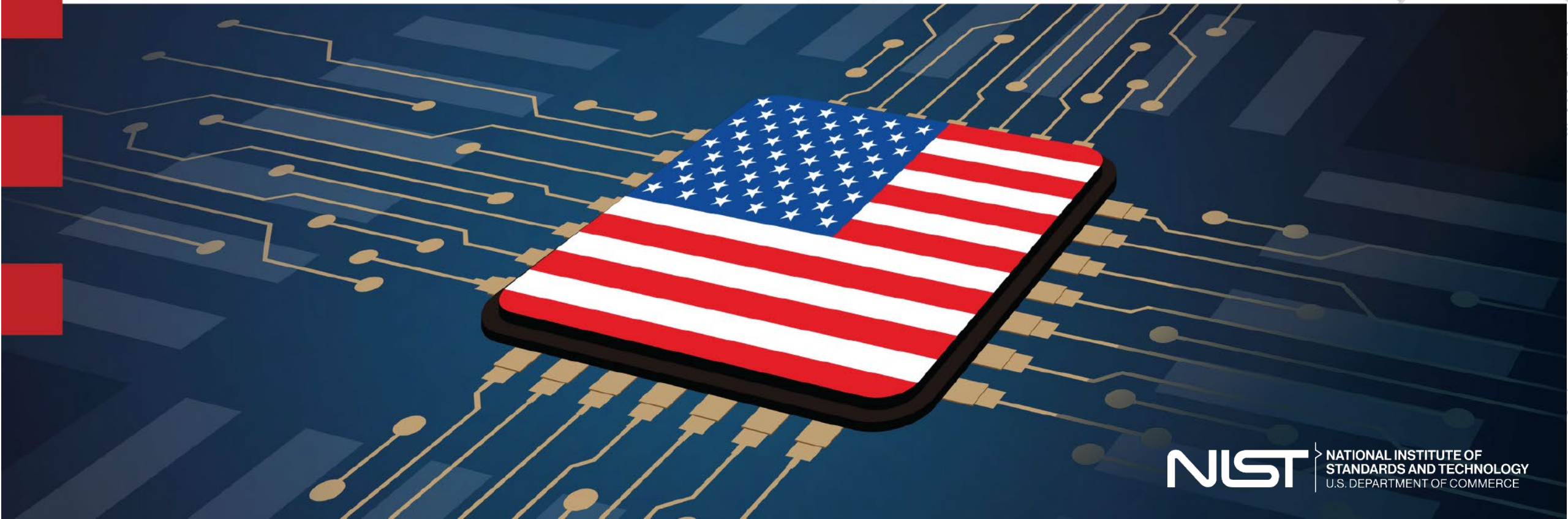
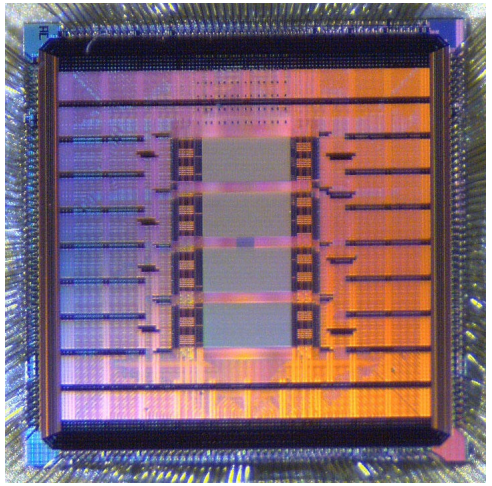
CHIPS for America
Research and Development Update

June 13, 2023



NIST NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
U.S. DEPARTMENT OF COMMERCE

CHIPS R&D Vision



U.S. Technology Leadership

The U.S. invents, develops, and deploys the foundational semiconductor technology of the future.

Accelerate Ideas to Market

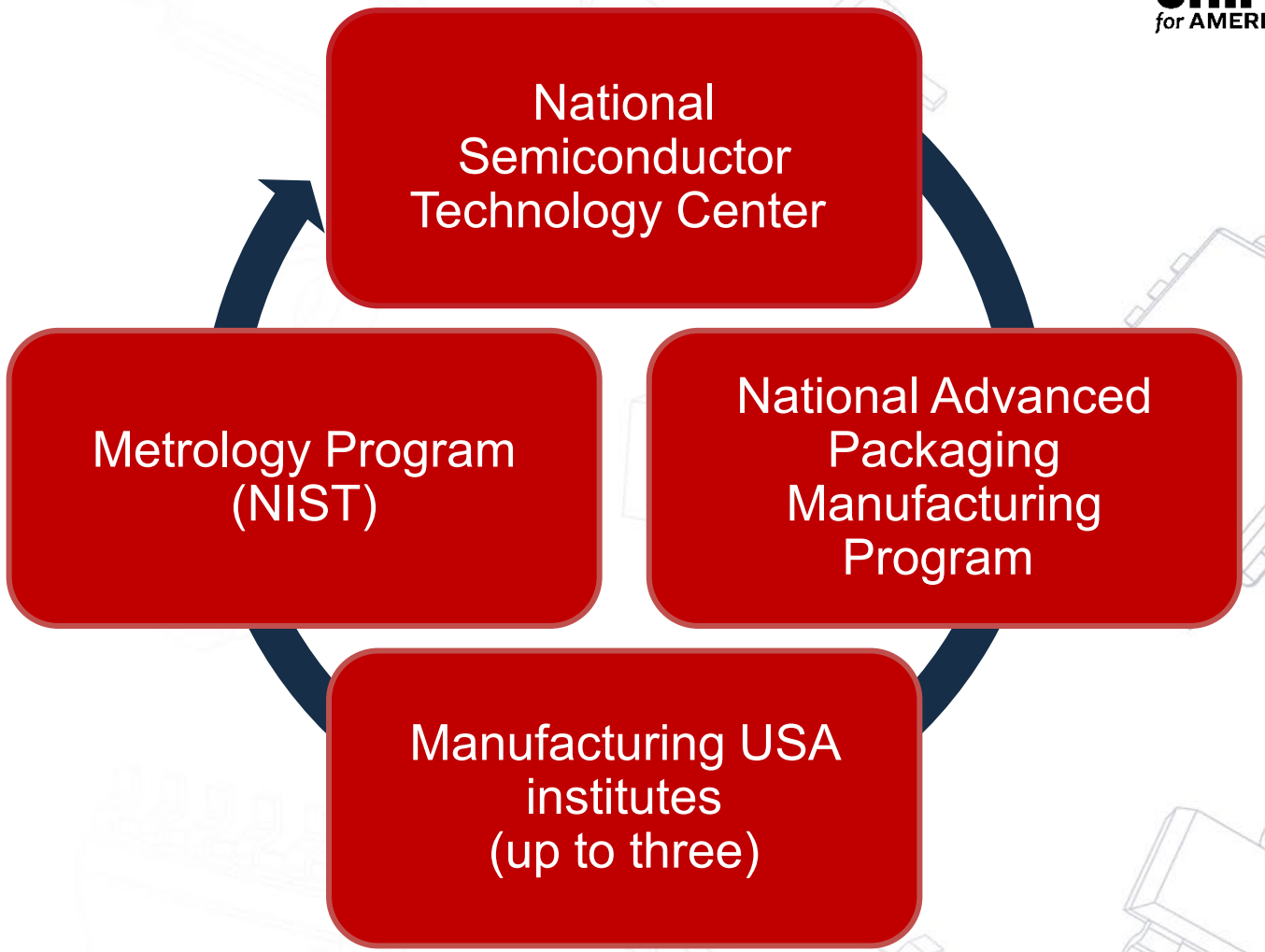
A thriving ecosystem that is focused on getting the best ideas to commercial scale as quickly and cost effectively as possible.

Talent

A new generation of skilled workers, inventors, designers, researchers, technicians, and others able to build and sustain semiconductor manufacturing in the U.S.

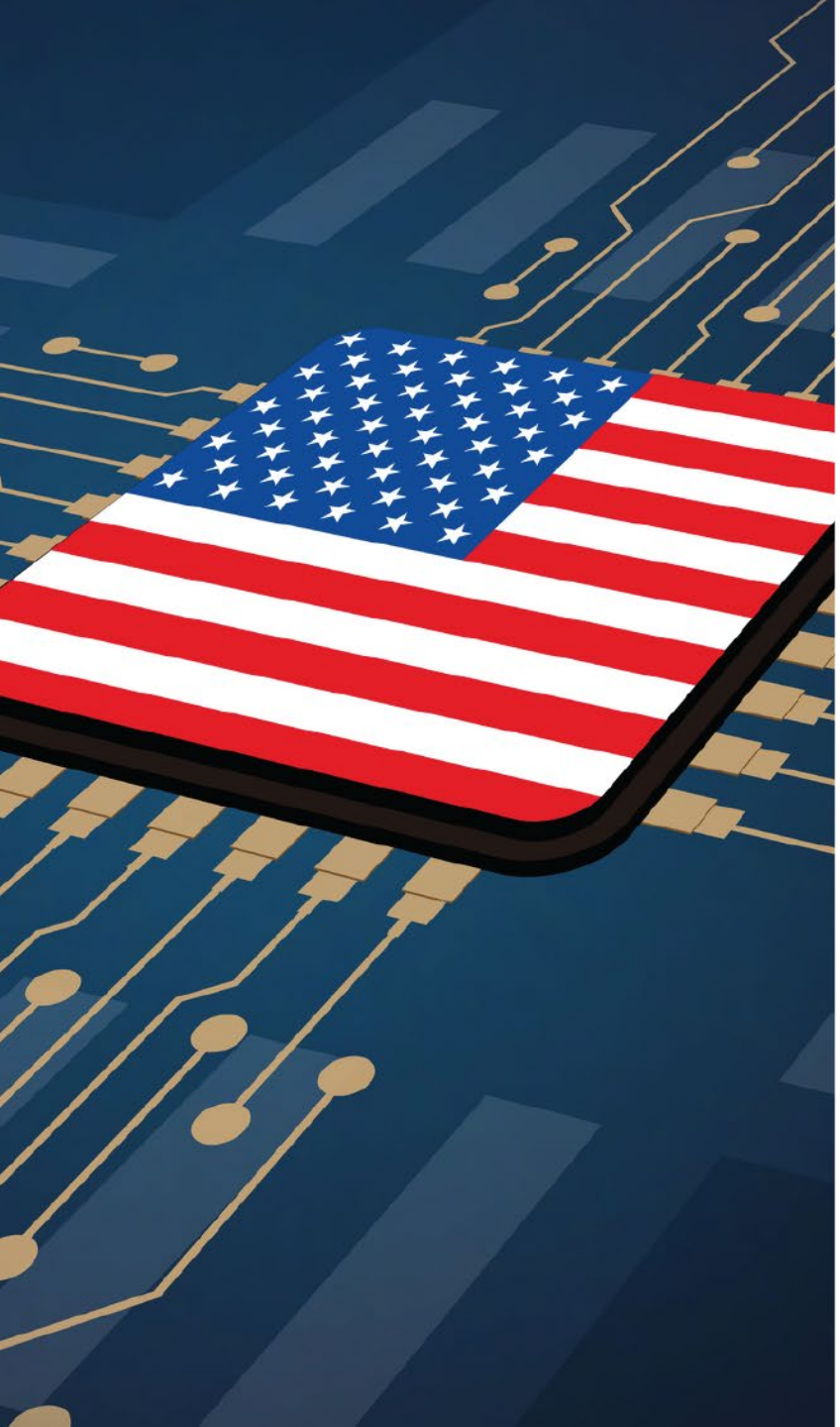
CHIPS for America R&D

- To strengthen and advance **U.S. leadership** in R&D
- An **integrated ecosystem** that drives innovation
- In **partnership** with industry, academia, government, and allies
- A strategic view of R&D infrastructure, **participant value-proposition**, and technology focus areas
- Informed by the **Industrial Advisory Committee**



Program Development Timeline

	SPRING 2023	SUMMER 2023	FALL 2023	WINTER 2023
National Semiconductor Technology Center	Vision/Strategy Paper Published	Selection Committee identifies Board of Trustees	Establish NSTC	
National Advanced Packaging Manufacturing Program		NAPMP vision and strategy paper		
Manufacturing USA institute(s)	RFI Summary Published	Select topic(s); begin proposal process		
Metrology Program (NIST)	Metrology Gaps Report Published	Select programs to begin		



NSTC Vision

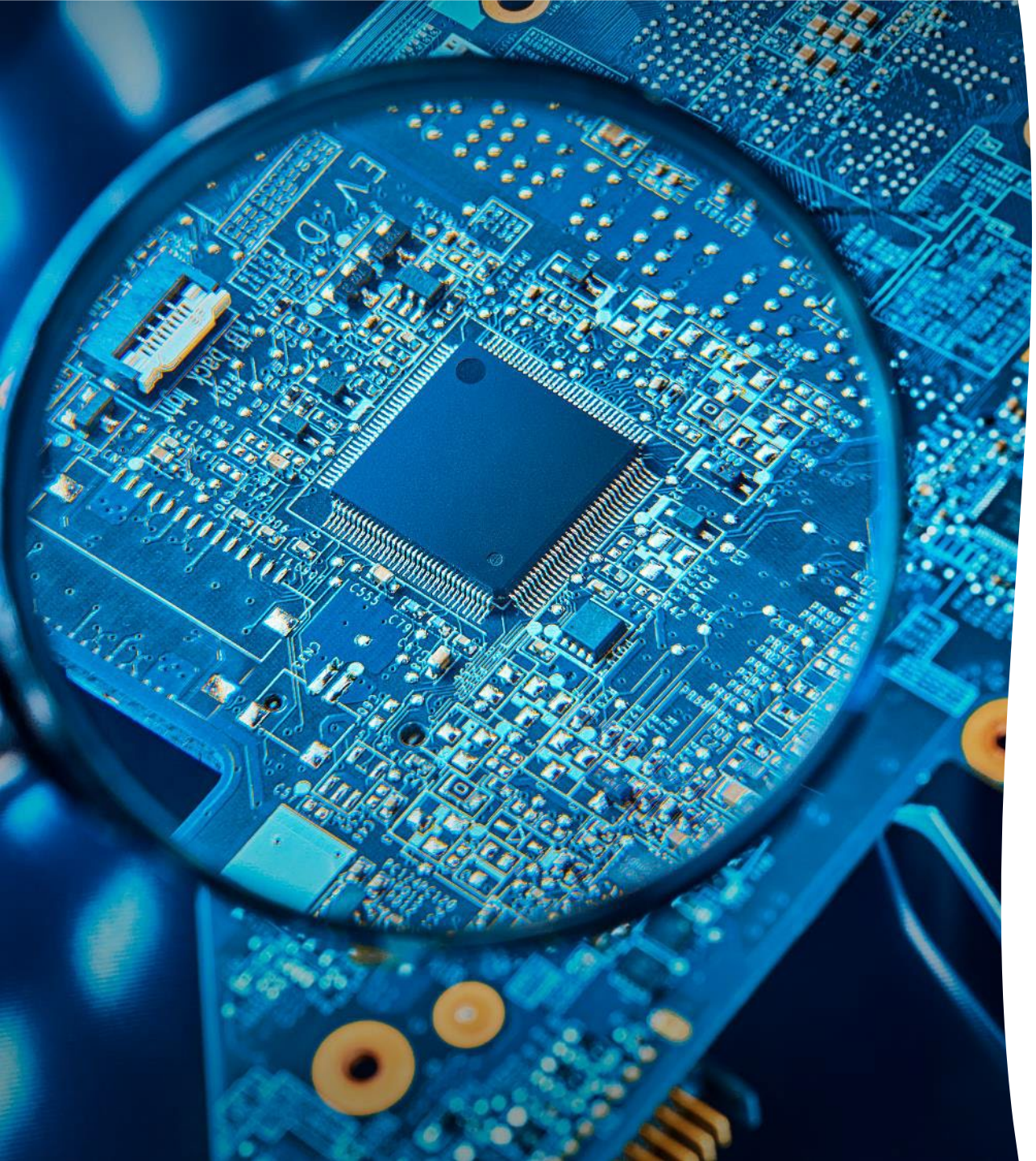
By the decade's end, the NSTC should be viewed throughout the world as an **essential resource** within the broad semiconductor ecosystem with a network of respected scientists and engineers, state-of-the-art facilities, effective programs, and demonstrated technical achievements.

Programs

Technology leadership

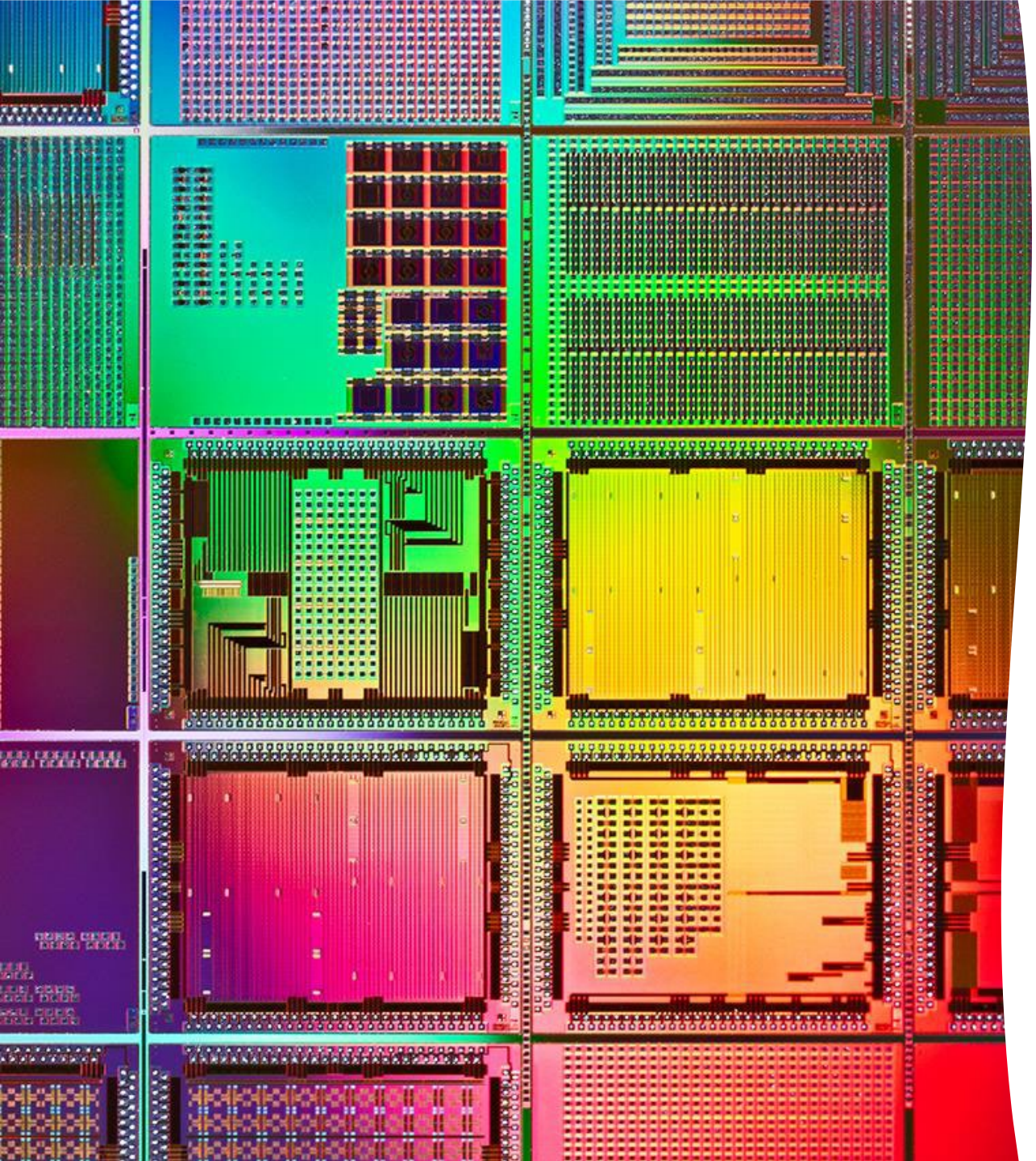
Community assets

Workforce



Technology Leadership

- In-house and funded research
- Grand challenges and road maps
- Standards and protocols
- Technical exchanges
- Security



Community Assets

- Chiplets
- Design Enablement Gateway
- Data sets
- Patents
- Technical centers for prototyping, research, and experimentation

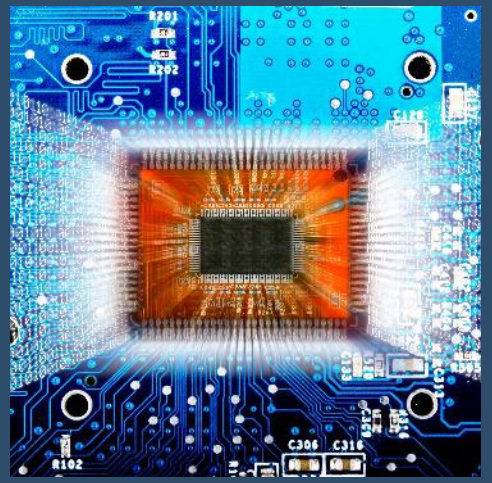
Workforce Programs

FOR SCIENTISTS, ENGINEERS, AND TECHNICIANS

- Outreach to groups traditionally underrepresented
- Support scale-up of existing quality programs
- Develop novel approaches to training

Membership

- Businesses of all sizes and at all stages
  - Fabless companies
  - Foundries
  - Integrated device manufacturers
  - Equipment vendors
  - Materials suppliers
- Research institutions, including minority serving institutions
- Community colleges
- State and local governments
- National labs
- Labor unions
- Sector investors



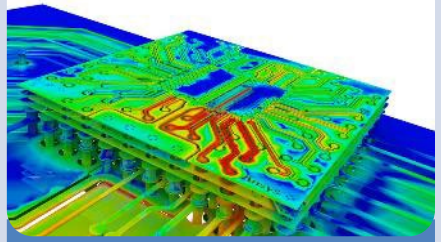
National Advanced Packaging Manufacturing Program

- Strengthen semiconductor advanced test, assembly, and packaging capability in the domestic ecosystem
- Leverage public-private partnerships, that can include support for facilities managed by the NSTC and MUSA
- Broad range of technologies:
  - Heterogeneous integration
  - Wafer and panel-based approaches
  - Tooling and automation
  - Substrate technology

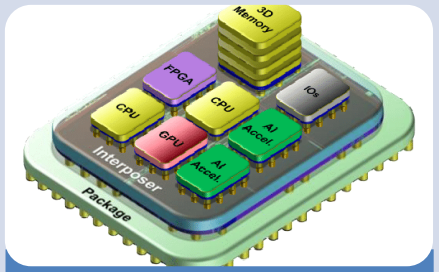
NAPMP Approach

Technology innovation — Create an R&D environment advancing the state-of-the art in advanced packaging.

Ecosystem support — Investments to bolster the growth in domestic capacity and enhance capabilities for competitive edge.



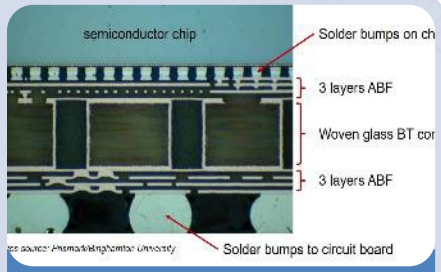
Co-design and simulation



Chiplets

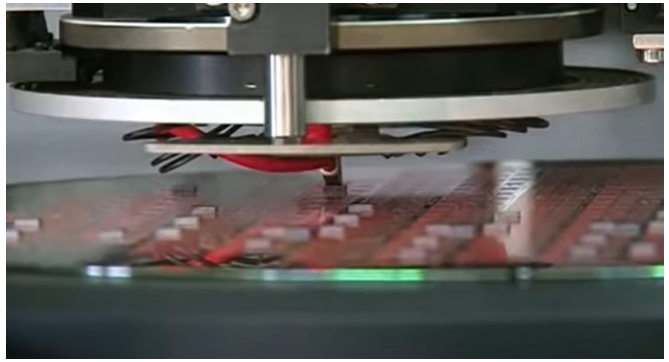
Pilot packaging facilities

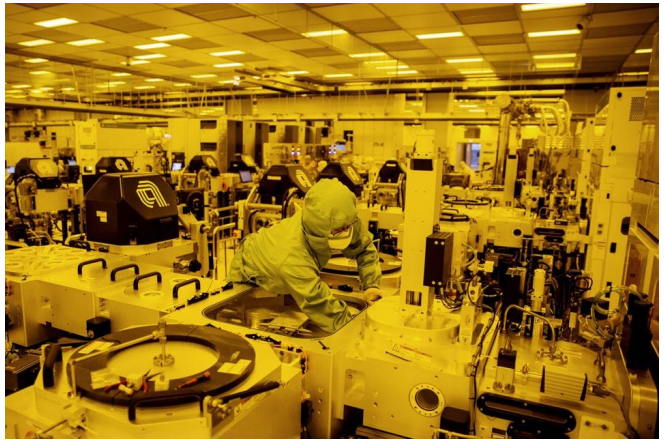
Tooling and automation



Materials and substrates

Pilot Packaging Facility(ies)





- The NAPMP will utilize the NSTC to support (a) packaging facility(ies) that enables R&D efforts.
- Prototype and pilot scale integration of components fabricated in NSTC facilities or 3rd party sources.
- Baseline packaging flows to support a goal of established package-proven IP.
- The facility should have sufficient tool redundancy to allow groundbreaking research on new materials and processes while still maintaining baseline capacity.
- Partnerships with domestic OSATs and electronics manufacturing services (EMS) to facilitate migration of successful prototypes to a production manufacturing environment.

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Manufacturing USA Institute(s)

- Up to three new public-private partnership institutes in the Manufacturing USA network
- To advance research and commercialization of semiconductor manufacturing technologies
- Pre-competitive collaboration among researchers and manufacturers
- Workforce training
- RFI Summary Report Published

Manufacturing USA Network

Electronics	Materials	Energy/Environment	Digital /Automation	Bio-Manufacturing

AIM Photonics
Integrated Photonics
Albany, NY
Rochester, NY

Advanced Functional Fabrics of America
Advanced Fibers and Textiles
Cambridge, MA

RAPID Transforming Process Industries
Modular Chemical Process Intensification
New York, NY

America Makes
Additive Manufacturing
Youngstown, OH
El Paso, TX

biofabusa
Regenerative Manufacturing
Manchester, NH

NextFlex
Flexible Hybrid Electronics
San Jose, CA

The Composites IACMI Institute
Advanced Composites
Knoxville, TN
Detroit, MI

REMADE Institute
Sustainable Manufacturing
Rochester, NY

ARM Institute
Robotics & AI
Pittsburgh, PA

NIMBL
Biopharmaceutical Manufacturing
Newark, DE

PowerAmerica
Wide Bandgap Semiconductors
Raleigh, NC

Lift — Where Manufacturing Technology and Talent Matter
Lightweight Materials
Detroit, MI

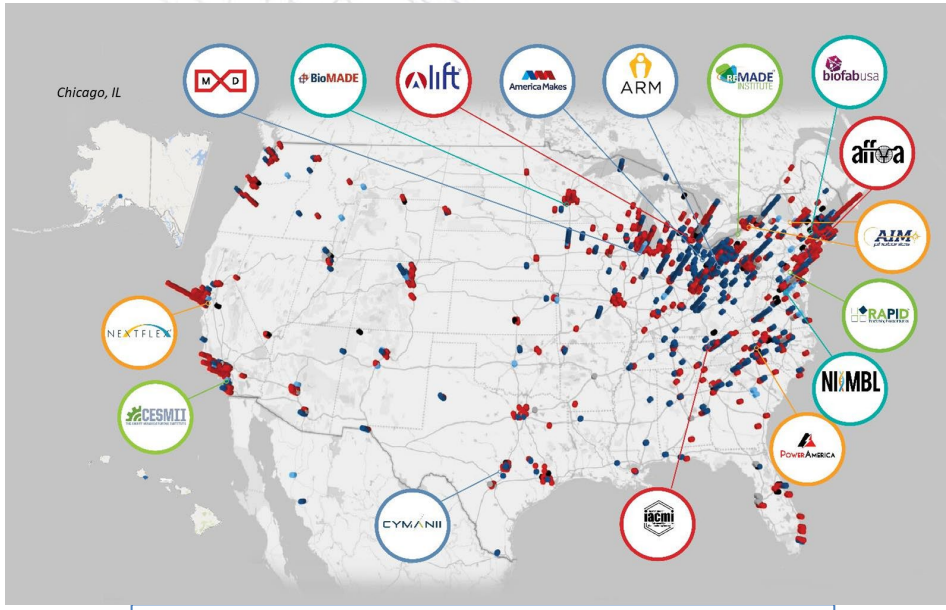
CESMII The Smart Manufacturing Institute
Smart Manufacturing
Los Angeles, CA

MxD The Digital Manufacturing & Cybersecurity Institute
Digital Manufacturing & Cybersecurity
Chicago, IL

BioMADE
Bioindustrial Manufacturing
St. Paul, MN

NEW— Electrified Processes for Industry without Carbon (EPIXC)
Phoenix, AZ

CYMANII the cybersecurity manufacturing innovation institute
Cybersecurity in Manufacturing
San Antonio, TX



16 institutes
Members in every state
9 partner federal agencies

DOC sponsors 1 institute + serves as the overall Program Office
DOD sponsors 9 institutes; DOE sponsors 6 institutes

Semiconductor Institute RFI Key Points

1 Institute Scope and Scale

- Several potential topic areas suggested
- No consensus on a single ‘super-sized’ all-topic institute vs. multiple focused institutes

2 Structure and Governance

- Consensus that the design framework for Manufacturing USA is sound, with exception of larger scale needed for impact in semiconductor space
- Consensus for tiered membership structures

3 Coordination

- Consensus that coordination with other CHIPS initiatives and with existing Manufacturing USA institutes in related sectors is critical

4 Sustainability

- Consensus that institutes are likely to need federal funding beyond 5 years
- Consensus that in longer-term, institutes achieve sustainability if focused on industry priorities

Semiconductor Institute Topic Examples

Cross-cutting technology topics

- Productivity enhancement via early design including co-design, digital twins, and artificial intelligence
- Smart manufacturing and automation
- New and advanced materials
- Metrology and testing

Focused institute topics

- Substrate manufacturing for advanced packaging
- Sensors and microelectromechanical systems
- Infrastructure to support technology transition to manufacturing

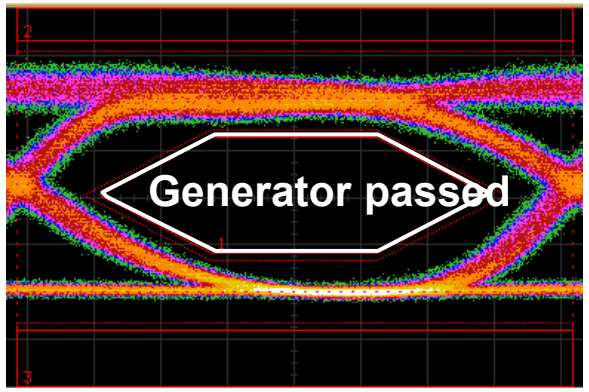
NIST and Advanced Microelectronics

NIST has a long history and broad portfolio of targeted investments in microelectronics spanning the following areas:

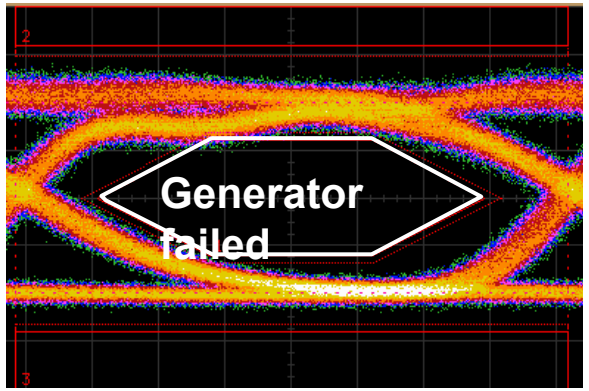
- Materials and chemistry
- Devices and interconnects
- Circuit design and computer automated design tools
- Fabrication/Manufacturing
- Packaging and test
- Computing architectures
- Software, modeling, simulation
- Beyond digital CMOS technologies
- RF electronics

Metrology Importance

Reduce Cost



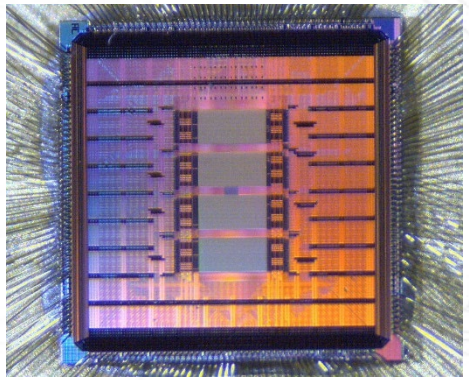
Same transceiver measured on two different oscilloscopes



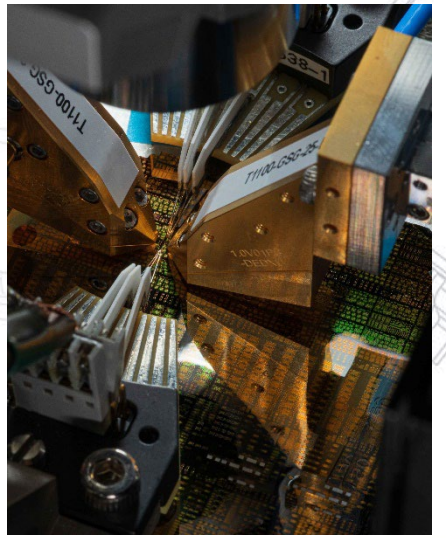
10 Gb/s Ethernet Transceivers
False rejects cost: $200M/yr

Measurements to test 6G technologies do not exist

Catalyze Innovation



NIST/Google
Open Source
Chip designs



NIST/DARPA
On-chip
Calibration Kits

Measurement designs so that industry and academia can evaluate their technology

Metrology Program

NIST Nanofabrication Facility

VISION: CHIPS R&D Metrology catalyzes innovation with emphasis on measurements that are accurate, precise, and fit-for-purpose for the production of microelectronic materials, devices, circuits, and systems.

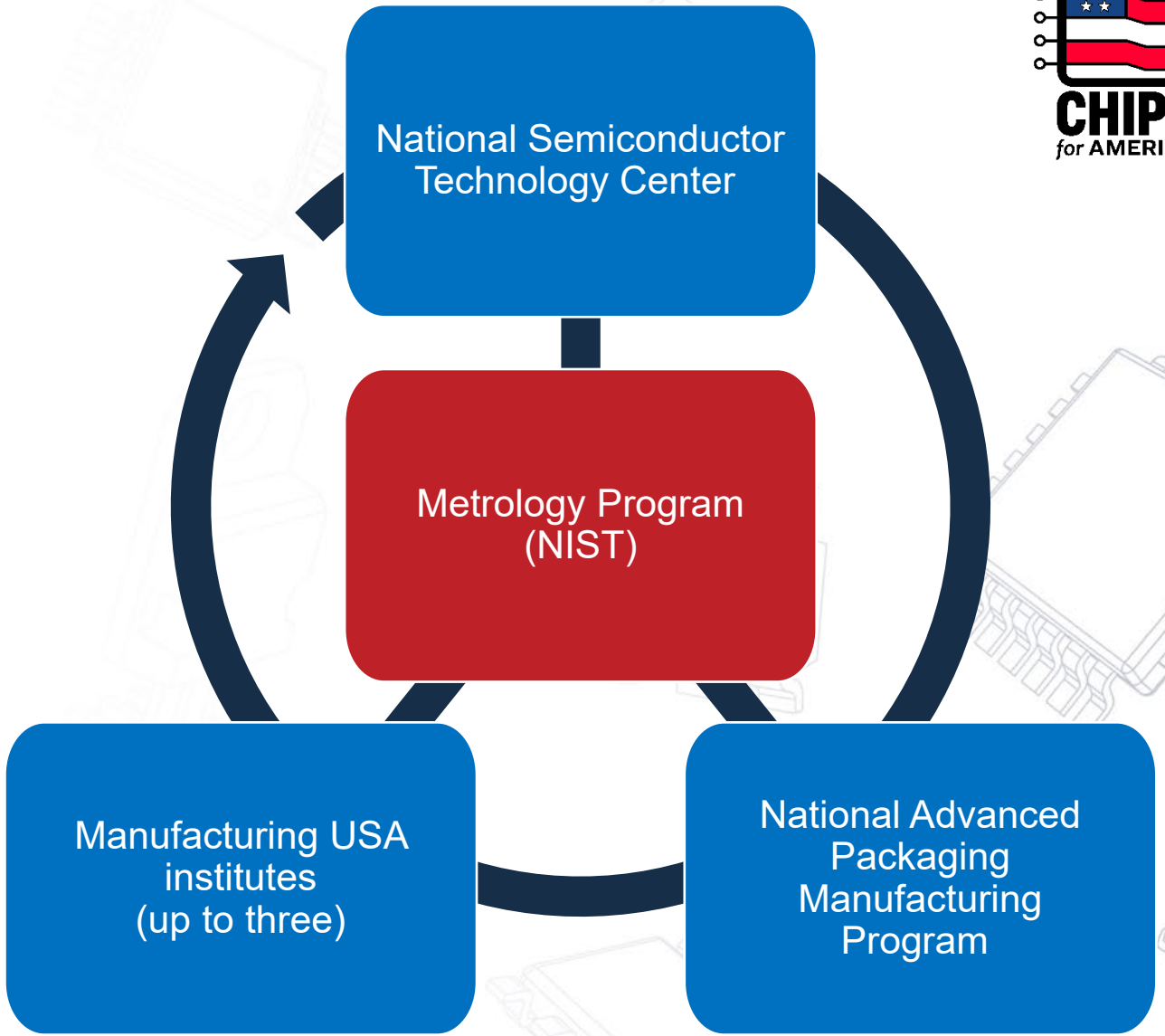
MISSION: Measure, innovate, lead to enhance a vibrant U.S. ecosystem for semiconductor manufacturing and to promote U.S. innovation and industrial competitiveness.

GOALS:

1. Expanding measurement solutions for the semiconductor ecosystem.
2. Increase the number of solvers by harnessing the diversity of people and ideas, inside and outside of NIST.
3. Expand education and workforce development opportunities that inspire excitement about manufacturing careers and expand career pathways.

Maximize Speed and Impact

- Metrology is **foundational** and **fundamental** for all R&D programming
- Metrology **tools are delivered** to other CHIPS R&D programs;
- High impact research areas **sourced from industry**
- Metrology technologies should reach **commercial scale**



Industry Input is Key

- Measurement science for new materials and packaging
- Physical metrology for next-generation microelectronics
- Computation and data
- Virtualization and automation
- Reference materials and data, and calibrations
- Standards for processes, cybersecurity, and test methods

https://nvlpubs.nist.gov/nistpubs/CHIPS/NIST.CHIPS.1000.pdf

Strategic Opportunities

Extensive feedback from stakeholders across industry, academia, and government

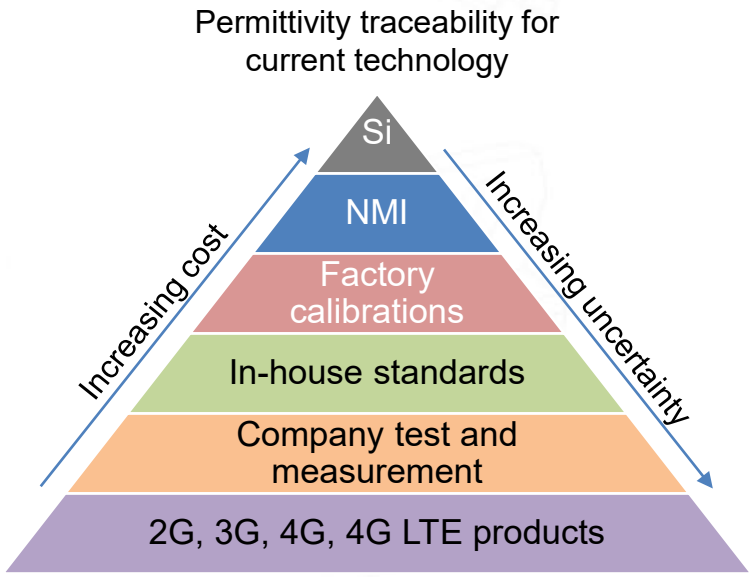
- Metrology for materials purity, properties, and provenance
- Advanced metrology for future microelectronics manufacturing
- Enabling metrology for integrating components in advanced packaging
- Modeling/ simulating semiconductor materials, designs, and components
- Modeling/ simulating semiconductor manufacturing processes
- Standardizing new materials, processes and equipment for microelectronics
- Metrology to enhance security and provenance of micro-electronic based components and products

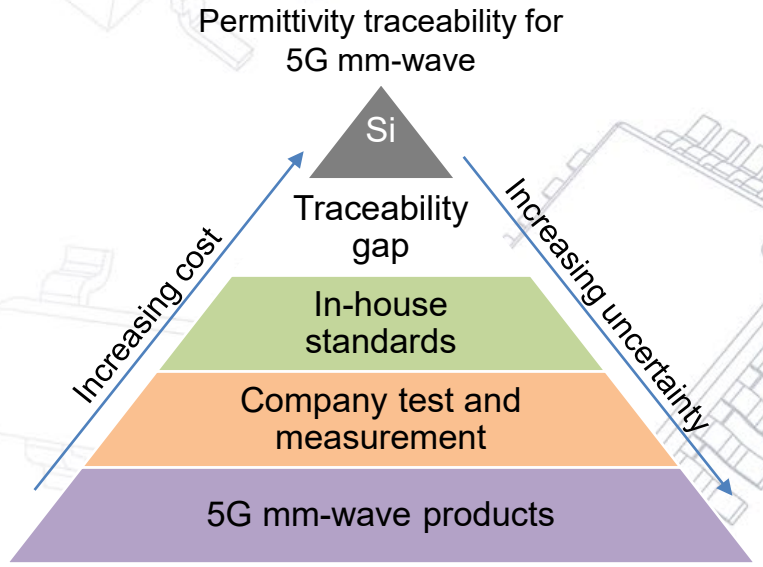
https://nvlpubs.nist.gov/nistpubs/CHIPS/NIST.CHIPS.1000.pdf

Example: SRMs for 5G materials

International Manufacturing Initiative (iNEMI)
"The lack of traceable reference material for mmWaves is a very serious problem. This lack makes verification of measurement methods and laboratory techniques impossible in an industry setting." - *5G Materials Characterization Project Report I*

Semiconductor Research Corporation
"Dielectric characterization up to 500 GHz and beyond. Scope includes anisotropic and inhomogeneous materials … High-frequency and high-temperature dielectric characterization of low-loss materials (encapsulants, mold compounds, substrates, etc.)." - *Research Needs: Packaging*





'5G' extends beyond wireless applications, including wired applications with needs for material characterization to 100+ GHz

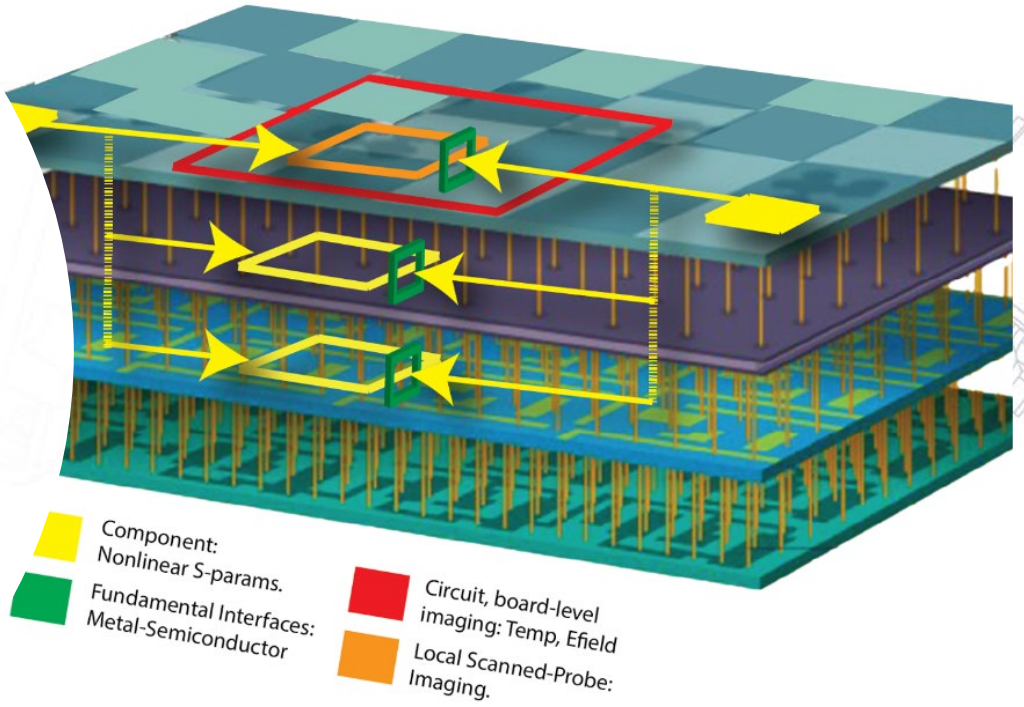
Example: Metrology for Increasing Circuit Complexity

Why?

- Increased integration density & functionality
- Add new materials & functionality
- Reduce power, cost, & latency

What's needed?

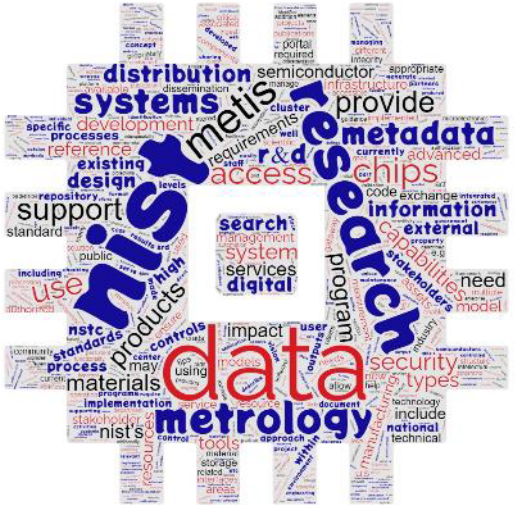
- Evaluate chips, interfaces, and materials buried in multilayer stacks
- New models to evaluated dynamic 3D systems
- Electromagnetic, thermal, & mechanical properties of constituent materials
- Broadband/dynamic material properties



Research Infrastructure

- Support metrology R&D
- Reduce technical risk for emerging technologies

WORLD-CLASS FACILITIES



- Ensure CHIPS R&D is available & useful for stakeholders
- Accelerating data ecosystem by leveraging existing resources

METIS

Metrology Exchange to Innovate In Semiconductors