AIM Photonics Manufacturing Technology for Photonic Integrated Circuits and Packaging

The American Institute for Manufacturing Integrated Photonics

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November 13, 2024

Institute Mission & Definitions

AIM Photonics – A U.S. Department of Defense Manufacturing Innovation Institute

Advance integrated photonic circuit and packaging manufacturing technology

Make the technology available

Create an adaptive integrated photonic circuit workforce

AIM Photonics provides an accessible best-in-class state-of-the-art 300 mm Photonic Integrated Circuit (PIC) MPW, Heterogeneous-Integration (HI), Interposers, and Test, Assembly, & Packaging (TAP) capabilities and services. We provide end-to-end photonics and advanced packaging solutions.

NYCREATES Albany NanoTech Complex

- AIM Photonics uses the Albany NanoTech 300 mm Facility with (>130K square feet of class-1 clean room)
- AIM Photonics also has the Rochester Test Assembly and Packaging (TAP) facility (12K square feet of class-1000 cleanroom)

AIM Photonics TAP facility

What is Photonics?

Photonics technology includes sources of light such as lasers, light-emitting diodes, and waveguides to guide light such as fiber optics, and a variety of opto-electronic devices that encode digital information onto optical signals and convert optical signals to electrical ones.

- Datacom/Telecom
- Chemical/Bio Sensors
- Precision Navigation and Timing
- Quantum Computing
- AR/VR/LiDAR
- Defense Applications (SWAP-C)






Our combination of accessible, customizable 300 mm PICs and packaging is unique in the domestic ecosystem

Accessible PICs

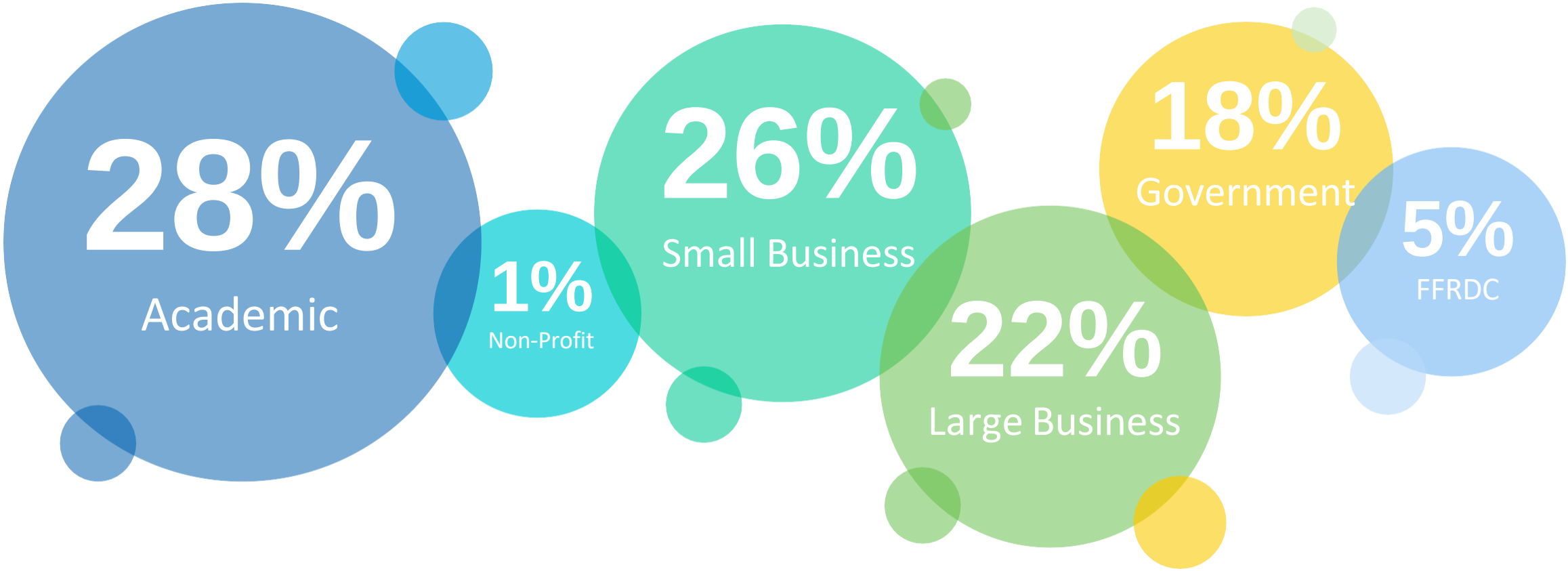
Custom Packaging

Prototype

This allows rapid development of state-of-the-art (SOTA) integrated photonic devices in a fully domestic environment.

Who are our key partners?

AIM Photonics Members & Strategic Partners…



…Who Enable & Utilize Our Offerings

Development

ANALOG PHOTONICS
SUNY
COLUMBIA UNIVERSITY
TEL
Aeluma™
DEVCOM ARMY RESEARCH LABORATORY
U.S. NAVAL RESEARCH LABORATORY
AFRL

Enablement

SYNOPSYS®
cadence®
lumerical
SPARC PHOTONICS
FREEDOM PHOTONICS
A LUMINAR COMPANY
TOPPAN
TOPPAN PHOTOMASK

Education

RIT
MIT
UNIVERSITY of ROCHESTER
WPI
BRIDGEWATER STATE UNIVERSITY
THE UNIVERSITY OF ARIZONA
STONEHILL COLLEGE
SUNY
lumerical
SPARC PHOTONICS
SYNOPSYS®
DREAM PHOTONICS

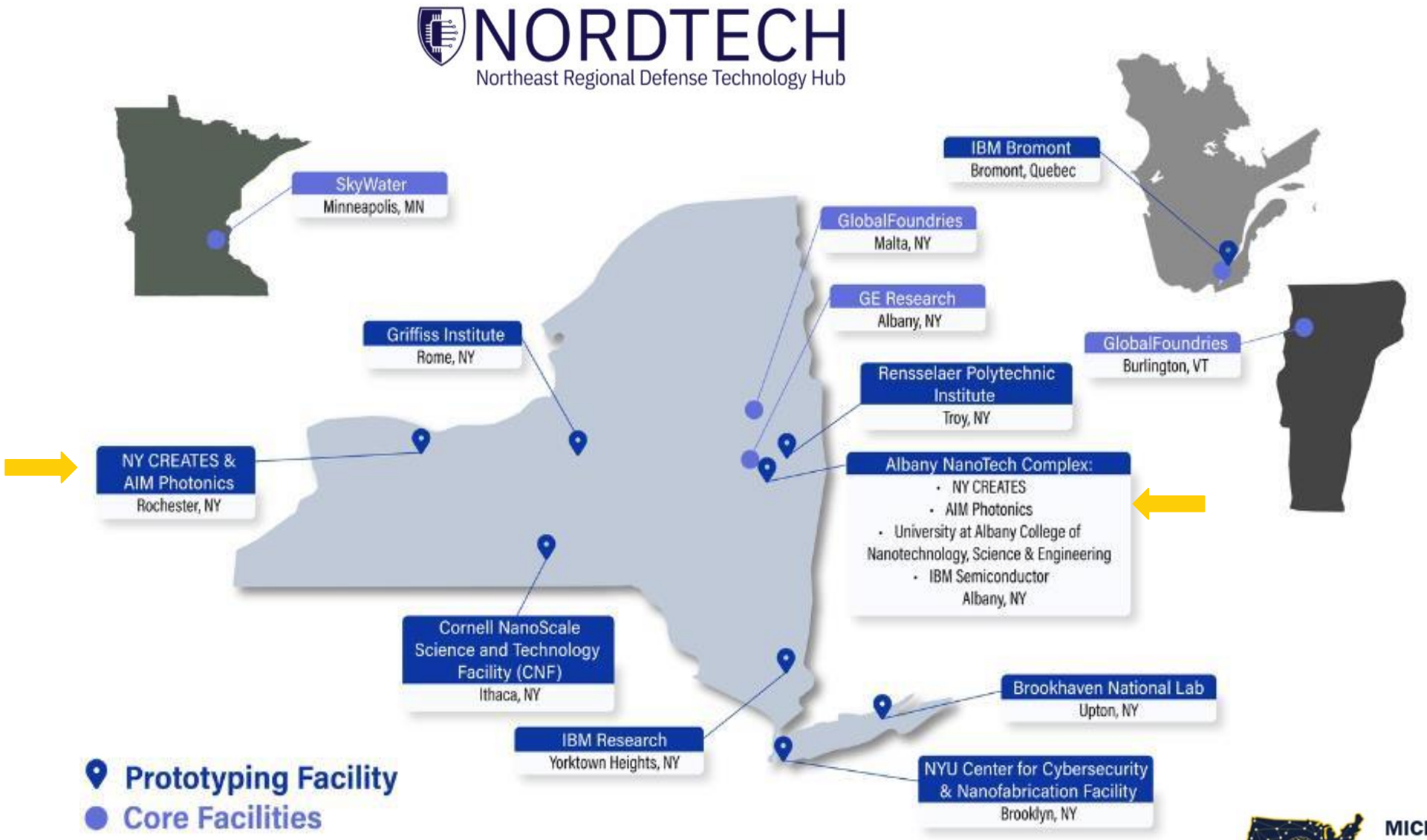
Application

ANAMETRIC
phlotonics
SiPhox
QuidelOrtho™
phase sensitive innovations
GD Mission Systems
RTX
LOCKHEED MARTIN
DEVCOM CHEMICAL BIOLOGICAL CENTER

Government

Sandia National Laboratories
Manufacturing USA
LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
NIST

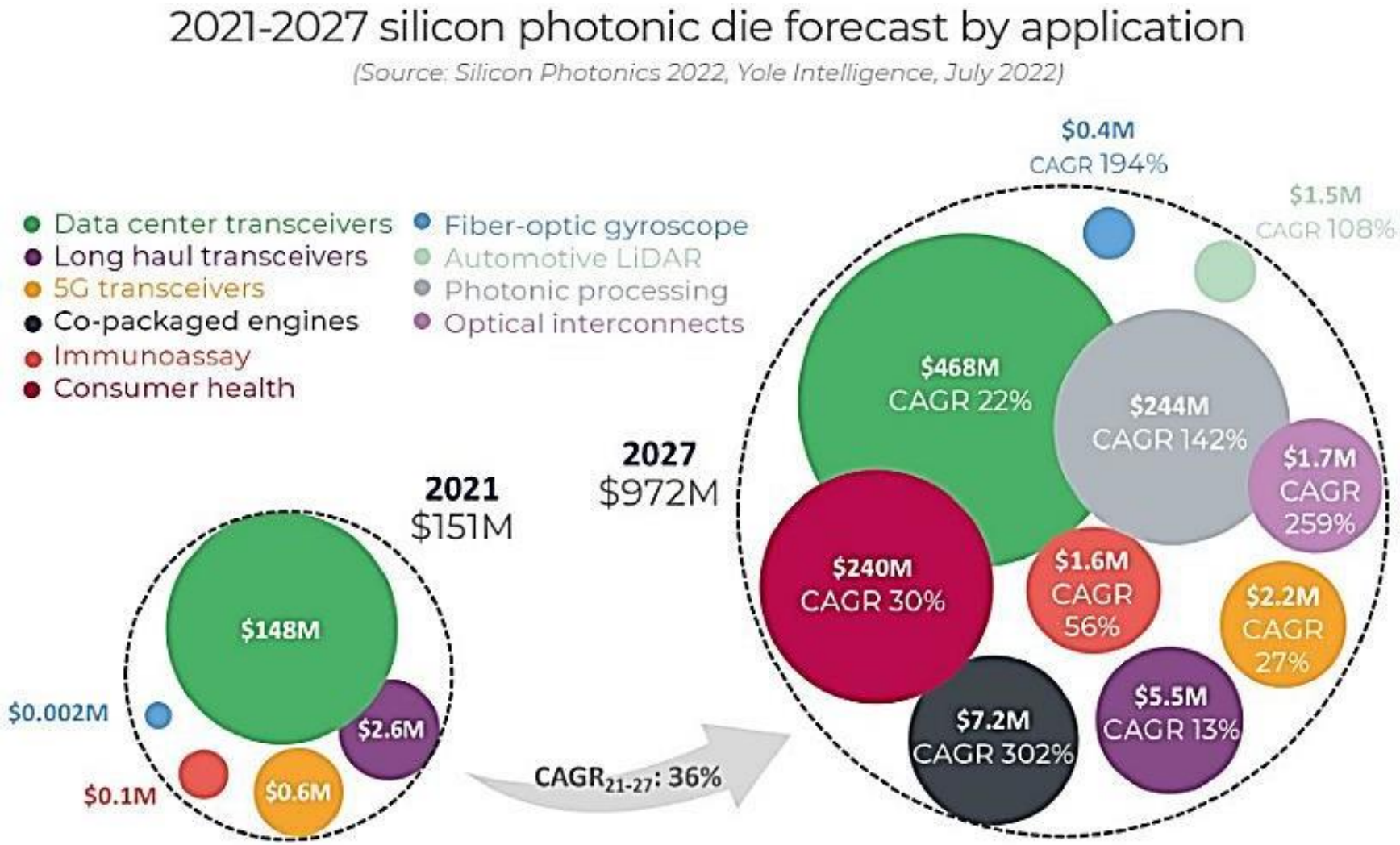
Microelectronics Commons Hub Partnerships



Market landscape

Market Forecast for Silicon Photonics Applications

AIM Photonics' focus is on specialty applications that have yet to attract large foundry interest.

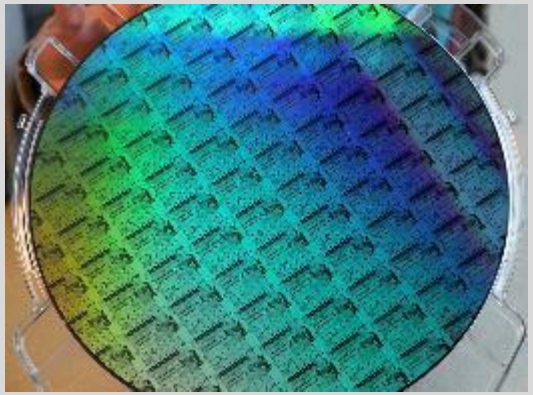
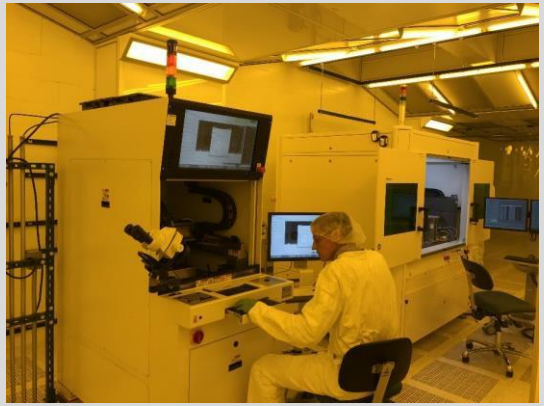
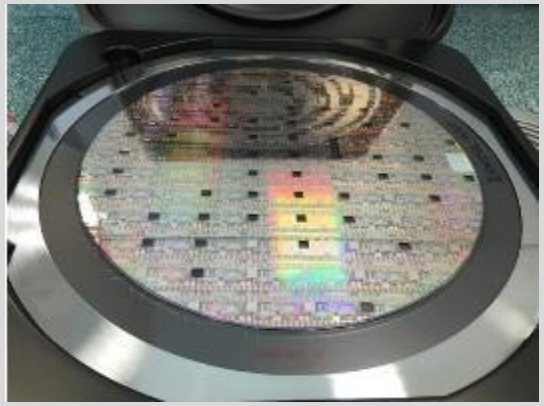
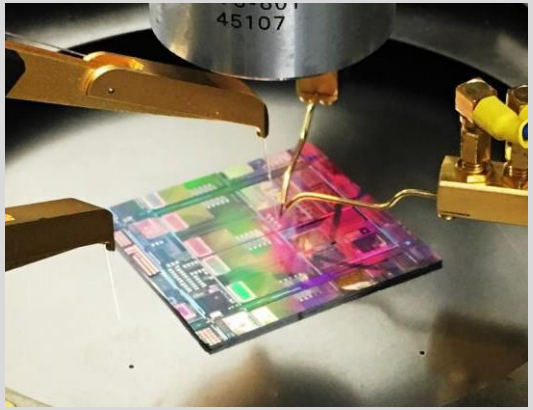


Our competencies and capabilities

Competencies

- R & D
- Technology
- Education & Training
- Workforce Development
- Expertise & Guidance
- Ecosystem Expansion
- Test, Assembly & Packaging



We provide four core areas of technical expertise

1. Photonic Integrated Circuits
2. Heterogeneous Integration and Interposers
3. Test, Assembly and Packaging
4. Electronic-Photonic Design Automation

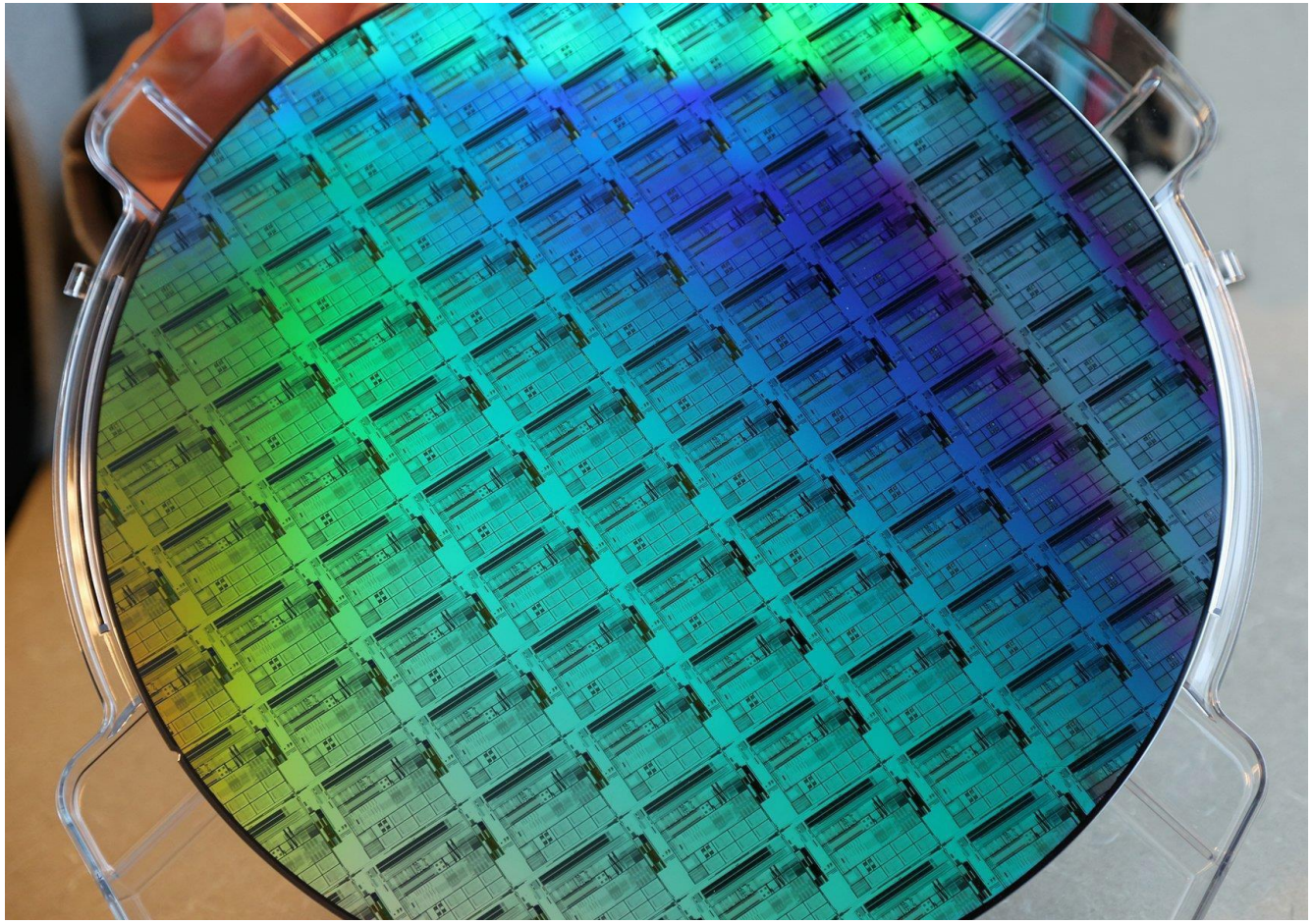
1. Best-in-class 300 mm PIC technologies
2. Heterogeneous Integration and interposers
3. Custom packaging services and packaging development
4. Electronic-photonic design automation support through process design kits (PDKs) and assembly design kits (ADKs) for all offerings

The best PICs are made on commercial-quality 300 mm wafer lines

300 mm wafer lines have the best
- Tools
- Process control
- Metrology

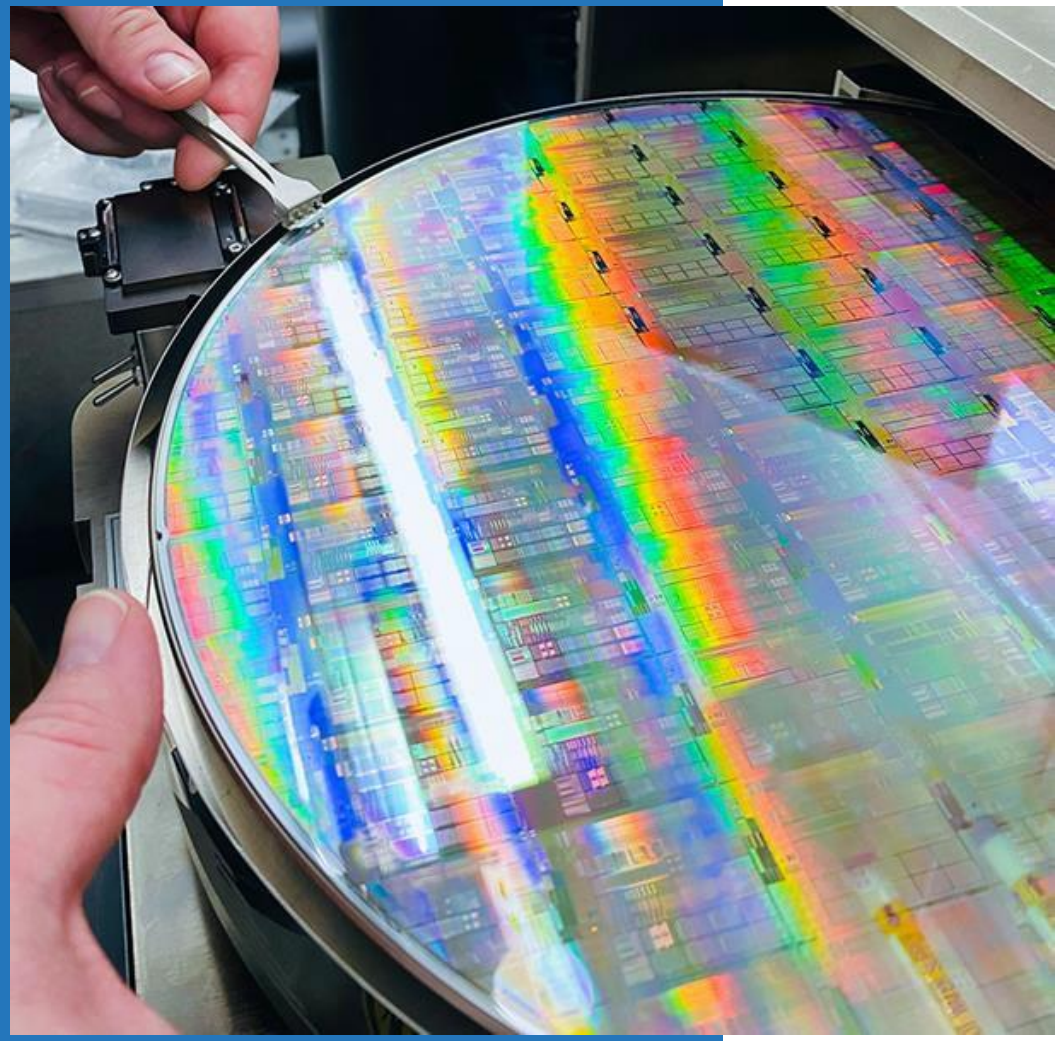
Which produces PICs with
- Highest uniformity
- Best repeatability
- Lowest optical losses

➢ Overall best performance



Multi Project Wafers

Multi-Project Wafers



Multi-Project Wafers (MPWs) allow several different chip designs to be fabricated simultaneously on a single wafer.

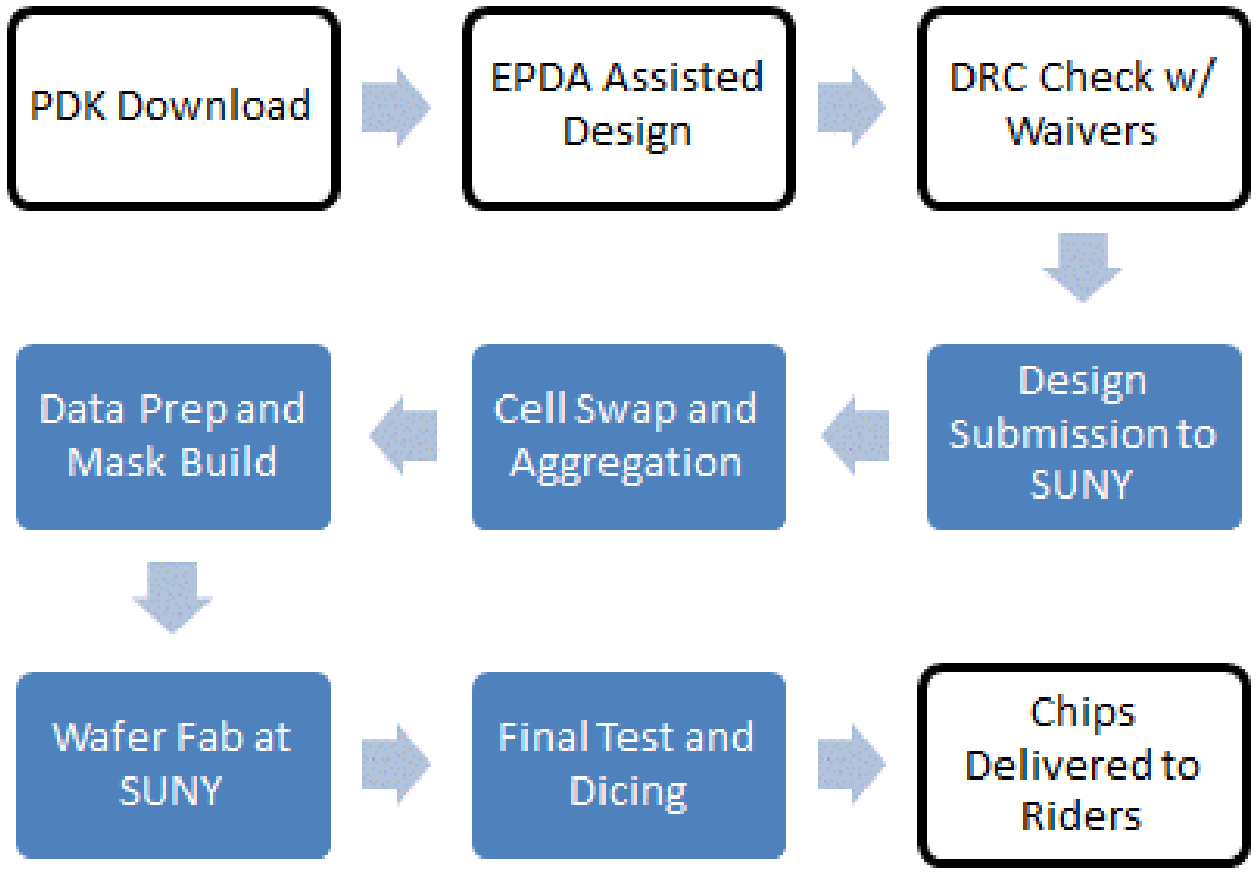
This approach allows for cost-effective prototyping services that enable multiple customers and projects to share common reticles, materials, and process flows – which **can greatly accelerate and de-risk the commercialization process**.

AIM Photonics MPW Program

Customer Experience

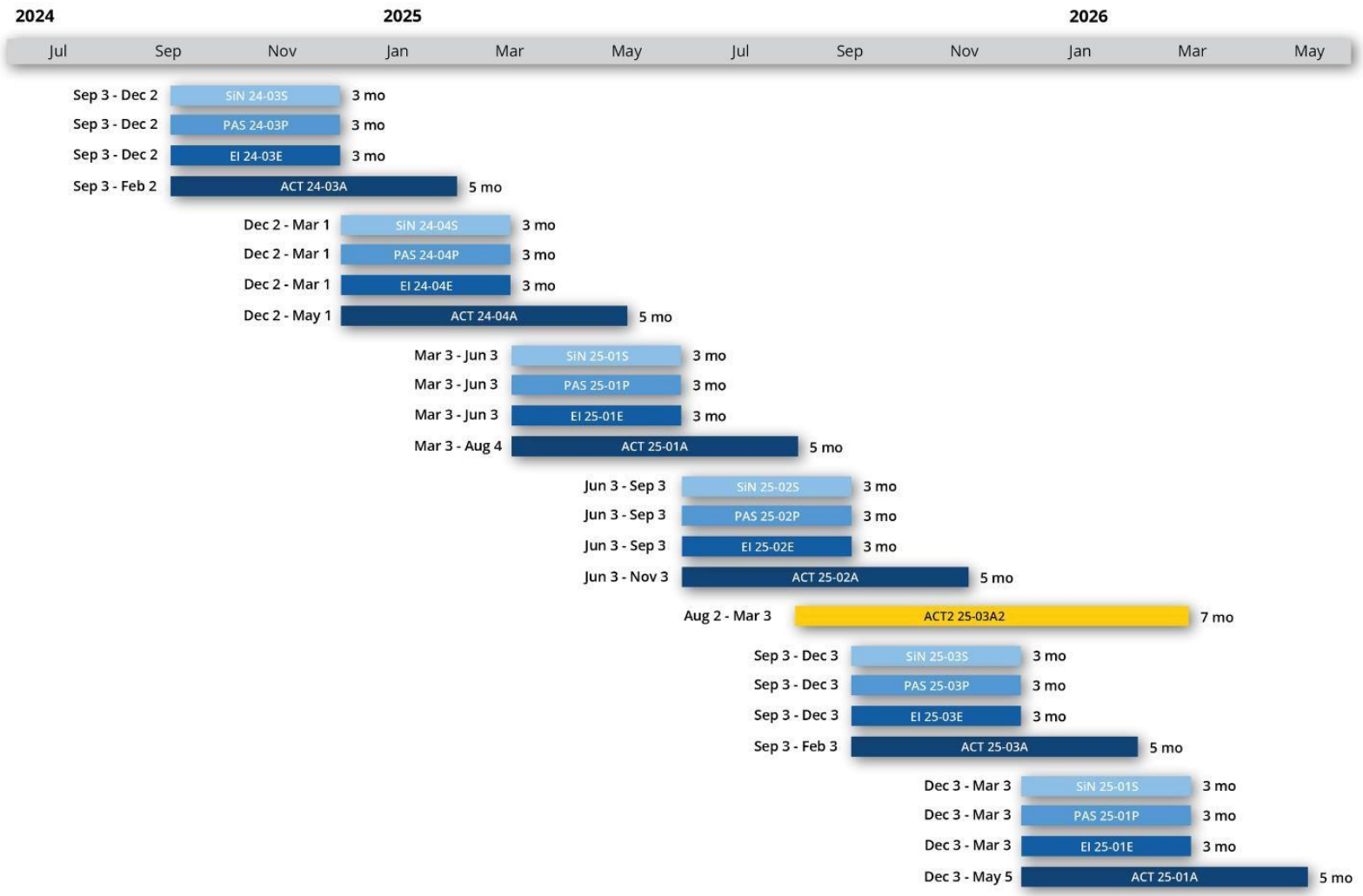
- Starts with a “rider” request
- Onboarding for a “shuttle run”
- Reserve space to “ride” on an MPW shuttle run
- Submit design
- Design is transformed into PICs
- Receive diced and tested chips

MPW Workflow



Multi-Project Wafer Program

MPW RUN SCHEDULES

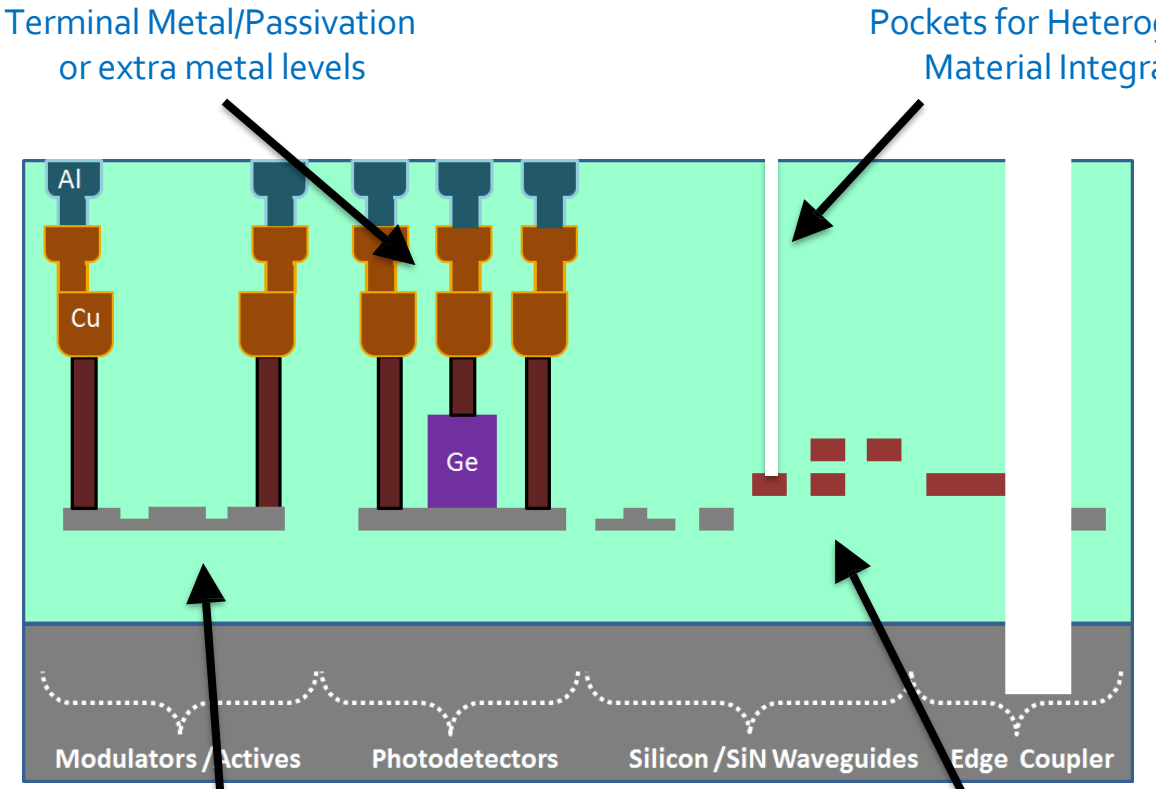


Advantages

- Dependable schedule
- Robust base offerings with superior quality
- Rapid turnaround and delivery
- Reduces cost from purchasing entire wafer

Bite-Sized Customization

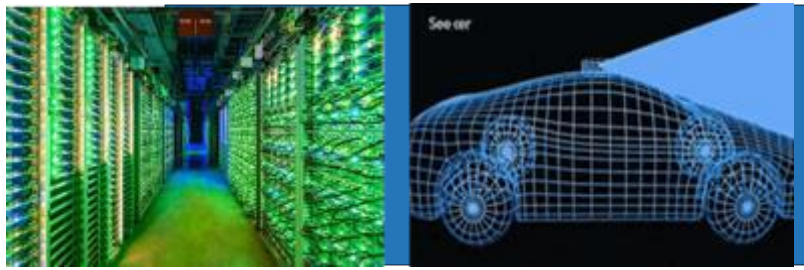
- AIM Photonics is able and willing to provide low-volume customizations for a wide variety of application spaces



Other Possibilities:
-Wafer bonding to interposers or CMOS wafers
-Flip chip packaging of CMOS chips or laser die

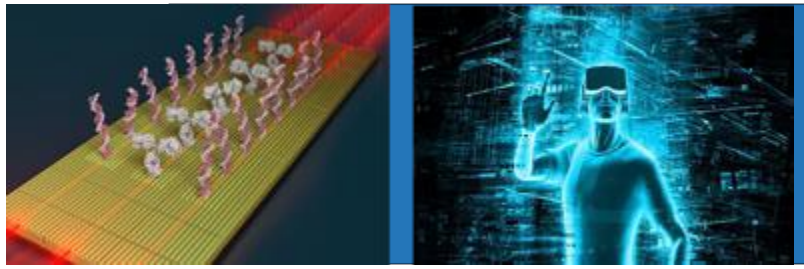
AIM Photonics Application PIC MPW Platforms

Industry/ecosystem-inspired | Application-driven | Evolves with capabilities



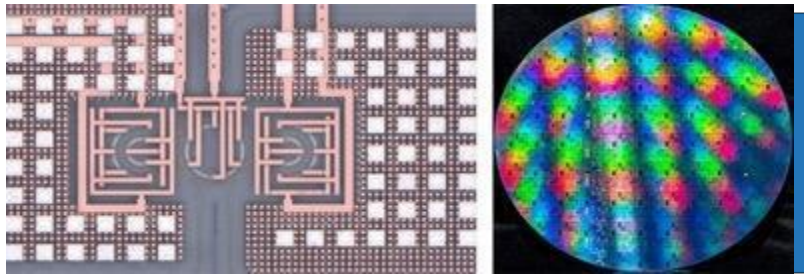
Base Silicon Photonics

- Mature 300 mm silicon photonic fabrication and design enablement
- Datacom/telecom, free-space coms, LiDAR, sensing, RF photonics
- Repeatable and rapid execution (90d fab). Customization is available.



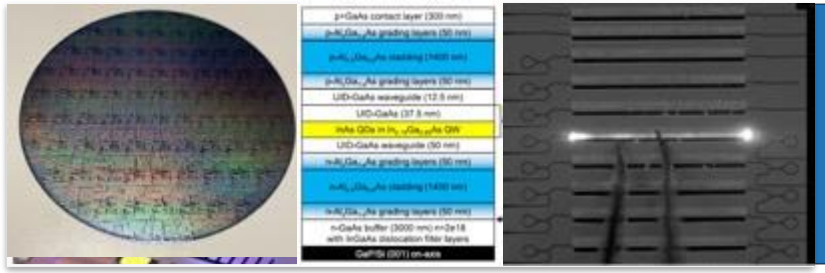
Silicon Nitride

- Passive PIC with silicon-nitride waveguides
- Chemical/biological sensing, augmented/virtual reality
- Rapid turn-around (<30d fab). Customizable low-loss SiN



Silicon Photonics for Quantum Applications

- Highly advanced, state-of-the-art silicon photonics
- Elements for quantum computing and networking
- Ultra-low loss Si/SiN, specialized electro-optic devices.



Hetero-Epitaxial Lasers Integrated on Silicon (HELIOS) III-V

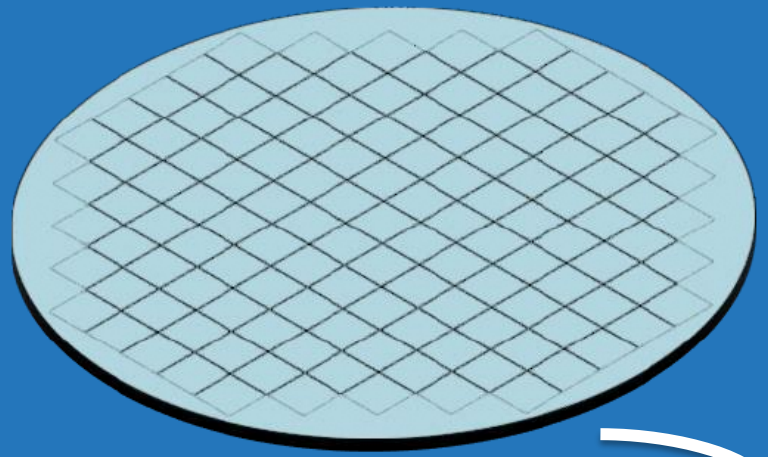
- Combining III-V epitaxy with silicon photonics from base silicon photonics
- The densest form of integration for lasers and optical amplifiers in silicon photonics
- On-chip gain and light to maximize data bandwidth density

Packaging

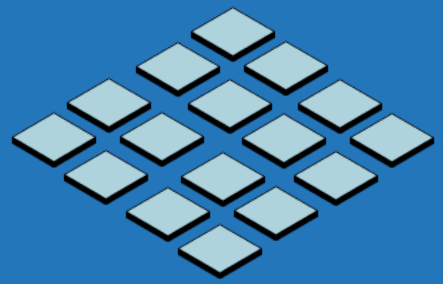
What is traditional packaging?

A means of boxing the silicon for electrical connectivity

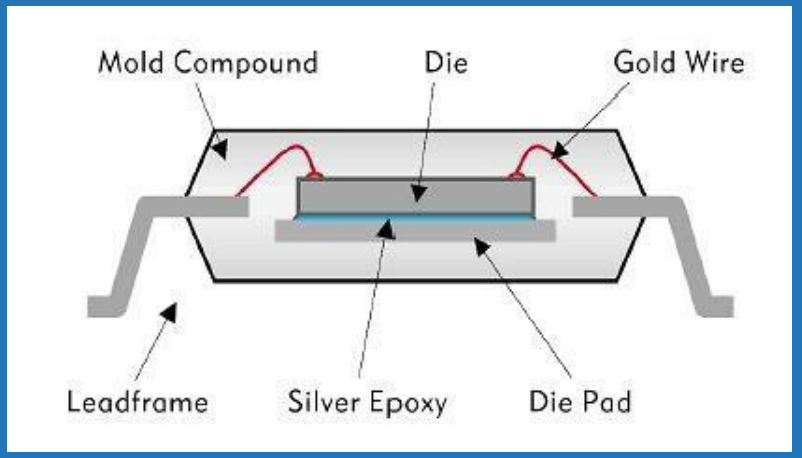
Completed wafer from foundry



Wafer diced into individual die

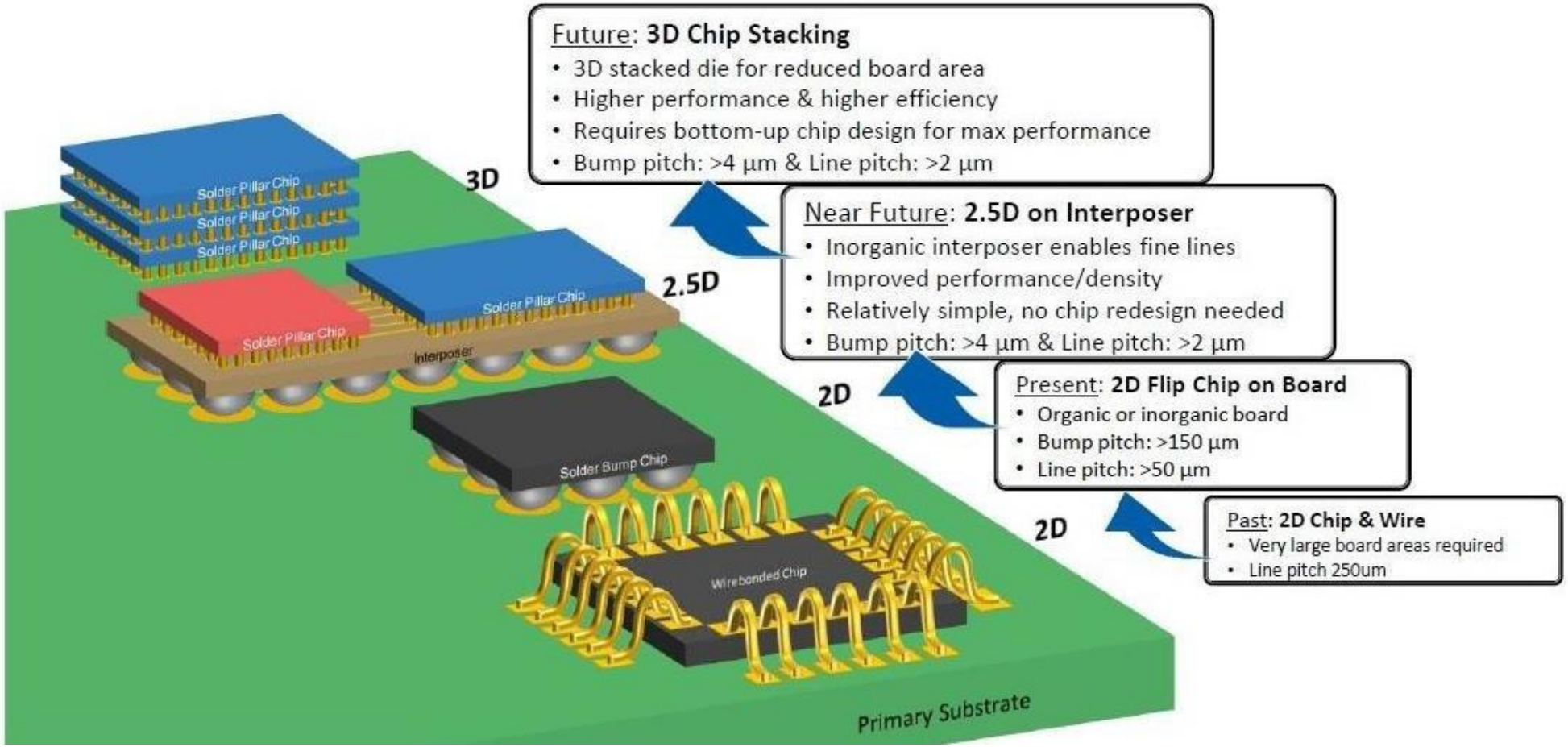


Die is packaged



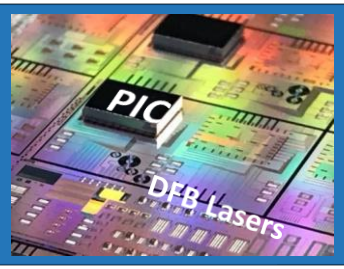
Advanced Packaging

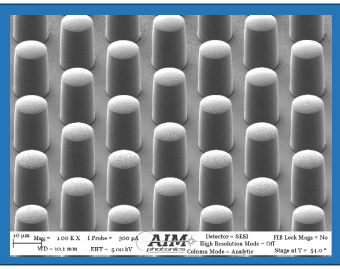
Innovation is happening at 2.5D and 3D. These components in the aggregate, provide enhanced functionality and improved operating characteristics.



AIM Photonics Application Packaging Platforms

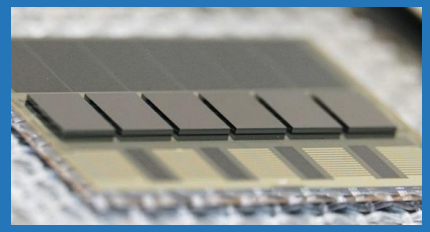
Industry/ecosystem-Inspired | Application-driven | Evolves with capabilities

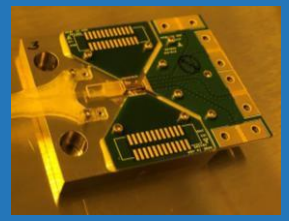




Area 1: Wafer-Level Packaging

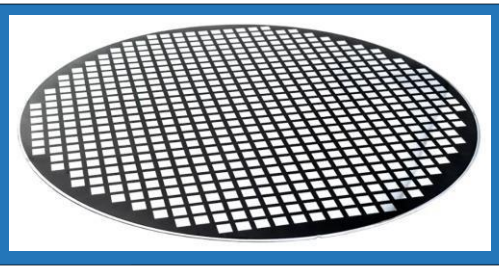
- Wafer-level packaging consists of operations that take place on a wafer-level
- Operations: PVD, lithography, plating, grind and polish, bond and debond, dicing
- **Why AIM Photonics**: AIM Photonics provides 300 mm wafer-level operations





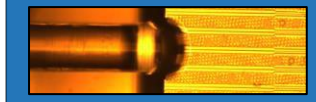
Area 2: Assembly Packaging

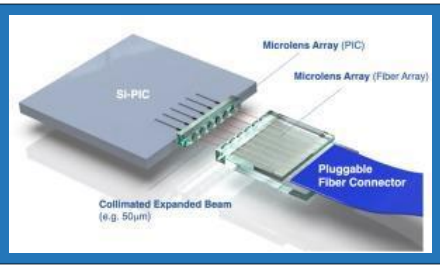
- Assembly of devices into a final package
- Includes wire bond, fiber attach, chip attach, flip chip, in package placement
- **Why AIM Photonics**: Customization is possible



Area 3: Reconstituted wafers

- Combines singulated known good die into a wafer format for wafer-level packaging
- Requires RDL and Molding
- **Why AIM Photonics:** This is a high-value process for silicon photonics and RF





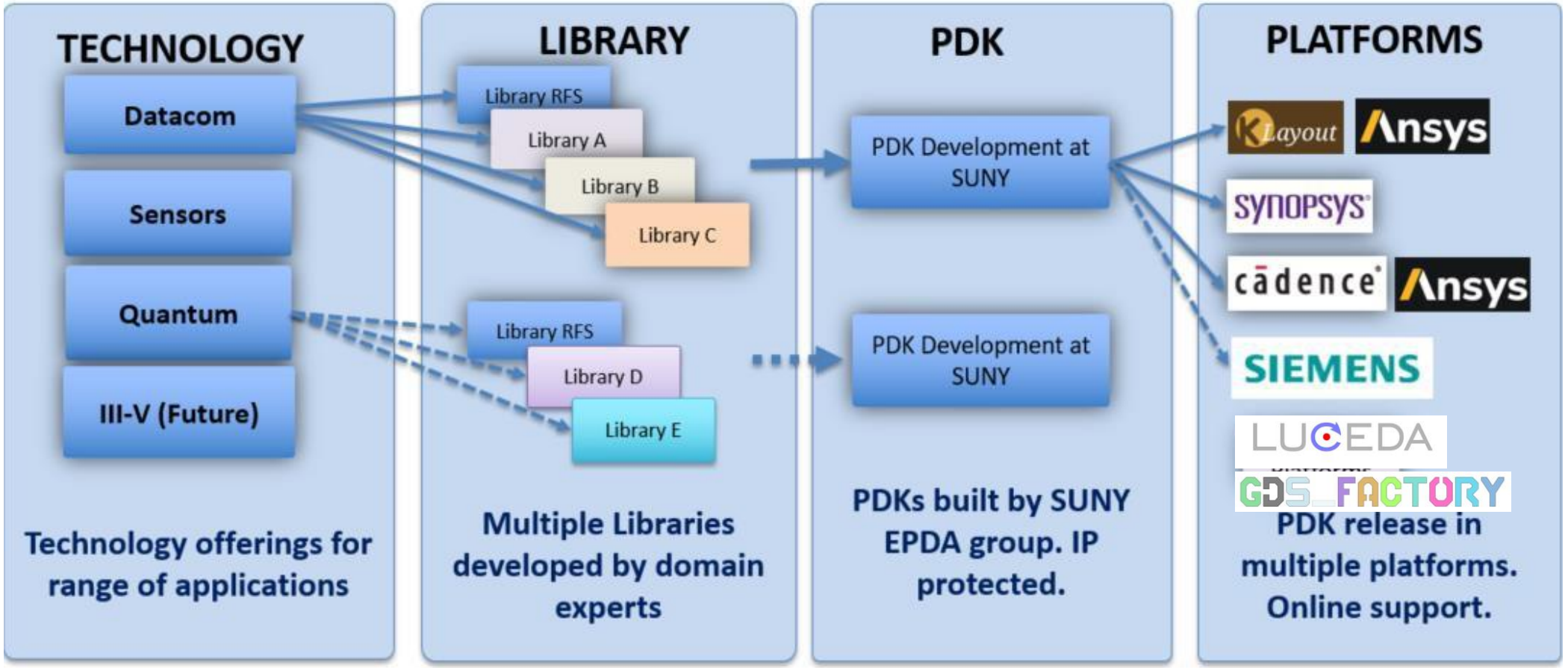
Area 4: Optical Coupling

- Highly advanced, state-of-the-art silicon photonics
- Includes edge coupling, microlenses, evanescent, grating, photonic wire bond, etc.
- **Why AIM Photonics**: Ultra-low loss Si/SiN, specialized electro-optic devices.

Electronic Photonic Design Automation - EPDA

AIM Photonics PDK Unique Value Proposition

The AIM Photonics approach to EPDA is to support all application-specific platforms by providing multiple component libraries that are supported by all the major EDA platforms.



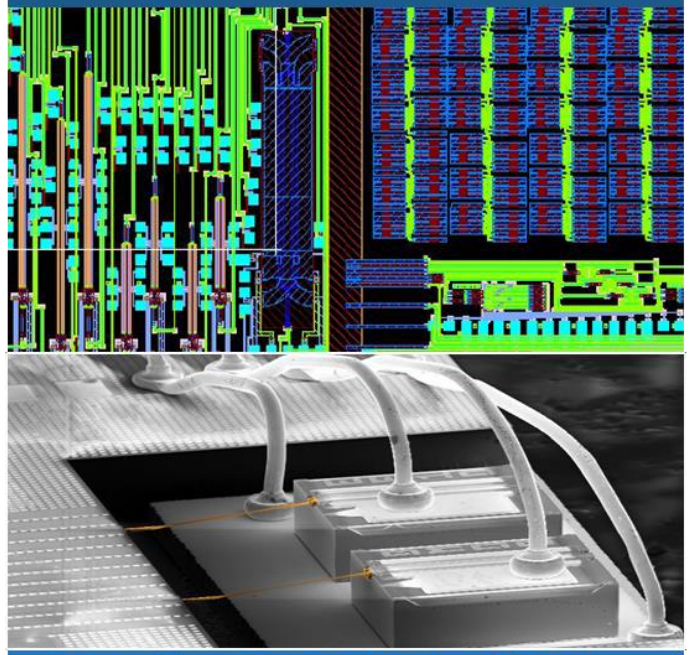
Education Workforce Development

Education & Workforce Development

Unique Learning Opportunities

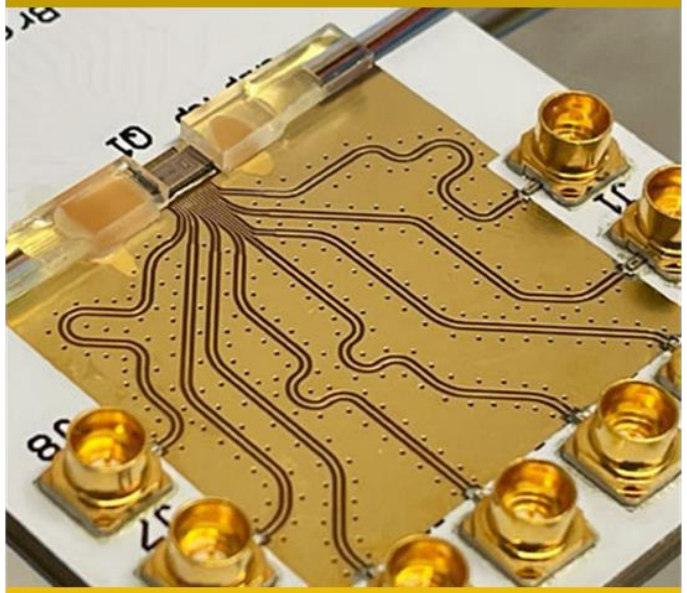
Courses designed to cultivate skills by providing hands-on, online, and experiential learning opportunities required to support the U.S. integrated photonics industry.

Electronic-Photonic Educational Design Offerings



National 'open source' design, fab and validation program for direct training and adoption of AIM design content at U.S. universities and semiconductor consortia

PIC/EPIC Educational Consortia



Regional and national consortia to deploy AIM course content and hands-on PIC/EPIC testing capabilities in community colleges, tech colleges and universities

PIC/EPIC Training and Engagement Program

An experiential learning initiatives, such as AIM's APEX and Diversity Experience programs, community college technician training partnerships, and summer academies

AIM Photonics: EWD Partners and Impacts

Online Courses

- PDK-based PIC design
- Layout, DRC, Tapeout
- MPW/TAP Engagement
- Virtual Learning & Training Environments

In-Person Training

- Summer Academies
- Packaging Workshops
- PIC Bootcamps
- Experiential Learning (Internships/Co-ops)

Curricula Creation

- Open Source Academic PDK for national scaling
- Chip-based 'HOPE' kits for hands-on education
- Digital Twin and Packaging Course development

Participation in online courses:

- **8,188** registrants from industry, gov't, academia
- **314**PIC designs submitted
- **101** PIC designs fabricated

Participation in F2F Training:

- **350** participants from industry, gov't, academia
- **100** teachers and faculty designs submitted

National Scaling Networks:

- **35** community colleges and universities in AIM/NSF
- **30** partnering photonics and IC industry partners
- **NORDTECH** Hub partner

Summary

Summary

- AIM Photonics is a DoD Manufacturing Innovation Institute with an end-to-end offering in Photonic Integrated Circuits (PICs), Interposers, Heterogeneous Integration (HI) and Packaging, and Electronic Photonic Design Automation (EPDA).
- AIM Photonics leverages the 300 mm Albany NanoTech Complex and the Rochester Test, Assembly, and Packaging (TAP) facility to provide state-of-the-art capability
- As an MII, AIM Photonics' mission is to advance photonics and packaging, make the advances available to the U.S. ecosystem, and build a skilled workforce.
- Packaging of photonic integrated circuit (PIC) chips into functional optoelectronic systems has not fully incorporated advances in electronic packaging because of the challenges in photonic packaging. Addressing these challenges will require the coordinated development of PIC fabrication processes and packaging technologies. There must be an end-to-end development cycle that includes PICs and packaging.

Learn More

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