Integrated Photonics Institute

for Manufacturing Innovation

AIM photonics

AMERICAN INSTITUTE for MANUFACTURING INTEGRATED PHOTONICS

Building the 21st Century Integrated Silicon Photonics Ecosystem

Integrated Photonics is about data and sensing

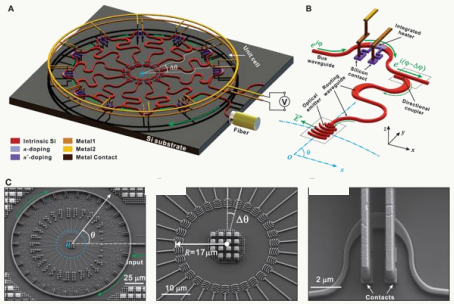
VISION **Establish technology, business, and education framework for industry, government, and academia to accelerate transition of integrated photonic solutions from innovation to manufacturing-ready systems spanning commercial and defense applications.**

Data Comm / Telecom

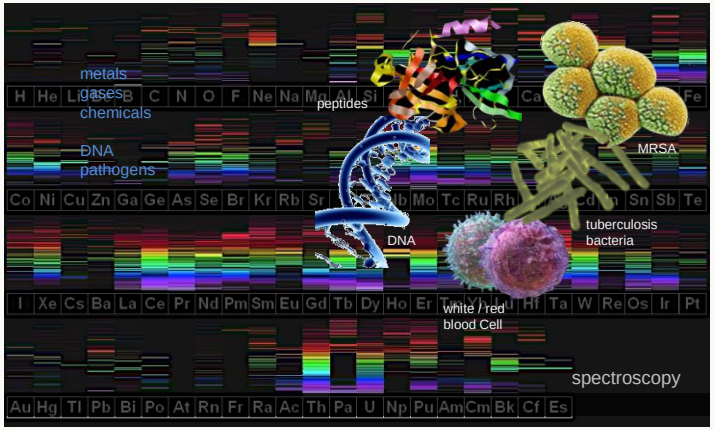
You can pack more information onto a light pipeline than an electric cable, all while consuming much less power

- Connect the world
- More energy efficient

Continuously Tunable
Optical Orbital Angular Momentum Generator



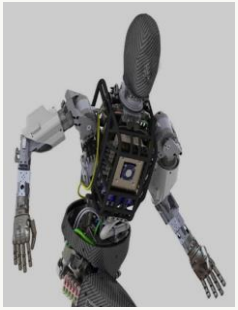
PIC Sensors



- Improved healthcare
- Threats mitigation

Augmented Reality

Robotics



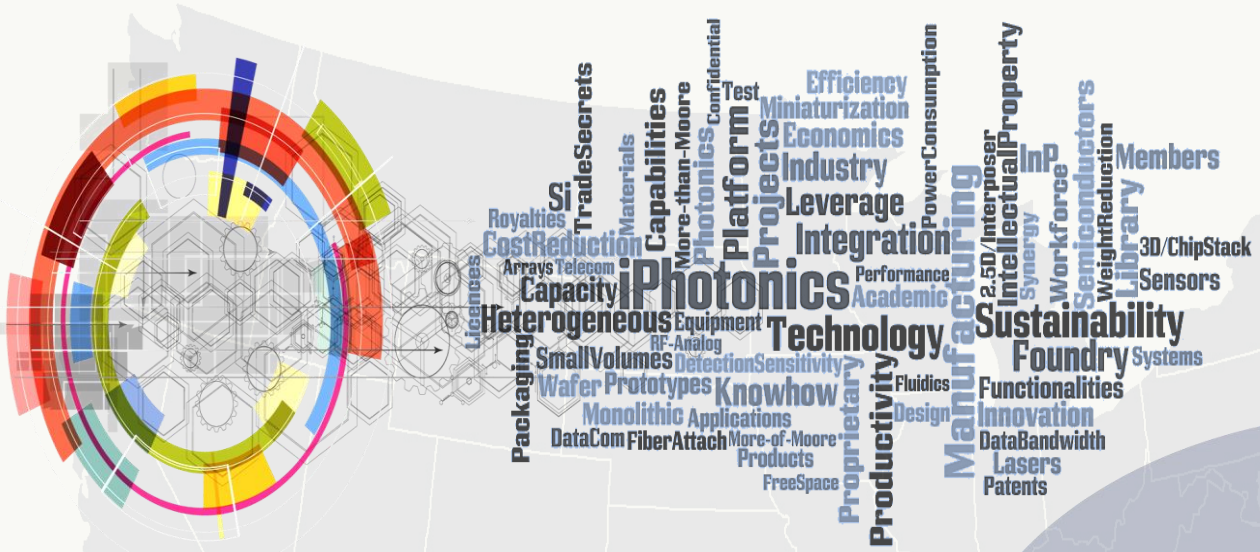
LIDAR

Defense

- Obstacle detection
- Lighter and faster
- Small / cost effective / reliable
- Very low power

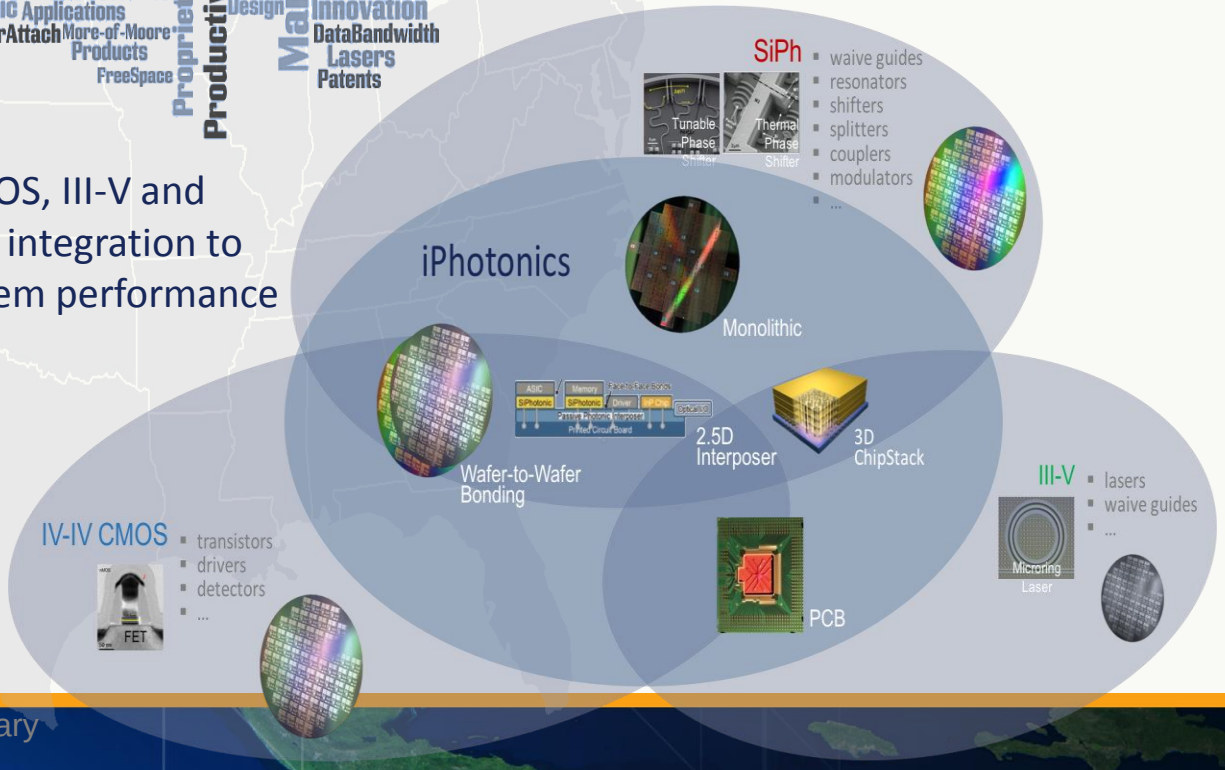
Close the gap between research & commercial production

Manufacturing Technologies which enable novel, leading edge product/system solutions



- Headquarters – NY
- Lead – SUNY Poly, Albany NY
- Nationwide Collaboration – interest in 33 States
- Over 80 Members

- Integrated Photonics; IV-IV CMOS, III-V and SiPh technology functionality(s) integration to enable advanced product / system performance

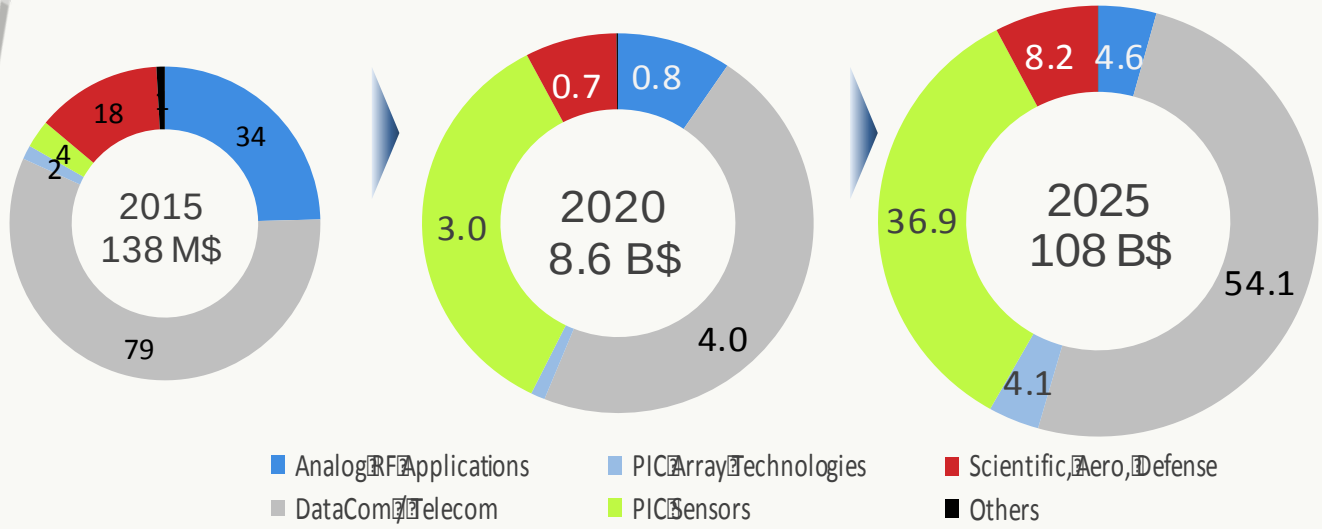


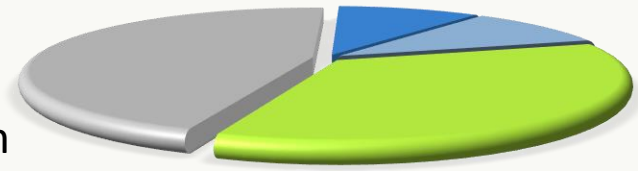
Integrated Photonics Market Environment

iPhotonics Market Characteristics

'Hockey Stick' Characteristic

- 5yrs slow growth
  - mature technology
  - overcome manufacturability issues
  - 3yrs to product commercialization
- then exponential growth
  - rapid adaption





DataCom / Telecom

- Industry driven / Aggressive Drive
- Solutions on-the-way
- Continuous / fast migration to iPhotonics

Arrays / RF Analog

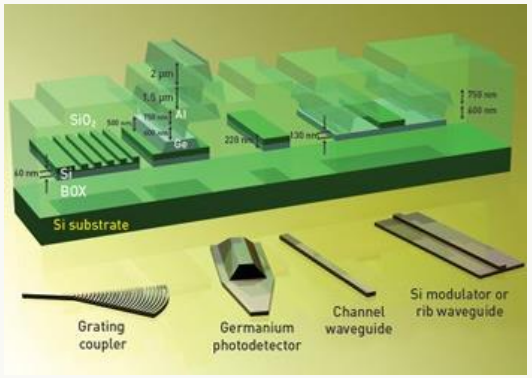
- Defense Industry driven / Virgin Territories
- Solutions evolve
- Slow migration to iPhotonics

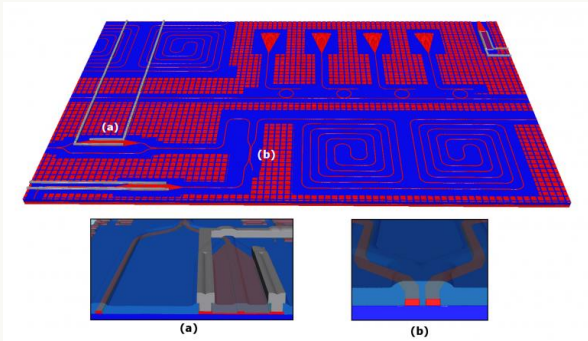
Sensors

- Bio / Healthcare, total lack of adaption to Si-Technology Solutions
- iPhotonics will be of disruptive nature (molecular diagnostics)
- Solutions (spectroscopy) to be driven in collaboration with Department-of-Health & Player that intends to jump into the market 'big'

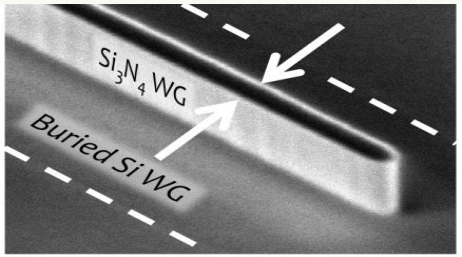
Critical CMP Levels

- Photodetector
  - Integrating photo detectors in silicon reduces costs
  - Detector Performance driven by polish
  - DFM and process efficiency still needs to be addresses
- Waveguides, Couplers, Modulators
  - Silicon Waveguides & Nitride Waveguides
  - Novel new materials
  - Surface integrity key to performance driven by polish
  - Multiple levels integrated with detectors
- Metallization (BEOL / 3D)
  - Non typical Aluminum & other metals due to integration
  - Multiple device connections
  - Wafer to wafer bonding
  - Chip to interposer
- CMP supply chain for integrated photonics
  - Address not only current process challenges
  - but hockey stick volume ramp
  - Investment in future new materials



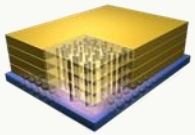


Si Photonics test die with top cladding removed to show structures, with close-ups of a (a) Mach-Zehnder modulator and (b) directional coupler.

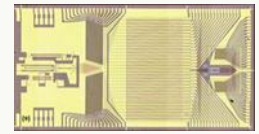


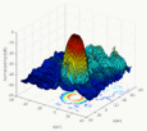
95nm Si3N4 taper on Si waveguide.

Projects



2016 PROJECT PORTFOLIO	
KTMA/MCE	**PROJECT NAME**
Datacom	High Capacity High Radix Optical Switch
Analog RF	Integrated Photonic Analog Link on Si
PIC Sensors	Raman Chem/Bio
EPDA	EPDA PDK
EPDA	DFM Methods and Tools
MPWA	Laser Integration into SUNY Platform with Heteroepitaxy
MPWA	Chip Level Packaging, Year 1 Pilot Phase
MPWA	PIC Integration on Interposer & Chip
MPWA	300mm MPWA Program, Year 1 Pilot Phase
ICT	Inline Controls & Testing, Year 1 Pilot Project
TAP	Functional Testing Development for Automated Scaled Manufacturing
TAP	High Density Fiber-Chip IO Packaging
TAP	High-throughput Mfg. for PIC Polymer WG Connection
PIC Sensors	Waveguide SPR
TAP	Rochester Hub
Analog RF	Integrated Photonic Analog Link and Processing on InP
EPDA	InP EPDA Tools
MPWA	InP PIC Foundry
PIC Array	Free Space Communications





Potential CMP Project Example for AIM Photonics

6000um Waveguide

- Uniformity across that length
- Not just height but smoothness
- CMP Absolutely critical for this device
- How to solve this problem

REQUIRES Multiple Partners

- Design / Simulation: PDK
- Silicon / Fabrication: MPW
- Process solution via:
  - DFM Predictability
  - Committed Consumable Supply
  - Final Manufacturing solution

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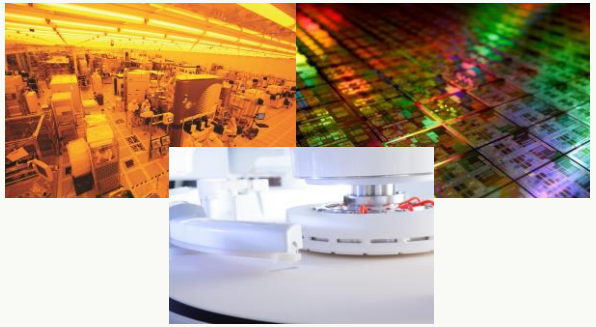
Massachusetts Institute of Technology

COVENTOR™



✓**QUALIFIED SUPPLY CHAIN!**

Silicon Photonics Process Design Kits (PDK)

- **PDK– 3 technologies, 2 major releases/year**
  - **Full (active)- v1.0 available now**
  - **Passive- v1.0 available now**
  - **Interposer- v1.0 available now**
  - Next: v1.5 (Aug'17), v2.0 (Jan'18)
  - Incremental releases add components & maturity **leading to guaranteed specs** based on full statistical corner validation
- **Extensive Component Library**
  - Passive, Active and Interposer components
  - Support for **simulation, layout, schematics, DRC, documentation**
  - Developed by Analog Photonics LLC (Boston)
- **EDA/PDA Design Software Supported**

cadence™ Mentor Graphics SYNOPSYS®

lumerical PhoeniX Software Solutions for Micro and Nano Technologies

- **Download the PDK from MOSIS**
  - AIM Membership or license required

PDK Passive Components	Qty	Selected Performance
Waveguides (Si & SiN), curves, etc.	16+	Si:<2.2dB/cm, SiN:<1dB/cm
Edge Couplers (Si & SiN)	2	<2.5dB/facet loss
Vertical Couplers (Si & SiN)	2	<3dB loss
3dB 4-Port Couplers (Si & SiN)	2	loss <0.5dB, deviation <1%
Y- Junctions (Si & SiN)	2	loss <0.25dB, deviation <1%
Directional Coupler (Si & SiN)	2	loss <0.5dB, deviation <1% @ 1550nm
Si-to-SiN Coupler (escalator)	1	loss <0.1dB
Crossing (Si)	1	loss <0.25dB, crosstalk < -60dB
PDK Active Devices	**Qty**	**Selected Performance**
Digital Ge Photodetector	1	>30GHz, <20nA dark
Analog Ge Photodetector	1	>25GHz, <80nA dark
Digital Mach-Zehnder Modulator	1	>15GHz, >25Gb/s, push-pull <2Vpp per arm, >5dB extinction, <5dB loss
Analog Mach-Zehnder Modulator	1	>15GHz, -10V< Vs <0V, 25dB lin., 1500–1600 nm
Thermo-Optic Phase Shifter (Si)	1	0.25dB loss, <50mW, range $0\pi<\Delta\theta<2\pi$
Thermo-Optic Switch (Si)	1	<1dB loss, 25mW
Tunable Filter (Si)	4	<0.5dB loss, 26nm FSR, >1nm/mW tuning efficiency
Microdisk Switch (tunable)	4	<2ns switch time, >200GHz EO tuning @ 1.2V
Microdisk Modulator (tunable)	4	15GHz, 25Gb/s, 1.2Vpp, 1dB Loss, 8dB extinction

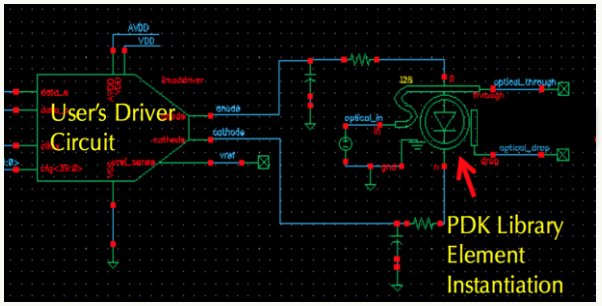
Silicon Photonics Multi Project Wafer (MPW)

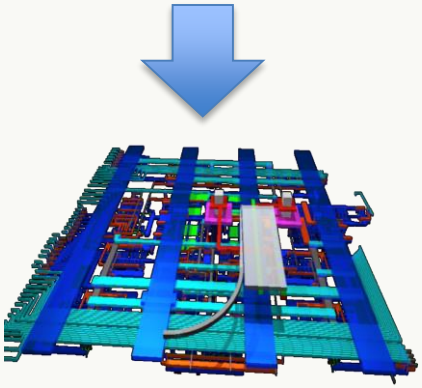
- **MPW Fab Runs Planned in 2017**
  - **SUNY Poly 300mm fab line**
  - **3 MPW offerings**
    - Full-Active- 2 planned in 2017
    - Passive Only- 2 planned in 2017
    - Interposer- 1 planned in 2017
  - **Reservations to be a rider can be started at** http://www.aimphotonics.com/pdk-mpw-sign-up/
    - Generates quote with terms
    - 20% down to hold slot; balance invoiced at design submission
- **MOSIS is the MPW Aggregator**
  - DRC clean designs are submitted to MOSIS
  - MOSIS also distributes the PDK
- **MPW Pricing**

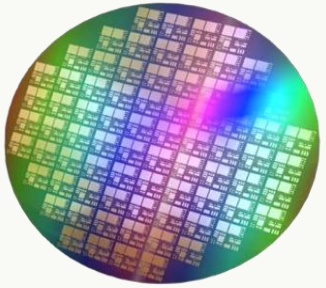
FULL
- 50mm² chips
  - $100K AIM members
  - $120K non-members
- **8mm² chips**
  - **$25K AIM members**
  - **$30K non-members**

PASSIVE
- 50mm2 chips
- $30K AIM members
- $36K non-members

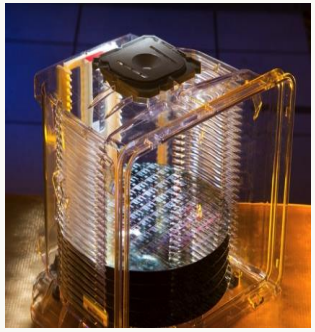
INTERPOSER
- 156mm2
- $93.6K AIM members
- $112.3K non-members



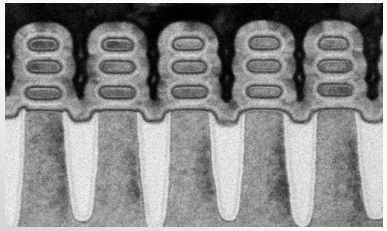




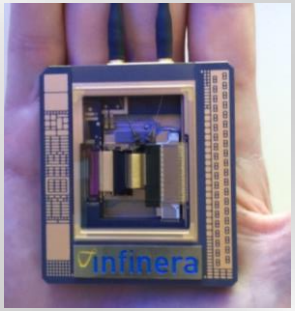
Now is time to be involved in the solution



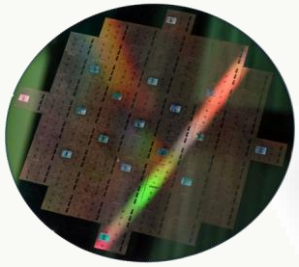
Intel integrated 4x25Gbps technology, with hybrid silicon lasers



IBM 5nm chip uses a "gate-all-around" transistor (GAAFET)



500 Gb/sec Infinera InP transceiver



Dies attached to a 300mm photonic interposer wafer at SUNY Poly