Septemeber 24, 2023

Comments on the Annex XV REACH restriction report

Restriction on the manufacture, placing on the market and use of PFASs

Submission deadline: September 25, 2023

SECTION I. Personal information

We may contact you about your comment and to request additional information.
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Any personal data submitted is subject to ECHA's data privacy rules.

SECTION II. Organisation

I am submitting information:

On behalf of an organisation or institution

Type of organisation/institution

Company

Country where the organisation or institution is legally established:

Belgium

Name of Organization:

Jones Day

Select one of the following options : *

X *I agree to the disclosure of the name of my organisation/institution to the public*

I want to keep the name of my organisation/institution confidential

Note: the type and country of your organisation/institution will always be disclosed.

SECTION III. Non-confidential comments

It is possible to provide both general comments on the Annex XV restriction report subject to this Consultation and answers to the specific questions posed. In both cases, it is necessary to provide supporting evidence to allow ECHA's Committees to take your comments into account. It is important not to leave the submission of any socio-economic information until the consultation on SEACs opinion but already submit relevant comments at this stage.

General Comments

Select the relevant boxes that cover the content of your comments and provide your non-confidential comments below, (maximum 9 000 characters)

- [x] Scope or restriction option analysis
- [x] Hazard or exposure
- [x] Environmental emissions
- [x] Baseline
- [ ] Description of analytical methods
- [x] Information on alternatives
- [x] Information on benefits
- [x] Other socio economic analysis (SEA) issues

- [x] Transitional period
- [x] Request for exemption

- [x] I understand that it is my responsibility not to include confidential information in responses to general comments and in any responses to requests for specific information (e.g. company name, email addresses, phone numbers, signatures etc.). ECHA will not be held liable for any damages caused by making non confidential responses publicly available.

Please provide your general comments in the box below:

This submission is made by Jones Day on behalf of a confidential client ("Client"). The Client is a technology company that designs and manufactures semiconductors.

The Client is a member of the semiconductor industry's "PFAS Consortium," as well as a member of European Semiconductor Industry Association ("ESIA") and SEMI. The Client endorses and incorporates by reference the submissions, comments, and derogation requests made by ESIA, SEMI, and the German Electrical and Electronic Manufacturers' Association ("ZVEI"), as well as related papers made available by the PFAS Consortium, in relation to the various uses of PFAS materials throughout the semiconductor manufacturing cycle.

Those papers and submissions accurately document the needs for substantially expanded derogations for the semiconductor industry's various PFAS uses, and include detailed information and alternatives information regarding PFAS uses in photolithography, in plasma etch and deposition, as an anti-bleed agent in die attach epoxy, in heat transfer fluids in semiconductor manufacturing equipment, in various pumps, fluids and lubricants used for semiconductor manufacturing, and other uses in semiconductor manufacturing equipment. Each of these issues is addressed in detail in the submissions and related papers made available by the PFAS Consortium, at this link: https://www.semiconductors.org/pfas/#:~:text=AND%20SEMICONDUCTOR%20PROCESSING%20%3E-,Technical%20Papers,-The%20Semiconductor%20PFAS.

For purposes of *these* comments, however, we focus only on providing additional information on certain non-replaceable uses of, and the necessity of derogations for, ***PFAS in a narrow but critically important subsector of the semiconductor sector: semiconductor devices known as microelectromechanical systems ("MEMS") devices***.

MEMS comprise components between 1 and 100 micrometers in size and usually include a central processor and several components that interact with other devices such as microsensors. As detailed in the PFAS Consortium's White Paper on Packaging: *"MEMS have widespread* *applications including as inkjet heads, pressure sensors, microphones, accelerometers, gyroscopes, magnetometers, inertial combs, thermopiles, microbolometers, optical MEMS, microfluidics, radio-frequency MEMS, oscillators and environmental sensors. MEMS markets include consumer, automotive, industrial, medical, telecommunications, and defense and aerospace. The unintentional adhesion of MEMS surfaces is detrimental to performance within the limits of the MEMS actuation and is one of the more pervasive problems with MEMS device fabrication, packaging and handling. (....)" See PFAS-Containing Materials Used in Semiconductor Manufacturing Assembly Test Packaging and Substrate Processes*, Semiconductor PFAS Consortium Assembly, Test, Packaging and Substrates Working Group (June 2, 2023).

Client's MEMS devices are sold in the European Union ("EU") into the following non-exhaustive list of markets for end products: medical devices, industrial, automotive, personal electronics, communications equipment, and enterprise systems. These products are essential to the functioning of the EU's, as well as the world's, modern economy, security and society.

EU authorities have, in the recently adopted Chips Act, already noted the systemic risks that supply chain and other business interruptions to the semiconductor sector pose to the EU's economic health and sustainability objectives. As the recitals to the Chips Act state: *"Semiconductors are at the core of any digital device and the Union's digital transition: from smartphones and cars, through critical applications and infrastructures in health, energy, communications and automation to most other industry sectors. As semiconductors are central to the digital economy, they are powerful enablers for the sustainability and green transition, contributing thus to the Green Deal objectives. While semiconductors are essential to the functioning of our modern economy, defence, security and society, the Union has witnessed unprecedented disruptions in their supply, the consequences of which are significant."*

The importance of the semiconductor sector and the supply chain deficiencies in the EU are also stressed in a recent report of the Joint Research Center ("JRC") - 'Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU'. Available at: https://publications.jrc.ec.europa.eu/repository/handle/JRC132889. The Report recognizes that semiconductors are fundamental to all digital technologies and are illustrative of the international nature of the market and supply chains. According to the JRC, there is a lack of public investment to support the manufacture of advanced technologies, when compared with the US and Asia, that has discouraged semiconductor industry development within the EU (EC, 2020). There are also supply risks at all stages of the value chain, from the poorly diversified production of certain critical raw materials such as rare earths and noble gases to the EU's limited manufacturing capacity of highly strategic processed materials and components, such as advanced logic and memory semiconductor chips. The Report states that China has the biggest share of most of the raw materials in digital technologies by 47% of share, followed by Africa as continent (12%). The EU share is approximately 3%. *"The higher supply risk for raw materials is associated with the manufacturing of the semiconductor, magnet and battery."* (page 103).

The use of PFAS in the semiconductor sector is not mentioned in the JRC Report. However, PFAS are referred to as "process materials" for the production of other key technology products (i.e. fuel cells, electrolysers).

The PFAS REACH Restriction Proposal as it presently stands would present yet another, but in scale unprecedented, disruptive impact to the semiconductor sector and the products that depend on semiconductors, including MEMS, for EU society's health, safety and sustainable well-being. This disruption will be felt not just in Europe, but globally should the REACH PFAS Restriction Proposal be adopted in its current version without realistic and meaningful derogations for semiconductors and their value chain. This global impact will, as well, amplify the adverse impacts in the EU.

We are pleased to provide this supplemental information on our MEMS devices in order to provide ECHA, the Dossier Submitters, and the European Commission with additional information about the critical function that PFAS plays in the operation and functionality of these MEMS devices, the *de minimis* PFAS emissions in the EU associated with those uses, the importance of these MEMS devices in a wide range of end products that cross many different applications with significant socioeconomic values, and the lack of available alternatives for PFAS for these applications at the current time and for the foreseeable future.

This submittal also proposes language for the derogation necessary to avoid the unprecedented disruptive impacts the PFAS restriction proposal would create if finalized in its current form.

For the reasons described in greater detail below, a derogation for this use is both clearly warranted and fully consistent with REACH's risk-based decision-making standards for Annex XVII restrictions. The absence of such a derogation, conversely would lead to a deeply non-proportional outcome, with severely adverse socio-economic impacts and negligible (and perhaps even undetectable) environmental benefits.

Where necessary to ensure the protection of confidential business information, we supplement the information in this public submission with more detail in our confidential attachment submitted under Section V below. We will identify with reference numbers the points where our public information is supplemented with additional information in Section V.

We would be pleased to meet with any ECHA or Member States officials to discuss any of the issues addressed in this submission in more detail and address any questions. We appreciate ECHA's attention to this submission.

1. **Sectors and (sub-)uses**: Please specify the sectors and (sub-)uses to which your comment applies according to the sectors and (sub-)uses identified in the Annex XV restriction report (Table 9). If your comment applies to several sectors and (sub-)uses, please make sure to specify all of them.

Electronics and semiconductors.

2. **Emissions in the end-of-life phase**: The environmental impact assessment does not cover emissions resulting from the end-of-life phase. To get a better understanding of the extent of the resulting underestimation, (sub-)use-specific information is requested on emissions across the different stages of the lifecycle of products, i.e. the manufacture phase, the use phase and the end-of-life phase. Please provide justifications for the representativeness of the provided information. In particular:

a. Please provide, at the (sub-)use level, an indication of the share of emissions (as percentages) attributable to these three different stages. An indication of annual emission volumes in the end-of-life phase at sector or sub-sector level would also be appreciated.
b. If possible, please provide for each (sub-)use what share of the waste (as percentages) is treated through incineration, landfilling and recycling. Please provide information to justify the estimates as well as information on the form of recycling referred to.

Key Points

As described in more detail below and in our response to Question 7, an irreducible minimum amount of PFAS is required for reliable operation of certain MEMS devices. These substances are sealed inside certain of the client's MEMS devices for the duration of their use phase.

The quantity of PFAS at issue in MEMS devices is minute: only a very small amount of PFAS (<900ppm, or <0.09% w/w) of PFAS is used in each device, and client continues to make incremental technology improvements to enable a lower total PFAS concentration for specific products/applications in those devices. The absolute amount of PFAS that is placed on the market in the EU, by virtue of being embedded in these MEMS devices, is extremely low. Client places on the global market a total of <1kg per year PFAS substances contained in MEMS devices; it is therefore highly likely that the absolute annual totals of PFAS used in these applications in products that are placed onto the market in the EU does not exceed 0.5 kg per year. Indeed, our estimate is that roughly 20% of the end products that contain these MEMS devices end up on the EU market.

Accordingly, we estimate that the absolute total of PFAS used in these applications in the EU does not exceed 0.2 kg per year. In, sum, therefore, the answer to Question 2 regarding PFAS emissions at the end-of-life phase is that such emissions from MEMS devices are likely at or near zero.

That *de minimis* result is a function of several factors, including:

a. the very low absolute volumes of PFAS that are placed on the EU market in the first place in MEMS devices;
b. the controls on emissions from electronics waste management that flow from compliance obligations imposed by Directive 2012/19/EU on waste electrical and electronic equipment ("WEEE"), which will apply to most if not all of the final equipment applications of products that contain MEMS devices; and
c. the obligations of waste treatment facilities to apply best available techniques ("BAT") under the Industrial Emissions Directive 2010/75/EU with respect to any incineration of waste fractions resulting from the waste processing.

Background -- Emissions in the Production Phase

All MEMS production by the Client takes place at a single production facility, outside the EU/EEA. There are, accordingly, no PFAS emissions in the EU from the Client's MEMS production.

That manufacturing process (which, again, sits outside of Europe) is essentially a closed loop under strictly controlled conditions. Releases of PFAS from MEMS manufacturing operations occur in very small quantities that may be released as air emissions or in wastewater discharges. We provide more confidential information about the production process in Section V (see part [2]).

The manufacturing process collects most of the PFAS that are not ultimately embedded in the MEMS device wafers themselves and then transfers them for thermal destruction. The process equipment that applies PFAS during the manufacturing phase has internal cold trap filters that are designed to remove PFAS residues from the exhaust stream. The Client is currently undertaking a review of the cold trap filter design and chiller capabilities to maximize PFAS removal efficiency from the manufacturing process equipment, which again is located outside the EU/EEA.

All PFAS waste collected from the condenser or otherwise captured during the manufacturing phase is collected for off-site thermal destruction located outside the EU/EEA. This includes waste consumables used in the manufacturing process and from maintenance activities. The solvent containing collected PFAS and consumable waste is destroyed by a governmentlicensed industrial waste incineration facility using high temperature thermal oxidation for industrial waste.

All waste handling practices and procedures at each step described above are designed to avoid occupational exposures to these residual PFAS.

Background -- Emissions in the Use Phase

The MEMS devices at issue in this submission are components that are used in a wide variety of end devices. They are marketed and sold to enterprise customers in several key market segments in the EU, including medical and safety applications, where they are further embedded into complex electronic articles, i.e., end products, on the EU market.

The tiny fraction of PFAS in the MEMS device is never designed to be released during the use phase of the end product. In fact, the device is specifically designed to *avoid* release of PFAS during the use phase of the product, because any release of PFAS during product use would cause rapid degradation and eventual failure of the MEMS device, and therefore of the affected component or end product.

Moreover, the MEMS devices at issue here are not accessible or replaceable by end users of the complex articles in which they are incorporated as components. Needless to say, the minute amount of PFAS that is incorporated in those devices is likewise inacessible to end users, and there are no consumer or occupational exposures at issue in connection with this important but limited use case.

Detailed Information on Emissions in the End-of-life Phase

Emissions from Waste Recycling -- WEEE Directive

The complex articles into which these MEMS devices are integrated are typically processed at end-of-life as scrap electronics to reclaim valuable materials contained within them, and where such processing occurs in the EU, in accordance with national implementation of the WEEE Directive. Such operations are carried out consistent with the minimum quality standards for environmental protection as specified in Article 8(5) of the WEEE Directive. It is unknown how much MEMS end-of-life processing occurs in the EU/EEA. As noted above, we estimate that roughly 20% of these MEMS produced will end up on the market in the EU/EEA.

With respect to the MEMS devices at issue in this submission, given that the total absolute quantities of PFAS in these MEMS devices are already insignificant in the EU/EEA (i.e., roughly 0.2 kg/year), the potential releases to the environment that are attributable to these releases should be considered *de minimis*. <u>To the extent such releases may occur, moreover, a restriction on PFAS uses in MEMS devices in order to mitigate those *de minimis* environmental emissions is not a proportional regulatory response.</u> Those emissions could instead be regulated via other EU legislation, and not through REACH. EU authorities have already explicitly acknowledged that alternative options are available, as explicitly stated in the PFAS working document (SWD(2020) 249 final) accompanying the Chemicals Strategy for Sustainability:

> *"Waste treatment facilities are covered by the IED and these can emit PFAS. The BAT conclusions for waste treatment address PFOA and PFOS, but not other PFAS. Permits given to waste treatment plants have to implement the obligations within four years of BAT conclusion publication. <u>Authorities can consider emissions limits for all other PFAS as well as for PFOS and PFOA. Based on this, there is scope to better address PFAS as a chemical class under the IED</u>"*. (Emphasis added)

In any event, some proportion of the already small quantity of PFAS found in the fraction of total waste MEMS devices actually processed in the EU/EEA will be captured and destroyed during the subesequent phase of WEEE processing. The output streams of such WEEE processing generally comprise two primary waste fractions: aqueous solutions of precious metals (which may contain PFAS surfactants), and high-inorganic content solid waste.

- With repect to the aqueous solutions, the precious metal content is removed by precipitation. PFAS can be sequestered from the resulting effluent by (concentration, absorption on porous media, novel remediation techniques, etc.).
- With respect to the solid waste, this fraction typically comprises main group elements and their oxides as well as PFAS- and non-PFAS containing organic polymers. This waste fraction is typically subjected to incineration. Solid waste subjected to incineration in a hydrocarbon-rich environment is unlikely to produce short-chain PFAS, as discussed further below. The primary fluorine-containing by-product will be HF, which is expected to be mineralized as fluoride-containing salts and minerals by reaction with the inorganic components in the waste stream.

Emissions from Incineration of WEEE Waste Fractions

When assessing emissions from waste incineration, BAT should be taken into account. BAT encompasses the current technological standard for EU waste incineration facilities and is required to be applied at such facilities.

BAT is not necessarily applied in other countries, which may lead to higher emissions. As such, only EU studies should be analyzed in order to assess the potential PFAS emissions into the environment from waste incinerators located in the EU.

We have performed a literature search to make that assessment, which is summarized below. In the relevant publications, waste incinerators in the EU were sampled and analyzed for PFAS, or experiments on the potential emissions arising from PFAS incineration were reported. Various different kinds of ash and water and in one case the flue gas were sampled.

- *Sandblom* (2014) sampled slag, fly ash, condensate and wastewater from four different waste incineration facilities in Sweden. The authors also state that the facilities are operating in agreement with the European and Swedish laws and as such it can stated that BAT are applied in these facilities. The study found individual PFAS concentrations in the fly and bottom ash of up to 6.63 ng/g. In the condensate and water, the individual PFAS concentrations reached up to 9.71 ng/L. The author concludes that "waste incineration plants in Sweden are unlikely to contribute significantly to environmental emissions of PFAAs" (Perfluoroalkyl acids).

- In another Swedish study *Kullh & Clark* (2020), the slag and water condensate from the gas scrubber from two different incineration facilities in Sweden were analyzed for their PFAS content. It can be assumed that the incinerators comply with EU law and hence with BAT. In the slag samples no PFAS could be detected (Limit of detection between 0.4 and 2 ng/g depending on substance). In the water samples PFAS concentrations of up to 3.6 ng/L could be found for individual PFAS. According to the authors, these results "are comparable to or lower than measurements from background lakes in Sweden" and as such are not a significant source of PFAS into the environment.

- Another Swedish study from *Wohlin* (2020) also analyzed the fly and bottom ash from eleven different waste incineration facilities in Sweden. The samples were taken in 2005 and may not represent the possible current emissions from waste incineration. In the bottom ash samples, individual PFAS concentrations of up to 1.6 ng/g were found. In the fly ash, the individual concentrations were lower with concentrations reaching up to 0.26 ng/g. The author concludes that long chain PFAS molecules "may degrade into shorter PFAS due to the incineration treatment" and that these PFAS can pose a problem when landfilled as they may leach out over time.

- A Dutch study from the ministry of infrastructure and water management *Rijkswaterstaat* (2020) analyzed the waste water and bottom ash from various Dutch incinerators. It can be assumed that the incinerator complies with EU law and hence with BAT. In the wastewater samples a PFAS concentration above the limit of detection (1 – 25 ng/L depending on substance) was found only in one out of two samples (Perfluorobutanesulfonic acid: 1.1 ng/L). In the ash PFAS could be detected more frequently (three out of four samples). The highest found concentration was 4.9 ng/g.

- A German study from *Aleksandrov et al.* (2019) analyzed the combustion of Polytetrafluoroethylene (PTFE) and assessed whether or not PFAS can be found after the incineration. This was done at a university incineration facility at the KIT in Karlsruhe, which complies with EU emission regulations. Only minimal concentrations of PFAS could be found from which the authors conclude that "no significant evidence that the PFAS studied were created during the incineration of PTFE could be found".

- A study from the Danish Environmental protection agency *Geertinger et al. (2019)* analyzed the behaviour of persistent organic pollutants during laboratory incineration. One of the analyzed substances was Perfluorooctanesulfonic acid (PFOS), which at 900 °C decomposed to 99.95% from which the authors conclude, "that more than 99 % of PFOS will be destroyed by co-incineration at a conventional waste incineration plant". It is, however, also stated that the fluorine may transform into hydrogen fluoride (HF), fluorinated dioxins and furans or simple short chain fluorinated gases such as CF4, CHF3, C2H2F2 and C2F6.

In sum, all studies analyzed here conclude that little to no PFAS are formed during waste incineration in the EU, and that waste incineration is not a significant source of PFAS into the environment.

References

Aleksandrov, K., Gehrmann, H. J., Hauser, M., Mätzing, H., Pigeon, D., Stapf, D., & Wexler, M. (2019). Waste incineration of Polytetrafluoroethylene (PTFE) to evaluate potential formation of per- and Poly-Fluorinated Alkyl Substances (PFAS) in flue gas. Chemosphere, 226, 898–906. https://doi.org/10.1016/j.chemosphere.2019.03.191

Eurostat. (2021). Treatment of waste by waste category, hazardousness and waste management operations [env_wastrt]. https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_wastrt&lang=en

Geertinger, A., Jensen, A. A., & Hansen, M. W. (2019). Belysning af destruktion af visse POP-stoffer på konventionelle affaldsforbrændingsanlæg til forbrænding af hovedsageligt ikke-farligt og forbrændingsegnet affald (Issue 2085). https://www2.mst.dk/Udgiv/publikationer/2019/07/978-87-7038-072-0.pdf

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RIVM. (2021). Report summary waste for the PFAS restriction proposal under REACH.

Sandblom, O. (2014). Waste Incineration as a Possible Source of Perfluoroalkyl Acids to the Environment - Method Development and Screening. 27. http://su.diva-portal.org/smash/get/diva2:1261025/FULLTEXT01.pdf

Wohlin, D. (2020). Analysis of PFAS in ash from incineration facilities from Sweden. January.

3. Emissions in the end-of-life phase: With respect to waste management options, additional information is requested on the effectiveness of incineration under normal operational conditions (for different waste types, e.g. hazardous, municipal) with respect to the destruction of PFAS and the prevention of PFAS emissions.

See our reply to Question 2 above.

4. Impacts on the recycling industry: To get an understanding of the impacts of the proposed restriction on the recycling industry, information is requested on:

a. The impacts that the concentration limits proposed in paragraph 2 of the proposed restriction entry text (see table starting on page 4 of the summary of the Annex XV restriction report) have on the technical and economic feasibility of recycling processes (together with a clear indication on the waste streams to which the described impacts relate).
b. The measures that recyclers would need to take to achieve the proposed concentration limits.
c. The costs associated with these measures.

We don’t have information on this topic.

5. Proposed derogations – Tonnage and emissions: Paragraphs 5 and 6 of the proposed restriction entry text (see table starting on page 4 of the summary of the Annex XV restriction report) include several proposed derogations. For these proposed derogations, information is requested on the tonnage of PFAS used per year and the resulting emissions to the environment for the relevant use. Please provide justifications for the representativeness of the provided information.

Please see our reply to Question 2 above and Question 7 below.

6. Missing uses – Analysis of alternatives and socio-economic analysis: Several PFAS uses have not been covered in detail in the Annex XV restriction report (see uses highlighted in blue and orange in Table A.1 of Annex A of the Annex XV restriction report). In addition, some relevant uses may not have been identified yet. For such uses, specific information is requested on alternatives and socio-economic impacts, covering the following elements:

a. The annual tonnage and emissions (at sub-sector level) and type of PFAS associated with the relevant use.
b. The key functionalities provided by PFAS for the relevant use.
c. The number of companies in the sector estimated to be affected by the restriction.
d. The availability, technical and economic feasibility, hazards and risks of alternatives for the relevant use, including information on the extent (in terms of market shares) to which alternative-based products are already offered on the EU market and whether any shortages in the supply of relevant alternatives are expected.
e. For cases in which **alternatives are not yet available**, information on the status of R&D processes for finding suitable alternatives, including the extent of R&D initiatives in terms of time and/or financial investments, the likelihood of successful completion, the time expected to be required for substitution (including any relevant certification or regulatory

approvals) and the major challenges encountered with alternatives which were considered but subsequently disregarded.

f. For cases in which **substitution is technically and economically feasible** but more time is required to substitute:
    i. the type and magnitude of costs (at company level and, if available, at sector level) associated with substitution (e.g. costs for new equipment or changes in operating costs);
    ii. the time required for completing the substitution process (including any relevant certification or regulatory approvals);
    iii. information on possible differences in functionality and the consequences for downstream users and consumers (e.g. estimations of expected early replacement needs or expected additional energy consumption);
    iv. information on the benefits for alternative providers.

g. For cases in which **substitution is not technically or economically feasible**, information on what the socio-economic impacts would be for companies, consumers, and other affected actors. If available, please provide the annual value of EU sales and profits of the relevant sector, and employment numbers for the sector.

PFAS use in the MEMS devices is not adequately recognized or addressed in the Annexes with regulatory background material accompanying the PFAS Annex XV REACH Report.

Please see our reply to Question 7 below for details.

7. Potential derogations marked for reconsideration – Analysis of alternatives and socio-economic analysis: Paragraphs 5 and 6 of the proposed restriction entry text (see table starting on page 4 of the summary of the Annex XV restriction report) include several potential derogations for reconsideration after the consultation (in [square brackets]). These are uses of PFAS where the evidence underlying the assessment of the substitution potential was weak. The substitution potential is determined on the basis of i) whether technically and economically feasible alternatives have already been identified or alternative-based products are available on the market at the assumed entry into force of the proposed restriction, ii) whether known alternatives can be implemented before the transition period ends (taking into account time requirements for substitution and certification or regulatory approval), and iii) whether known alternatives are available in sufficient quantities on the market at the assumed entry into force to allow affected companies to substitute.

A summary of the available evidence as well as the key aspects based on which a derogation is potentially warranted are presented in Table 8 in the Annex XV restriction report, with further details being provided in the respective sections in Annex E.

To strengthen the justifications for a derogation for these uses, additional specific information is requested on alternatives and socio-economic impacts covering the elements described in points a) to g) in question 6 above.

Introduction & Essential Background

Introduction

The use of PFAS in the MEMS devices is not covered by derogations under the proposed restriction. We therefore provide in this non-confidential section information that corresponds to each of the elements described in points (a)-(g) above, namely:

- Essential background on the MEMS devices;
- Annual tonnages and emissions of PFAS associated with this use;

- The use of PFAS in MEMS devices and the use of MEMS devices in end products, and the key functionalities provided by PFAS;
- The number of companies in this sub-sector that will be affected;
- The Client's analysis of alternatives and its work to identify a substitute;
- The socioeconomic impact of the PFAS REACH Restriction Proposal that would occur in the absence of a derogation.

The Client concludes its response to this section with the proposed text of the derogation request that is required in order to preserve these uses.

Where necessary to ensure the protection of confidential business information, we supplement this information with more detail in the confidential submission under Section V below.

Essential Background: What is a MEMS Device and Why Are They Important?

The inventory of PFAS uses assembled by the the Dossier Submitters in Annex A to the Annex XV REACH Report overlooks the unique application of PFAS in MEMS devices, notwithstanding extensive information that has previously been supplied to the Dossier Submitters. This is admittedly a highly specialized and narrow set of applications, but one that has widespread applications today and is essential to enabling further innovation in many socio-economically important sectors.

MEMS devices are a subset of the semiconductor sector that, unlike other semiconductor chips and LEDs, involve moving parts. MEMS comprise components between 1 and 100 micrometers (µm) in size and usually include a central processor and several components that interact with other devices such as microsensors. Please see Section V, part [1], for more information on the Client's MEMS devices.

The Client's MEMS devices are sold in the EU into the following non-exhaustive list of markets: medical devices, industrial, automotive, personal electronics, communications equipment, and enterprise systems. They are incorporated by our customers into end products for medical devices such as endoscopes, specialized medical display devices such as holotomographic devices and dental 3D scanners, flight simulators & pilot trainers, structured light patterning, 3D printing, video projection, spectroscopy, automotive equipment, optical switching, holotomography, 3D image creation, projection mapping, direct imaging lithography, augmented reality, and industrial automation, among other end applications. ***Additional detail on the Client's devices and end applications is included in the confidential attachment.***

The functionality of these tiny moving parts (5 to 13 micrometers) also requires the use of chemicals to facilitate and enable their rapid and reliable movement, up to 10,000 times per second. Those same subtances must also be capable of withstanding exposure to significant electromagnetic energy imparted by lasers, LEDs, phosphors, or other UV or infrared sources. PFAS alone provides that functionality, as described further below.

a. <u>How Much PFAS is Used in the EU in these MEMS Devices?</u>

An irreducible minimum amount of PFAS is required for reliable operation of certain MEMS devices. These substances are sealed inside the MEMS devices for the duration of their lifespan, which varies by end application but are required to meet 10 years of component service life in some end applications. Product life cycles are typically 10 to 15 years and often extend longer, consistent with many customers' requirements. In addition, replacement parts must be available for maintenance and repair throughout the life span of these products.

The quantity of PFAS at issue in these MEMS devices is minute. First, only a very small amount of PFAS (<900ppm, or <0.09% w/w) is used in each device, and the Client continues to make incremental technology improvements to enable a lower total PFAS concentration for specific products/applications in those devices. Second, the absolute amount of PFAS that is placed on the market in the EU, by virtue of being embedded in these MEMS devices, is extremely low. Client places on the global market a total of <1kg per year PFAS substances contained in MEMS devices; it is therefore highly likely that the absolute annual totals of PFAS used in these applications in products that are placed onto the market in the EU does not exceed 0.5 kg per year. Indeed, our estimate is that roughly 20% of the end products that contain these MEMS devices end up on the EU market. Accordingly, we estimate that the absolute total of PFAS used in these applications in the EU does not exceed 0.2 kg per year.

Please see the confidential attachment in Section V, part [2], for additional information on that substance. While the search for alternatives continues, the alternative PFAS replacement substance is the only alternative that has proven promising after nearly 20 years of research.

b. Key Functionalities: Why are PFAS Essential for MEMS Devices?

MEMS devices should be understood as a distinct and unique category of PFAS uses that straddles the semiconductor and electronics sector. PFAS are applied to MEMS devices during the semiconductor *production* phase, and then used (with no substitutes) during the semiconductor device's *use* phase; these MEMS devices (which rely on PFAS for their functionality) are ultimately used in a wide variety of end-product electronic applications.

- *Production Phase*: PFAS is applied as surface coating (akin to a lubricant) to MEMS parts during semiconductor wafer-level processing, as part of the semiconductor packaging manufacturing process. (For more detail on semiconductor packaging, see *PFAS-Containing Materials Used in Semiconductor Manufacturing Assembly Test Packaging and Substrate Processes*, Semiconductor PFAS Consortium Assembly, Test, Packaging and Substrates Working Group (June 2, 2023).) This PFAS application step occurs prior to capping the MEMS wafer, which seals the PFAS within the MEMS micro-environment for the lifespan of the MEMS.

- *Use Phase:* That sealed PFAS then performs its function in the MEMS device during the use phase of the MEMS device in end-products, as detailed further in the entry below, which could be added as a supplement to Table A.49 of Annex A to the Annex XV REACH Report.

Use Category	Sub-Use	Properties	Examples of PFAS
PFAS contained in Semiconductor Devices (Articles) -- Use Phase	MEMS Device Contact of the MEMS structures during operation is intentional and essential to the MEMS function for the Client's devices. MEMs are made up of components 1-100 micrometres in size and usually are made up of a central processor and several components that	MEMS devices require the use of PFAS as a type of highly specialized surface treatment substance (similar to a lubricant) to enable the repeated operation of moving parts within a microelectronic device during the use phase of the product. PFAS provide anti-stiction and surface energy modification properties	See confidential attachment in Section V, part [2].

	interact with the surroundings like microsensors. MEMS chips are often packaged together with an application-specific integrated circuit chip stacked together inside the plastic package, so that one package has the sensor and the circuitry, saving space and cost.	that cannot be achieved with other substances or materials. Specifically, PFAS provide (1) extremely low surface energies in microsystems where surfaces are repeatedly made to contact at very high pressures; and (2) resistance to degradation under extraordinary levels of electromagnetic radiation and flux density.	

For additional context on why PFAS are irreplaceable, it is essential to understand that key elements of our MEMS devices move, rub, and contact each other over 10,000 times each second during device operation. In addition, each MEMS device must have an extended operational lifetime, in some cases up to and exceeding 10 years. Compromising the surface energy of these microscopic parts - either through contamination or loss of the ultra-low energy surface -- will cause one or more of the moving elements to stick in place, rendering the device inoperable. Those forces – stiction (unintentional adhesion) and wear – will cause failures unless the MEMS device is treated with a protective interface (analogous to a coating or lubricant) that modifies the surfaces of the moving parts. *See PFAS-Containing Materials Used in Semiconductor Manufacturing Assembly Test Packaging and Substrate Processes*, Semiconductor PFAS Consortium Assembly, Test, Packaging and Substrates Working Group (June 2, 2023), at section 1.3.13.

As explained in more detail in the Analysis of Alternatives section below, ***there are no alternative substances or materials that provide this functionality other than PFAS.***

c. <u>Number of Companies in Affected Sector</u>

Please see the confidential attachment in Section V (part [3]) for details on this question.

d. <u>Analysis of Alternatives</u>

As noted above, our Client's MEMS devices involve repeated contact of the MEMS structures throughout the product's use phase. This property is an unusual characteristic of our Client's MEMS devices, which means that not only are there no current alternatives, but also that these devices may not benefit from broader industry R&D efforts to develop alternatives in the future, due to the unique features of this application.

We provide a detailed and comprehensive analysis of alternatives as a confidential attachment in Section V (part [4]). This attachment provides substantially more detail (with confidential business information) about the technology involved, the end applications, the role of PFAS in enabling the technology, and our Client's efforts to identify alternatives. In this section, we summarize the key non-confidential elements of that analysis. In short, there is no alternative to PFAS that is currently available, or currently foreseeable.

The Client has itself been and continue to be engaged in an extensive R&D effort spanning nearly 20 years. Please see the confidential attachment in Section V (part [4]) for more detail.

That work involves engagement with the larger scientific community through sponsored research programs that employ PhD scientists specializing in these and related disciplines, who continue to investigate the physics and chemistry of micro- and nano-scale contacting surfaces and seek and evaluate acceptable alternatives.

None of the other perfluorinated, partially fluorinated or nonfluorinated alternatives that we evaluated provide the requisite performance, reliability, and functionality necessary to satisfy our customers in various fields of application such as medical, instrumentation, and automotive.

For example, experimental evidence suggests that the surface energies present in these MEMS devices are approximately 6-8 mJ/m2. Due to the very small nature of these devices -- with moving elements only a few micrometers in length that are actuated electrostatically – higher surface energies for alternative materials create an energy barrier that could not currently be overcome. Higher electric fields, which might overcome the higher adhesion, cause interference between moving elements, dielectric breakdown within gaps separating elements with opposite polarity, irrecoverable charge injection, and other failure mechanisms that render the devices inoperable.

Put simply, many of the contact area reduction schemes published in the last decade are either not robust to mechanical wear or continue to rely on PFAS for surface properties. Indeed, our testing has found that unacceptable degradation takes place even for a *partially* fluorinated surface coating. Even within the universe of fluorinated materials, only a narrow set of molecular structures confer all of the necessary functions to ensure reliability in the myriad complex products built around these MEMS devices.

The Client has not limited their alternatives analysis to chemical alternatives to PFAS for MEMS devices. The Client has also explored options to replace or supersede the current technology. However, such a change would require invention and development of new non-contact or solid-state technologies, which would take decades and tens of millions of EUR. Current alternatives to the MEMS device technology are either immature or use even more fluorocarbons unable to provide comparable functionality in end products, and, therefore, unlikely to be accepted by the market. Any new technologies using non-fluorinated chemistry would first need to overcome the physics problems such as high flux densities, electromagnetic spectrum (UV, IR) energy, and accompanied heat development; would need to guarantee reliability over a commercially relevant operating and service lifetime under operating conditions; and would need to deliver comparable product performance (e.g. image quality). These results are not achievable today without PFAS, and cannot be achieved in the foreseeable future without PFAS absent an invention.

The Client is committed to explore and develop new and potentially promising non-PFAS related alternatives to currently state-of-the-art MEMS device technology. However, this is clearly unexplored territory and the technologies are still in their infancy. Further, based on the current knowledge, it cannot be estimated if such alternative technologies could replace all PFAS used in end-products in the marketplace.

e. Timeline Required

The Client will continue their internal work and external partnerships with the broader scientific community in efforts to advance science and technology in this regard.

The Client's experience to date with similar transition efforts in the semiconductor sector (e.g., PFOS and PFOA), however, is that the substution timeline for this sector – even with ambitious investments and enterprise-level commitments to transitions -- entails a minimum of 15-20 years *once an alternative is identified.*

At this point, as explained above, despite significant effort, we know of no substance or alternative material that would provide the essential functionality that PFAS, particularly the replacement substance identified in the confidential attachment to Section V, confers in order to enable MEMS technology. The Client's own internal research and survey of the last 20 years of published research reveals that fundamental discoveries and inventions of new topologies or new chemistries will likely be required in order to provide acceptable performance in our applications.

f. Cases where substitution is feasible: Section (f) is not applicable to this use case.

g. Socio-economic analysis

As explained above, unlike the conventional uses of PFAS in the semiconductor production process, where PFAS are used to build circuits that have no moving parts, these MEMS devices require the use of PFAS to enable the repeated operation of moving parts within a microelectronic device during the use phase of the product. PFAS, as a component of the MEMS device, thus enables the functionality of the many end products that contain such devices.

As such, PFAS plays an essential role across the entire operational lifetime of the affected devices. As explained above, there is no substitute for PFAS at the current time, and there is no obvious pathway for the future identification of a substitute. Therefore, without the ability to incorporate PFAS to perform this highly specialized lubrication function in the MEMS – and without the related ability to import, trade and use the products that contain those devices with such intentionally added (albeit minute) amounts of PFAS -- product lines and businesses that rely on these MEMS devices will no longer exist.

Numerous unique or superior applications that depend on MEMS devices that require PFAS as a lubricant or anti-stiction agent do not have PFAS-free substitute technologies or do not provide comparable functionality. Please see our confidential attachment in Section V for examples of end applications.

Please see the confidential attachment to Section V (part [5]) for more information about the estimated direct and indirect economic effects, if PFAS are not allowed to be used in MEMS devices. In addition, many of the end product applications described above contribute significantly to social welfare – such as in medical, automotive safety, and other similar applications. Because there are no alternatives to MEMS devices to enable the same functionality of those end products, and because PFAS is required for the operation of MEMS devices, the loss of PFAS would result in the cessation of their production and the social welfare benefits of those products would consequently be lost too, with incalculable costs.

Also, please note the specific impacts identified by the Semiconductor Industry Association PFAS Consortia's "*Initial Report – The Socio-economic Impact of a Potential PFAS Restriction on the Semiconductor Value Chain in Europe" found at* https://www.semiconductors.org/pfas/#:~:text=AND%20SEMICONDUCTOR%20PROCESSING%20%3E-,Technical%20Papers,-The%20Semiconductor%20PFAS.

Conclusion and Derogation Request

On the basis of the above, taking into account (a) the extremely low risk of environmental releases associated with this technology, and (b) the extremely high socioeconomic value of these applications, and because the use of PFAS in MEMs devices is not clearly covered by a derogation, we request an additional derogation to cover these uses.

That derogation could be added either by amending the scope of the current derogation 5[ee], i.e. *"the semiconductor manufacturing process which includes Semiconductor Manufacturing and Related Equipement, Semiconductor Manufacturing Infrastructure Equipment and the consumables used to produce semiconductors* ***and in semiconductors used in final electronic products including MEMS****"*, or by inserting "***in semiconductors used in final electronic products including MEMS***" as a separate derogation. A broader reference to semiconductors used in final electronic products would also capture derogations that are being requested for other semiconductor applications, e.g., use in semiconductor "packaging" requirements, which are being requested by SEMI, ESIA and others, and which we would endorse.

The derogation will need to extend for *at least* 13.5 years after entry-into-force of the future PFAS REACH Restriction. Indeed for the reasons noted above, we believe that this derogation could be fully justified for inclusion as one of the non-time-limited derogations.

8. **Other identified uses – Analysis of alternatives and socio-economic analysis**: Table 8 in the Annex XV restriction report provides a summary of the identified sectors and (sub-)uses of PFAS, their alternatives and the costs expected from a ban of PFAS. More details on the available evidence are provided in the respective sections in Annex E.

For many of the (sub-)uses, the information on alternatives and socio-economic impacts was generic and mainly qualitative. In particular, evidence on alternatives was inconclusive for some applications falling under the following (sub-)uses: technical textiles, electronics, the energy sector, PTFE thread sealing tape, non-polymeric PFAS processing aids for production of acrylic foam tape, window film manufacturing, and lubricants not used under harsh conditions.

More information is needed on alternatives and socio-economic impacts to conclude on substitution potential, proportionality, and the need for specific time-limited derogations. Therefore, specific information (if not already included in the Annex XV restriction report or covered in the questions above) is requested on alternatives and socio-economic impacts covering the elements listed in points a) to g) in question 6 above.

Please see our reply to Question 7 above.

9. **Degradation potential of specific PFAS sub-groups**: A few specific PFAS sub-groups are excluded from the scope of the restriction proposal because of a combination of key structural elements for which it can be expected that they will ultimately mineralize in the environment. RAC would appreciate to receive any further information that may be available regarding the potential degradation pathways, kinetics or produced metabolites in relevant environmental conditions and compartments for trifluoromethoxy, trifluoromethylamino- and difluoromethanedioxy-derivatives.

We don't have information on this topic.

10. **Analytical methods**: Annex E of the Annex XV restriction report contains an assessment of the availability of analytical methods for PFAS. Analytical methods are rapidly evolving. Please provide any new or additional information on new developments in analytics not yet considered in the Annex XV restriction report.

We don't have information on this topic.

SECTION IV. Non-confidential attachment

If needed, attach additional non-confidential information (data available in excel format, reports, etc.) below. Do not attach the same information already provided in section III here. If part of the information is confidential, please use section V to share it.

We don't have information on this topic.

If you would like to submit more than one document, please create a compressed archive where you include all files and upload the compressed file as attachment. Maximum file size is 20 MB.

* [X] I have removed/blanked the information I wish to keep/I have claimed confidential from all the attachments in section IV (e.g.: company name, company logo, personal names, email, signatures, other confidential business data). I understand that ECHA will not be held liable for any damages caused by making the attachments publicly available.