AIO Core Products and Technology update

Jan. 2022
AIO Core Co., Ltd.

Discussion Topics

◆ **AIO Core Company Profile**
- – Seeded by Photonics Electronics Technology Research Association (PETRA) R&D
- – 4x25G Si-Ph TRx products available

◆ **AIO Core Differentiation**
- – Ultra small Si-Ph TRx for reliable high temp operation
- – Industry leadership
- – Comparison with VCSEL

◆ **Module Development Strategy**
- – Embedded and Customized
- – System Vendor Customization
- – Roadmap

◆ **Recent Results**
- – 32G Module
- – Liquid Cooling Compatibility

◆ **Summary**

Company Profile

Founded Apr.2017 → **To Commercialize Cutting - Edge SiPh PETRA Technology**

2013~ **PETRA** — **Continue R&D**

- ➤ Company Name : AIO Core Co., Ltd.

- ➤ Location : (Headquarter, Test Center)   Bunkyo, Tokyo
  (Test Production Center)   Ohtsuki Yamanashi
  (Assembly Center) Myoko, Niigata

- ➤ Total Investment : $40M for four years

- ➤ Asset (Beginning) : Intellectual Property from PETRA (a part)

- ➤ Description of business : Si-Ph Products, Mass production & Sales

- ➤ CEO : Mr. Hidetaka Fukuda

- ➤ Establishment : April 17th, 2017

What is Optical I/O core ?

Ultra-small optical transceiver for computing.
Data rate: 100-400G (4x25G to 4x32G …)

Ultra compact & high density
Tx & Rx function integrated Package 5x5mm

Wide operating temperature
By using a high-efficiency quantum dot LD, operating at Tj 125 degC
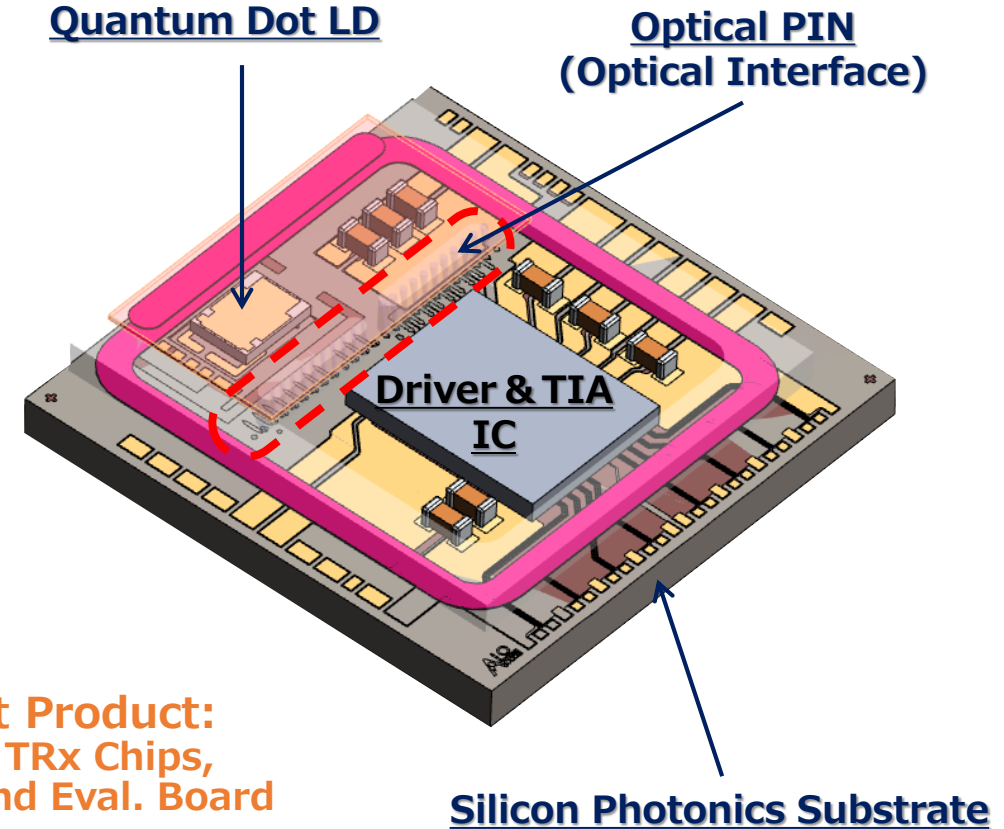It works as near packaged optics

High reliability
Quantum dot LD shows high reliability,
plus, redundancy function within the same package, integrated LD

Low power consumption

Easy fiber coupling
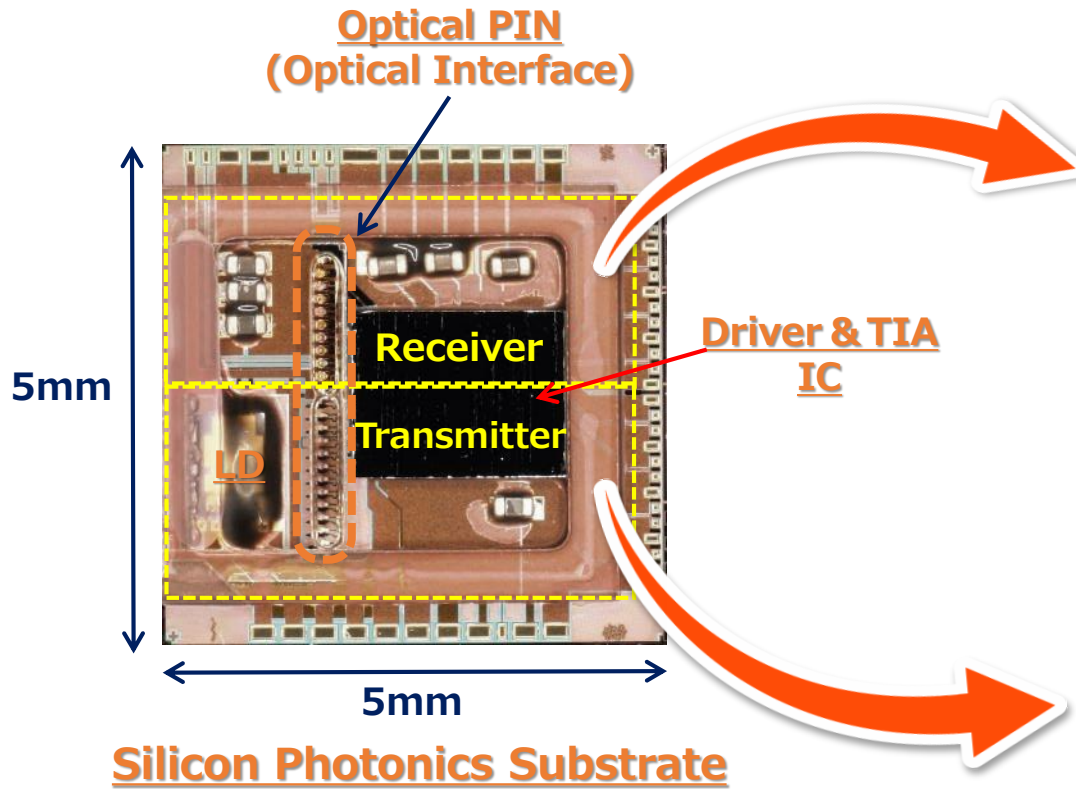Wide tolerance with MMF coupling by Optical PIN

Low cost

Quantum Dot LD

**Optical PIN
(Optical Interface)**

**Driver & TIA
IC**

Silicon Photonics Substrate

Current Product:
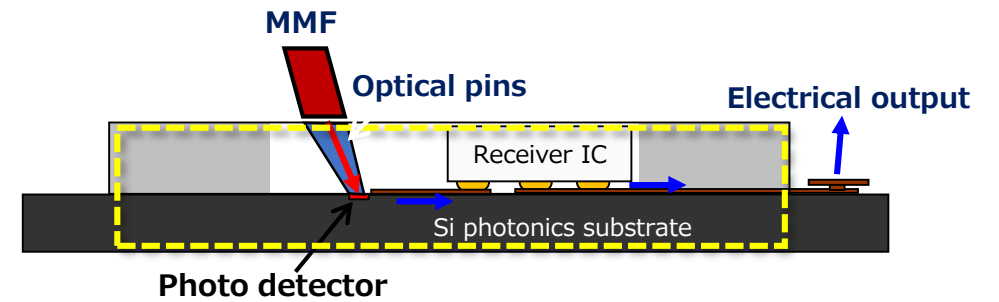4x25G TRx Chips,
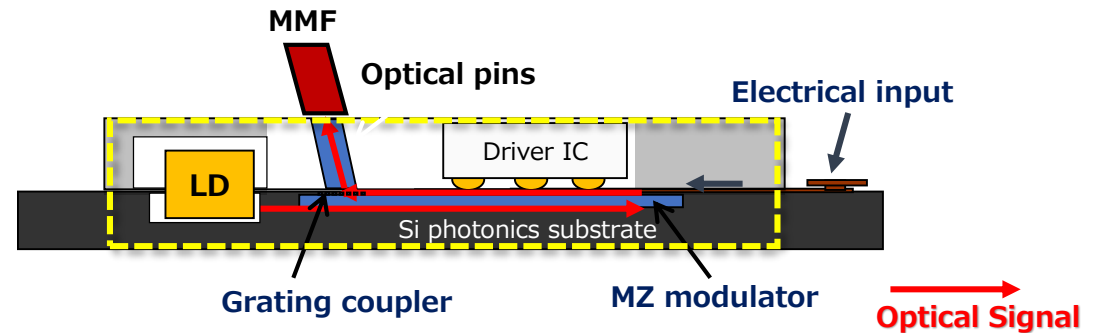EOM and Eval. Board

Next Product (2022):
4x32G TRx in 2022

Structure

➡ **LD, PD, Modulator, Driver and TIA,**
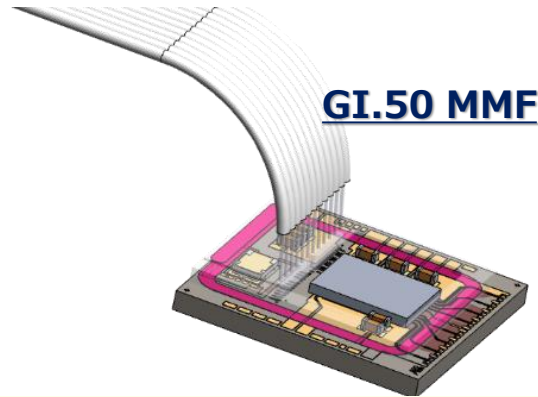**all functions are integrated in one package.**

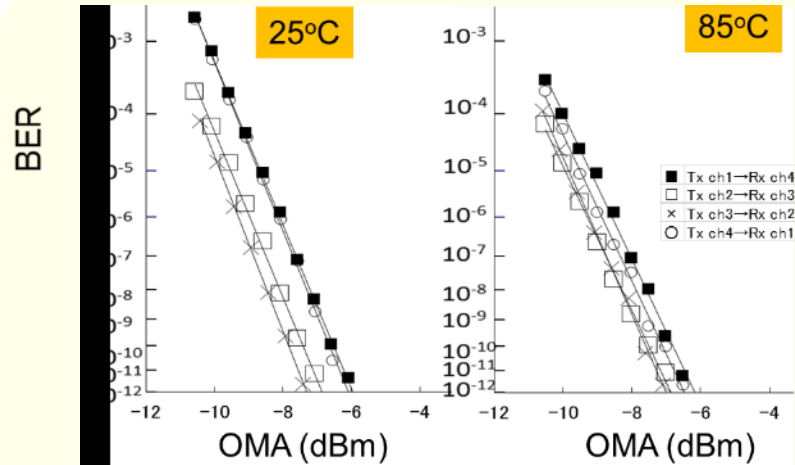**Optical PIN**
(Optical Interface)

Driver & TIA
IC

Receiver

Transmitter

LD

5mm

5mm

Silicon Photonics Substrate

Receiver

MMF

Optical pins

Electrical output

Receiver IC

Si photonics substrate

Photo detector

Transmitter

MMF

Optical pins

Electrical input

LD

Driver IC

Si photonics substrate

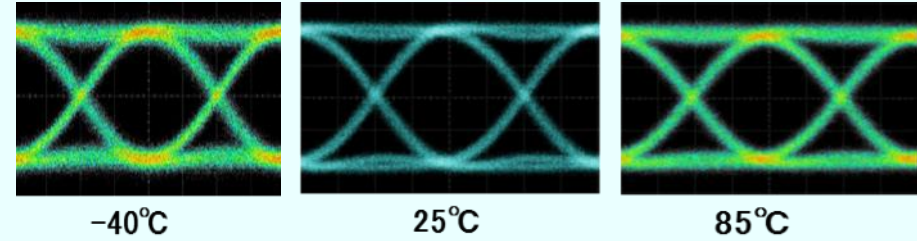Grating coupler

MZ modulator

Optical Signal

Performance

→ **Achieving clear eye waveforms and enough BER as 100Gbps by MMF transmission.**

GI.50 MMF

−40°C   25°C   85°C

■ **Wide temperature operation**

25°C   85°C

■ Tx ch1→Rx ch4
□ Tx ch2→Rx ch3
× Tx ch3→Rx ch2
○ Tx ch4→Rx ch1

BER / OMA (dBm)

■ **BER@25Gbps**

	BtoB	10m	20m	30m
OM3				

	B to B	100m	300m	500m
Corning ClearCurve®				
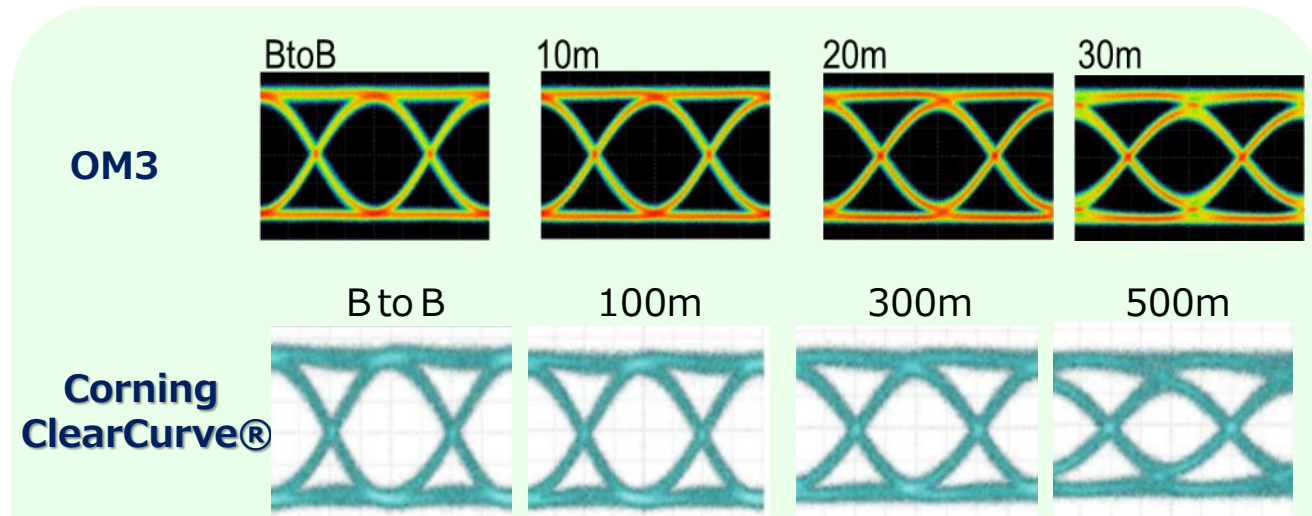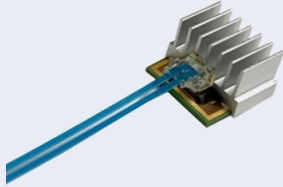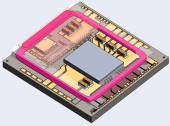
■ **Distance @ MMF**

AIO Core Optical Module Comparison

Item	AIO Core EOM (SiPh/ PAA-XW8032)	SiPh Vendor A
Bandwidth	128Gbps (32G x 4ch)	400Gbps (25G x 16ch)
Energy Efficiency	13.7pJ/bit	28.3pJ/bit
BW Density	82.1Gbps/cm^2(EOM) (512G/cm^2: Optical Engine)	34.0Gbps/cm^2
Size	1.56cm^2 (1.3x1.2cm)	11.76cm^2 (4.2x2.8cm)
Cost	<< 1$/ Gbps	-
Reliability	<15.5 FIT @Ta=85℃ (10years/ 4 or 16 laser array)	-
Liquid cooling	Available	Not available
Note	EOM Optical I/O core	

The combination of Si-Ph and MMF provides a reliable and low-cost solution.

MMF,GI_POF

Transceiver Cost
Low $

VCSEL
Transceiver module

Si-Ph MMF
Transceiver module

0.85μm   0.9μm   Reliability   1.3μmLD
VCSEL   QD-LD
>5fit   ≒5fit   <<5fit

High
$$$ Si-Ph SMF
             Transceiver module

SMF
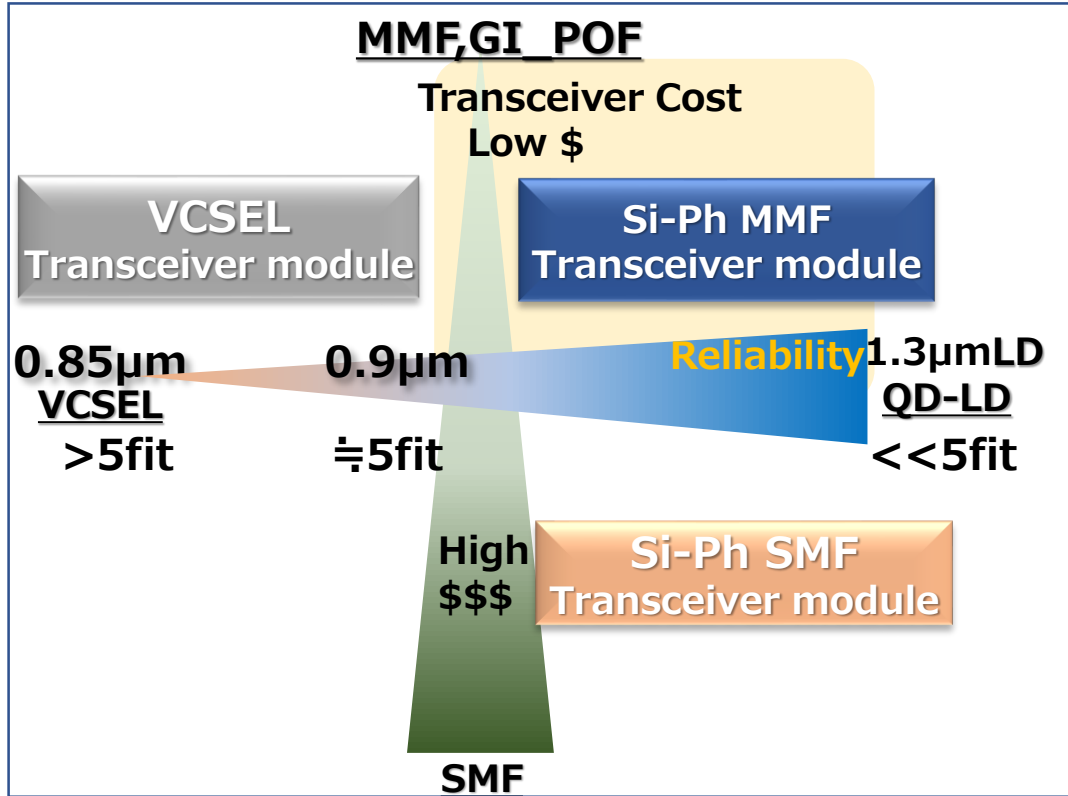
Corning clearcuve :300m-500m
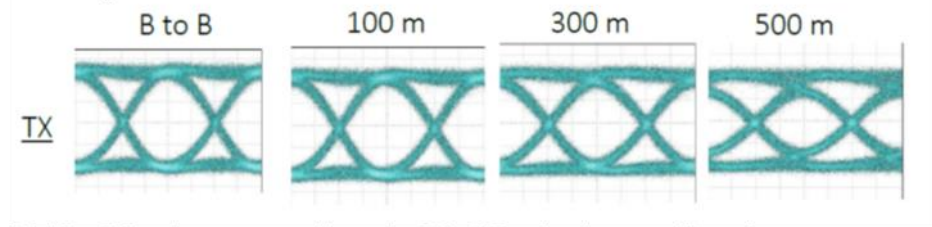
OM3 :30m(no equalizer) 50-60m(w/ equqlizer)
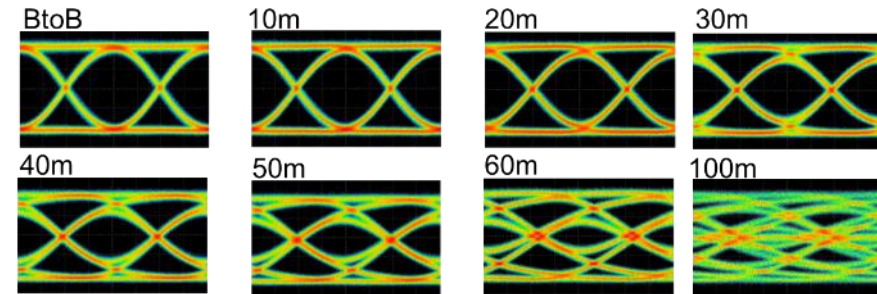
...heral report

Transceiver type	Relative transceiver cost 1)		
	10G	40G	100G
Multi mode	1	6	17
Single mode	3	14to21	24to58

1)https://www.photonics.com/Articles/The_Merits_of_Single-Mode_vs_Multimode_Fiber/a63723
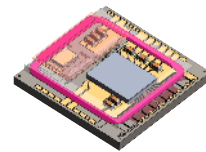2)https://www.ieee802.org/3/cz/public/29_jun_2021/ogura_3cz_01_290621_Status_SiPhotonicsReliabilityTest_v13.pdf

Module Development: Embedded and Customized

Module partners

EOB(4ch TRx)
(Embedded optical blade)
    100G : available
    128G : Coming soon
[I-PEX]

~105 deg C
(Tj 125 deg C)

EOM(4ch TRx)
(Embedded optical module)
    100G : available
    128G : Coming soon
[I-PEX & AIO Core]

Small Footprint
12x14mm

OBO(16ch TRx)
(On-Board Optics)
    400G/512G
    Under development
[KYOCERA]

High-density
32G×16ch=512G

Other customized modules
Collaboration development

(COBO)
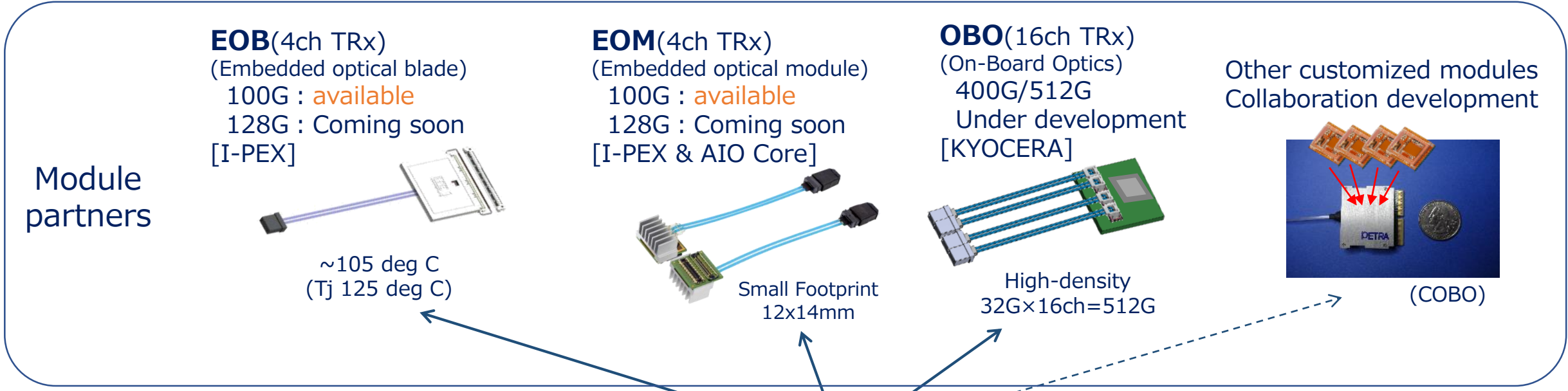
Optical I/O Core

Embedded Modules
    100G : available now
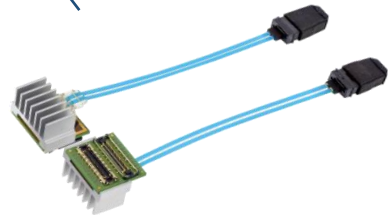   128G : In 2022

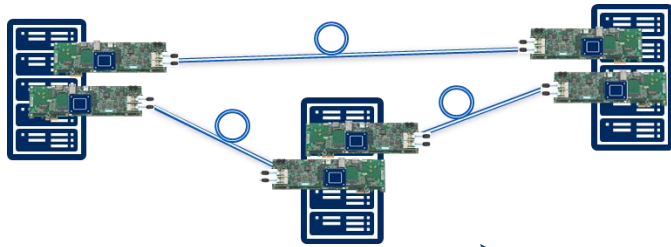Evaluation board
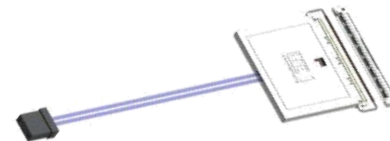
Customization for System Vendors
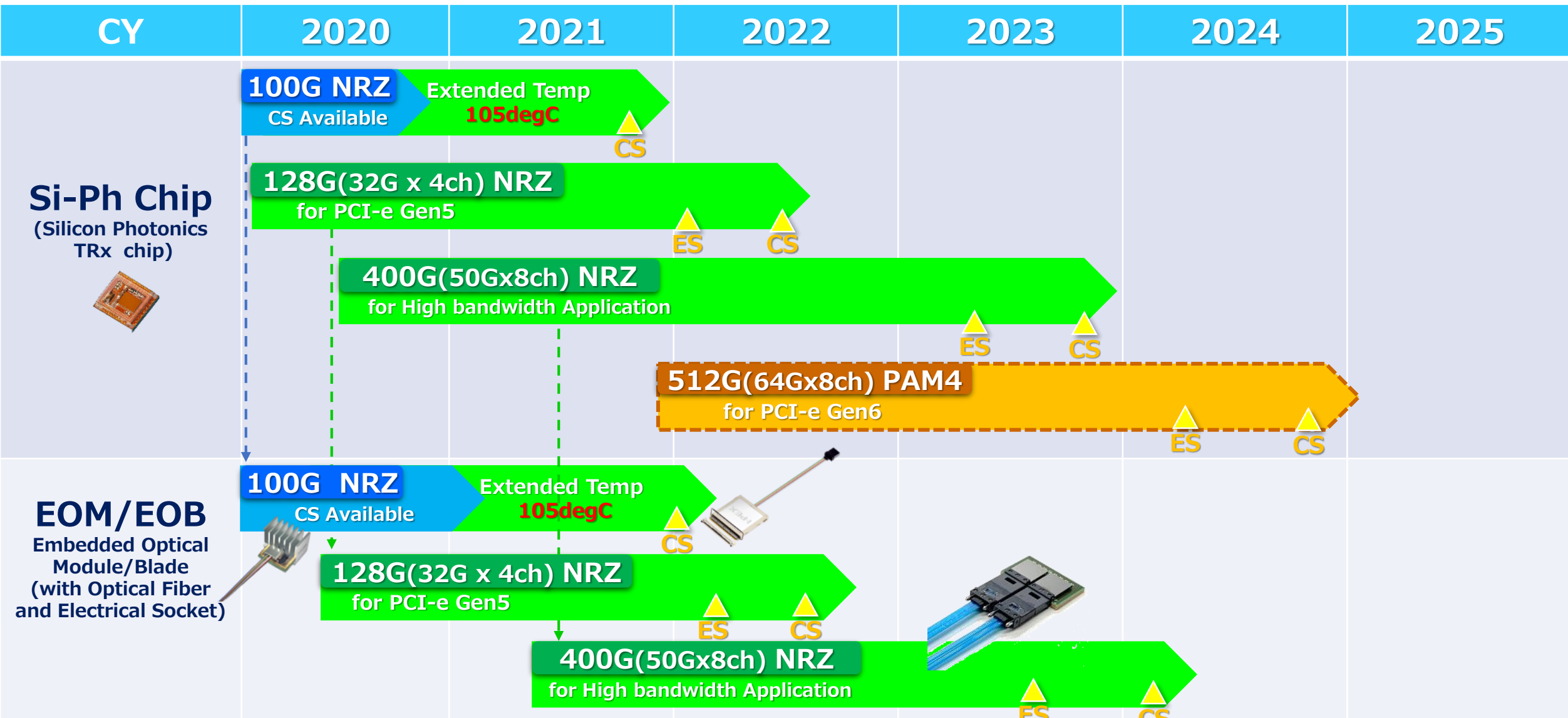
M.2 Card / NIC

FPGA Board + 800Gbps

Massive MIMO

EOM
(Embedded Optical Module)

EOB
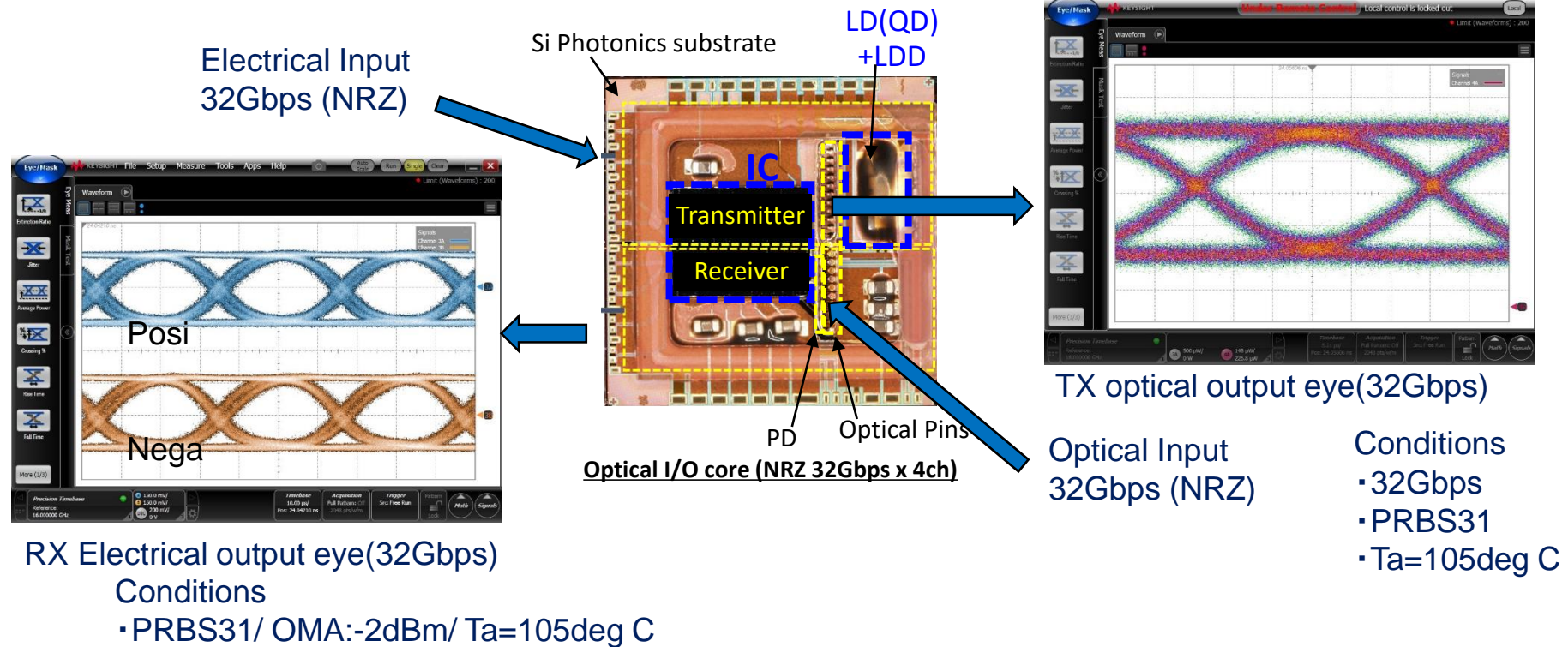(Embedded Optical Blade)
~105 deg C (Tj 125 deg C)

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Roadmap

CY	2020	2021	2022	2023	2024	2025

Si-Ph Chip
(Silicon Photonics TRx chip)

- **100G NRZ** — CS Available — Extended Temp **105degC** ▲ CS
- **128G(32G x 4ch) NRZ** for PCI-e Gen5 ▲ ES ▲ CS
- **400G(50Gx8ch) NRZ** for High bandwidth Application ▲ ES ▲ CS
- **512G(64Gx8ch) PAM4** for PCI-e Gen6 ▲ ES ▲ CS

EOM/EOB
Embedded Optical Module/Blade (with Optical Fiber and Electrical Socket)

- **100G NRZ** — CS Available — Extended Temp **105degC** ▲ CS
- **128G(32G x 4ch) NRZ** for PCI-e Gen5 ▲ ES ▲ CS
- **400G(50Gx8ch) NRZ** for High bandwidth Application ▲ ES ▲ CS

Shipping **Development** **Planning**
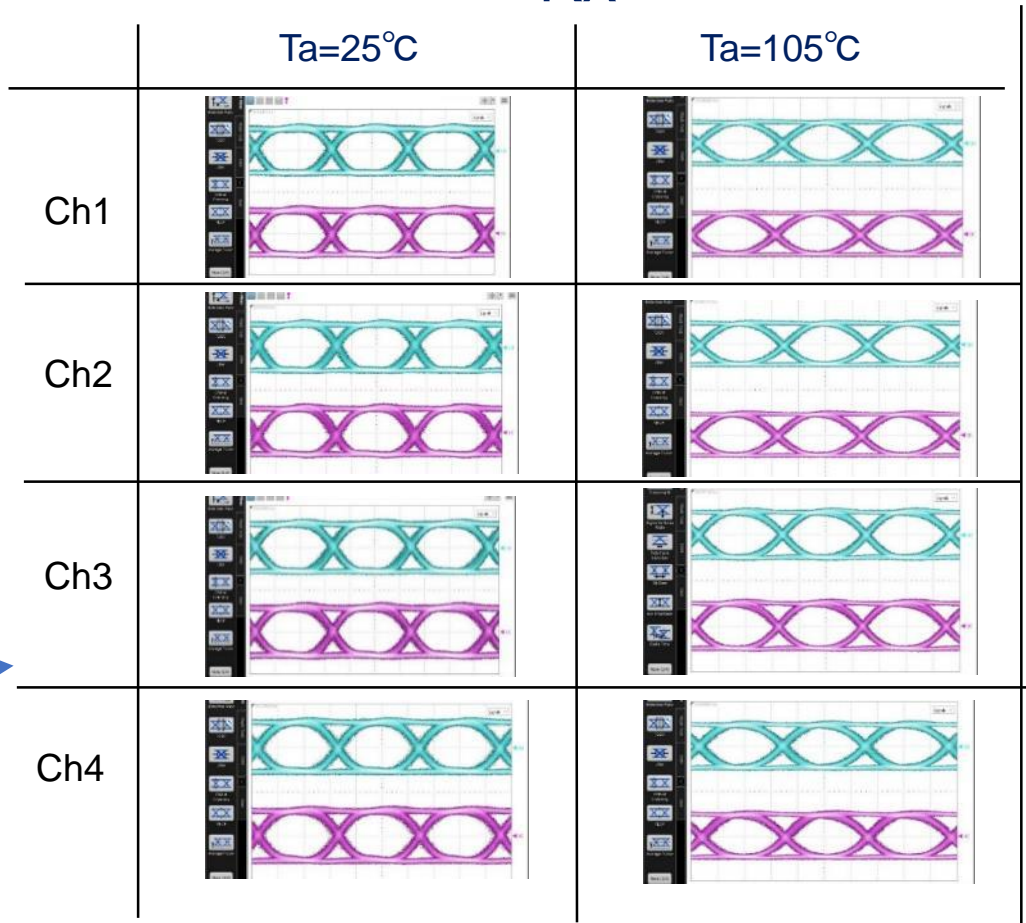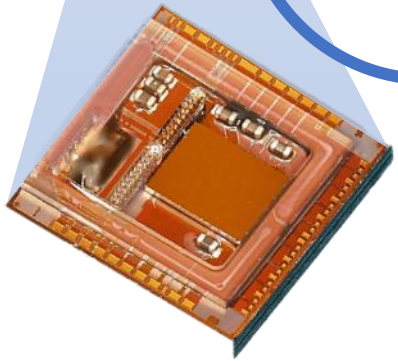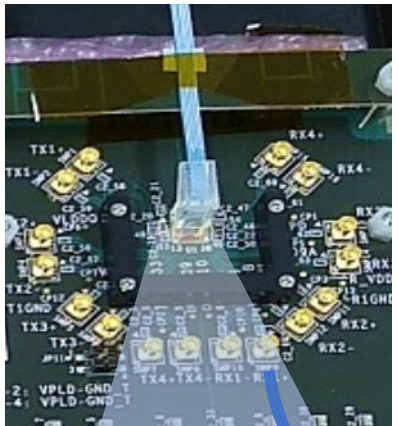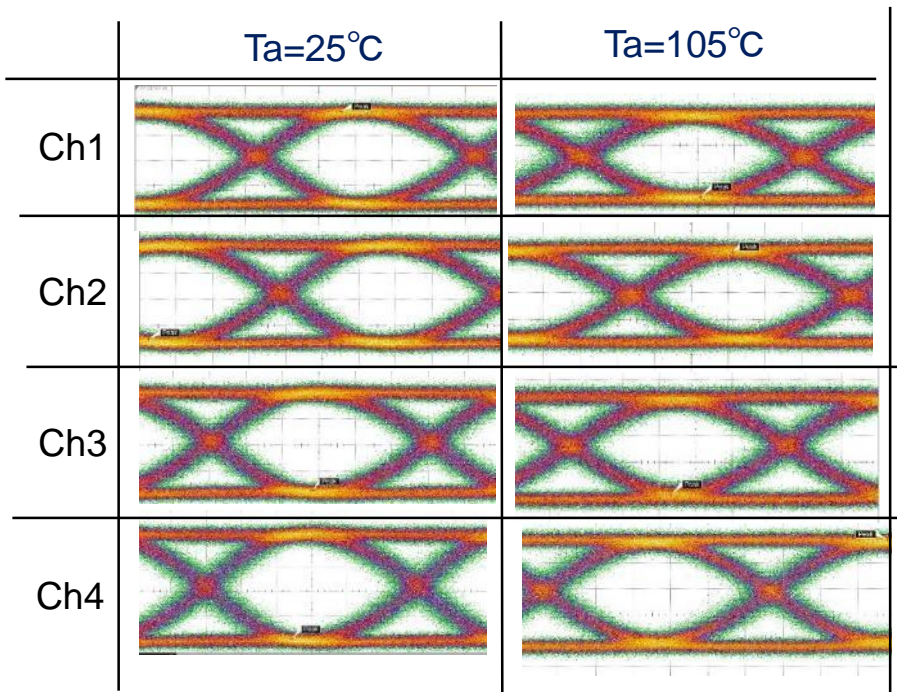
**Plan is subject to change without notice

1. Evaluation of optical transceiver is on going.
2. Tx optical output eye at 32Gbps is good eye opening.
3. Rx electrical output eye at 32Gbps.
   Confirmed high temperature operation of the optical I/O core.

Electrical Input
32Gbps (NRZ)

Si Photonics substrate

LD(QD) +LDD

IC

Transmitter

Receiver

PD   Optical Pins

Optical I/O core (NRZ 32Gbps x 4ch)

Posi

Nega

RX Electrical output eye(32Gbps)
Conditions
・PRBS31/ OMA:-2dBm/ Ta=105deg C

TX optical output eye(32Gbps)

Optical Input
32Gbps (NRZ)

Conditions
・32Gbps
・PRBS31
・Ta=105deg C

Signal integrity analysis at 32Gbps x 4ch Ta 105 deg C

Tx

Rx

32 Gbps PRBS[31] - TX,RX All lanes active
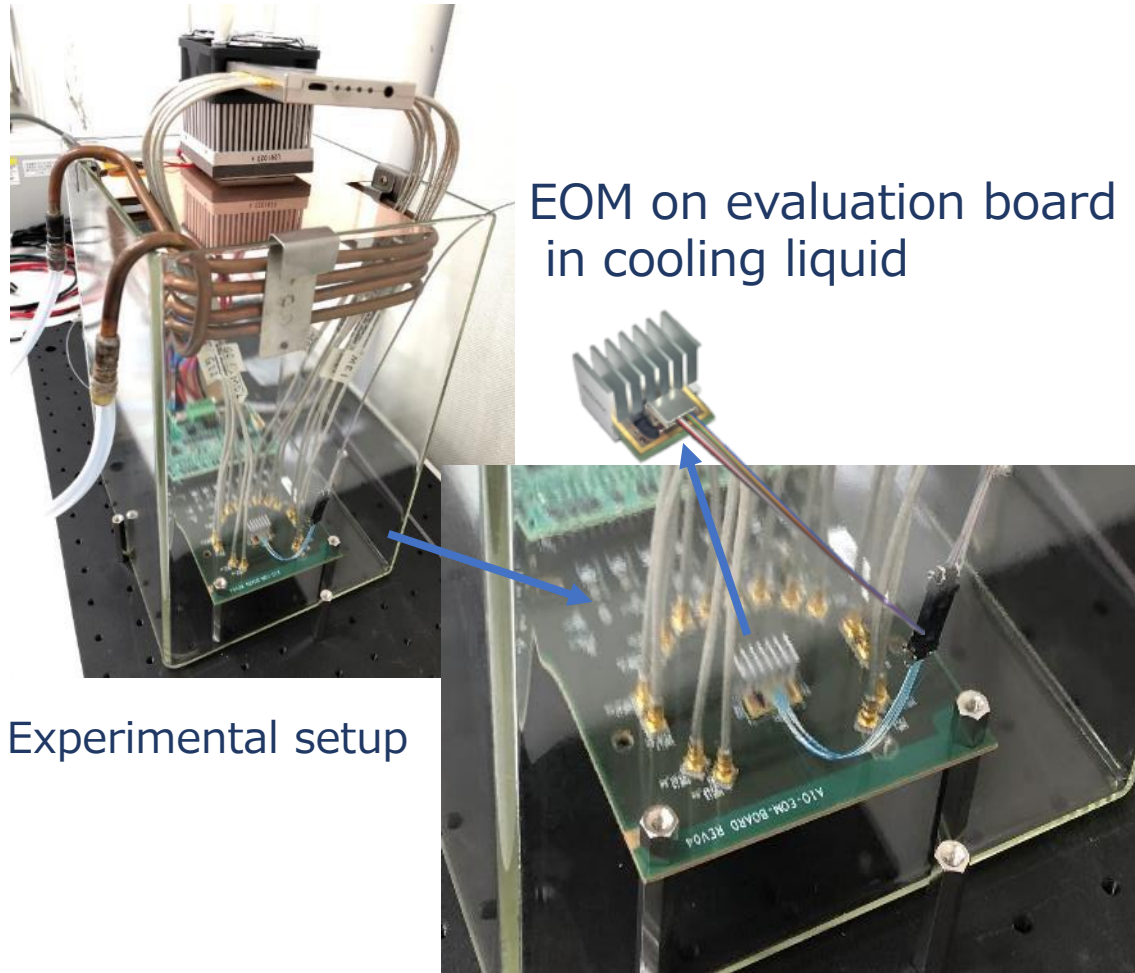
Operational current region

32 Gbps PRBS[31] - TX,RX All lanes active

Kurata, K. et al. "Short reach, high temperature operation and high reliability silicon photonic micro-transceivers for embedded and co-packaged system integration," Proc. SPIE 11692, Optical Interconnects XXI, 1169204 (16 March 2021); https://doi.org/10.1117/12.2576670

Applicable for Immersion Cooling

Excellent performance with 1-phase and 2-phase refrigerants

EOM on evaluation board in cooling liquid

Experimental setup

	Air	1phase coolant	2phase coolant
Room Temp	T_air 23℃ T_junction=75℃	T_air=24℃ T_liquid=23℃ T_junction=41℃	T_air=25℃ T_liquid=22℃ T_junction=38℃
Boiling Point	Evaluation schematic		T_air=23℃ T_liquid=52℃ T_junction=63℃

Summary

◆ **AIO Core is developing cutting-edge Si-Ph products:**
  – Compact TRx modules with QD Laser for high temp operation
  – 4x25G TRx products are available now
  – 4x32G Si-Ph TRx in 2022
  – Higher Rates in Future

◆ **AIO Core Module Products**
  – Flexible: Embedded Modules and Boards
  – Customized to System Vendor Needs

◆ **Recent Results Show**
  – 32G Module Feasibility
  – Liquid Cooling Compatibility

Thanks!