COLLEGE OF NANOSCALE SCIENCE & ENGINEERING
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College of Nanoscale Science and Engineering (CNSE) and
Semiconductor Equipment Materials International (SEMI)
Request for Information (RFI) Response --
NIST Advanced Manufacturing National Program Office (AMNPO)
National Network for Manufacturing Innovation (NNMI)
Institutes for Manufacturing Innovation (IMI)

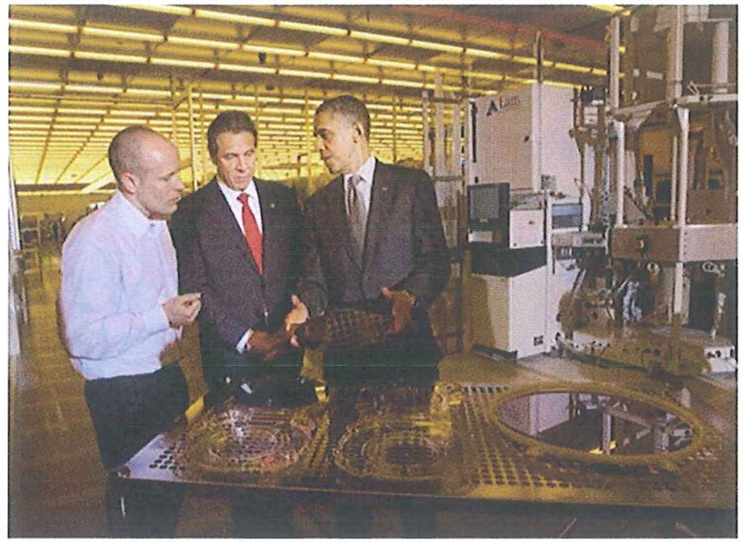
October 25, 2012

The College of Nanoscale Science and Engineering (CNSE) and Semiconductor Equipment and Materials International (SEMI) are pleased to partner on the submission of a response to the National Institute of Standards and Technology (NIST) Request for Information that reflects our combined experience and commitment to support the development and manufacturing of microelectronic technology in the United States.

SEMI is a global industry association representing the microelectronics manufacturing supply chain. The College of Nanoscale Science and Engineering, University at Albany, State University New York is the leading university-based research and development (R&D) infrastructure for advanced nano-scale innovation in the United States.

Both CNSE and SEMI are collaborative organizations that spur education, innovation and growth in high-technology manufacturing. Together, we offer a comprehensive perspective on the requirements for successful and coordinated programs to promote manufacturing in scientifically complex, capital intensive, strategically important, and economically vital sectors, such as semiconductor manufacturing technology.

We applaud the vision for a National Network for Manufacturing Innovation and respectfully offer input to support the broad vision of the proposed program. Combined, our organizations represent the manufacturing and R&D capabilities of the U.S.-based semiconductor manufacturing equipment industry. We develop and manufacture the equipment and materials to fabricate semiconductor devices – or "chips," which are the miniature "brains" in computers, smart phones, tablets and virtually every commercial and military electronic product. We represent over 500 U.S. companies, of which more than eighty percent are small and medium sized enterprises with less than $25 million in annual revenue. Together, these companies employ 70,000 direct workers responsible for over $20 billion in annual U.S. exports of U.S.-made semiconductor manufacturing equipment and materials.



In May 2012, President Obama visited CNSE, one of the world's only global nanotechnology education, research, development and technology deployment resource centers. In his remarks the president stated, "Right now, some of the most advanced manufacturing work in America is being done right here in upstate New York. Cutting-edge businesses from all over the world are deciding to build here and hire here. And you've got schools like this one that are training workers with the exact skills that those businesses are looking for. You've got an outstanding university. Now I want what's happening in Albany to happen all across the country." As we have seen, the President understands the importance of U.S. high-technology development and manufacturing. We applaud the President's leadership to put forth government programs to support the development and manufacturing of U.S.-based high-technology.

The NIST Advanced Manufacturing National Program Office has presented a number of important questions pertaining to the scope and structure of a proposed network of Institutes for Manufacturing Innovation (IMIs). Our response specifically responds to each question.

We also present the following key points that express our strongest recommendations for NIST to consider related to developing the NNMI IMIs.

We believe that the development of IMI technology focus areas should:

- Provide major economic impacts for retaining U.S. leadership in proven high-technology industries that are already proven job providers and export leaders;
- Support the enhancement of established U.S.-based technologies that have proven manufacturing-scale viability while continuing to innovate for next generation product offerings;
- Support proven high-technology industries that develop and follow industry-driven, multi-year technology development roadmaps;
- Support proven U.S. high-technology industries that are competing with global competitors and/or multi-national corporations that are supported by quantifiable foreign government technology development incentives and manufacturing assistance programs;
- Support an established organization with a proven track record of technology commercialization and established graduate and post graduate educational curriculum which leverages state and industrial investments;

- Provide a tight coupling between equipment manufactures and their supply chain with their end customers to ensure market viability and growth; and
- Fund a smaller number of IMI centers to support strategic U.S. industries that require large scale public-private partnership resources in magnitudes of hundreds of millions of dollars to develop and deploy proven technologies as these industries continue to advance next-generation technology as defined by the need of a proven large scale customer base.

It is our belief that the NNMI IMIs should focus on protecting and growing current areas of U.S. leadership in advanced manufacturing. U.S. leadership in all areas of advanced manufacturing is made possible by the continued R&D of these technologies, producing more advanced U.S. manufactured goods for the global markets they already serve. We suggest the NNMI IMIs should first and foremost protect current U.S. leadership in advanced manufacturing where hundreds of thousands of U.S. jobs are already in place. These jobs produce high employee wages and support the export of products, both of which provide resources to ensure our national standard of living remains vibrant. U.S. leadership in semiconductor manufacturing equipment, aviation and automobiles is made possible by the billions of dollars reinvested each year into these technologies to ensure quality next generation U.S.-made products are manufactured in the United States and can compete in the global market place.

We believe it is important for the proposed NNMI IMIs to protect and grow U.S. high-technology leadership in specific markets that are under intense global competition from both global competitors and foreign government technology development programs. As an example, Table 1 outlines exports for the U.S. semiconductor industry and its accompanying supply chain. This industry represents a large portion of overall U.S. exports. The semiconductor and semiconductor manufacturing equipment industry represent nearly $66 billion in exports, equal to approximately 13.3% of non-automotive U.S. capital good exports in 2011.[1] However, there is fierce international competition in this space, which is often supported by foreign federal government technology development programs.

Table 1: U.S. Semiconductor Industry Export Data, 2011	
Semiconductor manufacturing equipment	$17.3 billion[2]
Semiconductor materials	$3.9 billion[3]
Semiconductors and devices	$44.71 billion[4]
Total	**$65.91 billion**

U.S.-based semiconductor manufacturing equipment research, development, and manufacturing are now competing against global industry/university-government public-private partnerships, receiving significant national funding to develop the next generation semiconductor manufacturing capabilities (for example IMEC in Europe). Unlike funding from other regions worldwide, there is nothing comparable in the United States, and this has contributed to the loss of market share to overseas competitors. This global view has led to the development of a number of suggested topics that we believe NIST should review related to supporting technology development at the proposed IMI.

- Is the industry already a large-scale U.S. employer in the manufacturing and R&D economic segments?
- Is the industry already an established exporter of U.S.-manufactured products?
- Is the industry being targeted by foreign governments with incentive packages to move U.S. industries offshore? (See Figure 1 below)
- Are global based competitors already being supported by, or in the process of, securing host nation government support through public-private partnerships (like the NNMI IMI concept)?
- Has the U.S. industry been migrating offshore over a long, medium or short term time period? If so, what does the industry require from the federal government to remain within the United States and compete in the global economy?

Furthermore, we suggest that NIST review total government funding levels for the NNMI program and the appropriate number of IMIs be developed and funded. Significant government funding support matched by industry and state governments are needed to compete with foreign government programs. This will ensure taxpayer dollars are allocated to IMI technology centers that have the greatest opportunity to transition from technology readiness levels (TRL) 3-7 and greater to full-scale manufacturing and commercialization.

We believe that each IMI should incorporate a combination of large, medium and small size companies throughout the vertical supply chain of a given technology. This will strengthen the likelihood of the IMI developing a technology that moves from TRL 3-7 to full-scale manufacturing.

Technologies with Broad Impact

1. What criteria should be used to select technology focus areas?

The NNMI should balance support for riskier, unproven emerging or "disruptive" technologies with support for IMIs that address lower-risk (higher guaranteed return on investment) technology to protect and grow existing high-technology manufacturing with established jobs in the United States. CNSE and SEMI strongly recommend that the NNMI select technology focus areas for an IMI that will grow domestic leadership of next generation proven high-technology products, which will lead to employment retention and growth. The technology should meet several key criteria: retaining and/or growing U.S. high-paying jobs; aiding in combating our trade deficit; having a high level of exports to assist with the administration's goal of doubling U.S. exports; and providing the U.S. with long-term competitive advantages in technology leadership. The NNMI should primarily direct their resources towards IMIs that focus on existing technologies that are low risk and high reward.

Criteria for IMI selection should include a review of key high-technology manufacturing development industries in which the United States is leading but risks losing due to incentives from foreign countries. When awarding an IMI, NIST should require a detailed understanding as to the incentives that foreign governments are providing their own home-grown and multi-national businesses, specifically public-private partnerships to develop next generation high-technology industries, prior to awarding an IMI center.

The semiconductor equipment industry is a prime example of a domestic technology industry being courted by foreign governments and is in a position for IMI selection. The semiconductor equipment industry provides manufacturing equipment (wafer fab equipment (WFE)) to build semiconductor devices, the enabling technology for all electronics such as computers, cell phones, radar, and navigation. U.S. companies remain at the forefront of highly strategic semiconductor manufacturing equipment technology. While the majority of semiconductor manufacturing factory capacity has migrated overseas, production of engineering-intense and high-value WFE continues to be dominated by U.S. companies. The U.S. WFE industry played a critical role in lowering the cost per transistor by 20,000,000 times over the last 30 years with a commitment to Moore's law.[5]

At 1976 transistor prices, an iPod® would cost $3.2B

The foundation for semiconductor manufacturing is a round wafer, from which semiconductors are made. Every decade or so, the semiconductor industry transitions to a larger-sized wafers to achieve greater yield in the number of semiconductor devices (chips) on each wafer. This is due to the economics of scale in semiconductor production – wafer size and throughput drive down the transistor costs. The current state-of-the-art semiconductor manufacturing is done on silicon wafers 300mm in diameter (~12 inches). The previous generation was 200mm (~8 inches) in diameter. One of today's 300mm processed wafers can contain chips valued at $20,000 to $50,000, depending on the type of device being fabricated. With an average semiconductor factory (fab) processing 60,000-100,000 wafers per month, the enormity of the economic importance of semiconductor manufacturing is apparent.

Highlighting the threat of foreign government competition is a key innovative inflection point in the U.S. semiconductor manufacturing equipment industry. The semiconductor manufacturing equipment industry's major projected $30 billion transition to manufacturing devices on larger 450mm silicon wafers is underway. This transition creates the potential for foreign competitors to take market share (and thus manufacturing jobs) if they are bolstered by incentives from foreign governments. The evidence is clear that foreign governments are providing incentives and support funding toward this purpose. Figure 1 and Figure 2 delineate the levels of support in other world regions that constitute a formidable competitive challenge for U.S. manufactures.

We suggest that proposed IMI technology designations review with quantifiable detail the foreign government incentives that may cause this technology to be developed offshore. In our view, the U.S. government needs to compete with other nations' public-private partnerships. Figure 1 and Figure 2 below are templates that we suggest NIST utilize when reviewing the global implications of supporting IMI high-technology designations.

Figure 1: Foreign Incentives for 450mm Development[6]

Country or Region	Federal or National Equipment Program		450mm Specific Program	Incentives		
				Grants	Tax	Other
China	Program exists	12th Five Year Plan – High End Mfg Equipment	?	Program exists	Program exists	Program exists
Taiwan	Program exists	Ministry of Economic Affairs	Plans to create program	Plans to create program	Program exists	Program exists
S. Korea	Program exists	Semiconductor National Project 2015	Program exists	Program exists	Plans to create program	Program exists
European Union	Program exists	EEMI450 Initiative	Program exists	Program exists	Program exists	Program exists
Japan	Program exists	Super Silicon Initiative	Program exists	Program exists	Plans to create program	Program exists
U.S.	No program exists	None	No program exists	No program exists	No program exists	No program exists

Key: No program exists; Plans to create program; Program exists

Figure 2: Foreign Equipment Incentives – *More 450mm Specific Incentives Expected to Come*[7]

Country or Region	Government Agency or Policy	Equipment Funding	Goals & Incentives
China	12th Five Year Plan (2011-2015) - high end mfg equipment	• $600B for 7 priority areas, 2 of which include equipment; • $200-400M in equipment subsidies from local governments 2007-2011	High end manufacturing equipment one of seven new strategic priorities; equipment is also covered in energy efficiency. Eliminate dependence on the West for advanced semiconductor equipment, including etch a critical technology
Taiwan	Industrial Development Bureau under Ministry of Economic Affairs (MOEA)	Specific funding levels not disclosed; operating subsidies and tax incentives offered	Goal of 20% front end and 60% back end domestic semiconductor equipment market share by 2013
S. Korea	Ministry of Knowledge Economy (MKE) – Semiconductor National Project 2015	$130M over 5 years (2007-2012) • $55M government • $55M matching • $20M customers	Goal of 50% domestic semiconductor equipment and materials market share by 2015 from home grown companies including SEMES, Jusung, Wonik IPS, Eugene, DMS, Mujin and others; 450mm plasma technology is a focus area
European Union	ENIAC Joint Undertaking – EEMI450 Initiative EEM450PR SMART 2010	• $250M from ENIAC for nanoelectronics R&D, including equipment • $25M 2010-2013 phase 1 for 450mm standards, wafers and proof of concepts • ~$250M for 450mm pilot line	Grand Challenge 1: 450mm in 2018; Set up 450mm semiconductor prototype in Europe
Japan	Ministry of International Trade & Industry - Super Silicon Initiative	• $115M (1996-2001) to fund wafer development • $100M per year NEDO Mask Program	Protect silicon manufacturing; Develop key technologies for silicon wafers and backward integrate learning to 300mm

CNSE and SEMI suggest that NIST support technologies with a broad impact, specifically proven U.S.-based vertical supply chains that are manufacturing and developing products throughout the vertical supply chain. Vertical supply chain consortiums by their nature are better formatted to develop a technology from TRL 3-7 to full-scale manufacturing. One such industry is the semiconductor manufacturing equipment industry – making the advanced equipment that makes semiconductors. This industry is the enabling industry of tool and material manufacturers and provides the building blocks for the global manufacturing of any and all commercial goods that utilize semiconductor, flat panel, micro-electro mechanical systems (MEMS) solid state lighting and solar technology products. The electronic and equipment global markets for these U.S.-based technologies is estimated to be $1.4 trillion for 2012. The broad size of this global market ensures a long-term customer base for the U.S.-based technologies that enable the manufacturing of these products. The United States might be unable to manufacture a flat panel screen, but multiple enabling materials and tools used to build a flat panel screen can be sourced from U.S. companies. Many foreign industrialized nations have realized this, and foreign governments have or are in the process of developing incentives to innovate and manufacture these enabling technologies within their own nation.

2. What technology focus areas that meet these criteria would you be willing to co- invest in?

The key to an IMI's success will depend on the particular technology sector chosen as well as that technology development stage. CNSE and SEMI member companies are willing to co-invest in 450mm semiconductor manufacturing equipment technology with a focus on bringing technologies across the innovation "Valley of Death" toward product commercialization. CNSE and SEMI have worked with industry over many years (in partnership with other companies and organizations) to create technology development roadmaps for next generation technologies and standard platform sizes to ensure the overall semiconductor manufacturing equipment industry can interact with each vertical supply chain component technology. CNSE and SEMI have a proven track record of providing matching funds for public-private partnerships. It is our belief that part of the criteria for IMI RFP technology development selection should be verifiable financial matching funds from industry and state governments. We believe a 3:1 industry-to-federal match is a minimum requirement to develop TRL 3-7 technology to full-scale manufacturing. There should also be a state government matching requirement, separate from but complementary to the industry-to-federal match, which can include the construction of facility space and procurement of equipment to operate the IMI.

CNSE has developed an open innovation ecosystem by creating a co-location facility where leading device and equipment manufacturers, along with their supply chain, have established a presence on campus, utilizing the 300mm industry-compliant cleanroom for their advanced semiconductor research, development and deployment. CNSE has accomplished this by securing state government funding to leverage additional investments from industry in a unique public-private partnership which has flourished since its inception in 2004. In addition, in September 2011, it was announced that the Global 450 Consortia (G450C) would be established at CNSE. This first-of-its-kind collaboration headquartered and housed at CNSE is comprised of five leading international companies working to create the next generation of computer chip technology. Strong public-private partnerships, like the model at CNSE which supports mature industries with proven technology roadmaps and developed standards, are better suited to provide both the federal and state government taxpayer with a high return on investment and to successfully develop and manufacture a targeted technology within the United States.

3. What measures could demonstrate that Institute technology activities assist U.S manufacturing?

The IMIs should focus on technologies that have received recognition from multiple government agencies as a high-demand manufacturing sector. In 2004, The U.S. President's Council of Advisors on Science and Technology (PCAST) noted that "…the research to manufacturing process is not sequential in a single direction, but rather results from an R&D-manufacturing 'eco-system.'" PCAST suggested the establishment of a university-based "next generation Bell Lab's model" with close coordination between state and federal technology development programs is necessary to accelerating the commercialization of integrated circuits (ICs) in expanding applications and stemming the loss of critical technology leadership.[8] In addition, smart systems have been identified as a "critical technology" by the administration, which recently completed its assessment of worldwide technology capabilities based upon the breadth of influence of the technology and compliance with the requirements for criticality.[9] The transition to 450mm wafers will enable the next wave in smart systems technology. Retaining the industry and its supply chain provides one strong example of how critical 450mm development is to U.S. competitiveness in the global economy.

In summary, the United States leads in the manufacturing of semiconductor manufacturing equipment. This industry has been a U.S. economic driver for over 30 years, and this industry is the "enabling technology" for all electronics. The semiconductor manufacturing equipment industry is one of the last existing high-technology industries where the United States leads in manufacturing. This is, however, currently being threatened by foreign countries that are offering valuable incentives to lure U.S. semiconductor manufacturing equipment companies to their shores. Additionally, the semiconductor manufacturing equipment industry is facing the major challenge of transitioning to next generation equipment known as 450mm. This transition to develop a larger wafer size on which to manufacture more semiconductors is expected to cost the industry up to $30 billion. This transition is a major R&D undertaking by the industry and, given the high level of R&D costs, it is a prime opportunity for foreign countries to attempt to lure manufacturing from the United States. (Transitions to larger wafer sizes happen only every 10-15 years.) CNSE played a fundamental role in the previous industry transition, and as the move to 450mm approaches the industry is again looking to CNSE to take leadership in the development and commercialization of next-generation technology. Additionally, because of escalating R&D costs, particularly in the semiconductor industry, alignment of investments from industry, state and federal sources is more critical than ever if the United States is to continue to compete in this high-technology industry.

4. What measures could assess the performance and impact of Institutes?

Measures that can be established to assess the performance and impact of an institute include the following: 1) has it retained or created direct and vertical supply chain jobs; 2) does it solidify the United States as a leader in the industry; 3) does it maintain technology leadership and innovation in an industry with high impact to the U.S. economy; and 4) has it met clearly defined technology goal(s) by developing a roadmap for the future.

Institute Structure and Governance

5. What business models would be effective for the institutes to manage business decisions?

As the National Science Technology Council in the Executive Office of the President noted in its February 2012 report, *A National Strategic Plan for Advanced Manufacturing,* IMIs should follow the model of the nanotechnology cluster at the State University of New York in Albany, which includes several large manufacturers and the industry consortium SEMATECH. As the report notes, this model "provide[s] a fruitful setting for investments in partnerships. These clusters dramatically improve technology platform development, diffusion of knowledge, and subsequent scale-up. Additional synergies achieved through regional clusters include coordinated strategic planning, complementary asset sourcing and risk pooling within clusters, and co-located supply chains. Clusters provide vital resources for SMEs."

The IMI should be viewed as a public-private partnership. For example, the university/industry collaboration should constitute approximately a 3:1 match (industry-federal). The IMI should also leverage state resources where manufacturing facilities are located and in states where "virtual" IMI entities (like members from other states) are contributing financially and in-kind to the mission of the IMI. Additional investments at the state level should be used for capital expenses so that federal investments are not paying for infrastructure costs. Because scaling-up IMI R&D and manufacturing operations may happen early on in the life of the IMI, the IMI should seek a larger proportion of total IMI funds from federal, state and industry entities up-front. Regarding partnerships between private entities (e.g. component supplier SMEs, equipment manufacturers, device makers) and academia (e.g. research universities and pilot-production facilities) to serve the mission of the IMI, a Teaming Agreement Model should be put in place to facilitate integration of large and small companies into R&D, and pilot-production operations. Teaming Agreements have set goals to developing and commercializing products throughout the U.S. that encompass an end-user commercialized product. This Teaming Agreement Model should allow the IMI Chief Operating Officer (discussed below) to contract with private entities in order to best serve the mission of the IMI.

For the development of 450mm equipment a close coupling of business decisions with the device manufacturers who will ultimately be the customers is critical for the technology development and deployment. The G450C headquartered at CNSE would work with the IMI partners including small and medium sized business equipment manufacturers and supply chain to provide input on technical specifications and merits of proposed approaches at various stages of development. This feedback from customers will help guide business decisions.

6. What governance models would be effective for the Institutes to manage governance decisions?

Oversight of IMI governance should be the responsibility of a Board of Directors (BoD). The BoD should be representative of all key entities in the manufacturing supply chain, such as major technology area assignees/companies (equipment suppliers), standards-forming groups and industry associations, academic and research institutions, and manufacturing operations stakeholders. Additionally, since the focus of the IMI should be on pilot manufacturing and scale-up, the IMI should have a Chief Executive Officer who is responsible for the business operations of commercializing the product developed at the manufacturing facility. The IMI may also have management positions staffed by member assignees.

7. What membership and participation structure would be effective for the Institutes, such as financial and intellectual property obligations, access and licensing?

The IMI BoD should define the precompetitive collaboration initiatives set forth by each IMI. With regards to the specific technology area in question, the BoD should define for IMI members: 1) the governance structure of the IMI (outlined above), consisting of several constituent groups; 2) the technology focus areas and concepts that are to be addressed by these constituent groups (including component and equipment requirements, standards, prototyping, facilities and services requirements, and demonstration and optimization); and 3) the demonstration and timely adoption of these technology focus areas and concepts by each constituent group and member. The Teaming Agreement Model (discussed above) should be used to develop member-to-member partnerships.

Intellectual Property (IP) rights should be broken into exclusive and non-exclusive rights. Exclusive rights include IP industry has sole right to, while research, pilot-production, and workforce development entities derive academic and research rights. Non-exclusive rights include IP industry does not have sole right to; from which broader R&D entities derive academic and research rights; through which sublicensing could be allowed; and which may be exclusive based on industry's level of contribution -- such as membership dues or in-kind contributions – or nonparticipation – such as sole government (federal/state) contribution to development of certain IP.

8. How should a network of Institutes optimally operate?

AMNPO might organize a national, online repository of 1) generally applicable standards and IMI best practices; and 2) non-exclusive IP that can be shared within an individual IMI in a "virtual IMI" setting, or that can be licensed to entities outside of an individual IMI for academic or commercial purposes. AMNPO might also organize an annual NNMI summit in order to promote discussion of milestones met at respective IMIs and IMI best practices, and also to foster an environment for NNMI-wide collaboration, business development, and networking.

A conference should be held annually to involve the entire network of partners in the IMI. This will provide a forum for all partners in the IMI to assess status of goals, evaluate progress, and adapt next steps as needed. A key component of this conference would be to host a SME outreach session. This conference would promote engagement of the existing IMI partners to interface with SMEs. Partnerships between larger IMI members and SMEs are critical for providing that companies of all sizes have ample opportunity to participate in the IMI network.

9. What measures could assess effectiveness of Network structure and governance?

An IMI may measure the effectiveness for the structure of an IMI by the sustained financial and in-kind commitment of key members and their assignees over the course of the life of the IMI. New IMI membership growth (and retention) among industry and academia, new R&D staff for-hire, and attracting new outside investment and contribution (whether industry, academia or government) are other key indicators of an IMI's effective governing structure, which is ultimately charged with putting an IMI on a path towards self-sustainability. Finally, the effectiveness of an IMI's governing structure can be assessed by whether or not the IMI is meeting the realistic yet ambitious R&D and pilot-production goals and milestones of the IMI, set forth by the BoD which is designed to be representative of the key stakeholders in addressing an innovative manufacturing issue.

Strategies for Sustainable Institute Operations

10. *How should initial funding co-investments of the Federal government and others be organized by types and proportions?*

Federal funding for the IMIs will be a key enabler to retaining semiconductor manufacturing equipment assembly in the United States while attracting other funds in order to support this initiative. Matching funds to the federal government's investment will be needed in order to continue the in-sourcing of high-demand technologies including semiconductors and their supply chain, including, equipment manufacturers, materials suppliers and subcomponent suppliers. These matching funds should include contributions from the companies involved with the IMIs as well as contributions from the state government.

To obtain an NNMI award, NIST should require a high cost-match for industrial recipients over the term of the award. Initially, a majority of the funding would be from the federal award in order to purchase equipment and develop infrastructure. Over time, the ratio would reverse where most operational costs would be supplied by matching funds. These matching funds would be generated from programmatic activities that will directly support both the participating partners as well as the IMI itself, which in turn will enable the broader U.S.-based semiconductor industry as a whole. Having industry "buy-in" for the program creates an incentive for success allowing for a sustainable model. The IMI will be able to grow and develop its own infrastructure and sustainable business model as the federal funding terminates. Other innovative strategies for attracting funding would be encouraged.

11. What arrangements for co-investment proportions and types could help an Institute become self-sustaining?

For an IMI to be successful, significant funding will be required -- mostly up front from the federal government -- to align industrial partners and to develop and launch equipment development programs. Over time, as the level of federal government decreases the additional funding sources, mainly coming from industrial partners and local state government, will increase. This will assist in the sustainment program as the IMI will be mostly funded by non-federal sources towards the end of the federal funding period. The overall ratio of additional matching funds over the life of the program should be approximately 3:1 (non-federal funding to federal funding).

One requirement of an IMI should be to present to the NNMI a business model for sustainability centered on the specific purpose of the IMI. Here it would be a facility operated to enhance, improve and further develop the equipment required for the semiconductor industry. This same infrastructure could be leveraged to provide non-IMI participants' access, for a fee, to either use the tools or for the development of a research program which spans the proof-of-concept through pilot-prototyping phases.

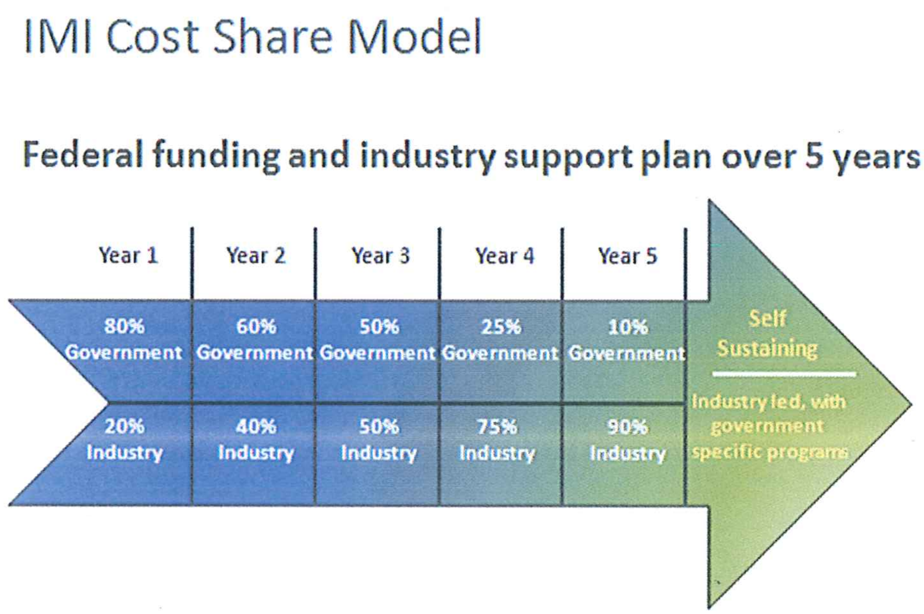
The IMI's minimum goal—with the strong partnership between government, industry and universities—is to attract additional funding and investments over the next decade for R&D,

commercialization and manufacturing programs. As a result of this magnitude of participation, it is anticipated that the IMI's financial model will achieve self-sustaining operations through access fees, IP licensing and other contributions by the end of its first five-year phase (see Figure 3 below).

The combined efforts of the IMI should help create, retain and sustain a critical mass of intellectual and physical resources and capabilities. This includes clusters of technical and engineering units from equipment, materials and component suppliers; R&D teams; and manufacturing groups necessary to ensure optimum execution of new processes, materials or devices, leading to maximum return on investment for the stakeholders while reducing risk for industry. CNSE is a successful example of this in the semiconductor industry where over 2,500 researchers have come together to development next generation technologies.

Another arrangement to help an IMI become self-sustaining is its relationship with an institute of higher learning that could provide workforce development to help continue the IMI once federal funding has ended. This will provide not just the next generation of engineers and employees, but also will allow the next generation of innovators to continue the progress already made at the IMI.

Figure 3: IMI Self-Sustaining Funding Model



12. What measures could assess progress of an Institute towards being self-sustaining?

Progress should be assessed over time by providing milestones in the proposal that tie the receipt of additional federal funds to matching funds, and by tracking the amount of additional funding that is generated for the IMI quarterly periodically throughout the program. With the initial front-loaded federal investment, the IMI should demonstrate its ability to continually attract additional funding to the institute. Goals for total funding of the IMI should be identified up-front in order to track progress over time. Participants in the IMI should articulate their ability to attain and sustain program funding, and preference should be given to those with a history of success. NIST has a long track record of successful sponsored research programs and has the infrastructure to monitor funding sources, both from the federal government and matching sources.

Another measure could be a measurement of impact to the specific industry that the IMI is engaged in promoting. For instance, the IMI could develop and publish of an industry-wide technology roadmap for the specific technology the IMI is operating within. It would be advisable for a participant within an IMI to have experience in gaining industry-wide consensus, and to have had a long history of member-driven success, not just for the individual members, but for elevating an entire industry. "A rising tide lifts all boats."

13. What actions or conditions could improve how Institute operations support domestic manufacturing facilities while maintaining consistency with our international obligations?

The IMIs should grant open access to the facility with a staged access fee structure that achieves full cost recovery from foreign-owned companies for their use of the facility. Programmatic funds from the federal government would only be used for domestic companies. In conjunction with state investment, this will encourage other local investments and staffing growth associated with the center and ultimately promote U.S.-based manufacturing.

14. How should Institutes engage other manufacturing related programs and networks?

The IMIs should engage with other related manufacturing programs and networks to leverage all U.S.-based assets. A highly organized and coordinated effort by the IMI proposer should outline the strategy for identifying partners in related programs across the country. This strategy should, at minimum, include: collaborating with local and national manufacturing trade organizations to organize and host seminars, workshops, symposiums on the specific topic of the IMI; providing outreach to the local and national community to educate the population on the new 21st Century vision of manufacturing; and focusing on the importance of the renaissance of the U.S.-based manufacturing economy.

Additionally, this matter relates to the roadmapping activity addressed in Question 12 above. Roadmapping is an important part of an industry and relates directly to manufacturing. It is imperative to have industry-wide participation in order to have a successful manufacturing operation. This includes having small, medium and large companies across the supply chain aligned with the needs, requirements, specifications and demands of the manufacturing entities. Each supply chain company will need to have their own manufacturing processes and formats operational according to the industry consensus determined in the larger industrial roadmap. These industrial interconnections are critical in order to improve, expand and succeed with manufacturing in the United States.

15. How should Institutes interact with state and local economic development authorities?

For the IMIs to have the greatest economic impact, they should work closely with state and local governments to assist in the strategic location of the IMI when there is a new facility involved. Preference should be given to proposals which would locate a facility in an area in need of economic stimulation. These areas would need an employee base made up of a skilled workforce to sustain the program and participate in workforce training programs. In addition state and local governments could provide funding as part of the match towards the IMI that would be returned through the economic development of the geographic region, while helping to maintain advanced manufacturing in the United States.

The interaction between IMIs and state and local economic development authorities should include, but not be limited to, the following: site location assistance – including the presentation and availability of pre-permitted sites ideal for each specific IMI; existing skilled workforce development programs; state and local incentives for such manufacturing sites to be counted as cost-matching contributions to the IMI; and the development of joint programs to help create a sustainable model at the IMI – which is to include an attraction model for the various supply chain companies discussed above to contribute to an efficient and sustainable eco-system for manufacturing.

16. What measures could assess Institute contributions to long term national security and competitiveness?

Various measures should be considered in calculating the IMI's ability to retain U.S. competiveness and promote national security. In highly competitive and global industries, such as the semiconductor industry, there is fierce international competition. In 2011, the United States exported approximately $66 billion in semiconductor manufacturing devices, equipment and materials (see Table 2). Retaining competitiveness in an industry with large global market opportunities such as this is critical for national security. IMIs that are able to partner with a variety companies in their respective supply chain will help to retain their presence and investments in the United States and potentially attract many of their international operations to relocate in the U.S. Proposers should demonstrate their ability to successful partner and grow with companies.

Additionally, there are certain technologies that lend themselves more toward the improvement of national security than others. For example, today more and more information is being transmitted globally through the use of the Internet and wireless devices. It is of critical importance for the U.S. military to continue to have a secure source of not just the mobile device itself, but of every component that goes into it, as well as the supply chain required to design, innovate and manufacture technology essential to the device. Continuing to manufacture these critical components requires many elements that have significant degrees of separation, from the finished, manufactured device to the materials used for its manufacture, to equipment and subcomponents. Therefore, from a national security perspective, having an IMI that can bring together, enable, expand and innovate here in the U.S. will allow for the entire process and manufacturing supply chain to remain in the United States.

In summary, it is important for a proposer to identify the market for the output of the proposed IMI, discuss the critical nature of the technology and the importance of it in a globally competitive market, and describe how it benefits national security. The proposer should have significant experience in enabling industry to not only be active in providing solutions for national security, but also in supporting the manufacturing that is required to provide the appropriate solutions.

Education and Workforce Development

17. How could Institutes support advanced manufacturing workforce development at all educational levels?

IMI members in academia should offer B.S., M.S., and Ph.D. degrees in specific technology areas central to the mission of the IMI, and additionally should coordinate with local community colleges. Students at all academic levels should be exposed to curriculum that includes courses on challenges in a manufacturing environment and that will provide a trained workforce to support domestic industry growth in the IMI technology area. CNSE has already outlined a program focused on manufacturing science. This is in partnership with other academic institutions and companies to develop curriculum specifically on manufacturing.

IMI academia members and trade association groups should also offer teacher training, short courses, and middle school and high school programs to create a "technology education pipeline." This will both educate K-12 teachers about how to incorporate advanced technology concepts into curriculum at a foundational level, and educate students about the challenge area addressed by the IMI while these students are choosing their high school or undergraduate majors and are thinking about potential careers in STEM fields. In addition K-12 would be able to participate in hands on activities at the IMI. CNSE hosts approximately 5,000 K-12 students each year in a variety of different activities to engage with students about opportunities in STEM, which could be expanded upon to include 450mm education.

18. How could Institutes ensure that advanced manufacturing workforce development activities address industry needs?

Ph.D. candidates at research university members of the IMI should facilitate doctoral internship programs with IMI industry members, and should draw on the workforce development programs of industry members to enhance the educational, research and workforce development functions of the IMI. Furthermore, technician-level programs could be implemented to train and reinforce best practices amongst for-hire R&D should be in place.

19. How could Institutes and the NNMI leverage and complement other education and workforce development programs?

The IMI should participate in a state government-led effort to utilize STEM field faculty, students, and resources across state university schools systems, where relevant. This should include state schools, research universities, community colleges and private institutions. It should also leverage key academic internship/workforce training programs of industry member affiliates in other states. This education and workforce training effort should utilize local and regional government economic development organizations to recruit, educate and train workers for STEM fields and in particular the technology area central to the mission of the IMI. Research university members should also encourage faculty sabbaticals for R&D activities instead of keeping permanent hires for IMI R&D purposes. Additionally, the IMI should form partnerships with federal agency workforce development programs that foster manufacturing and high-technology job creation and encourage new public and private investments in these industries. These workforce development and training programs include individual efforts at the U.S. Department of Commerce Economic Development Administration; National Institute of Standards and Technology Hollings Manufacturing Extension Partnership; Department of Energy Advanced Manufacturing Office; Department of Labor Employment and Training Administration; and Small Business Administration.

Finally, the IMI should partner with community colleges, economic develop organizations, state entities and the U.S. Department of Veterans Affairs to promote veteran hiring and training in STEM professional fields, undergraduate and advanced study work, specifically for career placement into the IMI and its member organizations.

20. What measures could assess Institute performance and impact on education and workforce development?

Some measures that could assess IMI impact on education and workforce development in the technology area central to the IMI include: number of K-12 students choosing college majors in STEM fields because of IMI outreach and programs; number of community college students participating in IMI academia member-led short courses, and community college students transferring to IMI academia member-relevant STEM majors; placement of STEM field undergraduate students, graduate students and veterans into IMI academic and industry member jobs, facilitated by the partnership of the IMI, state university, local economic development organization and community college career services; and Ph.D. candidate internship-to-hire ratio at IMI member entities.

21. How might institutes integrate R&D activities and education to best prepare the current and future workforce?

IMI academia members and trade association groups should also offer teacher training, short courses, and middle school and high school programs to create a "technology education pipeline." This will both educate K-12 teachers about how to incorporate advanced technology concepts into curriculum at a foundational level, and educate students about the challenge area addressed by the IMI while these students are choosing their high school or undergraduate majors and are thinking about potential careers in STEM fields.

Closing Remarks

In conclusion, we thank you for your consideration of our comments on the proposed National Network for Manufacturing Innovation Institutes for Manufacturing Innovation. We again commend the NNMI for charting a course that will lead to the resurgence of United States manufacturing leadership. We believe the program has the potential to greatly advance proven and emerging manufacturing industries by supporting these industries in the important work of innovation.

Sincerely,

Michael Liehr
CNSE Executive Vice President of Innovation and Technology
CNSE Vice President for Research
College of Nanoscale Science and Engineering of the University at Albany

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Semiconductor Equipment and Materials International

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[1] U.S. Census Bureau, U.S. Bureau of Economic Analysis (2012), *U.S. International Trade in Goods and Services: Annual Revision for 2011*, pp. 8, see http://www.census.gov/foreign-trade/Press-Release/2011pr/final_revisions/11final.pdf.

[2] Semiconductor Equipment and Materials International data.

[3] SEMI, op. cit.

[4] U.S. Census Bureau, op. cit.

[5] Applied Materials Corporation, Office of the Chief Technology Officer estimate based on published transistor price trends.

[6] SEMI data.

[7] SEMI data.

[8] The President's Council of Advisors on Science and Technology(January 2004), *Sustaining the Nation's Innovation Ecosystems, Information Technology Manufacturing and Competitiveness*, pp. 14, 24-5.

[9] Department of Defense Military Critical Technologies List (MCTL) (June 2009), Section 8: Electronics Technology, MCTL Data Sheets 8.5-3, 8.5-4, 8.5-8, 8.5-9, 8.5-10.