Microfluídica

Introducción:

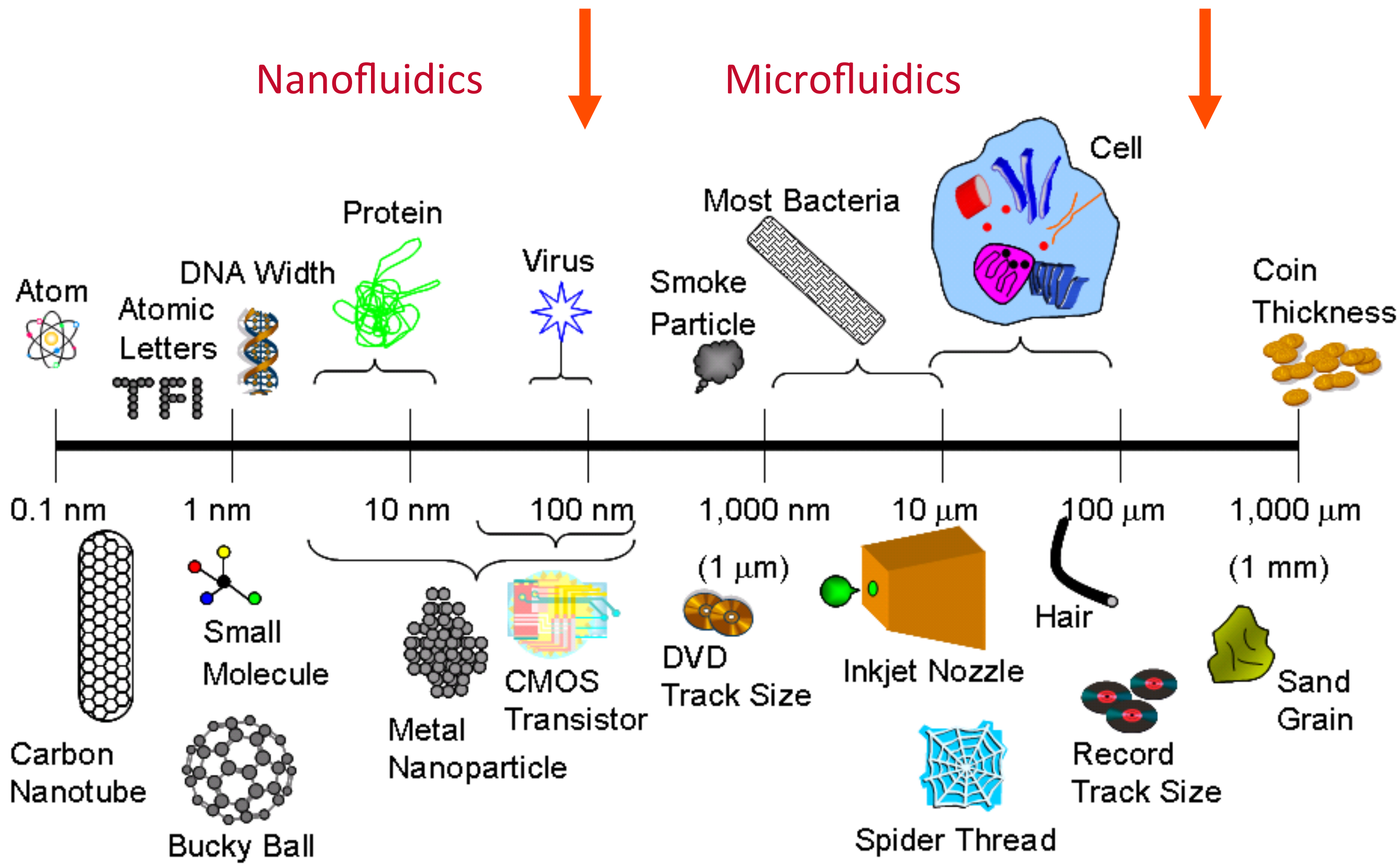
Fundamentos, Historia, Motivación, Aplicaciones, Tendencias…

universidad de buenos aires - exactas
departamento de física
Juan José Giambiagi

A que llamamos Microfluídica?

"Es la ciencia y tecnología que utiliza sistemas que procesan o manipulan cantidades pequeñas de fluidos (entre 10^{-18} y 10^{-9} litros), mediante canales cuyo tamaño esta entre decenas y cientos de micrones"

G. M. Whitesides

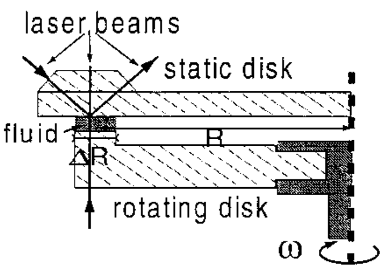


Microfluídica

Para que sirve?

Investigación Básica

Condición de no deslizamiento entre un fluido y un solido

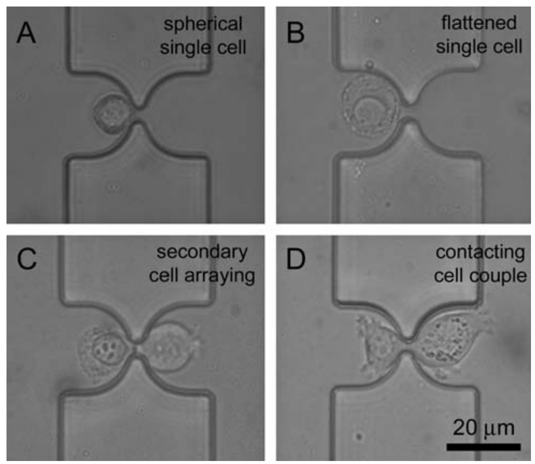


R. Pit, H. Hervet, and L. Léger, Phys. Rev. Lett., vol. 85, no. 5, pp. 980–983, Jul. 2000.

Investigación Básica

Dispositivos y Sistemas

Cultivo de Células y respuesta a estímulos externos



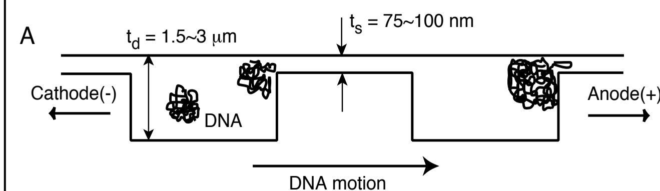
P. Frimat, et al," Lab on a Chip, vol. 11, no. 2, p. 231, 2011.

Investigación Aplicada

Nuevas o Mejores Tecnologías

<u>Mejor</u>: Cromatografía

<u>Nueva</u>: Separación entrópica



J. Han and **H. G. Craighead**, "Separation of Long DNA Molecules in a Microfabricated Entropic Trap Array," Science, vol. 288, no. 5468, pp. 1026 –1029, May 2000.

Nuevas oportunidades aprovechando las diferencias en el comportamiento a escala microscópica

La física no cambia,

pero los mecanismos dominantes pueden ser diferentes.

Ejemplo: Movimiento Browniano

MEMS, Microfluidica, Lab-on-a-chip, Nanotecnologia, …

Inspiración (1959?)

JOURNAL OF MICROELECTROMECHANICAL SYSTEMS VOL. 1, NO. 1, MARCH 1992

There's Plenty of Room at the Bottom

Richard P. Feynman

I imagine experimental physicists must often look with envy at men like Kamerlingh Onnes, who discovered a field like low temperature, which seems to be bottomless and in which one can go down and down. Such a man is then a leader and has some temporary monopoly in a scientific adventure. Percy Bridgman, in designing a way to obtain higher pressures, opened up another new field and was able to move into it and to lead us all along. The development of ever higher vacuum was a continuing development of the same kind.

I would like to describe a field, in which little has been done, but in which an enormous amount can be done in principle. This field is not quite the same as the others in that it will not tell us much of fundamental physics (in the sense of, "What are the strange particles?") but it is more like solid-state physics in the sense that it might tell us much of great interest about the strange phenomena that occur in complex situations. Furthermore, a point that is most important is that it would have an enormous number of technical applications.

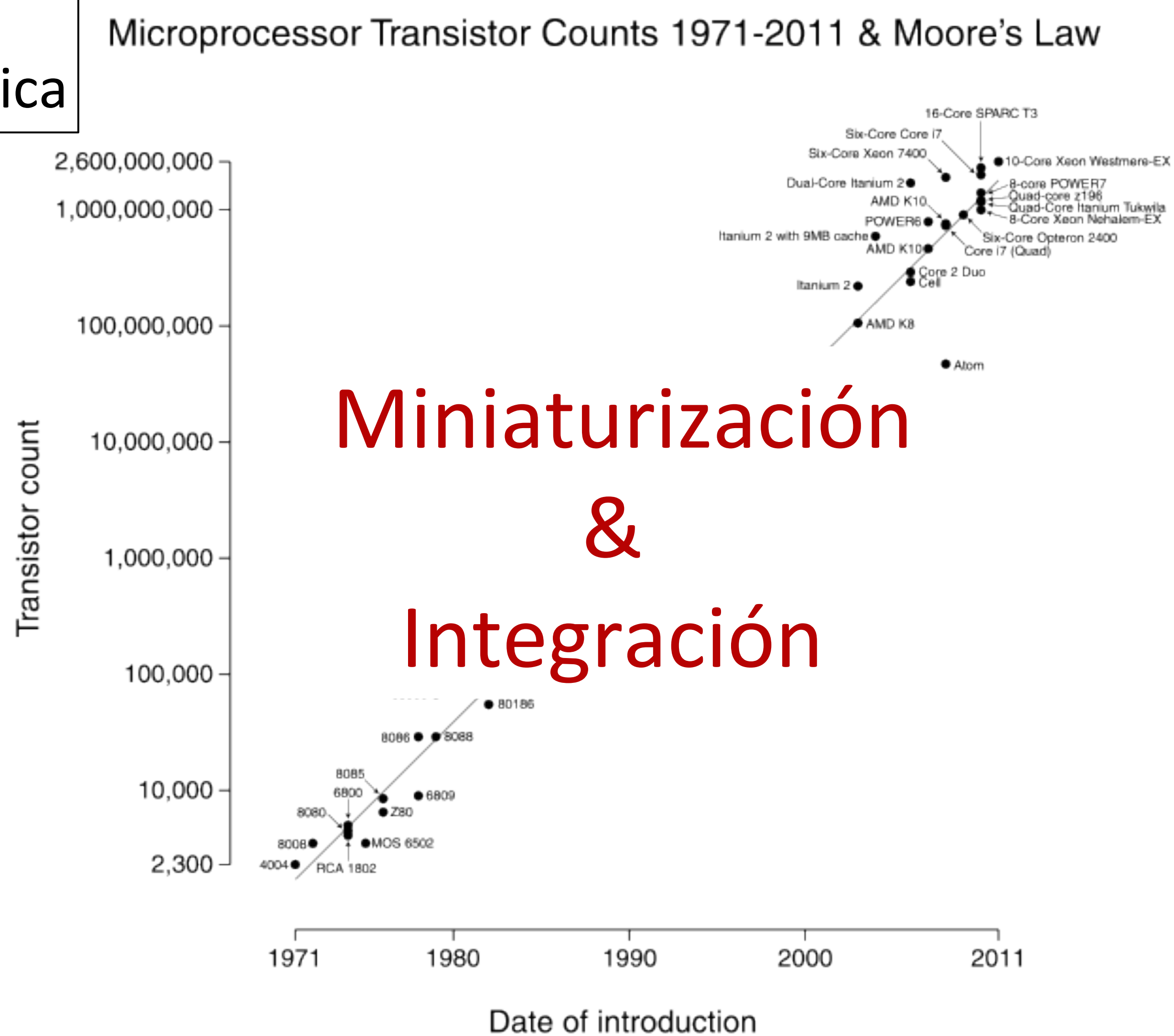
dots on the fine half-tone reproductions in the Encyclopaedia. This, when you demagnify it by 25 000 times, is still 80 angstroms in diameter—32 atoms across, in an ordinary metal. In other words, one of those dots still would contain in its area 1000 atoms. So, each dot can easily be adjusted in size as required by the photoengraving, and there is no question that there is enough room on the head of a pin to put all of the Encyclopaedia Britannica.

Furthermore, it can be read if it is so written. Let's imagine that it is written in raised letters of metal; that is, where the black is in the Encyclopaedia, we have raised letters of metal that are actually 1/25 000 of their ordinary size. How would we read it?

If we had something written in such a way, we could read it using techniques in common use today. (They will undoubtedly find a better way when we do actually have it written, but to make my point conservatively I shall just take techniques we know today.) We would press the metal into a plastic material and make a mold of it, then peel the plastic off very carefully, evaporate silica into the

Orígenes

70’
Microelectrónica

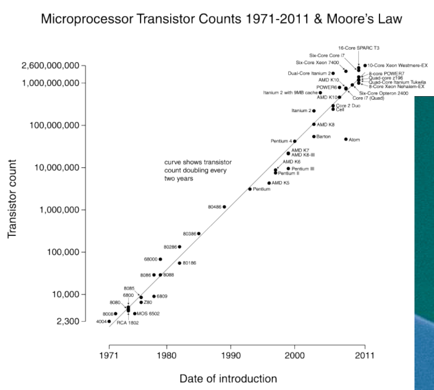


Miniaturización
&
Integración

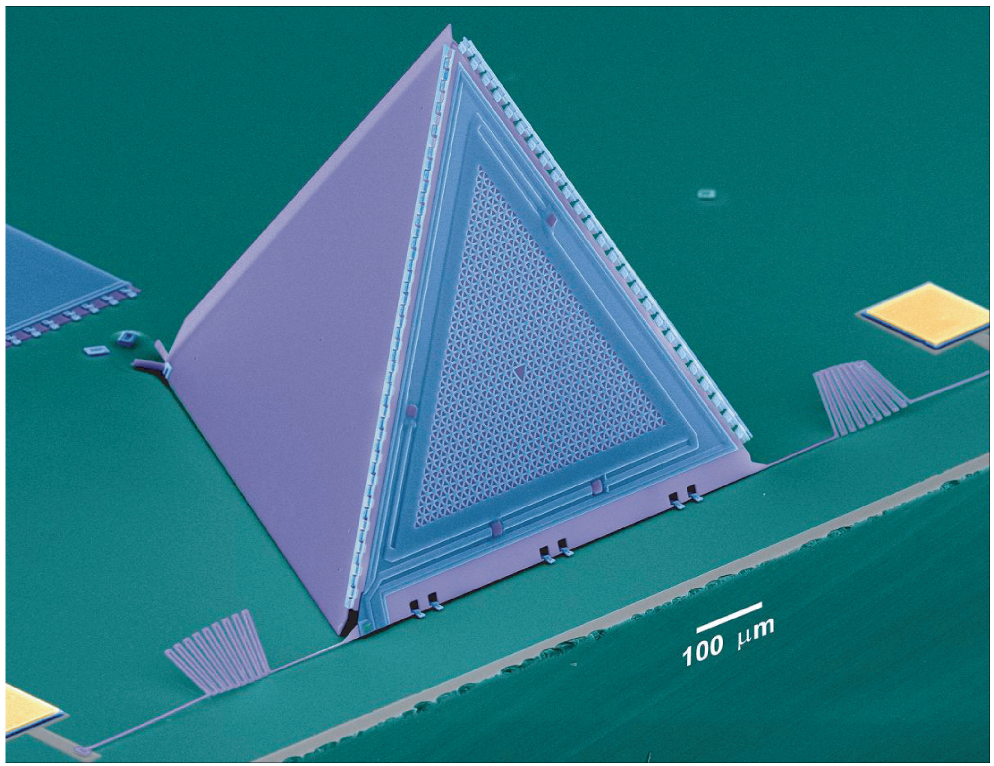
G. Moore, doble numero de transistores cada año, por lo menos hasta **1975!!**

Orígenes

70’
Microelectrónica



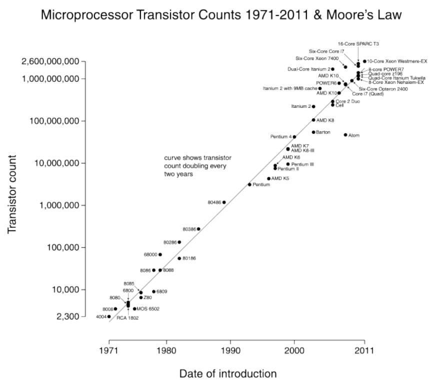
80’
MEMS



D. Lopez, F. Pardo y otros @ Lucent (2005)

Orígenes

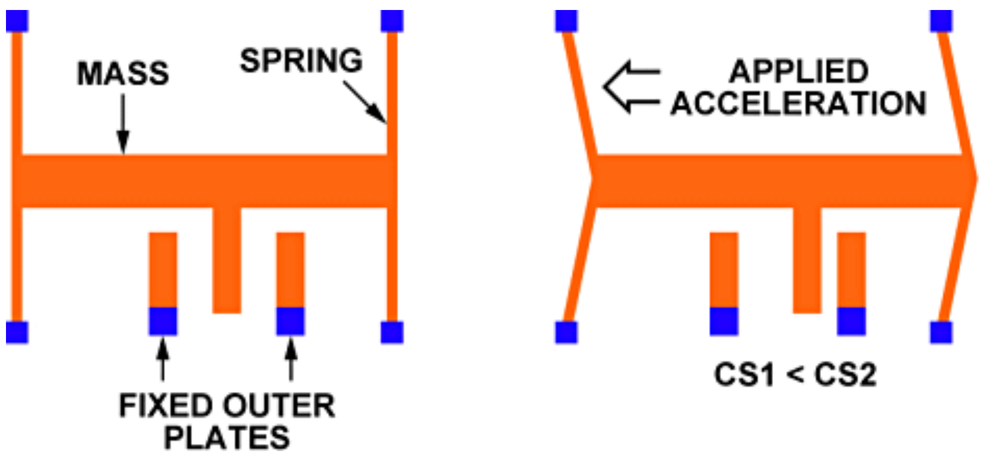
70’ Microelectrónica

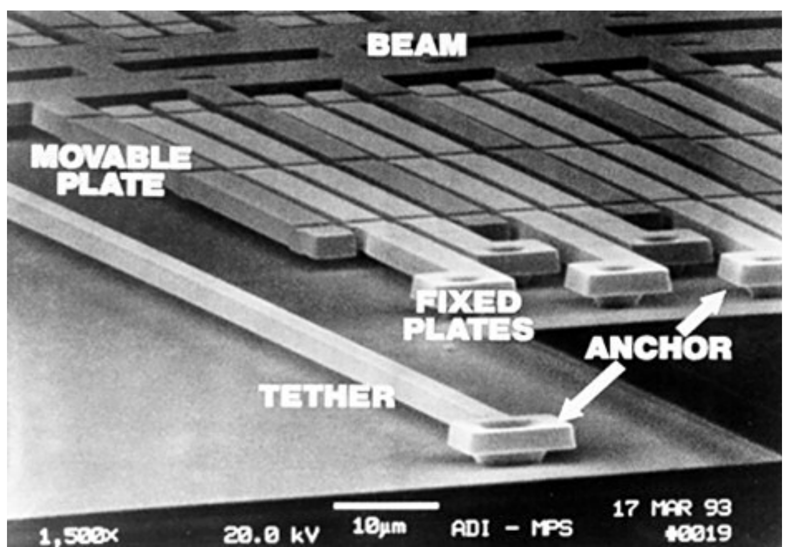


Integración y Miniaturización

80’ MEMS

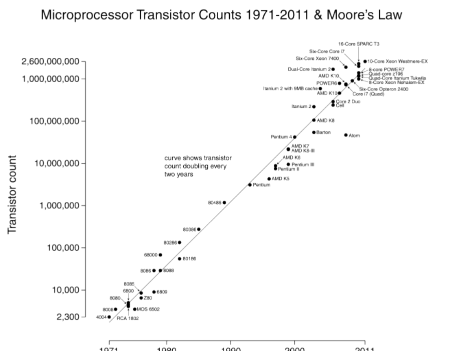
Acelerómetros





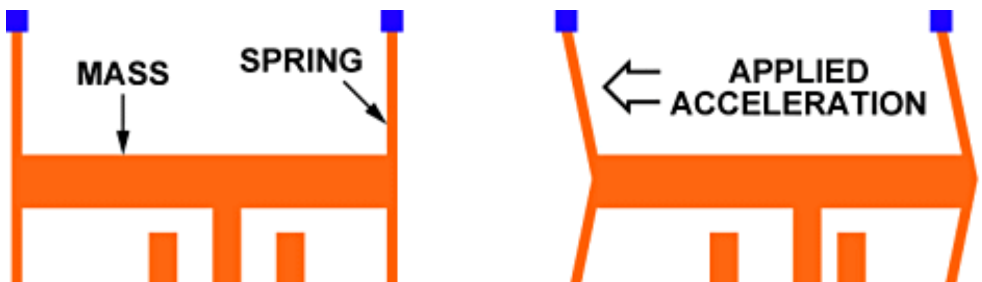
Orígenes

70’
Microelectrónica

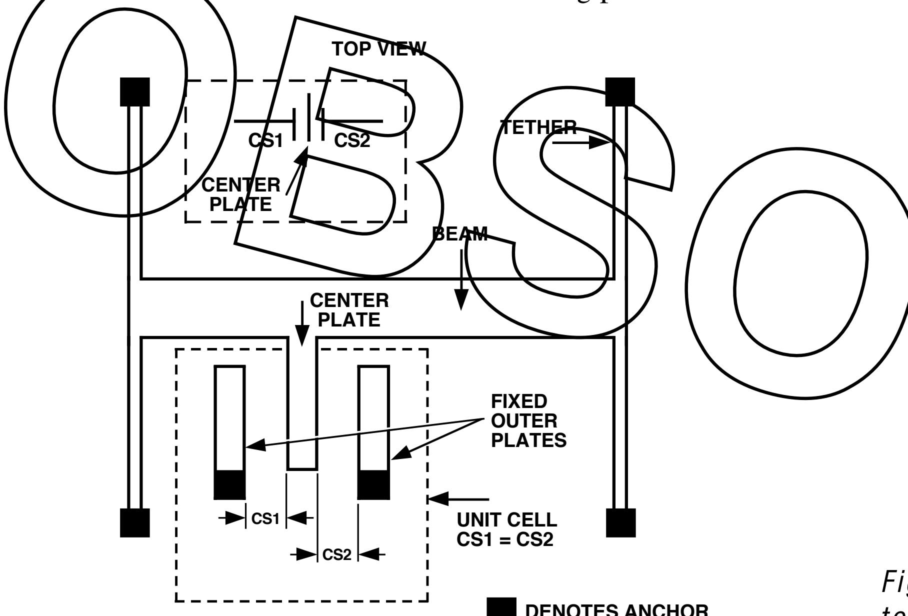


80’
MEMS

Acelerómetros



celeration and servos the sensor back to its 0 g position.



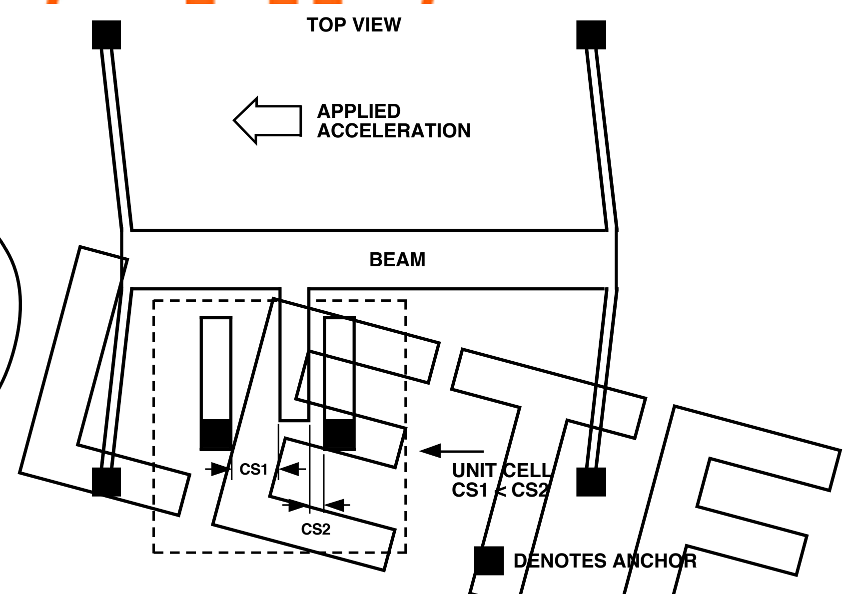
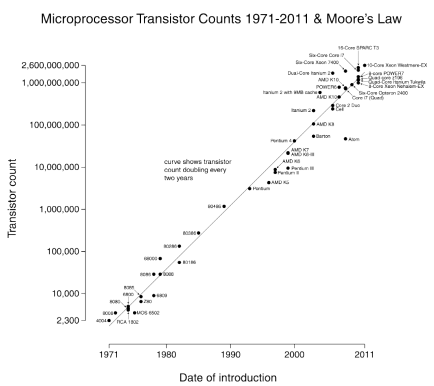


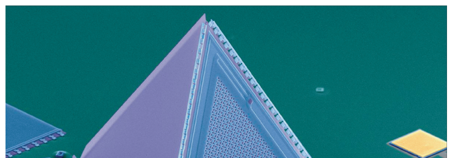
Figure 17. The ADXL50 Sensor Momentarily Responding to an Externally Applied Acceleration

Orígenes

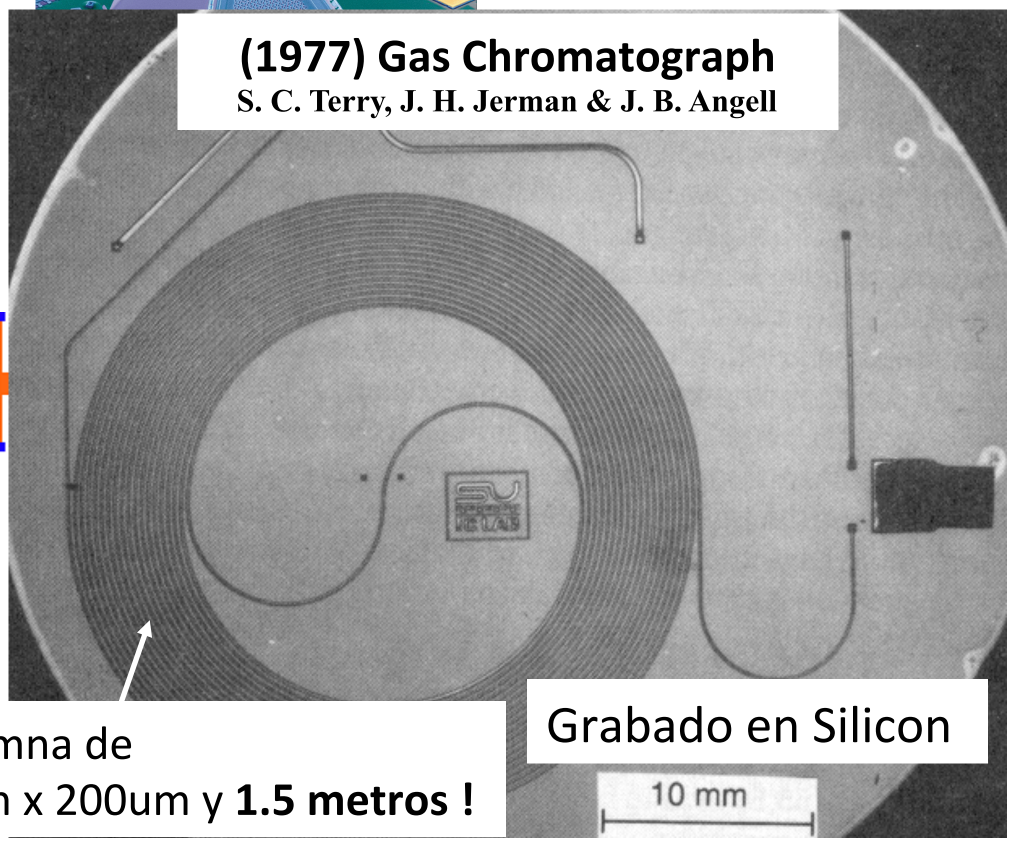
70'
Microelectrónica



80'
MEMS



90'
Microfluidica
Lab-on-a-chip



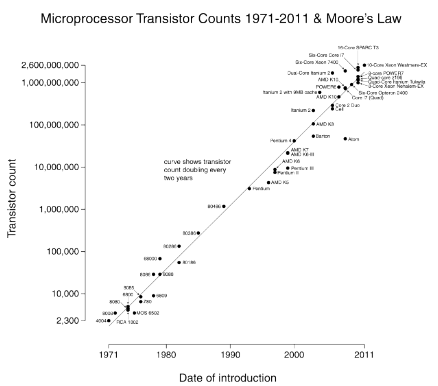
(1977) Gas Chromatograph
S. C. Terry, J. H. Jerman & J. B. Angell

Columna de
30um x 200um y **1.5 metros !**

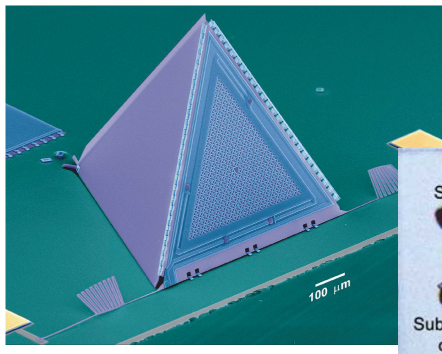
Grabado en Silicon

Orígenes

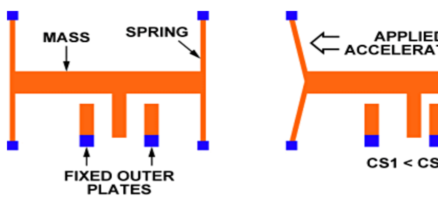
70’
Microelectrónica



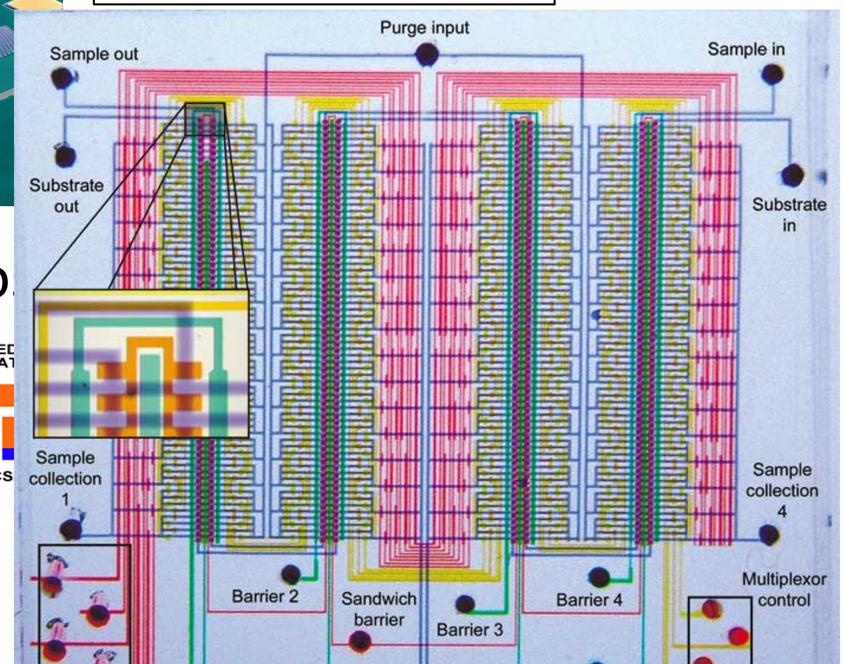
80’
MEMS



Acelerómetro



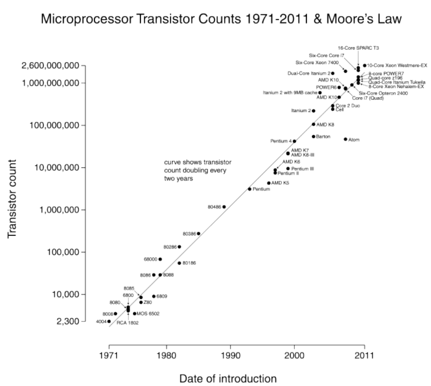
90’
Microfluidica
Lab-on-a-chip



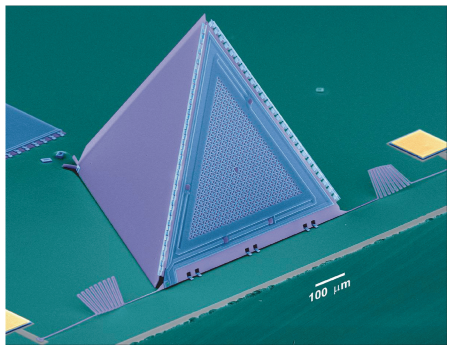
(2003) Large Scale Intergation
T. Thorsen, S. J. Maerkl & S. R. Quake
Miles de válvulas y conexiones

Orígenes

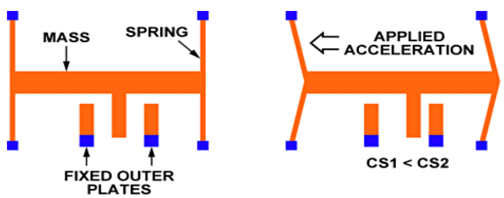
70'
Microelectrónica



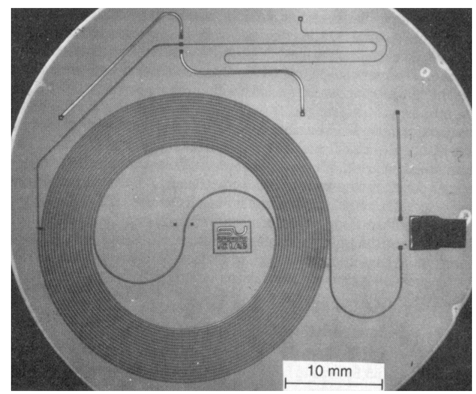
80'
MEMS

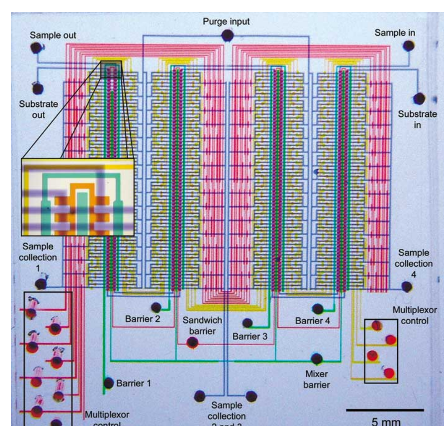


Acelerómetros



90'
Microfluidica
Lab-on-a-chip



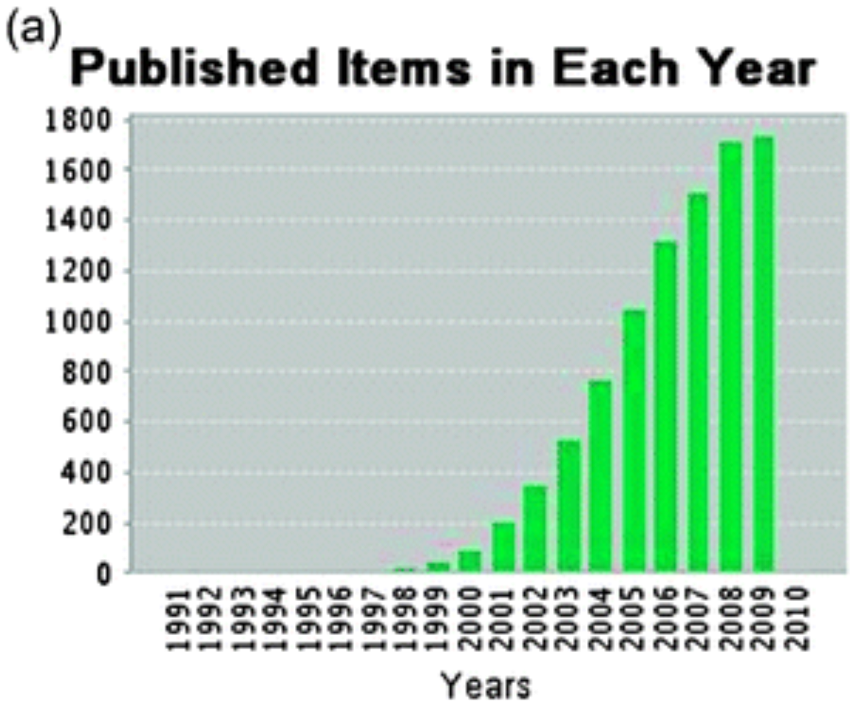


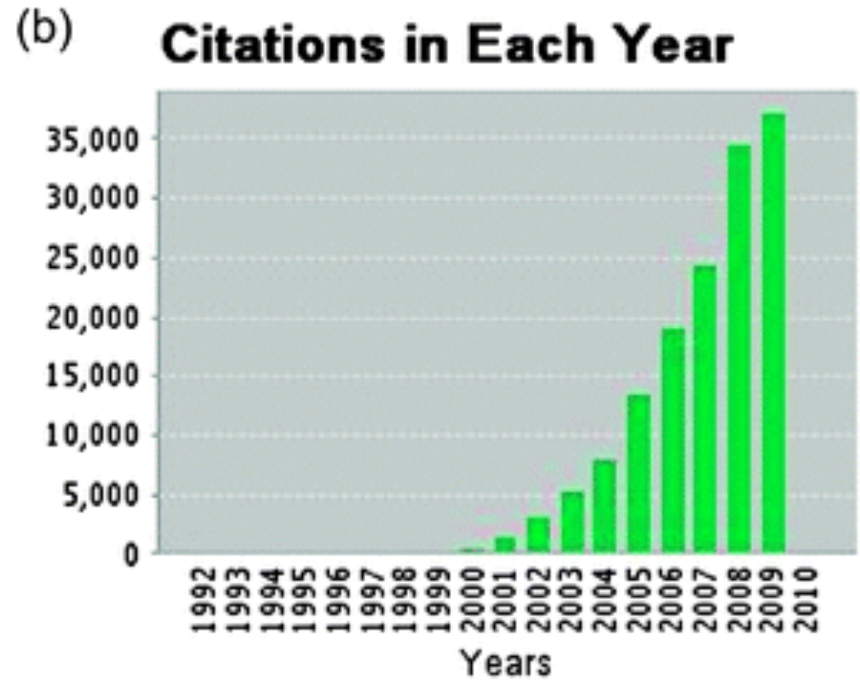
00'
Nanotecnología
Nanofluidica

Historia Breve (e incompleta)

- **1975**
  - 1^{st} dispositivo analítico en miniatura (cromatografía)
  - Fabricación: grabado en silicon. (Stanford; Terry y otros)
- **1990**
  A. Manz introduce la idea de µTAS (Micro-Total-Analysis-Systems)
  Se fabrican dispositivos
- **2000**
  Se introduce la idea de "soft-lithography".
  Se simplifica y populariza la fabricación de distintos sistemas
  Se amplia el concepto de µTAS a Lab-o-a-chip
- **2010**
  Empiezan a surgir ideas para simplificar aun mas la fabricación:
  "Paper-based microfluidics"; "CD-microfluidics" y otros
  Impresoras 3D con resolución ~ 100 micrones.

Popularidad





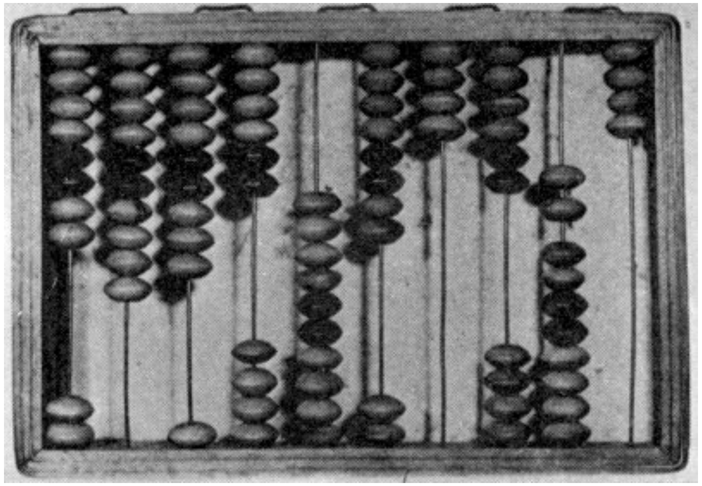
Microfluidic lab-on-a-chip platforms: requirements, characteristics and applications
D. Mark, S. Haeberle , G. Roth , F. von Stetten and R. Zengerle Chem. Soc. Rev., **2010**, 39, 1153-1182

Imposible mantenerse al dia!!

Microfluidica: desarrollo de tecnología

µTAS & Lab-on-a-chip

Información
y
cálculo:

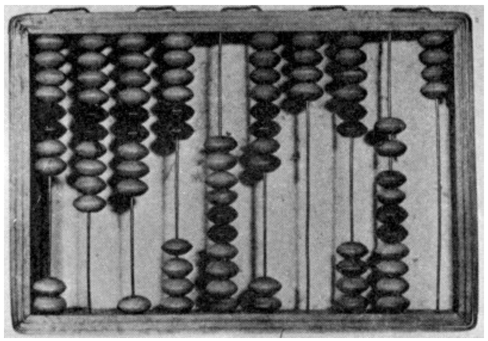


Automatización
Integración
Miniaturización

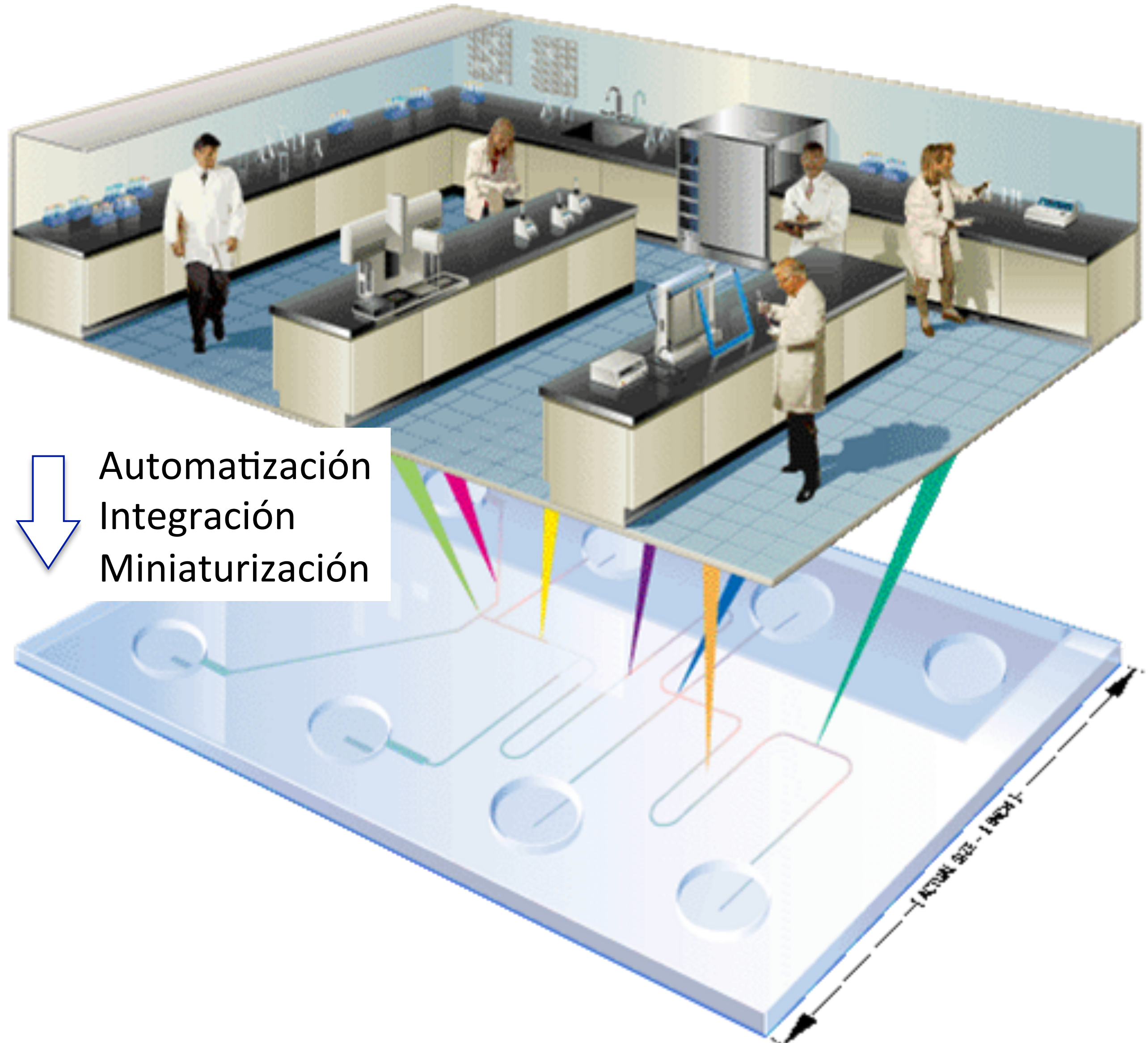
Microfluidica: desarrollo de tecnología

μTAS & Lab-on-a-chip

Información y cálculo:



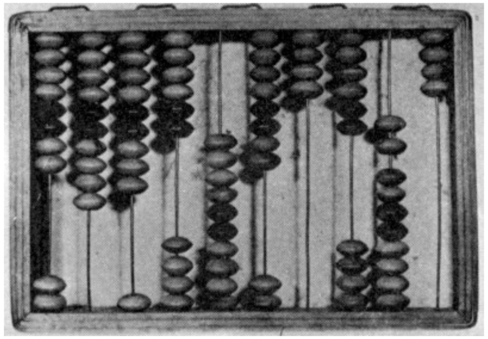
Automatización
Integración
Miniaturización



Automatización
Integración
Miniaturización

Microfluidica: desarrollo de tecnología
μTAS & Lab-on-a-chip

Información y cálculo:

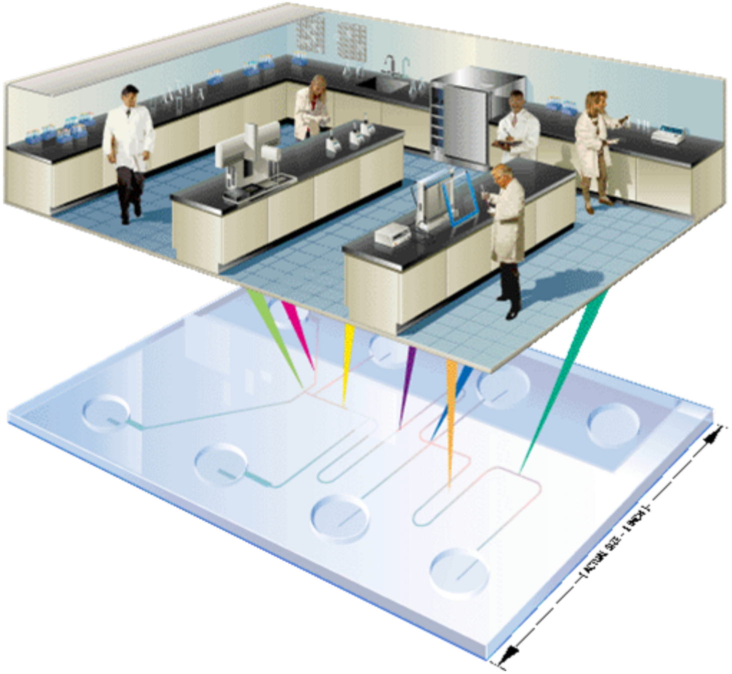


Automatización
Integración
Miniaturización

Tubos de ensayo...

Automatización
Integración

Automatización
Integración
Miniaturización



μTAS & Lab-on-a-chip

Que ventajas tiene?

más chico; más rápido; más simple, más economico, ...mejor!!

- Portátil
- Menos volumen de químicos
- Mayor seguridad
- Reduce la contaminación
- Bajo costo y producción masiva
- Más rápido
- Análisis en paralelo
- Usos novedosos (implantes?)
- Métodos novedosos ?

Microfluídica:

Areas de mayor uso y crecimiento

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Microfluidic Chemical Analysis Systems

Eric Livak-Dahl,[1,*] Irene Sinn,[2,*] and Mark Burns[1,2]

[1]Department of Chemical Engineering and [2]Department of Biomedical Engineering, University of Michigan, Ann Arbor, Michigan 48109; email: elivak@umich.edu, isinn@umich.edu, maburns@umich.edu

Química analítica;
control de reacciones químicas;
detección y muestreo;
ensayos químicos en paralelo;

Ej. Desarrollo de técnicas y dispositivos de separación

Microfluídica:

Areas de mayor uso y crecimiento

Annu. Rev. Biomed. Eng. 2001. 3:335–73

SOFT LITHOGRAPHY IN BIOLOGY AND BIOCHEMISTRY

George M. Whitesides[1], Emanuele Ostuni[1,2], Shuichi Takayama[1,3], Xingyu Jiang[1], and Donald E. Ingber[4]
[1]Department of Chemistry and Chemical Biology, Harvard University, Cambridge, Massachusetts 02138, and [4]Departments of Surgery and Pathology, Children's Hospital and Harvard Medical School, Enders 1007, Boston, Massachusetts 02115; e-mail: gwhitesides@gmwgroup.harvard.edu, eostuni@gmwgroup.harvard.edu, takayama@eecs.mich.edu, xjiang@gmwgroup.harvard.edu, and ingber@a1.tch.harvard.edu

Ventajas: *Bioquímica*: Numero grande de estudios simultáneos; *Biología*: *Células*: Control preciso de los estímulos/condiciones

Ej. Respuesta de células Madre a la falta de oxigeno

Desarrollo de medicamentos; ingeniería de tejidos; genética; ensayos bioquímicos, celulares;

Microfluídica:
Materiales

INSTITUTE OF PHYSICS PUBLISHING REPORTS ON PROGRESS IN PHYSICS

Rep. Prog. Phys. **68** (2005) 2495–2532 doi:10.1088/0034-4885/68/11/R01

Non-sticking drops

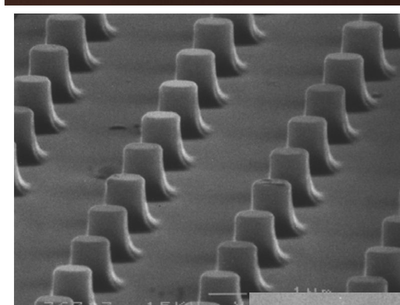
David Quéré

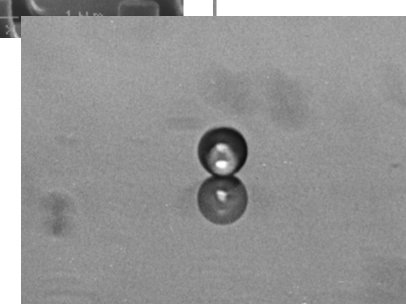
Laboratoire de Physique de la Matière Condensée, URA 7125 du CNRS, Collège de France, 75231 Paris Cedex 05, France

Received 1 August 2004, in final form 30 March 2005
Published 7 September 2005
Online at stacks.iop.org/RoPP/68/2495

Abstract

While the behaviour of large amounts of liquid is dictated by gravity, surface forces become dominant at small scales. They have for example the remarkable ability to make droplets stick to their substrates (even if they are inclined), which is a practical issue in many cases (windshields, window panes, greenhouses, or microfluidic devices). Here we describe how this problem can be overcome with super-hydrophobic materials. These materials are often developed thanks to micro-textures, which decorate a solid surface, and we describe the way such textures modify the wettability of that solid. We conclude by showing the unusual dynamics of drops in a super-hydrophobic situation.





Microfluídica:

Salud

INSIGHT REVIEW NATURE|Vol 442|27 July 2006|doi:10.1038/nature05064

Microfluidic diagnostic technologies for global public health

Paul Yager[1], Thayne Edwards[1], Elain Fu[1], Kristen Helton[1], Kjell Nelson[1], Milton R. Tam[2] & Bernhard H. Weigl[3]

The developing world does not have access to many of the best medical diagnostic technologies; they were designed for air-conditioned laboratories, refrigerated storage of chemicals, a constant supply of calibrators and reagents, stable electrical power, highly trained personnel and rapid transportation of samples. Microfluidic systems allow miniaturization and integration of complex functions, which could move sophisticated diagnostic tools out of the developed-world laboratory. These systems must be inexpensive, but also accurate, reliable, rugged and well suited to the medical and social contexts of the developing world.

Microfluídica:
Medicina

VIEWPOINT

Systems Biology and New Technologies Enable Predictive and Preventative Medicine

Leroy Hood,[1*] James R. Heath,[2,3] Michael E. Phelps,[3] Biaoyang Lin[1]

Systems approaches to disease are grounded in the idea that disease-perturbed protein and gene regulatory networks differ from their normal counterparts; we have been pursuing the possibility that these differences may be reflected by multiparameter measurements of the blood. Such concepts are transforming current diagnostic and therapeutic approaches to medicine and, together with new technologies, will enable a predictive and preventive medicine that will lead to personalized medicine.

ic knockout strain had a distinct pattern of perturbed gene expression, with hundreds of mRNAs changing per knockout. About 15% of the perturbed mRNAs potentially encoded secreted proteins (*8*). If gene expression in diseased tissues also reveals patterns characteristic of pathologic, genetic, or envi-