General Comment

Content

Overall perspective

This comment relates to products and processes that fall under the responsibility of the semiconductor division of a European company.

First, we would like to clarify that we fully agree with the intention to reduce PFAS in our environment as much as possible, considering the risks per PFAS subgroup.

The proposed PFAS restrictions would have a major impact on our semiconductor business. The proposed restrictions affect a large number of our core manufacturing processes and products, particularly in the area of MEMS (Micro-Electro-Mechanical Systems). In addition, in many cases, the proposed restrictions will prohibit the production of the products in Europe. Not only would several specific wafer fab sites in Europe be affected but also a number of customer plants in Europe, even though in many cases the final products themselves do not contain PFAS at all.
Regarding the current usage of PFAS in our own semiconductor products, such as pressure or inertial sensors (e.g., adhesives, anti-adhesive coatings, and protective gels), if available at all, alternative materials will most certainly significantly reduce the performance of our products in the respective applications. As a result, the restrictions will cause an additional burden on OEM customers, forcing them to undertake significant redesign and requalification efforts of their system products in cars, smartphones, etc. or, even worse, shifting their supplier strategy to non-EU-producing companies. Also, technological progress in the respective areas will be considerably delayed. It is even highly likely that the continuous resource-saving shrinking of semiconductor products over the last decades will be reversed and bigger sizes will have to compensate the weaker performance of non-PFAS materials.

PFAS substances have unmatched chemical and thermal properties. Their mechanical stability, together with these properties, results in unique, durable, and long-lasting performance in applications, contributing to product life extension and enabling the development of innovative semiconductor-based technologies.
In some cases, replacement materials can be identified and used. We are currently establishing a comprehensive replacement strategy for these cases.
However, for many MEMS specific products, alternative materials simply cannot replace PFAS because they frequently fail to fulfill the critical performance characteristics of PFAS substances and lack the properties required for electronic and semiconductor applications, such as high chemical and thermal resistance. One important example are pressure sensors used in harsh environments (high temperature and aggressive media) which are currently protected from the environment by PFAS-based gels; all currently known replacement materials do not have a sufficient ability to withstand the stress in the applications.
Acceleration sensors use PFAS based internal coatings to significantly improve the reliability and quality performance in the field.
Here, the only viable solution is a derogation for these specific PFAS materials (which are mainly fluoropolymers and hence "polymers of low concern" according to the OECD), since products produced with alternatives having lower durability and reliability would not only result in bigger sizes but also higher maintenance and replacement frequency and eventually increased e-waste.
PFAS are currently indispensable and cannot be replaced in the short term or at all without significant performance degradation. The restriction of PFAS without derogations and exemptions would be a disaster for the semiconductor industry in Europe. There are clear conflicts with two overarching goals of the European Union: Digitalization and the Green Transition.
The Chips Act intends to increase semiconductor production from 7% to a share of 20% of the worldwide production by 2030, which amounts to a factor 5 increase given the global growth. By providing considerable investment in the semiconductor field, our company is determined to significantly contribute.
The green transition requires a sophisticated systematic approach to energy production, distribution, storage, and use. Our company will contribute by electronics, components, and systems for green. The transition will only work with a massive deployment of state-of-the-art electronics, which should also be highly trustworthy to prevent acts of sabotage and hacking. So, all this can only happen with semiconductors/MEMS made in Europe.

We noticed that the information on semiconductor/MEMS products such as pressure or inertial sensors in semiconductor packages are very limited in the restriction proposal documents. We give details on those in response to question 8, proposing a derogation. In our answer to question 7 we provide detailed information supporting a derogation for the semiconductor manufacturing process.

In addition to the direct use of PFAS in products, there are numerous uses of PFAS in semiconductor manufacturing equipment and processes. Examples are photoresists, linings of tubes and etching gases. To ensure the continued existence of the semiconductor industry in Europe, a derogation is also required for these materials.

In summary: To avoid a supply crisis bigger than the recent semiconductor shortage, long lasting derogations for the complete semiconductor/MEMS supply chain upstream and downstream are vital (finding and qualifying alternatives takes 10+ years, see e.g. chapter 3.2 in document "Impact of a Potential PFAS Restriction on the Semiconductor Sector.pdf" from comment #4304 by SEMI association (RCOM part 13)). Special attention has to be put on the upstream supply chain. Derogations have to explicitly cover production of the necessary raw materials, may they remain in the product or may they be production aids.

Alternative proposal for definition of PFAS

Exclusion of isolated CF2-Moiety

There is no single globally adopted definition of per- and polyfluoroalkyl substances (PFAS) for human health or environmental regulation. The latest OECD Perfluorocarbon (PFC) Group (OECD, Reconciling Terminology of the Universe of Per- and Polyfluoroalkyl Substances: Recommendations and Practical Guidance, 2021) definition, which has also been adopted by the EU within its REACH restriction proposals (ECHA, 2022), defines PFAS as: fluorinated substances that contain at least one fully fluorinated methyl or methylene carbon atom (without any hydrogen, chlorine, bromine or iodine atom attached to it), i.e., with a few noted exceptions, any chemical with at least a perfluorinated methyl group (-CF3) or a perfluorinated methylene group (–CF2–) is a PFAS. Following the RMOA, which has adopted a narrower working definition of PFAS, removing the criterion that a single isolated methylene group (–CF2–) as being sufficient for classification as a PFAS.
The rationale for this is that compounds with a single isolated -CF2- group are generally understood not to degrade to any of the highly persistent substances that have given rise to the environmental and/or human health concerns about PFAS (Buck, Korzeniowski, Laganis, & Adamsky, 2021). Substances containing a single isolated –CF2– are likely to be subject to biodegradation
leading to breaking of the carbon–fluorine bonds and elimination of the fluorine atoms. For example, the fluorotelomer alcohols which possess a –CF2– group adjacent to a –CH2– group, have been shown to be readily degraded, breaking both –CF2– carbon– fluorine bonds (Buck, Korzeniowski, Laganis, & Adamsky, 2021). These highly persistent PFAS of concern are often referred to as the 'arrowhead' substances; the term is applied to a PFAS that represents the most stable transformation product of a precursor PFAS in the environment. In some cases, the arrowhead may be both a manufactured substance with its own commercial applications and a stable transformation product from one or more precursors (an example is perfluorooctanoic acid, PFOA). The working definition adopted is, therefore, a pragmatic approach to restricting the scope of REACH to persistent PFAS. (adapted from (Health and Safty Executive UK, 2023)).

Exclusion of polymeric PFAS

Polymeric PFAS may be persistent in environment, but according to (Anderson, et al., 2022) this is not a risk for human health. (1) there is not a clear understanding of which PFAS may be relevant for potential human health risk assessment and no consensus definition of what is or not a substance within the PFAS family; (2) there is sparse information on PFAS toxicity and human exposure that precludes an chemical-specific evaluation of the vast majority of PFAS; (3) most human exposures will be to an unknown mixture of PFAS; and (4) results of toxicity tests often lack concordance among assays in animals and observations in humans, and extrapolation from animal data to human relevance (for example, due to species-specific pharmacokinetics and pharmacodynamics and/or mechanisms of action) is highly uncertain. Furthermore the OECD has declared flouropolymers as substances of low concern (SLC) (OECD, DATA ANALYSIS OF THE IDENTIFICATION OF CORRELATIONS BETWEEN POLYMER CHARACTERISTICS AND POTENTIAL FOR HEALTHOR ECOTOXICOLOGICAL CONCERN, 2009).

Exclusion of CF3-Moietys not bonded to carbon

The Dossier submitters have excluded the CF3-Moiety bound to Oxygen, since this will degrade in environment to inorganic compounds (CO2 and HF). Following these and having in mind the binding energy of the CO-binding compared with other non-carbon atoms, it is visual that other chemical structure will finally hydrolysed to resulting in a C-O bond in environment, which will then decompose according to the findings of the dossier submitters.

Binding energy in carbon chemistry[1]

Atomar connection	Energy
C-F Binding: CF-R1-R2-R3	463 kJ/mol
C-F Binding: CF2-R1-R2	503 kJ/mol
C-F Binding: CF3-R1	537 kJ/mol
C-F Binding: CF4	549 kJ/mol
C-O Binding	**358 kJ/mol**
C-Si Binding	316 kJ/mol
C-N Binding	305 kJ/mol
C-S Binding	272 kJ/mol
C-P Binding	264 kJ/mol

Resulting new PFAS-Definition

Following the said above we propose the PFAS definition, adapted from the EPA (Environmental Protection Agency, 2021):

PFAS is a non-polymeric chemical substance or mixture with a Chemical Abstracts Service number (CAS Nr.)[2], that structurally contains the unit R-(CF2)-C(F)(R')R". Both the CF2 and CF moieties are saturated carbons but none of the R groups (R, R' or R") can be hydrogen.

Taking this definition, we propose that a polymer shall be defined according to the OECD definition "as a substance consisting of molecules characterized by the sequence of one or more types of monomer units and comprising a simple weight majority of molecules containing at least three monomer units which are covalently bound to at least one other monomer unit or other reactant and consists of less than a simple weight majority of molecules of the same molecular weight. Such molecules must be distributed over a range of

[1] https://www2.chemistry.msu.edu/faculty/reusch/OrgPage/bndenrgy.htm
[2] EPA maintains a webpage of chemicals that have been identified as PFAS (available at: https://comptox.epa.gov/dashboard/chemical-lists/pfasmaster)

molecular weights wherein differences in the molecular weight are primarily attributable to differences in the number of monomer units. In the context of this definition a 'MONOMER UNIT' means the reacted form of a monomer in a polymer.”

Cited literature

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