



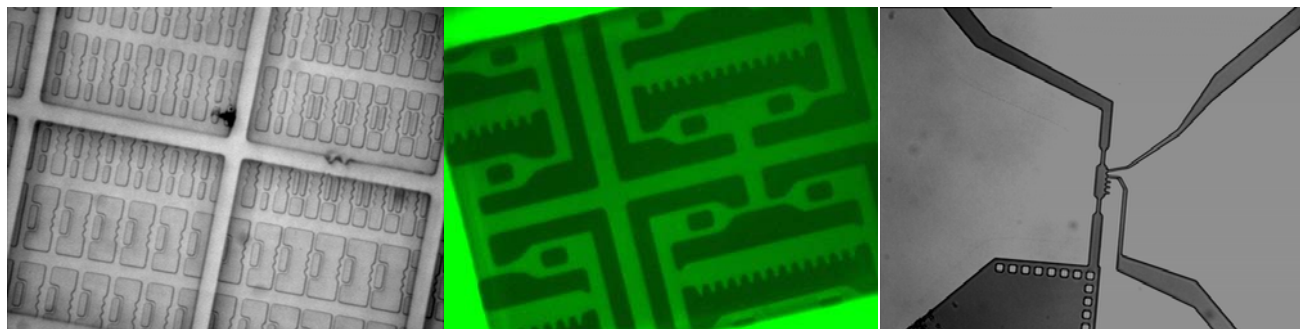
Colloidal Particles Operating Microfluidic Devices

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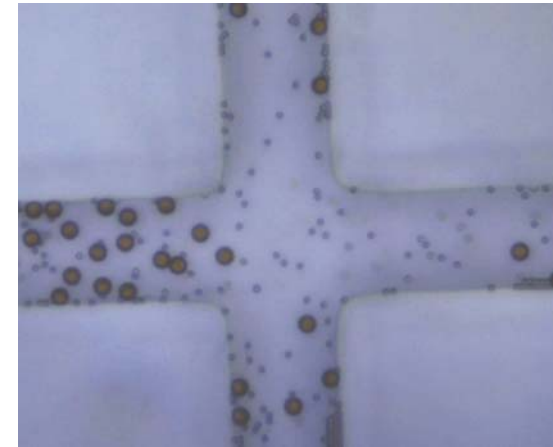
Outline

- I. Introduction: Lab on a Chip
- II. The Experiment
 - Our Approach
 - Setup
 - Methods
- III. Microfluidic Devices
 - Pumps
 - Mixers
 - Outlook
- IV. Summary

Introduction

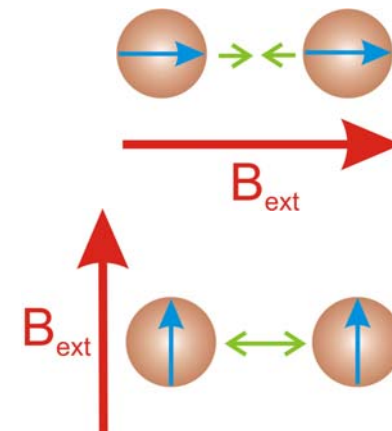
Our Approach:

- paramagnetic colloids
- 4.5 μm in diameter
- soft lithographic structures
- particles as building blocks for different functionalities
- noninvasive external actuation



Particles in Magnetic Fields:

- magnetic dipole induced
- attraction
- repulsion



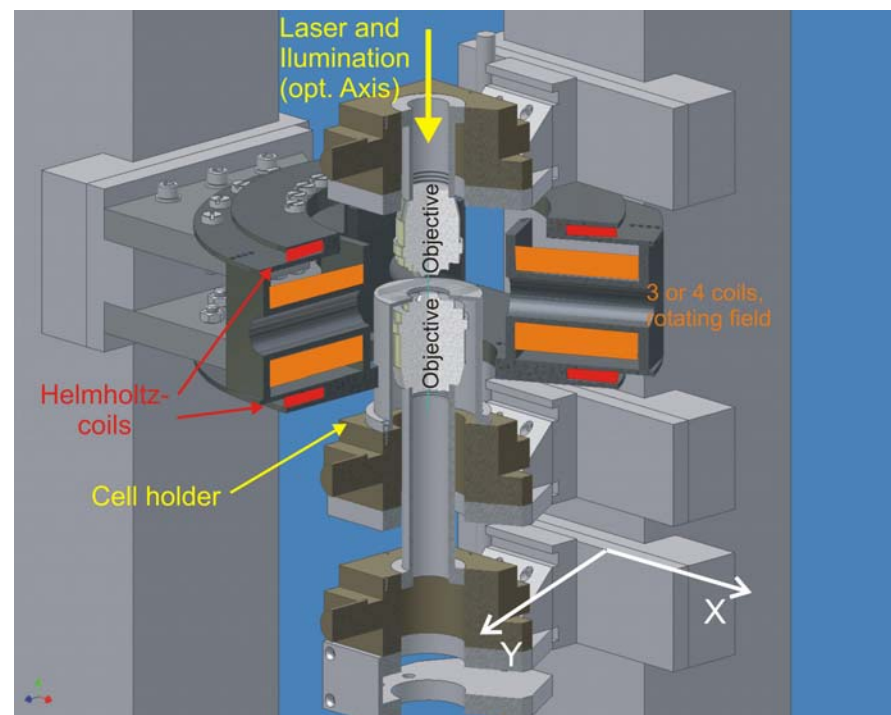
Setup

Setup:

- infra-red laser
- optical tweezers
- video microscopy

Magnetic Coils:

- 4 AC driven coils
 - in sample plane
 - phase difference 90°
 - rotating magnetic field
 - attraction AND torque
- pair of Helmholtz coils
 - perpendicular to sample plane
 - DC driven
 - repulsion



Ship-in-a-Bottle Assembly

- assembly of particles with magnetic fields
- final cluster bigger than inlets
- *in-situ* construction of different functionalities
- colloids as building bricks
- symmetric shape preferred
- => Self Assembly



15μm



Pumping Cluster

- symmetric cluster
- symmetry break of channel walls
- net pump volume
- external field rotation way faster than cluster
- Self Assembly!



15μm



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Pump/Valve - Combination

- rotating cluster
- one channel is blocked
- positioned by optical or magnetic fields
- direction of rotation defines direction of flow
- position defines addressed channels

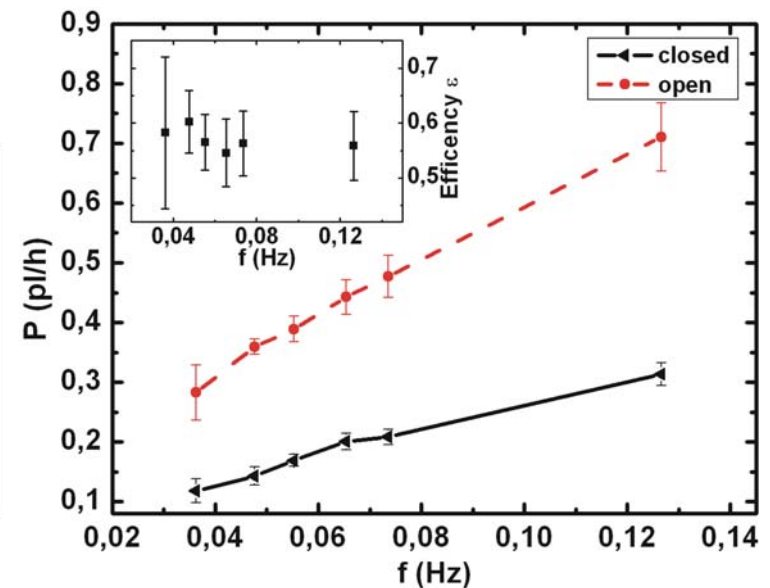
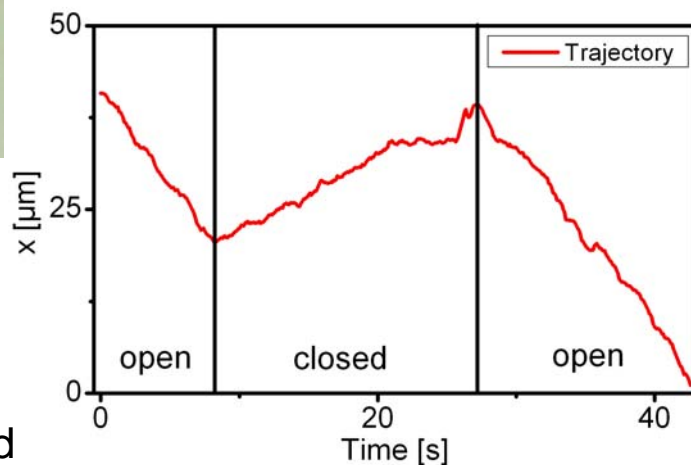
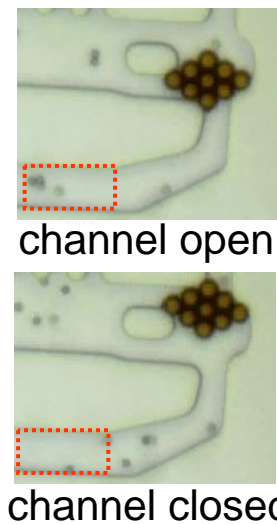
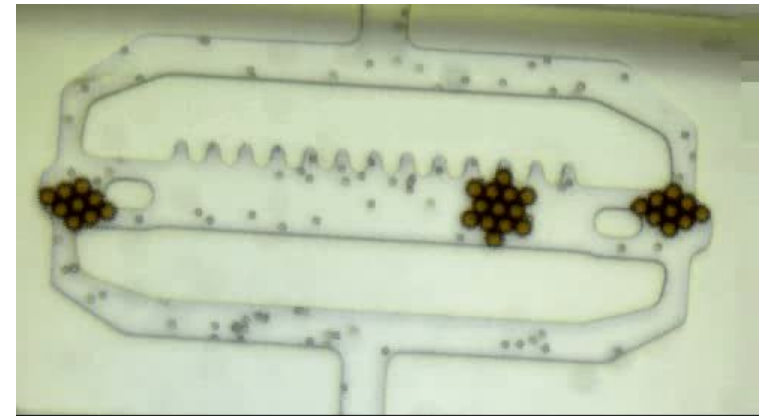
10μm



Pumps and Valves

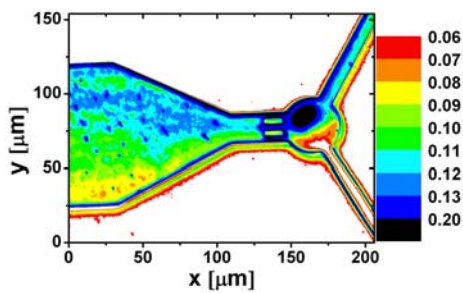
20 μm

- global magnetic field
- flow is rectified by valves
- single clusters couple to surrounding
- => synchronization of different functionalities!

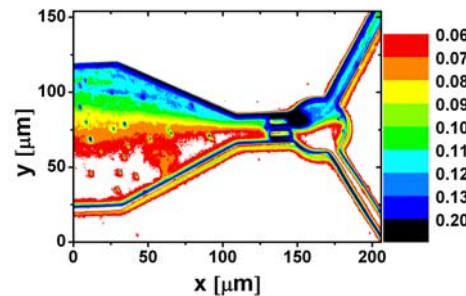


Mixers

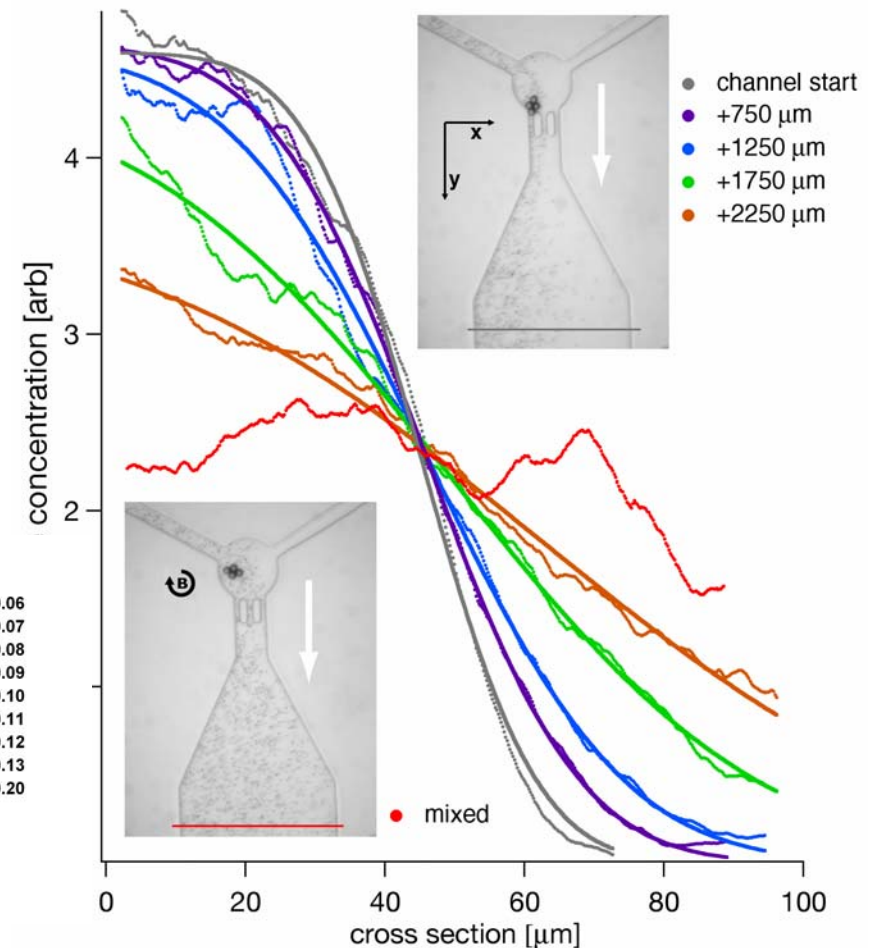
- mixing in laminar flows
- only by diffusion
- folding of interface by rotating cluster
- assisting of diffusion
- more efficiently mixed than after 10min of pure diffusion



mixed



unmixed



Summary

New Approach for Lab on a Chip Applications:

- Magnetic Colloids as 'Building Blocks'
- Noninvasive Actuation by Global Magnetic Fields
- Synchronization of Different Functionalities
- Scaleable and Not Limited to Special Materials