reconfigurable ferromagnetic droplets

outline
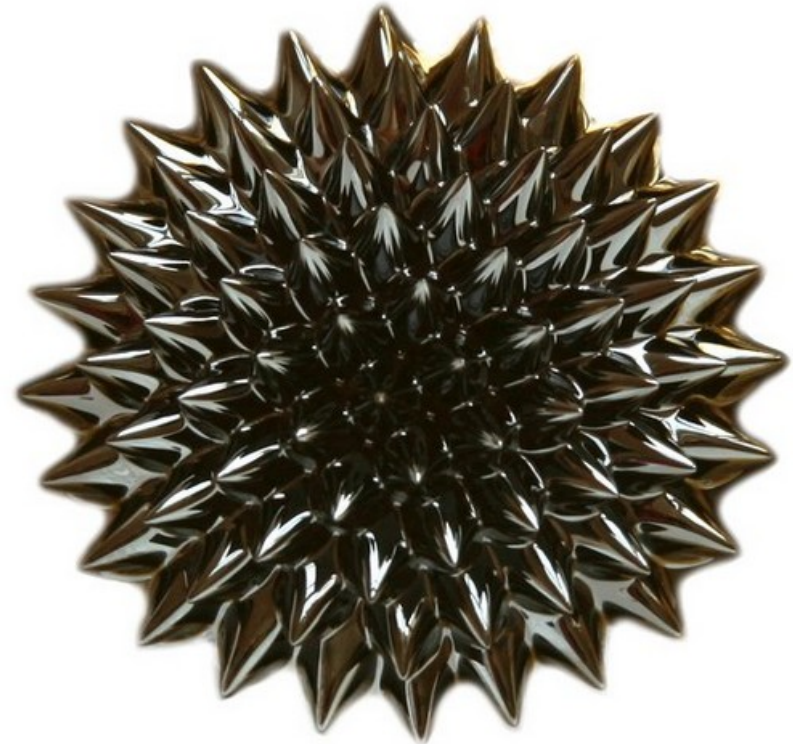- the problem
- the idea
- physical properties and characteristics
- outlook

research paper: "Reconfigurable ferromagnetic droplets (Xubo Liu et al., 2019)"

the problem – solid ferromagnets & ferrofluids

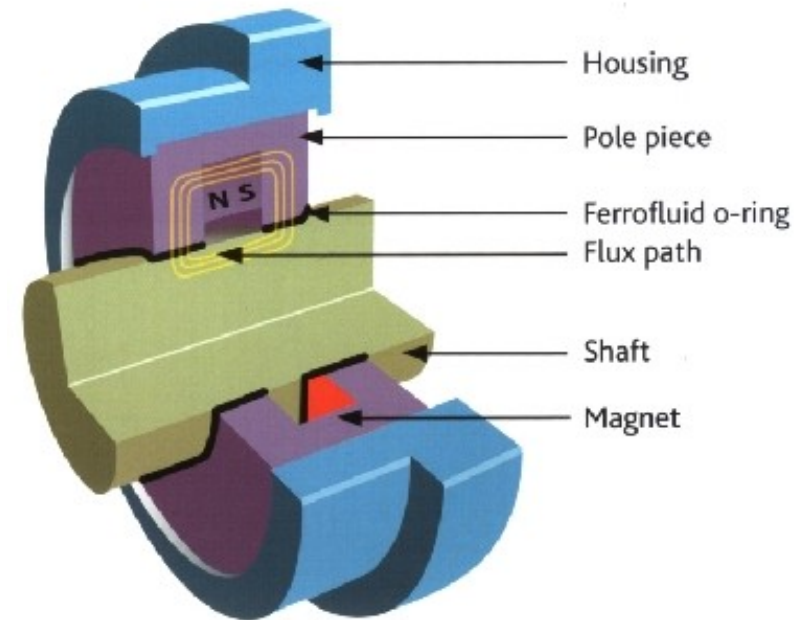+ ferromagnetic at room temperature

- rigid

+ reconfigurable

- paramagnetic at room temperature

# the problem – commercial usage

ferrofluidic sealing

- hermetic sealing in that enables rotary motion

- suspended in place by a solid ferromagnet ring
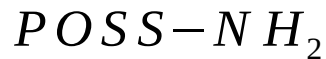
- no maintenance reuired, extremely low leakage

Housing
Pole piece
Ferrofluid o-ring
Flux path
Shaft
Magnet

N S

a sealing technique with very long operating life

the problem – ferrofluids

- magnetic nanoparticles (MNPs): provide the magnetic behaviour
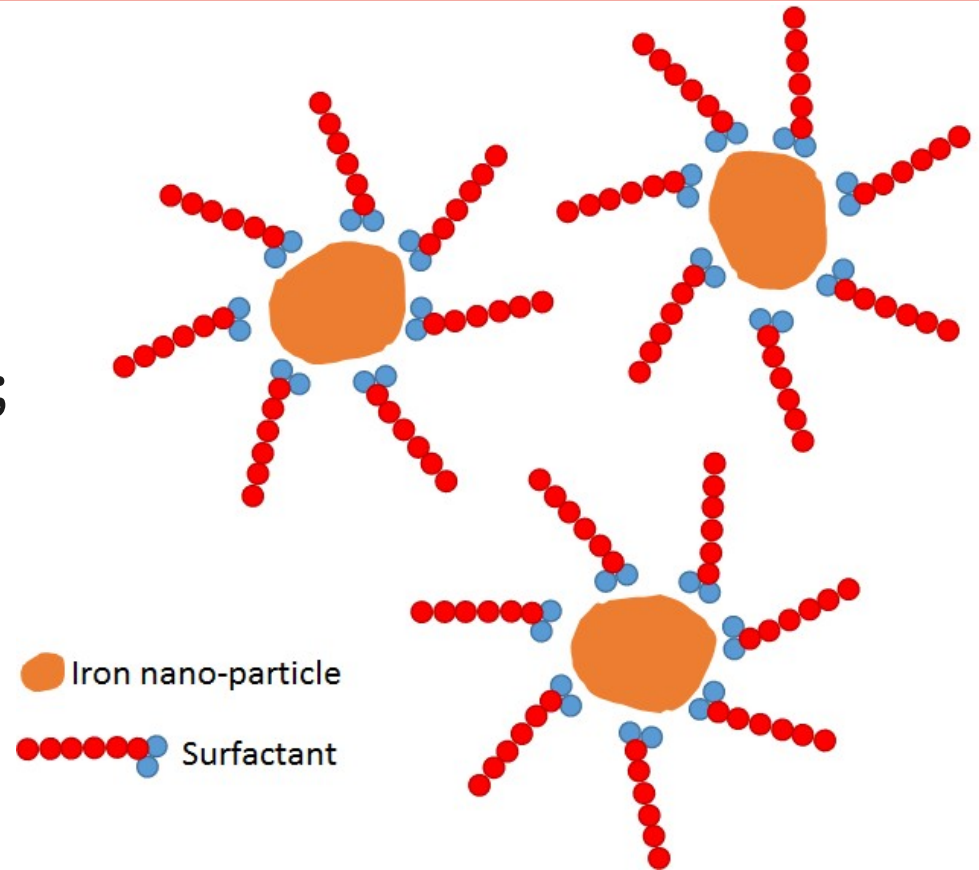
$$Fe_3O_4-CO_2H$$
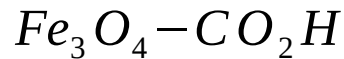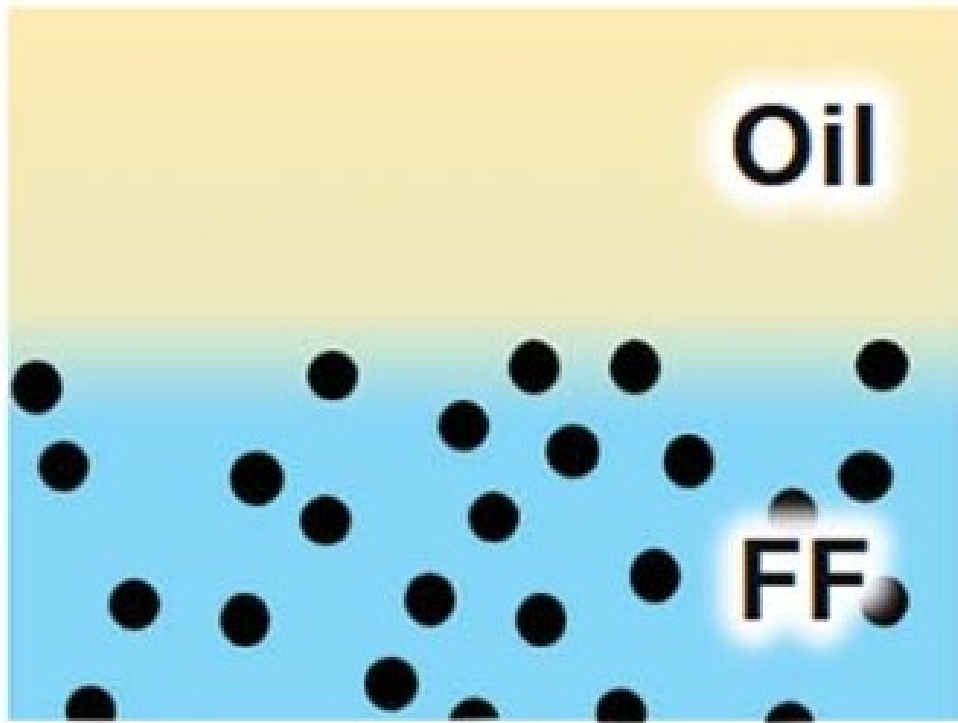
- surfactant: prevent sticking of MNPs; interacts electrostatically

$$POSS-NH_2$$

- carrier fluid: provide volume

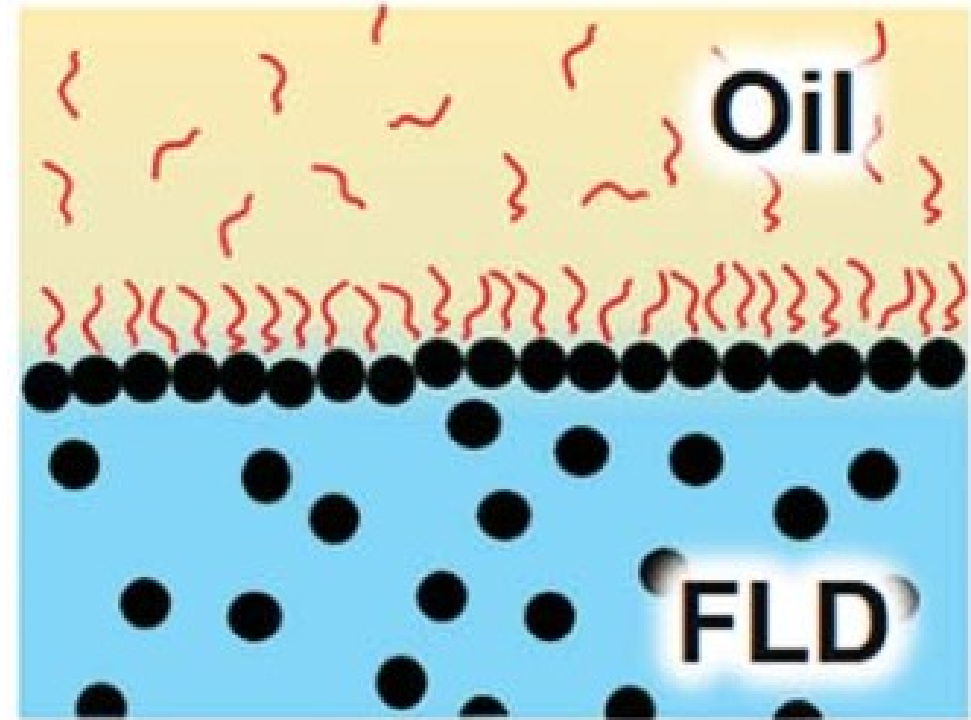*toluene*

Iron nano-particle

Surfactant

- ferromagnetic behaviour exhibited when the Brownian motion of MNPs is suppressed (low T or high viscosity)
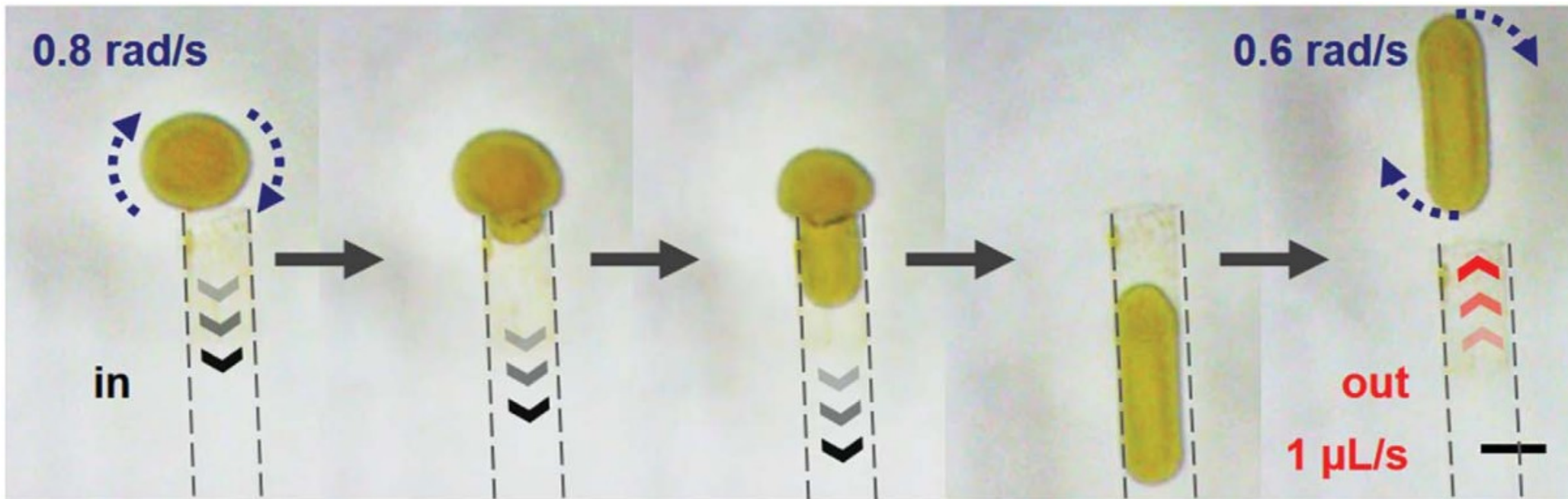
the idea – jamming of surfacial MNPs

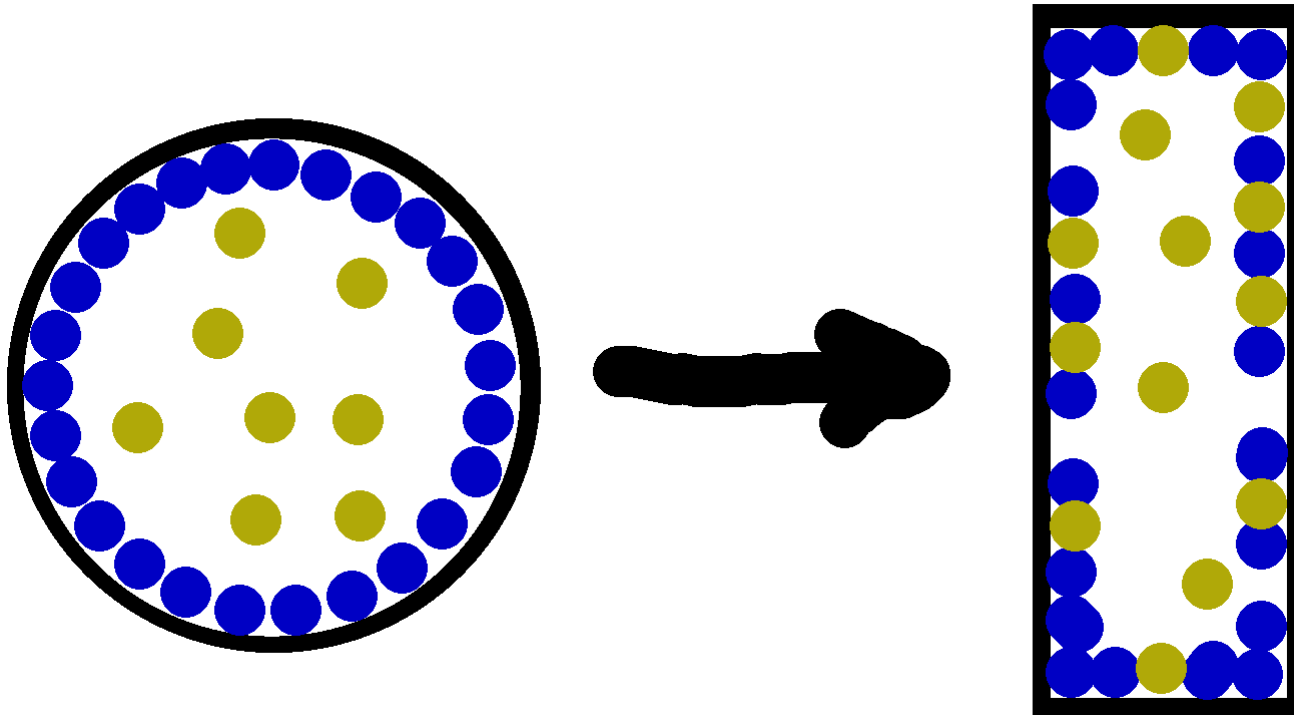water-based ferrofluid immersed in surfactant-oil solution

the surfactant assemble at the interface
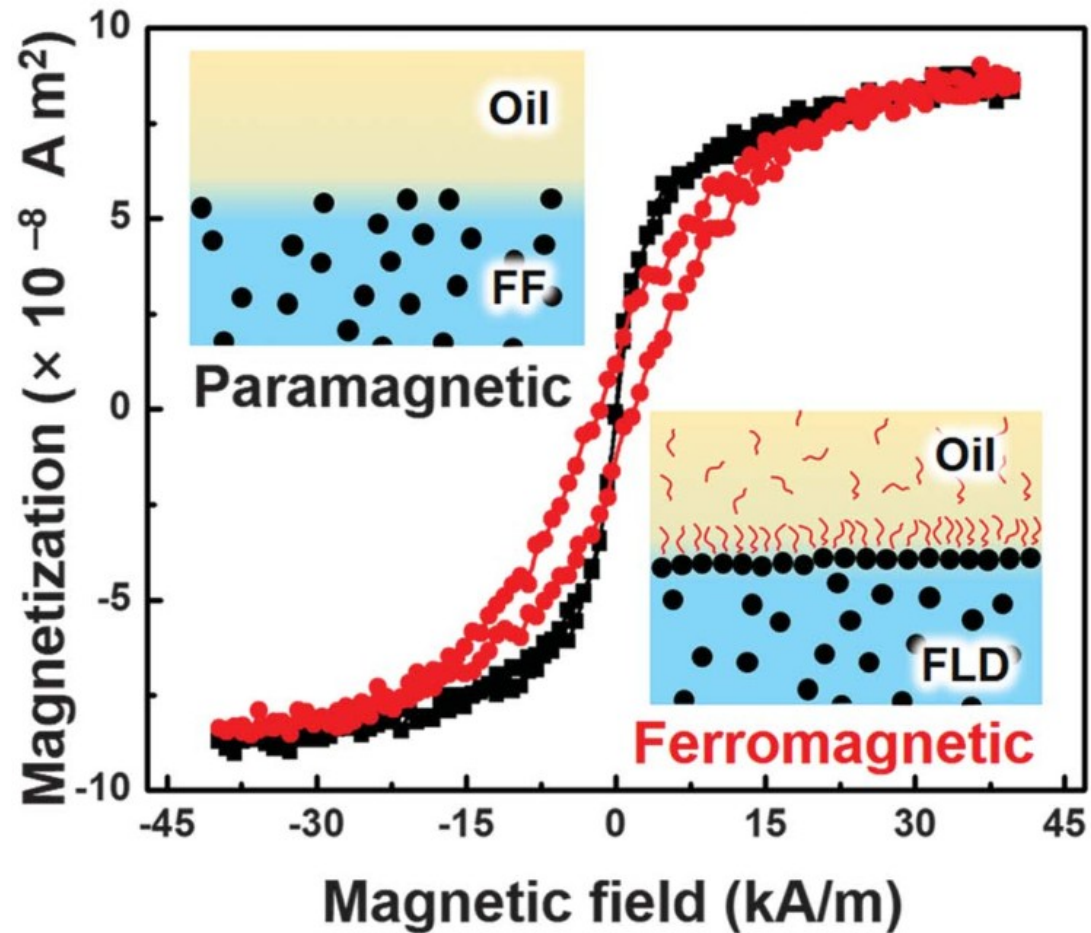
the idea – reshaping of the droplet

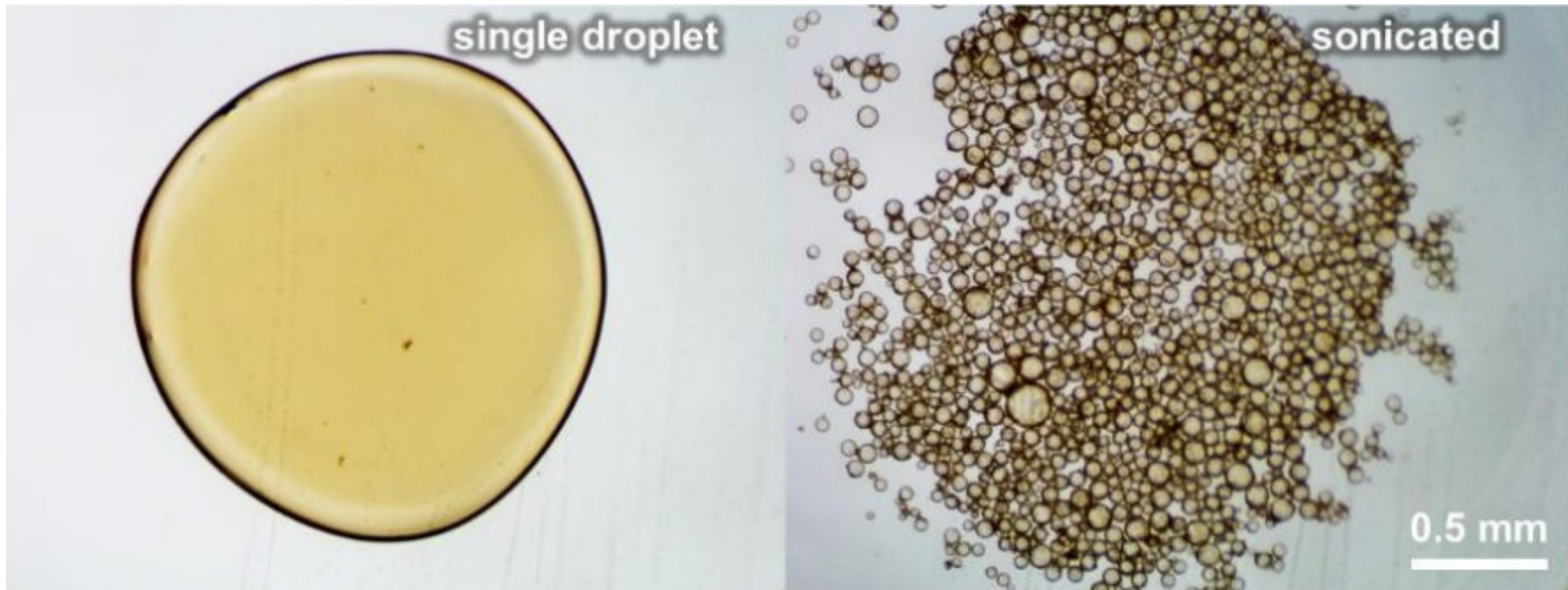- the droplet is drawn into a capillary then shot out

- reshaping increases surface while volume is unchanged

- more surfactants and MNPs assemble at the surface

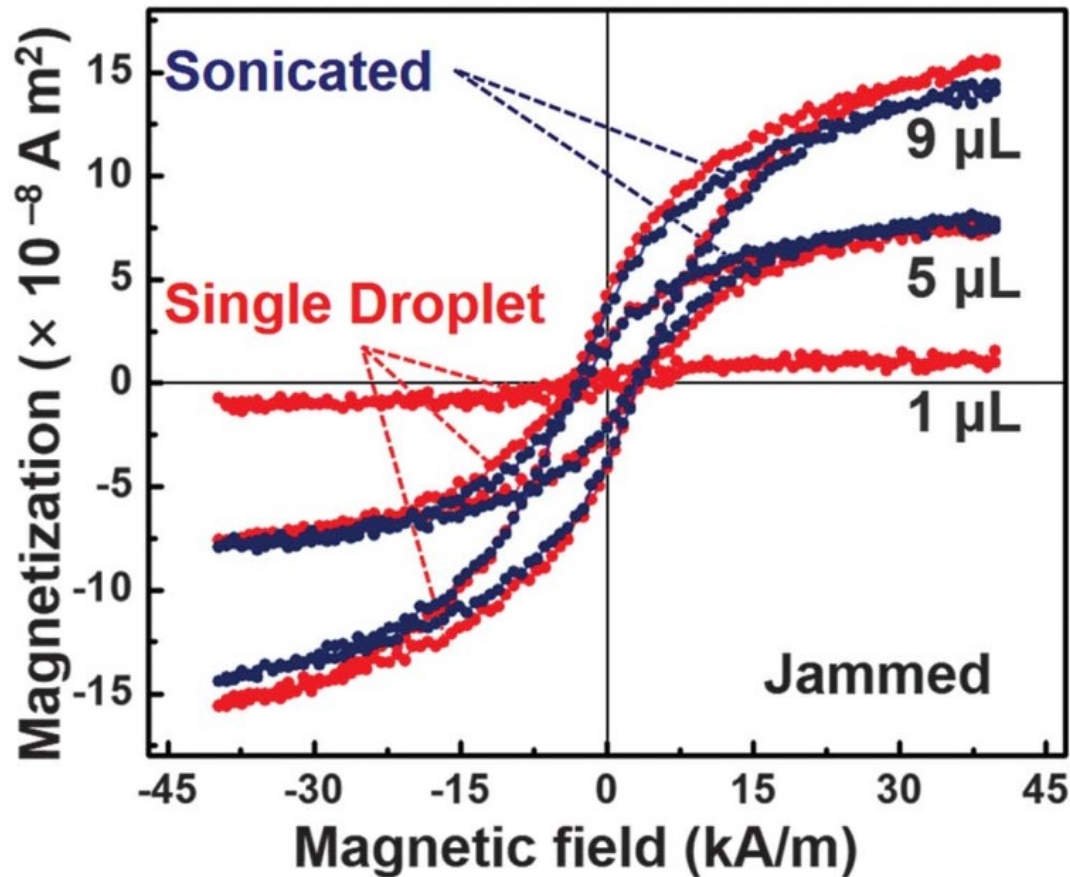- the droplet is now unable to regain its energetically optimal shape

the surfacial MNPs can no longer freely rotate in the jammed state
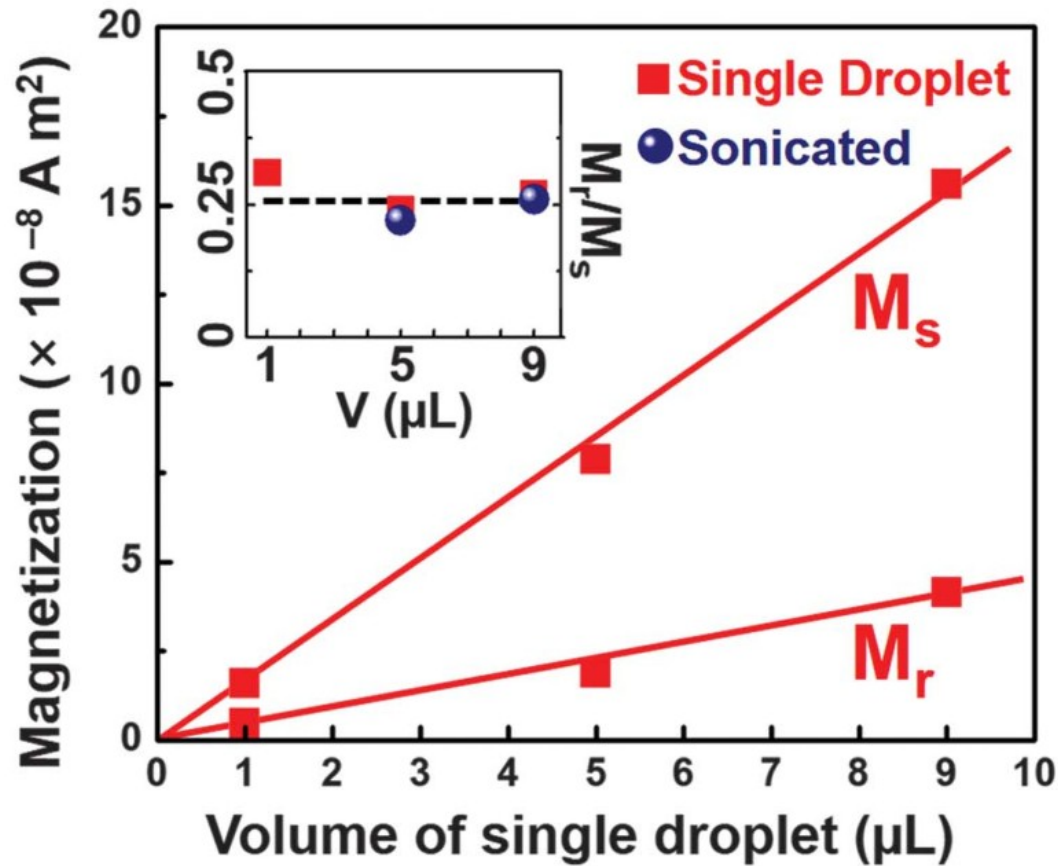
characteristics – sonicated droplets

sonication increases S/V while the # of MNPs remain the same
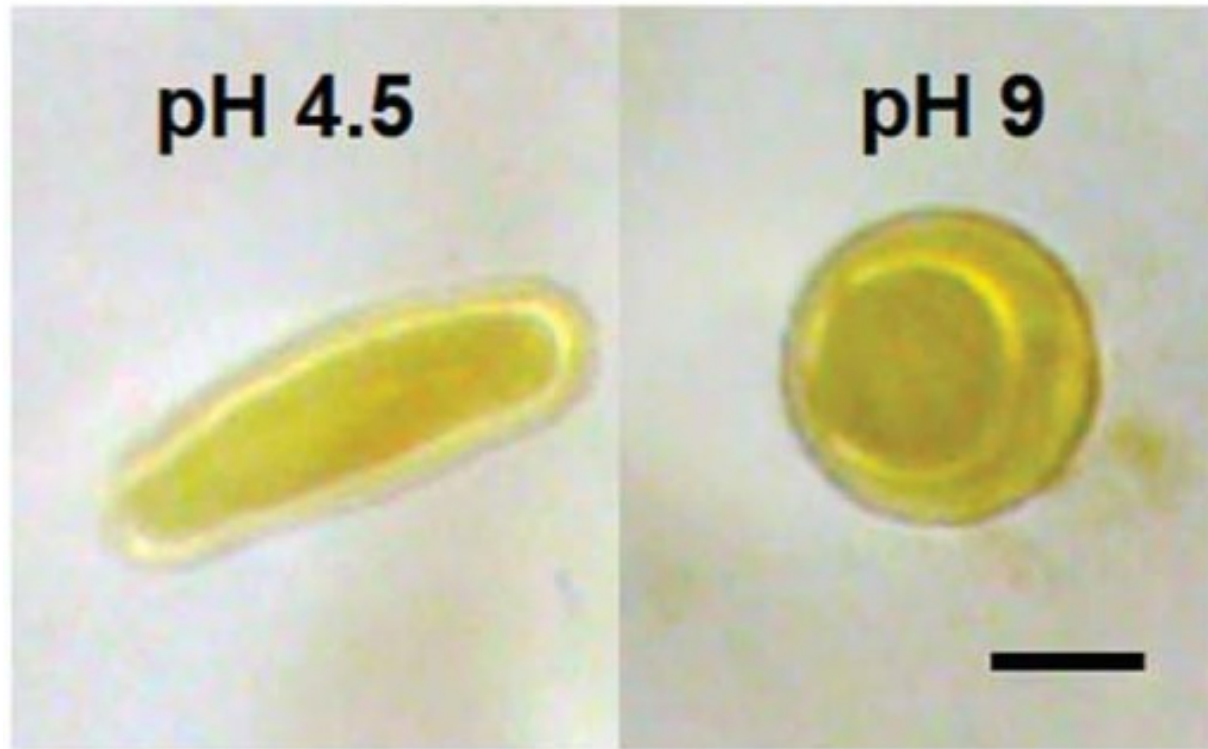
characteristics – sonicated droplets

magnetic properties are independent of S/V

characteristics – magnetic properties

the ratio of saturation magnetization and remanent magnetization is uniform: 0.25
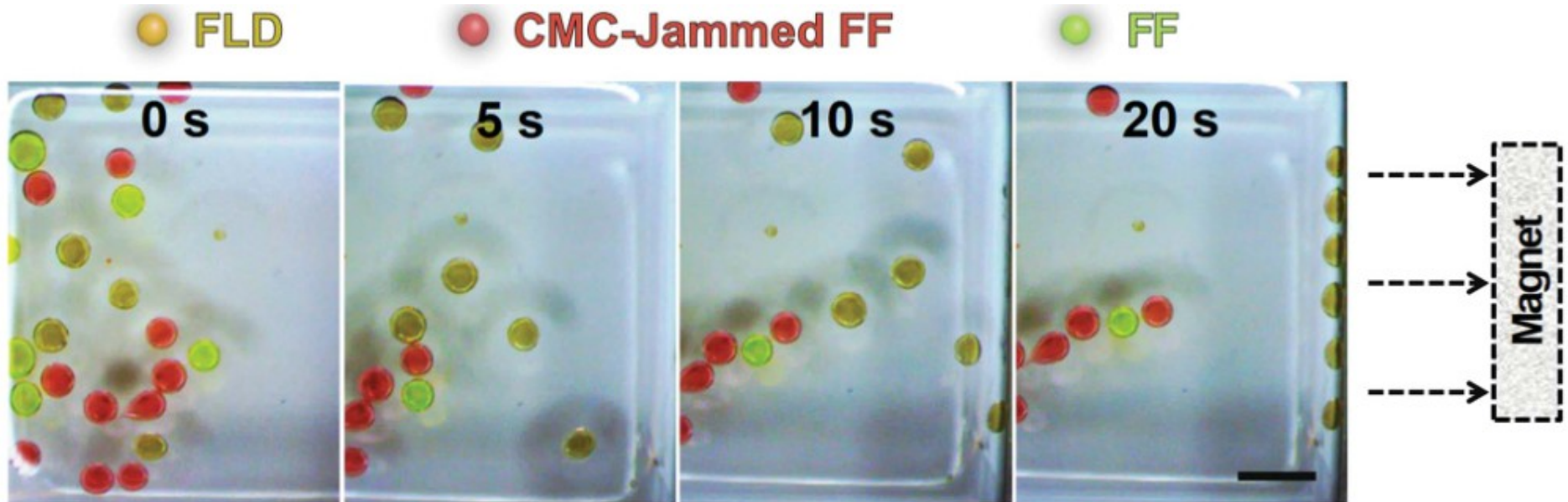
characteristics - unjamming

lowering the binding energy of MNP-surfactant unjams the system

- increasing pH

- applying external field
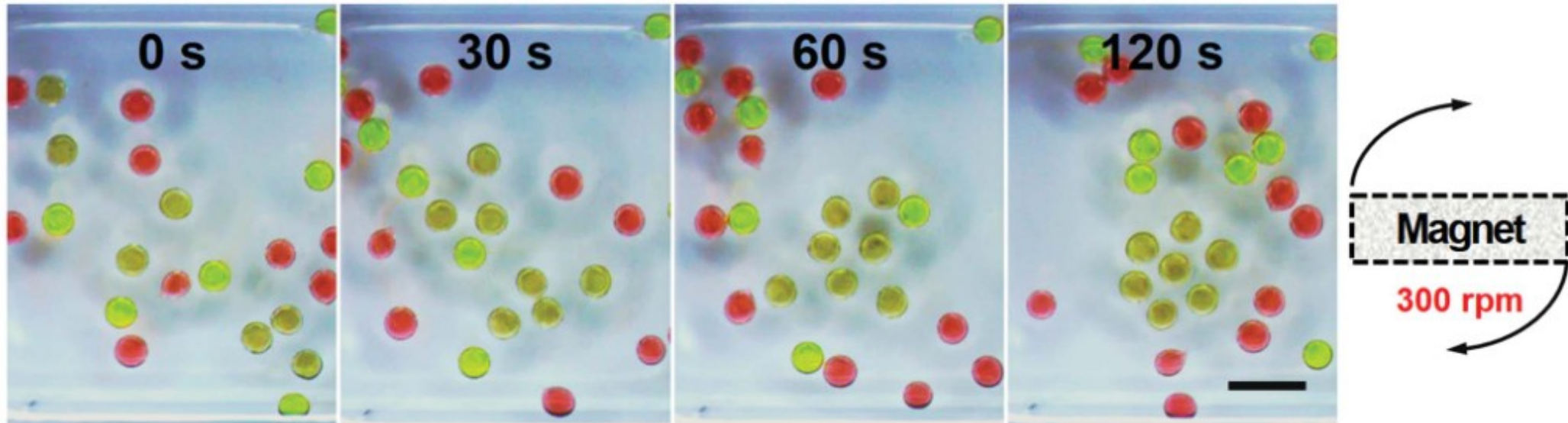
characteristics – ferromagnetic behaviour

- FLD = ferromagnetic liquid droplet

- FF = ferrofluid

- CMC-jammed FF = a ferrofluid with a jammed surafe

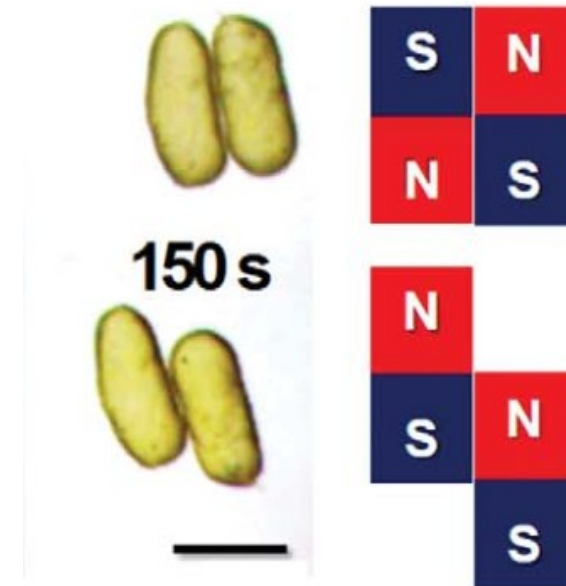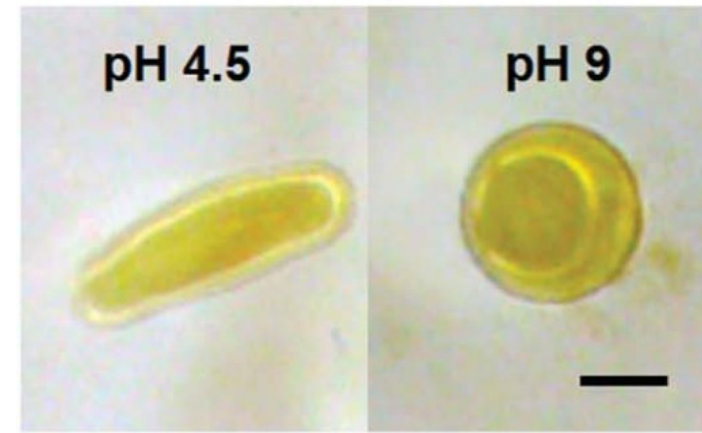- Equal number of MNPs

characteristics – ferromagnetic behaviour

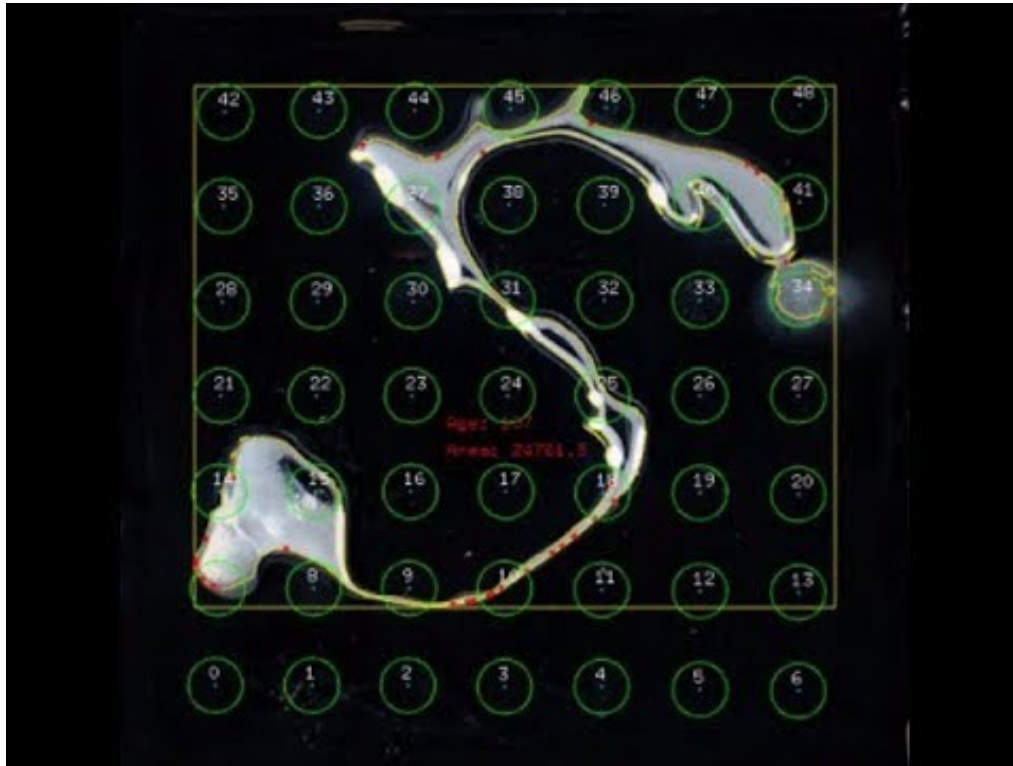the FLDs are much more responsive to the external fields

summary

- a reversible phase transition between ferrofluid and ferromagnetic liquid droplet states

- fluid characteristic of liquid & magnetic properties of solids

- translational and rotational motions can be actuated remotely

outlook

- **programmable liquid constructs**

thank you for your attention!