DIGITALEUROPE

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Impact of the PFAS restriction on electronics: Industry needs more time for the transition

Introduction: Shared goal of a safe transition toward PFAS-free electronics

The digital industry has been, and continues to be, committed to improving the environmental performance and safety of all products placed on the market.

DIGITALEUROPE members support moving towards PFAS-free electronics and are actively investigating the uses of PFAS and the availability of alternatives in an effort to substitute PFAS wherever possible in a timely fashion.

It will take time for the digital and electronics industries to replace PFAS in their products and processes in a safe, responsible manner. There are considerable challenges related to full implementation of PFAS substitution plans in this sector, such as accurately cataloguing PFAS uses across thousands of component articles, identifying and developing non-PFAS alternatives that can meet the safety and performance needs for *each* application, and the time needed for material qualification, component and full product re-design, testing and certification. In many cases, there are currently no technically viable alternatives known, and they will need to be developed, qualified and made commercially available.

To facilitate a successful and sustainable implementation, the electronics sector needs at minimum:

- A **five-year derogation** (in addition to the generally applicable 18-month transition period called for in the proposal) for electronics suppliers and manufacturers to gather complete, accurate data and to complete the redesign, testing, certification, and production steps described below.
- The **Commission must review the latest scientific information and status of alternative materials and processes and extend the derogation for a specific subset of uses** accordingly before the end of this derogation. Companies must have the opportunity to feed into this review to ensure that the latest information on uses and alternatives is taken into account.

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This additional requested time will enable crucial research and development, supply chain adaptation, product redesign, certification and conformity testing, ultimately facilitating the widespread adoption of PFAS-free electronic products.

The electronics industry is currently gathering technical information to support additional derogation requests related to essential uses of PFAS without currently available alternatives. In addition to the longer transition period needed by the entire electronics industry as outlined below, recommendations for these use-specific derogations will be submitted as a separate contribution during the consultation period.

Responsible PFAS substitutions and redesign of components and products require more time

Complex articles and supply chains present challenges for identifying and quantifying PFAS in electronics

Electronic products can contain more than 1000 individual parts, often complex articles themselves, and rely on global, complex supply chains which require appropriate lead times to adjust. In addition, there are many different applications of PFAS in electronics. Over 60 types of applications have been identified to date (see Appendix II) and this inventory is still not complete.

Entities in the sector's multi-layered value chain (including many small- and medium sized suppliers and suppliers outside of the EU) were so far under no obligation to identify or report on all PFAS uses in electronics. Indeed, because of the specific challenges of regulating PFAS materials in general, there are no established analytical tools or processes locating or measuring all PFAS with sufficient precision in complex electronics. Further complicating information-gathering are trade secret/confidential business information protections for PFAS substances.

Additionally, to identify PFAS in electronics at or near levels of detection (as the proposed restriction would require), PFAS uses will also need to be located in manufacturing processes, as they can cause cross-contamination in articles.

Accurately identifying PFAS presence in all complex electronic articles is a necessary first step toward proper substitution analyses but will take considerable time (multiple years by some estimations).

Incorrect statements in Annex XV report on availability of non-PFAS alternatives in the electronics industry

Similarly, supply chain and article complexity will also make it difficult to substitute materials. Where PFAS-free alternatives are available, they are often not drop-in replacements. This is because there is no other material with the same combination of properties as PFAS materials. In addition, any changes in product materials automatically prompts a requalification process and most likely redesign, which can take years to execute.

The most commonly used class of PFAS substances in electronics are fluoropolymers. They are generally selected because of their heat resistance, high flame-retardant ratings, dielectric constant, breakdown voltage, water and oil repellence properties, low friction, wear resistance, chemical resistance, mechanical strength or other special properties. This unique combination of properties is the reason fluoropolymers are chosen for use. There is no single alternative material that possesses the same unique combination of properties. This complicates the selection process of alternatives. Since not all required properties can be found in a single alternative material, the requirements must be met by a combination of substances, materials or components. This does not necessarily render it impossible to replace PFAS, but it requires more development time and effort to make an updated product design, rather than simply selecting another material from the catalogue.

The complexity of PFAS material substitution is not taken sufficiently into account in the dossier submitter's Annex XV report, which as a result inaccurately proposes a small number of non-PFAS alternatives for specific applications in the electronics industry. These proposed non-PFAS alternatives are in fact not technically viable for the suggested applications. Table E.128 on page 396 of Appendix E to the Annex XV report proposes that there are non-PFAS alternatives available for sealing and wire insulation in the electronics industry. Appendix 1 of this paper provides detailed comments on these proposed non-PFAS alternatives for sealing and cable insulation applications and explains why they cannot be considered to be appropriate substitutes.

In some cases where no alternatives can be identified, a completely new material with the required safety and performance attributes needs to be invented and this will require extensive fundamental laboratory research and development before the alternative can be made commercially available for use. For these specific cases, DIGITALEUROPE will request a specific derogation in a separate contribution.

Necessary redesign of components and end products with new materials

Sufficient time must be given to companies to redesign their products and comply with the new restriction after publication in the Official Journal, given the complicated and time-consuming redesign process.

When an alternative material is selected for a part or component in electronic equipment, that part or component will have different properties. For example, it could have different dimensions, move with higher friction, or have a higher flammability. In such cases a larger part of the equipment must be redesigned to accommodate for the change to one PFAS-fee part. Suitable product changes must be implemented (e.g., more space must be created, a stronger motor must be used, additional changes in other materials or overall product design must be made to ensure adequate flame ratings) in the finished product. Alternative materials could also require changes to the manufacturing equipment and process because the processability of the alternative material is different due to different physical properties. Redesigning electronic components – and end finished products – to eliminate PFAS can therefore involve substantial redesign time and resources.

Testing and certifying components and products using new materials

If PFAS is used in a component embedded within a finished electronic product, it will first have to be replaced and tested by the component manufacturer. Only after that step is completed for *all* components can the manufacturer of the electronic end-product redesign, test, and certify PFAS-free electronics.

For all electronic articles, after the PFAS-free alternative has been found and the product design has been suitably changed, it is crucial to follow rigorous testing protocols and the established certification processes. Regrettable substitution must be avoided, so alternatives must be thoroughly reviewed for chemical hazard before being qualified for use. Thorough testing helps ensure that the alternatives chosen meet the necessary performance, safety, quality, durability and environmental standards. Robust testing protocols and standardized procedures help to evaluate the performance of alternative materials in real-world conditions, which takes time. For example, fluoropolymers have a high durability, are fire resistant and have a very high breakdown voltage, so replacing them requires lifetime and/or safety testing of the alternative. If after six months testing the part fails, another design iteration, including redesign, is required.

For products that require certification or (mandatory) conformity testing, additional time is needed to re-certify the product. Conformity testing labs have limited testing capacity (both in personnel and laboratory facilities). Even if substitutes are known and implemented, long delays with respect to testing are to be anticipated if every producer in the electronics industry starts requesting testing of re-designed models of their equipment on top of tests already planned for normal product evolutions.

Below is an illustrative list prepared by the US National Association of Manufacturers of all of the steps entailed in replacing a chemical of concern for a single application. An estimation for the time required to complete each step has been provided using the example of a complex finished IT product, where maintaining certain performance characteristics is crucial.

Process		**Comment**	**Rough estimate for one PFAS material change used in a complex IT product**
1	Identify Current Use	Identify all places where chemical is used	6 month – 48 months +
2	Identify Alternatives	Identify potential alternative chemicals, formulate, formula testing, etc.	Longest lead time – can take up to 10 + years;
3	Source	Source appropriate supplier(s)	If the alternative is already mass-produced,

			it can take up to 2 years to qualify a new supplier; If the alternative is at R&D stage, it is a multiple year effort to commercialize the material
4	Formulation	Formulation of chemical	Captured in step 3
5	Chemical Testing	Testing of chemical (flammability, flexibility, corrosion resistance, etc.)	This will follow New Product development (NPI) or Post-Ramp Qualification, including various performance, quality and reliability testing at different stage of samples (HVT, EVT, DTV). It can be 6 months (for a simple mechanical part) to multiple years (for complex assembly) exercise.
6	Results analysis	Chemical company, parts supplier and OEM review and adjust as needed	
7	Formula Adjustment	Reformulate / adjust chemicals	
8	Retesting	Testing of chemical (flammability, flexibility, corrosion resistance, etc.) as needed	
9	Results analysis	Chemical company, parts supplier and OEM review and ad-just as needed	
10	Test Parts Development	Manufacture initial sample parts for testing – confirmation that compound will work	
11	Testing	Testing of initial samples	
12	Analysis	Review results and feedback for adjustment	
13	Chemical manufacturing	Chemical company needs to manufacture enough chemical and de-pending on company, may be doing so for many customers	
14	Modify manufacturing process	As needed, manufacturing processes, tools, etc. may need to be changed or new tooling made to allow use of new alternate chemical	
15	Tooling Trial	Initial trial for use of new tool/process; analyze results	
16	Modify/improve tooling or process as needed	If changes are needed, retesting may be required	
17	Retrial/test	Retest and analyze results	
18	Sample Parts	Receive sample parts	External party evaluation for safety and other regulatory requirements. Schedule is dependent on the availability of 3rd party accredited labs.
19	Parts safety approval	Perform applicable safety approval for parts	
20	Parts testing	Testing of parts	
21	Product Testing	Install and test in product	
22	Drawing Updates	OEM needs to update applicable drawings, possible new model numbers, part numbers, etc. to control inventory	

23	Product safety approval	Perform applicable safety approval for products	Testing happens in series starting from components to the finished assembly. Timeline can be 6 months up to 2 years.
24	Order parts for mass production	Order after approvals	Rough estimate is 2 years.
25	Produce products	OEM manufacturing	
26	Ship to distribution	OEM's ship from factories to warehouses	
27	Distribution ship to customers	Ship from OEM warehouse to distributor warehouse	
28	Customers sell to end users	Distributor sells to contractor or customer for install	Not known

Many companies are already engaged in the replacement of PFAS even though the PFAS restriction is still in a very early stage. For some large investments, however, more legal certainty is needed before these investments can be done. As long as the exact scope, exemptions and conditions are not final, large investments cannot be justified by all companies. Discussions with suppliers have also shown that the early stage in the restriction process and the lack of legal certainty is still inhibiting PFAS replacement. A restriction in its final form often differs from the one originally proposed. There is no obligation for actors in the supply chain to already adapt their products based on a proposal.

Consequently, after publication in the Official Journal, sufficient time must be given to companies to redesign their products and comply with the new restriction.

Our recommendations

Recommendation for a time limited derogation for electronic products

Based on the information provided above, **we request a five-year derogation** (in addition to the generally applicable 18-month transition period called for in the proposal) for electrical and electronic equipment. This will allow electronics suppliers and manufacturers to gather complete, accurate data, to complete the redesign, testing, certification, and production steps described above.

Recommendation for a review of the derogation

Many companies already have started the long process of PFAS substitution but given the complexity and depth of the electronics products and supply chains, more time is required to gather information on the uses of PFAS in all components of complex electronic products. Once this information has been collected, it must be determined if the product can be redesigned to eliminate the PFAS. In some cases, this information is available based on previous research. In other cases, the feasibility of alternatives is not known yet. As already described in the previous chapters, substitution analyses and redesign take time. Only after (long) material research and/or product design iterations, it will be known if the use of PFAS is essential, and a longer derogation is needed.

Before PFAS is accurately located and the feasibility of alternatives is determined, it is not possible to justify a longer specific derogation request for a specific use in electronic products. Full information on the feasibility of alternatives will not always be available before the deadline of the public consultation. During the public consultation DIGITALEUROPE will request derogations for all identified uses that cannot be replaced before the end of the transition period, based on the information currently available. Future research might reveal that a longer or a different derogation is required. It is therefore necessary to review the broad derogation for EEE in due time, taking into account the latest information about alternatives in order to determine the need to extend the derogation for certain specific applications within EEE.

Therefore, we request the **European Commission to review the latest scientific information and status of alternative materials and processes and extend the derogation for a specific subset of uses accordingly before the end of this derogation.** Companies must have the opportunity to feed into this review to ensure that the latest information on uses and alternatives is considered.

Giving industry this necessary additional period to responsibly transition to PFAS-free electronics will not have a material impact on PFAS-related risks in the EU. The electronics sector is only a minor contributor to PFAS releases in the EU. According to the Annex XV report, the electronics sector together with the semiconductor sector count for less than 1% of all PFAS uses and releases. Even though many applications in electronics had not been recognized in the report and the usage will in reality be higher, emissions, especially from fluoropolymers, will not increase significantly due to waste management under the WEEE Directive. However, **the additional time will minimize unnecessary market and supply chain disruptions in the sector, and related socioeconomic impacts, such as higher failure rates and reduced product lifetime due to sub-optimal substitution, on consumers and end users of electronics.**

Precedent for longer transition periods in other legislation

Chemical substances in electronics are regulated in a wide range of other legislation. These provide for different precedents of transition times that more suitably account for the need of product re-design.

- One example is the Restriction of Hazardous Substances in Electrical and Electronic Equipment (RoHS; 2011/65/EU). The most recent addition of new substances to the RoHS directive were four phthalates via directive (EU) 2015/863. Adopted in March 2015, the substance restrictions applied from 22 July 2019: a transition period of 4 years.
- The REACH restriction of perfluorooctanoic acid (PFOA), its salts and related substances (Regulation (EU) 2017/1000) included a 36-month transition period.
- The final draft of the Sustainable Batteries Regulation provides for a 42-month transition period after entry into force for requirements regarding removability and replaceability of portable batteries and LMT batteries. This transition is precisely included to grant industry sufficient time to prepare to comply with the new rules, to invest in necessary R&D and identify suitable product changes.

Notably, the PFAS proposal is the broadest-reaching chemical restriction ever proposed in the EU in terms of number of substances covered, over 10,000 which have never before been regulated, and the number of critical applications impacted. This should be reflected in the time before the restriction applies. An additional five-year derogation for electronic products is therefore appropriate.

Conclusion

DIGITALEUROPE remains committed to contributing to a cleaner and safer future. We understand the urgency to mitigate the risks posed by PFAS and we reiterate our full support for the objective of phasing out PFAS.

It is essential to recognize the complexities involved in completely phasing out PFAS in electronic products, given the identification process, wide range of applications and the intricacies of implementing alternatives.

Rushing into an immediate ban without considering the time it takes to identify the concerned substances and replace a highly functional substance in complex electronics products may lead to unintended consequences, such as disrupted supply chains, product shortages, increased costs, potential job losses, and environmental harm through regrettable substitution.

The limited time for submitting derogation requests (the current public consultation) does not provide sufficient opportunity to gather information about all PFAS uses and perform research on alternatives for all PFAS uses.

We therefore strongly believe that to facilitate successful and sustainable implementation the electronics sector needs:

- A **five-year derogation** (in addition to the generally applicable 18-month transition period called for in the proposal) for electronics suppliers and manufacturers to gather complete, accurate data and to complete the redesign, testing, certification, and production steps described above.
- The **Commission must review the latest scientific information and status of alternative materials and processes and extend the derogation for a specific subset of uses accordingly before the end of this derogation**. Companies must have the opportunity to feed into this review to ensure that the latest information on uses and alternatives is taken into account.

This additional requested time will enable crucial research and development, supply chain adaptation, product redesign, certification and conformity testing, ultimately facilitating the widespread adoption of PFAS-free electronic products.

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About DIGITALEUROPE

DIGITALEUROPE is the leading trade association representing digitally transforming industries in Europe. We stand for a regulatory environment that enables European businesses and citizens to prosper from digital technologies. We wish Europe to grow, attract, and sustain the world's best digital talents and technology companies. Together with our members, we shape the industry policy positions on all relevant legislative matters and contribute to the development and implementation of relevant EU policies, as well as international policies that have an impact on Europe's digital economy. Our membership represents over 45,000 businesses who operate and invest in Europe. It includes 102 corporations which are global leaders in their field of activity, as well as 41 national trade associations from across Europe.

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National Trade Associations

Austria: IOÖ
Belgium: AGORIA
Croatia: Croatian Chamber of Economy
Cyprus: CITEA
Czech Republic: AAVIT
Denmark: DI Digital, IT BRANCHEN, Dansk Erhverv
Estonia: ITL
Finland: TIF
France: AFNUM, SECIMAVI, numeum
Germany: bitkom, ZVEI
Greece: SEPE
Hungary: IVSZ
Ireland: Technology Ireland
Italy: Anitec-Assinform
Lithuania: Infobalt
Luxembourg: APSI
Moldova: ATIC
Netherlands: NLdigital, FIAR
Norway: Abelia
Poland: KIGEIT, PIIT, ZIPSEE
Portugal: AGEFE
Romania: ANIS
Slovakia: ITAS
Slovenia: ICT Association of Slovenia at CCIS
Spain: Adigital, AMETIC
Sweden: TechSverige, Teknikföretagen
Switzerland: SWICO
Turkey: Digital Turkey Platform, ECID
Ukraine: IT Ukraine
United Kingdom: techUK

Appendix I – Incorrect statements in Annex XV report on availability of non-PFAS alternatives in the electronics industry

The Dossier Submitters in their Annex XV report and associated annexes propose a small number of non-PFAS alternatives for specific applications in the electronics Industry (see extract below)[1].

Electronics

In general, there are very few alternatives. The alternatives available might not fulfil the requirements e.g. thermal/chemical resistance or durability. Some stakeholders report that it is likely that alternatives can be found for a lot of smaller components, e.g. gaskets, wires, cables etc. as these components are used in many categories. For some uses, e.g. of fluorinated polymers, in electronics alternatives might be available.

Semiconductors

According to industry stakeholders, no non-PFAS technically feasible alternatives are available that can replace the properties necessary for semiconductor manufacturing process chemistries. No single "drop-in" replacement is possible for all semiconductor applications where substitutes exist. Almost every use has to be re-engineered to see if a replacement material will meet the technology requirements. Moreover, even within the semiconductor industry technologies are not consistent. Alternatives that work for one application or one company, will not necessarily work for another application or another company.

The Dossier Submitters identified only a small number of alternatives that can be linked to specific uses, see Table E.128.

Table E.128. List of available non-PFAS substances and technics in Electronics, Semiconductor industry.

Use	Non-PFAS alternatives
Electronics industry	a) Ethylene propylene diene monomer (EPDM) and silicone rubbers as alternatives for fluoroelastomers in sealing. b) Silicone materials, Polyetheretherketone(PEEK), mica, EPDM, Polyvinyl chloride, Polyethylene, ceramic based and one confidential polymer as alternatives for wire insulation. c) Mineral oils, synthetic oils, natural oils, Hydrocarbon fluids as alternatives in heat transfer fluids for immersion cooling (no current but possible future use) d) Cyano group instead of CF3 for liquid crystal displays (LCD).

The following text comments on the technical viability of these non-PFAS alternatives proposed by the Dossier Submitter and explains why they cannot be considered technically viable substitutes in the stated applications. These examples illustrate that the complexity of PFAS material substitution in the electronics industry is not taken sufficiently into account in the dossier submitters' Annex XV report.

Sealing applications

Ethylene propylene diene monomer (EPDM) and silicone rubbers are proposed in the Annex XV report as alternatives for fluoroelastomers in sealing. The function of sealing is predominantly to protect electronic components from heat, corrosion, moisture etc. Fluoroelastomers have an outstanding performance record in terms of attributes with respect to temperature range, chemical resistance, long term reliability, low outgassing properties and minimisation of internal contamination of electronics components. EDPM lacks the combined

[1] European Chemicals Agency, Per- and polyfluoroalkyl substances (PFAS), Annex XV restriction report, p. 396, https://echa.europa.eu/documents/10162/57812f19-8c98-ee67-b70f-6e8a51fe77e5

characteristics necessary to sustain such demands on electronics, especially those associated with temperature range. Having a Limiting Oxygen Index (LOI) of 19.5 implies that it is a highly flammable substance that restricts its further application and development particularly within the electronics industry (Tang et al. 2013). Silicone rubbers have positive characteristics at first glance with respect to electronics sealing applications. They are known to be resistant to hot and cold temperatures, have low flammability and high dielectric strength. However, their widespread application as seals within the electronics industry has been negatively impacted by its very poor tear strength, chemical incompatibility and tends to attract dirt and other particles that adhere to it.

Both proposed non-PFAS alternatives are therefore not considered to be technically viable substitutes as sealing materials for the wide range of those performed by fluoroelastomers but rather a very limited application.

Cable insulation

The next application proposed by the Dossier Submitter for the use of non-PFAS alternatives is with cable insulation. These non-PFAS alternatives are PEEK, PC and EDPM. A review was conducted to ascertain their feasibility as viable non-PFAS alternatives, focusing upon several prominent properties.

Dielectric Constant

Most fluoropolymers have a dielectric constant of ~ 2.0 (Matweb 2023). This is extremely critical as the size of electronic devices continues to shrink, which introduces new obstacles such as signal crosstalk, power consumption and time delays, as a result, fluoropolymers with low dielectric constants are needed to achieve faster and stable signal transmission (Dong et al. 2023). Such dielectric characteristics are the result of the fluoropolymers' symmetrical molecular structure (C2F4)n and the short distance between the carbon and fluorine (Daikin 2023).

The three proposed non-PFAS alternatives have much higher dielectric constants ranging from 2.7 – 4.5 (Matweb 2023 and Gunaskaran et al. 2008), which will result in much slower and unstable signal transmission. This will greatly affect the functioning, safety and quality of the electronic product for which these cables are utilised. Consequently, on this critical property alone, none of the proposed non-PFAS alternatives are suitable for the intended use in wire insulation.

Dissipation Factor

The dissipation factor can also be used to assess the characteristics or quality of an insulating material in applications such as cables, connectors, terminations, joints etc. The lower the value, the better the dissipation factor. Fluoropolymers have a low value of 2.0 (Omnexus 2023) which provides a highly efficient insulator. EPDM also performs well with this quality with a dissipation factor of 2.5 (Thorne & Derrick 2023), however, the other proposed non-PFAS alternatives PC and PEEK have dissipation factors of 9 and 30 (Omnexus 2023) respectively which are not best suited for cables.

Coefficient of Friction

Fluoropolymers have a Coefficient of Friction (COF) in the range of 0.02 - 0.08 (Matweb 2023) which are effectively the lowest of any known solid material. Such properties have proven to be invaluable to the electronics industry in providing sustained durability. PC has the closest COF with a range of 0.05-0.18 (Matweb 2023) to that of the fluoropolymers. PEEK has higher values of 0.15-0.40 (Matweb 2023) while EPDM has very high values of 1.36 - 2.76 (Mukhopadhyay 2014) which are not suitable for cables.

Flame Retardancy

In terms of flame retardancy, a primary safety function, fluoropolymers are unique with their extremely high Limiting Oxygen Index (LOI) of ~95% (Omnexus 2023) which inherently means they are non-flammable. The proposed alternatives have LOI values ranging from 19.5 - 24 (Omnexus 2023). As noted for seals, EDPM's LOI value of 19.5, implies that it is a highly flammable substance and is not suitable for such an application in electronics cables. PC and PEEK also have low LOI values which would require flame retardant additives to be employed. However, the "Regulatory Strategy for Flame Retardants" published by the European Chemicals Agency in March 2023, which stated that "the substances in scope of this strategy are in principle all flame retardants.", places a very high degree of uncertainty on the future availability of flame retardants that would be required for the non-PFAS alternatives proposed by the Dossier Submitters.

In essence, the proposed non-PFAS alternatives have some of the necessary properties required for use in cables. However, they all have inappropriate characteristics that would require in some cases, the addition of supplemental chemical substances to render them functional which are also on a roadmap to be regulated under the REACH regulation. Others such as EPDM with its flammability properties precludes them on safety grounds from undertaking a meaningful function with cables.

References

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Thorne & Derrick 2023, Properties of EPDM & Silicone Rubbers, viewed 13 June 2023, <https://www.powerandcables.com/euromold-connectors-properties-performance-40-years-of-market-leadership/>

Appendix II – indicative list of PFAS uses in electronics

The following list of PFAS uses in electronics has been compiled jointly by several industry associations. It should be considered non-exhaustive but provides an impression of the many uses of PFAS in this sector. This list does not imply that PFAS is used in all products that contain a component listed below. Sometimes PFAS are only required in more demanding applications or under harsh conditions. The table also does not provide information on to what extent it is possible to replace PFAS for a non-PFAS alternative.

Application	PFAS-Containing Article Description	PFAS Properties / Function
Coatings	Printed circuit board coatings, electronic components coatings	Electrical performance characteristics
	Fluor polymer coating for machinery and drive technology for use in e.g. food industry, pharma industry, cosmetics industry	Chemical and permeation resistance
	Coating electroluminescent lamps in commercial signage and safety exit signs	
	Coatings in smartphones, tablets, computers, screens, trackpads	Low optical index of refraction to maintain optical performance in display assemblies
	Electronic circuit boards, semiconductors, small electronic components (e.g. capacitors, resistors, coils, diodes, transistors, switches, connectors and electrical junction points), motors, voice coils, parts to protect optical features (e.g. liquid crystal panels, touch panels, optical sensors, LED, Toslink, optical fibers, lenses for electronic cameras, projection lenses, polarizers, thermal assemblies	Chemical and permeation resistance, Electrical performance characteristics, Repellency properties, Resistant to UV, Temperature stability (high and low)
	Hearing aids	Chemical and permeation resistance, Repellency properties
	Epilame coating in quartz watches, hard disks	Low Surface Tension, chemical resistance
	Plasma nano-coatings on non-woven filters Other coatings	Chemical and permeation resistance, Repellency properties Low coefficient of friction, Temperature stability (high and low). Low optical index of refraction
Printed circuit boards	Printed Circuit Boards	Electrical performance characteristics,

		Temperature stability (high and low), Mechanical characteristics
	Electric boards, Nano-coating of solder paste printing stencils	Repellency properties
	Solder paste	Low Surface Tension
High voltage/power	Fluoropolymer sin High Voltage DC Converter Valves; Gas-Insulated Switchgears (GIS)	Electrical performance characteristics, Temperature stability (high and low), Chemical and permeation resistance
	Tubes in transformers and chokes in power supply	Electrical performance characteristics, Temperature stability (high and low), Chemical and permeation resistance
	Dielectric fluids, Capacitors	Non-flammability, electrical performance characteristics
	Fluorinated gases in Gas-Insulated Switchgears (GIS)	Electrical performance characteristics, Temperature stability (high and low), Chemical and permeation resistance
	Broadcasting equipment	Mechanical characteristics, Electrical performance characteristics
Cables and Connectors	Cables, wires, Cable glands; connectors	Non-flammability, Temperature stability (high and low)
	Cable insulation, particularly high performance and/or high-volume data	Electrical performance characteristics, Chemical and permeation resistance, Mechanical characteristics, Resistant to UV, Temperature stability (high and low)
	Optical fibres	Resistant to UV
Components	Capacitors, dielectric Films High temperature film capacitors	Electrical performance characteristics
	Electret films in microphones, electret film in sensors	Electrical performance characteristics, temperature stability
	Gaskets, sealing in various electronic equipment including hard disk drives	Temperature stability (high and low), Chemical and permeation resistance, Mechanical characteristics

	Vents (filter membranes) in phones, hard disks, smart watches, speaker modules	Chemical and permeation resistance
	Piezo in acoustical equipment	Electrical performance characteristics
	Rubber parts in image forming process in printers	Chemical and permeation resistance
Power radio-frequency components	Printed circuit boards (power amplifiers, antenna's), connectors, coaxial cables, circulators, couplers, isolators, filters	Electro-magnetic properties (dielectric constant and dissipation factor) for radio wave propagation; Temperature stability (high and low)
Displays	Electronic displays and touch screens (Provide the Liquid Crystal with a dipole moment).	Electrical performance characteristics
	Coatings in displays	Chemical and permeation resistance
	Light management films in flat panel displays, touch screens	Electrical performance characteristics, repellency properties
	Surfactants in coatings in flat panel displays	Low Surface Tension
Fuel cells	Fuel cells	Chemical and permeation resistance
Batteries	Batteries	Binder material for electrodes (chemical, electrochemical and thermal stability, mechanical flexibility, adhesion properties)
	Lithium batteries	Lithium salt anions and additives for electrolyte (chemical stability, electrochemical performance characteristics)
	Batteries	Sealing and insulation materials (chemical, electrochemical and thermal stability, permeation resistance)
	Lithium batteries	Separator material (chemical, electrochemical, thermal and mechanical stability)
	Lithium-sulfur batteries	
	Zinc batteries	Low Surface Tension
	Alkaline manganese batteries	
Fire prevention	Fire suppression	Non-flammability
	Additive in plastic parts in electronic equipment. Anti-dripping agent.	Non-flammability, temperature stability

	Polycarbonate casings and other plastics, insulation film	Non-flammability
Heat transfer	Immersion cooling in data centres	Electrical performance characteristics, non-flammability
	Refrigerant in heating and refrigeration systems	Non-flammability
	Heat transfer fluid for vapor phase soldering	Non-flammability
Chemical equipment	Tubing, sealing, valves, pump etc in production plants	Chemical and permeation resistance, purity, Temperature stability (high and low)
	Tubing, sealing in printers	Chemical and permeation resistance
Chemicals	Inks, toners	Low surface tension
	Solvent cleaning	Low surface tension
	Lubricant	Lubrication of Article, Low Surface Tension
	Lubricant for electronic precision instruments (camera's, drives for hard disks and more)	Lubrication of Article, Repellency properties
	Lubricant for electrical contact wetting	Lubrication of article
	Adhesives	
Mechanical applications	Industrial brakes, electronic drives	Low coefficient of friction, Temperature stability (high and low)
	Moving parts, machinery, printers, Bearings, gear boxes, compressors etc	Low coefficient of friction, repellency properties
	Sealings in electric and mechanic equipment	Low coefficient of friction
	Hydraulic components	Unknown
Others	Inert fluids for electronics testing	Electrical performance characteristics, non-flammability
	Razors	
	Various (Switches, Vacuum cleaners, Coffee makers, Keyboards, Screens, TVs)	
	Polyurethane foam	