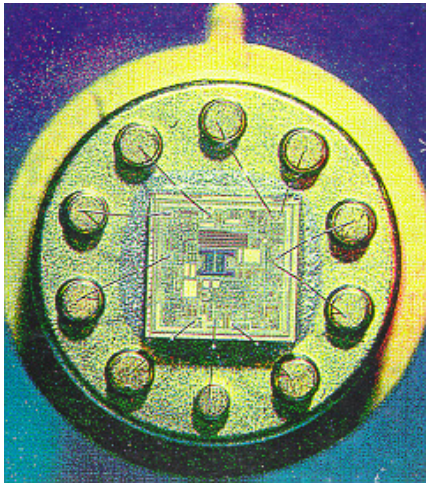
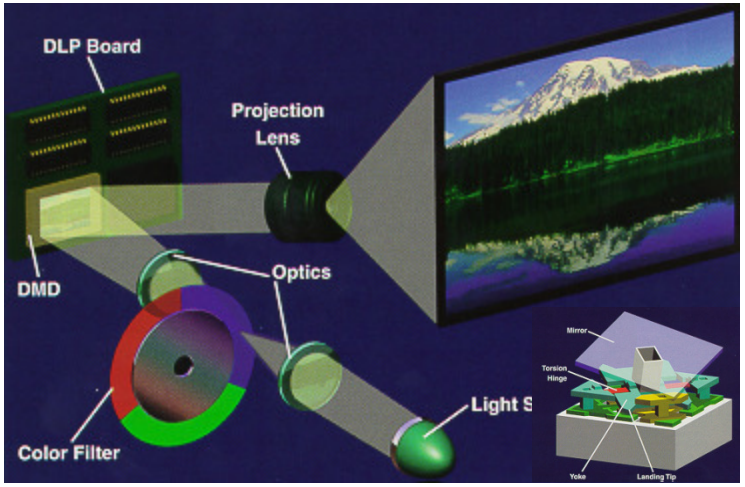
Overview of MEMS Applications

Chang Liu
Micro Actuators, Sensors, Systems Group
University of Illinois at Urbana-Champaign

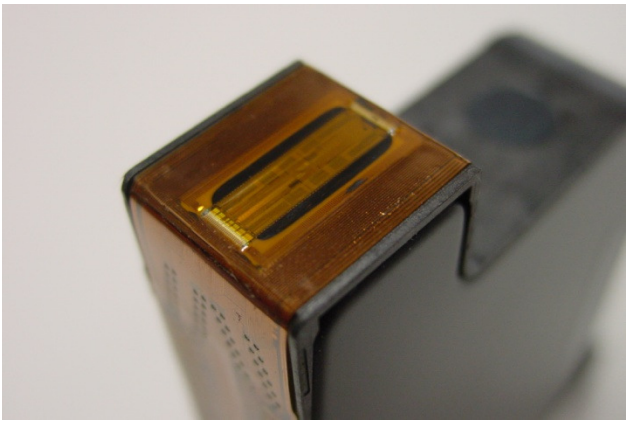
Micro Electro Mechanical Systems



Accelerometer
(Analog Devices)



Digital Light Processors (DLP)
(Texas Instruments)



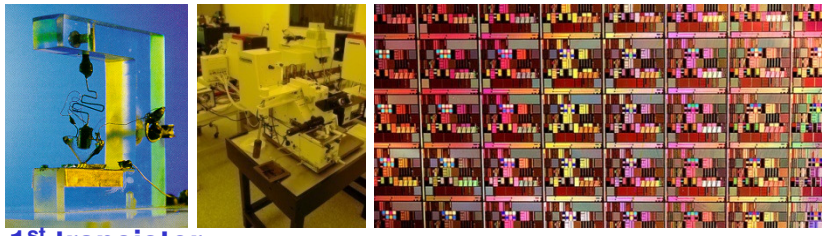
Ink Jet Nozzle
(HP)

Miniaturization & Resolution (1 µm-1mm)

Mechanics/ Electronics Integration

Parallel Fabrication

Evolution of MEMS



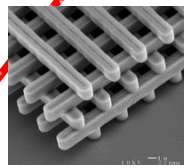
1st transistor (1947)

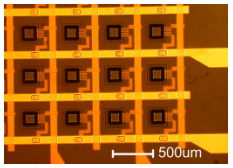
Materials
Processes
Equipment

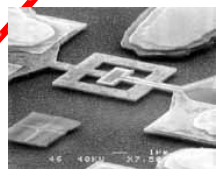
bioMEMS and microfluid

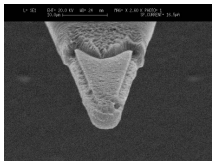
micromotor

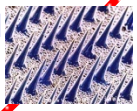
Petersen paper

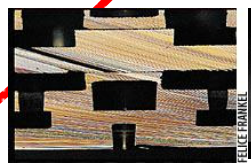


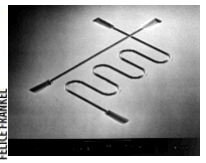


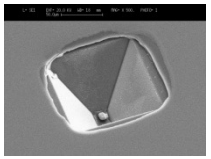


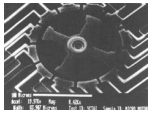


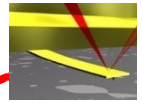


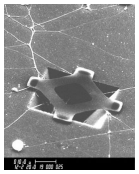


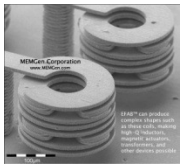


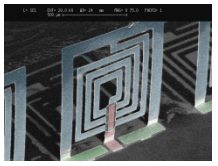


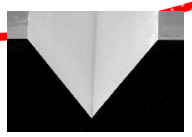


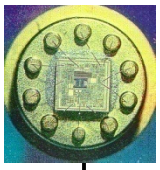


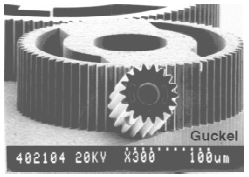


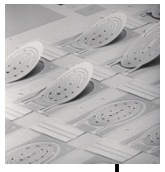


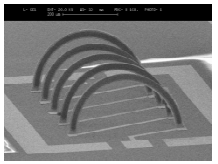






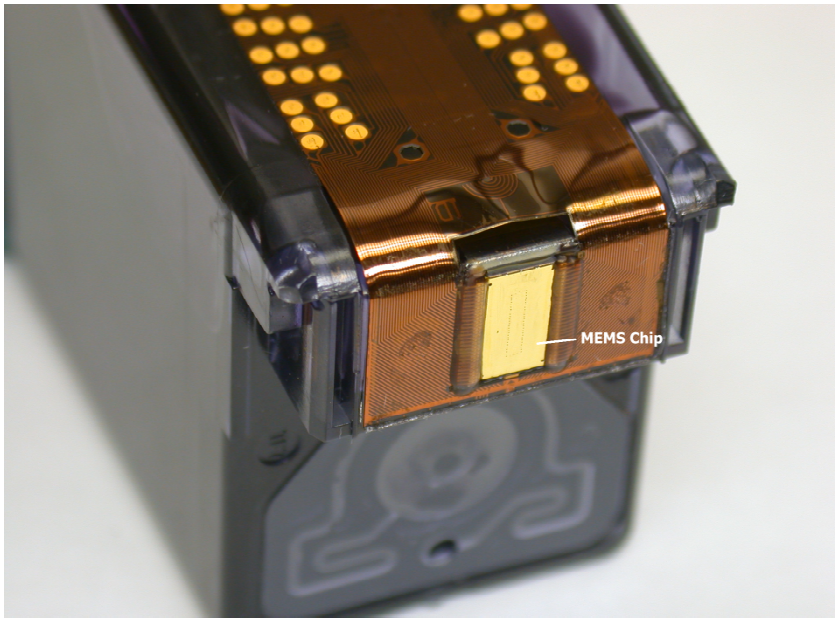


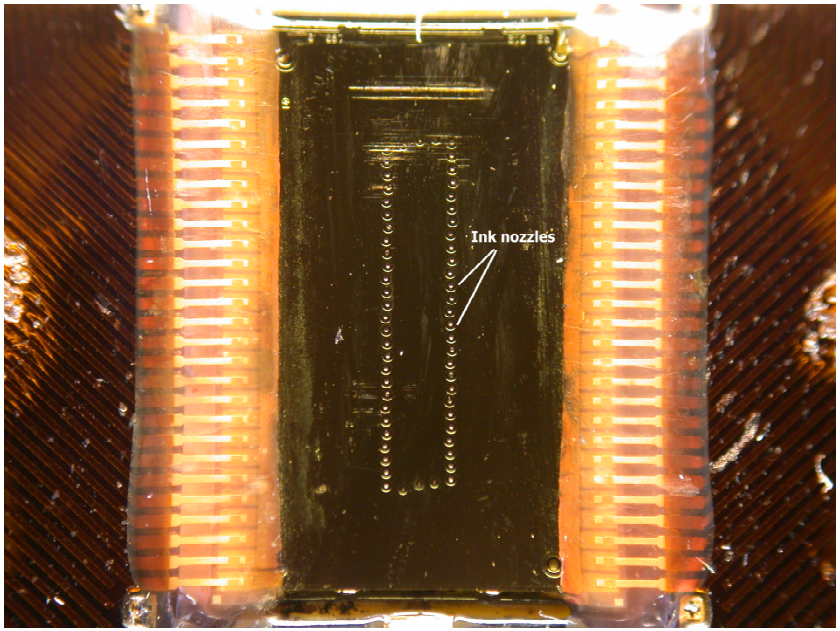


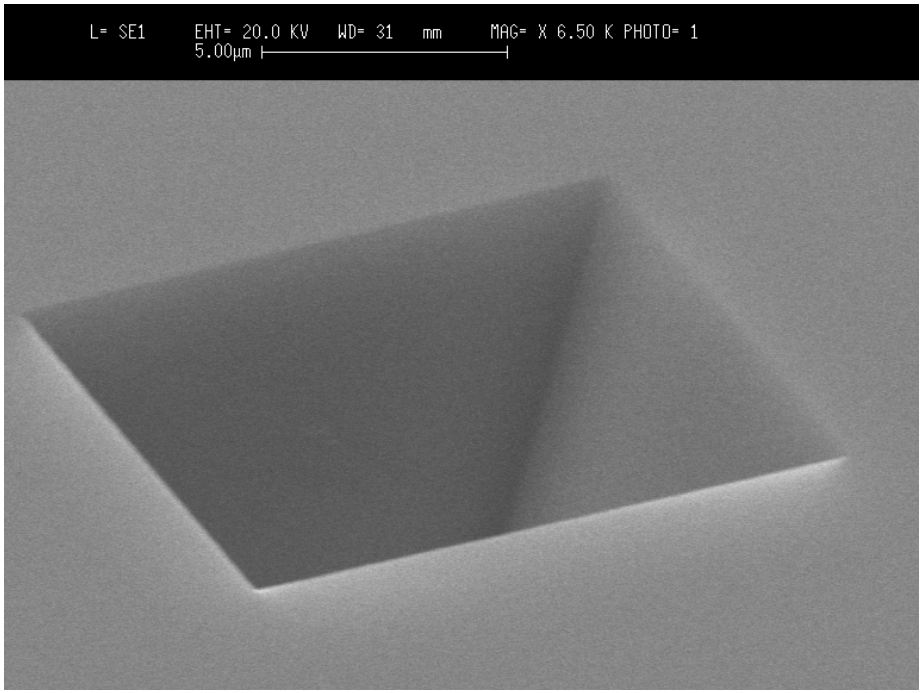


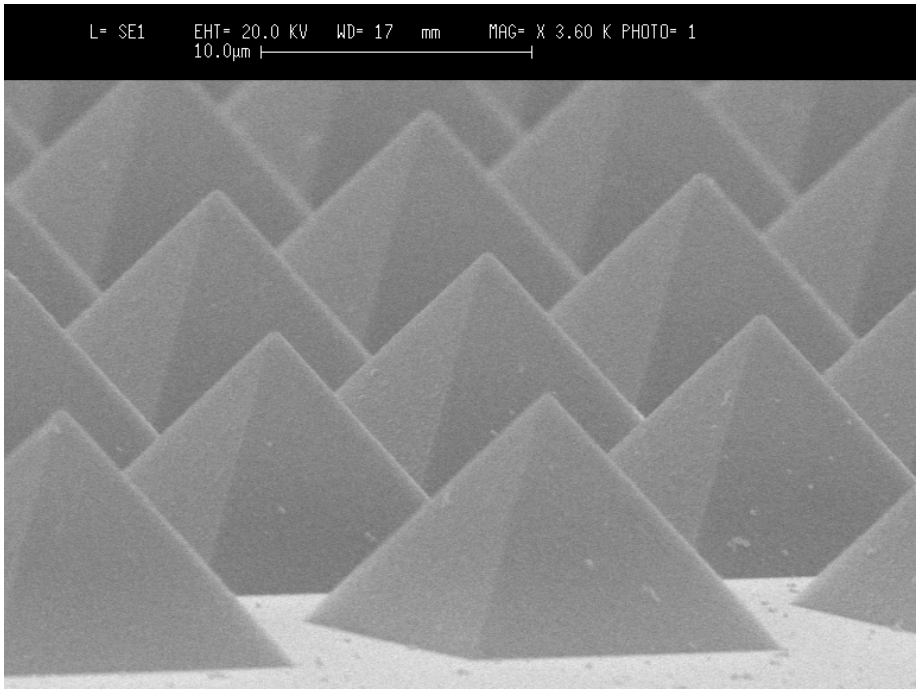
1980 1990 2000

Power Elec.
Dist. MEMS
Env. Monit.
Biometrics
Security
Inertial Sen.
Data store
Foundry
PowerGen
µRobotics
SoftLitho
Display
NEMS
SensorNet
AeroMEMS
RFMEMS
Microfluid
BioMEMS


MEMS Chip

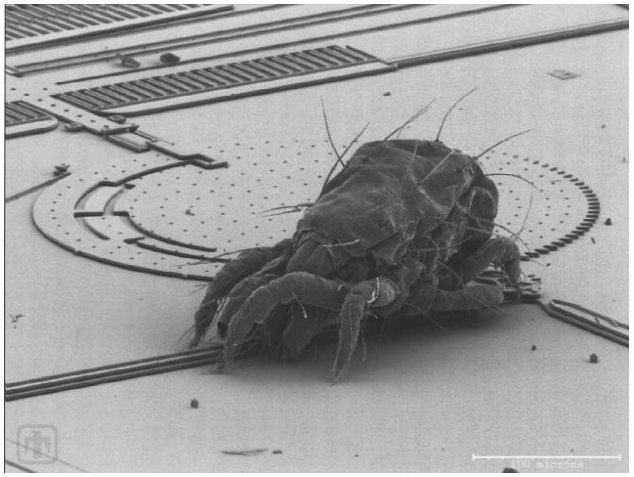

Ink nozzles

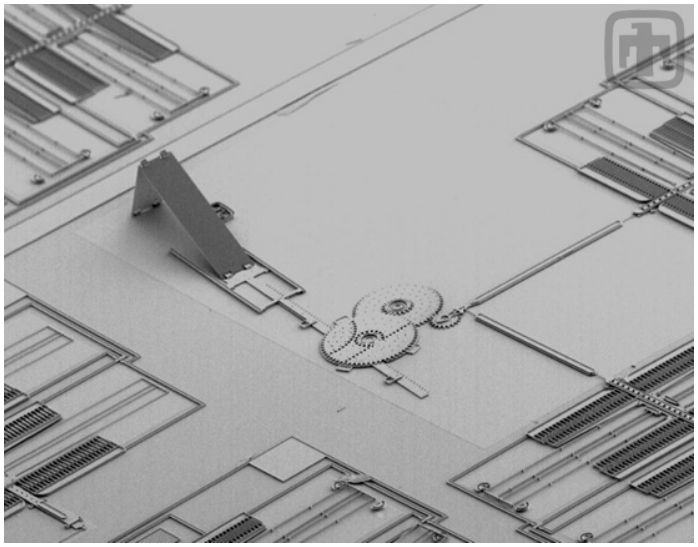

L= SE1 EHT= 20.0 KV WD= 31 mm MAG= X 6.50 K PHOTO= 1
5.00µm

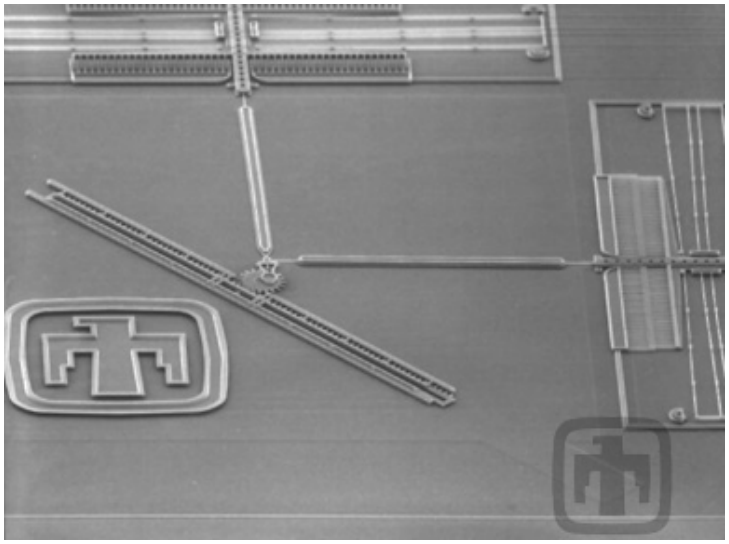

L= SE1 EHT= 20.0 KV WD= 17 mm MAG= X 3.60 K PHOTO= 1
10.0µm

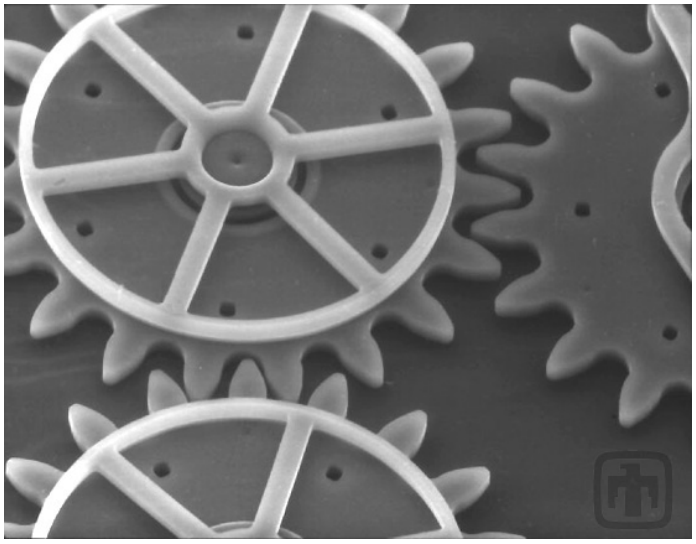
Weapon Safeguarding – Sandia National Lab.

- http://www.mdl.sandia.gov/Micromachine/

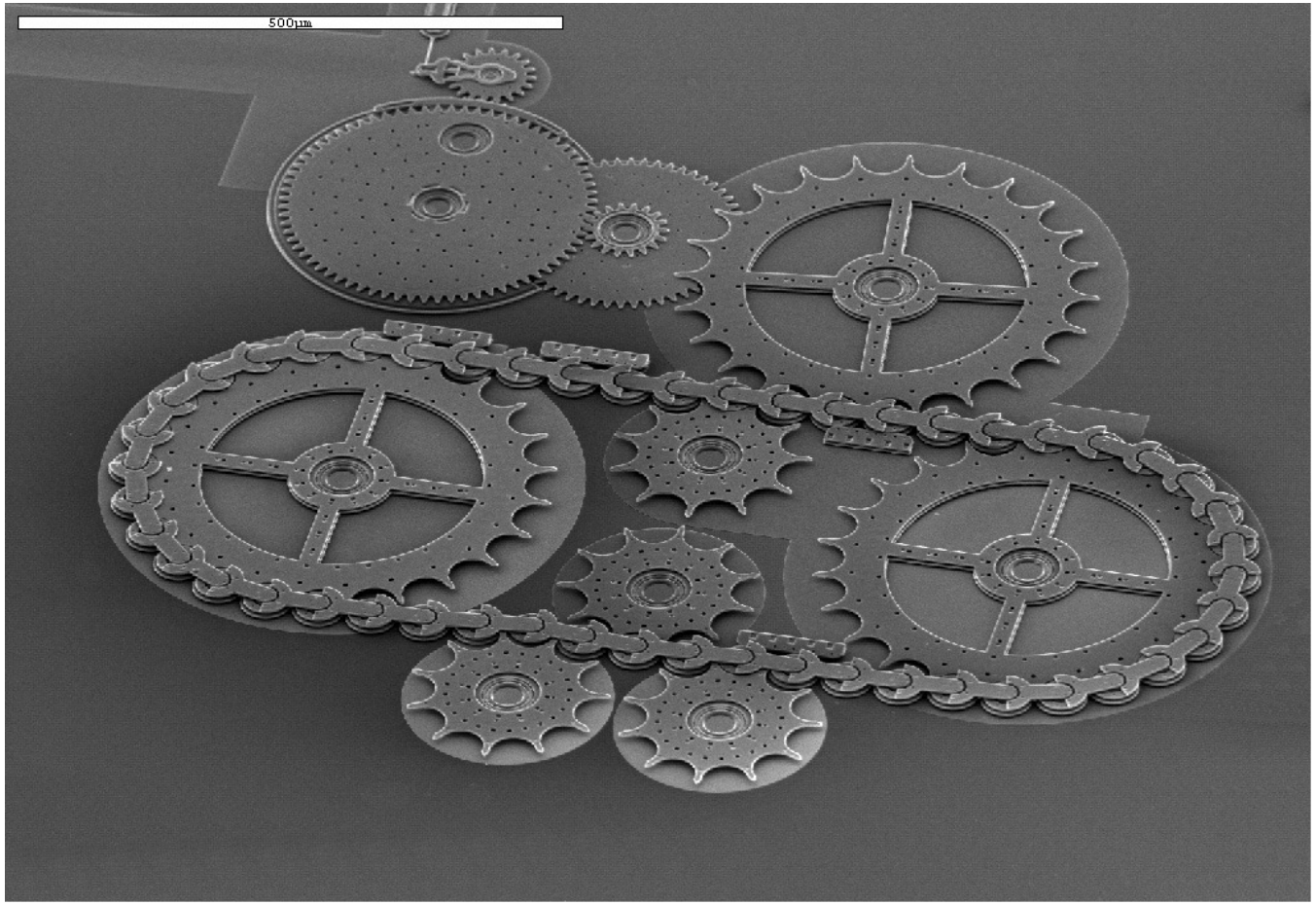




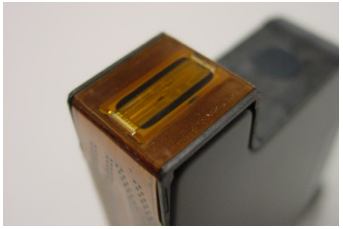




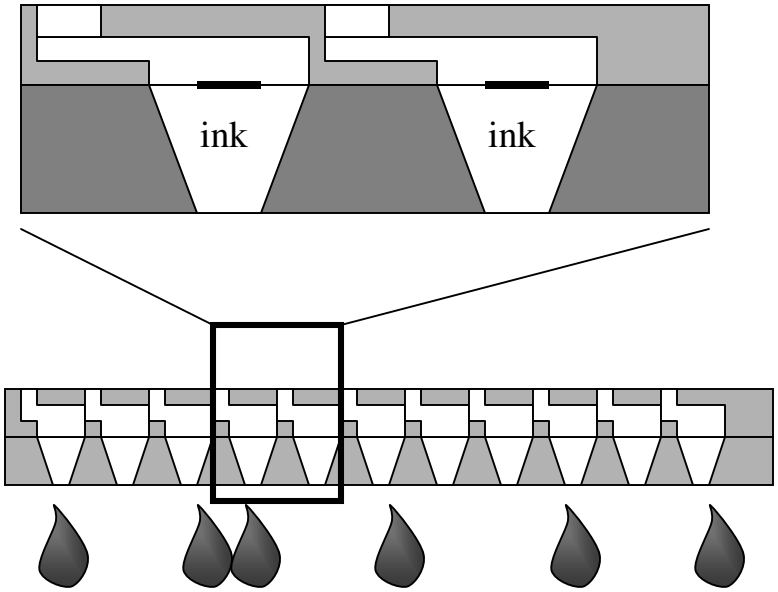
Surface Micromachined Gear Chains



Ink Jet Printer

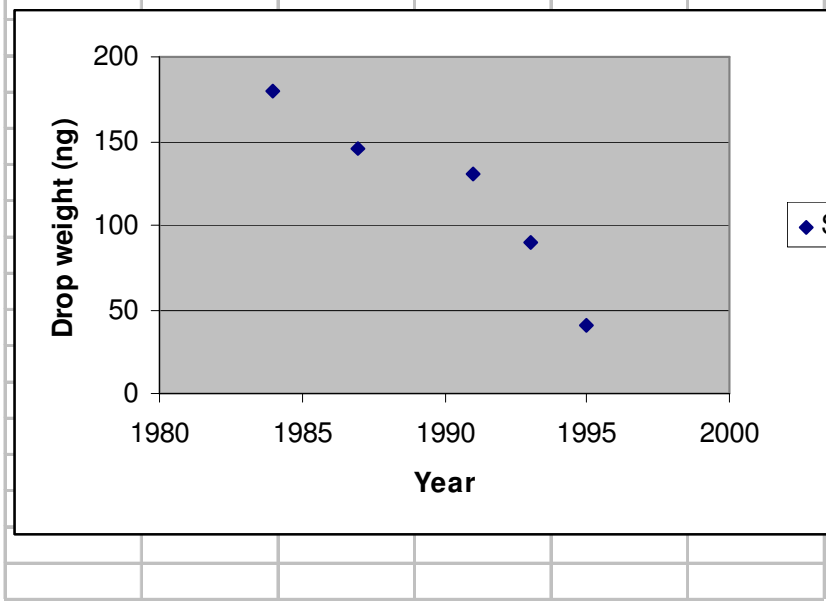


Hewlett-Packard Photo

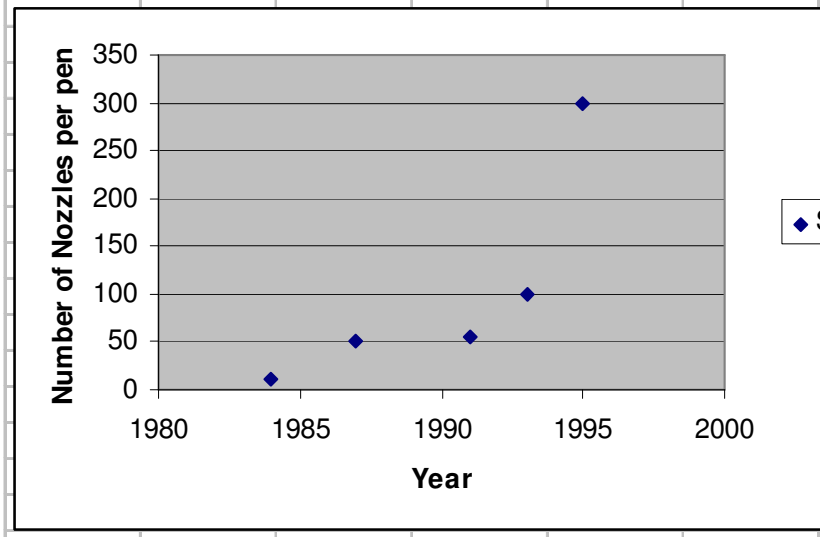


Ink jet printer

1984	1987	1991	1993	1995
180	145	130	90	40

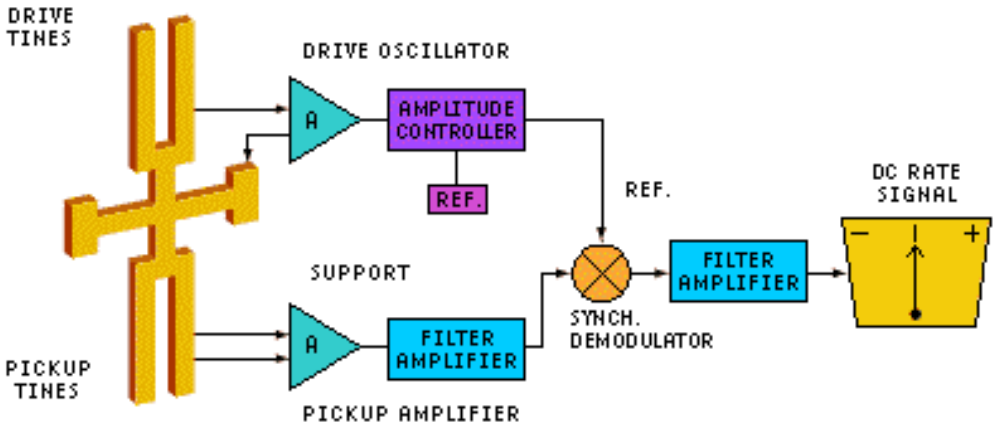


1984	1987	1991	1993	1995
10	50	55	100	300



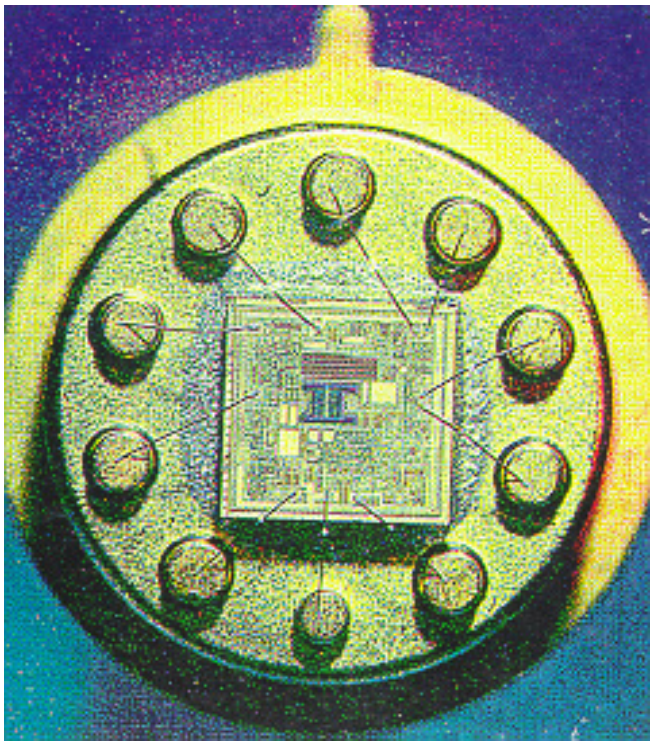
Micromachined Gyro Chip

- Range: +/- 50-1000 °/sec
- Stability
  - 0.002 °/sec short term
  - 0.2 °/sec long term



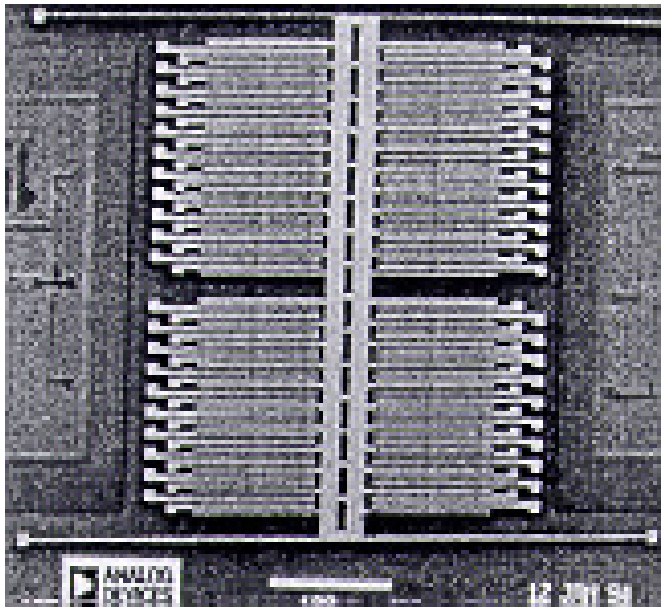
Comparison with conventional
Large scale gyro

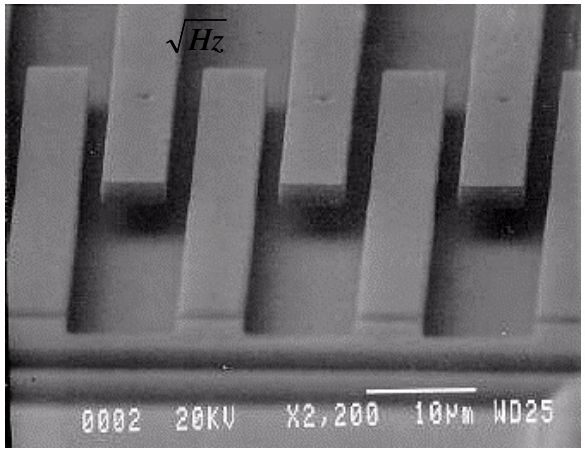
Accelerometers



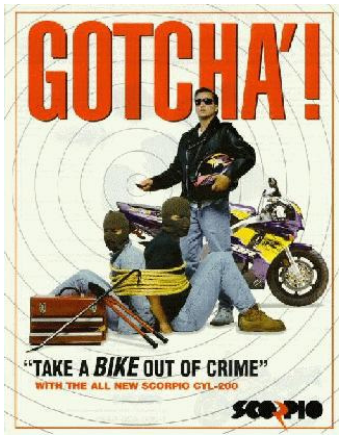
Analog Devices Accelerometer

Full range: 0-5g
sensitivity: 200 mV/g
resolution: 5 mg at 100 Hz
noise floor: 0.5 mg/(Hz)$^{1/2}$





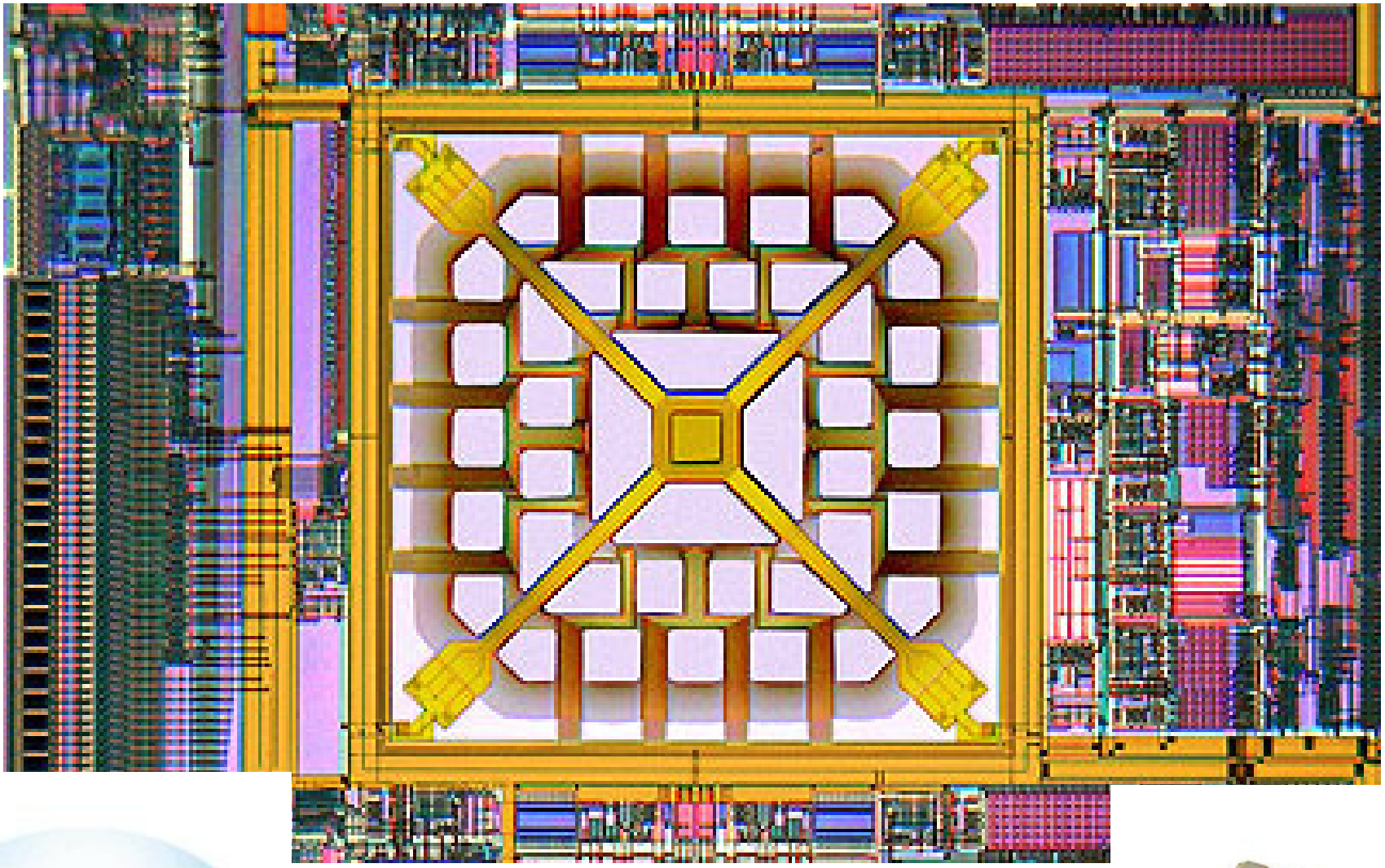
Also, 10 million sold on 5/15/1998 by Motorola



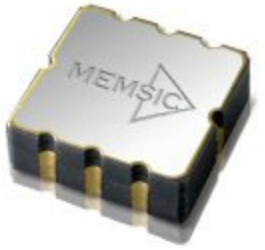
Motorcycle security sensor

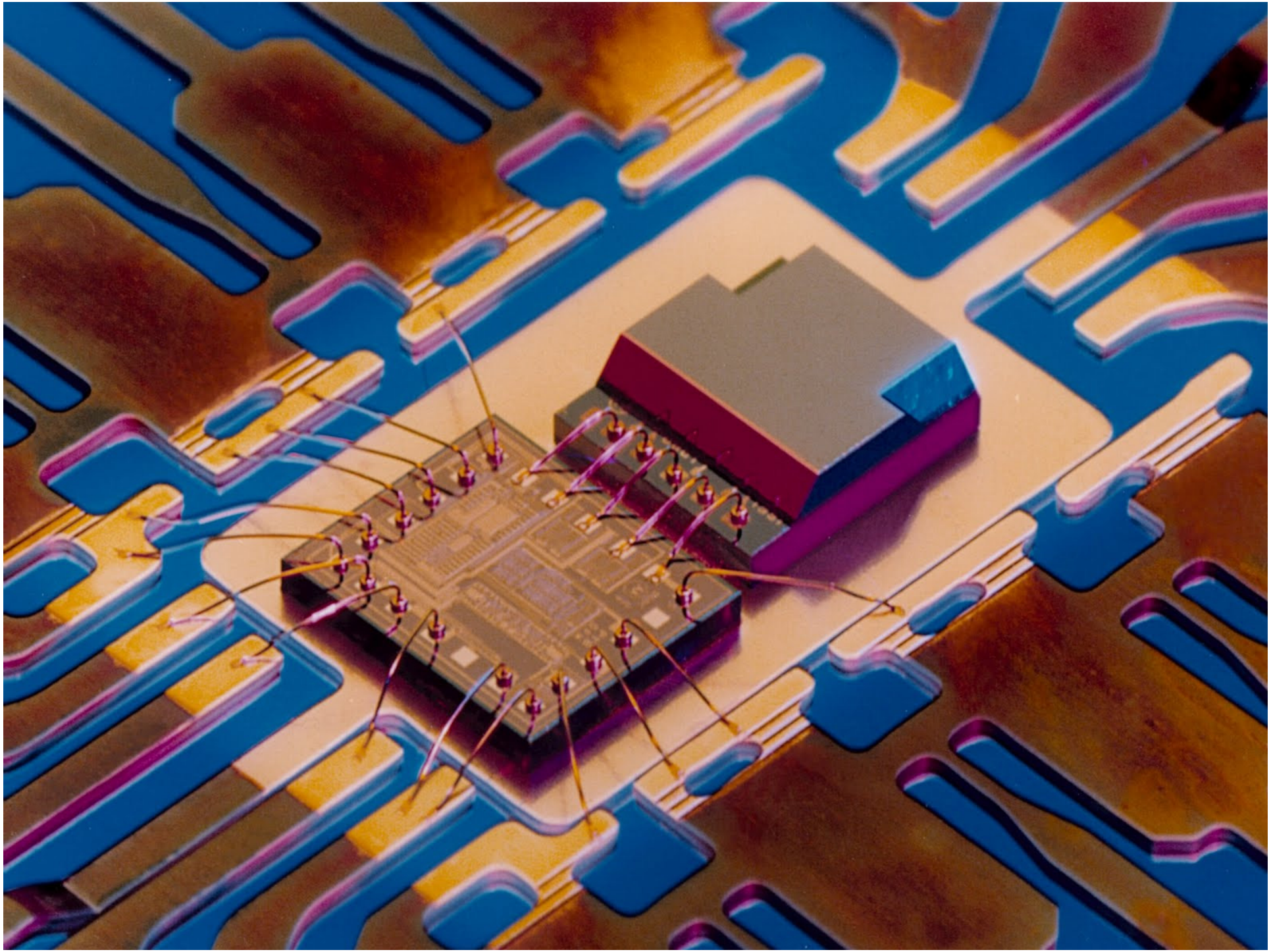
BT Smart Quill

http://www.bt.com/innovation/exhibition/smartquill/index.htm

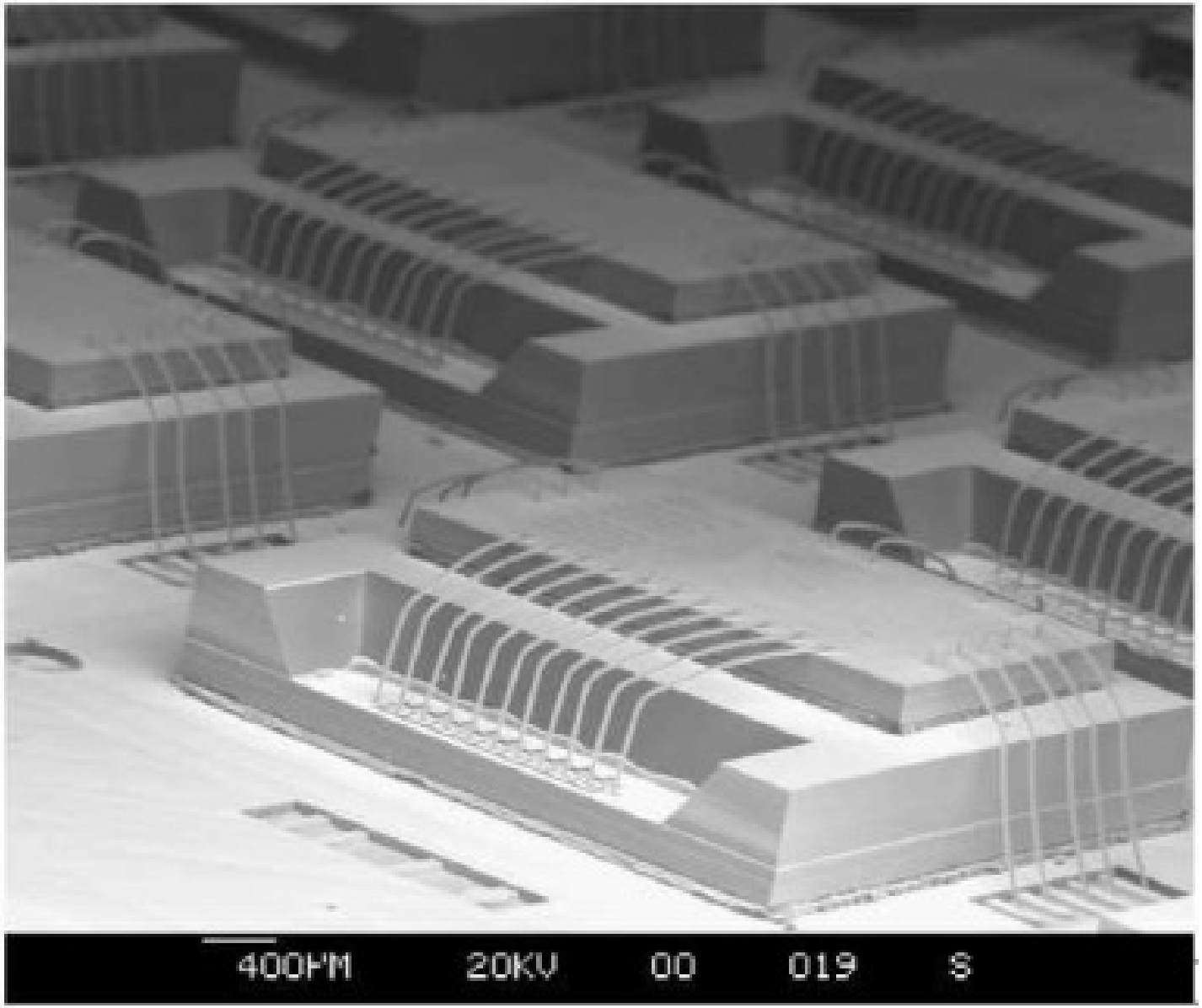



Air Cavity
Heated Air
Temperature Sensor
Trench
Heater Bar
Silicon Substrate

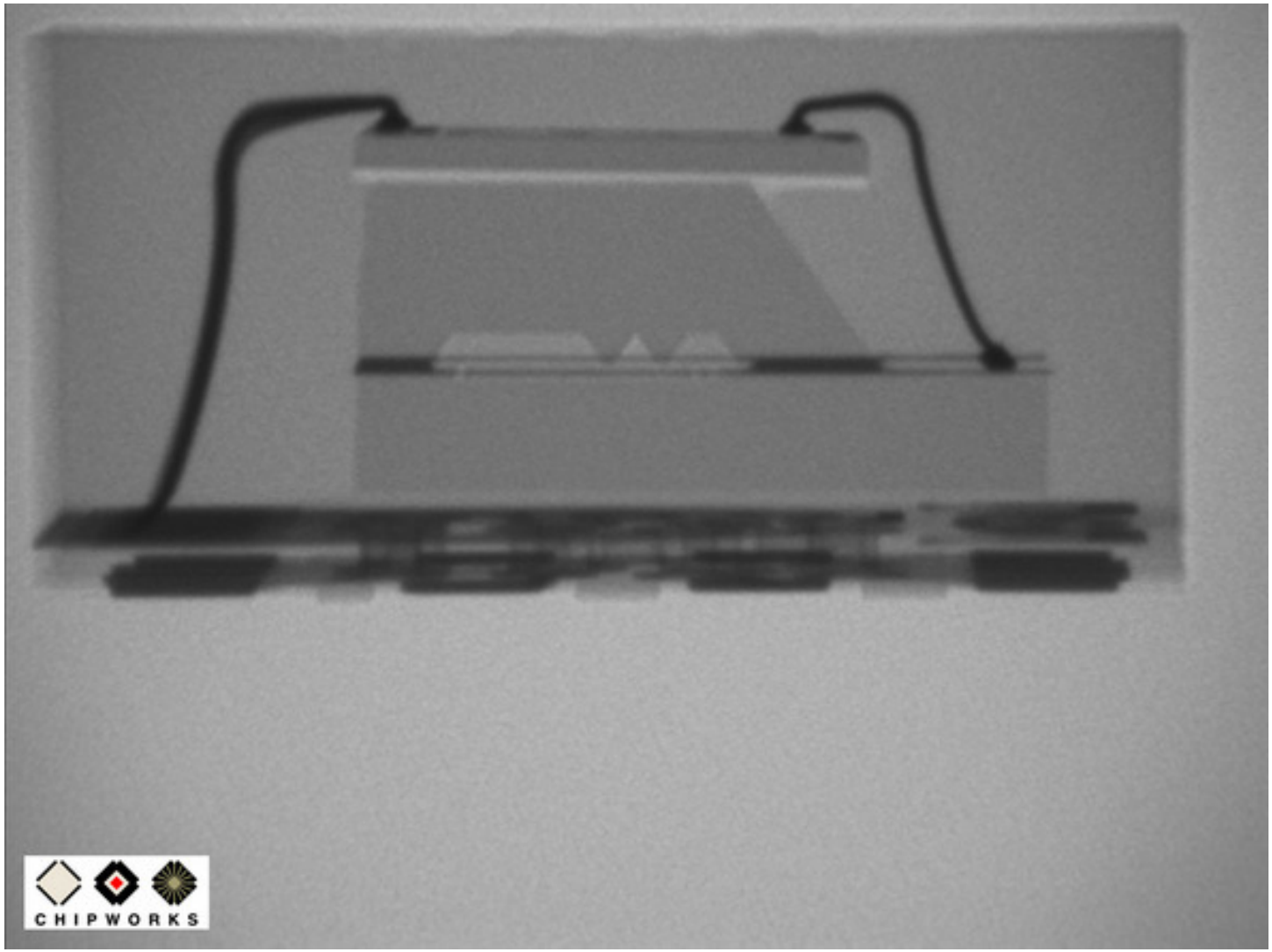

MEMSIC



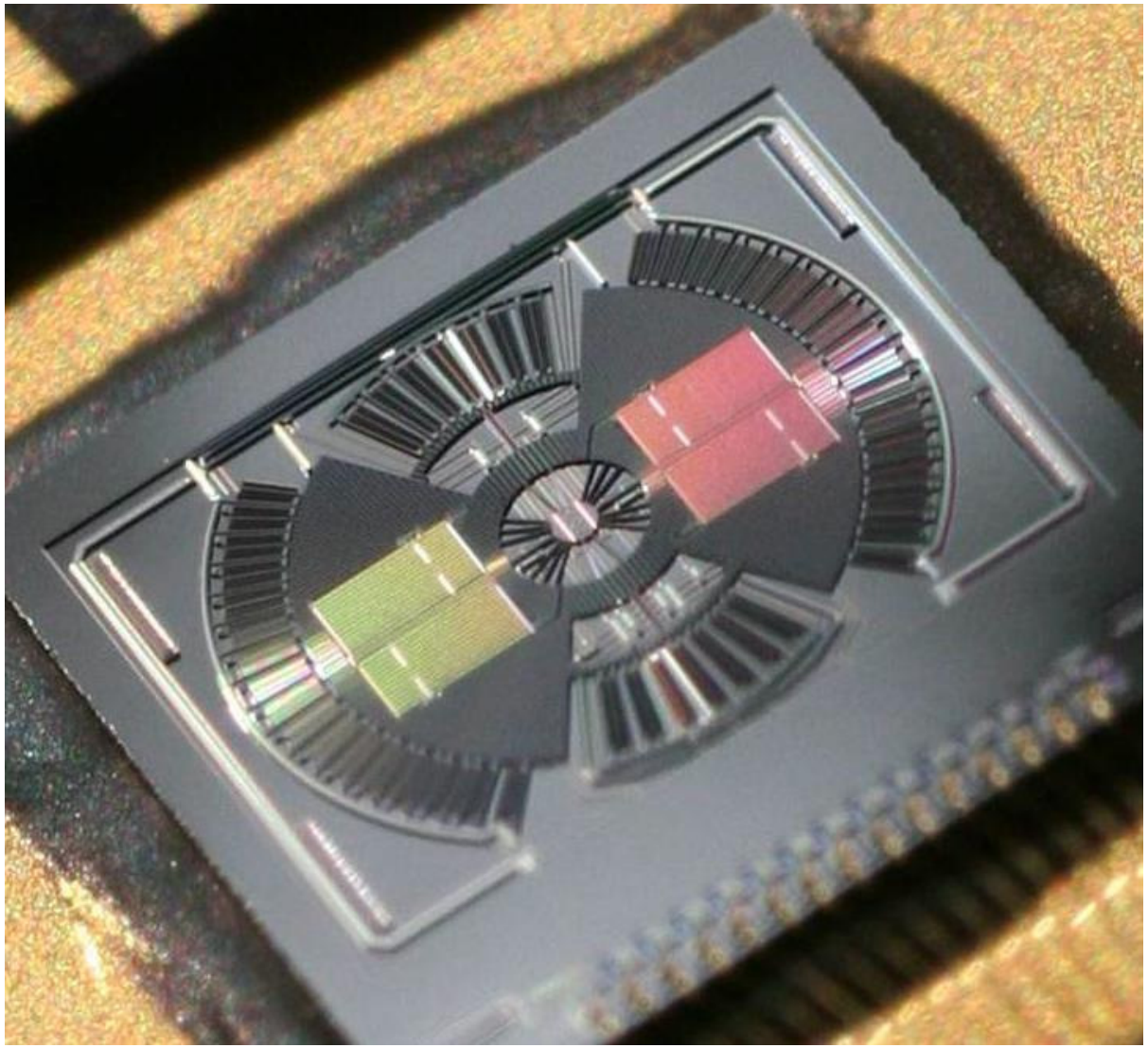
ST Microelectronics Gyro



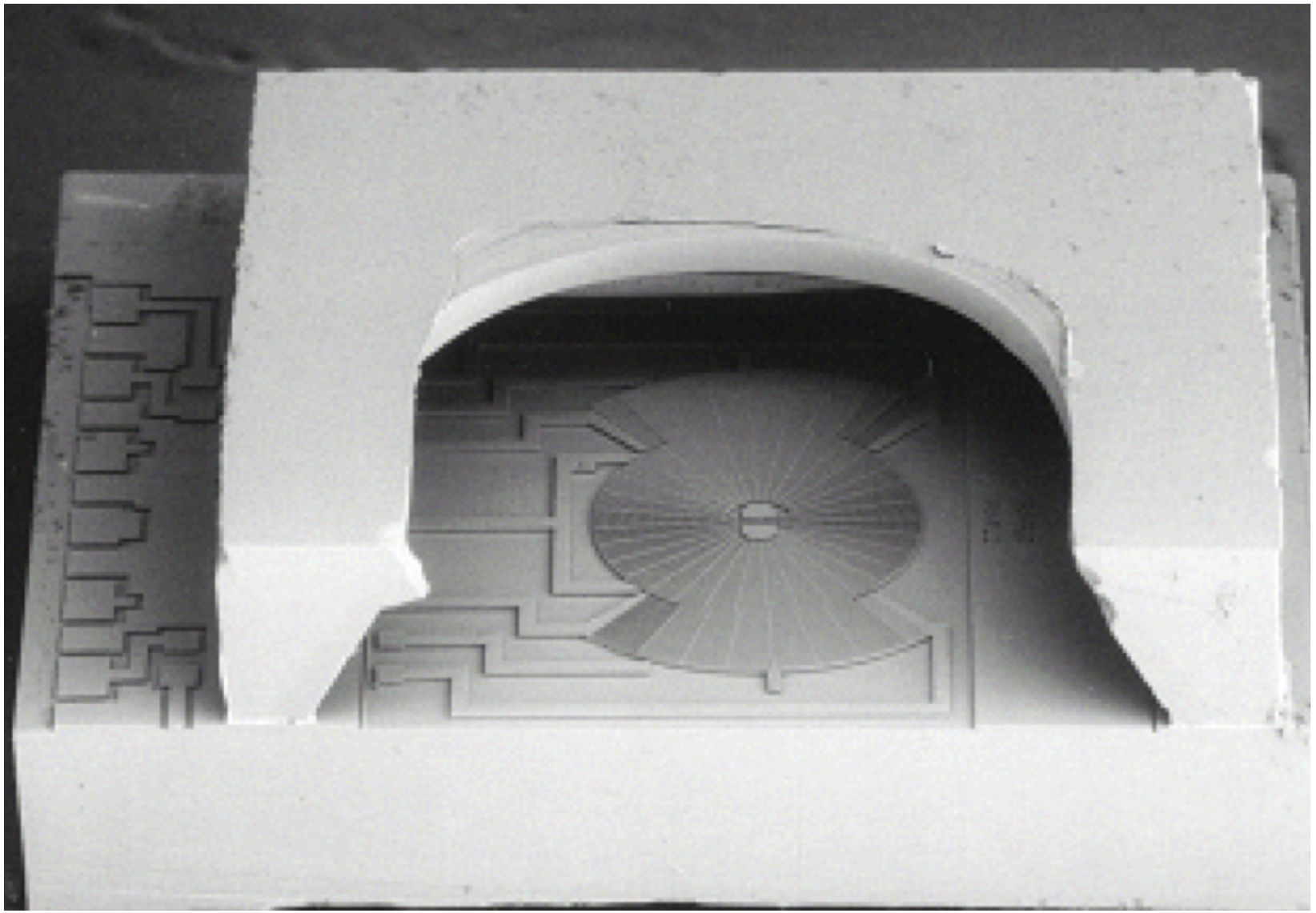
SiTime Silicon Clock – replacement for quartz



Gyro - Invensense



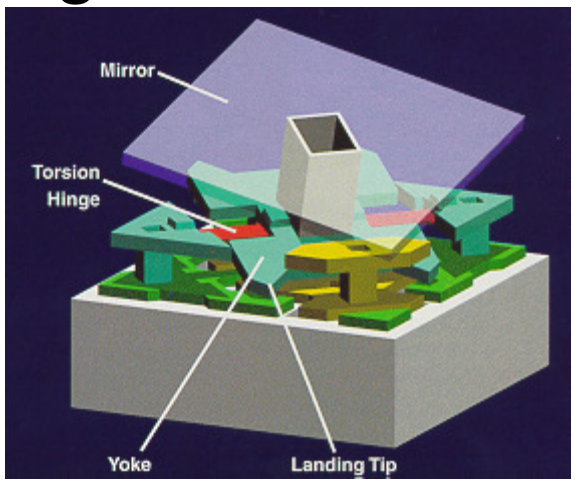
Gyro InvenSense

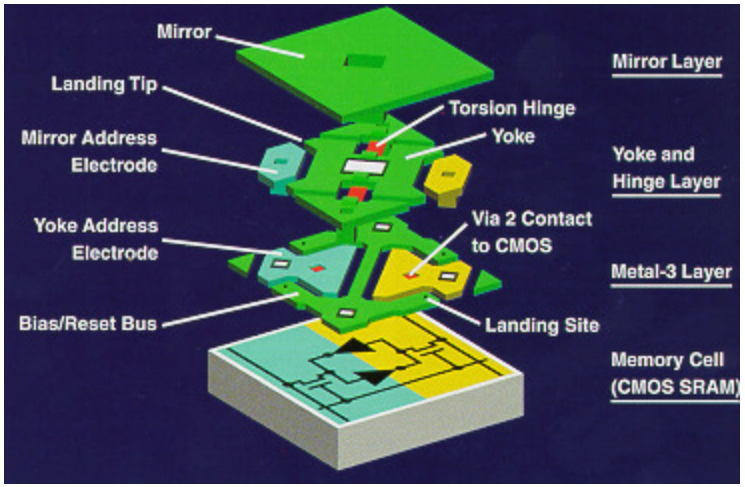


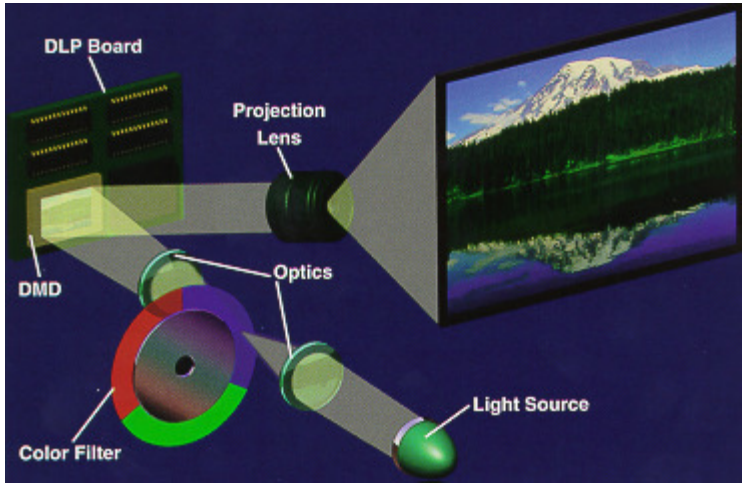
Digital Micro Mirrors

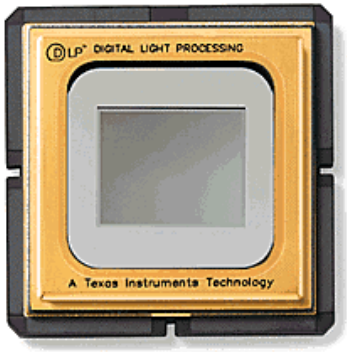
www.ti.com/dlp

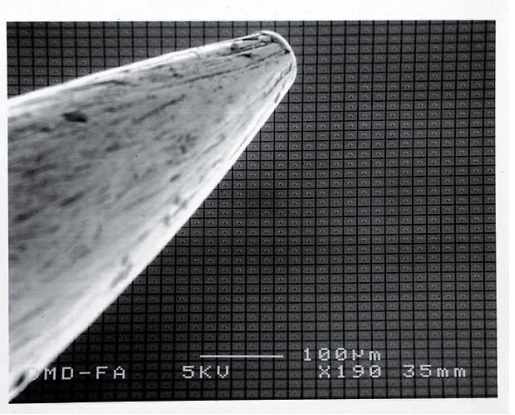
TI Photos



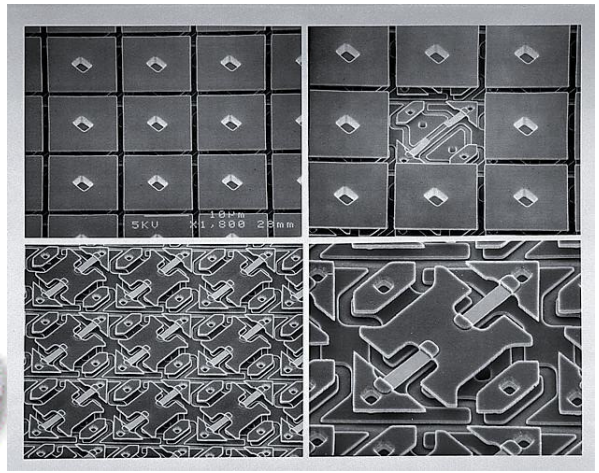


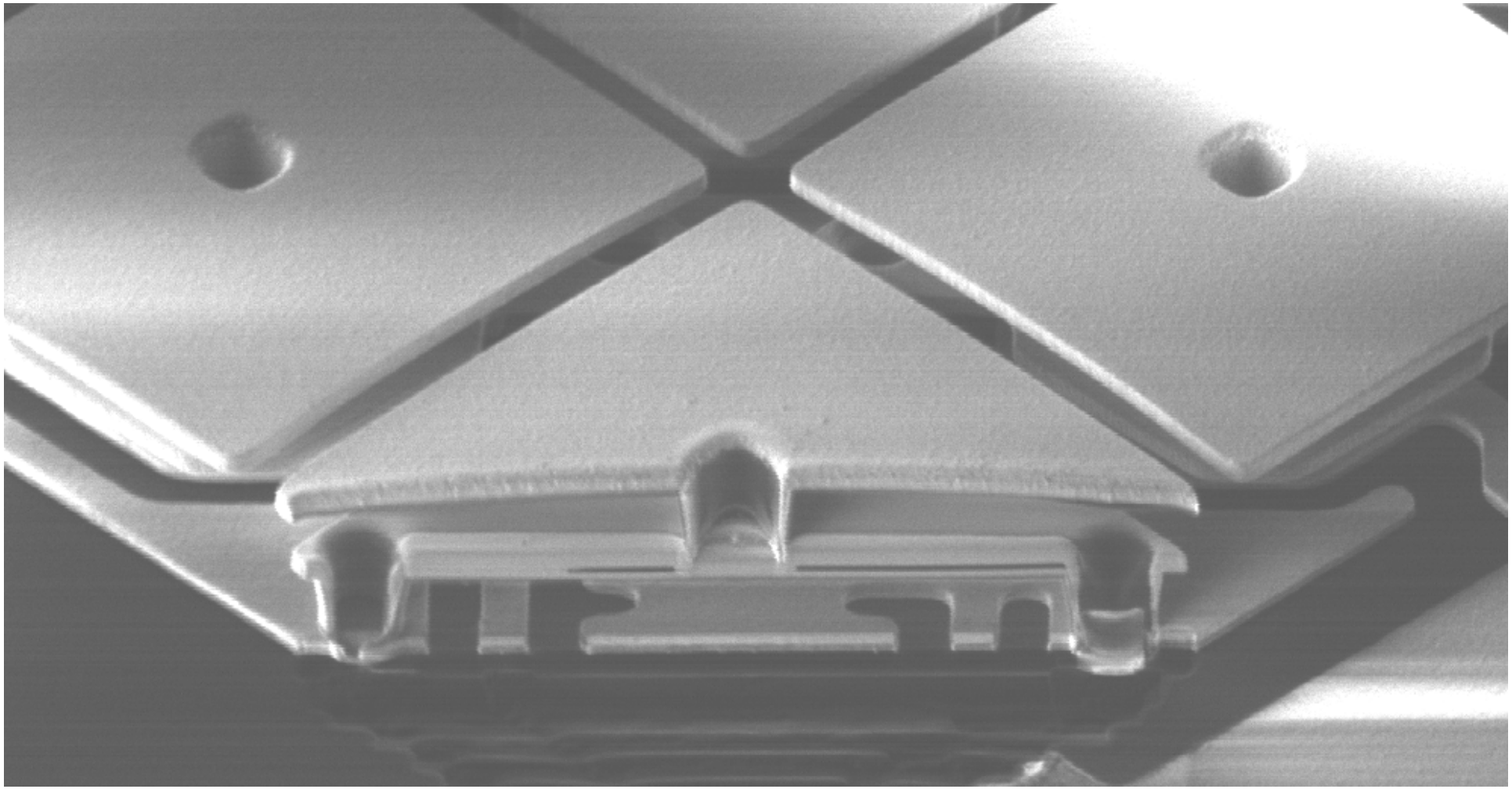




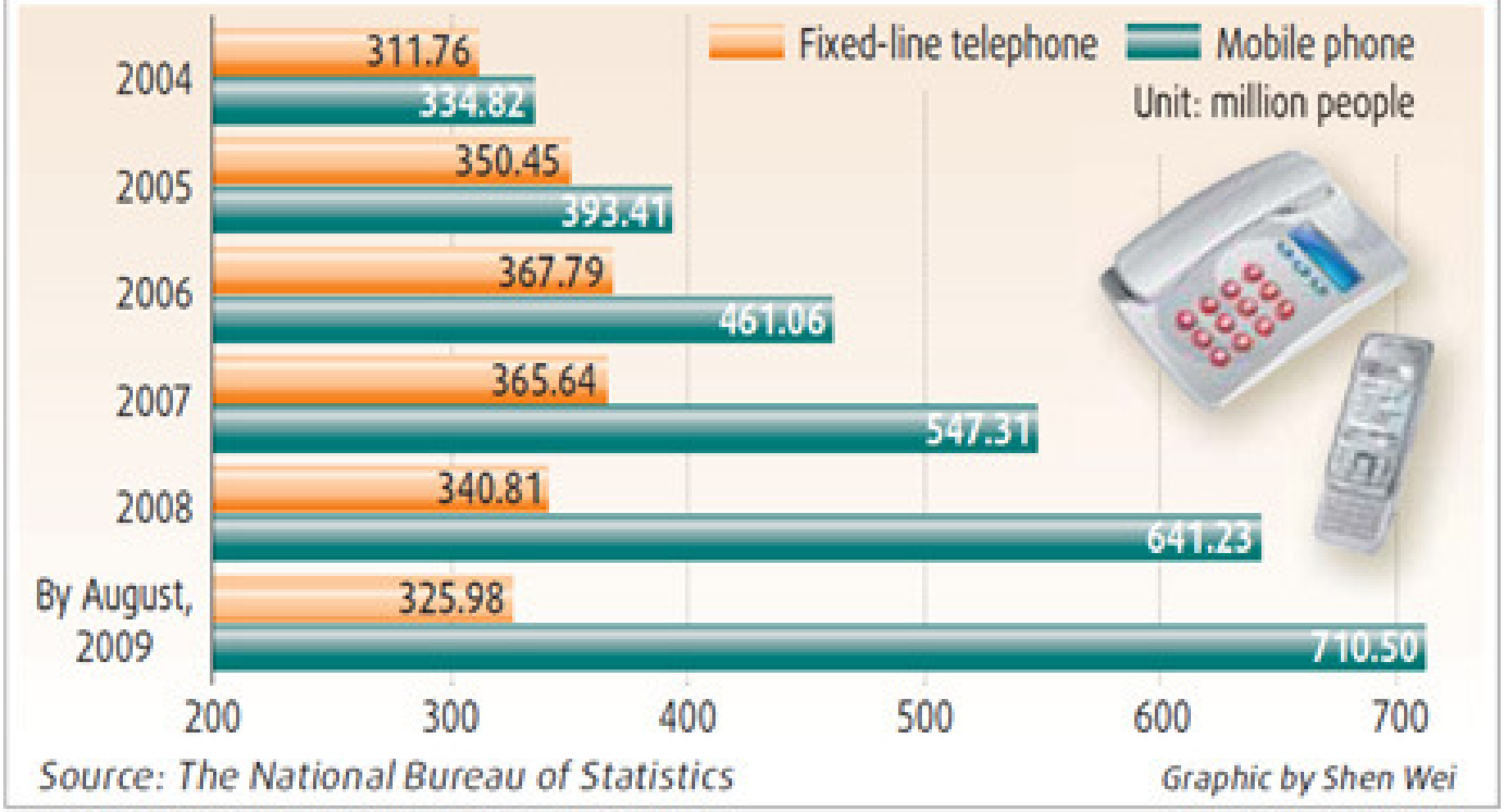


DLP™
A TEXAS INSTRUMENTS TECHNOLOGY





China's telephone subscribers

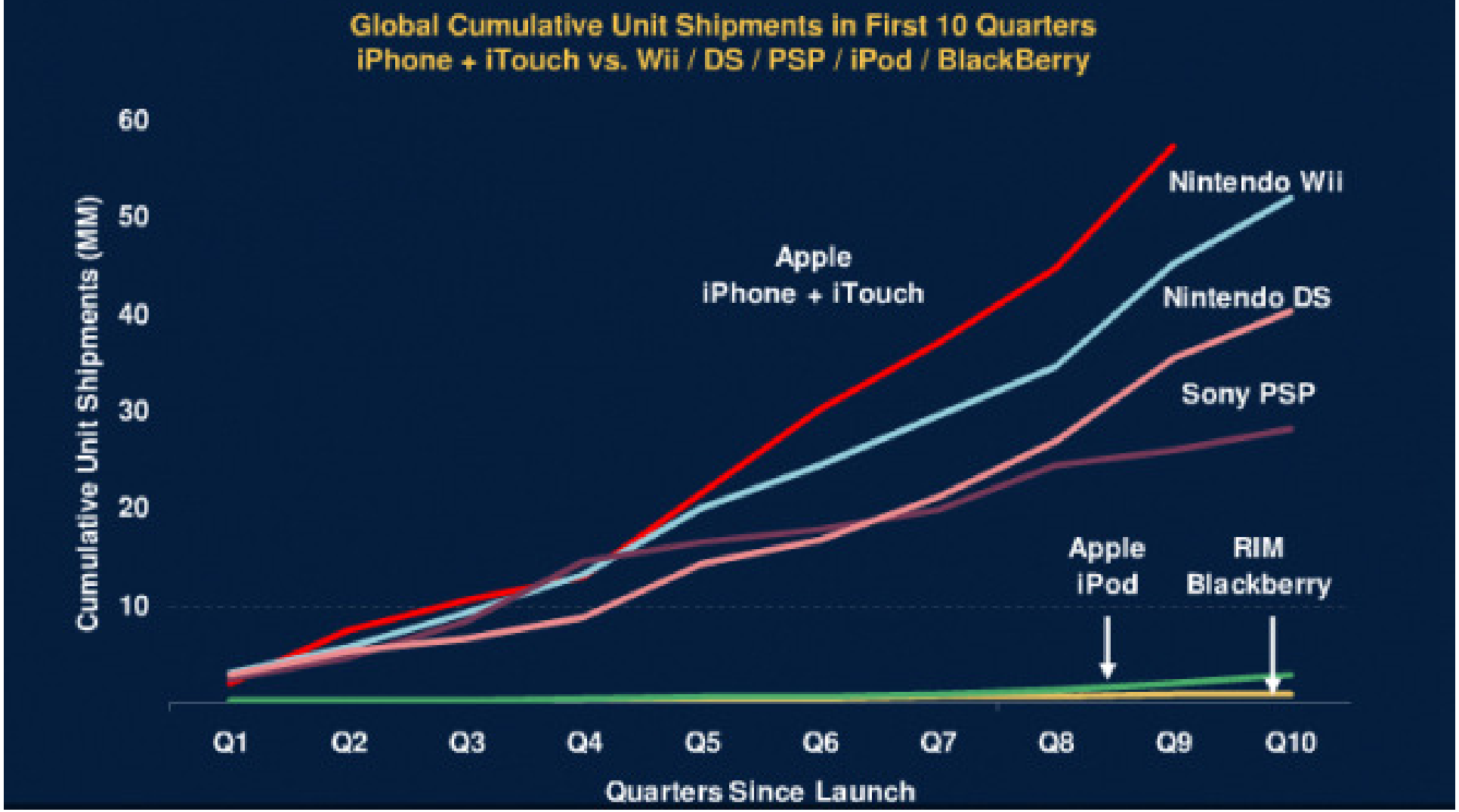


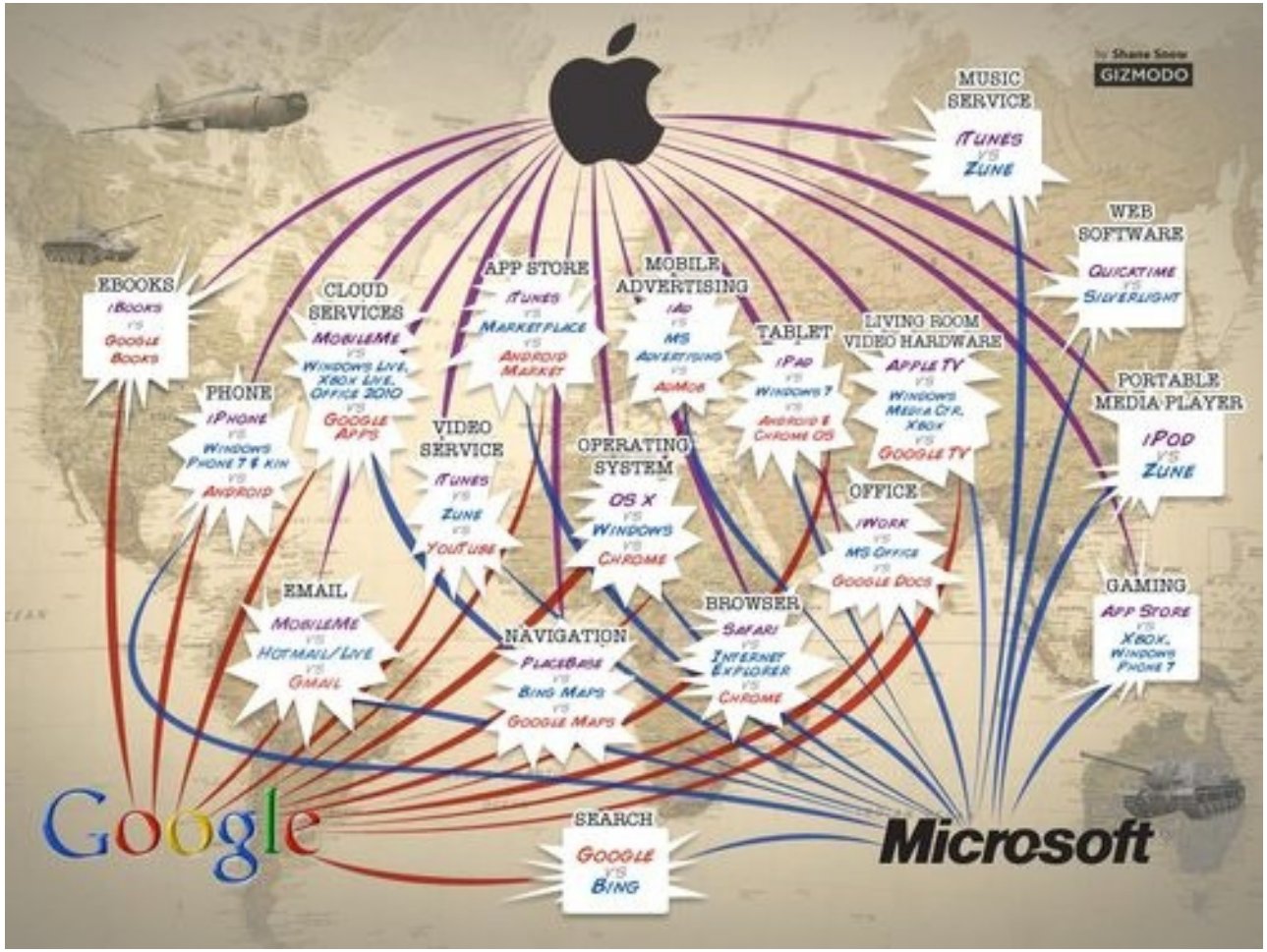
Source: The National Bureau of Statistics

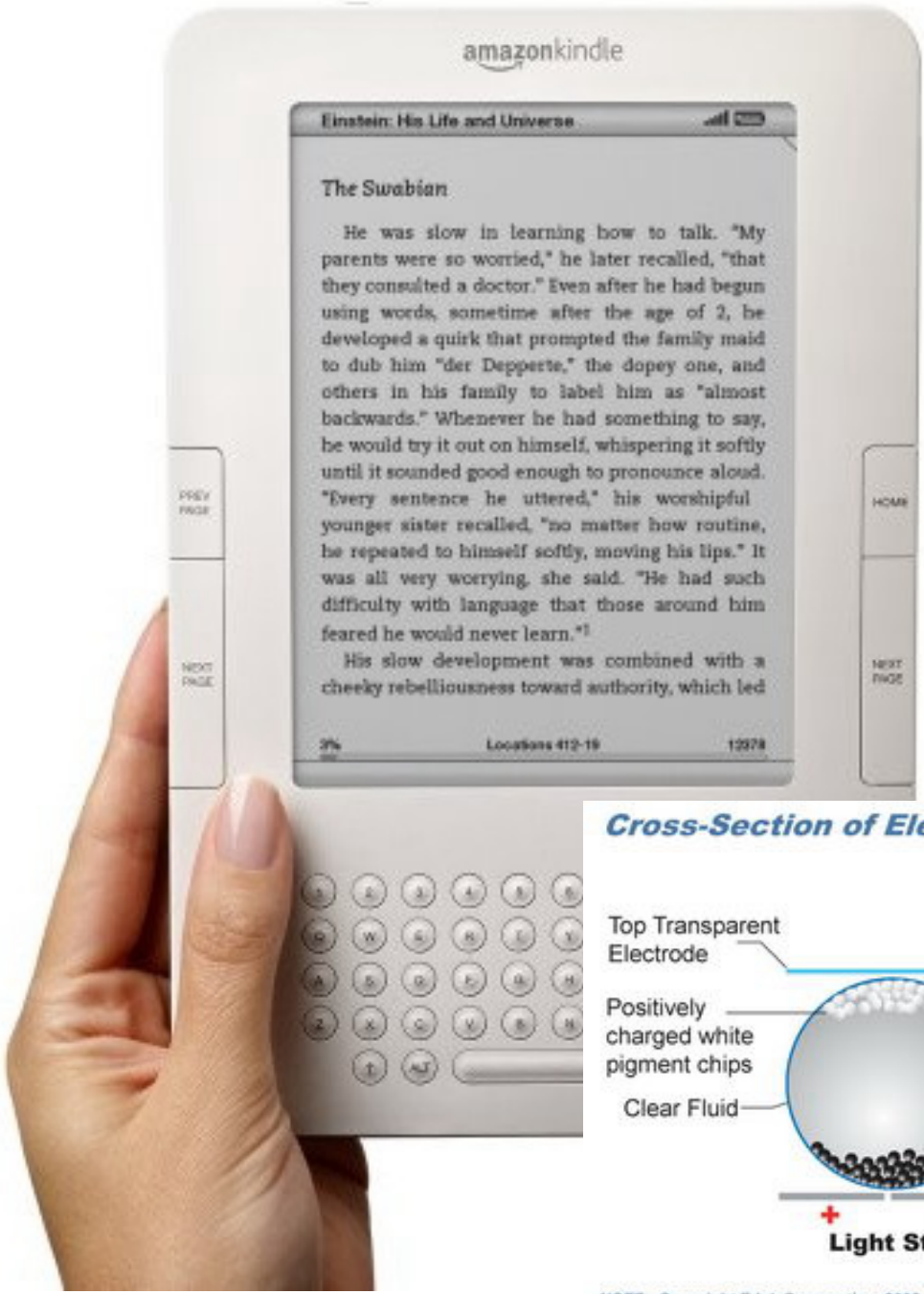
Graphic by Shen Wei

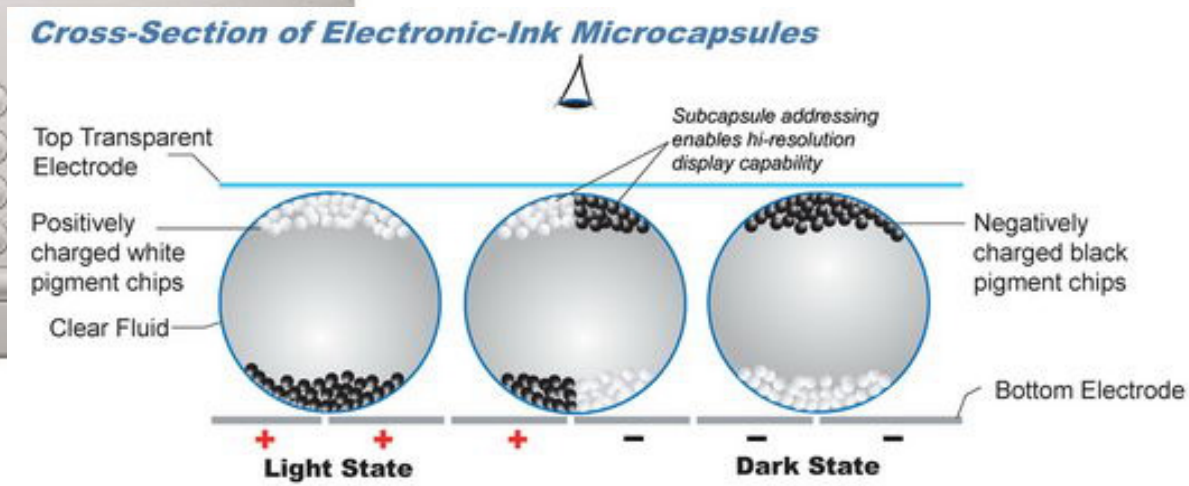
Momentum Favors Apple iPhone + iTouch Ecosystem

Fastest Hardware User Growth in Consumer Tech History



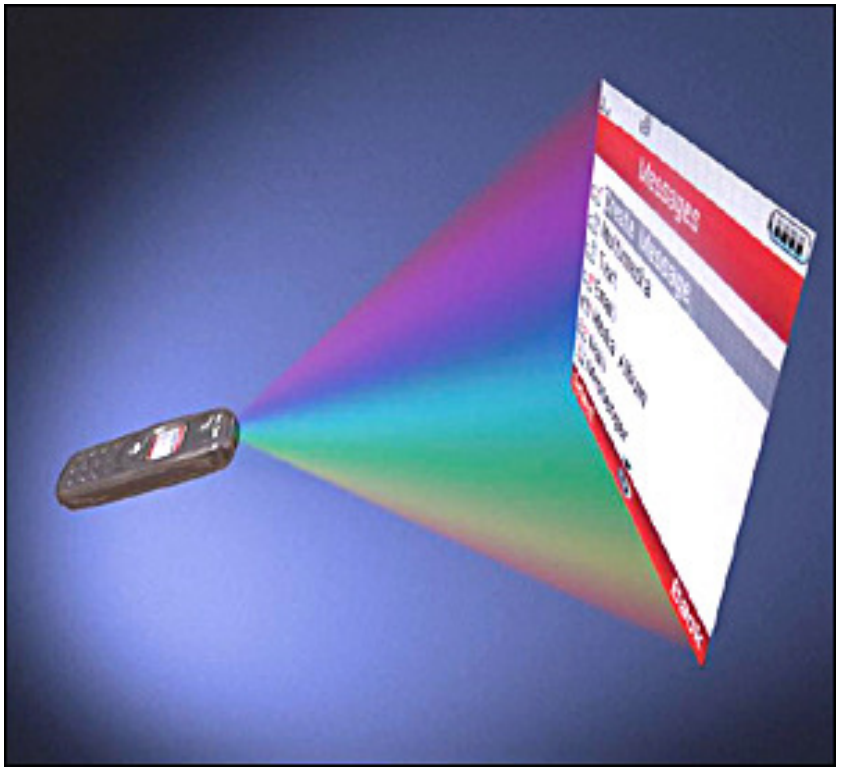

by Shane Snow
GIZMODO
MUSIC SERVICE
iTunes vs Zune
WEB SOFTWARE
Quicktime vs Silverlight
EBOOKS
iBooks vs Google Books
CLOUD SERVICES
MobileMe vs Windows Live, Xbox Live, Office 2010 vs Google Apps
APP STORE
iTunes vs Marketplace vs Android Market
MOBILE ADVERTISING
iAd vs MS Advertising vs AdMob
TABLET
iPad vs Windows 7 vs Android & Chrome OS
LIVING ROOM VIDEO HARDWARE
Apple TV vs Windows Media Ctr, Xbox vs Google TV
PORTABLE MEDIA PLAYER
iPod vs Zune
PHONE
iPhone vs Windows Phone 7 & Kin vs Android
VIDEO SERVICE
iTunes vs Zune vs YouTube
OPERATING SYSTEM
OS X vs Windows vs Chrome
OFFICE
iWork vs MS Office vs Google Docs
EMAIL
MobileMe vs Hotmail/Live vs Gmail
NAVIGATION
Placebase vs Bing Maps vs Google Maps
BROWSER
Safari vs Internet Explorer vs Chrome
GAMING
App Store vs Xbox, Windows Phone 7
Google
SEARCH
Google vs Bing
Microsoft





E · I N K

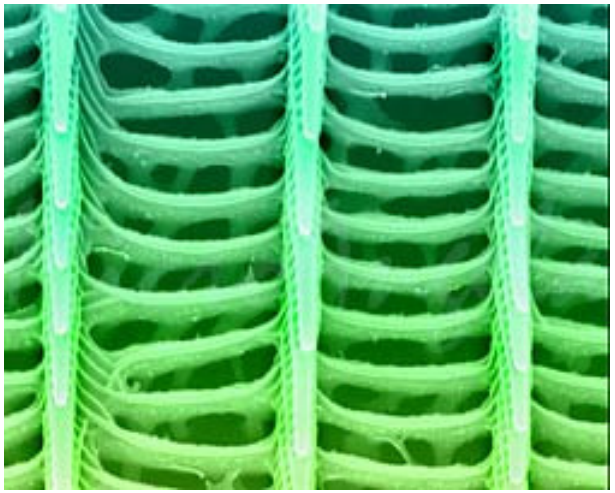

willkommen auf der cebit.
this is cool !
Close
Abc

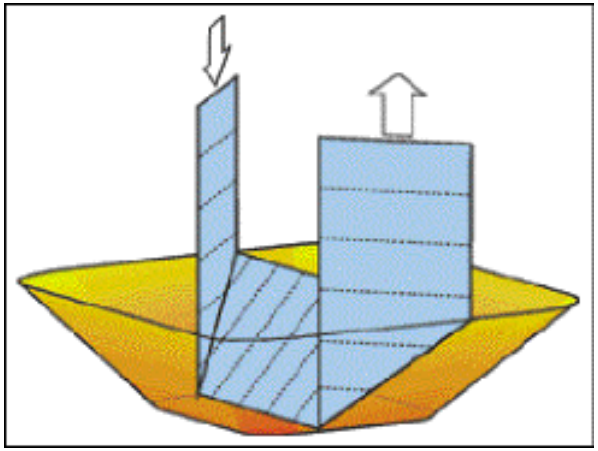


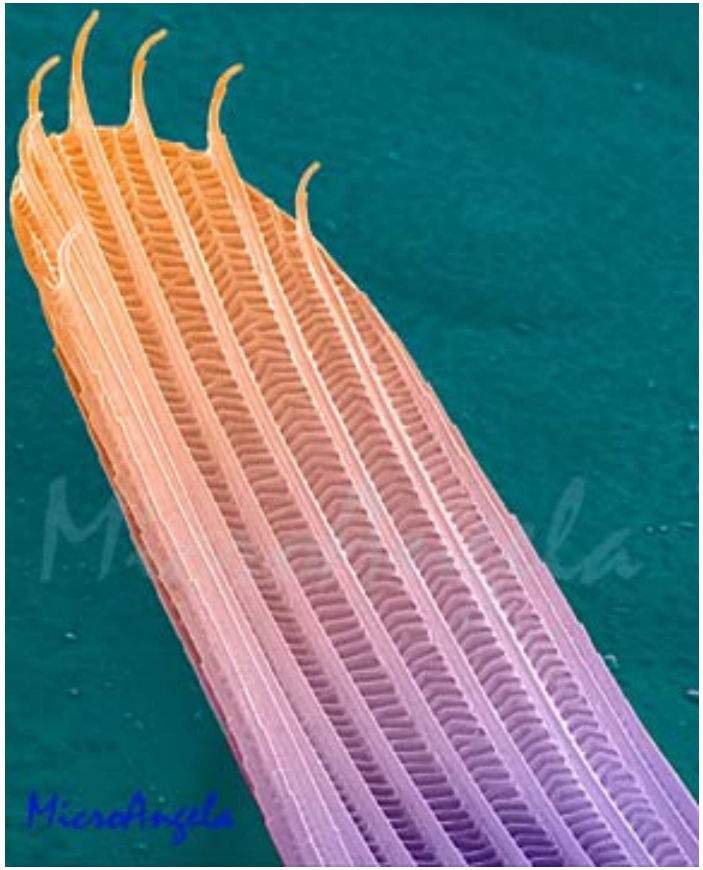

Dock

Butterfly Wing – Inspiration for display

- Butterfly and mouth derives their vibrant color partially from structural optical interference and diffraction.

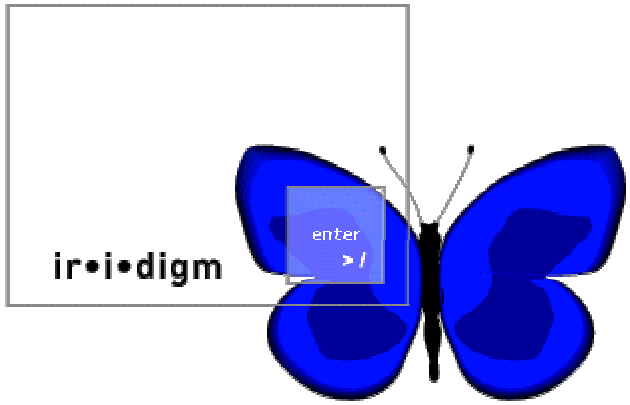






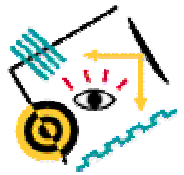
Digital paper

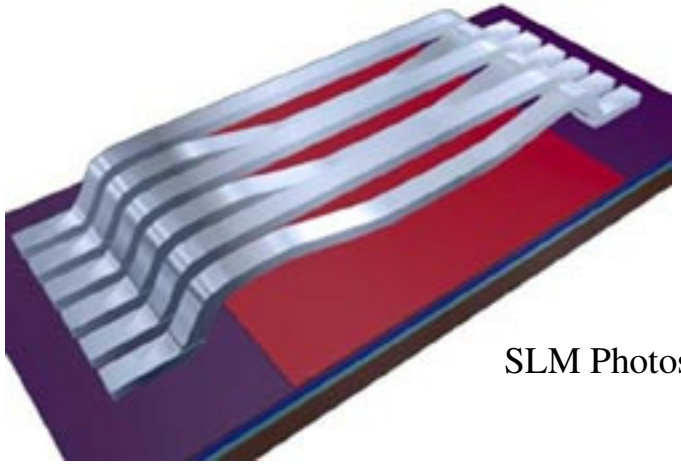
- Reflectivity 80%
- Contrast ratio: 20:1
- Viewing angle: +/- 60^{o}
- Operating voltage: 5 v
- 1000 dpi resolution possible



Iridigm Displays Photos
www.iridigm.com

- Silicon Light Machines

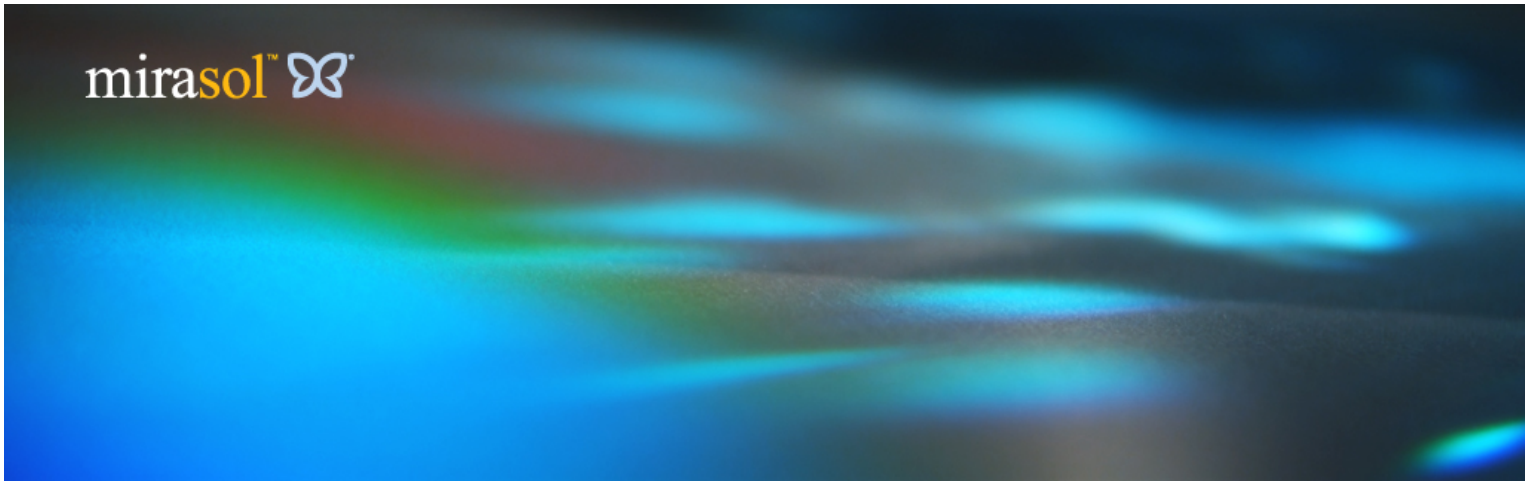




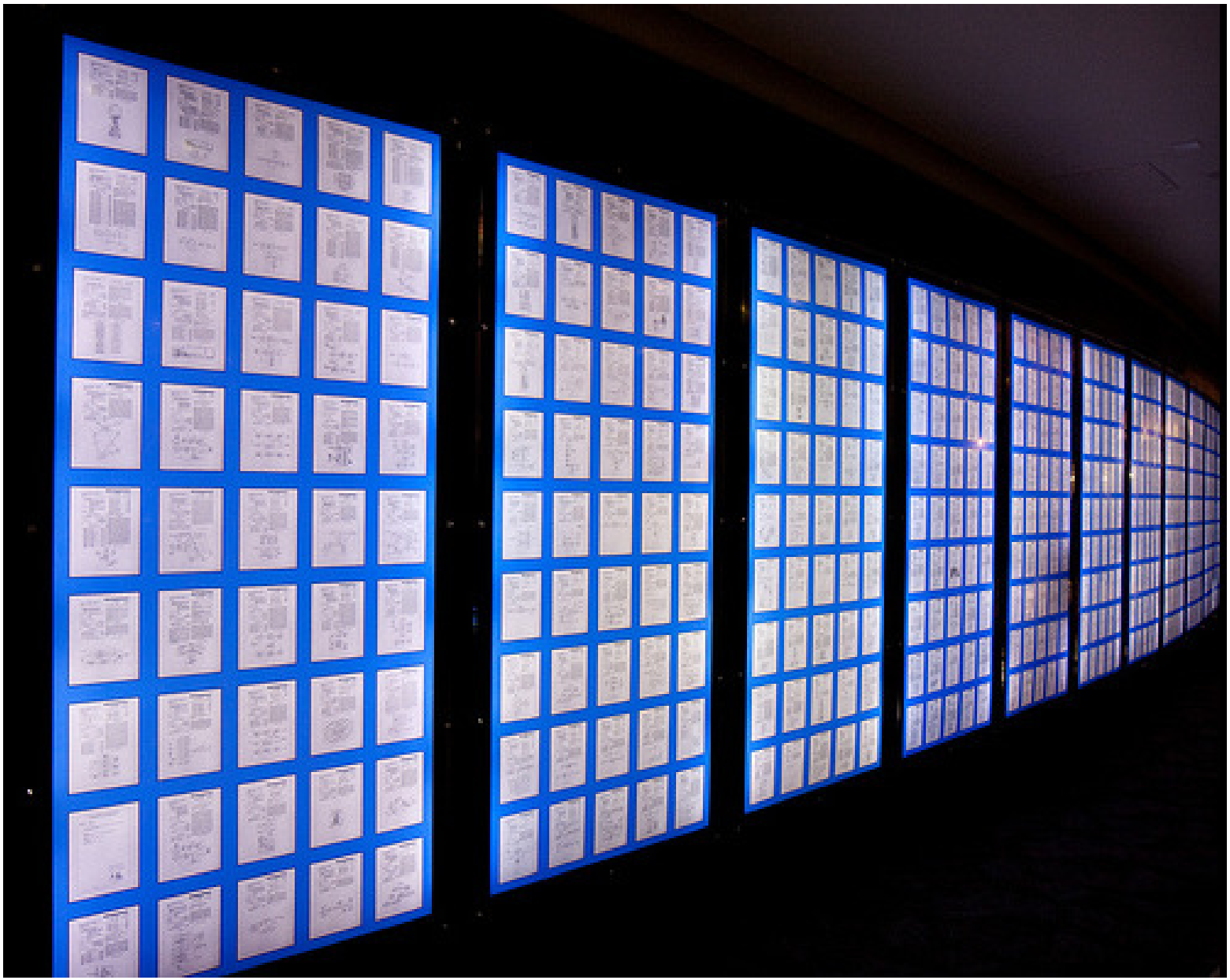
SLM Photos

Mirasol Technology from Qualcomm

- http://www.mirasoldisplays.com/mems-displays/how-mirasol-works-mems-technology.php

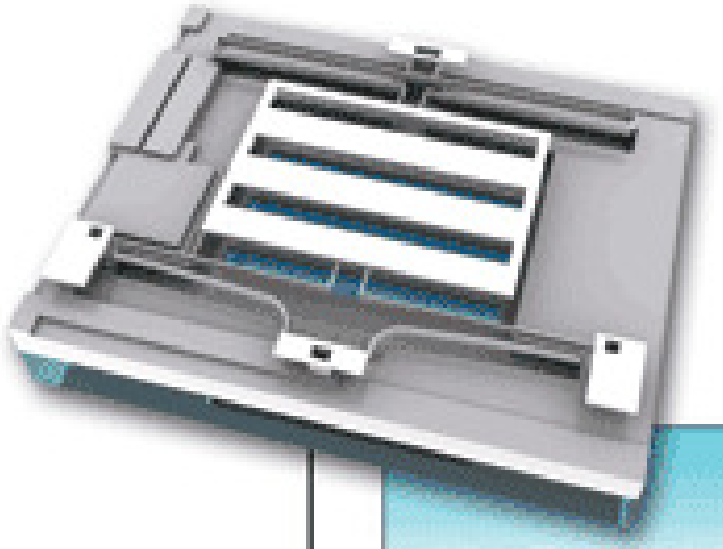


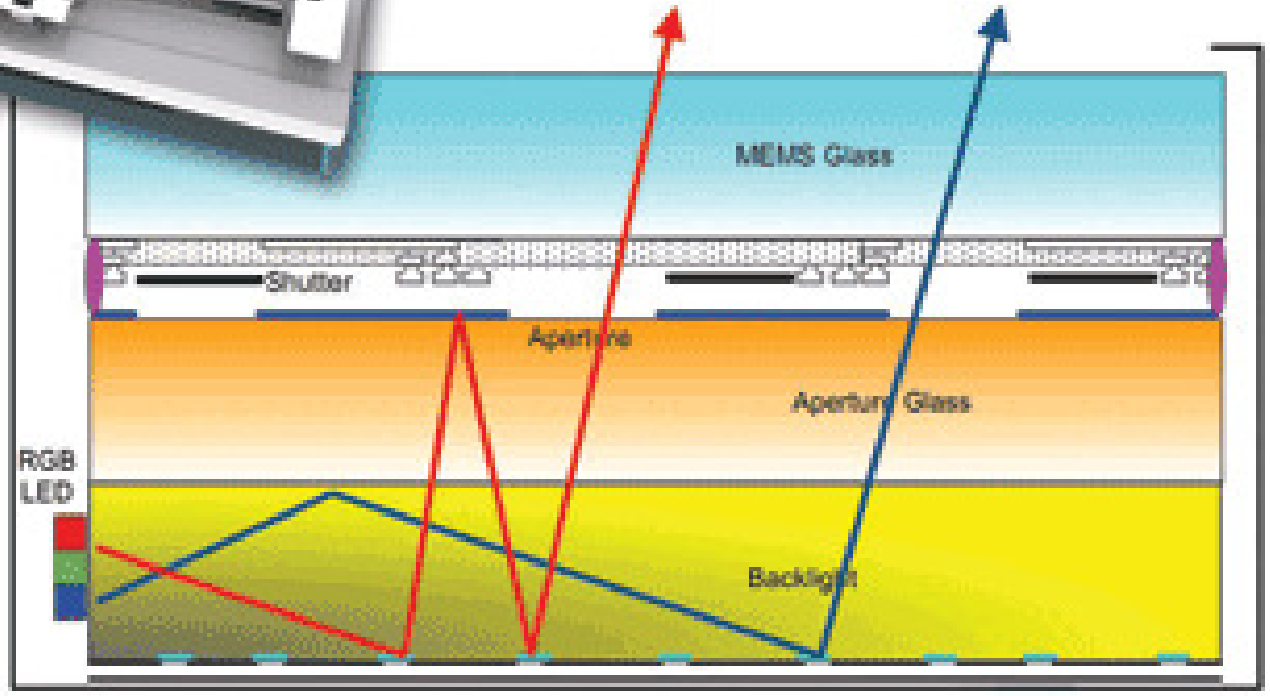
Qualcomm – wall of patents




QUALCOMM PATENT WALL

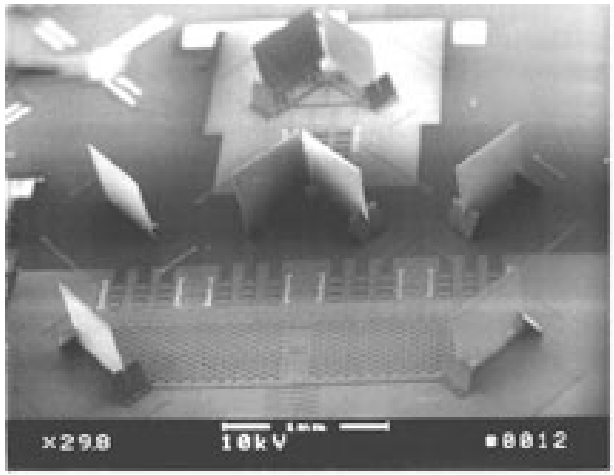
Pixtronics Digital Micro Shutter

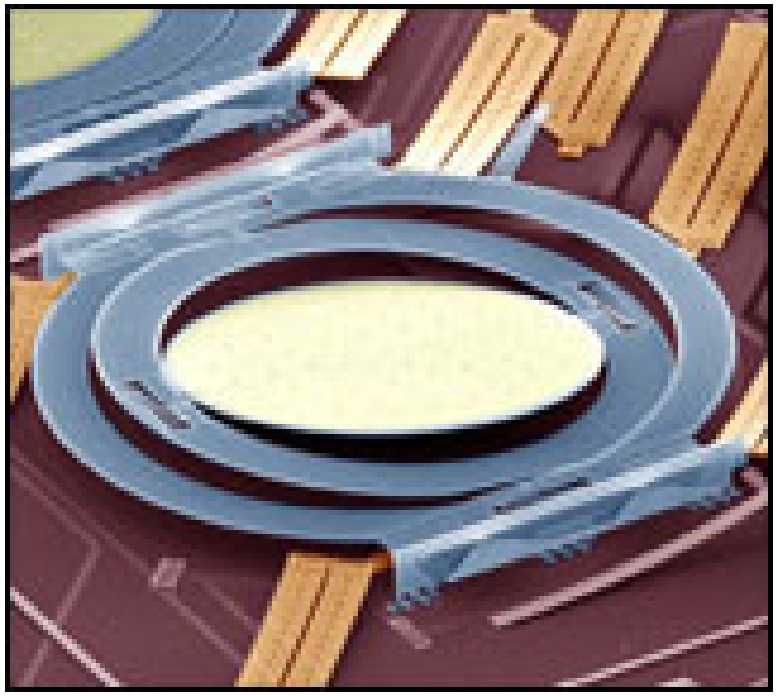


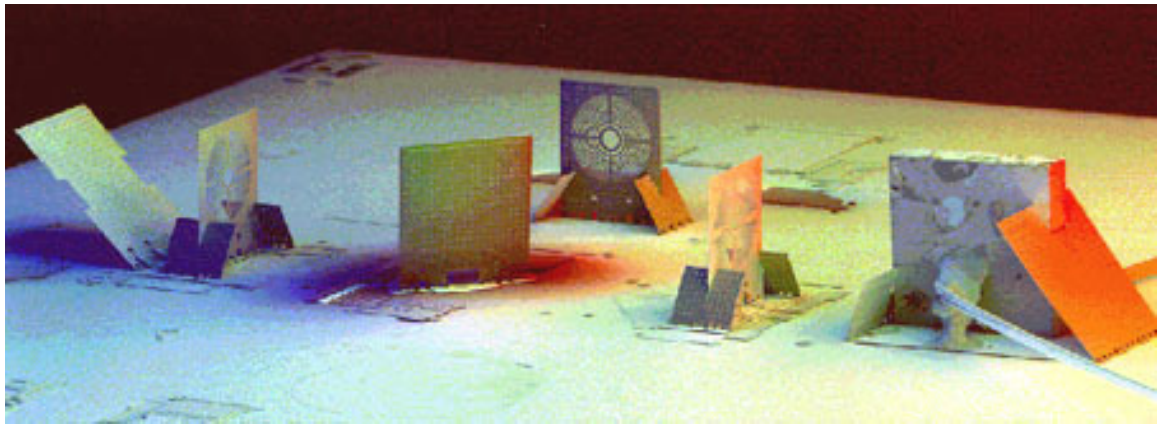


Micro Optical Systems

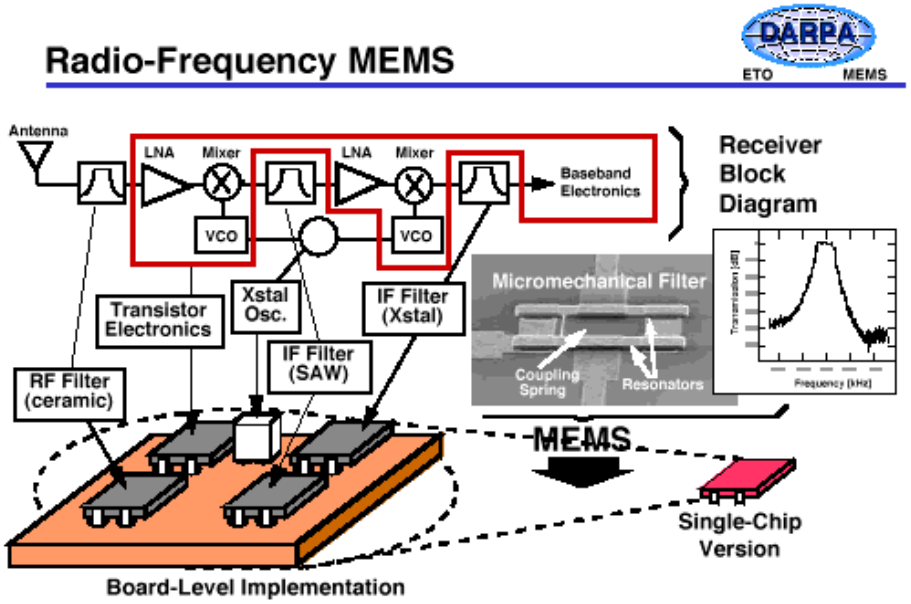
- high-speed, low-loss, electrically controlled optical switches
  - MxN switches
  - 1xN switches
  - add/drop switches

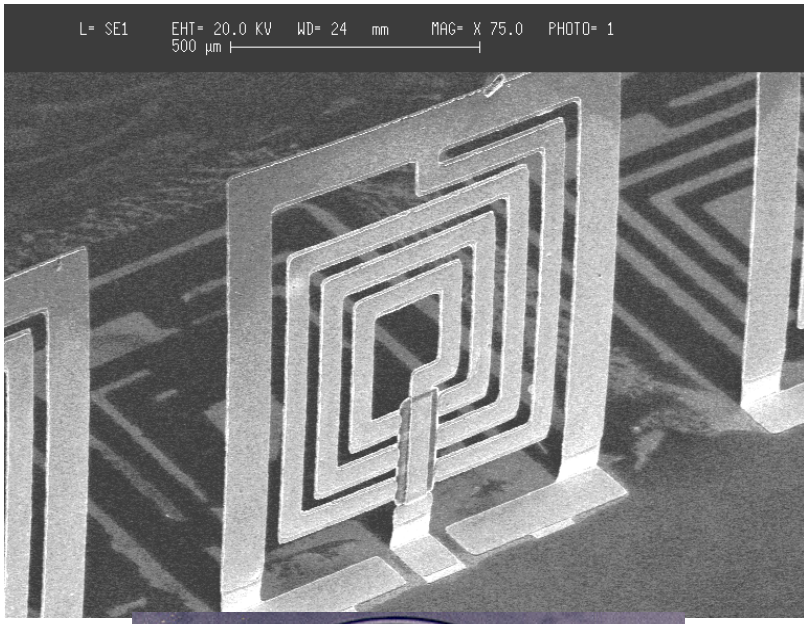


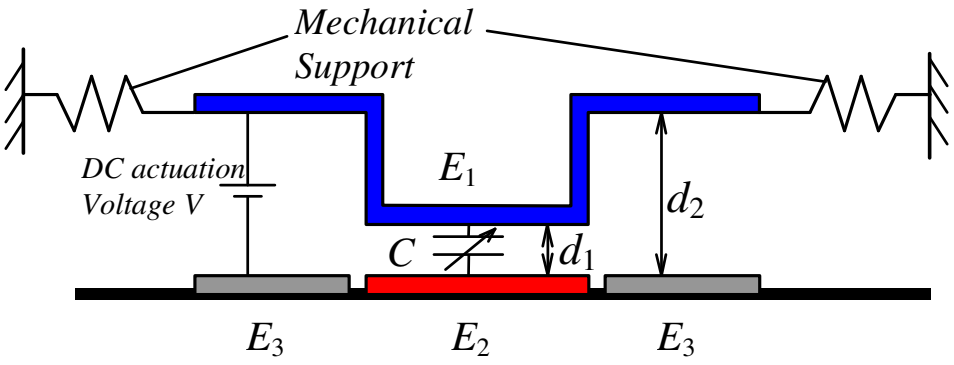


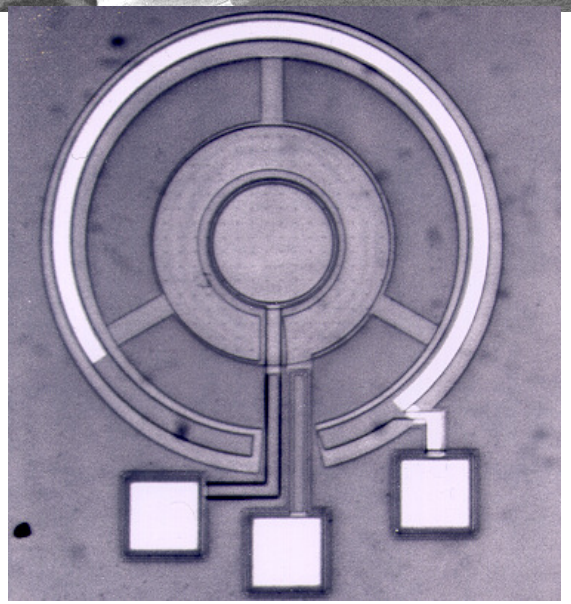


MEMS for Information Technology









Better Than the Dick Tracy Watch

GPS

Cellular Phone

30 GB memory

True color display

DC-200KHZ microphone

Pressure sensor

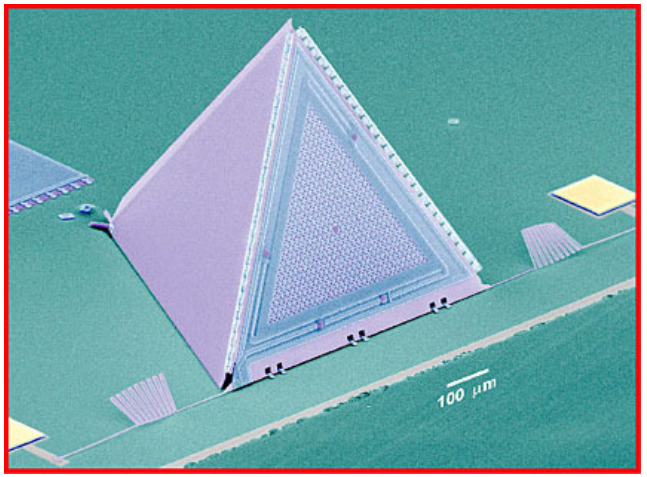
Pulse sensors

Heart monitor

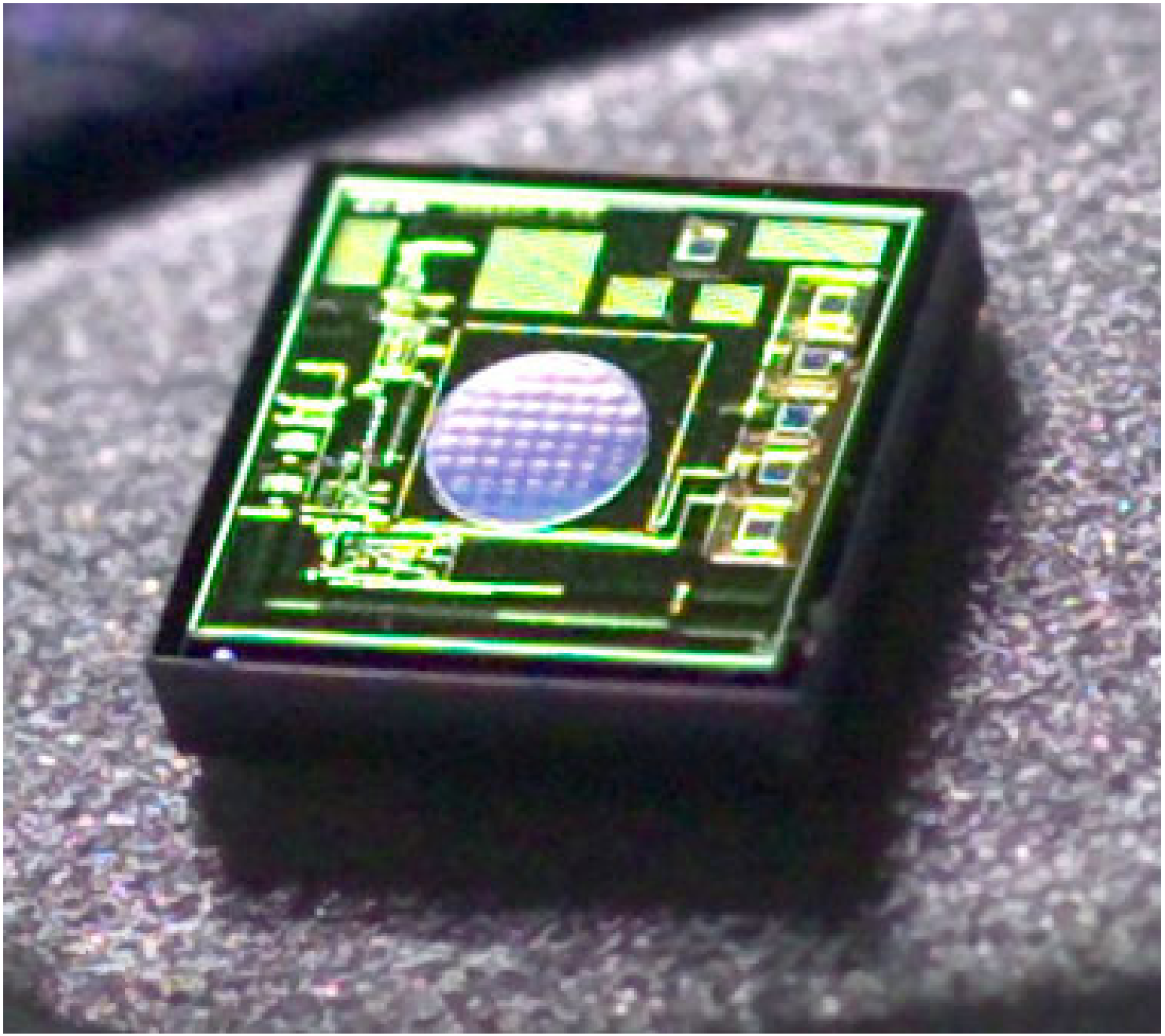
Personal digital assistance

Digital camera and movie

Large screen projection display



Lucent Omni-directional Microphone



Akustica AKU 2000

Bosch acquires MEMS microphone pioneer Akustica

R. Colin Johnson
EE Times
(08/19/2009 1:48 PM EDT)

PORTLAND, Ore. — MEMS microphone pioneer Akustica Inc. has been acquired by Robert Bosch North America and will become part of its MEMS division, Bosch Sensortec GmbH (Reutlingen, Germany).

All of Pittsburgh-based Akustica's employees will be hired by Bosch, and the new company will continue to operate as an independent, wholly-owned subsidiary at Akustica's U.S. headquarters. Financial terms of the agreement were not disclosed.

"This is good for both companies; together we will be addressing the two largest market segments of the consumer MEMS market--accelerometers will be Bosch Sensortec's side and microphones from Akustica," said Davin Yuknis, vice president of marketing at Akustica. "Those are the two fastest growing segments of the MEMS market in the consumer electronics" segment.

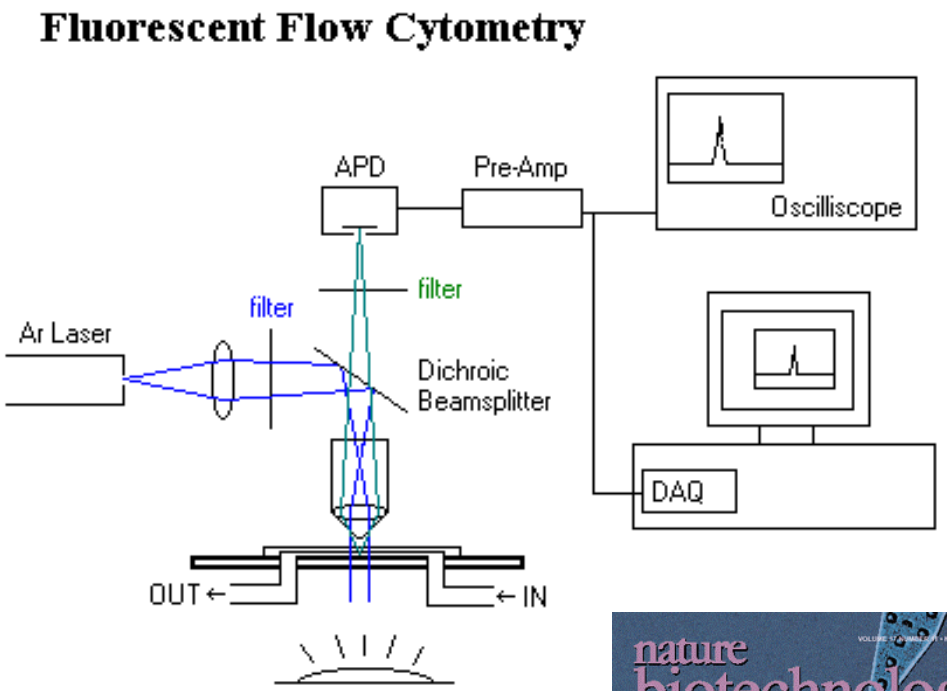
The companies claim that the MEMS market will reach $2.5 billion worldwide by 2012, and that the microphone market is fastest growing segment at annual rate of greater than 30 percent, which they say is on track to ship a billion units by 2012.

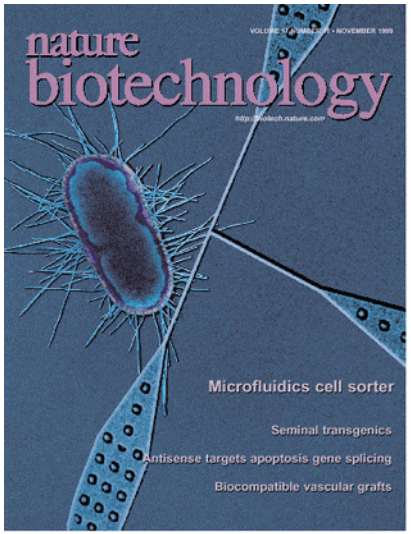
Earlier this month, Akustica's founder, chairman and CTO, Kaigham ("Ken") Gabriel, was appointed deputy director of the Defense Advanced Research Projects Agency (Darpa).

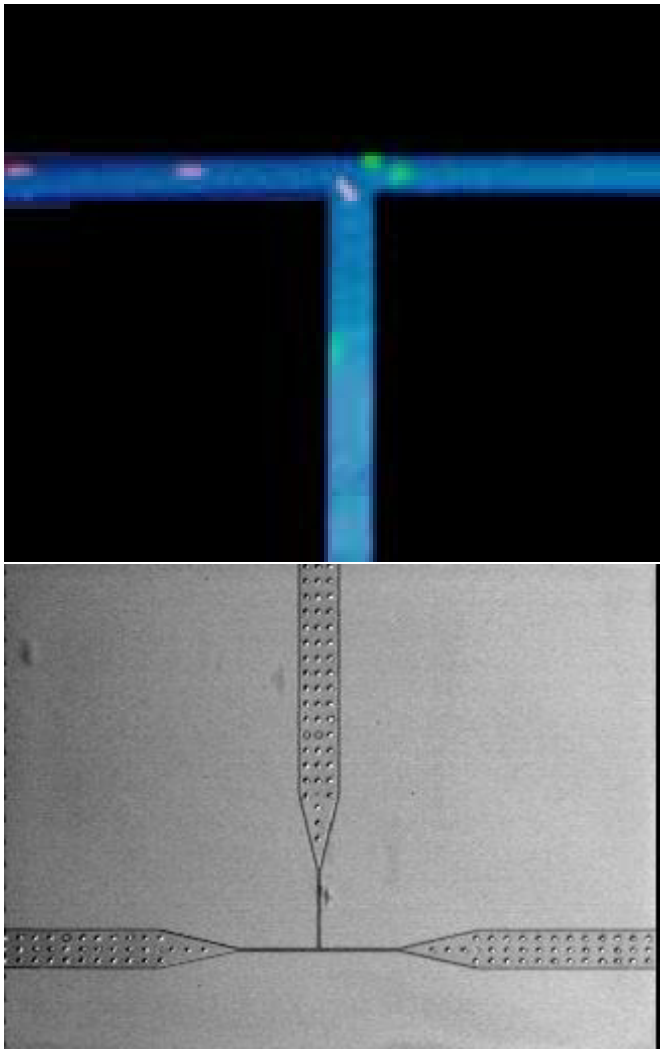
Whole Blood Analysis at Home …
Nasdaq: STAT. Www.I-stat.com

- Patient-side testing with disposable cartridge for 11 tests
- electrochemical sensors
  - potentiometric (Na, K, Cl, urea, Ca, pH and CO2)
  - amperometric (glucose, creatinine, oxygen)
  - conductometric.
  - Coagulation detection
    - viscometric endpoint detection

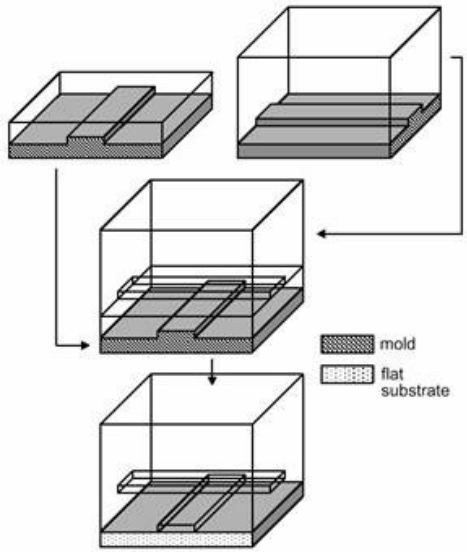
Portable Cell Sorters for Medical Diagnosis

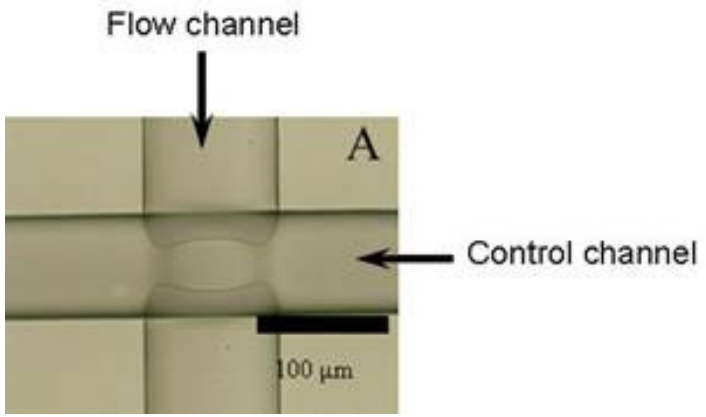


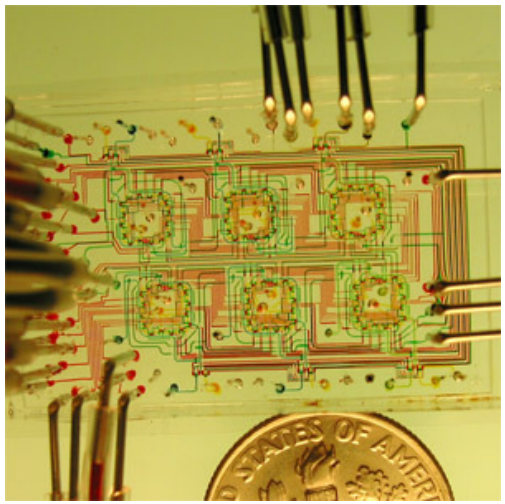




Quake, Caltech, APH







Google Scholar BETA

Web Images Video News Maps **more »**

steven quake Search

Advanced Scholar Search
Scholar Preferences
Scholar Help

Monolithic Microfabricated Valves and Pumps by Multilayer Soft Lithography - ▶mit.edu [PDF] - Fin
MA Unger, HP Chou, T Thorsen, A Scherer, SR **Quake** - Science, 2000 - sciencemag.org
Soft lithography is an alternative to silicon-based micromachining that uses replica molding of nontraditional elastomeric materials to fabricate stamps and microfluidic channels. We describe here an extension to the soft ...
Cited by 746 - Related articles - Web Search - BL Direct - All 11 versions

Microfluidic Large-Scale Integration - ▶epfl.ch [PDF] - Find it @ NU
T Thorsen, SJ Maerkl, SR **Quake** - Science, 2002 - sciencemag.org
We developed high-density microfluidic chips that contain plumbing networks with thousands of micromechanical valves and hundreds of individually addressable chambers. These fluidic devices are analogous to electronic integrated ...
Cited by 509 - Related articles - Web Search - BL Direct - All 19 versions

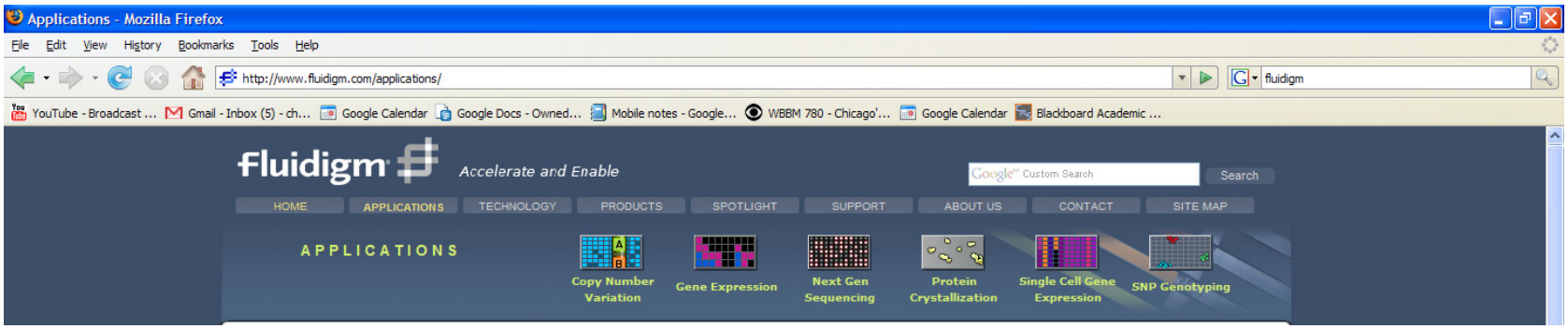
Single Cell Analysis | Chemical Synthesis on a Chip | Systems Biology | Structural Biology | In-Vitro Proteomic Biology | Medical Diagnostics | Single Molecule Biophysics

Biological Large Scale Integration

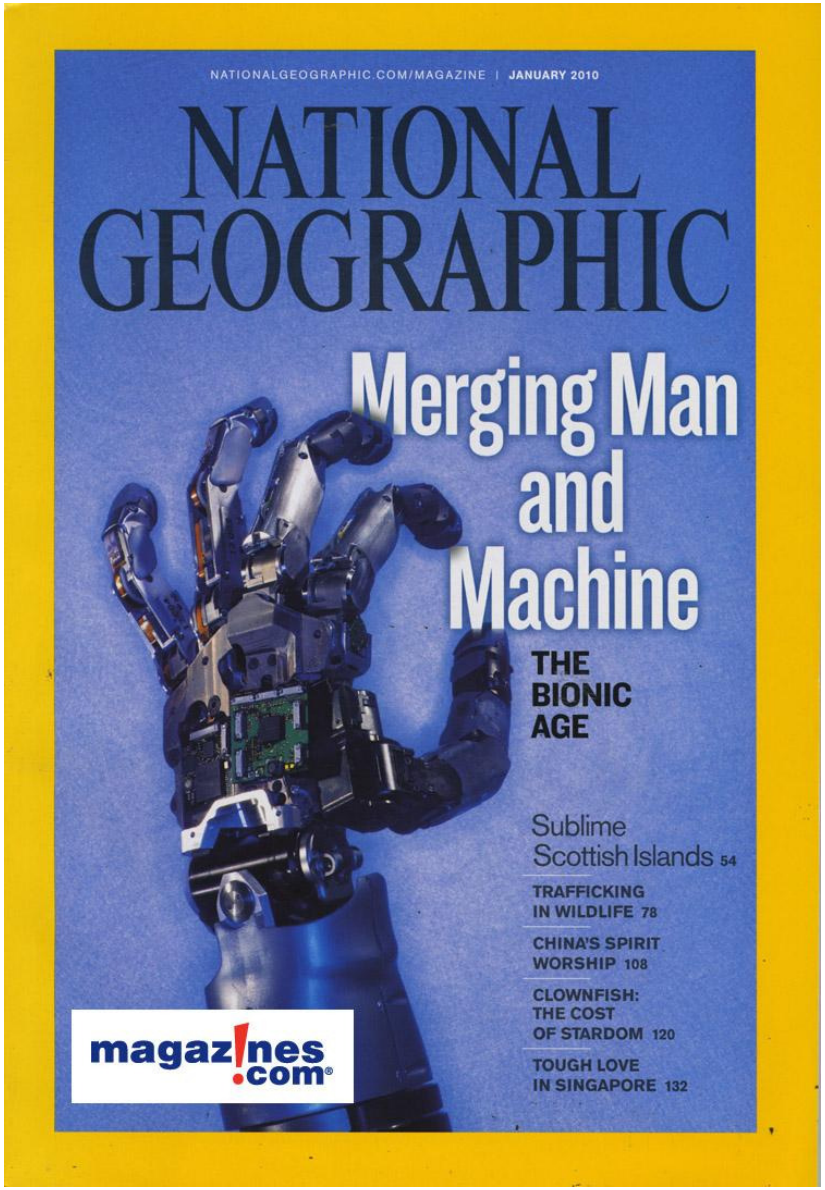
In the first part of the 20th century, engineers faced a problem commonly called the "Tyranny of Numbers": there is a practical limit to the complexity of macroscopically assembled systems. Using discrete components such as vacuum tubes, complex circuits quickly became very expensive to build and operate. The ENIAC I, created at the University of Pennsylvania in 1946, consisted of 19,000 vacuum tubes, weighed thirty tons, and used 200 kilowatts of power. The transistor was invented at Bell Laboratories in 1947 and went on to replace the bulky vacuum tubes in circuits, but connectivity remained a problem. Although engineers could in principle design increasingly complex circuits consisting of hundreds of thousands of transistors, each component within the circuit had to be hand-soldered: an expensive, labor-intensive process. Adding more components to the circuit decreased its reliability as even a single cold solder joint rendered the circuit useless.

In the late 1950s Kilby and Noyce solved the "Tyranny of Numbers" problem for electronics by inventing the integrated circuit. By batch fabricating all of the components on a single semiconductor wafer, Kilby and Noyce created circuits consisting of transistors, capacitors, resistors and their corresponding interconnects in situ, eliminating the need for manual assembly. By the mid-1970s, improved technology led to the development of large scale integration (LSI): complex integrated circuits containing hundreds to thousands of individual components. This technology completely revolutionized the role of automation in computation, and automated computers became so powerful and inexpensive that people realized their applications could reach far beyond simple scientific calculations. As a consequence, today computation is a ubiquitous part of our lives and is used as a tool not just for science, but also medicine, communication, entertainment and commerce. In addition to these practical effects, another important consequence of the automation of computation is the development of formal approaches to algorithms, i.e. computer science.

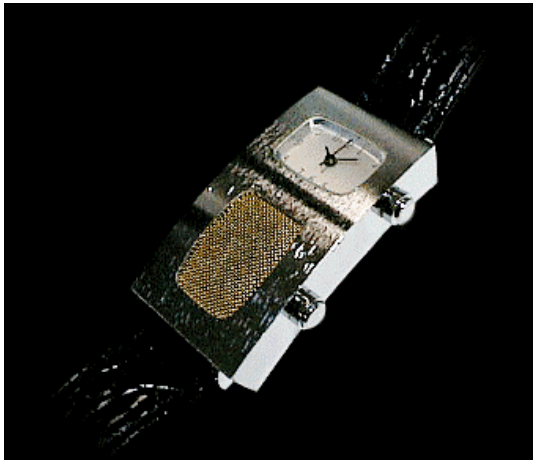

Fluidigm Corporation - Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://www.fluidigm.com/
fluidigm
YouTube - Broadcast ... Gmail - Inbox (5) - ch... Google Calendar Google Docs - Owned... Mobile notes - Google... WBBM 780 - Chicago'... Google Calendar Blackboard Academic ...
Fluidigm
Accelerate and Enable
Google Custom Search
Search
HOME APPLICATIONS TECHNOLOGY PRODUCTS SPOTLIGHT SUPPORT ABOUT US CONTACT SITE MAP
NEXT GEN SEQUENCING
SINGLE CELL GENE EXPRESSION
HIGH THROUGHPUT GENOTYPING
HIGH THROUGHPUT GENE EXPRESSION
DISCOVER...
CAPABILITY
Single Cell Gene Expression
Examine 96 genes from a single cell
quickly and easily using TaqMan reagents.
News & Upcoming Events
Columbia River Inter-Tribal Fish Commission Uses Fluidigm IFC Technology for Genetic Analysis of Salmon and Steelhead (01/08/09)
Fluidigm and Stemgent Awarded One of CIRM'S First Grants to the Biotech Industry (12/16/08)
Fluidigm Secures Licenses to Key Inventions for Detecting Fetal Genetic Characteristics in Maternal Plasma (12/01/08)
More news...
INTRODUCING: The Fluidigm® EP1 System
Setting the new standard for SNP Genotyping
99% or greater call rates
200K+ genotypes per day
Low running and instrument costs
Learn more about this exciting new product – Overview Video
96x96
Fluidigm® 96.96 Dynamic Arrays
Perform 9,216 simultaneous Gene Expression or Genotyping experiments without pre-spotting and with complete flexibility - Join the Revolution


Applications - Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://www.fluidigm.com/applications/
fluidigm
YouTube - Broadcast ... Gmail - Inbox (5) - ch... Google Calendar Google Docs - Owned... Mobile notes - Google... WBBM 780 - Chicago'... Google Calendar Blackboard Academic ...
Fluidigm
Accelerate and Enable
Google Custom Search
Search
HOME APPLICATIONS TECHNOLOGY PRODUCTS SPOTLIGHT SUPPORT ABOUT US CONTACT SITE MAP
APPLICATIONS
Copy Number Variation
Gene Expression
Next Gen Sequencing
Protein Crystallization
Single Cell Gene Expression
SNP Genotyping

Bionic Technologies

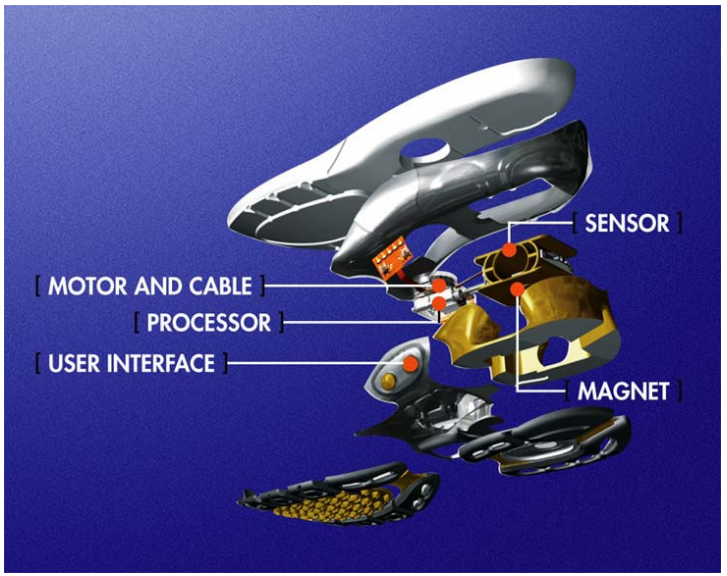


Towards a real Dick Tracy Watch



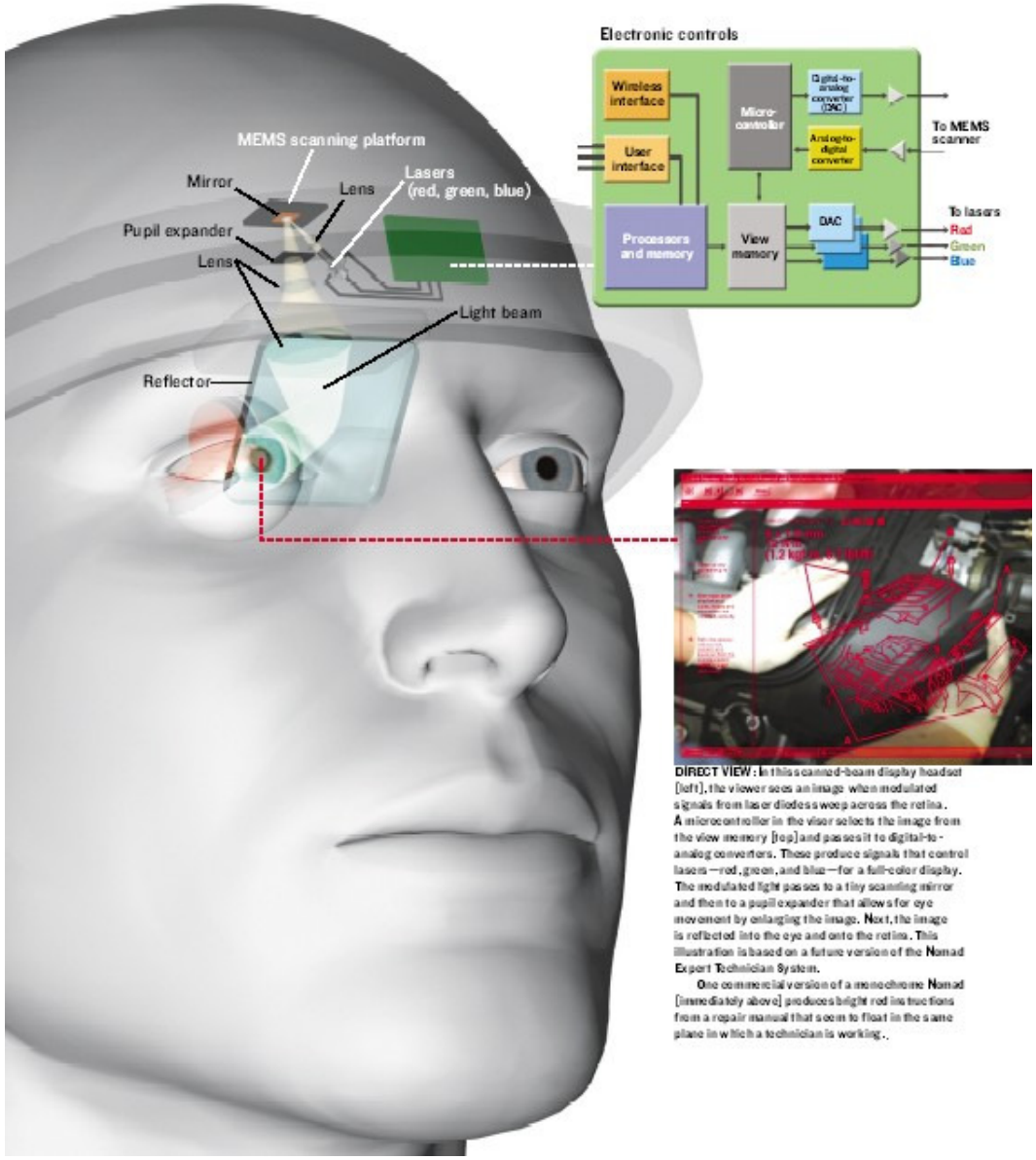
Samsung S911, January 2010 Release

Wearable Enbedded Systems



- Adidas 1 smart shoe

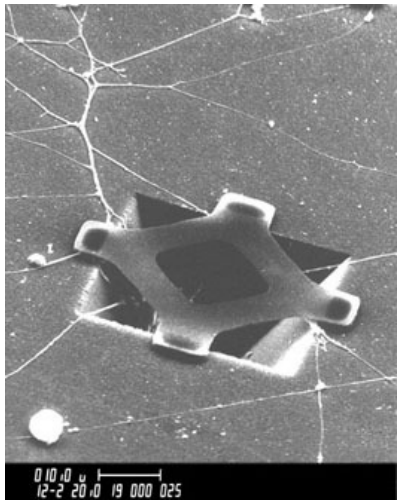
Augmented Reality



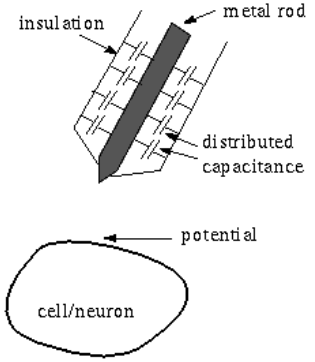
DIRECT VIEW: In this scanned-beam display headset [left], the viewer sees an image when modulated signals from laser diodes sweep across the retina. A microcontroller in the visor selects the image from the view memory [top] and passes it to digital-to-analog converters. These produce signals that control lasers—red, green, and blue—for a full-color display. The modulated light passes to a tiny scanning mirror and then to a pupil expander that allows for eye movement by enlarging the image. Next, the image is reflected into the eye and onto the retina. This illustration is based on a future version of the Nomad Expert Technician System.

One commercial version of a monochrome Nomad [immediately above] produces bright red instructions from a repair manual that seem to float in the same plane in which a technician is working.

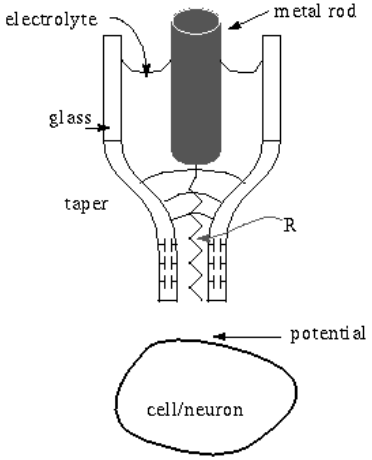
Micro-machined Neuron Interfaces



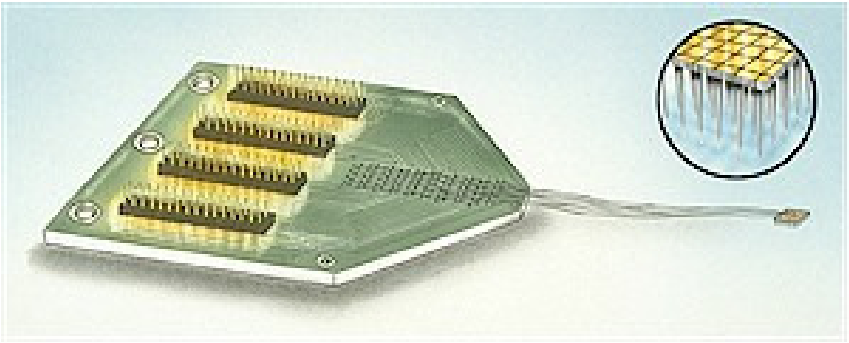
Caltech Neuron Well



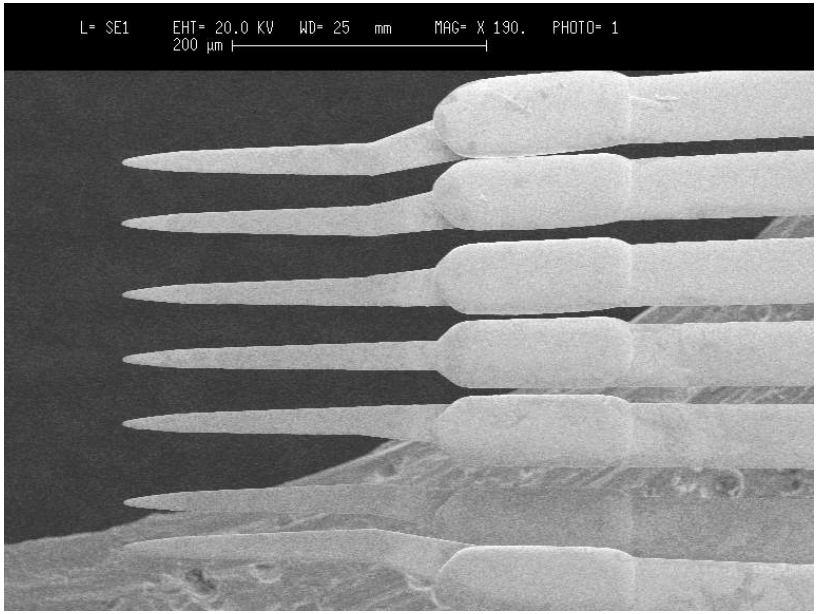
(a) Metal microelectrode



(b) Capillary microelectrode

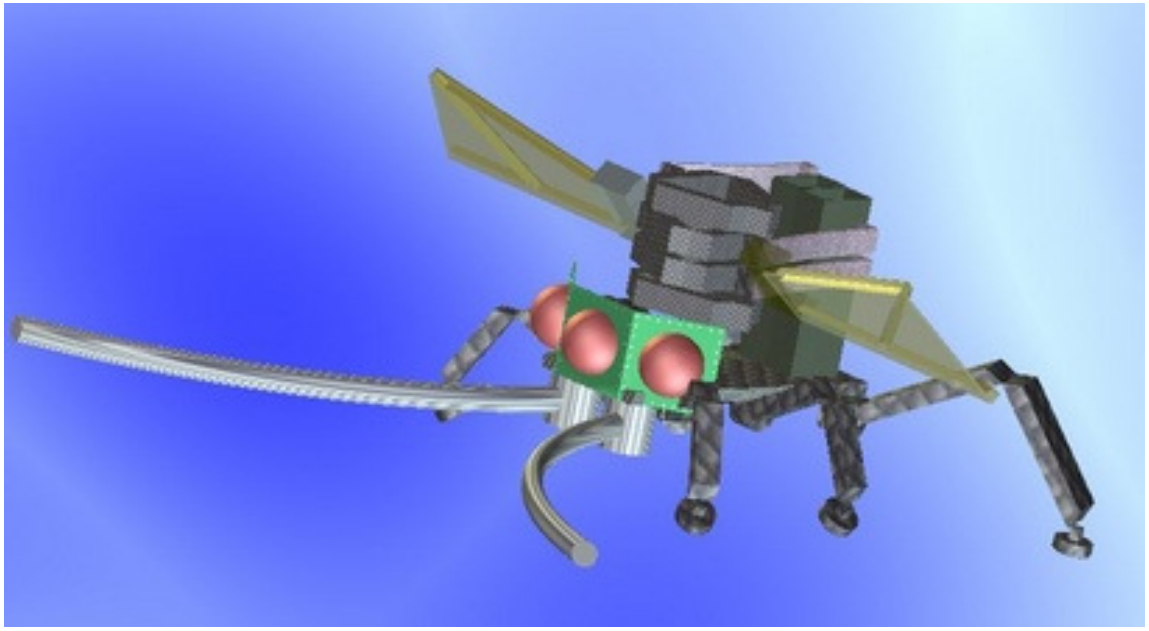


Utah Implantable Neuron Probe



Illinois Neuron Probe Array

Ron Fearing, Berkeley Biomimetic Flyer



- http://robotics.eecs.berkeley.edu/~ronf/Biomimetics.html

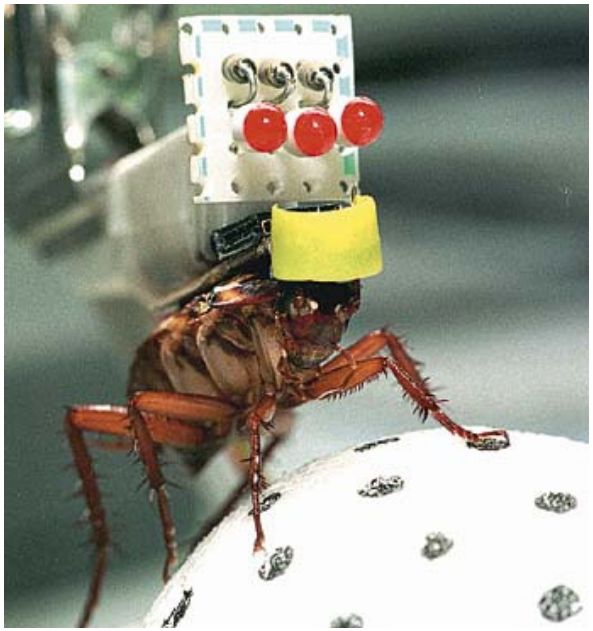
You Tube

Dash

The Big Dog

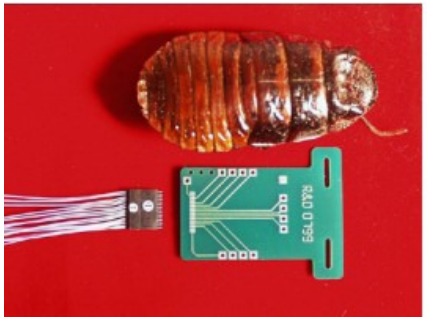
Cooperating with Biology - RoboRoach

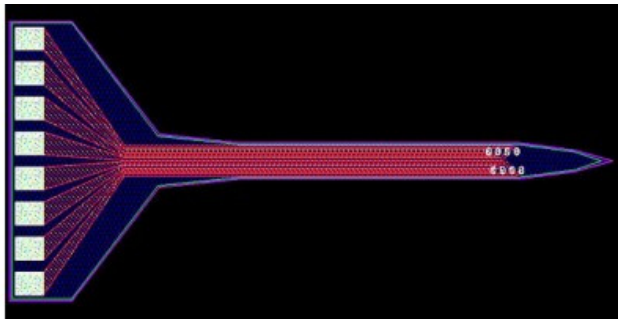
- http://www.cae.wisc.edu/~sonic mem/

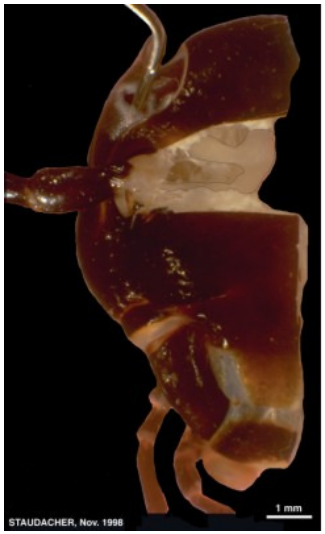


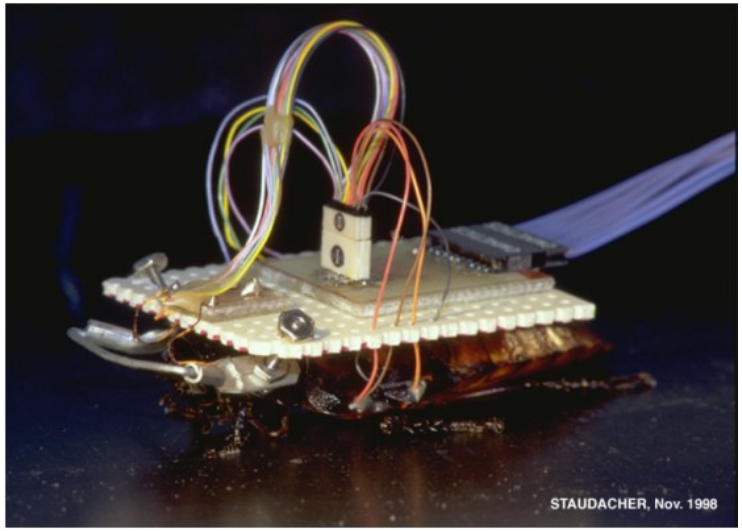
Isao Shimoyama,Tokyo University

- U. Michigan









Minority Report Spider

Technology jigsaw Puzzle


Prepare yourself well
PHOTOGRAPHERS
DIRECT.COM


For YOUR moment