

SEMICONDUCTORS AND PFAS: NAVIGATING INNOVATION AND SUSTAINABILITY

Semiconductors are the backbone of modern technology, found in everything from smartphones and computers to medical devices and defense systems. Semiconductor production is critical to the global economy and depends on a group of chemicals called per- and polyfluoroalkyl substances (PFAS). This document explores the essential role of PFAS in chip manufacturing and the need for a balanced approach to PFAS policy to ensure health and environmental safety while enabling innovation.

Requests to Policymakers on PFAS

- 1 Develop risk-based PFAS regulations that do not restrict chip production
- 2 Support R&D programs to accelerate progress on environmental controls and viable PFAS alternatives

Semiconductors Enable Everything Digital and Shape Our Modern World

Aerospace/
Defense



High-
Performance
Computing



Artificial
Intelligence



Medical
Devices



Automotive



Quantum
Computing



Energy



Telecom and
5G



Economic Impact and Global Governmental Support

While the global semiconductor market is expected to generate more than \$600 billion in revenue in 2024, chips underpinned over \$2.5 trillion in electronics systems globally. In recent years, governments worldwide have recognized the strategic importance of semiconductor manufacturing and the significant contributions of chips to economic prosperity and modern life.

The disruptions caused by the COVID-19 pandemic highlighted the vulnerabilities in global supply chains, prompting calls for greater domestic chip production. Government initiatives, such as the U.S. CHIPS Act and the EU Chips Act, are collectively investing hundreds of billions of dollars in the semiconductor industry in response to supply shortages and the expanding importance of chips across all economic sectors.



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PFAS as Process Chemicals

Photoresists, plasma etching gases, chamber cleaning

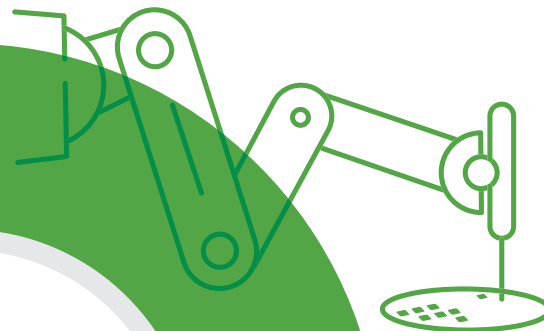
1



PFAS in Semiconductor Manufacturing Related Equipment

Heat transfer fluids, fluoropolymer in equipment

2



PFAS Use by the Semiconductor Industry

4

PFAS in Chips and Related Products

Semiconductor devices, adhesives, cables, printed circuit boards



3

PFAS in Facilities

Cooling/heating systems, polymers in infrastructure: filters, tubing, linings, o-rings



Manufacturing Complexity and Role of PFAS

Creating semiconductors is a complex process, involving thousands of intricate steps. State-of-the-art technology nodes require over 2,000 processing steps, utilizing specialized equipment and materials, all of which collectively cost billions of dollars. Due to their extremely small feature size, chips are highly sensitive to any source of contamination and require atomic precision in manufacturing.



Why PFAS?

Various types of PFAS are essential to the semiconductor manufacturing process because they have low surface tension, high heat and chemical resistance, high thermal stability, radiation stability, favorable electrical characteristics, compatibility with other chemicals, purity, and other properties that enable them to fulfill the unique demands of semiconductor manufacturing. Fluoropolymers, fluorochemicals, and fluorinated gases are all used by the industry to meet many needs within the manufacturing process and can be found in:

- Components used in factory water, liquid, gas, and exhaust distribution systems;
- Components used in wafer processing tools and factory control systems;
- Specialized clean room design features;
- Personal protective equipment;
- Lubricants used in high technology robotics and vacuum pumps;

- Heat transfer fluids and refrigerants for high-precision temperature control units and process chillers;
- Process chemicals in photolithography, dry etching, cleaning, and deposition to reduce the potential for defects and enable high-resolution microstructures and deliver required yield; and
- Some semiconductor devices.

In short, the semiconductor manufacturing process is enormously dependent on fluorine chemistry in a variety of use cases, the majority of which currently have no viable alternatives.

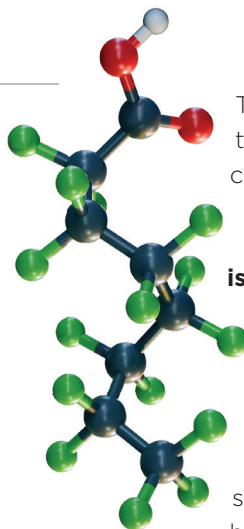


Due to the numerous special properties of PFAS there are no known equivalent alternatives for most of the 1,000+ semiconductor manufacturing applications.



Understanding PFAS

Some PFAS serve critical functions across a wide array of sectors, including personal protective equipment, civil and military aerospace applications, specialty gases, clean energy generation, and battery manufacturing, just to name a few. These perfluorinated compounds are designed to resist breakdown under extreme temperatures to be effective for their intended use.



The unique nature of the carbon-fluorine bonds, among the strongest known to chemists, make PFAS and PFAS-containing materials difficult, and in some cases impossible, to replace while maintaining the same performance metrics.

Applying a universal restriction or classification to all PFAS is scientifically unjustified and would be as catastrophic to modern society as removing all insects from agriculture because some are problematic.

Not all PFAS are the same, and they should not be regulated as such. The PFAS group includes thousands of substances in many sub-groups: polymers and non-polymers; solids, liquids, and gases; persistent and non-persistent; highly reactive and inert; mobile and insoluble; and toxic and non-toxic. **Frequently, efforts to address important health and environmental topics use the broad term PFAS when they are most interested in a distinct sub-group of PFAS** like perfluoroalkyl acids such as PFOA.

Industry Response and Request for Engagement

The semiconductor industry actively works to promote environmental protection in the design, manufacture, and use of its products, and prioritizes practices aimed at ensuring health and safety throughout the semiconductor supply chain. SEMI member companies have proactively taken steps to collaborate on material detection capabilities, abatement and destruction technology, circularity (recycling, reuse, and repurpose), and alternatives. However, significant technical challenges remain to be overcome in finding alternatives for many PFAS use-cases in semiconductor applications due to the unique characteristics that PFAS provide to the industry.

SEMI members remain available to offer recommendations and industrial insight and request that governments adopt a more targeted and multi-pronged approach to addressing PFAS concerns. Collaboration and innovation will ensure continued progress and prosperity in this vital industry, all the while protecting human health and the environment.

SEMI® is the global industry association connecting over 3,500 member companies and 1.5 million professionals worldwide across the semiconductor and electronics design and manufacturing supply chain.

How Governments Can Help

- 1** Support PFAS legislation and regulations that effectively empower authorities to implement risk-based analysis and emission controls while ensuring access to chemicals that are vitally important to the production of semiconductors. All proposed policies should account for the fact that developing alternatives to critical applications of PFAS within the semiconductor industry is a decades-long process.
- 2** Support research and development (R&D) with programs that leverage industry and academic expertise to develop enhanced detection, monitoring, control, and abatement capabilities; investigate potential PFAS alternatives; and overcome technical challenges associated with developing and implementing alternative substances and related manufacturing processes



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