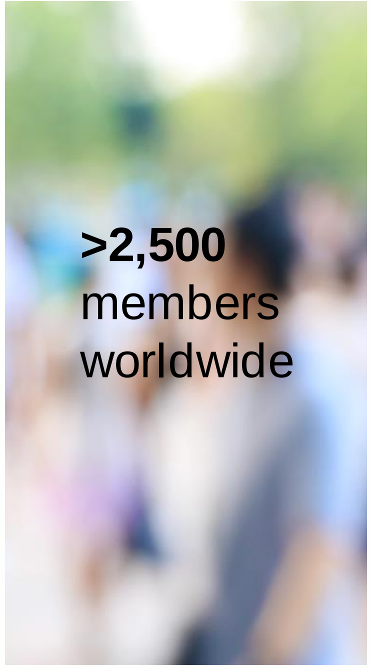
PFAS Workshop

26th October 2023

SEMI – A Global Scope for a Global Industry!

2023 Top Priorities



Thought Leadership

1,000+ Standards

Expositions/ Conferences

EHS/ESG

Worldwide Offices

2,300+ Program Hours

170+ Tech Programs

20+ Tech Communities

Market Intelligence Reports

Strategic Tech Communities: ESDA, FOA, FlexTech, MSIG, SOIC

Tech partners: imec, Fraunhofer, CEA-Leti, IEEE, ITRI, AIST

Smart Initiatives

Think Tanks

Talent Development, DEI & e-learning

Sustainability

Global Advocacy

Supply Chain Management

SEMI PFAS WG
245 members

Introduction to ESIA

Represent the interests of the European-based semiconductor industry and advocate for its international competitiveness

- Most R&D-intensive sector
- Highly competitive global market
- Highly-developed global supply chain
- Enabler for a multitude of other industries

EU

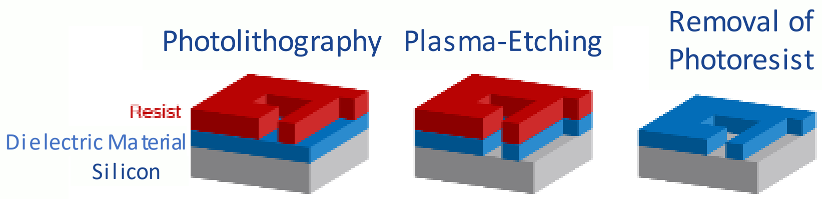
- 8% of global production capacity
- Direct employment 200.000
- indirect up to 1.000.000
- ESIA is member of the World Semiconductor Council (WSC)

Agenda

1. Opening remarks by ESIA and SEMI
2. Presentation of key evidence and main findings on the use of PFAS in the semiconductor industry
3. Roundtable discussion among European Commission and industry representatives
   a. PFAS in the semiconductor industry
      i. Need for PFAS and their unique characteristics in the semiconductor industry
      ii. Definition of the "semiconductor manufacturing process" derogation
      iii. Criticality of the semiconductor industry as enabler for key initiatives (Green Deal, NZIA, Chips Act etc.)
   b. Input to research projects
      i. Complexity of semiconductor industry's R&D needs.
      ii. TTC agreement on incentives for research into PFAS alternatives for the semiconductor industry.
   c. International collaboration agreements
      i. Diminished competitiveness/level playing field with other jurisdictions
      ii. PFAS manufacturers and supply chain issues
4. Closing remarks by SEMI and ESIA

PFAS In The Semiconductor Industry

PFAS use by the Semiconductor industry



PFAS as Process Chemicals (photoresists, plasma etching gases, chamber cleaning)

PFAS in Semiconductor Manufacturing related equipment (Heat Transfer Fluids, Fluoropolymer in equipment)

PFAS in articles (semiconductor products, adhesives, cables, printed circuit boards)

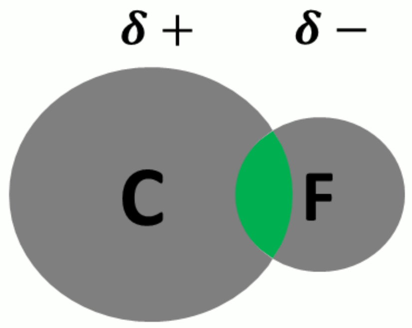
PFAS in Facilities (cooling/heating systems, Polymers in infrastructure: filters, tubing, linings, o-rings)

Application examples in Semiconductors

Reasons for the use of PFAS in Semiconductor Industry:

- Chemically restistant to agressive media (acidic, caustic, oxidative)
- High thermal stability (>260°C)
- Low friction, very little abrasion (very little particle-emission)
- Source for highly reactive flourine species in plasma, which reacts with Silicon, forming gaseous molecules such as SiF_4
- Source of strong acids via optical amplification (Photoacid Generators)
- Low refractive index, good UV-Transmission
- Very low Surface energy
- Hydrophobic and oleophobic propeties enabling multi-barrier role
- Good mechanical stability
- Favourable electric properties (good isolation, low κ dielectric)

Due to the numerous special properties of PFAS there are no known equivalent PFAS-free alternatives in most applications.

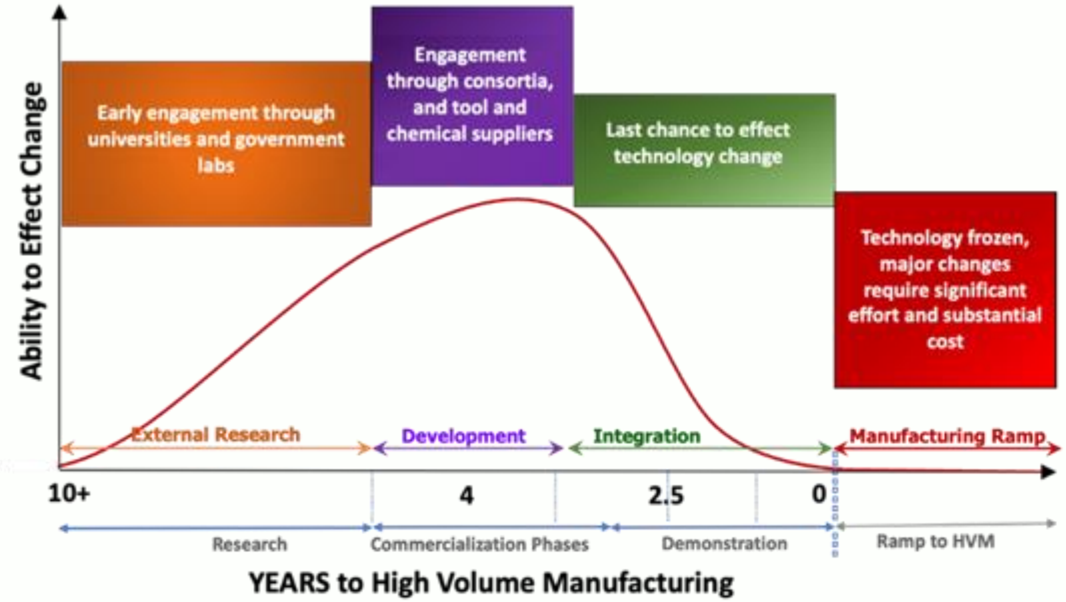


Strongest single-bond in organic chemistry!

Atom-bonding	Binding energy
C-F (in CF_2-R1-R2)	503 kJ/mol
C-O (single Bond)	358 kJ/mol
C-N (single Bond)	305 kJ/mol
C-C (in Ethane)	376 kJ/mol

Reasons for a comprehensive derogation

- Annex XV dossier does not fully capture latest state of knowledge on PFAS uses in the semiconductor industry (Table A.49 is not complete)
- R&D efforts are ongoing across the industry
- Most applications have no known alternatives today. There is no guarantee that all applications can be substituted.
- Development cycles in the semiconductor industry are significantly longer than the proposed derogation (between and 10 and +- 25 years)
- PFAS restrictions will affect the entire value chain: material, manufacturing equipment, manufacturing, servicing and imports.



Semiconductors crucial for EU policy objectives

Not securing a comprehensive derogation will effectively stop the value chain. Several EU policy priorities would be affected:

- **The EU industrial strategy**
  - Supporting the EU's global competitiveness
  - Making the EU climate neutral by 2050
  - Shaping Europe's digital future
- **Chips Act:** EU goal to reach 20% of global production from currently 9%.
- **Net Zero Industry Act** the deployment of clean energy and its associated technologies
  - Achieving European climate neutrality by 2050, will be harder, if not impossible to achieve
  - 55% reduction in greenhouse gas emissions by 2030 could be in jeopardy

Example: Semiconductors and the green transition:

Green energy generators have high-power semiconductor content :

- Wind: ~3,000 €/MW
- Solar: ~4,000 €/MW

Accelerated conversion from fossil to electrical in mobility

Roughly 80% of car sales in 2030 will be EV (up from ~15% in 2021)

- Semiconductor content in cars more than doubles from traditional to EV
- BEV: ~$1,000 per vehicle

(2021, Source: Gartner; Strategy Analytics; BCG semiconductor supply-demand forecast)

Way Forward

- Without an appropriate derogation covering the entire semiconductor supply and value chains, the semiconductor industry in Europe will be in jeopardy.
- The derogation should provide a clear path for renewal to account for technology development times and possible impossibility of substitution.
- Need for support to enable semiconductor industry R&D to replace PFAS wherever possible.

Input To Research Projects

PFAS alternative commercial implementation time

Fundamental Substance R&D +

The time required to develop a PFAS alternate targeted to certain technical use cases.

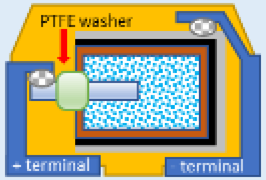
What one company makes another company might buy as a component – repeating this cycle several times.

Semi-industry technology

Commodity technology

The time required to generally qualify the alternate for the *technical use* cases. For example…

Ex. Case T1: PTFE Tanks for acid processes.

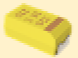


Ex. Case T2: PTFE barrier in SMD tantalum cap.

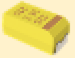
\+ The time required to productize the *technical uses* into many *basic products*. For example…

Case T1P1: PTFE tank for Sulfuric acid rinse

Case T1P2: PTFE tank for HCL acid clean



Case T2P1: 35Volt 28 µF cap



Case T2P2: 35Volt 32 µF cap

Case T2P3: 35Volt 28 µF cap

Case T2P4: 35Volt 24 µF cap

New component part numbers

\+ The time required to modify and requalify each *design case* incorporating a *basic product*.

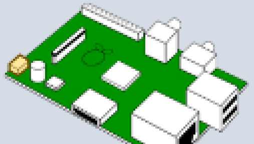
Centx N tool

Centx RA tool

PureRun module 4

PureRun T module

Damasc retrofit kit 447



New assembly part numbers

\+ Additional Time

A. Time to modify the part number of incorporating assemblies, and possibly electrical and physical interfaces in the assembly, as well

B. Time to requalify chip production processes if process-related parts were changed. (6-18 months)

C. Time modify manuals, assembly procedures, spares lists, and other documentation referencing old part numbers

D. Time to learn (e.g., accelerated lifetime testing*) and adjust for asymmetric aspects of substitution - such as a shorter item lifetime requiring revised maintenance/inspection schedules.

The semiconductor industry companies will have a much better understanding of timelines and impacts to semi-industry technology such as process chemicals, process-touching components, process chambers, etc.. The impact to commodity technologies, such as capacitors, batteries, and general electronics, will not be well understood directly in the semiconductor eco-system.

Engineering resources in normal circumstances is difficult to obtain because of competing priorities (e.g. safety, innovation, customer special requests). 8 hours of engineering time often takes 3 months calendar time to complete. There could be thousands of simultaneous PFAS-related changes required in a given equipment manufacturing company, straining resources even more.

* Designing, executing, and analyzing an accelerated lifetime test takes 1 to 3 years.

Benefit analysis of a PFAS alternative

The benefit of switching to a PFAS alternative should be balanced against impacts from the production, transportation, and use of the alternate & related basic products, such as:

A. Factory and equipment redesign
How will the factories and equipment used to manufacture
- The raw alternate substance
- Alternate substance distribution forms, and
- The basic products made with the alternate substance

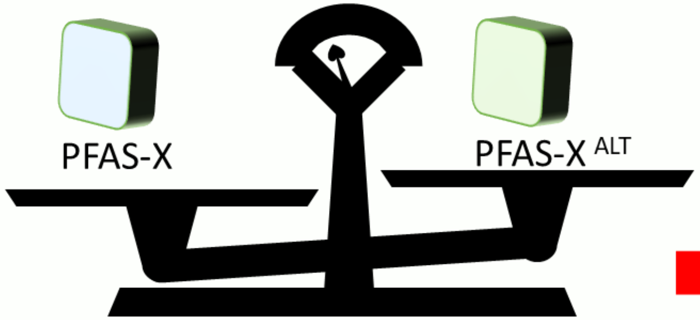
have to be redesigned to accommodate different characteristics of the alternate?

B. Product certifications
What type of certifications will the
- The raw alternate substance (e.g. flame retardancy), and
- The basic products made with the alternate substance (e.g., CE marking)

have to obtained per regulation or industry custom?

C. Energy use / CO2eq emissions
What is the overall energy/carbon footprint of the alternate considering
- The raw alternate substance ?
- The alternate substance distribution forms ?
- The basic products made with the alternate substance ?

Including transportation through the supply chain.




Example alternative distribution forms

D. Other environmental impacts and substance restrictions
What restrictions nonetheless apply to alternate substance?
PFAS alternatives that can function as well, or nearly as well, as PFAS are likely to also have environmental impacts.

E. Safety of workers
In the manufacture of the
- The raw alternate substance,
- The alternate substance distribution forms, and
- The basic products made with the alternate substance

What hazards will workers be exposed to?

F. Legal encumbrances
What patents and intellectual property considerations will limit use of the alternative?

G. Geo-politics & Geo-capacities
Where will the alternate be produced? Will there be sufficient quantities available where it is needed soon enough to meet market demands?

EU PFAS research pipeline – what we know

- The Semiconductor Industry and its ecosystem will need collaborative research to ensure progress in finding/developing alternatives to PFAS, advancing capture technologies and developing analytical techniques.
- It is imperative that the EU research mechanisms cater for PFAS.
- It's looking very likely that Horizon Europe will be the primary mechanism for semiconductor research on PFAS.

Investments to support the Chips Act

The Chips Act itself should result in additional public and private investments of more than €15 billion.

These investments will complement:

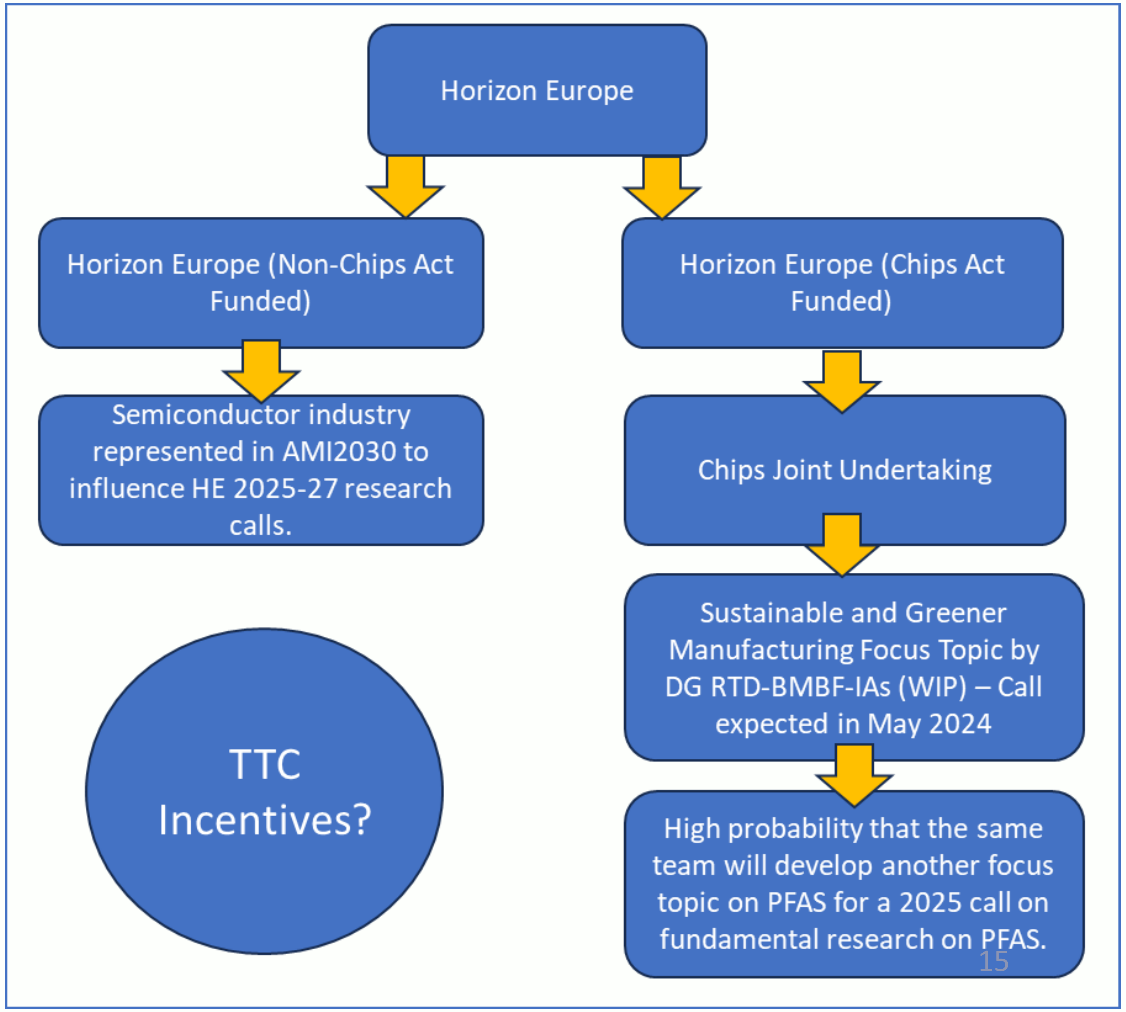
- existing programmes and actions in research and innovation in semiconductors such as Horizon Europe and the Digital Europe programme
- announced support by Member States

In total, more than €43 billion of policy-driven investment will support the Chips Act until 2030, which will be broadly matched by long-term private investment.

Horizon Europe funding & TTC incentives

- The Semiconductor industry is currently working to develop a PFAS research roadmap to prioritise specific research projects.
- In parallel, the industry is engaged with working groups and alliances to ensure PFAS is explicitly named in pending and future research calls – both the "regular" Horizon Europe programme and the element under the Chips Act via the Chips Joint Undertaking.
- Based upon the analysis undertaken by the industry, such research will need to be of a multiyear and possibly multidecade for certain PFAS uses.
- In the 4th TTC Ministerial meeting in May'23, it was noted in the minutes that PFAS research and the industry was discussed. Are there any specifics to this that can be shared?

  "Going forward, we are exploring additional ways to collaborate, including how to cooperate on incentives for research on alternatives to the use of per- and polyfluorinated substances (PFAS) in semiconductor manufacturing."



International Collaboration Aspects

The Potential Impact on the Industry Calls for Global Cooperation

PFAS is also on the radar of the US Environmental Protection Agency (EPA) and regulatory initiatives are ongoing. The US semiconductor industry has a large share of the manufacturing market and hosts leading chipmakers and equipment manufacturers.

- The EPA evaluation framework seems to have:
  - a **differentiated approach**, depending on potential for exposure and environmental release
  - a focus on PFAS that are likely Persistent Bioaccumulative Toxic (PBT)
  - a strong distinction between **dispersive/non-dispersive** uses
  - reporting rules with **narrower PFAS definition** (C1 PFAS seem largely excluded)
- At State level: Minnesota, Maine and New Jersey are working on rulemaking and reporting

While other jurisdictions (USA, Canada, UK) are looking into possible PFAS regulation, there are currently no initiatives equivalent to the EU PFAS restriction proposal which poses a **big risk of a further competitiveness loss** for the EU.

Considering potential restrictions at a global scale is critical to ensure a level playing field in terms of **timing** and **scope** (clarity on PFAS definition, sector (consumer vs. industrial), derogations and applications).