JP4EE Annex 8 Explanation on PFAS essential uses in EEE mfg in List C (Annex 7)

Application examples and PFAS essentiality in the manufacturing process of Electrical and Electronic Equipment and its components.

As of 22 September 2023

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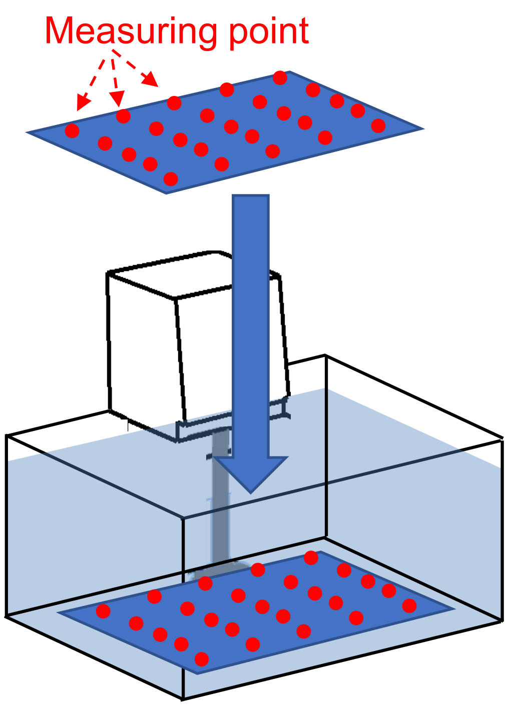
P1-1. Measurement and inspection of temperature characteristics (Immersion process)

Immersion measurement → Excellent temperature uniformity and temperature distribution

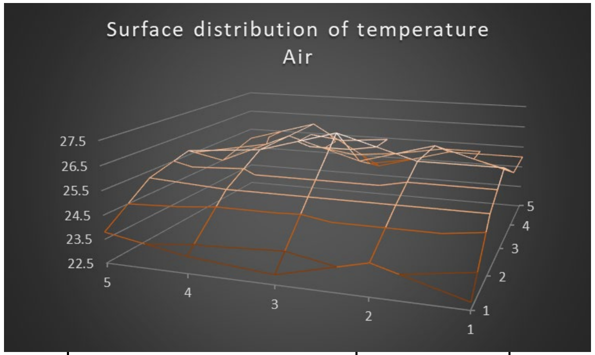
Eg. To provide a measurement temperature environment having high insulation property, high thermal conductivity, low viscosity and high fluidity, uniform and free from variation over time. Therefore, it is applied to the inspection of temperature sensors for temperature measurement, sensors with high temperature dependence, etc.

[Overview of the Measurement System]



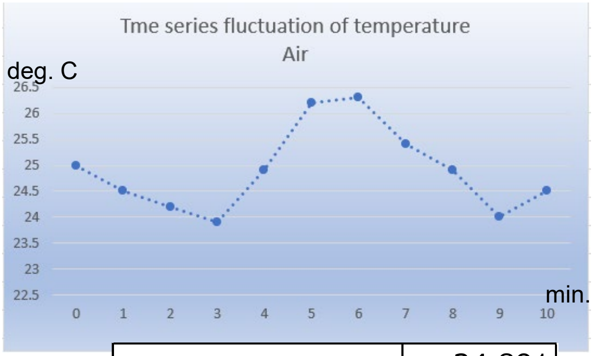
non-PFAS system

in-plane temperature distribution in a thermostatic bath



average	24.956
standard deviation	1.063

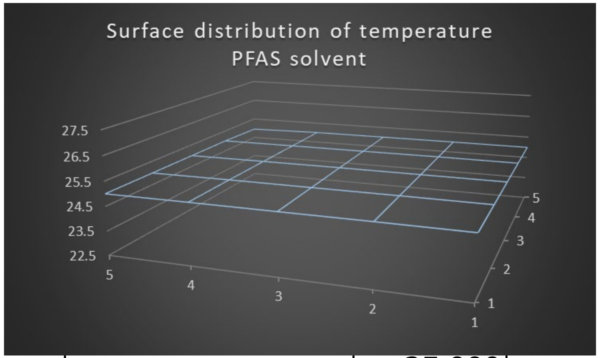
Temporal change of temperature at a specific position in a thermostatic bath



average	24.891
standard deviation	0.808

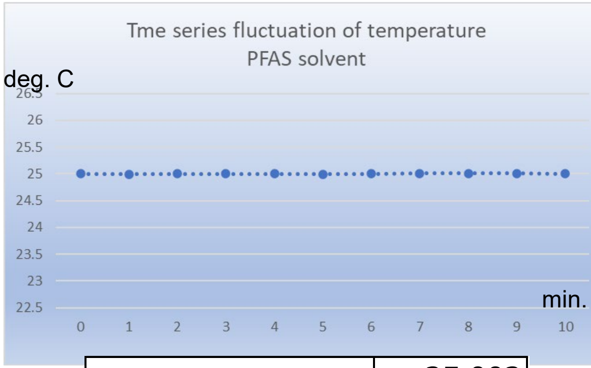
PFAS system

in-plane temperature distribution in a thermostatic bath



average	25.000
standard deviation	0.012

Temporal change of temperature at a specific position in a thermostatic bath



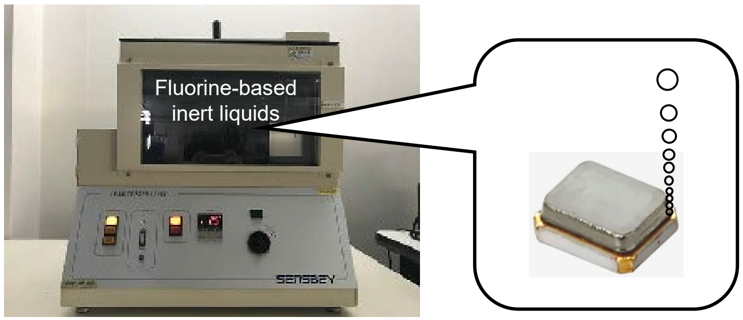
average	25.002
standard deviation	0.005

PFASs are the only media that meet all the requirements of high insulation for measuring electrical properties, high thermal conductivity, low viscosity, and high fluidity for temperature uniformity, and high volatility for preventing contamination of products and tools after inspection.

P1-2. Gross-leak and fine-leak test (Immersion process)

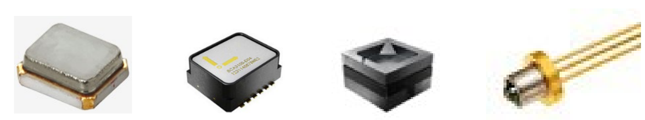
The immersion process provides a highly accurate gross-leak and fine-leak test, which ensures the reliability of the hollow-packaged electrical and electronic devices.

[Application Example] Gloss leak test based on MIL-STD-883 METHOD1014 SEAL.



- In hollow-packaged electrical and electronic devices, if the hollow part is sealed with inert gas or vacuum atmosphere and airtightness is not maintained, moisture and oxygen, which are atmospheric components, can penetrate into the hollow part and affect the function of the element by oxidation, corrosion, change of internal pressure, etc. Therefore, in order to ensure the reliability of this sealing property, it is essential to have advanced sealing technology and high-precision leak tests that can verify the existence of such leaks.
- Fluorine-based inert liquids (PFASs) are used in tests (gross leak tests) to check the airtightness of hollow-packaged electrical and electronic devices by immersing them in liquid. This test is standardized by the MIL standard.

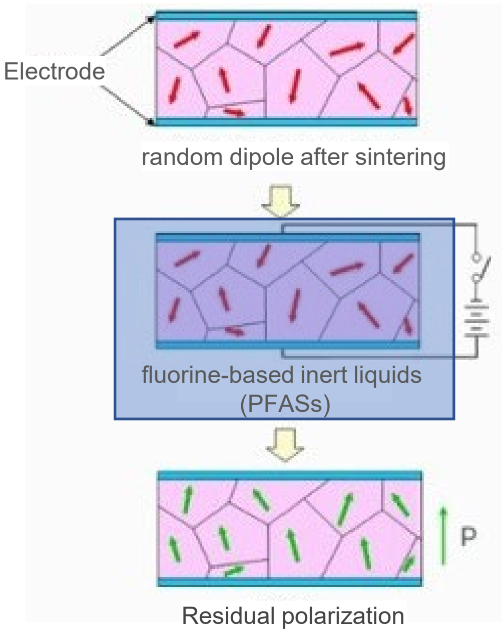
[Device to be tested]
Hollow-packaged electrical and electronic devices to be tested include, for example, crystal devices, acceleration sensors, MEMS and optical communication devices.



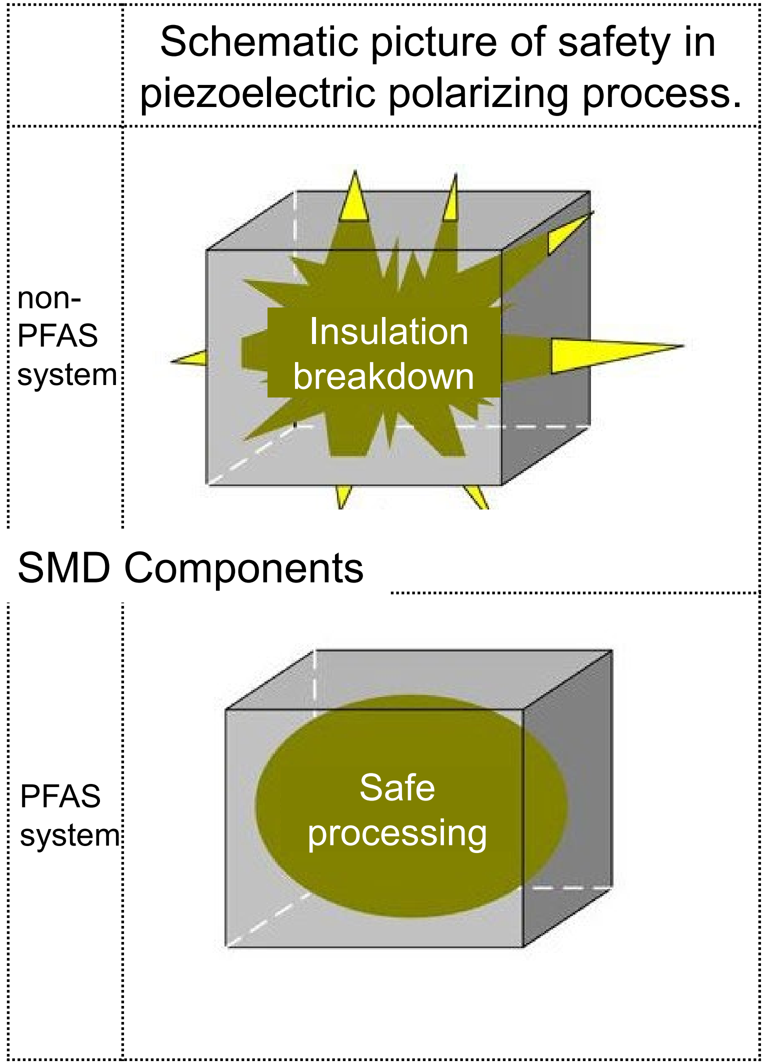
PFASs are the only media that meet all of the requirements for gross-leak and fine-leak test:
extremely low surface tension, low erodibility without eroding the product, chemical stability, and high volatility without contaminating the product or tool after testing.

P1-3. Piezoelectric polarizing (Immersion process)

In the piezoelectric polarizing, a high voltage can be safely applied by the immersion process.



- In the manufacture of ceramic oscillators, piezoelectric polarizing, in which a high voltage (about 30 kV/cm) is applied to piezoelectric ceramics, is an essential process.
- At this time, piezoelectric polarizing is performed while immersed in fluorine-based inert liquids (PFASs) to prevent dielectric breakdown.

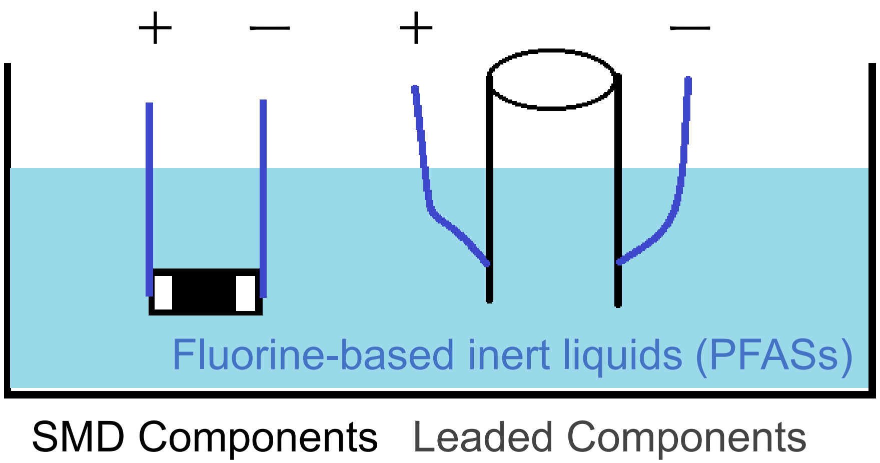


- The primary use of ceramic oscillators is as a clock signal source in digital circuits such as microprocessors.
- Ceramic oscillators are used in a wide range of applications, including automotive electrical equipment, communication equipment, PC-related equipment, medical and healthcare equipment, and home appliances.
- In particular, for automotive electrical equipment, there is no substitute for ceramic oscillators in terms of the speed of oscillation and the stability of oscillation.

PFASs are the only media that meet all the requirements of high insulation for piezoelectric polarizing at high voltage, chemical stability that does not react with products, and high volatility that does not contaminate products or tools after piezoelectric polarizing.

P1-4. Measurement and inspection of voltage proof and/or breakdown voltage (Immersion process)

High-voltage testing of electronic components in an insulated atmosphere prevents the generation of sparks during testing, thus enabling safe and accurate measurement of voltage proof and/or breakdown voltage.



- Electronic components used in high-voltage circuits require a high level of voltage assurance.
  E.g. The safety standard IEC 60384-14 requires screening with 100% in-line voltage proof inspection in the manufacturing process.
- When developing high voltage electronic components, breakdown voltage measurements may be performed to examine the ability of the components to voltage proof.
- High voltage application in fluorine-based inert liquids (PFASs) atmosphere is essential for safe and effective voltage proof and/or breakdown voltage measurement because it prevents sparks between electrodes.
- In addition to PFASs, there are insulating gases and oils, but there are major problems such as:
  Other insulating gases have a negative impact on global warming, and,
  Other insulating oils cannot be removed by drying or volatilization.

In order to carry out high voltage and continuous 100% voltage proof screening and breakdown voltage measurement of products, it is necessary to satisfy all the requirements of high insulation, chemical stability that does not react with products, and high volatility that does not contaminate products and tools, but only PFASs satisfy these requirements.

■ What is a Film capacitor?

Film capacitors are capacitors that use plastic film as the dielectric and are one of the essential passive components in the circuit configuration of electrical and electronic equipment.

[Example of appearance of Film capacitors]

[Applications]

It is widely used in home appliances, game machines, measuring devices, medical devices, solar power generation, mobile phones, etc.

With the electrification of automobiles, the use of electric cars in automotive applications has expanded.

■ Safety function of film capacitor

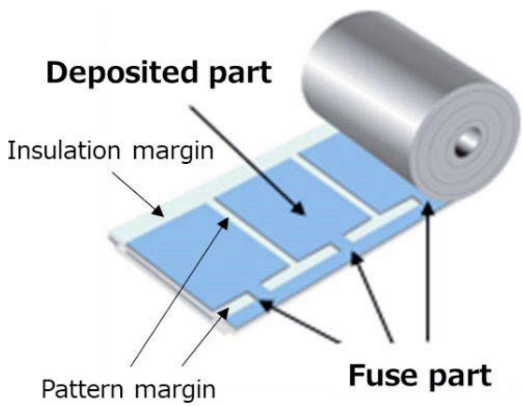


Fig. Internal electrode structure of film capacitor

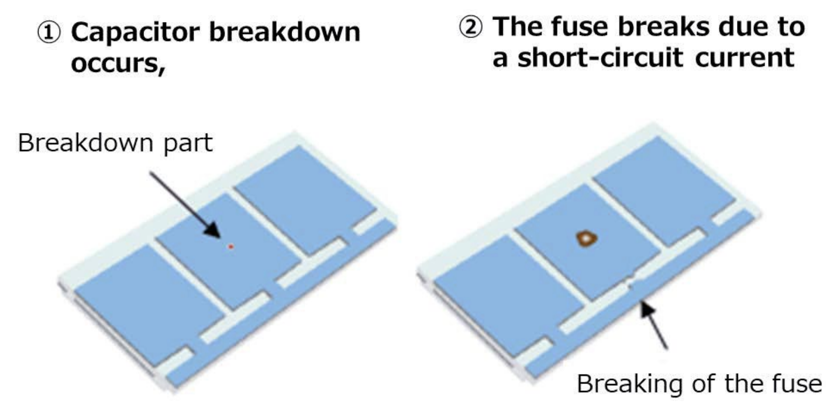


Fig. Safety function of film capacitor by fuse

For film capacitors, it is necessary to separate the deposited electrodes with a "pattern margin" and install an internal electrode pattern (fuse) to protect against overvoltage and overcurrent, and to install an "insulation margin" to ensure insulation between different electrodes.

This fuse is indispensable for the safety function of film capacitors. When a local breakdown occurs, the fuse breaks due to a short-circuit current, and the cell where the breakdown occurs due to the breaking of the fuse is electrically cut off from other cells to maintain the overall function of the capacitor.

In film capacitors, PFPE, a type of PFAS, is used in the manufacturing process when forming pattern margins and insulation margins.

In particular, the use of high voltage is increasing in applications for electrification of automobiles.
In order to ensure the safety of equipments, film capacitors must have safety fuses.

■ Safety function of film capacitor

Manufacturing process of film capacitor using PFPE

To form a fuse, PFPE oil is deposited on a plastic film (oil masking with PFPE), followed by metal deposition. Because no metal is deposited in the oil-masked area, fuses and insulation margins are formed. It is necessary to make the area without metal deposition as thin as possible because it becomes a loss part without generating capacitance. In addition, since the fuse part must be formed as thin as possible in order to enhance the operability, the dimensional accuracy of the order of 0.01 mm is required for oil masking by PFPE (refer to figure below). This technology can only be achieved with highly water-repellent/oil-repellent fluorinated compounds, and no other useful alternative materials exist.

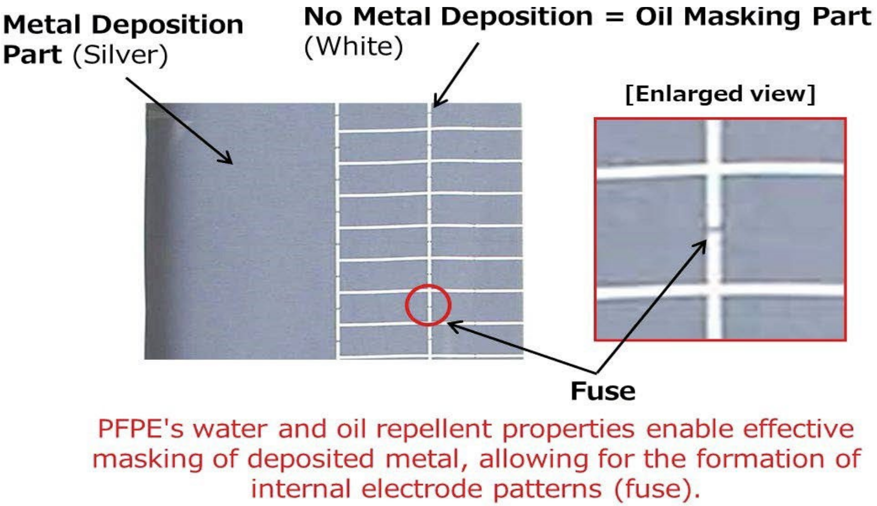


Fig. Appearance of the internal electrode pattern (fuse)

PFPE oil achieves high temperatures during metallization process which takes place under vacuum. Most of the properties of this oil are relevant for process itself and final product performance.

- A non-outgassing oil with a low evaporation loss is required for evaporation under vacuum.
- Chemical stability, non-corrosive, electrical insulation and high dielectric strength are mandatory properties due to this oil is in contact with the main part of film capacitors, which is the metallized film (metallized film = dielectric base film + metal layer).
- Thermal stability, heat resistance at extreme temperatures and non-flammability are also properties required for the oil considering the evaporation process.

Forming a fuse with oil masking using PFPE

■ Concerns about substitution

As disclosed in the patent (平3-59981), when paraffin oil or silicone oil is used as an oil other than PFPE (perfluoroalkyl polyether) to form margins, deposited metal may also adhere to the masked margins. This causes problems with the insulation function, which is the original purpose. In addition, bleeding occurs at the boundary between the vapor deposition part and the margin part, and the margin itself becomes discolored, making it impossible to form patterns and fuses with high precision. In addition, bleeding occurs at the boundary between the vapor deposition part and the margin part, and the margin itself becomes discolored, making it impossible to form patterns and fuses with high precision.

At present, there is no prospect of a technology or material that can replace the oil masking performance of PFPE. Therefore, restrictions on PFPE in the film capacitor manufacturing process should be exempted.

ては、上記した転写ロールの他に、噴霧塗布手段が好適に用いられるほか、装置的な制約の許す範囲で各種印刷手段も用いられる。更に、蒸着はベルジヤーを用いたバツチ方式により行うこともできる。蒸着方式としては、狭義の真空蒸着のほか、各種スパツタリングも可能であり、それに応じて真空度も、例えば10^{-1}〜10^{-6}Torrと巾広い範囲が選択可能である。更にフイルムあるいはシート状基材への蒸着は片面に限らず、両面に実施してもよいことは云うまでもない。

以下、代表的な実施例、比較例により、更に具体的に本発明を説明する。

オイル供給装置6として、転写ロールの代りに、スリツト状開口部を有する中空パイプ状噴霧塗布装置を用いる以外は、第1図に示したような、オイルマスク方式の半連続式蒸着機を用い、*

*オイルの種類を変えて蒸着を行つた。基材フイルム2としては、ポリエチレンテレフタレートのフイルム（厚み2μ、巾500mm、長さ20000m）を用い、その片面にフイルムの巻取り速度240m／minでAlを蒸着した。蒸着機A内のオイル供給装置設置部の真空度は約10^{-2}Torr、Al蒸着される近辺の真空度は1〜3×10^{-4}Torrであつた。オイルは8mm間隔毎に巾1mmでフイルム面に蒸気として噴出付着させた。またAl蒸着部の表面抵抗は1.7Ω／□（膜厚として約400Å）になるようにした。

異なるオイルを使用して得られたコンデンサ用金属化フイルムについて、巻取られたロール状態でのマージン部における金属付着量および金属化フイルムの蒸着部とマージン部との境界のボケを目視観察した結果は第1表の如くであつた。

第　1　表

オイルの種類		マージン部における金属の付着状態(色)	ボ　ケ
名　称	平均分子量		
パーフロロアルキルポリエーテル(n=14)	2500	なし(白色、テープマスクと同等)	なし
流動パラフイン(1)	310	有(やや薄ねずみ色)	あり小
流動パラフイン(2)	420	有(やや薄ねずみ色)	あり大
ジメチルシリコーン	800	大(黒褐色)	マージン部着色のため観察不能

更にメタノールを含浸させたガーゼでマージン部を拭きとつて発光分析にかけたところ、流動パラフインおよびジメチルシリコーンを使用したものからはAlが検出されたが、パーフロロアルキルポリエーテルを使用したものからは検出されなかつた。

上記第1表からわかるように、オイルマスク方式によるマスキングの効果はオイルの種類によつて大きな差があり、パーフロロアルキルポリエーテルの特異性が極めて明確である。

次いで、パーフロロアルキルポリエーテルの各種フイルムに対するAl蒸着のマスキング効果を見るために、ベルジヤー型蒸着試験機を使用して実験した。パーフロロアルキルポリエーテル（平均分子量2500）を綿棒に含浸させて各種のフイルムに巾約5mmの線状に塗布し、フイルムのオイル塗布面にAlを蒸着した。比較のため、ポリエチレンテレフタレートフイルムについてのみ、流動パラフイン（平均分子量310）を塗布したものも実験した。

蒸着後のフイルムについて、オイル塗布部へのAlの付着状態およびオイル塗布部の外周の乱れを観察した結果を第2表に示す。

Only PFPE meets all the requirements for film capacitor foil metallization: thermal and chemical stability, low evaporation loss, non-corrosion, electrical insulation, high dielectric strength and heat resistance at extreme temperatures.

P3. Electrode formation process of Electric Double Layer Capacitor (EDLC)

■ Electric Double Layer Capacitors (EDLCs) one of the essential passive components in the circuit configuration of electrical and electronic equipments. EDLCs are used as power storage devices in backup power supplies for electrical and electronic equipment, leveling of output fluctuations in renewable energy, and energy regeneration systems for automobiles.

■ Electrode formation for EDLC (used as binder)

⇒ High dispersibility in activated carbon, chemical and electrical stability, and high reliability (heat resistance and durability) can be secured, and the characteristics of EDLC are stabilized, so the performance and reliability of the backup power supply can be guaranteed.

[Application example : Backup in case of vehicle power failure]

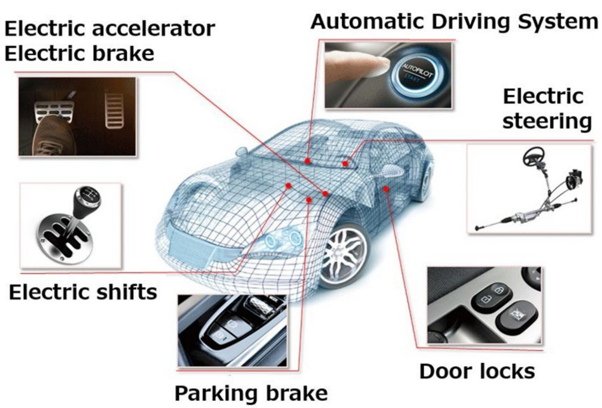


Fig. Examples of use in automotive applications

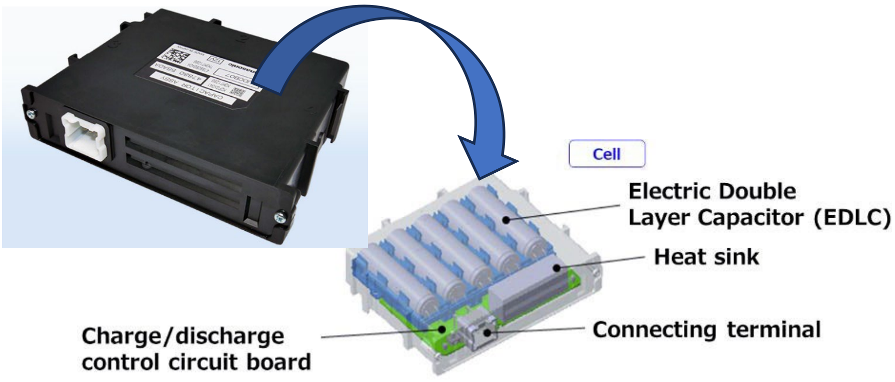


Fig. Backup power supply (power storage device) configuration

P3. Electrode formation process of Electric Double Layer Capacitor (EDLC) for backup power supply

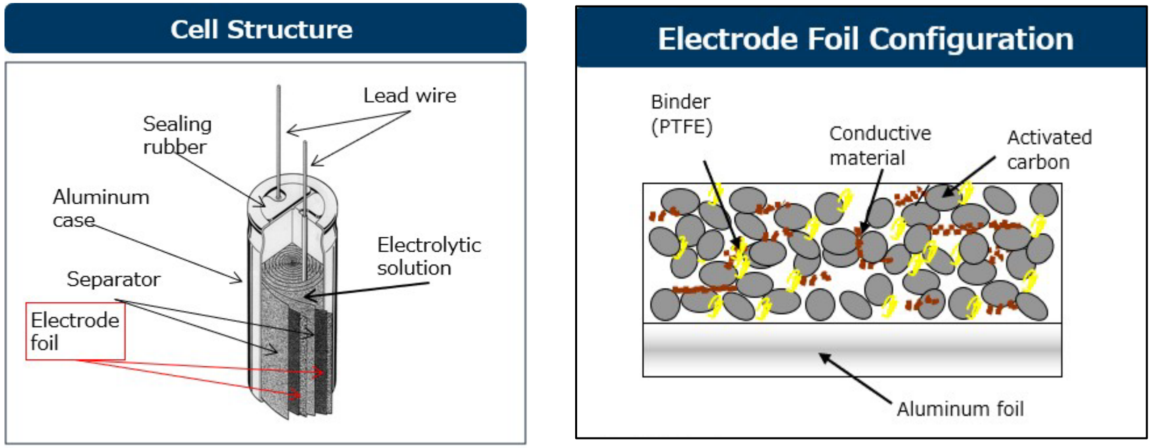


Fig. Cell structure and electrode foil configuration of EDLC

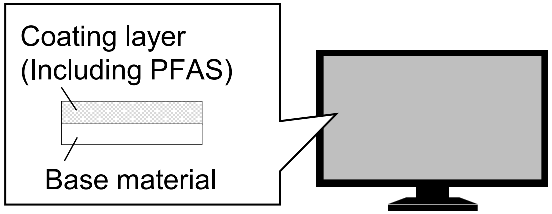
<PTFE Binder>

PTFE bonds activated carbon and aluminum foil. Fibrillated PTFE can hold activated carbon in small amounts

Electrodes are required to store a large amount of electric charge and realize high-speed charge/discharge, while at the same time they are required to have durability and reliability against vibration and impact. As with lithium batteries, the binder must have chemical stability that can withstand electrolytes, durability against electrochemical oxidation/reduction, and heat resistance. In addition, in order to achieve low resistance, it is necessary to form an electrode using a small amount of binder. PTFE is the only binder that simultaneously satisfies these required properties (there are no alternative materials).

P4. Optical film manufacturing process for LCD displays

In the manufacturing process “coating” of optical films for liquid crystal displays, it is important from an explosion-proof point of view not to generate static electricity at the contact points between the coating machine and the substrate. One of the advantages of this is that it spreads quickly during coating. Fluorine materials are optimal materials from the viewpoint of low surface tension and wettability with the coating layer substrate.



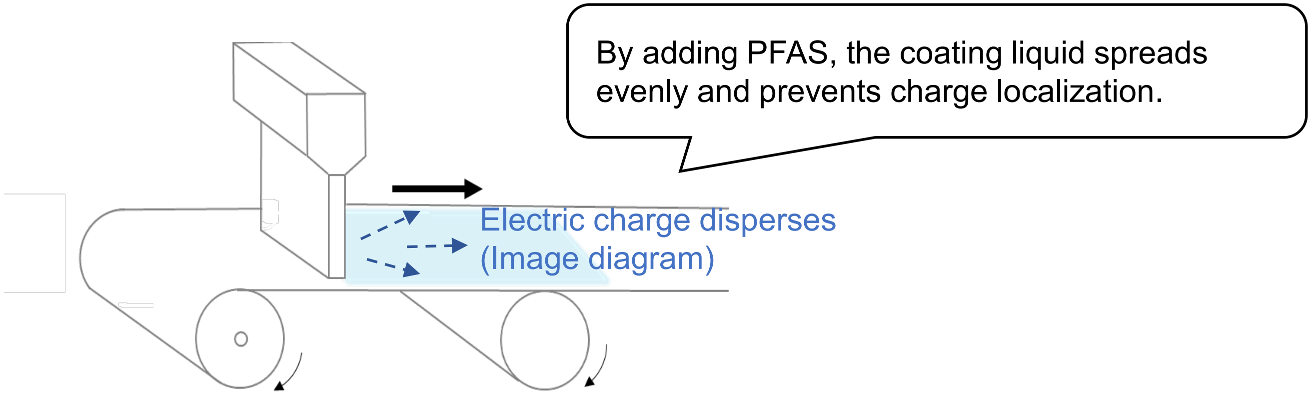


Fig. Manufacturing process “coating” for liquid crystal display materials

Figure. An example of a fire accident caused by static electricity