SIZE-DEPENDENT PARTICLE FILTERATION USING MAGNETICALLY DRIVEN MICROTOOL AND CENTRIFUGAL FORCE IN MICROCHIP

H. Maruyama, S. Sakuma, Y. Yamanishi and F. Arai
Department of Bioengineering and Robotics, Tohoku University, Sendai, Miyagi, Japan

TOHOKU UNIVERSITY

ACTUATOR

How to separate particles with different sizes continuously in a microchip.

Abstract:

We succeeded in size-dependent filtration of microparticles by rotation of magnetically driven microtool (MMT) and centrifugal force in a microchip. Microparticles with different sizes flow in spiral microchannels and are separated according to their sizes by pass through under each sidewall of microchannels by centrifugal force. MMT is set inside the microchamber and rotated by external magnetic force. Rotation of MMT avoids the clogging of the microparticles and enhances the sorting efficiency.

Motivation : Continuous size-dependent filtration of microparticles in a microchip

Size-dependent filtration of microparticles such as copolymer beads and cells is a very important.

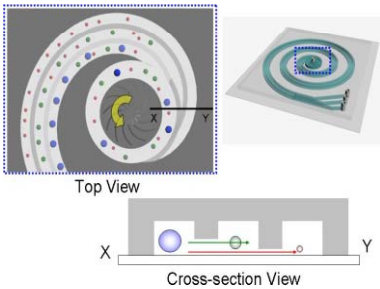
Size-dependent filtration of microparticles by rotation of 3D magnetically driven microtool (MMT) and centrifugal force in a microchip was proposed.

Conventional methods for particle separation:

Electrophoresis, Dielectrophoresis, Magnetic force, Hydrodynamic force, optical Tweezers, etc.

- Hydrodynamic force does not cause damage to particles.
- Hydrodynamic force can handle various particles with different properties (electric permeability, magnetism)

This method is not robust against pressure fluctuation.

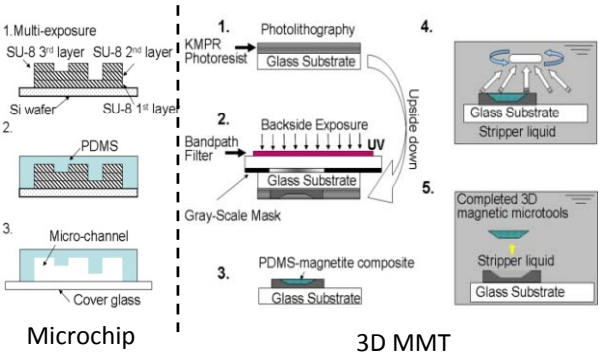


Schematic of filtering microchip

Characteristic of our approach

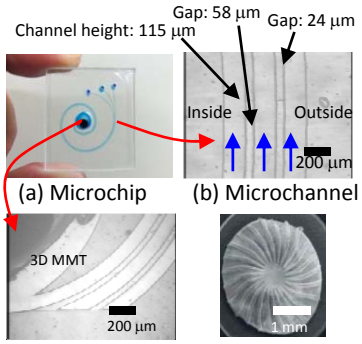
- Microchip with spiral microchannels, which are divided by internal sidewalls
  Robust against the pressure fluctuation because particles are separated mechanically by the sidewalls.
- Using 3D-MMT rotation in microchamber
  Avoiding the clogging of particles and enhancing the particle separation.

Fabrication : Microchip with spiral microchannels and 3D-MMT



Microchip 3D MMT

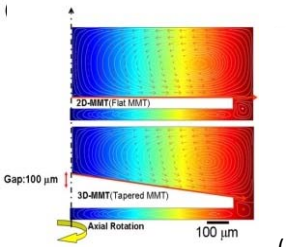
Fabrication process of microchip and 3D MMT



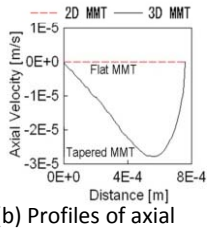
(c) Microchamber (d) 3D MMT (SEM image)

Fabricated microchip and 3D-MMT

Swirling flow caused by 3D-MMT rotation stirrer particles and avoid clogging of particles.



(a) FEM analysis of velocity distribution



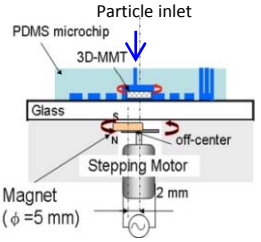
(b) Profiles of axial velocity along the lateral component

Distribution of velocity around MMT.

Experiments : Size-dependent particle filtration using centrifugal force and 3D- MMT

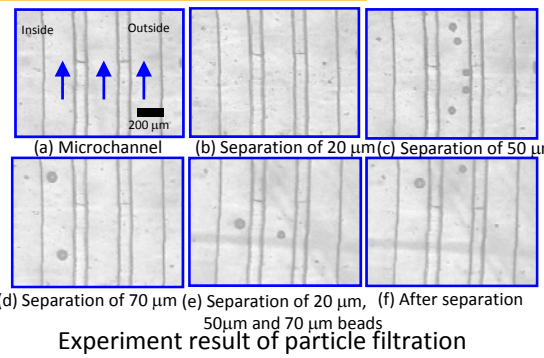
Size-dependent particle filtration was succeeded.

Improvement of filtration efficiency by MMT was confirmed.



Rotation speed of MMT: 6000 rpm
Particle : 20 μm, 50 μm, 70 μm

Actuation system



(a) Microchannel (b) Separation of 20 μm (c) Separation of 50 μm

(d) Separation of 70 μm (e) Separation of 20 μm, 50μm and 70 μm beads (f) After separation

Experiment result of particle filtration

Comparison of filtering efficiency between with MMT rotation and without MMT rotation.

Particle size	20 μm		50 μm		70 μm	
MMT rotation	Without	With	Without	With	Without	With
Outer channel	24%	38%	0%	0	0%	0%
Middle channel	43%	32%	64%	81%	0%	0%
Inner channel	33%	30%	36%	19%	100%	100%

- Continuous particle filtration of different-sized particle was succeeded.
- Mechanical filtration of different-sized particles was achieved by sidewalls.
- Filtration throughput: more than 360 particles per second
- Filtration efficiency was improved to about 50% by 3D-MMT rotation.

Conclusions & Further work:

Size-dependent filtration of microparticles by rotation of magnetically driven microtool and centrifugal force and 3D-MMT was developed. Clogging of the particles in the microchamber and enhanced the efficiency of filtration was achieved by rotation of 3D-MMT .

References :

H. Maruyama, S. Sakuma, Y. Yamanishi and F. Arai, “SIZE-DEPENDENT PARTICLE FILTERATION USING MAGNETICALLY DRIVEN MICROTOOL AND CENTRIFUGAL FORCE IN MICROCHIP”, Proc. of MEMS2009, pp. 375-378 (2009).