

Manufacture and Test of Photonics within the Electronics Ecosystem

Ted Schmidt
Juniper Networks
Sunnyvale, USA
tedschmidt@juniper.net

Roberto Marcoccia
Juniper Networks
Sunnyvale, USA
rmarcoccia@juniper.net



Engineering
Simplicity

Optics manufactured like electronics

Opto-ASIC: A scalable optical technology that is manufactured within the silicon microelectronics ecosystem (design, fabrication, packaging, and test) enabling high volume, low cost transceivers that can be co-packaged within larger electronic systems.

Optics Manufacturing Today

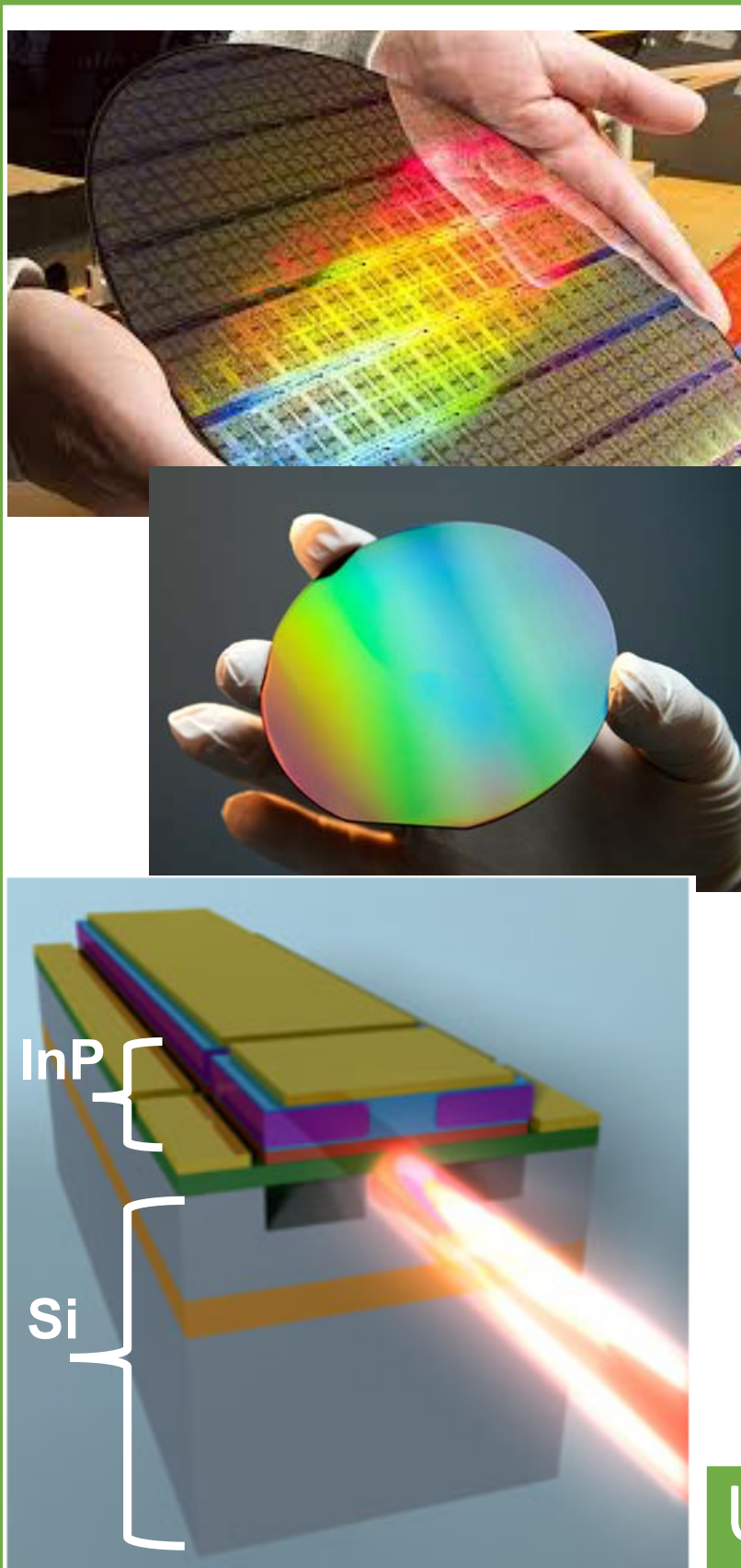
Specialized Fabs **Labor Intensive**

- Discrete manufacturing approaches
- Many different technologies – no economies of scale
- Transceiver designed to package

Juniper Silicon Photonics

Silicon Fabs **Microelectronics Assembly & Test** **Contract Manufacturers**

- Utilize the highly automated multibillion-dollar microelectronics ecosystem used across industries
- Transceiver agnostic to package



- ### Silicon (Si)
- Elemental material abundant on earth
 - Semiconductor - conducts electricity under some conditions, insulates electricity under other conditions
 - Strong mechanical properties
 - Can “guide” photons (light)
 - Cannot generate photons (light) efficiently
- ### Compound Semiconductors
- Composed of elements from two or more different groups of the periodic table - e.g., Indium + Phosphate (InP)
 - Compound crystals more difficult to grow than silicon
 - Higher number of crystal defects
 - Wafers become fragile
 - Cost of making the crystal is higher
 - But** can efficiently generate photons (light)
- USE BOTH: InP only where needed!**

Heterogeneous Integration

Silicon Processing

- Older node technology (High resolution for photonics but low cost)

Heterogeneous Integration

- No critical alignment of laser
- Lowers power
- Multiple Photonic functions

III-V/Si Processing

- Best in class performance

Simplified Manufacturing of Optical Transceivers

Lasers Integrated in PIC

- Hermetic at chip scale
- Wafer scale process

Separable Optical Connector System

Simple assembly – no specialized tooling required

Opto-ASIC: System-in-Package Optical Transceiver

Labels: Optical Fiber Interface, Microcontroller, CWDM or PSM PIC, Datapath ASICs, Organic Substrate with BGA, Control ASIC, Lens Receptacle Assembly, Clip, Separable Single-Mode Ferule.

Scaling Beyond Pluggable Optics

3.2 Tb/s Opto-ASIC Transceiver

Co-Packaged Optics

Optical I/O: 8 x 400G
Electrical I/O: 32 x 100G XSR

Petabit-per-second System Switching Capacity

Opportunities

Advances in Electronics-Photonics Design Automation (EPDA) tools are required to streamline:

- Co-design of electronic and photonic devices and circuits, including associated interconnect
- Co-layout of electronic and photonic ICs
- Stress and thermal analysis
- Monte Carlo and corner statistical analysis to support Design for Manufacturing (DFM)

High count fiber I/O solutions are required:

- 16 fiber for 400G/fiber use cases
- 64 fiber for 100G/fiber use cases

Labels: Data Path Electronics, Photonics, Control & Management, Substrate, Fiber Interface.

