Comments of the
Semiconductor Industry Association (SIA)
To the
Office of Science and Technology Policy (OSTP)
On the
Request for Information
on
Identifying Critical Data Gaps and Needs To Inform Federal Strategic Plan for PFAS Research and Development

87 Fed. Reg. 41,749 (July 13, 2022)

Submitted August 29, 2022

The Semiconductor Industry Association (SIA)[1] submits these comments to the Office of Science and Technology Policy (OSTP) in response to the Request for Information (RFI) on "Identifying Critical Data Gaps and Needs To Inform Federal Strategic Plan for PFAS Research and Development." 87 Fed. Reg. 41,749 (July 13, 2022).

The semiconductor industry and its key suppliers are currently working to collect the information and data needed to address these issues. The industry and its key suppliers have formed a Semiconductor PFAS Consortium to collect the technical data needed to better inform public policy and legislation, including:

- Identification of critical uses,
- Application of the pollution prevention hierarchy to, where possible: reduce PFAS consumption or eliminate use, identify alternatives, and minimize and control emissions,
- Identification of research needs, and
- Development of socioeconomic impact assessments.

The consortium membership includes semiconductor manufacturers and members of the supply chain including chemical, material and equipment suppliers.

SIA offers the following responses to several of the questions posed in the RFI:

> <u>OSTP Question 1</u> – *"Should the USG consider identifying priority PFAS when developing a strategic plan for PFAS research and development? If so, what criteria should be used to identify priority PFAS for research and development (e.g., tonnage used per year; releases to the environment per year; toxicology or other human or environmental health concerns; national security or critical infrastructure uses)?"*

[1] The Semiconductor Industry Association (SIA) is the voice of the semiconductor industry, one of America's top export industries and a key driver of America's economic strength, national security, and global competitiveness. Learn more at www.semiconductors.org.

SEMICONDUCTOR INDUSTRY ASSOCIATION

As part of its strategic plan for PFAS research and development, the USG should prioritize PFAS used in the semiconductor industry, along with other essential uses of PFAS that are critical to the economy and national security and where there are no known substitutes for these chemicals.

PFAS are essential to the continued ability of the semiconductor industry to innovate and achieve new advancement in semiconductor technology. The unique properties of PFAS enable continued innovation in process technology necessary to fabricate increasingly complex devices at smaller feature sizes and employing complex designs and novel materials.

U.S. leadership in semiconductor manufacturing and design is a national priority and essential to the U.S. economy, national security, and technology leadership.[2] To maintain U.S. leadership in semiconductor technology while also addressing emerging environmental and health concerns and sustainability requirements, the federal research agenda on PFAS must prioritize the research needs of the U.S. semiconductor industry.

> *OSTP Question 3* – *"What are the scientific and technological challenges that must be addressed?"*

SIA believes research is needed to ensure the semiconductor industry can continue to use PFAS for the foreseeable future, while at the same time identifying substitutes that may be suitable for future use. In particular, we believe PFAS-related research is needed on (A) treatment methods, (B) measurement technologies, (C) alternatives to specific PFAS that are identified as presenting potential concerns, (D) predictive models for physicochemical properties, environmental fate parameters, and toxicity endpoints of PFAS, and (E) methods for the identification of high priority PFAS.

A. Treatment methods

To ensure ongoing uses of PFAS can continue during the near term in a manner that protects the environment, research is needed on technologies to detect, treat, control, and minimize or eliminate environmental releases of PFAS.

Use of PFAS chemistries within the manufacturing process has the potential to result in the production of PFAS-containing waste streams that require further characterization and the development of controls aimed at the permanent destruction of the very strong carbon-to-fluorine bonds that PFAS contain. Many promising new PFAS destruction techniques are being researched that will require further innovations, development,

---

[2] Congress recently passed legislation, the CHIPS and Science of 2022 (P.L 117-167), to incentivize increased semiconductor manufacturing in the U.S. This legislation also includes substantial investments in semiconductor research, and SIA believes some of this funding should be directed at PFAS-related research applicable to the semiconductor industry.

demonstration and integration to treat complex semiconductor wastewaters. However, at present, demonstrated technologies do not exist for identifying and treating all of the substances of concern. Additional treatment techniques will need to be developed and will require time-consuming and costly evaluations.

We believe priority research efforts should encompass the following:

- Gaseous emission controls – on-site
- Liquid effluent controls – on-site for high volume, low concentration wastestreams within complex matrices (i.e., those containing high organic and dissolved solid content)
- Solid and hazardous waste disposal – off-site

In order to be cost effective and useful in large scale manufacturing, these treatment technologies need to use low energy and achieve the destruction of PFAS at low concentrations in complex vapor and liquid phase mixtures.

B. Measurement technologies

The semiconductor industry currently uses carefully selected PFAS for many of which no proven analytical techniques exist, particularly PFAS that could be present at the very low concentrations (<1 ppb) that might be found in semiconductor wastestreams. The semiconductor industry believes that validated analytical methods will be required to show the ability to meet the intent and the letter of emerging regulations.

We believe near-term research efforts are needed particularly on the following:

- Air and wastewater techniques for low concentration wastestreams, including both consumed PFAS and all its PFAS-based byproducts.
- Quick portable identification methods of PFAS in solids
- Methods useful for development of treatment systems, like the ability to measure the extent of PFAS destruction via measurement of mineralization

C. Alternatives to PFAS

To assist in the exploration of alternatives to PFAS, fundamental research is needed to identify environmentally preferable alternatives to PFAS that also meet the stringent functional needs and performance characteristics of substances used in the semiconductor industry.

To date, no suitable alternatives have been found that successfully replace the remaining PFAS in use within the semiconductor industry. If suitable non-PFAS alternatives can be identified, larger studies will need to follow which must identify and resolve all aspects related to the integration of these new materials into the highly complex and inter-dependent semiconductor manufacturing process. A typical semiconductor process technology change timeline is approximately 10-15 years to fully prove and integrate such solutions.

In order to be deployed at commercial fabs, such alternatives need to be highly purified and achieve the same (or improved) performance as existing PFAS analogues.

D. Predictive models for physicochemical properties, environmental fate parameters, and toxicity endpoints of PFAS

PFAS encompasses a large and diverse group of chemicals of potential concern to human health and the environment. To date, only limited toxicity studies have been conducted across this large set of compounds with much work being focused primarily on perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA), two compounds which are no longer used by the semiconductor industry. Data suitable for assessing the potential risks for the majority of PFAS are lacking. Given the size and diversity of PFAS as a chemical category, the lack of environmental fate and transport data as well as biological effects data cannot be readily addressed through conventional toxicity testing. Therefore, there is a need to identify methods to efficiently measure or predict the toxicity, bioaccumulation and biomagnification potential of PFAS.
This type of modeling can help enable evaluations of PFAS currently being used by industry as well as avoid the identification of substitutes that fail to offer an improved environmental profile as compared with currently used PFAS.

E. Identification of high-priority PFAS

Rather than focusing on PFAS as a broad category, research efforts should focus on identifying higher-priority PFAS on the basis of the substances' potential effects on human health and/or the environment. This will better enable a systematic quest for seeking substitutes and a focused approach for informing regulatory efforts intended to phase down uses of specific substances of greatest concern. Broad categorical approaches on PFAS using categorical definitions will diffuse research efforts at a time when resources (in terms of funding and laboratory expertise and capabilities) may be limited. Broad categorical approaches will also diffuse implementation efforts of identified replacements for PFAS of greatest concern.

OSPT Question 4 – "Are there specific chemistries and/or intended uses that PFAS provide for which there are no known alternatives at this time?"

The semiconductor industry uses a number of highly specialized PFAS in chemical formulations in the fabrication process. Certain PFAS also can be found within components of manufacturing process tools, and within features of facilities' infrastructure. Given the specific chemical and physical attributes of PFAS, in many of these applications PFAS provide unique performance and functional capabilities in the semiconductor fabrication process, for which there are no known viable alternatives. As documented in one recent article, for example, many of the uses of PFAS in the photolithography process are essential and there are currently no known alternatives for these uses.[3] The article states: "The use of fluorochemicals in lithography and semiconductor patterning plays a critical role in the success of semiconductor technology." The article continues:

> The addition of small quantities of fluorinated materials enables patterning capabilities that are otherwise not possible to achieve and this leads to superior device performance. The compact size of the fluorine atom and its strong electron withdrawing characteristics make it stand out in the periodic table and gives fluorocarbon materials unique properties, unmatched by other chemical compounds.

> *OSTP Question 6* – *"What should be the research and development priorities for accelerating progress, improving efficiency, and reducing the cost of: analytical methods, detection limits, non-targeted detection?"*

SIA believes OSTP should prioritize, among other things, research on analytical methods and detection limits. PFAS may be present in wastewater discharges from semiconductor fabs and extremely small concentrations, and improved analytical methods and detection limits are needed – along with effective treatment technologies – to minimize environmental releases of PFAS.

> *OSTP Question 9* – *What goals, priorities, and performance metrics would be valuable in measuring the success of National, federally funded PFAS research and development initiatives relating to:*
> *a. The removal of PFAS from the environment;*
> *b. Safely destroying or degrading PFAS; and*
> *c. Developing safer and more environmentally-friendly alternatives to PFAS?*
> *d. Mitigating negative human effects of PFAS, whether related to health or additional domains*

As stated above in our response to Question 3, SIA's priorities for PFAS research efforts are focused on treatment methods to minimize or eliminate releases of PFAS to the environment and the identification and qualification of safer and more environmentally-friendly alternatives to PFAS that meet the functional and performance requirements of the semiconductor industry.

\+ \+ \+

SIA appreciates the opportunity to provide input to OSTP on the federal strategic plan for PFAS research and development.

---

[3] Christopher K. Ober, Florian Käfer, Jingyuan Deng, "The essential use of fluorochemicals in lithographic patterning and semiconductor processing," J. Micro/Nanopattern. Mater. Metrol. 21(1), 010901 (2022), doi: 10.1117/1.JMM.21.1.010901, available at http://dx.doi.org/10.1117/1.JMM.21.1.010901.