

BTO-enhanced Silicon Photonics for Next-Generation Optical Transceivers

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Lumiphase



Lumiphase at a glance



Fast-growing startup

**Founded 2020
Roots at IBM
~70 people**

Unique Technology

**Thin-film-BTO-
enhanced silicon
photonics**

Chip supplier

**Design,
manufacture & sell
optical chips**

Moving to commercialization

**First product launch
H2/2026:
DP-IQM transmitter**

Agenda

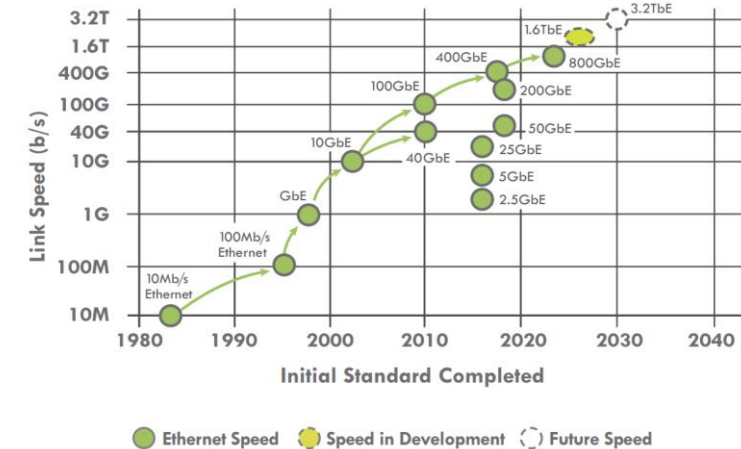
- Introduction
 - Motivation
 - BTO technology
- Key Challenges
 - Integration
 - Reliability
 - Optical packaging
 - Scaling production
- Summary

Introduction - Motivation

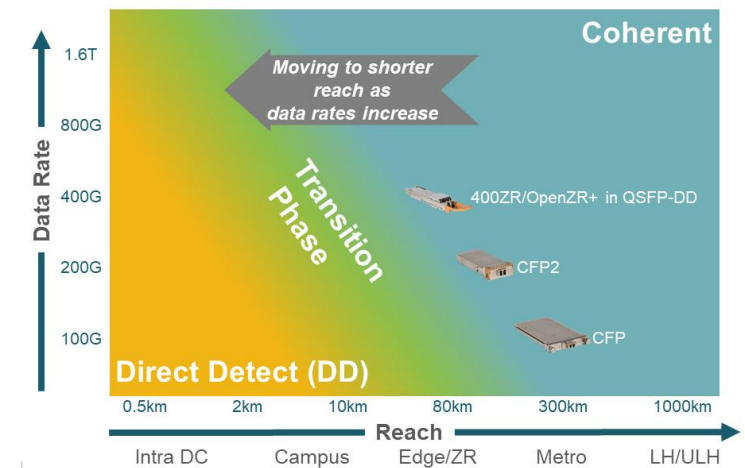
- Data center capacity demand drives need for increased lane data rates
→ novel photonics technologies required to support higher speeds
- Increasing density of data centers pushing power consumption
→ critical need for more energy-efficient and cost-effective optical interconnects
- Optics penetrating deeper into data center architecture
→ reduced crossover reach between copper and optical links and between IMDD and coherent
→ need for lower-loss modulator technology

Lumiphase's BTO-based transmitter chips address bandwidth, cost, and power consumption challenges

ETHERNET SPEEDS



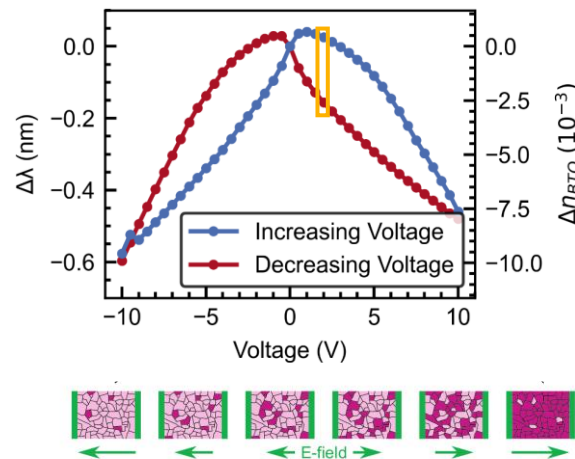
Source: Ethernet Alliance



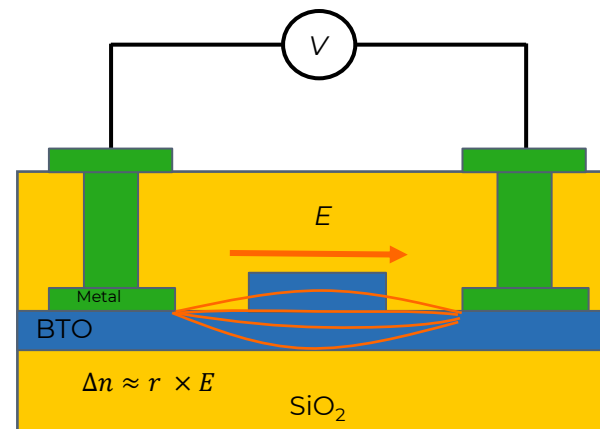
Source: Acacia

Introduction - BTO technology

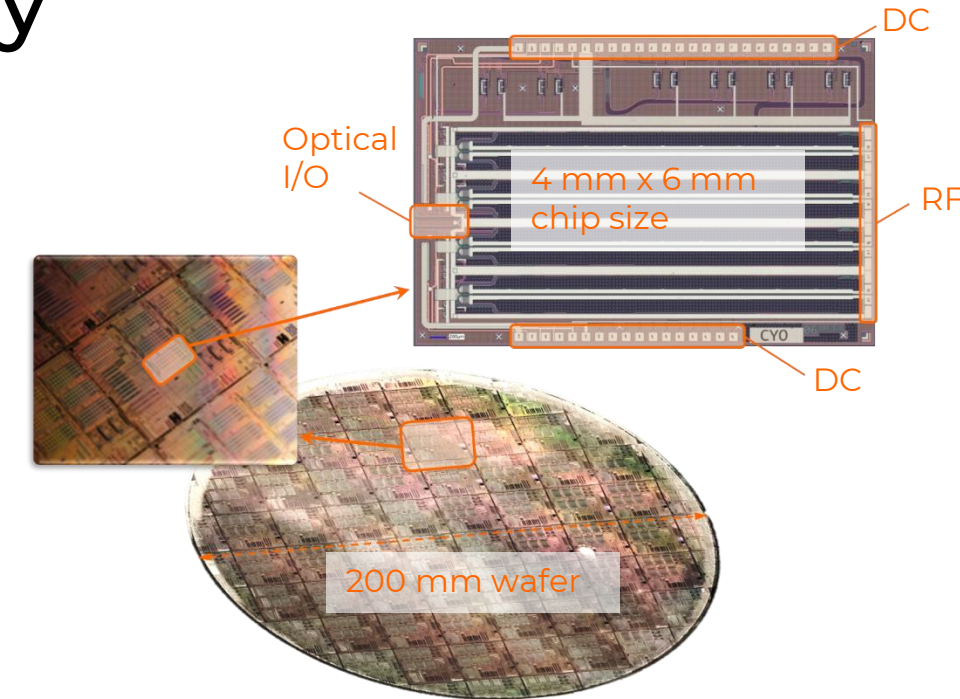
- Pockels effect: property of a material to change refractive index under electric field
- Barium titanate (BTO) is a ferroelectric material with the strongest known Pockels effect
- Can be used to modulate light by electric signals
- Integrating BTO with silicon photonics enables compact, low-voltage, high-speed EO modulators



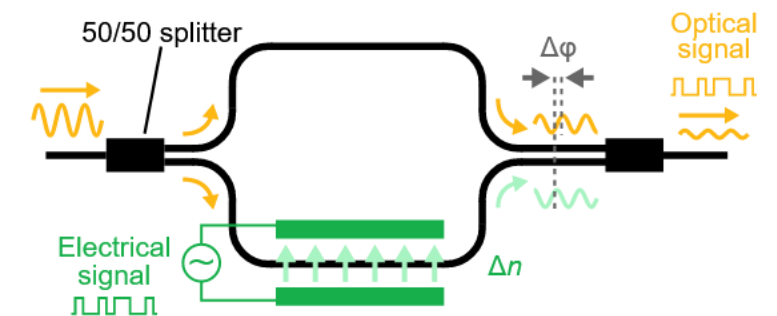
Pockels effect in BTO (Geler-Kremer et al., 2022)



Principle of BTO phase shifter



BTO chips for coherent optical data transmission



Light modulation in Mach-Zehnder structure (Eltes 2019)

Challenges - Integration

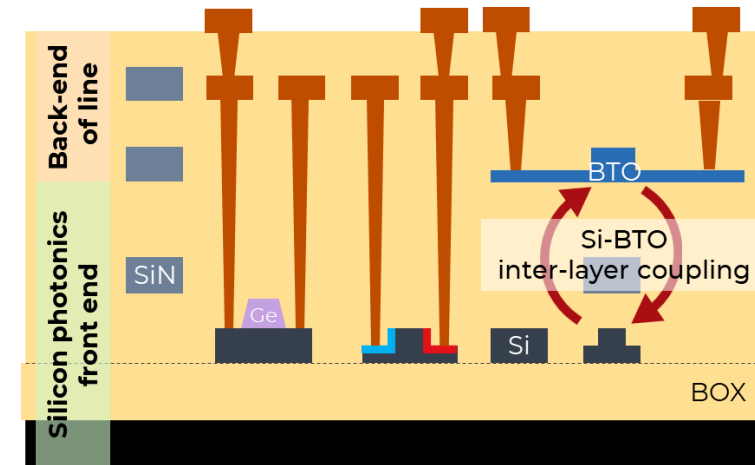
Goal: Scalable manufacturing of transmitter chips (PICs) with integrated BTO modulators

Challenges:

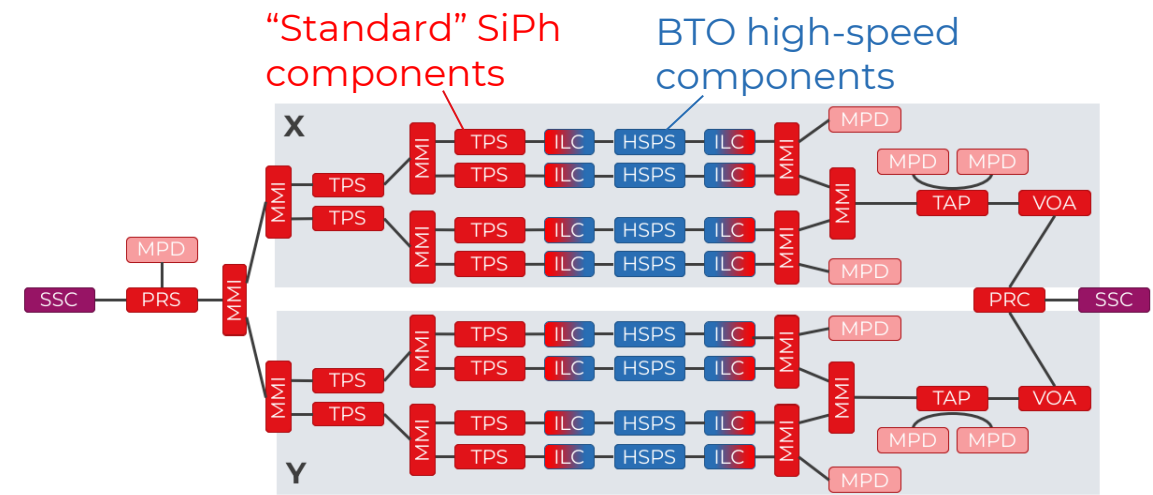
- Exotic materials complicate integration with standard foundry processes
- Need to leverage mature Si photonics components and waveguide technologies

Our approach:

- Combine available FEOL Si photonics platform and PDK components with novel BTO fabrication steps
- Device architecture uses BTO only where essential (high-speed phase shifter)
- Key fabrication steps in-house or with local partner (epitaxy, integration, wafer testing)

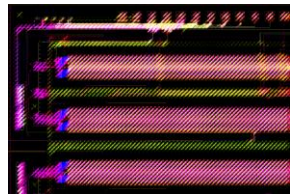


Simplified stack of BTO-based SiPh device

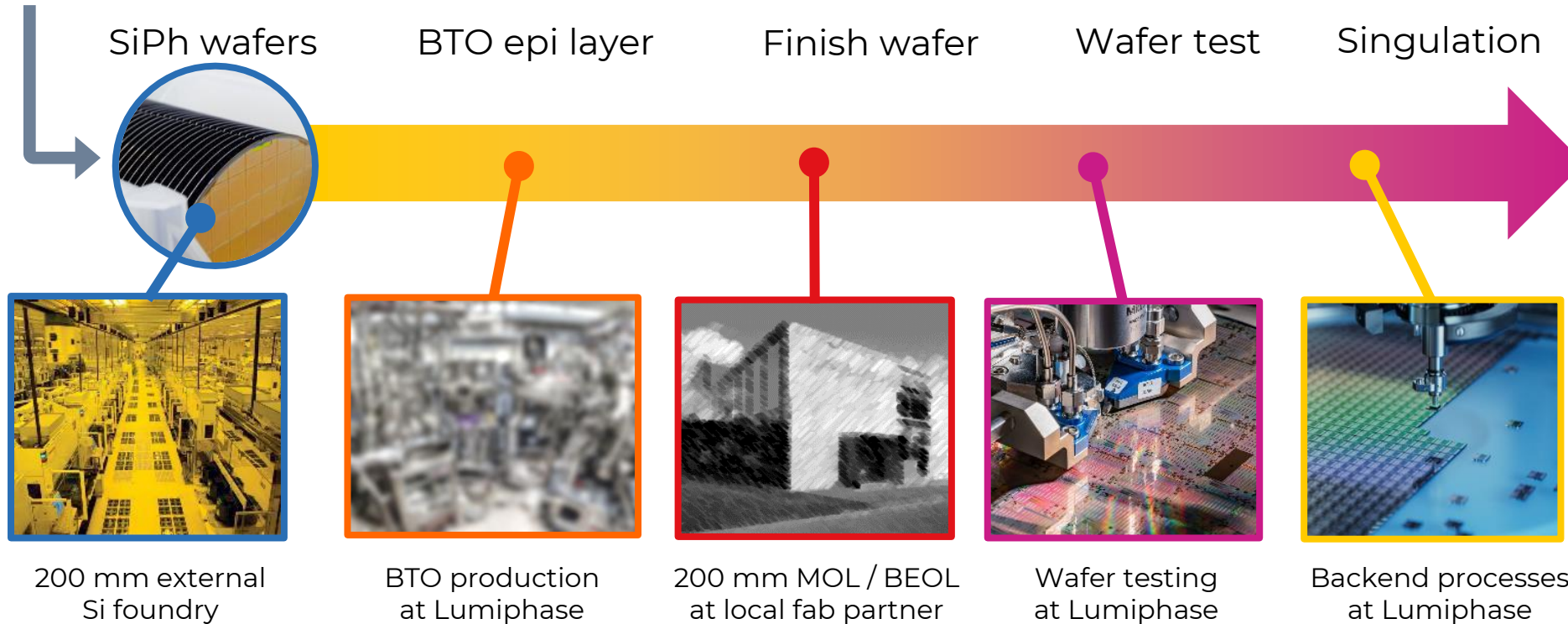


Functional block diagram of BTO-based coherent modulator PIC

Lumiphase KGD production



Standard product or custom chip design

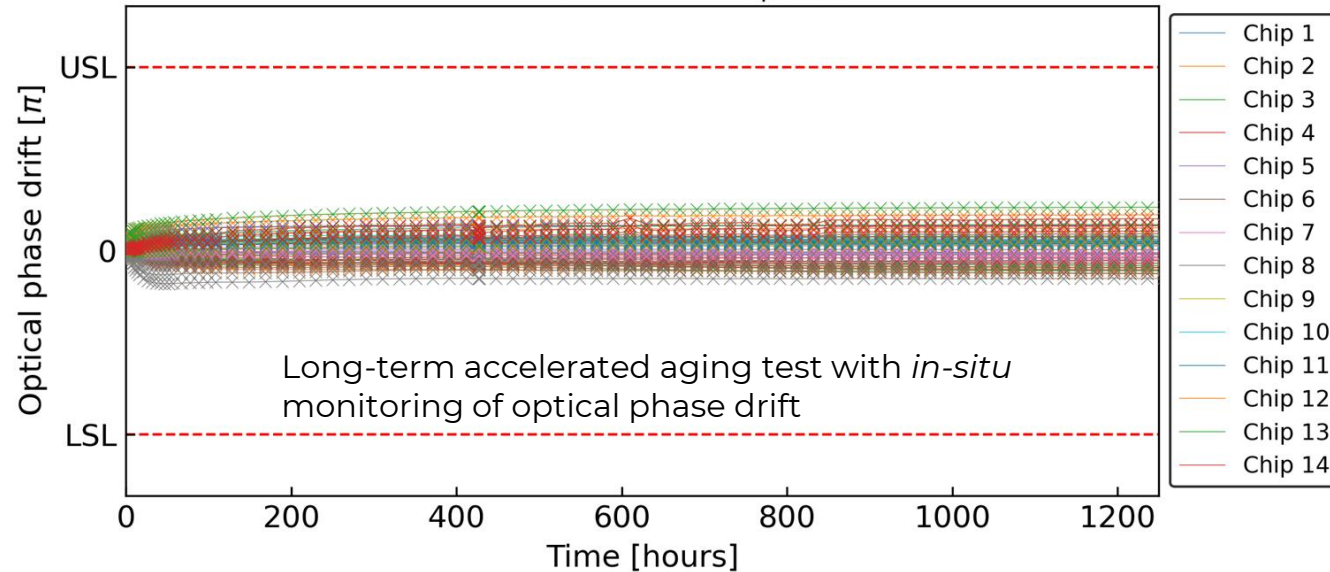


Product KGDs



Challenges - Reliability

HTOL @ 95 °C, $V_{op,max}$



Goal: Prove that BTO devices are long-term reliable

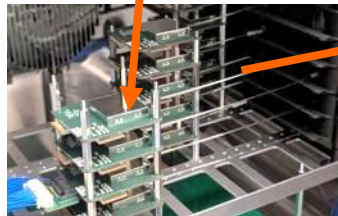
Challenges:

- Need suitable sample format and sophisticated test capabilities
- Time-consuming long-term tests, limited sample throughput

Our approach:

- All tests according to GR-468 (+ harsher conditions)
- Suitable chip-on-PCB packaging
- In-house test capabilities for automated chip characterization and *in-situ* EO performance monitoring

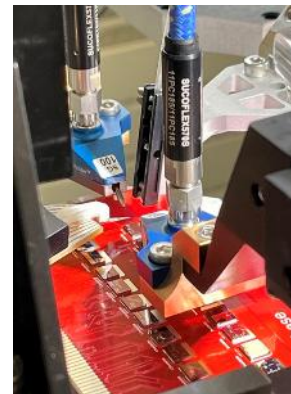
Chip-on-PCB sample



Rack with samples



Reliability setup



Chip prober

Challenges - Optical Packaging

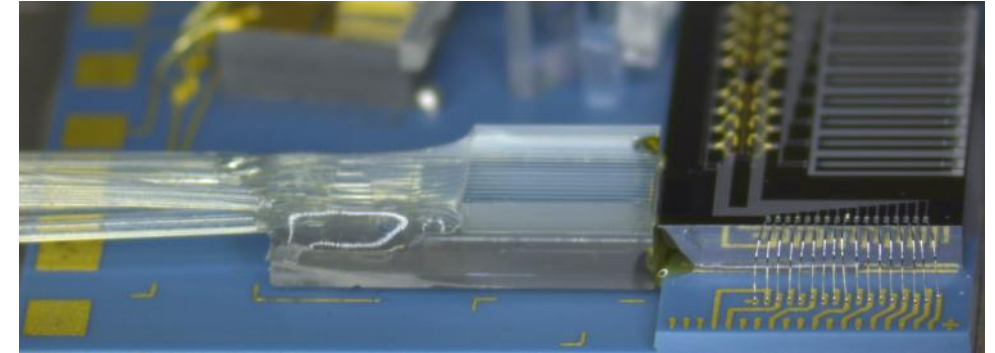
Goal: Ensure our chips can be optically packaged with minimal coupling losses

Challenges:

- No established packaging standards; many customer-specific and proprietary solutions
- High cost of parts, processes, and equipment

Our approach:

- Collaborate early with customers to align design and process needs
- Prototype packaging in-house; qualification samples via external partners (ideally using customer-qualified processes)

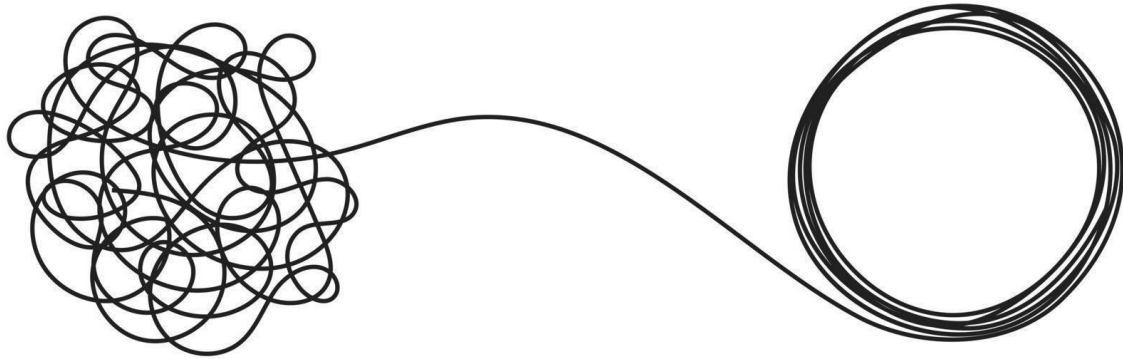


Edge-coupled fiber attach for prototype assembly



Sample for reliability qualification

Challenges – From Start-Up to Production



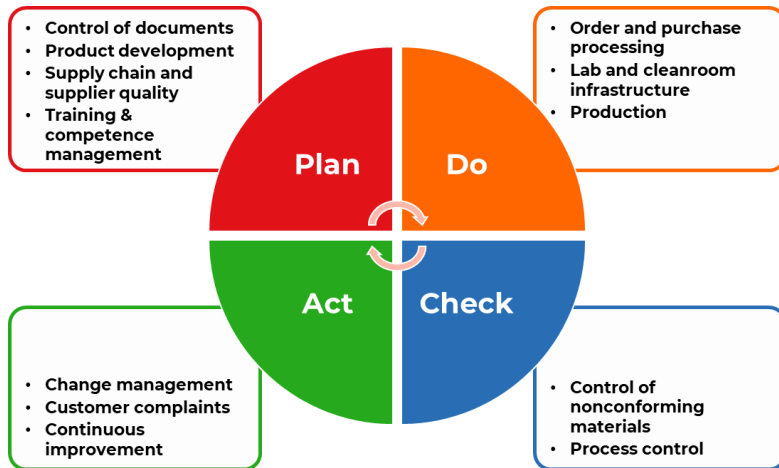
Goal: Establish scalable production framework in short time

Challenges:

- “Chicken and egg” dilemmas
- Compliance with quality and regulatory standards
- Cost and lead times for infrastructure
- Organizational transition

Our approach:

- Leverage close strategic partnerships
- Implement lean quality system aligned with customer expectations
- Infrastructure and team growth to match product maturity and market needs



Simple quality management framework

Summary

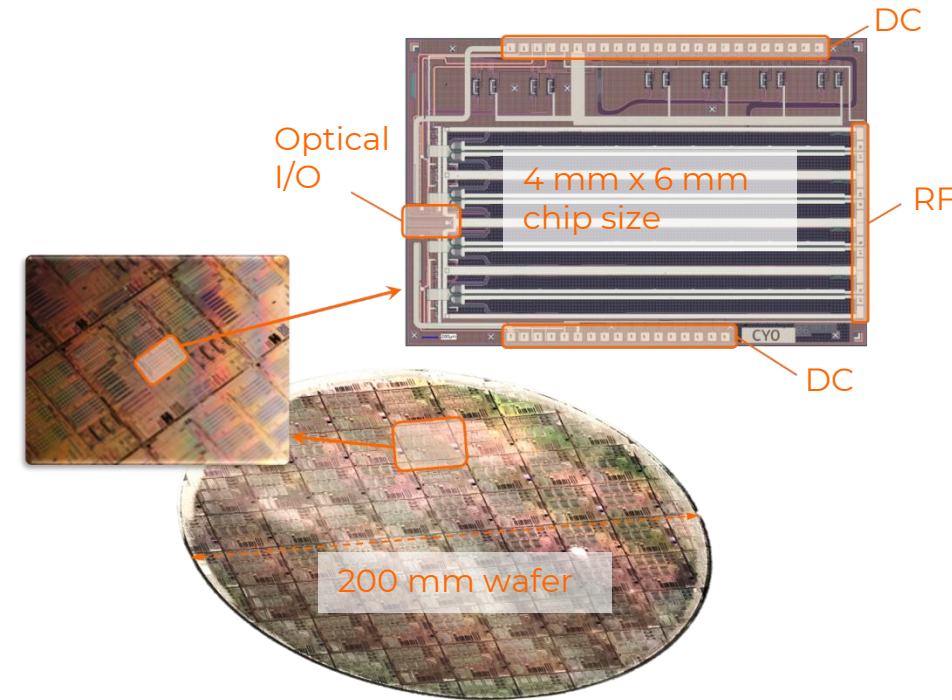
Our vision: Deliver energy-efficient high-speed optical modulators using BTO on silicon photonics

Technology Highlights:

- BTO crystal with low optical loss & high reliability
- Strong Pockels effect
→ compact, low-voltage, high-speed modulation
- Monolithic integration on SOI
→ compatible with standard foundry processes

Key Challenges & Solutions:

- Integration: Combine SiPh foundry platform + in-house fab for critical processes
- Reliability: GR-468-based testing with in-house packaging and test capabilities
- Packaging: Early customer collaboration + hybrid in-house / external packaging
- Scaling to production: Lean quality system, infrastructure and team growth



BTO chips for coherent optical data transmission