CHAGO
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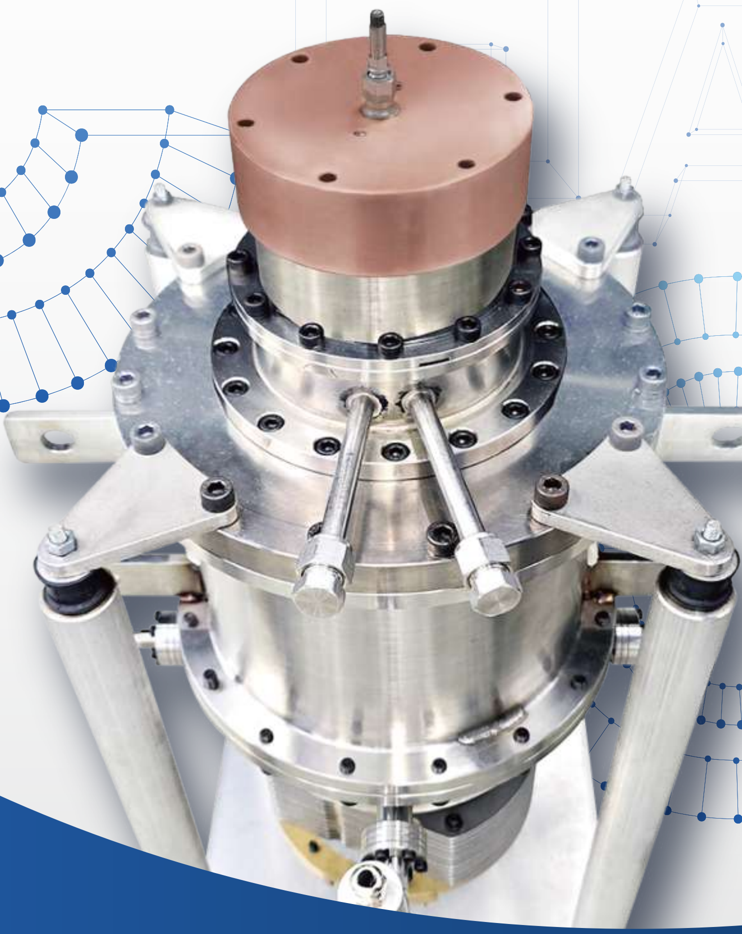
PRODUCTS CATALOG



Eco-friendly cooling systems for a better future

CHAGO ENGINEERING

As a progressive company focused on cooling systems, we emphasize environmental sustainability as a top priority.

Company History

2019

- Established CHAGO ENGINEERING Co., Ltd. (August, Hwasung, Gyeonggi)
- Selected as an Innovative R&D Projects by the Ministry of SMEs and Startups

2020

- Acquired Seed funding
- Developed a process chiller for PCW circulation
- Developed a heat exchanger for laser cooling
- Localized development of semiconductor cryogenic chillers
- Selected as a strategic R&D project by the Ministry of SMEs and Startups

2021

- Established a corporate-affiliated research institute (January)
- Acquired Series Pre-A funding
- Developed water cooling chillers for cleaning equipment
- Developed ultra-low temperature multi chillers for semiconductors
- Relocated the Hwasung headquarters (Annyeong-dong, Hwasung, Gyeonggi)

2022

- Established the Cheongju branch (relocated the corporate-affiliated research institute to Cheongju, Chungbuk)
- Developed semiconductor air cooling chillers
- Selected as an R&D project in parts and equipment by the Ministry of Trade, Industry and Energy's Materials

2023

- Relocated the headquarters (Cheongju, Chungbuk)
- Established the Hwaseong branch (Hwaseong, Gyeonggi)
- Selected as a Super Gap Startup 1000+ Project
- Developed Cryo Engine (1kW) refrigeration units

2024

- Acquired Series A funding
- Selected as a Family Business by the Korea Institute of Machinery and Materials
- Started mass production of the Cryo Engine
- Commenced development of Turbo Brayton Technology
- Participated in the Semicon Europa Exhibition
- Localized Non-PFAS Coolants
- Selected as a Scale-Up Tips R&D Project

Main Customer

SK hynix · SK hynix system ic · SAMSUNG · FOXCONN · Apple · tsmc · LG Electronics · AP Systems · EO TECHNICS · (주)씨앤씨테크 · MiCo

Corporate Certification

Corporate Patent

Eco-friendly
Cooling Technology
Specialist Company

ECO - friendly **TECHNOLOGY**

CHAGO ENGINEERING is a leading high-tech eco-friendly cooling technology company that developed the world's first eco-friendly solution of Cryo Engine Engine using helium to protect a comfortable global environment in response to climate change. We are constantly striving to realize environmental protection and industrial development at the same time for a sustainable future.

Freon Gas

Freon gas is used as a refrigerant in industrial chillers, but it also acts as a greenhouse gas that contributes to ozone layer depletion and global warming.

Progress of the Climate Change Convention

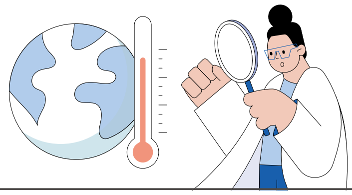
1992
Rio Climate Change Convention
For regulating the artificial emissions of greenhouse gases

1997
Kyoto Protocol
Established legally binding emission reduction targets

2015
Paris Agreement
Expanded greenhouse gas regulations, initially applicable only to developed countries, into international law

Response and adaptation to climate change

Since the adoption of the Rio Climate Change Convention in 1992, the international community has been actively encouraging nations to lower their greenhouse gas emissions in response to climate change. This context becomes evident when analyzing the chart that highlights the differences in the specific implementation processes of the Kyoto Protocol and the Paris Agreement.



	The Kyoto Protocol (1997)	The Paris Agreement (2015)
Goal	Reduction of greenhouse gas emissions (1st phase: 5.2% → 2nd phase: 18%)	Effort to achieve 2°C and 1.5°C
Scope	Focus on greenhouse gas reduction	In addition to greenhouse gases, key elements include adaptation, resource mobilization, the developmentof technology transfer capabilities, and transparency
Reduction obligation countries	Developed countries (38)	All parties (195)
Goal-setting strategy	Top-down	Bottom-up
Consequences of failing to meet goals	Punitive	Non-punitive
Criteria for goal settings	-	Principle of progress
Sustainability	Sustainability concerns arise because there is an endpoint in the commitment period	By not establishing an endpoint, we can ensure a sustainable response

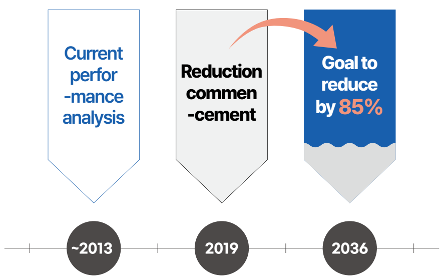
News Research

Why should we reduce the use of Freon gases?

Climate change conventions are making progress in reducing Freon gas emissions, with regulations being tightened and the development of alternativerefrigerants being accelerated, resulting in a decreasing trend of Freon gasemissions that contribute to global warming. We will analyze these patterns usingthe specific indicators described below.

Announcement regarding the reduction plan for **Freon gas**

The international community has introduced rules with the goal of reducing Freon gas emissions by 85% by 2036, following initial reductions in 2019.



The announcement of the reduction plan has led to heightened international regulations

Promoting the development of alternative refrigerants

With the evolution of climate change responses, alternative refrigerants have become more popular, making Freon gas a less common choice for refrigeration.

	CFCseries	HCFCseries	HFCseries	Alternative refrigerants
Alternative	R-12class	R-123class	R-404Aclass	R-600aclass
ODP	High	High	Non	Non
GWP	High 3,800~14,000	High 90~1,800	High 140~11,700	Non(Low) 0~4

1st generation | 2nd generation | 3rd generation

Montreal Protocol | Climate Change Agreement

Diversifying eco-friendly refrigerants that are more efficient than Freon gas

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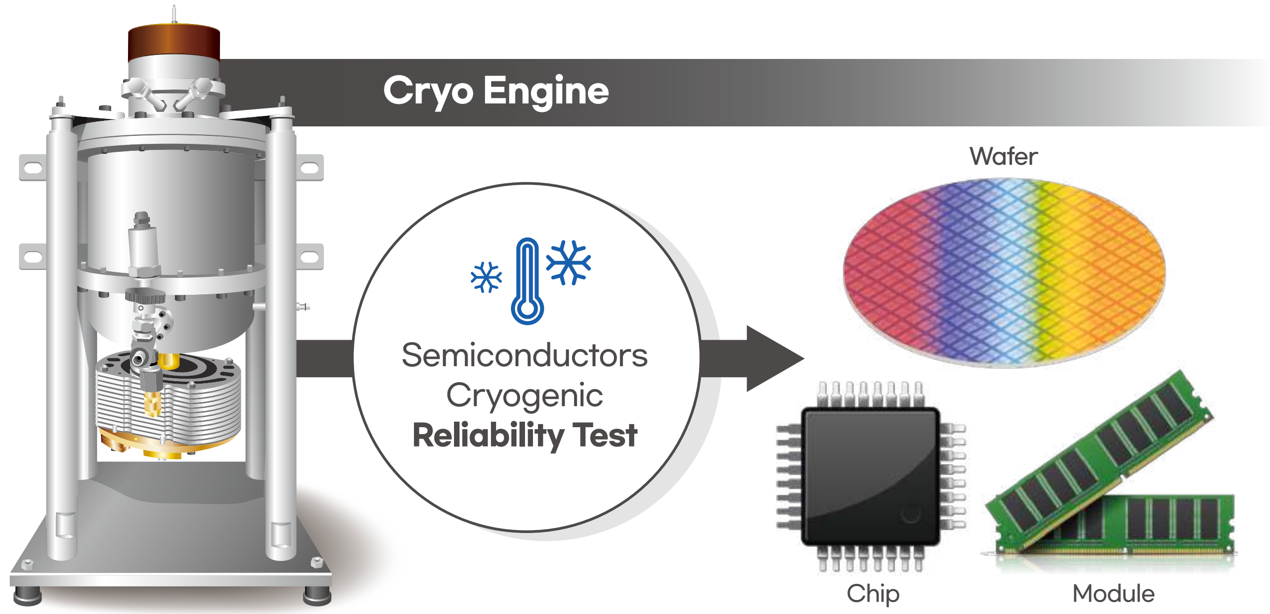
Cryo Engine

CHAGO ENGINEERING's cryogenic cooling technology uses helium instead of freon gases, providing an eco-friendly cooling solution. The Cryo Engine, which employs eco-friendly helium instead of freon gas is an advanced cooling system that is efficient and energy-saving. It is also safe for the environment, eliminating concerns related to flammability, toxicity, and human health risks.

What is Cryo Engine?

This advanced cooling technology can replace existing chiller systems, providing eco-friendly features, a compact size, and high performance at extremely low temperatures, making it ideal for testing semiconductor wafers, chips, and modules.



Specifications Table

TEMP **Range**	-200°C to -20°C
TEMP **Stability**	±0.1°C
Cooling Capacity	700W at -20°C; 350W at -50°C; 100W at -150°C
Input Power	1P.200V.5A (50/60Hz)

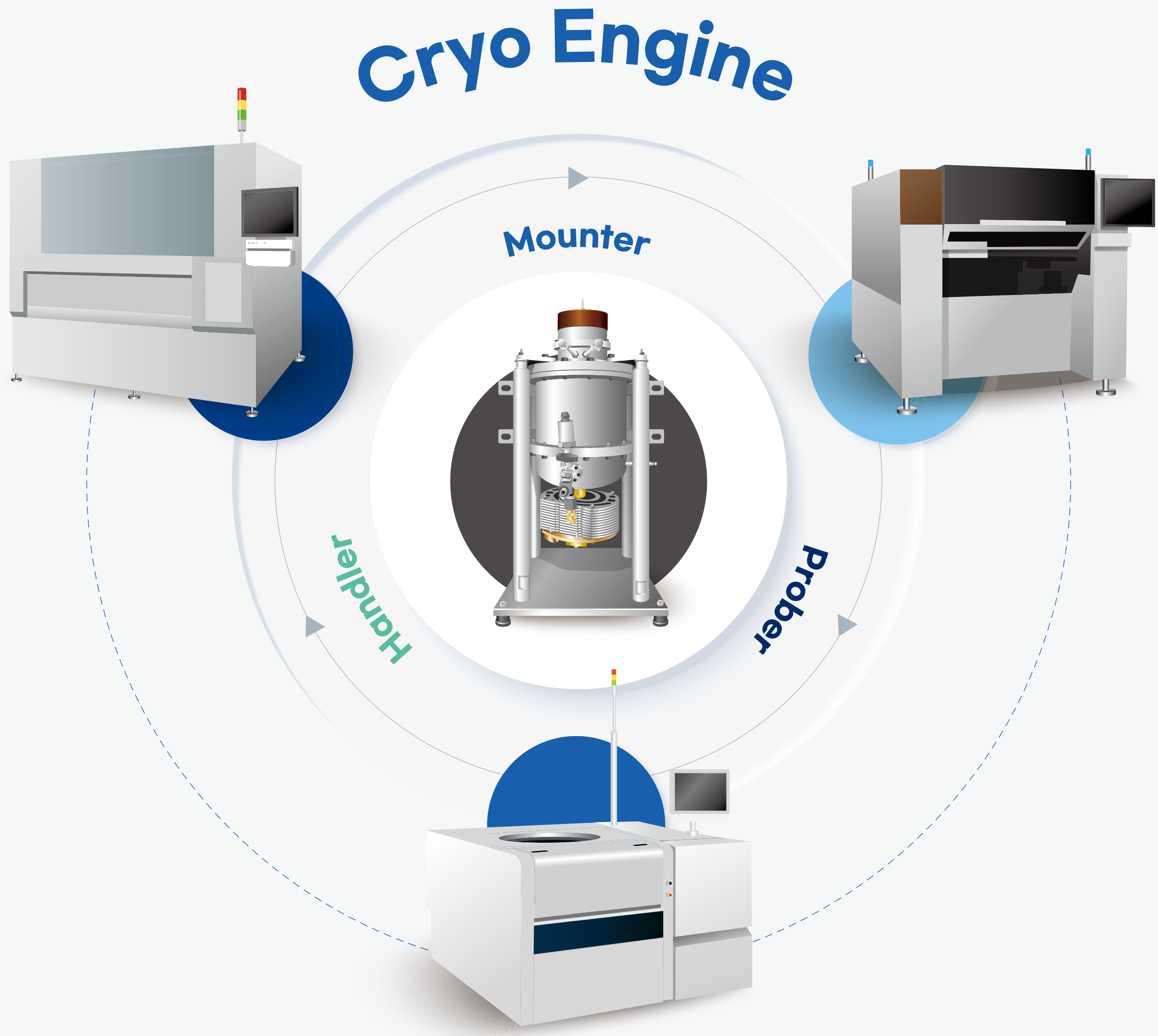
Cooling device for semiconductor testing

The Cryo Engine is specially designed for testing semiconductor packaging. The next-generation innovative solution can be incorporated into semiconductor packagingequipment, such as prover handler and mounting machine, allowing for semiconductor Hot/Cold Tests without requiring external chiller installations.

Process Equipment Integration Built-in Cooling System

The Cryo Engine is the world's smallest cryogenic cooling system, an innovative solution optimized for testing extreme temperature conditions to ensure semiconductor reliability inside process equipment for semiconductor manufacturing.

Built-in cooling solutions



Prior to the Cryo Engine installation

A large chiller occupying space is installed separately next to the process equipment or beneath the FAB.

Efficient use of space

In semiconductor manufacturing processes, space utilization within the factory is a crucial factor. Building clean rooms and equipment with strict environmental control is expensive, making it difficult to cut costs without affecting main-tenance and workflow. To tackle this challenge, CHAGO ENGINEERING has created an innovative device that significantly minimizes the cooler's size and integrates it directly into the cooling target. This offers a solution that improves space efficiency and lowers construction and operational expenses.

After the Cryo Engine installation

Ultra-low temperature cooling can be attained without needing a separate chiller installation by integrating a Cryo Engine into the processing equipment.

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Liquid Chiller

Feature —— Cooling equipment designed for precise temperature control in industrial process facilities. Our specialized recycling system is crucial equipment for industrial sectors, as it helps to decrease volume and improve power efficiency.

Applications Industrial cooling equipment is crucial in a variety of fields, including process equipment and testing in process operations.

Name	Temp. Range	Temp. Stability	Cooling Capacity	Flow Rate (lpm)
Iron-3	30 °C ~ + 150 °C	±0.1 °C	1.0KW at 125 °C	Max, 8 lpm
Iron-7	-50 °C ~ + 95 °C	±0.1 °C	0.5Kw (at -50 deg °C)	Max, 2.5 lpm
Iron-10	-50 °C ~ + 25 °C	±0.1 °C	2KW(+@) (at -50 deg °C)	Max, 5 lpm

※ Custom development can be tailored to the client's specifications.

Heat Exchager

Feature —— The device efficiently transfers heat between two fluids to reuse energy and enhance the thermal efficiency of the system, commonly utilized for thermal management and energy conservation.

Applications It is utilized to effectively manage process heat.

Name	Temp. Range	Temp. Stability	Cooling Capacity	Flow Rate (lpm)
Thor-2	+25 °C ~ + 50 °C	±0.1 °C	2kW (at +30 deg °C)	Max, 20 lpm
Thor-3	+25 °C ~ + 50 °C	±0.1 °C	3kW (at +30 deg °C)	Max, 20 lpm
Thor-5	+25 °C ~ + 50 °C	±0.1 °C	5kW (at +30 deg °C)	Max, 25 lpm
Thor-8	+25 °C ~ + 50 °C	±0.1 °C	8kW (at +30 deg °C)	Max, 30 lpm
Thor-10	+25 °C ~ + 50 °C	±0.1 °C	10kW (at +30 deg °C)	Max, 30 lpm
Thor-25	+25 °C ~ + 50 °C	±0.1 °C	25kW (at +30 deg °C)	Max, 40 lpm

※ Custom development can be tailored to the client's specifications.

Air Chiller

Feature —— The cooling system is simple and efficient, using air directly as the cooling medium. There is no requirement for cooling fluid management, simplifying maintenance. Specifically, we have improved durability and competitiveness by using our in-house heat exchangers.

Applications Industrial cooling equipment is crucial in a variety of fields, including process equipment and testing in process operations.

Name	Temp. Range	Temp. Stability	Cooling Capacity	Flow Rate (lpm)
Nos-1	-10 °C ~ + 30 °C	±0.1 °C	1Kw (at +20.0 deg °C)	Max, 200 lpm
Nos-2	-10 °C ~ + 30 °C	±0.1 °C	2Kw (at +20.0 deg °C)	Max, 400 lpm
Nos-3	-10 °C ~ + 30 °C	±0.1 °C	3Kw (at +20.0 deg °C)	Max, 605 lpm
Nos-4	-10 °C ~ + 30 °C	±0.1 °C	4Kw (at +20.0 deg °C)	Max, 800 lpm
Nos-5	-10 °C ~ + 30 °C	±0.1 °C	5Kw (at +20.0 deg °C)	Max, 1,000 lpm
Nos-6	-50 °C ~ + 150 °C	±0.1 °C	1Kw (at -50.0 deg °C)	Max, 600 lpm

※ Custom development can be tailored to the client's specifications.

Vapor Chamber

This metal plate with a specialized internal structure functions as a refrigerant circulation thermal conductor, offering superior heat transfer abilities despite being lighter and thinner than a heat pipe.

Key Feature

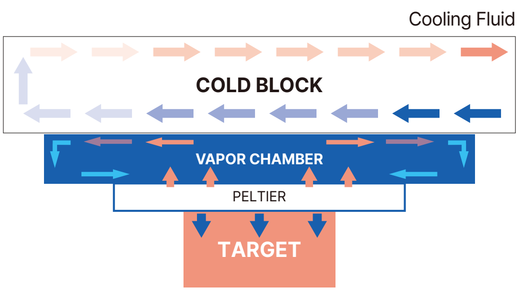
- 01 Great thermal performance
- 02 Compact
- 03 Durability
- 04 Superb thermal conductivity

Specifications Table

Material	Thermal Conductivity W/m K	Max. Heat Flux, W/cm²	Minimum Thickness	Max. Size, cm	Direct Die Attach
Vapor Chamber (SUS)	5,000 to 100,000	1,000 (1cm²)	0.3 mm (0.012 in.)	11cm	possible

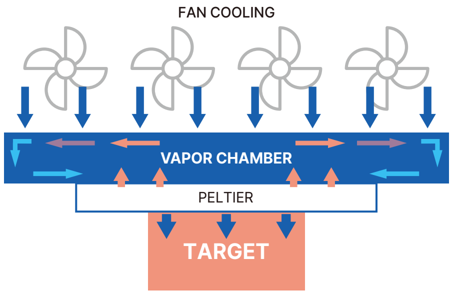
※ Custom orders can be tailored to meet specific size and shape specifications.

Application Field



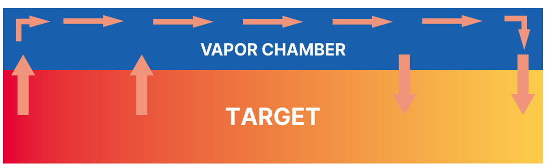
Vapor chamber applied with **Cold Block**

Incorporating a vapor chamber between the cooling target and the cold block improves the target's heat dissipationefficiency, resulting in quicker cooling.



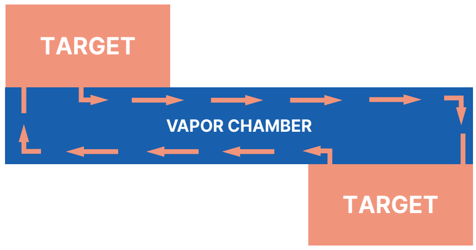
Vapor chamber with **fan cooling**

The cold pen is rotated above the vapor chamberwithout fluid, allowing for efficient heat dissipation using only air.



A vapor chamber that can **evenly distribute heat** to the desired area.

The vapor chamber allows for even heat transferacross the entire target by applying heat to only a portion.



A vapor chamber that allows for **quick heat transfer** to the target

Efficient heat transfer can be rapidly accomplished by using the vapor chamber to transfer heat between targets, creating an optimal thermal transfer environment.

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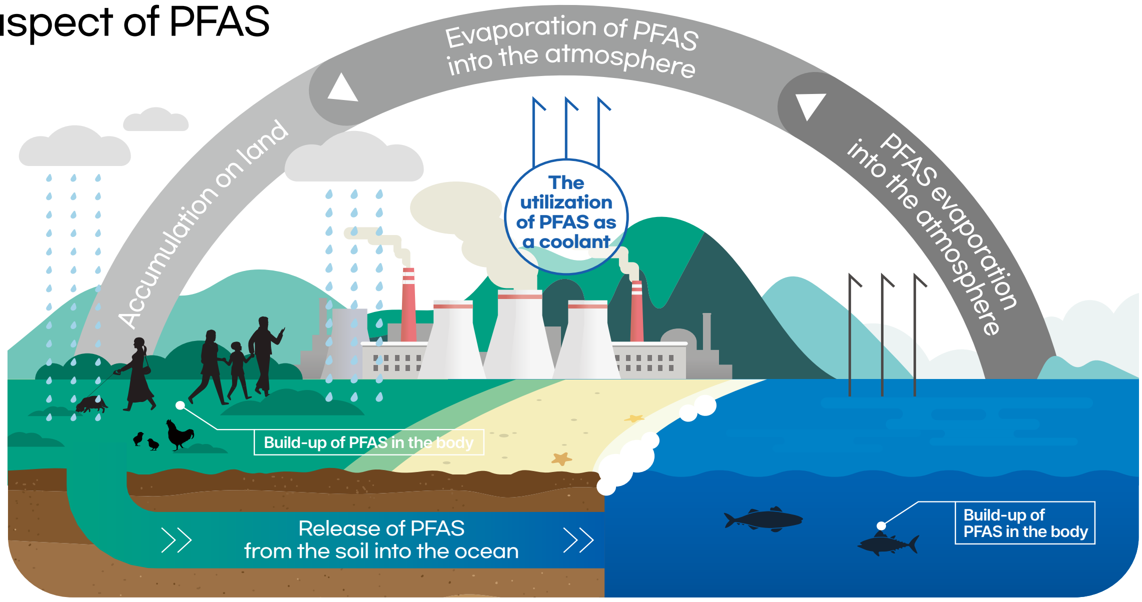
PFAS

*PFAS (Per-and polyfluoroalkyl substances) are commonly used in semiconductor coolants, cosmetics, and packaging materials because of their heat resistance, chemical resistance, and water repellency. However, since it is known as a "persistent chemical compound," this substance does not break down in the human body and builds up, increasing the risk of cancer and other illnesses.

***PFAS(Per-and polyfluoroalkyl substances)** : A chemical substance that is resistant to contamination from water and oil, while also exhibiting high thermal stability.

The negative aspect of PFAS



Environmental pollution ▶▶ **Accumulation in the human body** ▶▶ **Deterioration of health**

Environmental pollution	Accumulation in the human body	Deterioration of health
Poses a major threat to agriculture and drinking water by polluting watersources and soil.	PFAS can build up in living organisms and harm humans, plants, and animals through the food chain.	Excessive accumulation of PFAS in the human body can result in owered immune system function, reproductive problems, liver damage, and increased cancer risk.

ESG Economy

3M Announces the Discontinuation of 'Forever Chemicals' PFAS

NEWS PAPER | by Lee Sin-hyung | 2022.12.21 Extract from a news article

Following multiple lawsuits with environmental groups, the decision to halt production was made, facing criticism for causing serious health issues. Investors are also calling for the initiative to be discontinued.

Growing need to discover coolant fluid

Halt of PFAS Production

3M, the leading company in the PFAS coolant industry, has stated that it will stop producing PFAS coolants by the end of 2025 in response to worldwide regulations.

Increasing Demand for Eco-Friendly Cooling Fluid

The government and associated industries are increasing their efforts to develop alternatives, leading to a growing demand for environmentally friendly cooling fluids that do not harm the environment.

Non-PFAS Coolant

An eco-friendly product that is safe for human consumption as a cooling fluid in semiconductor processes, as it is free from PFAS and does not contain fluorine.

Key Feature

- 01 Eco-friendly coolant (GWP · ODP ZERO, PFAS FREE)
- 02 Korean product
- 03 Inexpensive
- 04 MSDS · food grade certification

Specifications Table

Property	Unit	Our product (Hydrocarbon series)				Other company product (Fluorine series)			
		GCL-90	GCL-70	GCL-50	GCL-10	FC-3283	FC-40	HT170	HT230
Appearance	-	Clear, Colorless				Clear, Colorless		Clear, Colorless	
Temperature Range	°C	-50~140	-30~160	-20~190	-5~250	-40~120	-30~155	-30~160	-10~230
Boiling Point	°C	180	290	260	320	128	165	170	230
Pour Point	°C	-90	-70	-48	-18	-65	-57	-97	-77
Flash Point	°C	144	166	192	252	-	-	-	-
Density	g/cm^3	0.79	0.79	0.83	0.84	1.82	1.86	1.77	1.82
Kinematic Viscosity (@25°C)	cSt	5.3	7.7	17.8	57.8	0.75	2.2	1.8	4.4
Vapor Pressure	kPa	0.001	0.001	0.001	0.001	1.44	0.29	0.1	0.004
Specific Heat	cal/g-k	0.46	0.46	0.49	0.49	0.26	0.26	0.23	0.23
Thermal Conductivity	W/m·K	0.14	0.14	0.14	0.14	0.066	0.065	0.065	0.065
Volume Resistivity	Ω-cm	$>10^{15}$	$>10^{15}$	$>10^{15}$	$>10^{15}$	10^{15}	10^{15}	1.5×10^{15}	6×10^{15}
GWP(Global Warming Potential)	100year	less than 1				5000	5000	10000	10000
Material		Synthetic Hydrocarbon				Fluorocarbon		PFPE(Perfluoropolyether)	

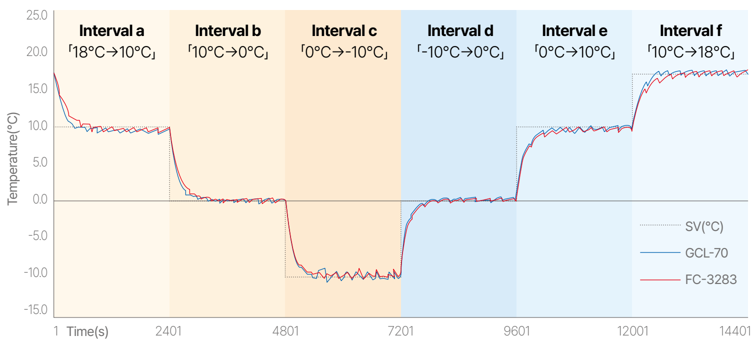
Application Field

Completed the evaluation of alternatives to PFAS coolants, such as FC-3283, that provide comparable cooling performance in semiconductor equipment.

Performance comparison Data

Category	FC-3283			GCL-70		
Set temperature	Time to reach	Flow rate (LPM)	Temperature deviation (°C)	Time to reach	Flow rate (LPM)	Temperature deviation (°C)
18°C→10°C	13′ 10″	31.1	0.15	07′ 18″	45.5	0.15
10°C→0°C	14′ 15″	31.3	0.08	09′ 34″	44.4	0.09
0°C→-10°C	12′ 38″	32.2	0.20	08′ 53″	40.3	0.39
-10°C→0°C	14′ 03″	32.0	0.08	12′ 37″	44.4	0.10
0°C→10°C	15′ 53″	32.5	0.16	13′ 35″	45.3	0.16
10°C→18°C	17′ 23″	32.0	0.20	08′ 39″	46.2	0.14

GCL-70 VS FC-3283 Cooling performance comparison graph



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