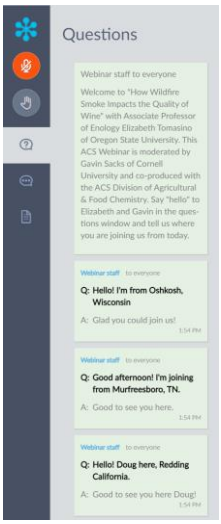
ACS Chemistry for Life®

www.acs.org/acswebinars

ACS Webinars
CLICK • WATCH • LEARN • DISCUSS

Questions or Comments?

Type them into the questions box!



"Why am I muted?"
Don't worry. Everyone is muted except the Presenter and the Host. Thank you and enjoy the show.

1

1

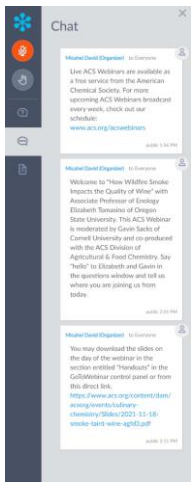
ACS Chemistry for Life®

www.acs.org/acswebinars

ACS Webinars
CLICK • WATCH • LEARN • DISCUSS

Chat

Announcements and hyperlinks from our team



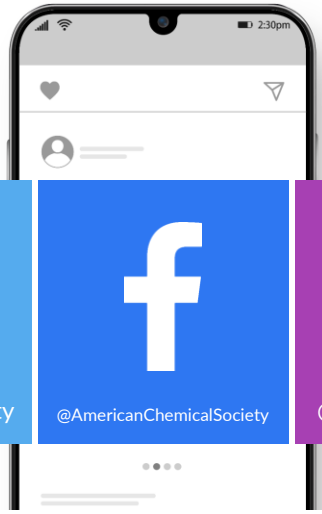
2

2

ACS Chemistry for Life®

www.acs.org/acswebinars

ACS Webinars® CLICK • WATCH • LEARN • DISCUSS



Let's Get Social!

Follow the American Chemical Society on Twitter, Facebook, Instagram, and LinkedIn for the latest news, events, and connect with your colleagues across the Society.

@AmerChemSociety

@AmericanChemicalSociety

@amerchemsociety

linkedin.com/company/american-chemical-society

Contact ACS Webinars® at acswebinars@acs.org

3

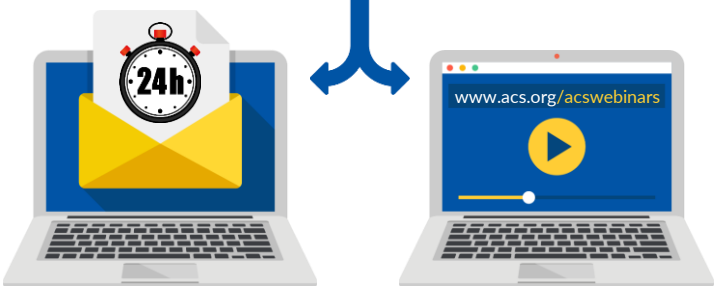
3

ACS Chemistry for Life®

www.acs.org/acswebinars

ACS Webinars® CLICK • WATCH • LEARN • DISCUSS

Where is the Webinar Recording?



All Registrants

Watch the unedited recording linked in the **Thank You Email for 24 hours.**

ACS Members w/Premium Package

Visit the ACS Webinars® Library to watch the **edited and captioned recording.**

4

4

A Career Planning Tool For Chemical Scientists

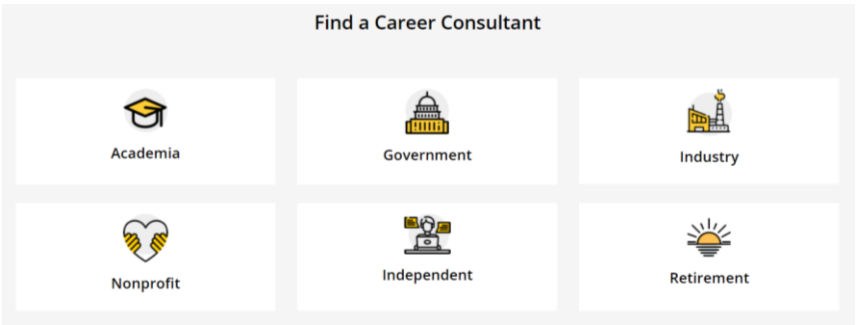
ChemIDP is an Individual Development Plan designed specifically for graduate students and postdoctoral scholars in the chemical sciences. Through immersive, self-paced activities, users explore potential careers, determine specific skills needed for success, and develop plans to achieve professional goals. **ChemIDP** tracks user progress and input, providing tips and strategies to complete goals and guide career exploration.

https://chemidp.acs.org

5

5

Career Consultant Directory



- ACS Member-exclusive program that allows you to arrange a one-on-one appointment with a certified ACS Career Consultant.
- Consultants provide personalized career advice to ACS Members.
- Browse our Career Consultant roster and request your one-on-one appointment today!

www.acs.org/careerconsulting

6

6

APPLY Today!

www.acs.org/industryworkshop

A PhD Workshop for Industrial Careers

WEDNESDAY, JUNE 21 2023 | 1:00 – 5:30 PM ET

Apply today for a chance to win $500 and an interview with DuPont!

ACS Chemistry for Life®
AMERICAN CHEMICAL SOCIETY
DuPont GOLD

7

7

ACS Bridge Program

ACS Chemistry for Life®

Are you thinking of Grad School?

If you are a student from a group underrepresented in the chemical sciences, we want to empower you to get your graduate degree!

The ACS Bridge Program offers:

- A FREE common application that will highlight your achievements to participating Bridge Departments
- Resources to help write competitive grad school applications and connect you with mentors, students, and industry partners!

Learn more and apply at www.acs.org/bridge

Email us at bridge@acs.org

8

8

ACS Chemistry for Life®

Make Our Future Greener Through Hydrocarbon Research

Interested? Learn more:
www.acsprf.org

CALL FOR PROPOSALS | AUGUST 14 – SEPTEMBER 8, 2023

American Chemical Society Petroleum Research Fund
Seed Money for Petroleum-Relevant Science

ACS PRF

9

9

ACS Scholar Adunoluwa Obisesan

BS, Massachusetts Institute of Technology, June 2021
(Chemical-biological Engineering, Computer Science & Molecular Biology)

"The ACS Scholars Program provided me with monetary support as well as a valuable network of peers and mentors who have transformed my life and will help me in my future endeavors. The program enabled me to achieve more than I could have ever dreamed. Thank you so much!"

GIVE TO THE ACS SCHOLARS PROGRAM

Donate today at www.donate.acs.org/scholars

10

10

ACS OFFICE OF DEIR

Advancing ACS' Core Value of Diversity, Equity, Inclusion and Respect

Resources

Inclusivity Style Guide
Designed to help staff and members use language and images that respect diversity in all its forms.

ACS Webinars on Diversity
Covering diversity and inclusion at the workplace

ACS Publications DEIR Hub
See what ACS Publications is doing for fostering inclusivity in scholarly publishing

ACS Volunteer and ACS Meetings Code of Conduct
Fostering a positive and welcoming environment for attendees, volunteers and staff.

C&EN Trailblazers
C&EN highlights scientists from different backgrounds who are making an impact in chemistry.

NEW! Download DEIR Educational Resources
Download this educational guide for additional recommendations on videos, articles, books, podcasts, and more on diversity, inclusion, and related topics.

Quick Guide: Inclusion Moments
Learn more about what Inclusion Moments are and see ideas to host them during your meetings.

Quick Guide: How to host inclusive in-person events
Recommendations and best practices to ensure that your events can accommodate everyone.

Diversity, Equity, Inclusion, and Respect
**Adapted from definitions from the Ford Foundation Center for Social Justice:

Equity**
Seeks to ensure fair treatment, equality of opportunity, and fairness in access to information and resources for all. We believe this is only possible in an environment built on respect and dignity. Equity requires the identification and elimination of barriers that have prevented the full participation of some groups.

Diversity**
The representation of varied identities and differences (race, ethnicity, gender, disability, sexual orientation, gender identity, national origin, tribe, caste, socio-economic status, thinking and communication styles, etc.), collectively and as individuals. ACS seeks to proactively engage, understand, and draw on a variety of perspectives.

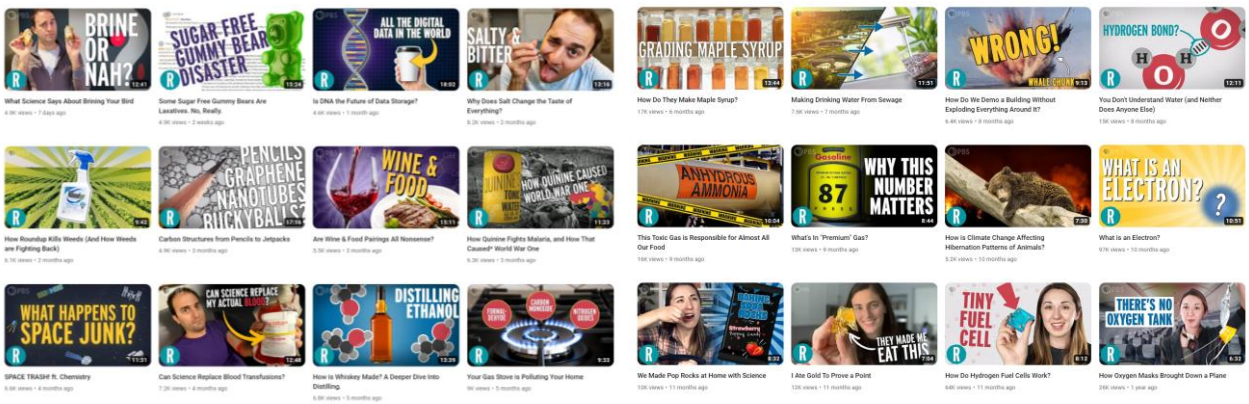
Inclusion**
Builds a culture of belonging by actively inviting the contribution and participation of all people. Every person's voice adds value, and ACS strives to create balance in the face of power differences. In addition, no one person can or should be called upon to represent an entire community.

Respect
Ensures that each person is treated with professionalism, integrity, and ethics underpinning all interpersonal interactions.

https://www.acs.org/diversity

11

11



https://www.youtube.com/c/ACSReactions/videos

12

12

ACS Chemistry for Life®

Looking for a new science podcast to listen to?

TINY MATTERS

Check out Tiny Matters, from the American Chemical Society.

Sam Jones, PhD
Science Writer & Exec Producer

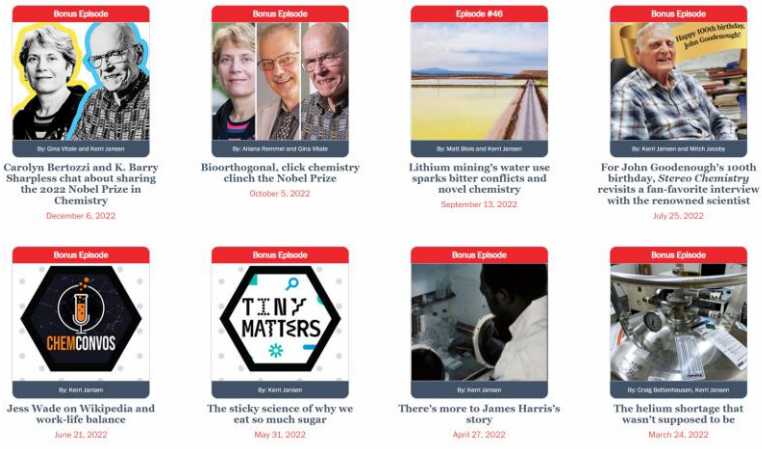
Deboki Chakravarti, PhD
Science Writer & Co-Host

TO SUBSCRIBE
visit http://www.acs.org/tinymatters or scan this QR code

13

13

c&en's STEREO CHEMISTRY



VOICES AND STORIES FROM THE WORLD OF CHEMISTRY

Subscribe now to C&EN's podcast

Apple Podcasts · Google Podcasts · STITCHER · Spotify · amazonmusic

cen.acs.org/sections/stereo-chemistry-podcast.html

14

14

ACS Industry Member Programs

- **ACS Industry Matters**

ACS member only content with exclusive insights from industry leaders to help you succeed in your career. #ACSIndustryMatters

Preview Content: acs.org/indnl

- **ACS Innovation Hub LinkedIn Group**

Connect, collaborate and stay informed about the trends leading chemical innovation.

Join: bit.ly/ACSinnovationhub

15

ACS on Campus is the American Chemical Society's initiative dedicated to helping students advance their education and careers.

ACS ON CAMPUS

16

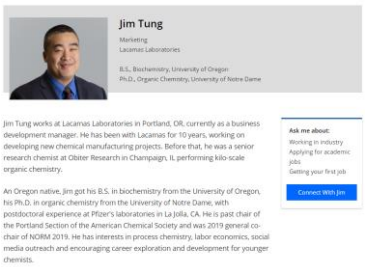
ACS Career Resources

ACS Chemistry for Life®

Virtual Office Hours

https://www.acs.org/careerconsulting.html

Personal Career Consultations



https://www.acs.org/careerconsulting.html

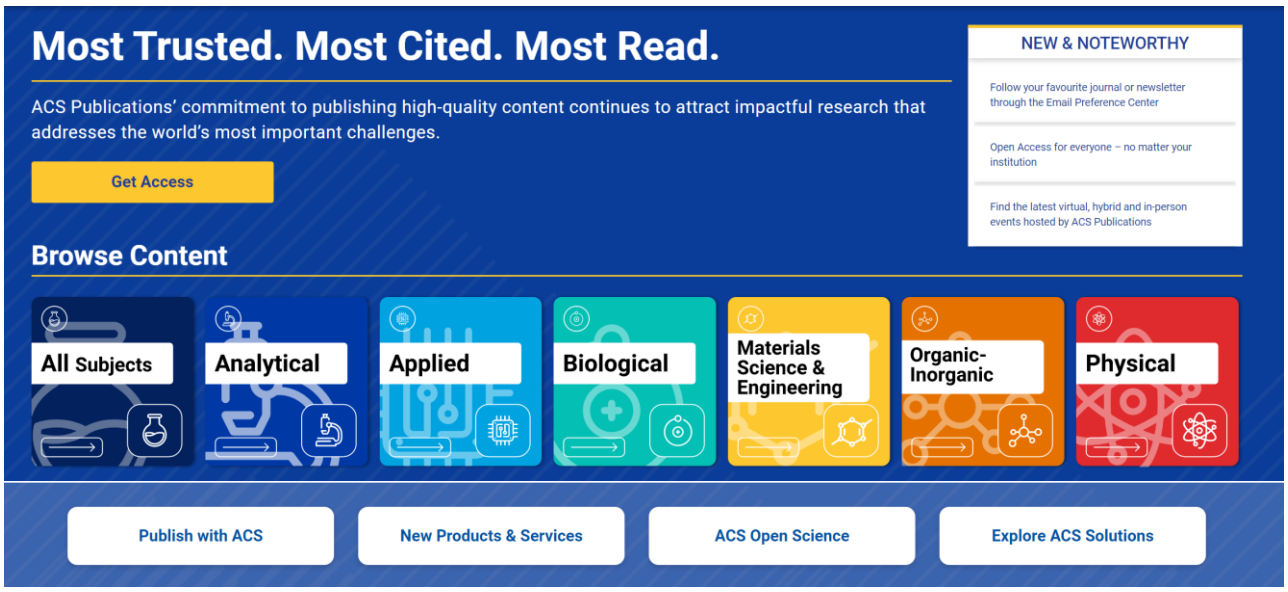
LinkedIn Learning

https://www.acs.org/linkedInlearning

17

17

ACS Publications
Most Trusted. Most Cited. Most Read.



https://pubs.acs.org

18

18

ACS Green Chemistry Institute
Chemistry for Life®

Home | About | Program | Register | Hotel | Students | Expo | Sponsor

TWENTY-SEVENTH ANNUAL

GREEN CHEMISTRY & ENGINEERING CONFERENCE

June 13-15, 2023 | Long Beach, CA & Hybrid

Closing the Loop: Chemistry for a Sustainable Future

Platinum Sponsor MilliporeSigma

Register Now!

www.gcande.org

19

19

ACS Chemistry for Life®
AMERICAN CHEMICAL SOCIETY
MEETINGS & EVENTS

#ACSFall2023

ACS FALL 2023

HARNESSING THE **POWER** OF DATA

AUGUST 13–17 | San Francisco, CA | Hybrid

https://www.acs.org/meetings/acs-meetings/fall-2023.html

20

20

ACS Chemistry for Life®

www.acs.org/acswebinars

ACS Webinars®
CLICK • WATCH • LEARN • DISCUSS

Thursday, June 22, 2023 | 11am-12:30pm ET

Biosynthetic Breakthroughs

Co-produced with ACS Publications and the ACS Division of Medicinal Chemistry

Thursday, June 29, 2023 | 2-3pm ET

ERGO: A Potential Answer in Mushrooms to Healthy Aging?

Co-produced with ACS Division of Agricultural & Food Chemistry

Wednesday, July 12, 2023 | 2-3pm ET

Chemistry and the Economy: 2023 Mid-Year Review

Co-produced with ACS Industry Member Programs

Register for Free

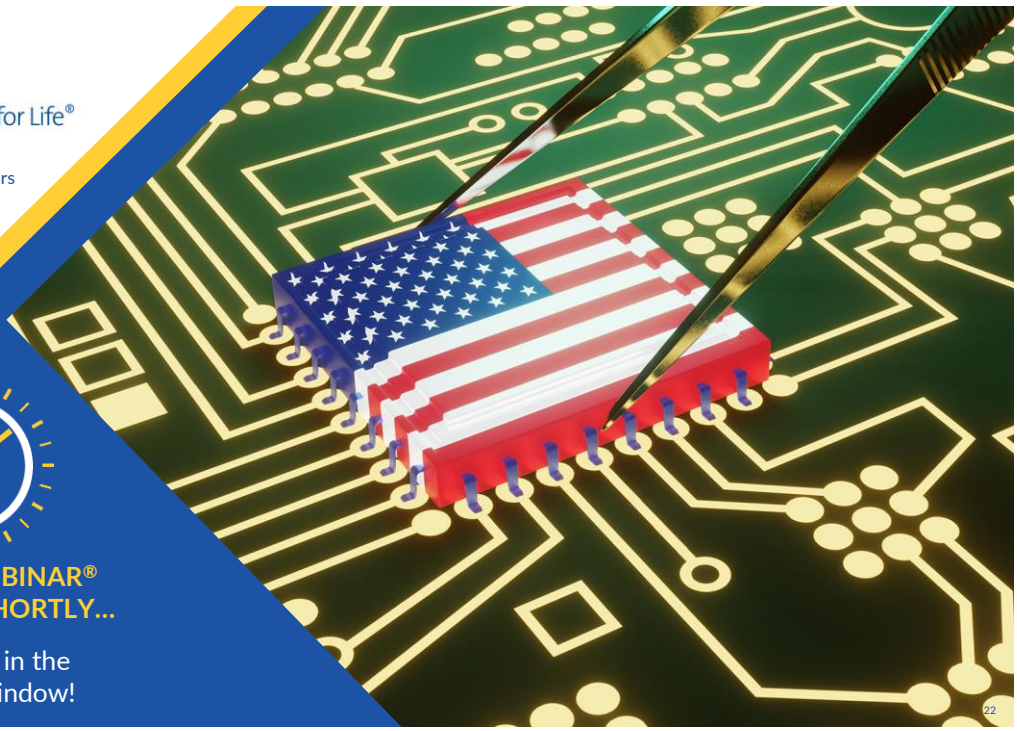
Browse the Upcoming Schedule at www.acs.org/acswebinars

21

21

ACS Chemistry for Life®

www.acs.org/acswebinars



THIS ACS WEBINAR® WILL BEGIN SHORTLY...

Say hello in the questions window!

22

22

ACS Chemistry for Life®

www.acs.org/acswebinars

Download Presentation Slides under "Handouts" in GTW Control Panel

ACS Webinars
CLICK • WATCH • LEARN • DISCUSS

The CHIPS and Science Act:
What's in it for the Chemistry Enterprise?

NITIN J. SHAH, BA, MA, PhD

Principal Innovator, MITRE Engenuity

HEATH WEEMS, BS

Advocacy Manager, American Chemical Society

This ACS Webinar® is co-produced with ACS Advocacy and ACS Government Affairs.

1

1

The CHIPS and Science Act: What's in it for the Chemistry Enterprise?

American Chemical Society Webinar

Nitin J. Shah
MITRE Engenuity
June 15, 2023

MITRE ENGENUITY™

2

The CHIPS and Science Act of 2022: The Basics

The CHIPS and Science Act of 2022 directs $ 280Bn in spending over the next ten years, with the bulk for scientific R&D

~ $ 200Bn proposed funding in STEM, R&D, and workforce and economic development program authorizations at
The National Science Foundation, US Department of Energy and US Department of Commerce

~ $ 52Bn has already been appropriated in the CHIPS Act with focus on the Semiconductor industry

https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/09/fact-sheet-chips-and-science-act-will-lower-costs-create-jobs-strengthen-supply-chains-and-counter-china/
https://www.congress.gov/bill/117th-congress/house-bill/4346
https://www.mckinsey.com/industries/public-sector/our-insights/the-chips-and-science-act-heres-whats-in-it

MITRE ENGENUITY

3

The CHIPS Act: Creating Helpful Incentives to Produce Semiconductors (CHIPS) for America Defense Fund

The CHIPS Act
2021 National Defense Authorization Act

'9902'	'9903'	'9906'
Financial Incentives $39 B*	**DOD Microelectronics (ME) Commons** $2 B*	**Research and Development** $11 B*
Department of Commerce	***Department of Defense***	***Department of Commerce***
"provides Federal financial assistance to covered entities to incentivize investment in facilities and equipment in the US…"	"to ensure the development and production of measurably secure microelectronics"	"to strengthen the economic competitiveness and security of the domestic supply chain"
		Includes: - National Semiconductor Technology Center (NSTC) - Packaging Program: NAPMP - Mfg. USA Institute (up to 3) - NIST Metrology Program

*Funding appropriated in the 2022 CHIPS and Science Act

MITRE ENGENUITY

4

CHIPS Act R&D Entities: the NSTC and the NAPMP

National Semiconductor Technology Center

- **Oversight:** Led by Sec. of Commerce in collaboration with Sec. of Defense. Industrial Advisory Committee assesses progress.
- **What it is:** a public-private partnership
- **Objective**: Conduct research and prototyping of advanced semiconductor technology to strengthen the economic competitiveness and security of the domestic supply chain
- **Functions**:
  - **R&D**: Conduct advanced semiconductor manufacturing, design and packaging research, and prototyping that strengthens the entire ecosystem
  - **Invest:** support startups with the goal of commercializing innovations
  - **Workforce**: incentivize and expand participation in graduate and undergraduate programs and develop programs and apprenticeships.

National Advanced Packaging Manufacturing Program

- **Oversight:** Established by Sec. of Commerce. Led by Director of NIST, in coordination with the NSTC. Industrial Advisory Committee assesses progress.
- **What it is:** a program
- **Objective**: Strengthen the semiconductor advanced test, assembly, and packaging capability in the domestic ecosystem.
- **Coordination**: Must coordinate with the Manufacturing USA Institute in 9906(f), if it is established.

MITRE ENGENUITY

The Background to the CHIPS Act

The United States has the highest spend in R&D, education and venture investments.

And yet…

- US share of chip manufacturing has slipped from ~30% in 90s and projected to be 9% by 2030.
- US currently has a market share ~3% in semiconductor packaging
- US has deep strengths in Electronic Design Automation software and semiconductor process equipment supply, enabling the manufacturing of semiconductor products globally
- US lacks the workforce to meet the current and emerging demand for the semiconductor industry

The pandemic and supply chain disruptions have illustrated vulnerabilities:

Supply chain resiliency is needed to strengthen economic and national security

"Getting the R&D infrastructure right will determine our success for decades."
-Commerce Secretary Gina Raimondo, Industrial Advisory Committee meeting Dec. 8, 2022, Washington D.C.

MITRE ENGENUITY

Bottom Line Up-Front (BLUF): Over the horizon innovation

- The CHIPS & Science Act provides a generational opportunity for industry, academia and individuals for imaginative solutions
- For funded programs such as the CHIPS Act, already technology roadmaps are being defined and specific programs established
- This is the time to communicate, collaborate, propose ideas into the marketplace, take lead and address numerous challenges in the develop of chemical processes and solutions for:
  - Processing of Silicon and wide bandgap semiconductors for electronics, optics and other applications: density (2D and 3D patterning), yield, power, sustainability goals
  - Advancement of packaging solutions for microelectronics, photonics and integration, requiring new materials, 2D and 3D patterning, demanding thermal, physical, environmental conditions

MITRE ENGENUITY

7

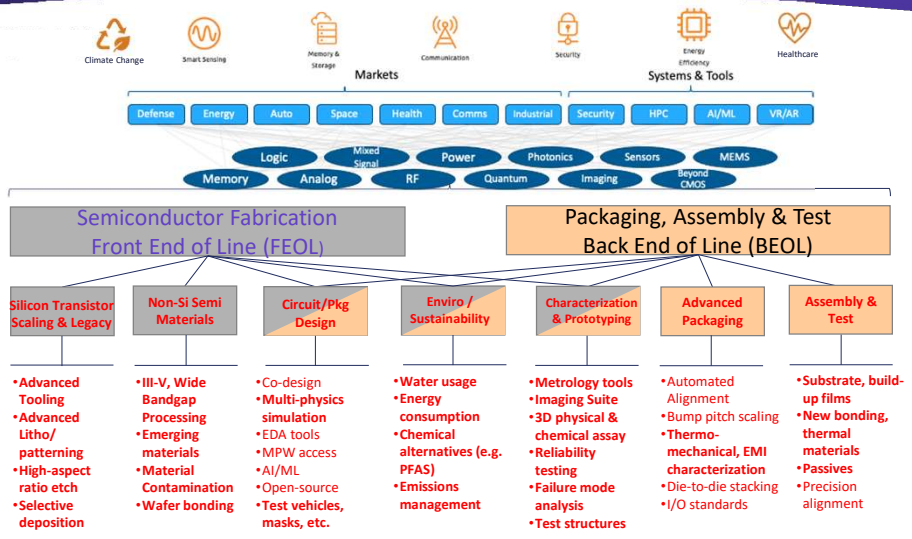
Opportunities for ACS Members to contribute to the CHIPS Act
The need for Over-The-Horizon Innovation, Roadmaps, Skills

Trends and Markets

Technology Stacks

Areas of Focus

Examples of Enabling Technology, Processes, and Tools



MITRE ENGENUITY

8

Bottom Line Up-Front (BLUF): Over the horizon innovation

- The CHIPS & Science Act provides a generational opportunity for industry, academia and individuals for imaginative solutions
- For yet to be funded programs (the other $ 200Bn), collaboration between Government, Academia and Industry can drive roadmaps and investment
- Examination of the "& Science" part of the Act illustrates opportunities and challenges and the broad objectives
- This is the time to collaborate and educate government on the possibilities
- And to gear up with training, skills and enthusiasm to build critical mass of talent

9

MITRE ENGENUITY

9

Introduction to MITRE and MITRE Engenuity

MITRE

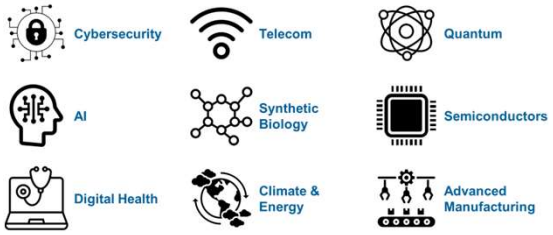
MITRE solves problems for a *safer world*, through federally funded research and development centers and public-private partnerships.

MITRE, a non-profit organization, works across government to tackle challenges to the safety, stability, and well-being of our nation.

MITRE ENGENUITY
A Foundation for Public Good

MITRE Engenuity brings MITRE's independence and objectivity as an honest broker.

MITRE Engenuity works with the private sector on problems no one organization can solve alone to accelerate *innovation for public good.*



1 0

MITRE ENGENUITY

10

Semiconductor Alliance | Mission

Leading American Semiconductor Innovation for American Growth

VALUE PROPOSITION

- Neutral, Balanced, Resilient Governance
- A Marketplace of Competitive Ideas
- A Whole-of-Nation Effort
- Breakthrough Technical Leadership
- Accountability to Government Objectives

Securing US semiconductor technology innovation, manufacturing leadership, & supply chain resilience

Accelerating Innovation for Public Good

PRINCIPLES

- **Collaboration** — Responsibility to do what's best for the whole
- **Fairness** — The best ideas win
- **Democracy** — The Alliance serves everyone

11

A Vision for the National Semiconductor Technology Center

A vision for how the US intends to leverage Incentives and R&D funds to strengthen supply chain and national security (white paper published November 2021)

KEY THEME: A Marketplace of Ideas

- **Breakthrough Challenges and Full Stack Innovation:** market and technology goals
- **Nationwide Network** of new and existing facilities, infrastructure, tools, metrology
- **Strategic Investment Fund** capital and incubator for de-risking investments
- **Domestic semiconductor Workforce** at all skill levels and stages of career
- **Effective Governance** addressing openness, conflicts, and intellectual property
- **Coordination** with **existing and future U.S. government programs**

12

MITRE ENGENUITY

12

The Semiconductor Alliance's Work to Date

Scan me to download the paper!

Vision Paper
Jun – Nov 2021

RFI Response
Jan – Mar 2022

Blueprint Paper
Feb 2023
>100 contributors

Objectives for NSTC

- Lower barriers for access
- Create value for the ecosystem
- Build trust through neutrality
- Full-stack, system-level approach
- Whole-of-nation engagement

Key Tenets for an Impactful NSTC

- Effective and neutral governance
- Ambitious technology agenda
- A robust network and operating model
- Long-term financial sustainability
- Targeted workforce development
- Integrated startup investment fund

MITRE ENGENUITY

Circuit Talk: Full Stack

EPISODE 4

ELECTRONIC DESIGN AUTOMATION (EDA), EQUITY, AND EXPANSION IN THE CLOUD

Guest(s): Deirdre Hanford
Chief Security Officer, Synopsys

EPISODE 3

WORKFORCE DEVELOPMENT AND ADVANCED PACKAGING

Guest(s): Jim Vandevere
President, BRIDG

EPISODE 2

THE FUTURE OF THE SEMIVERSE

Guest(s): Rick Gottscho
Executive Vice President and Chief Technology Officer, Lam Research

EPISODE 1

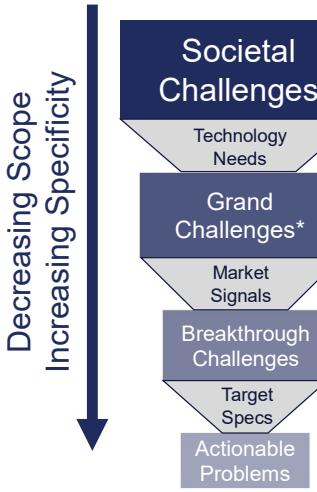
AN INTRODUCTION TO FULL STACK INNOVATION

Guest(s): Todd Holmdahl
Corporate Vice President, Microsoft

https://mitre-engenuity.org/semiconductors/circuit-talk/full-stack/

MITRE ENGENUITY

Making Market-Driven Breakthrough Challenges Actionable



Examples

- Healthcare
- Climate change
- Energy demand
- Space domain

- Smarter world-machine interfaces
- Memory wall
- Data deluge
- Compute energy efficiency

- Smart biometric sensing
- Memory-centric compute
- THz Comms
- 10-100X power reduction

Redefining the Datacenter for Sustainable Power Consumption

Actionable Problem Statements

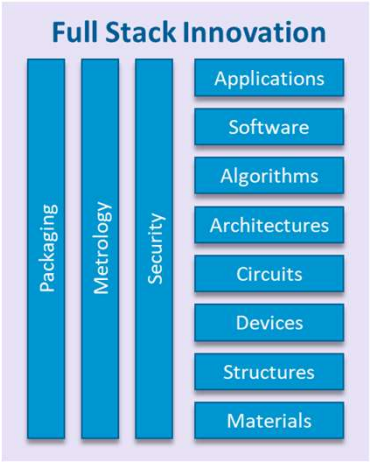
- Demonstrate logic devices that operate at 0.1 V
- Implement 10x more power efficient architectures
- Improve data movement between logic and memory for 10x power reduction

Target Key Performance Indicator >10x;
Emphasis on multi-disciplinary, multi-company efforts

MITRE ENGENUITY

15

Innovation: Full Stack Innovation



The future will be shaped by those who understand full stack innovation and implications for the market, supply chains and external factors

- Historically the industry grew by cooperation by partners in vertical integration and supply chain
- Over time, the industry has grown at all layers of the stack *e.g. fabless, Electronic Design Automation, foundries, materials providers, tools and patterning*
- Hennessy and Patterson: prediction that the next generation of products will require companies to innovate at all layers of the stack to achieve major breakthroughs

https://www.acm.org/hennessy-patterson-turing-lecture

MITRE ENGENUITY

16

SIA/Semiconductor Research Corporation Decadal Plan

Five Seismic Shifts That Will Define The Future of Semiconductors and ICT

1. Fundamental breakthroughs in analog hardware are required to generate smarter world-machine interfaces that can sense, perceive, and reason. Annual investment need: $600M throughout this decade to pursue analog-to-information compression/ reduction with a practical compression/reduction ratio of 10^5:1 for practical use of information more analogous to the human brain.

2. The growth of memory demands will outstrip global silicon supply, presenting opportunities for radically new memory and storage solutions. Annual investment need: $750M throughout this decade to develop emerging memories/memory fabrics with >10-100X density and energy efficiency improvement for each level of the memory hierarchy. Discover new storage systems and storage technologies with >100x storage density capability.

3. Always-available communication requires new research directions that address the imbalance of communication capacity vs. data-generation rates. Annual investment need: $700M throughout this decade for communication enabling data movement of 100-1000 zettabyte/year at the peak rate of 1Tbps@ <0.1nJ/bit. Develop intelligent and agile networks that effectively utilize bandwidth to maximize network capacity.

4. Breakthroughs in hardware research are needed to address emerging security challenges in highly interconnected systems and AI. Annual investment need: $600M throughout this decade for privacy and security hardware advances that keep pace with new technology threats and use cases (e.g., trustworthy AI systems, secure hardware platforms, and emerging postquantum and distributed cryptographic algorithms).

5. Ever-rising energy demand for computing vs. global energy production is creating new risk, and new computing paradigms offer opportunities to dramatically improve energy efficiency. Annual investment need: $750M throughout this decade to discover computing paradigms/architectures with a radically new computing trajectory demonstrating >1,000,000x improvement in energy efficiency.

SIA/SRC Decadal Plan for Semiconductors - *https://www.src.org/about/decadal-plan/*

Five Seismic Shifts shared with permission from David Henshall at SRC

MITRE ENGENUITY

17

Mega-Trends: External Factors in the Semiconductor Market

Questions that face our industry and its future:

- **Talent**
  - How can we encourage the next generation to be excited about working in our industry?
  - What are the skills required for the next few decades?
- **Power**
  - How will we generate reliable power to run our fabrication facilities?
  - How can we continue to reduce the power required to operate our products?
- **Sustainability**
  - How can be reduce our impact on the environment (e.g. elimination of PFAS)?
  - What can we do to reduce the long-term effects of our products and materials?

1 - Public Statement of the Semiconductor PFAS Consortium - Semiconductor Industry Association (semiconductors.org)

MITRE ENGENUITY

18

Market Growth: Continued Growth of Current Segments

What current product segments will sustain and grow in the next decade?

- **Computing**
  - Data centers, edge, everything
  - Driven by power but also software efficiency and architectures
- **Memory**
  - Cost, density
- **Communications**
  - Wireless, optical, wired

  - Major trend: advanced packaging:

  tension between Moore's Law approach to next node vs heterogeneous integration and customization

MITRE ENGENUITY

Market Disruptions: Transformation of the Market

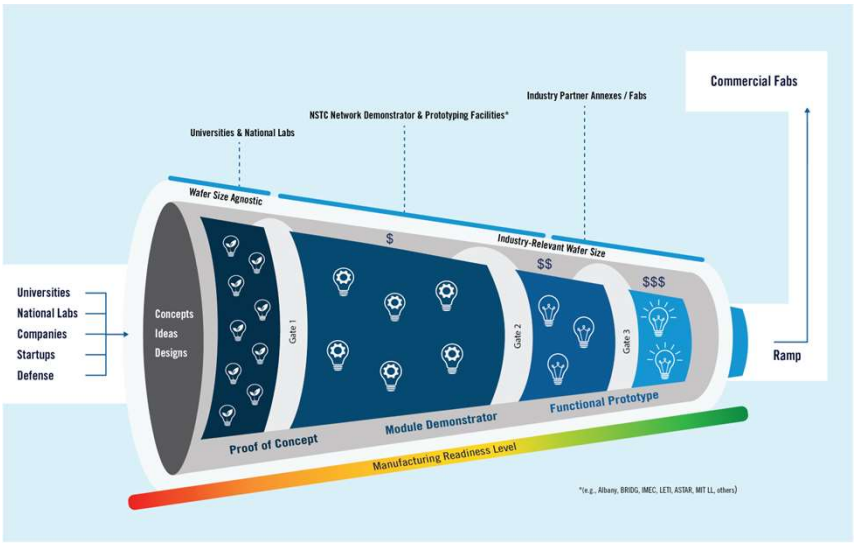
How will the industry go from $ 500Bn to > $ 1Tn in the next decade?

What will we sell and to whom?

- **Things**
  - Transportation: automotive, aeronautics, personal vehicles
- **Spaces**
  - Home, public places, cities, professional and medical spaces
- **Industry**
  - Automation, robotics, manufacturing
- **Medical**
  - Personal care, professional, physical and mental
- **Education/Media/Platforms**
  - Virtual, augmented and mixed reality, enhanced communications and sensing

MITRE ENGENUITY

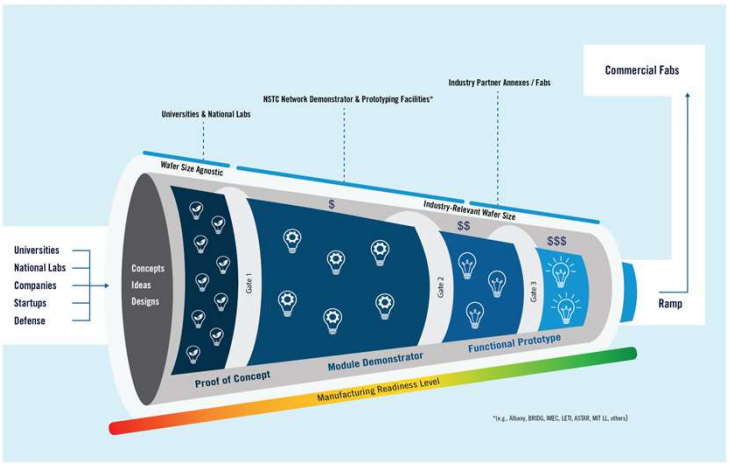
Innovation: Lab to Fab



MITRE ENGENUITY

21

The NSTC's Role in Lab-to-Fab Transition



Stages of Development

Proof Of Concept
- Basic R&D
- Scientific Understanding
- Novel concepts/methods/designs
- Common baselines & test structures

Module Demonstrator
- Concept hardening
- Industry relevant baselines
- Module/test site demonstration

Functional Prototype
- Prototypes
- Functional check

NSTC's Focus

Ramp
- Transition tech to commercial partners

MITRE ENGENUITY

22

An Emerging Opportunity: Advanced Packaging

National Advanced Packaging Manufacturing Program

- **Oversight:** Established by Sec. of Commerce. Led by Director of NIST, in coordination with the NSTC. Industrial Advisory Committee assesses progress.
- **What it is:** a program
- **Objective**: Strengthen the semiconductor advanced test, assembly, and packaging capability in the domestic ecosystem.
- **Coordination**: Must coordinate with the Manufacturing USA Institute in 9906(f), if it is established.

NIST Webinar October 18th, 2022
"CHIPS for America Strategy Paper Briefing – R&D Programs"

NATIONAL ADVANCED PACKAGING MANUFACTURING PROGRAM

- To expand and grow U.S. capacity in advanced packaging
- Capture available market share in packaging revenue
- Pilot facility for testing and integration of new processes
- A network of public private partnerships with universities, industry, and other government agencies focused on a range of issues including:
  - Substrate technology
  - Heterogeneous integration
  - Wafer and panel-based approaches
  - Tooling and automation

National Institute of Standards and Technology | U.S. Department of Commerce 18

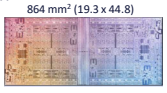
MITRE ENGENUITY

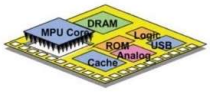
23

Industry Roadmap: "More Moore" to "More-than-Moore"

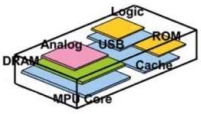
Transistor Scaling: System on Chip

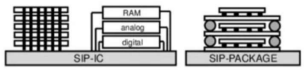
Apple M1 Ultra – 114 bn transistors
864 mm² (19.3 x 44.8)





Advanced Packaging: Heterogeneous Integration





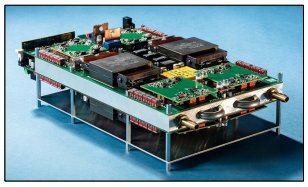
Multiple components onto a single chip	Multiple components into single package
Low flexibility	High flexibility
Longer time to market	Shorter time to market
All components manufactured at same node	Components manufactured at any node
Large chip size, low yield, increased cost	Smaller chip-'let' size, higher yield, decreased cost

The *transistor scaling* approach of the past few decades will be transitioning to a *systems* approach through Advanced Packaging & Heterogenous Integration

MITRE ENGENUITY

24

Future Technologies Enabled by Advanced Packaging

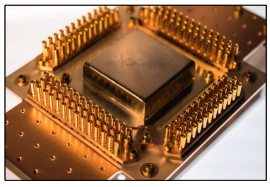


WBG & Power

- Thermal management
- HV materials
- Improved reliability

Neuromorphic Computing

- Reconfigurability
- Weighted connections



Quantum Computing

- Cryogenic operation
- Low-loss RF and Optical coupling
- Chip-to-chip entanglement

Advanced packaging will require innovations in materials, patterning, 3D structures, new process and manufacturing techniques, measurement and characterization, automation, data analytics and tools

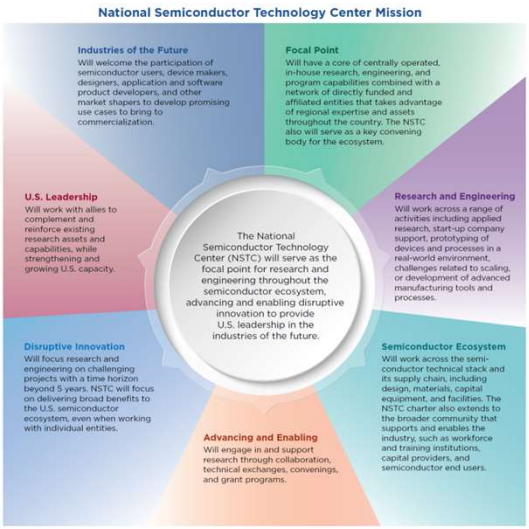
MITRE ENGENUITY

25

National Semiconductor Technology Center:

"Focal point for research and engineering throughout the semiconductor ecosystem"

https://www.nist.gov/chips



The US CHIPS Act: R&D Highlights
Manufacturing USA
Metrology Research
National Semiconductor Technology Center (NSTC)
National Advanced Packaging Manufacturing Program (NAPMP)

National Institute of Standards and Technology: https://www.nist.gov/

MITRE ENGENUITY

26

NIST Whitepaper on the NSTC: Overview

- Department of Commerce anticipates the creation of a new, purpose-built, independent, nonprofit entity with the requisite neutrality, expertise, leadership, and capacity to serve as the operator of the NSTC.
- Three Programs: Technology leadership ; Managing assets that benefit the community; Workforce programs
- A "whole-of-government approach"

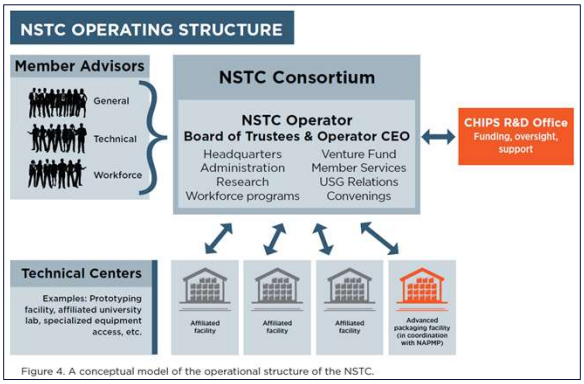
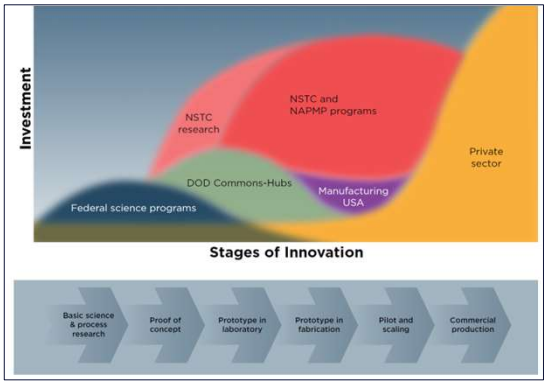


Figure 4. A conceptual model of the operational structure of the NSTC.



MITRE ENGENUITY

27

NIST Whitepaper on the NSTC: Community Input

Technical Centers (page 15)

Design Enablement Gateway (page 16)

Membership Structure (page 20)


TECHNICAL CENTERS: COMMUNITY INPUT

The semiconductor community has provided extensive input to the requirements for potential technical centers. The NSTC will embark on a prioritization process to ensure that the highest priority needs are met with the funds available. Identified needs for the NSTC to consider include:

- Baseline CMOS (complementary metal-oxide semiconductor): Fully functional and supported CMOS process flow at 22 nm or below with a capacity of 10,000 wafer starts per month on 300 mm wafers.
- CMOS R&D process: Front-end short loops supporting < 3 nm technology R&D at a capacity of 2,000 wafers per month using extreme ultraviolet technology enabling the development of leading-edge materials, devices, and process and metrology tools.
- Manufacturing test vehicles that provide low-cost patterned and functional substrates that can be used to provide data through electrical test, to enable materials, equipment, process, and device development and optimization, especially for CMOS+X enabled technologies.
- Extended metrology capacity to enable R&D in a production environment including rapid failure analysis to shorten prototype development cycles, extensive in-line process monitoring capabilities, and off-line characterization facilities.
- Space and flexibility to accommodate next-generation or prototype processing and metrology tools so that they can be demonstrated in a production environment.
- Back-end short loop processing from specialized capabilities enabling "fab-to-lab"[27] finishing of R&D devices and high-quality processing of novel materials and devices while maintaining process and material segregation.
- Power electronics: Power management devices often require non-silicon substrates (e.g., silicon carbide, gallium nitride) and specialized designs, tools, and processes.
- Radio frequency, mixed signal, and analog: Communication and sensing applications require diverse capabilities distinct from leading-edge CMOS.
- Photonics: Advancements in quantum, sensing, and interconnect are all possible at the intersection of light and electronics.
- Microelectromechanical systems: Sensors for mobile, automotive, health care, and internet-of-things are all growth areas that require resources distinct from traditional CMOS flow.
- Bioelectronics: The convergence of microfabrication and biotechnology brings new opportunities, but also increased complexity and significant integration challenges.
- Mature node: The NSTC may seek to have capacity at a mature node (e.g., 130 nm), with such a facility well suited to certain research programs and workforce education.
- Design tools: New design tools and methodologies to accelerate the generation of circuit IP; virtualize devices, circuits, and processes; and enable co-design, simulation, and heterogeneous integration.


DESIGN ENABLEMENT GATEWAY: COMMUNITY INPUT

The semiconductor community has provided extensive input to the requirements for a new hosted design environment. Specifications that have been identified include:

- A complete set of resources needed for the design, simulation, and tape-out of integrated systems to be made in the U.S., without proprietary information leaving the cloud environment.
- A well-structured, version-controlled interchange system between all participants within a multi-party "nondisclosure agreement ecosystem" to facilitate sharing IP as needed by the members, especially circuit design-IP surrounding foundry process design kits.
- An "app-store"-like environment where users can exchange integrated circuit design-IP under standardized licensing and support terms for basic R&D as well as for commercial use, as determined by the owner of the circuit design-IP.
- A catalog of IP generated from NSTC-sponsored projects, along with a pre-defined set of contractual obligations to determine the ownership of that IP; IP may be owned or co-owned by members or the NSTC itself.
- A catalog of circuit design-IP from NSTC-sponsored projects and, to the extent possible, of other federal agencies, that is made available for license at a reasonable cost.
- A resource to help trace the provenance of circuit design-IP, both to ensure it is secure and to prevent piracy of proprietary information.
- Collaboration between commercial EDA vendors and universities or startups to consider interoperability via industry standard tool formats or application programming interfaces (APIs) that would allow EDA innovations (open source or proprietary) to more tightly integrate and leverage commercial tool investment, adoption, and support.

The community has suggested options in licensing that the NSTC could consider in partnership with providers of EDA tooling and integrated IP:

- Enabling the contribution of circuit design-IP under standard contributor license agreements.
- Allowing NSTC members to access NSTC EDA resources using their own existing licenses ("bring your own license").
- Subsidizing EDA and circuit design-IP license access for U.S. government agencies, universities, and early-stage startups.
- Developing, promoting, and supporting existing or new licensing models that improve community access, such as a non-commercial, research-only licenses at low or no cost.


MEMBERSHIP STRUCTURE: COMMUNITY INPUT

The following benefits have been requested as part of the membership structure, and could be included either in the base fee or as an *ad hoc* cost:

- Use of technical centers
- Access to research and development programs, technical expertise, emerging materials and process technologies, and manufacturing test vehicles
- Access to digital assets, such as EDA and design enablement tools, IP, and aggregated data sets
- Facilitated access to multi-project wafers at leading-edge and mature foundries
- Access for startups to a nurturing ecosystem, including resources such as incubation support, IP-licensing guidance, convening opportunities that introduce startups to interested investors, and coordination with the efforts of other federal agencies
- Participation in the groups that advise the NSTC leadership on different program objectives
- Participation in industry convenings including groups focused on road maps, standards, and grand challenges
- Participation in training, workforce development, technical exchange programs, and access to the workforce data clearinghouse

MITRE ENGENUITY

28

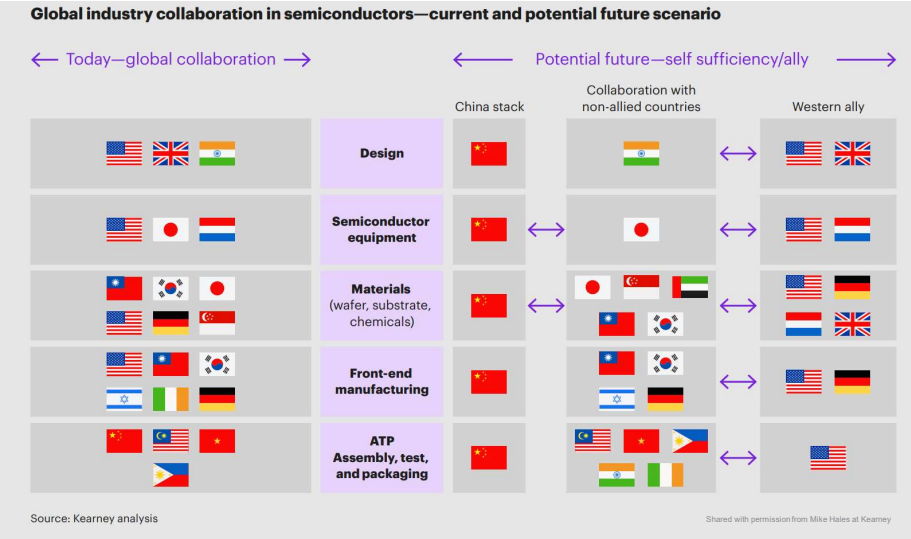
Profile of the Global CHIPS Acts

Country	Objective	Incentive Amount ($B)	Date passed
US	Bolster U.S. leadership in semiconductors	$52B	Aug 2022
China	Counter U.S. moves aimed at slowing its technological advances	$143B	Dec 2022
South Korea	"K-Semiconductor Belt" strategy: Become a comprehensive (beyond memory) semiconductor powerhouse by 2030	25% R&D tax credits 5% Capex tax credit	May 2021
Taiwan	Encourage semi manufacturers to invest in facilities & new technologies	- Up to 40~50% tax credit for R&D - Up to 10~20% tax credit for facility investments	Jan 2023
India	Position India as global hub for electronics manufacturing	$10B	Dec 2022
Japan	Double domestic chip revenue to $114 billion by 2030	$6.8B	2021/2022
European Union	Double the EU's current 10% share of the global semiconductor market by 2030	$30B - $50B	Feb 2022

- Multiple nations are providing incentives for the Semiconductor industry
- Factors affecting government actions
  - Driven by Pandemic and Disruption to Global Supply Chain and resulting Economic Impact

29

Global Supply Chain and Alliances



https://www.kearney.com/industry/technology/article/-/insights/why-a-resilient-semiconductor-supply-chain-is-imperative-and-how-to-create-one

30

CHIPS Act Summary

Topics to consider to meet the global market demand for semiconductor products

- What is the best path for industry to align with government actions?
- How to respond to the changes in the market?
- How to attract the best technical and business talent to our industry?

MITRE ENGENUITY

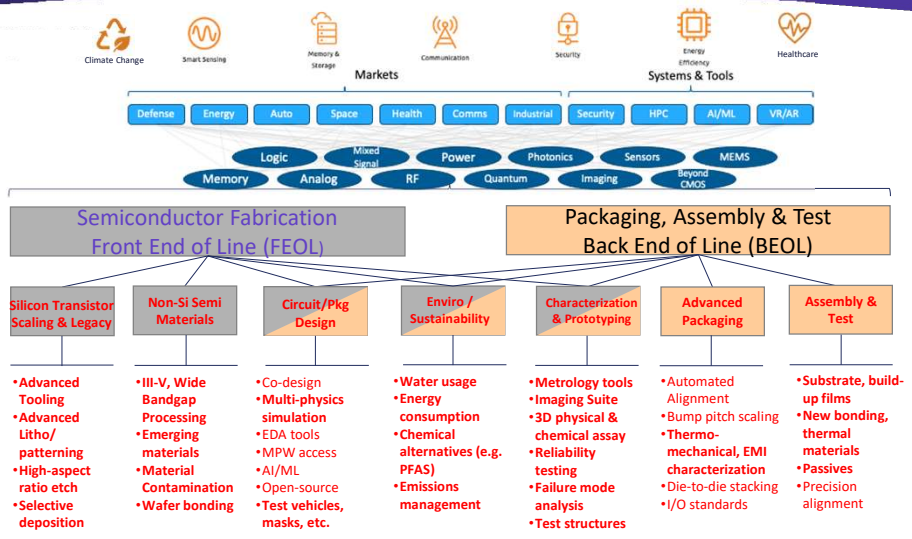
Opportunities for ACS Members to contribute to the CHIPS Act
The need for Over-The-Horizon Innovation, Roadmaps, Skills

Trends and Markets

Technology Stacks

Areas of Focus

Examples of Enabling Technology, Processes, and Tools



MITRE ENGENUITY

Nitin J. Shah

nshah@mitre-engenuity.org

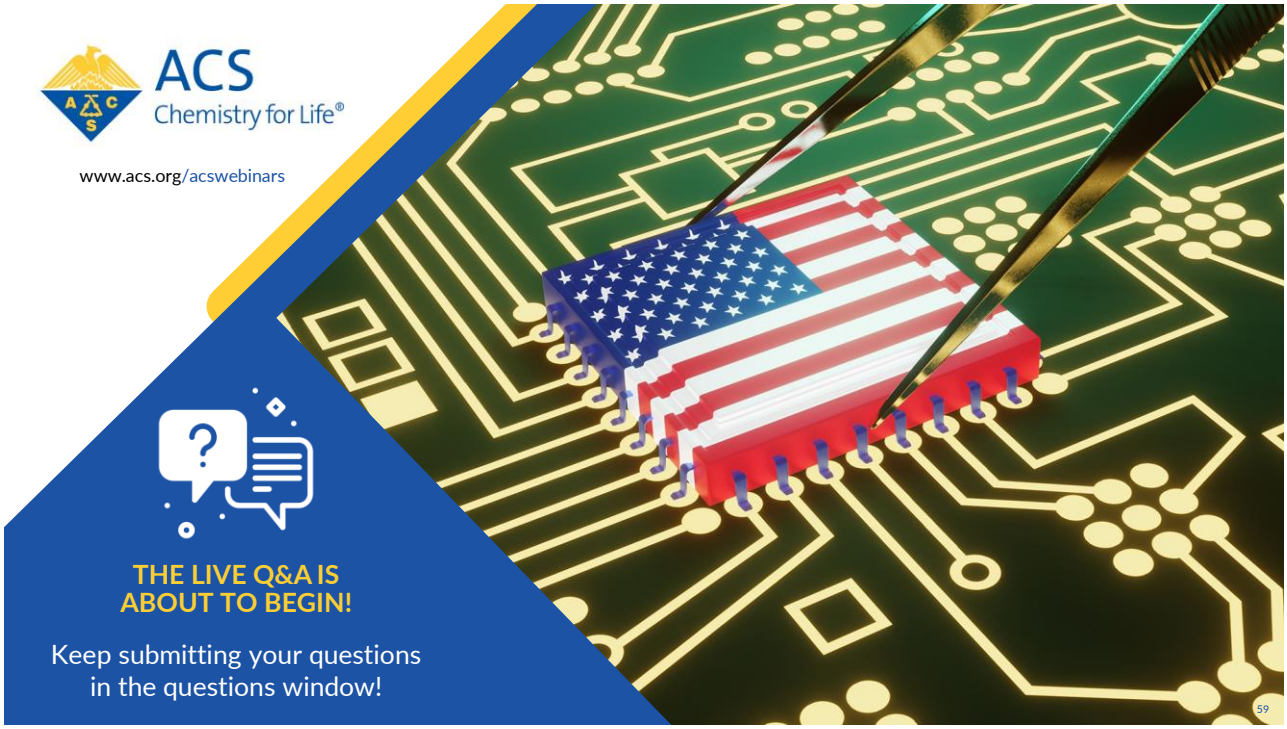
- Nitin J. Shah is an innovator, with over 35 years of experience in technology development, corporate and product strategy, marketing, and business development.
- Currently Nitin is Principal Innovator at MITRE Engenuity, a not-for-profit tech foundation for the public good, and is based in Silicon Valley.
- He is a leading architect of the MITRE Engenuity proposal for the National Semiconductor Technology Center and worked with corporations, start-ups, academia and financial institutions, to craft a position in support of the CHIPS Act and the resurgence of the US semiconductor industry.
- Previously, he orchestrated the successful proposal to NASA for an award to Nokia for deployment of first ever 4G/LTE network on the lunar surface. Nitin was in Nokia's Tech Ventures initiative, to commercialize IP and technology from Bell Labs via partners and incubators.
- Nitin's career spans AT&T Bell Labs, Lucent Technologies, Nokia Bell Labs, several start-ups, and providing consulting and decision services for clients such as DoCoMo, Ericsson, and Intel. He has expertise in mobile networking, digital media, consumer privacy and semiconductors.

MITRE ENGENUITY

Final Thoughts and Takeaways

- ***What is in the CHIPS and Science Act and what will it mean for the chemical enterprise:***
  - A Generational opportunity to accelerate innovation and manufacturing
- ***Insights into future directions of U.S. funding agencies like NSF, NIST, and DOE:***
  - Emphasis on workforce, a rich marketplace of ideas
  - Alignment and commitment by academia and industry to leverage the new funding
- ***How this legislation seeks to address science and technology challenges of the future, and how other countries are responding:***
  - We are in a global ecosystem where choices are going to be dictated by complex issues related to the supply chain, allies and collaborations, and broader issues of sustainability, climate and the environment

MITRE ENGENUITY



59

Final Thoughts and Takeaways

- ***What is in the CHIPS and Science Act and what will it mean for the chemical enterprise:***
  - A Generational opportunity to accelerate innovation and manufacturing
- ***Insights into future directions of U.S. funding agencies like NSF, NIST, and DOE:***
  - Emphasis on workforce, a rich marketplace of ideas
  - Alignment and commitment by academia and industry to leverage the new funding
- ***How this legislation seeks to address science and technology challenges of the future, and how other countries are responding:***
  - We are in a global ecosystem where choices are going to be dictated by complex issues related to the supply chain, allies and collaborations, and broader issues of sustainability, climate and the environment

MITRE ENGENUITY

60

ACS Chemistry for Life®

www.acs.org/acswebinars

ACS Webinars®
CLICK • WATCH • LEARN • DISCUSS

Thursday, June 22, 2023 | 11am-12:30pm ET

Biosynthetic Breakthroughs

Co-produced with ACS Publications and the ACS Division of Medicinal Chemistry

Thursday, June 29, 2023 | 2-3pm ET

ERGO: A Potential Answer in Mushrooms to Healthy Aging?

Co-produced with ACS Division of Agricultural & Food Chemistry

Wednesday, July 12, 2023 | 2-3pm ET

Chemistry and the Economy: 2023 Mid-Year Review

Co-produced with ACS Industry Member Programs

Register for Free

Browse the Upcoming Schedule at www.acs.org/acswebinars

61

61

ACS Chemistry for Life®

www.acs.org/acswebinars

ACS Webinars®
CLICK • WATCH • LEARN • DISCUSS

Learn from the best and brightest minds in chemistry!

Hundreds of webinars on a wide range of topics relevant to chemistry professionals at all stages of their careers, presented by top experts in the chemical sciences and enterprise.

Edited Recordings

are an exclusive benefit for ACS Members with the Premium Package and can be accessed in the ACS Webinars® Library at www.acs.org/acswebinars

Live Broadcasts

of ACS Webinars® continue to be available free to the general public several times a week generally from 2-3pm ET. Visit www.acs.org/acswebinars to register* for upcoming webinars.

*Requires FREE ACS ID

62

62

ACS Chemistry for Life®

www.acs.org/acswebinars

ACS Webinars®
CLICK • WATCH • LEARN • DISCUSS

ACS Webinars® does not endorse any products or services. The views expressed in this presentation are those of the presenter and do not necessarily reflect the views or policies of the American Chemical Society.

Contact ACS Webinars® at **acswebinars@acs.org**

63

63