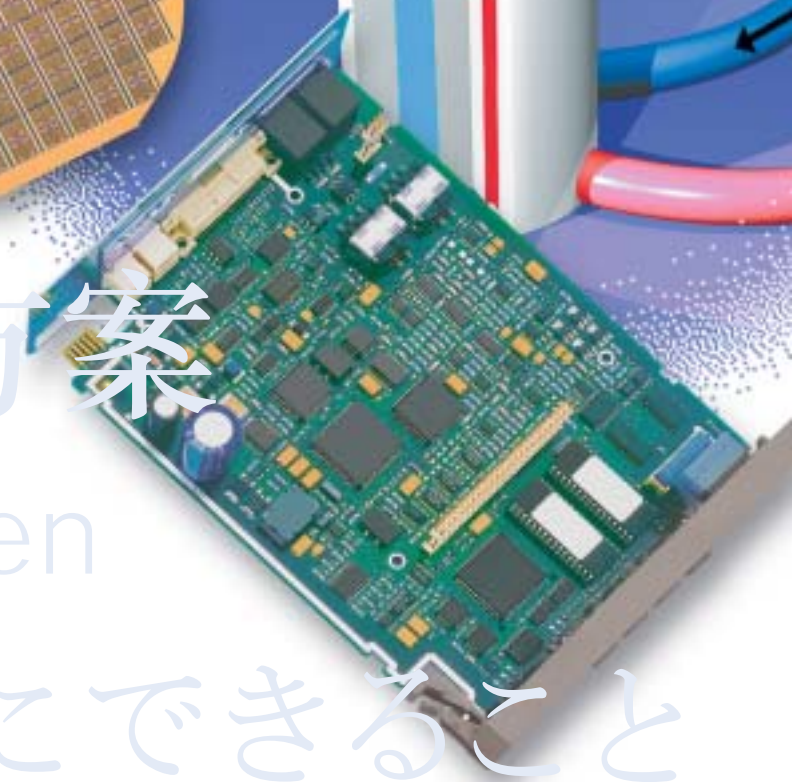
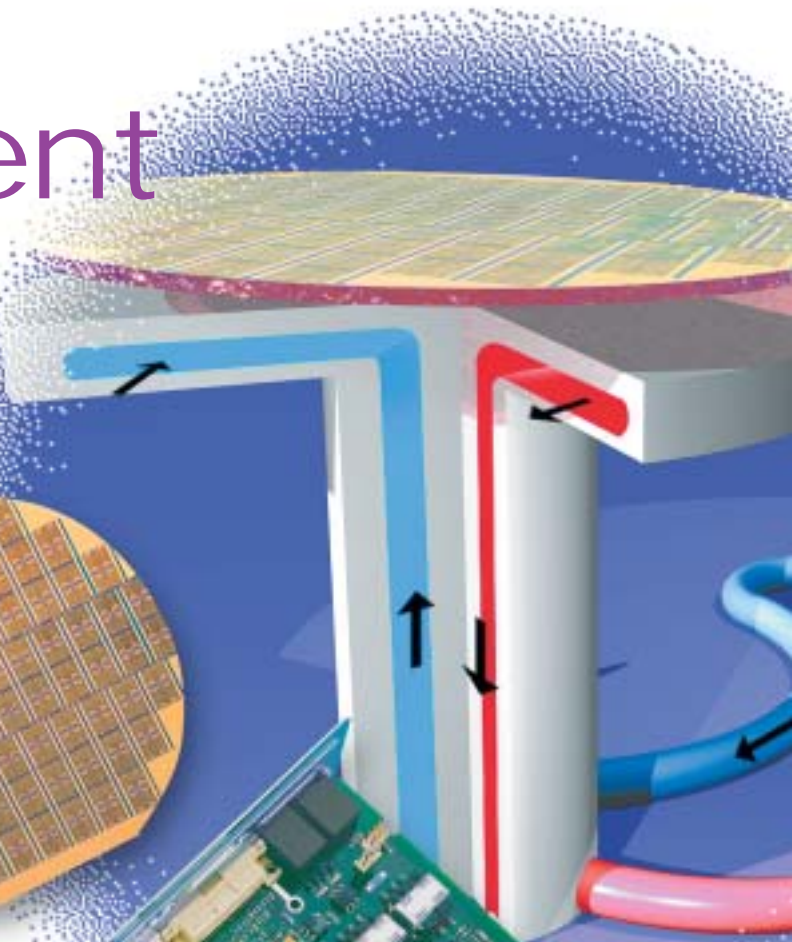
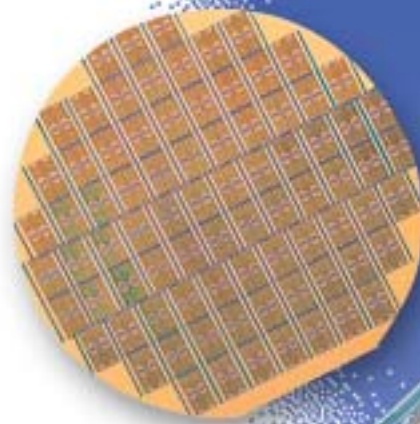


Real World Solutions

3M Electronic Materials

Thermal Management Fluids and Services

Real World
Solutions
for the
Electronics
Industry



真實解決方案

Reale Lösungen

私たちにできること

3M Innovation

Thermal management issues are becoming increasingly important to electronics and semiconductor fabricators. New designs put more demands on the dielectric fluids used to maintain the proper temperature. Environmental factors play an ever increasing role in fab or plant operating decisions. And cost is always an issue. In short, selection of a heat transfer fluid for your semiconductor and electronics equipment can no longer be an afterthought. Long-term, high-performance solutions are needed.

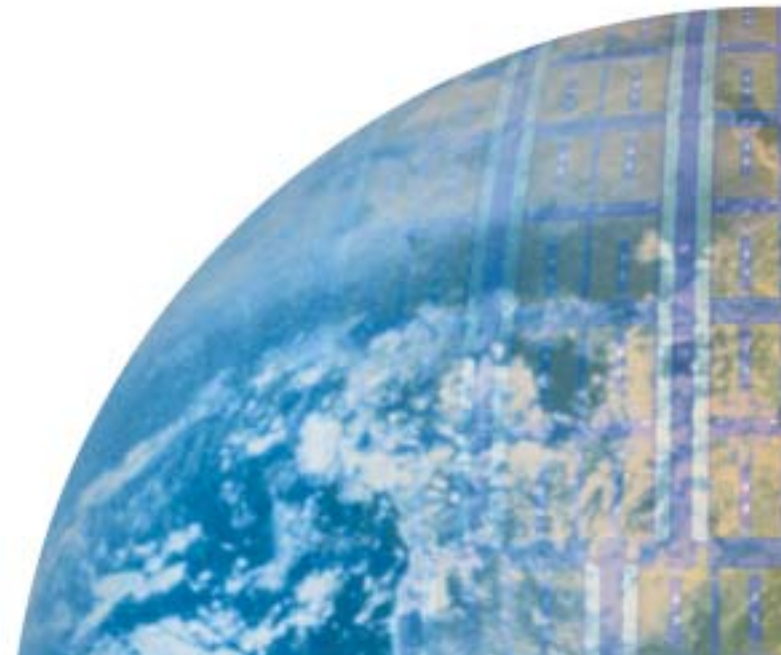
3M has the thermal management fluids and technical support you need to make the right choice for your particular needs—helping you improve reliability and lower your overall operating costs.

It begins with the fluid

The two main heat transfer fluid choices available today are deionized (DI) water and fluorinated liquids. Although DI water is less

expensive than fluorinated liquids, its disadvantages quickly offset any apparent cost savings: For example, at operating levels above 1 Mohm-cm, DI systems may require stainless steel chillers costing 40%-50% more than comparable copper chillers; above 60°C, DI water is highly-corrosive—even to stainless steel; DI bed filters can cost thousands of dollars and require periodic maintenance to sustain the high degree of purity necessary for volume resistivity and high dielectric strength; and DI systems cannot operate above 80°C because of the temperature limits of DI filters.

3M fluorinated liquids, in comparison, can add value to your process. These fluids require little maintenance, have high resistivity, high dielectric strength and will not damage electronic equipment or wafers in the event of a leak or other failure. A properly designed, tight system utilizing 3M™ Fluorinert™ Electronic Liquids or 3M™ Novec™ Engineered Fluids can have very low operating costs—which means you can dedicate resources to *running* your system, rather than maintaining it.



3M™ Fluorinert™ Electronic Liquid

3M™ Fluorinert™ Electronic Liquids are part of a family of fully-fluorinated compounds known as perfluorocarbons, or PFCs. For more than forty years, Fluorinert liquids have been used as heat transfer media in a variety of industries. Direct contact cooling, testing, reflow soldering...these applications all require the unique inertness and electrical properties exhibited by Fluorinert liquids.

- Excellent dielectric material
- Wide range of boiling points
- Good materials compatibility
- Low toxicity
- Nonflammable
- Zero Ozone Depletion Potential (ODP)

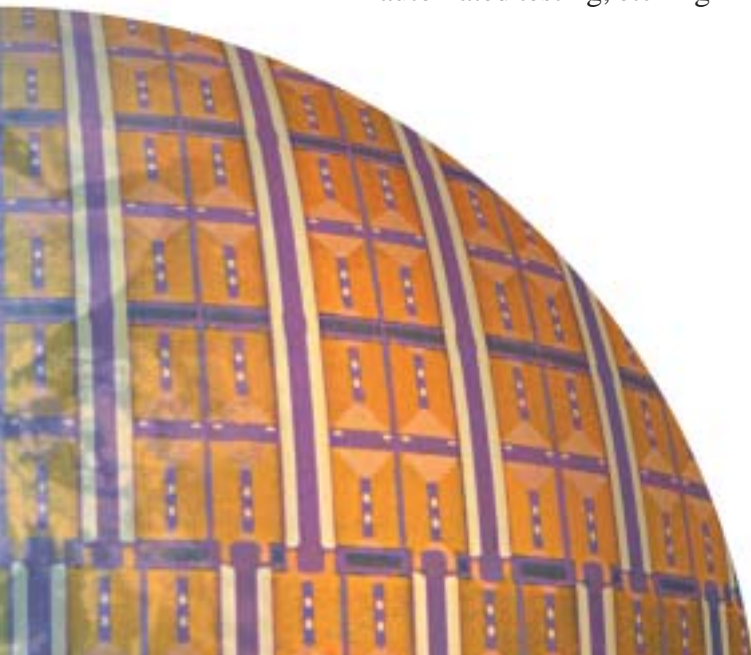
Today, Fluorinert liquids are most commonly used in the electronics industry in applications that benefit from this combination of properties, such as thermal management in automated testing, etching

and CVD, as well as in steppers and other process equipment. Fluorinert liquids have high global warming potentials (GWP) and long atmospheric lifetimes. As such, they should be carefully managed to minimize emissions.

3M recommends that users of Fluorinert liquids further limit emissions by employing good conservation practices, and by implementing recovery, recycling and/or proper disposal procedures.



Direct contact cooling with 3M™ Fluorinert™ Electronic Liquids helped enable the development of dense electronics, such as supercomputers.



3M™ Novec™ Engineered Fluids

Increasingly businesses are demanding low-GWP fluids. That's why 3M developed 3M™ Novec™ Engineered Fluids—the next generation of fluorinated thermal management fluids.

3M introduced Novec fluids in 1995. This family of low-GWP fluids (hydrofluoroethers) was designed to balance performance with favorable environmental and worker safety properties. In heat transfer applications, Novec fluids offer:

- Excellent dielectric properties
- Wide range of boiling points
- Good materials compatibility
- Low toxicity
- Nonflammable
- Low Global Warming Potential (GWP)
- Zero Ozone Depletion Potential (ODP)

It is the favorable environmental properties of Novec fluids, however, which make them such an exciting development. They are poised to be a long-term solution to the chemical industry's problem that first started with the ban on production of chlorofluorocarbons (CFCs).

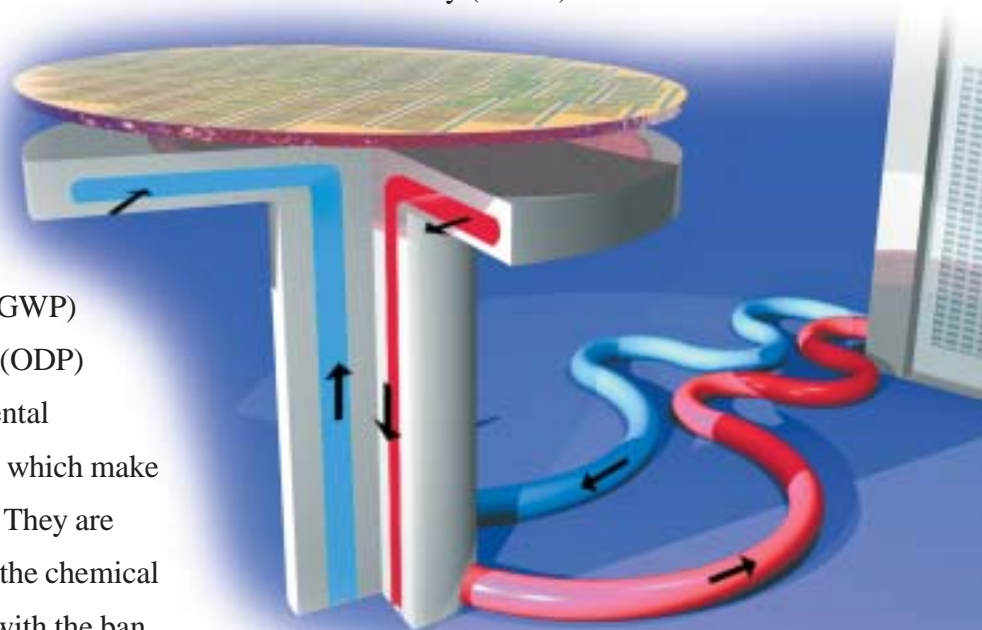
Novec fluids have been recognized by a number of industry and regulatory bodies around the world, including:

- 1997 American Chemical Society "Heroes of Chemistry Award" in the category of Chemistry and the Environment for the development of

hydrofluoroethers as alternatives to ozone-depleting materials.

- In April 1999, 3M™ Novec™ Engineered Fluid HFE-7200 was designated a "Clean Air Solvent" by the South Coast Air Quality Management District.

- 3M™ Novec™ Engineered Fluid HFE-7100 and HFE-7200 are approved for "use without restriction" under the U.S. EPA's Significant New Alternatives Policy (SNAP).



- The United Nations Environment Programme (UNEP) Technology and Economic Assessment Panel has recognized Novec fluids as meaningful low-GWP replacements for ozone-depleting substances like hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).

The right fluid. . . the right application

3M manufactures a full range of 3M™ Fluorinert™ Electronic Liquids and 3M™ Novec™ Engineered Fluids for thermal management applications, allowing you to choose the fluid that

works best in your process. 3M's road map for future Novec fluids includes the development of higher and lower boiling fluids that cover the entire range of electronic fluid applications.

3M™ Fluorinert™ Electronic Liquids

(All values determined at 25°C unless otherwise specified)

	FC-87	FC-72	FC-84	FC-77	FC-3283	FC-40	FC-43	FC-70
Selection Guidelines (Equipment operating temperature)	Low	Low	Low	Med	Med	High	High	High
Boiling Point (°C)	30	56	80	97	128	155	174	215
Pour Point (°C)	-115	-90	-95	-110	-50	-57	-50	-25
Vapor Pressure (Pa)	81.1x10 ³	30.9x10 ³	10.6x10 ³	5.62x10 ³	1.44x10 ³	432	192	15
Density (kg/m ³)	1650	1680	1730	1780	1820	1850	1860	1940
Coefficient of Volume Expansion (°C ⁻¹)	0.0015	0.00156	0.0015	0.00138	0.0014	0.0012	0.0012	0.0010
Kinematic Viscosity (cSt)	0.28	0.38	0.53	0.72	0.75	1.8	2.5	12
Absolute Viscosity (centipoise)	0.45	0.64	0.91	1.3	1.4	3.4	4.7	24
Specific Heat (J kg ⁻¹ °C ⁻¹)	1100	1100	1100	1100	1100	1100	1100	1100
Heat of Vaporization @ B.P. (J/g)	103	88	90	89	78	68	70	69
Dielectric Strength (kV, 0.1" gap)	48	38	38	40	43	46	42	40
Dielectric Constant (1 KHz)	1.73	1.75	1.80	1.90	1.89	1.90	1.90	1.98
Volume Resistivity (Ω cm)	10 ¹⁵	10 ¹⁵	10 ¹⁵	10 ¹⁵	10 ¹⁵	10 ¹⁵	10 ¹⁵	10 ¹⁵

3M™ Novec™ Engineered Fluids

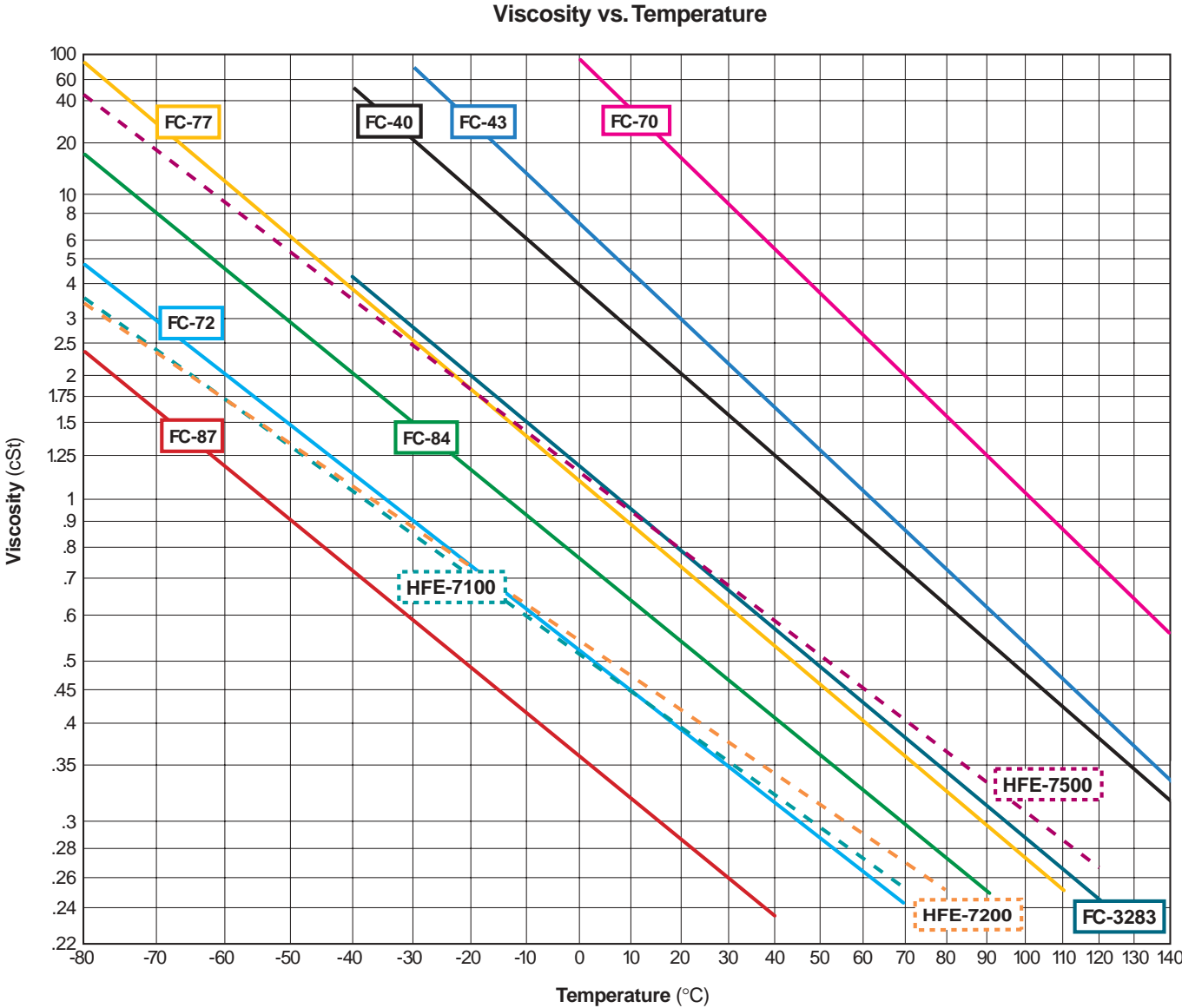
(All values determined at 25°C unless otherwise specified)

	HFE-7100	HFE-7200	HFE-7500*
Selection Guidelines (Equipment operating temperature)	Low	Low	Med
Boiling Point (°C)	61	76	128
Pour Point (°C)	-135	-138	-110
Vapor Pressure (Pa)	26.8x10 ³	15.7x10 ³	2.1x10 ³
Density (kg/m ³)	1510	1420	1610
Coefficient of Volume Expansion (°C ⁻¹)	0.0018	0.0016	0.0013
Kinematic Viscosity (cSt)	0.38	0.41	0.77
Absolute Viscosity (centipoise)	0.58	0.58	1.240
Specific Heat (J kg ⁻¹ °C ⁻¹)	1180	1220	1130
Heat of Vaporization @ B.P. (J/g)	112	119	88.5
Dielectric Strength (kV, 0.1" gap)	~40	~40	~40
Dielectric Constant (1 KHz)	7.4	7.3	5.8
Volume Resistivity (Ω cm)	10 ⁸	10 ⁸	10 ⁸

* Samples available. Commercial quantities available 2001.

Thermal Management Fluids

Kinematic Viscosity



Material Compatibility

3M™ Novec™ Engineered Fluids and 3M™ Fluorinert™ Electronic Liquids are compatible with a wide variety of materials used in heat transfer equipment. As with any design, selection of these materials is very important. A 3M specialist in this area can help you make the proper choice.

Polymers—Most of the materials commonly considered “hard” plastics will perform well with both Novec fluids and Fluorinert liquids:

Polyethylene

Nylon/ABS

Phenolic

Acrylic

Polysulfone

Polyetheretherketone (PEEK)

Polypropylene

Polyvinylchloride (PVC)

Polycarbonate

PTFE

Thermoplastics

Elastomers—Elastomers should be limited to those that are not heavily plasticized. 3M engineers can recommend specific compounds for evaluation or help you test a compound.



The hidden benefit: 3M experience

The use of fluorochemicals in heat transfer systems is a science that 3M has studied like no other company. Bringing this extensive knowledge to bear on your heat transfer equipment is a major part of our Thermal Management program... and a major benefit of purchasing 3M™ Fluorinert™ Electronic Liquids or 3M™ Novec™ Engineered Fluids.

Here are just some of the services that 3M can provide to help you utilize these innovative fluids in your heat transfer equipment:

Heat Transfer Seminar—Given free of charge at qualifying customer sites, this seminar teaches appropriate design procedures by discussing material compatibility, sources of leakage, pumping, component selection, environmental

issues and more. The content of these seminars can be tailored to the specific interests of the audience. 3M has successfully conducted seminars at a number of customer locations.

Compatibility Testing—3M engineers can evaluate polymeric parts with advanced testing methods to help you determine if a component or material is suitable in your design.

On-Site Consultations—Working side-by-side with equipment designers and end users, 3M engineers frequently help to tighten-up equipment and optimize system performance.

Analytical Services—3M has state-of-the-art analytical resources which are used to answer customer questions.

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