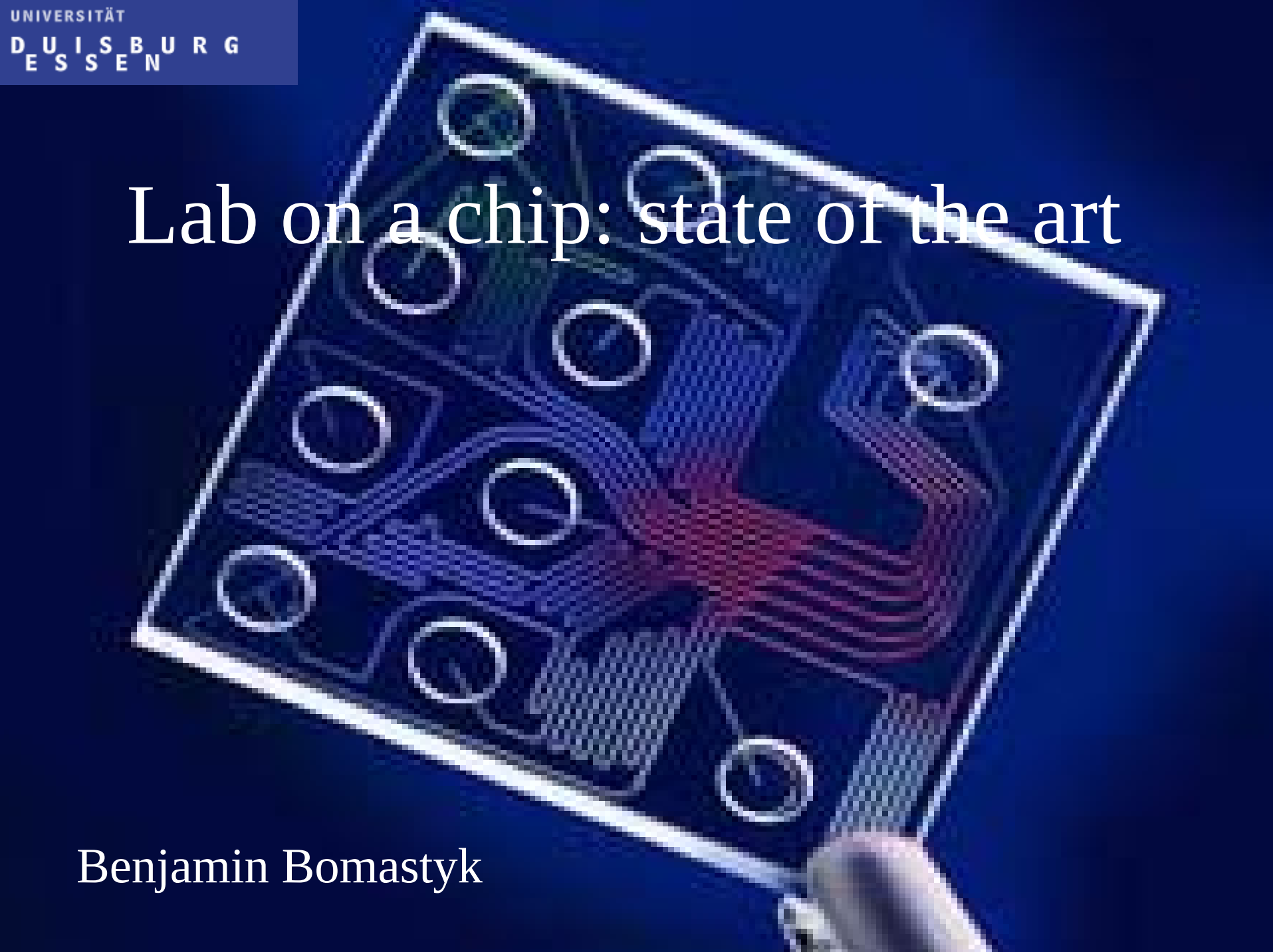
UNIVERSITÄT
DUISBURG
ESSEN

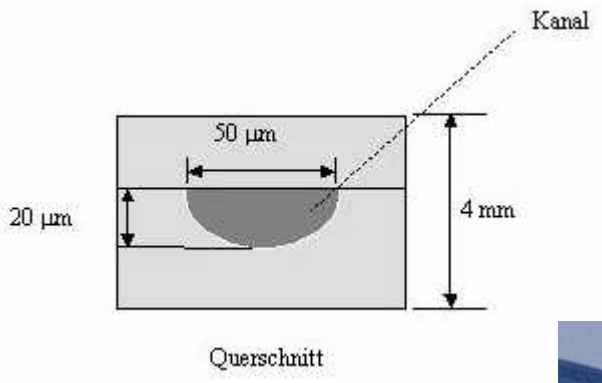
Lab on a chip: state of the art

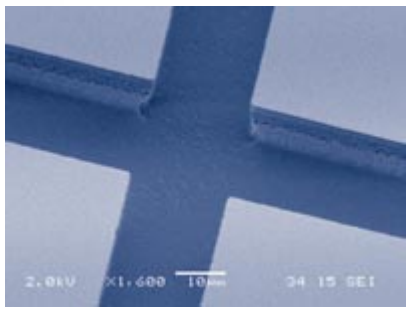


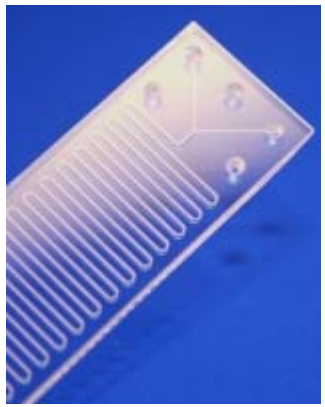
Benjamin Bomastyk

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

Lab on a chip technology
Applications

„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

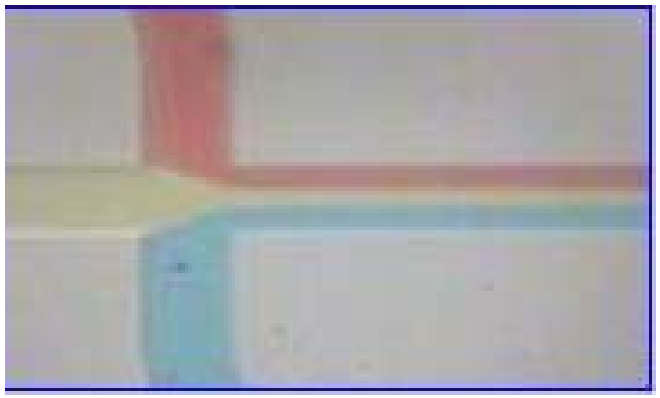
Source: http://en.wikipedia.org/wiki/Lab-on-a-chip

Lab on a chip technology
Advantages

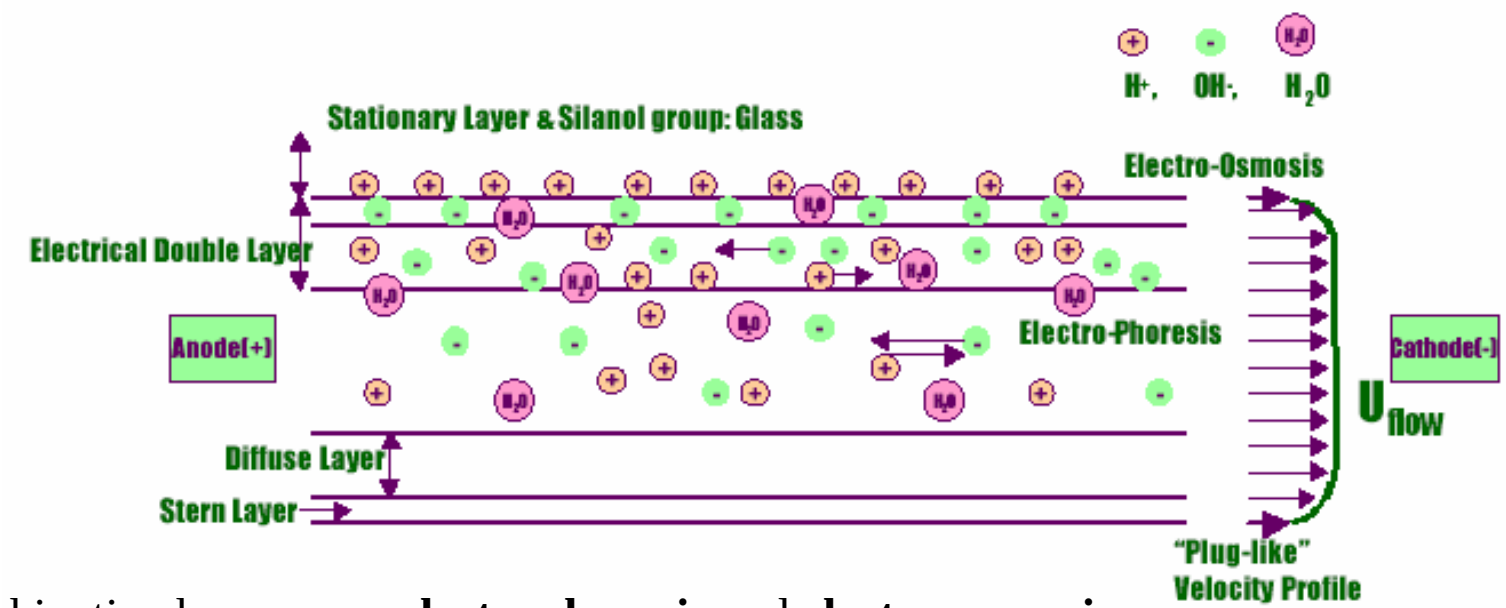
-Low fluid volumes consumption (less waste, lower costs of expensive reagents)
-Less sample fluid needed for the analysis
-Short mixing times (short diffusion distances)
-Fast heating
-Better process control (faster response of the system by chemical reactions)
-Suitable for high-throughput analysis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

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

Lab on a chip technology
Microfluidics and Electrokinetics



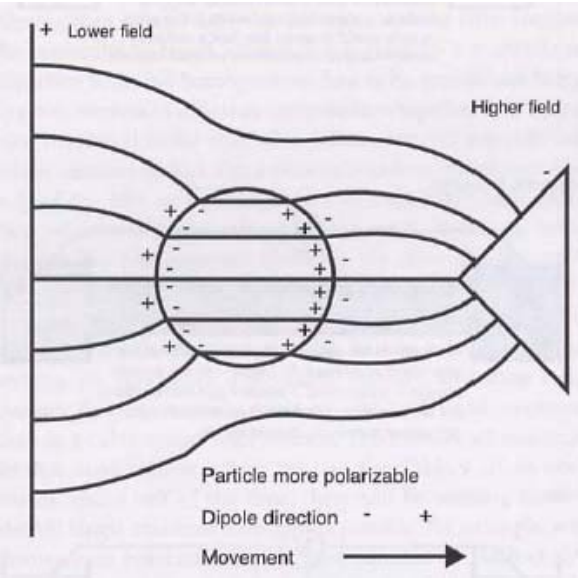
Laminar flow in a microchannel
Low Reynolds number <<1



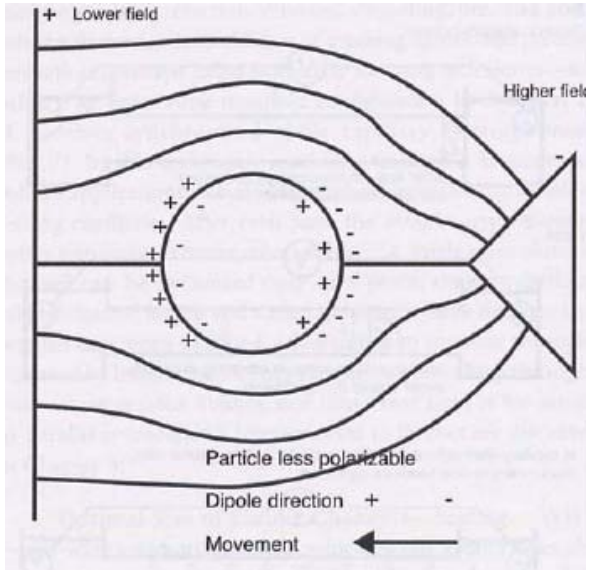
Electrokinetic phenomena: **electrophoresis** and **electro-osmosis**

Source: http://microfluidics.tripod.com/PDF/msthesis.pdf

Dielectrophoresis



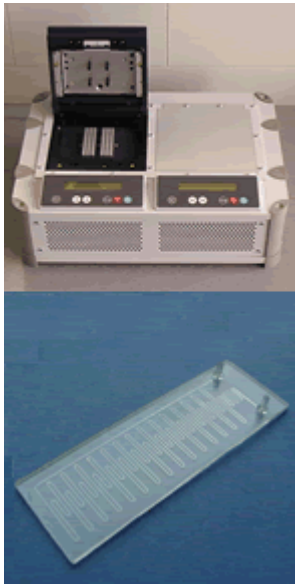
Positive DEP

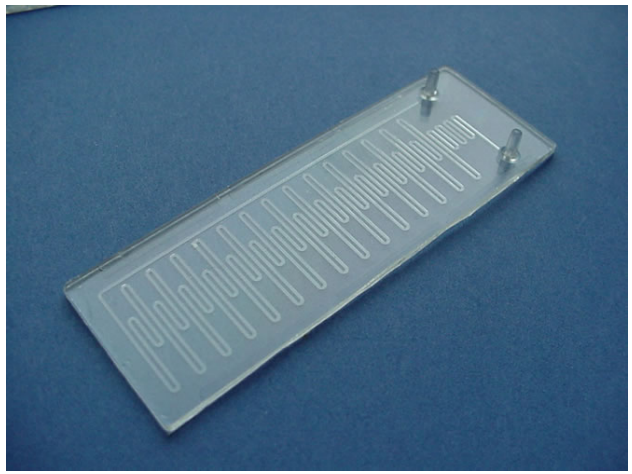


Negative DEP

Source: http://nanoparticles.org/pdf/noh.pdf

Lab on a chip technology
PCR-Chip

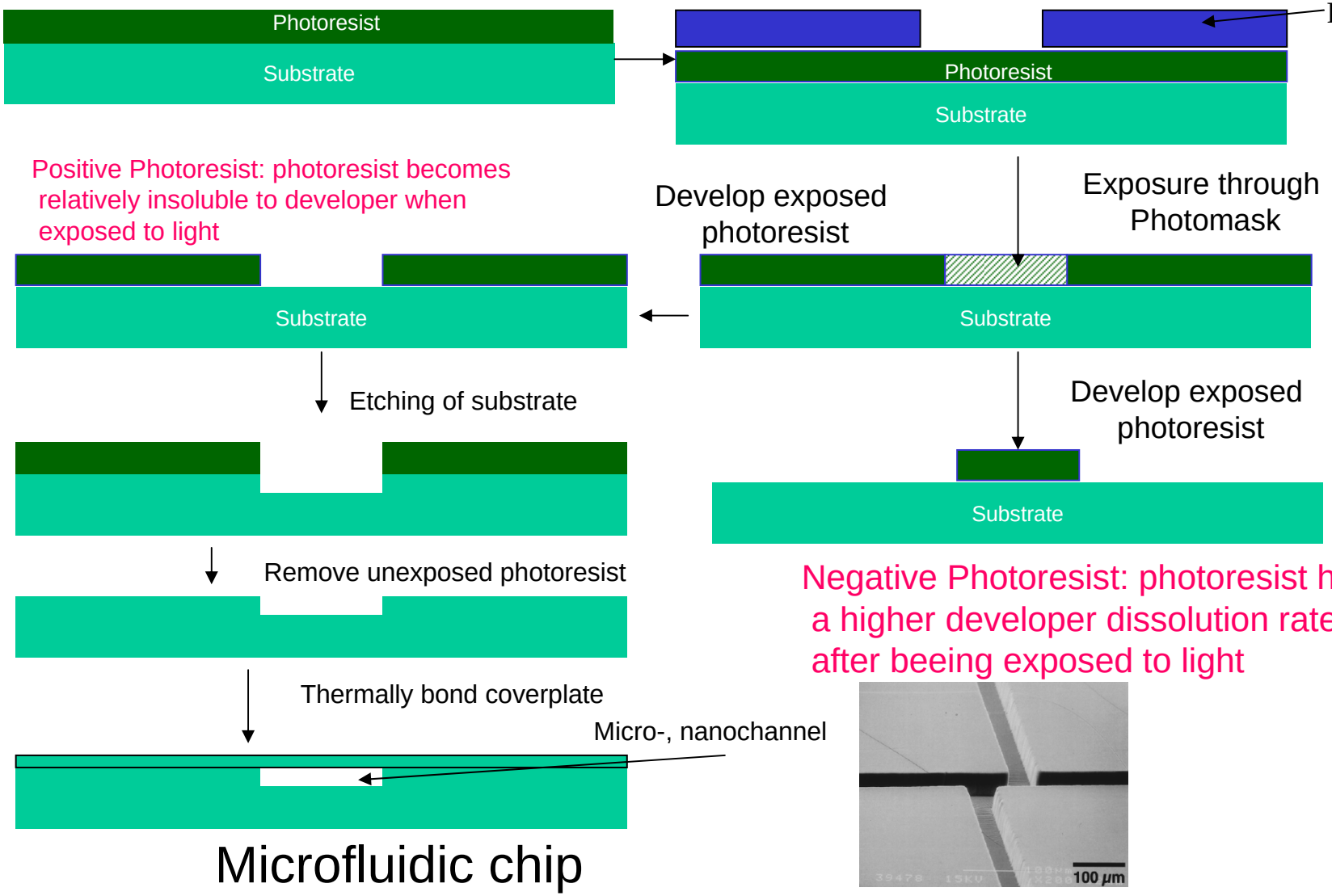




3 spacial separated heating zones are held on constant temperature

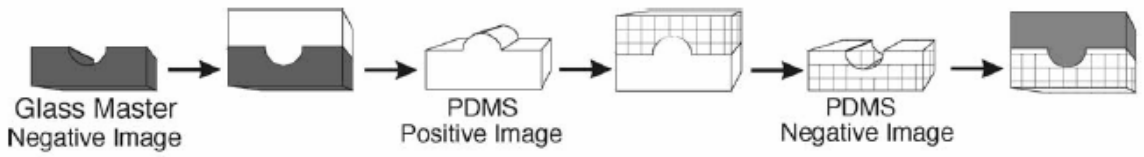
Source: http://www.chemie.de/products/d/54025/

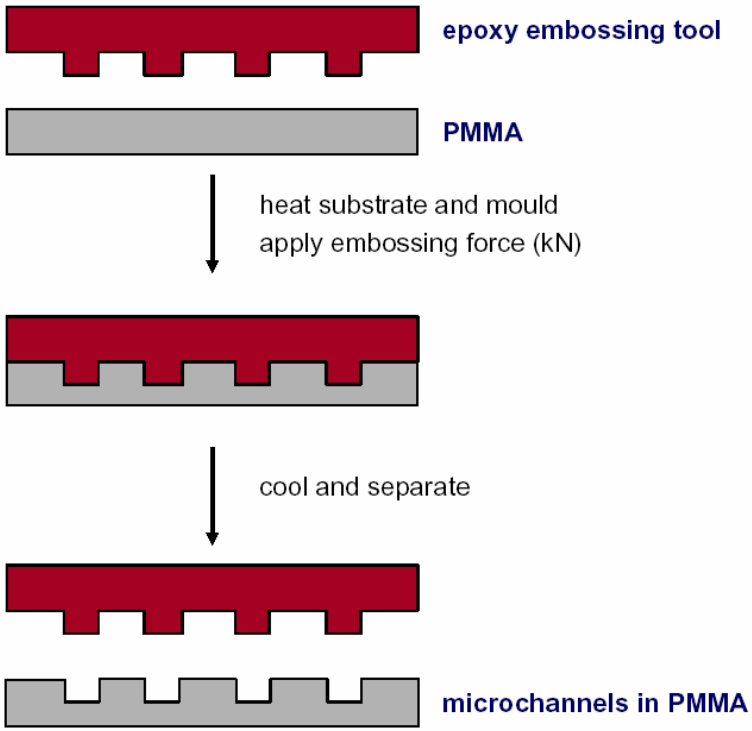
Lab on a chip technology
Photolithography



Source:http://www.intelligentmp.com/SF100How.htm

Lab on a chip technology
Photolithography



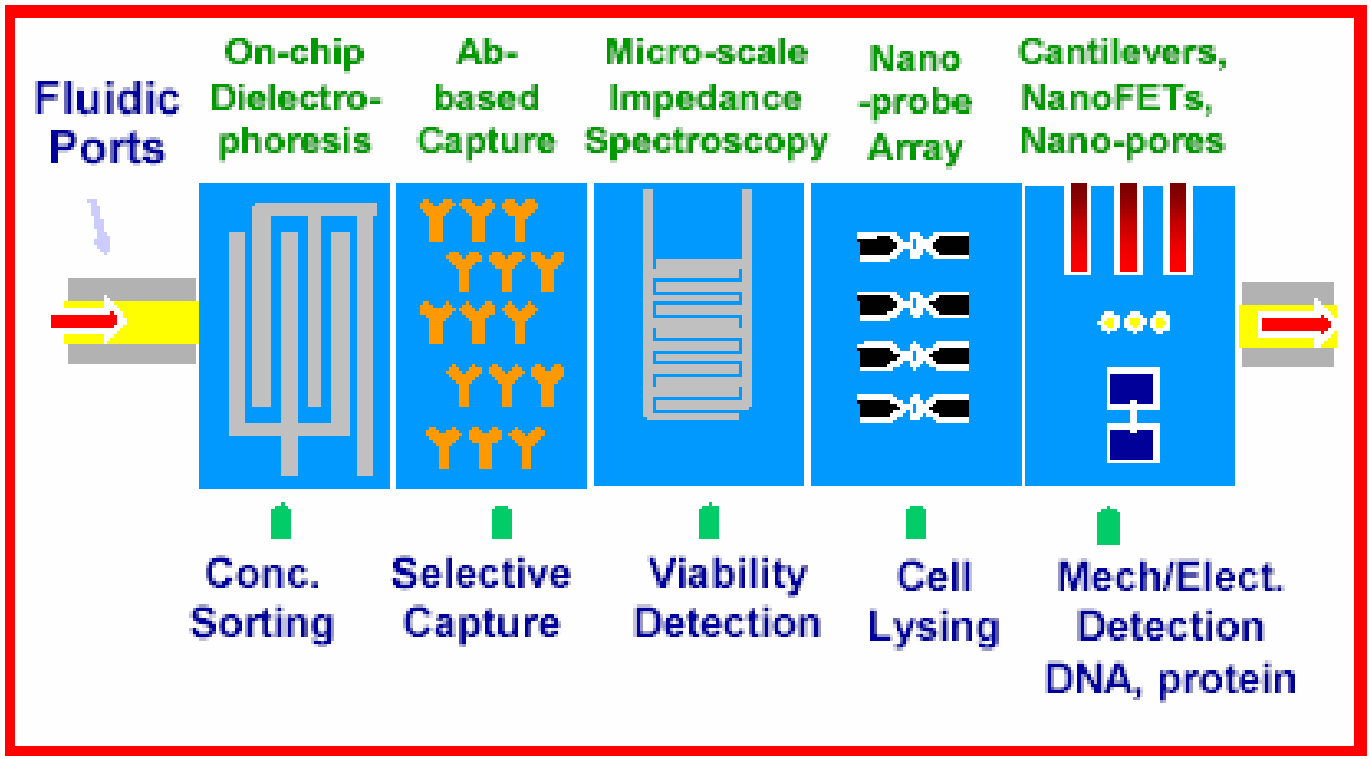


substrate heated to near its glass transition temperature (T_g)

Source:http://www.intelligentmp.com/SF100How.htm
www.ntmdt.ru/Publications/2005/download/publication725.pdf

Lab on a chip technology

Microfluidic Chip for rapid microorganism and cell detection

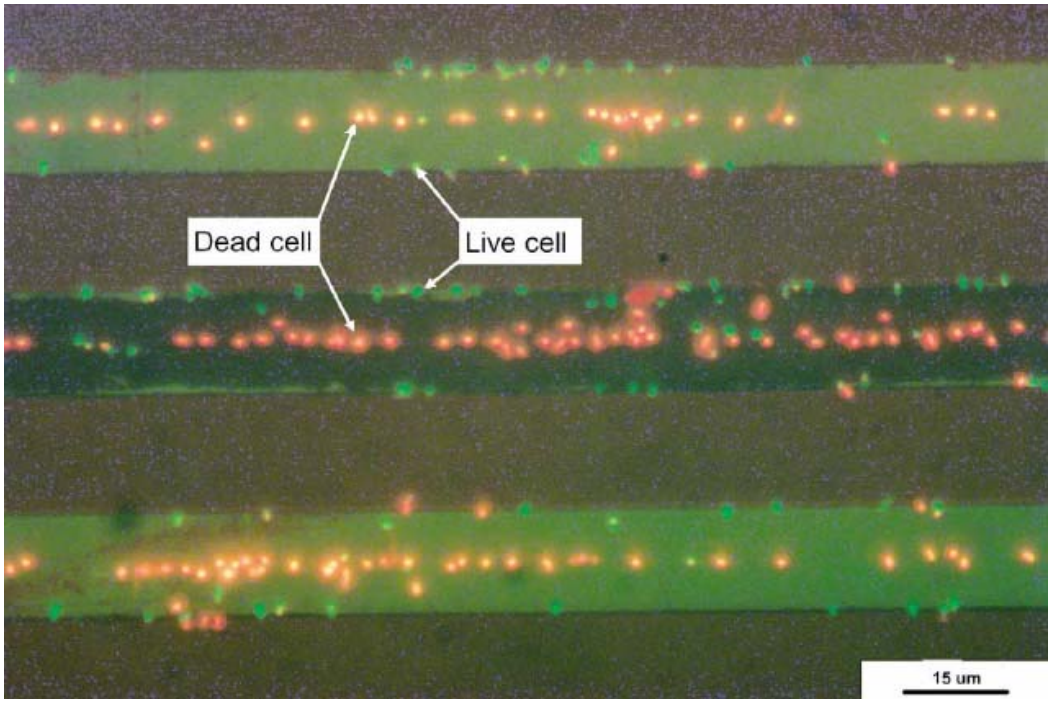


Functions needed in an integrated fluidic biochip for rapid cell detection

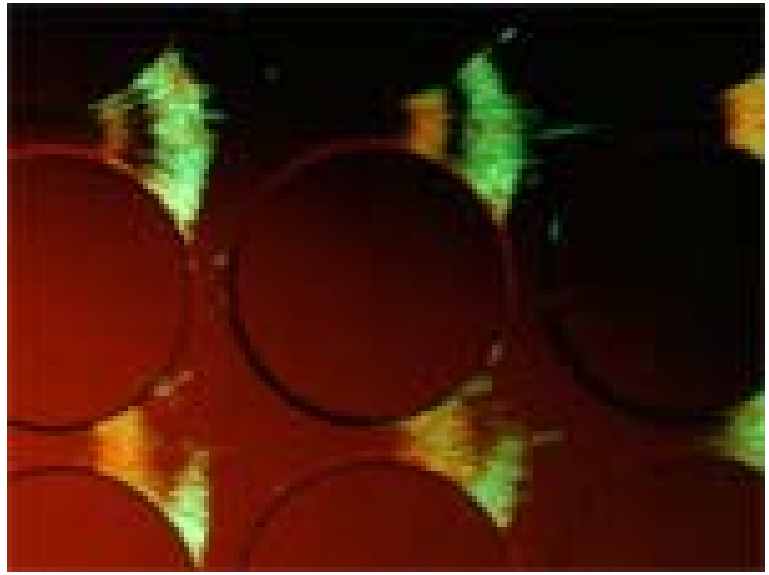
Source:https://engineering.purdue.edu/LIBNA/journals.html

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

Source:https://engineering.purdue.edu/LIBNA/journals.html

Lab on a chip technology
DNA Chip

Genetics

becomes

Genomics

Typische Genomgrößen

Organismus	Anzahl der Gene	Anzahl der Basenpaare
Pflanzen	<50000	$<10^{11}$
Mensch	35000	$3x10^{9}$
Fliegen	12000	$1.6x10^{8}$
Pilze	6000	$1.3x10^{7}$
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

Source:http://learn.genetics.utah.edu/units/biotech/microarray/;
http://flexicon.doccheck.com/Gen

Lab on a chip technology
DNA Chip

DNA Microarray
Gene Array
Gene Chip
Genome Chip

Source:www.affymetrix.com

Lab on a chip technology
GeneChip

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

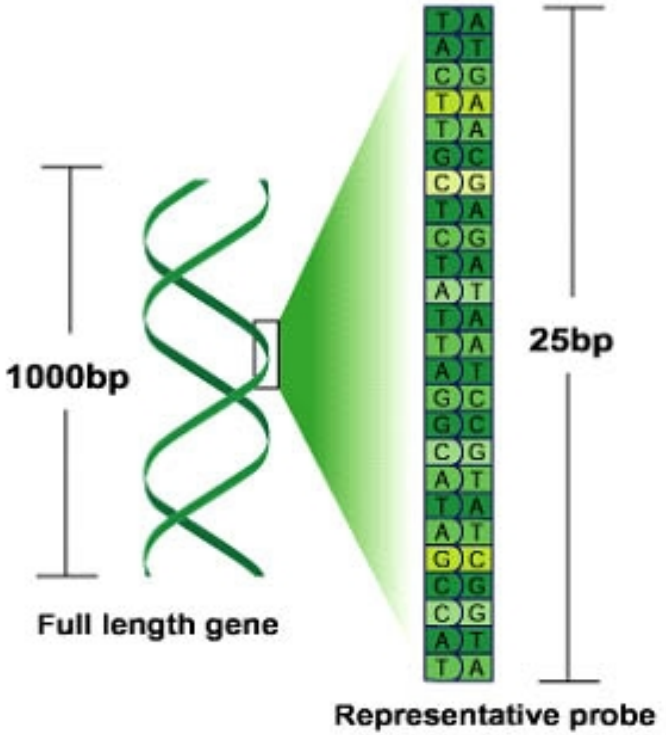
Identification of the presence or absence of 33 different species of animals in any food product.

Detection of DNA sequences specific to an animal.

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

Source:www.affymetrix.com

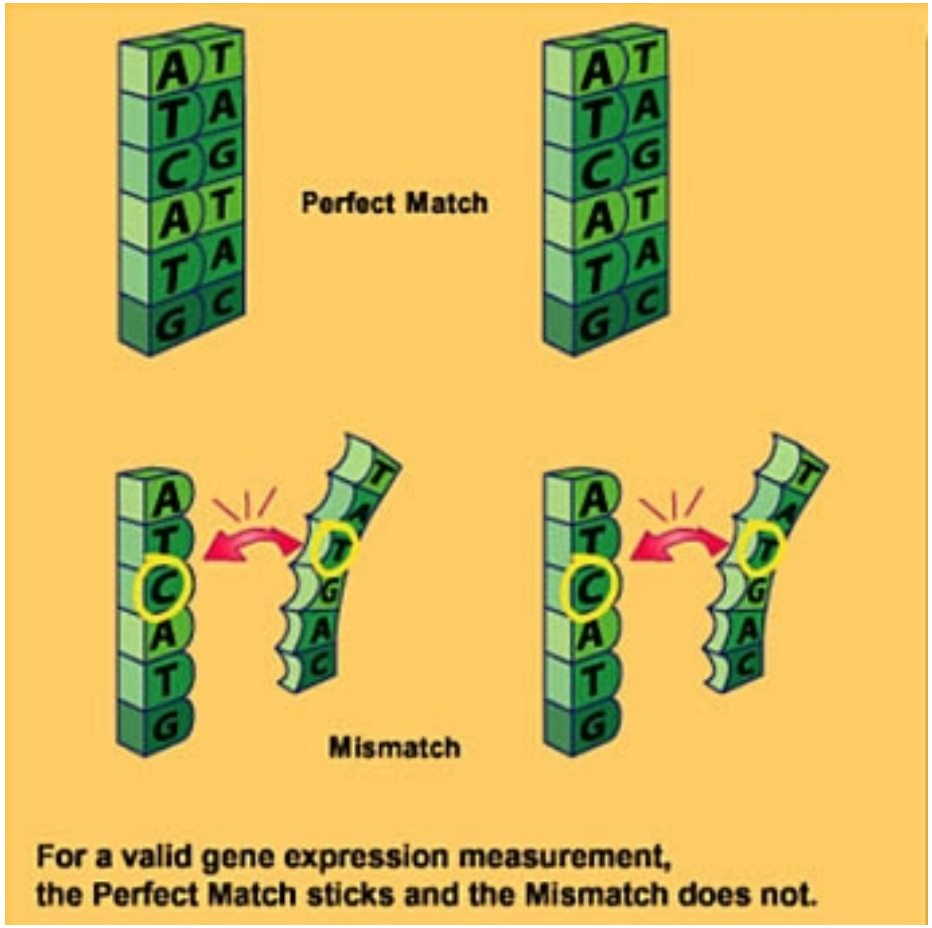
Lab on a chip technology
GeneChip



Construction of probes

Source:www.affymetrix.com

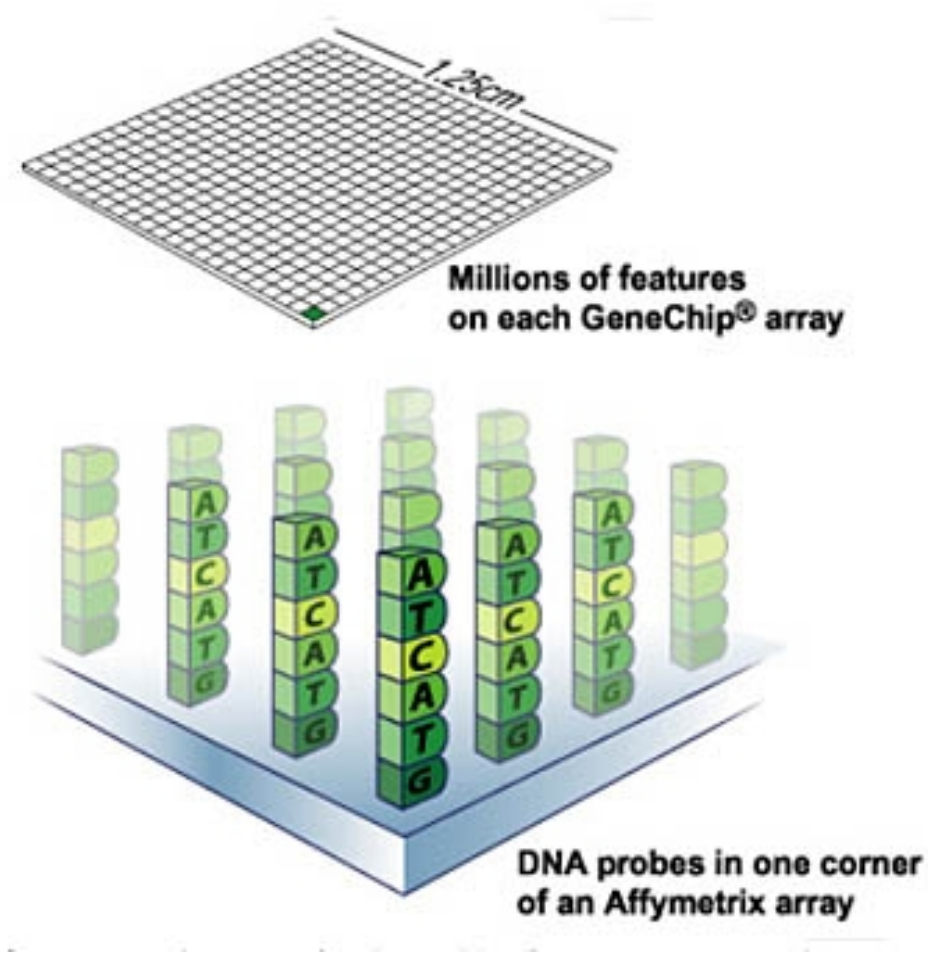
Lab on a chip technology
GeneChip



Matchmaker

Source:www.affymetrix.com

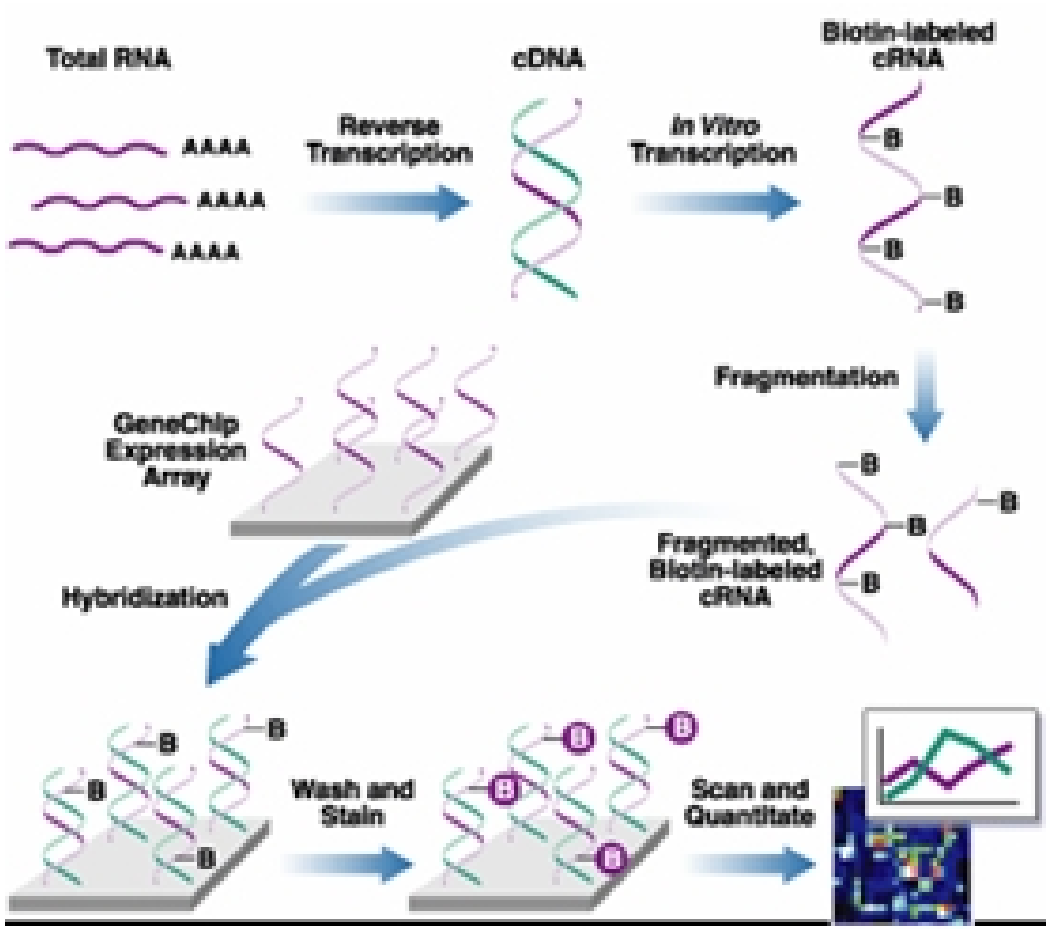
Lab on a chip technology
GeneChip



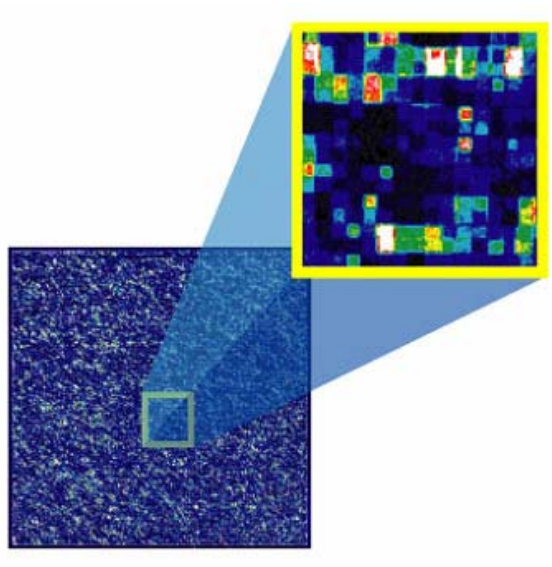
Features and probes

Source:www.affymetrix.com

Lab on a chip technology
GeneChip



Principle of using an Affymetrix Gene Expression chip



Gene Expression Image

Source:www.affymetrix.com

References

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