3M Science. Applied to Life.™

3M™ Dyneon™ Perfluoroelastomers (PFE)

Engineered for endurance.

Reliable sealing solutions for critical applications

In extreme environments where other elastomer materials fail, 3M™ Dyneon™ Perfluoroelastomers excel.

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The right mix.

Balanced properties and application engineering expertise

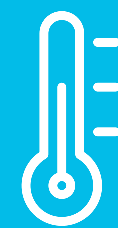
From semiconductor manufacturing equipment to deepwater drilling and high-flying jet engines, harsh chemicals and extreme temperatures place enormous demands on seals and gaskets. **3M™ Dyneon™ Perfluoroelastomers** are designed to withstand some of the most challenging operating conditions, helping extend equipment life and reduce costly downtime for maintenance.

Connect with a 3M expert at 3m.com/fluoropolymers

Bench-to-bench support from our experienced 3M Technical Specialists can help you with product, technical and application advice to help you solve your toughest material challenges.

Our breadth of technologies and material capabilities gives you the flexibility you need to develop integrated solutions precisely fit to your systems and processes.

Broad resistance to chemicals and plasma

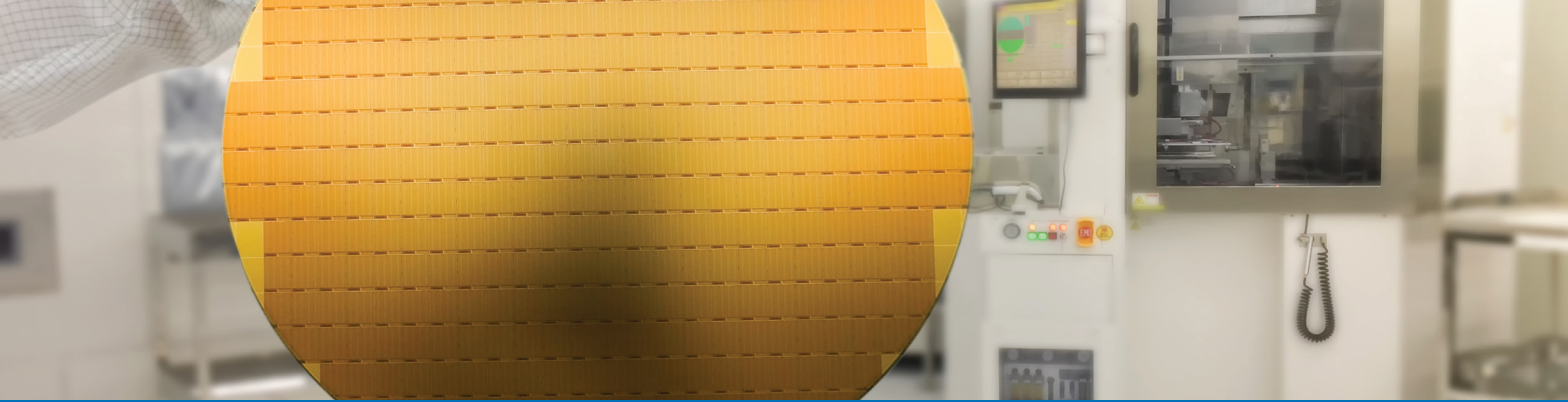


High temperature resistance

Low permeation

High reliability and long service life

Easy processability



Semiconductor Industry

From plasma etching and chemical vapor deposition (CVD) chambers to vacuum systems, seals and gaskets for the semiconductor industry require extraordinary materials. Their high purity and resistance to plasma, heat and harsh chemicals make 3M™ Dyneon™ Perfluoroelastomers ("3M PFE") excellent solutions for semiconductor fabrication or sub-fabrication processes. Together, these properties add up to longer seal life and less contamination – giving you higher wafer yield and lower total cost of ownership.

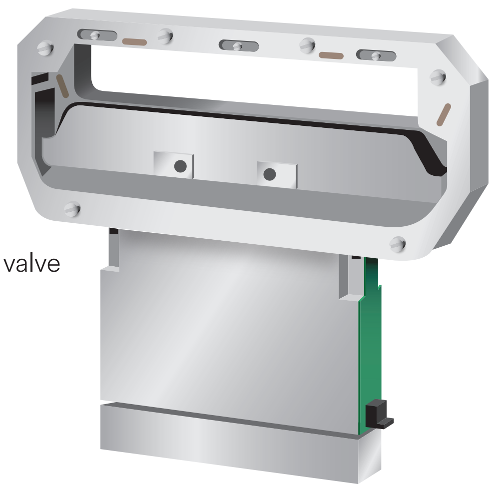
At 3M, our global application engineering teams are constantly evaluating the unique and emerging needs of the semiconductor industry. Our testing equipment is designed to simulate stringent real-world conditions in order to optimize our materials and support. Our PFE testing capabilities include plasma resistance, stiction force determination and metal content determination.

Typical Applications:

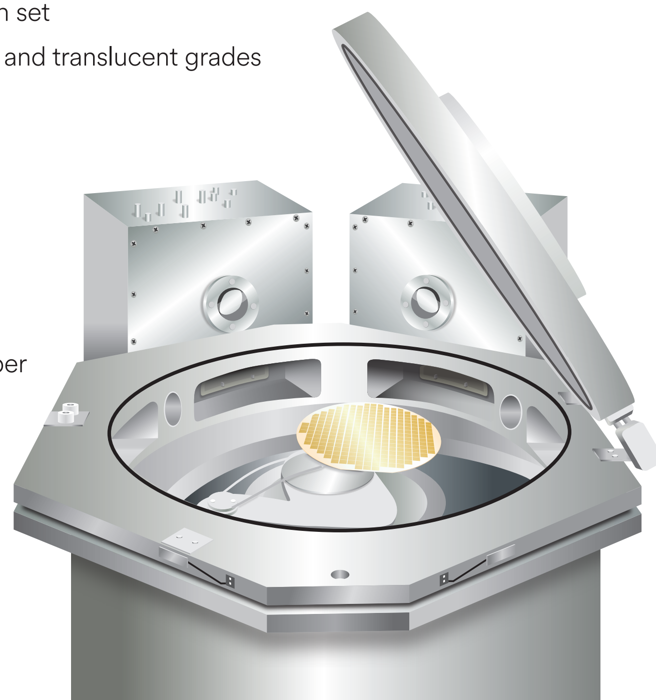
- Chamber lid seal (etch, deposition and cleaning processes)
- Gate valve seals for load lock
- O-rings
- Bonded seals
- Pump linings

Why is 3M PFE vital to the semiconductor industry?

- High temperature resistance up to 315°C
- Plasma resistance (O_2, CF_4, SF_6, NF_3 etc.)
- Low particle generation
- High purity/low metal ion content
- Permeation resistance
- Low volatile generation/outgassing
- Resistance to harsh chemicals
- Low compression set
- Available in clear and translucent grades



Gate valve



Wafer chamber

Semiconductor Industry

In the semiconductor industry, customers are looking for materials with the lowest metal ion content to prevent contamination. The information below has been generated using an ash and digestion test.

Trace metal ion analysis: Ash and digestion ICP-MS[1]

Component	Detection Limit (ppb)	PFE 131T (ppb)	PFE 132TB (ppb)	PFE 133TB (ppb)
Aluminum (Al)	1	58	11	18
Barium (Ba)	1	4	7	*
Beryllium (Be)	10	*	*	*
Bismuth (Bi)	10	*	*	*
Cadmium (Cd)	1	*	*	*
Calcium (Ca)	10	120	12	20
Cesium (Cs)	1	*	*	*
Chromium (Cr)	5	*	*	*
Cobalt (Co)	1	*	*	*
Copper (Cu)	5	19	*	*
Gallium (Ga)	1	*	*	*
Indium (In)	1	*	*	*
Iron (Fe)	10	*	*	*
Lead (Pb)	1	*	*	*
Lithium (Li)	1	*	*	*
Magnesium (Mg)	1	5	*	*
Manganese (Mn)	1	*	*	*
Molybdenum (Mo)	5	*	*	*
Nickel (Ni)	1	*	*	*
Potassium (K)	10	20	*	*
Rubidium (Rb)	1	*	*	*
Silver (Ag)	10	*	*	*
Sodium (Na)	5	420	*	93
Strontium (Sr)	1	*	8	*
Thorium (Th)	10	*	*	*
Tin (Sn)	10	*	*	*
Titanium (Ti)	10	*	*	*
Vanadium (V)	1	*	*	*
Zinc (Zn)	10	*	20	*
Zirconium (Zr)	10	*	*	*
Total (ppb)		**646**	**58**	**131**
Total (ppm)		**0.646**	**0.058**	**0.131**

* = Analysis revealed that the element was not found at or above the detection limit
[1] Testing performed by Balazs™ NanoAnalysis, a division of Air Liquide Electronics U.S. LP, printed with permission.
Note: Results are a compilation of sample(s) from production lot(s) and shall not be construed as a representation of overall testing variability or relied upon as an assurance of any kind.

Aerospace Industry

Often used to meet AMS 7257E, 3M™ Dyneon™ Perfluoroelastomers ("3M PFE") help protect against high temperatures and aggressive fluids in aerospace gas turbine engines. PFE seals perform in some of the toughest environments, such as aerospace gas turbine engines – helping prevent aggressive fluids from leaking even at high temperatures.

Typical Applications:

- Molded rings
- Compression seals
- O-ring cord
- Molded-in-place gaskets

Why is 3M PFE used for aerospace sealing?

- 3M PFE can be compounded to meet AMS 7257E
- Continuous use temperatures of up to 315°C/599°F
- Helps protect against HTS (high thermo-oxidative stability) lubrication fluids that contain aggressive additive packages which attack other elastomers

Authorization to Use
Ensure products meet all applicable specifications, standards, and maintenance manual requirements for the platform being worked on and validate all aircraft approvals against current technical documentation.

Aerospace Industry

3M PFE for Aerospace - AMS 7257E

Formulation

Ingredient	A	B
3M™ Dyneon™ PFE 131T	65	93
3M™ Dyneon™ PFE 81T	28	–
3M™ Dyneon™ PFE 02CZ	2.5	2.5
3M™ Dyneon™ PFE 01CZ	6	6
Aerosil® R972	1.5	1.5
N550	15	15
Total	**118**	**118**

Typical Physical Properties

Original Properties	A	B	AMS 7257E
Tensile, psi	1865	2115	> 1500
Elongation, %	130	120	> 120
100% Modulus, psi	1280	1560	–
Hardness, Type A	80	80	70 - 80

Thermal Air Aging: Forced Air Oven, 70 hours, 290°C (554°F), ASTM D573			
Tensile, % change, maximum	-8	2	-20
Elongation, % change, maximum	31	50	-5
Hardness, pts change, maximum	-3	-2	- 5
Weight Loss, maximum %	1	1	5

Fluid Aging: ASTM Reference Fuel B, 70 hours 25°C (77°F) ASTM D471			
Tensile, % change, maximum	7	-3	-20
Elongation, % change, maximum	8	8	-15
Hardness, pts change, maximum	-1	0	- 5
Volume change, maximum %	0	1	5

Compression Set, 70 hours, 230°C (446°F), ASTM D1414	A	B	AMS 7257E
Compression set, %, 0.139" O-ring	21	21	<40

The data generated above were evaluated using ASTM D412 and D2240, which use tensile dumb bells instead of the o-rings called out in the AMS 7257E specifications.

Typical Physical Properties (continued)

Fluid Aging: Block Oven, 70 hours, 125°C (257°F) in AS 1241 Type IV, ASTM D471			
Tensile, % change, maximum	-25	-23	-40
Elongation, % change, maximum	-8	0	-15
Hardness, points change, maximum	-6	-5	- 15
Volume change, maximum %	6	6	15

Fluid Aging: Block Oven, 70 hours, 200°C (392°F) in AMS 3085 (RF 300), ASTM D471			
Tensile, % change, maximum	8	11	-10
Elongation, % change, maximum	12	0	-15
Hardness, points change, maximum	-2	-2	- 5
Volume change, maximum %	1	1	5

Fluid Aging: Block Oven, 70 hours, 200°C (392°F) in AMS 3085 (Mobil Jet 254), ASTM D471			
Tensile, % change, maximum	2	0	-10
Elongation, % change, maximum	4	13	-15
Hardness, points change, maximum	-3	-2	- 5
Volume change, maximum %	1	1	5

Low Temperature Retraction (TR-10), ASTM D1329			
TR10, °C, maximum	-1.9	-1.8	5

Vulcanizates Physical Properties per ASTM D412 and D2240
Press Cured: Compression molded Tensile Sheets 188°C (370°F) × 15 minutes
Post Cured: 250°C (482°F) x 16 hours

Oil & Gas and Chemical Processing Industry

Whether it's 1000 feet down a borehole or a pipeline carrying harsh chemicals, extreme environments require extraordinary sealing materials. 3M™ Dyneon™ Perfluoroelastomers ("3M PFE") are proven sealing solutions in applications where other materials may fail because of their outstanding chemical, thermal and compression set resistance.

Typical Applications:

- Oil and gas downhole seals
- Petrochemical pump seals
- Packers
- Reactors
- Mixers
- Valves
- Rubber-metal bonding parts

Why is 3M PFE used for Oil & Gas and CPI?

- Broad range of chemical resistance
- Steam resistance
- Thermal resistance
- Seal ability – good compression set
- High pressure extrusion resistance
- High pressure extrusion resistance
- Rapid gas decompression (RGD)
- High hardness
- High modulus
- High processability

Drill pipe float valves

Line stops

Photos courtesy of CTG, Inc.

3M Perfluoroelastomer Solutions and Typical Physical Properties

3M™ Dyneon™ Perfluoroelastomers ("3M PFE") are a class of fully fluorinated fluoroelastomers that provide some of the highest levels of heat and chemical resistance available in an elastomer. 3M offers both peroxide curable grades which provide outstanding overall chemical resistance and triazine curable grades that provide outstanding heat resistance and excellent chemical resistance.

Peroxide Cure Perfluoroelastomers

Engineered for both reliable performance in harsh environments and ease of processing, with good flow and mold release.

Peroxide Curable	Test Compound	TR10 (°C)	Mooney Viscosity (ML1 +10@ 121°C)	Tensile Strength (MPa)	100% Modulus (MPa)	Elongation (%)	Hardness (Type A)	Compression Set (%)*, 70 hrs. @ 200°C
3M PFE 40	VI	-6	40	16.3	9.4	140	72	19
3M PFE 60	I	-2	60	17.9	11.0	165	75	49
3M PFE 80Z	II	-2	80	11.0	4.8	230	72	49
3M PFE 90	I	-2	98	21.2	10.6	155	75	40

Mechanical properties of PFE 60 and PFE 90 measured after post cure of 16 hours @ 232°C
Mechanical properties of PFE 40 and PFE 80Z measured after post cure of 16 hours @ 200°C

High Temperature Perfluoroelastomers

Designed to meet the challenges of higher temperature applications, with an upper continuous use temperature of 315°C (599°F) and excellent compression set resistance.

High Temperature	Test Compound	TR10 (°C)	Mooney Viscosity (ML1 +10@ 121°C)	Tensile Strength (MPa)	100% Modulus (MPa)	Elongation (%)	Hardness (Type A)	Compression Set (%)*, 70 hrs. @ 232°C	Compression Set (%)*, 70 hrs. @ 300°C
3M PFE 81T	III	-2	80	11.9	4.7	230	71	27	50
3M PFE 131T	III	-2	80	15.9	9.1	165	77	20	43
3M PFE 191T	III	-2	80	15.6	15.2	110	80	15	33
3M PFE 194T	III	-2	90	16.4	13.5	120	80	15	31
3M PFE 132TB	IV	-2	100	15.6	6.9	241	79	36	73
3M PFE 133TB	IV	-2	110	16.0	9.1	192	79	26	60

Mechanical properties measured after post cure of 24 hours @ 250°C

* ASTM D1414, 18% deflection

Typical Physical Properties by Perfluoroelastomer Class

High Temperature Perfluoroelastomer Cure Technologies

High Temperature 3M PFE Catalysts are used to initiate the cross-linking reaction for high temperature 3M PFE. We offer the following high temperature 3M PFE catalysts.

PFE Catalyst	Description	Physical Form	Composition	Application Notes
3M™ Dyneon™ Perfluoroelastomer Cure Catalyst Masterbatch PFE 01CZ	Catalyst	Slab	20% masterbatch of 3M™ Dyneon™ cure catalyst	Cure with 3M™ Dyneon™ High Temp Perfluoroelastomer
3M™ Dyneon™ Perfluoroelastomer Accelerator Masterbatch PFE 02CZ	Accelerator	Slab	20% masterbatch of cure accelerator	Cure modifier with 3M™ Dyneon™ High Temp Perfluoroelastomer

Dyneon PFE 02CZ cure accelerator should be used in combination with Dyneon PFE 01CZ catalyst masterbatch.

Note: Data in this document are not for specification purposes.

Typical Physical Properties by Perfluoroelastomer Class (continued)

Cure-Incorporated High Temperature Perfluoroelastomer

A PFE polymer with incorporated cure technologies.

Pre-Compound	Test Compound	TR10 (°C)	Mooney Viscosity (ML1 +10 @ 121°C)	Tensile Strength (MPa)	100% Modulus (MPa)	Elongation (%)	Hardness (Type A)	Compression set (%)*, 70 hrs @ 232°C	Compression set (%)*, 70 hrs @ 300°C
3M PFE 4131TZ	V	-2	100	17.1	12.1	155	81	17	39

Mechanical properties measured after post cure of 16 hours @ 250°C

Clear/Translucent High Temperature Perfluoroelastomer Systems

Each kit includes the gum and catalyst that can be used to compound clear and translucent PFE seals.

PFE Kit (Gum and Catalyst)	Test Compound	TR10 (°C)	Mooney Viscosity (ML1 +10 @ 121°C)	Tensile Strength (MPa)	100% Modulus (MPa)	Elongation (%)	Hardness (Type A)	Compression set (%)**, 70 hrs @ 250°C	Compression set (%)**, 70 hrs @ 275°C
3M PFE 300Z	VII	-2	80	17.9	1.7	295	60	19	33
3M PFE 301Z	VIII	-2	110	18.9	3.6	260	72	26	32

Mechanical properties measured after the following step post cure:

1. Room Temperature to 150°C (302°F) over 1 hour

2. Hold at 150°C (302°F) for 7 hours

3. 150°C (302°F) to 300°C (572°F) over 2 hours

4. Hold at 300°C (572°F) for 4 hours

5. 300°C (572°F) to Room Temperature over 2 hours

Perfluoroelastomer Compound Formulations

Test Compound Formulations	I	II	III	IV	V	VI	VII	VIII
Polymer	100	100	94	94	100	100	100	100
3M™ Dyneon™ PFE 300C							1.1	
3M™ Dyneon™ PFE 301C								1.1
MT Black (N990)	15	15				20		
N550 FEF Carbon Black			15		15			
Aerosil® R972			1.5	1.5				
Trigonox® 101-50pd						1.5		
Varox® DBPH-50	1.5	0.75						
Co agent TAIC™ (100%)		1.5						
Co agent TAIC™ (72%)	2.5					2.5		
3M™ Dyneon™ Perfluoroelastomer Catalyst PFE 01CZ			7.5	7.5				
Zinc Oxide, Zn0	5.0							
Titanium Dioxide, TiO_2				5.0				

Note: Data in this document are not for specification purposes.

Chemical Resistance of Peroxide Cured Perfluoroelastomer (3M PFE 40)

3M PFE 40 is used in applications needing better performance over a broad chemical range. The ability to cure without the use of metal oxide provides some of the best resistance to combinations of solvent and aqueous chemicals.

Recipe	3M PFE 40
Polymer	100
MT Black (MT990)	20
TAIC (70%)	2.5
Trigonox® 101-50D	1.5

Chemical Resistance of 3M PFE 40	Change in Volume, %	Change in Shore A Hardness, pts
Solvent and Oil		
Toluene (reflux) - 168 hours at 100°C	6	-3
Reference Oil 300 - 168 hours at 200°C	1	-1
Acids		
Glacial Acetic Acid (99.5%) – 168 hours at 100°C	3	-3
H_2SO_4 (98%) – 168 hours at 175°C	8	-4
HNO_3 (65%) – 168 hours at 65°C	2	-3
Bases		
NaOH (50%) – 168 hours at 100°C	-0.4	0
Ethylenediamine – 168 hours at 90°C	6	-4
Water and Steam		
H_2O – 168 hours at 230°C	6	-6
Steam – 168 hours at 230°C	-0.1	-4

Note: Data in this document are not for specification purposes.

Customer Service

Europe

Dyneon GmbH
3M Advanced Materials Division
Carl-Schurz-Straße
41453 Neuss
Germany
Phone: +00 800 396 366 27
Fax: +00 800 396 366 39
www.dyneon.eu

Italy
Phone: 0 800 7 910 18
Fax: 0 800 7 910 19

USA

3M Advanced Materials Division
3M Center, 280-01W-03
St. Paul, MN 55144-1000
United States
Phone: 1 800 810 8499

Latin America

3M Brasil
Via Anhanguera km
110 Sumare
Sao Paulo CEP 13181-900
Brasil
Phone: 0800 0132333

3M Mexico
Santa Fe 190, Col. Santa Fe
Deleg. Alvaro Obregon
Mexico D.F., C.P. 01210
México
Phone: 0052 5552700 400
Ext 82935

Asia

3M Japan
6-7-29, Kita-Shinagawa
Shinagawa-ku
Tokyo 141-8684
Japan
Phone: 81 570 022 123

3M Korea
19F, 82, Uisadang-daero
Yeongdeungpo-gu, Seoul, 150-705
Korea
Phone: 82 2 3771 4027

3M Taiwan
6F, No.95, Sec. 2
Dunhua S. Rd.
Taipei 10682
Taiwan
Phone: 886 2 2704 9011

3M Thailand
150 Soi Chalongkrung 31
Ladkrabang Bangkok, 10520
Thailand
Phone: 66 2739 4803 9
Ext 2354

3M Advanced Materials Division

3M Center
St. Paul, MN 55144 USA

Phone 1-800-367-8499
Web www.3M.com/fluoroelastomers