrature amplitude modulation)
- ✓ OFDM (Orthogonal frequency division multiplexing)

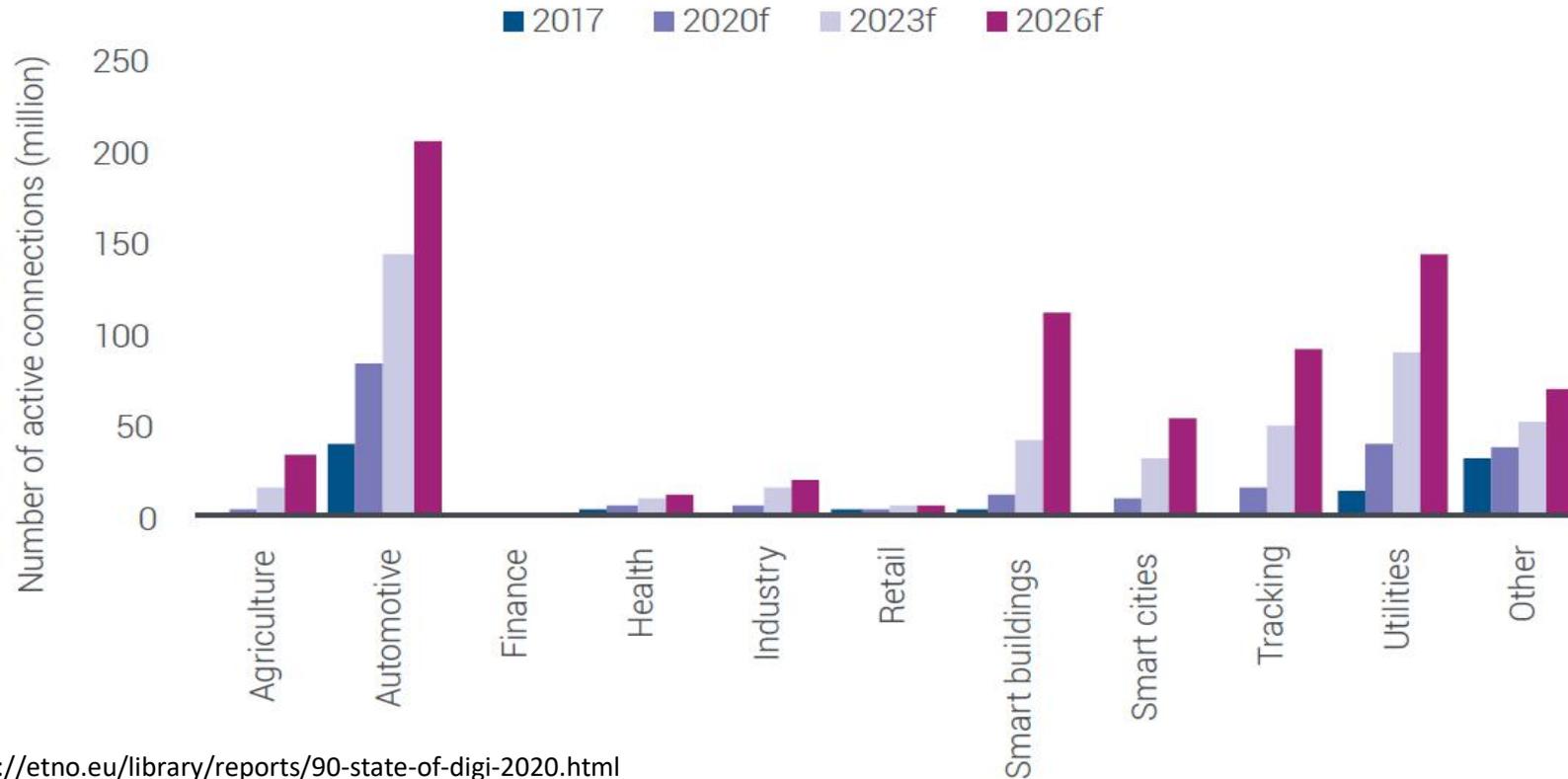
Chipset-development: on the way to 2025



20 Gb/sec demo
400 lumen
2 deg spot module

LiFi: Automotive Data needs

Figure 2.15: Number of active IoT connections by vertical industry sector, Europe

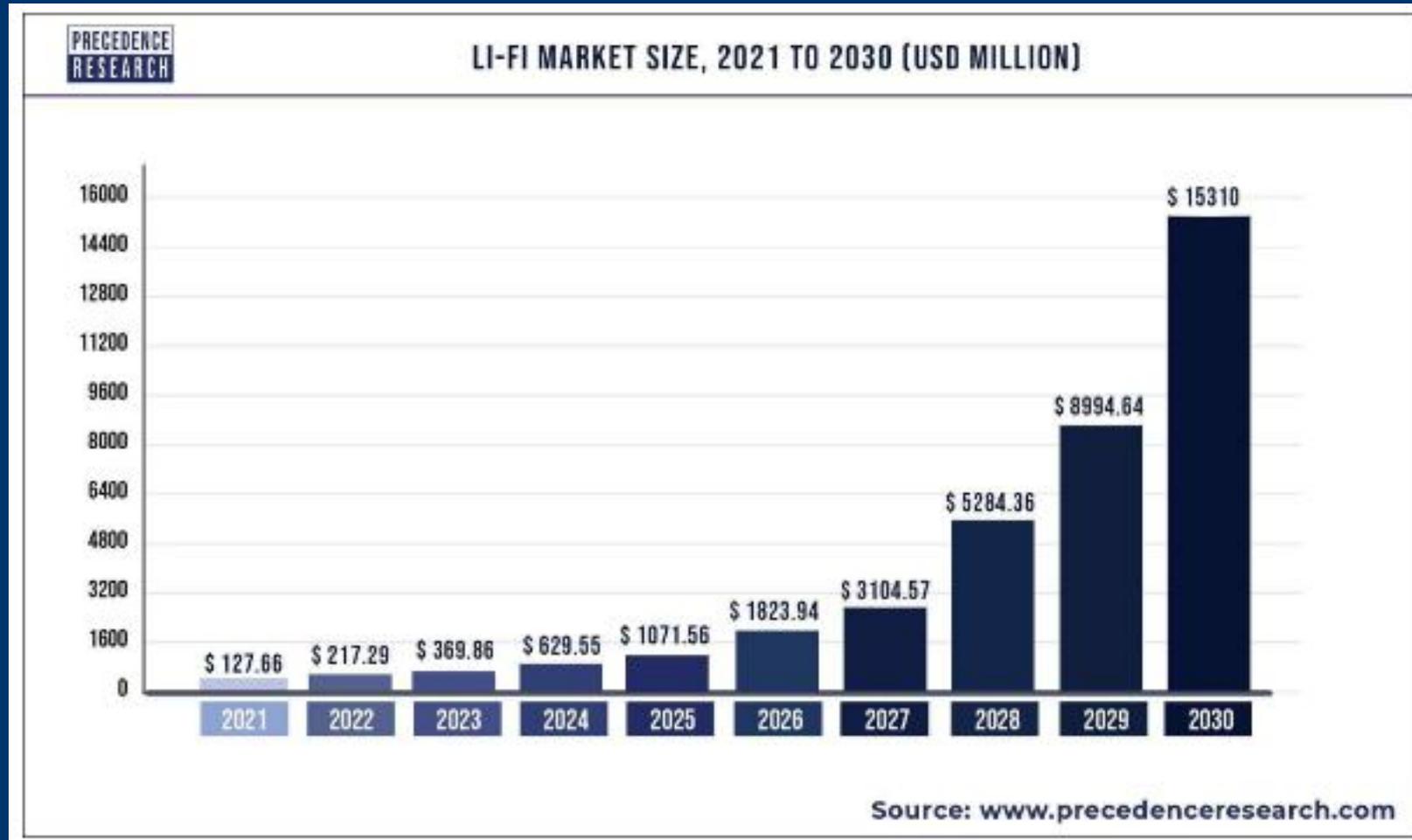


<https://etno.eu/library/reports/90-state-of-digi-2020.html>

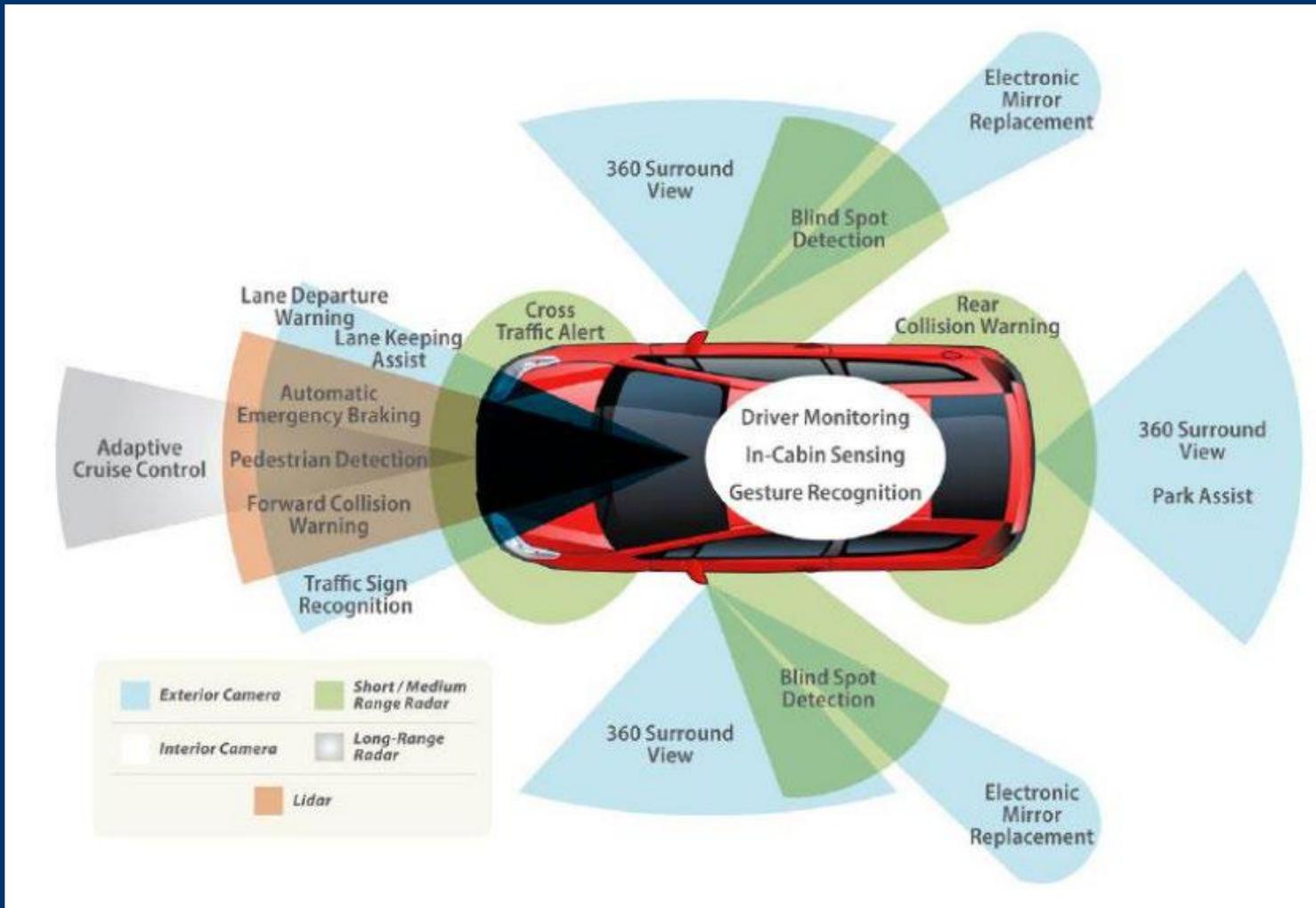
LiFi Market Outlook 2022 to 2030



- LiFi market size 2021 \$128M with CAGR of 51% projected over 2022-2030 reaching \$15B in 2030
- LaserLight LiFi expected to be a growing share in this overall LiFi market by enabling 100x faster speeds

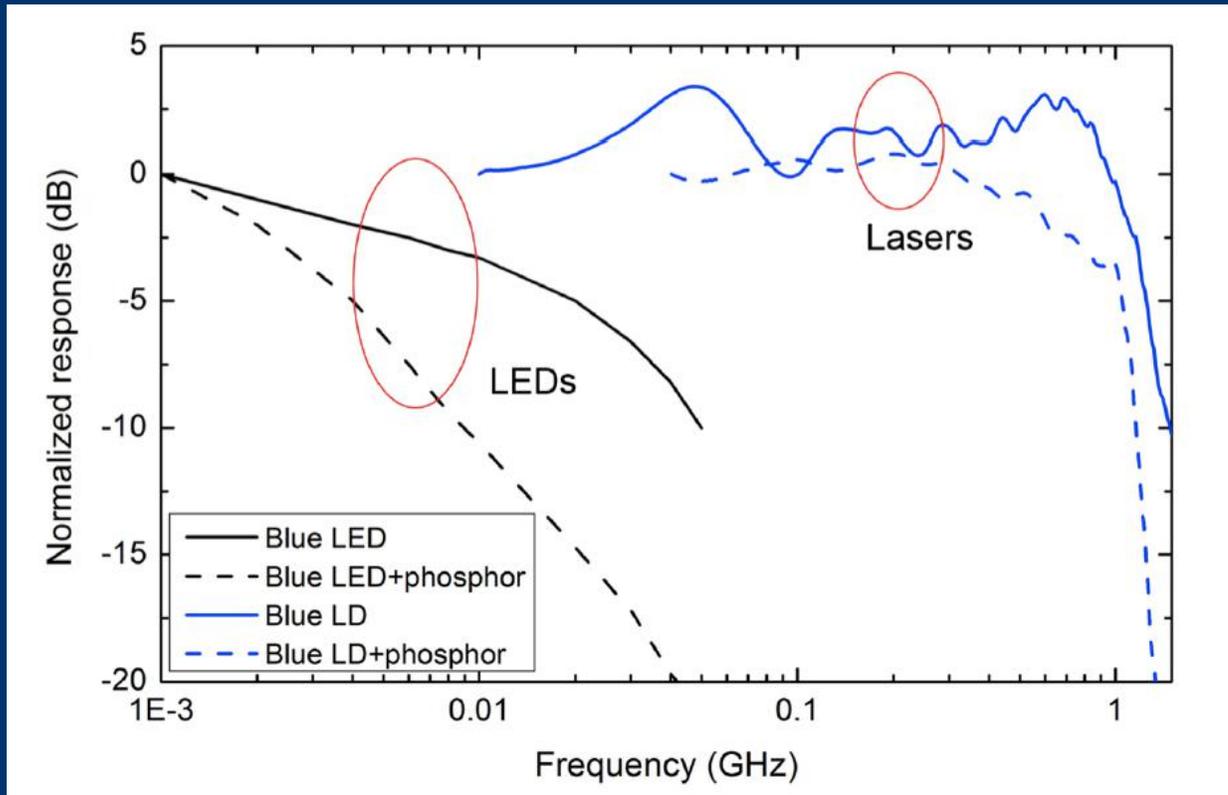


Towards Autonomous Driving: L3 (>L4>L5)



- For L3 AD, cars are equipped with numerous sensors.
- LiDAR (various principles) is being implemented.
- Steadily larger demands for resolution and performance
- Data sharing & exchange - V2V and V2X - will become imperative.
- High Speed – Large Bandwidth data management will be required.

LaserLight-SMD LiFi vs. LED LiFi

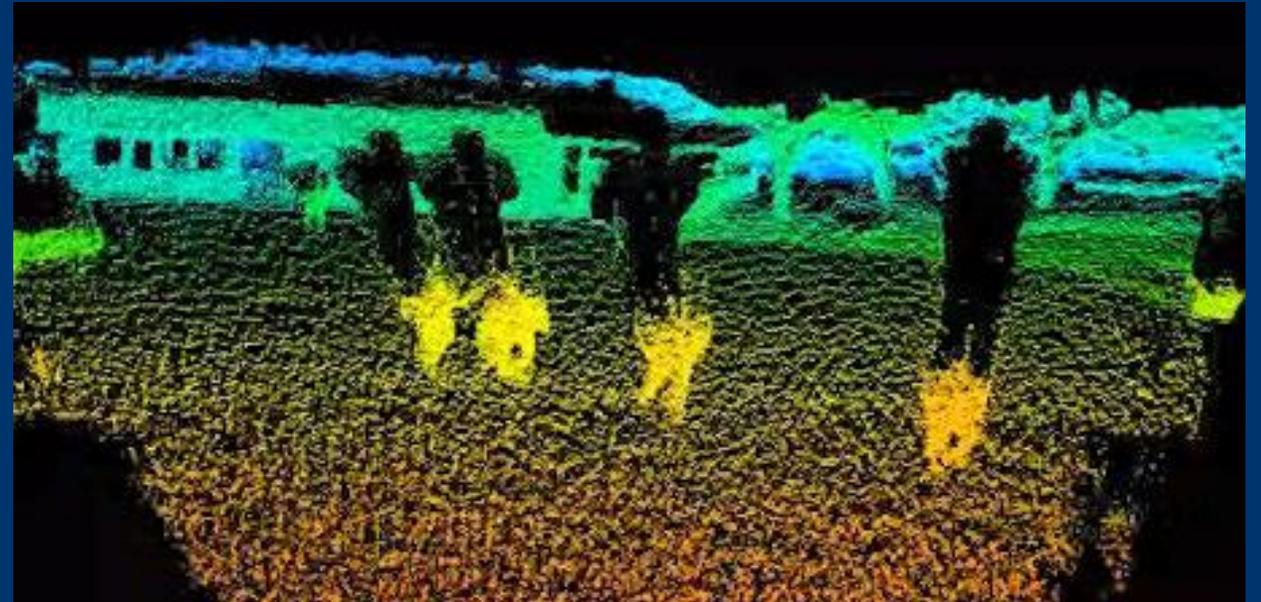
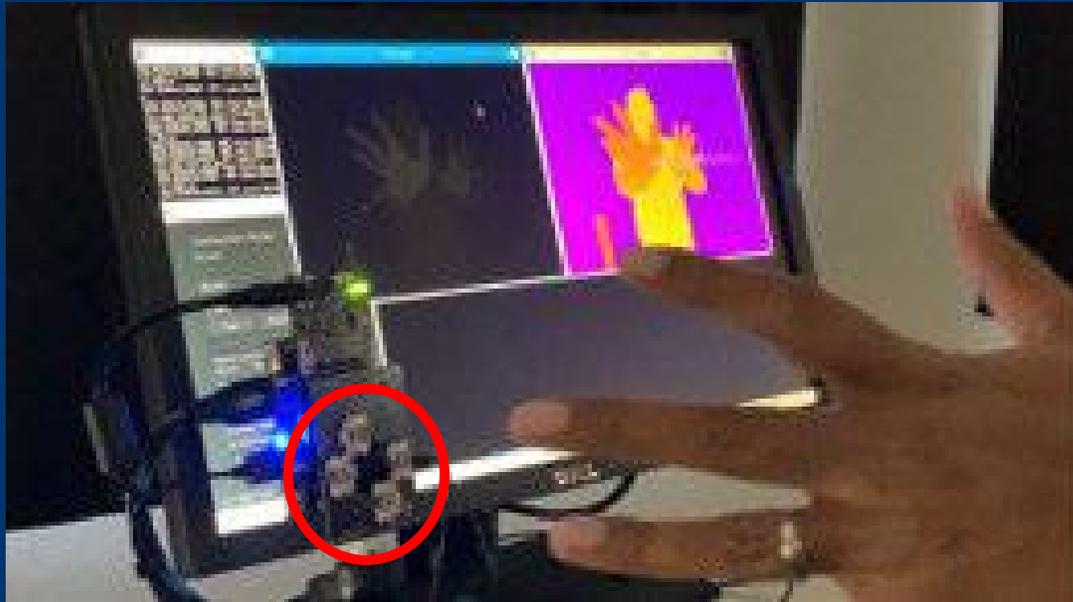


LaserLight LiFi: : works in strong sunlight



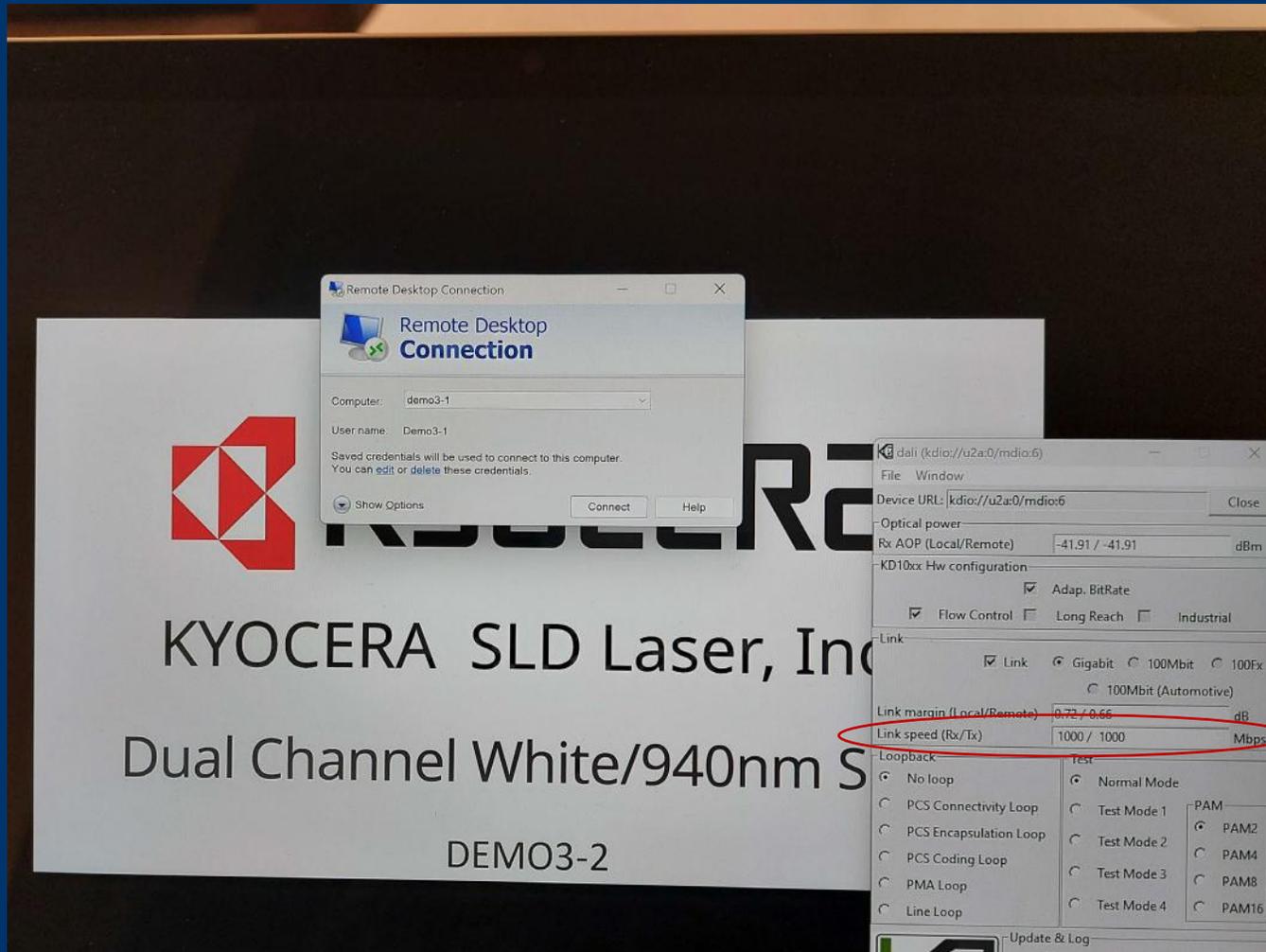
		Dark Room	Sunlight Irradiance	Sunlight + Blue Filter
S8664-05K [0.19 mm ²]	Average SNR [dB]	18.58	16.42	17.36
	SNR degradation compared to Dark Room	0%	11.6%	1.7%
	Data rate @ BER < 3.8e-3 [Mbps]	1139.26	1015	1080
	Degradation of data rates compared to Dark Room.	0%	10.9%	5.18%

M. S. Islam *et al.*, "The Impact of Solar Irradiance on Visible Light Communications," in *Journal of Lightwave Technology*, vol. 36, no. 12, pp. 2376-2386, 15 June, 2018.



Non-scanning Flash LiDAR

- Based on Dual Emission SMD
- No moving part, all solid state
- High resolution (640x360 pixels)
- Middle range detection (50-150m)
- High intensity IR laser

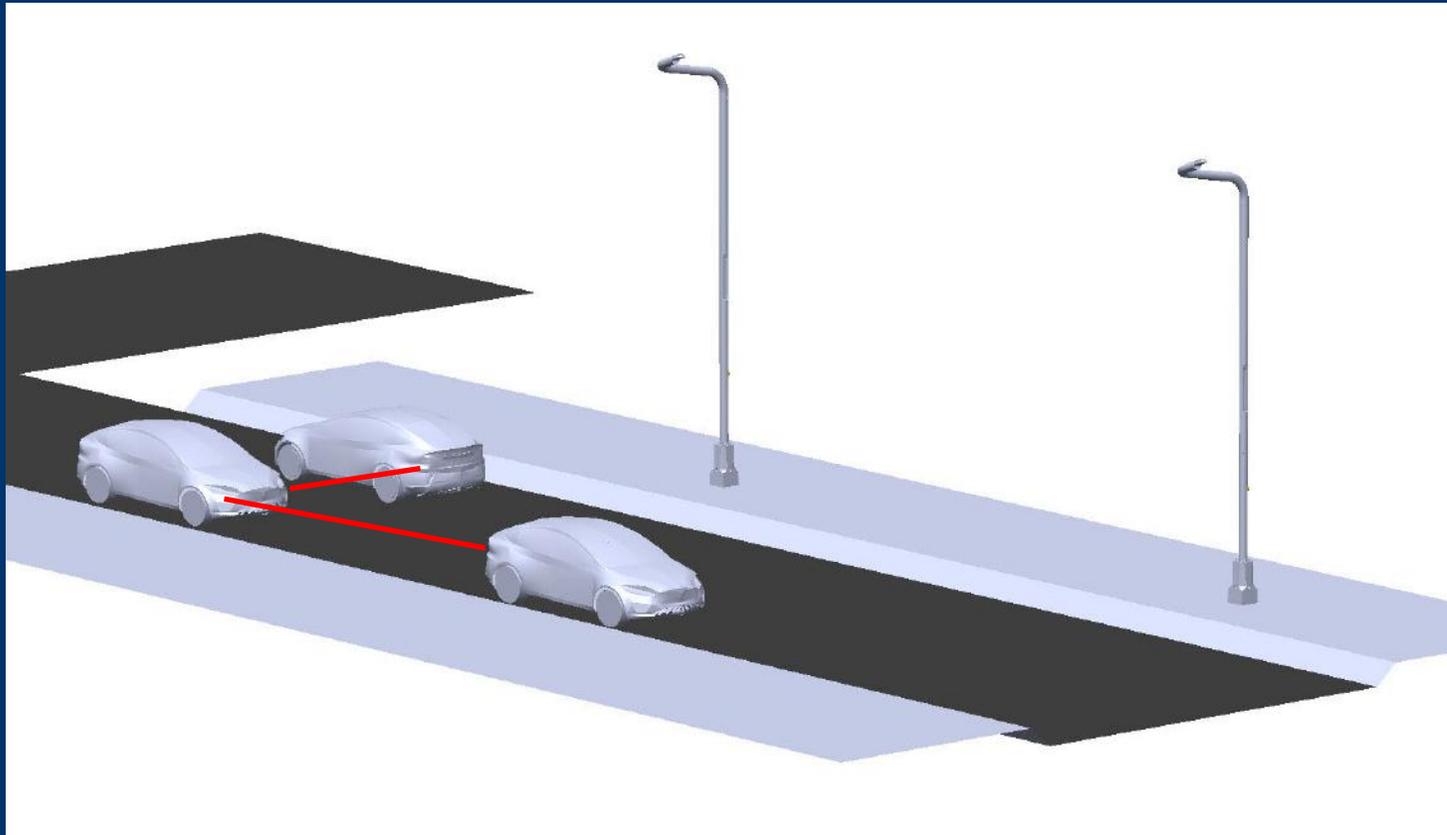


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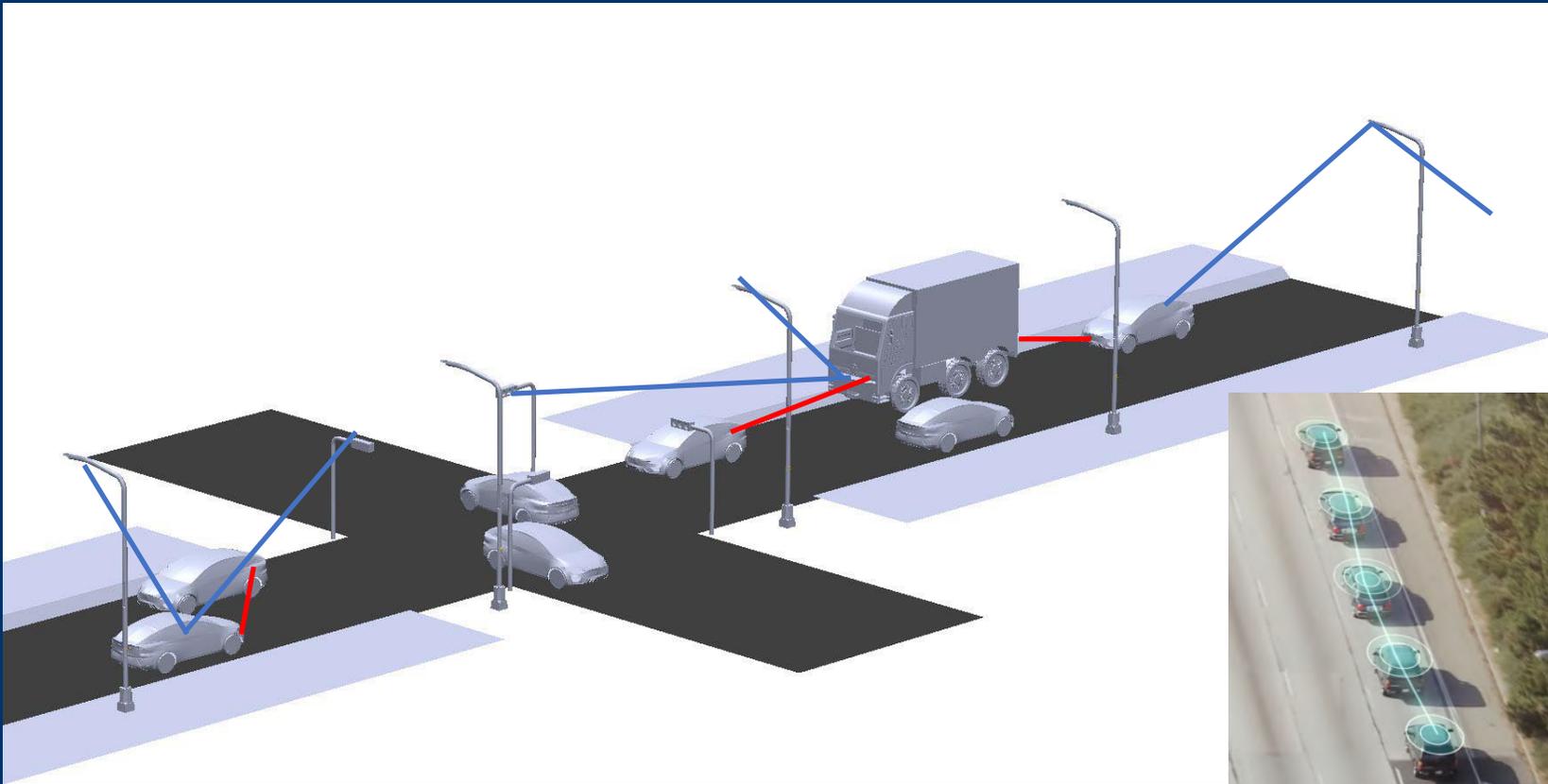
LaserLight LiFi: V2V communication



- LiDAR Point Clouds /Data / Video & information sharing between cars
- Interoperability via protocols, which comply with the upcoming LiFi networking standard IEEE 802.11 bb (2023)

Car2Car

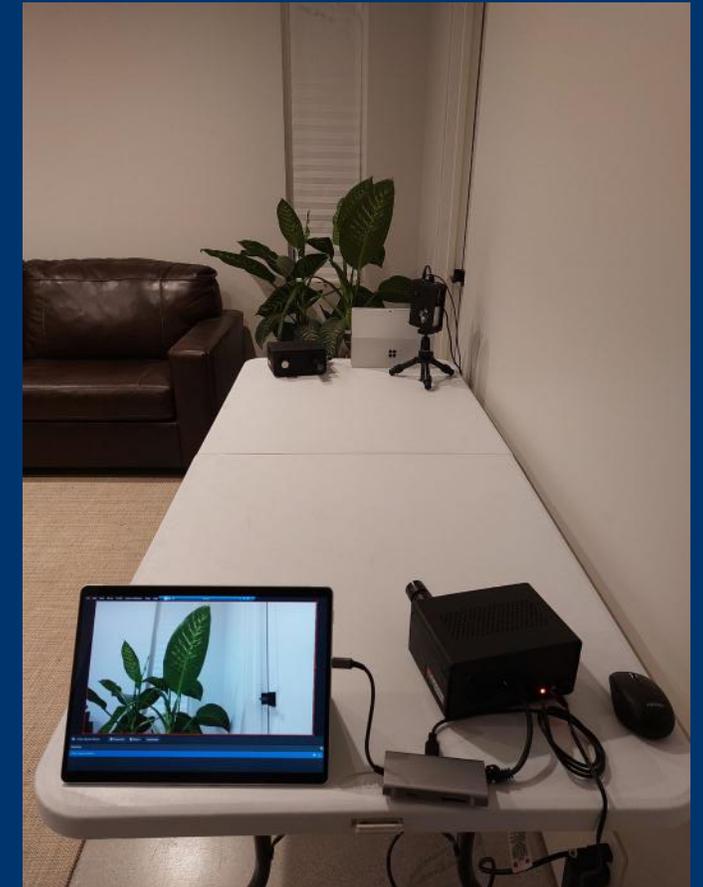
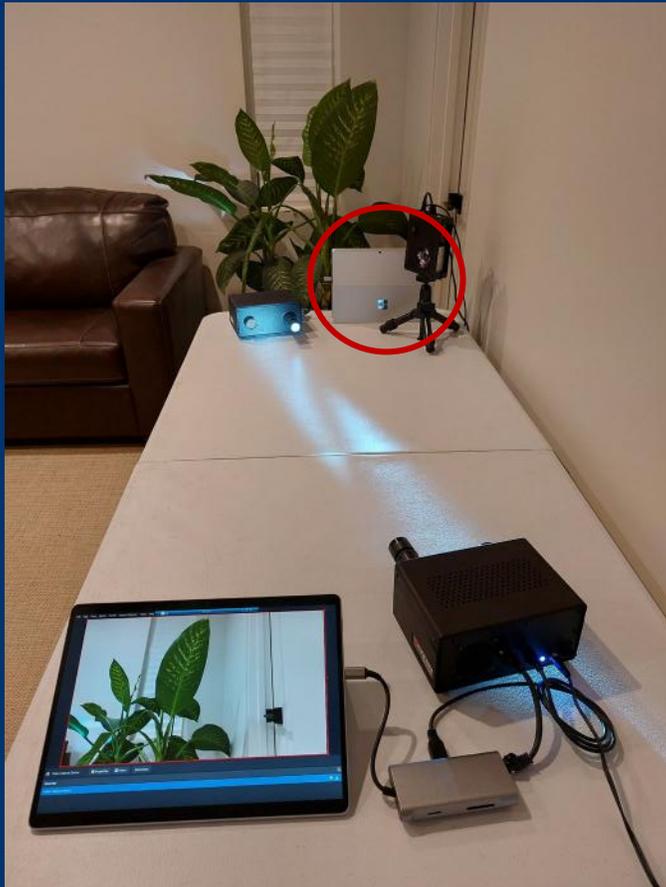
LaserLight LiFi: V2V and V2X



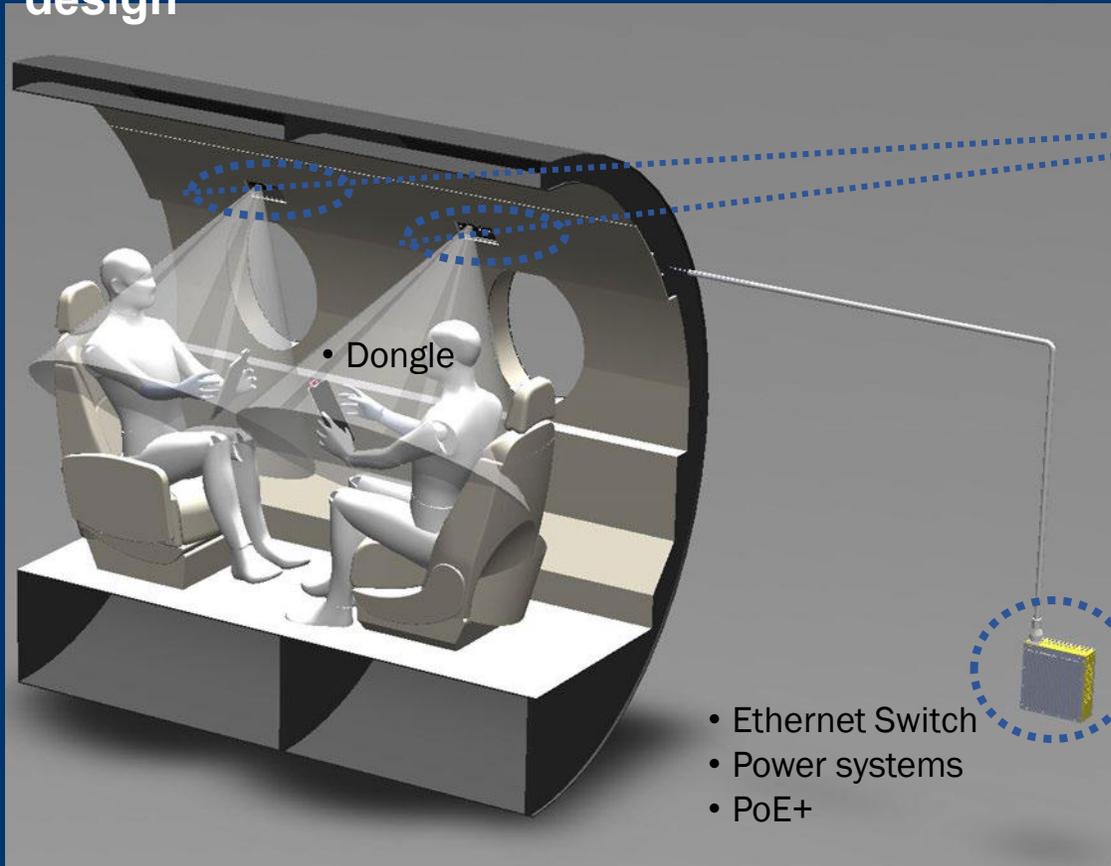
- Vehicles at varying speeds and distances.
- e.g. LiDAR data of 1st/2nd car are shared via V2V and/or V2X by LiFi.
- Data being processed in cars (fleets) or via infrastructure at high speeds.
- Infrastructure may process data and/or add specific information.
- Accessibility to data through individual IP protocols (safety).

Car2Car, Fleets, Convoys, Car2X

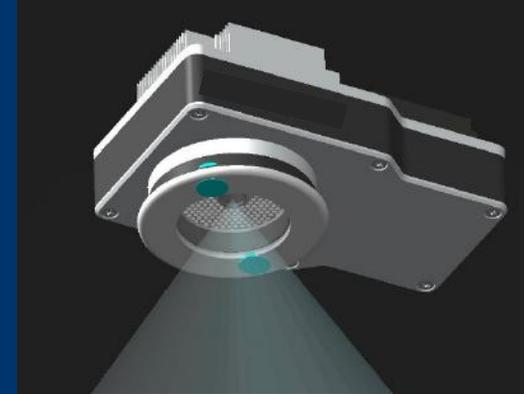
LaserLight LiFi: Real-time transfer of LiDAR and Video



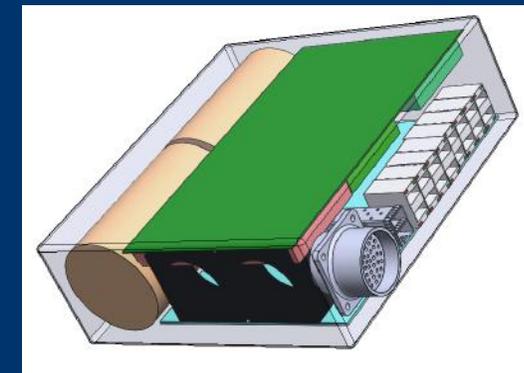
LiFi System design



SCCA = Super Circuit Card Assembly
(SMD + Optics + LiFi circuitry)



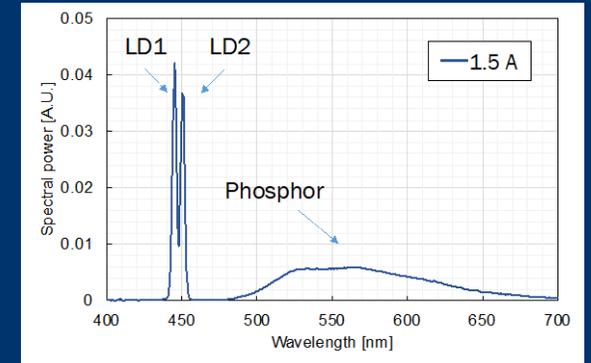
LDU = Light Distribution Unit



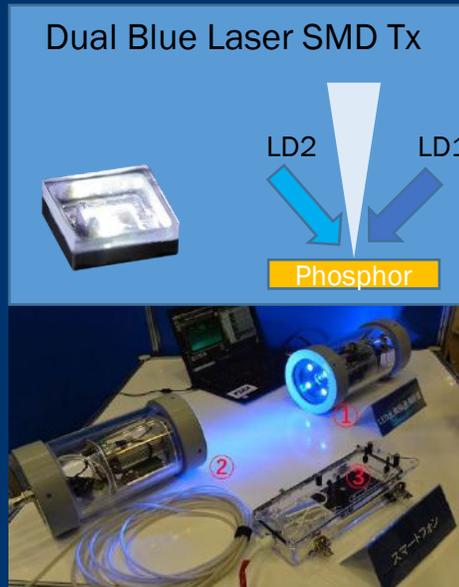
LaserLight LiFi underwater: Light and/or Data



- Undersea comm is challenging: RF does not work, sonar is too slow
- Blue laser is ideal for best transmission wavelength and high data rates
- Standalone blue, or combined with white if illumination needed
- Defense/security, industrial/professional oil & gas, future consumer apps.



Courtesy of KDDI



Courtesy of Softbank

Key Messages

- Laser-based white light “LaserLight™” offers unique benefits over LED:
10-100X the brightness, 10X the range, dynamic beam shaping, fiber delivery, sensing, LiDAR and LiFi.
- LaserLight™ LiFi overcomes conventional RF wireless challenges/limits and enables 50-100X the data rate of LED based LiFi.
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Thank you for your attention

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KSLD Laser Based Product Portfolio



Semipolar GaN LD



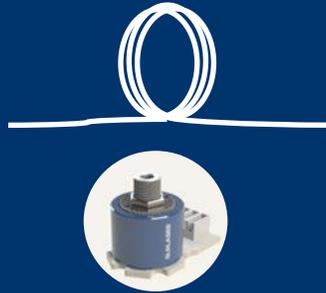
World's first High Gain High Power Semipolar Blue LD

LaserLight SMD SMD W+IR



World's only laser light and first laser light source White + IR with UL safety certification

LaserLight FC



World's thinnest and brightest side emitting flexible fiber

LaserLight Microspot & Flashlight



World's first device with 1100m range of White Laser light

LaserLight Lifi Kit



World's first portable 1Gbps DataLight device

