Industrial Advisory Committee (IAC)
Meeting Summary

CHIPS Research and Development Office
National Institute of Standards and Technology (NIST)
Washington, DC
(Hybrid)
August 1, 2024

Advisory Committee Members:

Michael Splinter, Chair	MRS Business and Technology Advisors
Scott DeBoer, Vice-Chair	Micron Technology
Daniel James Armbrust	Silicon Catalyst
Ahmad Bahai	Texas Instruments
Elif Balkas	Wolfspeed
Gregg Bartlett	GlobalFoundries
Michael Fritze	Potomac Institute for Policy
Rajarao Jammy	imec USA
Kenneth Joyce	Brewer Science
Ann Kelleher	Intel Corporation
Mukesh Khare	IBM
Meredith Ballard LaBeau	Calumet Electronics
Tsu-Jae King Liu	University of California, Berkeley
Omkaram Nalamasu	Applied Materials
Debo Olaosebikan	Kepler Computing Inc.
Mark Papermaster	Advanced Micro Devices
Willy Shih	Harvard Business School
Kristin Toth	General Motors
Brandon Roderick Tucker	Washtenaw Community College
Philip Wong	Stanford University
Anthony Yen	ASML
Todd Younkin	Semiconductor Research Corporation

NIST Leadership:

Laurie Locascio	Under Secretary of Commerce for Standards and Technology Director, NIST
Eric Lin	CHIPS R&D Deputy Director
Briana Frisone	CHIPS for America Senior Policy Advisor
Kathryn Mitchel	CHIPS R&D Chief of Staff

Call to Order

Mr. Benjamin Davis, serving as the Designated Federal Officer (DFO) for the IAC, called the meeting to order and took roll call of the committee members.

Mr. Davis announced the DOC and NIST wholly appreciate the time, effort, and thought that go into the IAC's recommendations, DOC and NIST have no obligation to implement them. He also stated that a recording of the meeting and all presentations will be posted to CHIPS.gov following the meeting, and that a consensus of the body is defined as two-thirds of the committee.

Mr. Davis took roll call with the following results:

- Daniel Armbrust (Silicon Catalyst): Present
- Ahmad Bahai (Texas Instruments): Present
- Elif Balkas (Wolfspeed): Present
- Gregg Bartlett (GlobalFoundries): Present
- Scott DeBoer (Micron Technology): Present
- Michael Fritze (Potomac Institute for Policy): Present
- Rajarao Jammy (imec USA): Present
- Kenneth Thomas Joyce (Brewer Science): Present
- Ann Kelleher (Intel Corporation): *Not in Attendance*
- Mukesh Vijay Khare (Hybrid Cloud): Present
- Meredith Ballard LaBeau (Calumet Electronics): Present
- Tsu-Jae King Liu (University of California, Berkeley): Present
- Omkaram Nalamasu (Applied Materials): Present
- Debo Olaosebikan (Kepler Computing Inc.): Present
- Mark Papermaster (Advanced Micro Devices): Present
- Willy Shih   (Harvard Business School): Present
- Michael Splinter (MRS Business and Technology Advisors): Present Virtually
- Kristin Toth (General Motors): Present
- Brandon Roderick Tucker (Washtenaw Community College): Present
- Philip Wong (Stanford University): Present
- Anthony Yen (ASML): *Not in Attendance*
- Todd Younkin (Semiconductor Research Corporation): Present

I.   IAC Welcome and Opening Remarks

Mr. Michael Splinter joined the meeting virtually and welcomed all meeting attendees on behalf of the IAC. Mr. Splinter congratulated the Dept. of Commerce, Secretary Gina Raimondo, and

the entire CHIPS R&D team for moving quickly over the last 8 months. Mr. Splinter announced that two leaders of the IAC, Deirdre Hanford and Susan Feindt are now leaders of the NSTC. Mr. Splinter then introduced new members of the IAC, as follows:

- Scott DeBoer, IAC Vice Chair (Micron Technologies)
- Mark Papermaster (AMD)
- Greg Bartlett (GlobalFoundries)
- Todd Younkin (SRC)
- Kristin Toth (General Motors)
- Elif Balkas (Wolfspeed)

Mr. Splinter said that as CHIPS R&D moves from concept to implementation the work of the IAC will shift to focusing more on the longer term outlook of the nation's semiconductor strategy, as well as assessing the performance of the various entities created by the CHIPS Act. Mr. Splinter thanked the IAC members for the dedication to this committee.

Mr. Splinter outlined that the audience would hear recommendations from the following groups:

- The Workforce Working group on how to expand participation in the semiconductor workforce for underrepresented groups and regions
- The R&D Gaps team on metrology and digital twins
- The Organizational/PPP Working group on enabling domestic manufacturing of R&D breakthroughs and recommendations on how to align with CHIPS R&D efforts in allied countries.

Dr. Scott DeBoer thanked all of the IAC members as well as non-members who are part of the working groups. Dr. DeBoer said he looks forward to the discussions that will occur today and feels that the recommendations are well thought out, have been robustly debated, and represent a round view of this Advisory Committee's views.

II.   CHIPS R&D Update

Dr. Laurie Locascio thanked Mr. Splinter for his leadership as chair of the CHIPS Industrial Advisory Committee and thanked everyone in the room and online for joining this meeting.

Dr. Locascio said the Biden-Harris Administration is protecting our economic and national security and restoring American leadership and capacity in semiconductor manufacturing and industry by allocating 39 billion dollars to build factories domestically and investing 11 billion more in research and innovation. Dr. Locascio shared that CHIPS is unlocking more than 300 billion dollars in private investment and creating more than 100,000 jobs.

Dr. Locascio thanked the IAC for their dedication and tireless work in helping develop the CHIPS R&D programs. Dr. Locascio shared a few figures about the IAC:

- There are 22 members
- There are 3 working groups
- There are 12 working group members
- There are 70 recommendations, with a new set coming today.

Dr. Locascio shared that over the past two years the CHIPS Program Office Team has announced more than $30 billion in proposed direct funding for factories to build domestically and $25 billion in proposed loans. Dr. Locascio shared that the proposed grants will support 19 greenfield fabrication plants, equivalent to 131.5 football fields worth of clean room space, and 665,000 metric tons of steel.

Dr. Locascio shared that according to the Semiconductor Industry Association (SIA) in a recent industry report, the U.S. is now on pace to grow its share of global logic manufacturing to 28% by 2032, and is on pace to capture 28% of capital expenditures.

Dr. Locascio highlighted a few of the CHIPS R&D Office actions that had taken place since the last IAC meeting in November 2023, based on IAC recommendations. These actions included:

- Announcing 3 Notices of Funding Opportunities to support advanced packaging materials and substrates, to support small business innovation research, and to establish a new CHIPS Manufacturing U.S.A. Institute.
- Later this year, CHIPS R&D will award approximately $285 million to a CHIPS Manufacturing USA Institute dedicated to digital twins for semiconductors.
- Funded more than 50 teams on 34 projects to address metrology ground challenges, including several projects on topics recommended by the IAC.
    - More than $130 million are committed to address measurement challenges informed by and in partnership with industry.
- In collaboration with the Small Business Innovation Research Program, the CHIPS R&D Office launched a funding opportunity for up to $54 million for a small business to fast-track the technologies needed to manufacture more complex, smaller, and multi-layered devices. Recipients of this funding will be announced this Fall.
- Established plans to support 6 foundational technology areas and built a plan for an advanced packaging pilot facility.
- Released a Notice of Intent to invest up to $1.6 billion in an open competition for new R&D activities to accelerate and establish domestic capacity for semiconductor advanced packaging in 5 technical areas ranging from process integration to chipless ecosystem to EDA.

Dr. Locascio applauded Dr. Subramanian Iyer for his leadership as director of the National Advanced Packaging Manufacturing Program (NAPMP) and welcomed the new NAPMP Director, Dr. Dev Palmer. Dr. Locascio also thanked Dr. Marla Dowell for leading the metrology program while also helping lead NAPMP.

Dr. Locascio shared that the National Center for the Advancement of Semiconductor Technology (NATCAST), the nonprofit established to lead the National Semiconductor Technology Center (NSTC) consortium, will now be led by former IAC member Deirdre Hanford. Dr. Locascio shared that NSTC will serve as a funding organization and as a gateway to access state-of-the art facilities for semiconductor R&D.

Dr. Locascio shared what can be expected from CHIPS R&D in the coming months, including:
- Updates on CHIPS R&D infrastructure.
- A second research funding opportunity for the NSTC.
- A second funding opportunity for the NAPMP.
- An announcement on how CHIPS R&D will support efforts for sustainability in semiconductor manufacturing along with funding opportunities for these efforts.
- An announcement of several new advanced metrology projects with opportunities for industry to engage with NIST in cooperative research.

Dr. Locascio thanked IAC members who have moved away from the committee or taken other positions, including:
- Deirdre Hanford
- Susan Feindt
- Chuck Gray
- Tsu-Jae King Liu, who is not leaving IAC but stepping down from leading the Workforce Working group.

Dr. Locascio welcomed the following new IAC members:
- Elif Balkas
- Kristin Toth
- Scott DeBoer

Dr. Locascio gave special thanks to Briana Petyo Frisone, Senior CHIPS Advisor since January, 2024.

III.   Fireside Chat

Dr. Locascio welcomed Dr. Arati Prabhakar, Director White House Office of Science and Technology Policy, to the stage for a seated interview.

Dr. Locascio first asked Dr. Prabhakar to tell the audience about her background.

- Dr. Prabhakar shared that she earned her PhD 40 years ago, at which time she wrote a study called "Microelectronics R&D." After four decades of working on semiconductors, Dr. Prabhakar shared she was joyfully stunned when the CHIPS Act was signed two years ago, and she is impressed with what has been accomplished in those two years. Dr. Locascio shared that Dr. Prabhakar is also a former NIST Director, and the first female director.

Dr. Locascio next asked Dr. Prabhakar to share what she is looking forward to most in this industry.

- Dr. Prabhakar said she is interested to see how this deeply technical industry changes quickly, particularly the boundary between chips and packaging. Dr. Prabhakar is curious to learn what R&D advances will lead to competitive advantages here in the U.S. so that global companies will continue to build their operations and support a robust and resilient supply chain.

Dr. Locascio then asked Dr. Prabhakar to share her thoughts on bridging the gap between basic R&D and commercial product development and avoiding the so-called "Valley of Death."

- Dr. Prabhakar said she believes some projects will fail, but sometimes that is necessary and part of the process when making breakthroughs and disrupting industry norms. Dr. Prabhakar cautioned against incremental change, which will not meet the current challenge.

Dr. Locascio asked Dr. Prabhakar to share her thoughts about building the workforce to support the domestic semiconductor industry.

- Dr. Prabhakar shared a story about how her uncle, an immigrant, built a great life for his family by working his way up in the semiconductor industry. Dr. Prabhakar said the semiconductor industry will make it possible for people to have good-paying jobs that will change their lives.

Dr. Locascio then asked Dr. Prabhakar to share her thoughts on how to encourage sustainability in the semiconductor industry.

- Dr. Prabhakar said surviving isn't the objective of this effort; the goal is to have a real impact that results in an American competitive advantage, and the rest will follow.

Dr. Locascio then opened the floor to questions from IAC members.

Michael Fritze asked Dr. Prabhakar to share her thoughts on how the government can play a role in driving demand for more secure domestic sources, considering the cost of domestic manufacturing is likely to be more expensive.

- Dr. Prabhakar stated that finding ways for more affordable manufacturing is something R&D could tackle. Dr. Prabhakar also spoke about military demand for semiconductors, stating that although it may not be as strong as it once was, there are specialized needs that may overlap with commercial needs.

Mr. Mark Papermaster asked Dr. Prabhakar to share her thoughts on how the current administration could promote workforce development by creating more pull for youth to go into semiconductor and overall technology workforce development paths.

- Dr. Prabhakar stated that federal funding of R&D is important, but at some point, industry takes over, which is the case in the United States, and is what drives innovation. Dr. Prabhakar shared that there are numerous ways semiconductors are the basis of remarkable innovations in this country and she shared many examples. Dr. Prabhakar said she believes that the many different ways technology can be used for public good will excite the next generation.

IV.   R&D Gaps Working Group Report Out and Discussion

Mr. Dan Armbrust thanked Dr. Locascio for the thorough recap and thanked Dr. Prabhakar for her appreciation and for putting CHIPS R&D into perspective with whole government activities.

Dan Armbrust shared that in the working group's first charge, they were asked to comment on what capabilities need to be established that are missing today and to comment on the importance of thinking strategically about grand challenges. Dan Armbrust named a couple of the grand challenges:

1. Providing affordable and accessible prototyping capability for silicon and chiplets and advanced packaging.
2. Digital semiverse – the group's way of indicating they believe digital twins have the potential to dramatically change how the industry can research and control and make efficient manufacturing. Investment in this realm could be hugely advantageous for US leadership and make a workforce shortage far more productive.

Mr. Dan Armbrust shared that in response to those challenges, the working group was then charged with providing recommendations on how to implement digital twins. Mr. Dan Armbrust shared that simultaneous to receiving that charge, a new Manufacturing USA Institute was announced focused on digital twins (DT Mfg. USA Institute), with far more invested in the technology than ever before.

Mr. Dan Armbrust thanked his fellow working group members and stated that three members recused themselves from this sprint because of a potential conflict of interest. Those members were:

- Philip Wong
- Todd Younkin
- Ann Kelleher

Mr. Dan Armbrust shared a general definition of a digital twin: a virtual representation of a physical entity. Mr. Dan Armbrust explained that the interaction of those two elements is the essence of digital twins. Mr. Dan Armbrust explained that the model created by the digital twin allows you to predict what will happen with the physical entity in real-time and leads to decisions. Mr. Dan Armbrust said the bidirectional interaction between the virtual and the physical is central to the digital twin.

Mr. Dan Armbrust shared that the working group held meetings weekly since March 2024, and in their second meeting they spoke with CHIPS R&D Deputy Director Eric Lin, and in their third meeting they spoke with Eric Forsythe, Technical Director of the CHIPS Manufacturing USA Institute.

Mr. Dan Armbrust shared that the group approached over 20 experts to respond to 12 questions about digital twins in 20 minutes time increments via recorded videos. Mr. Dan Armbrust said the working group members split into two teams to review the videos.

Mr. Dan Armbrust shared that the group learned that digital twins can be conceived and used in many different ways. Mr. Dan Armbrust shared that the measure of success for digital twins is adoption into R&D, and they must be purpose-built. Mr. Dan Armbrust shared there are several barriers for adoption, including lack of standards, what the workflow should look like, lack of interoperability, and reluctance to share data.

Mr. Dan Armbrust then submitted the R&D Gaps Working Group's recommendations, as follows:

Shared Capabilities:
1. There is a strong consensus that a large unmet need exists for pre-competitive standards, workflows, data sharing and security protocols (while protecting privacy), and intra/interoperability among digital twins. Establishing and disseminating these should be the highest priorities of the DT Mfg. USA Institute, and especially methods to promote greater data availability and sharing through various methods such as federation, anonymization, encryption, and synthetic data --- which are of even greater importance

with recent advances in data driven models such as machine learning/artificial intelligence (ML/AI).

2. The DT Mfg. USA Institute should focus on building an 'agnostic digital backbone' as a seed for industry solutions such as sustainability, energy consumption, throughput, variability, yield and cost. The rough priority ordering* should be:
- From unit process/equipment (including tool fleet matching) to short loops to partial/full flow
- From development to ramp to high-volume manufacturing
- From fab to packaging to test that link to yield and reliability outcomes
- From ab-initio to purely empirical models
The IAC does not recommend Digital Twins for materials synthesis or supply-chain / logistics as they are addressed by existing programs elsewhere across academia, gov't labs and industry

3. Digital twin projects should build multiple models based on the spectrum of multi-physics to data driven ML/AI approaches and implement hybrid models combining these approaches (e.g., mixture of experts).

4. The DT Mfg. USA Institute should prioritize digital twin projects that address a critical pain point in R&D and manufacturing for at least one grand challenge for the NSTC, and one for the NAPMP. This can be a unique opportunity to leverage direct access to the physical fabrication dataset from facilities that support CHIPS Act NSTC/NAPMP research and prototyping.

Industry Solutions

1. Digital Twin projects must establish a clear vision of the pain point being addressed (such as yield, throughput, variability, cost, sustainability and life cycle management) in R&D and manufacturing, the frequency that the twin needs to be updated, and the anticipated beneficial outcomes — that is, they must be purpose built without the expectation that they need to be general purpose solutions.
    - The needs for Digital Twins in R&D will likely differ from the transition to tech transfer & high-volume Mfg.
    - Complexity and accuracy of DT should correspond to expected pain points, goals, and success metrics.

2. There is an emerging opportunity to build digital twin capabilities for an open chiplet marketplace that link the fab, packaging, test (including design and test vectors) and system level functionality. A project in this space has the potential to attract the test, design (product and system), and manufacturing communities in ways that cut across

traditional silos — and represents a unique and valuable capability that tackles the complex data, logistics, and supply chain integration associated with this objective. The goal would be to enable a greater use of mix and match capabilities for open chiplet marketplace for 3D heterogeneous advanced packaging.

3. A small business/startup funding track should be established that more readily aligns with their specific timing, financial, and overhead needs, enabling rapid experimentation of higher-risk innovation that can be scaled up if successfully demonstrated.

Work Force Development
1. Digital Twins should fill an important gap in facilitating the training of our future workforce on equipment, processes, integration, and design capabilities. This may be best facilitated by soliciting specific proposals to address each capability, with a focus on under-represented groups and regions lacking access to physical assets. These Work Force Development (WFD) targeted proposals should focus on training efficacy where lower model precision and accuracy is acceptable.

2. The Digital Twins Institute should work directly with each WFD development group in the CHIPS ecosystems to develop collateral and curriculum that is shared across the entire education and workforce development ecosystem to educate the future workforce on the development and use of digital twins.

3. As part of a 'branding' campaign to increase the STEM/microelectronic pipeline for K-12, the Digital Twin Institute should consider a virtual twin of an entire fabrication facility, enabling an immersive in-fab tour.

Institute Operations (Governance)
1. Achieving widespread adoption of digital twins will require building consensus around standards and interoperability considerations. A properly constructed governance and advisory structure for the Digital Twin Mfg. USA Institute should ensure appropriate representation from pivotal stakeholders and the relevant ecosystem that can help achieve this goal.

Deliberation Period:
Q. Mr. Mark Papermaster: Did you discuss the role that either the Digital Twins Institute or, more broadly, NSTC could play in driving standards? It would be a new area, so have you considered barriers you may need to overcome and governance to drive those standards?
A. Mr. Dan Armbrust: I'd like someone from my team to comment. Yes, it was talked through and discussed. The simplified takeaway was to get to standards—everyone is hungry for

someone to declare approximately good standards. The desperate need for them is as far as we got. The complexion and work associated with lack of them is hurting everyone.

Comment from Mr. Ben Davis: As Dan indicated, two members did need to recuse themselves. Todd Younkin and Philip Wong won't be participating in deliberations and voting.

Q. Dr. Willy Shih: Just to reinforce the point—it would seem the standards definition is going to be a very important process in terms of how we ensure a clean interface and no dependency or a certain amount of independence. That is an important design goal.
A. Mr. Dan Armbrust: I would just add to that, we didn't feel confident we had done the work that would allow us to weigh meaningfully to determine the shape and complexity of the standards. That was our first recommendation: get that right.

Q. Dr. Scott DeBoer: Do you have any comments on specific pain points you or the team were thinking of highlighting?
A. Mr. Dan Armbrust: There was one in the recommendations. We think the pain point around declaring a known good die is a very specific technical challenge. That is an adoption barrier for chiplets today and it's been solved in high bandwidth memory and will probably be solved in transceivers soon but as you generalize that it brings us back into early days of does the chip work or not, and how do we know, and can we declare it at the die level before it gets in this complex package? Most of it was in retrospect. We wish we had a digital twin to address some of the long, intensive R&D activities. Forward looking, the one that is not packaging related is around what are the next candidates to replace charge based transistors. We better be building digital twins around the fabrication of those sensitive processes defining characteristics of an electron's spin, for example, or a magnetic spin. Again, it would probably relate to the processing conditions related to device characteristics that ultimately related to the design box that we're trying to produce. That's nonspecific because we really wanted to have the NSTC and NAPMP weigh in on a research problem that they could get very specific about, so we elected not to declare the pain point itself.

Comment from Dr. Mukesh Khare: This is a semiconductor and CHIPS advisory committee. Digital twins are very deeply connected to AI related activities. AI and semiconductors are deeply connected, so as a part of our thinking we need to figure out, how we bring those two communities together and leverage the advancement of AI into digital twins. Or else we live in a world of modeling and simulation and AI will take off in a separate direction.

Mr. Ben Davis called the IAC to consensus vote on the R&D Gaps Working group recommendations:

<u>Shared Capabilities</u>

Recommendation 1: 0 Opposed
Recommendation 2: 0 Opposed
Recommendation 3: 0 Opposed
Recommendation 4: 0 Opposed

Industry Solutions
Recommendation 1: 0 Opposed
Recommendation 2: 0 Opposed
Recommendation 3: 0 Opposed

Workforce Development
Recommendation 1: 0 Opposed
Recommendation 2: 0 Opposed
Recommendation 3: 0 Opposed

Institute Operations
Recommendation 1: 0 Opposed

Vote Result:
All recommendations were passed.

The meeting broke for lunch and reconvened at 12:50 p.m. ET.

VI.   **Organizational and PPP Working Group Report Out and Discussion**

Dr. Willy Shih emphasized this was a team effort and a diverse group with a wide range of experiences that made for some really powerful meetings. Dr. Shih expressed significant thanks to Mr. Ben Davis.

Dr. Shih shared that the charges the working group were given were first focused on recommendations for opportunities to facilitate and encourage domestic manufacturing of CHIPS R&D innovations. Dr. Shih shared that, secondly, the group was asked to provide recommendations for opportunities and challenges for coordinating, aligning, and partnering with allied countries.

Dr. Shih shared the group's timeline and stated that the group has met nearly weekly since February 2024.

Dr. Shih shared that the group's approach to their first charge was to focus on ways to create attraction for the industry for a variety of groups, including traditional manufacturers, universities and R&D organizations, users, and strategic customers.

Dr. Shih shared that the group encourages NSTC to think about the space for innovation and harness, encourage and provide a forum for setting new standards, and center the chip, not the foundry. Dr. Shih shared that the group also sees opportunities for centering sustainability and green initiatives in materials and in power use through domestic manufacturing. Dr. Shih also shared the group's thoughts on creating pathfinding projects in the post-scaling world, such as road mapping and simplifying error-prone and yield-lowering complex logic processes, among other suggestions. Dr. Shih said the group agreed that demand-side incentives could also help encourage domestic manufacturing, such as investment tax credits or tradable production credits.

Dr. Shih explained that the working group examined the characteristics of successful collaboration models, including maintaining an open science environment and establishing a forum for international participants.

Dr. Shih shared the group's recommendations, as follows:
1. The NSTC should host compelling projects that attract semiconductor manufacturers, equipment makers, universities, and R&D organizations, as well as significant users from hyperscalers, product companies, and strategic companies.
2. Initiatives should revolve around later technology stage work – investments to bridge the gap between R&D and volume manufacturing.
3. Suggested themes: enhanced chip security and provenance, sustainability, pathfinding projects in the post-scaling world, and demand side incentives.
4. NSTC should advocate for demand-side incentives that would be complementary to CHIPS Act supply-side incentives, citing Presidential Policy Directive -- Critical Infrastructure Security and Resilience.
5. Create compelling programs and assets in the pre-competitive space through NSTC Design Centers that will attract international collaborators.
   – Linking first-principles calculations to a world-class materials/devices laboratory
   – Leverage the Design Enablement Gateway to collect data for domain-specific model building
   – Establish modular interfaces around a pre-competitive core to enable proprietary additions
6. Commit to an open pre-competitive research model, and an open science environment.
7. Enable proprietary collaborations that build on the pre-competitive research using the model that was described in the June 2023 ORG/PPP working group recommendations.
8. NSTC should be a forum for international participation

       – Convenor and collecting inputs
       – Cooperative activities
       – Transitioning ideas from outside the U.S. to domestic manufacture

Deliberation Period:

Mr. Dan Armbrust: We recommended not doing materials discovery for digital twins. It didn't mean we shouldn't do materials discovery. It's just that we didn't think it fit under the construct of a digital twin. So, if it looks like there's a lack of harmony between the two, it's actually because when we met earlier in the cycle, we agreed that this team should focus on materials discovery, we should not slot it into the digital twin.

Dr. Shih: Especially when looking at materials discovery, having standard software that are more or less standardized approaches for doing those things and maybe there is an opportunity there.

Mr. Mark Papermaster: Commentary on silicon provenance. The reason that fits is that there is a common theme of opening up innovation and getting more players to bring innovation, but the security of the supply chain is fundamental. Without trust, it doesn't work. In early discussions we find the time is right. There is new tech coming out that enables us to use metadata and the blockchain to train the whole life cycle of silicon.

Dr. Shih: I think that also reinforces this is a great time to set standards, or really lay out some of these areas for US leadership right? Because I think the consensus of our group, I would say, is that people are beginning to realize how important this is, so the timing on it is very good.

Dr. Michael Fritze: I do want to foot-stomp a point about foreign participation. There is a precedent that we understand; for example, Japanese automakers provide many U.S. jobs. Many districts could benefit enormously from jobs working with allies. This also diversifies us from our U.S. adversary, China. But that is something that needs to be socialized.

Q. Ahmad Bahai: In your earlier proposal you emphasize late-stage lab-to-fab. Material discovery is not in that stage. It is more in research than R&D. Can you reconcile that?

A. Dr. Shih: Things that we know are coming that are important that may not attract international investment that we can accelerate. Depending on the area the stage is going to be a little different. I know this is important, but I have short-term issues. Is there an opportunity to accelerate those things? We use the lab-to-fab example because when you think about first principle material calculations, there is a gap in reduction to practice, but could we accelerate that when you're thinking about newer material? Can we drive more experimentation and accelerate some disruptive discoveries?

Q. Dr. Rajarao Jammy: I like the way you talked about the push and the pull part of it. Was there any discussion around supply chain and strengthening the supply chain? Components and subcomponents?

A. Dr. Shih: You hit on an essential point. I need the Bill of Materials (BOM) of the product that I deem to be strategic that I need resilience on. People don't want to disclose their BOM, which is a problem. The philosophy is: let me incent the person who owns the top of the BOM because that person will know everyone in the supply chain, but if I incent the top, I can have competition among multiple suppliers and have things like domestic content incentive.

Q. Dr. Mukesh Khare: The semiconductor industry, as we all agree, is a global industry, and as it was mentioned earlier on, we all know that it's the national security interest that was very important for the CHIPS Act, in addition to the commercial aspect. After US leadership in CHIPS Act, a handful of countries also introduced their version of the CHIPS Act, and I know there has been a bilateral discussion between U.S. and other countries, and there is only a handful of regions that are focused on semiconductors, maybe five or six, Europe, Japan, Korea, India come to mind. Should we take a more proactive role? Because many of them actually followed a similar blueprint of the CHIPS Act, and they are all looking for some kind of central coordination so that they can all work together. And is this an opportunity for us to maybe have a first convening forum where maybe five regions, which we all know, can come together and start to figure out, how do we coordinate it at a national level? Maybe start with R&D and then expand it into manufacturing.

A. Dr. Shih: I think that's right. How can NSTC be a convener? And then you'll see our points around open science and ensuring a level playing field for non-domestic headquarter manufacturers, if that is as much about setting a tone of how we want to collaborate. If we can set that kind of higher-level tone and encourage participation among allied nations, everybody ends up much stronger as a result of that.

Dr. Om Nalamasu: I think of 9906 as the reassuring, globalizing manufacturing. So, if you think about the 9902 I guess there are two objectives. One would be to address fundamental challenges for the industry from now to 10 years down the road, 15 years down the road, for example, 1,000x energy efficiency. Then I'm also assuming that part of the charter of the 9902 funding is to give a competitive advantage to the domestic industry in semiconductor manufacturing. But if you just look at the first objective about the industry challenges, along the lines of what Mukesh was saying, there are multiple initiatives in Fair Trade countries—a significant amount of dollars, and if we can work with them, we can certainly accelerate solving these problems together. And there are models whether it is universities working under the construct of NSF or DOE, with relevant institutions in those countries. So, I don't even know if there is a problem of money going from here to companies outside the United States because they have their own funding, which could be deployed on problems of mutual importance.

Dr. Willy Shih: Adding to that, you have the US market, the Indian market, collectively that's a huge market.

Mr. Ben Davis called the IAC to consensus vote on the Organizational and PPP Working group recommendations:

Recommendations:
Recommendation 1: 0 Opposed
Recommendation 2: 0 Opposed
Recommendation 3: 0 Opposed
Recommendation 4: 0 Opposed
Recommendation 5: 0 Opposed
Recommendation 6: 0 Opposed
Recommendation 7: 0 Opposed
Recommendation 8: 0 Opposed

Vote Result:
All recommendations were passed.

VII.   R&D Workforce Working Group Report Out and Discussion

Dr. Tsu-Jae King Liu began by acknowledging her colleagues in this working group and welcoming new member, Kristin Toth. Dr. King Liu also thanked Kevin Kornegay and George White, who joined midway through this sprint, and thanked IAC member Philip Wong for joining this working group.

Dr. King Liu shared that the group's charge was to provide recommendations for opportunities, challenges and strategies to broaden participation in the semiconductor workforce specifically from underrepresented groups and in regions that do not have a critical mass of semiconductor activity.

Dr. King Liu explained that the working group met almost weekly and invited expert speakers to each of their meetings. Dr. King Liu shared that the group reached out to educators at 22 Historically Black Colleges and Universities in addition to meeting with Mark Whitty, a marketing expert. Dr. King Liu said the group's goal was to create a coordinated workforce marketing strategy to get millions of people to think about STEM and careers in the semiconductor industry.

Dr. King Liu shared the group's key findings, as follows:
- There is a need to increase the capacity and availability of existing chip facilities to a larger number and diversity of students.

- There is a need to provide adequate resources to support the professional development of teachers and faculty in STEM, especially at community colleges and non-R1 universities.
- Need to increase exposure, get people more comfortable so they are inspired. The key is marketing. Start early, K-12. Come up with a strategy to encourage industry engagement.
- National coordination (sharing of resources and best practices) is necessary for efficiency and speed of workforce development in underserved regions.
- Need to increase opportunities for students (and instructors) to gain hands-on learning experiences.
- Support Minority Serving Institutions to partner and lead collaborations with R1 universities for curriculum development, faculty training, and research
- To recruit and retain employees, wraparound services are needed, such as assistance for finding job/career opportunities, advice/education for managing personal finances, subsidized housing for employees.
- Need to cultivate a broader workforce development ecosystem.
- There will likely also be a need to balance talent supply & demand in the long term.

Deliberation Period:
Q. Dr. Om Nalamasu: If you talk to our engineering workforce, one of the things they mention about the attractiveness of the semiconductor industry is that they get to work and travel across the world. So, I think the global element is an attractive element of the semiconductor industry. Can the NSTC play a convening role? Is there an opportunity to be thinking about externships or internships outside the US as an attractive feature?
A. Dr. King Liu: I think we do recommend to include that explicitly.

Q. Dr. Willy Shih: Did you have any discussion on stable demand? As in, are there things we can encourage to do that would provide a longer-term view for people to want to have a career in this?
A. Dr. King Liu: I think this is a sort of implicit in this finding, that employees need to be able to grow professionally. The need to build a clearinghouse so students and professionals can always find where the jobs are could really be helpful in this regard.

Q. Dr. Willy Shih: This is really tough, especially in a commodity segment and you have a cyclical downturn and employers have to reduce costs. Are there incentives we could recommend that encourage and help employers have a more stable longer-term view on employment? It's a difficult question. The worst thing to do is build this pipeline for workers and then we run out of jobs. I've seen this happen with students over the past few decades.
A. Dr. King Liu: Maybe, if there are members from the industry who could comment.

Dr. Ahmad Bahai: The industry is cyclic but the envelope is going up. So, opportunities are growing. Advanced opportunities and AI are going to change the landscape. The future will be quite different from the past.

A. Dr. King Liu: So, your answer is continual professional development because the nature of the jobs or nature of work will change and will be evolving so preparing students to be lifelong learners so that they don't get discouraged. If you know some doors are closed, they will always be able to find other opportunities.

Q. Dr. Philip Wong: On the clearinghouse, which is really an important part, how do we make sure that the companies who are supplying this data are not overstating their demand? The result would be an oversupply of students and an artificial depression in their compensation.

Q. Dr. Rajarao Jammy: I also want to touch on this. The demand side is always the important thing. To prevent the bleeding of talent from the industry and the country, is it time to have an insurance plan that protects employees who don't have immediate jobs? Is that something to be considered?

Mr. Richard-Duane Chambers: You mentioned MSIs and HBCUs do a great job graduating a large population of our industry but a lot of these universities don't have the research capabilities. Did you find any models that work well for these institutes or areas of research they could jump into early on?

A. Dr. King Liu: Each of the 22 universities in the 22 HBCU network has strengths for the semiconductor industry. One fundamental challenge is that the faculty there teach a lot. Typically, 3-4 courses per term so they don't have time for research. So, the administration needs to let them buy time off from teaching so they can do research. How do we gradually evolve a different track for faculty who would like to spend significant time on research? By offering support that could help incentivize these universities to grow their research programs strategically.

Dr. Scott DeBoer: in response to Dr. Philip Wong: In general, as we all know, there is a bullish forecast and a large number of fabs being built in the U.S. This is a great idea, mapping out job opportunities in the country, it just has to be done thoughtfully with ranges of job creation in different places because this is a topic that everyone recognizes as a challenge. We are so far behind that there may be an overly bullish forecast at this moment and there will be ups and downs, as there always have been. But even the downside of the range is so big that the opportunity is to get this pipeline going and then to make sure we're not overestimating in the future. We don't want to undershoot it, though, because the opportunity is huge.

Dr. Philip Wong: I totally agree with you, the situation is dynamic and we don't want to undershoot. When something is free, there is no cost in requesting it. Is there any way to make sure the companies who make the request actually hire those people?

Dr. Scott DeBoer: That requires more thought, as we go through workforce development there is huge investment so coordinating this between investments of government and the private sector and organizing it in a good way so that its synergistic is important.

Mr. Ben Davis called the IAC to consensus vote on the R&D Workforce Working group recommendations:

Recommendations:
Recommendation 10: 0 Opposed
Recommendation 11: 0 Opposed
Recommendation 12: 0 Opposed

Vote Result:
All recommendations were passed.

VIII. Public Comment period:

Mr. Mr. Ben Davis stated that these public comments were submitted during registration, and they are not for consideration or response by the IAC; this is the public's opportunity to be heard. Mr. Davis shared that IAC members are under no obligation to respond to comments that have been provided.

Mr. Davis read the following list of public comments:
- Supply chain, traceability and security should be a foundational component of any award enabling hardware, Bill of Materials tracking from foundry through deployment.
- I appreciate the opportunity to provide comment to the NIST IAC regarding two inconsistent federal employment earnings and establishment for semiconductor manufacturing. The North American Industry Classification System, or NAICS has two codes of interest. The NAICS code 334413, represents semiconductor related device manufacturing, and the NAICS code 333242, is for semiconductor machinery manufacturing. On July 5, NIST submitted an emergency information collection request, (ICR) to the Office of Management and Budget for review and approval by July 15 of an ecosystem questionnaire for states and territories to inform CHIPS R&D facility site selection process. Simultaneously, NIST published a notice in the Federal Register inviting the public to comment on the ICR by July 12. The questionnaire asked for employment figures within both of the semiconductor NAICS codes of interest that were

mentioned before. Both alert the Bureau of Labor Statistics (BLS) and the Census Bureau published employment figures for the NAICS codes that were mentioned. When comparing the numbers provided by the BLS and the Census Bureau, I found the numbers to be inconsistent. The success of the CHIPS for America program depends, it seems to me, on the reliability of available statistics on the magnitude, location, and characteristics of semiconductor-related manufacturing industries. That two federal statistical agencies generate somewhat different numbers for the same industries, I believe, reduces the likelihood of CHIPS for America's success, or could be an obstacle. Furthermore, I ask the question, to what extent does the IAC believe the inconsistent federal manufacturing statistics are problematic for the success of CHIPS of America? If the IAC believes the inconsistent numbers represent any problem whatsoever, would it make a recommendation to the Secretary regarding the need to address it, and an approach for doing so? If the IAC would like to make a recommendation, what does it think it needs to know before it does so?

IX.   Summary and Closing Remarks

Dr. Locascio thanked everyone and expressed enthusiasm about the recommendations presented. Dr. Locascio affirmed that the advice and comments provided here were very thought-provoking and are already driving a lot of conversation among the CHIPS members. Dr. Locascio thanked Dr. Arati Prabhakar and all of the IAC members and working group members for their insights and recommendations.

X.   Adjournment

Mr. Davis shared that a recording of this meeting, a summary of this meeting, and all presentations will be posted online at CHIPS.gov for public access.

Mr. Ben Davis adjourned the meeting at 2:28 p.m. ET.

I hereby certify that to the best of my knowledge; the foregoing minutes are accurate and complete.
IAC Chair: Scott DeBoer
Date: 11/27/24