Integrated microfluidics / lab-on-chip systems for point-of-care medical diagnostic applications

Anita Bányai
Supervisor: Dr. Péter Fürjes

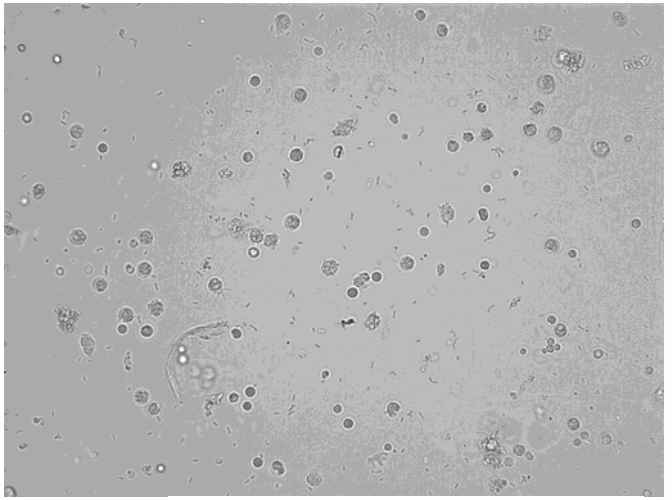
ELKH Centre for Energy Research
Institute of Technical Physics and Materials Science
Microsystems Laboratory

E-mail: banyai.anita@ek-cer.hu

www.ek-cer.hu | www.mems.hu | www.biomems.hu

The aim of my research

- design and development of integrated microfluidic systems for sample transporters to be used in fast and reliable diagnostic tools
- screening for urine bacteria on a targeted microfluidic platform
- study and determine the geometry and material structure of the microfluidic system;
- promoting compatibility with industrial technologies

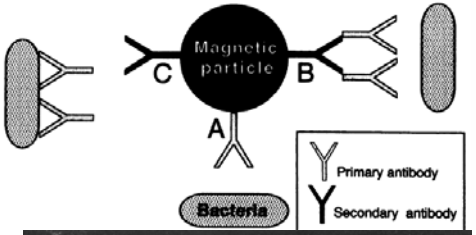


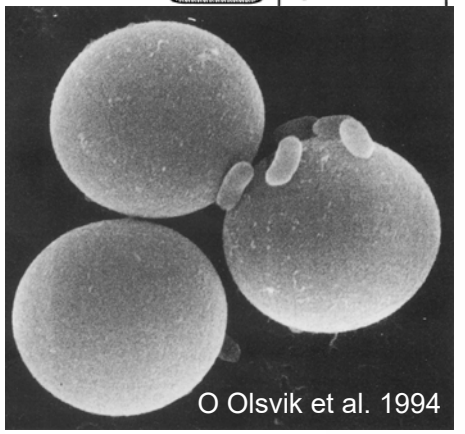
Main tasks of this semester

Until now passive and active separation methodes were tested: **Deterministic lateral displacement (DLD)**, **Crossflow filtration (CF)** ,**Lateral focusing (LF)** and **Magnetoforetic separation**.

In this semester:

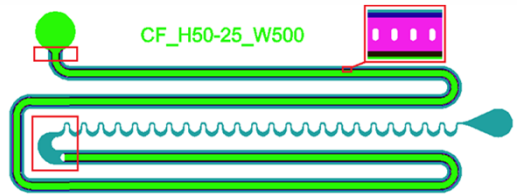
- **Magnetoforetic separation** – in autonom fluidics
- **Lateral focusing (LF)** – with living cell



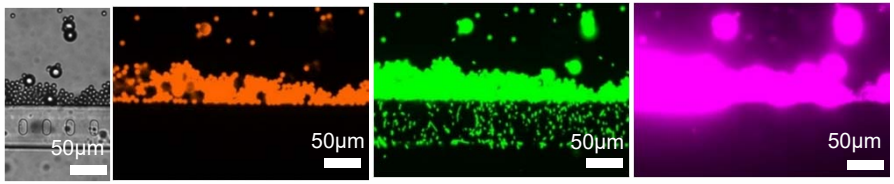


Previous semester – passive vs. active separation

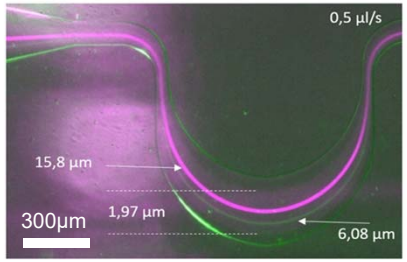
Crossflow

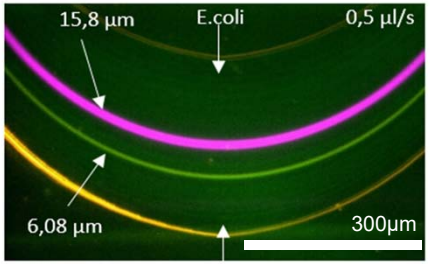


15,8 µm DAPI (purple)	6,08 µm Cy3 (orange)	E.Coli FITC (green)

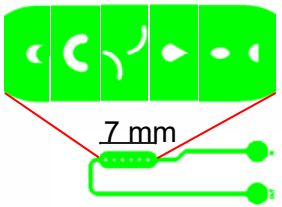


Lateral focusing





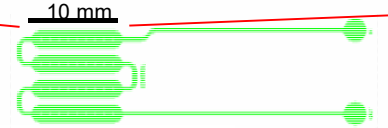
Magnetic

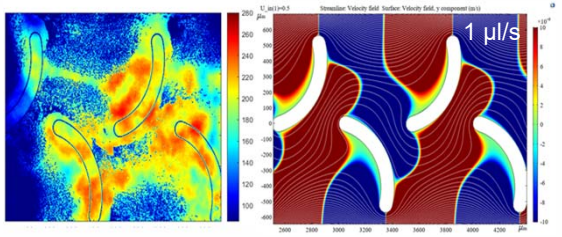


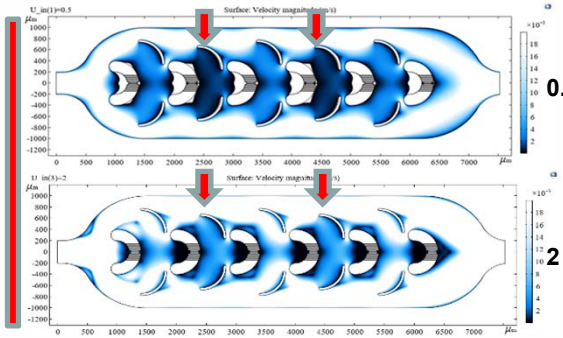
25µm_1µl/s_2.8µm_ M: 5x5x5 mm³ _N48

25µm_1µl/s_2.8µm_ M: 10x4x2 mm³_N52

25µm_1µl/s_2.8µm_ M: 10x10x5 mm³ _N52



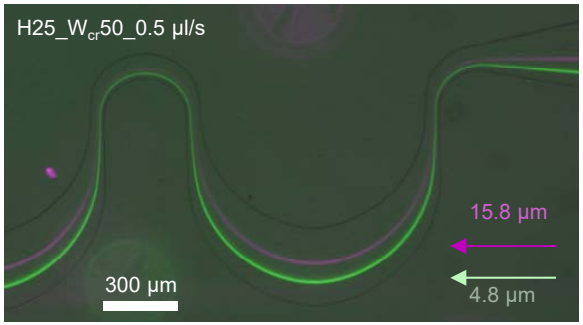


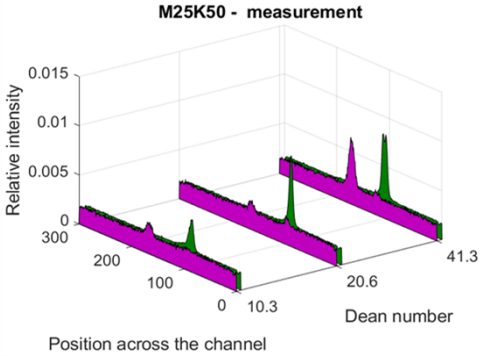


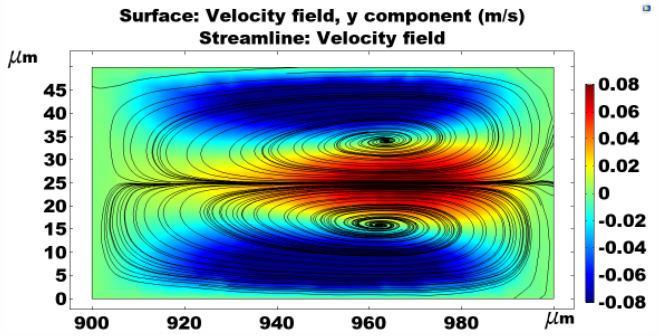
Current semester – active separation, IVD

- **Manuscript writing** about Lateral focusing
  - one article already published, the second one will be give in summer
- Continuing **work at 77 Elektronika Kft.** in the frame of Cooperative doctoral program: Lab-on-a Chip device development for in-vitro diagnostics (IVD) device.
- Studies in autonom fluidics, aiming **Magnetoforetic separation**
  - the effect of the capillary pump with different suction strengths on trapping (bead Ø = 2.9 µm)
  - the effect of changed flow rates on the magnetic trapping due to surface treatment
  - the behavior of fluorescent magnetic beads (Ø = 0.35 - 0.47 - 0.9 - 1.31 µm) in sample dosing and washing step
  - the efficiency of several magnets based on its size, strength, and position

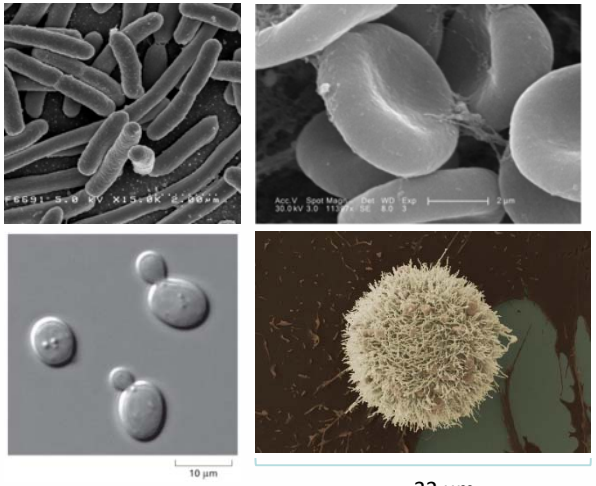
Lateral focusing – Model vs. living cell





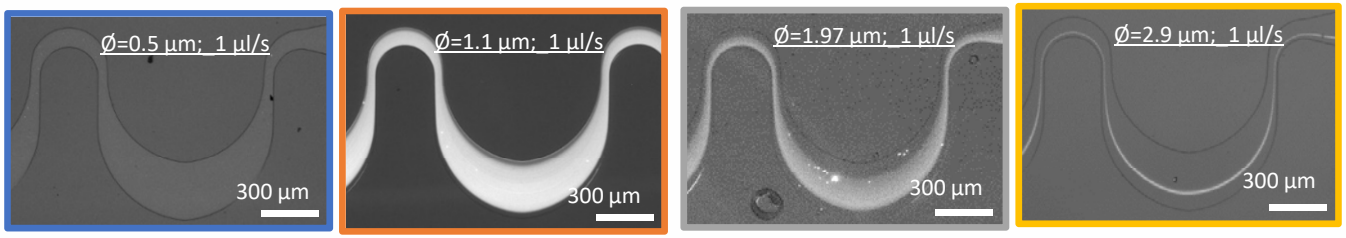


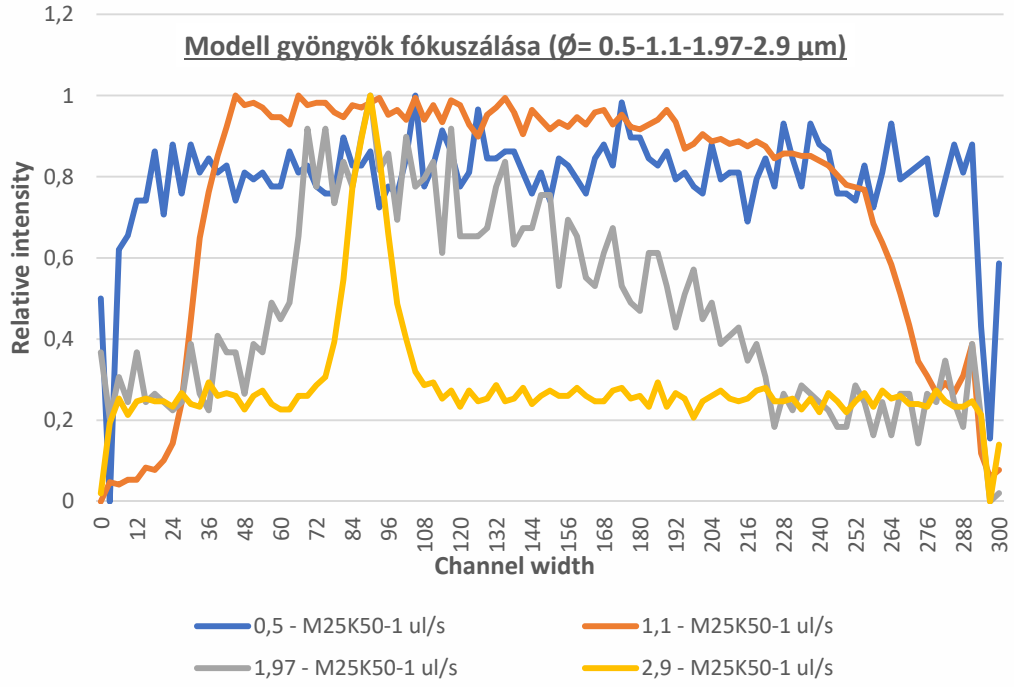
			Size		
	Used cell	Figure	Height	Width	Size of the Modell beads(Ø)
Bacteria	E.coli	stick	0.5 µm	2 µm	0.5 - 1.1 - 1.97 - 2.9 µm
Hematopoietic	Red Blood Cell	donut	2.2 µm	7.2 µm	2.9 - 4.8 - 5.4 - 6.08 µm
Yeast	Saccharomyces cerevisiae	round or oval	5-10 µm		5.4 - 6.08 - 10.2 µm
Cancer cell line	HeLa cell	diverse, inhomogeneous, spherical in suspension	20-40 µm (according to some sources: 17.1 µm)		15.8 - 16.8 µm



https://www.microbiologyinpictures.com/bacteria-photos/escherichia-coli-photos/e.coli-bacteria-sem.html
https://www.nisenet.org/catalog/scientific-image-human-red-blood-cells-sem
B. Alberts, *Essential cell biology*, Fourth edition. New York, NY: Garland Science, 2013
https://wellcomecollection.org/works/a3q9b4tb

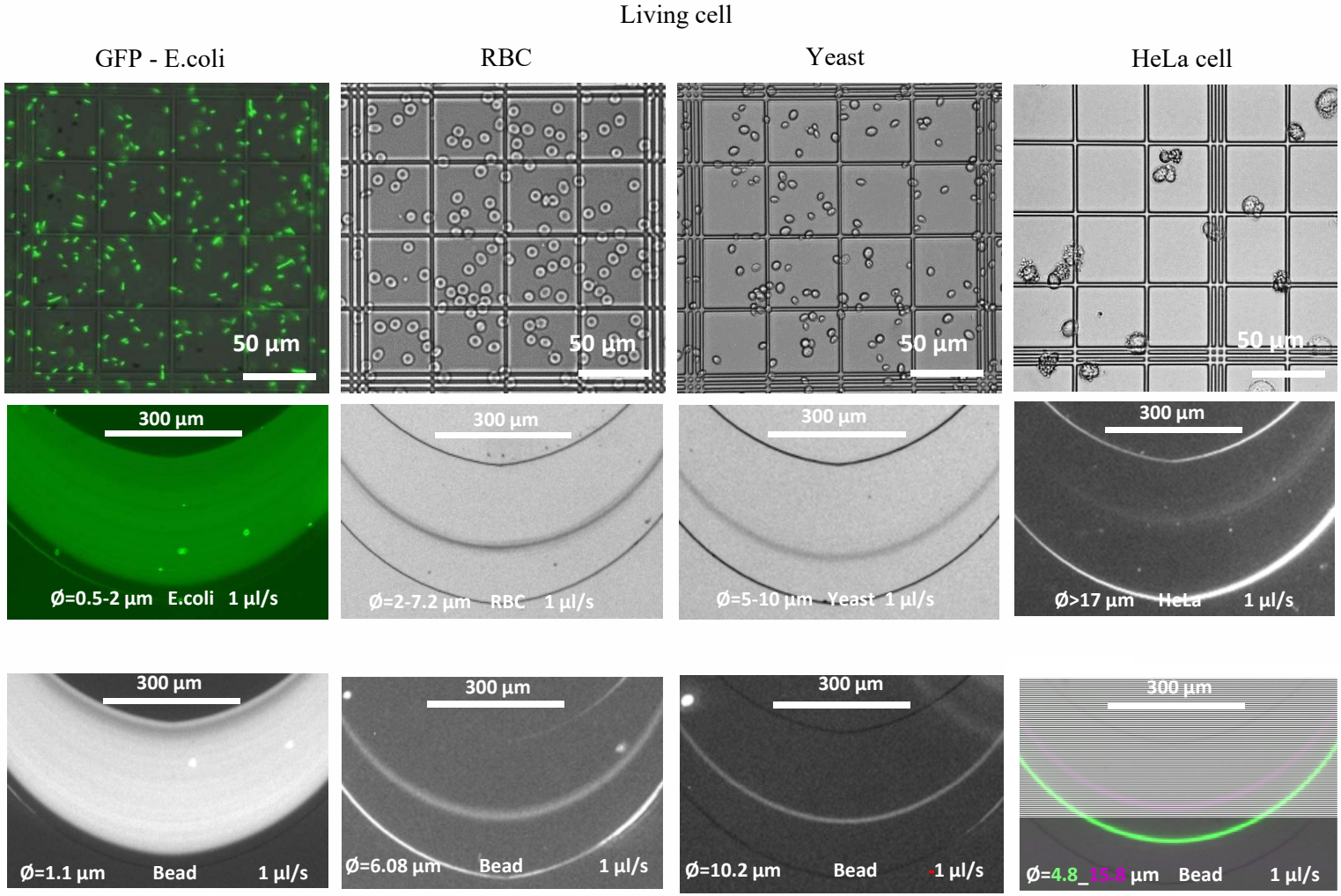
Lateral focusing – Model vs. living cell





Bead' size (µm)	Lateral pozition (0-300 µm)
2,90	90
4,80	98,2
5,40	138
6,08	135
10,20	117
15,80	164,2
16,50	114

Lateral focusing – Model vs. living cell



Bead models equivalent to the lateral position of the selected living cells

Summary

- Lateral focusing of biological samples (RBC, E.Coli, yeast, HeLa cells) were characterised and compared to behaviour of rigid beads
- Magnetic separation was investigated by using autonomous microfluidics design to ensure homogenous trapping of magnetic beads at the sensor zone

(1) Influence of capillary pump strength (flow) on homogeneous trapping
(2) Filling test of fluidics after materials surface treatment
(3) Magnetic tests (same magnet size)
- Pole orientation.
- Magnetic field.
- Distance.

Plan

- Fulfill measurements with surface treated magnetic beads
- Give in the manuscript for the second article in Lateral focusing
- Futher investigation in DRIE methods and hot embossing technology

Conferences – in this month
(abstracts already accepted)

- 2022. June 12-17. Mátrafüred conference 2022, Visegrád
  Own topics: **Filtration efficiencies of crossflow type microfilters for E.Coli separation**
  Anita Bányai[1,2,3], Máté Varga[3], Péter Fürjes[1]
- 2022. June 20-21. SelectBio, Lab-on-a-Chip and Microfluidics Europe 2022, Rotterdam 2022
  Own topics: **Magnetophoretics separation in microfluidics application**
  Anita Bányai[1,2,3], Eszter Leelőssyné Tóth[1], Péter Fürjes[1]
- 2022. June 26-1. AMETIS 2022, Taglio, Corse, France
  Own topics: **Shape design dependent performance of DLD (deterministic lateral displacement) based particle separation systems - FEM modelling and validation**
  Anita Bányai[1,2], Petra Hermann[1], Orsolya Hakkel[1], Zoltán Hajnal[1], Péter Fürjes[1]

Publications

[1]Geometry-Dependent Efficiency of Dean-Flow Affected Lateral Particle Focusing and Separation in Periodically Inhomogeneous Microfluidic Channels
by Anita Bányai 1,2,3,*,Eszter Leelőssyné Tóth 1,Máté Varga 2 and Péter Fürjes 1

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