Before the Office of Science and Technology Policy (OSTP)

Subject

Notice of Request for Information (RFI): National Strategic Plan for Advanced Manufacturing

Federal Register / Vol. 83, No. 24 / February 5, 2018 / Notices

Submitted March 7, 2018

Written Comments from the Semiconductor Industry Association

The Semiconductor Industry Association (SIA)[1] welcomes the opportunity to provide written comments in response to the Request for Information (RFI) on the National Strategic Plan for Advanced Manufacturing from the Office of Science the Technology Policy (OSTP).

[1] The Semiconductor Industry Association (SIA) is the voice of the U.S. semiconductor industry, one of America's top export industries and a key driver of America's economic strength, national security, and global competitiveness. Semiconductors – microchips that control all modern electronics – enable the systems and products we use to work, communicate, travel, entertain, harness energy, treat illness, and make new scientific discoveries. The semiconductor industry directly employs nearly a quarter of a million people in the U.S. In 2017, U.S. semiconductor company sales totaled $189 billion, and semiconductors make the global trillion-dollar electronics industry possible. SIA seeks to strengthen U.S. leadership of semiconductor manufacturing, design, and research by working with Congress, the Administration and other key industry stakeholders to encourage policies and regulations that fuel innovation, propel business and drive international competition. More information about SIA is available at www.semiconductors.org.

1 – In priority order, what should be the near-term and long-term objectives for advanced manufacturing, including R&D objectives, the anticipated time frame for achieving the objectives, and the metrics for use in assessing progress toward the objectives?

The number one near-term and long-term strategic objective for advanced manufacturing in the U.S. semiconductor industry should be to **support and maintain the semiconductor manufacturing base in the United States.** Policies and incentives significantly affect that outcome.

Few products in the world are as potent in enabling innovation as semiconductors. Their importance to **economic growth** and **national security** has made leadership in semiconductor production a strategic priority of governments around the world. Yet, few other devices are as technologically challenging to produce, or "fabricate," than semiconductors. Semiconductors have been at the center of advanced manufacturing for over 50 years.

Semiconductors were invented in America, and the U.S. semiconductor industry is currently the global sales market share leader with roughly half of all annual semiconductor sales. Importantly, nearly half of all the U.S. semiconductor industry's manufacturing base is located in the United States (see Table 1).

To assess whether federal programs and activities are sufficiently supporting U.S. semiconductor manufacturing competitiveness, two metrics should be used to assess our level of industry leadership:

1) Monitor U.S. industry sales global market share – if the U.S. industry starts to slip below roughly half sales market share, like it did in the mid-1980s when the threat from the Japanese semiconductor industry became very real, then we know the U.S. is in danger of losing its leadership position in this critical industry.

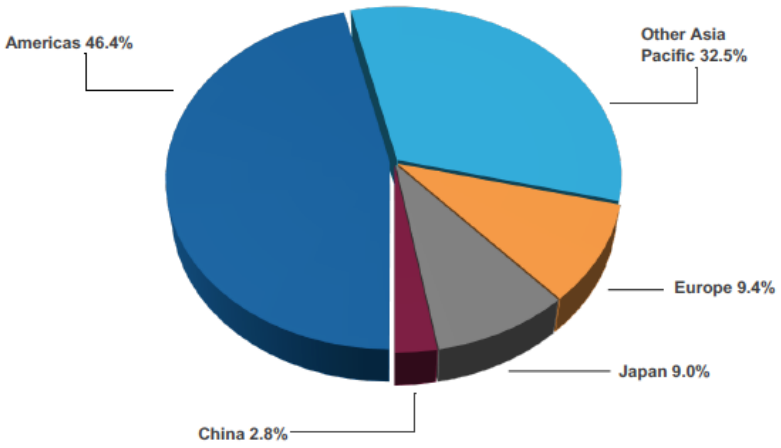
2) Monitor the share of U.S. industry advanced manufacturing capacity in the United States – if this share decreases to the level at which the U.S. is either relying on U.S. semiconductor manufacturing abroad, or worse, foreign semiconductor manufacturing abroad, for the majority of U.S. domestic consumption, then the U.S. advanced manufacturing base poses a strategic national and economic security weakness. This is especially true in strategic end markets such as military and aerospace applications.

Table 1

THE U.S. SEMICONDUCTOR INDUSTRY CONDUCTS THE MAJORITY OF ITS MANUFACTURING IN THE UNITED STATES

In 2016, about 46 percent of U.S.-headquartered firm wafer capacity was located in the Americas region. The Asia Pacific region was the second largest area, accounting for 33 percent of the total capacity.

Percent of U.S.-Headquartered Firm Wafer Capacity by Location



Note: Figures are rounded to the nearest 10th.
Source: IC Insights Global Fab Database and SIA Estimates.

U.S. semiconductor industry global leadership is not a birthright, and a strategic plan should be in place to support our leadership and incentivize growing our industrial base. Other countries' governments continue to prioritize the development of their own domestic semiconductor industries in an effort to overtake U.S. leadership, and if the U.S. does not act, this could occur.

To maintain U.S. leadership in semiconductor innovation, and to keep and support semiconductor advanced manufacturing in the United States, these additional objectives should be part of the Administration's short-term and long-term plan:

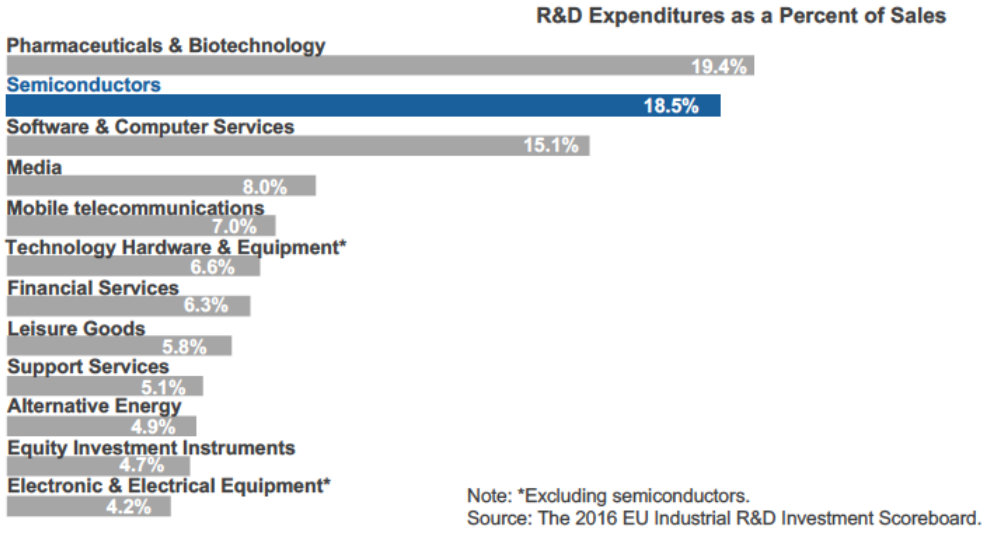
1) **Robustly fund pre-competitive research** – R&D is the lifeblood of the U.S. semiconductor industry. As a share of sales, the U.S. semiconductor industry perennially ranks number one or near the top of all U.S. industries in terms of R&D funding as a share of sales (see Table 2). Yet, industry R&D works most effectively if it is matched by pre-competitive government funded basic research to bring scientific discoveries and inventions to the stage where industry is willing to take a financial chance to fund further development toward commercially viable products and solutions. This is especially true for R&D in semiconductor manufacturing process technology and innovation. Without higher levels of government funding for pre-competitive research on semiconductor technologies, the nation risks losing U.S. semiconductor leadership in this industry. This would create **a significant risk to national security**.

Federal funding typically goes toward fundamental scientific research, while industry funding is largely focused on later stages of research and technology development. Numerous economic studies – synthesized in a recent report by the American Association for the Advancement of Science – have found that government and industry R&D funding strategies are highly complementary and that government funding in early-stage research tends to incent additional funding by industry.

Table 2

THE U.S. SEMICONDUCTOR INDUSTRY IS A LEADER IN R&D SPENDING AS A PERCENT OF SALES AMONG U.S. INDUSTRIES

The rate of U.S. semiconductor industry R&D spending is among the highest in key high technology industrial sectors. Based on the 2016 EU Industrial R&D Investment Scoreboard, the U.S. semiconductor industry was second only to the U.S. pharmaceuticals & biotechnology industry in terms of the rate of R&D spending as a percent of sales.



2) **Ensure the industry has access to the best workforce** – A talented semiconductor workforce is one of the keys to maintaining global leadership in semiconductor manufacturing, and certain policies are critical to ensuring the U.S. industry has access to the best talent for jobs in the United States. Work in several specific areas are key:

   a. Grow the domestic workforce through STEM education promotion;

   b. Enact immigration policies to enable top talent to stay and work in the U.S. for our industry;

   c. Create new classes of jobs. Semiconductor industry jobs today do not always require a college degree. What matters most is relevant skills, sometimes obtained through vocational training. A new education model aimed at building technical skills to fill good jobs in the United States is developing today. This new education paradigm, called Pathways in Technology Early College High Schools

(P-TECH), is a system of innovative public schools spanning grades 9 to 14 that brings together the best elements of high school, college, and career. The skills acquired here are particularly suited for technicians in the very high-tech semiconductor industry;

d. Understand and promote federal university research to build the semiconductor workforce. As mentioned above, federal investment in university research both leads to new ideas and knowledge, and it builds relevant skills in the semiconductor workforce. It also contributes to a world-class body of students and faculty knowledgeable in the disciplines needed in the semiconductor industry, including physics, chemistry, materials science, and electrical engineering, to name just a few.

Working on these four specific areas will promote the growth of the domestic semiconductor industry, which will **create more semiconductor industry jobs in the United States.**

3) **Promote tax incentives to grow our industry domestically** – SIA strongly supported the Tax Cuts and Jobs Act, passed by Congress and signed into law in late 2017. It immediately instituted a globally competitive corporate tax rate of 21 percent, preserved the research and development (R&D) tax credit, modernized international taxation, and provided a lower effective tax rate for foreign income derived from intellectual property such as patents. These important reforms significantly improve the competitiveness of U.S. semiconductor research, design and manufacturing.

4) **Trade and export policies to enable sufficiently and economically supplying foreign markets domestically** – With over 80 percent of U.S. semiconductor industry sales to markets abroad, maintaining free and open global markets is a key priority for the U.S. semiconductor industry. Also, because the U.S. semiconductor industry maintains a significant share of it advanced manufacturing in the U.S., being able to supply foreign markets from the U.S. without costly barriers is essential for our competitiveness. Barriers to foreign trade and access to foreign markets could erode the U.S. domestic manufacturing base, if firms are forced to move abroad to supply foreign markets.

2 – How can Federal agencies and federally funded R&D centers supporting advanced R&D foster the transfer of R&D results into new manufacturing technologies and United States-based manufacturing of new products and processes for the benefit of society to ensure national, energy, and economic security? What role can public-private partnerships play, and how should they be structured for maximum impact?

The manufacturing institutes established under the National Network for Manufacturing Innovation, now known as Manufacturing USA, provide excellent value. They serve as a model for how such centers supporting advanced R&D can foster the transfer of R&D results into new

manufacturing technologies and U.S.-based manufacturing of new products and processes for the benefit of society. SIA members are engaged with several of these institutes both formally and informally, including the American Institute for Manufacturing Integrated Photonics (AIM Photonics), Advanced Robotics Manufacturing (ARM), Digital Manufacturing and Design Innovation Institute (DMDII), NextFlex and Power America. Such programs play a vital role in the U.S. innovation economy, and the U.S. government should continue to fund them.

As a public-private partnership, the manufacturing institutes bring together the public sector, academia, and the industrial sector. While each institute may be structured differently to fit specific needs, it is critical that the benefit of the network is clear to all three participants. Therefore, for maximum impact, the value proposition must be made clear and kept in the forefront of institute operations, strategy, and governance. In order to further a sustainable, scalable, and ultimately effective program, it is critical to create shared value between industry and the centers.

One of the stated, fundamental goals of Manufacturing USA is to address the so-called "valley of death" in which research advances often fail to find a path to commercialization. Addressing this challenge is also a priority for the U.S. semiconductor industry, as it seeks to strengthen the link between the precompetitive basic research initially undertaken by such partnerships as the manufacturing institutes and the industry's own commercially-based R&D investments.

3 – What innovative tools, platforms, and technologies are needed for advances in manufacturing? Of those that already exist, what are the barriers to their adoption?

Advanced manufacturing and semiconductors are intertwined on two fronts: 1) the manufacturing of semiconductors in fabrication facilities is one of the most advanced processes in the world, and 2) semiconductors themselves are increasingly enabling advances in manufacturing in other sectors. In terms of maintaining U.S. semiconductor manufacturing technology leadership, responses to question 1 above list our priorities for achieving this.

On the second front, semiconductors are a key enabling technology for advances in innumerable downstream sectors. Specifically, semiconductors are the brains that power high-performance computing, machine learning and artificial intelligence applications, and industrial robotics, technologies that all play key roles in advancing manufacturing across sectors.

Funding for pre-competitive research and support for public private partnerships, such as the manufacturing institutes discussed above, are key to furthering these technologies. Further, the government should robustly support national user facilities – including the leadership computing facilities, light sources, and nanoscience centers at the national labs – and implement programs like the new High Performance Computing for Manufacturing (HPC4Mfg) program that provide industry access to those facilities on a competed basis. Federal agencies should also expand use of Other Transaction Authority and other mechanisms that minimize red tape in contracting and partnership agreements to open government programs to more industrial firms. Programs like the Defense Advanced Research Projects Agency (DARPA) Electronics Resurgence Initiative are an

excellent step toward enabling greater engagement on technology development between government and largely commercial advanced manufacturing industries like the semiconductor industry.

4 – How can such Federal agencies and centers develop and strengthen all levels of manufacturing education and training programs to ensure an adequate, well-trained U.S. workforce for the new advanced manufacturing jobs of the future?

A talented semiconductor workforce is one of the keys to maintaining global leadership in semiconductor manufacturing, and certain policies are critical to ensuring the U.S. industry has access to the best talent for jobs in the United States. Specific policies that would improve the capabilities of the domestic semiconductor manufacturing workforce include:

- Policies to attract and retain highly skilled workers in Science, Technology, Engineering, and Math (STEM) fields.

- Policies that invest in STEM education to develop a highly skilled American workforce.

One strategic option to strengthen manufacturing education and training programs is to build in future education and training needs with anticipated future innovations in advanced manufacturing. Considering the future education and training needs of the workforce helps to more effectively match future skills with R&D. Achieving this would require a shift to leveraging real time input from stakeholders to ensure education and training needs are demand driven. The payoff is potentially significant, as education and training would become significantly more relevant to the needs of advanced manufacturing firms.

6 – How would you assess the state of the following factors and how they impact innovation and competitiveness for United States manufacturing?

The United States should focus on policies that will promote 1) U.S. semiconductor industry market share leadership, and 2) the maintenance of the necessary advanced semiconductor research and manufacturing base in the United States to ensure U.S. national and economic security is not compromised.

(a) Technology transfer and commercialization activities

The United States needs more focus and funding into technology transfer activities. The United States has a uniquely robust university research capability, but moving ideas from the university to industry remains weak. Innovation "hubs" or "ecosystems" are needed to integrate new ideas from research into commercialized technology. "Innovation hubs" can play a critical role in

bringing together disparate elements of a supply chain, from small, medium to large organizations, and to speed up technology transfer.

The federal government can play a critical, neutral convening role with such organizations. Partnership benefits come to all participants. Large companies often provide program management skills and access to extensive supply chains that small companies do not have and seek to access. On the other hand, small companies often provide niche expertise that large companies seek. As a result, these partnerships reduce costs, speed access to technology, and provide commercialization paths that are otherwise unavailable.

Another avenue to pursue would be for the United States to fund research to increase the capability of existing technologies. Leveraging current technology and building product differentiation would provide value to manufacturing and drive marketplace success.

Also, it is important to support and fully fund new "innovation hubs" to increase access of technology users, whether in DOD or DOE programs, to existing technologies. These "hubs" should focus on the need to speed commercialization and to accelerate new technology integration with existing systems and drive differentiation.

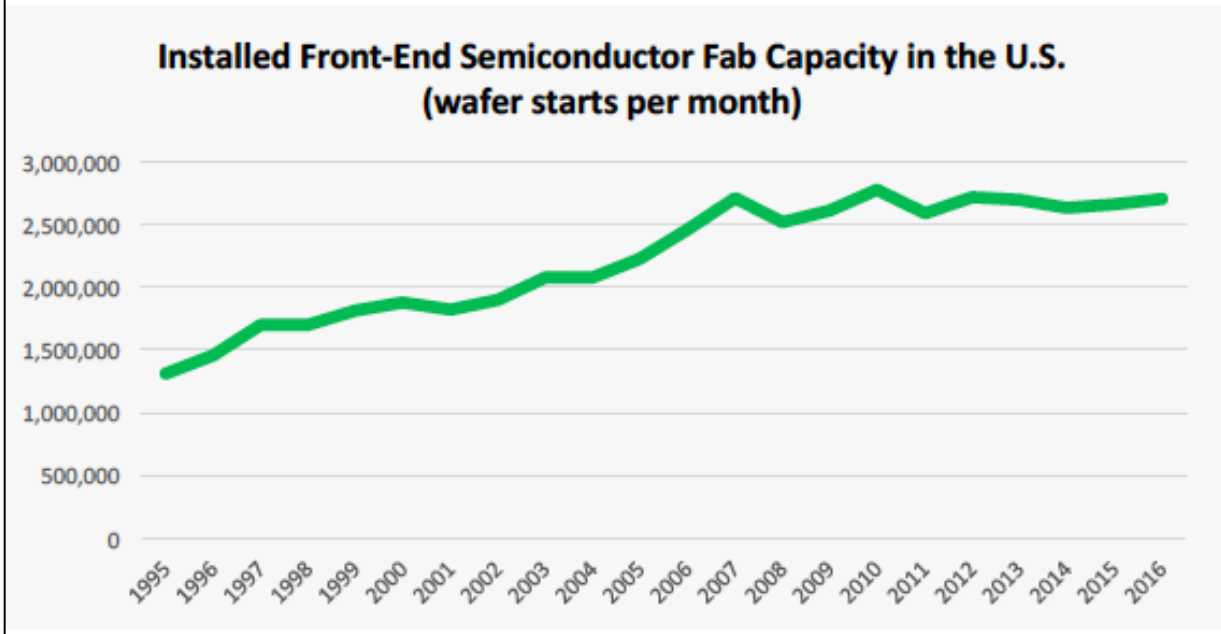
The U.S. needs to increase access to rapid prototyping of novel designs and devices, especially for both critical national security and civilian infrastructure applications, and to expand university/industry Centers of Excellence.

(b) The adequacy of the national security industrial base

Semiconductors are a key enabling technology, and this is especially the case when it comes to national security applications. Being able to rely on a domestically sourced supply of semiconductors is critical for national security.

The U.S. semiconductor manufacturing base has remained remarkably stable over the past 20 years (see table 3). Front-end semiconductor fabrication capacity in the United States has steadily increased over the past several years, and the vast majority of domestic semiconductor front-end fabrication capacity is done by U.S. headquartered semiconductor firms. The stability in the level of domestic U.S. semiconductor capacity has therefore led to stable levels of domestic semiconductor shipments and exports.

Table 3



Source: SEMI, World Fab Watch, Status 03/2016.
Note: Monthly wafer start capacity is normalized to 8-inch equivalent wafers.

However, as the semiconductor industry has become more global and overseas markets have grown in importance, foreign semiconductor producers have increased their capacity abroad, and domestic manufacturers are diversifying where they manufacture, often choosing to produce close to global end markets. This trend has caused the U.S. domestic fab capacity share of overall global capacity to decrease.

The defense industrial base needs access to leading edge technologies, like artificial intelligence, quantum computing, neuromorphic computing and needs to begin implementing these technologies into its platforms and systems. However, the U.S. military should not simply be "receivers" of technology; to ensure effective applications, they must be involved in technology development.

(c) The capabilities of the domestic manufacturing workforce

A talented semiconductor workforce is one of the keys to maintaining global leadership in semiconductor manufacturing, and certain policies are critical to ensuring the U.S. industry has access to the best talent for jobs in the United States. As discussed above, specific policies that would improve the capabilities of the domestic semiconductor manufacturing workforce include:

- Policies to attract and retain highly skilled workers in Science, Technology, Engineering, and Math (STEM) fields.

- Policies that invest in STEM education to develop a highly skilled American workforce.

Separate but related to the issue of attracting, retaining, and investing in the domestic semiconductor workforce, policies must also be put in place to reform our immigration system, so our domestic manufacturing workforce is further strengthened.

Brilliant researchers, scientists and engineers flock to U.S. world-class universities, but once they have their diplomas U.S. immigration policy makes it almost impossible for these U.S. educated professionals to work in the United States, including to contribute to semiconductor advanced manufacturing.

In a world where talent and capital are available globally, this is a significant problem for strengthening U.S. semiconductor advanced manufacturing capabilities. Foreign nationals represent a large percentage of the science and engineering graduates that will be key in solving industry challenges in advanced manufacturing. **It is imperative to our nation's economic future that we not allow these talented individuals to get lost in our immigration system.**

Congress has failed to reform the employment-based (EB) green card and H-1B visa systems that U.S. employers use to recruit and retain top worldwide talent, resulting in:

- The broken green card system causes employees to spend years in limbo, unable to be promoted or relocated without restarting the process.

- Over 3,700 H-1Bs in the semiconductor industry seek permanent resident status.

The result is that America is losing the world's best and brightest at a time when other countries are increasing their efforts to attract these individuals to support their semiconductor advanced manufacturing efforts.

The U.S. federal government should act to ensure U.S. semiconductor companies can attract and retain the best and brightest by exempting graduates with advanced STEM degrees from U.S. universities from the EB green card cap; and streamlining the path from STEM student to permanent resident.

(d) Export opportunities and trade policies

With over 80 percent of U.S. semiconductor industry sales to markets abroad, maintaining free and open global markets is a key priority for the U.S. semiconductor industry. Also, because the U.S. semiconductor industry maintains a significant share of it advanced manufacturing in the U.S., being able to supply foreign markets from the U.S. without costly barriers is essential for our competitiveness. Given this priority, SIA's key policy priorities in this area include:

- Maintain and expand access to global markets and support robust international trade.
- Enforce international trade rules to maintain a level playing field for U.S. businesses.
- Ensure U.S. industry can compete in overseas markets on fair and equal terms

- Remove munitions controls from 5G technologies and ensure export control regulations allow U.S. semiconductor companies to effectively compete in the global market for commercial and dual-use semiconductors.

(e) Financing, investment, and taxation policies and practices

SIA strongly supported the Tax Cuts and Jobs Act, passed by Congress and signed into law in late 2017. The U.S. tax code had put American semiconductor companies at a distinct disadvantage, with a high statutory rate and outdated international provisions. The Tax Cuts and Jobs Act immediately instituted a globally competitive rate of 21 percent, preserved the research and development (R&D) tax credit, modernized international taxation and provided a lower effective tax rate for foreign income derived from intellectual property such as patents. These important reforms significantly improve the competitiveness of U.S. semiconductor research, design and manufacturing.

The Department of Treasury and the Internal Revenue Service are tasked with promulgating regulations and issuing notices to implement the sweeping reforms enacted by statute. Legislation to make technical corrections to certain provisions in the tax bill is also expected in 2018.

(f) Federal regulations

Semiconductor manufacturing is a highly complex process involving the precise and controlled use of chemicals and advanced materials, coupled with highly advanced and automated manufacturing equipment and facilities ("fabs") that are designed to operate using these specific chemicals. The industry relies on specialty chemicals with unique chemical and physical properties that make possible the production of advanced semiconductors. In order to ensure quality and consistency in the production process, chemicals and materials used in semiconductor manufacturing are subject to significant and often redundant controls and safety measures.

Given the critical role of chemicals with specialized properties and performance attributes in contributing to ongoing innovations in our industry, the industry needs an effective and efficient system for regulating chemicals. This system must effectively balance the protection of human health and the environment with the ability to act promptly. It must employ a well-defined and objective chemical evaluation methodology for the approval of new chemicals and new uses. The evaluation methodology needs to consider the risk and exposure of chemicals in specific uses, and not just the inherent hazards of a chemical. The system needs to prioritize among the uses of specific chemicals and focus on applications with a high potential for exposure and risk. The system needs to account for the rapid pace of innovation in industries such as semiconductor manufacturing. The system also needs to protect confidential business information (CBI).

The existing chemicals regulatory system is generally structured to achieve these goals, but sometimes the system falls short in applying these principles. In order to promote advanced

semiconductor manufacturing in the U.S., the implementation of regulations governing new and existing chemicals should recognize the importance of key chemicals to the industry's production processes and evaluate these chemicals according to the unique use, risk, and exposure models applicable to our industry.

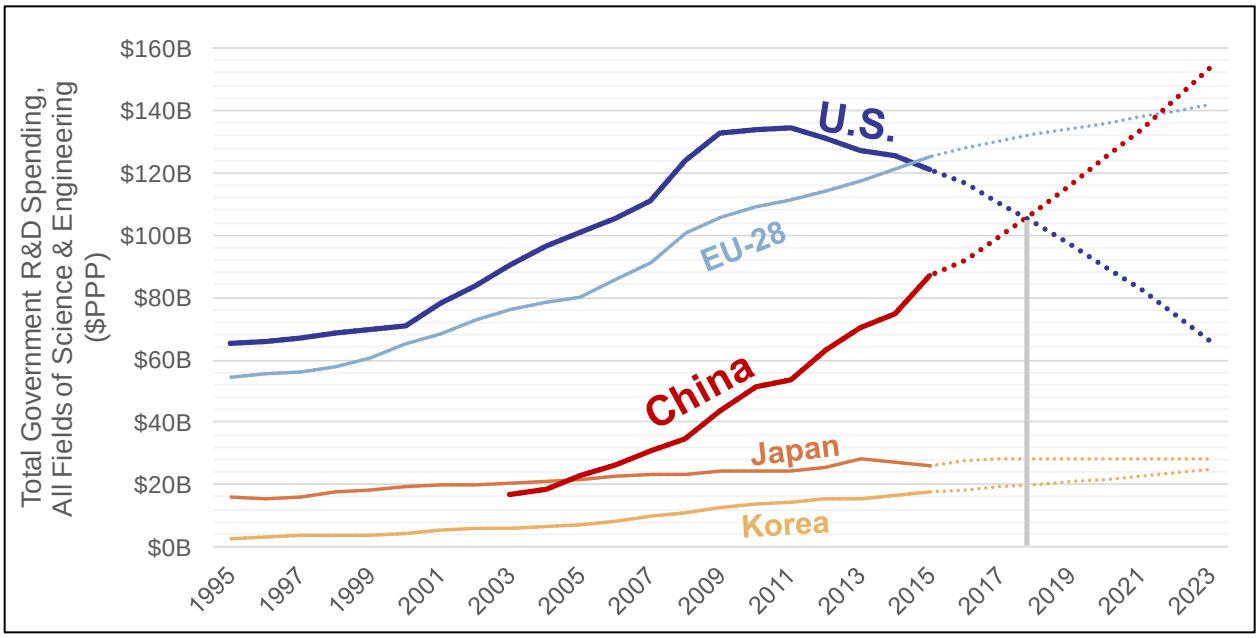
(g) Emerging technologies and markets

As a key enabling technology for innovation advanced in innumerable downstream sectors, semiconductors will play a key role in the development of new technologies and markets. One market relevant to the development of U.S. advanced manufacturing is machine learning and industrial robots. Machines and robots are enabled by highly-advanced semiconductors such as processors. As advanced manufacturing becomes more reliant on machine tools, this represents a growing market for the semiconductor industry. As advanced manufacturing grows in the United States and the demand for machine tools and robots grows, this represents growth in a domestic market for the U.S. semiconductor industry.

(h) Advanced manufacturing research and development undertaken by competing nations

While U.S. government funded R&D levels have stagnated or decreased in recent years, other competing countries, including China, have been doubling down on R&D funding, especially in areas critical to semiconductor innovation [see Table 4]

Table 4

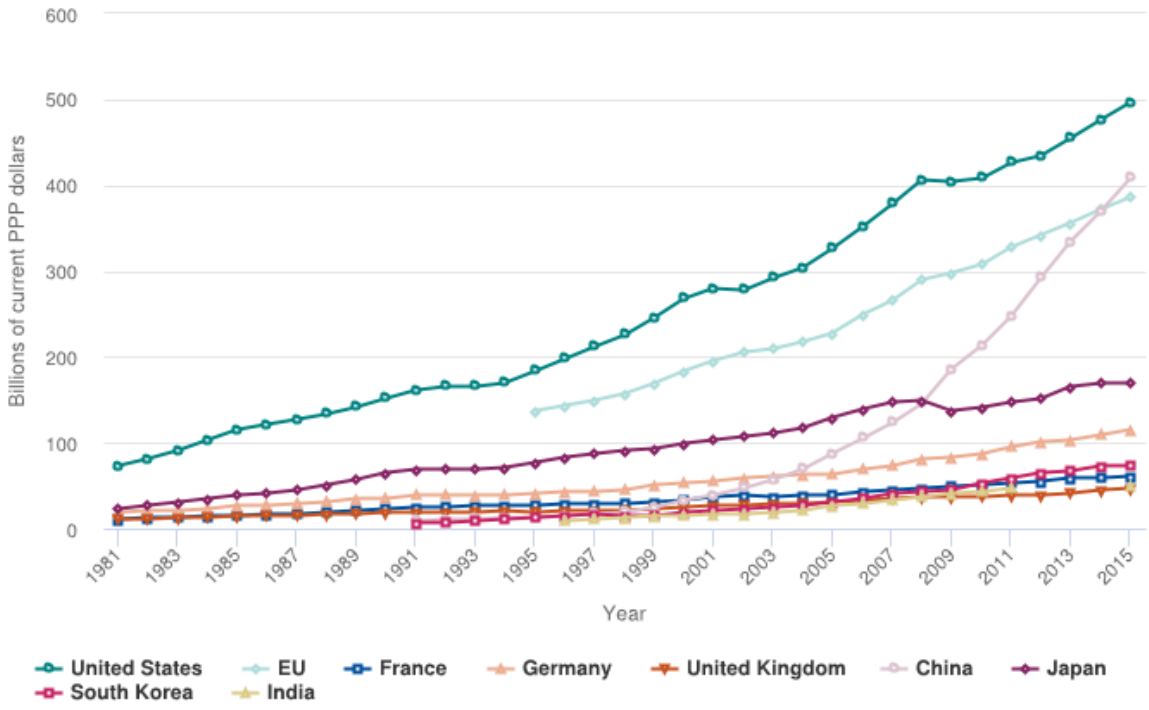


Note: Dotted lines are linear projections beyond 2015
Source: OECD Main Science and Technology Indicators (2017) and IMF World Economic Outlook (2017)

The level of industry funding from foreign nations has also increased. This is most notable with China, which has announced and acted on new policies since 2014 to grow its domestic semiconductor industry through massive government funding in semiconductor manufacturing capacity.

Table 5

Gross domestic expenditures on R&D, by the United States, the EU, and selected other countries: 1981–2015



EU = European Union; PPP = purchasing power parity.

Note(s): Data are for the top eight R&D-performing countries and the EU. Data are not available for all countries for all years. Data for the United States in this figure reflect international standards for calculating gross expenditures on R&D, which vary slightly from the National Science Foundation's protocol for tallying U.S. total R&D. Data for Japan for 1996 onward may not be consistent with earlier data because of changes in methodology. Data for Germany for 1981–90 are for West Germany.

Source(s): National Science Foundation, National Center for Science and Engineering Statistics, National Patterns of R&D Resources (annual series); Organisation for Economic Co-operation and Development, *Main Science and Technology Indicators* (2017/1); United Nations Educational, Scientific and Cultural Organization Institute for Statistics Data Centre, data.uis.unesco.org, accessed 13 October 2017. See Appendix Table 4-12.

Science and Engineering Indicators 2018

(i) The capabilities of the manufacturing workforce of competing nations

As mentioned above, by returning to their countries highly-educated foreign-born students, the U.S. immigration system enables the capabilities of the manufacturing workforce of competing nations at the expense of the domestic workforce. After foreign-born students complete their science and engineering studies at top U.S. universities, U.S. immigration policy makes it almost impossible for them to work in the United States, including to contribute to semiconductor advanced manufacturing.

In a world where talent and capital are available globally, this is a significant problem for strengthening U.S. semiconductor advanced manufacturing capabilities. Foreign nationals represent a large percentage of the science and engineering graduates that will be key in solving industry challenges in advanced manufacturing. **It is imperative to our nation's economic future that we not allow these talented individuals to get lost in our immigration system.**

The result is that America is losing the world's best and brightest at a time when other countries are increasing their efforts to attract these individuals to support their semiconductor advanced manufacturing efforts.