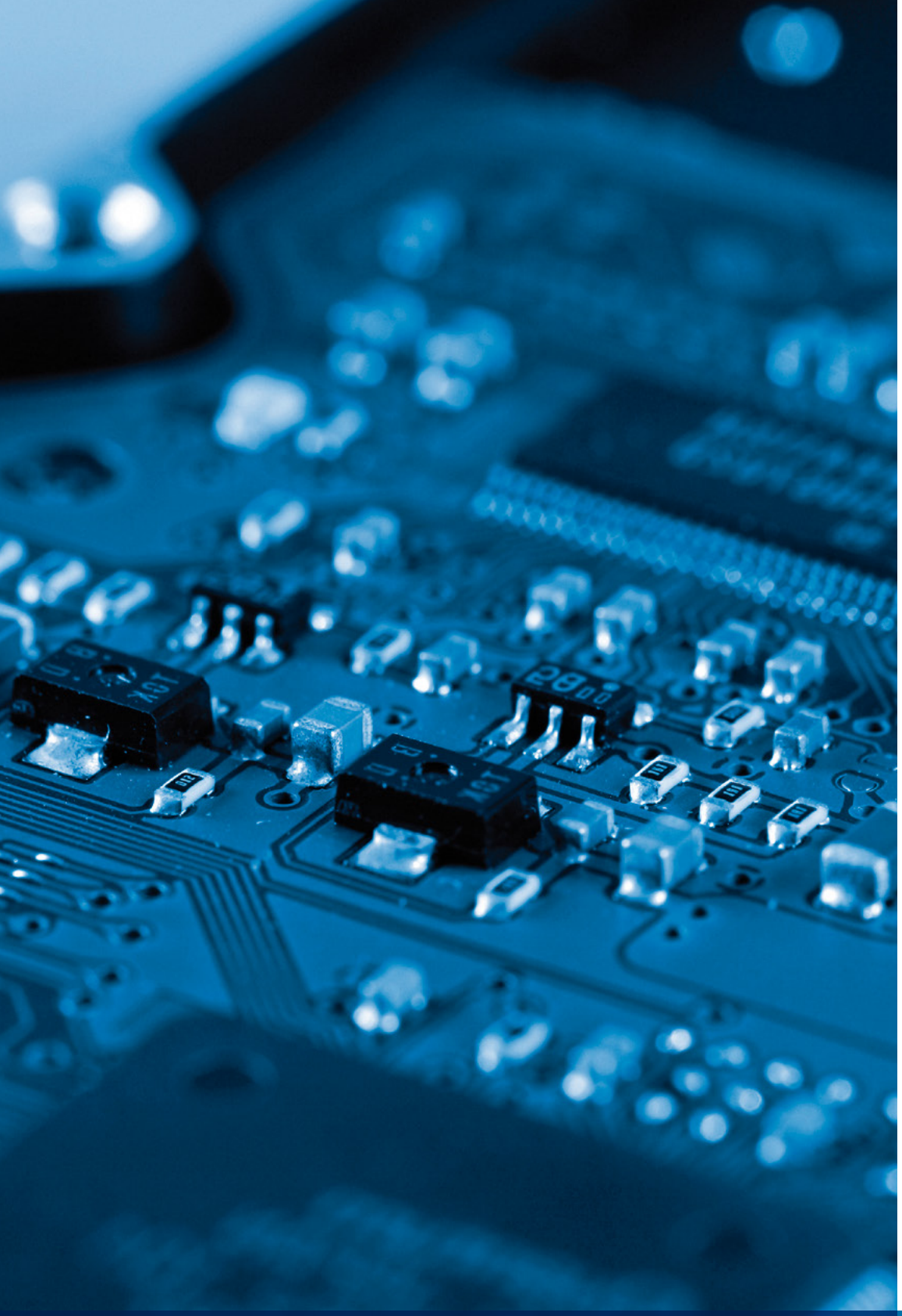


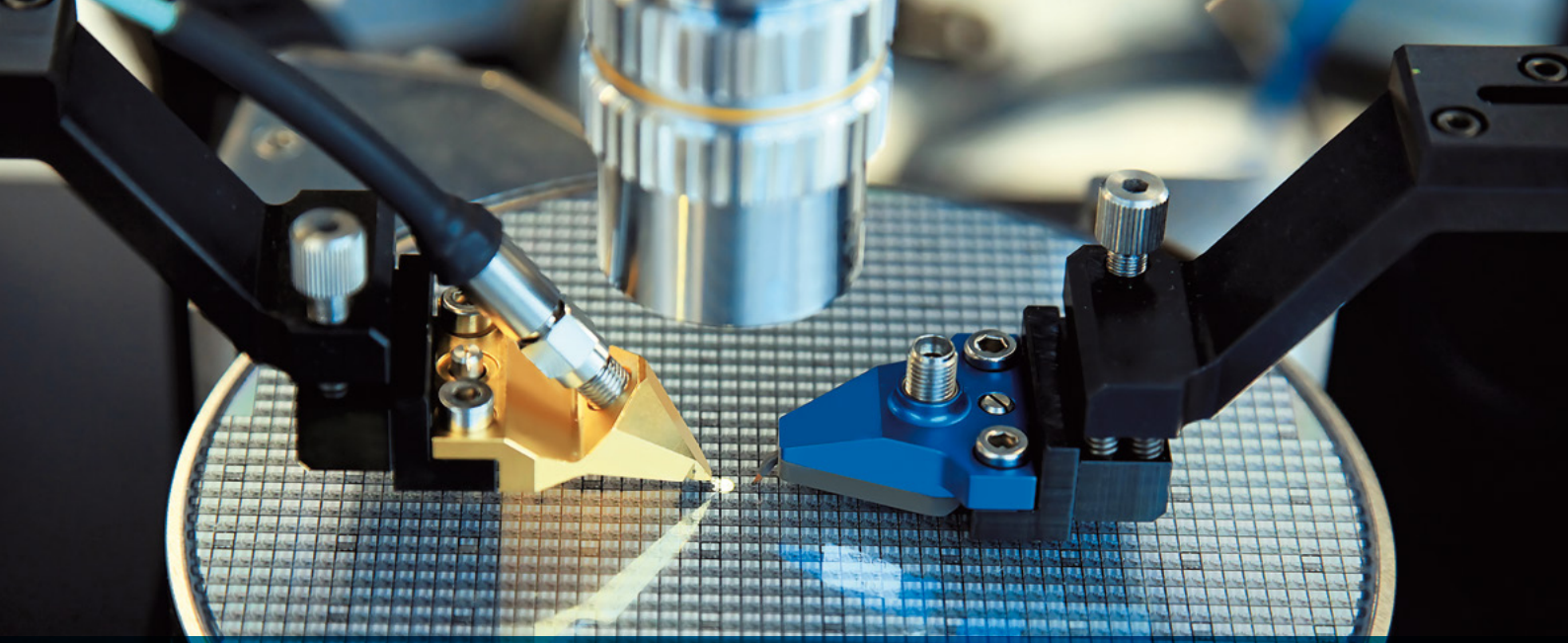
SOLVAY

asking more from chemistry®

High-Performance Polymers for the

Semiconductor and Electronics Industry

SPECIALTY POLYMERS



Supplying the Broadest Range of Products for a Fast Moving Industry

Solvay Specialty Polymers is a leader in the research, development and manufacturing of high-performance polymers, which are designed to withstand the most challenging requirements of the Semiconductor and Electronics industry.

We Provide:

- Essential materials for wafer processing (front-end-of-line) and test, assembly & packaging (back-end-of-line)
- Fluoro-specialties (fluids, elastomers, plastics and coatings) used as:
  - Process consumables
  - Capital equipment (materials of construction)
  - Critical plant and process system components

Application Matrix

	PFPE	PVDF	ECTFE	FFKM	PEEK	PAI	PESU
Specialty O-rings				•			
Specialty seals				•			
Ambient and hot UPW pipe systems		•	•				
Sheet linings		•	•				
Powder coatings (UPW & HP chemicals)		•	•				
HP chemical tubings & fittings		•	•				
CMP rings and etch chamber components					•	•	
Wafer handling equipment including cassette and housing					•		•
Burn-in test sockets, handler						•	•
Packaging (tray, boat, ~ 265 °C baking temp)							•
Vacuum pump oils	•						
Mold release film							
Lubricants for robotic devices	•						
High vacuum lubrication	•						
Heat transfer fluids	•						
Reliability testing fluids	•						
Vapor phase soldering	•						
Exhaust pipe coatings			•				

Other applications with Solvay products: pellicle system, probe cards

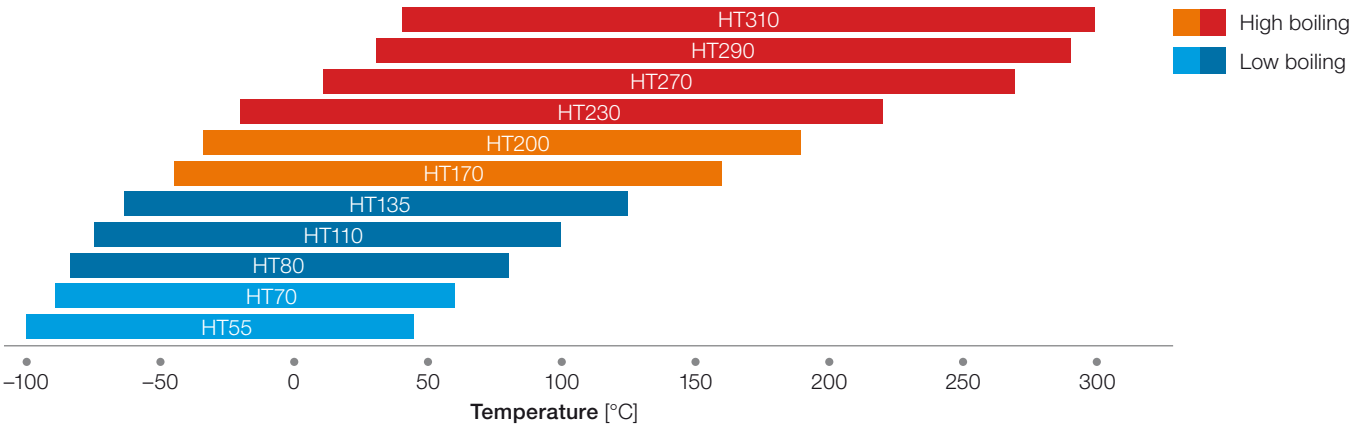
Heat Transfer Fluids

Galden® HT PFPE

Galden® HT PFPE are inert, dielectric and high-performance heat transfer fluids with boiling points ranging from 55 to 320 °C. This range is broader than other fluorinated heat transfer fluids and enables PFPE to be used at end-use temperatures up to 290 °C.

Features	Benefits
Excellent thermal and chemical stability	No corrosion or reaction with construction materials
Good compatibility with materials	No formation or decomposition residues No circulating pump seizure due to fluid degradation or corrosion
Good heat transfer performance	Good temperature control
Grades with wide range of boiling point	Wide choice of grades to optimize performance
High boiling point with low pour point and low viscosity	High boiling grades reduce evaporation losses without affecting performance
Low evaporation losses	Low costs of ownership
No flash or fire points No explosion hazards No toxicity No auto-ignition point	Safe to use at high temperature Enhanced safety

Suggested operating temperature range



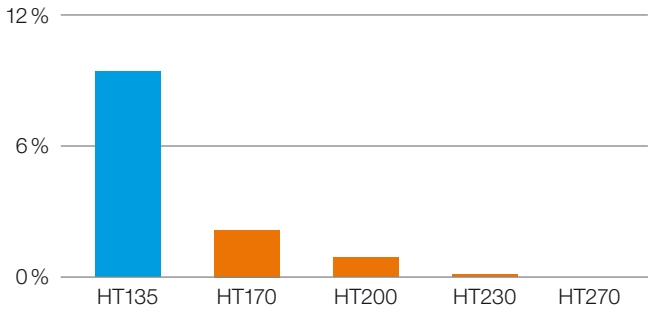
Galden® High Boilers (HB)

Galden® HT High Boilers is a line of dielectric fluids with boiling points ranging from 170 to 270 °C. These high performance fluids are a family of heat transfer fluids engineered for high temperature applications. Thanks to their high boiling point, they offer a significantly lower evaporation rate than that of low boiling point fluids.

Galden® HB fluids can also be used at moderate temperatures to replace fluids with higher evaporation rates, thereby reducing evaporation losses.

Evaporative loss comparison

According test method JIS C2101
(after 8 hrs at 40 °C)

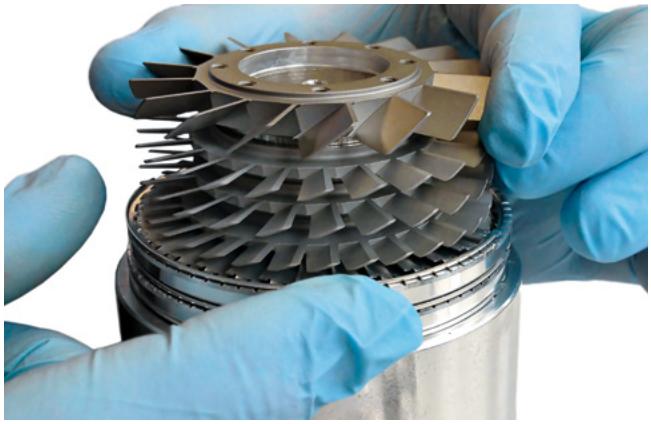


Vacuum Pump Oils

Fomblin® PFPE

Fomblin® Y grades are perfluorinated polyether inert fluids for use as lubricants in vacuum pumps. Fomblin® PFPE fluids are a mixture of fluorinated polymers obtained by a photochemical process that begins with hexafluoropropylene. Since the Fomblin® PFPE chemical chain contains only carbon, fluorine and oxygen atoms, these fluids have exceptional properties such as:

- Low vapor pressure
- Chemical inertness
- High thermal stability
- Good lubricant properties
- No flash or fire point
- Non-toxicity
- Excellent compatibility with metals, plastics, elastomers
- Good aqueous and non-aqueous solvent resistance
- High dielectric properties
- Low surface tension
- Good radiation stability
- Environmentally acceptable



	Y LVAC Grades				Y LVAC RP Grades Anti-rust Additivated			Y HVAC Grades
Application	**06/6**	**14/6**	**16/6**	**25/6**	**06/6RP**	**14/6RP**	**25/6E**	**140/13**
Rotary pumps – sealing & lubricant fluid	•	•		•	•	•	•	
Turbomolecular pumps – lubrication	•				•			
Roots pumps – lubrication			•	•			•	
Diffusion pumps – working fluid								•

Fomblin® Y LVAC Grades

		Y LVAC Grades			
Typical Property	**Unit**	**06/6**	**14/6**	**16/6**	**25/6**
Average molecular weight	amu	1,800	2,500	2,700	3,300
Density at 20 °C	g/cm^3	1.88	1.89	1.89	1.90
Kinematic viscosity at 20 °C	cSt	64	148	168	276
Viscosity index		71	97	110	113
Vapor pressure					
at 25 °C	torr	$8 \cdot 10^{-7}$	$1 \cdot 10^{-7}$	$9 \cdot 10^{-8}$	$6 \cdot 10^{-8}$
at 100 °C	torr	$3 \cdot 10^{-3}$	$2 \cdot 10^{-4}$	$2 \cdot 10^{-4}$	$6 \cdot 10^{-5}$
Pour point	°C	–50	–45	–45	–35
Heat of vaporization at 200 °C	cal/g	11	8	8	7
Surface tension at 20 °C	dyne/cm	21	22	22	22
Evaporation loss (22 hrs; 149 °C for 14/6, 16/6, and 25/6, 120 °C for 06/6)	% by wt.	2.8	2.6	3.9	0.6

UPW Piping Systems and Wet Tools Materials

Purely the Best Solef® HP PVDF

Manufacturing operations in the Semiconductor Industry demand high purity conditions. To maintain purity, the materials of construction for UPW piping and system components must meet a unique set of specifications to prevent contamination from leaching and bacterial growth. At the same time, the piping system materials must satisfy mechanical and process demand requirements to provide long service life.

Solef® PVDF, UPW Piping Systems Material of Choice

For over 30 years, polyvinylidene fluoride (PVDF) has been the material of choice for UPW systems because the qualities of this fluoropolymer ensure purity and long-term performance.

PVDF is inherently pure. Unlike other polymers, due to its intrinsic stability and fire and oxidation resistance, PVDF does not need additives, fillers, pigments, or fire retardants which can leach out. PVDF offers exceptional chemical and thermal resistance, standing up to aggressive chemicals without degradation. It provides exceptional surface smoothness to prevent bacterial and biofilm growth. Other piping materials historically used in UPW piping systems such as stainless steel, polyvinyl chloride (PVC), and polypropylene (PP) can compromise purity. Over time, chemical attack and corrosion can result in iron (rouging), stress cracking, or biofilm adhesion. This does not happen to PVDF piping systems.

Solef® HP provides essential properties for critical semiconductor applications. These include:

- UPW pipe, tubing and fittings
- High purity water components
- Valves, flow meters, filters, tanks
- Coatings and linings
- Wet bench and other HP process tooling
- Membranes and filter media

Photos courtesy of Agru Kunstofftechnik GmbH

Cleanroom production of high purity equipment
Photo courtesy of Gemü GmbH

Halar® ECTFE for Wet Tools Construction

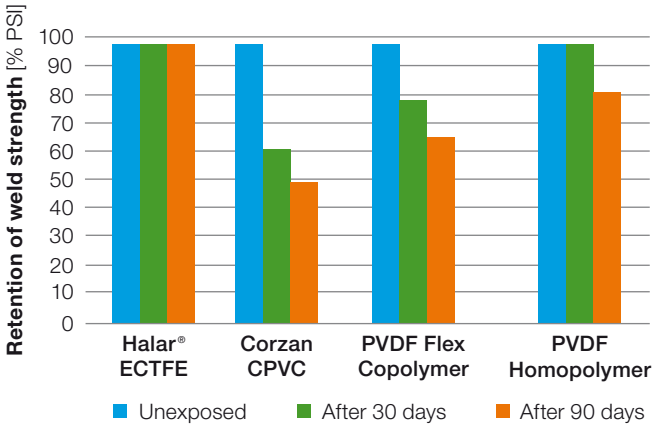
Halar® ECTFE combines excellent chemical resistance, wide temperature range, outstanding abrasion resistance, and excellent impact strength. Halar® ECTFE is resistant to the full line of semiconductor chemicals and solvents. It is also ultrapure parts suitable, and has a micro smooth surface, offering the potential of low particle hang up and easier cleanability. Halar® ECTFE is also a FM4910 listed material and required no fixed fire protection.

Following conditions used in a Sematech test project, plaques of welded plastic sheets were exposed and evaluated for:

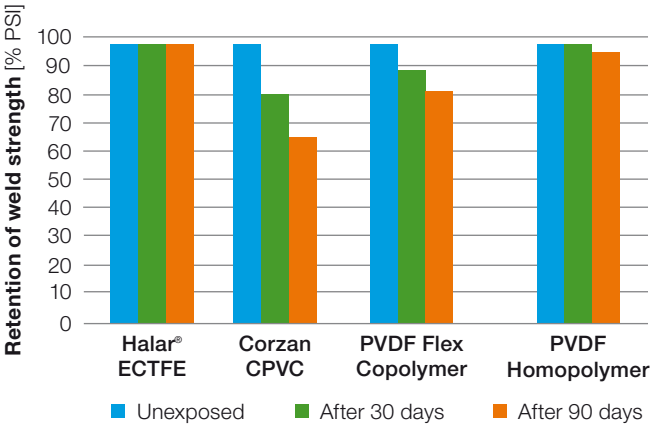
- Retention of weld strength
- Swelling
- Weight loss
- Color and surface changes

Halar® ECTFE outperformed all of the competing plastics in all areas. Each material was immersed in aggressive chemicals commonly found in semiconductor processing plants for 30 and 90 days at 88 °C, including 30 % ammonium hydroxide, SC1, 20 % TMAH, and 30 % H_2O_2. The results are documented on page 8.

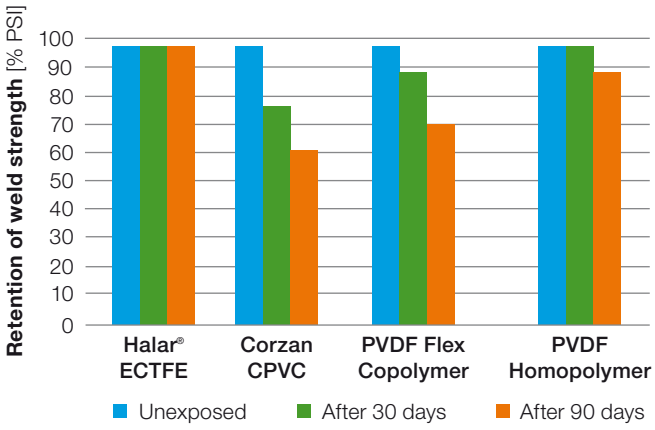
Retention of weld strength in 30 % Ammonium hydroxide



Retention of weld strength in 30 % H_2O_2



Retention of weld strength in SCI



Approximate Values for Standard Grades	PVDF	ECTFE	PFA	HDPE	PVC
90 % H_2SO_4, 25 °C	+	+	+	o	+
90 % H_2SO_4, 80 °C	+	+	+	–	–
98 % H_2SO_4, 25 °C	o	+	+	–	o/–
98 % H_2SO_4, 80 °C	–	+	+	–	–
38 % HCl, 25 °C	+	+	+	+	+
50 % HNO_3, 25 °C	+	+	+	o	+
100 % CH_3CO_2H, 25 °C	+	+	+	o	o/–
90 % HCO_2H, 25 °C	+	+	+	+	+
40 % NaOH, 25 °C	–	+	+	+	+
40 % NaOH, 80 °C	–	+	+	+	–
100 % Cl_2, 25 °C	+	+	+	o	o
100 % Br_2, 25 °C	+	+	+	–	–
30 % H_2O_2, 25 °C	+	+	+	o	o

Wafer Processing Equipment Materials

Solef® PVDF, Halar® ECTFE and KetaSpire® PEEK

Key Material Applications

- Protective linings
- Ultrapure water systems
- Wet tools – cleaning and etch
- Chemical distribution lines, storage tanks
- Chemical resistance
- Wear resistance

Solef® PVDF and Halar® ECTFE have been used successfully in wet benches, high purity water piping as chemically resistant surfaces, for process tanks, valves, nozzles and wafer handling carriers etc. Several grades have FM 4910 approval.

KetaSpire® PEEK has been used successfully in wafer cassette, wafer jars and dicing cassette.

Exhaust Duct Coating

Halar® ECTFE

A Leading Choice in Semiconductor Fabs

Halar® ECTFE powder coatings is used successfully for corrosion protection of exhaust duct systems that must meet the FM4922 fire safety standard. In addition, Halar® ECTFE plastic sheet is used to meet FM4910 and UL2360 standards for fabrication of fire-safe cleanroom tools. In addition, seamless Halar® ECTFE powder coatings have been successfully used in ultrapure water (UPW) systems (i.e. filter housing, ion exchange beds, storage tanks).

Halar® ECTFE over ETFE for fluoropolymer coated duct applications

Property	Halar® ECTFE	ETFE
Fire safety	**Superior**	Average
Surface smoothness	**Superior**	Average
Permeation resistance	Equal	Equal
Chemical resistance	Equal	Equal
Hardness	**Superior**	Average
Adhesion	**Superior**	Average

Superior Fire Safety Properties of Halar® ECTFE

In response to industry-wide concerns about the fire resistance of all materials and components used in cleanroom process tools, the more stringent standards of FM4910, UL2360, and FM4922 were established. These standards govern materials of construction for cleanroom equipment and exhaust duct systems. Halar® ECTFE can help you meet these standards, with performance properties for exhaust duct that include:

- FM4922 listing
- FM4910 listing
- Superior limiting oxygen index (LOI)*
  60 for Halar® ECTFE vs. 30–50 for ETFE
- UL rated to 94 V-0

In addition, Halar® ECTFE plastic sheet is FM4910 listed and meets the UL2360 standard for cleanroom wet bench and tool construction.
ETFE plastic sheet does not meet these standards.

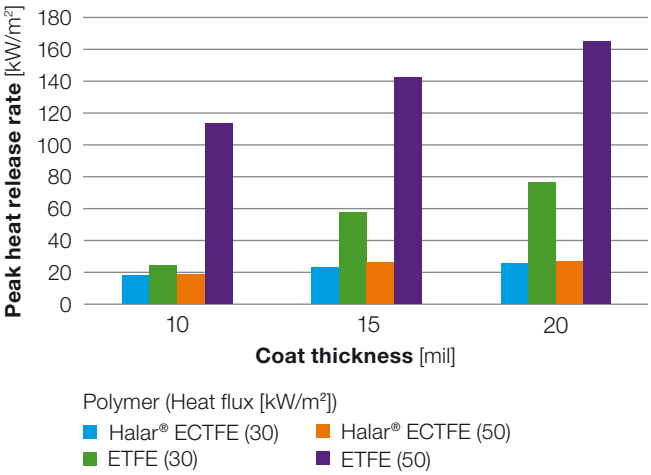
Outstanding Resistance to Fire Spread

Halar® ECTFE resists fire spread better than ETFE. Halar® ECTFE forms a char to inhibit the flow of molten polymer. By contrast, ETFE breaks down into low molecular weight fragments that induce flow and cause fire dripping. Within the Uniform Building Code (UBC), the ASTM E-84 test is used to measure surface burning characteristics of building materials. Halar® ECTFE coated steel panels are rated to a value of 5** which places it within Class I of the safest materials in the UBC. ETFE coated steel panels were rated 10. Halar® ECTFE consistently measures onehalf the value of ETFE in flame spread testing.

Coating Thickness: Fire Safety Unaffected

Compared with ETFE, the flammability of Halar® ECTFE is relatively unaffected by coating thickness, giving fabricators more flexibility in adding extra protection against corrosion and pinholes. In FM4922 testing, ETFE coating with a thickness of 10 mil had a temperature of 510 °C *** at the exhaust duct end, marginally meeting the requirement of 538 °C. Halar® ECTFE, with a thickness of 12 mil had a temperature of 329 °C at the exhaust duct end. This result implies that ETFE coating with a thickness greater than 10 mil will not pass the FM4922 requirement. Heat release data shown in the chart demonstrates the superior resistance to ignition and fire spread of Halar® ECTFE coatings versus ETFE coatings, regardless of thickness or energy source.

Heat release comparison of fluoropolymer coatings



* *LOI is used to define the level of oxygen needed to support combustion, according to ASTM Method D2863.*

** *Reference: concrete = 0; red oak = 100*

*** *As reported in competitor's published data*

Properties of Halar® ECTFE Coated Ductwork

Halar® ECTFE is particularly suitable for coatings in contact with highly corrosive chemicals, ultrapure chemicals, strong inorganic bases, strong mineral acids and strong oxidizing acids. Halar® ECTFE powders are applied primarily by an electrostatic powder coating process.

Exceptional surface smoothness properties

As shown in the AFM images and calculated surface roughness (Ra) values and AFM images, Halar® ECTFE powder coated duct has a much smoother surface than ETFE coated duct. Benefits of a smoother surface include:

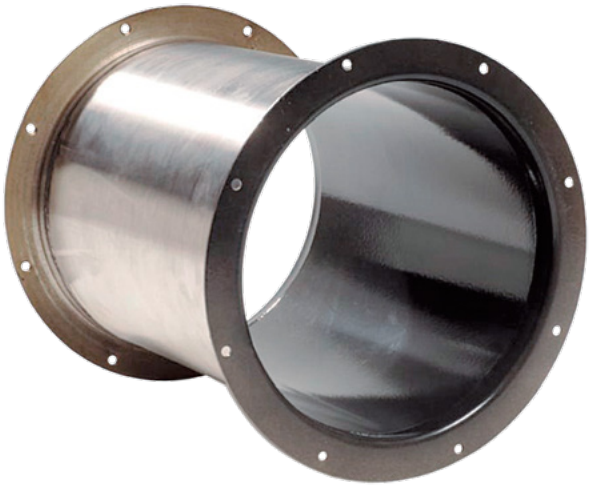
- Reduces the risk of pinholes in the coating
- Inhibits buildup and accumulation of particles and metallic salts

These benefits result in better corrosion protection.

Surface smoothness parameters of fluoropolymer powder coatings

Property	Halar® ECTFE	ETFE T1	ETFE T2	ETFE A
Mean roughness (Ra) [nm]	21.93	59.99	63.77	53.67
	Superior	Average	Average	Average

Note: Results on actual powder coated samples



High Purity Materials for Cleanroom Environment

KetaSpire® PEEK

Components used in cleanroom equipment must be constructed of inert materials that can withstand thermal cycling, harsh chemicals and the constant, frictional motion associated with semiconductor fabrication without adversely affecting their environment.

Polyetheretherketone (PEEK) has proven itself as the material of choice for structural components that require superior strength and stiffness while exhibiting chemical resistance that is on par with fluoropolymers. Additionally, the material's well-balanced combination of dimensional stability, low particulation, and dynamic fatigue make it an excellent choice for applications that require indexing and repeated motion.

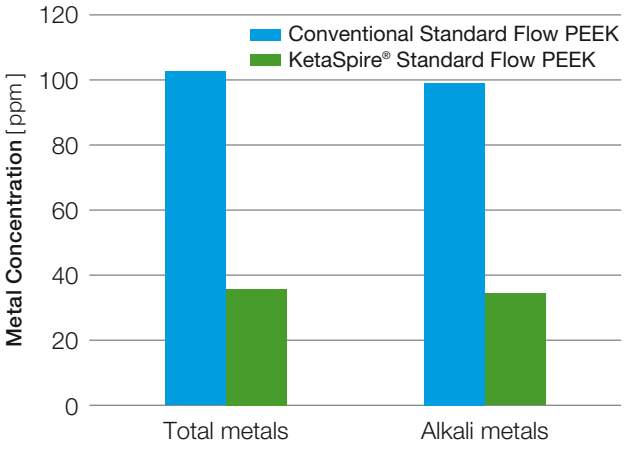
PEEK must also deliver high purity and toughness to help optimize the performance of device manufacturing equipment.

Higher Purity than Traditional PEEK

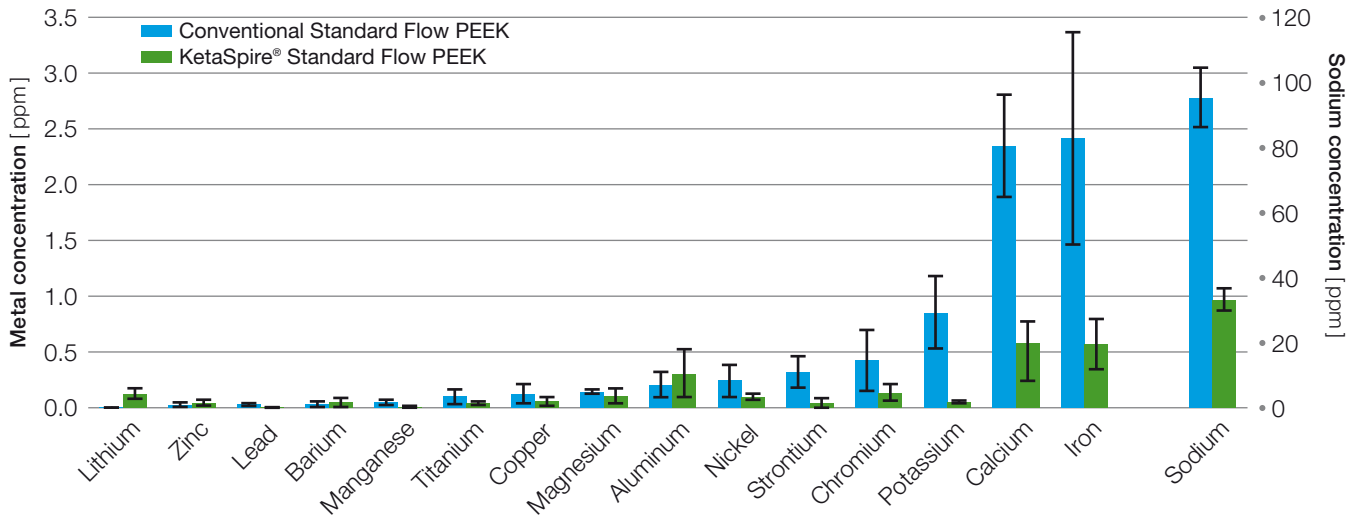
Blind samples of KetaSpire® KT-820 conventional flow PEEK and conventional standard flow PEEK were submitted for evaluation to Fremont, California-based Balazs Labs, an independent lab that offers analytical services for high-technology products. The materials tested did not contain additives, lubricants or processing aides. Five lots of KetaSpire® PEEK and six lots of conventional PEEK were analyzed using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). Test results from all lots for each product were averaged and are summarized in the figures below.

The concentrations of total metals and alkali metals are significantly lower for KetaSpire® PEEK. The concentrations of most elemental metal contaminants present in KetaSpire® PEEK were lower than the concentrations of those present in conventional PEEK. This is especially noticeable for sodium, calcium, and potassium.

ICP-MS analysis of total metals and alkali metals



ICP-MS analysis of elemental metals

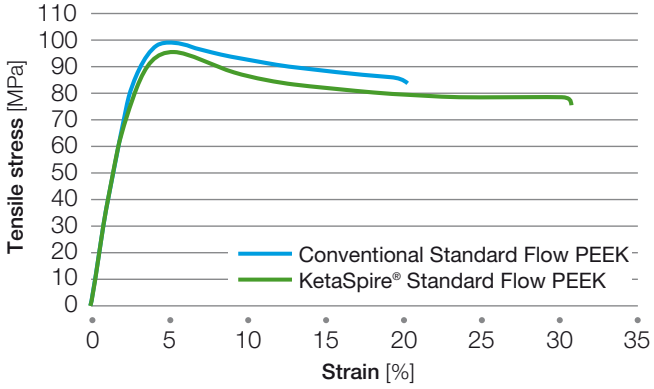


Note that the scale used to report sodium concentration is different than the scale used for the other elements.

Superior Toughness

The area under each tensile stress-strain curve shown below represents the material's practical toughness. The higher value of KetaSpire® PEEK indicates that it has a greater capacity to absorb a higher amount of energy or load before breaking versus conventional PEEK.

Tensile stress-strain curves (ASTM D638)



The tensile bars used to generate the stress-strain curves are shown below. The KetaSpire® PEEK bar has a fully developed, smooth neck region that is characteristic of shear banding; the conventional PEEK bar exhibits less necking and a drawdown that is characteristic of crazing.

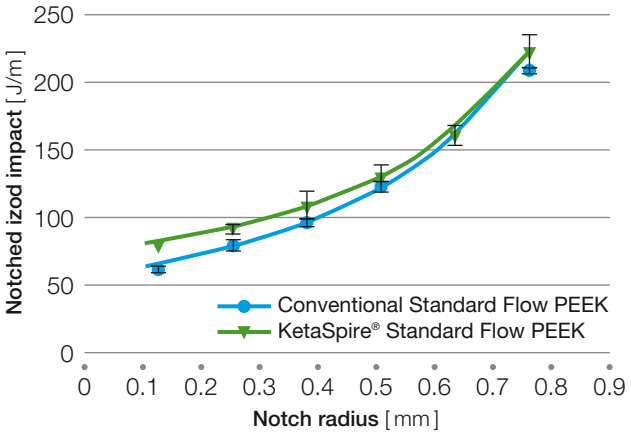
Tensile bars used to generate tensile stress-strain curves

Conventional Standard Flow PEEK

KetaSpire® Standard Flow PEEK

The superior toughness of KetaSpire® PEEK can also be demonstrated through notch sensitivity testing. Solvay's PEEK exhibits superior toughness as the notch radius is decreased, which indicates that it will be less likely to crack or chip when machined or impacted in sharp-edge geometries.

Notched Izod vs. notch radius (ASTM D256)



Not All PEEK is Created Equal

Extensive testing has been conducted to evaluate KetaSpire® PEEK's performance versus other commercial PEEK products. Results show that KetaSpire® PEEK offers distinct performance advantages that can be attributed to Solvay's newer polymer production technology.

KetaSpire® PEEK offers higher purity than the PEEK traditionally used in the semiconductor industry. Solvay's PEEK contains a lower amount of the metals that pose the largest risk in cleanroom processes. Higher purity enables higher precision, and that can give OEMs a competitive advantage.

KetaSpire® PEEK also offers superior toughness and a greater capacity to absorb a higher amount of energy or load before breaking versus conventional PEEK.

Similar to conventional PEEK, KetaSpire® PEEK meets existing performance requirements for components used in cleanroom equipment, including end effectors, push pins, in-process transport media, part carriers, IC test equipment, sockets, and other applications that require a well-balanced combination of strength, stiffness, dimensional stability, and excellent resistance to chemicals, wear and fatigue.

Assembly, Packaging & Test Components

Torlon® PAI and Veradel® PESU

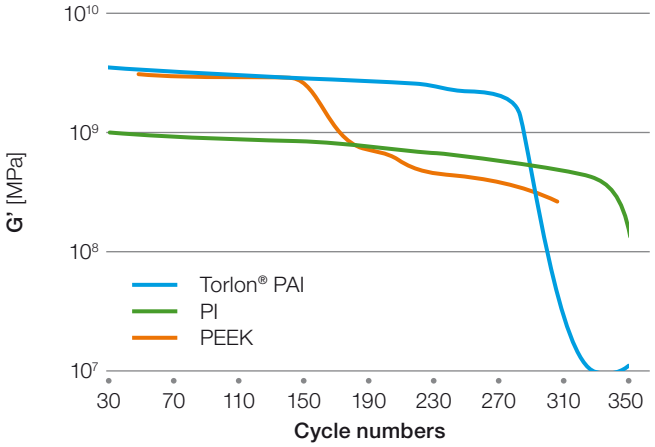
Proven performance in back end applications requirements:

- Thermal stability
- Dimensional stability
- Outstanding wear, creep and chemical resistance
- Static dissipation

High-strength grades deliver metal-like performance and are routinely specified for precision components used in repetitive-use, load-bearing operations. Glass fiber and carbon fiber filled grades retain their strength and stiffness at high temperatures with the added benefit of low creep and excellent fatigue resistance.

Wear-resistant grades offer select combinations of mechanical and tribological properties. Their inherent heat and chemical resistance, makes them an effective alternative to metal in high-temperature friction and wear applications – even when lubrication is marginal or non-existent. Select grades can perform in lubricated environments at exceptionally high pressures and velocities (PV).

Torsional DMA

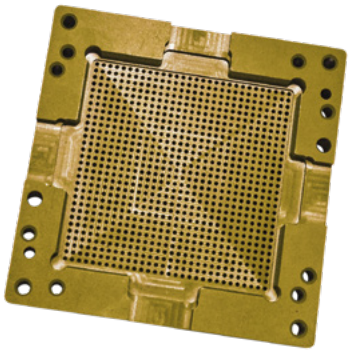


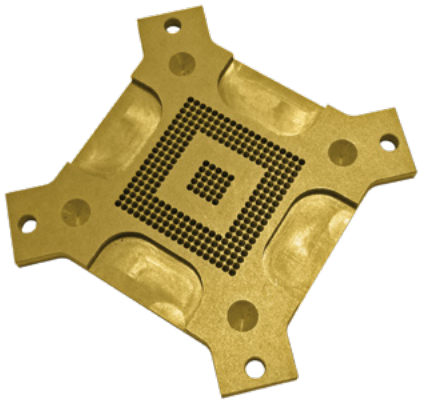
Torlon® PAI attributes:

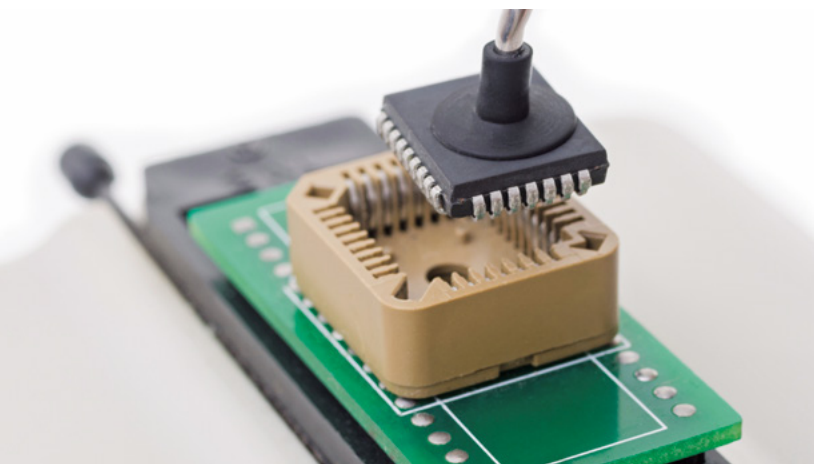
- Low CTE from –60 to 160 °C
- Retains strength to 260 °C
- Dimensional stability to 270 °C (SMT process)
- Precision machinable to tight tolerances
- Resistance to many harsh chemicals
- ESD grades available

Veradel® PESU attributes:

- Retains strength to 180 °C
- Precision injection mold to tight tolerances
- Resistance to many harsh chemicals
- ESD grades available







High Performance Sealing Applications

Tecnoflon® PFR (FFKM)

Used in a variety of critical sealing applications for wet and dry processes in the IC manufacturing process – etch, deposition, patterning, wet clean.

Typical Applications

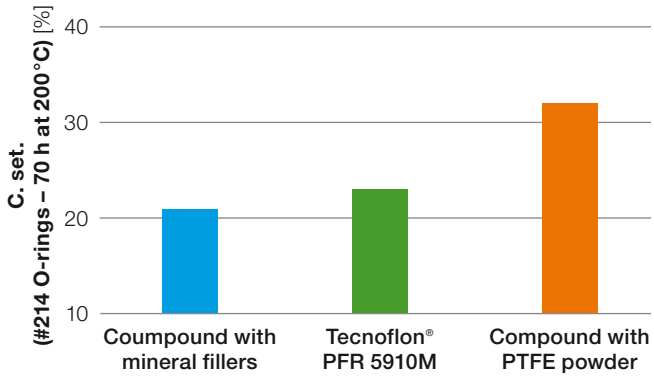
- Seals
- O-rings
- Bonded gates

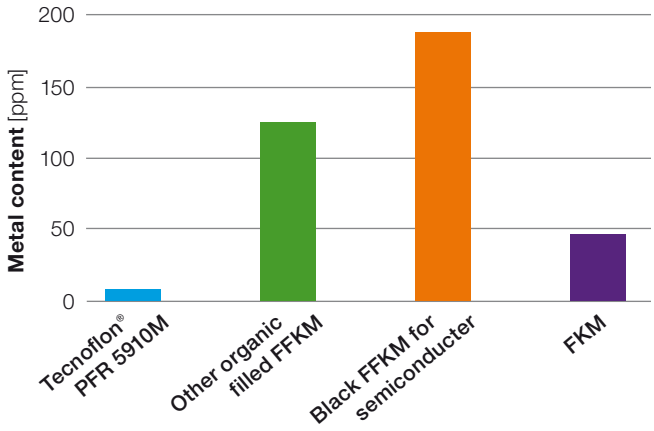
Key Properties

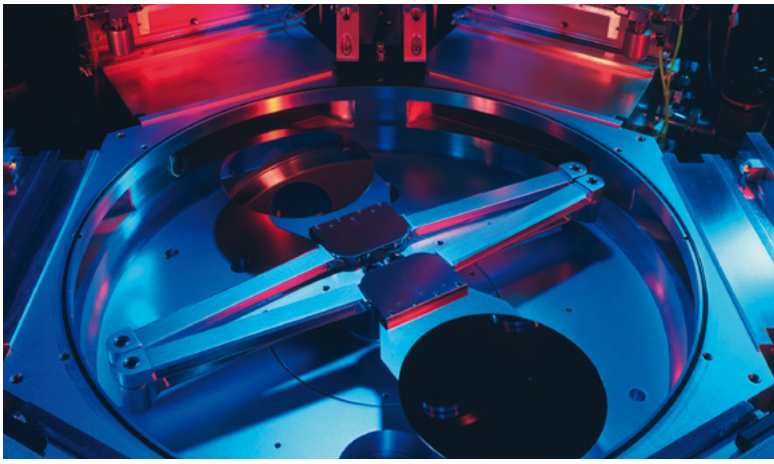
- Thermal resistance to 320 °C
- Plasma resistance
- High purity
- Low metal content

Nano organic filled grades

- Tecnoflon® PFR 5910M, PFR 5920M and PFR X1075O
- Specifically designed for the Semiconductor industry
- Solvay's proprietary technology
  - No mineral fillers, no mineral particle generation
  - Nanoparticle PTFE (< 40 nm) with excellent dispersion within the polymer matrix
  - Best mechanical properties among other FFKM transparent materials
- High purity and low metal content







SOLVAY

asking more from chemistry®

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