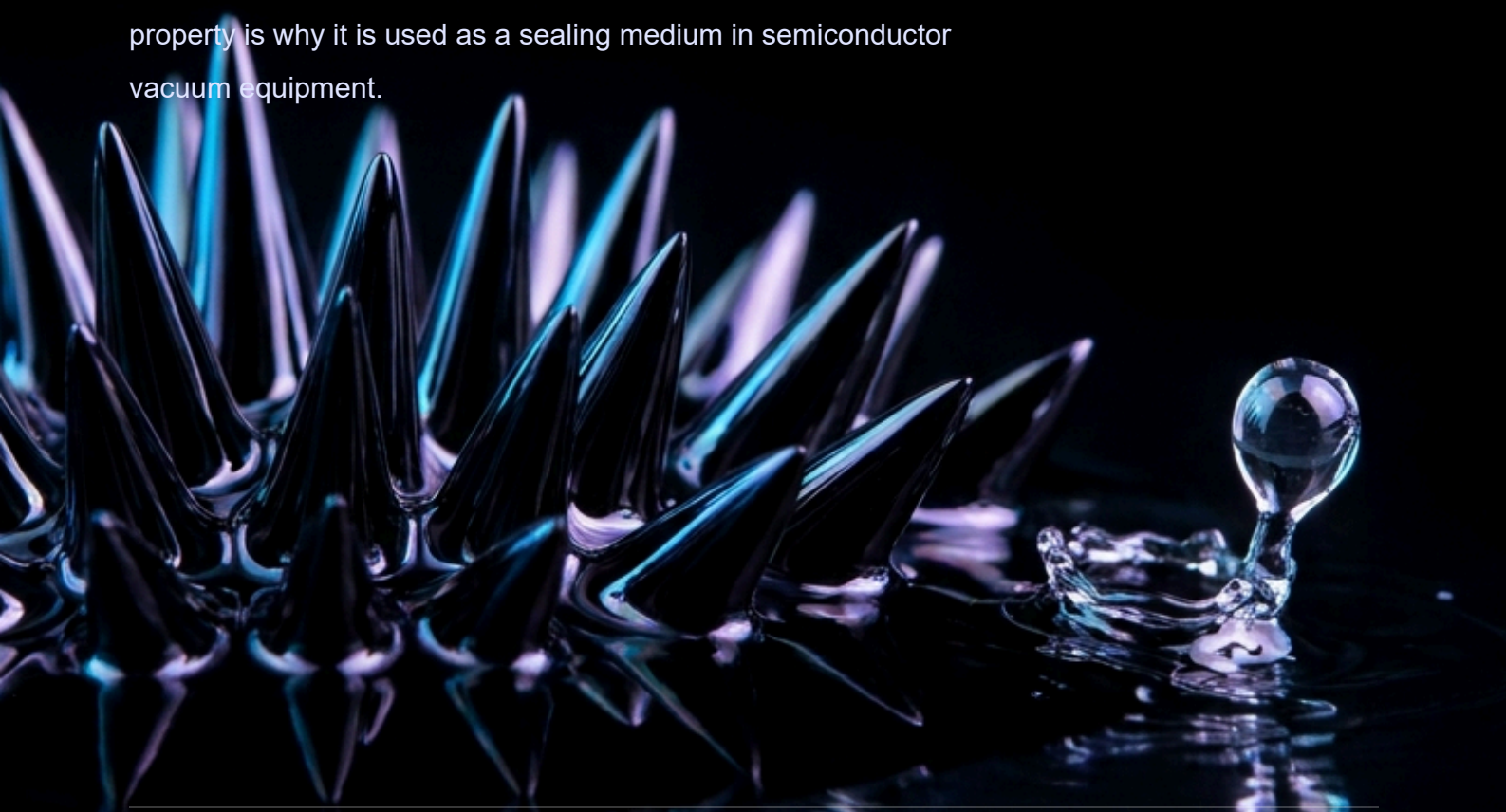
MAGRON TECHNICAL GUIDE

What is Ferrofluid?

자성유체란 무엇인가

A liquid that answers to a magnet. It is neither a solid magnet nor ordinary oil, but a third kind of material. Made by dispersing nanometer-scale magnetic particles through an oil, it changes shape the moment a magnetic field is applied and returns to an ordinary liquid the moment the field is taken away. That single property is why it is used as a sealing medium in semiconductor vacuum equipment.



≈ 10 nm

Magnetic particle diameter
One ten-thousandth of a human hair

3 parts

Magnetite · Surfactant
· Carrier fluid

Superparamagnetic

Magnetism vanishes the instant
the field is removed

MAGRON CO., LTD.
Ferrofluid · Feedthrough · Magnet manufacturer

01 What ferrofluid is made of

COMPOSITION

Ferrofluid is a liquid that carries magnetism. Bring a magnet close to the black liquid and the whole body of it is drawn toward the magnet.

The reason a liquid answers to a magnet like metal is simple: magnetic material such as magnetite or iron oxide has been ground extremely fine and mixed into an oil. Mixed on its own, though, the powder would settle out or clump together. The third ingredient, a surfactant, is what prevents that.

01 NANOPARTICLE

Magnetite

Magnetic ultrafine particles roughly **10 nm (100 Å)** across, from the magnetite and iron-oxide family. Only at this size can they stay suspended in a liquid.

02 SURFACTANT

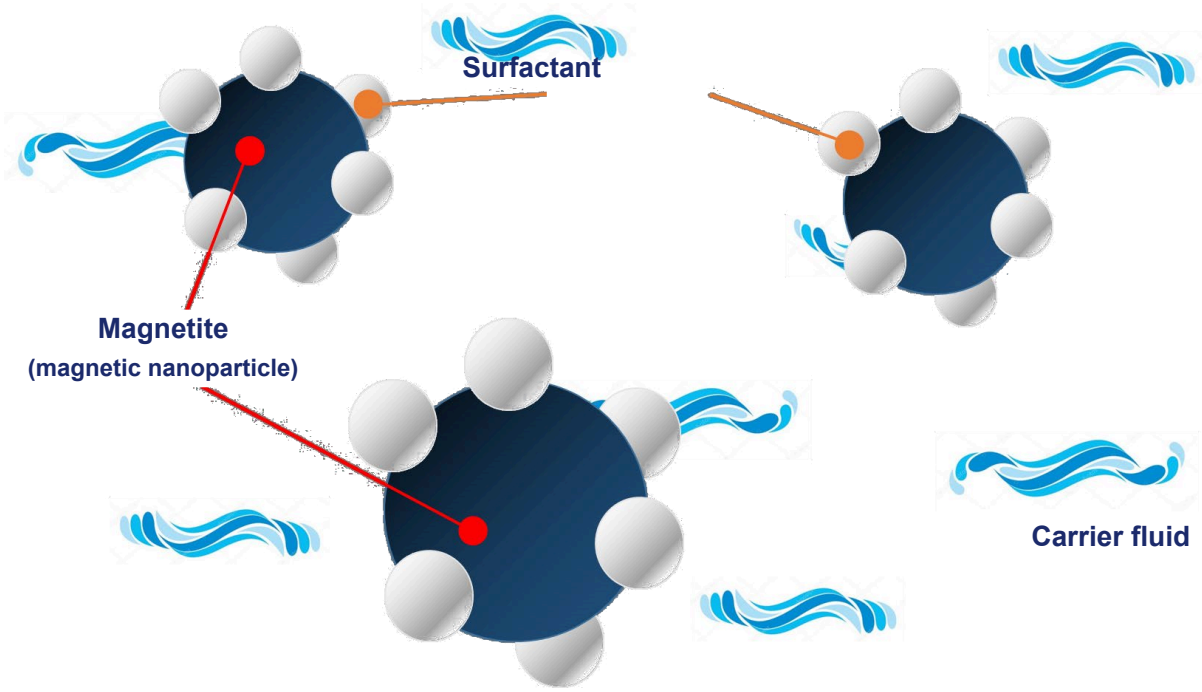
Surfactant

Adsorbs onto the particle surface and forms a film. It keeps the particles from sticking to one another, holding the **colloid stable**.

03 CARRIER FLUID

Carrier fluid

The base liquid that holds the particles. Chosen from **hydrocarbon, silicone and fluorinated (PFPE)** families to suit the operating environment.



Basic structure of a ferrofluid — surfactant-coated magnetite particles dispersed evenly through the carrier fluid

How small is 10 nanometers? About one ten-thousandth of the width of a human hair. Only at that size does the pushing and colliding of the oil molecules outweigh the gravity trying to pull the particle down, so the particle stays afloat in the liquid.

02 Why it stays liquid instead of settling

STABILITY

Put magnetic powder into oil and it would normally clump together and sink. Two forces work together to keep a ferrofluid a uniform liquid over long periods.

FORCE 01

Brownian motion

Oil molecules batter the magnetic particles from every side without pause. Because the particles are on the order of 10 nm, those collisions alone keep them adrift.

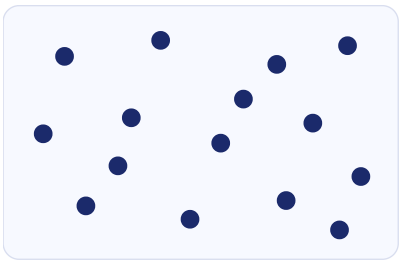
FORCE 02

Interparticle repulsion

Surfactant-coated particle surfaces push one another away. Even at close range they cannot bind, so no agglomeration occurs.

Thanks to the balance of these two forces, the dispersion stability of a ferrofluid **holds up in zero gravity and inside a strong magnetic field alike**. Applying a field lines the particles up along the lines of force; remove the field and they scatter at random again, back to the uniform liquid they were.

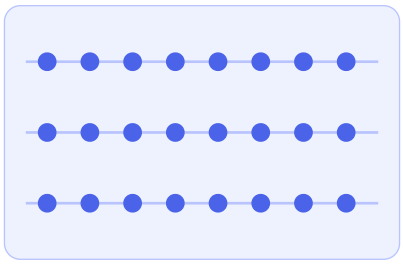
No magnetic field
WITHOUT MAGNETIC FIELD



Particles scattered at random

Magnet approaches

Magnetic field applied
WITH MAGNETIC FIELD

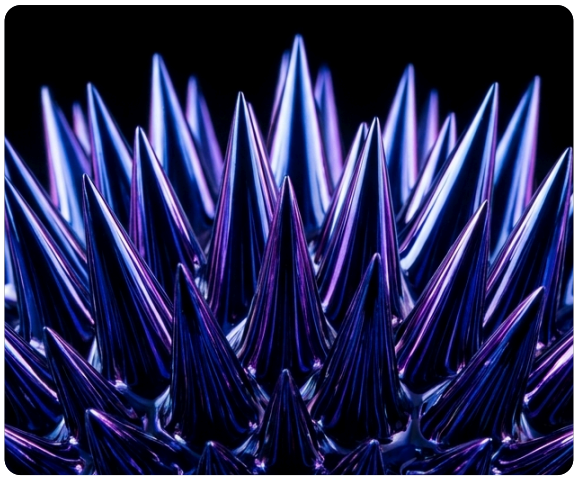


Chained along the lines of force

Remove the magnet and it returns to its original state

Why the spikes form

Set ferrofluid on a magnet and the surface rises into sharp spikes. Magnetic force tries to draw the liquid up along the lines of force, while surface tension and gravity try to flatten it back down. The regular array of peaks is where those opposing forces settle at the lowest energy. It is called **normal-field instability**, and it is the clearest visual evidence that the ferrofluid is genuinely responding to the field.

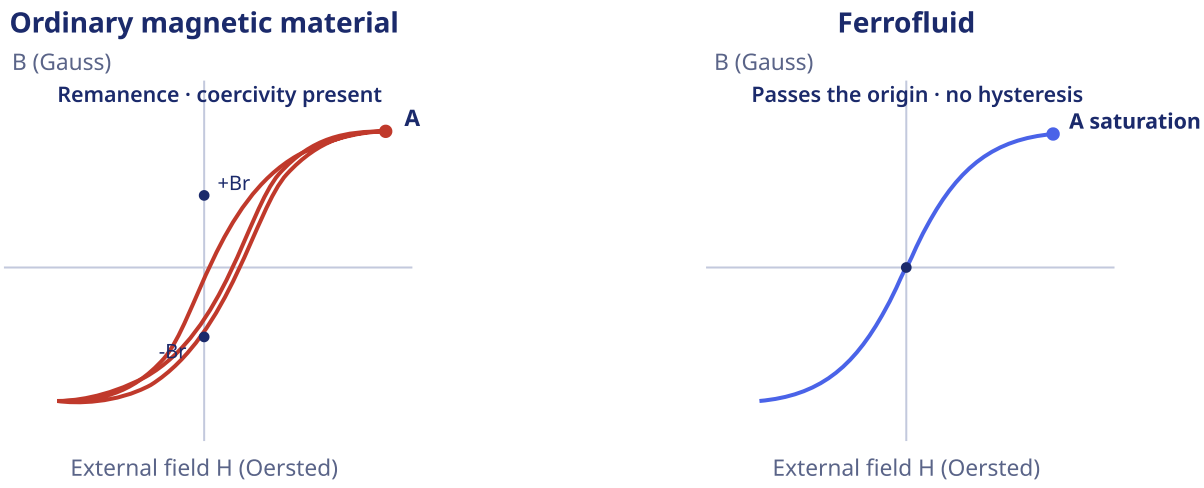


03 The key property

Apply a field and it becomes a magnet; take the field away and the magnetism is gone at once.

This is the single most important property of a ferrofluid. An ordinary magnet, once magnetized, keeps some magnetism even after the external field is removed — remanence. A ferrofluid does not. At zero field its magnetism is zero and it is simply an ordinary liquid again. That behavior is called **superparamagnetism**.

State	Behavior of the ferrofluid
Zero field	No magnetism. Behaves exactly like an ordinary liquid.
Field applied	The particles line up along the lines of force and magnetize. Keep raising the field and it reaches a ceiling beyond which it grows no stronger — the **saturation magnetization**.
Field removed	The magnetism disappears at once. With no **remanence (Br) or coercivity (Hc)**, no hysteresis appears.



Magnetization (B-H) curves compared — an ordinary magnetic material traces a wide hysteresis loop, while a ferrofluid traces a single S-shaped curve through the origin

Why this matters. No remanence means **it returns to the same state it started in, however many times the cycle repeats**. Used as a seal on a rotating shaft, the ferrofluid keeps its characteristics however long the equipment runs, forming the same liquid O-ring in the same place every time. With no parts in contact to wear, service life is long as well.

04 Where it is used

APPLICATIONS

Ferrofluid is **the only liquid that can be held in place by a magnetic field**. That is what lets it close the gap between a rotating shaft and a vacuum chamber with liquid. Unlike a solid seal there is no part in contact to wear away, so there is no friction and service life is long.

MAIN

Vacuum feedthrough seal

The field built by the magnet and pole pieces holds the ferrofluid around the shaft as a **liquid O-ring**, maintaining high vacuum. Stacking several rings raises the pressure it withstands.

CONSUMER

Fishing reel waterproofing

Injected between the magnets inside the reel, it forms a waterproof film that holds even while the reel spins, keeping out seawater and corrosion.

EDUCATION

Display kit

An exhibition and teaching set that lets the spiking of a ferrofluid be observed directly with the naked eye.

Industries served

Industry	Applications
Semiconductor	CVD · sputtering equipment, ion implanters, etching equipment, vacuum transfer robots, ion beam equipment
Display	LED · OLED manufacturing equipment, film panels, vacuum chucks, anode X-ray generators
Energy	Solar panels, new-energy batteries, nuclear fusion
General manufacturing	Single-crystal growth furnaces, vacuum furnaces, stirring assemblies
Aerospace · medical	Aerospace, nuclear, medical imaging equipment (CT and similar)

MAGRON selects a different carrier fluid for each duty. Semiconductor processes carrying corrosive gases take the chemically stable PFPE (fluorinated) family; inert environments take the silicone and hydrocarbon families. Build-to-order to your own specification is also available.

MAGRON CO., LTD.
Rm 403, Bldg 3, Gyeonggi Technopark, 705 Haean-ro, Sangnok-gu, Ansan-si, Gyeonggi-do 15588, Korea
TEL +82 31-500-4633 · FAX +82 31-500-4631 · magron@magron.co.kr
www.magron.co.kr · www.ferrofluidmagron.com