UNIVERSITY OF CAMBRIDGE

Designing Platinum features to mimic protein channels

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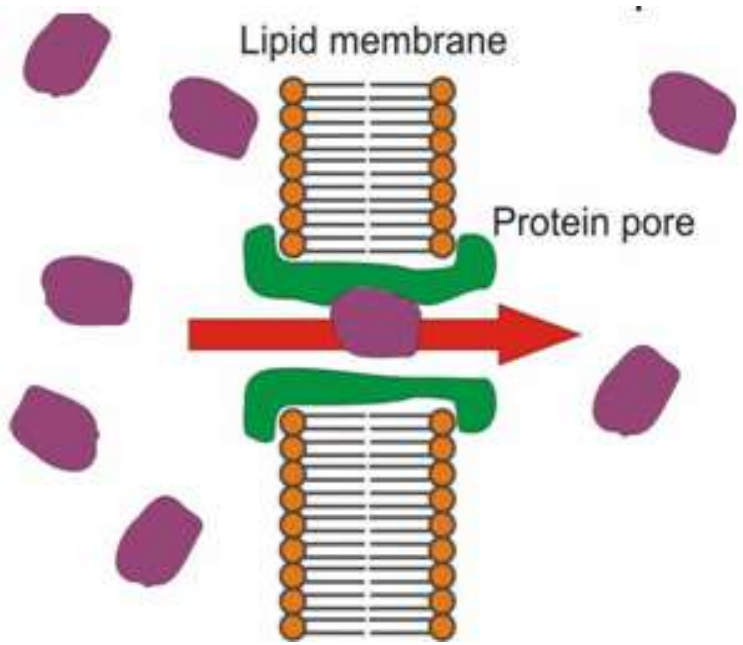
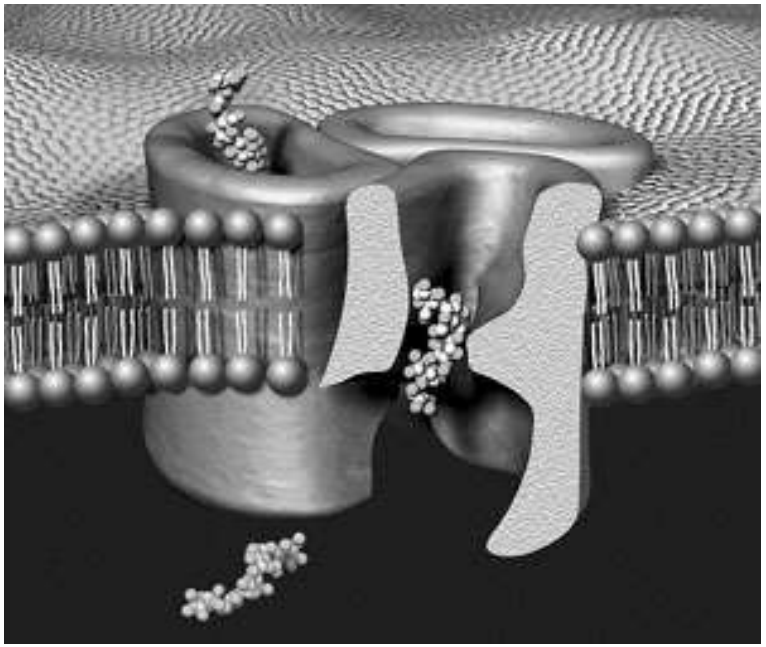
Outline

- Channel-facilitated membrane transport
- Lab-on-a-chip fabrication technologies
- Chip fabrication exploiting Platinum features
- Single particle control
- Conclusions and outlook

Channel-facilitated membrane transport

Transport of solutes across living system membranes occurs through membrane protein forming water-filled channels





Maltose translocating the maltoporin channel in E. Coli

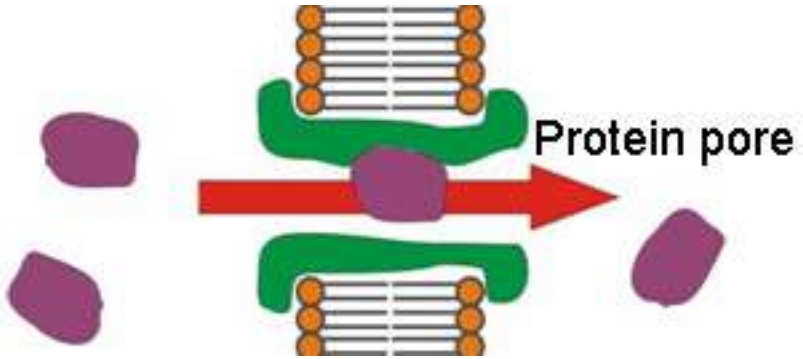
Understanding the transport mechanism → more efficient drugs

L. Kullman *et al*, *Biophys J* **82**, 803, 2002

E. M. Nestorovich *et al*, *PNAS* **99**, 9789, 2002

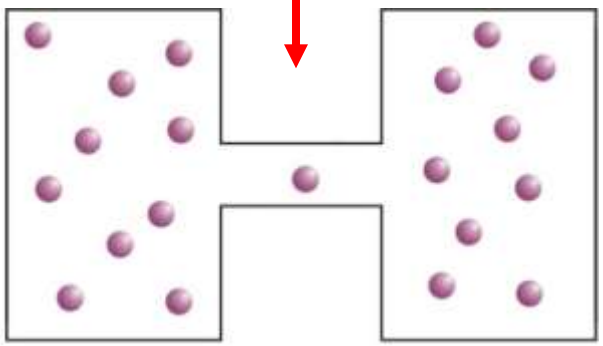
Model system

Nanoscale inaccessible natural system

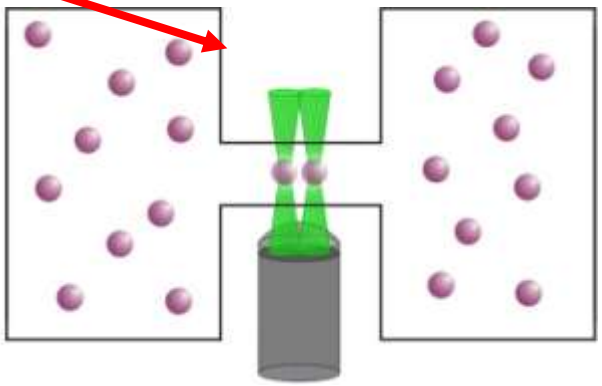


Microscale controllable model system

Colloids



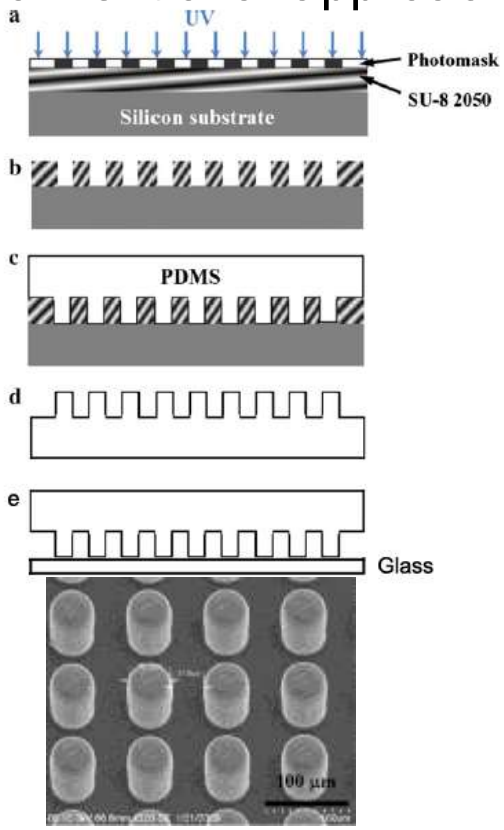
Microfluidics



Holographic optical tweezers

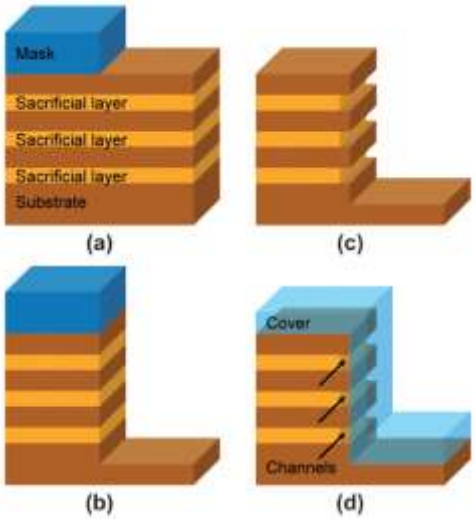
Lab-on-a-chip fabrication technologies

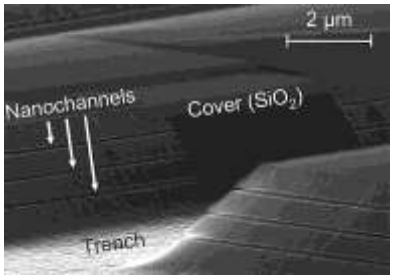
Conventional approach



Microscale planar features

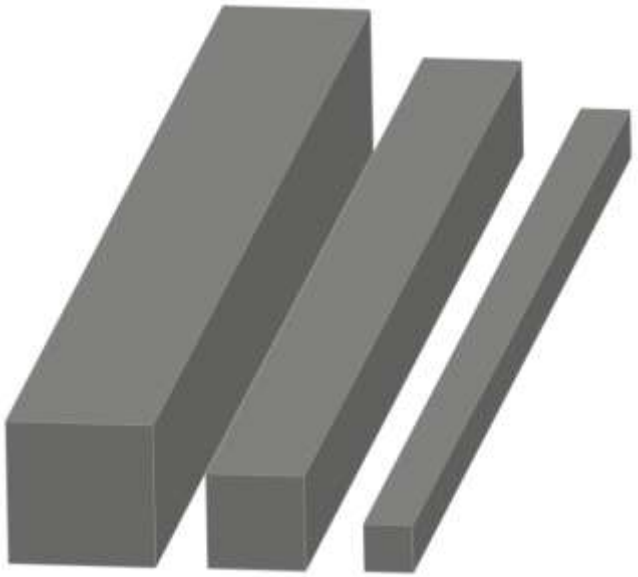
Alternative approach





Nanoscale planar features

Challenge: 3D control



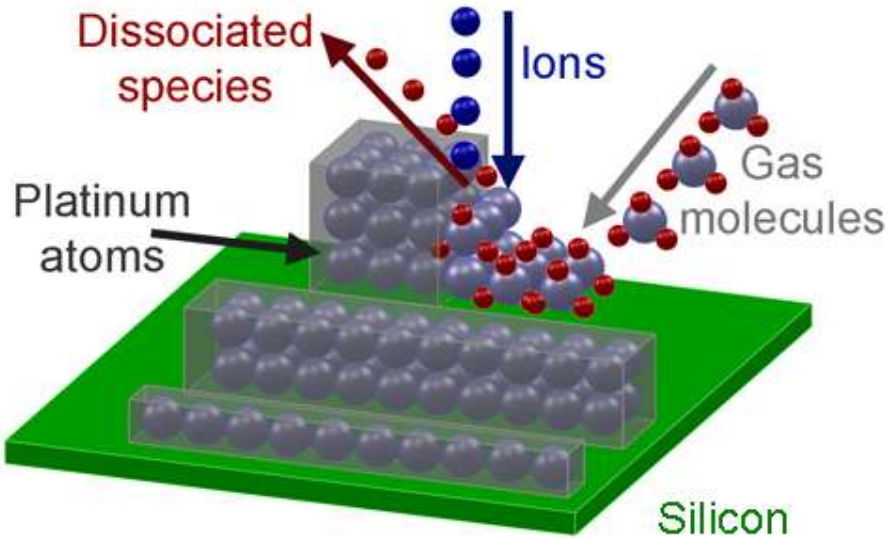
Nanoscale features

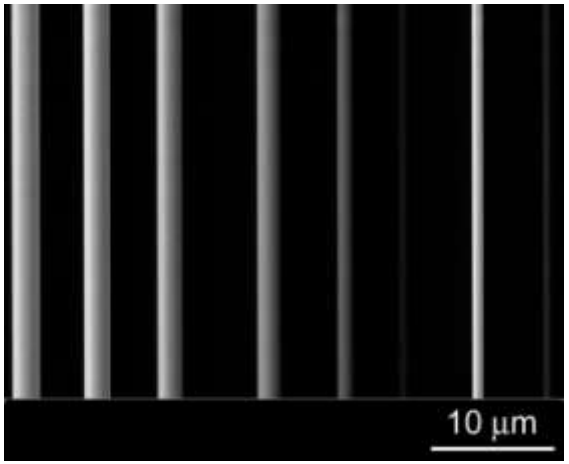
with variable thickness

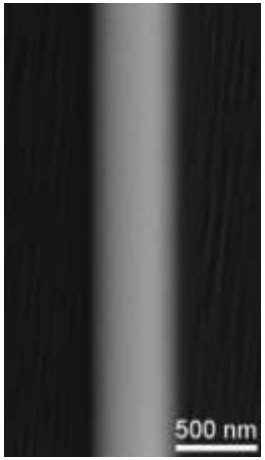
J. Yeo et al *Microsyst Technol* **16**, 1457, 2010

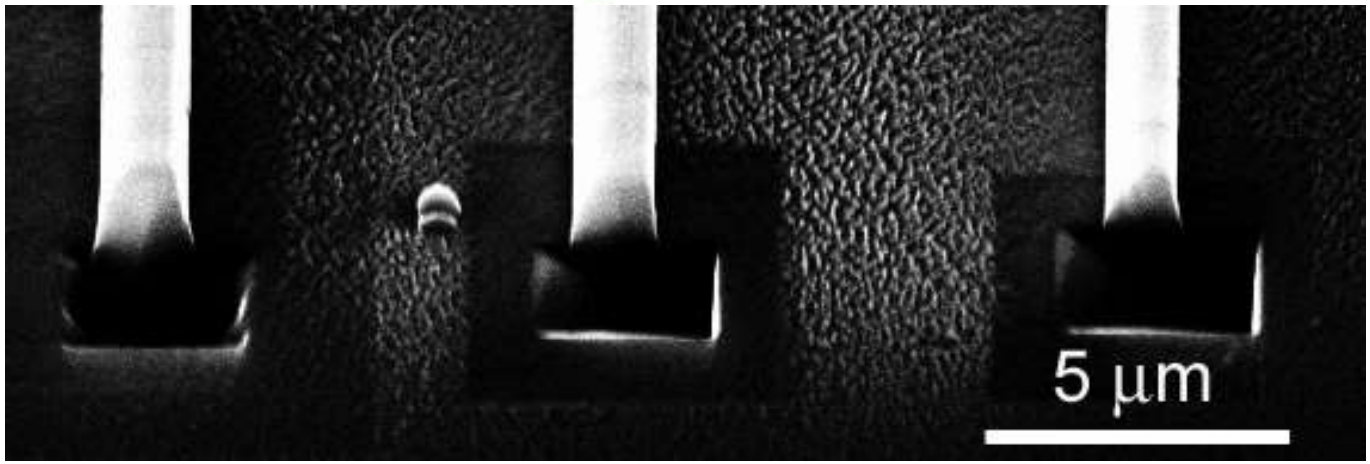
R. Sordan et al *Lab Chip* **9**, 1556, 2009

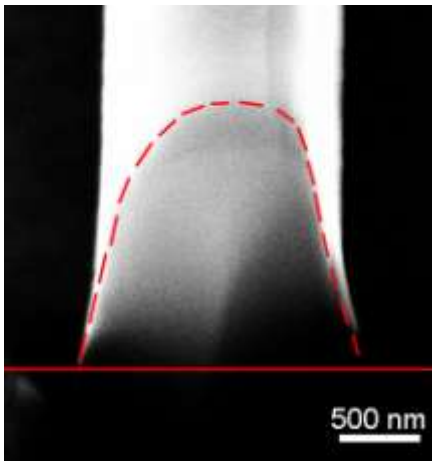
Chip fabrication exploiting focused ion beam



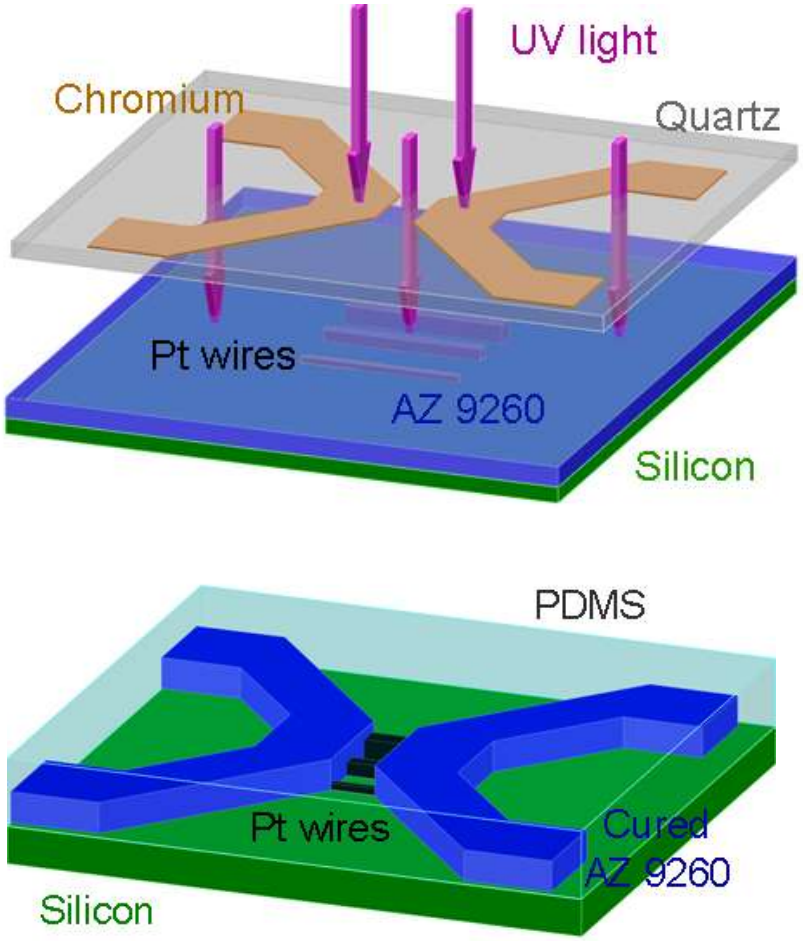


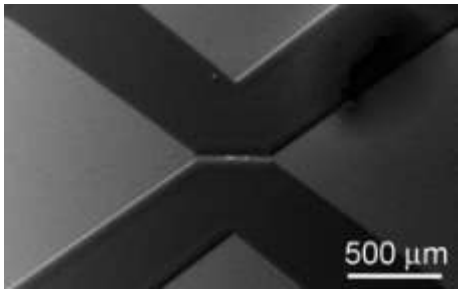


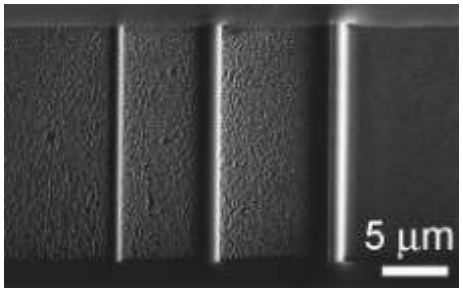


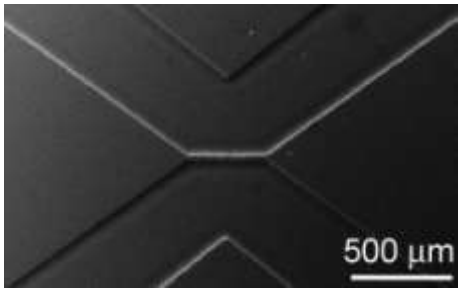


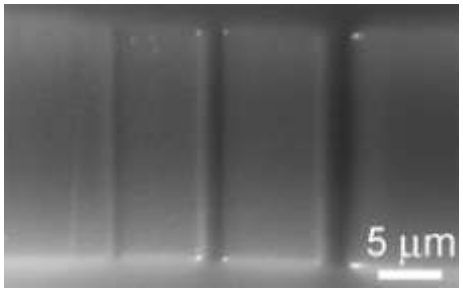
Chip fabrication. Photolithography and replica molding



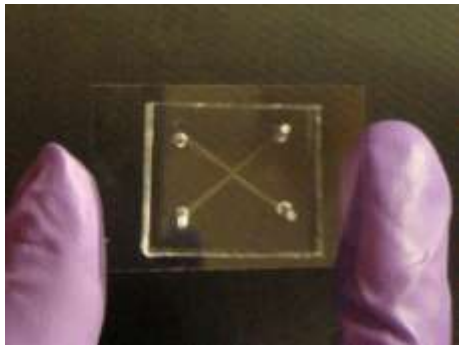








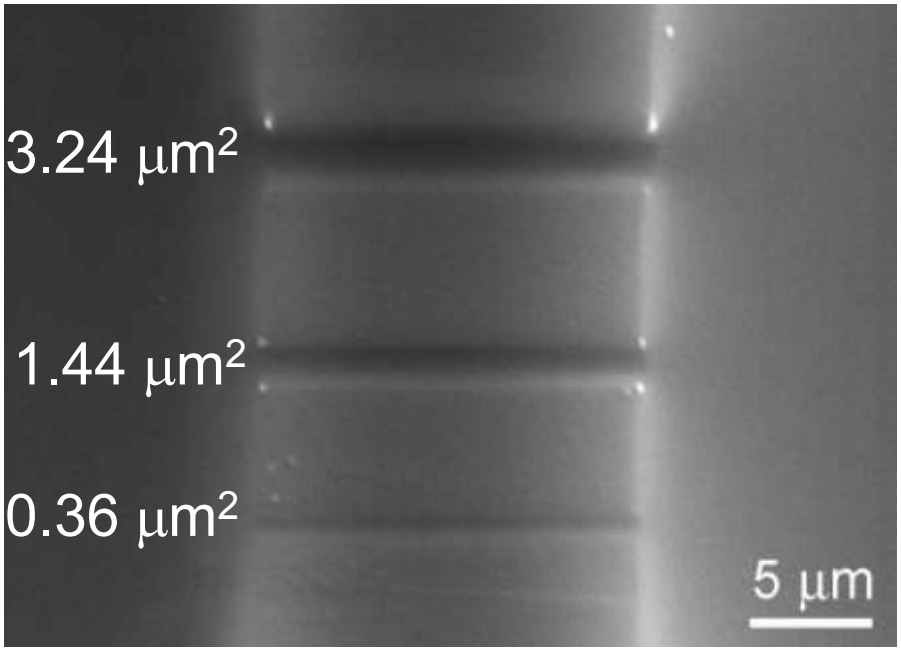
Final device: patterned PDMS chip bonded to a glass slide



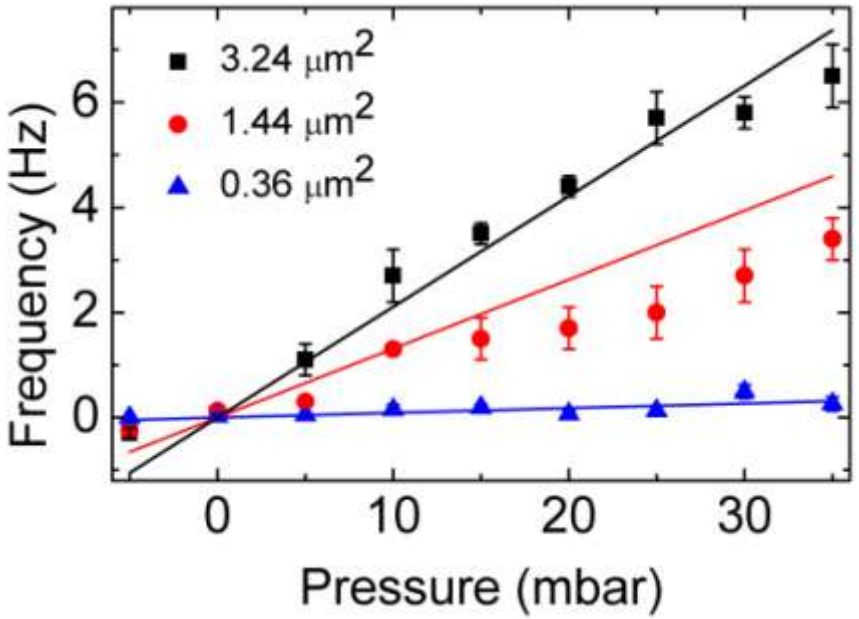
S. Pagliara, *Lab Chip* **11**, 3365, 2011

Particle control by pressure gradient

Flow control of 300 nm particles through an array of microchannels with different cross section via computerized pressure-based flow control system



Poiseuille flow $f \propto \Delta P$



S. Pagliara, *Lab Chip* **11**, 3365, 2011

Particle manipulation with holographic optical tweezers (HOT)

Use of a spatial light modulator to split a single laser beam into many optical traps that can be independently positioned in 3D

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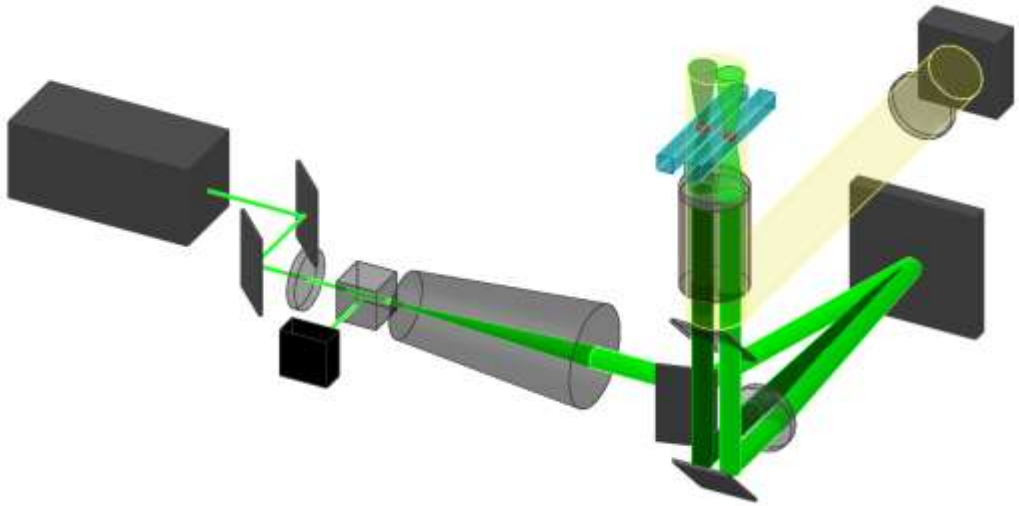
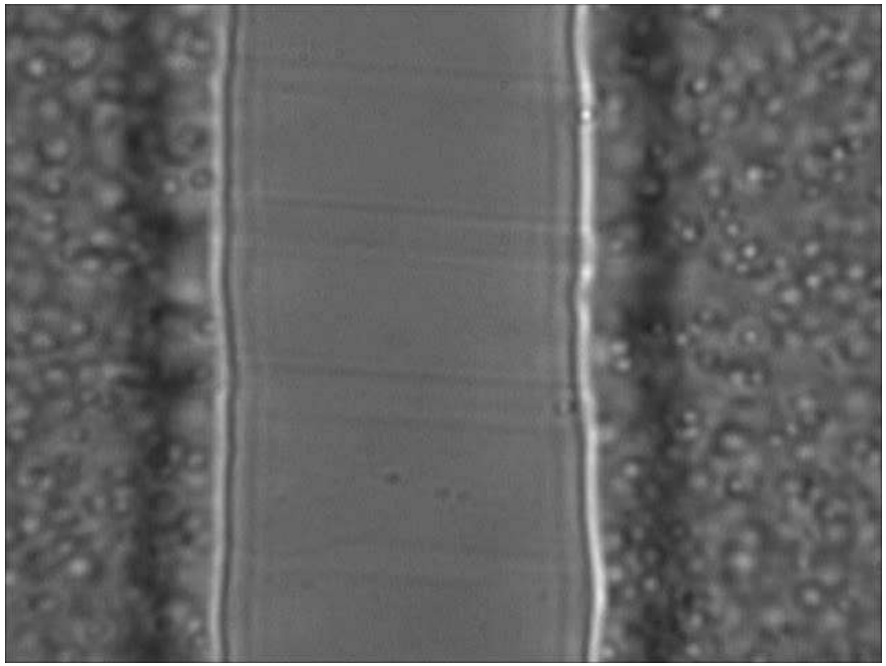
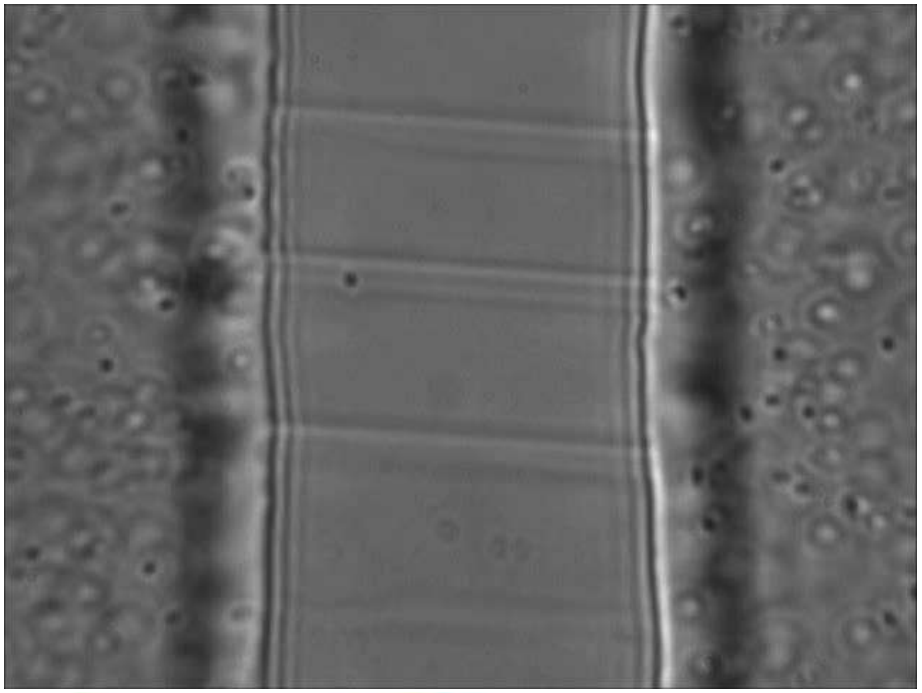
Manipulation of different particles in different channels



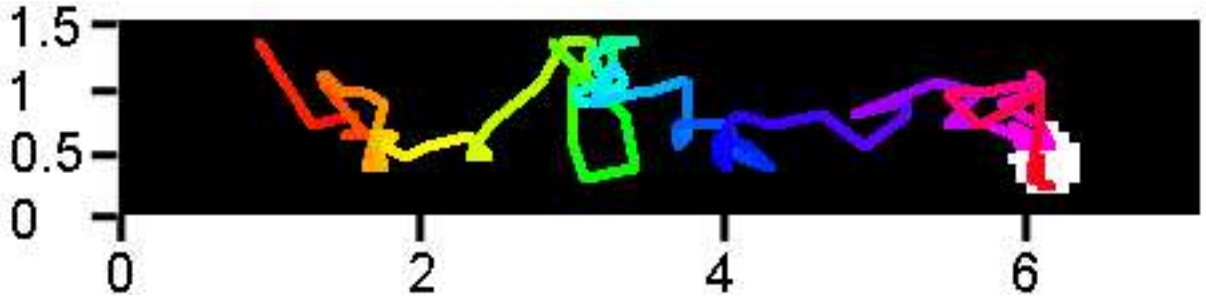


Particle tracking

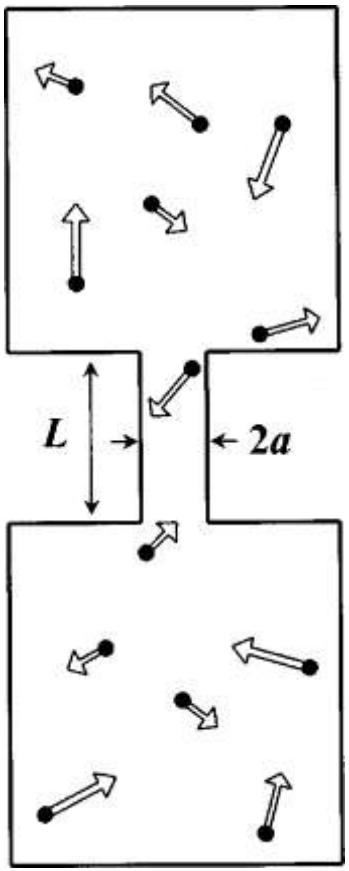
Tracking single particles diffusing through the different microfluidic channels



Particles are isolated from the background and tracked by a custom-made program based on Labview



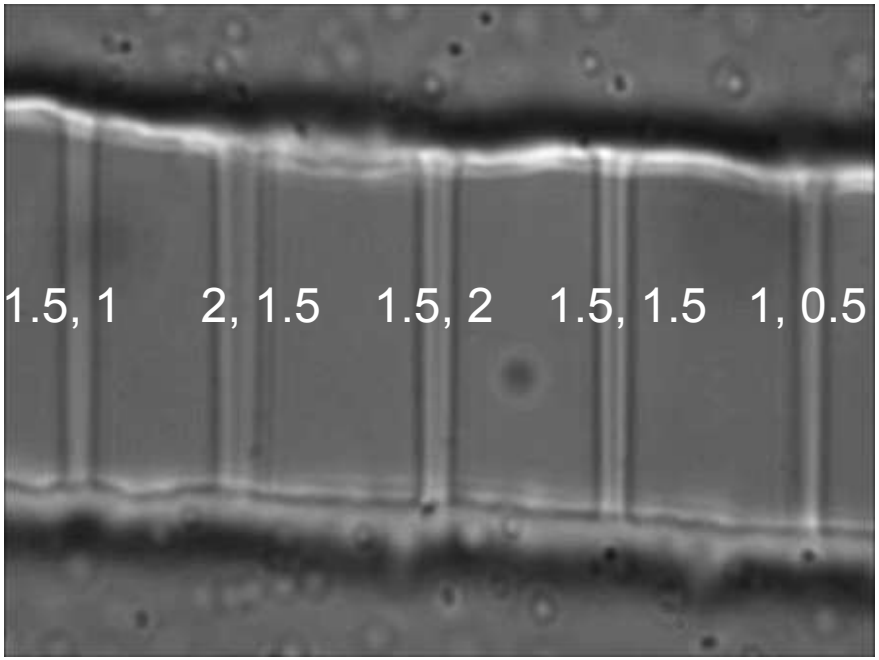
Particle diffusion through long and narrow microchannels



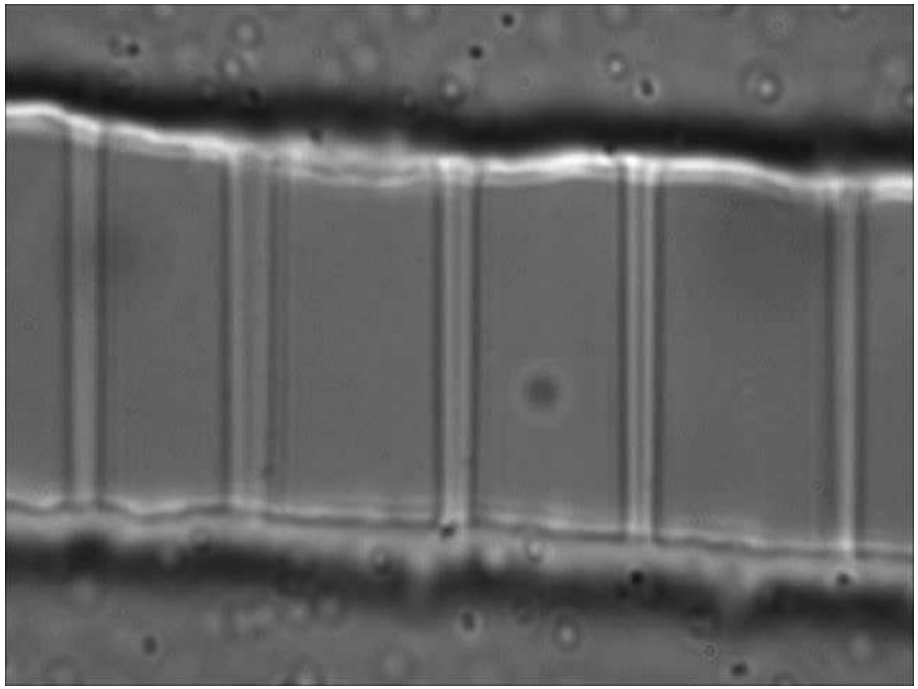
The microfluidic chip is filled with carboxyl-functionalized polystyrene particles with mean diameter of 500 nm dispersed in a 0.2 % solids (w/v) 5 mM KCl suspension

27 particles per 10 μm^3

The microscopic reservoirs are connected by five parallel channels with different width and thickness:



Particle diffusion through arrays of microchannels

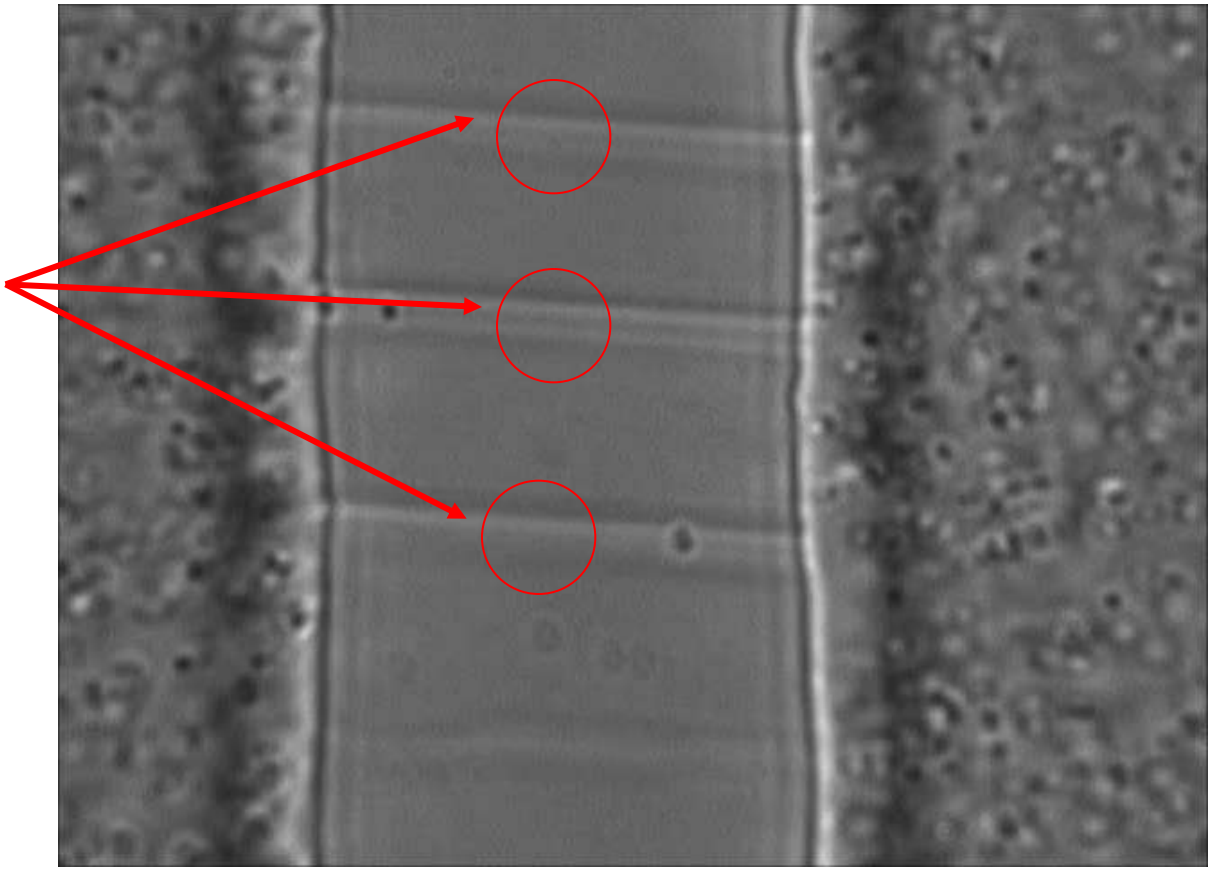


Width Thick.	1.5 1	2 1.5	1.5 2	1.5 1.5	1 0.5
Pred. Att.	1.5	2.5	2.5	1.5	0
Top Att.	2	2	3	1	0
Bot. Att.	1	3	1	1	0

Particle diffusion with binding sites

Looking for the optimal binding potential in protein channels

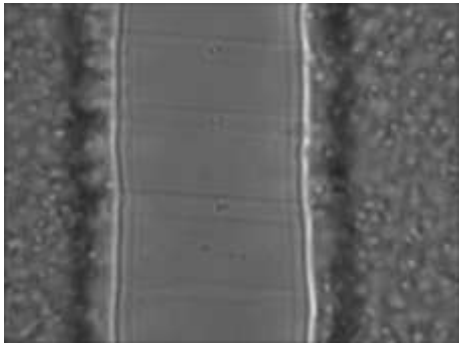
3 optical traps with different intensity placed in the middle of 3 different channels with the same dimension



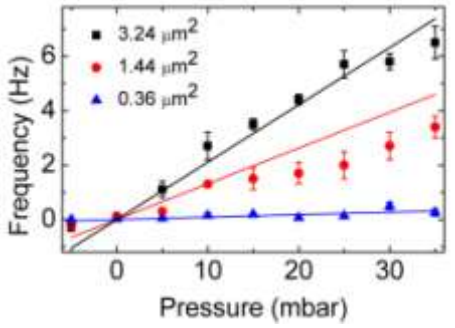
Conclusions

- Parallel channels with variable height and width

- Particle diffusion inside microfluidic channels

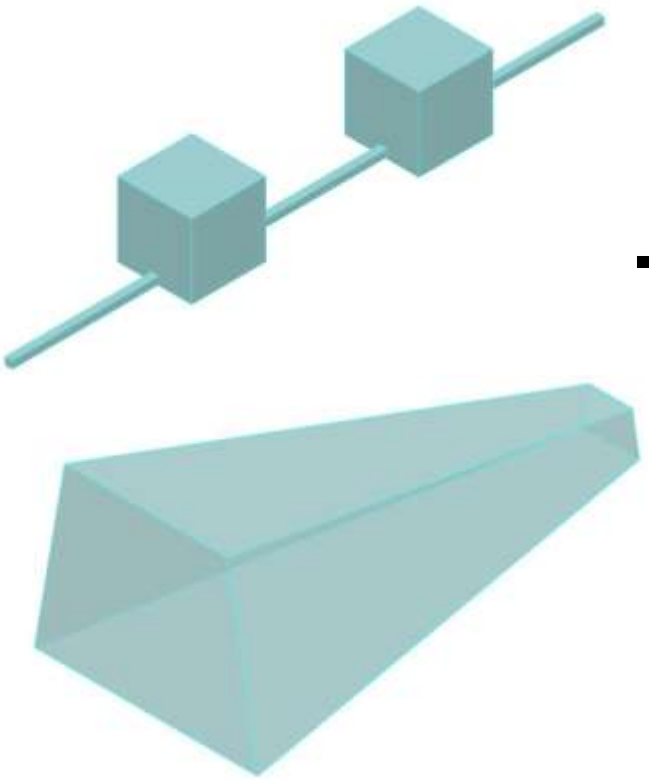


- Particle control through holographic optical tweezers and pressure gradient

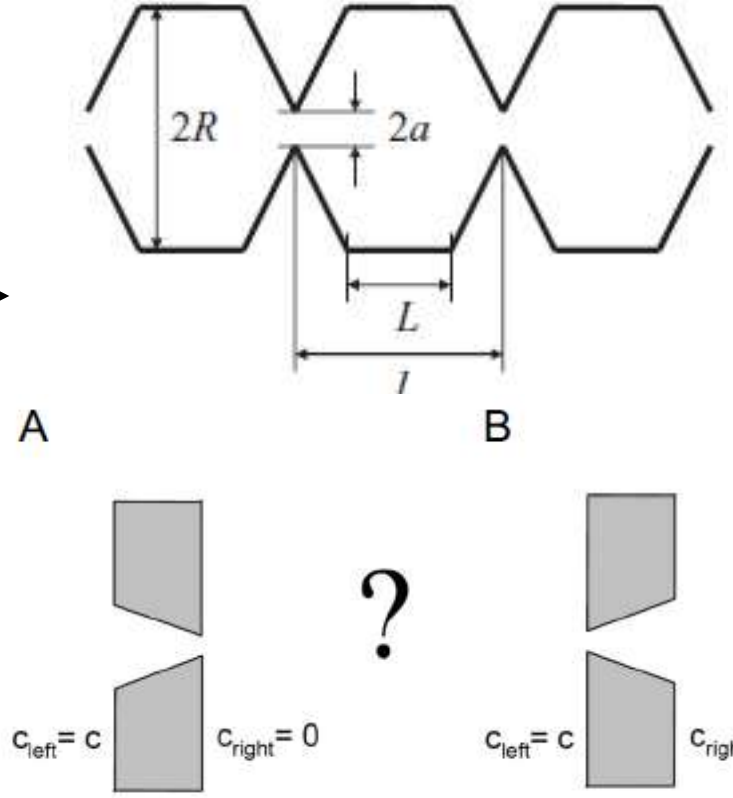


Outlook

FIB deposition of complex 3D structures



Entropic effects in particle transport



L. Dagdug *et al*, *J Chem Phys* **134**, 101102, 2011

A. M. Berezhkovskii *et al*, *Phys Rev E* ***80***, 020904, 2009

Acknowledgments

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Thank you for the attention!