



5th International Symposium for Optical Interconnect in Data Centres

Date: 19th September 2017

Location: Meeting Room J2, ECOC Exhibition 2017

FIBER TO THE CHIP





InP vs Silicon Photonics

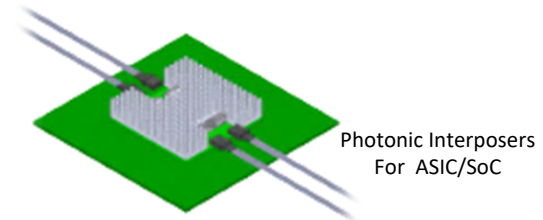
Peter De Dobbelaere
Luxtera Inc.
9/19/2017

Luxtera Company Introduction



- ▶ Founded in 2001, Luxtera has the world's first Silicon Photonics platform proven in volume transceiver production
- ▶ In continuous production since 2009, > 1Mu transceivers deployed
- ▶ Strong demand for Luxtera's 100G products: Cloud Operators require cost-effective 100G Single Mode Optics at high volume

- ▶ Shipments of new 100G products started in Q1 2016, with now more than 300k units deployed leading the market on price/performance and availability. Scaling production of new 100G optics products (1M units/year)
- ▶ Continuing R&D Investment: Roadmap supports 5 year hyper-growth cycle of 25/50/100/400G SMF transceivers leading to broad scale SoC integration.

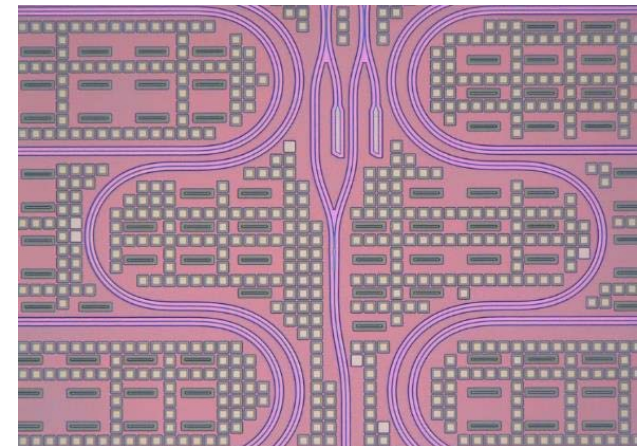
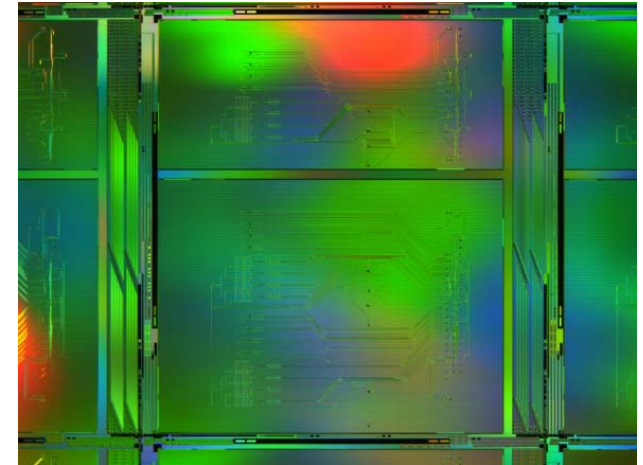


Luxtera's Silicon Photonics

- **Fabless approach leveraging semi-conductor technology**
 - Commercial semiconductor fabs
 - Commercial OSAT for assembly and test
- **Advanced photonic device libraries are a must**
 - State-of-the-art transceiver performance is required
 - Many opportunities for improvement still to be explored
- **In-house electronic and photonic circuit design**
 - Co-design of electronics and photonics within a common EDA-environment
 - Silicon Photonics allows new architectures and high level of integration
- **Reliable and stable light source**
 - Micro-packed laser diode or remote light source

Silicon Photonics Wafer Manufacturing

- **Fabless approach leveraging IC technology**
 - No “boutique” processes
 - Commercial fabs & OSAT for assembly and test
 - Over its history Luxtera worked with 3 fabs for silicon photonics wafer manufacturing. March 2017 announcement: Luxtera works with TSMC on developing a 300 mm silicon photonics process
- **Silicon photonics wafer yields are usually very high**
 - Capable processes and tool sets in commercial fabs
 - Capable process monitors
 - Low density of photonic circuits
- **Process Design Kit (PDK) allows IC design approach**
 - Device Library p-cells w/behavioral models based on measured performance
 - DRM/DRC Deck
 - LVS & Parasitic extraction
 - Co-simulation photonics + electronics



Silicon Photonics Device Library

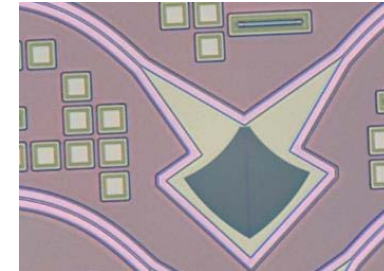
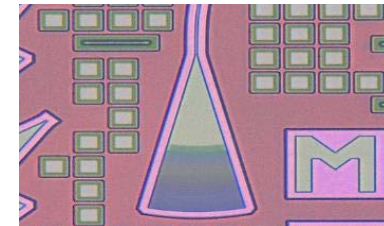
- **Advanced photonic device libraries are a must**

State-of-the-art transceiver performance is required, scaling to higher data rates requires:

- Higher signal to noise ratio: lower losses, higher modulation efficiency, higher detector responsivity
 - Losses of coupling in and out of the Si Photonics chip are one of the major challenges
- Higher bandwidth modulators
- Higher bandwidth photodetectors

- **Developing design devices in TSMC process**

- Advanced process:
 - Enhanced device performance
 - Process capabilities allow broader design space for photonic devices
- Streamlined supply chain:
 - Electronic and Photonic ICs
 - TSV capability

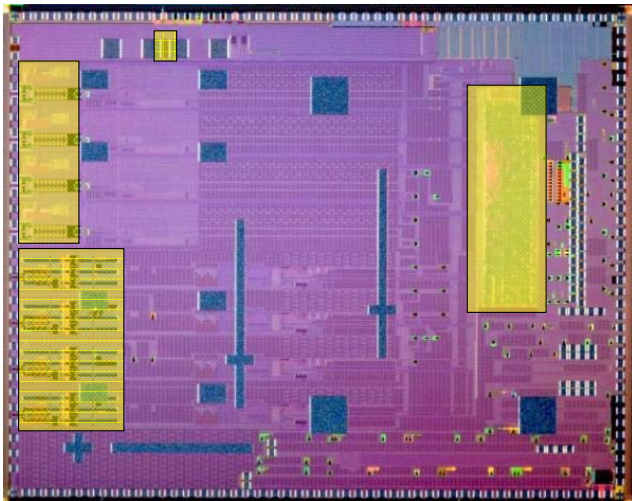


Integration Photonics & Electronics

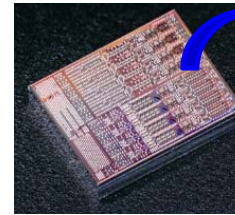
Luxtera commercialized both, each approach has merits, we opted for hybrid integration going forward:

- Scalability
- Product and development cost
- Business/Supply chain considerations

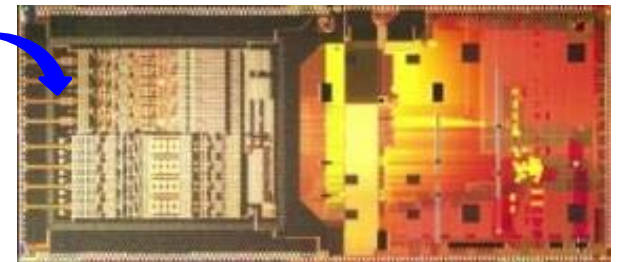
Monolithic Integration (4x14 Gbps IC)



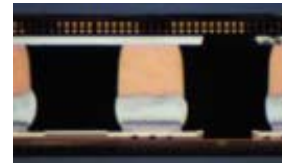
Hybrid Integration (4x28 Gbps ICs)



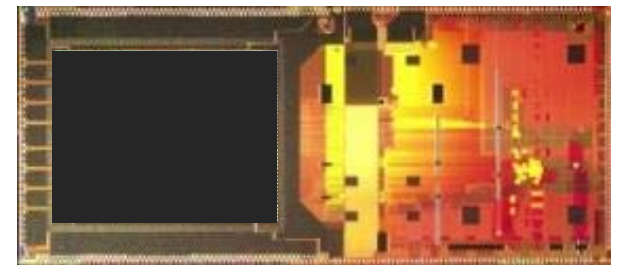
Electronic IC



Photonic IC



Micro-bumps

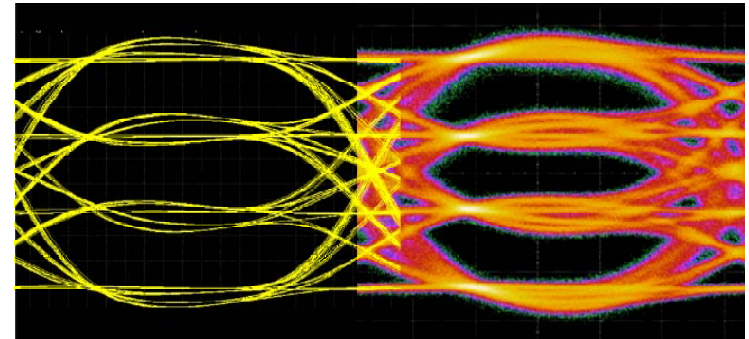
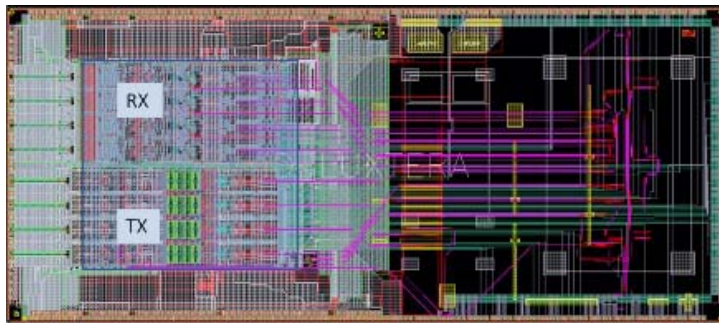
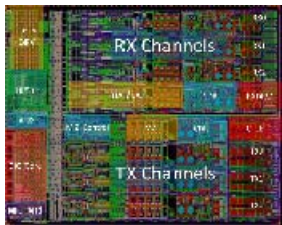


In-house electronic and photonic circuit design

- Co-design of electronics and photonics within a common EDA-environment

System level simulation using behavioral models & parasitics of photonic devices and interconnects

TX output 26 GB PAM-4, simulation vs actual:

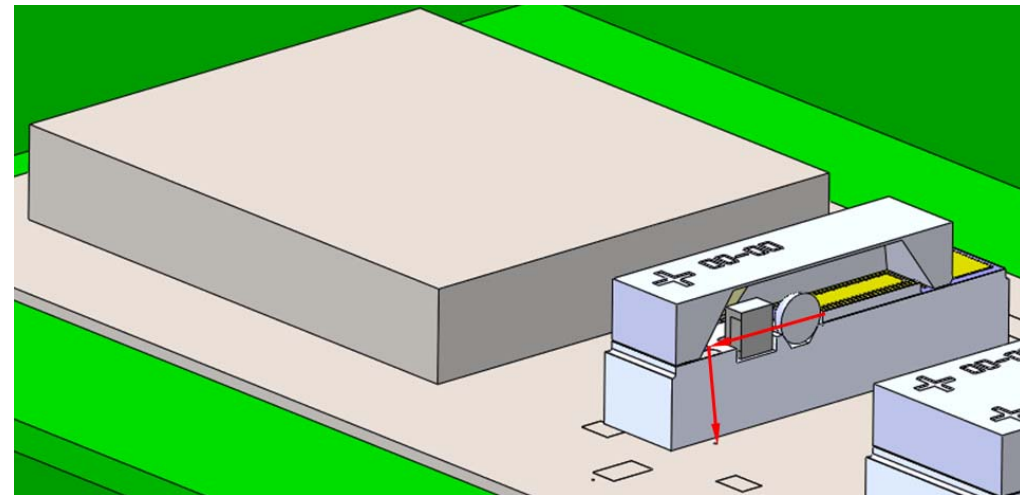
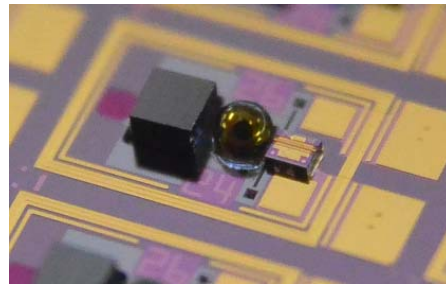
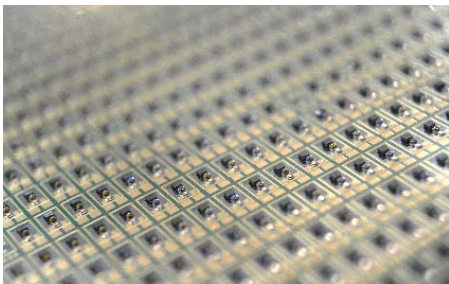


- Silicon Photonics allows new architectures and high levels of integration

Light Source Integration

Reliable and stable light source

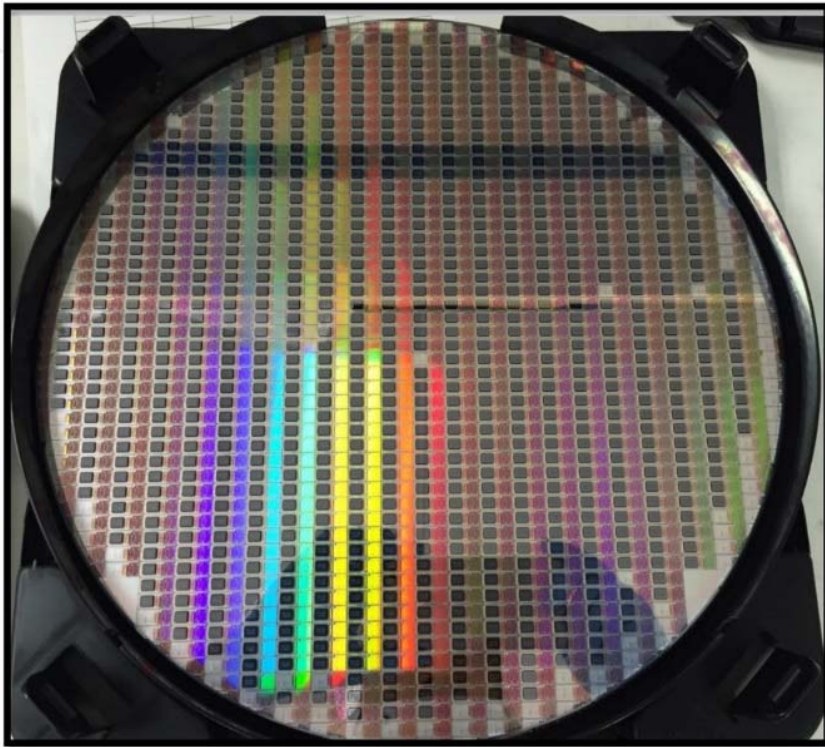
- **Micro-packed InP laser diode** for pluggable modules (require co-packaging)
- **Remote light source** for highly integrated and dense systems decouples light source and transceiver functions, e.g. ASIC integration (High T, serviceability, yield,...)
- **Conventional InP laser diode in silicon micro-package:**
 - Mature InP laser diode technology
 - Faraday rotator as optical isolator for laser stability
 - Efficient coupling scheme
 - Delivered to module assembly line as known good light source
 - Wafer level manufacturing:



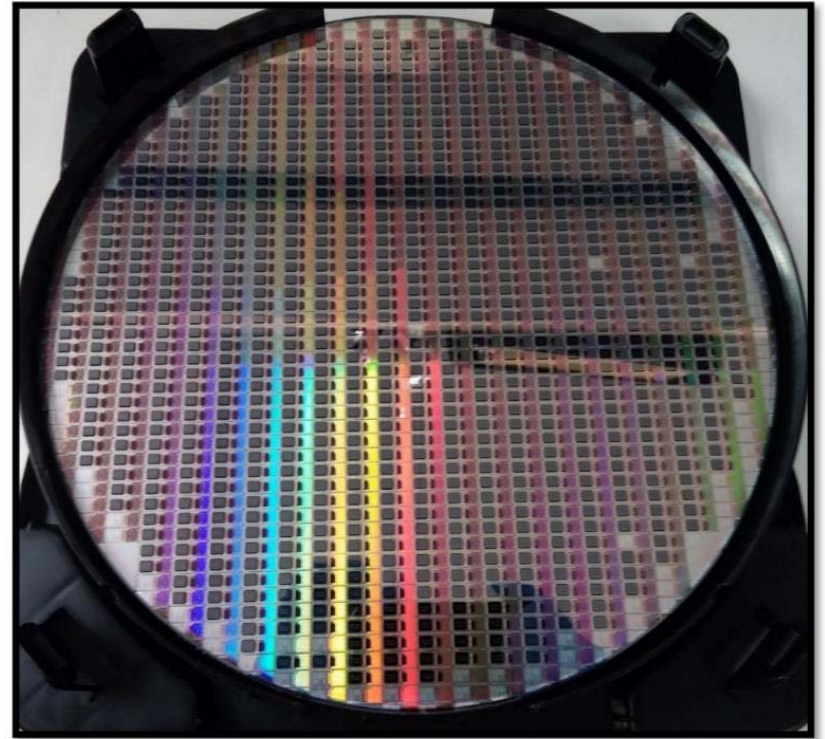
- **High wall-plug efficiency:**
 - > 15% (incl. coupling efficiency LD to Si P IC)
 - Single light source for 8 channels 25 Gbps (PSM-4)

Wafer Level Optical Assembly of Electronics and Photonics

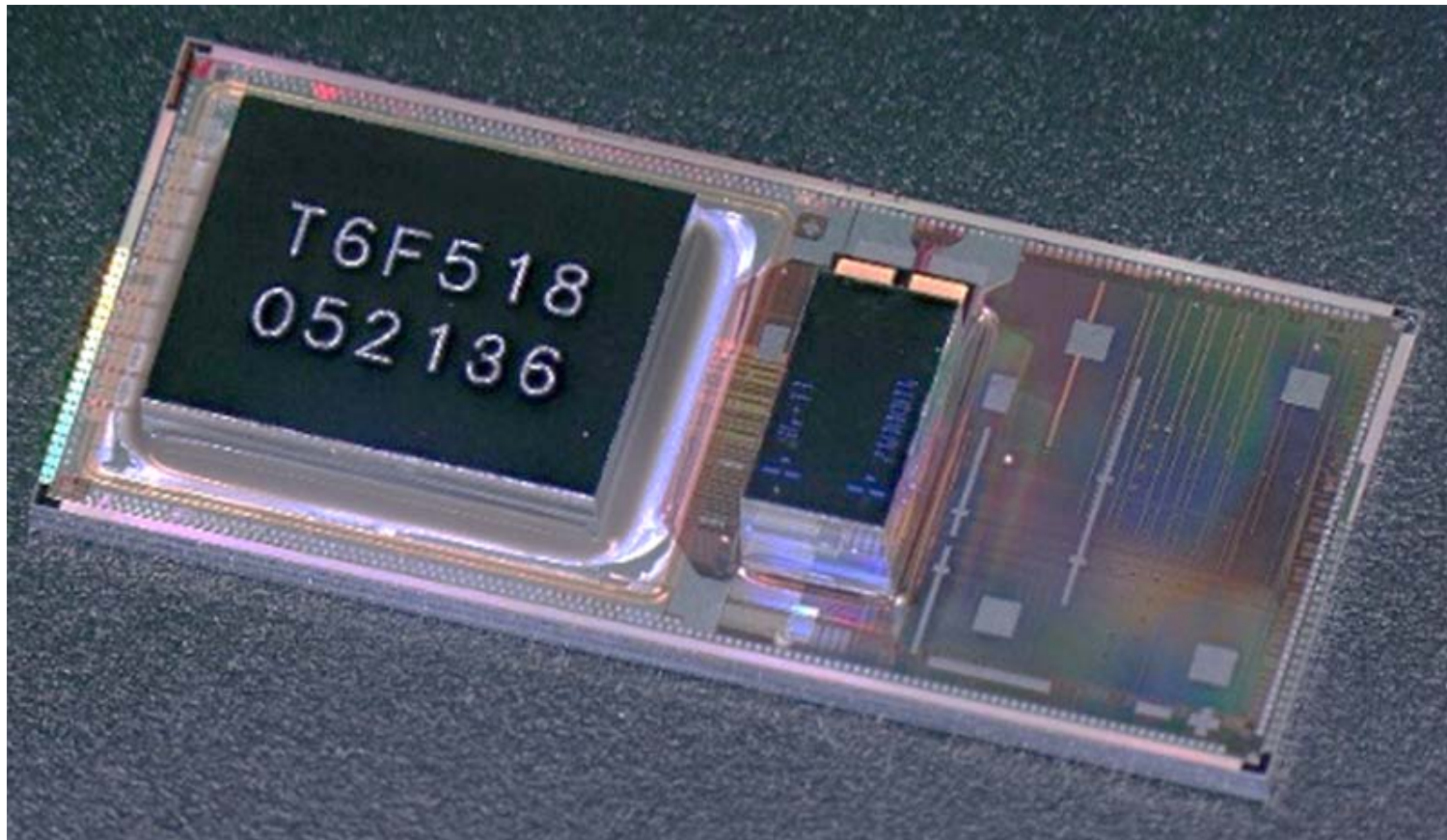
Electronic IC to Photonic IC



Light Source to Photonic IC



Silicon Photonics Optical Engine (100G TX+RX PSM-4)

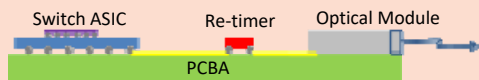


High-Speed Interconnect Implementations & Form Factors

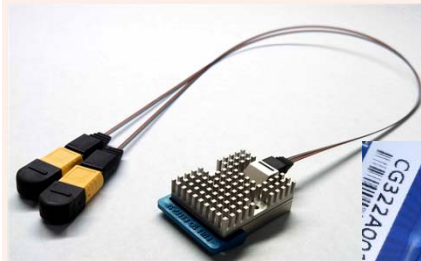
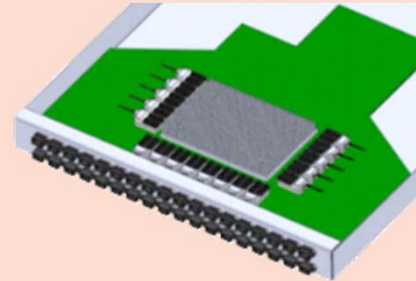
CONTEMPORARY – Today Front Pluggable Modules



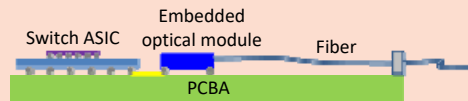
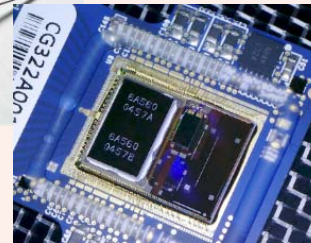
QSFP28
Module



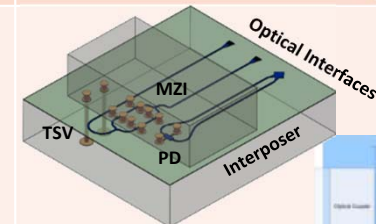
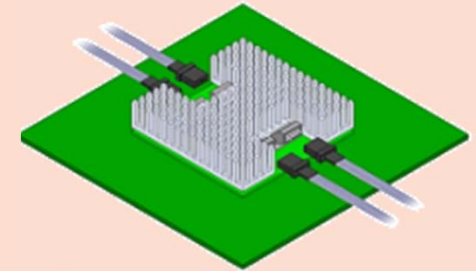
EMERGING – 2017/18 Embedded Optical Modules



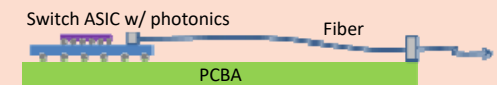
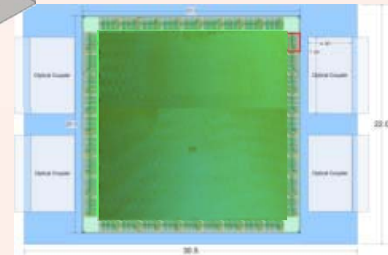
200 Gbps Mid-Board
Optics Module



Next– 2020+ ASIC/SOC Integration



ASIC with photonic
I/O on interposer



Silicon Photonics is the winning technology for DC interconnect

Scales in Performance

- Advanced photonic device libraries allow link margin and performance needed for ever increasing data rates
- Latest CMOS technology nodes for electronic circuits required for electronic functions (28 nm, 7 nm)
- Density scaling in multiple dimensions: data rate, modulation, wavelength, spatial
- Enables SoC integration with ASICs:
 - Very large scale integration of hundreds of transceivers on a single device
 - Very harsh (hot) environment -> remote III-V light source

Scales in Manufacturing

- Leverages semiconductor industry manufacturing infrastructure (fabless)
- Leverages semiconductor technology roadmap
- OSAT for Wafer Test & Assembly
- DFM, DFT, DFR
- Simplified and highly automated optical assembly



Acknowledgement:
This presentation contains work of the entire Luxtera team and its past and present technology partners, their contributions are greatly acknowledged.

Thank you for your interest.