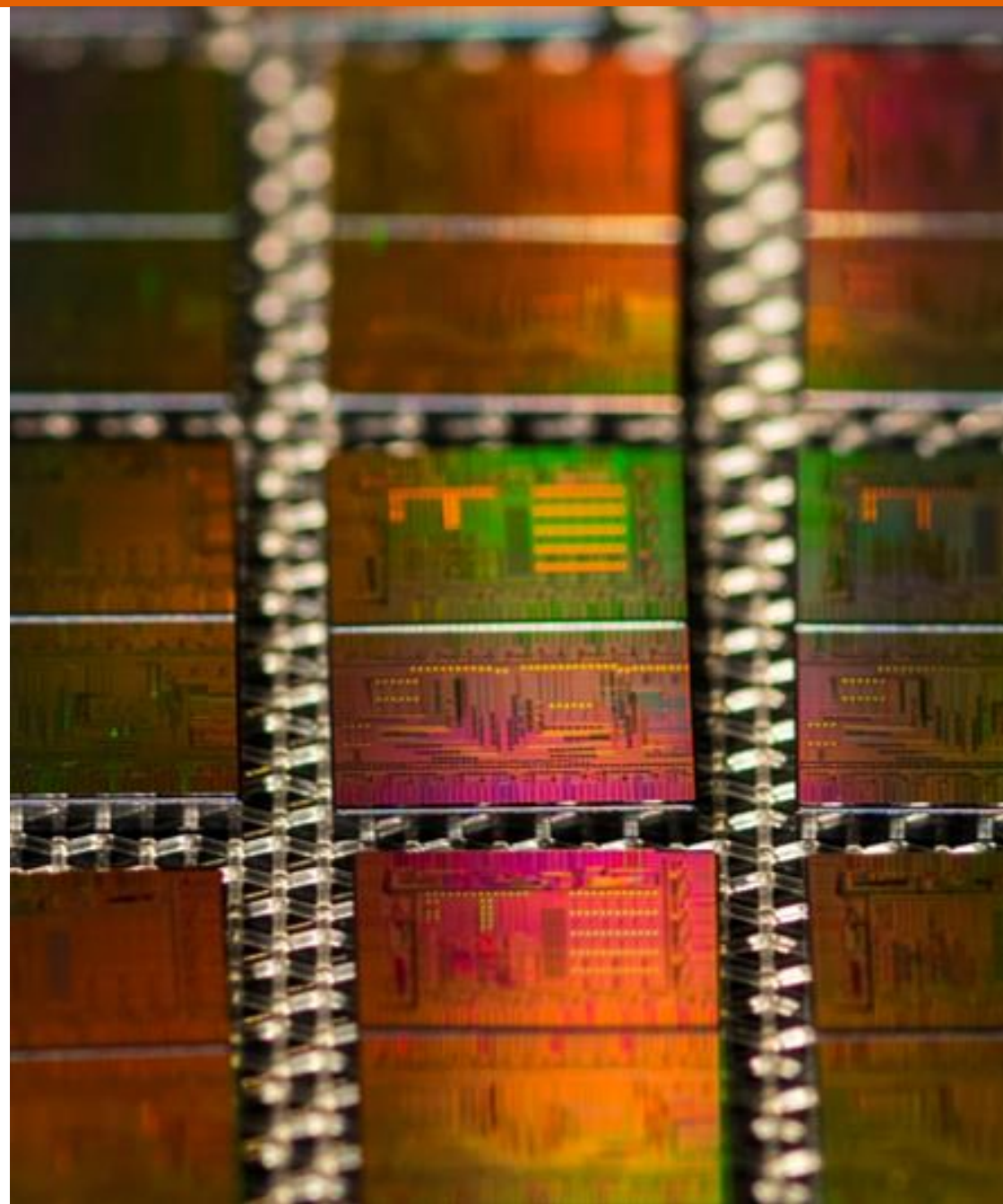
PIC Testing & Packaging



Stefan Preble, Professor and Director
Rochester Institute of Technology

AIM photonics
AMERICAN INSTITUTE for MANUFACTURING INTEGRATED PHOTONICS

EPIC Online Technology Meeting on Automated Packaging & Testing of PICs

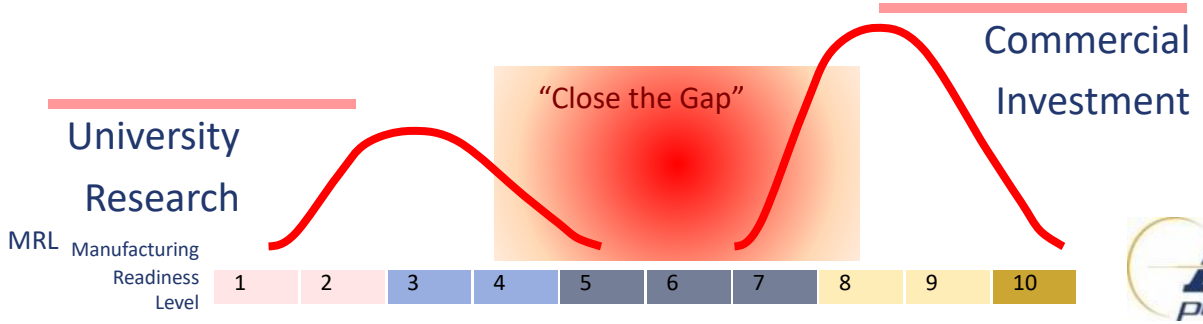
AIM Photonics Overview

Established: July 2015 with three primary goals listed below.
Object is to close the gap between R&D and Manufacturing
Location Hubs: Albany NY, Rochester NY

"Light brings us the news of the universe..and it's called photonics." J. Biden July 27, 2015 kickoff for AIM Photonics

Goals:

- Create a national Institute supporting the end-to-end integrated photonics manufacturing ecosystem in the U.S. by expanding upon a highly successful public-private partnership model with open-access to world-class shared-use resources and capabilities.
- Advance integrated photonic circuit manufacturing technology development
- Create an adaptive integrated photonic circuit workforce

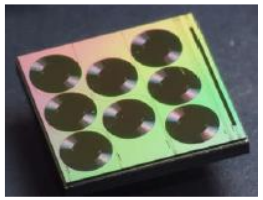


AIM Roadmap supports Established PIC/AIM Ecosystem

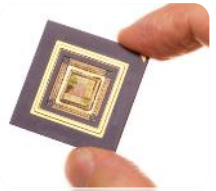
- A full service provider and consortium for Integrated Photonics as part of the DoD Manufacturing USA network
  - AIM Photonics foundries – Best in Class 300mm Photonic Integrated Circuit (PIC) prototyping
    - MPW Support Infrastructure
  - Electronic and Photonic design/co-design
  - Full 300mm wafer-scale and chip-scale Test, Assembly, and Packaging using wafer and die infrastructure
    - Low cost optical connector attach
    - Final assembly, test, product
  - Custom development for key segments
  - Interposers, chip attach, wafer bonding
  - Heterogeneous Integration

Optical Transceivers

Optical RF Cables



Sensors

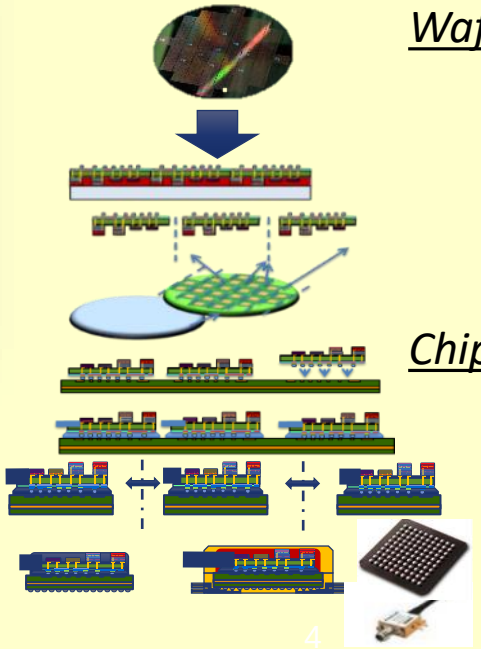


Phased Arrays (LIDAR)

AIM Test, Assembly, & Packaging (TAP) Rochester NY

Mission: Develop Advanced Manufacturing Processes for Photonic & Microelectronic Test, Assembly and Packaging

- *12,000 sq. feet, Class 1000 Cleanrooms*
- *Test & Metrology Lab*



Wafer-scale Test and Assembly

- Wafer-scale testing *(Opt/RF/DC)*
- PIC & Interposer Metallization
- Die bonding *(laser & PIC)*
- Singulation

Chip-scale Test, Assembly and Packaging

- Chip Scale Testing *(Opt/RF/DC)*
- Fiber Attach
- Laminate attach
- Surface Mount Assembly

300mm, Open Access, Photonics & Electronics Packaging Development Center with Wafer Scale and Chip Scale capability

AIM Test, Assembly, & Packaging (TAP) Capabilities

Wafer and Die Level Assembly and Packaging

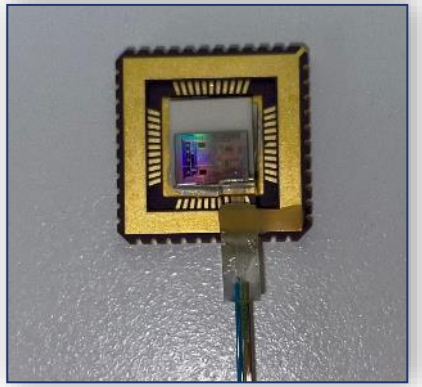
- Fiber Attach - single mode fiber, fiber arrays, PM fiber
- Flip Chip (photonic and electronic) - thermal, sonic and compression and placement within 0.5 µm tolerance
- Wafer Probing - optical/RF/DC
- Dicing - standard thickness wafers 775 µm, thin wafers ~100 µm, dicing street ≥ 100 µm mechanical and ~10-15 µm plasma and laser
- Die Attach - conductive and/or non-conductive adhesives
- Wire Bonding - ~100 µm pitch with 1 mil wire and ~150 µm pitch with 2 mil wire
- Metallization - plating: Cu, SnAg, PD, Ni, Au and sputtering: Ti, TiW, Cu, NiV, Ni
- Bumping - depending on aspect ratio, >75 µm pitch; <75 µm is on the roadmap

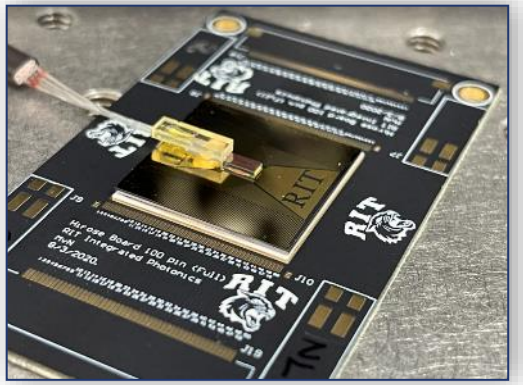
Metrology

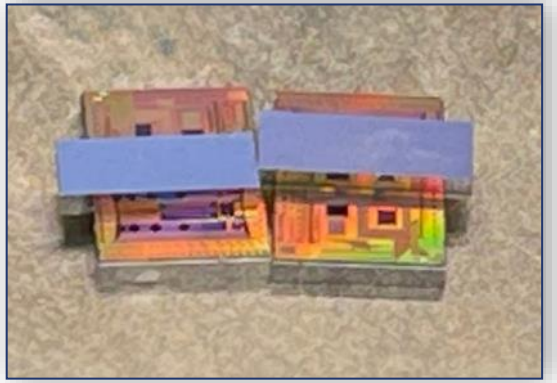
- Scanning electron microscope
- UV-VIS Spectrometer
- Overlay metrology TMAP
- Silicon thickness measurements 4SEE
- Spectroscopic ellipsometer
- Optical backscatter reflectometer
- Optical vector analyzer
- NIR microscope and camera
- Digital scanning calorimetry
- X-ray fluorescence system
- Confocal scanning acoustic microscope
- Stereo microscope
- Digital microscope

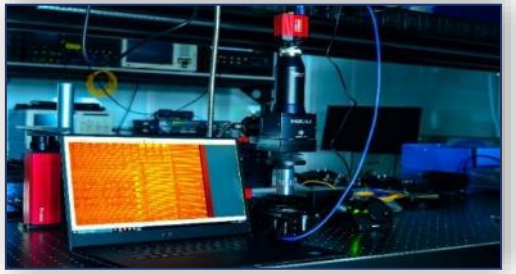
Testing

- Laser Sources
- Photodetectors/Power Meter
- Optical Amplifiers - C-band, L-band, 1310 nm pre and boost amplifiers
- Optical Modulators
- Analyzers - Optical modulation and lightwave component (s-parameters)
- Data - bit error rate PG and analyzers and arbitrary waveform generator
- Bench Test









AIM photonics

Disposable Photonics: ***Passive microfluidics-integrated photonic sensors***

Platform diagnostic technology used for 1-minute COVID-19 antibody detection

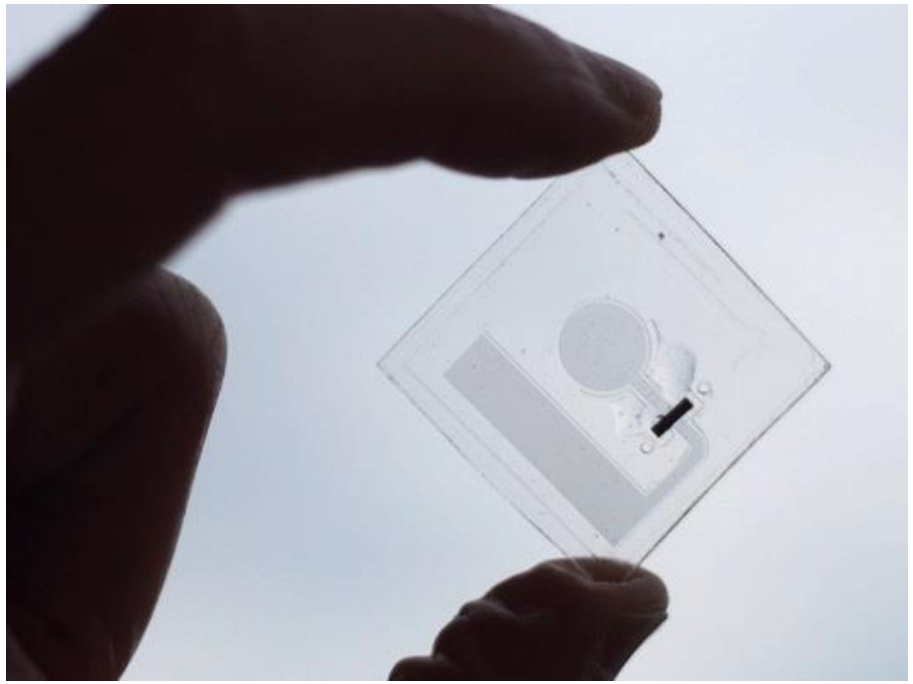
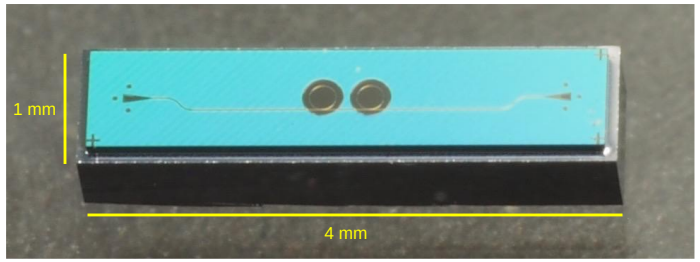
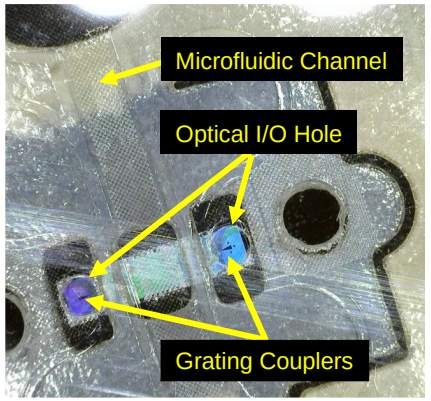
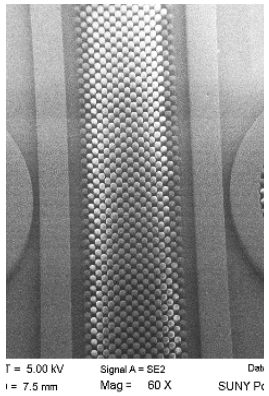


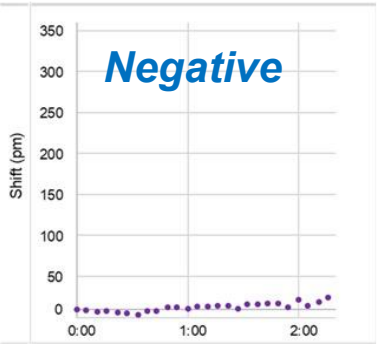
Photo of the assay consumable



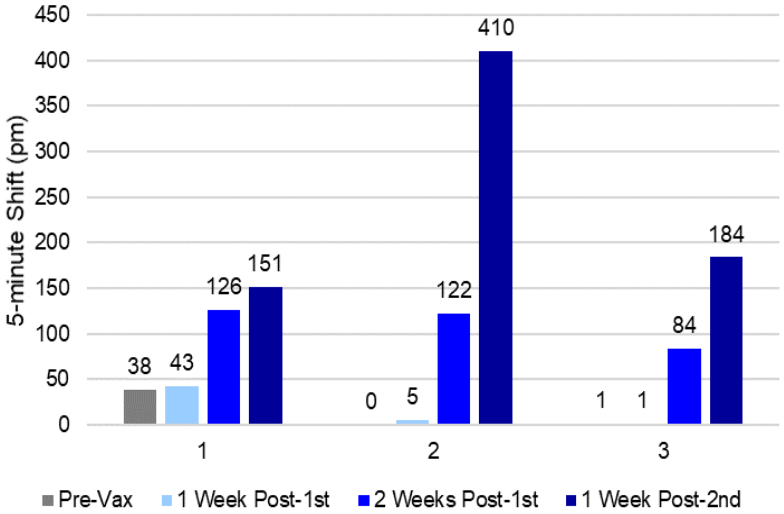




Rice-sized silicon nitride ring resonator PIC (top) is mated to a plastic micropillar card (bottom) for fluidic transport. The entire consumable is very low cost and provides rapid detection capability

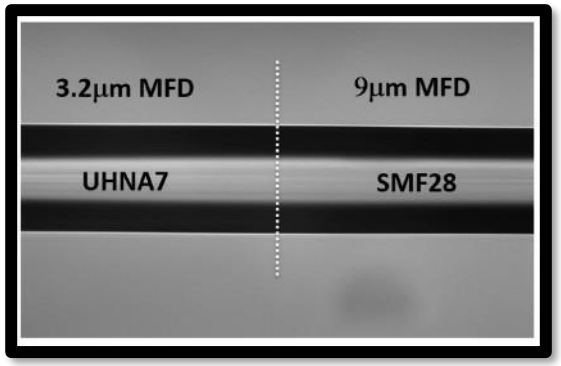


Above: comparison of a human serum sample positive for COVID-19 antibodies, and a negative sample. Accurate detection is obtained in 1 minute. Bottom: application to assessment of vaccine efficacy for COVID-19.



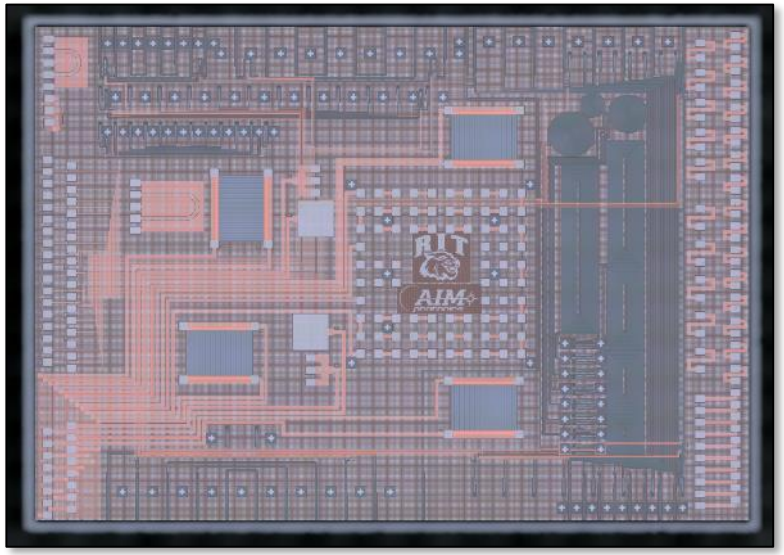
Cognetti, et al. *Lab on a Chip*, **2021**, *21*, 2913

Fiber-PIC Coupling



- **High-NA Fiber Coupling**
  - <1.5dB PIC Coupling Loss (~3μm MFD)
  - <1dB Polarization Dependent Loss
- **Edge Couplers**
  - Optimal Match to SMF28
  - <1.25dB PIC Coupling Loss
  - Relaxed alignment tolerances

Standards



- **Reference PICs**
  - Facilitate the development of robust packaging processes and benchmarking
    - Edge and Grating Couplers at Standard Pitches (127μm, 250μm)
    - DC and RF
    - Flip-Chip & Wire Bonding
    - Thermal Structures
  - Collaboration with PIXAPP

Education

- **Workforce Development**
  - PIC Kits - Passive + Active Circuits
    - Mach-Zehnder Interferometers
    - Ring Resonators
    - Thermo-optic Phase Shifters
    - Electro-Optic Modulators
    - Photodetectors
  - Workshops / Boot Camps
  - Design Course – edX: Photonics Integrated Circuits 1

Questions?