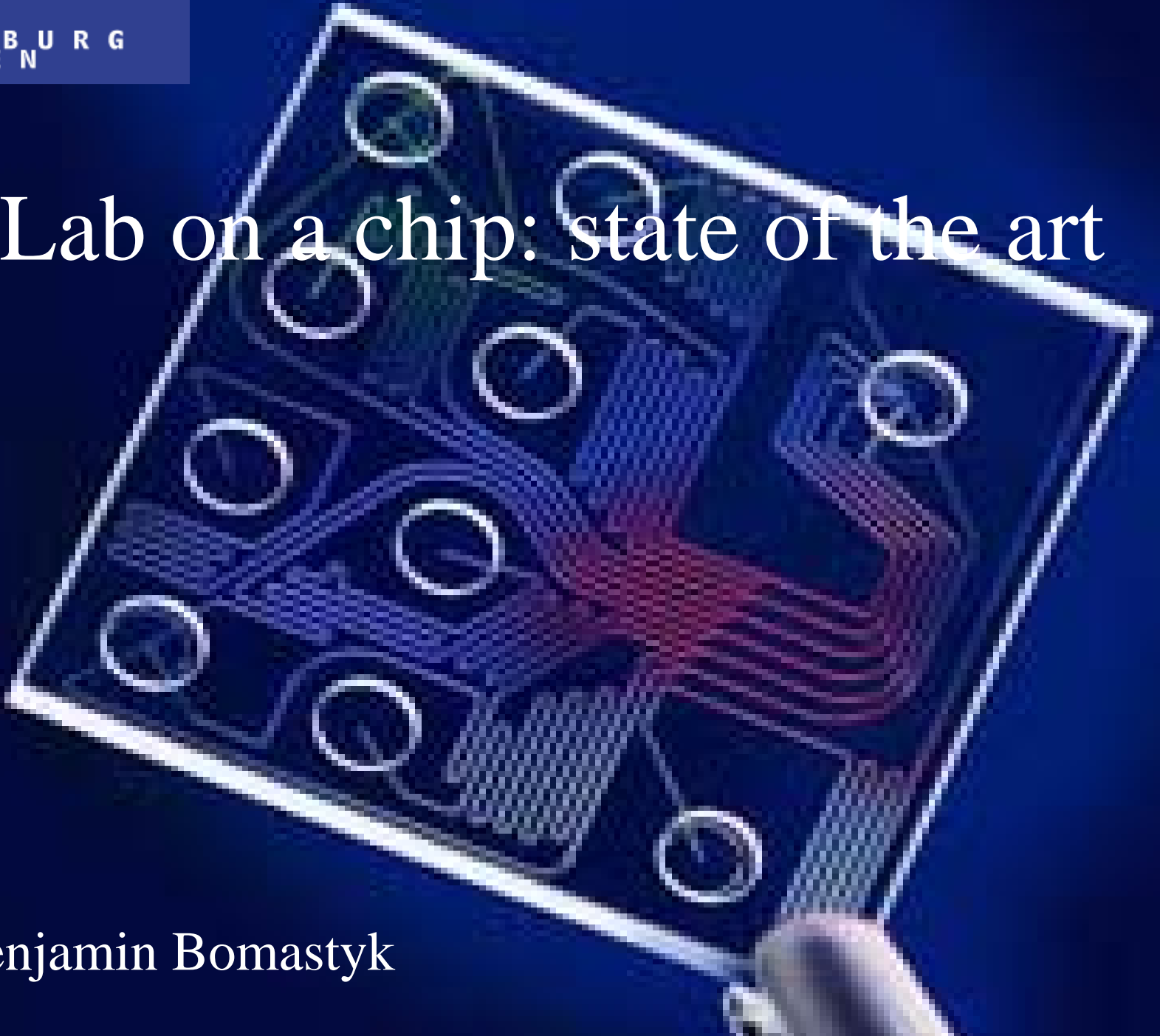


Lab on a chip: state of the art

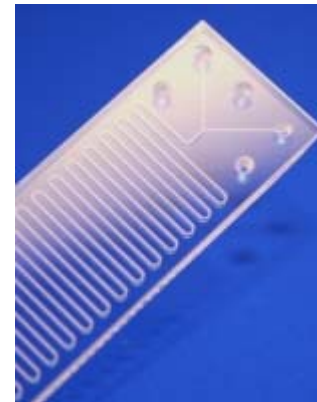
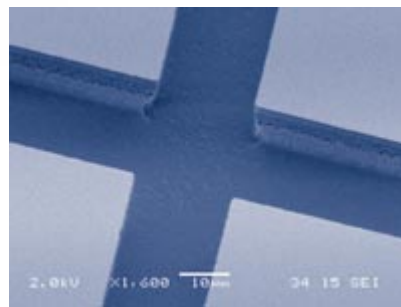
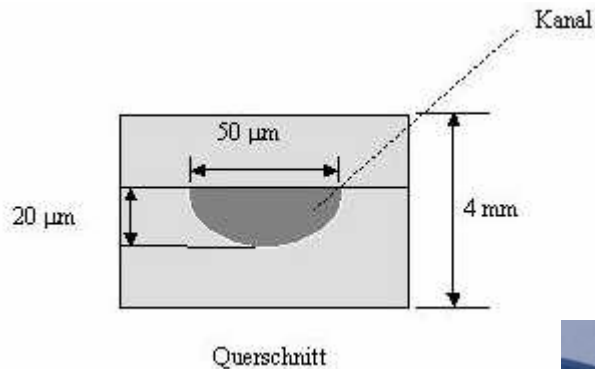
Benjamin Bomastyk



Lab on a chip technology

Definition

- Devices that integrate multiple laboratory functions on a single chip
- Size of only millimeters to a few square centimeters
- Handling of extremely small fluid volumes down to less than pico liters



Source: <http://en.wikipedia.org/wiki/Lab-on-a-chip>

<http://www.micronit.com/>

Lab on a chip technology

Beneficiaries

- Biotechnology
- Pharmacy
- Chemistry
- Research

„Microfluidics“

- Microfluidic dispenser
- Concentration gradient generator
- Electrophoretic separator
- Micro bio-reactor
- PCR chip for DNA amplification
- Quantitative DNA sensor chip (capable of detecting single-pair mismatch)
- Flow cytometer Lab-on-a-Chip
- Immunoassay Lab-on-a-Chip for bacteria (e.g., E.coli, H. pylori) detection
- Real-Time PCR detection chips (for detecting E. coli, cancers, etc)
- Blood sample preparation Lab-on-a-Chip
- Cellular analysis Lab-on-a-Chip

„Microarrays“ (Biochips)

DNA microarrays

Protein microarrays

Lab on a chip technology

Advantages

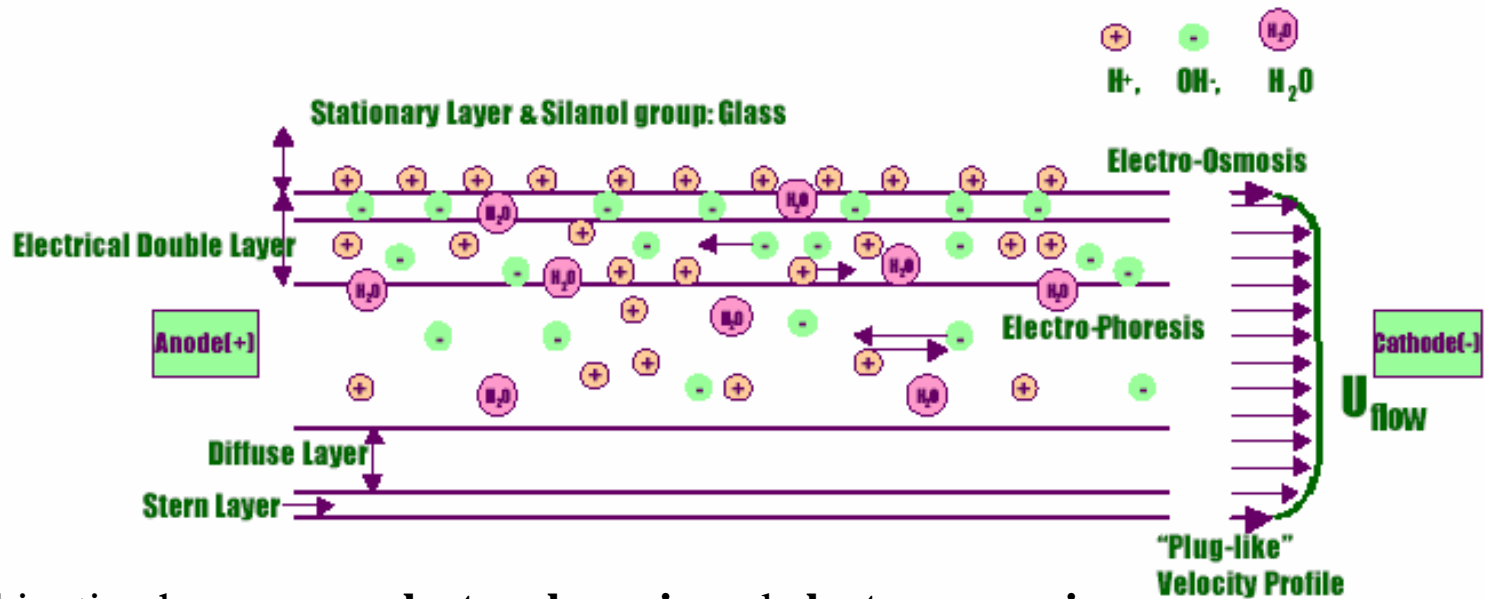
- Low fluid volumes consumption (less waste, lower costs of expensive reagents)
- Less sample fluid needed for the analysis
- Short mixing times (short diffusion distances)
- Fast heating
- Better process control (faster response of the system by chemical reactions)
- Suitable for high-throughput analysis
- Lower fabrication costs for chips fabricated in mass production
- Safer platform for chemical, radioactive or biological studies
(low stored fluid volumes and energies)

Lab on a chip technology

Microfluidics and Electrokinetics



Laminar flow in a microchannel
Low Reynolds number $\ll 1$

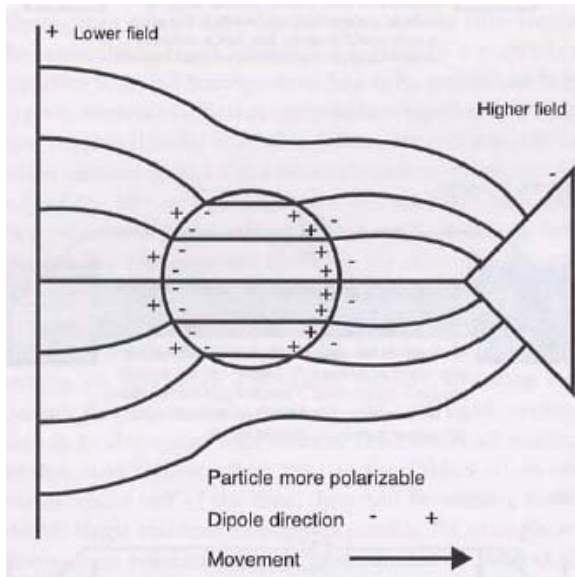


Electrokinetic phenomena: **electrophoresis** and **electro-osmosis**

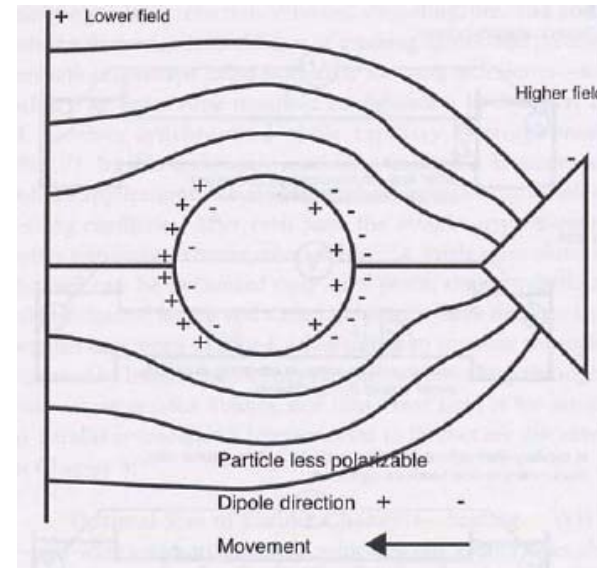
Lab on a chip technology

Microfluidics and Electrokinetics

Dielectrophoresis



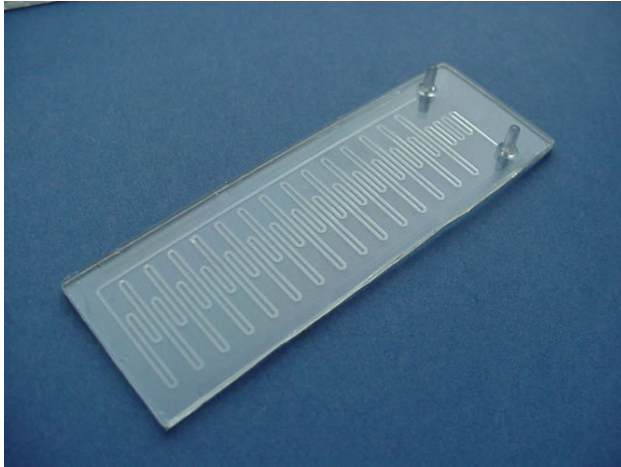
Positive DEP



Negative DEP

Lab on a chip technology

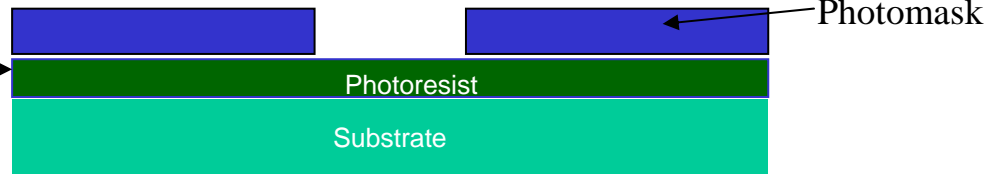
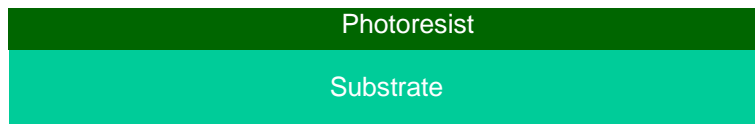
PCR-Chip



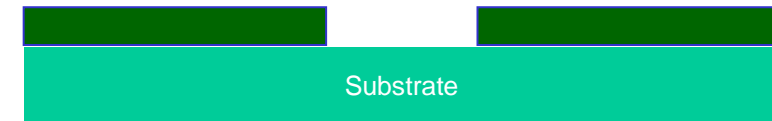
3 spacial separated heating zones are held on constant temperature

Lab on a chip technology

Photolithography



Positive Photoresist: photoresist becomes relatively insoluble to developer when exposed to light



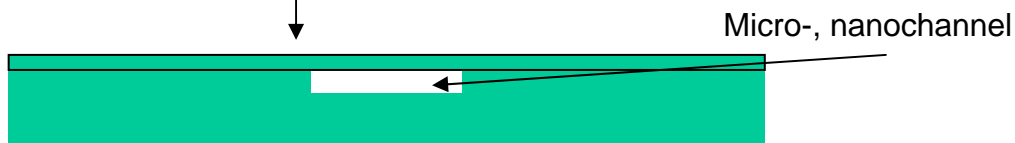
Etching of substrate



Remove unexposed photoresist

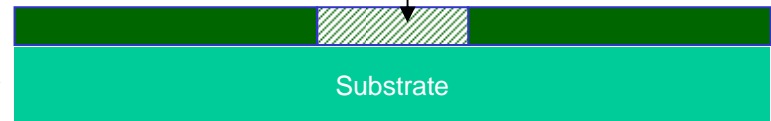


Thermally bond coverplate



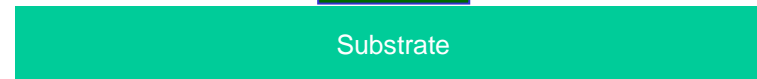
Microfluidic chip

Develop exposed photoresist

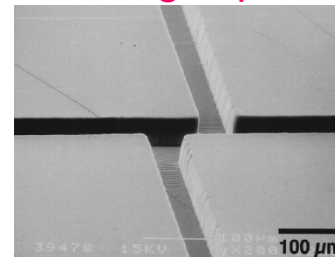


Exposure through Photomask

Develop exposed photoresist

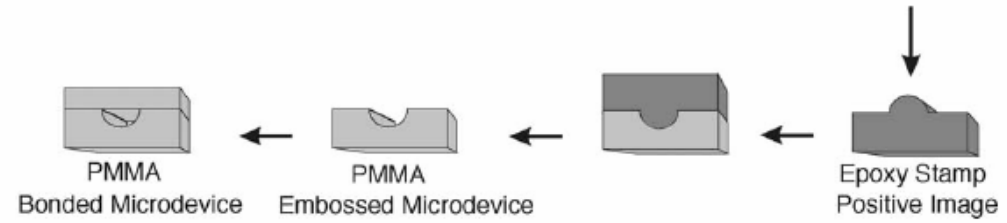
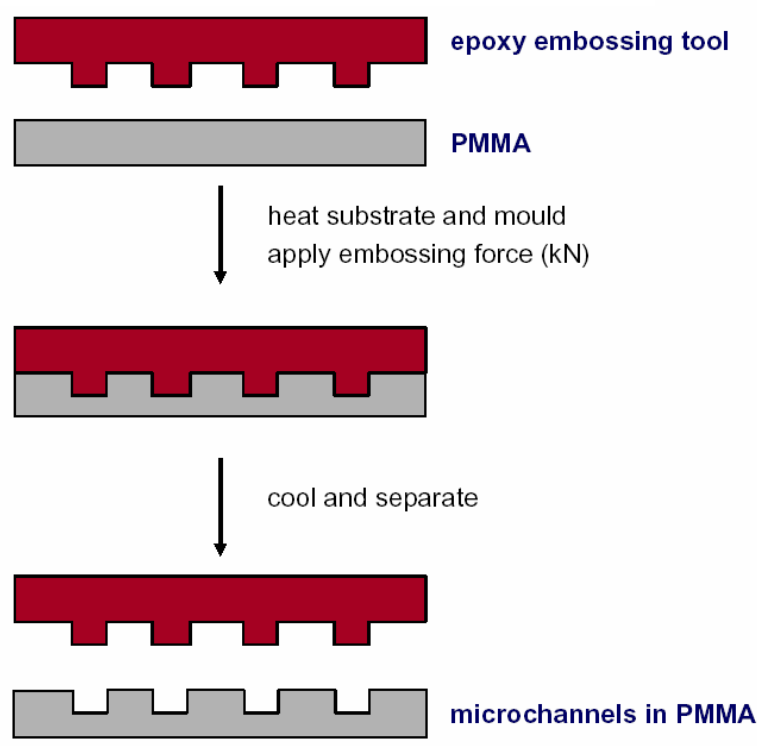
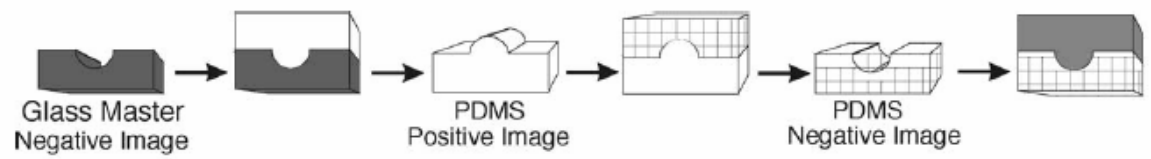


Negative Photoresist: photoresist has a higher developer dissolution rate after being exposed to light



Lab on a chip technology

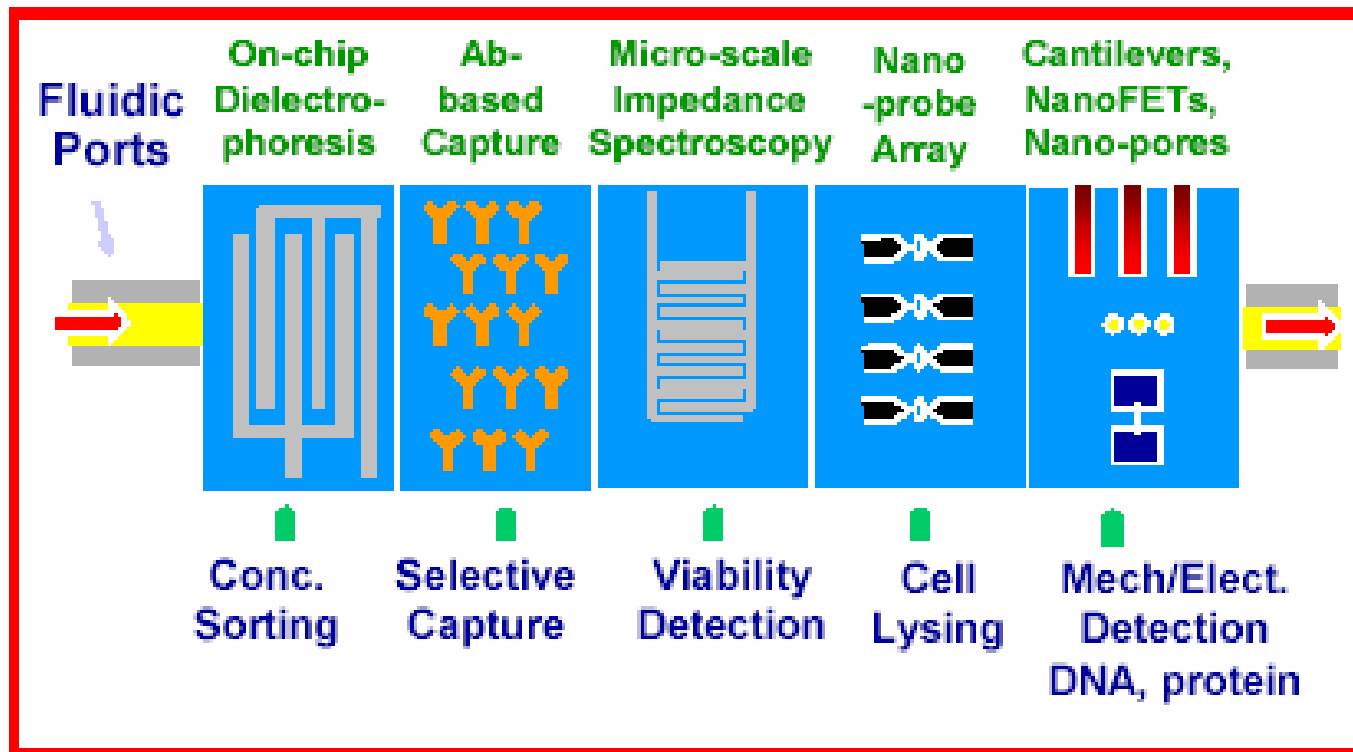
Photolithography



substrate heated to near its glass transition temperature (T_g)

Lab on a chip technology

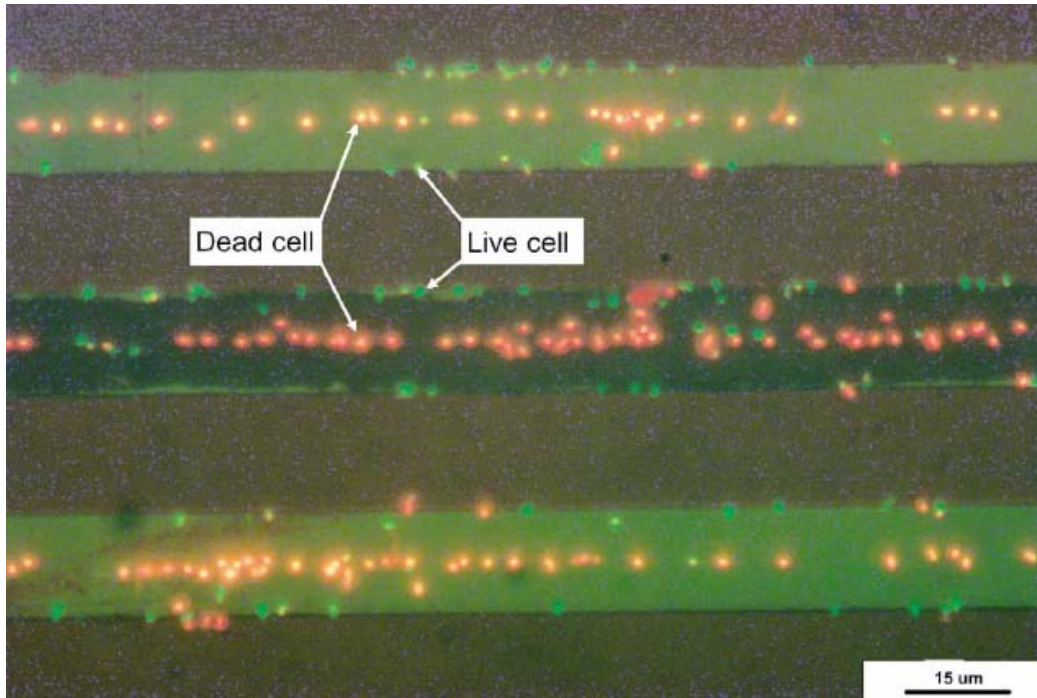
Microfluidic Chip for rapid microorganism and cell detection



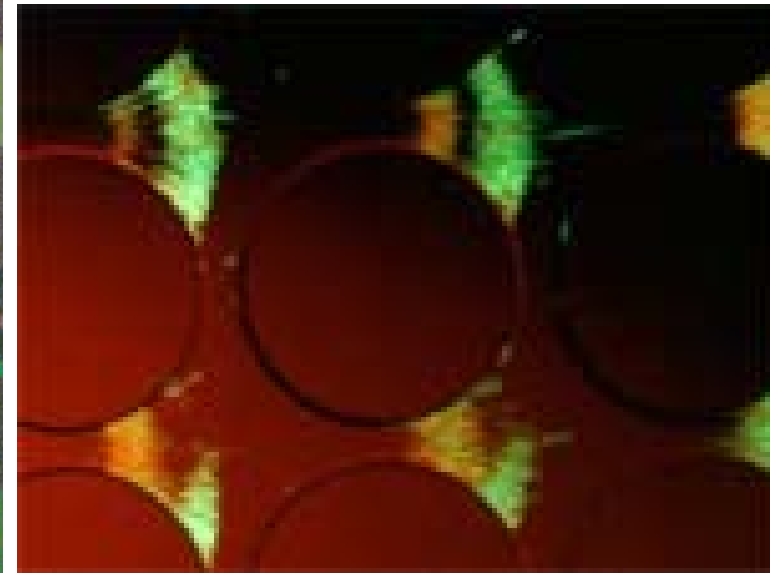
**Functions needed in an integrated fluidic biochip
for rapid cell detection**

Lab on a chip technology

Microfluidic Chip for rapid microorganism and cell detection



Dielectrophoretic separation (1V 50kHz Signal)
of alive (green)
and heat-treated (dead, red) Listeria cells



Live and dead E.coli

Genetics

becomes

Genomics



Typische Genomgrößen

Organismus	Anzahl der Gene	Anzahl der Basenpaare
Pflanzen	<50000	<10 ¹¹
Mensch	35000	3×10 ⁹
Fliegen	12000	1.6×10 ⁸
Pilze	6000	1.3×10 ⁷
Bakterien	500-6000	10 ⁷
Mycoplasma genitalium	500	10 ⁶
DNA-Viren	10-300	5000-200.000
RNA-Viren	1-25	1000-23.000
Viroide	0-1	~500
Prionen	0	;0

Lab on a chip technology

DNA Chip

DNA Microarray

Gene Array

Gene Chip

Genome Chip



The bioMérieux FoodExpert-ID microarray,
powered by Affymetrix GeneChip® technology,



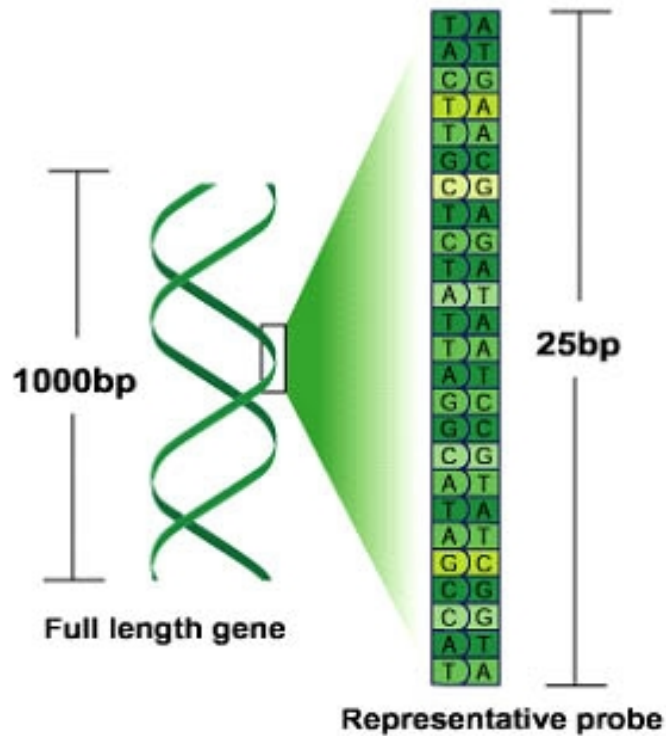
Identification of the presence or absence
of 33 different species of animals
in any food product.

Detection of DNA sequences specific to
an animal.

Great concern for public health,
economic, **religious** and legal reasons

Lab on a chip technology

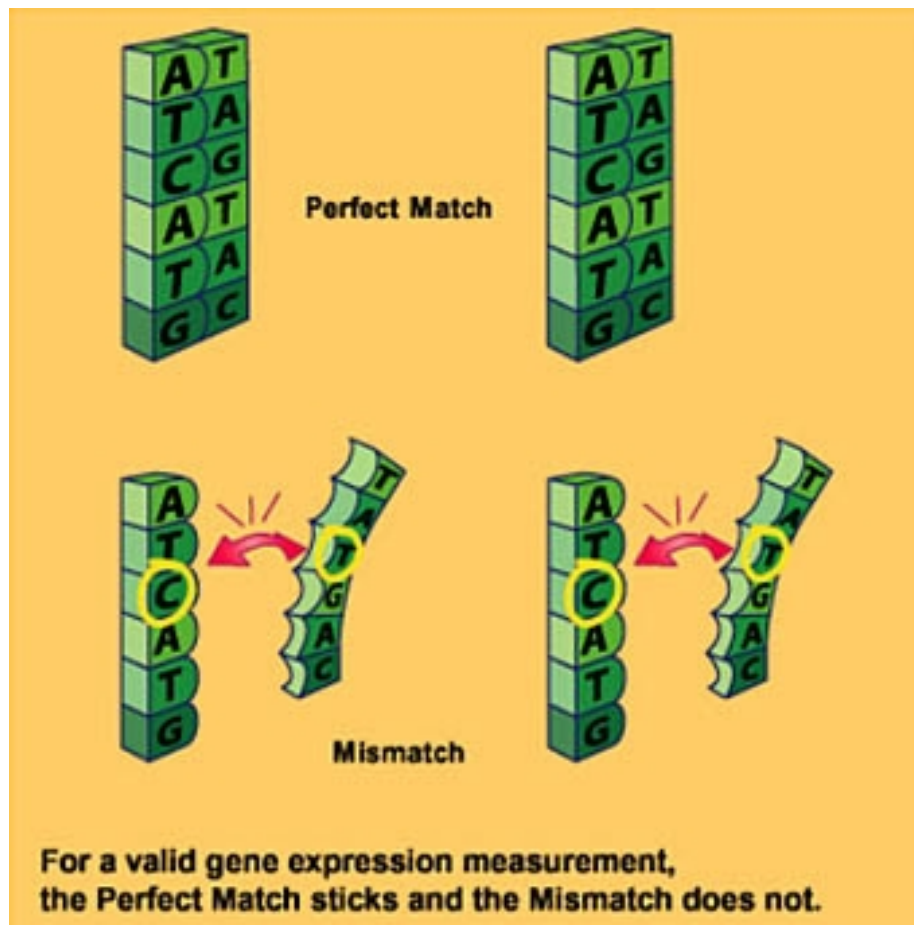
GeneChip



Construction of probes

Lab on a chip technology

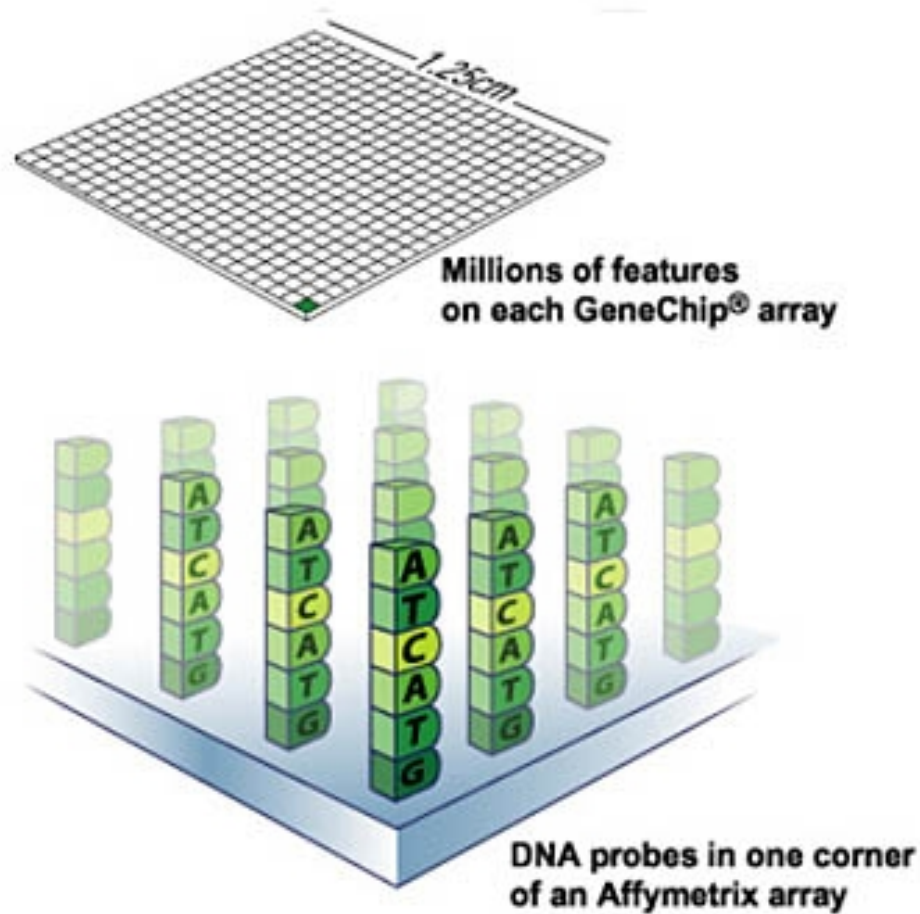
GeneChip



Matchmaker

Lab on a chip technology

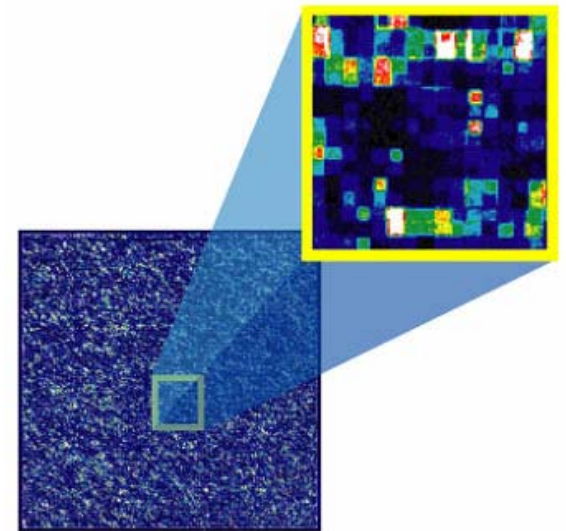
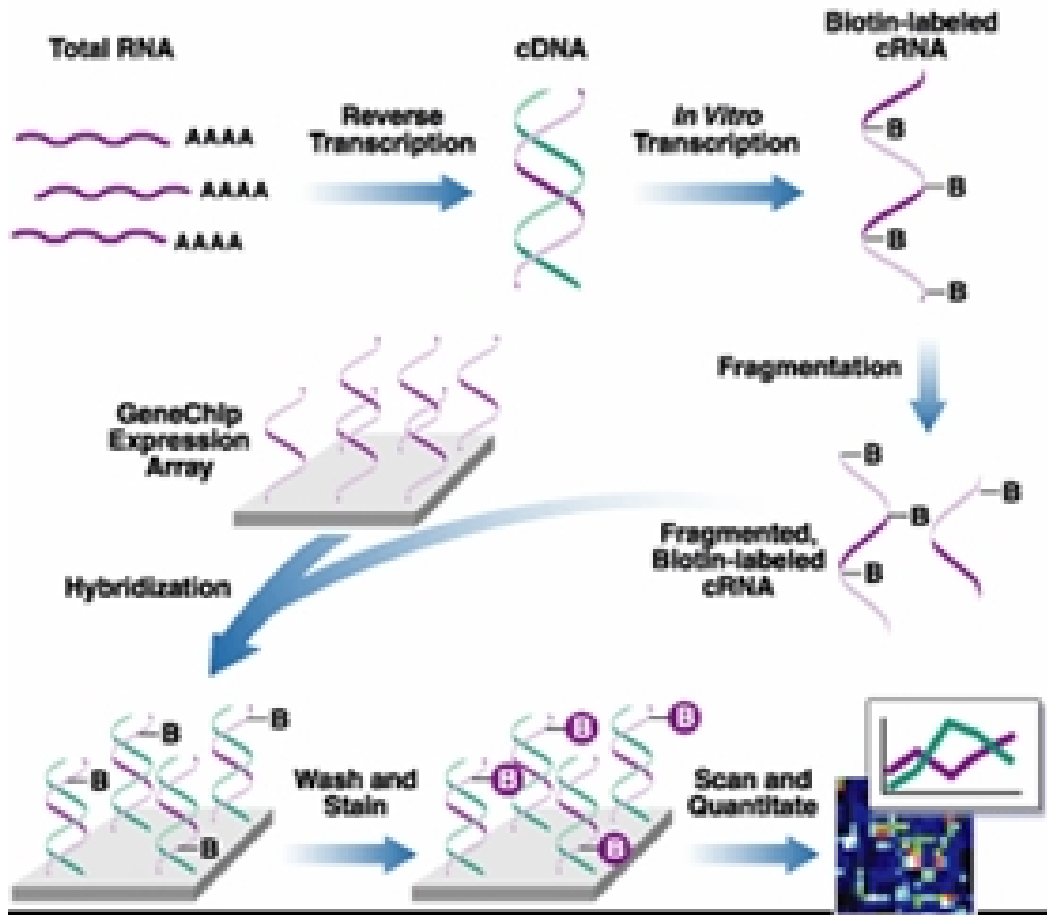
GeneChip



Features and probes

Lab on a chip technology

GeneChip



Gene Expression Image

Principle of using an Affymetrix Gene Expression chip

- RSC Lab on a Chip
- ACS Analytical Chemistry
- IOP Journal of Micromechanics and Microengineering