NTT Innovative Devices

Realizing IOWN 2.0 : Development Status and Future Outlook of Opto-Electronics Convergence Network Switches

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Introduction

NTT Innovative Devices

Challenging the World with IOWN and Optical Communication

Effectively No Distance

IOWN 1.0 （PEC-1）

Solving Power Issues in Data Centers

IOWN 2.0 （PEC-2）

AI : The Tilt for Computational Performance

	Legacy cloud services	AI (e.g. LLM)
Tasks	Relatively small	Huge
Server (processor)	With one processor shared across multiple tasks	To do one task, 1000 + processors
Key Technology	Virtualization	Between processors **communication network**

Accelerating need for **optical** links between processors

AI : The Tilt for Computational Performance

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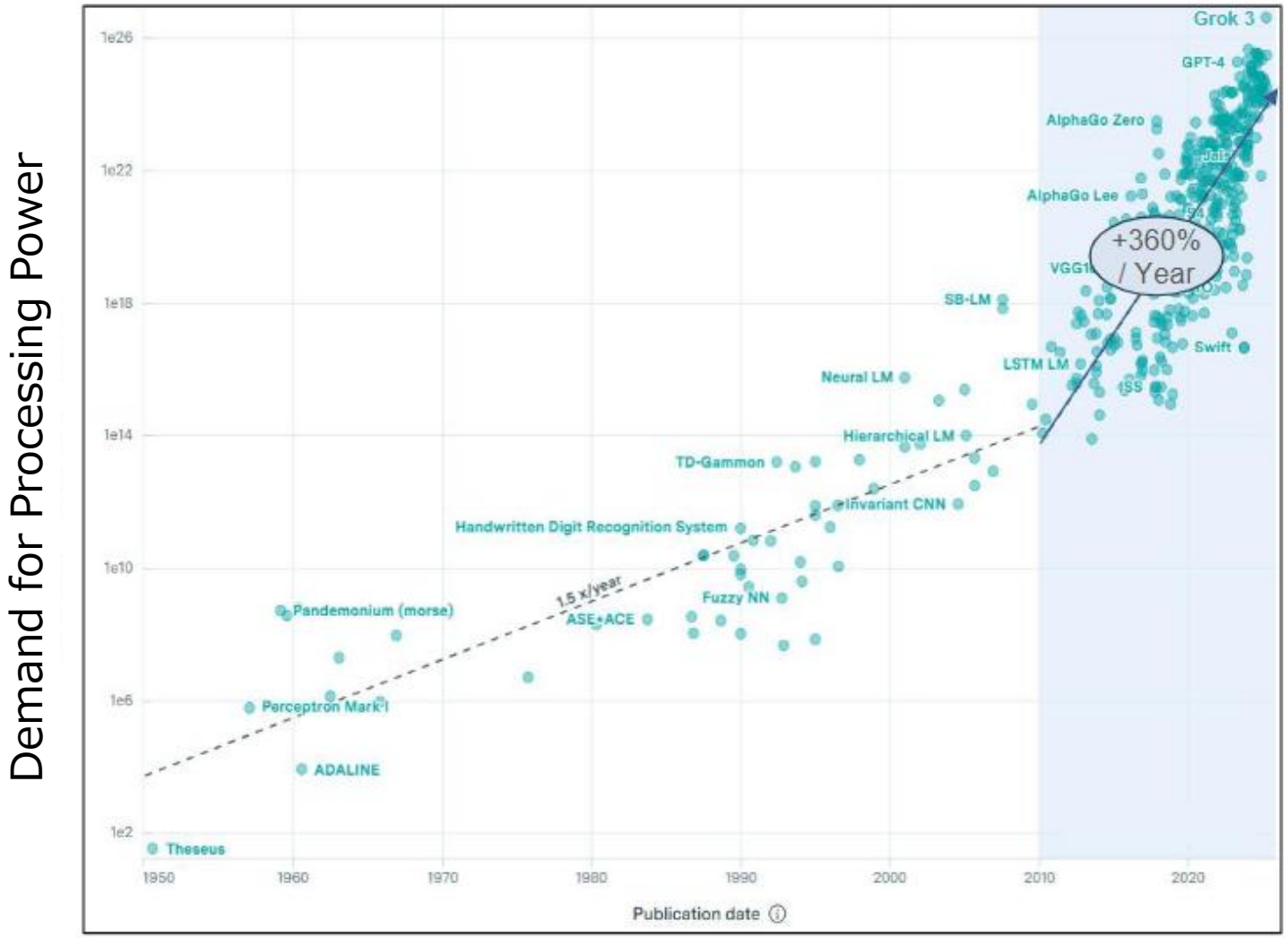


Directions for Surging AI Demand

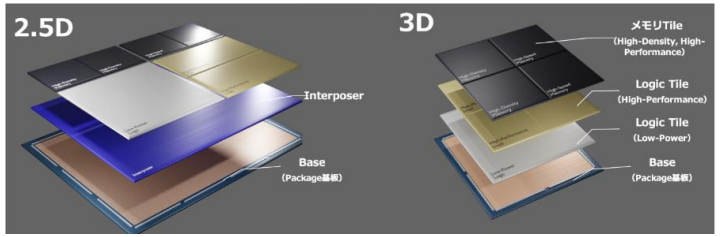
Three Pillars of Semiconductors

Advanced Semiconductor Miniaturization

Pushing Miniaturization to the Limit
（7nm ➡ 5nm ➡ 3nm ➡ 2nm ➡ Sub2nm ➡ Å）

Ultra-Dense Packaging

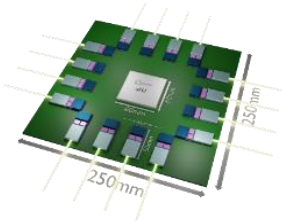
Planar integration is reaching its limits
— shifting toward 2.5D and 3D packaging

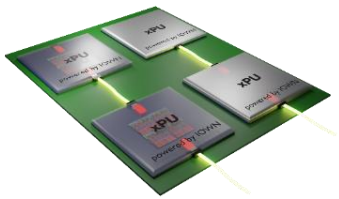


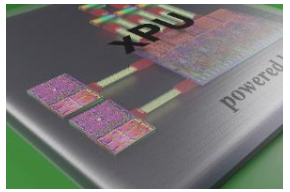
Opto-Electronic Integration

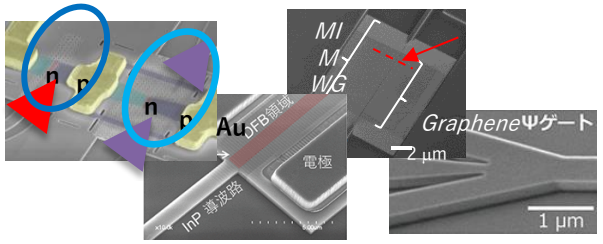
Limits of electrical technology (bandwidth + power)
➡ Opto-Electronic Convergence ➡ Partial replacement by photonics in the future

Application of optical communication technology expands from networking to **networking + computing**









Advanced Semiconductor Miniaturization

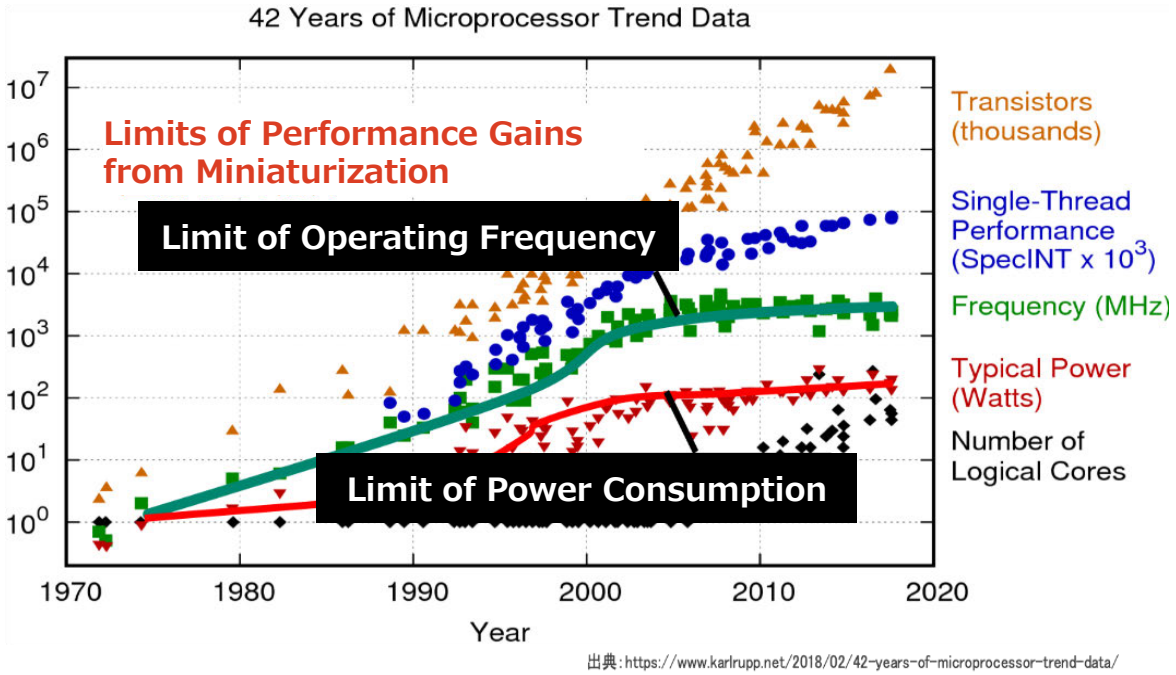
The Limits of Moore's Law

- Moore's Law: **The integration rate of semiconductor integrated circuits doubles every 18 months (later, every 24 months).**
- When a circuit is miniaturized to 1/k, the area becomes 1/k², the power consumption becomes 1/k², and the performance per unit area becomes k².
  ➡ This supports strong demand for semiconductors.
- **However, it has become increasingly difficult to improve performance through conventional scaling.**

・Limit of miniaturization
- Get closer to the atomic size.
- The influence of leakage currentcannot be ignored.

・Limit of heat generation
- Increased internal resistancedue to heat generation -> Further fever
- Increase in leakage current due to heat generation
- Cannot raise the operating frequency.

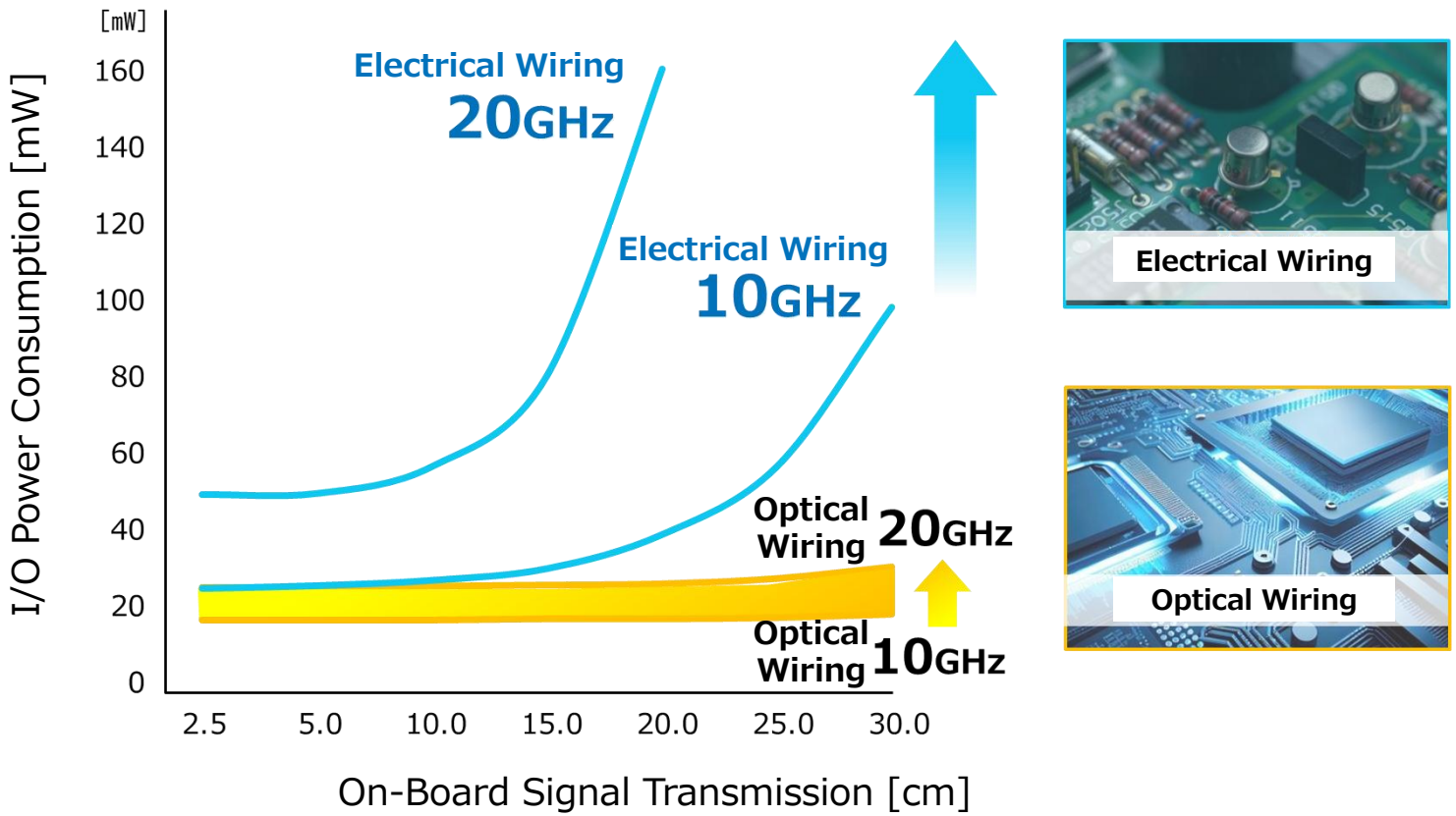
・Power consumption limit
- Increased power consumption
  -> Performance degradation due to heat generation (dark silicon)



The Road to High Frequency and Low Power

Toward Opto-Electronic Convergence

50~100 GHz is already in practical use



Optical signals are reaching deep into data centers, servers, and even semiconductor chips!

Evolution of Opto-Electronic Devices

Roadmap

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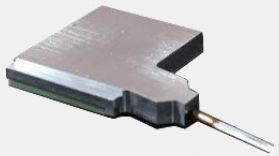
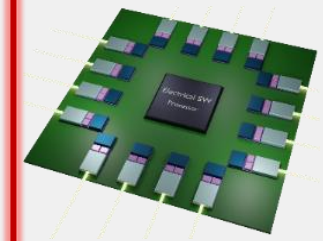
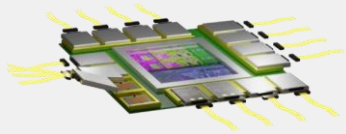
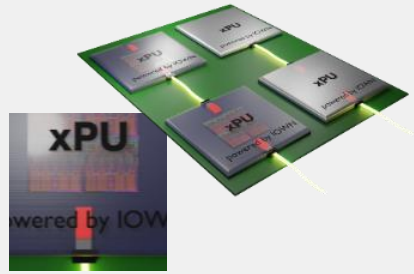
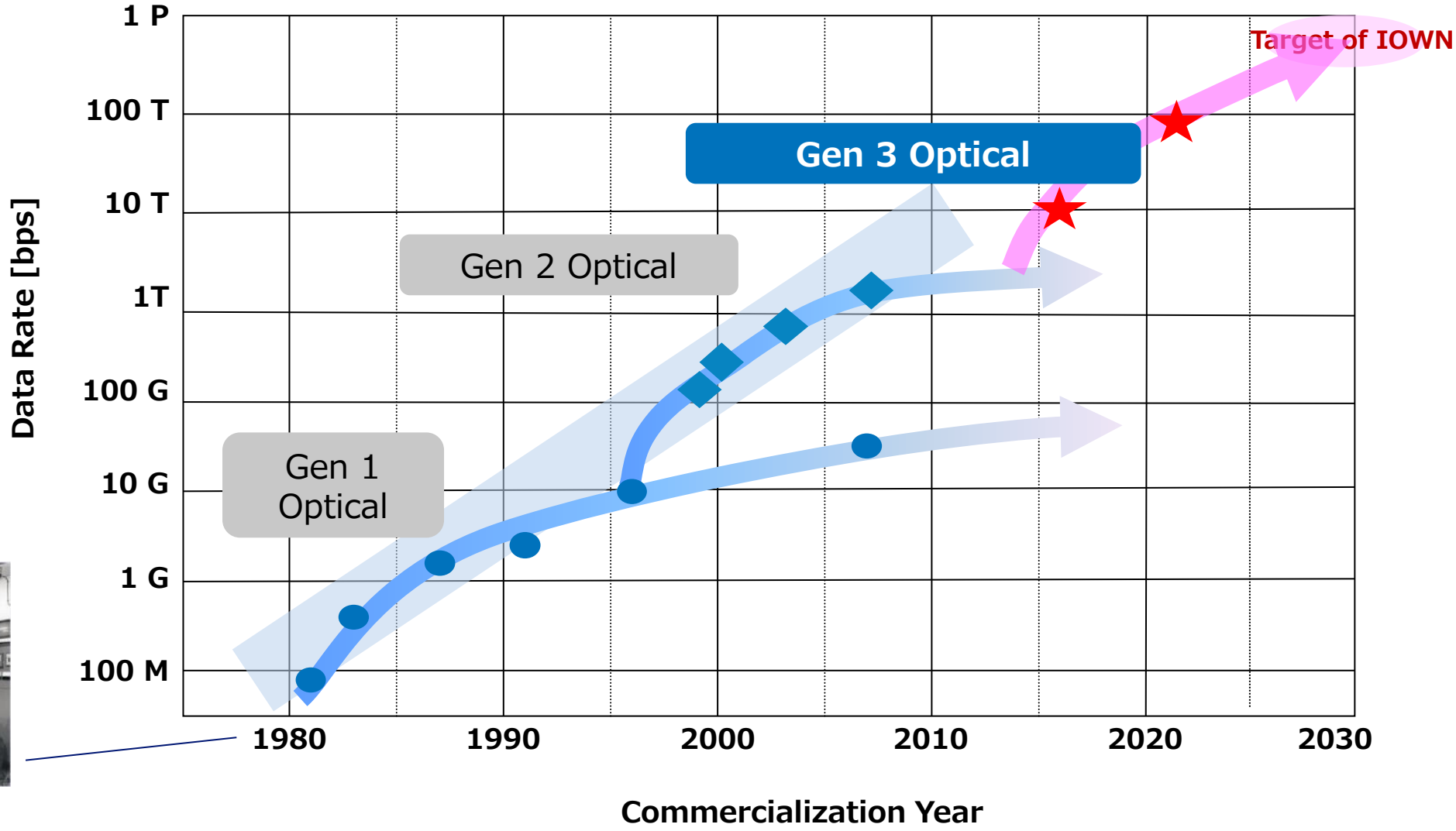
PEC : Photonics Electronics Convergence

Commercialization	CY2021	CY2023	CY2025 – CY2026	CY2028	CY2032
Generation	PEC-1 DC to DC		PEC-2 Board to Board	PEC-3 Package to Package	PEC-4 Die to Die
Data-rate /Device	400G->800G->1.6T->3.2T->		1.6T->3.2T->6.4T->	64G->128G->	
Business Domain	Telecom	Telecom	Computing	Computing	Computing
Images	 COSA	 CoPKG	 CY25:LFF  CY26:AFF		
Distance	1000km	100km	10m	~cm	~mm

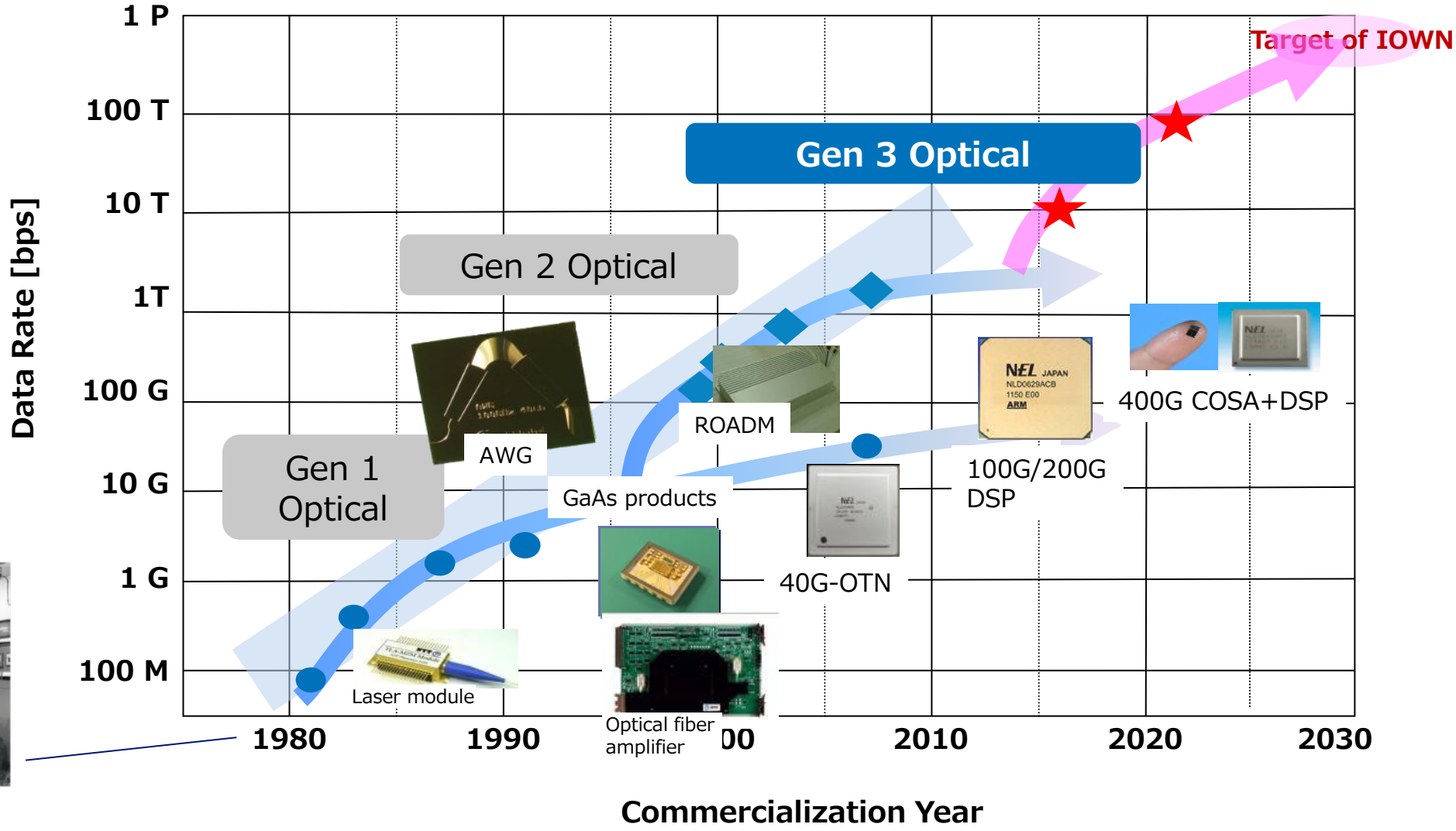
increase in shipment

NTT and the History of Optical Innovation



NTT and the History of Optical Innovation

NTT Innovative Devices



NTT and the History of Optical Innovation

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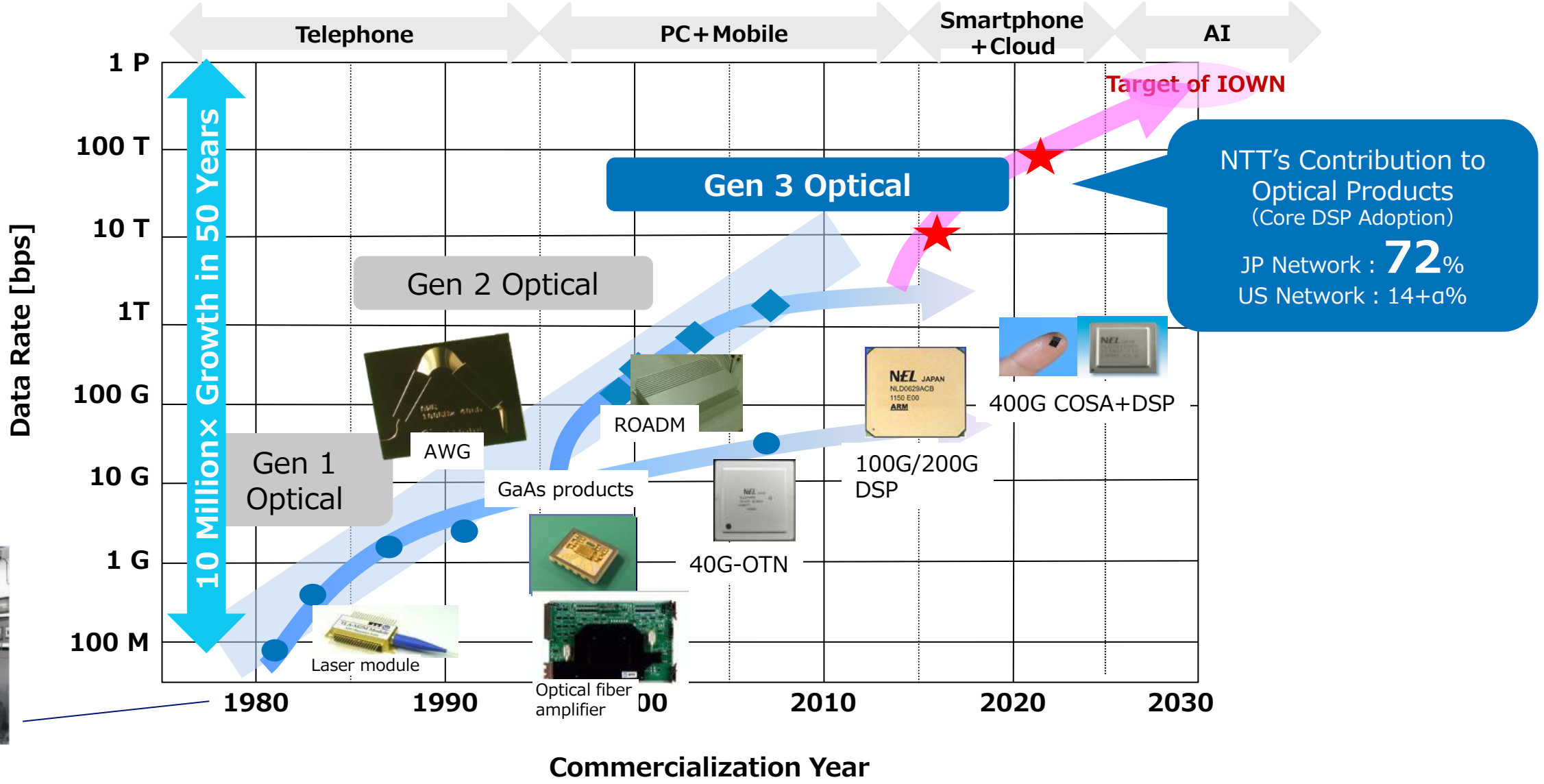

NTT's Contribution to Optical Products
(Core DSP Adoption)

JP Network : **72**%

US Network : 14+α%

Opto-Electronic Switch Overview

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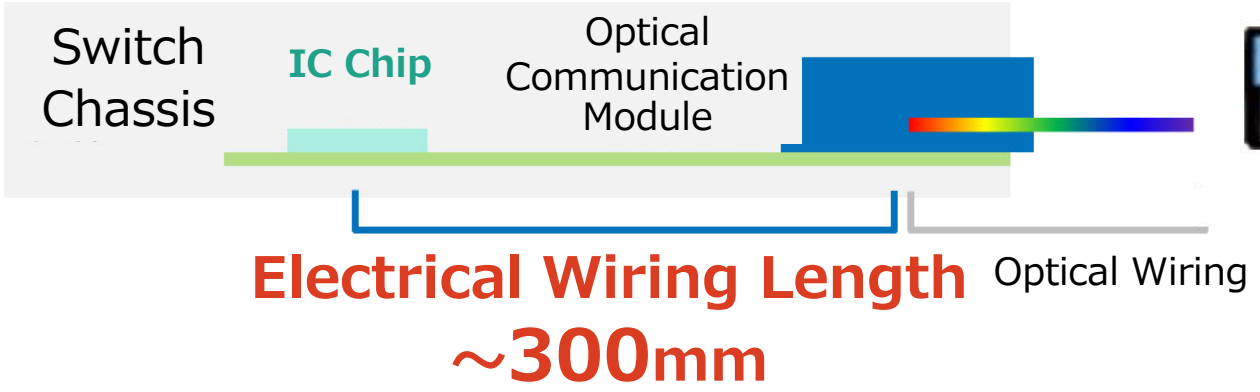
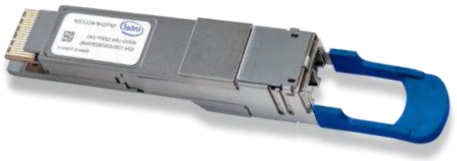
Conventional Optical Communication Switch

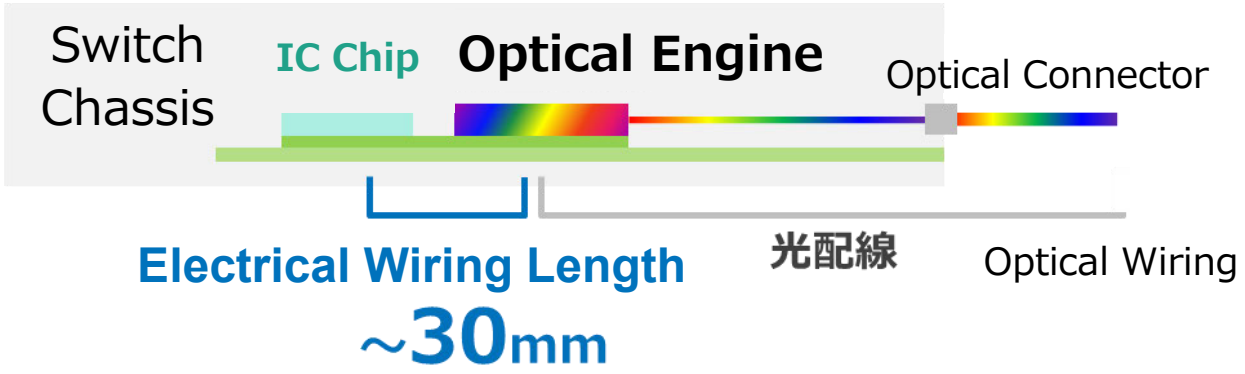


Front View

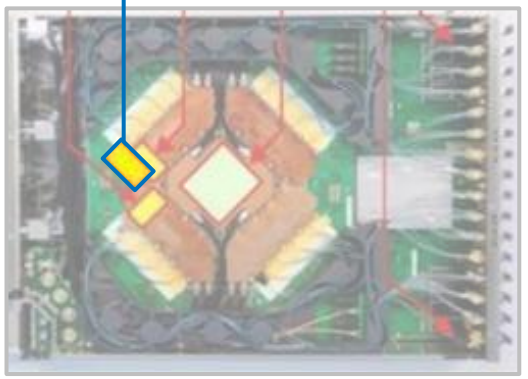
Insertion Port for Optical Communication Module



Opto-Electronic Converged Switch



Top View

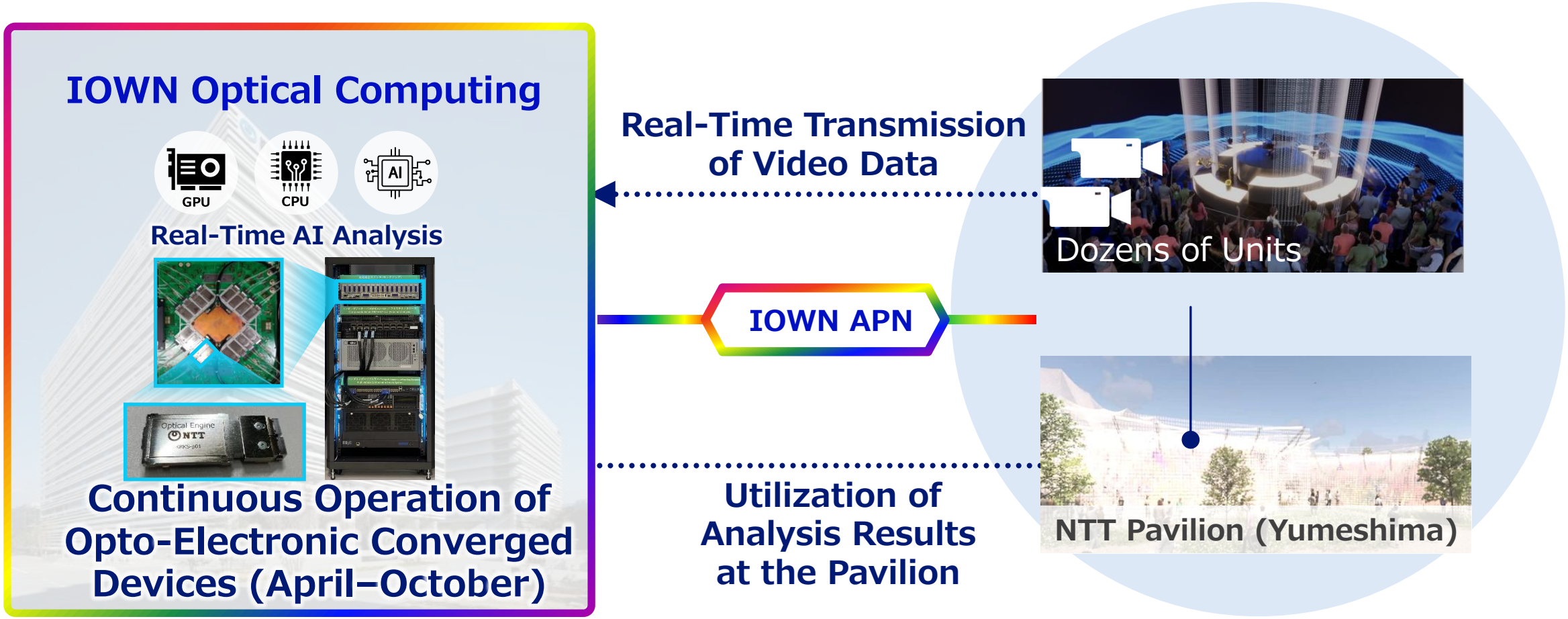


NTT **Optical Engine**

(Opto-Electronic Converged Device PEC-2)

Optical Computing at the Expo Pavilion

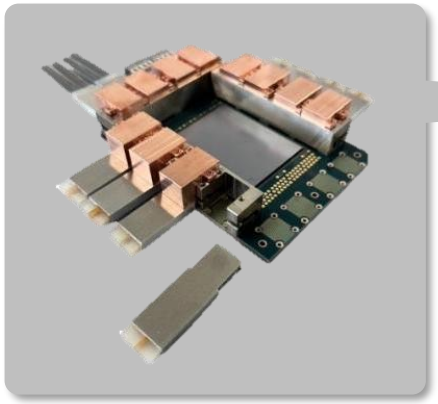
- At the NTT Pavilion of the Osaka-Kansai Expo, a computer powered by IOWN 2.0 achieved one-eighth the power consumption.
- This remarkable efficiency was made possible by a **combination** of **advanced devices, computer architecture, and software**.



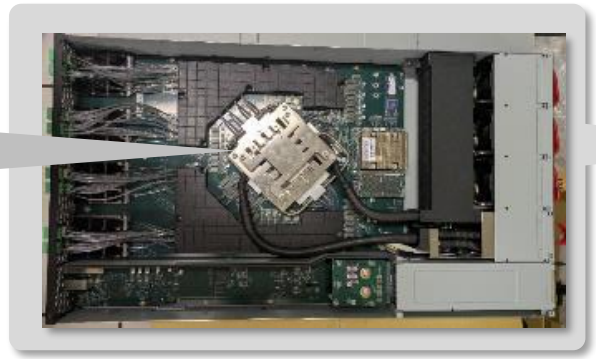
※DCI: Data-Centric Infrastructure

PEC-2

Commercial Deployment of Opto-Electronic Converged Switches



NID Products
"6.4T Optical engine &
102.4T CPO-SW Module"



System Partner Products
"102.4T SW-BOX"

System Partner Products
"Switch Rack"

Server-to-Server Interconnection within a Data Center

- **Commercialization Target: Q4 2026 (Sample Release)**
- Verification of Component Characteristics in Progress
- Significant Power Reduction, High-Capacity Switch, and Lower Repair & Operational Costs through Replaceable Optical Engines
- Expansion of Manufacturing Capacity Underway
  (5,000 Units per Line per Month)

Prototype Switch with 51.2 Tbps Capacit

Within AI Data Centers From Scale-Out to Scale-Up

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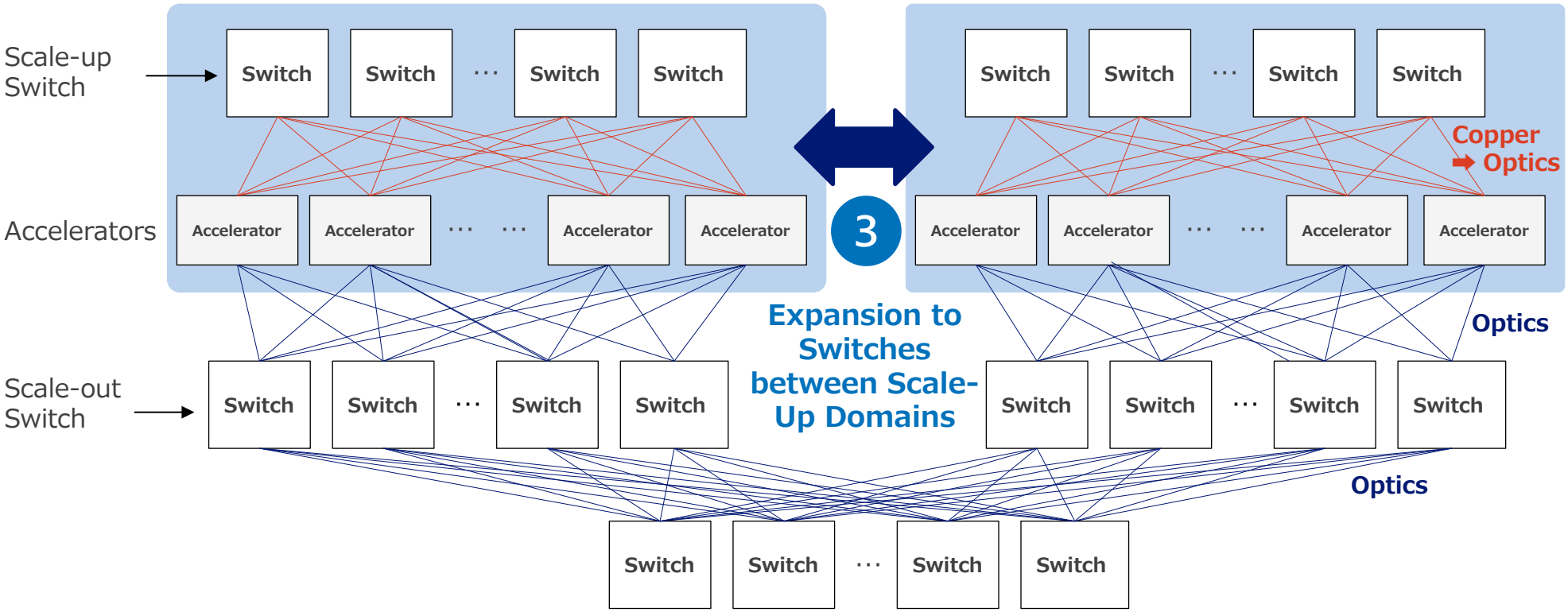
Data Center Switch Architecture & Opto-Electronic Switch Deployment



2

Optical Integration within the Scale-Up Domain

1

Initial Deployment Domains for Opto-Electronic Switches

Candidate Domains for the Introduction of Opto-Electronic Converged Switches:

1.Initial deployment in the Scale-Out domain

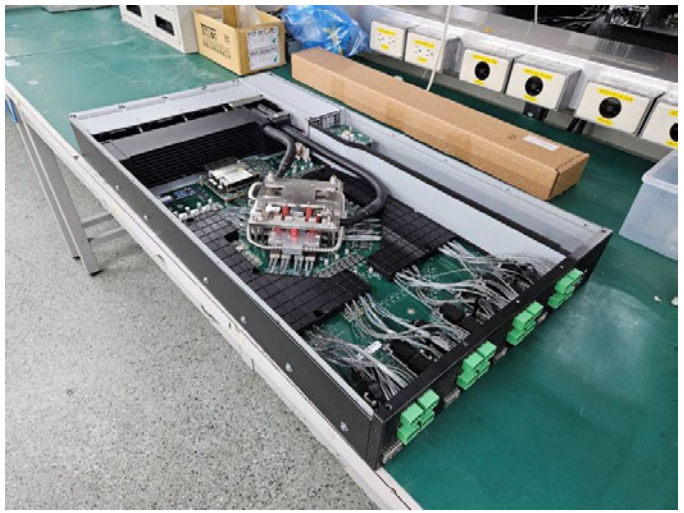
2.Optical integration within the Scale-Up domain

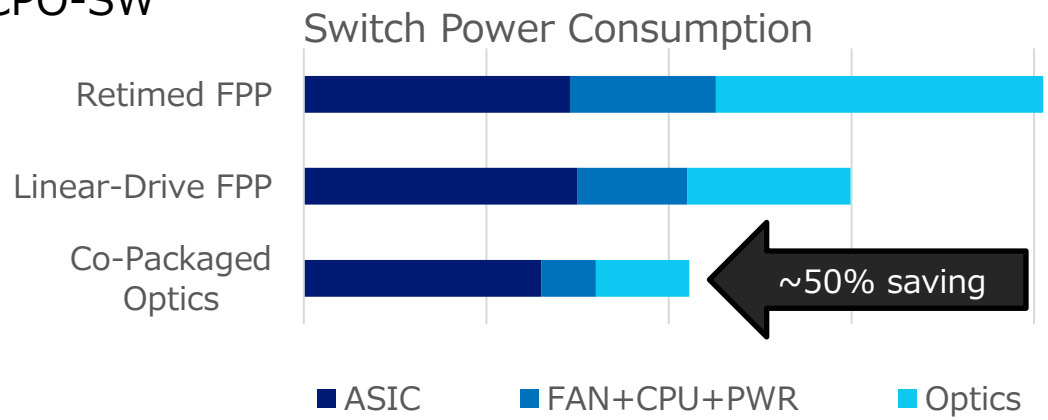
3.Potential expansion to inter-Scale-Up domain switches

PEC-2

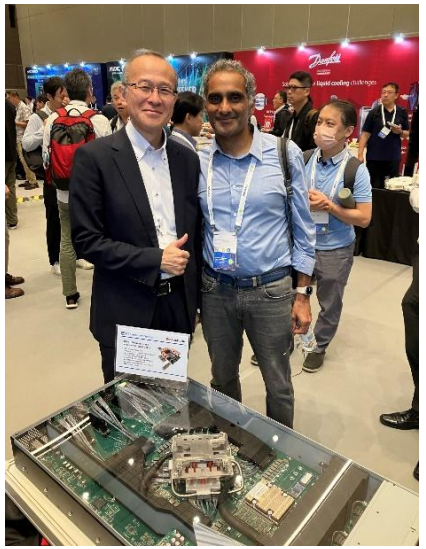
Commercial Deployment of Opto-Electronic Converged Switches

- 102.4 Tbps Capacity, 50% Power Reduction with Switch Alone
- Partnership Established: Broadcom + Accton
- Market Launch Starting in 2026
  - 2026 Q2: Optical Engine Samples
  - 2026 Q3: Live Demonstration at OCP 2026
  - 2026 Q4: Commercial Samples of CPO-SW





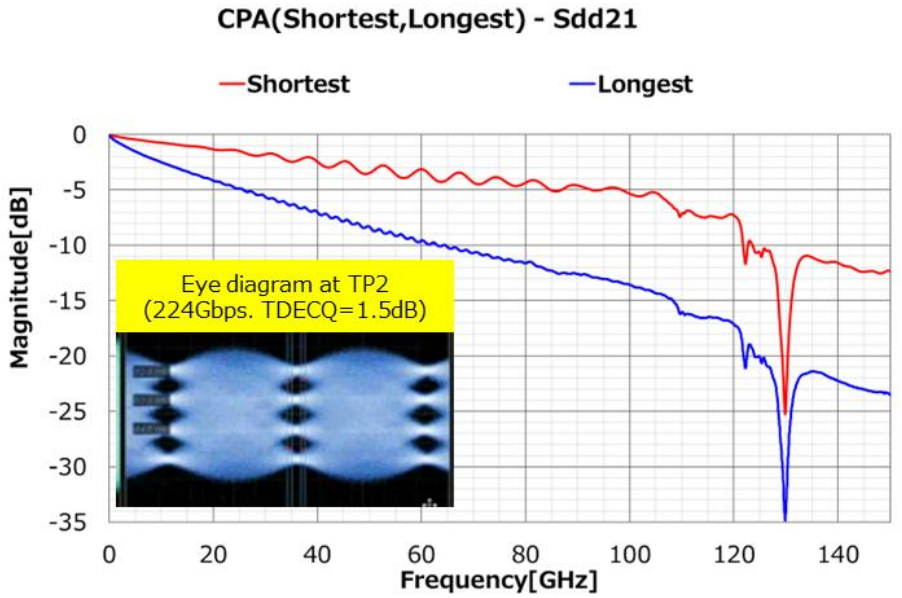
BROADCOM



Accton
Making Partnership Work

On Market Competitiveness

- **A Unique Socket-type Optical Engine**
  - Enables fundamental reduction in repair costs in case of optical engine failure
  - Flexibly supports media mix (short-reach, long-reach, wavelength-division multiplexing, etc.) and evolving data center configuration
  - A multi-vendor supply chain is also being considered for future scalability
- **Target Performance Metrics for Opto-Electronic Convergence**
  - **3.9pJ/b** power efficiency
  - **0.4Tbps/mm** shoreline density



		Optical Connection Types	
		Fiber	Connector
Electrical Connection Types	Soldering		
	Socket		

Partner List

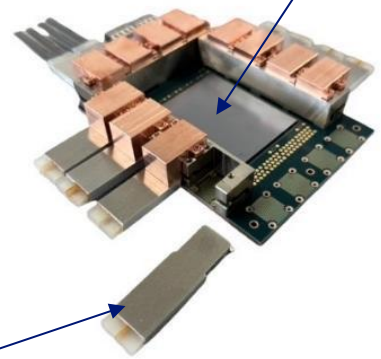
NTT Innovative Devices is responsible for the overall design of the CPO-SW module, and a coordination of the entire process including an alignment of partner companies to deliver the product.

SHINKO

Manufacture of the substrate
Assembly of CPO-SW module

BROADCOM

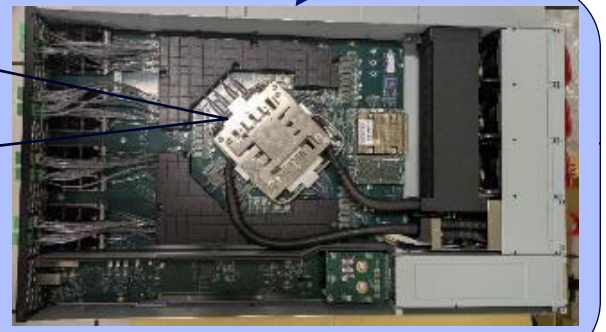
Design & delivery of
102.4Tbps SW-LSI



Products of NTT Innovative Devices
“102.4T CPO-SW module & 6.4T Optical engine”

Accton
Making Partnership Work

Design & manufacture of
102.4Tbps SW-BOX



Product of system partner
“102.4T SW-BOX”

NTT Innovative Devices

Design & assembly of 6.4Tbps
Optical engine

NTT Innovative Devices

Aloe Semiconductor · fj scaler

Subsidiaries of
NTT Innovative Devices

Design and delivery of Photonic IC
and Electronic IC

PEC-3（Next-Generation）

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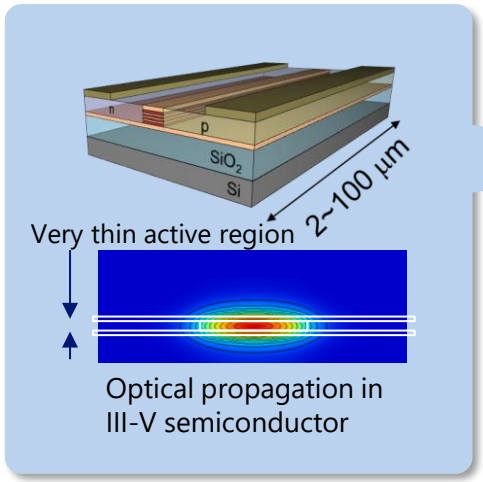
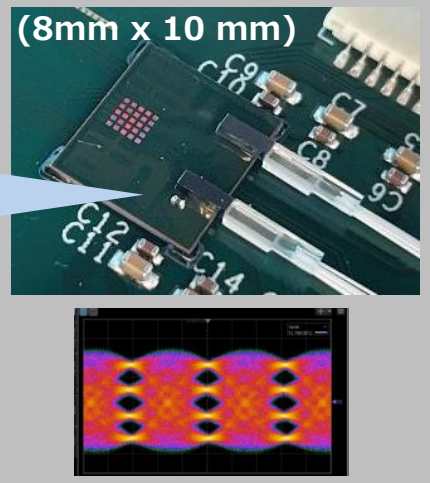
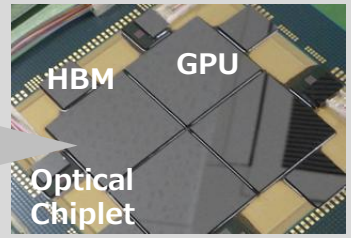
Chip-to-Chip Optical Interconnect (Optical Chiplet)



NTT Laboratories Proprietary Technology
"Membrane Device"

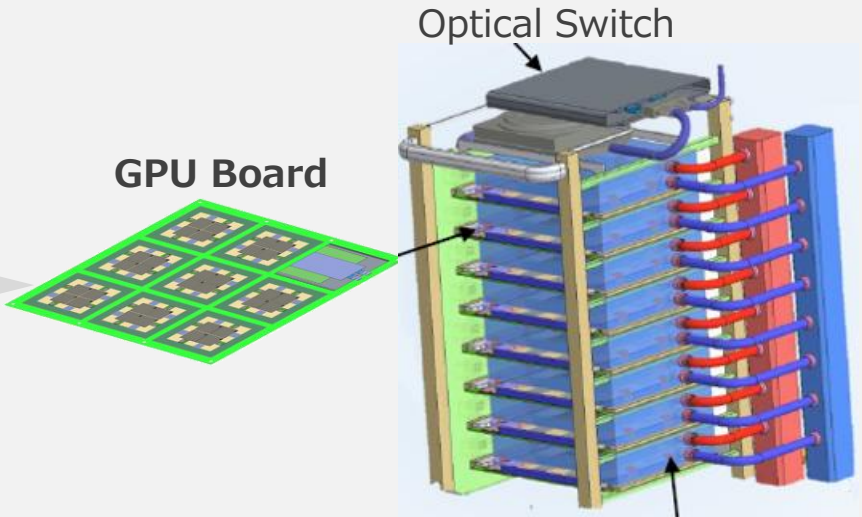


NID Product
"Optical Chiplet"



GPU Package

Semiconductor Partner Product (planned)
"GPU Package"



- **Commercial sample scheduled for Q4 2028**
- Evaluation with prototype in progress
- Ambitious target for further drastic power reduction:~0.26pJ/bit

Feasibility check 0.26 pJ/bit Demonstration

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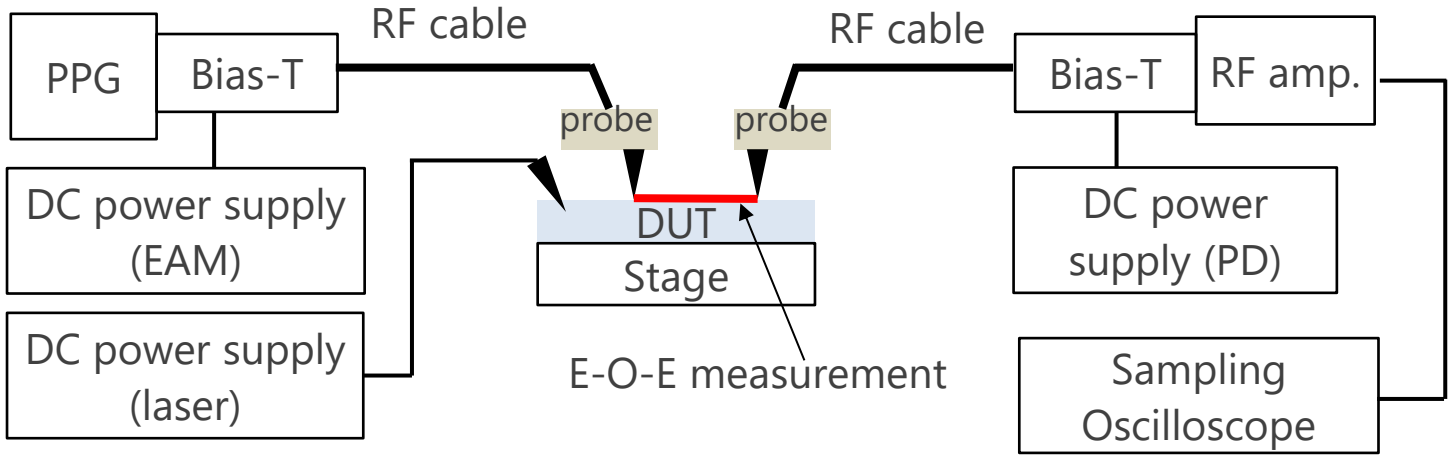
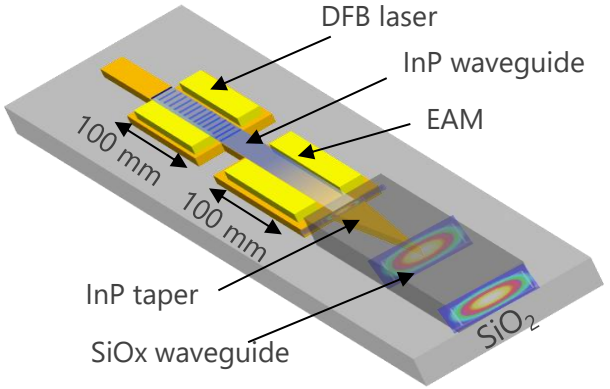
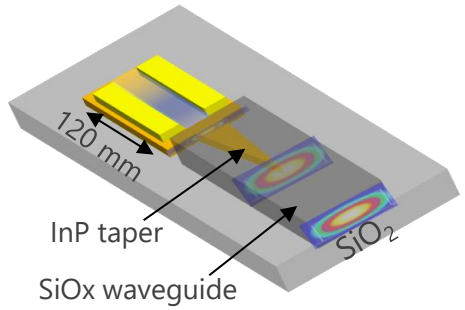
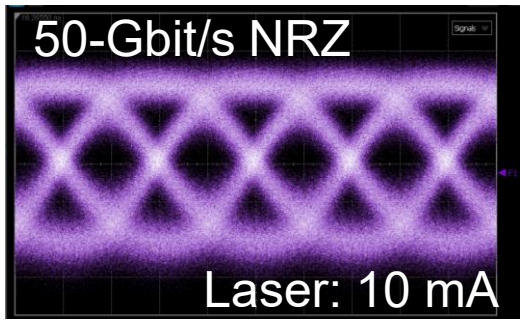
DUT: Device under test

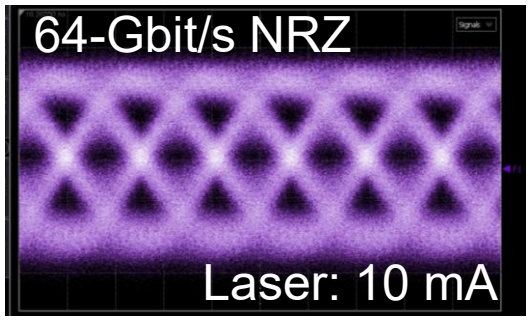


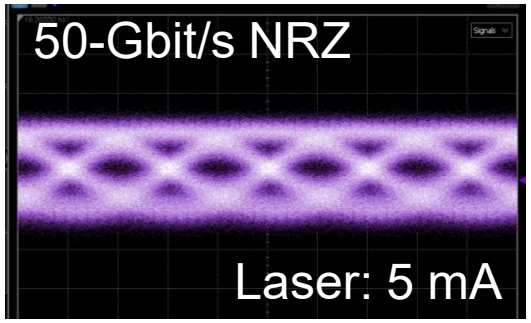
Experimental setup











0.26 pJ/bit
for 64 Gbps @ 10 mA
0.14 pJ/bit
for 50 Gbps @ 5 mA

Measured eye diagrams for NRZ signals

Summary

NTT Innovative Devices

As AI becomes mainstream, connecting vast numbers of processors through networks is essential.

For low-power connections,
optical communication is virtually the only viable solution.

NTT will continue to leverage its extensive experience in optical communications to take on global challenges.

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