List of cards (samples are shown in red frame)

A1 Infrared sensor, imager
A2 Infrared sensor
A3 2 axis galvano optical scanner
A4 DMD (Digital Micromirror Device)
A5 Digital cinema DMD
A6 Optical encoder
A7 Piezoelectric, thermal inkjet printer head
A8 Electrostatic inkjet printer head
A9 MEMS resonator
A10 MEMS resonator (disk, Lamb etc.)
A11 FBAR (Film Bulk Acoustic Resonator)
A12 SAW device on LSI
A13 Tunable SAW filter using variable capacitor
A14 SAW passive wireless sensor

B1 Piezoresistive pressure sensor
B2 Integrated capacitive pressure sensor
B3 Resonant pressure sensor
B4 Capacitive vacuum sensor
B5 Capacitive vacuum sensor products
B6 MEMS microphone
B7 MEMS microphone wafer
B8 MEMS microphone for humid environment
B9 Capacitive accelerometer for automobile
B10 Wafer of accelerometer by surface micromachining
B11 Various accelerometers
B12 Integrated capacitive accelerometer
B13 3-axis accelerometer
B14 Electrostatically levitated rotational gyroscope

C1 Electromagnetically driven resonating gyroscope
C2 Silicon ring gyroscope
C3 Piezoelectric gyroscope
C4 Electrostatically driven capacitive sensing gyroscope
C5 Yaw rate, acceleration sensor
C6 Accelerometer and gyroscope for automobile and smartphone
C7 Patterning
C8 Etching (Deep RIE, XeF_2 Etching, etc)
C9 Deposition
C10 Probe for scanning probe microscope (SPM)
C11 Near-field optical probe and bow-tie antenna
C12 Highly sensitive sensors using thin resonator
C13 Multi-probe data storage
C14 Electron source

D1 Electrode for biopotential recording
D2 Semiconductor ion sensor (ISFET)
D3 Catheter pH, CO_2 sensor
D4 Intermittent sampling continuous blood gas monitor
D5 Application of ISFET to dentistry, oceanography and fish cultivation
D6 Micro ISFET and integrated micro probe
D7 Gas sensors
D8 Disposable chemical analysis chip
D9 Bio LSI and tactile sensor network
D10 Catheter blood pressure sensor
D11 Active catheter
D12 Multi-link motion mechanism using shape memory alloy
D13 Imaging for minimal invasive medicine
D14 Implantable stimulator

E1 LIGA process
E2 Laser processes and stealth dicing
E3 Anodic bonding
E4 Anodically bondable LTCC with electrical feedthrough
E5 Bonding materials
E6 Shared CMOS LSI wafer
E7 Laser-erased wafer process
E8 Massive parallel electron beam write
E9 Micro pump, micro valve and chemical analysis system for liquid
E10 Micro mixer and particle analysis
E11 Flow sensor and mass-flow controller for gas
E12 Bakable micro valve and anticorrosive mass-flow controller
E13 Sensing in harsh environment
E14 Silicon carbide (SiC) mold for glass press-molding

F1 Small size gas turbine engine dynamo
F2 Si micro-turbine and thermoelectric generator
F3 SiC and PZT by lost-mold process, Si_3N_4 by reaction sintering
F4 Micro fuel cell
F5 Micro fuel reformer
F6 Digital micro thruster (solid rocket engine array)
F7 Electrostatic micro motor, actuator
F8 Distributed electrostatic micro actuator
F9 Piezoelectric micro stage
F10 Lateral motion piezoelectric microactuator
F11 Tactile display and tactile imager
F12 Micro refrigeration system
F13 Thermal MEMS switch
F14 Electrostatic and piezoelectric MEMS switch

G1 Wavelength swept pulsed quantum cascade laser
G2 Optical melt pressure & temperature sensor
G3 Capacitive high sensitive differential pressure sensor "MANOSTAR"
G4 10th anniversary of SEMI MEMS seminar

H1 Tohoku Univ. and Belgium IME
H2 Poly-SiGe for MEMS sensor applications
H3 MEMS gyroscope on CMOSIC using poly-SiGe
H4 SiGe micro-mirror array on CMOS IC
H5 CMORE SiGeMEMS mluti project wafer
H6 Holographic displays
H7 MEMS for energy harvester & electronic noise

I1 Piezoelectric and electrostatic optical scanners
I2 Immunological analyzer of Helicobacter pylori's urease

J1 Telegraph using electric wire in bottom of ocean
J2 CPU board for super computer
J3 Microwave radar using anode split magnetron
J4 Shimada laboratory in which high power anode split magnetron was developed before the end of war (Z project)
J5 Crystal detector and point contact transistor
J6 Transitions of power devices used in Shinkansen
J7 Massive parallel electron beam write
J8 Electromagnetically levitated lamp
J9 Model railway of magnetically levitated linear liner
J10 Linear Chuo Shinkansen using superconductivity and its model railway
J11 Linear subway (Linear metro) travelling on wheels
J12 Micro car
J13 Disassembly of FOMA (3G) smartphone
J14 Continuous arterial pressure waveform with Tonometry
J15 Topics related to collected books
J16 Micro flying robot (μ FR)
J17 Planimeter (area meter) and proportional compass

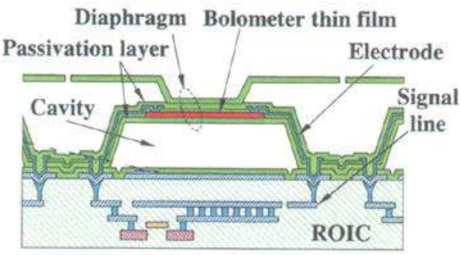
K1 Books, photograph and 0ther materials about Prof. Jun-ichi Nishizawa

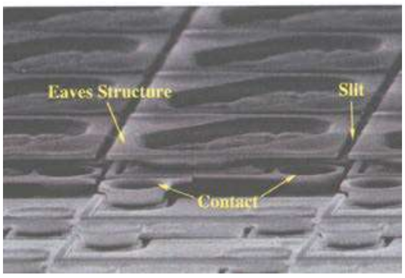
L1 Hermetic seal bonding at low temperature with sub-micron Au particles

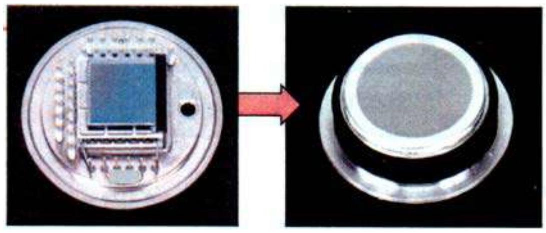
M1 Five-storied pagoda made of glass

N1 Infrared array sensor (Panasonic Corp.)
N2 3D LSI (Honda research Institute Japan, Co Ltd)
N3 Remote control switch using energy harvester (EnOcean GmpH)
N4 Membrane switch array for electrophoresis display and oscillometric blood pressure monitor (E-paper, Tokyo Sanyo Electric Co. Ltd, Kazuo Senda)

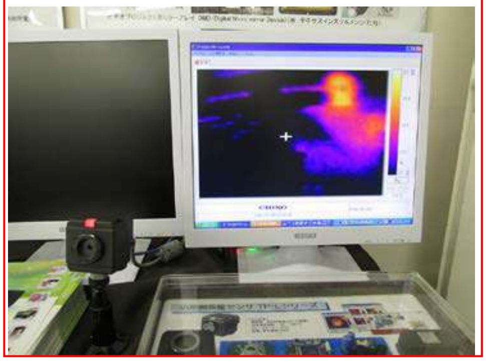
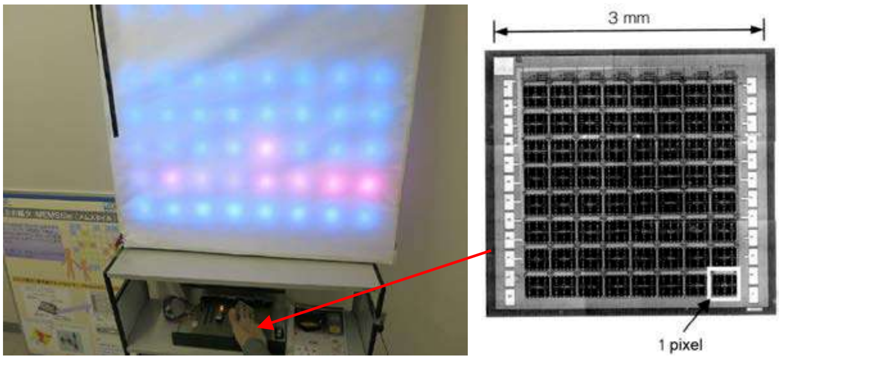
A1 # Infrared sensor, imager



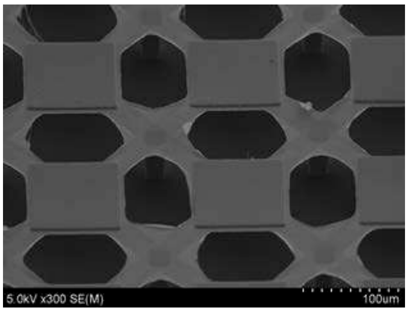


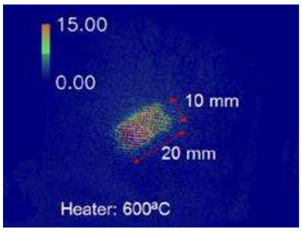


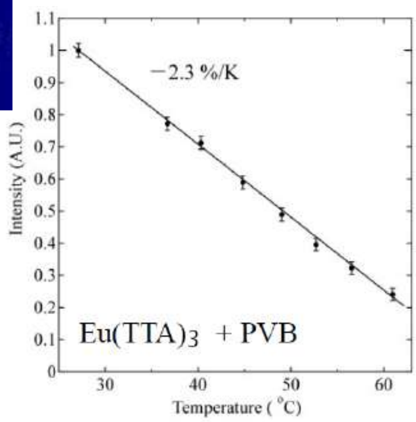
640×480 Thermal infrared imager using VO_2 bolometer (NEC)　(S.Tohyama, Optical Engineering, **45** (2006) 14001)

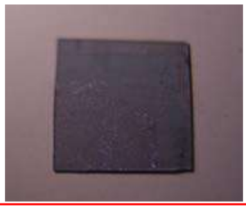



Compact thermal image sensor (Chino)　　8×8 Thermopile infrared sensor (Panasonic) (displayed in corridor　Card N!)

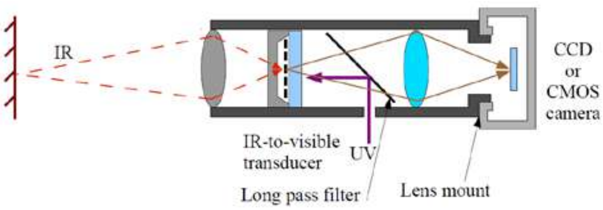




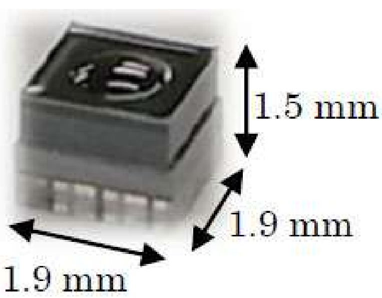


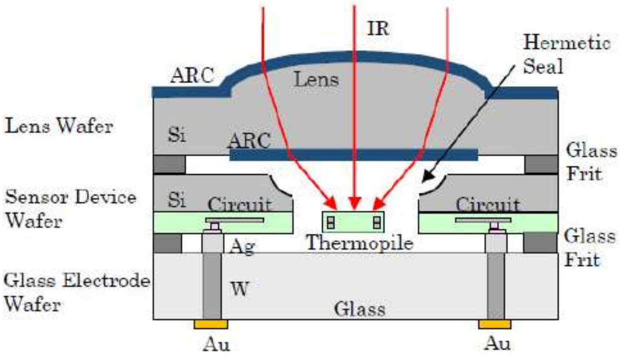


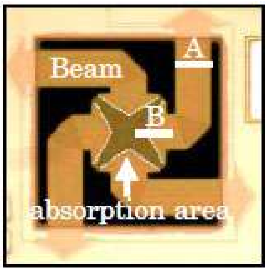
IR–to–visible transducer



Thermal imaging method using temperature sensitive luminescent material $Eu(TTA)_3$
(T.Tsukamoto, M.Esashi and S.Tanaka, J. of Micromechanics and Microengineering, 23, 11 (2013) 114015)

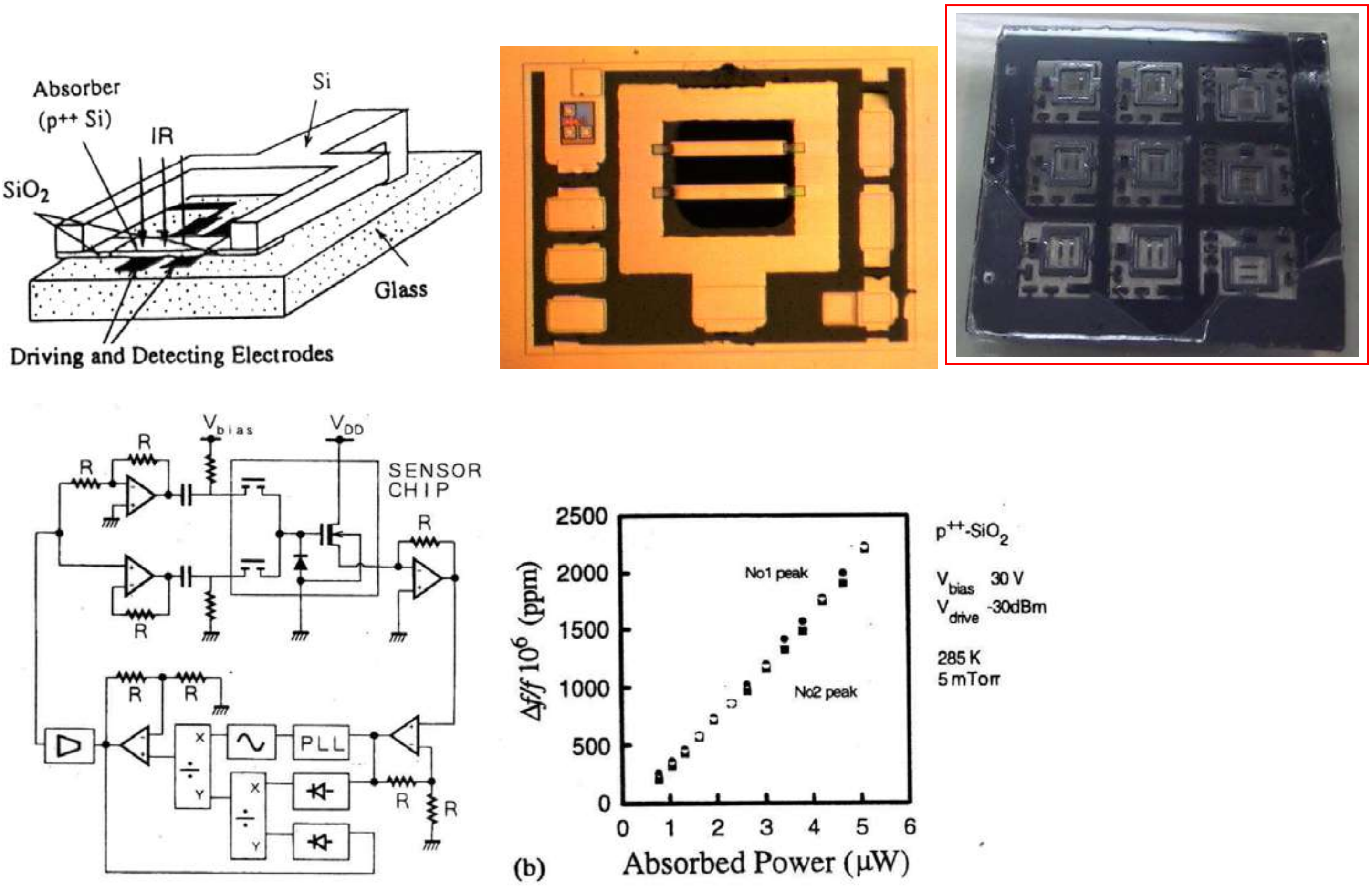






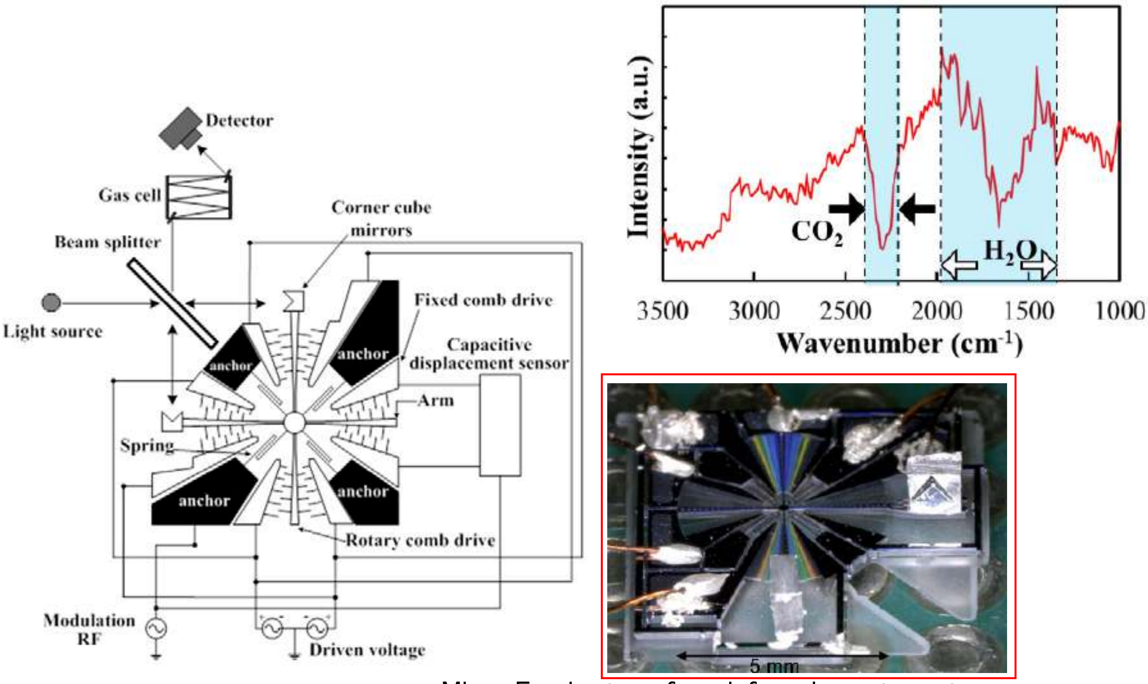
Ultra–small infrared temperature sensor using thermopile integrated with Si lens (Ricoh)
(H.Noguchi, H.Watanabe et.al, 31th Sensor Symposium (2014) 21pm1–B1)

A2 Infrared sensor



Resonant infrared sensor

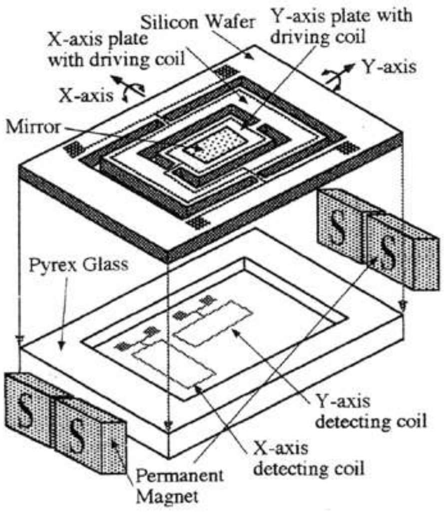
Reference : C.Cabuz, S.Shoji, K.Fukatsu, E.Cabuz, K.Minami and M.Esashi, Fabrication and Packaging of a Resonant Infrared Sensor Integrated in Silicon, Sensors and Actuators A, 43 (1994) pp.92–99

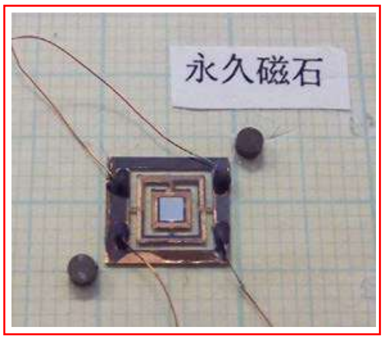


Micro Fourier transform infrared spectrometer

Reference : Y.-M. Lee, M. Toda, M.i Esashi, and T. Ono, Micro wishbone interferometer for Fourier transform infrared spectrometry, J. of Micromechanics and Microengineering, 21 (2011) 065039

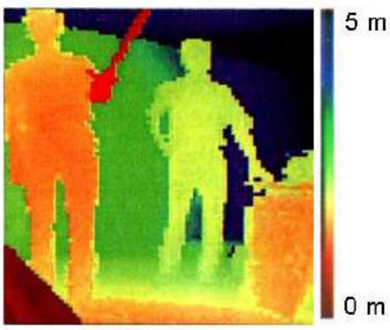
A3 # 2 axis galvano optical scanner





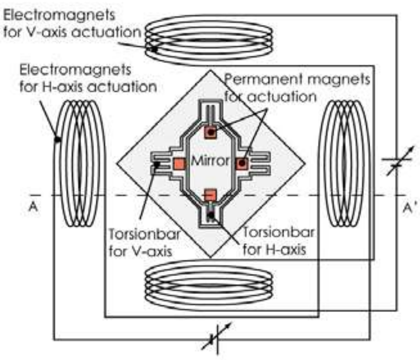
2 axis galvano optical scanner　(Tohoku Univ. − Japan Signal)

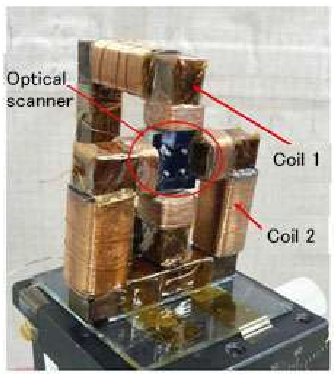
Reference : N.Asada, H.Matsuki, K.Minami and M.Esashi : Silicon micromachined two-dimensional galvano optical scanner, IEEE Trans. on Magnetics, 30 (1994) pp.4647-4649

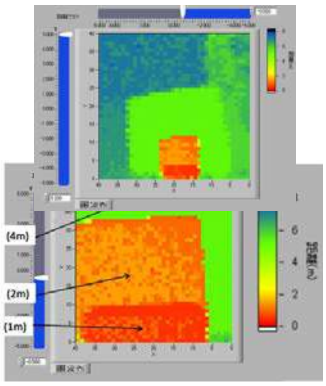


Ranging imager system "Eco scan" (Japan Signal) applied for platform door in railway station

Reference : T.Ishikawa, H.Inomata : Laser Ranging Sensor Using MEMS Optical Scanner "ECO SCAN"、Japan Signal Technical Report、33, 1, pp.41-46 (2009)





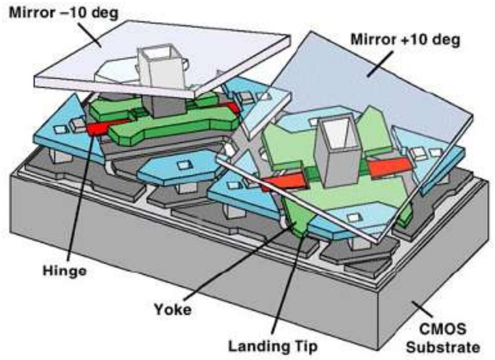


Electromagnetic non-resonance large scan-angle 2-axes optical scanner　　Zooming function

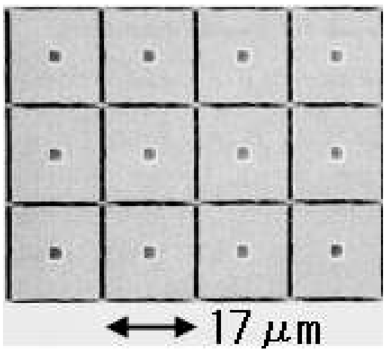
Reference :　W.Makishi, Y.Kawai and M.Esashi : Magnetic Torque Driving 2D Micro Scanner with a Non-Resonant Large Scan Angle, Trans. on IEEJ, 130-E, 4 (2010) 135-136

A4 DMD (Digital Micromirror Device) (TI (Texas Instruments), USA)

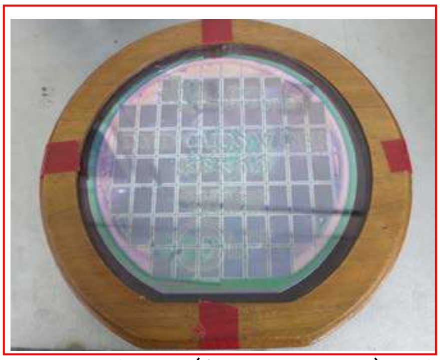
Electrostatically actuated mirror array is fabricated on CMOS chip for video projectors and digital cinema.
Binary pulse width modulation called DLP (Digital Light Processing) is used for gray scale sensation.
Amorphous metal of Al_3Ti is used for the hinge to solve the fatigue.

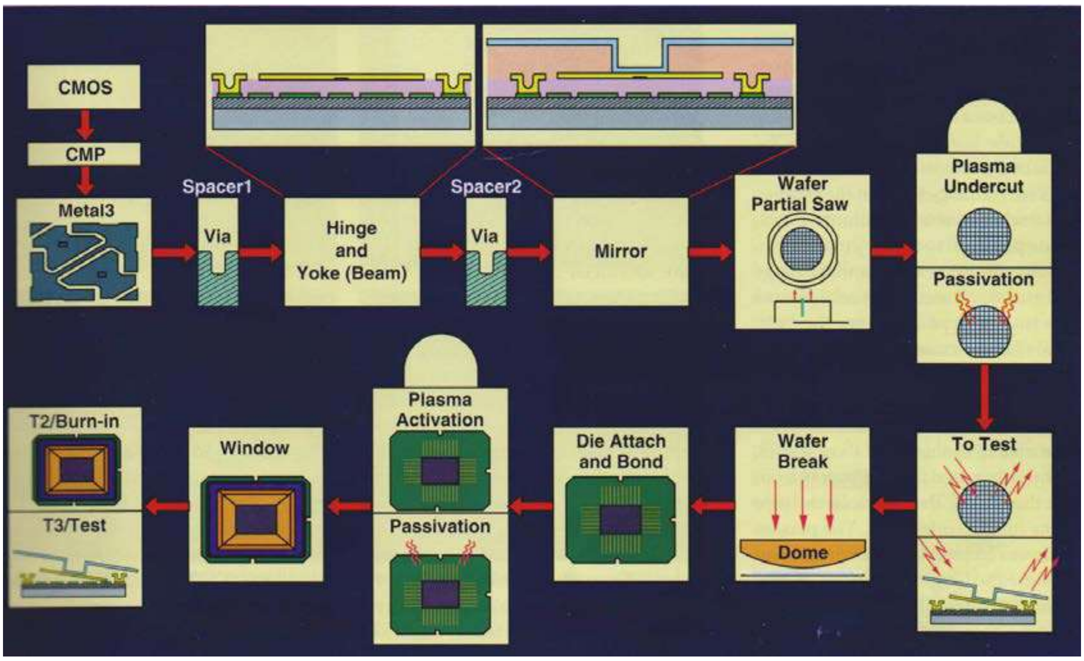


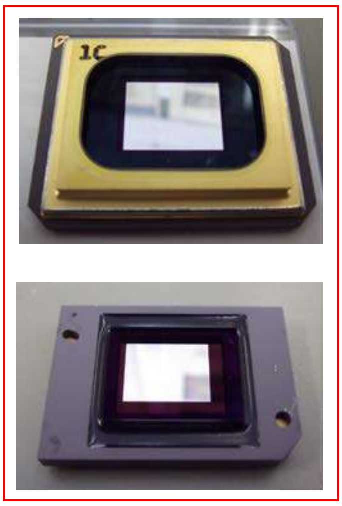
Principle of the movable mirror



Photograph of the mirror array

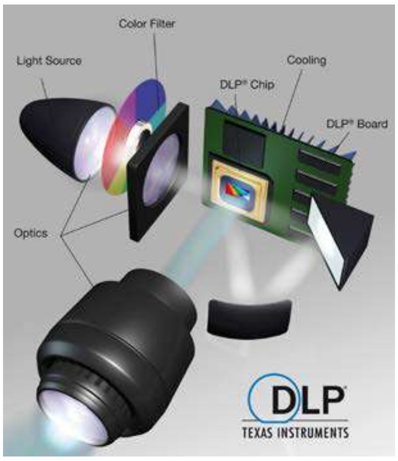

DMD on 6 inch (15cm diameter) wafer





DMD process flow

References : P.F.Van Kessel, L.J.Hornbeck, R.E.Meier and M.R.Douglass: A MEMS-based projection display, Proc. of the IEEE, 86, 8 (1998) 1687-1704



Video projector

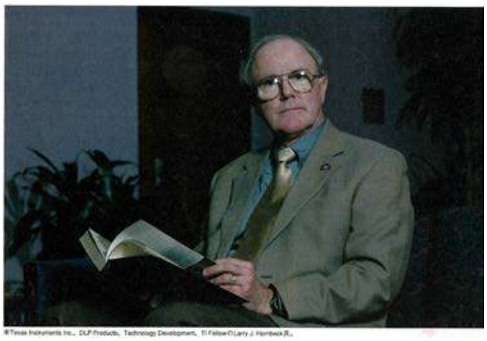

Digital cinema


DLP Pico projector for mobile use

A5 Digital cinema using DMD (Digital Micromirror Device)


DLP
―光を受け継ぐ者たち―
第1回
NIKKEI ELECTRONICS 2005.2.28 199
20年間あきらめなかった男

Man who didn’t give up for 20 years



Video projector using DMD in 1995

DLP (no.1— no.6), Nikkei Electronics, 2005.2.28 – 2005.5.9 (in Japanese) http://www.dlp.com/jp/
https://www.ti.com/about-ti/newsroom/news-releases/2015/2015-02-09-texas-instruments-fellow-larry-j--hornbeck--phd--wins-the-oscar-.html

Texas Instruments Fellow Larry J. Hornbeck, PhD, Wins the Oscar®

Academy Award® of Merit (Oscar® statuette) presented to DLP® chip inventor for his contribution, converting a 100-year-old industry to digital cinema technology

DALLAS, Feb. 9, 2015 /PRNewswire/ -- Larry J. Hornbeck, PhD, the inventor of the digital micromirror device (DMD) or DLP® chip, the technology that led to the design and development of DLP Cinema® display technology from Texas Instruments (TI) (NASDAQ: TXN), has been awarded an Academy Award® of Merit (Oscar® statuette) for his contribution to revolutionizing how motion pictures are created, distributed and viewed. The industry's conversion from 35-mm motion picture film to digital cinema is nearly complete worldwide, with DLP Cinema technology now powering more than eight out of 10 digital movie theatre screens.

DLP Cinema technology gives viewers consistent brightness and color-accurate images compared to 35-mm motion picture film. The technology not only makes it easier for studios to package and distribute movies, but also enables audiences to experience the true vision of the creators of the content.

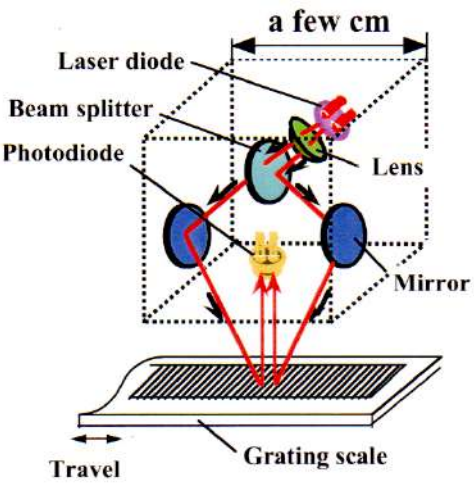
As a result of Hornbeck's invention, for more than two decades, award-winning TI DLP® product innovations have solved some of the world's most complex display and light-control issues in the personal electronics, industrial and automotive markets with powerful, flexible, programmable optical chipsets based on DLP technology.

Development of the DLP chip began in TI's Central Research Laboratories in 1977 when Hornbeck first created "deformable mirrors" to manipulate light in an analog fashion. But the analog technology consistently fell short of expectations. It was not until 1987 that he invented the DMD, the breakthrough technology that would become known as the DLP chip. During the mid-1990s, TI established the DLP Cinema team, chartered to develop a digital projector that could match the quality of 35-mm motion picture film.

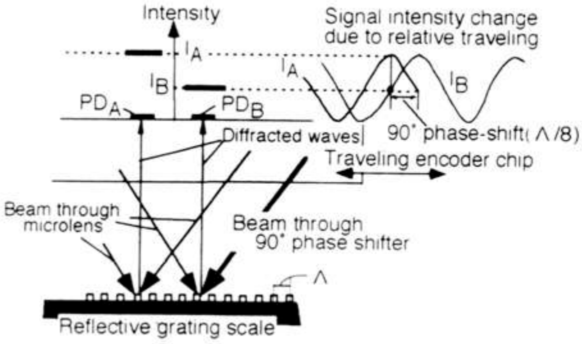
After years of testing and perfecting, the resulting technology made its public debut in 1999, when "Star Wars: Episode 1 – The Phantom Menace" was released as the first full-length motion picture shown with DLP Cinema technology. Over the subsequent 15 years, the cinema industry has nearly completed the conversion from film projectors to digital cinema projectors. Today, digital projectors powered by DLP Cinema technology are installed in more than 118,000 theatre screens around the globe, according to TI.

"It's wonderful to be recognized by the Academy. Following the initial inventions that defined the core technology, I was fortunate to work with a team of brilliant Texas Instruments engineers to turn the first DMD into a disruptive innovation," said Hornbeck, who has 34 U.S. patents for his groundbreaking work in DMD technology. "Clearly, the early and continuing development of innovative digital cinema technologies by the DLP Cinema team created a definitive advancement in the motion picture industry beyond anyone's wildest dreams."

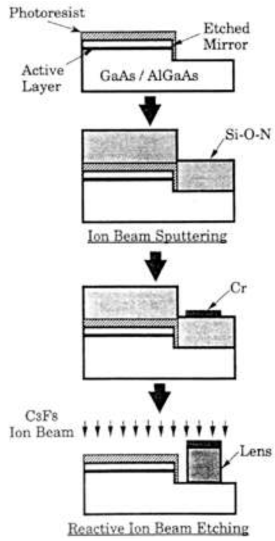
A6 Optical encoder (NTT)



Principle of conventional optical encoder

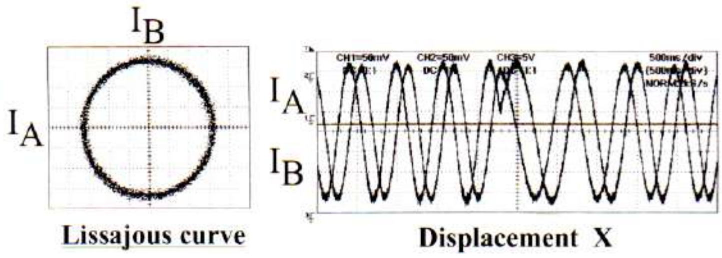


Principle of the developed optical encoder



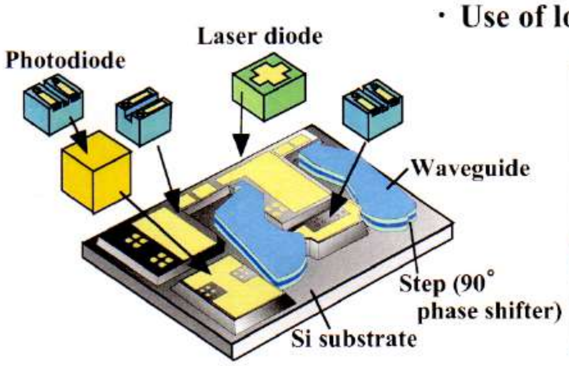
Fabrication of etched mirror

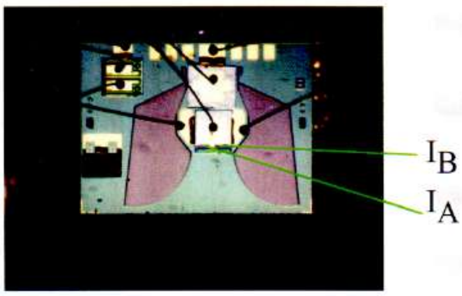
One revolution of Lissajous curve corresponds to displacement of 0.8 or 1.6 μm.

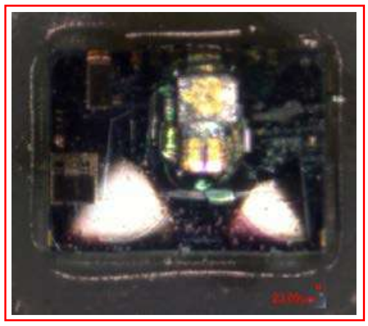


Measurement of displacement

- **Accurate bonding on silicon substrate**
- **Use of long-life optical elements (LD, PD)**

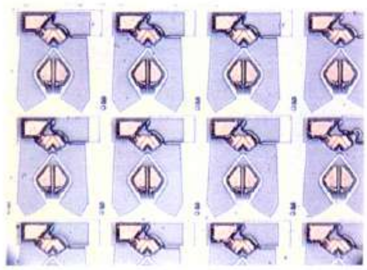


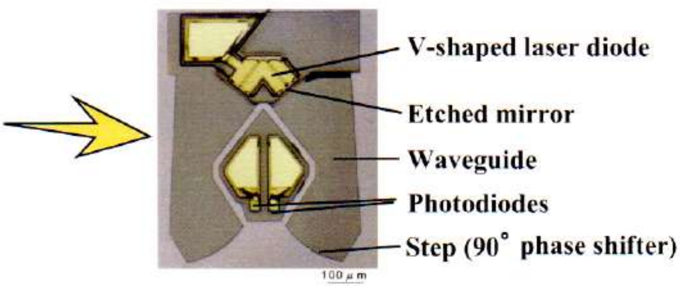


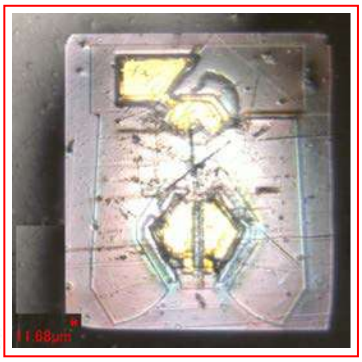


Hybrid method (assembly)

- **4000 chips fabricated using batch process on 2-inch GaAs substrate**



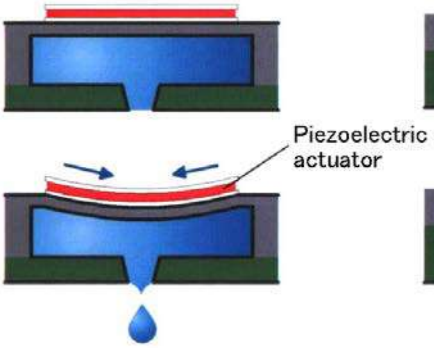




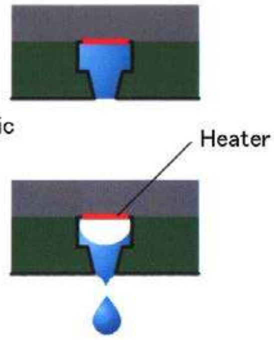
Monolithic method

Reference : R.Sawada, O.Ohguchi, K.Mise and M.Tsubamoto, Fabrication of Advanced Integrated Optical Micro-encorder Chip, IEEE MEMS'94 (1994) pp.337-342

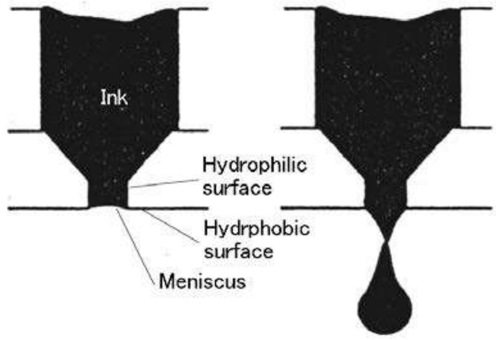
A7 Piezoelectric, thermal inkjet printer head



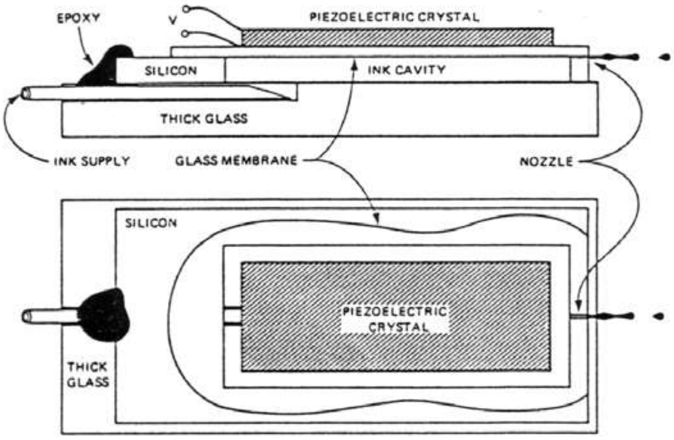
Piezoelectric type
(EPSON, XAAR)



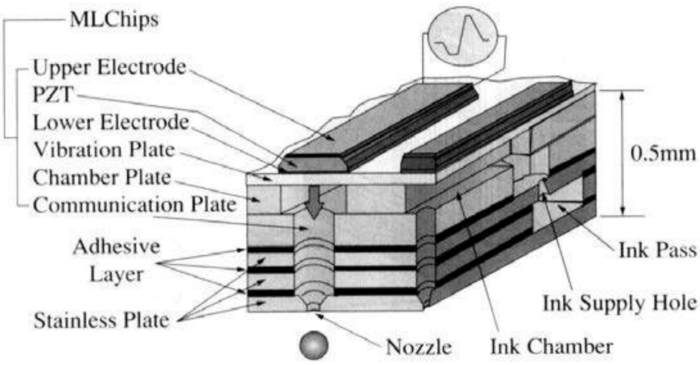
Thermal type
(CANON. HP, Lexmark, XEROX)



Principle of ink droplet ejection



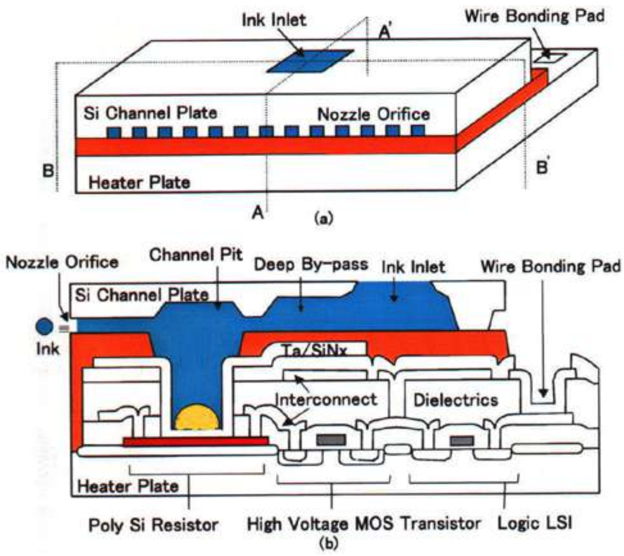
On demandPiezoelectric Ink-jet print head



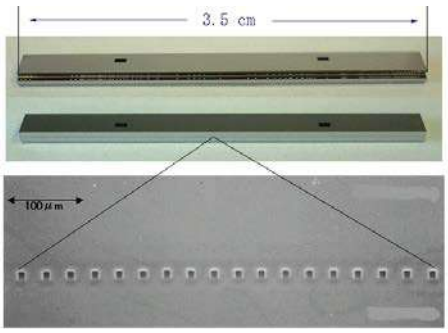
Piezoelectric Ink-jet print head (Seiko Epson)

Reference : K.P.Petersen, Fabrication of an Integrated, Planar Silicon Ink-Jet Structure, IEEE Trans. on Electron Devices, ED-26 (1979) pp.1918-1920

Ink-jet Head (Seiko Epson), 2003 MEMS Technology Outlook (2003) pp.71-74



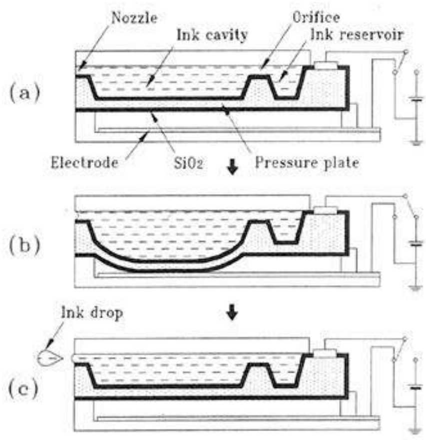
Structure

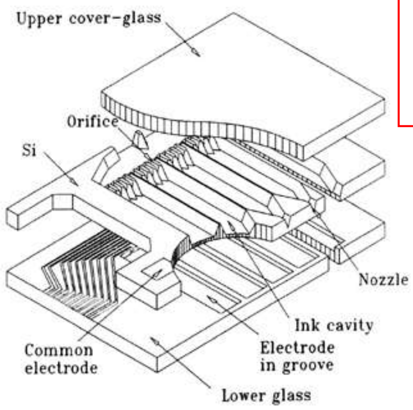


Nozzle

Reference : M.Murata, M.Kataoka, R.Nayve, A.Furugawa, Y.Ueda, T.Mihara, M.Fujii and T.Iwamori (Fuji Xerox), High Resolution Long Array Thermal Ink Jet Printhead with On-chip LSI Heater Plate and Micromachined Si Channel Plate, IEICE Trans. Electronics, E-84-C (2001) pp.1792-1800

A8 Electrostatic inkjet printer head



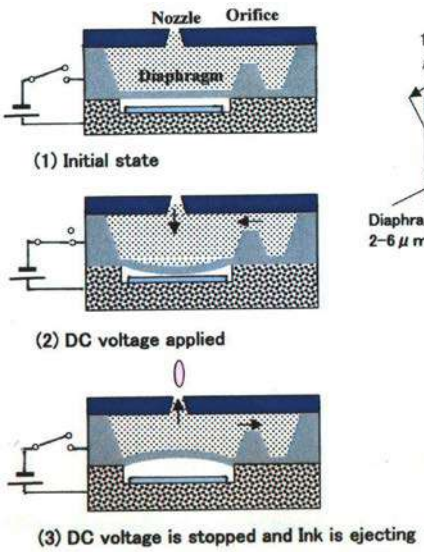


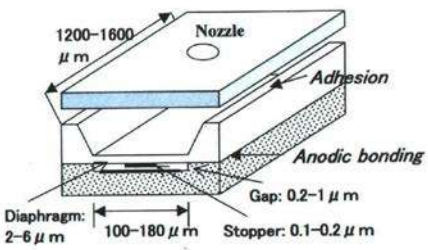
Ink tank – head assembly

Principle Structure

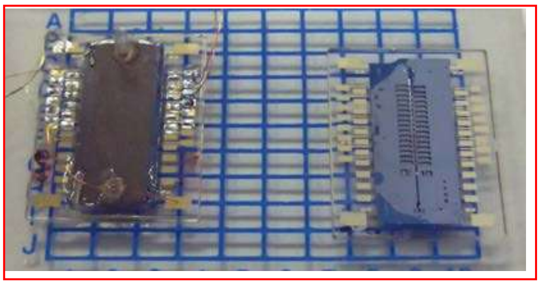
Electro static printer head (Seiko Epson)

Reference : S.Kamisuki, T.Hagata, C.Tezuka, Y.Nose, M.Fujii and M.Atobe, A Low Power, E;ectrostatically-driven Commercial Inkjet Head, Proc. of IEEE MEMS (1998) pp.63-68

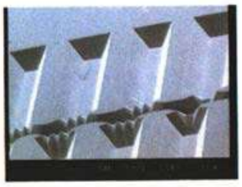




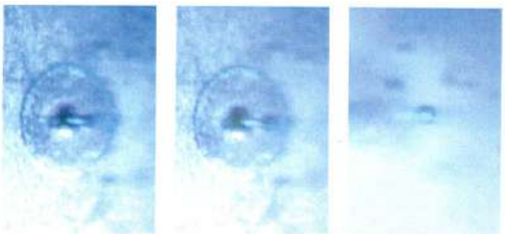
Schematic structure



Ink head

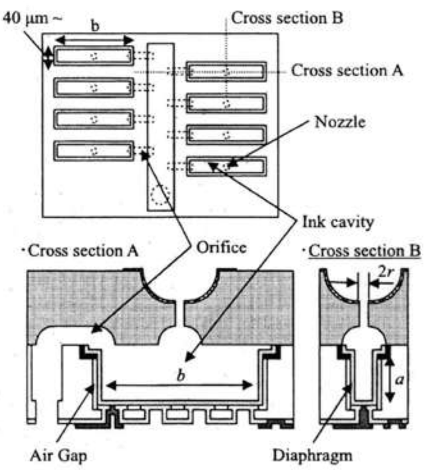


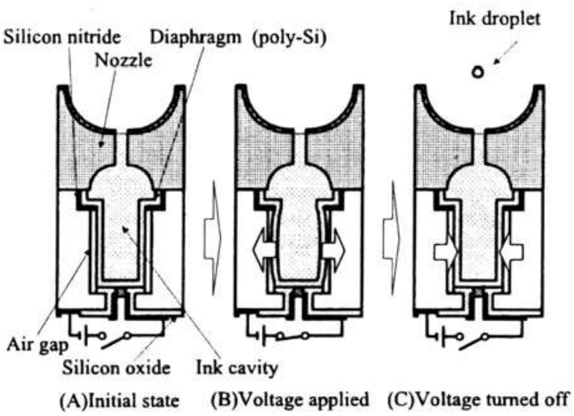
Cavity

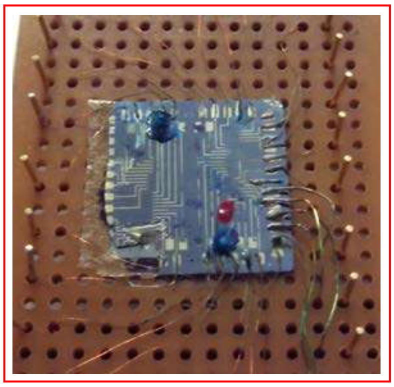


Principle Structure and nozzle photograph Strobe observation of the ink ejection

Electrostatic inkjet printer head for high speed low power line printer (Tohoku Univ. — Sony)



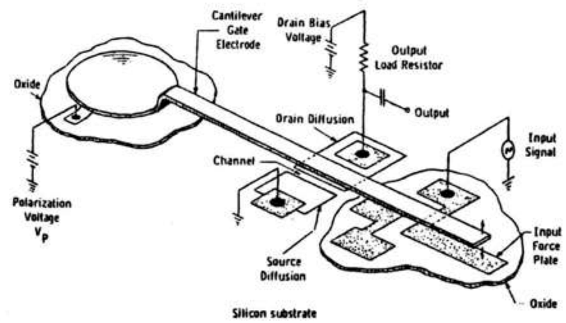


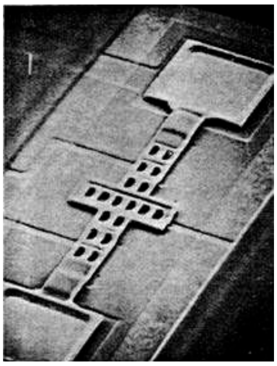


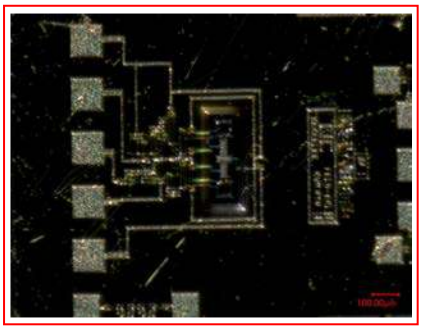
Electrostatic inkjet printer head with vertical diaphragms

Reference : T.Norimatsu, S.Tanaka and M.Esashi, Vertical Diaphragm Electrostatic Actuator for a High Density Ink Jet Printer Head, Trans. IEE ofJapan, 125-E (2005) pp.350-354

A9 MEMS resonator (USA)



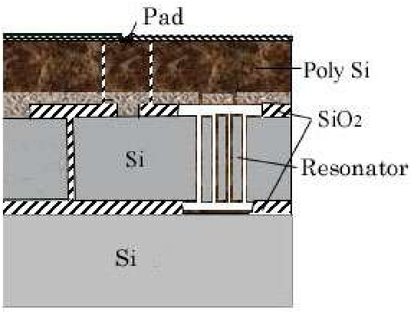


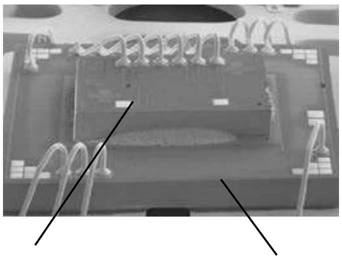


Resonant gate transistor (Westing house) **Resonant micro-bridge** (U.C.Berkeley)

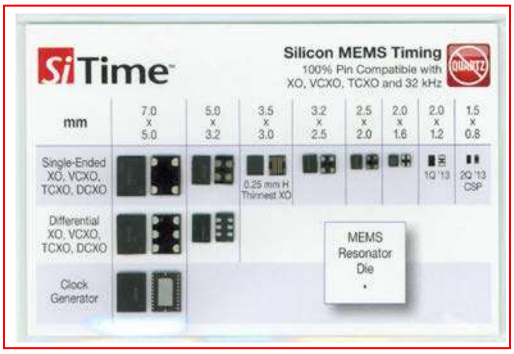
Reference : H.C.Nathanson et.al. The resonant gate transistor, IEEE Trans. on Electron Devices, ED-14 (1967) 117-133

R.T.Howe and R.S.Muller, Resonant-Microbridge Vapar Sensor, IEEE Trans. on Electron Devices, ED-33 (1986) pp.499-506

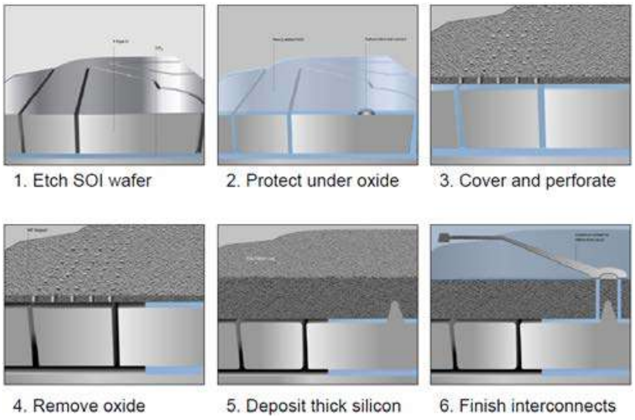


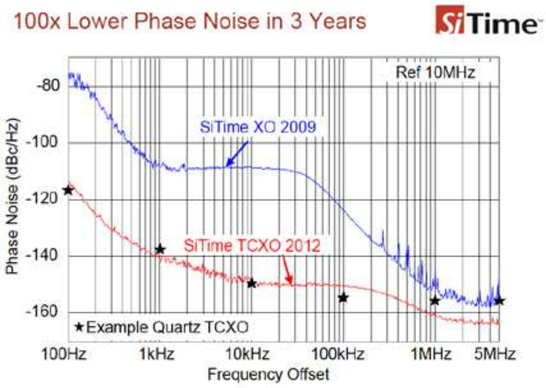


MEMS resonator chip Circuit chip



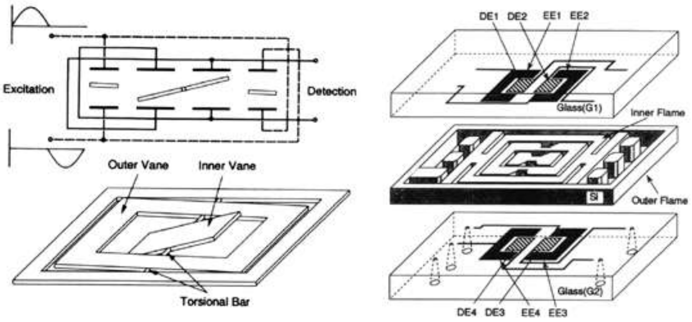
MEMS oscillator (SiTime)

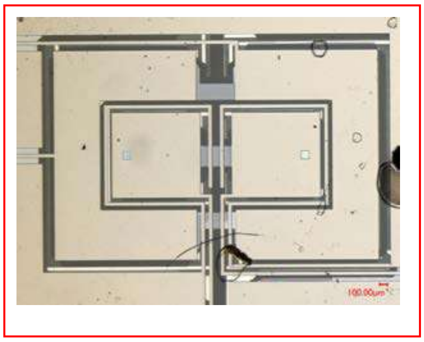




Reference : M.Lutz, A.Partridge, P.Gupta, N.Buchan, E.Klassen, J.McDounald and K.Petersenand, MEMS Oscillators for High Volume Commercial Applications, Technical Digest of Transducers' 07 (2007) pp.49-52

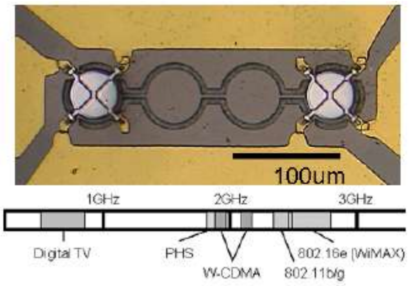
A10 MEMS resonator（disk, Lamb etc.)

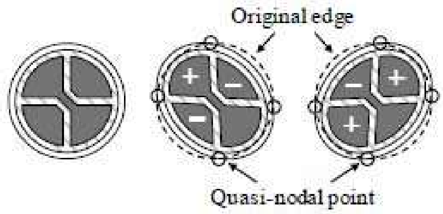


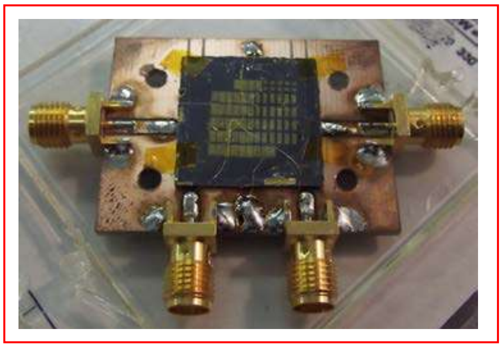


Packaged high Q MEMS trsonator (Tohoku Univ. – Shimazu)

Reference : K.Yoshimi, K.Minami, Y.Wakabayashi and M.Esashi, Packaging of Resonant Sensors, Technical Digest of the 11th Sensor Symposium(1992) pp.35–38

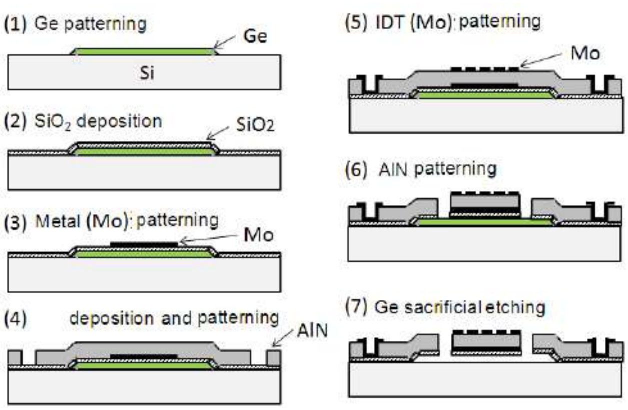


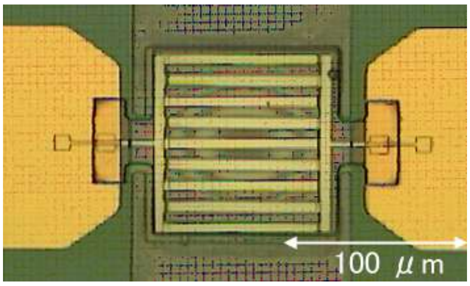




Micro disk resonator（Tohoku Univ. – NICT)

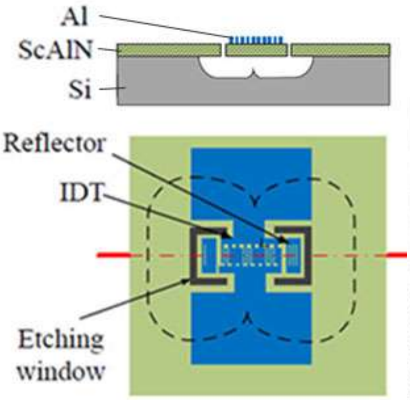
Reference :T.Matsumura, M.Esashi, H.Harada and S.Tanaka : Multi-band Radio-frequency Filter Fabricated Using Polyimide-based Membrane Transfer Bonding Technology, J. of Micromech. Microeng., 20, 9 (2010) 095027(9pp)

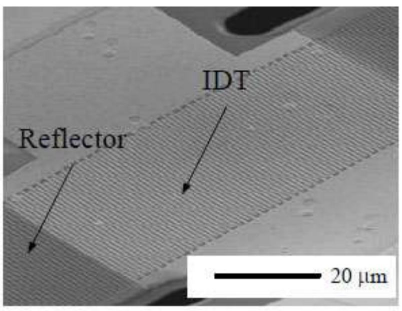


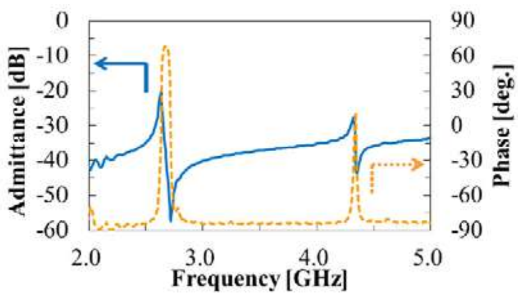


Lamb wave resonator (Tohoku Univ. – Japan Denpa)

Reference : K.Hirano, M.Esashi and S.Tanaka, Aluninum Nitride Lamb Wave Resonator Using Germanium Sacrificial Layer, 2nd International Workshop on Piezo-devices Based on Latest MEMS Technologies (2008) pp.111–117



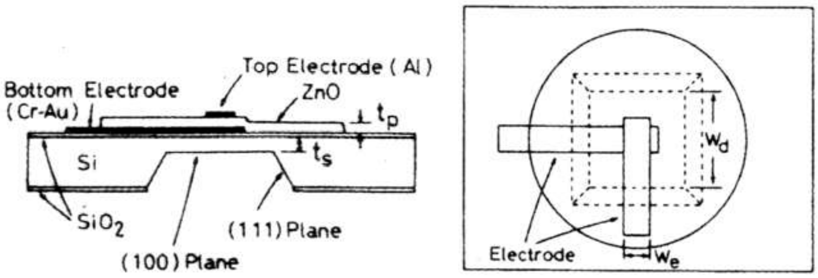


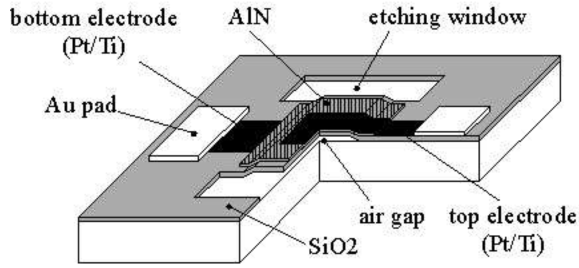


Lamb wave resonator using Sc–AlN,

Reference : A.Konno et.al ::ScAlN Lamb Wave Resonator in GHz Range Released by XeF_2 Etching, 2013 IEEE Ultrasonics Symposium 2013 1378–1381)

A11 # FBAR (Film Bulk Acoustic Resonator)

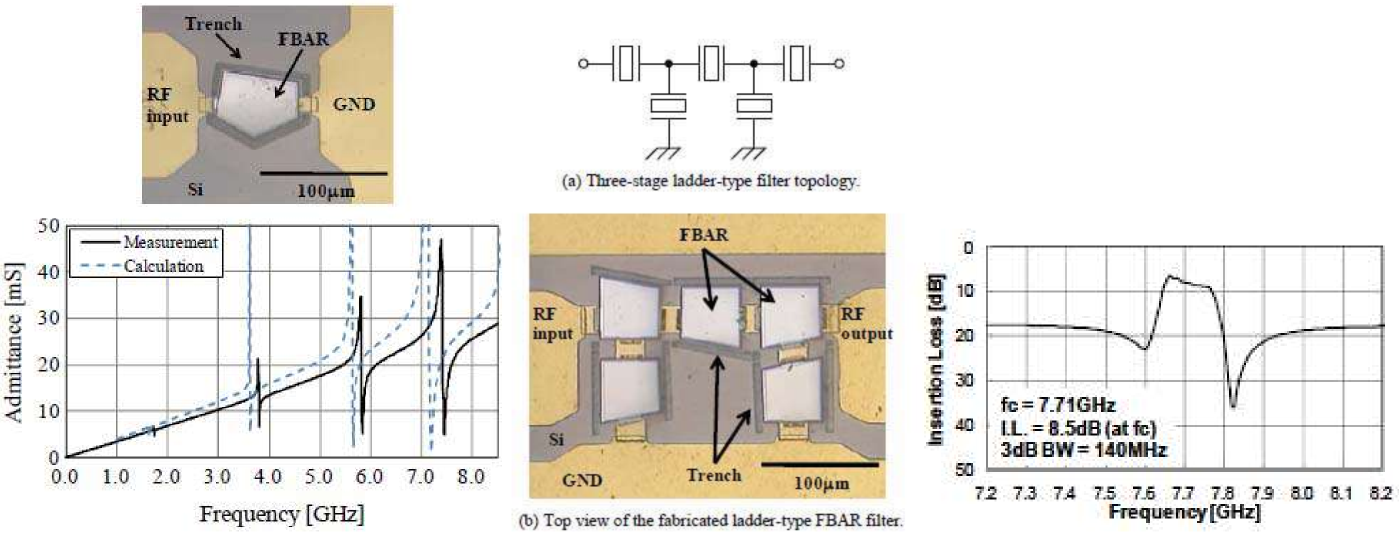




FBAR (S. Nakamura, Tohoku Univ.) FBAR

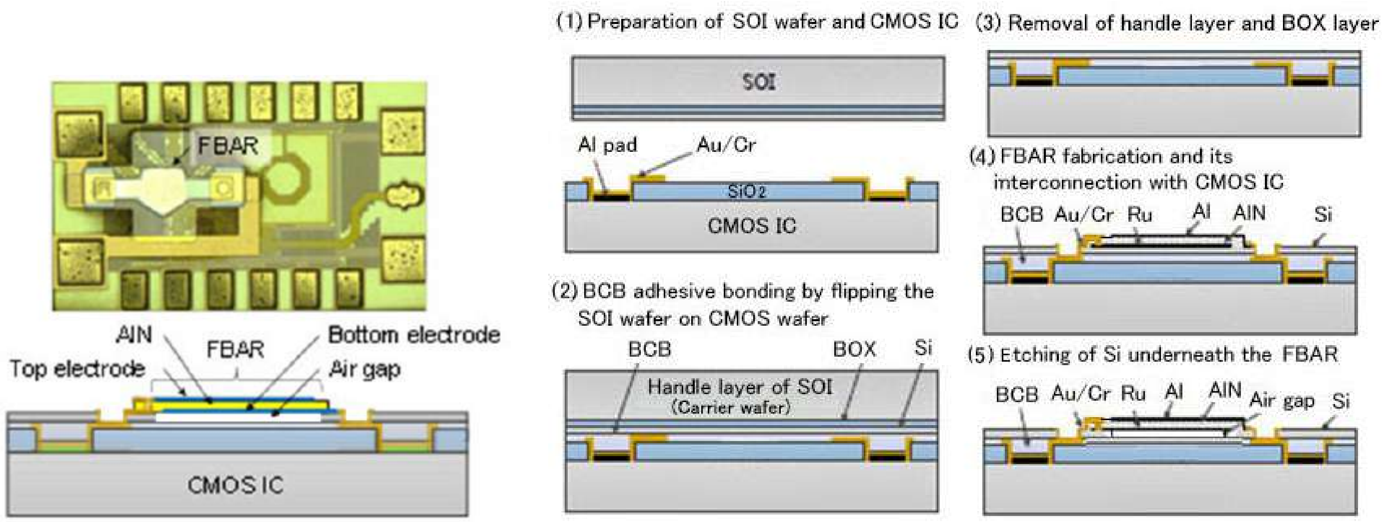
Reference : K.Nakamura, H.Sasaki and H.Shimizu, A Piezoelectric Composite Resonator Consisting of a ZnO Film on an Anisotropically Etched Silicon Substrate, Proc. of 1st Symp. On Ultrasonic Electronics (1980), Jap. J. of Applied Physics, 20(1981) Supplement 20-3, pp.111-114

M.Hara, J.Kuypers, T.Abe and M.Esashi, Surface Micromachined AlN Thin Film 2GHz Resonator for CMOS Integration, Sensors & Actuators A, 117 (2005) pp.211-216



FBAR (Film Bulk Acoustic Resonator) (Tohoku Univ. – NICT)

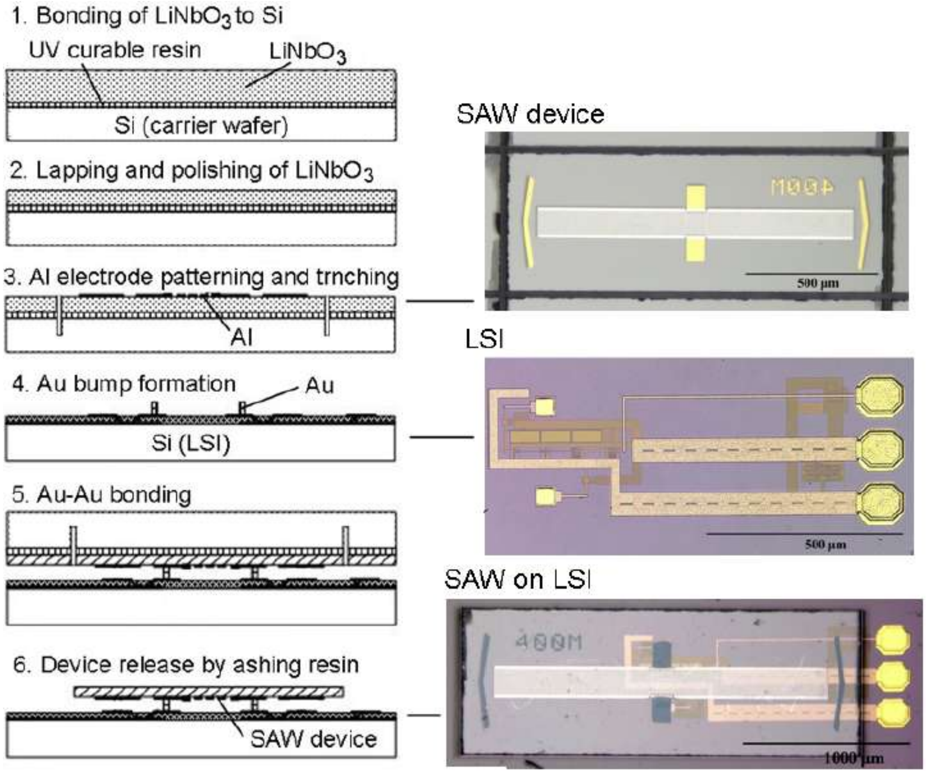
Reference : T.Matsumura, M.Esashi, H.Harada and S.Tanaka, Multi-band Radio-frequency Filter Fabricated Using Polyimide-based Membrane transfer Bonding Technology, J. of Micromech. Microeng., 20 (2010) 095027(9pp)



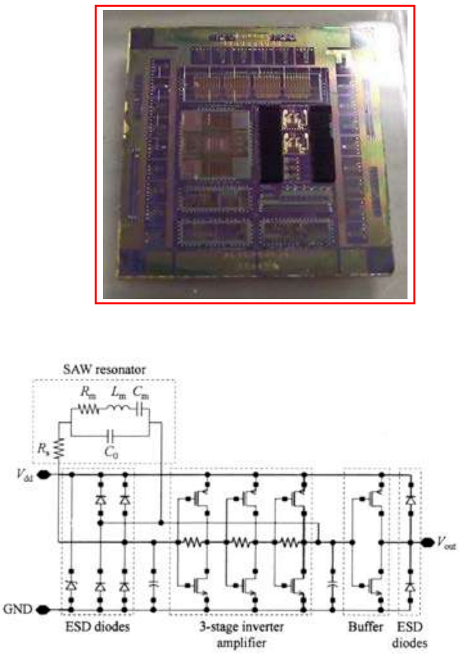
FBAR(film bulk acoustic resonator) fabricated on LSI

Reference : Kochhar et. al, 2012 IEEE Internl. Ultrasonic Symp. (2012) 1047

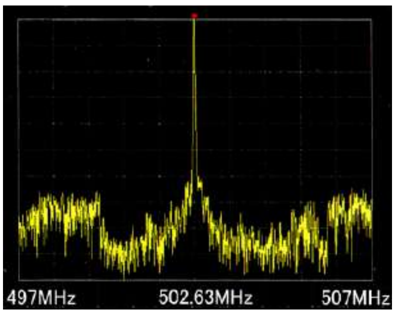
A12 SAW device on LSI (surface acoustic wave device on LSI)



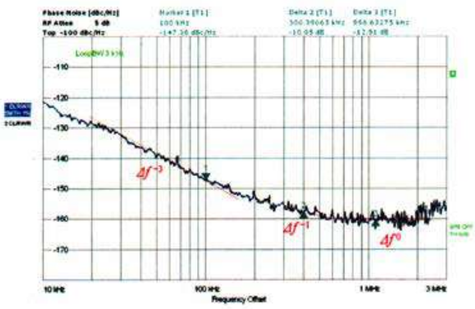
Fabrication process



CMOS circuit

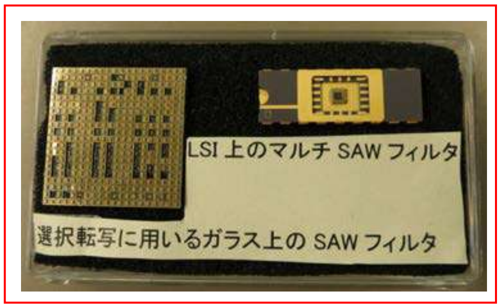


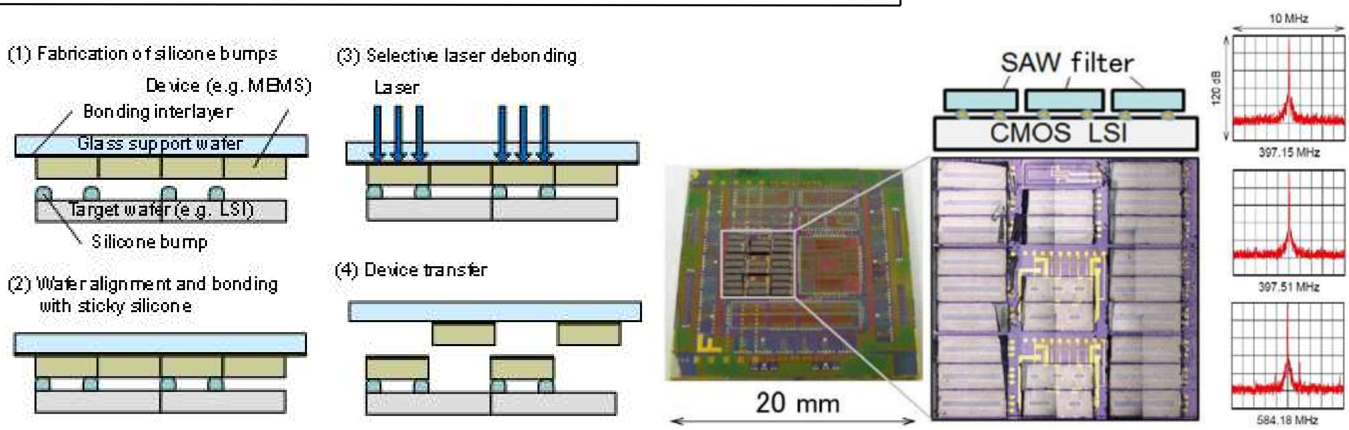
Oscillation spectrum



Jitter characteristics

Reference : K.D.Park, M.Esashi and S.Tanaka, Preparation of Thin Lithium Niobate Layer on Silicon Wafer for Wafer-level Integration of Acoustic Devices and LSI, Trans. of IEE in Japan, 130-E (2010) pp.236-241

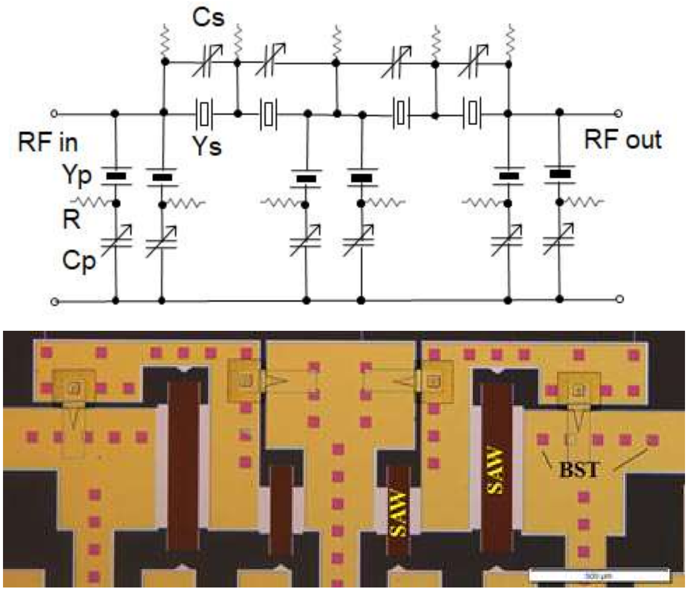




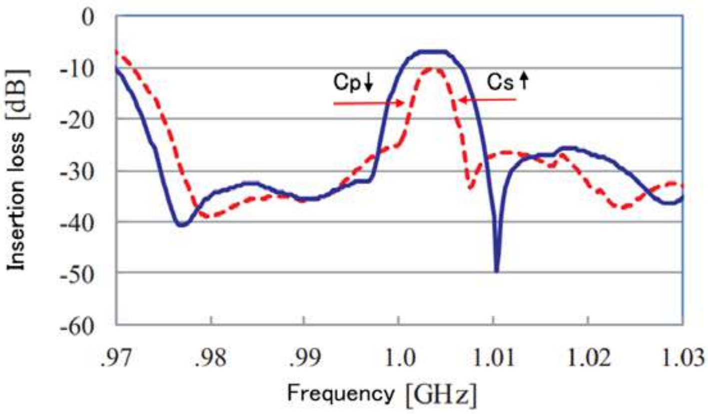
Multi SAW filter using selective transfer process

Reference ; S. Tanaka, M. Yoshida, H. Hirano and M. Esashi, Lithium Niobate SAW Device Hetero-transferred onto Silicon Integrated Circuit Using Elastic and Sticky Bumps, 2012 IEEE International Ultrasonics Sympsium (2012) p.1047

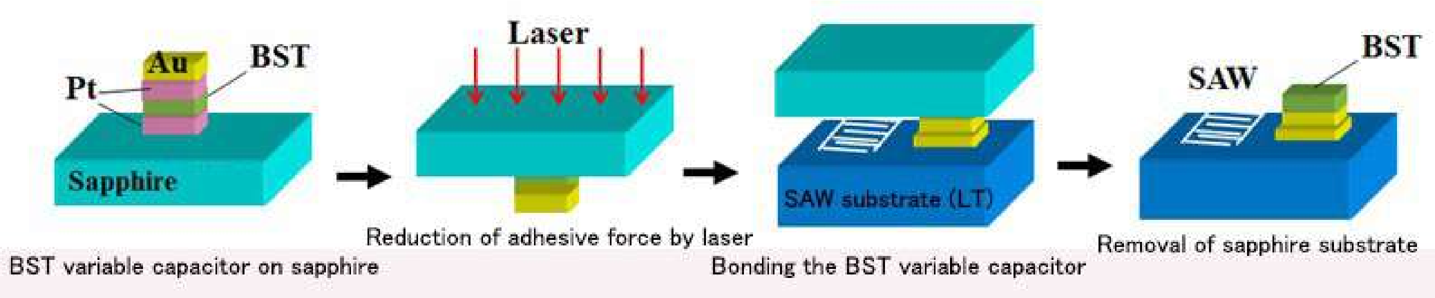
A13 Tunable SAW filter using variable capacitor



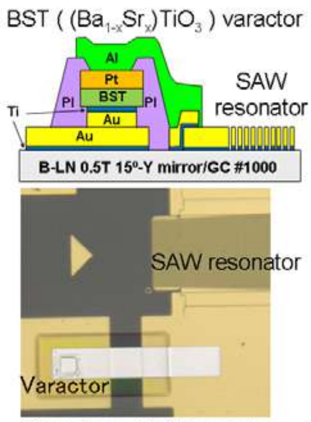
Principle and photograph



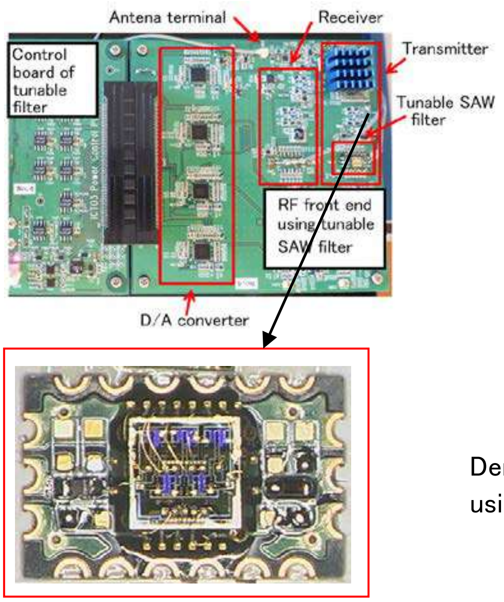
Chracteristics

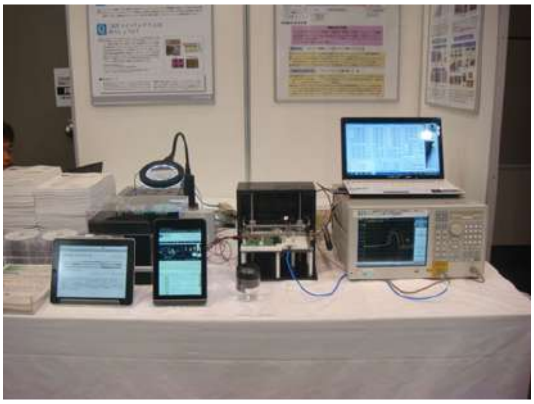


Fabrication process of variable capacitor using BST($(Ba_{1-X}Sr_X)TiO_3$)



Transferred BST varactor
(Tuning ratio of 1.6 at 3 V)





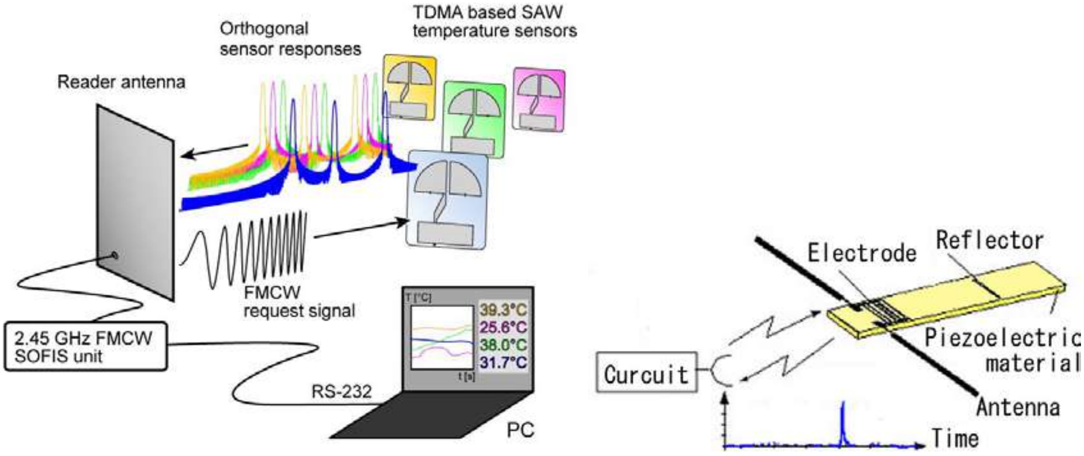
Demonstration of wireless communication system using cannel of digital TV in case of emergency

Reference : Hideki Hirano et.al, Bandwidth-tunable SAW Filter Based on Wafer-level Transfer-integration of $BaSrTiO_3$ Film for Wireless LAN System using TV White Space, Proc. IEEE Ultrason. Symp., USA (2014) 803-806

Reference : H.Hirano, T.Kimura, I.P.Koutsaroff, M.Kodato, K.Hashimoto, M.Esashi and S.Tanaka, Integration of BST Varactors with Surface Acoustic Wave Device by Film Transfer Technology for Tunable RF Filters , J. of Micromech. Microeng., 23, 2 (2013) 025005 (9pp)

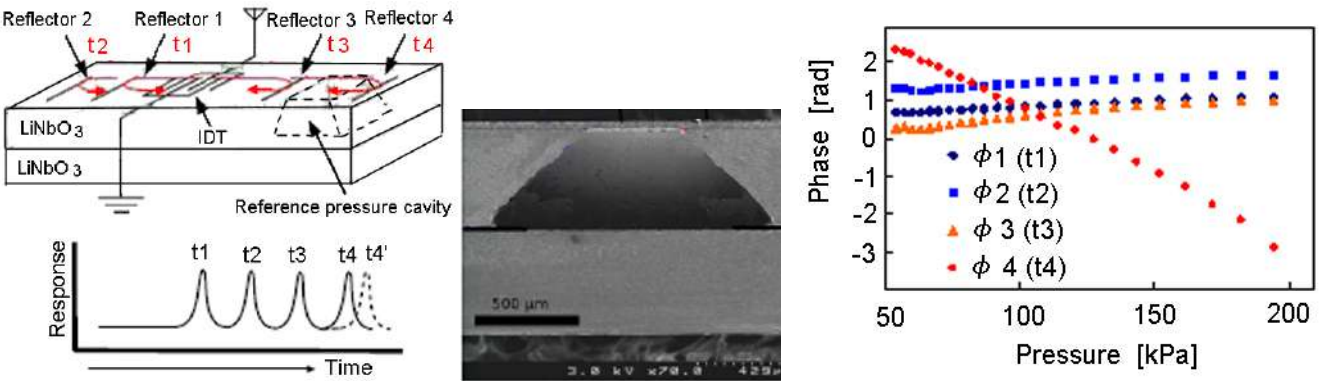
A14 SAW passive wireless sensor

(Strategic Information and Communication R&D Promotion Program (SCOPE) 2006FY – 2008FY)



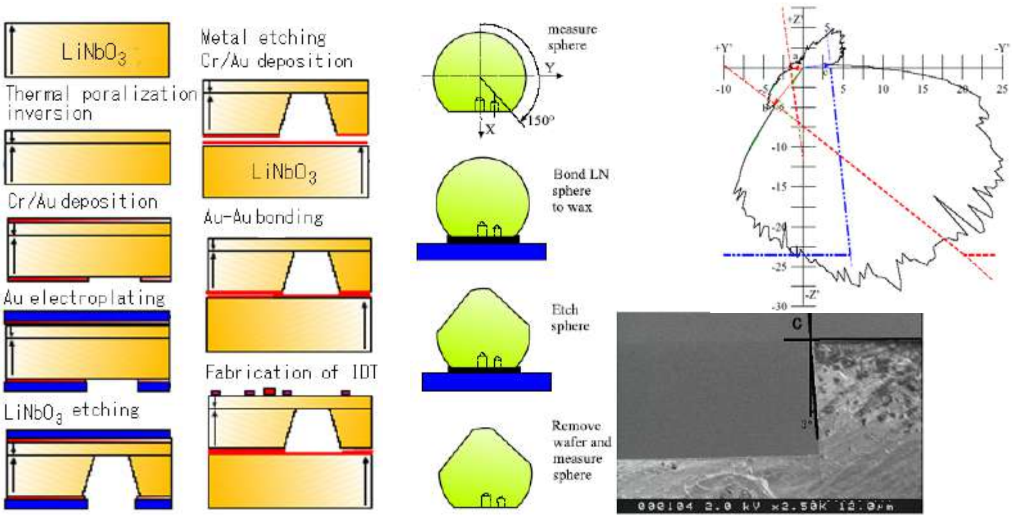
Principle of SAW passive wireless sensor

Reference : J. H. Kuypers, L. M. Reindl, S. Tanaka and M. Esashi, Maximum Accuracy Evaluation Scheme for Wireless SAW Delay Line Sensors, IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control, 55 (2008) pp.1640–1652



Application to tire pressure monitor (Tohoku Univ. – Nissan motor)

Reference : S.Hashimoto, J.H.Kuypers, S.Tanaka and M.Esashi, Design and Fabrication of Passive Wireless SAW Sensor for Pressure Measurement, Trans. IEE of Japan, 128-E (2008) pp.231–234



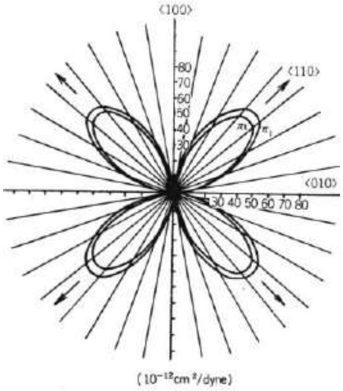
Selective etching and simulation of anisotropic etching of $LiNbO_3$

Reference : A. B. Randles, M. Esashi and S. Tanaka, Etch Stop Process for Fabrication of Thin Diaphragms in Lithium Niobate, Jap. J. of Applied Physics, 46 (2007) pp.L1099–L1101

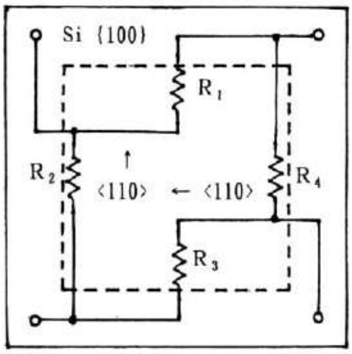
A.B.Randles, M.Esashi and S.Tanaka, Etch Rate Dependence on Crystal Orientation of Lithium Niobate, IEEE Trans. on Ultrasonics, Ferroelectrric, and Frequency Control, 57 (2010) pp.2372–2380

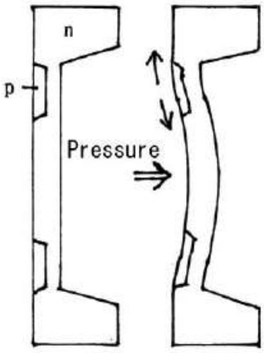
B1 Piezoresistive pressure sensor

Dr. Isemi Igarashi
(Toyota Central Research Laboratory)

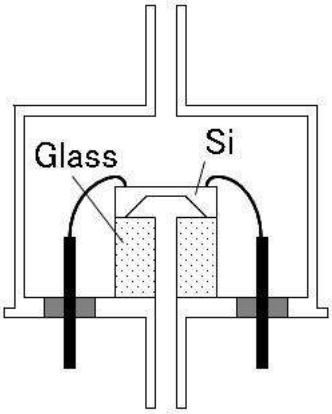


Piezoresistive coefficient on (100) p−Si
maximum in <110> direction

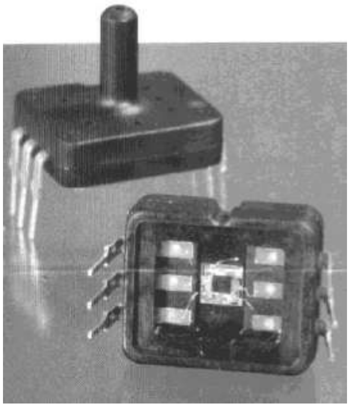




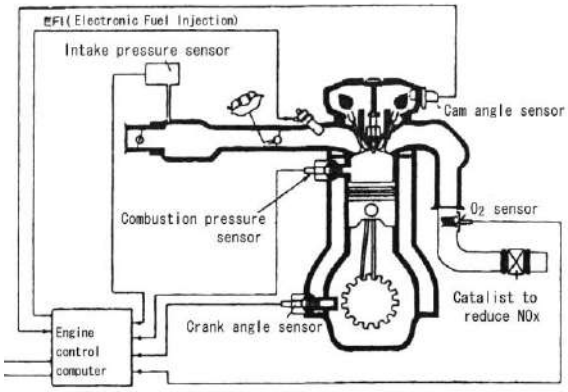
Piezoresistive Si diaphragm pressure sensor



Packaging of pressure sensor



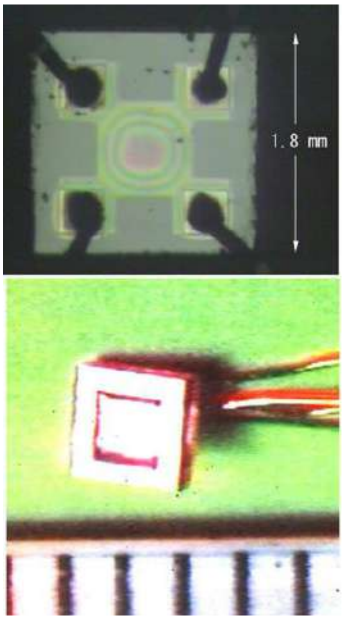
Pressure by Fujikura Ltd.

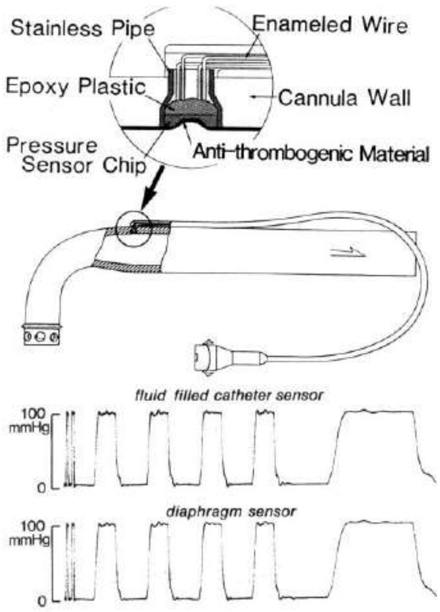


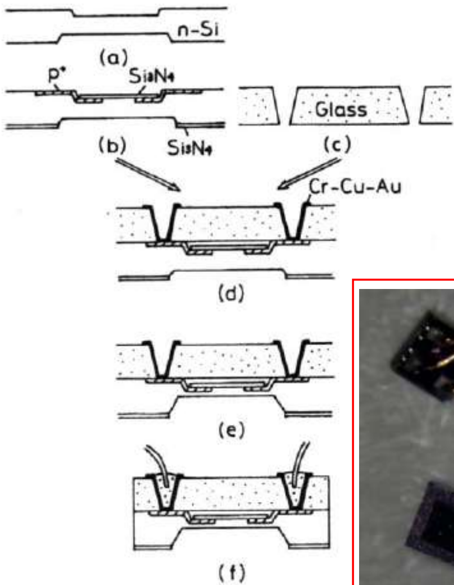
Pressure sensor applied for engine control

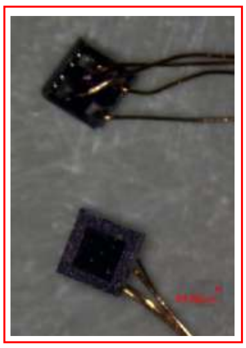
Reference : I.Igarashi, Piezo−resistive Effect of Ge and Its Application to Strain Gages, Applied Physics, 29 (1960) pp.73−78
O.N.Tufle (Honeywell), Silicon Diffused−element Piezoresistive Diaphragms, J. of Applied Physics, 33 (1962) pp.3322−3327)

Piezoresistive Absolute Pressure Sensor





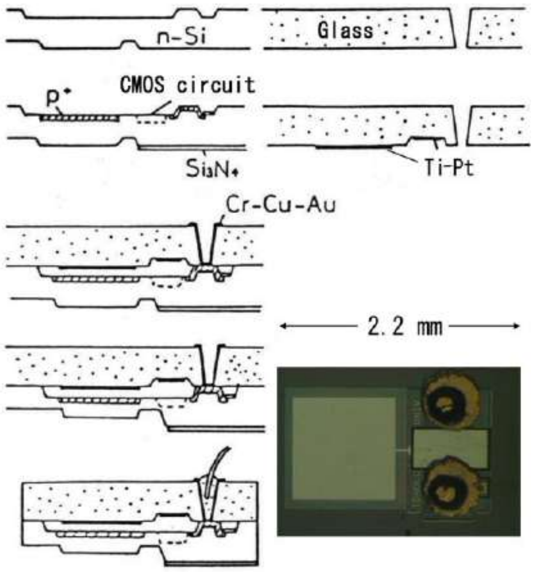




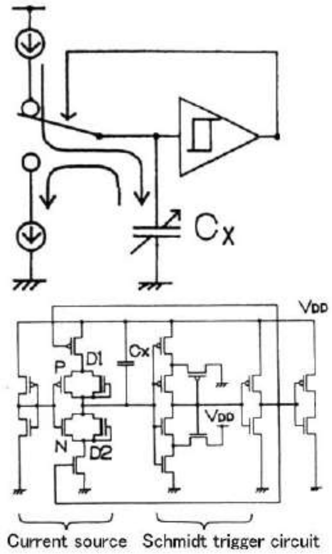
Photograph　　Blood pressure monitor in ventricular assist device　　Fabrication process

Reference : M.Esashi, Y.Matsumoto and S.Shoji, Absolute Pressure Sensors by Air−tight Electrical Feedthrough Structure, Sensors and Actuators, A21−A23 (1990) pp.1048−1052

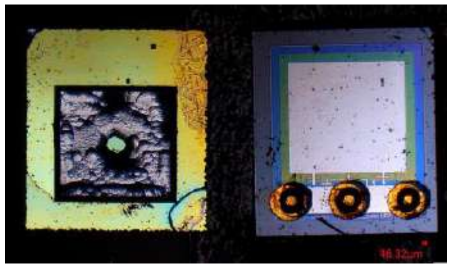
B2 **Integrated capacitive pressure sensor**

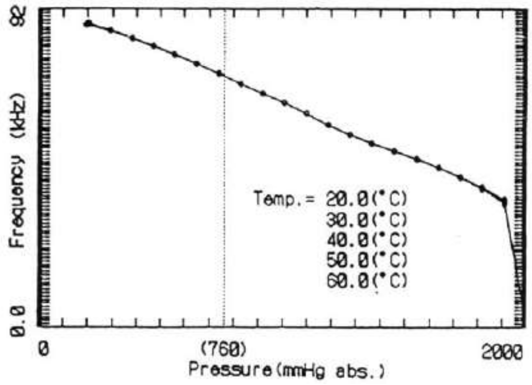


Fabrication process



Circuit





Characteristics

For low pressure measurement

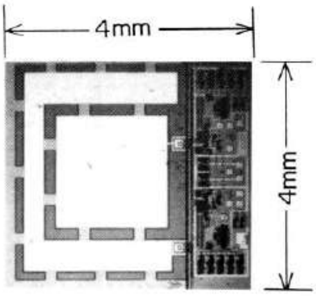
10mmH2O～300mmH2O

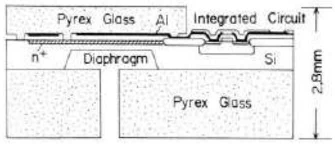
Frequency and analog output

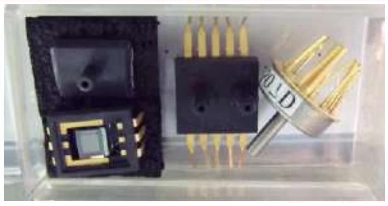
TOYODA

Toyoda Machine Works, LTD.

Monolithic capacitive pressure sensor



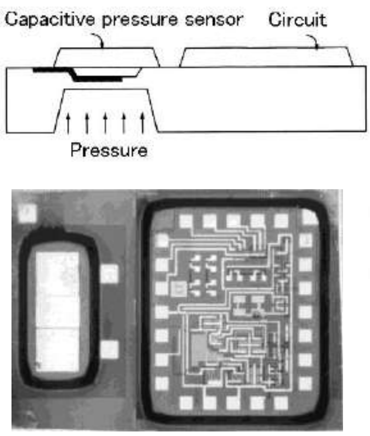




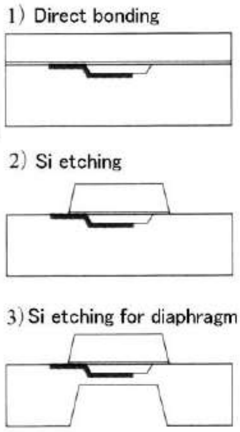
Wafer level packaged integrated capacitive pressure sensor (Tohoku Univ. — Toyda Machine Works)

(This sensor was used for filter clogging detection of air conditioner for about 20 years)

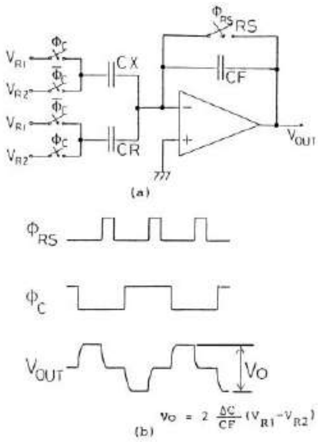
Reference : Y.Matsumoto, S.Shoji and M.Esashi, A Miniature Integrated Capacitive Pressure Sensor, Extended Abstracts of the 22nd International Conference on Solid State Devices and Materials (1990) pp.701-704



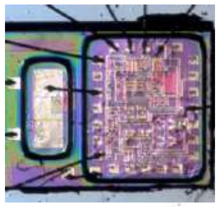
Structure and photograph

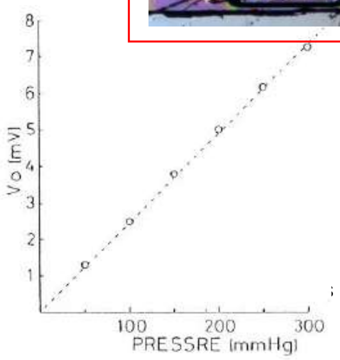


Fabrication



Circuit

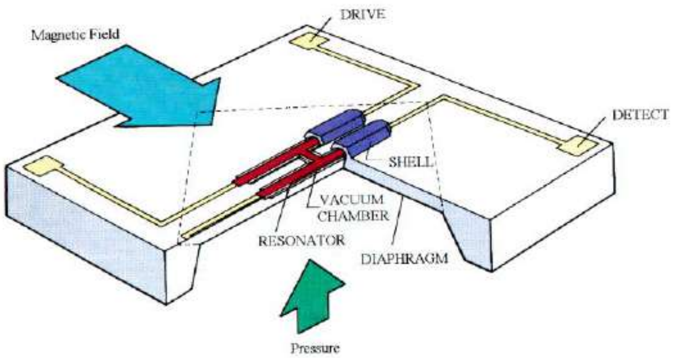




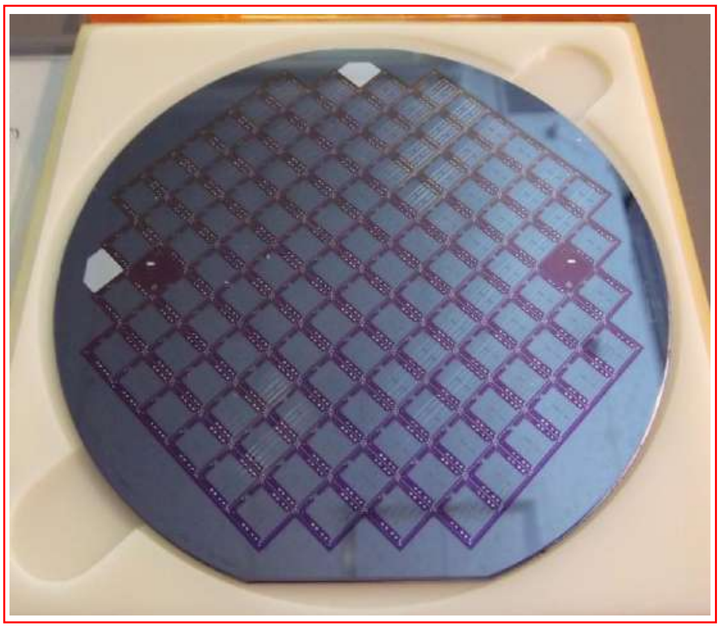
Integrated Capacitive Pressure Sensor by Si Direct Bonding

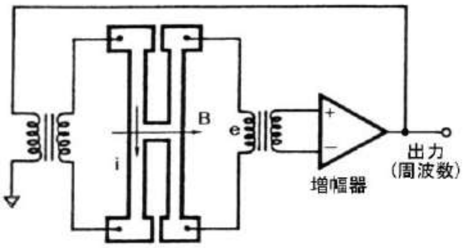
Reference : S.Shoji, T.Nisase, M.Esashi and T.Matsuo, Fabrication of an Implantable Capacitive Type Pressure Sensor, The 4th Int. Conf. on Solid State Sensors and Actuators (transducers' 87), (1987) pp.305-308

B3 Resonant pressure sensor (Yokogawa Electric Work)



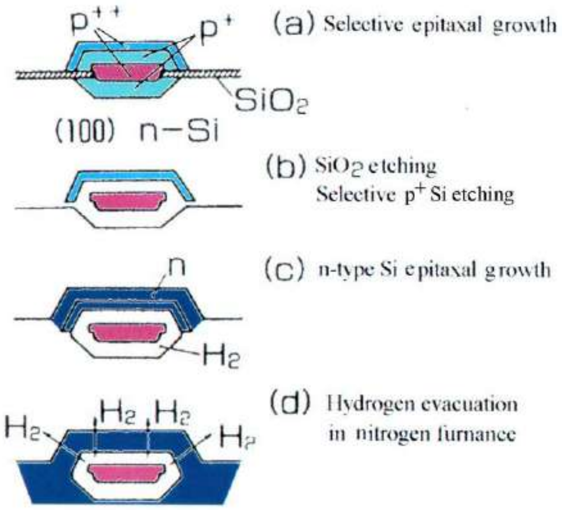
Principle



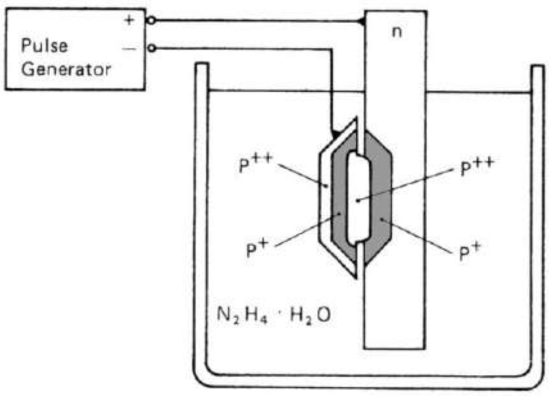


Circuit

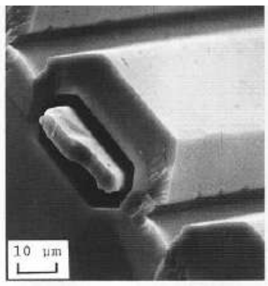
Resonant mode



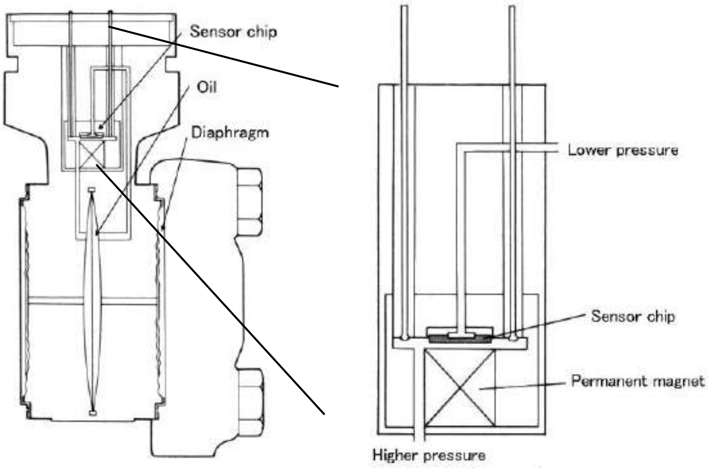
Fabrication process



Etching apparatus in process (b)



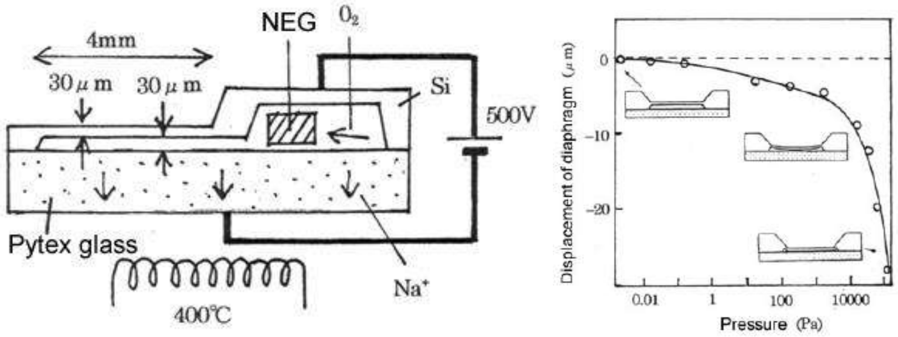
Cross section of resonator



Differential pressure transmitter (DP harp)

Reference : K.Ikeda, H.Kuwayama, T.Kobayashi, T.Watanabe, T.Nishikawa and T.Yoshida, Silicon Pressure Sensor with Resonant Strain Gages Built into Diaphragm, Tech. Digests of the 7th Sensor Symposium (1988) pp.55–58

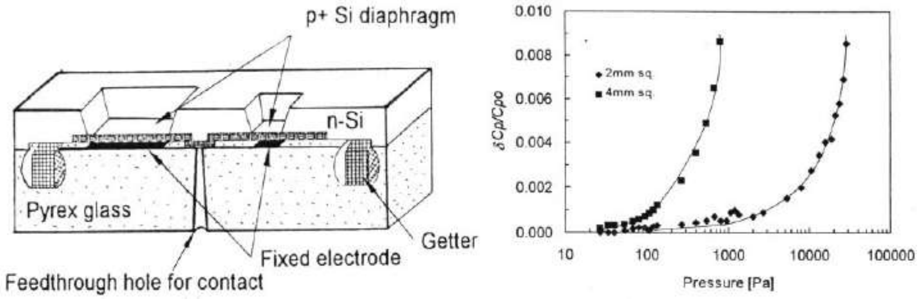
B4 Capacitive vacuum sensor



Vacuum encapsulation by anodic bonding with getter

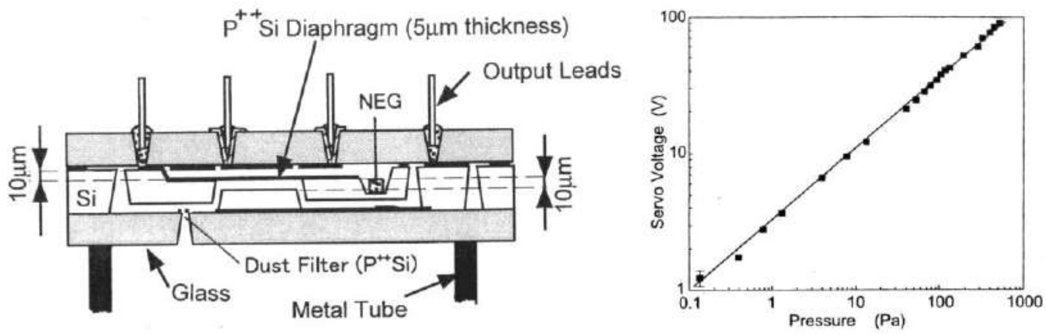
Reference : M.Esashi, S.Sugiyama, K.Ikeda, Y.Wang and H.Miyashita, Vacuum−Sealed Silicon Micromachined Pressure Sensors, Proc. of the IEEE, 86 (1998) pp.1627−1639

Reference : H.Henmi, S.Shoji, Y.Shoji, K.Yoshimi and M.Esashi, Vacuum Packaging for Micro−sensors by Glass−Silicon Anodic Bonding,, Sensors and Actuators A, 43 (1994) pp.243−248



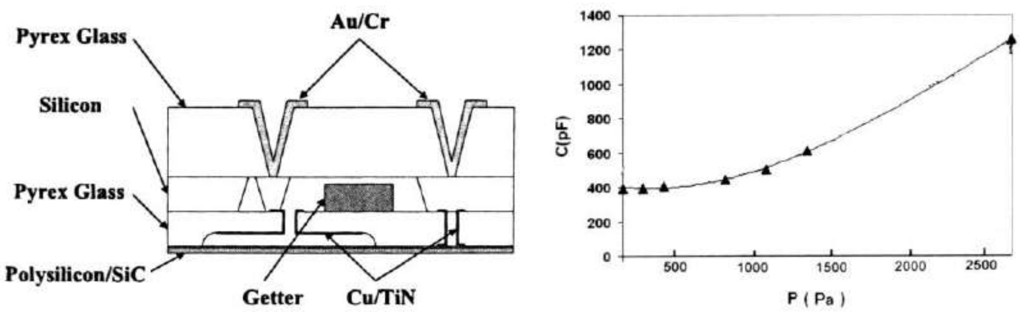
Dual diaphragm vacuum sensor

Reference : K.Hatanaka, D.Y.Sim, K.Minami and M.Esashi, Silicon Diaphragm Capacitive Vacuum Sensor, Tech. Digest of the 13th Sensor Symp.,(1995) pp.37−40



Electrostatic servo vacuum sensor

Reference : H.Miyashita and M.Esashi : Wide Dynamic Range Silicon Diaphragm Vacuum Sensor by Electrostatic Servo System, J. Vac. Sci. Technology, B18, (2000) pp.2692−2697



SiC diaphragm anti−corrosive vacuum sensor

Reference : B.Larangot, S.Tanaka and M.Esashi, Fabrication of Anti−Corrosive Capacitive Vacuum Sensors with a Silicon Carbide/Polysilicon Bi−Layer Diaphragm and Electrical Through−Hole Connections on the Opposite Side, Trans. IEE of Japan, 128−E (2008) pp.331−336

B5 Capacitive vacuum sensor products (Canon ANELVA, Daiavac)


ANELVA

キャパシタンスゲージ
M-340DG

●概要

マイクロマシン技術による、小型、高性能キャパシタンスゲージ

絶対圧測定を可能とするキャパシタンスゲージ（静電容量型隔膜真空計）をマイクロマシン（MEMS）技術を用いて作製し、小型化、高性能、低価格を実現した画期的な真空計です。

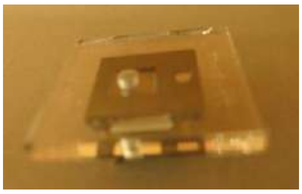
●特長

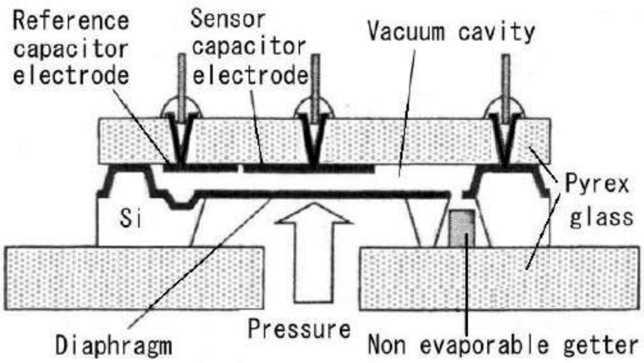
- コンパクト、低価格
  マイクロマシン（MEMS）技術を用いて、小型化、低価格（量産化）を実現
- 測定レンジ 5 タイプをラインナップ
  33Pa、133Pa、1.33kPa、13.3kPa、133kPaの5タイプ
- 高感度、高再現性
  単結晶シリコンダイヤフラムの採用により、高感度、高再現性を実現
- メンテナンスコスト低減
  センサチップのみの交換が可能※
- 優れた対震動ノイズ性
  小型・軽量ダイヤフラムのため、機械震動ノイズを受けにくい
- 取付け方向を選ばない
  垂直、水平、逆さ、どの取付け方向においても正確な測定が可能

●用途

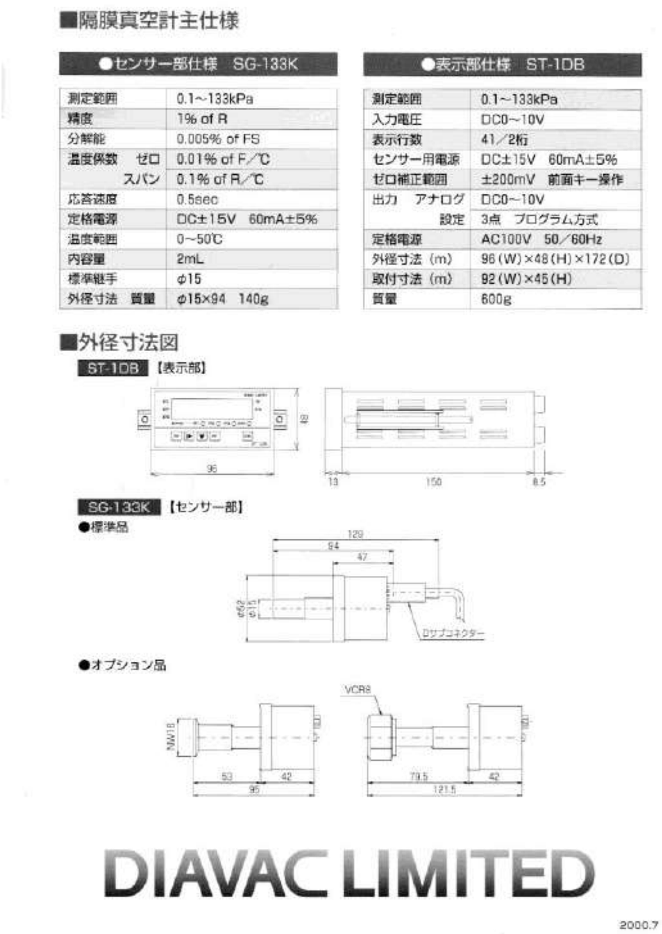
- スパッタリング装置のプロセス圧力測定
- ロードロックチャンバの圧力測定
- ガス分析装置の圧力測定
- 真空乾燥装置の圧力測定
- ランプのガス封入プロセス圧力測定
- 正確な大気圧測定

※メーカでのチップ交換・調整作業が必要です。





Reference : H. Miyashita, Y. Kitamura, Micromachined Capacitive Diaphragm Gauge, Anelva Technical Report, 11 (2005) pp.37-41 (in Japanese)


■隔膜真空計主仕様

●センサー部仕様　SG-133K

測定範囲	0.1~133kPa
精度	1% of R
分解能	0.005% of FS
温度係数　ゼロ	0.01% of F／℃
スパン	0.1% of R／℃
応答速度	0.5sec
定格電源	DC±15V　60mA±5%
温度範囲	0~50℃
内容量	2mL
標準継手	φ15
外径寸法　質量	φ15×94　140g

●表示部仕様　ST-1DB

測定範囲	0.1~133kPa
入力電圧	DC0~10V
表示行数	41／2桁
センサー用電源	DC±15V　60mA±5%
ゼロ補正範囲	±200mV　前面キー操作
出力　アナログ	DC0~10V
設定	3点　プログラム方式
定格電源	AC100V　50／60Hz
外径寸法（m）	96(W)×48(H)×172(D)
取付寸法（m）	92(W)×45(H)
質量	600g

■外径寸法図

ST-1DB【表示部】

SG-133K【センサー部】

●標準品

●オプション品

DIAVAC LIMITED

2000.7


DIAVAC LIMITED

Diaphragm Vacuum Gauge
ST-1DB
シリコン隔膜真空計

●相対圧から絶対圧へ！

センサー部にシリコンダイヤフラムを採用した小型で絶対圧力測定の隔膜真空計です。表示部にはオートゼロ機能を有し、外部出力3点、更にアナログ出力として0~10Vを標準装備しています。小型で使い易さを追求した真空計です。

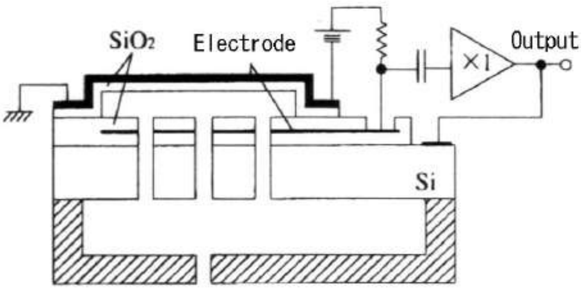
■気体の圧力を力として検出しますので気体の種類に関係なく測定ができます。但し、強腐食性気体を除く。
■ダイヤフラムにシリコンチップを採用することにより小型で再現性に優れています。
■検出回路は静電容量方式ですので安定して低圧力まで測定出来ます。
■表示部はシンプル機能とし、小型で使い易さを実現しました。

DIAVAC LIMITED

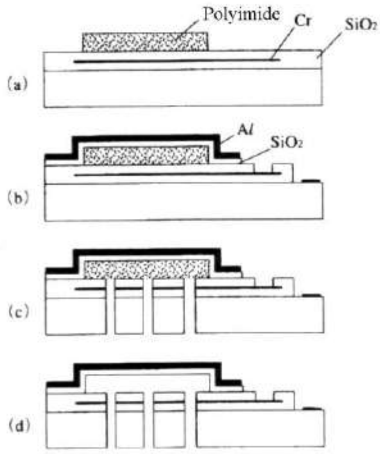
大亜真空株式会社
DIAVAC LIMITED

TEL 047(459)7628
TEL 06(6396)1771

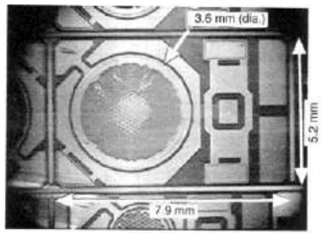
MEMS microphone



Structure



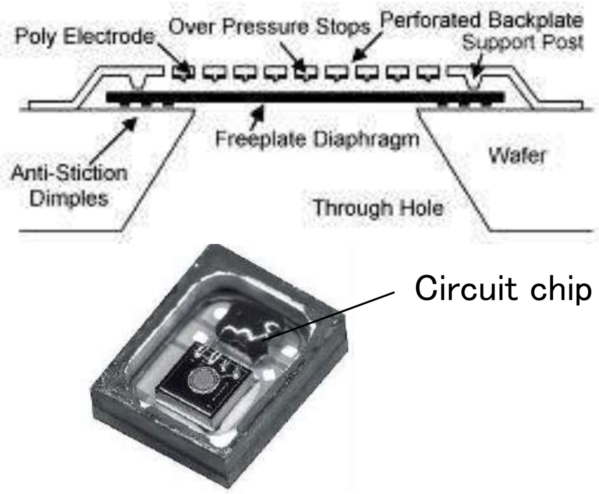
Fabrication process



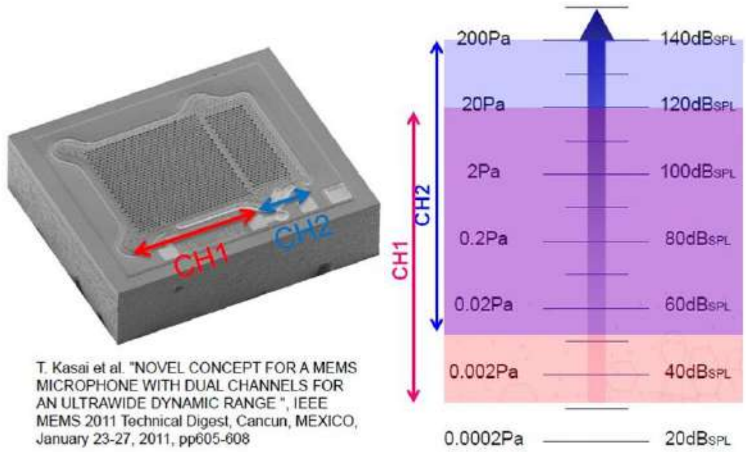
Photograph

Driven Shield MEMS Microphone (Tohoku Univ. – Matsushita Communication Industry)

Reference : M.Ikeda, N.Shimizu and M.Esashi, Surface Micromachined Driven Shielded Condenser Microphone with a Sacrificial Layer Etched from the Backside, Tech. Digest of the Transducers' 99, (1999) pp.1070–1073

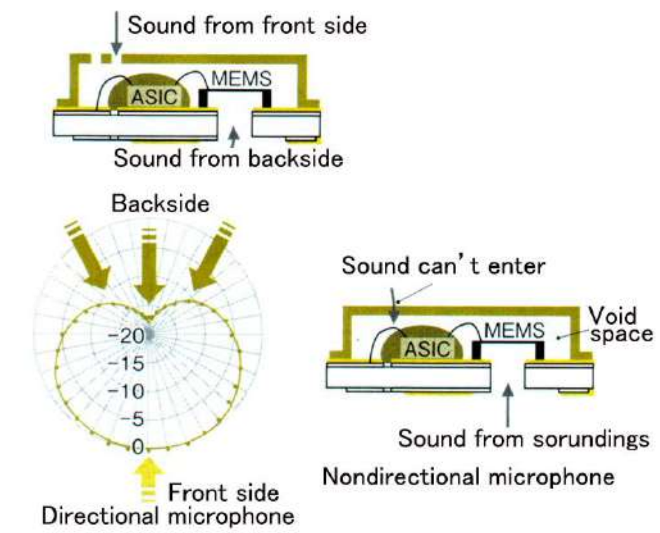


MEMS microphone used for smartphone (Knowles)



Wide dynamic range MEMS microphone (Omron)

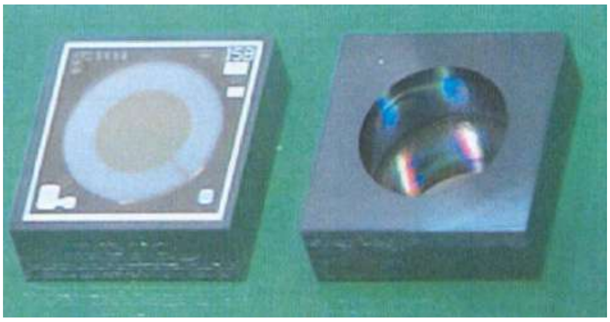
Reference : Nikkei Micro Device, 248 (2006/2) p.38) in Japanese



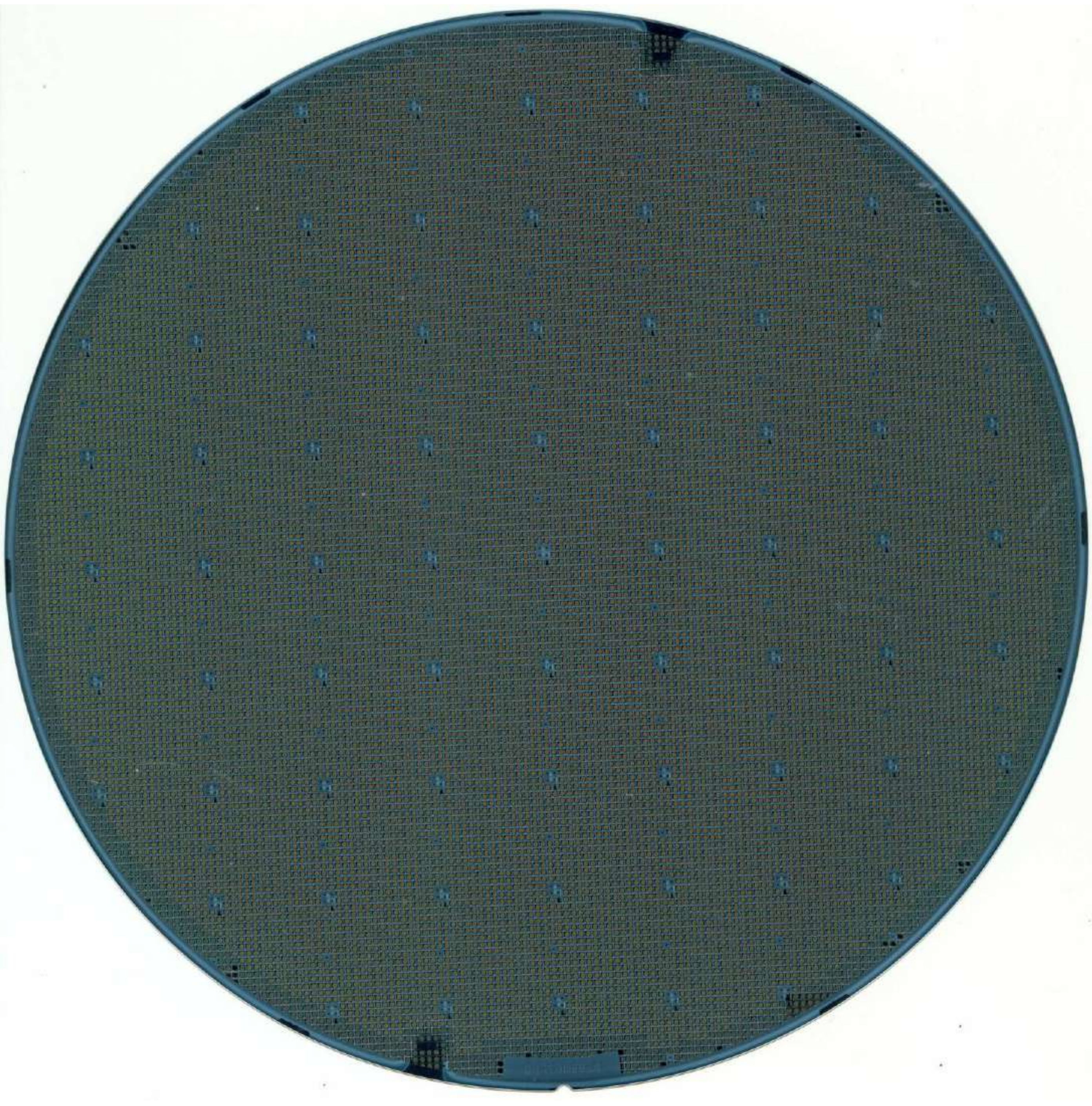
Principle of cancelling ambient noise by double microphone

Noise cancell by double microphones

B7 # MEMS microphone wafer (Nisshinbo Micro Devices)

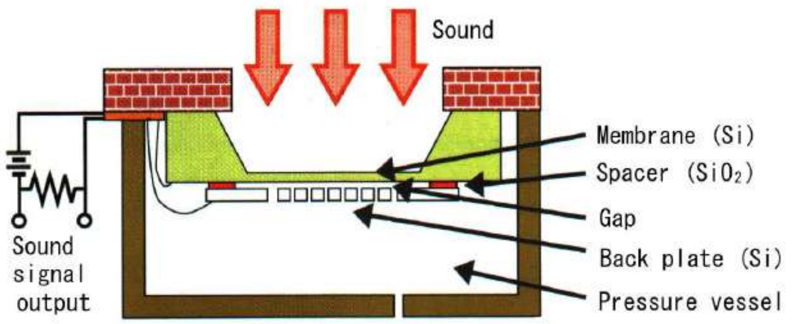


Capacitive MEMS microphone chip (New Japan Radio)



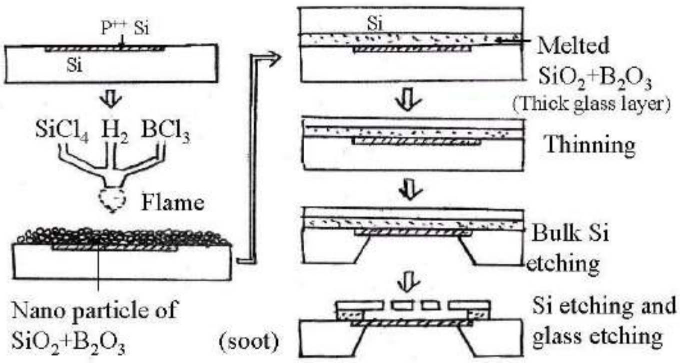
MEMS microphone chips on a 8 inch wafer (20 cm in diameter) (20,000 chips)

B8 MEMS microphone for humid environment

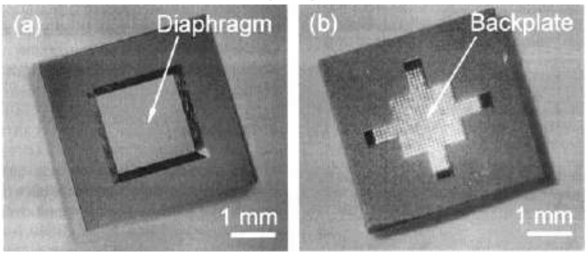


Structure

TV program



Fabrication process

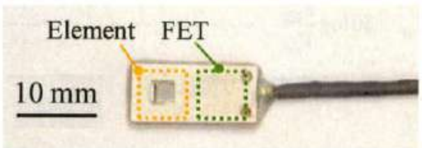


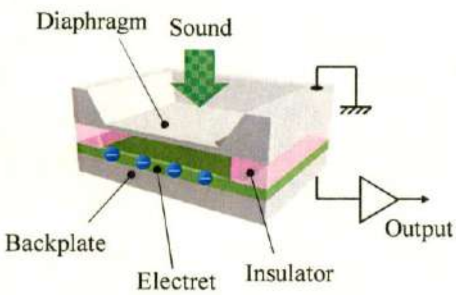
Photograph of chip

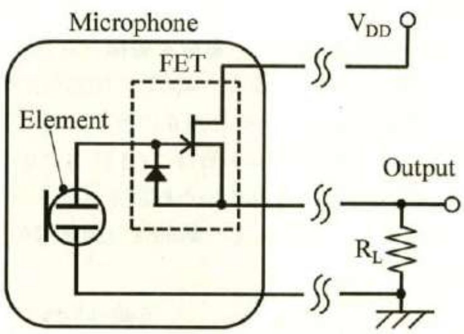
Used in TV for swimming game in Beijing Olympic game etc

MEMS microphone for broadcasting (NHK – Tohoku Univ. – Panasonic)

Reference : T.Tajima, T.Nishiguchi, S.Chiba, A.Morita, M.Abe, K.Tanioka, N.Saito and M.Esashi, High-performance Ultra-small Single Crystalline Silicon Microphone of an Integrated Structure, Microelectronic Engineering, 67-68 (2003) pp.508-519



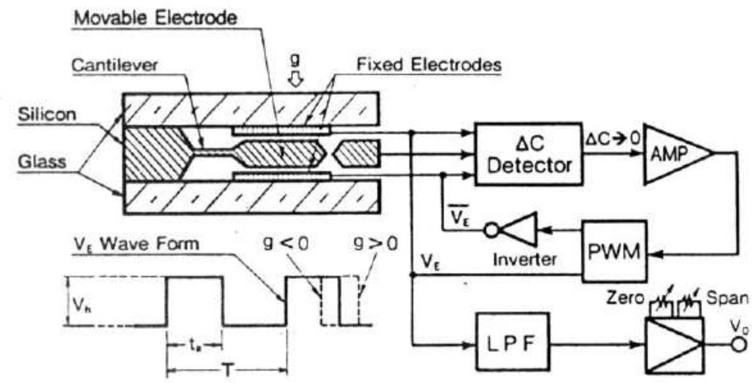


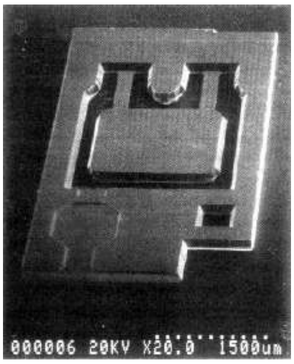


Si microphone using inorganic electret for humid environment (NHK, Kobayashi Inst. of Physical Research, Rion)
(Hands-on-Access Fab. Was used)

Reference : M.Goto et.al, Si electret condenser microphone with inorganic electret、IEEJ Trans. 132-E (2012) 309-315)

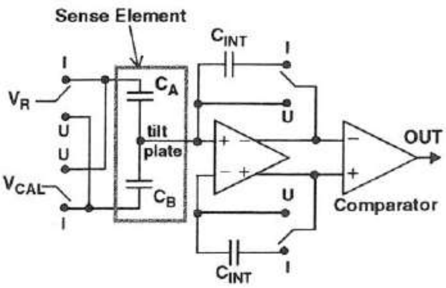
B9 Capacitive accelerometer for automobile

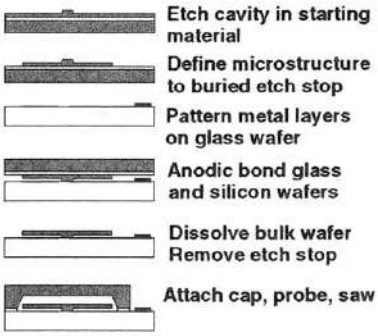


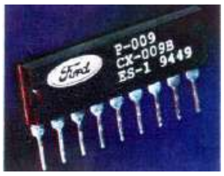


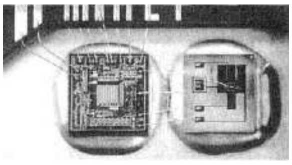
Accelerometer with electrostatic servo controller (Hitachi)

Reference: S.Suzuki, S.Tuchitani, K.Sato, Y.Yokota, M.Sato and M.Esashi : Semiconductor capacitance type accelerometer with electrostatic servo controller, Sensors and Actuators, A21-23, (1990) 316-319



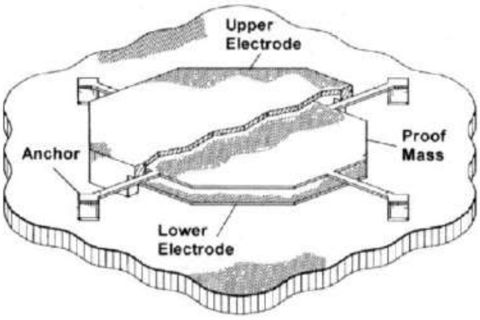


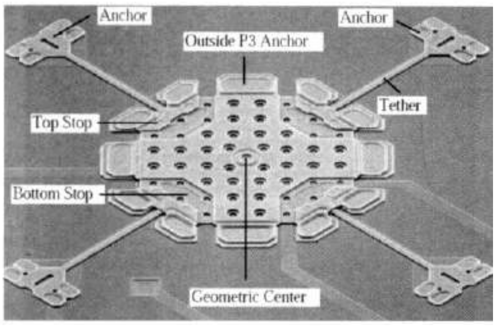


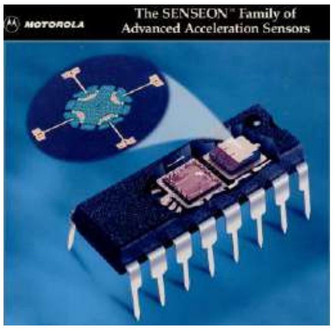


Accelerometer with ΔΣmodulation (Ford motor, USA)

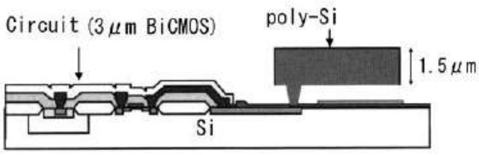
Reference : L.(Chip) Spangler and C.J.Kemp, ISAAC—Integrated Silicon Automobile Accelerometer, Transducers' 95 (1995) pp.585-588

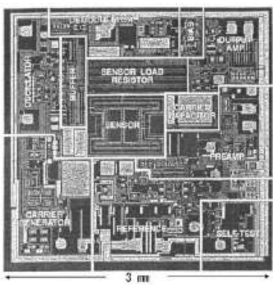


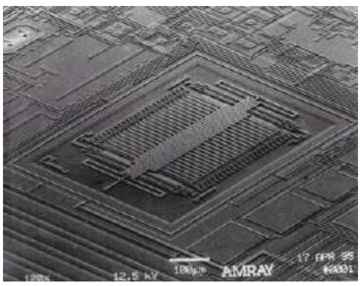


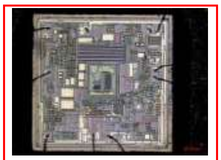


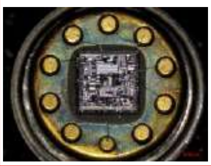
Z axis two-chip accelerometer by surface micromachining (Motorola, USA)







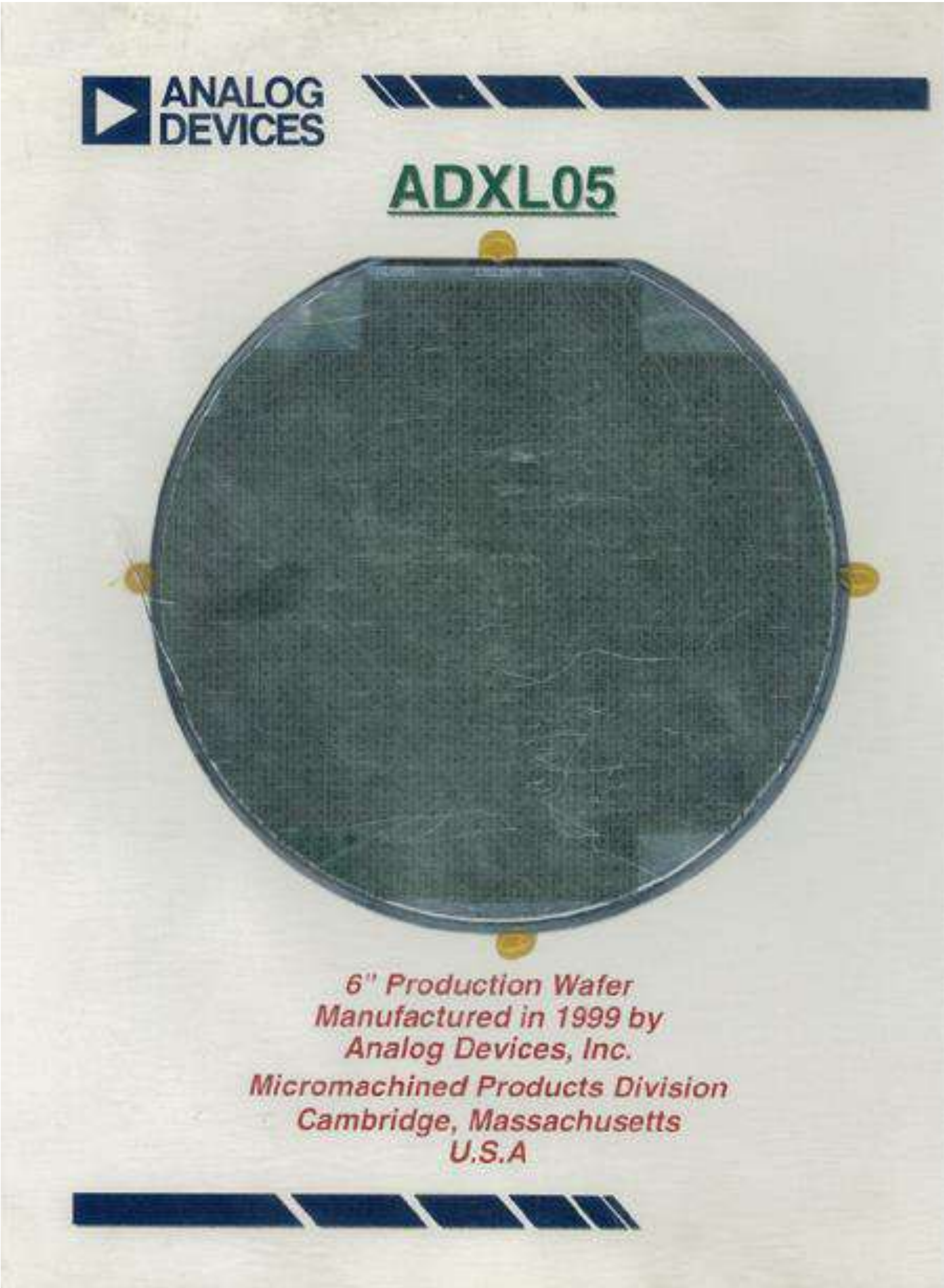




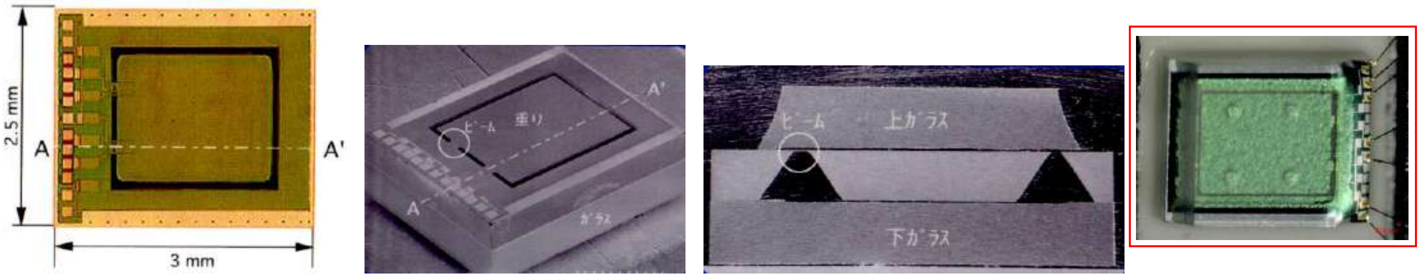
Monolithic integrated accelerometer (Analog Devices, USA) (Wafer and chips are in A12)

Reference : K.H.-L..Chau, S.R.Lewis, Y.Zhao, R.T.Howe. S.F.Bart and R.G.Marcheselli, An Integrated Force-Balanced Capacitive Accelerometer for Low-G Applications, Transducers' 95 (1995) pp.563-596

B10 Wafer of accelerometer by surface micromachining (Analog Devices USA)

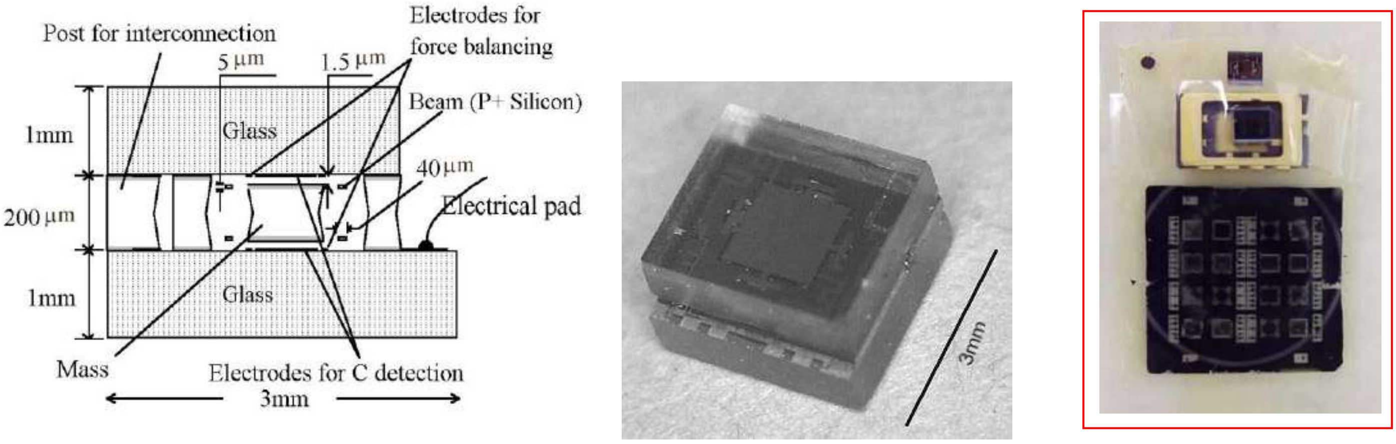


B11 Various accelerometers



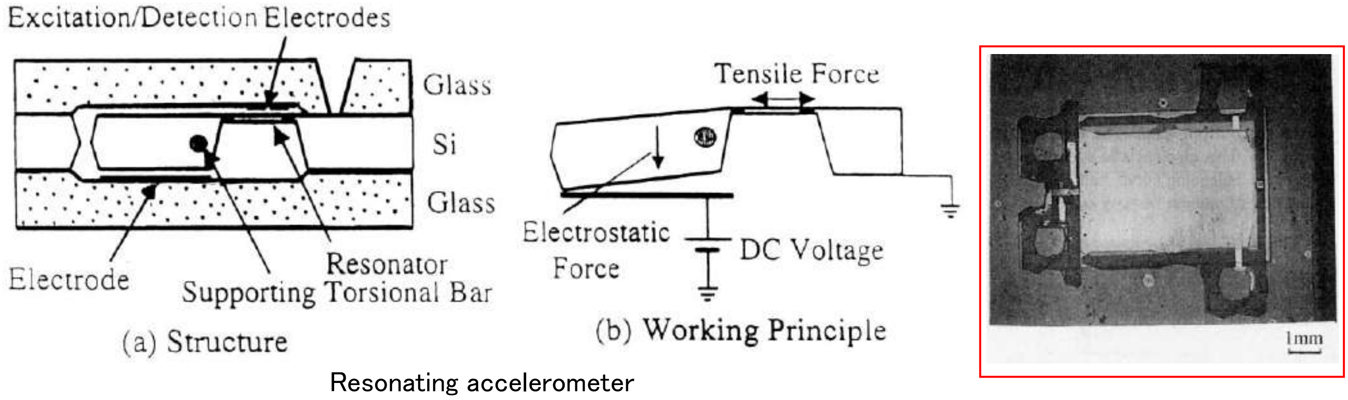
Piezoresistive accelerometer (Panasonic Electric Works)

Reference : High-accuracy high-reliability MEMS accelerometer, Technical Report of Panasonic Electric Works (Nov.2003) pp.15-21



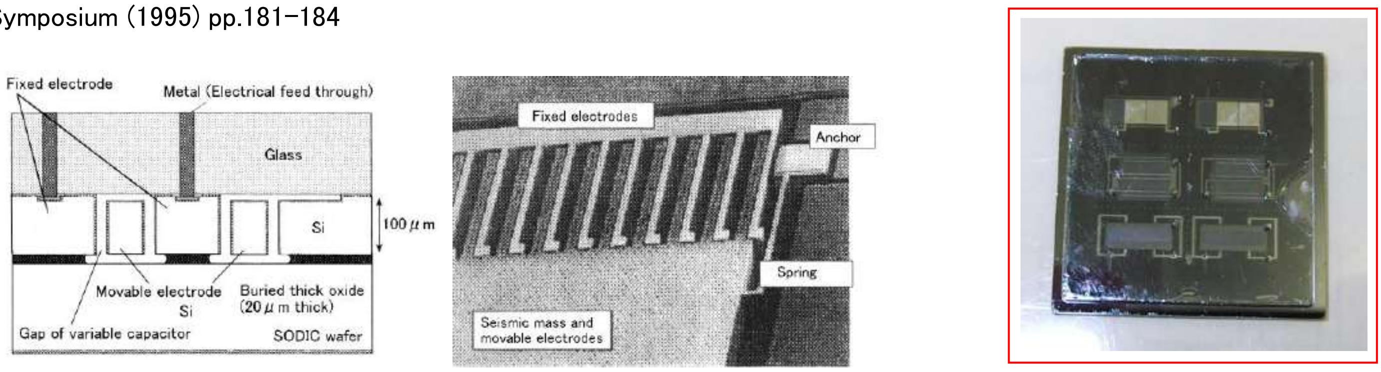
Narrow gap capacitive servo accelerometer (Tohoku Univ. - Samsung)

Reference : G.Lim, S.Baek and M.Esashi : A New Bulk-Micromachining Using Deep RIE and Wet Etching for an Accelerometer, Trans. IEE of Japan, 118-E (1998) pp.420-424



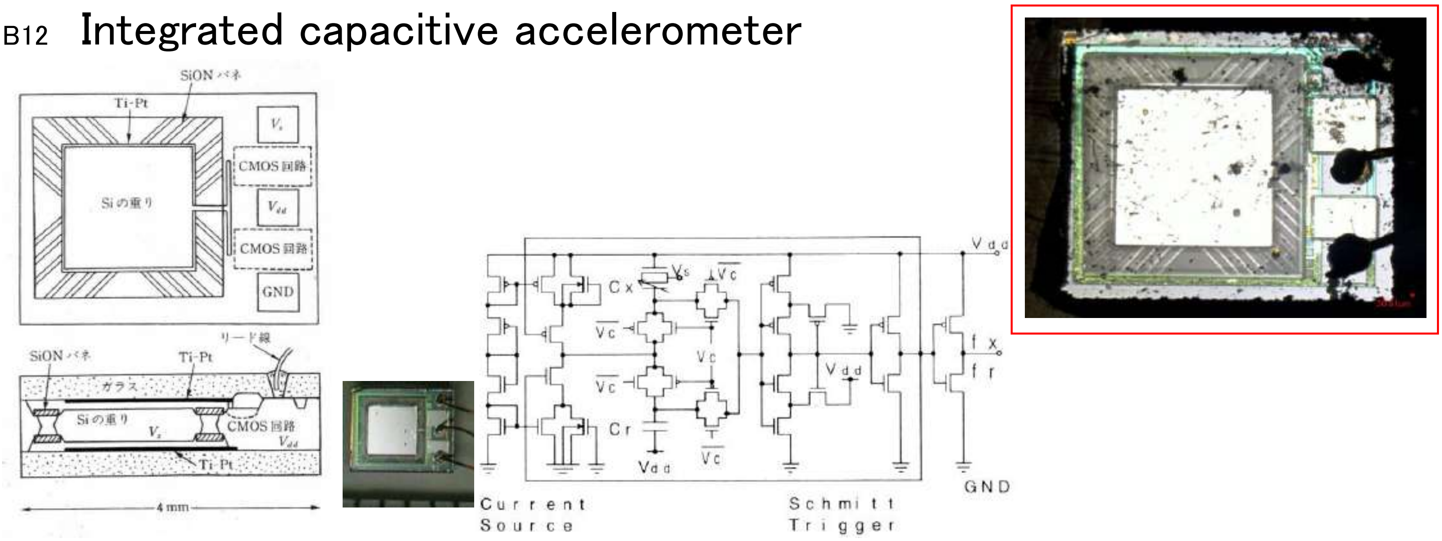
Resonating accelerometer

Reference : H.Hashimoto, K.Minami and M.Esashi, Silicon Resonant Accelerometer, Technical Digest of the 13th Sensor Symposium (1995) pp.181-184



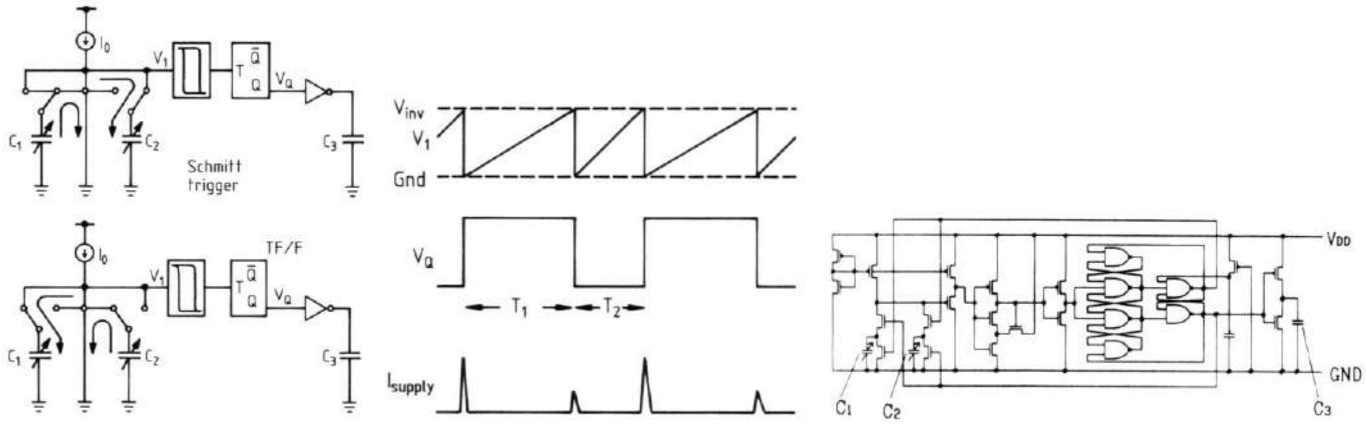
Capacitive accelerometer using deep RIE of SOI wafer with thick buried oxide (Tohoku Univ. - Daimler-Chrysler)

B12 Integrated capacitive accelerometer



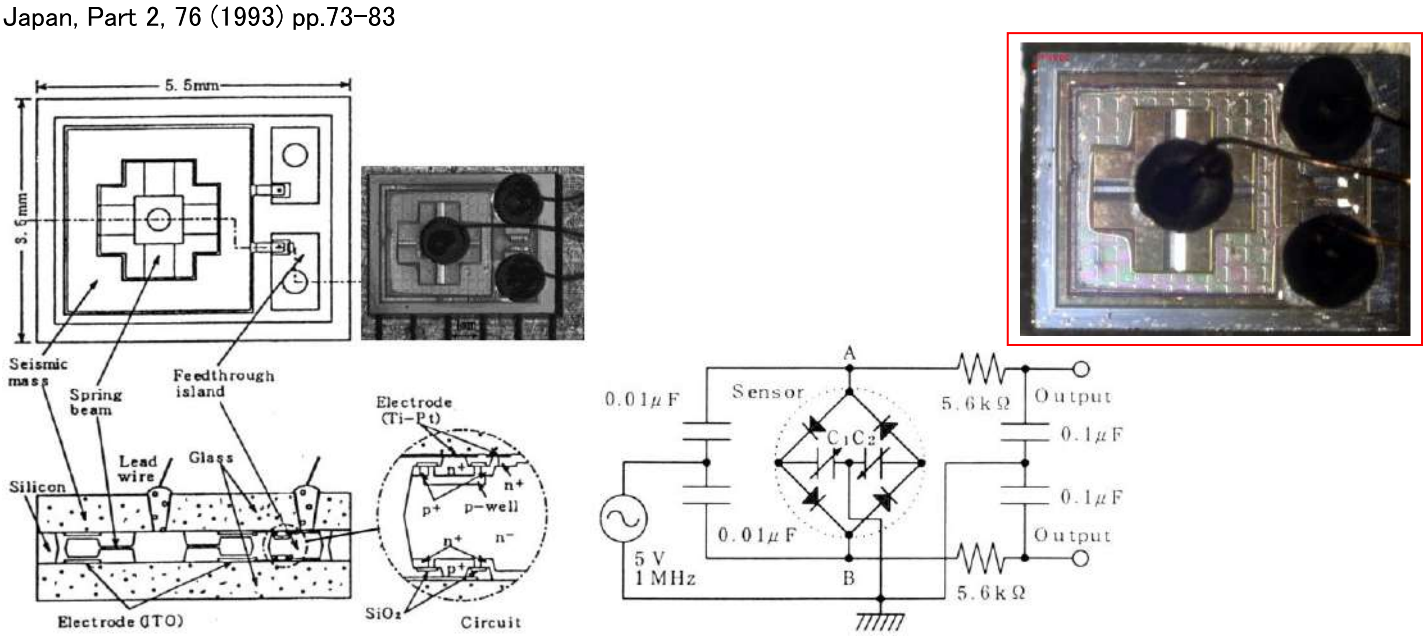
Integrated Capacitive Accelerometer

Reference : Y.Matsumoto and M.Esashi, Integrated Silicon Capacitive Accelerometer with PLL Servo Technique, Sensors and Actuators A, 39 (1993) pp.209-217



Differential capacitance two-wire accelerometer temperature sensor

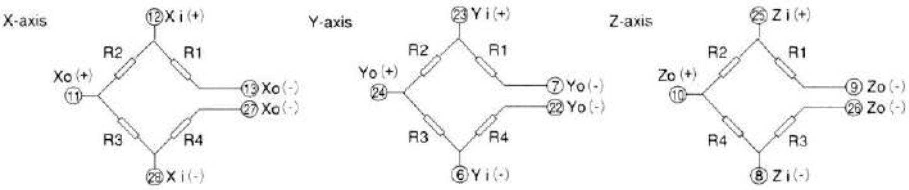
Reference : T.Shirai, M.Esashi and N.Ura, A Two-Wire Silicon Capacitive Accelerometer, Electronics and Communications in Japan, Part 2, 76 (1993) pp.73-83

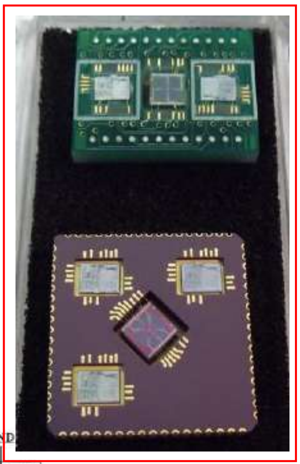


Diode bridge Integrated capacitive accelerometer

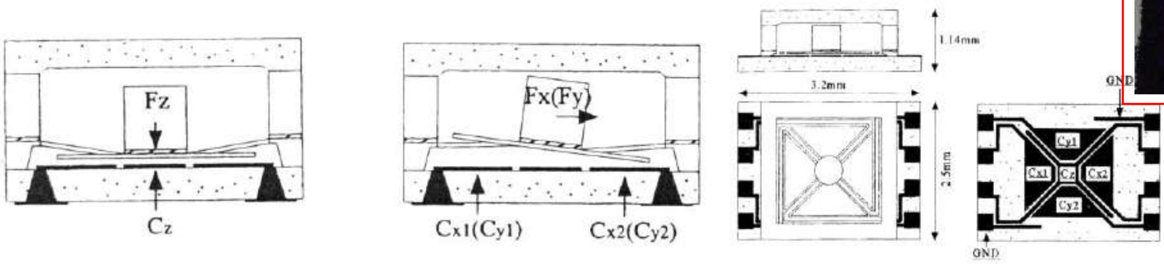
Reference : Y.Shoji, M.Yoshida, K.Minami and M.Esashi, Diode Integrated Capacitive Accelerometer with Reduced Structural Distortion, Transducers'95 (1995) pp.581-584

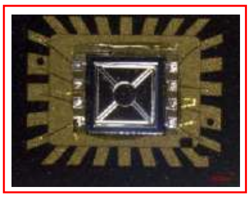
B13 3-axis accelerometer





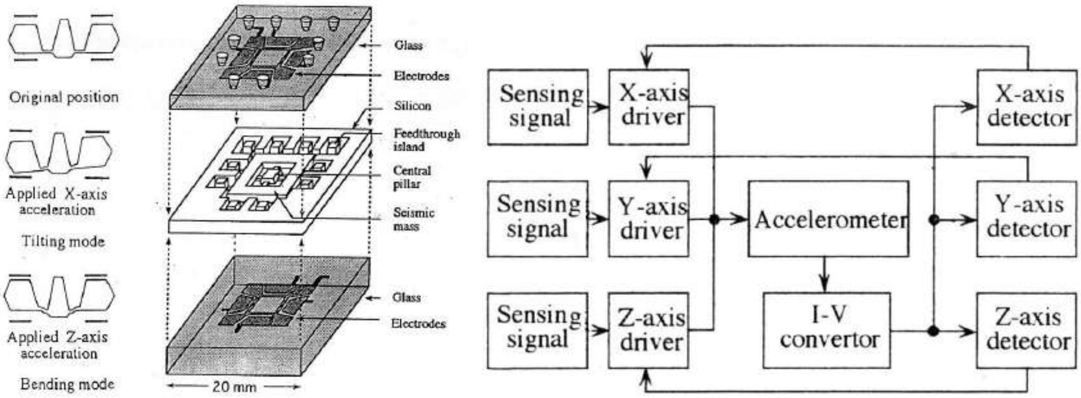
Piezoresistive 3-axis accelerometer (Fujikura)

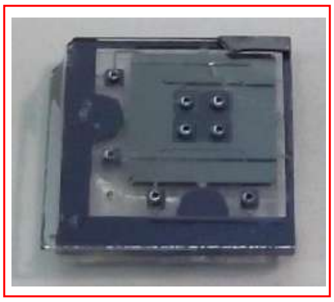




Capacitive 3-axis accelerometer (Tohoku Univ. – Tateyama Kagaku)

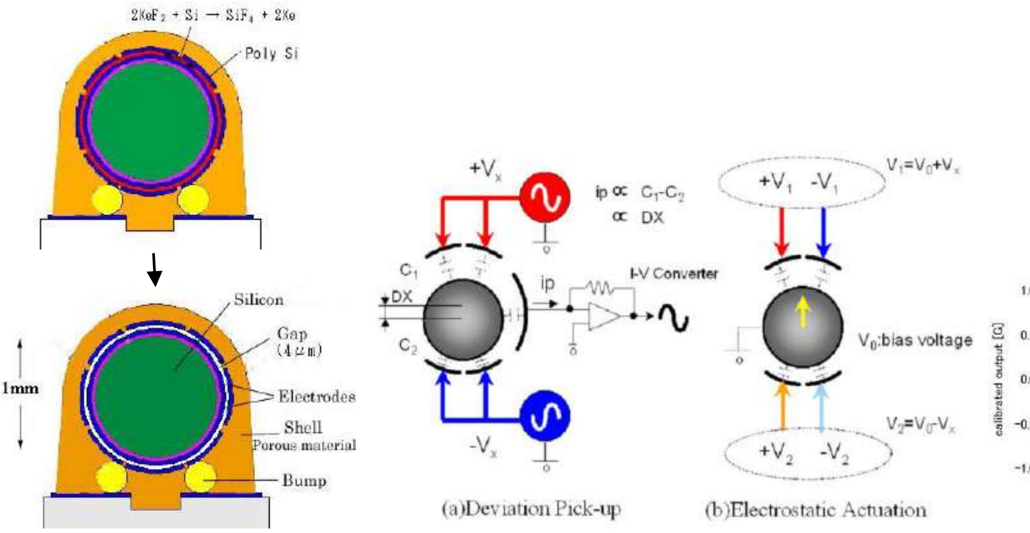
Reference : M.Mizusima and M.Esashi : Capacitive 3-axis Accelerometer Using SOI Wafer, Technical Digest of the 17th Sensor Symposium, (2000) pp.225-230

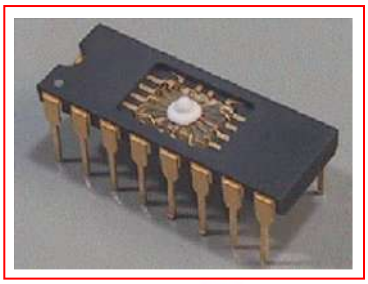




Capacitive 3-axis servo accelerometer (Tohoku Univ. – Kobe Steel)

Reference : K.Jono, K.Minami and M.Esashi, Electrostatic Servo Type Three-axis Silicon Accelerometer, Measurement Science and Technology, 6 (1995) pp.11-15





Electrostatically levitated spherical 3-axis accelerometer (Ball Semiconductor – Tohoku Univ.)

Reference : R.Toda, N.Takeda, T.Murakoshi, S.Nakamura and M.Esashi : Electrostatically Levitated Spherical 3-Axis Accelerometer, Technical Digest MEMS'2002 (2002) pp.710-713

Electrostatically levitated rotational gyroscope

The Electric Vacuum Gyro

H.W. Knoebel: "*The Electric Vacuum Gyro*", Control Engng, 11, 2, p 70, (Feb. 1964).

The Electric Vacuum Gyro Is a high precision 2-axis gyro for inertia navigation systems. A metal spherical rotor is levitated by high electric field in high vacuum (10^{-8} – 10^{-9} mmHg) and rotated. The friction by mechanical supports are eliminated and hence high precision and low drift are achieved. This method was invented by Prof. A.Nordsieck in University of Illinois during his research on the inertia navigation systems for Polaris submarine.

Pinpoint for Polaris Launching

0.0001 deg per hr

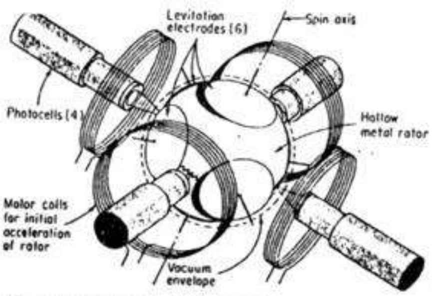


FIG. 1. Basic elements of the electric vacuum gyro include hollow rotor and levitation electrodes.

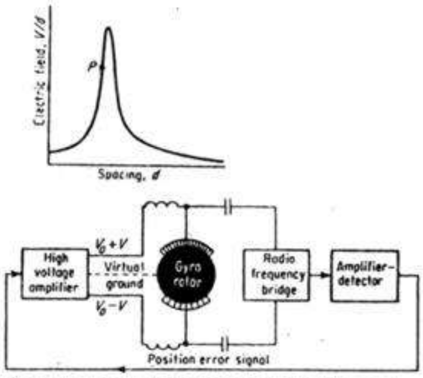
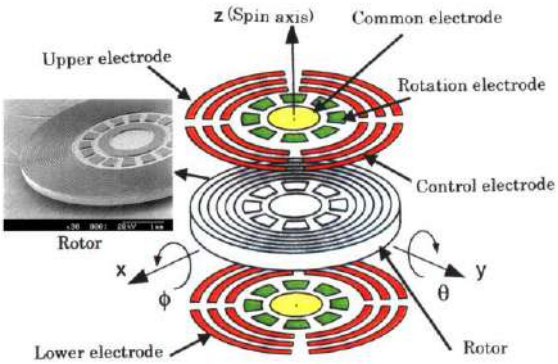
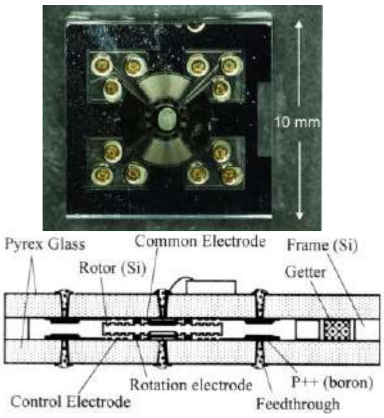


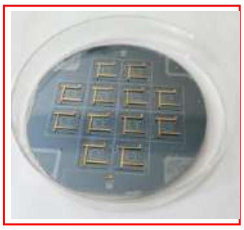
FIG. 6. Electronic levitation servo can be used to support rotor centrally in gap between electrodes (single axis).



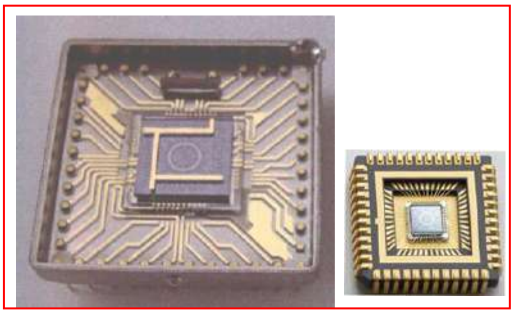


Electrostatically levitated disk rotor type rotational gyro (Tohoku University – Tokimec (at present Tokyo Keiki))

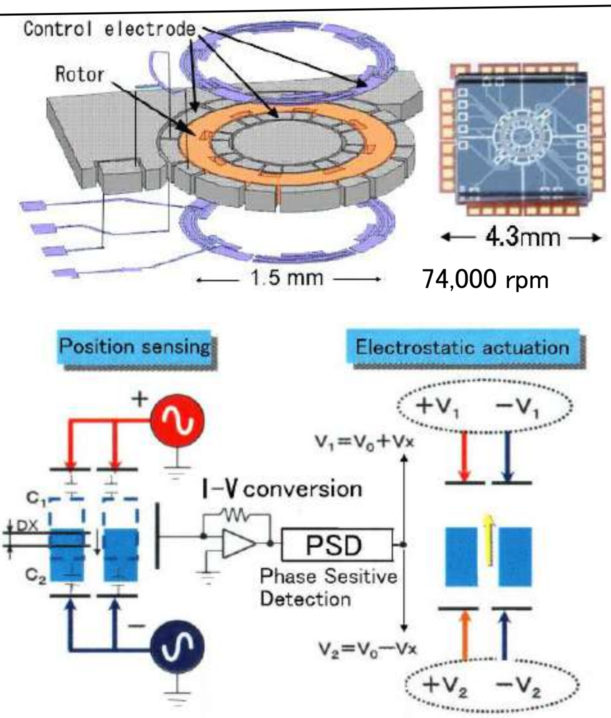
Ref. : K.Fukatsu, T.Murakoshi and M.Esashi, Electrostatically Levitated Micro Motor for Inertia Measurement System, Tech. Digest of the Transducers' 99 (1999) p.1558



Wafer for electrostatically levitated ring rotor type rotational gyro (large ring type)



Electrostatically levitated ring rotor type rotational gyro (large ring & small ring type)

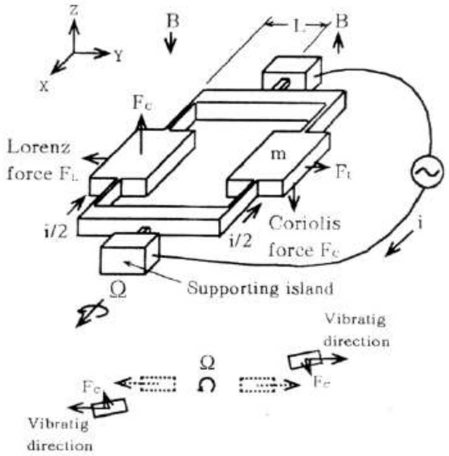


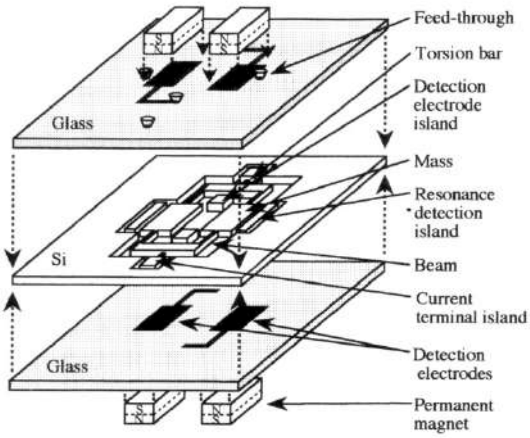
Electrostatically levitated ring rotor type rotational gyro (2 axis rotation and 3 axis acceleration) (Tohoku University – Tokimec (at present Tokyo Keiki))

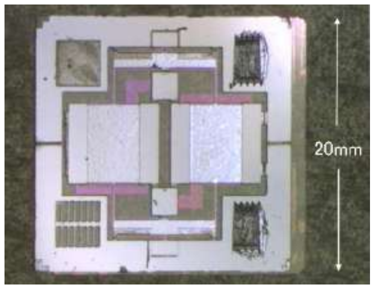
Application to motion logger used for subway in Tokyo

Reference : T.Murakoshi, Y.Endo, K.Sigeru, S.Nakamura and M.Esashi: Electrostatically levitated ring-shaped rotational-gyro/accelerometer, Jpn. J. Appli. Phys., 42, Part1 (2003) 2468-2472

C1 Electromagnetically driven resonating gyroscope

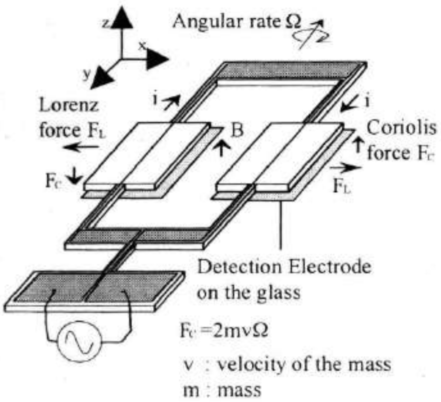


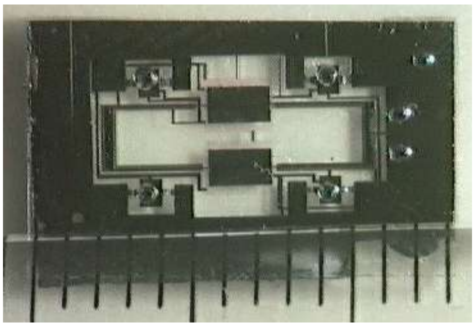


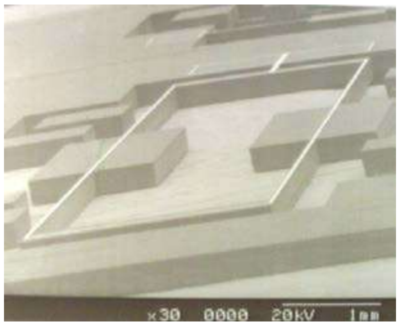


Electromagnetically excited capacitive sensing gyro by anisotropic etching of (110) Si (Tohoku Univ. – Toyota Motor)

Reference : M.Hashimoto, C.Cabuz, K.Minami and M.Esashi, Silicon Resonant Angular Rate Sensor Using Electromagnetic Exitation and Capacitive Detection, Micro System Technologies'94 (1994) pp.763-772

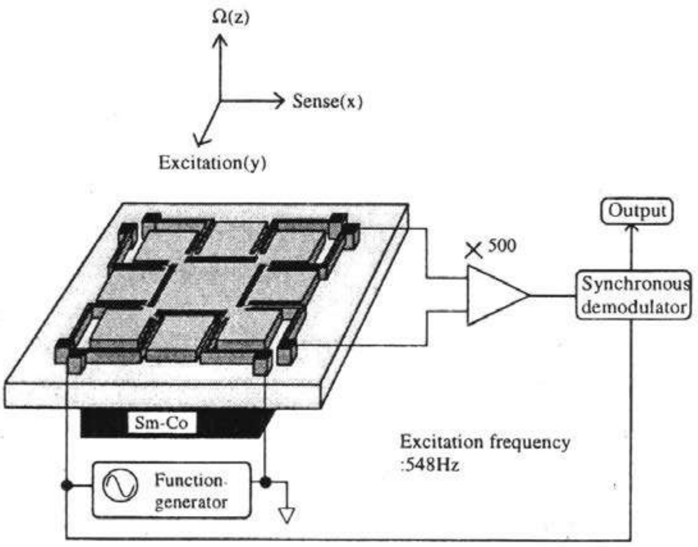


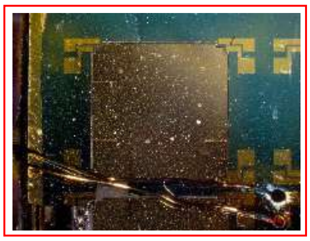


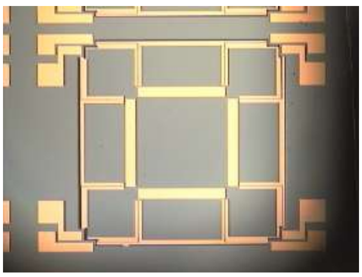


Electromagnetically excited capacitive sensing gyro by Deep RIE

Reference : J.Choi, K.Minami and M.Esashi : Application of Deep Reactive Ion Etching for Silicon Angular Rate Sensor, Microsystem Technologies, 2 (1996) pp.186-199



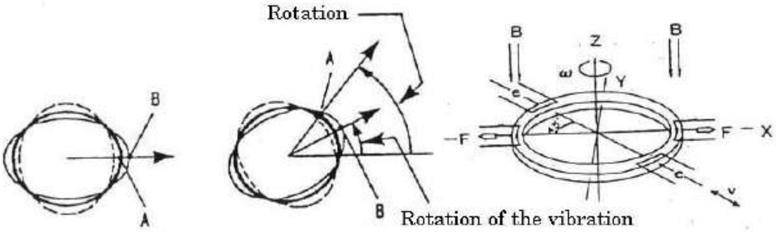


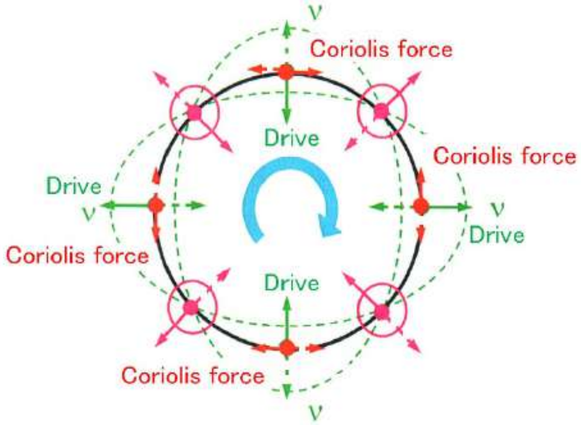


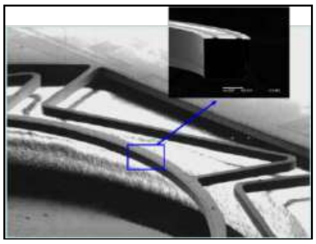
Electromagnetically excited and electromotive voltage sensing resonating gyro for Z-axis

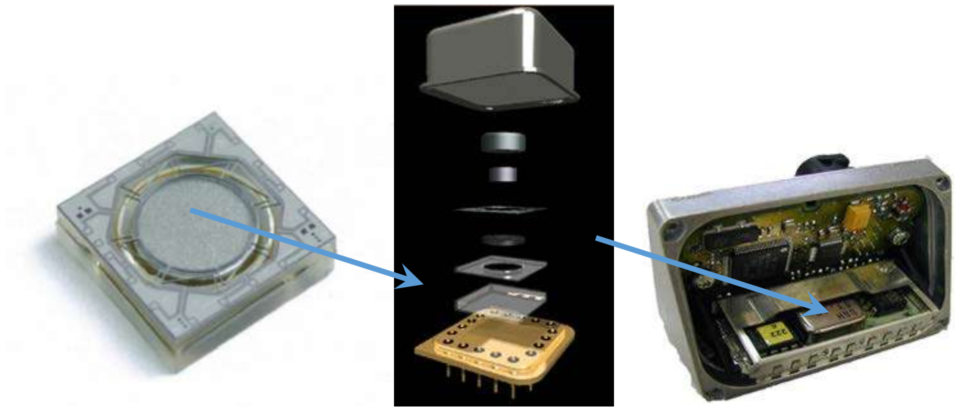
Reference : J.-J. Choi, K.Minami, M.Esashi, Electromagnetical Excitation and Induced Electromotive Voltage Sensing Silicon Angular Rate Sensor, Trans. IEE of Japan, 118-E (1998) pp.641-646

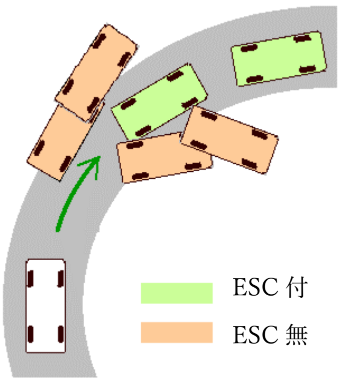
C2 Silicon ring gyroscope



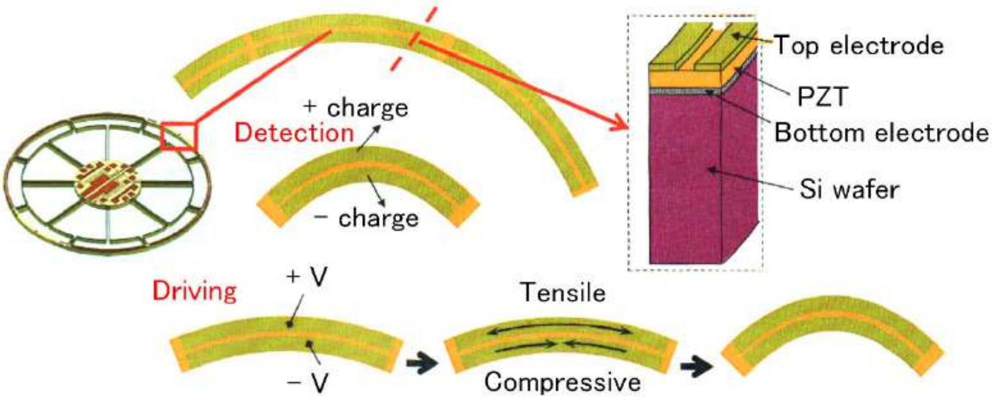


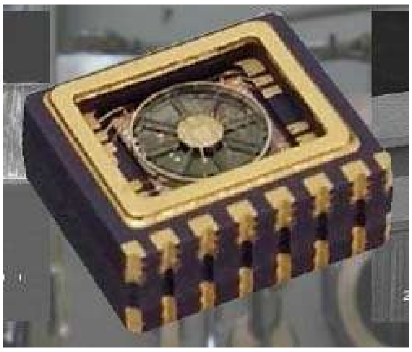






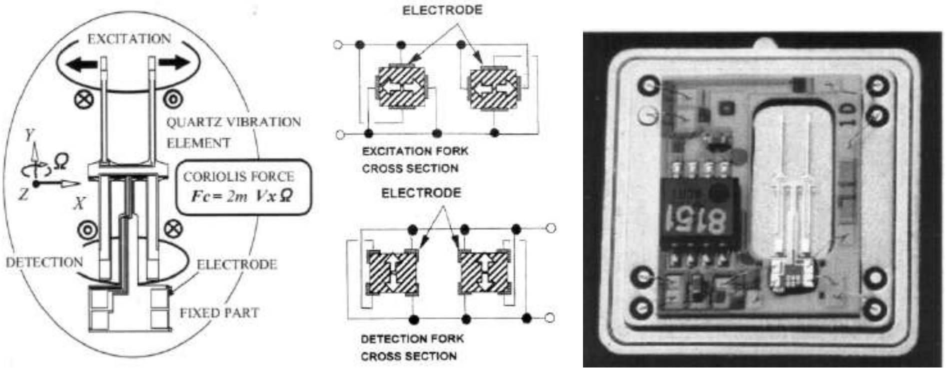
Electromagnetic Si vibrating ring gyroscope　　ESC（Electronic Stability Control）





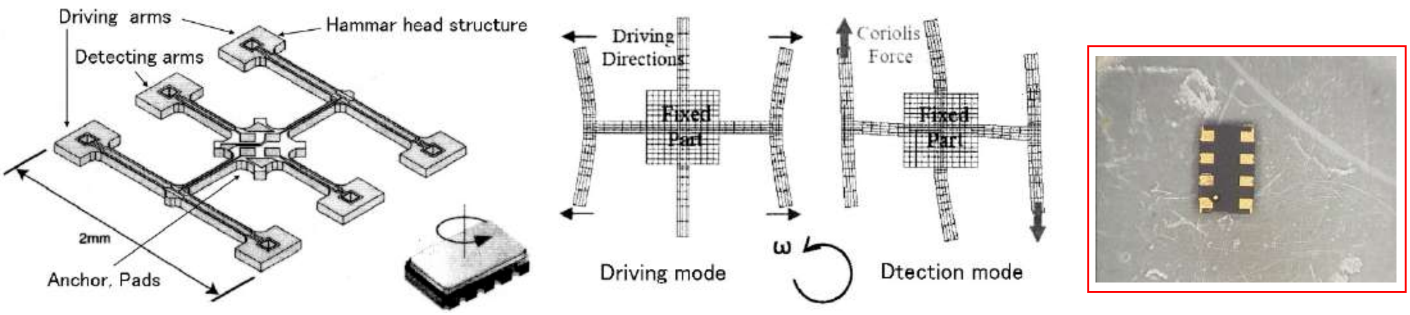
Piezoelectric Si vibrating ring gyroscope

C3 Piezoelectric gyroscope



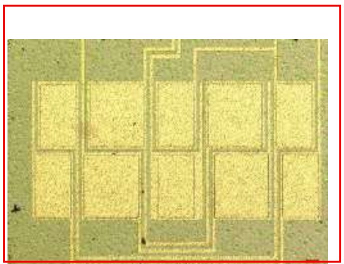
Quartz resonating gyro (Toyota Central Research Laboratory)

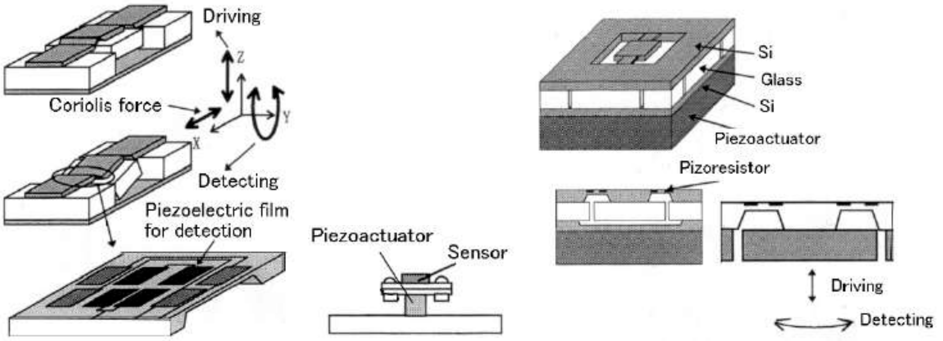
Reference : Y.Nonomura, M.Fujiyoshi, Y.Omura, K.Tsukada, M.Okuwa, T.Morikawa, N.Sugitani, S.Satou, N.Kurata and S.Matsushige, Quartz rate gyro sensor for automotive control, Sensors and Actuators A, 110 (2004) pp.136-141

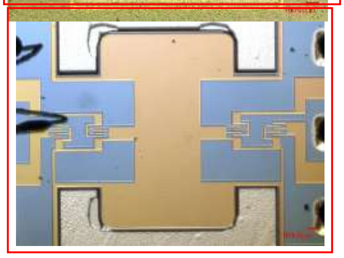


Quartz rate gyro (Epson Toyokom)

Reference : T.Kikuchi, Miniturized Quartz Vibratory Gyrosensor, 4th Intnl. Symp. On Acoustic Wave Devices for Future Mobile Communication Systems (2010) pp.51-55

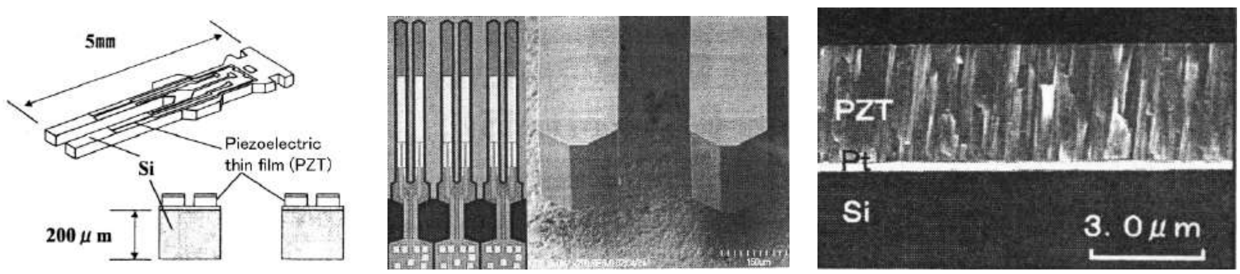






Piezoelectric rate gyro (Tohoku Univ. – Toyota Motor)

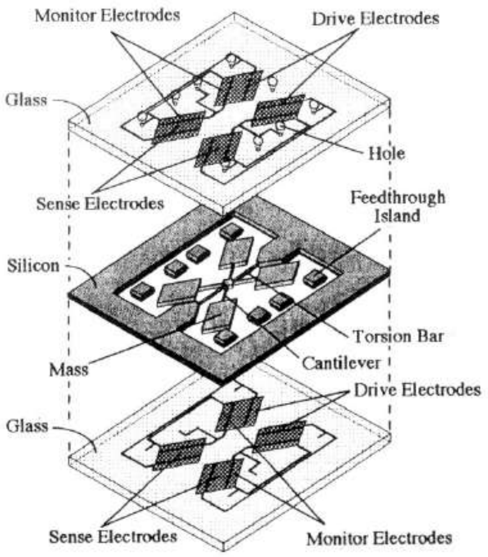
Reference : M.Nagao, K.Minami and M.Esashi, Silicon Angular Rate Sensor Using PZT Thin Film, Sensors and Materials, 11 (1999) pp.31-39

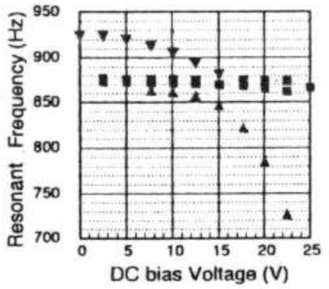


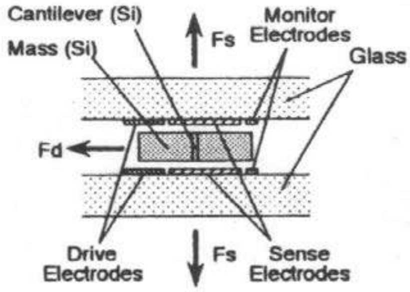
Piezoelectric angular rate sensor (Matsushita Electric Industry)

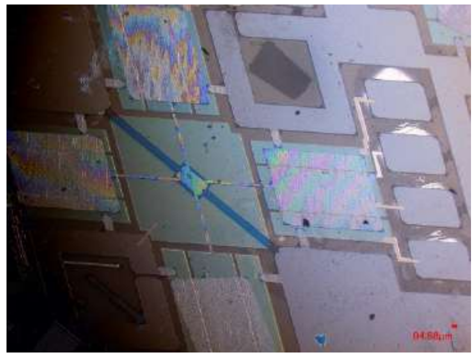
Reference : R.Takayama, E.Fujii, T.Kamada, A.Murata, T.Hirasawa, A.Tomozawa, S.Fujii,H.Torii, K.Murata, Preparation of <001> Oriented Thin Films and the Applications to Micro Pizoelectric Devices, Trans. of IEE in Japan, 127-E (2007) pp.553-557

C4 Electrostatically driven capacitive sensing gyroscope



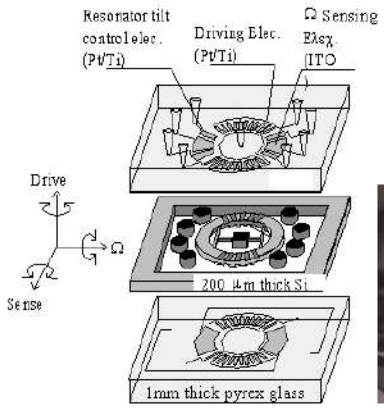


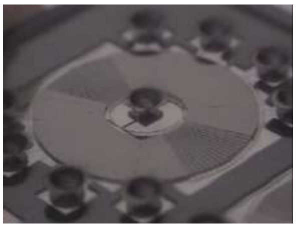


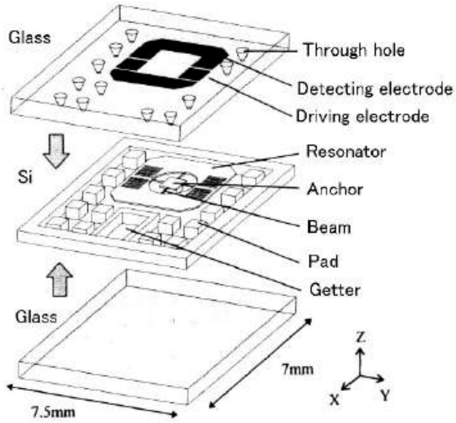


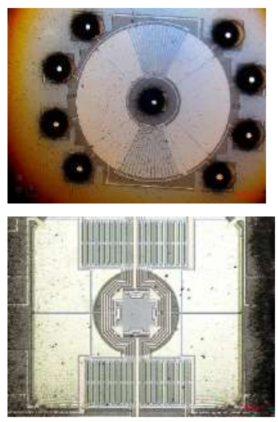
Electrostatically driven capacitive sensing gyro with electrostatic frequency tuning (Tohoku Univ. – Panasonic)

Reference : M.Yamashita, K.Minami and M.Esashi, An X-shaped Tuning Fork Type Resonant Gyroscope by Silicon Micromachine Technology, Micro System Technologies'96 (1996) pp.385-390



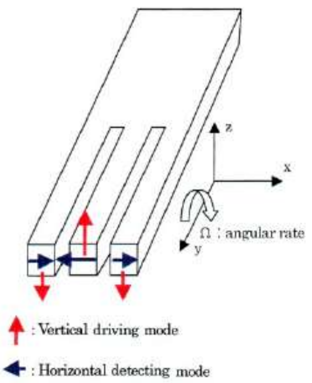


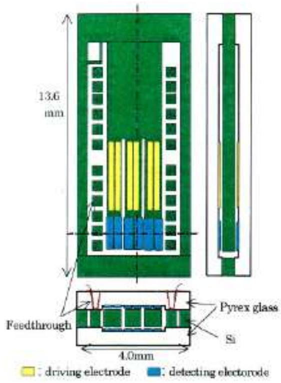




Electrostatically driven capacitive sensing gyro with rotating resonance
(Tohoku Univ. – Ford Motor)(Tohoku Univ. – Toyota Motor)

Reference : J.-J. Choi, R.Toda, K..Minami and M.Esashi, Silicon Angular Resonance Gyroscope by Deep ICPRIE and XeF_2 Gas Etching, Proc.of the Micro Electro Mechanical Systems'98 (1998) pp.322-327
M.Nagao, K.Minami and M.Esashi, A Silicon Micromachined Angular Rate Sensor, Trans. of IEE in Japan, 118-E (1998) pp.212-217





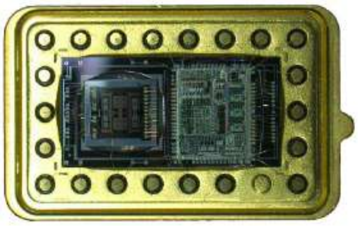
Trident-type Tuning Fork Gyro (Tohoku Univ. – ALPS Electric)

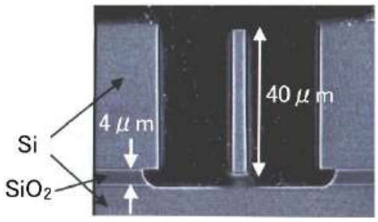
Reference : M.Abe, E.Shinohara, K.Hasegawa, S.Murata and M.Esashi Trident-type Tuning Fork Silicon Gyroscope by the Phase Difference Detection, Proc. of the Micro Electro Mechanical Systems'2000 (2000) pp.508-513

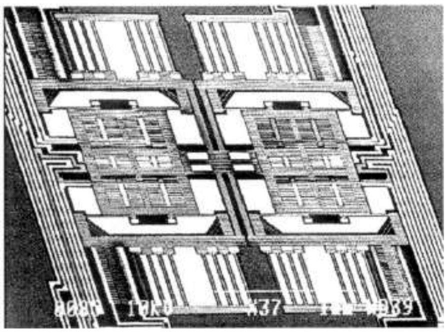
C5 # Yaw rate, acceleration sensor (Toyota Motor)

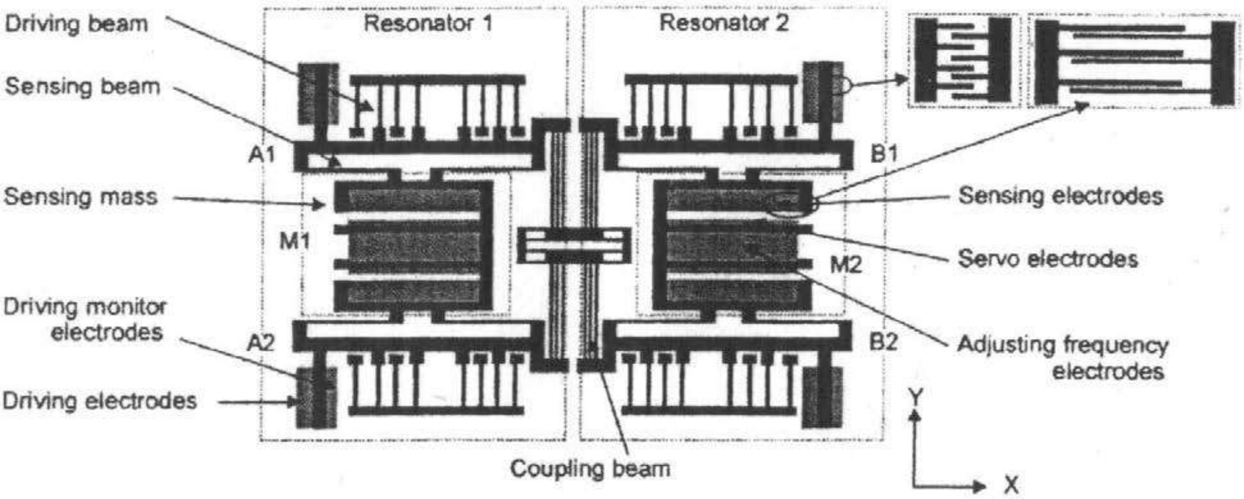
1992–1997

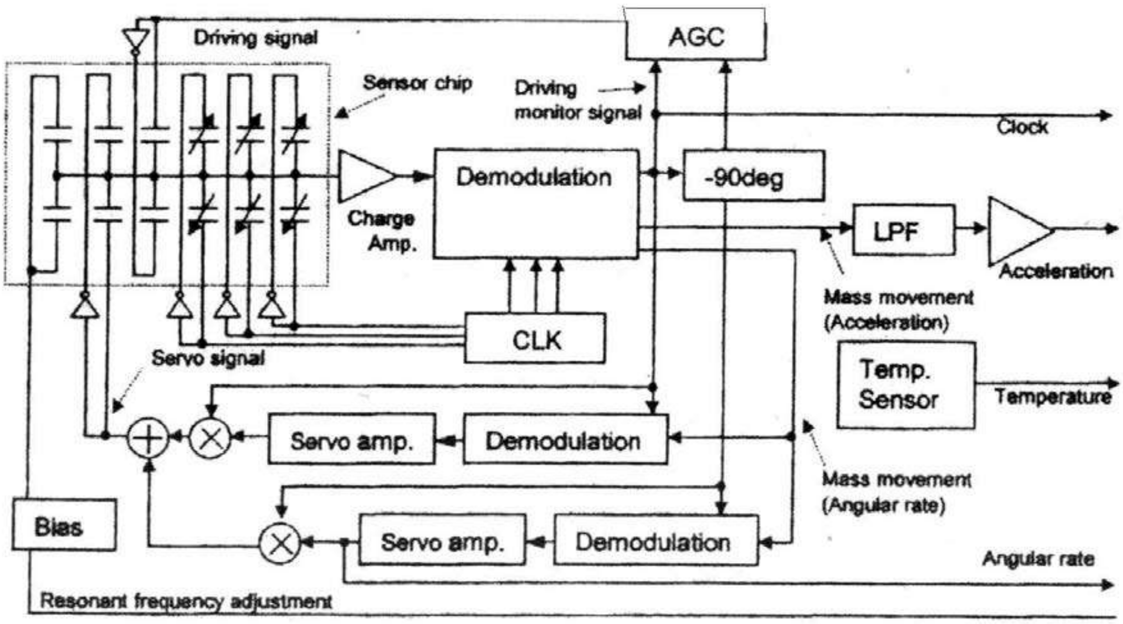
Two researchers from Toyota stayed in Tohoku University for collaborative development of resonating gyroscope





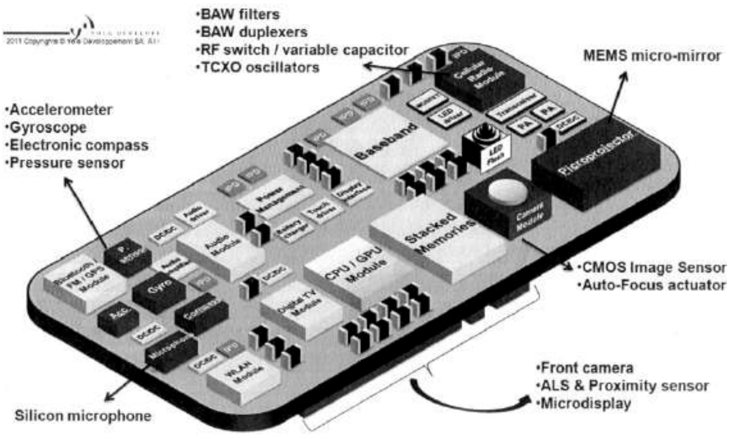




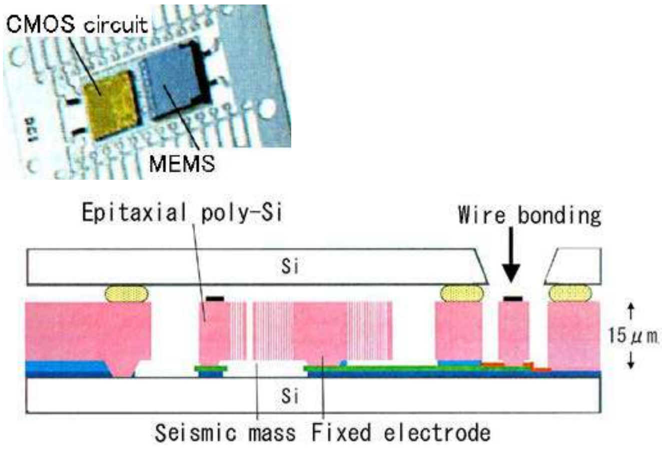


Reference : M.Nagao, H.Watanabe, E.Nakatani, K.Shirai, K.Aoyama and M.Hashimoto: A silicon micromachined gyroscope and accelerometer for vehicle stability control system, 2004 SAE World Congress, 2004-01-1113 (2004)

C6 Accelerometer and gyroscope for automobile and smartphone

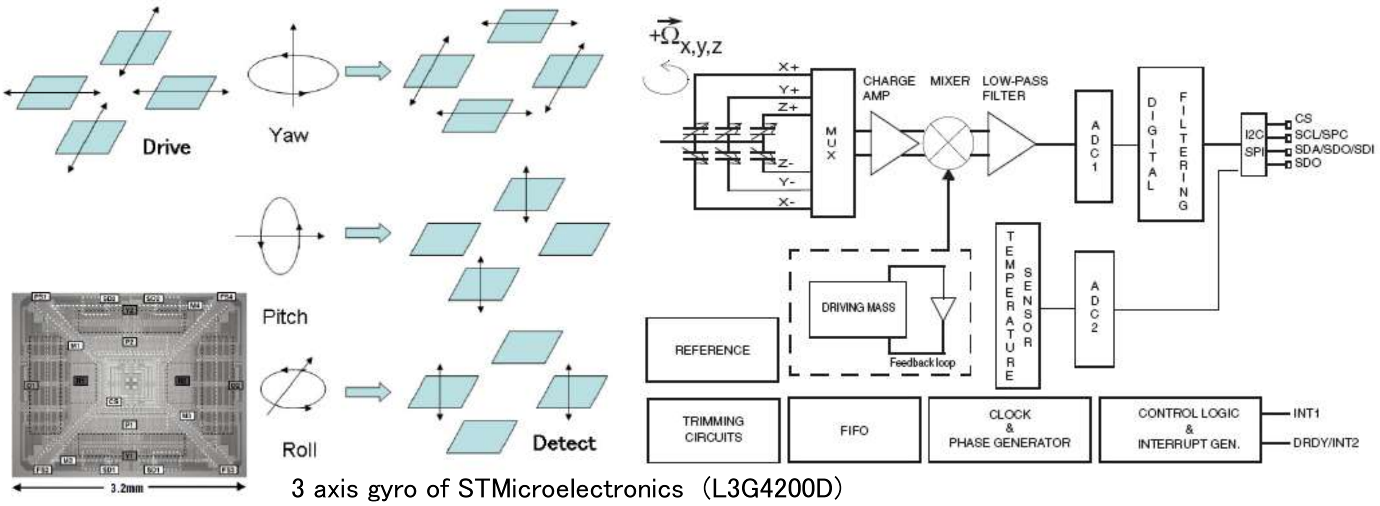


MEMS in mobile equipments (Yole Development)



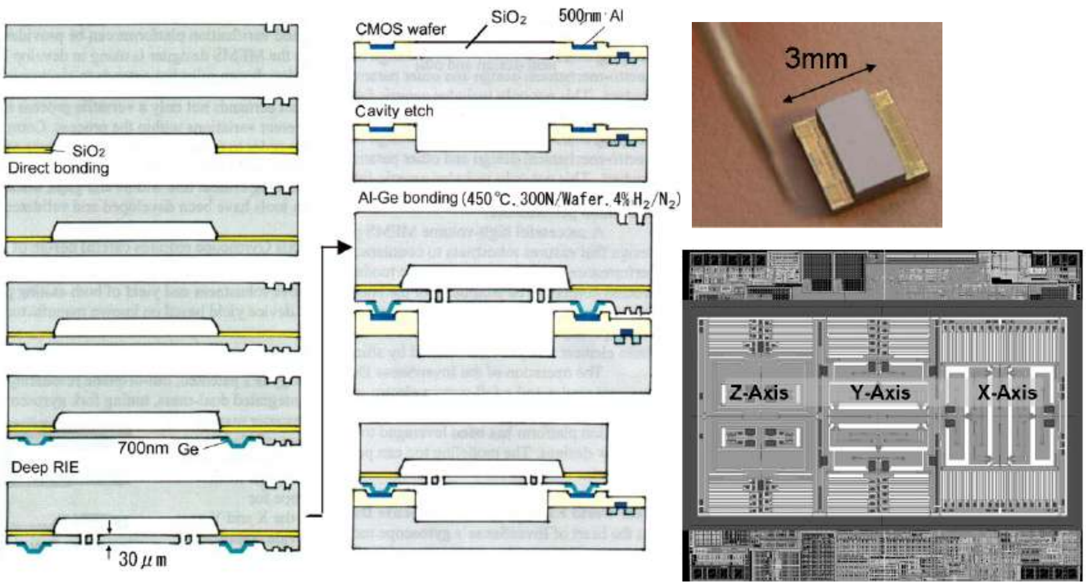
Accelerometer of STMicroelectronics

Reference : H.Noguchi, Latest Developments on MEMS Inertial Sensors and Its Applications, SEMI Technology Symposium 2008, Makuhari, p.45 (2008)



3 axis gyro of STMicroelectronics (L3G4200D)

Reference : L.Prandi, C.Caminada, L.Coronato, G.Cazzaniga, F.Biganzoli, R.Antonello and R.Oboe, A Low-power 2-axis Digital-output MEMS Gyroscope with Single Drive and Multiplexed Angular Rate Readout, ISSCC 2011. (2011) pp.104-105

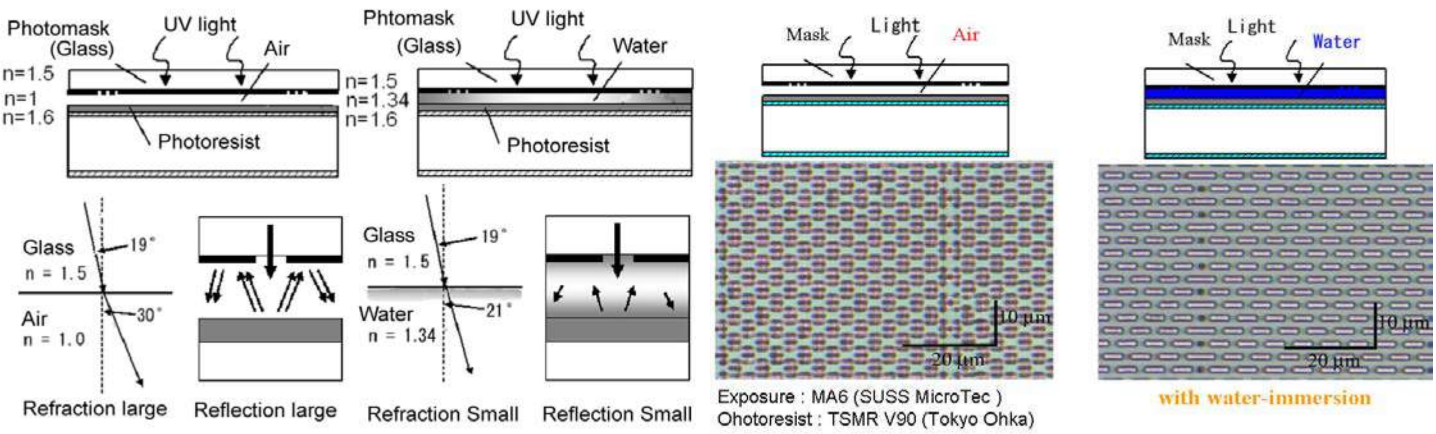


Gyro of Invensense

Reference : J.Seeger, M.Lim and S.Nasiri, Development of High-performance, High-volume Consumer MEMS Gyroscopes, Solid-State Sensors, Actuators and Microsystems Workshop, (2010), p.61

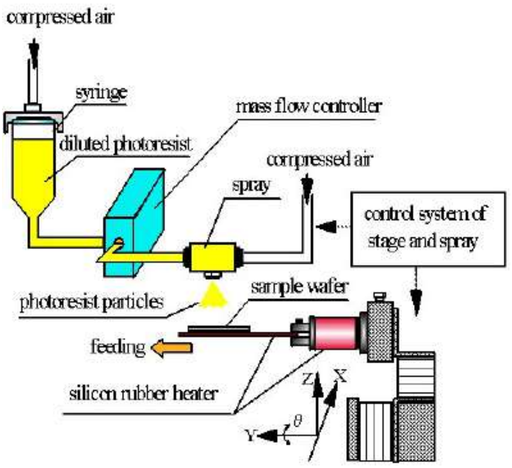
1axis angular rate sensor (Gyroscope)
2 axes accelerometer
Donated by Akebono brake Industry Corp. Ltd..

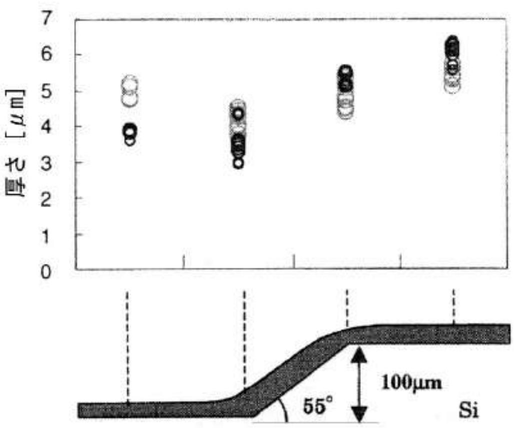
C7 Patterning



Liquid immersion contact lithography

Reference : K.-S.Chang, S.Tanaka and M.Esashi, A Micro-Fuel Processor with Trench-Refilled Thick Silicon Dioxide for Thermal Isolation Fabricated by Water-immersion Contact Photolithography, J. of Micromech. Microeng., 15 (2005) pp.S171-S178

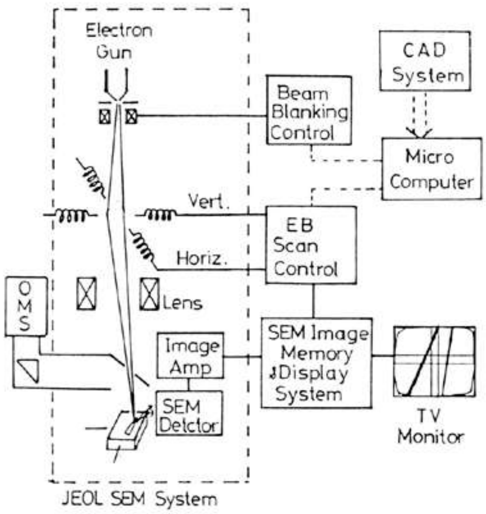


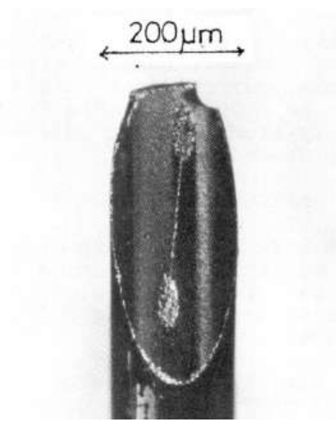


Resist spray coater

Usio

Reference : V.K.Singh, M.Sasaki, K.Hane and M.Esashi, Flow Condition in Resist Spray Coating and Patterning Performance for Three-Dimensional Photolithography over Deep Structures, Jpn. J. Appl. Phys., 43 (2004) pp.2387-2391

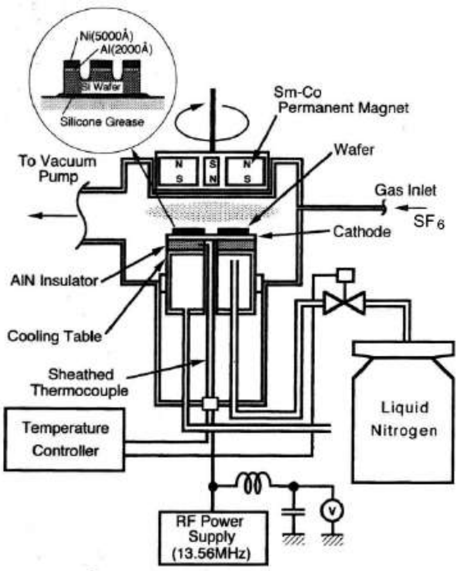




Electron beam exposure system for alignment without mark

Reference : S.Shoji, M.Esashi and T.Matsuo, A New Three-Dimensional Lithographic Technique and its Applications to the Fabrication of Micro Probe Sensors, Digest of Technical Papers, The 4th Int. Conf.on Solid State Sensors and Actuators (1987) pp.91-94

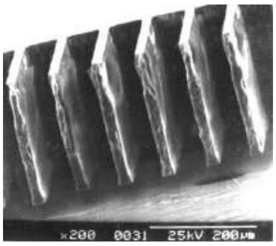
C8 # Etching (Deep RIE, XeF_2 Etching, Thickness Monitor during Etching)



Wet anisotropic etching of (110) Si
(thickness 200 μm, width 25/50/100 μm)

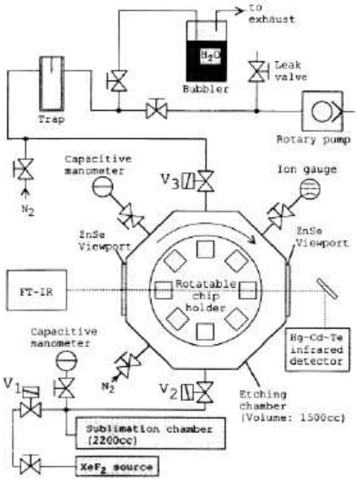
Si Deep RIE
(thickness 200 μm, wafer temp. −120℃)

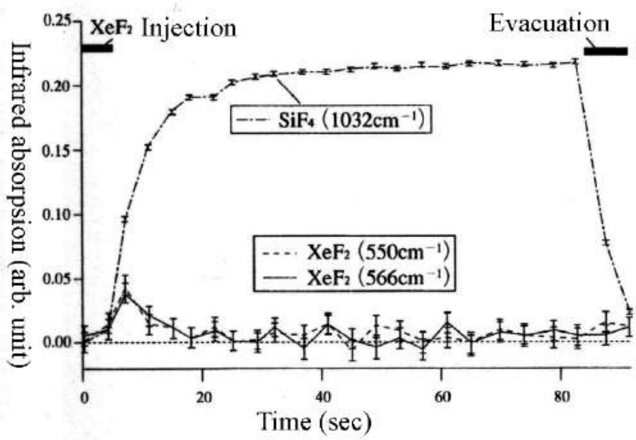
Polyimide RIE
(Thickness 80 μm, O_2 gas)



Deep RIE

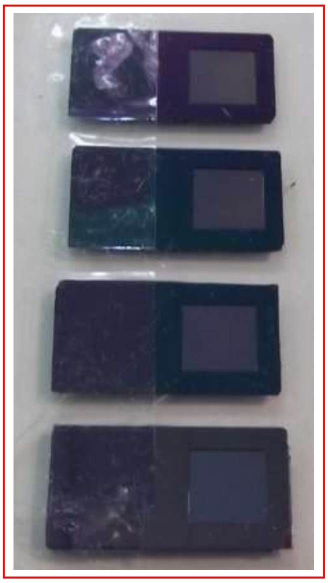
Reference : M.Takinami, K.Minami and M.Esashi : High-Speed Directional Low-Temperature Dry Etching for Bulk Silicon Micromachining, Technical Digest of the 11th Sensor Symposium (1992) pp.15-18



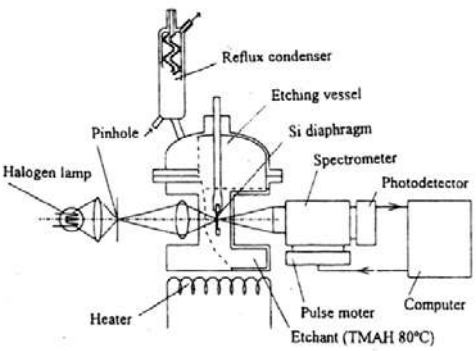


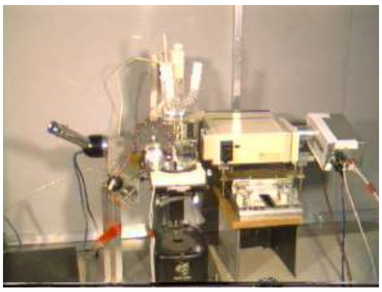
Si dry etching with XeF_2

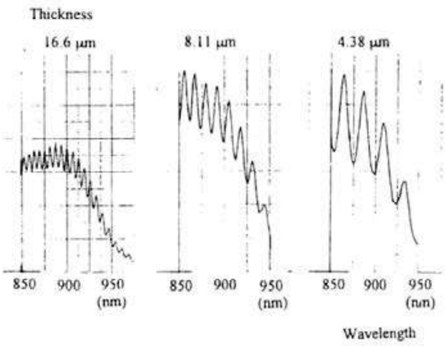
Reference : R.Toda, K.Minami and M.Esashi, Thin Beam Bulk Micromachining Based on RIE and Xenon Difluoride Silicon Etching, Sensors and Actuators, A66 (1998) pp.268-272



Thickness 2/3/5/7 μm from the top



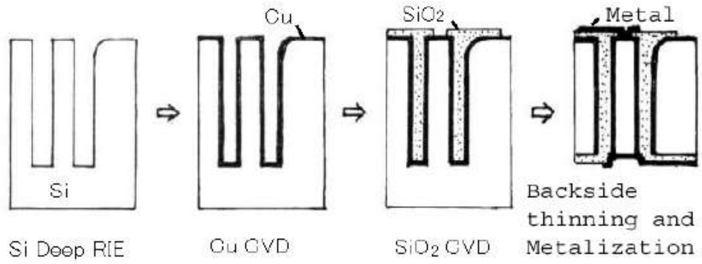


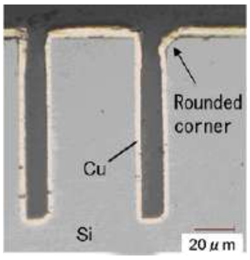


Thickness monitor during wet etching

Reference : K.Minami, H.Tosaka and M.Esashi, Optical in-situ Monitoring of Silicon Diaphragm Thickness during Wet Etching, J. of Micromechanics and Microengineering, 5 (1995) pp.41-46

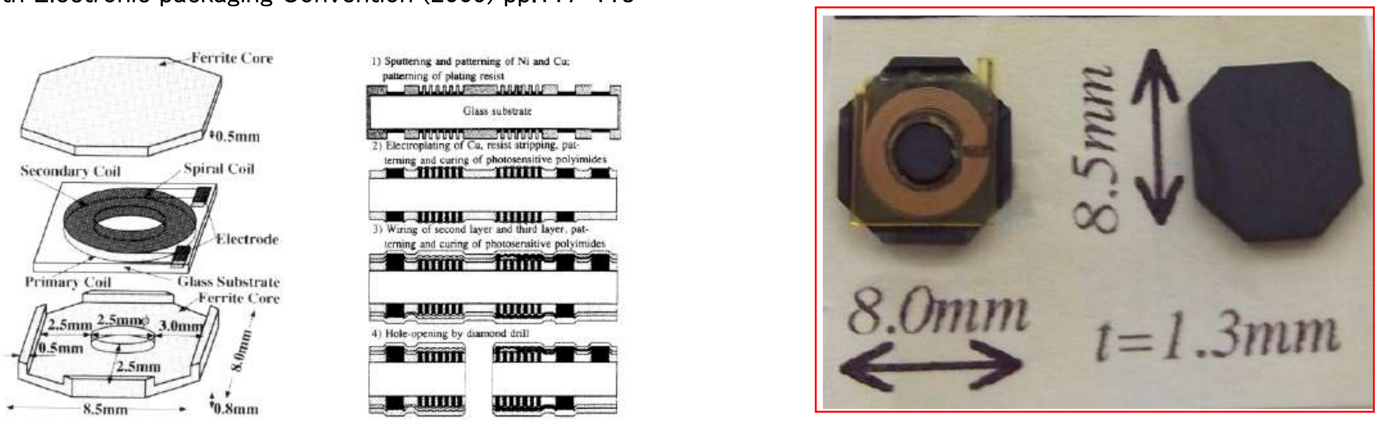
 Deposition





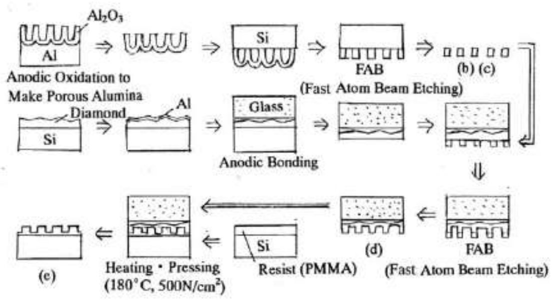
Electrical interconnection through Si wafer for high speed signal, Cu conformal CVD Ozone TEOS SiO_2 CVD
(Tohoku Univ. – Sharp Inc.) (Trench refill)

Reference : M.Sumikawa and M.Esashi, Electrical interconnection through Si wafer for high speed signal , 19th Electronic packaging Convention (2005) pp.117–118

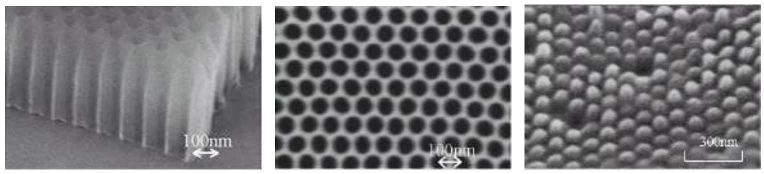


Planar transformer using electroplated coil (Tohoku Univ. – Japan Signal)

Reference : N.Asada, H.Matsumoto and M.Esashi, A Fail–Saif Logic Operator Using an Insulated Planar Transformer, Trans. of IEE in Japan, 114–A (1994) pp.255–259

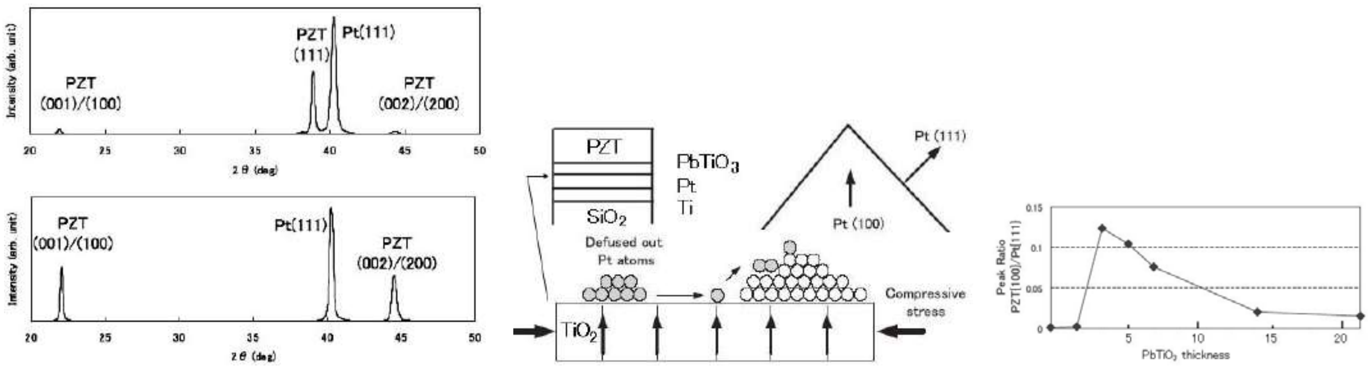


Nanoimprint using diamond mold



(b) (c) (d)

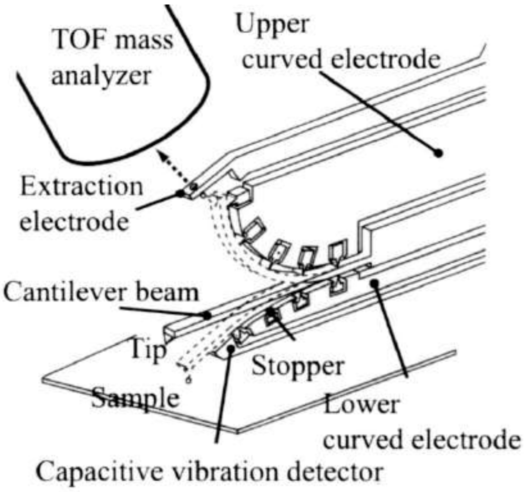
Reference : T.Ono, C.Konoma, H.Miyashita, Y.Kanamori and M.Esashi, Pattern Transfer of Self–Ordered Structure with Diamond Mold, Jpn. J. Appl. Phys., 42, Part 1 (2003) pp.3867–3870

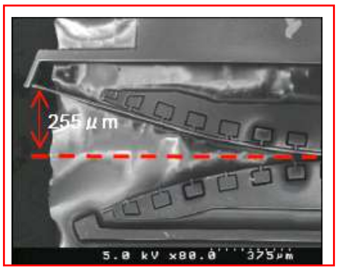


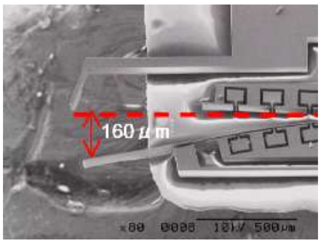
(100) oriented PZTfilm by LD MO (Liquid Delivery Metal Organic) CVD (Tohoku Univ. – Japan Signal)

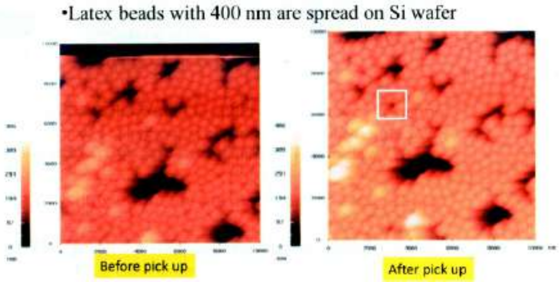
Reference : H.Matsuo, Y.Kawai, S.Tanaka and M.Esashi, Investigation for (100)–/(001)–Oriented $Pb(Zr,Ti)O_3$ Films Using Platinum Nanofacets and $PbTiO_3$ Seeding Layer, Jap. J. Appl. Phys, 49 (2010) 061503

C10 Probe for scanning probe microscope (SPM)

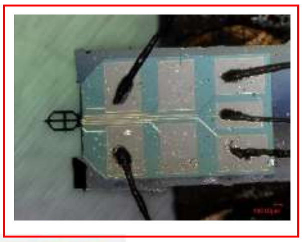




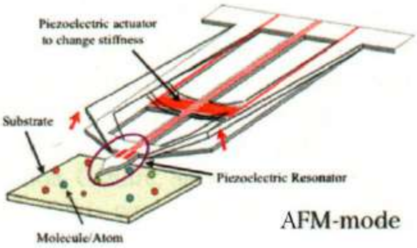


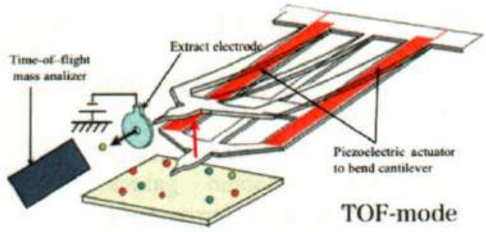


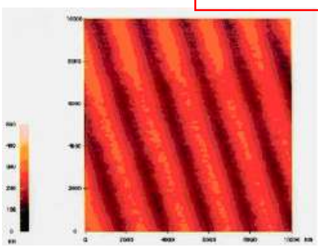
Electrostatically driven probe for Time–of–flight Scanning Force Microscopy



Reference : C.Y.Shao, Y.Kawai, M.Esashi and T.Ono, Electrostatic Actuator Probe with Curved Electrodes for Time–of–flight Scanning Force Microscopy, Review of Scientific Instruments, 81 (2010) 083702

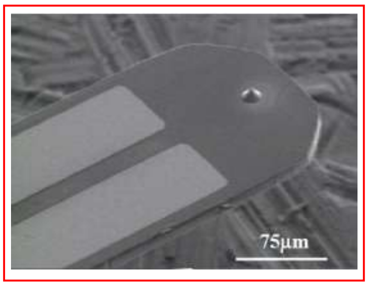


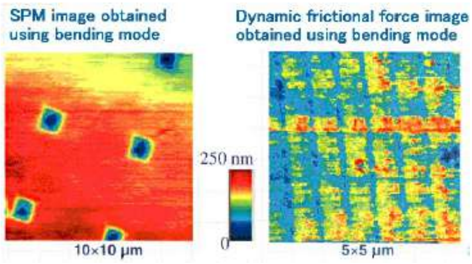




Piezoelectric driven probe for Time–of–flight Scanning Force Microscopy

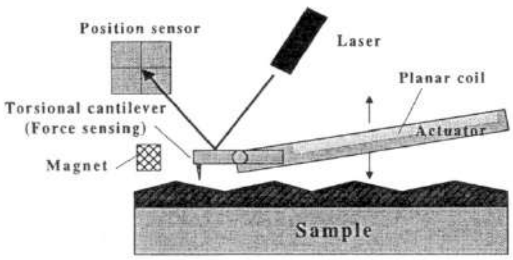
Reference : Y.Kawai, T.Ono, M.Esashi, E.Meyer and C.Gerber, Resonator Combined with a Piezoelectric Actuator for Chemical Analysis by Force Microscopy, Rev. of Sci. Instru., 78 (2007) 063709(4pp)

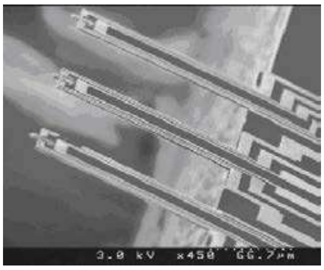




Quartz AFM probe

Reference : A.Takahashi, M.Esashi and T.Ono, Quartz–crystal Scanning Probe Microcantilevers with a Silicon Tip Based on Direct Bonding of Silicon and Quartz, Nanotechnology, 21 (2010) 405502(5pp)

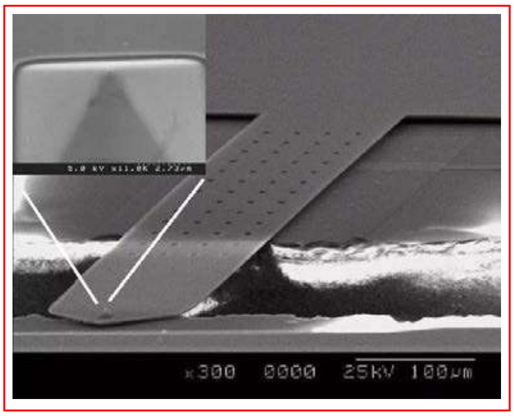


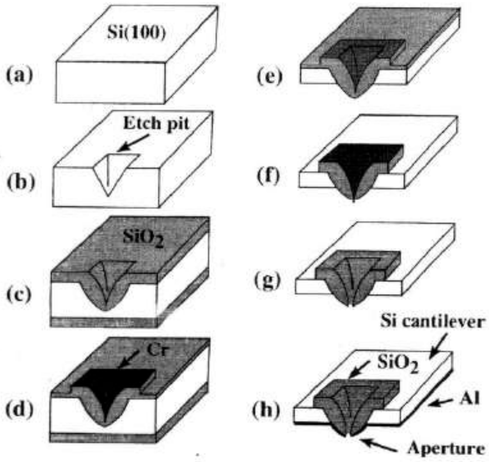


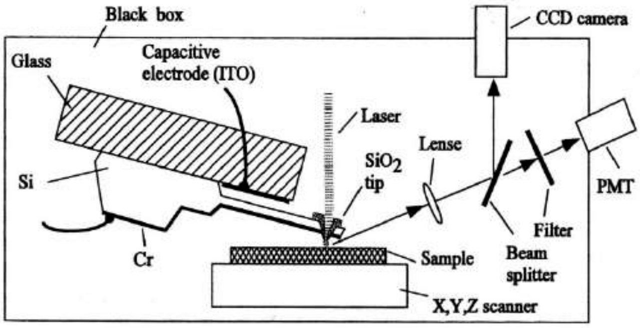
Electromagnetically driven AFM probe

Reference : D.W.Lee, T.Ono and M.Esashi, High–Speed Imaging by Electro–Magnetically Actuated Probe with Dual Spring, J. of Microelectromechanical Systems, 9 (2000) pp.419–424

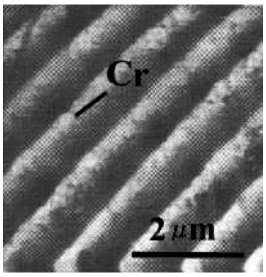
C11 Near-field optical probe and bow-tie antenna



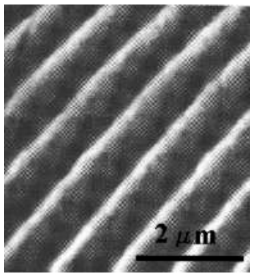




AFM

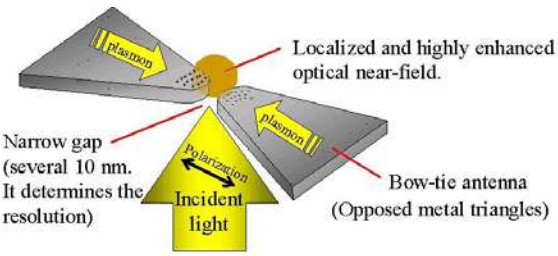


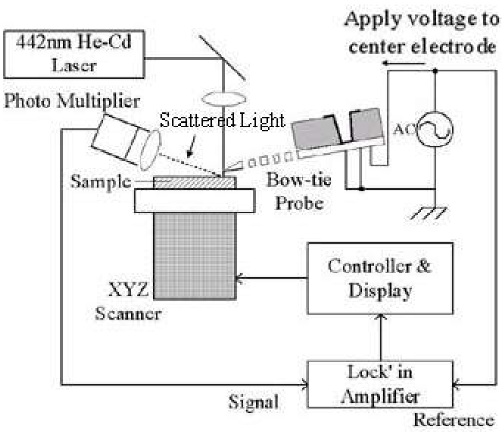
NSOM

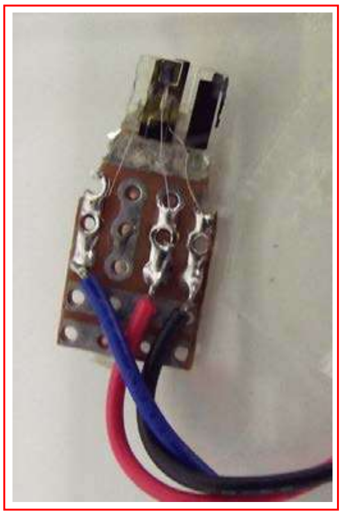


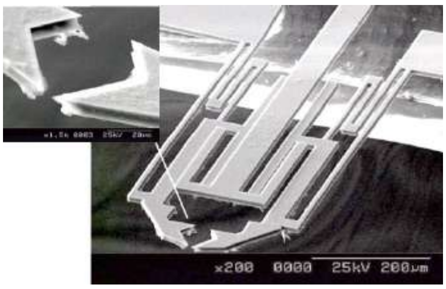
Probe for Near-field Scanning Optical Microscopy

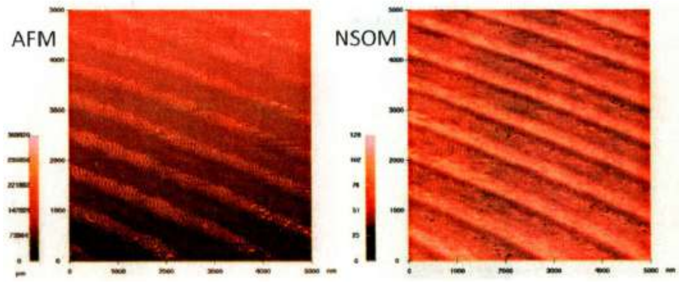
Reference : P.N.Minh, T.Ono and M.Esashi, Microfabrication of Miniature Aperture at the Apex of SiO_2 Tip on Silicon Cantilever for Near-field Scanning Microscopy, Sensors and Actuators, A80 (2000) pp.163-169







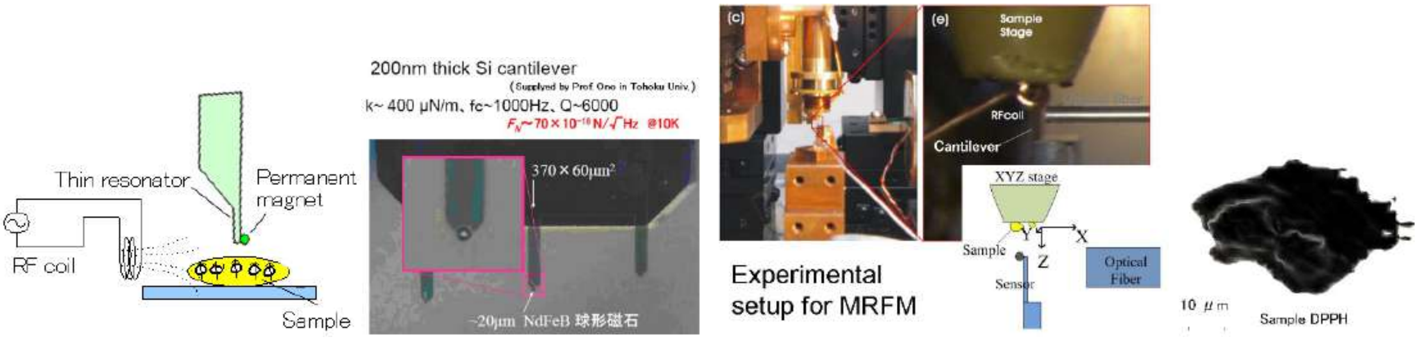




Bow-tie antenna

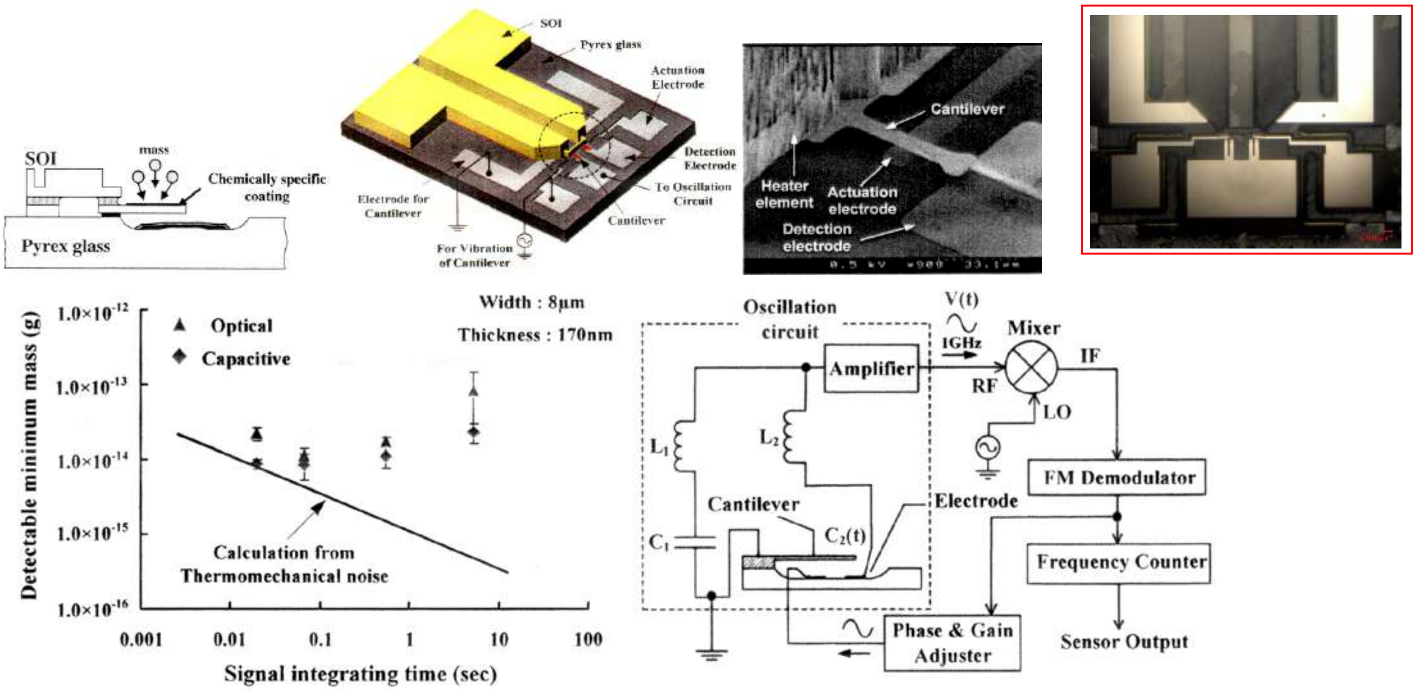
Reference : K.Iwami, T.Ono and M.Esashi, Optical Near-Field Probe Integrated with Self-Aligned Bow-Tie Antenna and Electrostatic Actuator for Local Field Enhancement, J. of Microelectromechanical Systems, 15 (2006) pp.1201-1208

Highly sensitive sensors using thin resonator



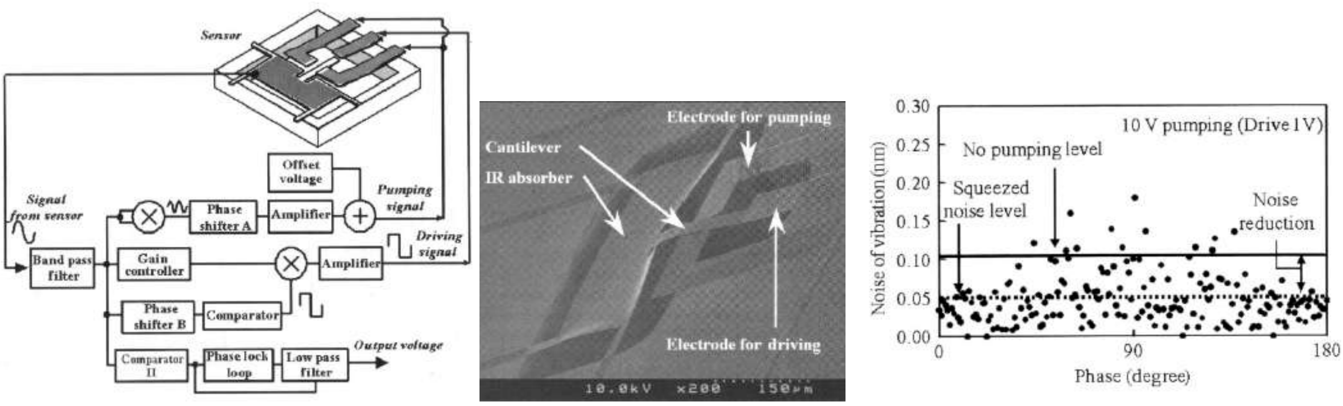
ESR (Electron Spin Resonance) imaging by MRFM (Magnetic Resonance Force Microscope) (JEOL – Tohoku Univ.)

Reference : S.Tsuji, Y.Yoshinari, E.Kawai, K.Nakajima, H.S.Park and D.Shindo, Magnetic resonance force microscopy combined with surface topography, J. of Magnetic Resonance, 188 (2007) pp.380-396



Capacitive detection of resonating cantilever mass sensor

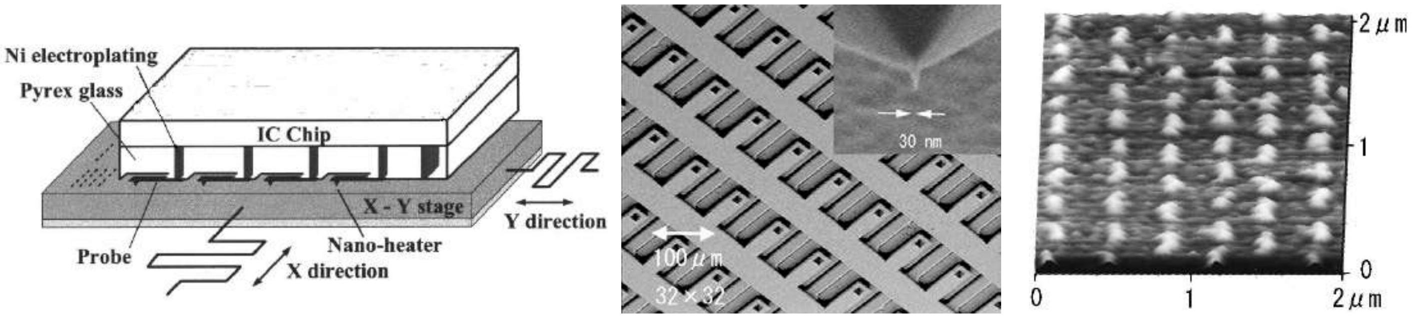
Reference : S.-J.Kim, T.Ono and M.Esashi, Mass Detection Using Capacitive Resonant Silicon Resonator Employing LC Resonant Circuit Technique, Rev. of Sci. Instru., 78 (2007) 085103(6)



Reduction of thermal fluctuation of resonant frequency by parametric noise squeezing

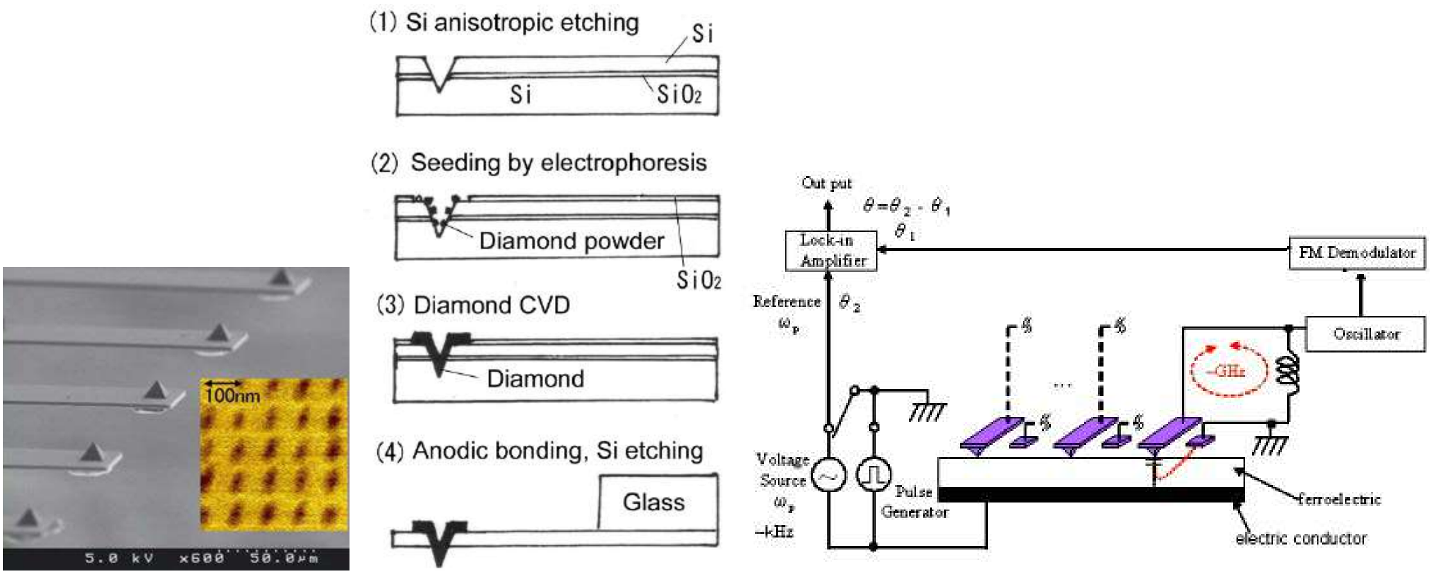
Reference : T.Ono, H.Wakamatsu and M.Esashi, Parametrically Amplified Thermal Resonant Sensor with Pseudo-Cooling Effect, J.of Micromech. Microeng., 15 (2005) pp.2282-2288

C13 Multi-probe data storage



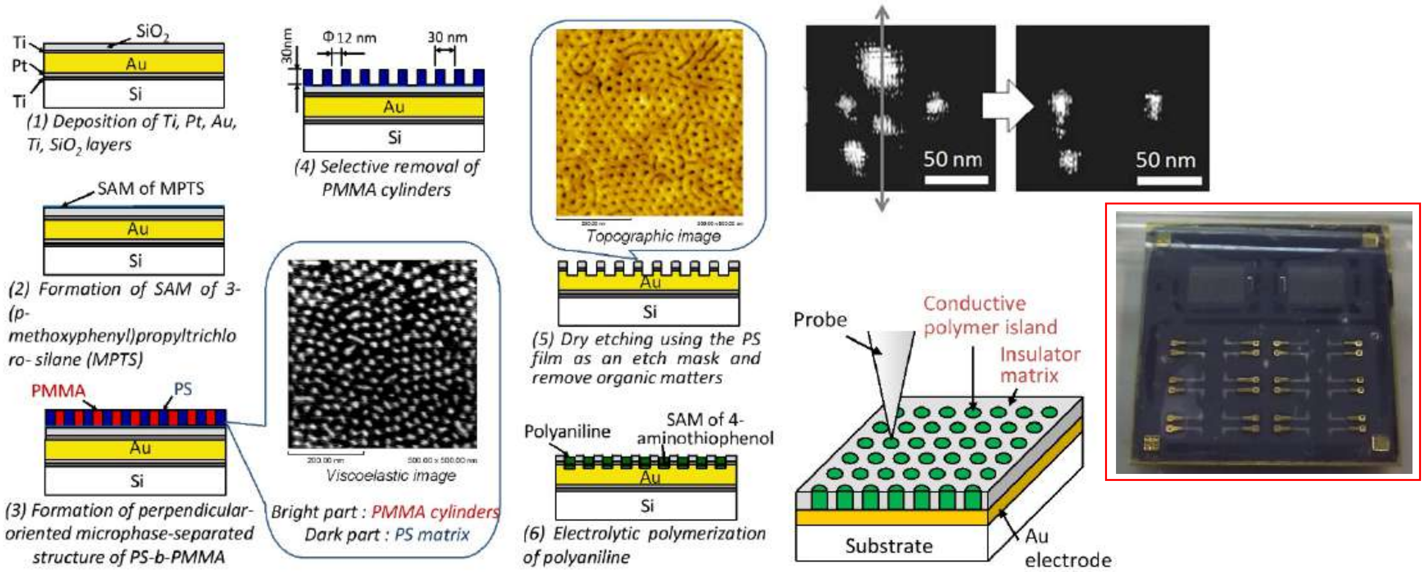
Thermal recoding to phase change recording media

Reference : D.W.Lee, T.Ono, T.Abe and M.Esashi, Microprobe Array with Electrical Interconnection for Thermal Imaging and Data Storage, J. of Microelectromechanical Systems, 11 (2002) pp.215-219



Electrical recoding and reading using diamond probe (Tohoku Univ. - Pioneer)

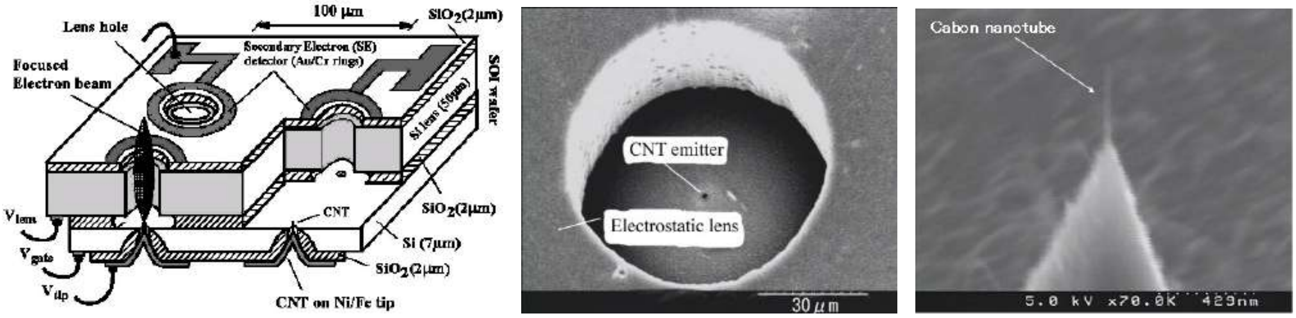
Reference : H.Takahashi, A.Onoe, T.Ono, Y.Cho and M.Esashi, High-Density Ferroelectric Recording Using Diamond Probe by Scanning Nonlinear Dielectric Microscopy, Jap. J. of Applied Physics. 45 (2006) pp.1530-1533



Patterned recording media using micro-phase separation of diblock copolymer

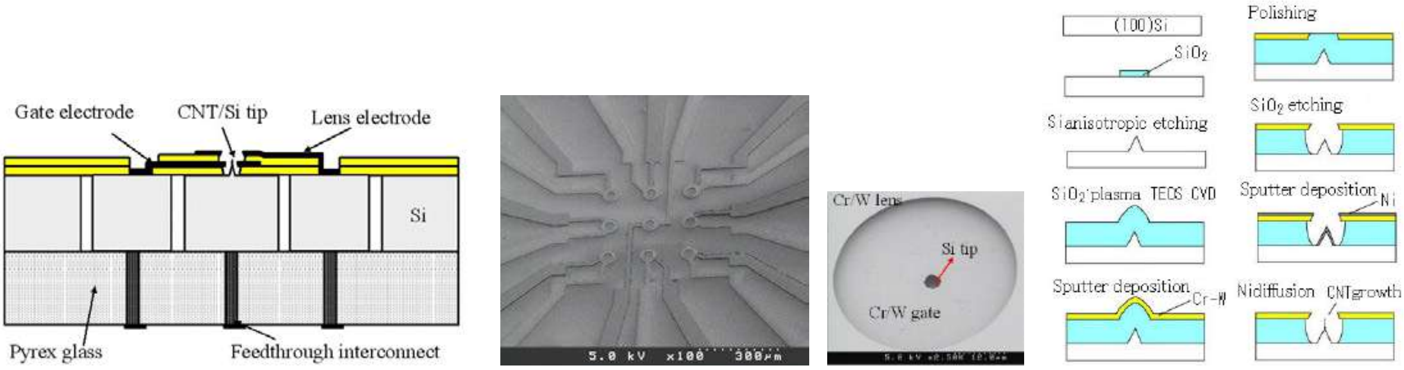
Reference : S.Yoshida, T.Ono and M.Esashi, Conductive Polymer Patterned Media for Scanning Multiprobe Data Storage, Nanotechnology, 18 (2007) 505302(5pp)

Electron source



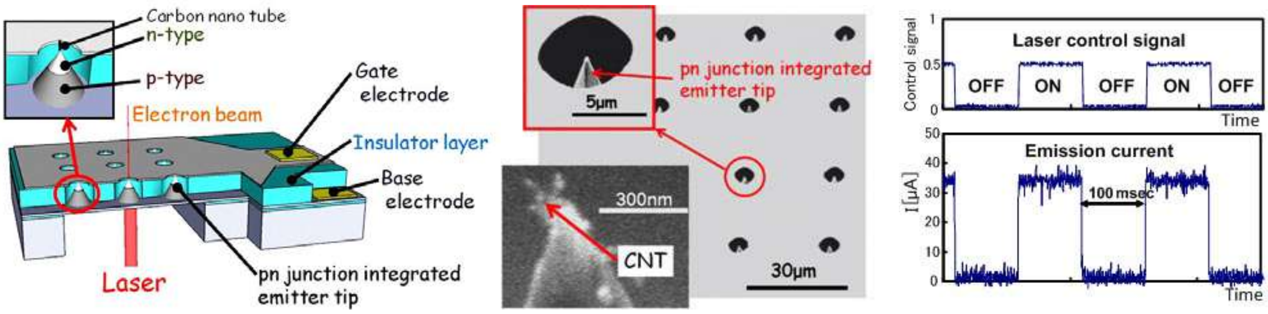
Cabon nanotube electron source

Reference : P.N.Minh, L.T.T.Tuyen, T.Ono, H.Mimura, K.Yokoo and M.Esashi, Carbon Nanotube on a Si Tip for Electron Field Emitter, Jpn. J. Appl. Phys., 41 Part2 (2002) pp.L1409–L1411



Carbon nanotube electron source with electrostatic lens

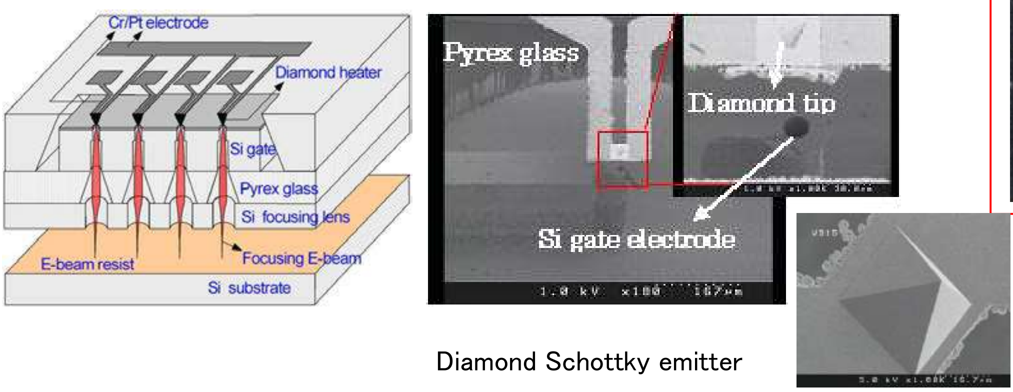
Reference : J.Ho, T.Ono, C.–H Tsai and M.Esashi, Photolithographic Fabrication of Gated Self-aligned Parallel Electron Beam Emitters with a Single-stranded Carbon Nanotube, Nanotechnology, 19 (2008) 365601(5pp)



Optically–controlled multi electron source

Reference : E.Tomono, H.Miyashita, T.Ono and M.Esashi, Optically-Controlled Multi Electron Source, The 5th Asia-Pacific Conference on Transducers and Micro-Nano Technology (APCOT 2010) (2010) pp.78–79

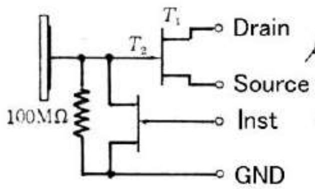
Optically–controlled multi electron source

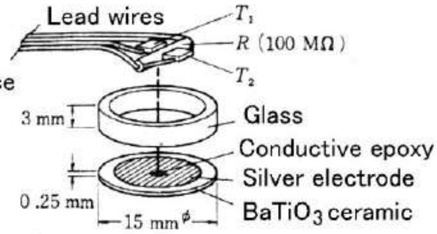


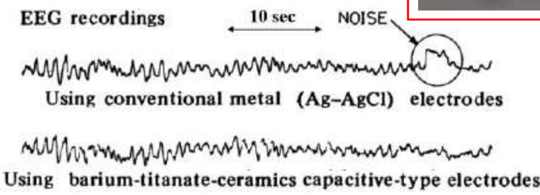
Diamond Schottky emitter

Reference : C.–H.Tsai, T.Ono and M.Esashi, Fabrication of Diamond Schottky Emitter Array by Using Electrophoresis Pre-treatment and Hot-filament Chemical Vapor Deposition, Diamond and Related Materials, 16 (2007) pp.1398–1402

D1 # Electrode for biopotential recording



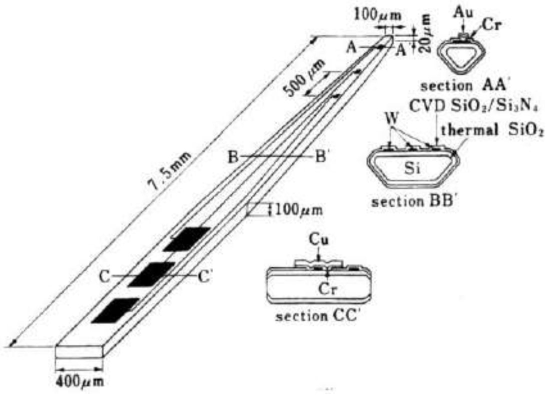


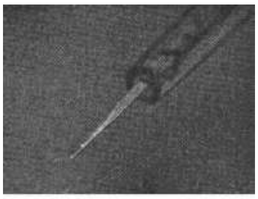


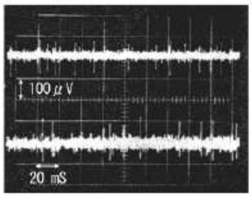
Capacitive electrode

Reference : T.Matsuo, M.Esashi, K.Iinuma, Capacitive Electrode for Biomedical Use (—the Use of Barium-titanate Ceramics for Biomedical Sensing Electrode—), Medical Electronics and Biomedical Engng., 11 (1973) pp.156-162

T.Matsuo, K.Iinuma and M.Esashi, A Barium-Titanate-Ceramics Capacitive-Type EEG Electrod, IEEE Trans.on Biomedical Engineering, BME-20 (1973) pp.299-300





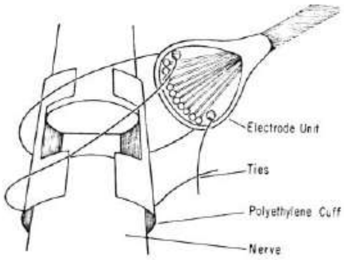


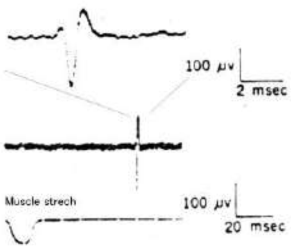
Micro multielectrode

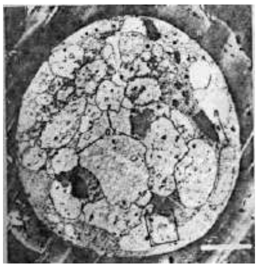
Flexibl multilectrodes

Reference : Y.Ohta, M.Esashi, T.Matsuo, Multielectrode Fabrication for Simultaneous Recording of Nerve Impulses Using IC Techniques, Medical Electronics and Biomedical Engng., 19 (1981) pp.106-113

T.Matsuo, A.Okitsu, M.Esashi, Fabrication of Flexible Multi Electrode for Biomedical Use, Tohoku region meeting of Electrical Eng., 1B11 (1978)

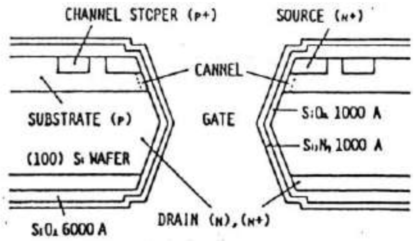


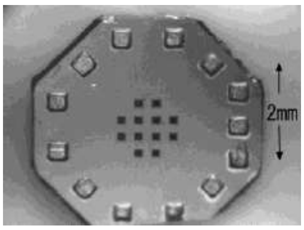


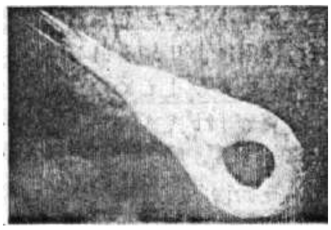


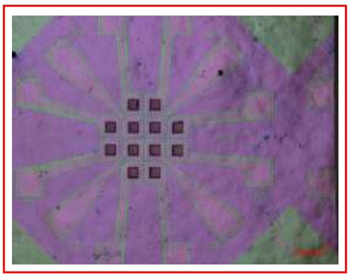
Nerve regeneration electrode (Univ. of Alberta, Canada)

Reference : A.Mannard, R.B.Stein and D.Charles, Regeneration Electrode Units : Implants for Recording from Single Peripheral Nerve Fibers in Freely Moving Animals, Science, 183 (1974) pp.547-549





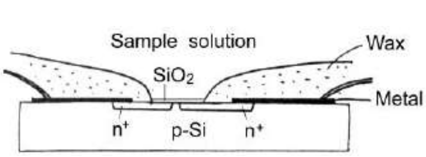


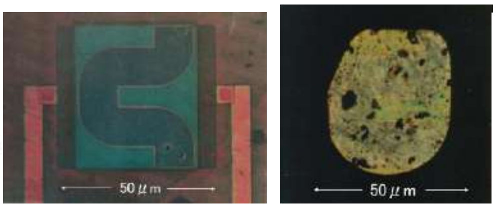


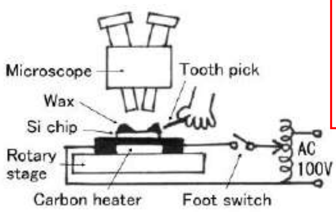
Nerve regeneration electrode using open gate MOSFET

Reference : A.Yamaguchi, T.Matsuo, M.Esashi, Fabrication of Multi-Hole-Active Electrode for Nerve Bundle, 17th Convention of Japan Soc. ME & BE (1978) p.261

D2 Semiconductor ion sensor (ISFET)



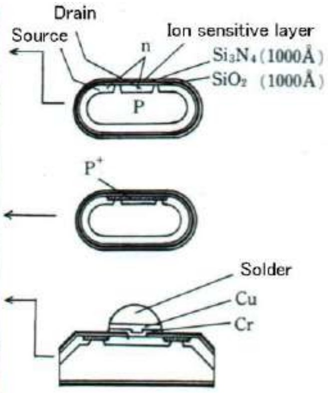


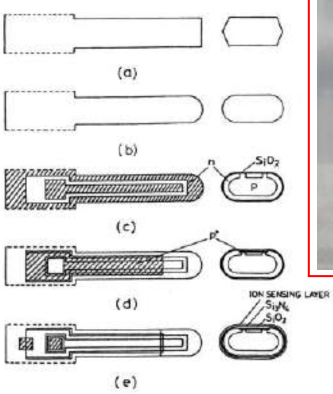


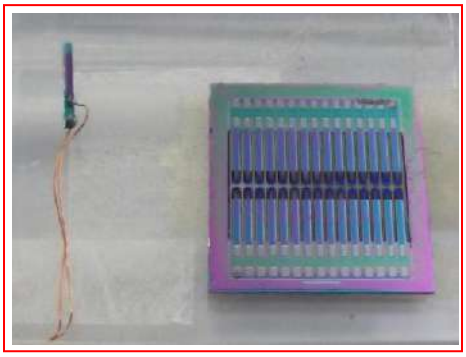
Medical active electrode

Reference : T.Matsuo, M.Esashi, K.Iinuma, Medical Active Electrode Using Field Effect of Semiconductor(1), Tohoku Convention in Electrical Soc.. (1971) p.28

M.Esashi, T.Matsuo, Medical active electrode using field effect of semiconductor―Operation as a cation selective electrode―, 12th Convention ME&BE, (1973) pp.507–508

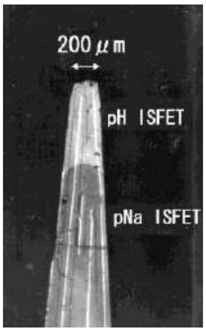


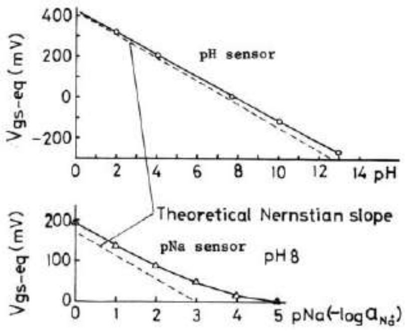


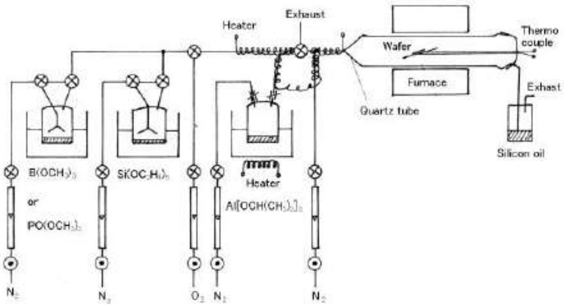


ISFET (Ion Sensitive Field Effect Transistor)

Reference : M.Esashi and T.Matsuo, Biomedical Cation Sensor Using Field Effect of Semiconductor, J. of the Japan Soc. of Applied Physics, 44, Supplement (1975) pp.339–343

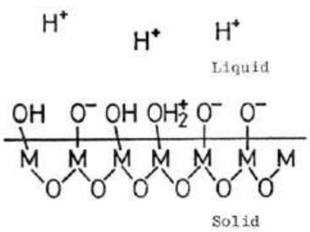


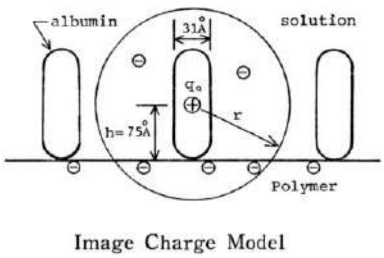


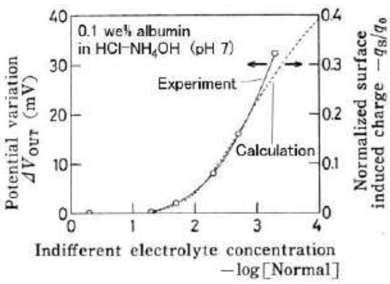


Multi ion sensitive ISFET

Reference : M.Esashi and T.Matsuo, Integrated Micro Multi Ion Sensor Using Field Effect of Semiconductor, IEEE Trans. on Biomedical Engineering, BME-25 (1978) pp.184–192



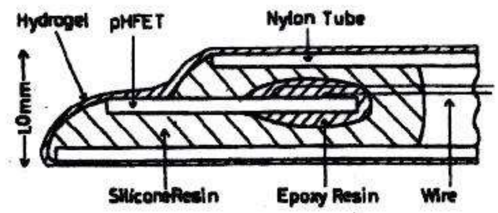




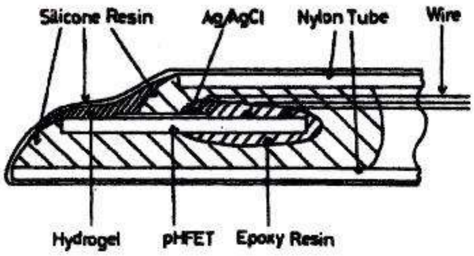
Polymer gate FET

Reference : H.Nakajima, M.Esashi and T.Matsuo, The pH-response of Organic Gate ISFETs and the Influence of Macro-molecule Adsorption, J. of Chemical Soc. of Japan, 10 (1980) pp.1499–1508

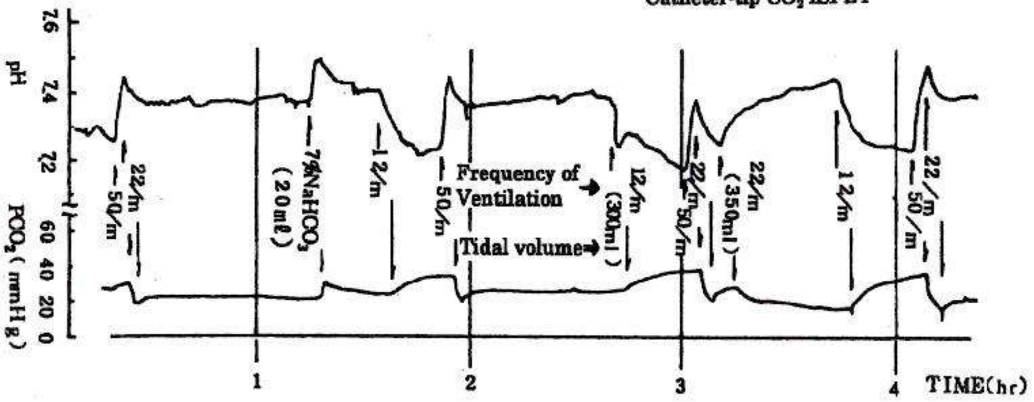
D3 Catheter pH, CO_2 sensor



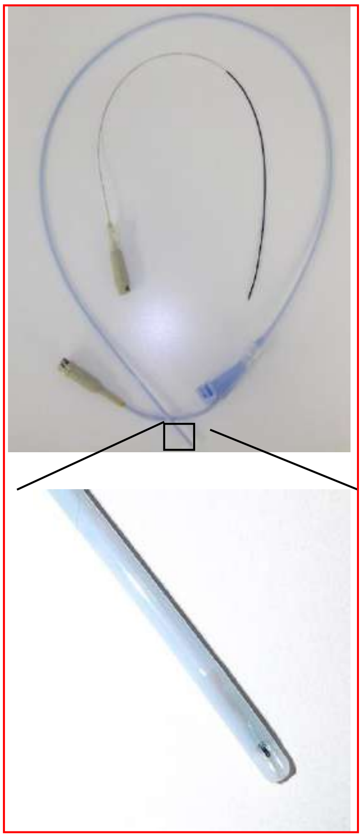
Catheter-tip pH ISFET



Catheter-tip CO_2 ISFET

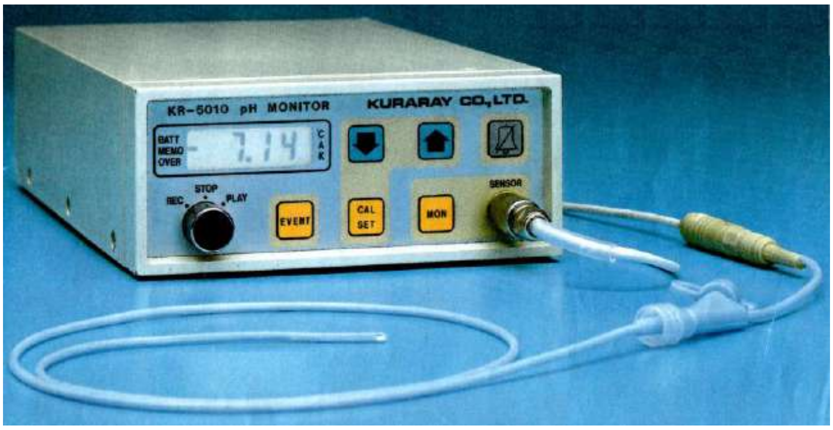


Continuous pH and CO_2 measurement of sed arterial blood of mongral dog by the catheter-tip pH ISFET and catheter-tip CO_2 ISFET.

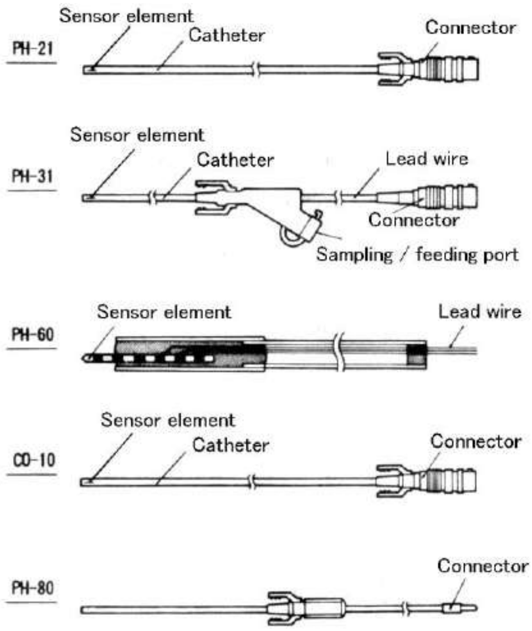


Catheter pH, CO_2 sensor (Kurare – Tohoku Univ.)

Reference : K.Shimada, M.Yano, K.Shibatani, Y.Komoto, M.Esashi and T.Matsuo, Application of Catheter–tip I.S.F.E.T. for Continuous in Vivo Measurement, Med.& Biol.Eng. & Comput., 18 (1980) pp.741–745



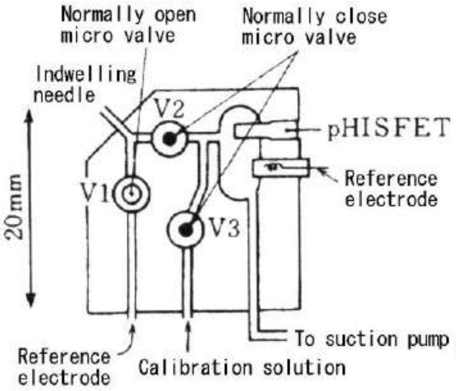
Catheter pH, CO_2 sensor commercialized in 1980 (Kurare, Nohon Kohden)

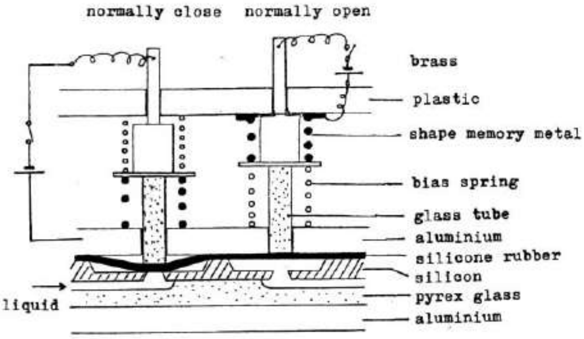


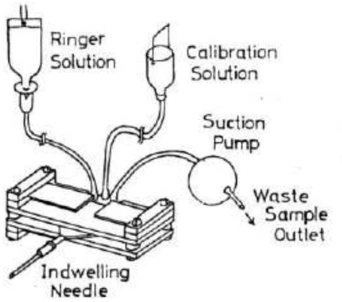
NIHON KOHDEN

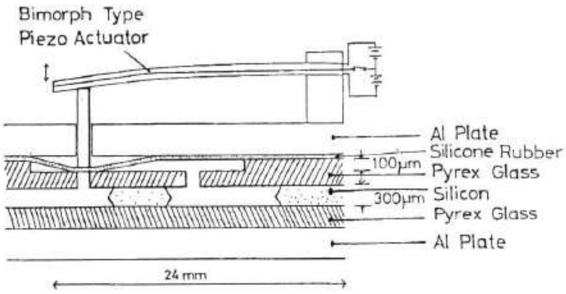
Type	Application	No	Catheter (mm) Length	Catheter (mm) Diameter	Monitor	Note
PH-21	pH measurement in muscle etc	PH-2135	350	1.1	KR-5000	With reference
PH-31	pH measurement in esophagus and stomach	PH-3110 (Adult)	1000	2.4	KR-5000	With reference and feed port
		PH-3165 (Infant)	650	2.4	KR-5010	
PH-60	pH measurement in mouth	PH-6010	100	1.0	KR-5000	Without reference
PH-80	Reference electrode for PH-60	PH-8005	50	1.1	KR-5000	
CO-10	PCO_2 measurement in muscle etc	CO-1035	350	0.9	KR-5000	With reference

D4 Intermittent sampling continuous blood gas monitor

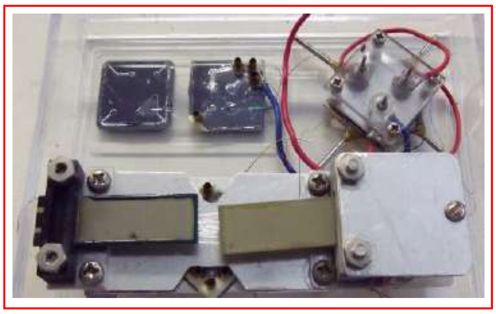




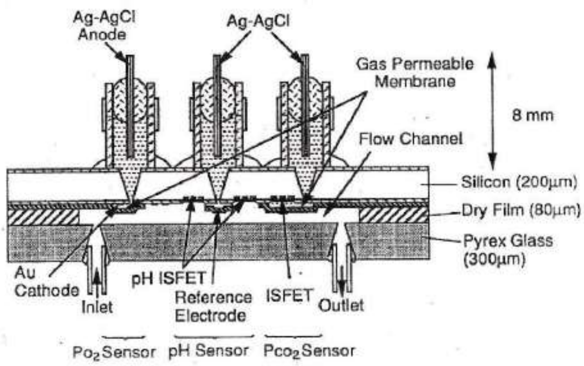


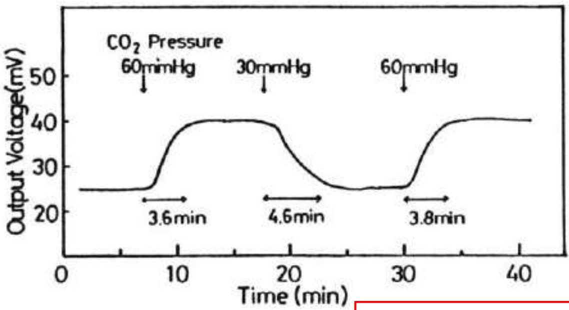


Intermittent sampling blood gas monitor

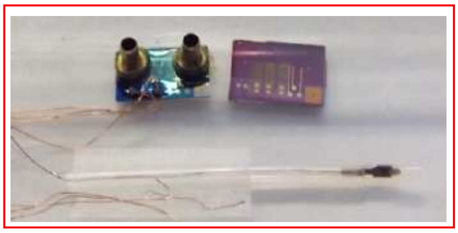


Reference : S.Shoji, M.Esashi and T.Matsuo, Prototype Miniature Blood Gas Analyser Fabricated on a Silicon Wafer, Sensors & Actuators, 14 (1988) pp.101–107

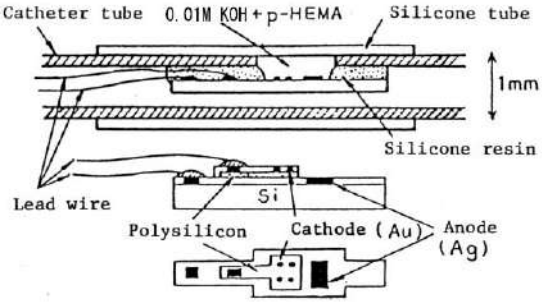


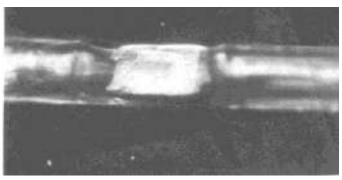


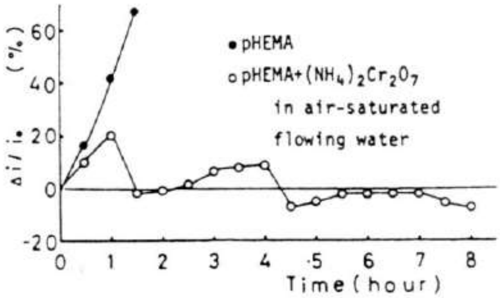
Flow cell for continuous blood gas analysis



Reference : S.Shoji and M.Esashi, Micro Flow Cell for Blood Gas Analysis Realizing Very Small Sample Volume, Sensors and Actuators B, 8 (1992) pp.205–208



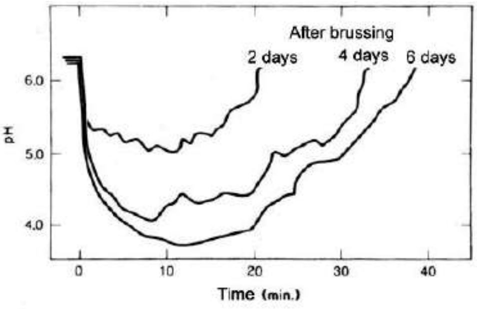




Clark type oxygen sensor in blood vessel

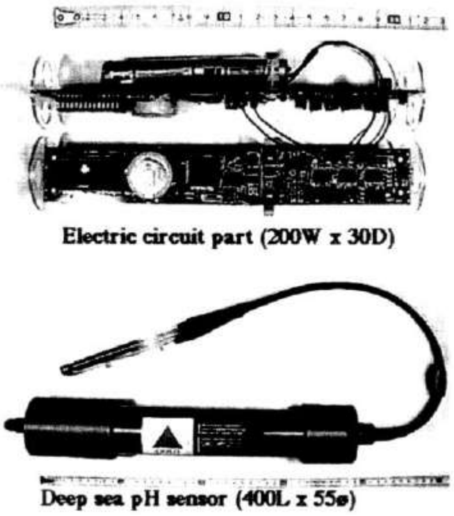
Reference : M.Esashi, A.Nishikawa, T.Matsuo, Fabrication of Micro Oxygen Sensor by IC Techniques, Technical Report of ICEC, MBE81–36 (1981)

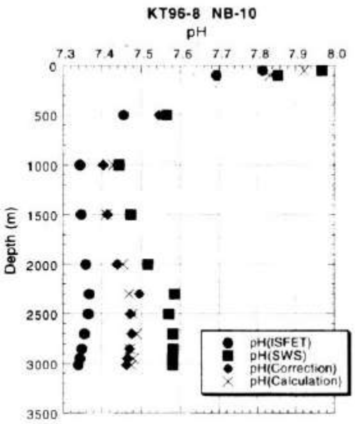
D5 Application of ISFET to dentistry, oceanography and fish cultivation

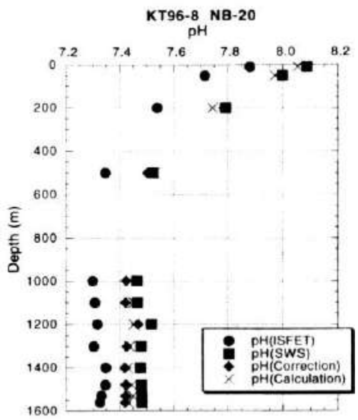


pH measurement of teeth

Reference : R.Chida, K.Igarashi, K.Kamiyama, E.Hoshino and M.Esashi, Characterization of Human Dental Plaque Formed on Hydrogen-ion-sensitive Field-effect Transistor Electrodes, J. of Dental Research, 65 (1986) pp.448-451







Vertical profiles of pH obteined by ISFET-pH sensor (●), on board analysis (■ : glass electrode at 25℃ : SWS scale), correction with *in situ* temperature and pressure (◆) and calculation from total carbonate and alkalinity (×).

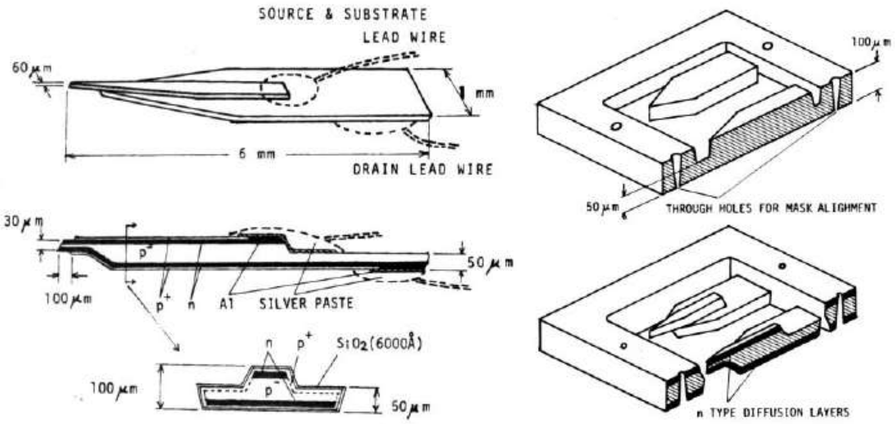
Application of ISFET to oceanography (Central Research Institute of Electrical Power Industry, Japan Marine Science and Technology Center)

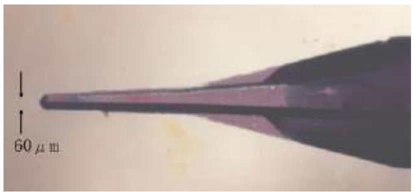
Reference : K.Shitashima and M.Kyo, Application of Chemical Sensors to Oceanography — Development of Deep Sea pH Sensor Using ISFET —, Geochemistry, 32 (1998) pp.1-11

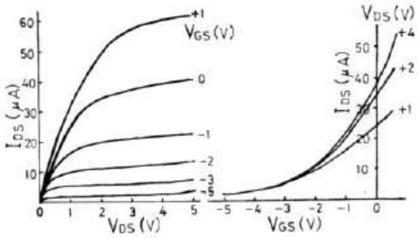
Portable pH sensor (Shindengen Kogyo)

Reference : Y.Ito, Development of ISFET and pH Sensors, Chemical Sensors, 14 (1998) pp.8-17

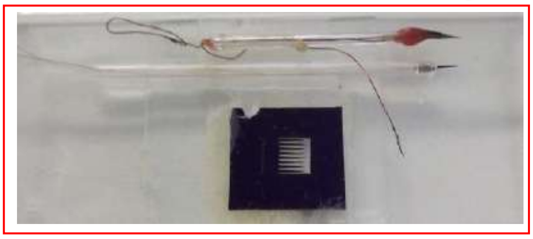
D6 Micro ISFET and integrated micro probe



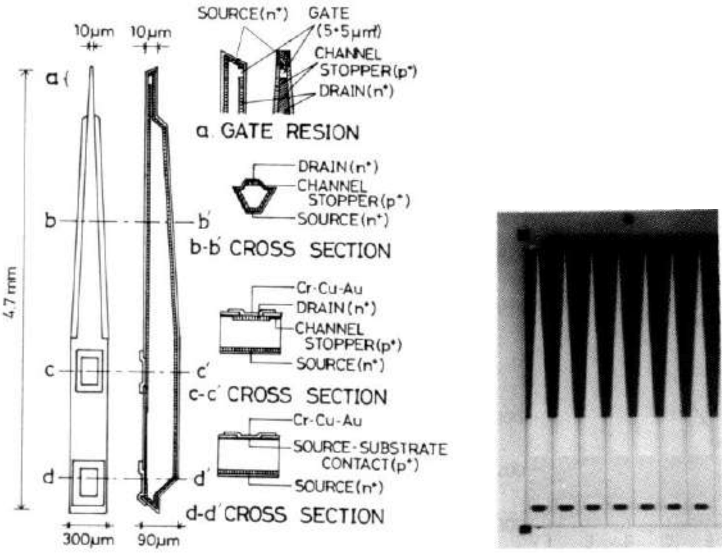


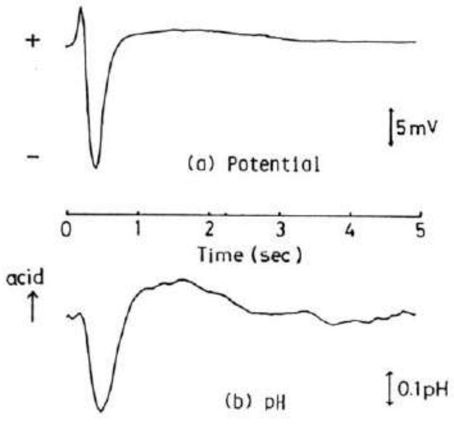


Micro ISFET with 60 μm tip



Reference : M.Esashi and T.Matsuo, Biomedical Cation Sensor Using Field Effect of Semiconductor, J. of the Japan Soc. of Applied Physics, 44, Supplement (1975) pp.339–343

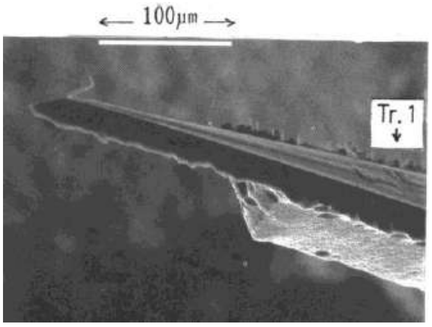


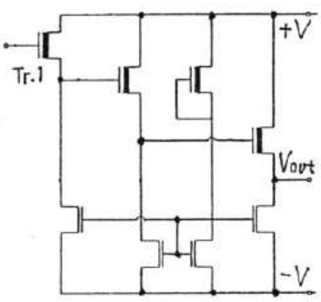


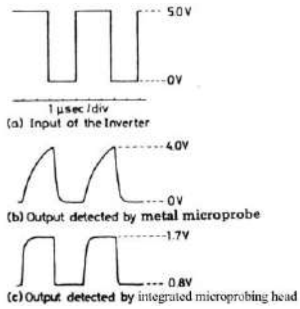
Activation potential and pH after light stimulation

Micro ISFET with 10 μm tip

Reference : S.Shoji, M.Esashi and T.Matsuo, Prototype Micro ISFET for Biomedical Research, Electronics and Communications in Japan, Part 2, 69 (1986) pp.21–29



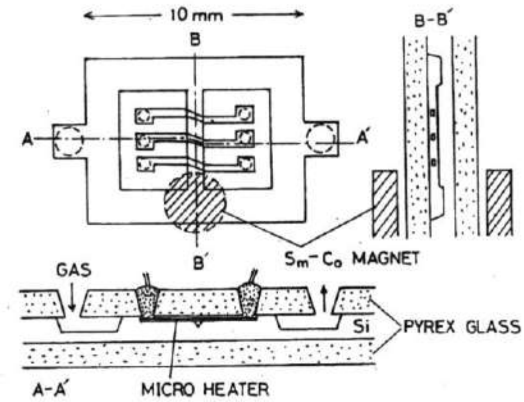


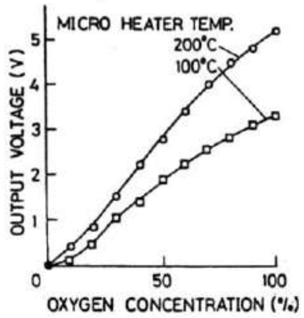


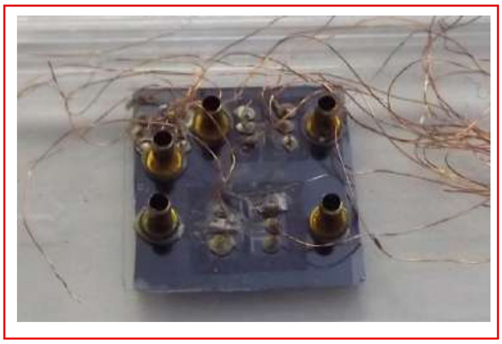
Integrated micro probe

Reference : S.Shoji, M.Esashi and T.Matsuo, Fabrication of an Integrated Micro Probing Head for Fault Analysis of MOS Integrated Circuits, Sensors & Actuators, 14 (1988) pp.125–132

Gas sensors

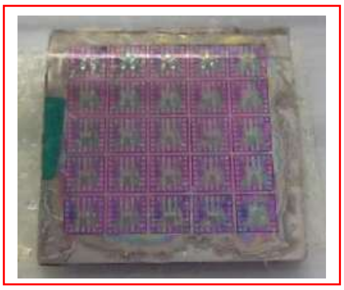


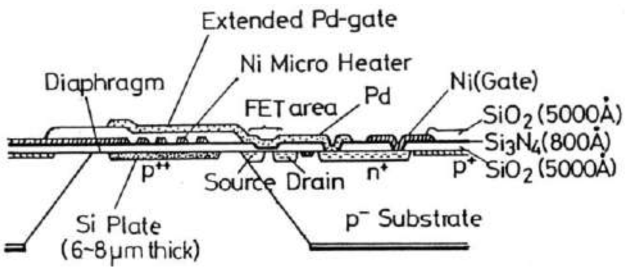


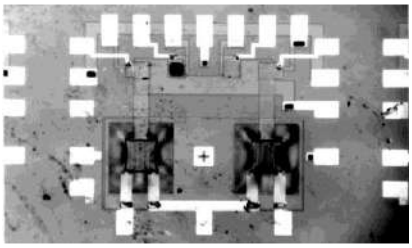


Magnetic oxygen sensor

Reference : M.Esashi, Micro Flow Sensor and Integrated Magnetic Oxygen Sensor Using It, Digest of Technical Papers Transducers'91 (1991) pp.34-37

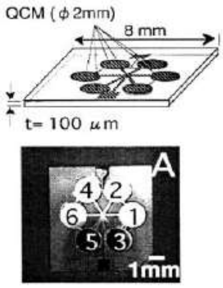


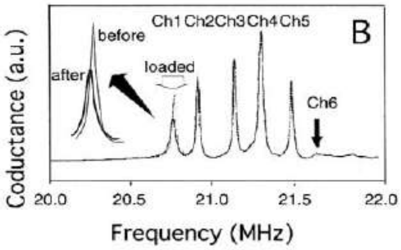


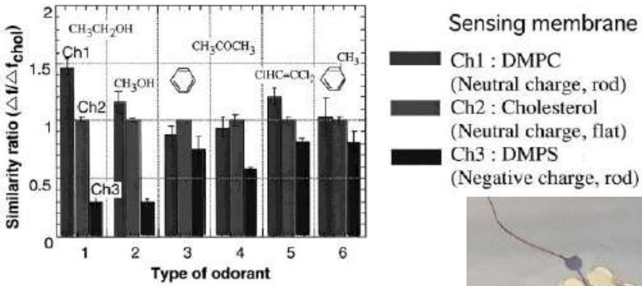


Extended palladium-gate FET (Tohoku Univ. - Linkoping Univ. of Tech.. (Sweden))

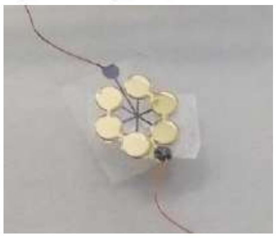
Reference : F.Enquist, M.Esashi, M.Armgarth, I.Lundstrom and T.Matsuo, Design of a High Temperature Extended Palladium-gate Field Effect Transistor for the Detection of Organic Molecules, Digest of Technical Papers, The 4th Int.Conf.on Solid State Sensors and Actuators (1987) pp.644-648



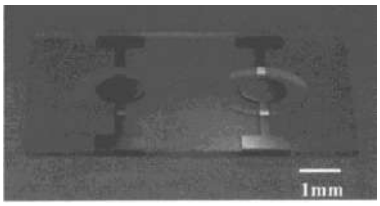


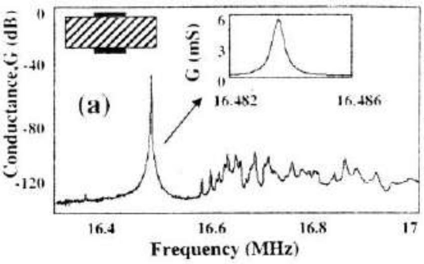


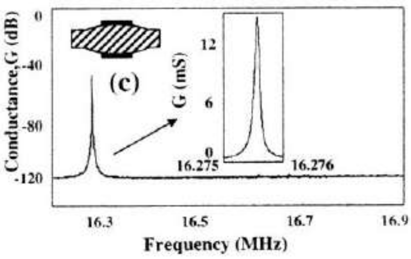
Multi QCM by deep RIE of quartz



Reference : T.Abe and M.Esashi, One-chip Multichannel Quartz Crystal Microbalance (QCM) Fabricated by Deep RIE, Sensors and Actuators, A82 (2000) pp.139-143



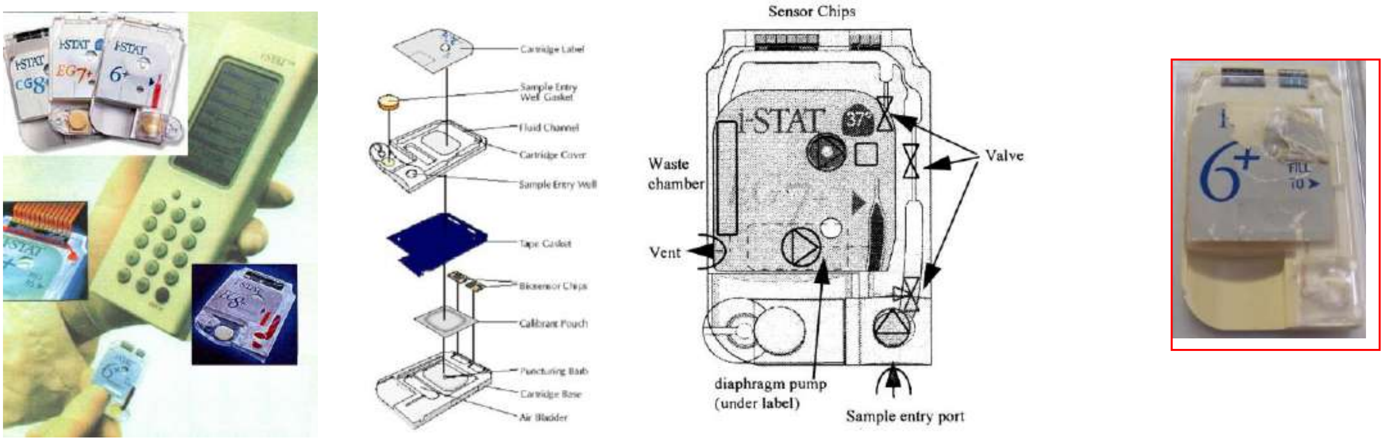




Bi-convex QCM

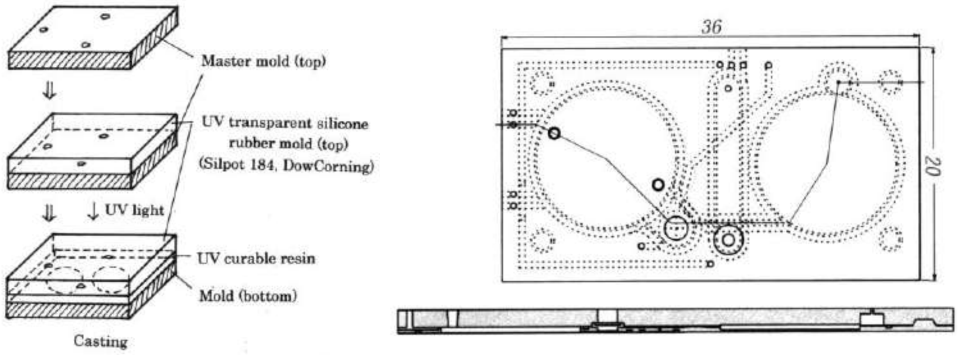
Reference : L.Li, T.Abe and M.Esashi, Fabrication of Miniaturized Bi-convex Quartz Crystal Microbalance Using Reactive Ion Etching and Melting Photoresist, Sensors & Actuators A, 114 (2004) pp.496-500

D8 Disposable chemical analysis chip



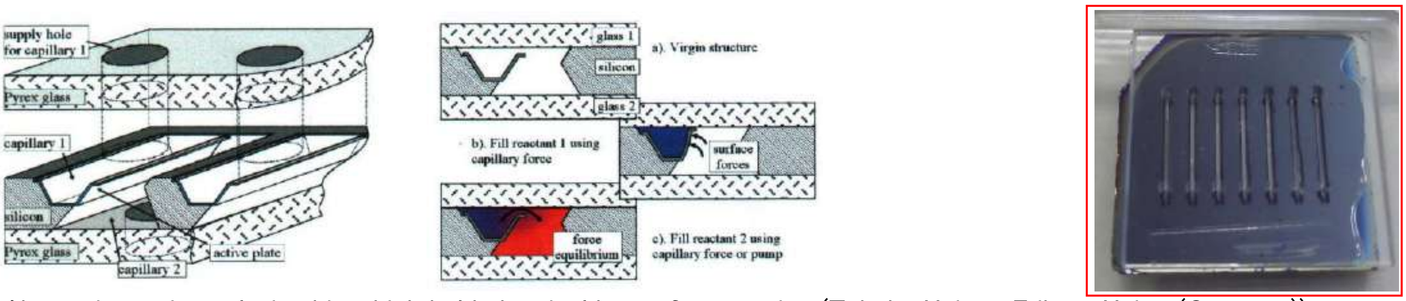
Blood analysis chip (i-STAT)

Reference : I.R.Larks, Microfabricated Biosensors and Microanalytical Systems for Blood Analysis, Acc. Chem. Res., 31 (1998) pp.317-324



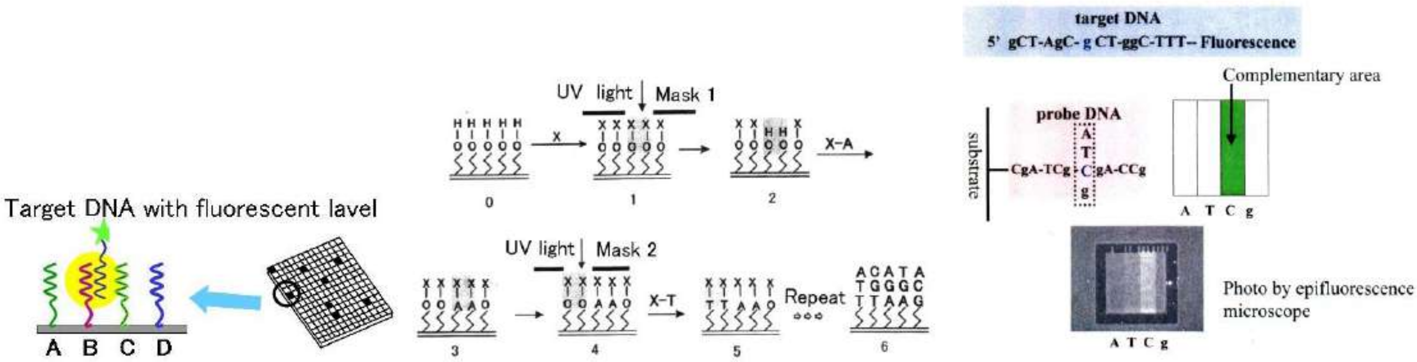
Absorptiometric blood analysis chip made of polymer UV imprinting (Tohoku Univ. – Sysmetics)

Reference : K.Sawa and M.Esashi : Micromolding of Disposable Polymer Parts for Medical Diagnostics, Technical Digest of the 18th Sensor Symposium (2001) pp.229-232



Absorptiometric analysis chip which hold chemical by surface tension (Tohoku Univ. – Friburg Univ. (Germany))

Reference : R.U.Seidel, D.Y.Sim, W.Menz and M.Esashi, A New Approach to On-Site Liquid Analysis, Sensors and Materials, 12 (2000) pp.57-68

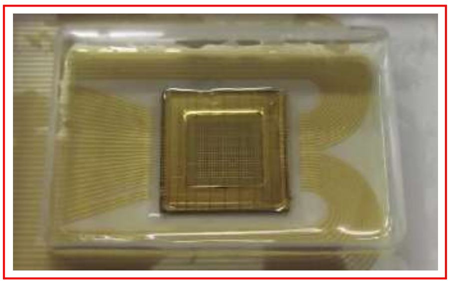


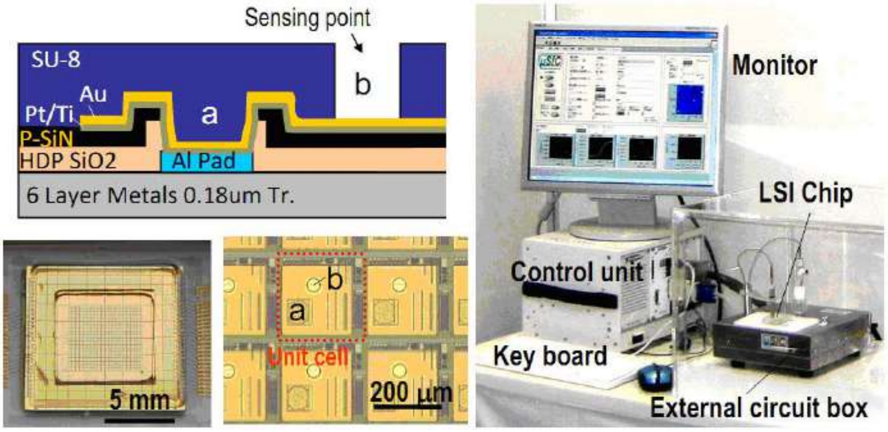
DNA chip for gene analysis for SNPS of lever cancer (Tohoku Univ. – Cancer Institute – Tokyo Institute of Technology)

Reference : K.Takahashi, K.Seio, M.Sekine, O.Hino and M.Esashi, A Photochemical/chemical Direct Method of Synthesizing High-performance Deoxyribonucleic Acid Chips for Rapid and Parallel Gene Analysis, Sensors and Actuators, B83 (2002) pp.67-76

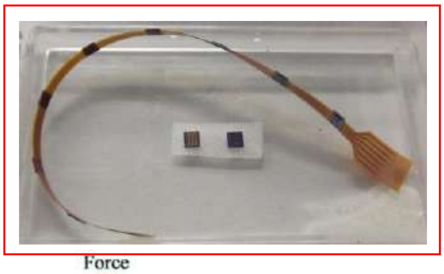
Bio LSI and tactile sensor network

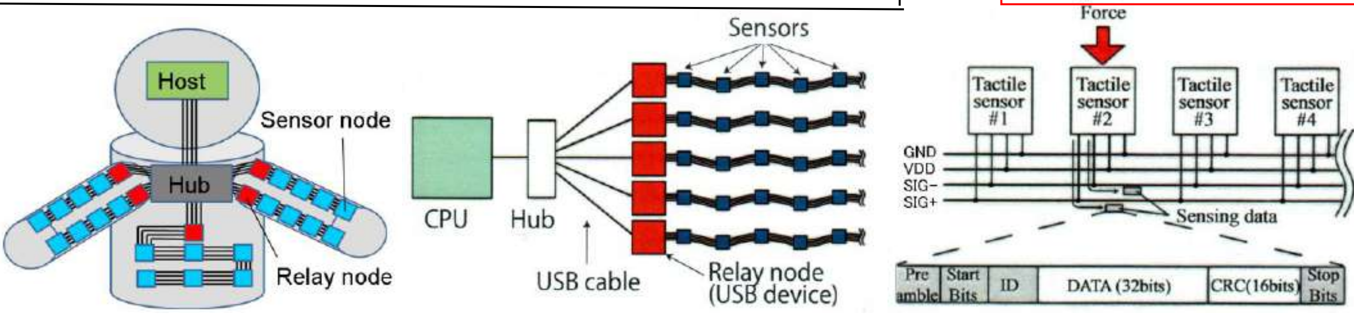
(Special Coordination Funds for Promoting Science and Technology, Formation of Innovation Center for Fusion of Advanced Technologies)



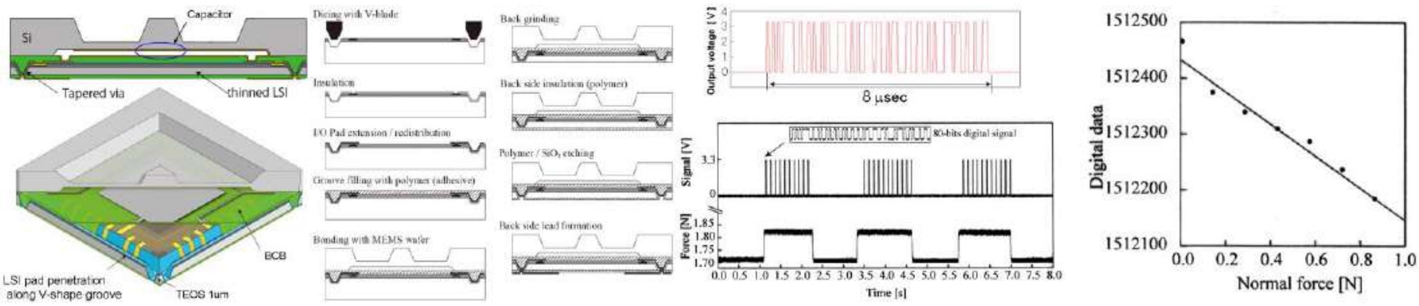


Bio LSI (Tohoku Univ. Matsue)



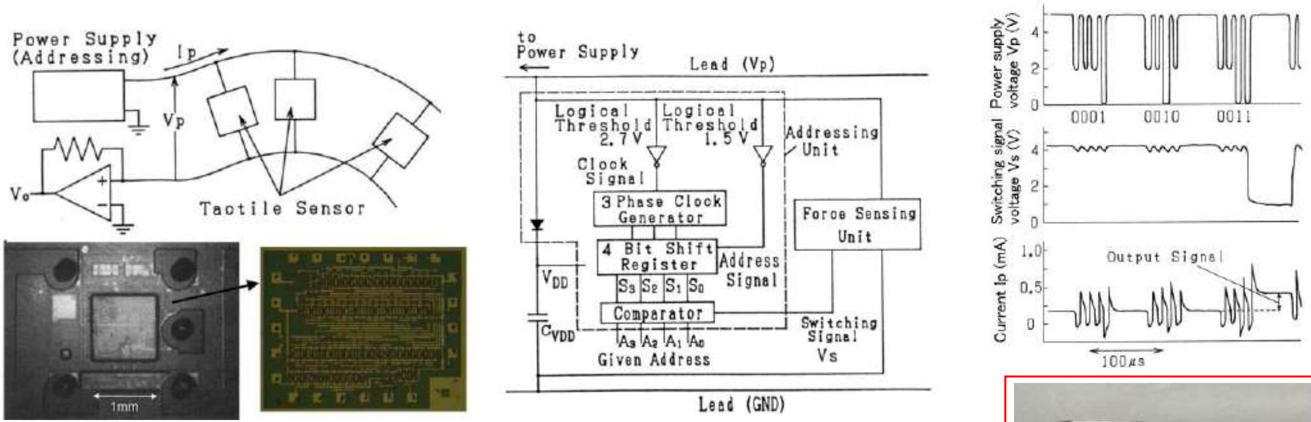


Event driven type tactile sensor network for nursing care robot (Tohoku Univ. – Toyota Motor – Toyota Central Research Laboratory)



Tactile sensor for robot skin (Tohoku Univ. – Toyota Motor – Toyota Central Research Laboratory)

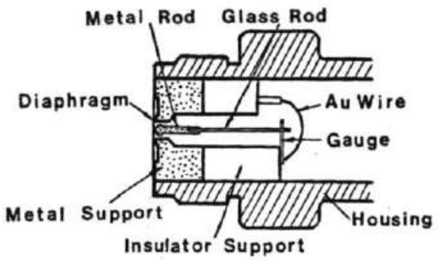
Reference : M.Muroyama, M.Makihata, Y.Nakano, S.Matsuzaki, H.Yamada, Ui.Yamaguchi, T.Nakayama, H.Nonomura, M.Fujiyoshi, S.Tanaka and M.Esashi, Development of an LSI for Tactile Sensor Systems on the Whole-Body of Robots, Trans. IEE of Japan, 131-E (2011) pp.302-309

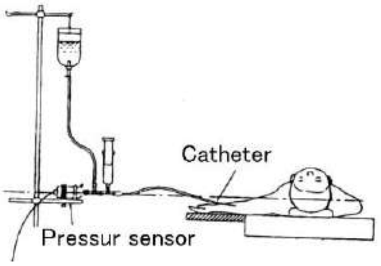


Tactile sensor network with polling type common 2-wire

Reference : S.Kobayashi, T.Mitsui, S.Shoji and M.Esashi, Two-Lead Tactile Sensor Array Using Piezo-resistive Effect of MOS Transistor, Technical Digest of the 9th Sensor Symposium (1990) pp.137-140

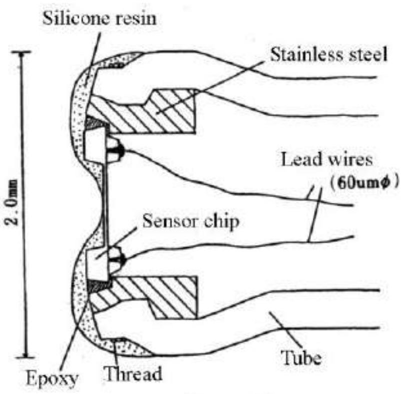
D10 Catheter blood pressure sensor

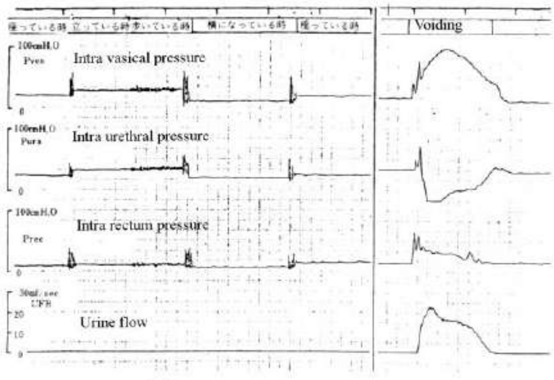


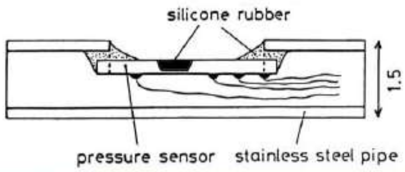


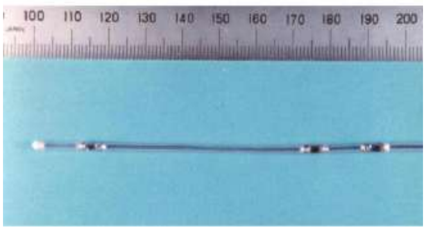
Blood pressure transducer with liquid filled catheter (Nihon Kohden – Tohoku Univ.)

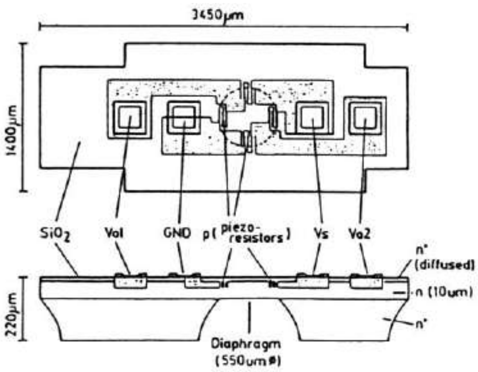
Reference : H.Ozawa, T.Shibuya, S.Takeda, M.Hyogo, T.Sekiguchi and M.Esashi, Property Improvement of Blood Pressure Transducers, 25th Convention of ME&BE, 3-PF-3 (1986)

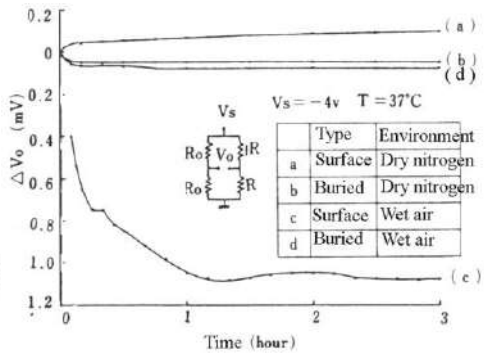






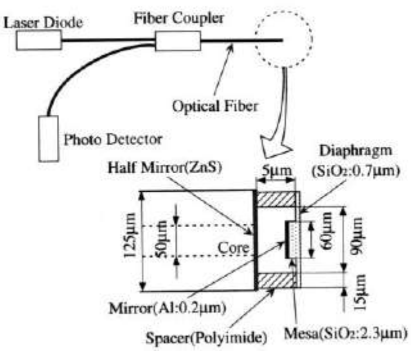


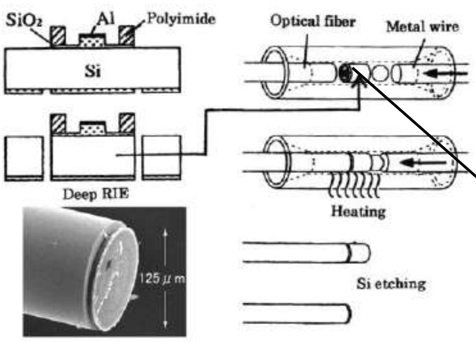


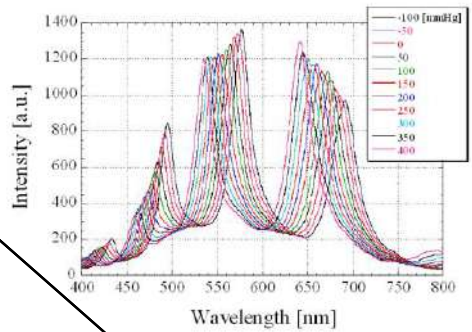


Piezoresistive multi pressure sensor catheter (Tohoku Univ. – Nihon Kohden)

Reference : M.Esashi, H.Komatsu, T.Matsuo, M.Takahashi, T.Takishima, K.Imabayashi and H.Ozawa, Fabrication of Catheter-tip and Sidewall Miniature Pressure Sensors, IEEE Trans. on Electron Devices, ED-29 (1982) pp.57-63



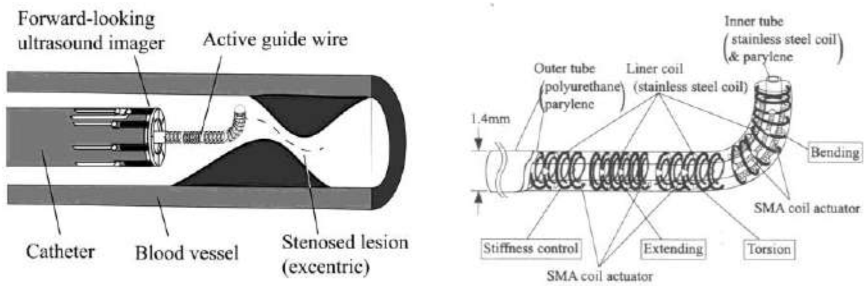


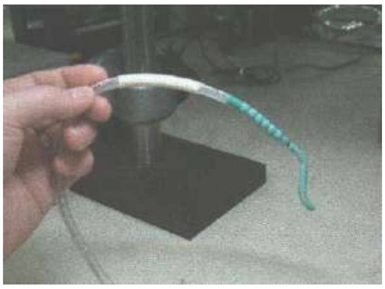


Small diameter fiber optic blood pressure sensor

Reference : T.Katsumata, Y.Haga, K.Minami and M.Esashi Micromachined, 125 μm Diameter Ultra Miniature Fiber-Optic Pressure Sensor for Catheter, Trans. IEE of Japan, 120-E (2000) pp.58-63

D11 Active catheter

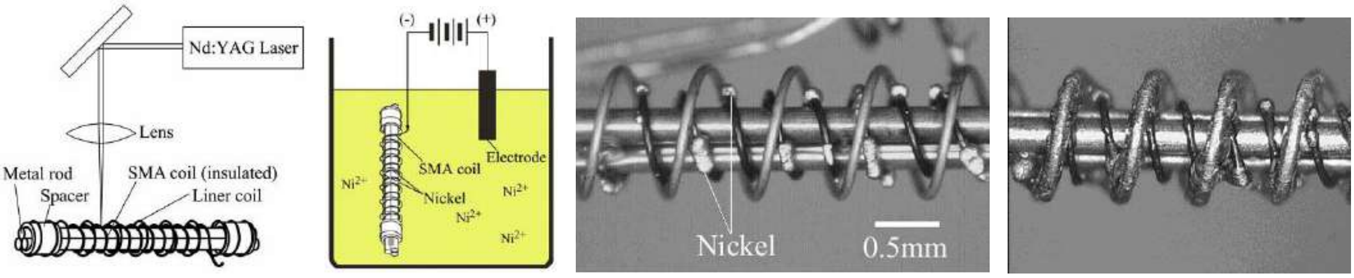




Concept of multifunction active catheter

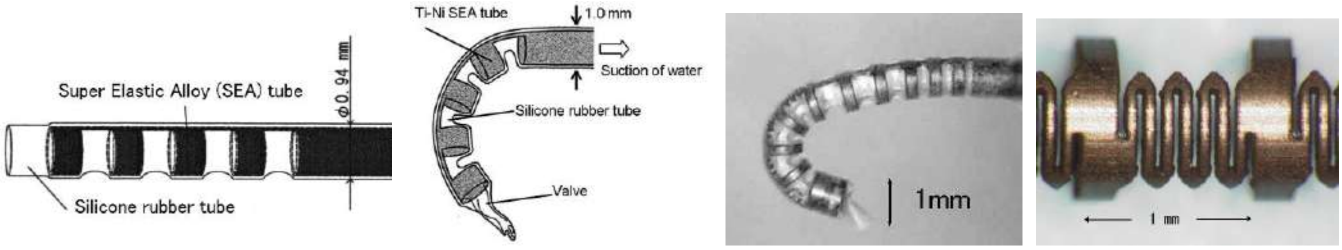
Active ileus tube

Reference : Y.Haga and M.Esashi, Biomedical Microsystems for Minimally Invasive Diagnosis and Treatment, Proc. of the IEEE, 92 (2004) pp.98-114



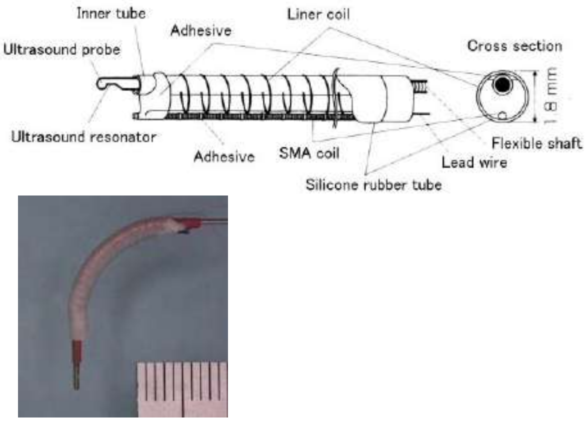
Assembly of multi-function active catheter using Shape Memory Alloy (SMA)

Reference : Y.Haga, M.Esashi, Assembly of Bending, Torsional and Extending Active Catheter Using Electroplating, Trans. IEE of Japan, 120-E (2000) pp.515-520



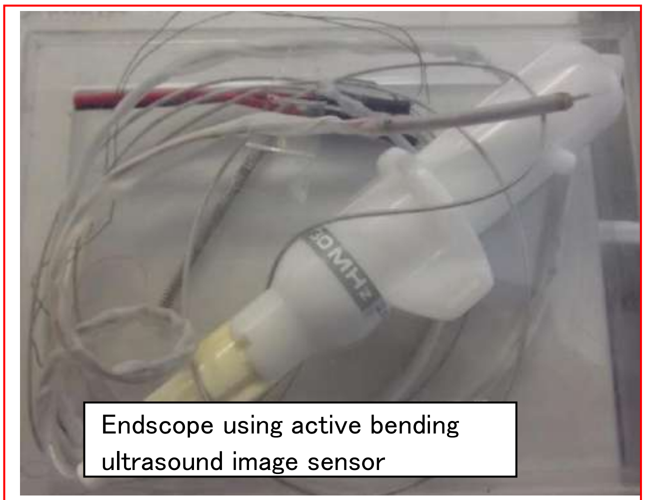
Suction type active catheter

Reference : Y.Muyari, Y.Mineta, T.Mineta and M.Esashi, Development of Hydraulic Suction Type Active Catheter Using Super Elastic Alloy Tube, Proc. of the 20th Sensor Symposium (2003) pp.57-60



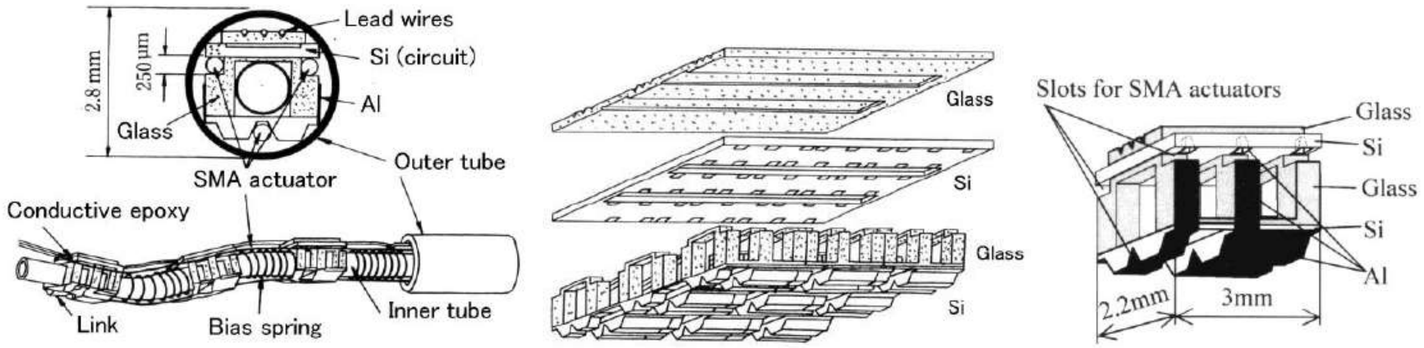
Small diameter ultrasound image sensor with active bending mechanism using SMA

Reference : Y.Haga, Y.Tanahashi and M.Esashi, Small Diameter Active Catheter Using Shape Memory Alloy, Proc. of IEEE MEMS'98 (1998) pp.419-424



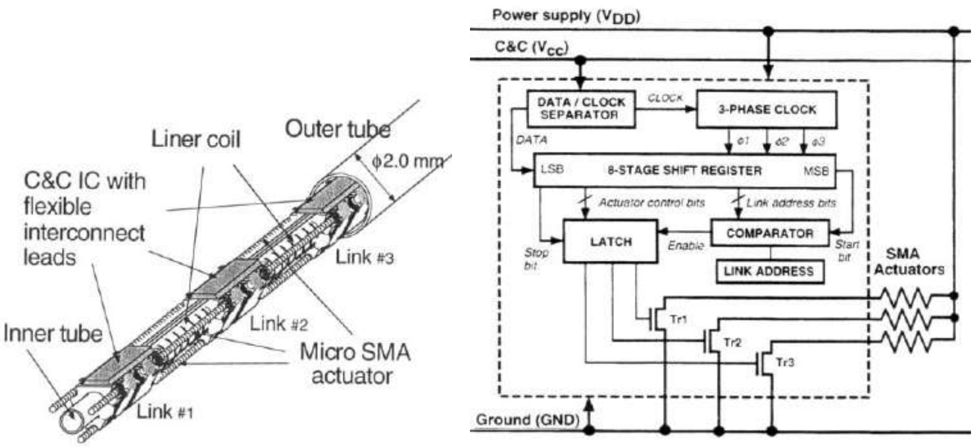
Endscope using active bending ultrasound image sensor

D12 Multi-link motion mechanism using shape memory alloy



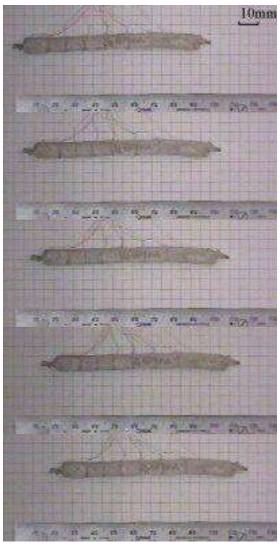
Multi-link Active Catheter using Shape Memory Alloy (SMA)

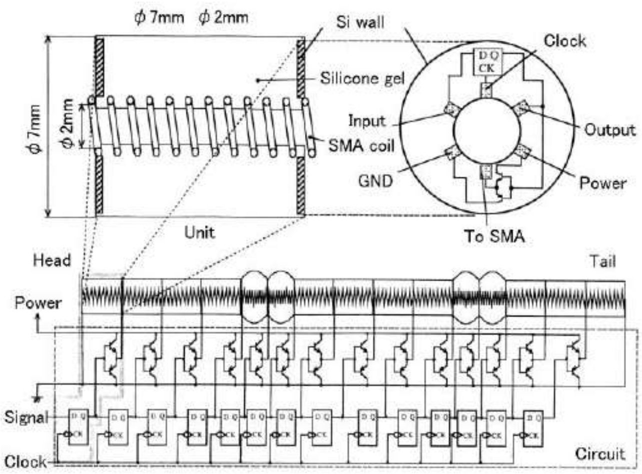
Reference : G.Lim, K.Minami, K.Yamamoto, M.Sugihara, M.Uchiyama and M.Esashi, Multi-link Active Catheter Snake-Like Motion, Robotica, 14 (1996) pp.499-506

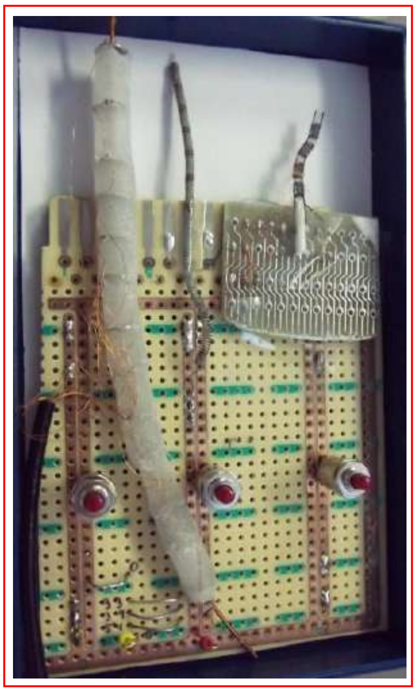


Multilink active catheter with common 2-wire integrated CMOS communication control circuits

Reference : K.-T.Park and M.Esashi, A Multilink Active Catheter with Polyimide-Based Integrated CMOS Interface Circuits, IEEE J. of Microelectromechanical Systems, 8 (1999) pp.349-357



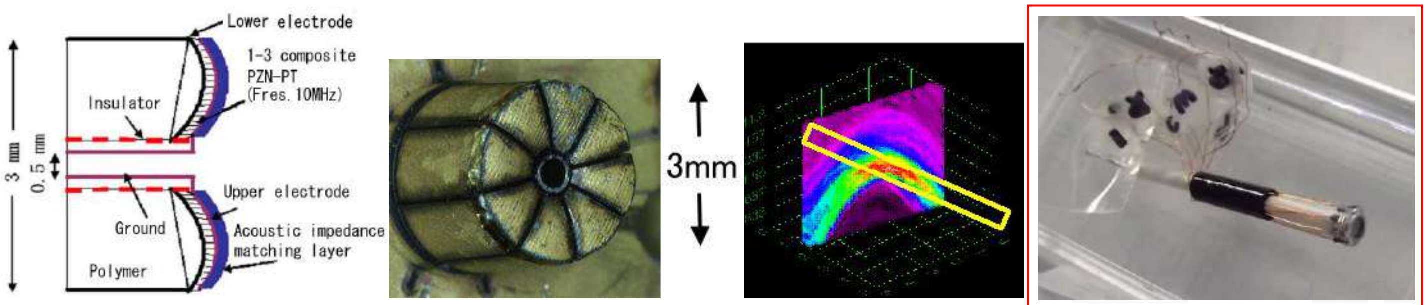




Peristaltic Motion System (Artificial earthworm)

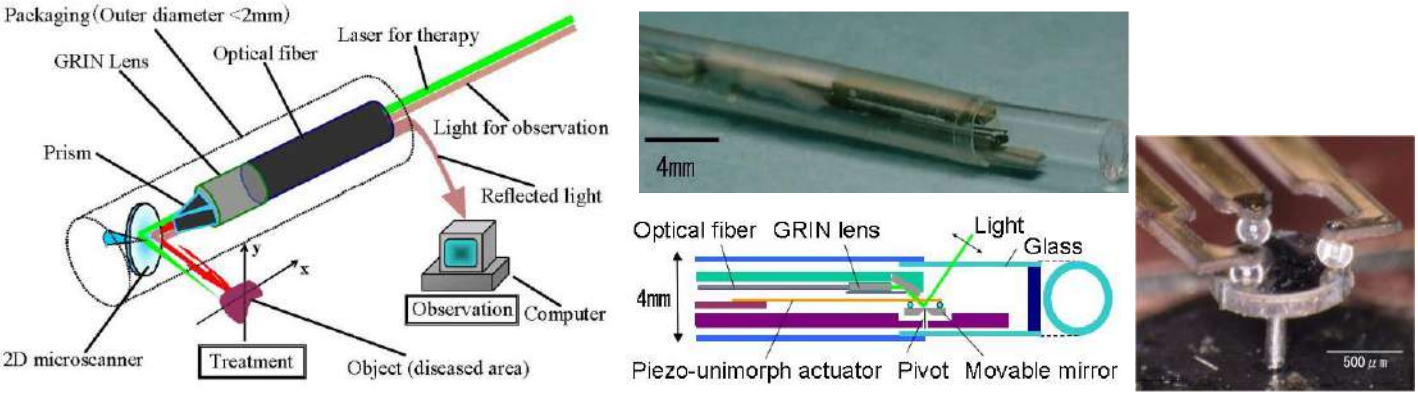
Reference : E.Shinohara, K.Minami and M.Esashi, Peristaltic Motion System Like Earthworm, Trans. IEE of Japan,119-E (1999) pp.334-339

Imaging for minimal invasive medicine



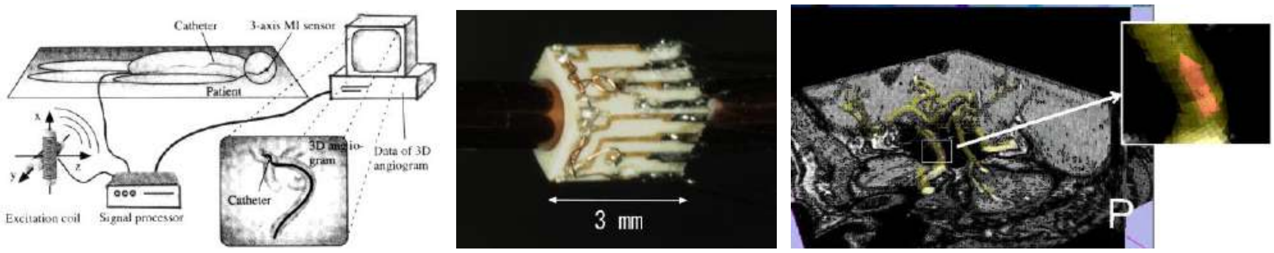
Forward looking ultrasound imager

Reference : J.-J.Chen, M.Esashi, O.Osato, K.Chihara, Y.Haga, Development of a Forward -looking Ultrasound Imager for Intravascular Treatment, Trans. of the Japanese Soc. For Medical and Biological Engng., 43 (2006) pp.553-559



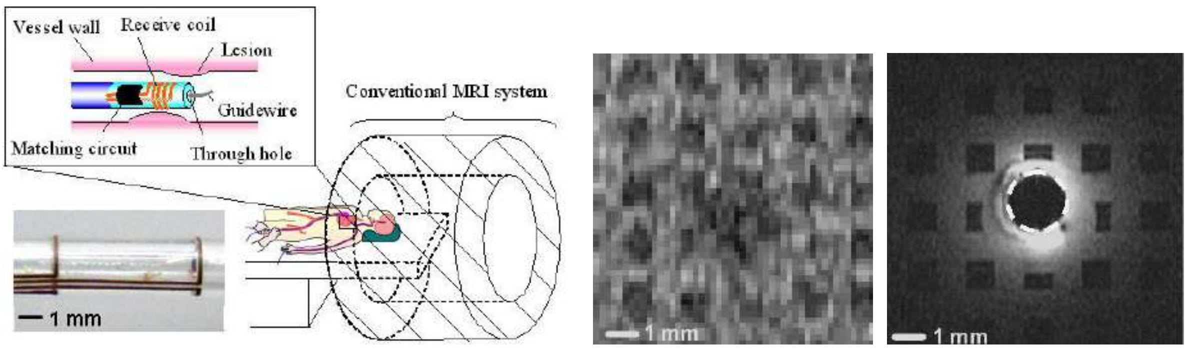
Optical scanner endoscope

Reference : H.Akahori, H.Wada, M.Esashi and Y.Haga, Tube Shape Piezoelectric 2D Microscanner for Minimally Invasive Laser Treatment, Technical Digest MEMS'2005 (2005) pp.76-79



Display system of position and direction for catheter tip using 3-axis magnetic sensor

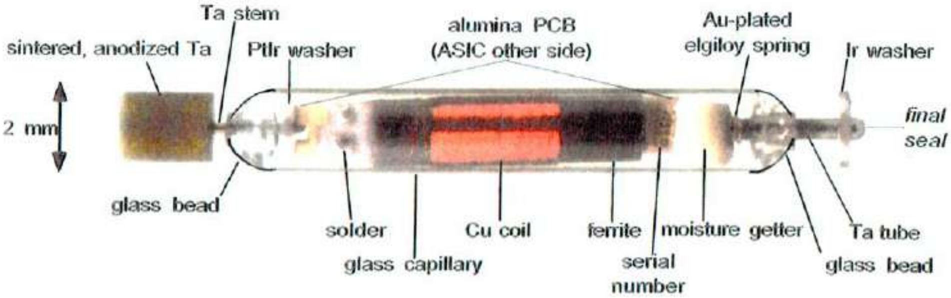
Reference : K.Totsu, Y.Haga and M.Esashi, Three-axis Magneto-impedance Effect Sensor System for Detecting Position and Orientation of Catheter Tip, Sensors and Actuators, A 111 (2004) pp.304-309

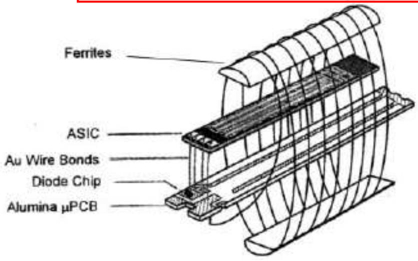


Receiving coil for MRI signal located at the catheter end

Reference : S.Goto, T.Matsunaga, Y.Matsuoka, K.Kuroda, M.Esashi and Y.Haga, Development of High-Resolution Intraluminal and Intravascular MRI Probe Using Microfabrication on Cylindrical Substrates, Tech. Digests of MEMS 2007 (2007) pp.329-332

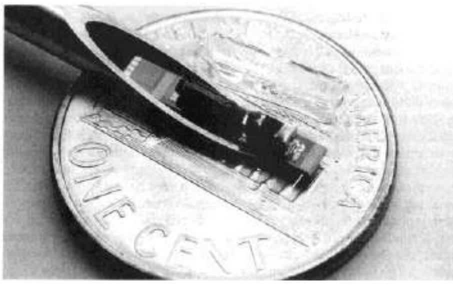
D14 Implantable stimulator

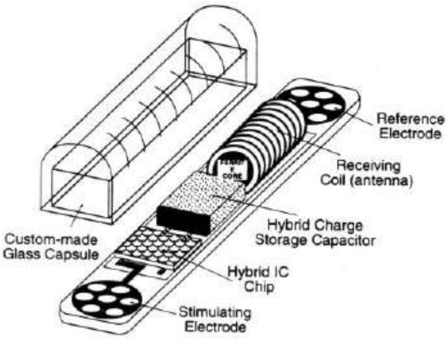


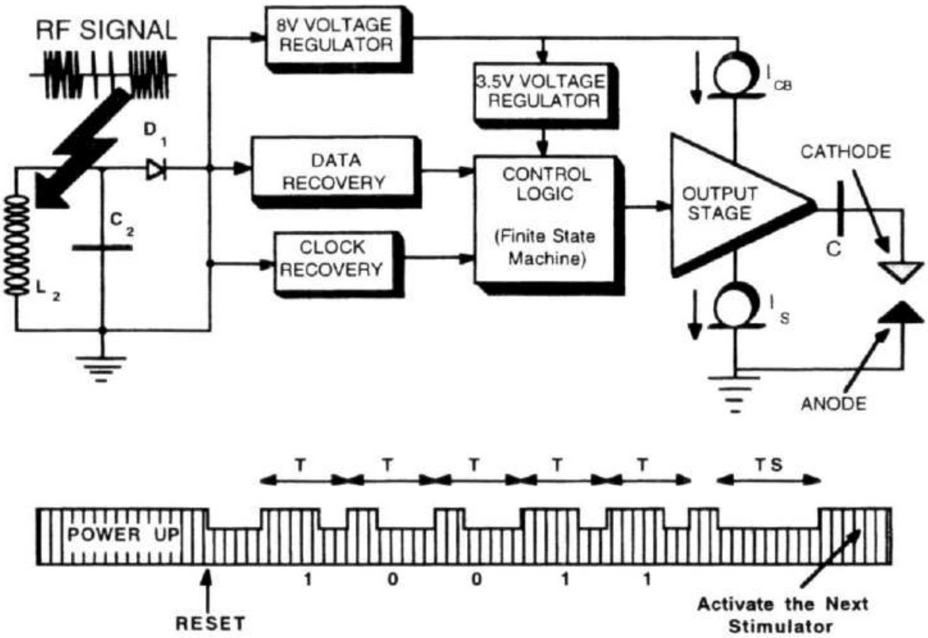


Implantable electrical stimulator BION (BIOnic Neuron) (Univ. of Southern California)

Reference : G.E.Loeb, F.J.R.Richmond, W.H.Moore and R.A.Peck, Design and Fabrication of Hermetic Microelectronic Implant, 1st Annual Internl. IEEE-EMBS Special Topic Conf. on Microtechnologies in Medicine & Biology (2000) pp.455-459

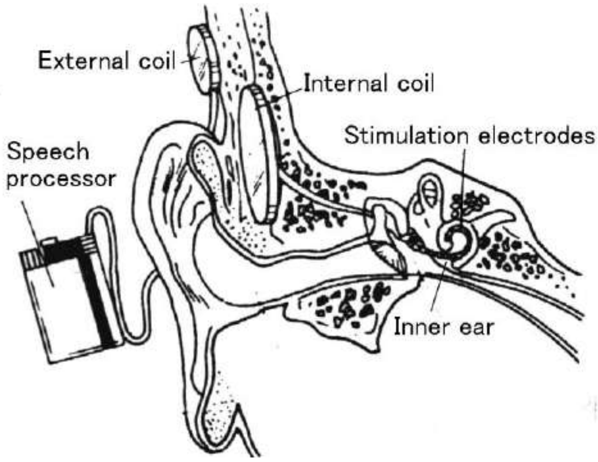






Implantable electrical stinulator (Univ. of Michigan)

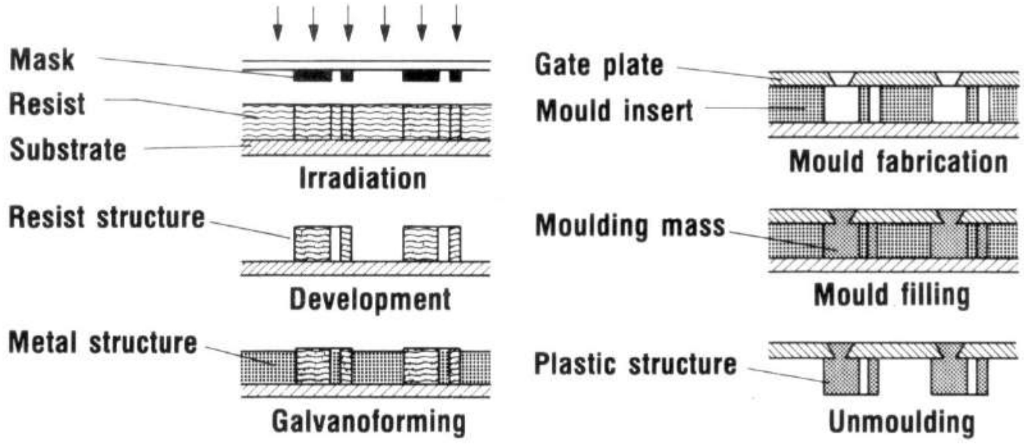
Reference : B.Ziaie, M.D.Nardin, A.R.Coghlan and K.Najafi : A single-channel implantable micro stimulator for functional neuromuscular stimulation, IEEE Trans. on Biomedical Eng., 44 (1997) pp.909-920



Cochlear implant (Cochlear (Australia))

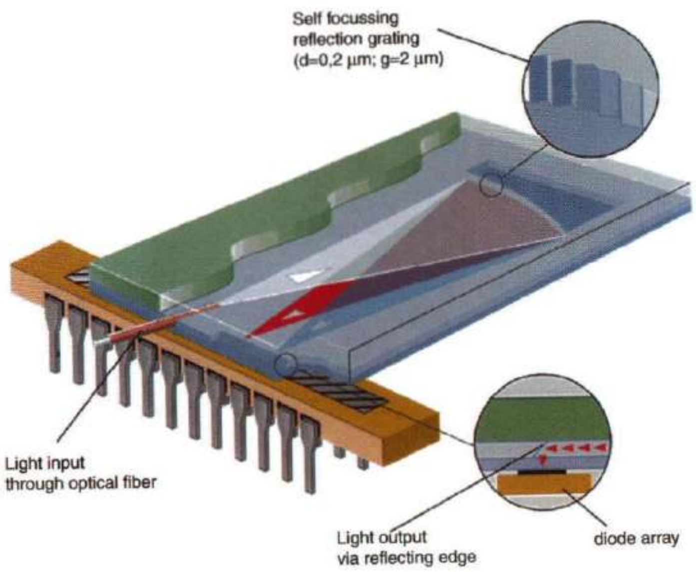
Reference : T.R,Gheewala, R.D.Melen and R.L.White : A CMOS implantable multielectrode auditory stimulator for the deaf, IEEE J. Solid-State Circuit, SC-10 (1975) pp.472-479

E1 LIGA process



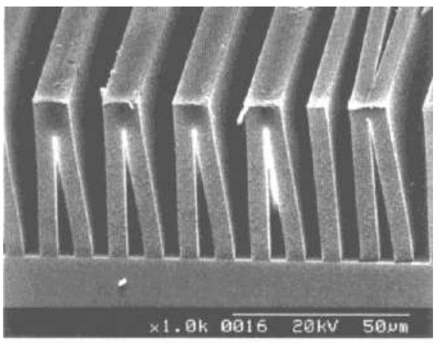
LIGA process by X ray exposure, electroplating and plastic molding (Germany)

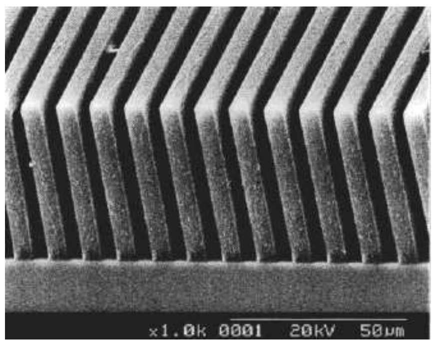
Reference : E.W.Becker, W.Ehrfeld, P.Hagmann, A.Maner and D.Munchmeyer, Fabrication of Microstructures with High Aspect Ratios and Great Structural Heights by Synchrotron Radiation Lithography, Galvanoforming, and Plastic Moulding (LIGA Process), Microelectronic Engineering, 4 (1986) pp.35–56



Micro spectrometer fabricated with LIGAprocess (Micro Parts, Germany)

Reference : Microspectrometer Fabricated by the LIGA Process, Interdisciplinary Science Review, 18 (1993) pp.273–279



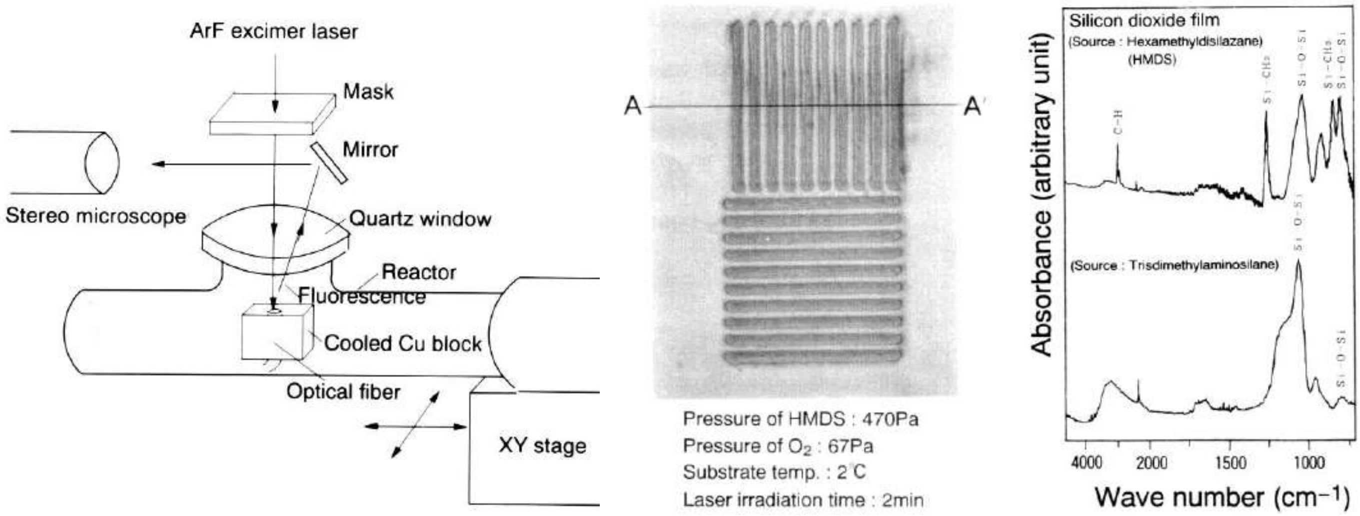


Synchrotron orbital radiation facility (SORTEC) Adhesion during drying Drying using low surface tension liquid

LIGA process using negative resist (THB-N1 (JSR) Ltd.) (Tohoku Univ. – SORTEC)

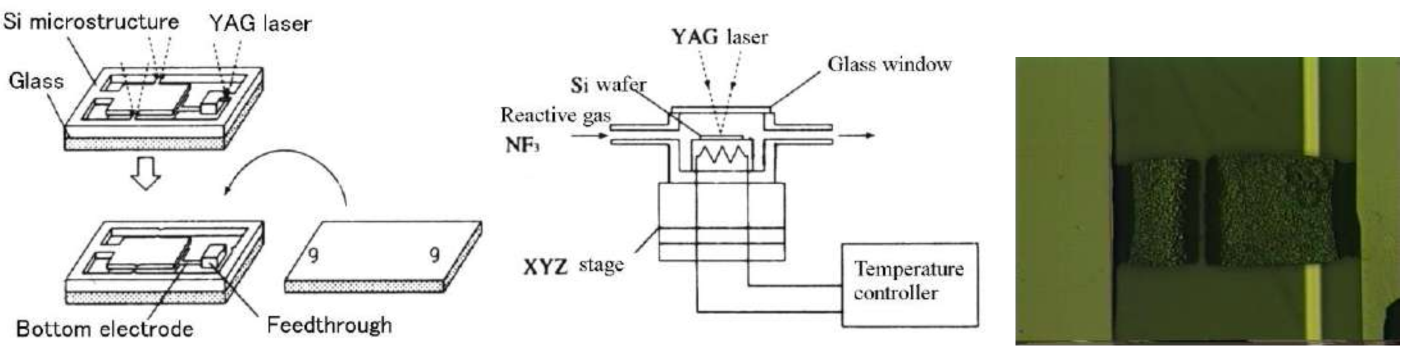
Reference : S.Watanabe, M.Esashi and Y.Yamashita, Fabrication Methods for High Aspect Ratio Microstructures, J.of Intelligent Material Systems and Structures, 8 (1997) pp.173–176

E2 # Laser processes and stealth dicing



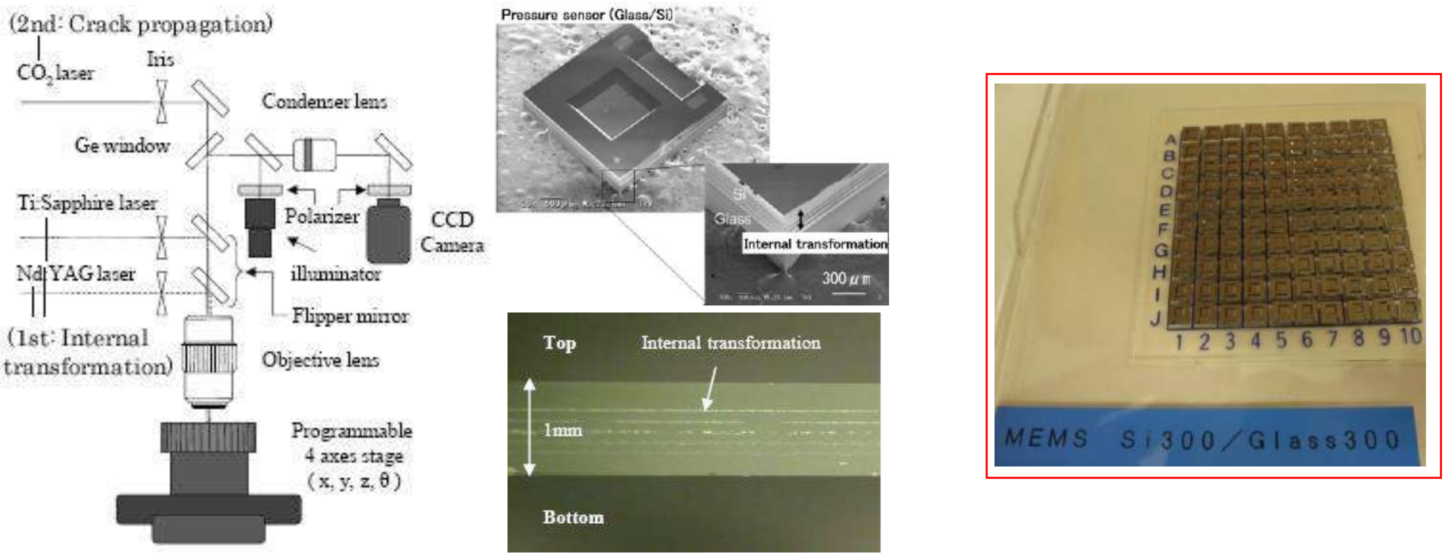
Laser projection CVD

Reference : K.Takashima, K.Minami, M.Esashi and J.Nishizawa, Laser Projection CVD Using the Low Temperature Condensation Method, Applied Surface Science, 79/80 (1994) pp.366–374



Laser assisted Si etching

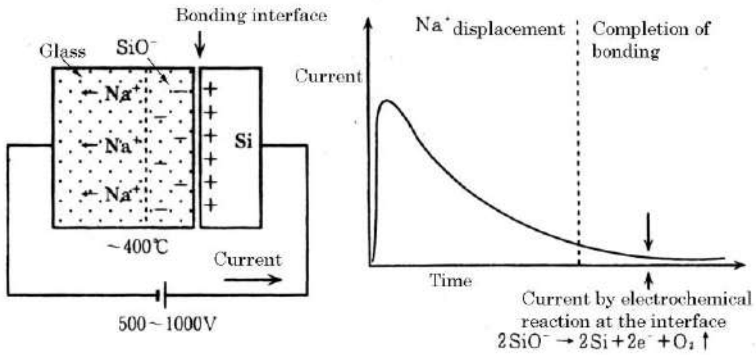
Reference : K.Minami, Y.Wakabayashi, M.Yoshida, K.Watanabe and M.Esashi, YAG Laser-Assisted Etching of Silicon for Fabricating Sensors and Actuators, J. of Micromechanics and Microengineering, 3 (1993) pp.81–86



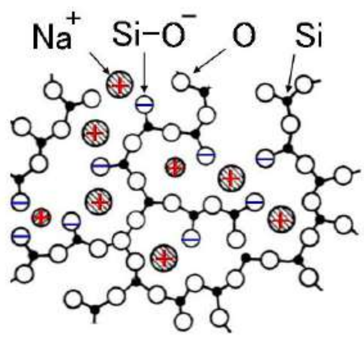
Laser (stealth) dicing of Si-glass structure (Tohoku Univ. – Inst. For Laser Tech.)

Reference : M.Fujita, Y.Izawa, Y.Tsurumi, S.Tanaka, H.Fukushi, K.Sueda, Y.Nakata, M.Esashi and N.Miyanaga , Debris-free Low-stress High-speed Laser Assisted Dicing for Multi-layered MEMS, Trans. IEE of Japan, 130-E (2010) pp.118–123

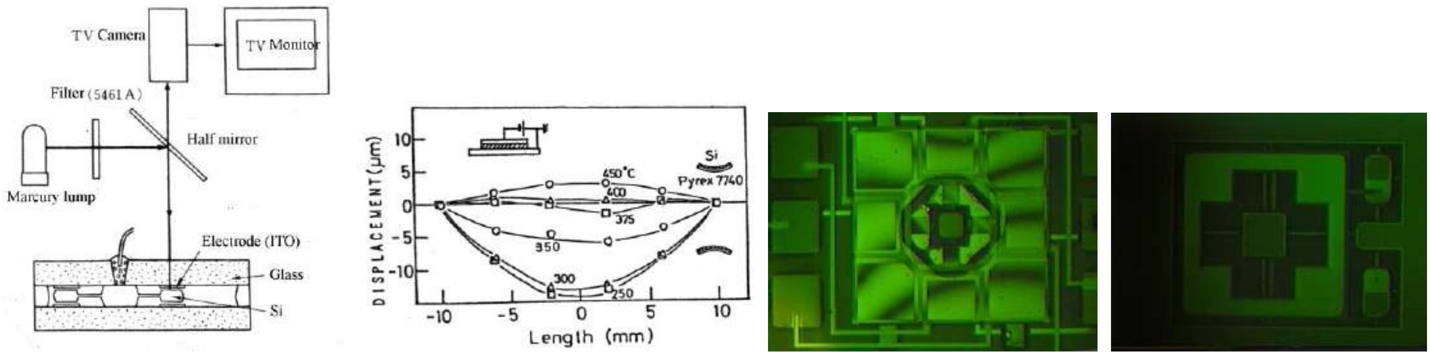
E3 Anodic bonding



Principle of anodic bonding

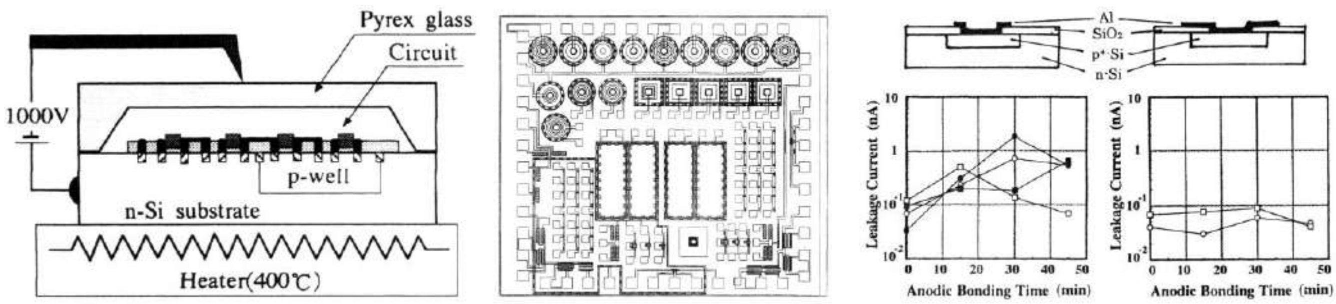


Molecular structure of glass



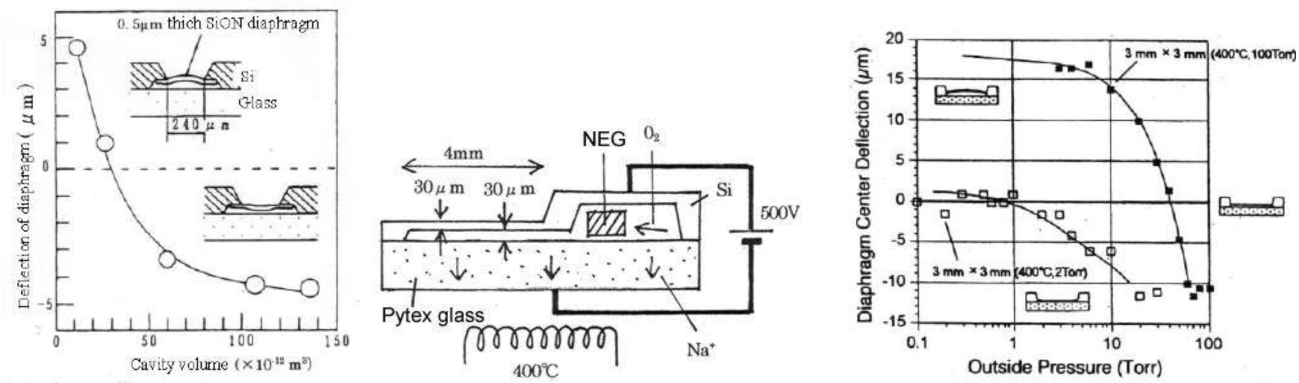
Distortion after anodic bonding

Reference : Y.Shoji, K.Minami, M.Esashi, Glass-silicon Anodic Bonding for the Reduction of Structural Distortion, Trans. IEE of Japan, 115-A (1995) pp.1208-1213



Influences of anodic bonding to CMOS circuit

Reference : M.Shirai, M.Esashi, Circuit Damage by Anodic Bonding, Technical Report IEE of Japan, ST-92-7 (1992) pp.9-17

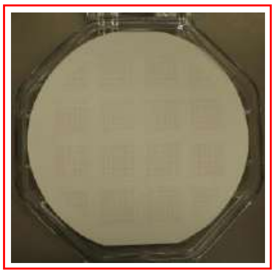


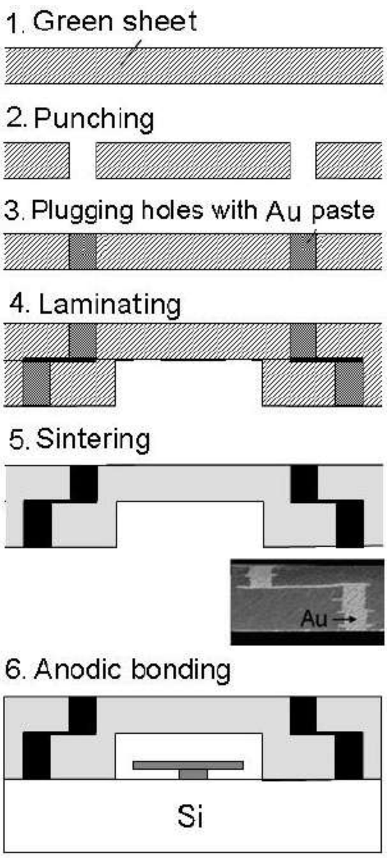
Vacuum packaging and pressure controlled packaging (right) by anodic bonding

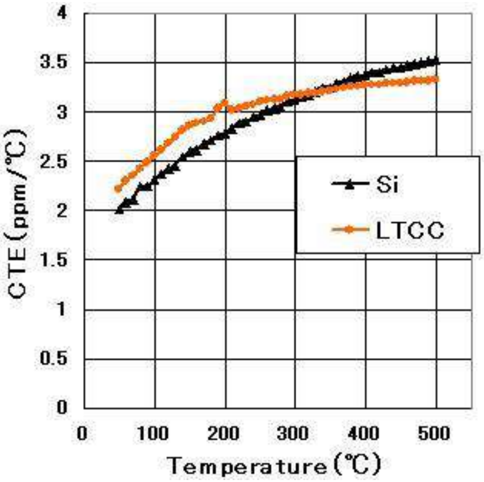
Reference : N.Ura, K.Nakaichi, K.Minami, M.Esashi, Vacuum Packaging by Anodic Bonding, The 11th Sensor Symposium (1992) p.63

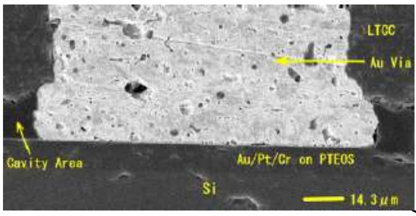
M.Esashi, Vacuum Packaging Technology for Microsensors, Trans. IEE of Japan, 120-E (2000) pp.310-314

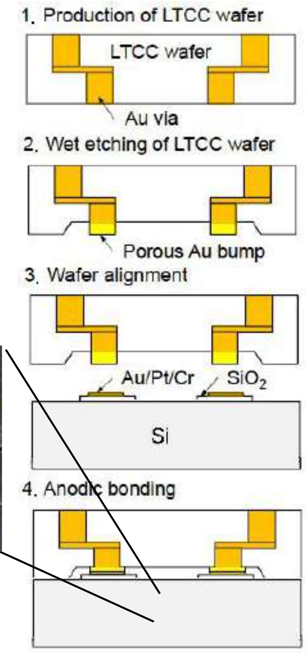
E4 Anodically bondable LTCC with electrical feedthrough (Nikko)





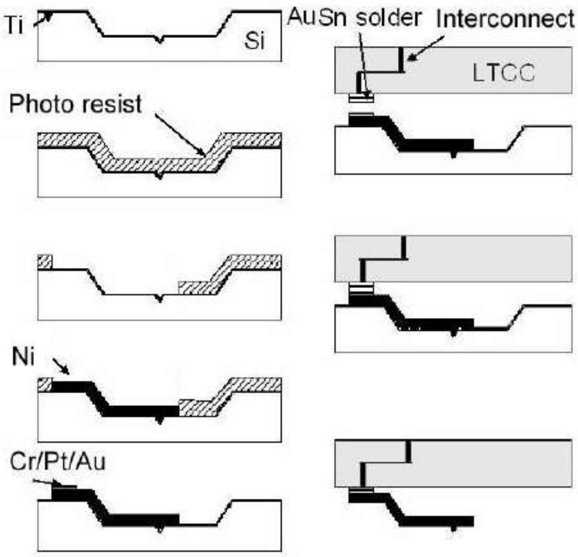


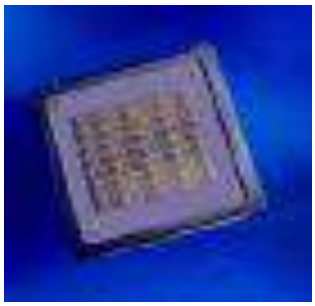




Anodically bondable LTCC (Low Temperature Co-fired Ceramics) with electrical feedthrough and electrical interconnection using porous gold (Nikko – Tohoku Univ.)

Reference : M.Mohri, A.Okada, H.Fukushi, M.Esashi and S.Tanaka, Packaging Technology for Hermetic Sealing with Electrical Connection Using Anodically-Bondable LTCC Substrate with Etched Cavities, The 28th Sensor Symposium on Sensors, Micromachines and Applied Systems (2011) p.62

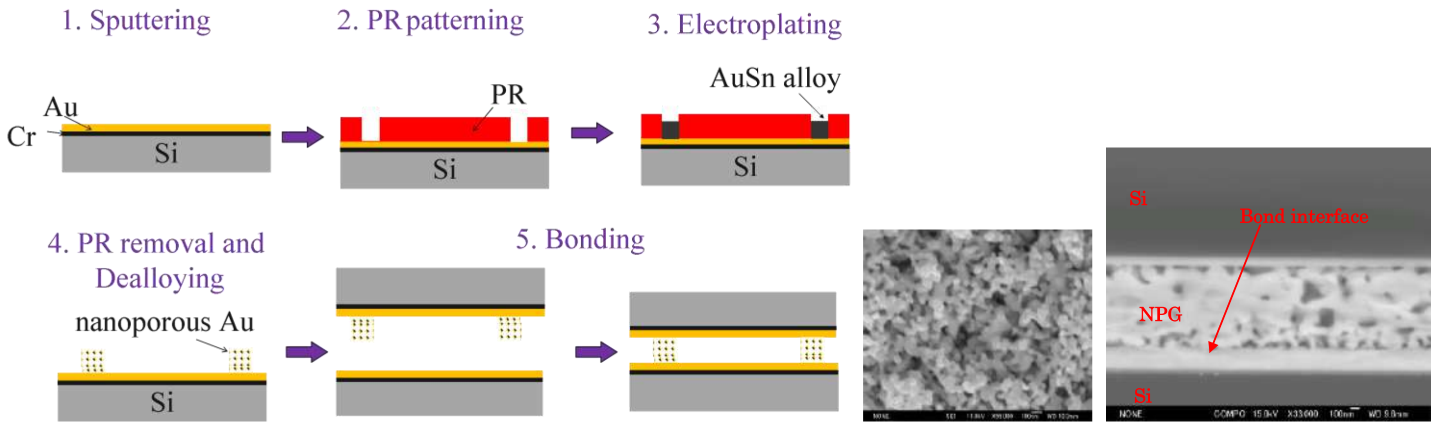




Probe card using LTCC for wafer-level burn-in test

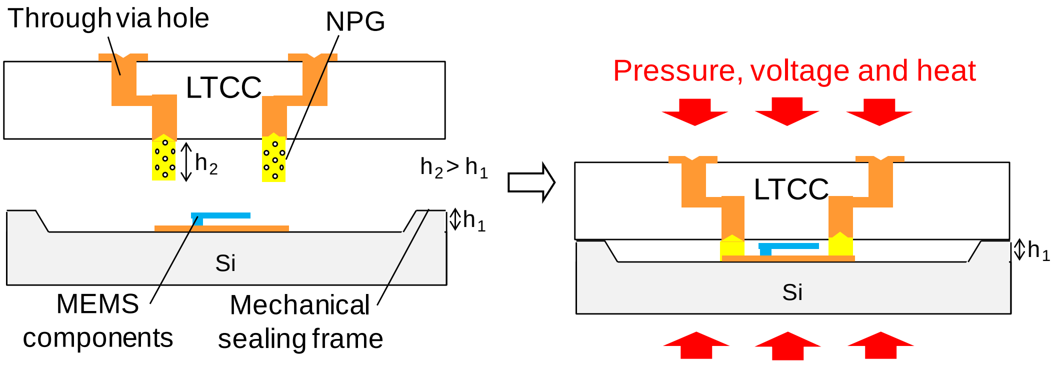
Reference : S.-H.Choe, S.Tanaka and M.Esashi, A Matched Expansion MEMS Probe Card with Low CTE LTCC Substrate, IEEE International Test Conference 2007 (2007) Paper 20.2

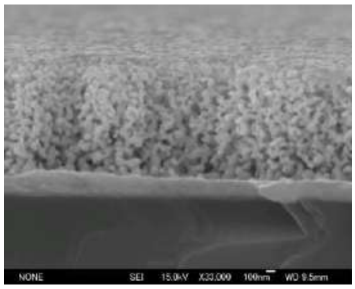
E5 Bonding materials (WPI-AIMR, Fraunhofer ENAS – Tohoku University)



Nanoporous gold (NPG) for low temperature substrate bonding

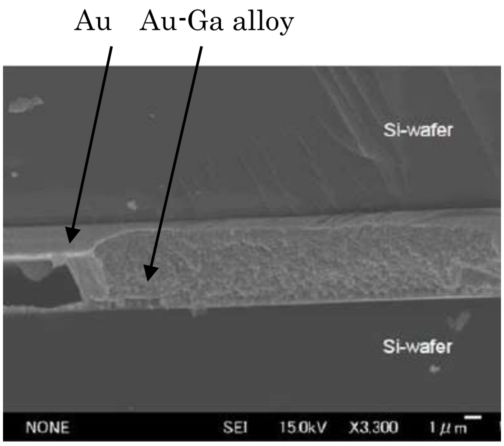
Reference : W. –S. Wang, Y. –C. Lin, L. Y. Chen, M. W. Chen, T. Gessner and M. Esashi, Demonstration of Substrate Bonding utilizing Au Film and Nanoporous Gold Structures, Proceedings of the International Conference on Wafer Bond ' 11, Dec. 7–8 (2011)

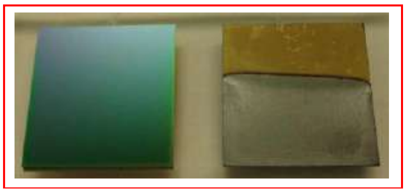




Electrical interconnection by using nano–sponge for MEMS packaging

Reference : Y. –C. Lin, W. –S. Wang, L. Y. Chen, M. W. Chen, T. Gessner and M. Esashi, Anodically–bondable LTCC substrates with Novel nano–structured electrical Interconnection for mems packaging, Proceedings of the international conference on solid–state sensors and actuators (Transducers ' 11), June 5–9 (2011) pp. 2351–2354





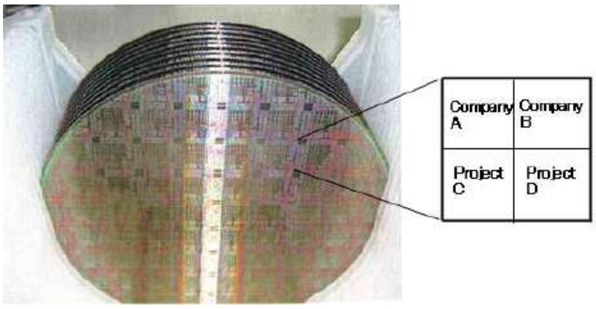
Left : Bonded wafer
Right : Ga is electroplated on the lower part

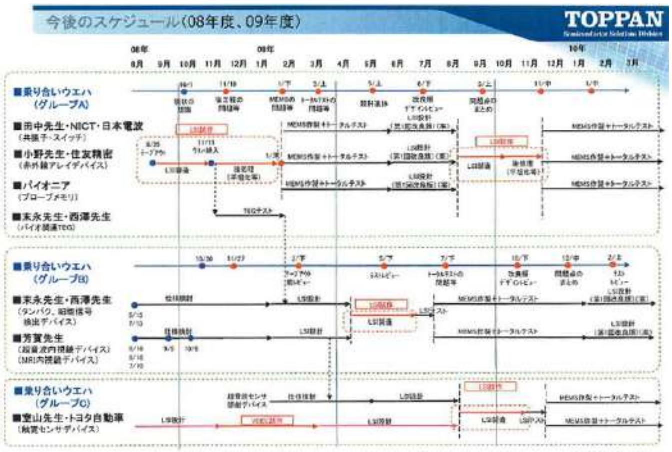
$GaCl_3$	gallium cloride
$C_6H_{15}NO_3$	triethanolamine
NaCl	sodium chloride
KOH	potassium hydroxide

Room temperature Ga SLID (Solid–Liquid Inter–Diffusion bonding) (left:bonding interface, right:electroplating)

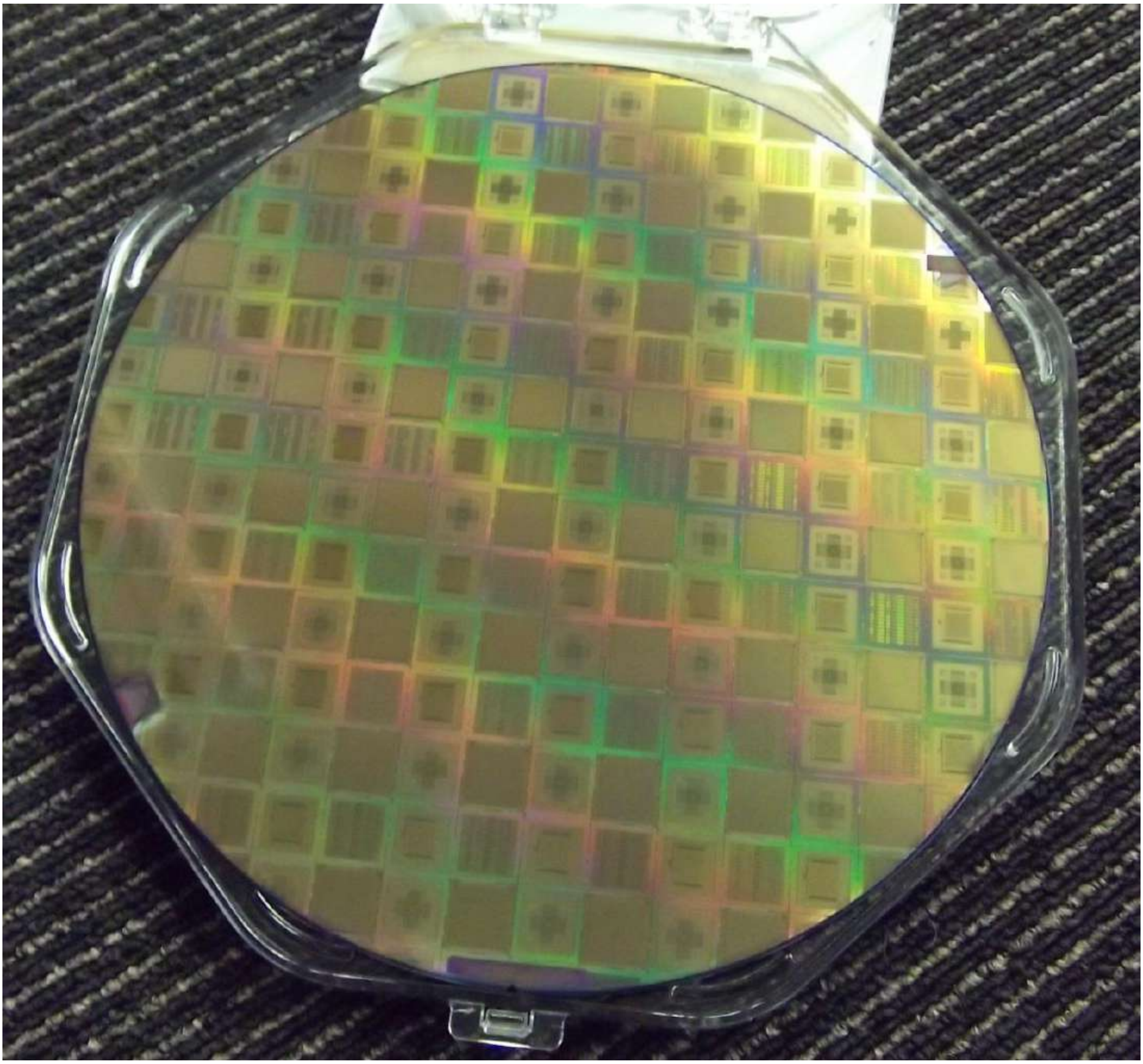
Reference : J.Frömel, Y.–C.Lin, M.Wiemer, T.Gessner and M.Esashi, Low Temperature Metal Interdiffusion Bonding for Micro Devices, 2012 3rd IEEE International Workshop on Low Temperature Bonding for 3D Integration (LTB–3D), Tokyo (2012, 22–23 May) 163)

E6 **Shared CMOS LSI wafer** (Special Coordination Funds for Promoting Science and Technology, Formation of Innovation Center for Fusion of Advanced Technologies)

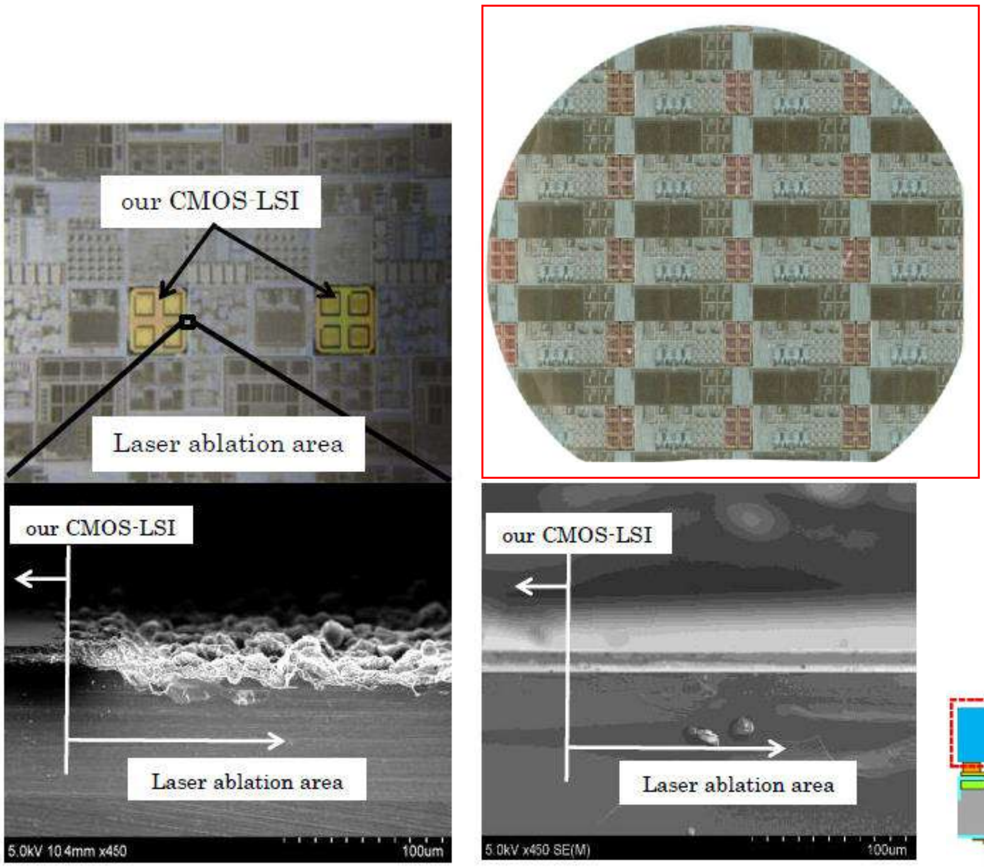


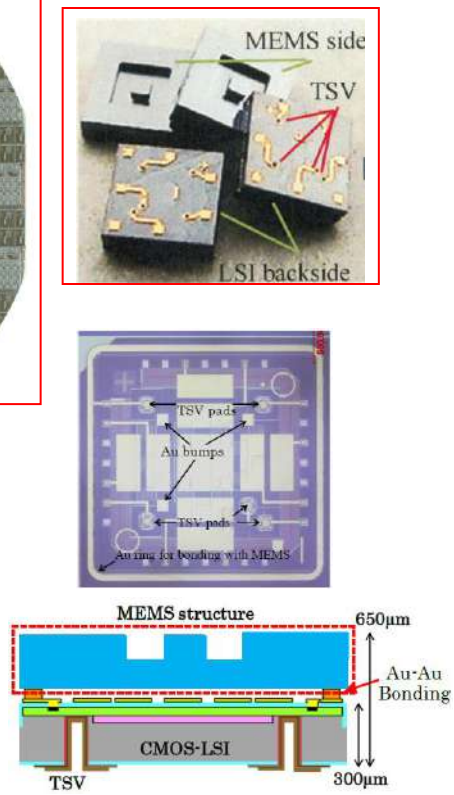


Shared CMOS wafer



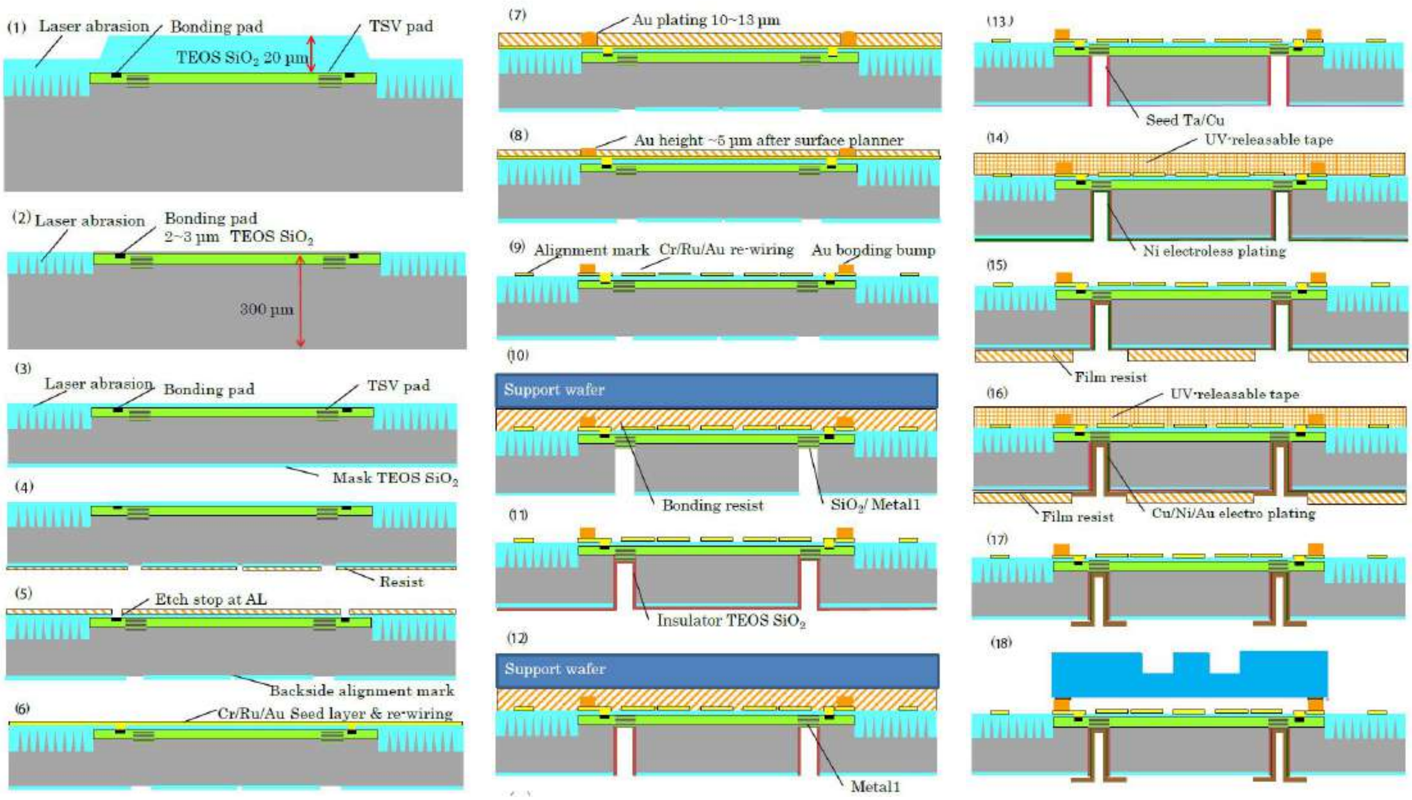
E7 Laser-erased wafer process





Multi project wafer in which other chips are erased by laser and process for making MEMS and TSV on the CMOSLSI wafer

Application to tactile sensor network chip

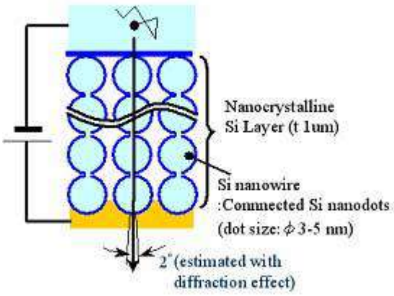


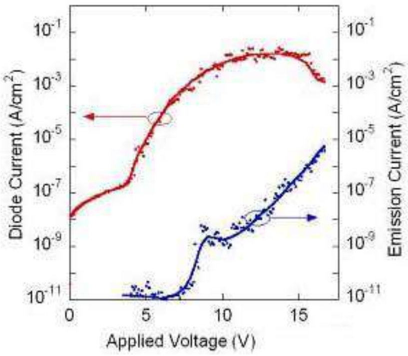
Fabrication process

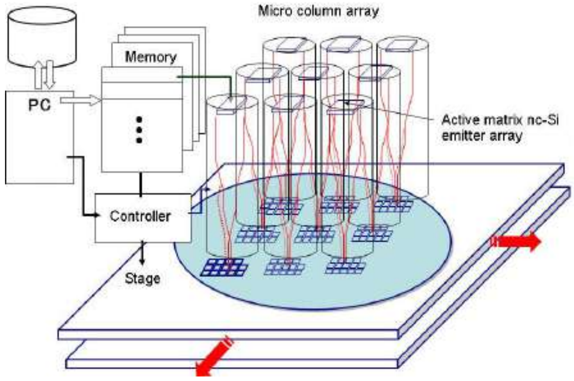
(Y.Suzuki, S.Tanaka et.al, Fabrication of Deep TSV in Laser-Erased CMOS-LSI Multi-project WAFER for Surface MountableIntegrated MEMS, Sensor Symp. 2016, 24pm2-B-6)

E8 Massive parallel electron beam write (MPEBW)

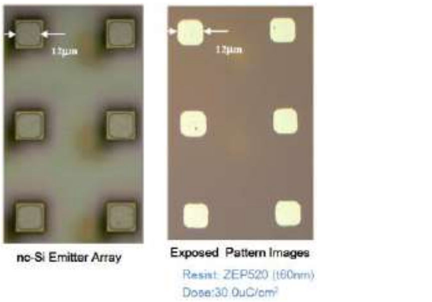
(Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST))



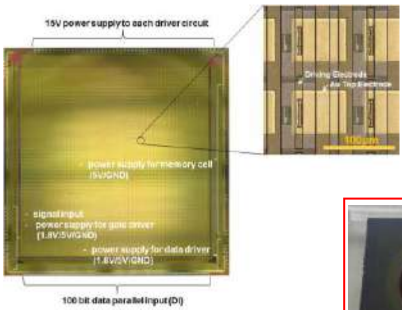




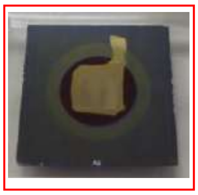
Principle of nano-crystalline (nc) Si emitter and concept of the electron beam exposure system using the nc-Si emitter



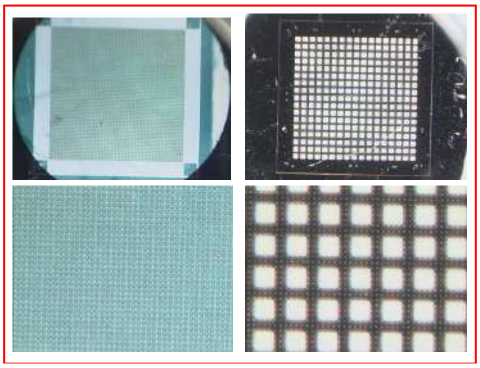
Planer type nc-Si emitter with through Si via and result of exposure



CMOS LSI for driving active matrix electron emitter

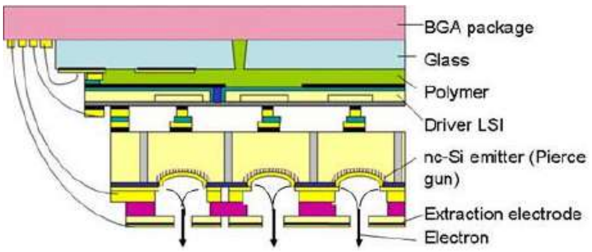


Nc-Si electron emitter

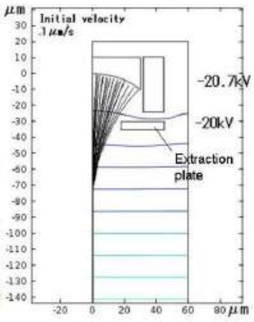


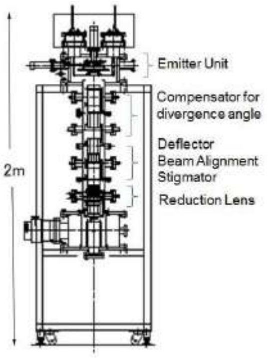
Electron emitter array
(left : front side、right : back side)
(top : chip、bottom : magnified)

N.Ikegami, T.Yoshida, A.Kojima, H.Ohyi, N.Koshida and M.Esashi., Active-Matrix nc-Si Electron Emitter Array for Massively Parallel Direct-Write Electron-Beam System, J. Micro/Nanolith. MEMS MOEMS 11, 3 (2012) 031406

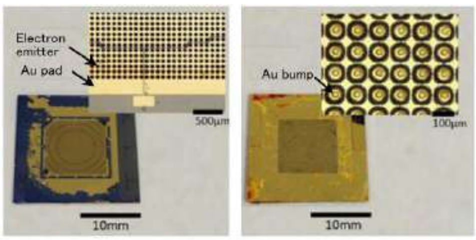


Experiment of electron emission driven by CMOS LSI

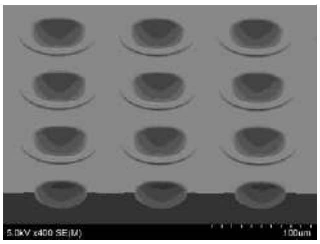




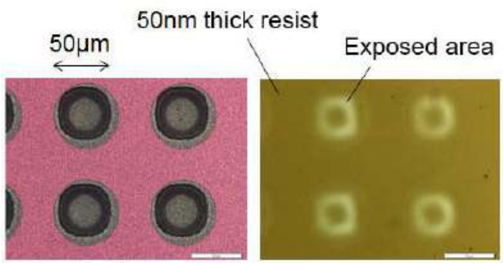
Fabrication of nc-Si emitter on CMOS LSI (under development)



nc-Si Pierce-gun emitter, emitter side (left), bump side (right)



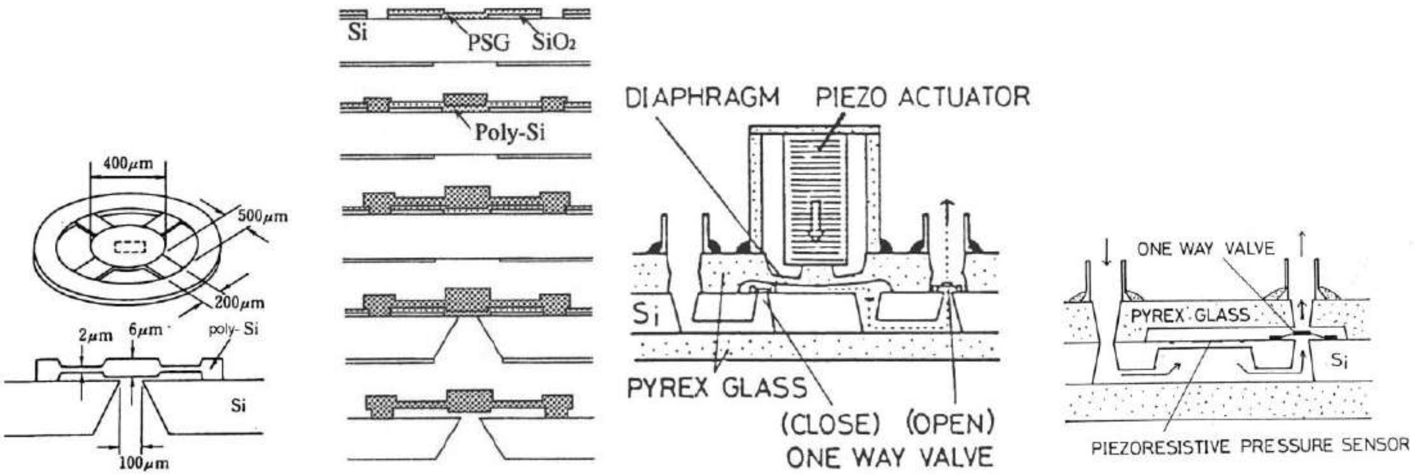
nc-Si Pierce-gun emitter



Exposure using nc-Si emitter

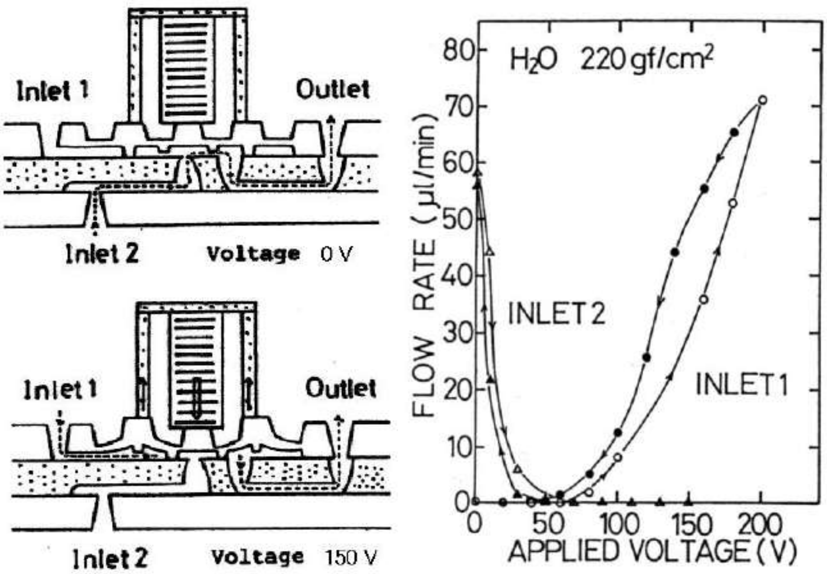
H.Nishino, S.Yoshino, S.Tanaka, M.Esashi, A.Kogima, N.Ikegami, N.Koshida, Basic study for fabrication of integrated Pierce-gun type area electron emitter for massive parallel electron beam exposure system, 2013 IEEJ convention, (2013/3/20 Nagoya) 3-127 (in Japanese)

Micro pump, micro valve and chemical analysis system for liquid

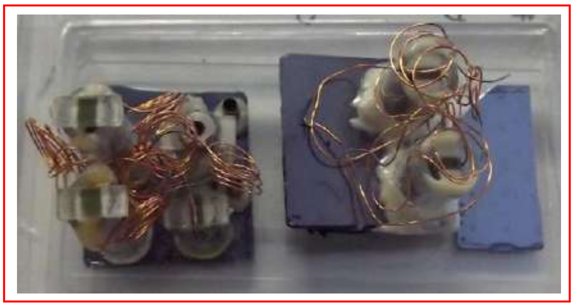


One-way valve, micro pump and flow sensor

Reference : S.Shoji, M.Esashi, Fabrication of a Micro-pump for Integrated Chemical Analysing Systems, Trans. ICIEC, J71-C (1988) pp.1705-1711

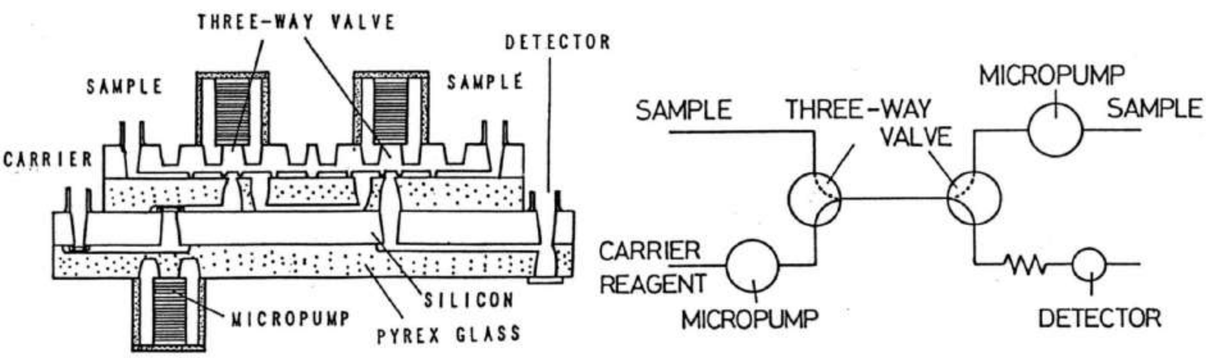


Tree-way valve



On-chip Flow-injection analysis system and micro pump

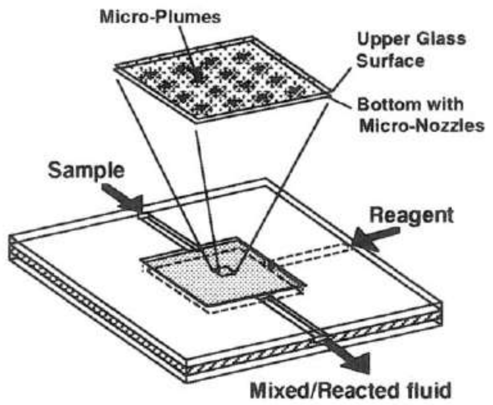
Reference : S.Shoji, S.Nakagawa and M.Esashi, Micropump and Sample-injector for Integrated Chemical Analyzing Systems, Sensors and Actuators, A21-A23 (1990) pp.189-192

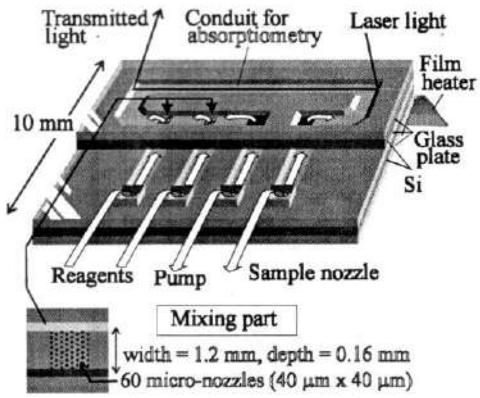


Flow injection analysis system integrated on a chip

Reference : S.Nakagawa, S.Shoji and M.Esashi, A Micro Chemical Analyzing System Integrated on a Silicon Wafer, Proc. of the Micro Electro Mechanical Systems'90 (1990) pp.89-94

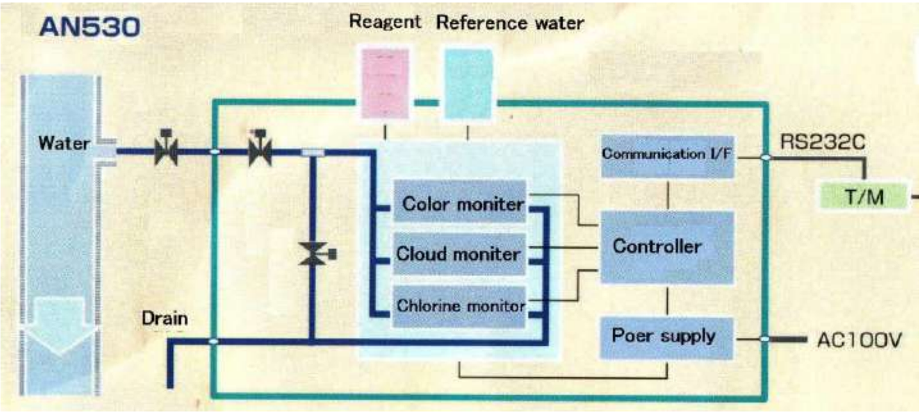
E10 Micro mixer and particle analysis (Hitachi)





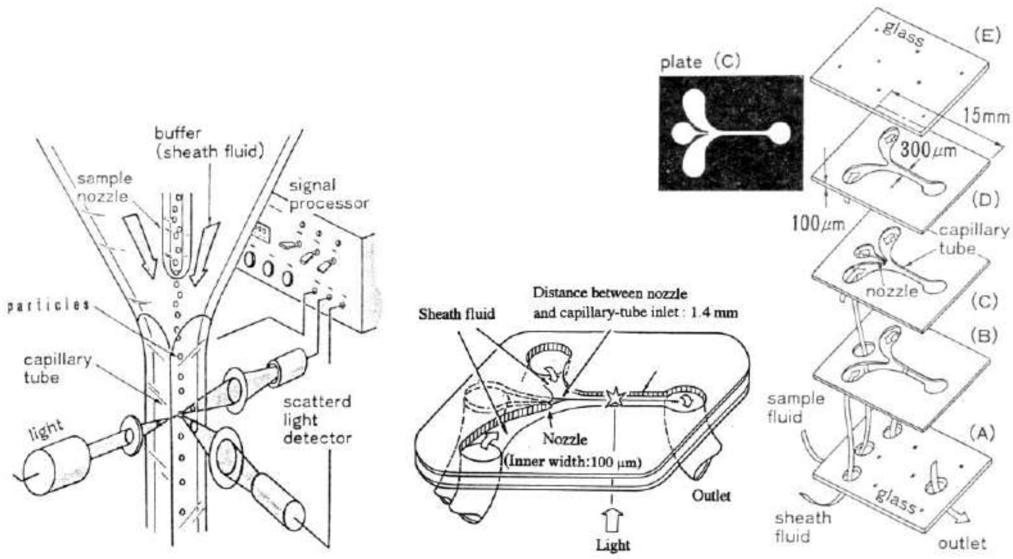
Absorptionmetric Micro-flowcellusing micro mixer

Reference : R.Miyake, K.Tsuzuki, T.Takagi, K.Imai, A Highly Sensitive and Small Flow-type Chemical Analysis System with Integrated Absorptionmetric Micro-flowcell, Trans. IEE of Japan, 117-E (1997) pp.147-154



Water-analysis system

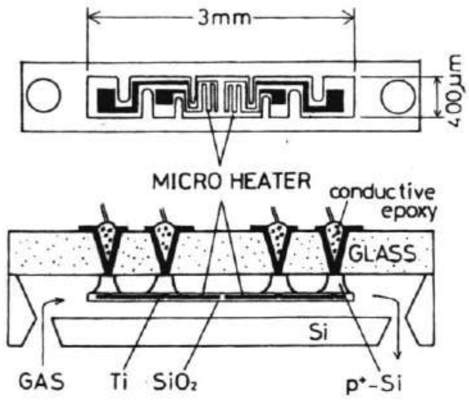
Reference : R.Miyake, H.Enoki, S.Mori, T.Ishihara, A Small Water-Analysis System with Micro-machined Flowcells, Technical Report IEE of Japan, CHS-00-7 (2000) pp.33-37

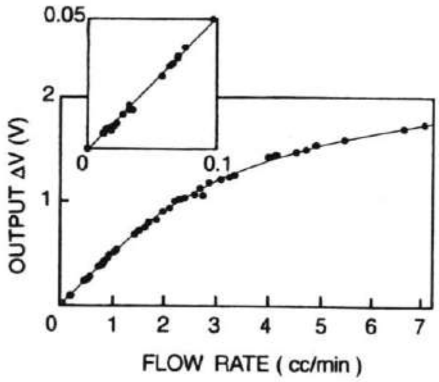


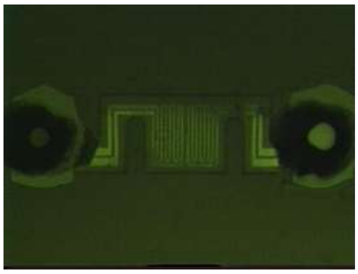
Micro sheath flow chamber for flow cytometer

Reference : R.Miyake, H.Ohki and I.Yamazaki, A Development of Micro Sheath Flow Chamber, Proc. of IEEE MEMS'91 (1991) pp.265-270

E11 Flow sensor and mass-flow controller for gas

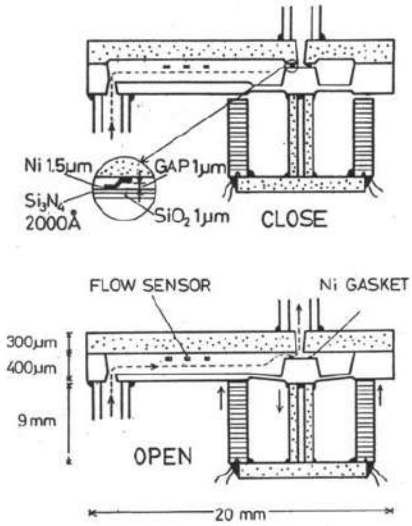


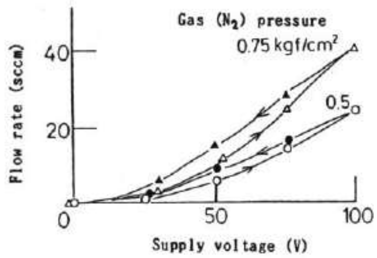


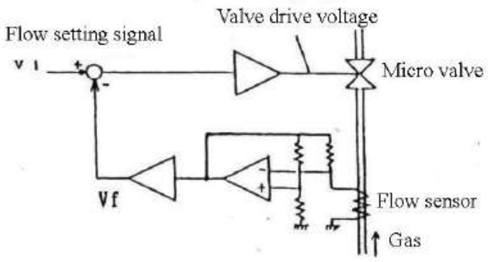


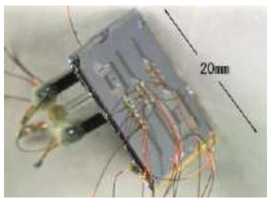
Thermal mass-flow sensor

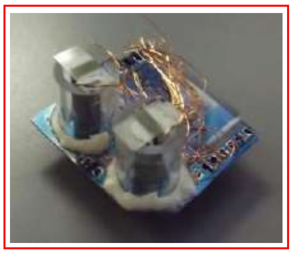
Reference : M.Esashi, H.Kawai, K.Yoshimi, Differential Output Type Micro Flow Sensor, Trans. ICIEC, J75-C-II (1992) pp.738-742

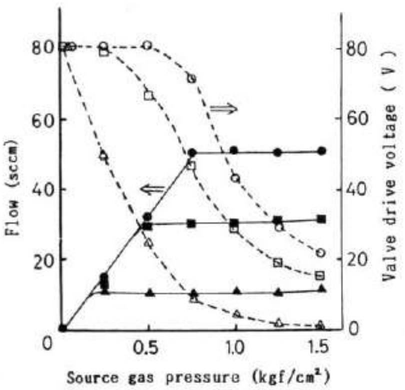


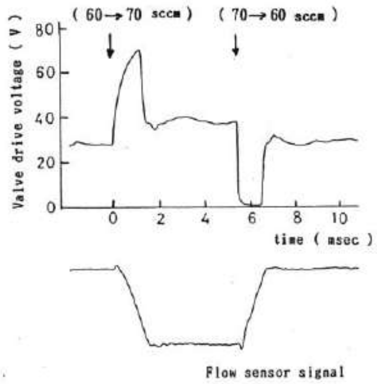




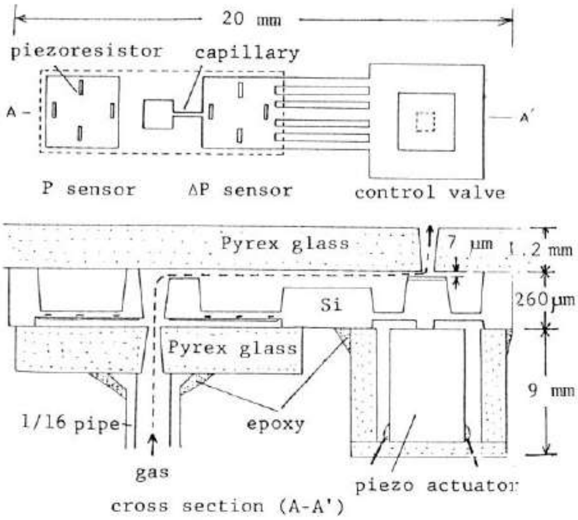








Thermal mass-flow sensor + micro valve

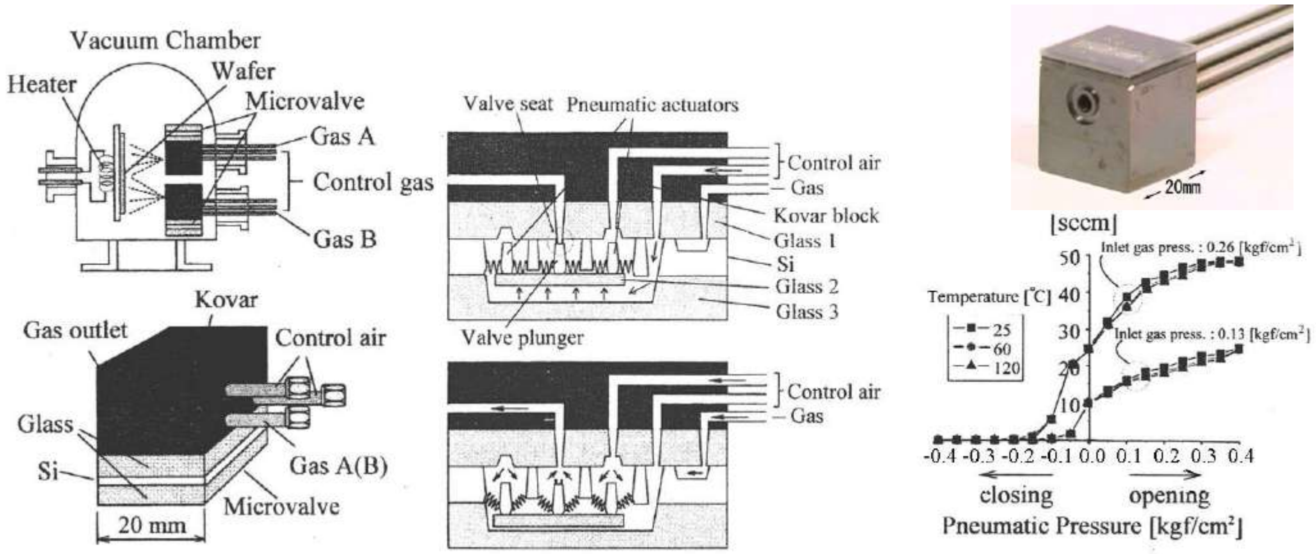


Differential pressure mass-flow sensor+micro valve

Integrated mass-flow controller

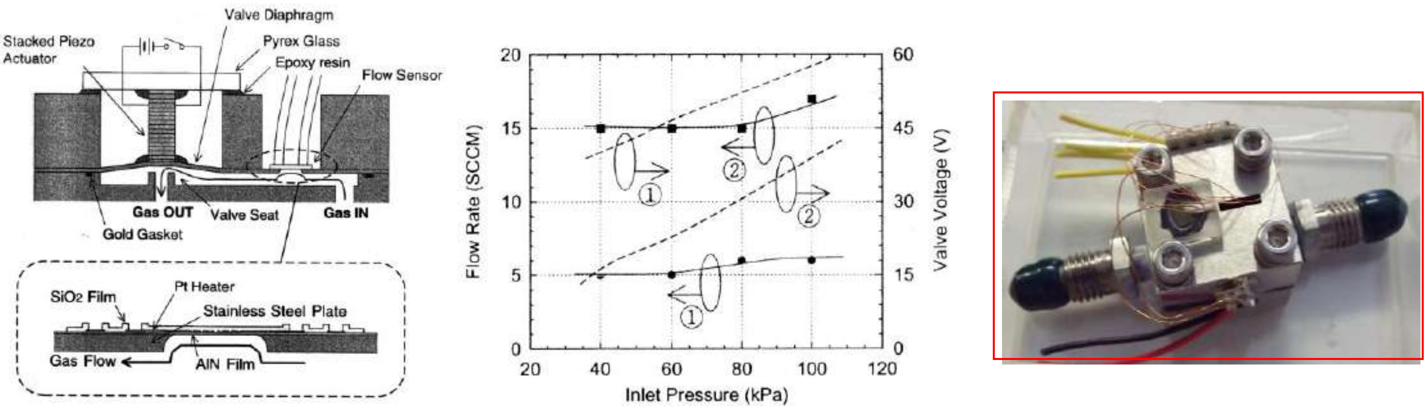
Reference : M.Esashi, S.Eoh, T.Matsuo and S.Choi, The Fabrication of Integrated Mass Flow Controller, Digest of Technical Papers, The 4th Int.Conf.on Solid State Sensors and Actuators (1987) pp.830-833

E12 Bakable micro valve and anticorrosive mass-flow controller



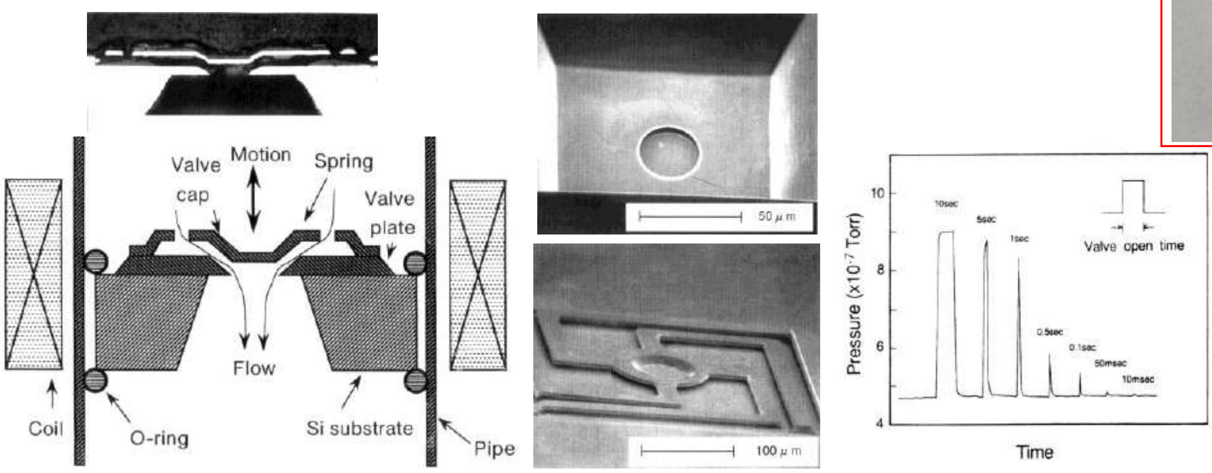
Bakable micro valve

Reference : D.Y.Sim, T.Kurabayashi and M.Esashi, A Bakable Microvalve with a Kovar-Glass-Silicon-Glass Structure, J. of Micromechanics and Microengineering, 6 (1996) pp.266-271



Anticorrosive mass-flow controller

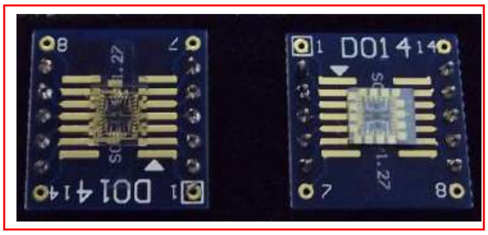
Reference : K.Hirata, D.Y.Sim and M.Esashi, Stainless Steel-Based Integrated Mass-Flow Controller for Reactive and Corrosive Gases, Technical Digest of the Transducers' 01 (2001) pp.962-965

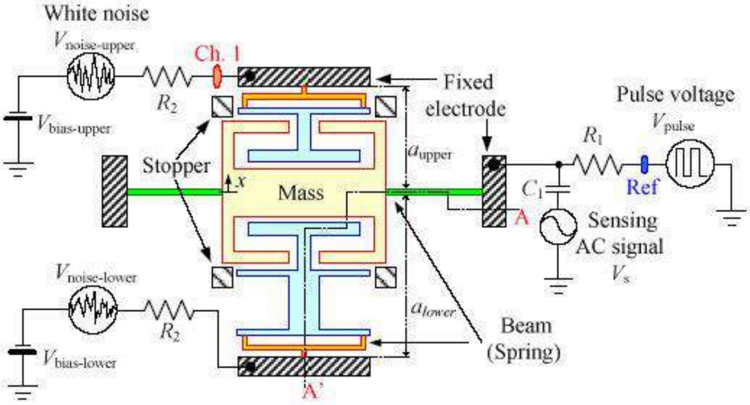


Electromagnetically driven microvalve (NTT)

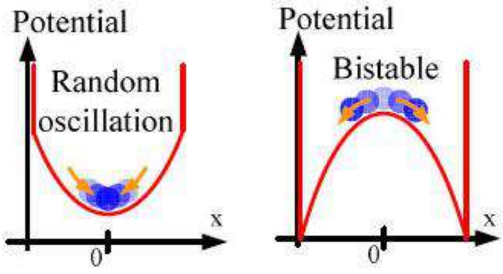
Reference : K..Yanagisawa, H.Kuwano and A.Tago, An Electromagnetically Driven Microvalve, Digest of Technical Papers, Transducers' 93 (1993) pp.102-105

E13 Sensing in harsh environment

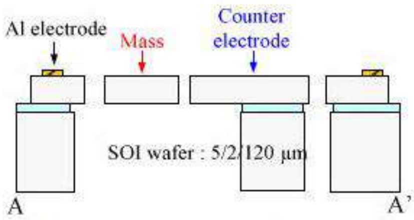




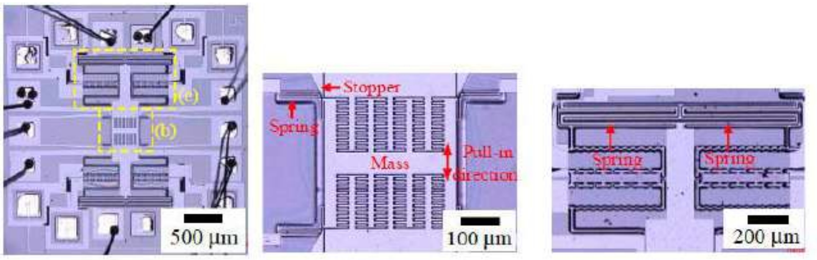
(a) Planar structure



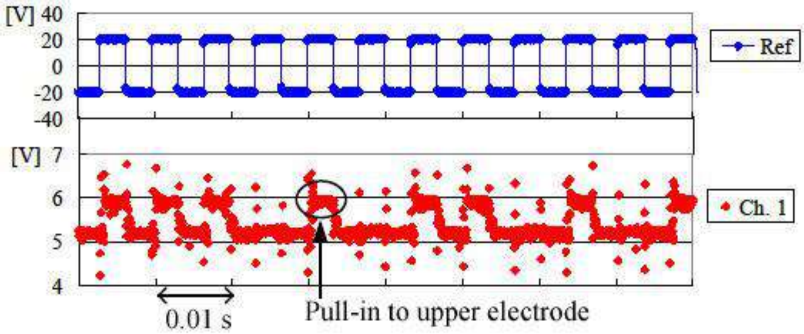
(a) V_{pulse} is zero or low. (b) V_{pulse} is high.

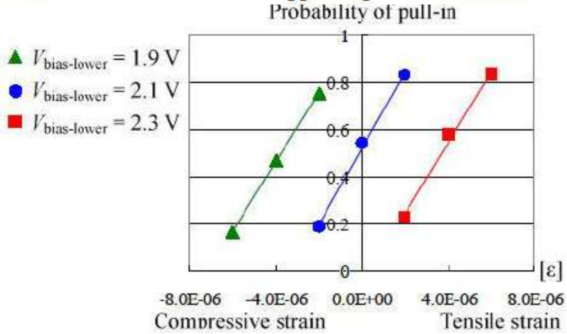


(b) Cross-sectional structure



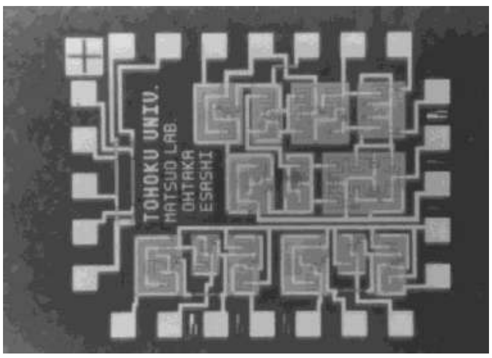
(a) Overall top view (b) Magnified view of the mass (c) Magnified view of springs supporting counter electrode

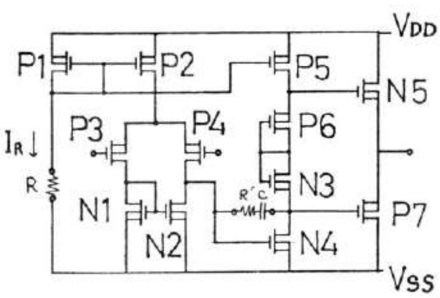


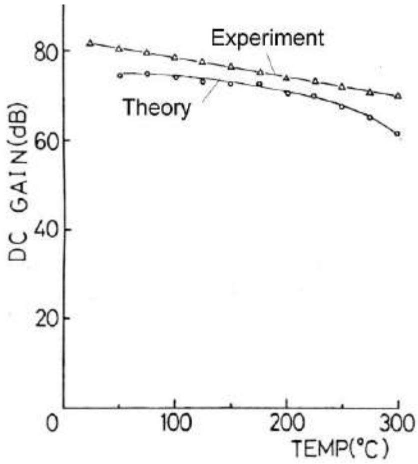


Stochastic sensor

Reference : Y.Hatakeyama, M.Esashi and S.Tanaka, Stochastic Gravity Sensor with Robust Output Using White-Noise-Applied Vi-Stable State for Low S/N Environments, Tech. Digest IEEE MEMS 2012 (2012) pp.132-135



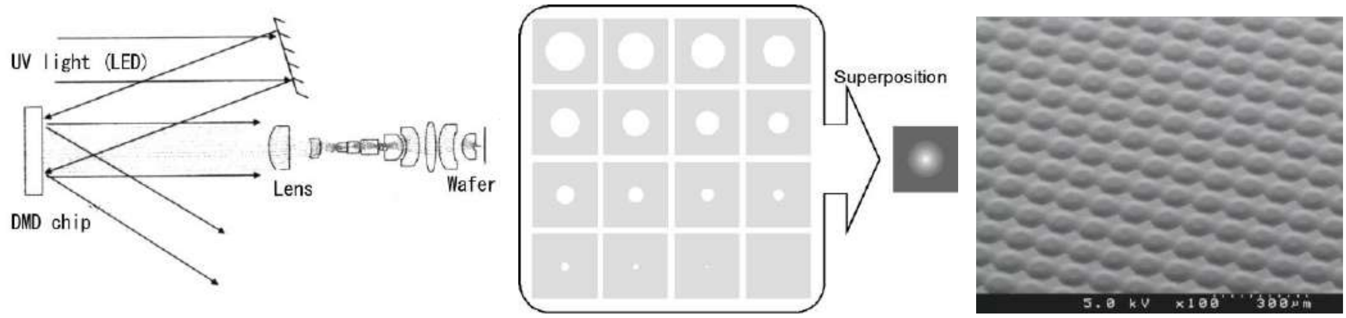




Operational amplifier for high temperature SOS (Silicon On Sapphire) OMOS

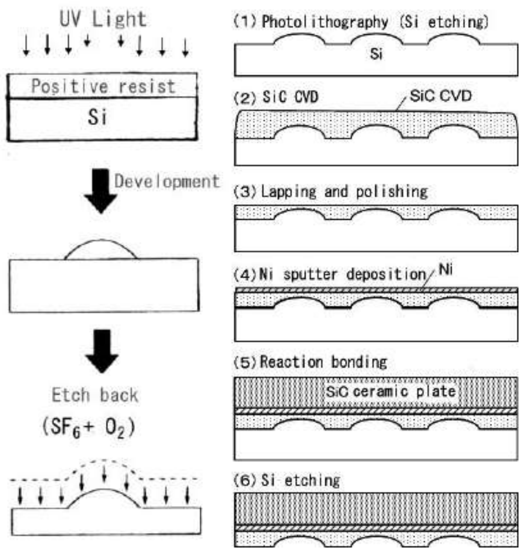
Reference : M.Esashi, S.Ohtaka, T.Matsuo, Fabrication of High Temperature Integrated Circuit and High Temperature Pressure Sensor, Technical Report, IEICE of Japan, SSD86-57 (1986) pp.67-74

E14 Silicon carbide (SiC) mold for glass press-molding

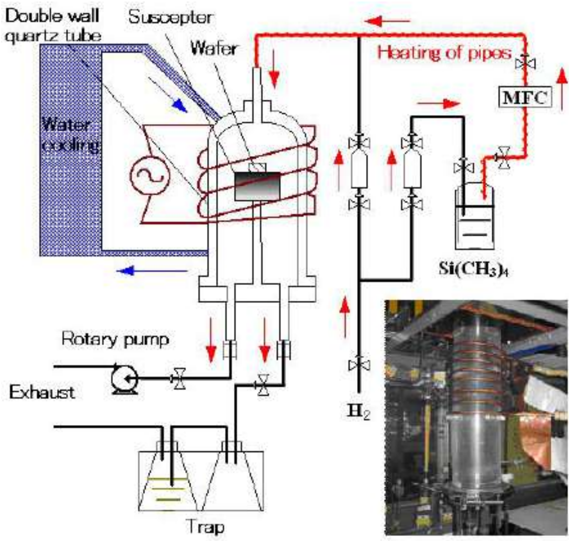


Forming of non-spherical lens shape by multiple maskless exposure using DMD

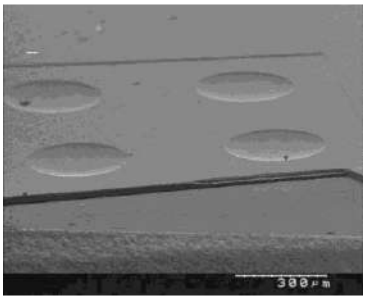
Reference : K.Totsu, K.Fujishiro, S.Tanaka and M.Esashi, Fabrication of Three-dimensional Microstructure Using Maskless Gray-scale Lithography, Sensors and Actuators A, 131 (2006) pp.387-392



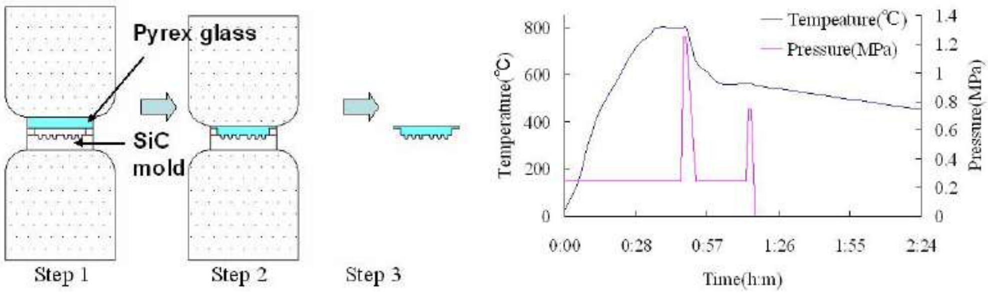
Fabrication of SiC mold



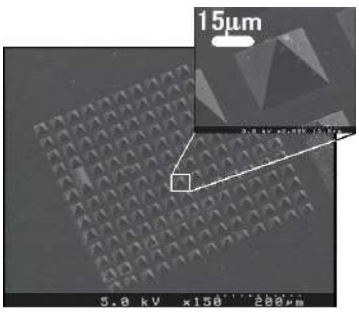
SiC CVD system

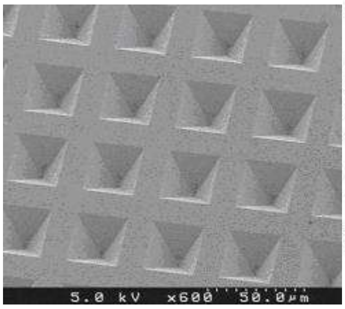


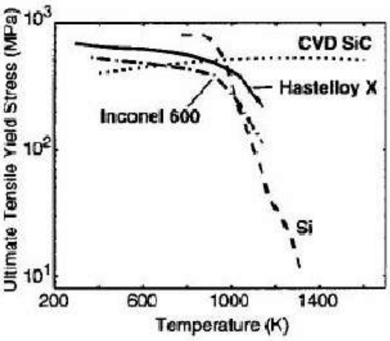
SiC mold



Glass press-molding





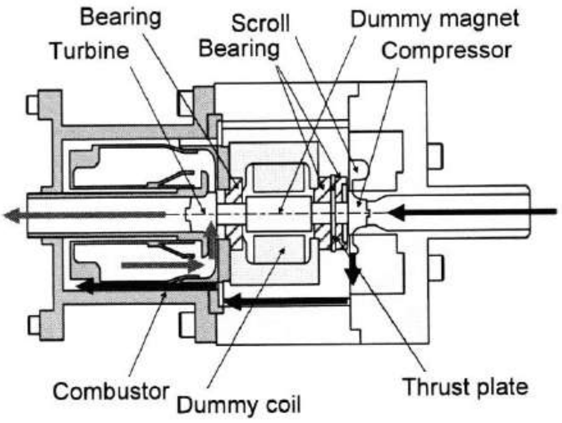


SiC mold (after 4 time use) Pyrex glass formed by molding Mechanical property of SiC at high temperature

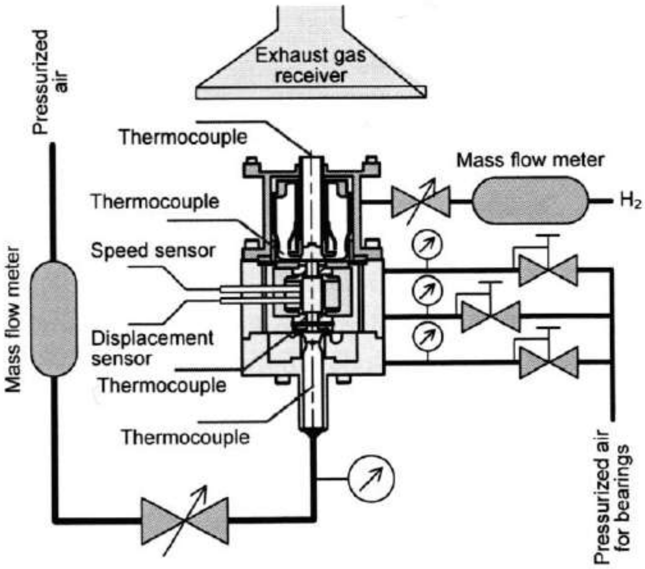
Glass press-molding using SiC mold (A.H.Epstein, J. of Eng.. for Gas Turbines and Power, 126, (2004) 205)

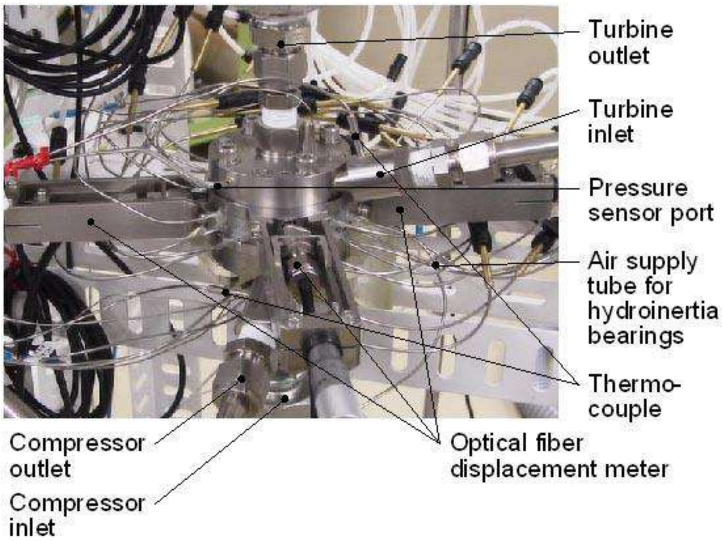
Reference : K.-O. Min, S.Tanaka and M.Esashi, Glass Press Mold Fabricated by SiC APCVD, SiC-SiC Bonding and Silicon Lost Molding, Proceedings of the 21th Sensor Symposium (2004) pp.473-478

F1 Small size gas turbine engine dynamo



Gas turbine dynamo developed in IHI

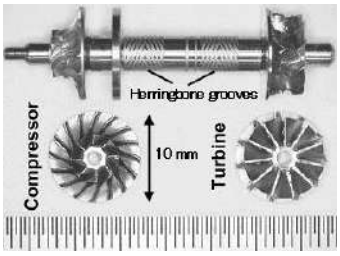


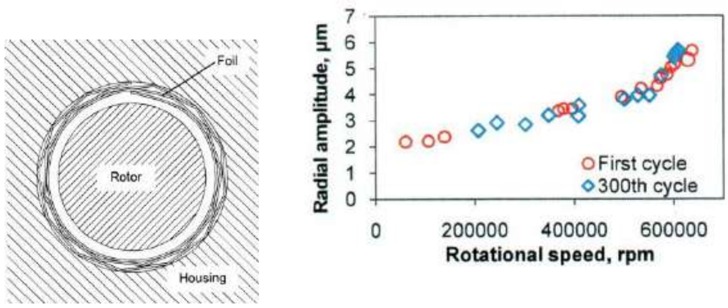


Small gas turbine dynamo (Tohoku Univ. – IHI Corp. – Tohoku-Gakuin Univ. – Tokyo Metroplitan Univ. – The Univ. of Tokyo) (for outdoor robot etc.)

Reference : S.Tanaka, K.Hikichi, S.Togo, M.Murayama, Y.Hirose, T.Sakurai, S.Yuasa, S.Teramoto, T.Niino, T.Mori, M.Esashi and K.Isomura, World's Smallest Gas Turbine Establishing Brayton Cycle, Technical Digest, Power MEMS 2007 (2007) pp.359-362

5 axis stage high speed spindle milling machine used for shaping turbine blade (Toshiba machine F-MACH)

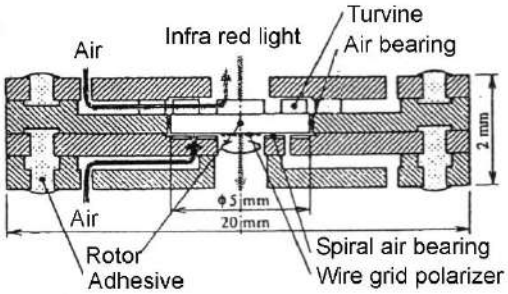


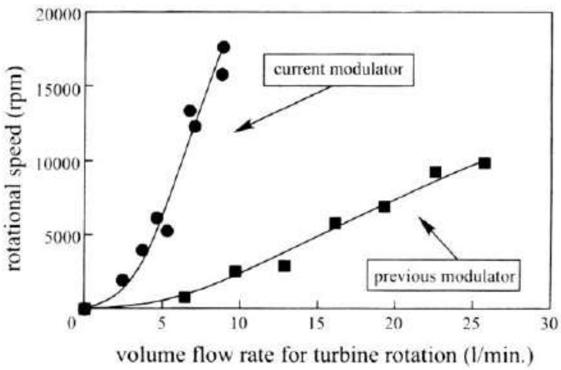


Radial foil bearing (Tohoku Univ. – IHI – Tohoku-Gakuin Univ.)

Reference : K.Hikichi, S.Togo, K.Isomura, N.Saji, M.Esashi and S.Tanaka, Ultra-high-speed Tape-type Radial Foil Bearing for Micro Turbomachinery, Technical Digests Power MEMS 2009 (2009) pp.79-82

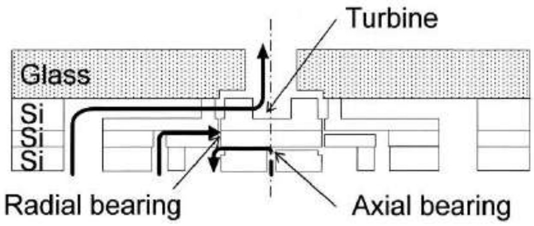
F2 Si micro-turbine and thermoelectric generator

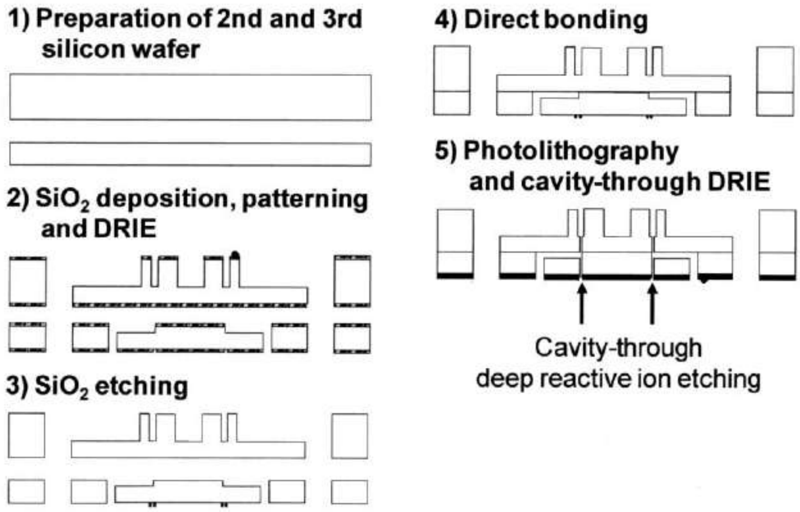




Si air-turbine for high-speed polarization modulator

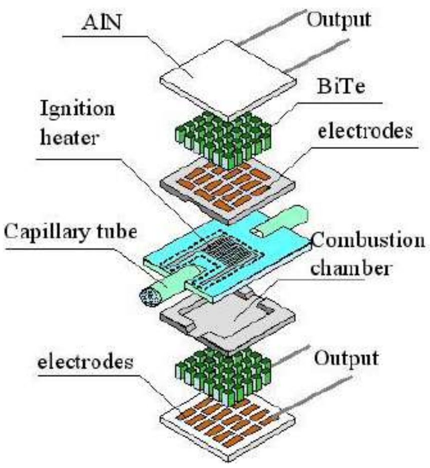
Reference : S.Tanaka, M.Hara and M.Esashi, Mechanical Polarization Modulator Using Micro-turbo Machinery for Fourier Transform Infrared Spectroscopy, Sensors and Actuators, A 96 (2002) pp.215-222

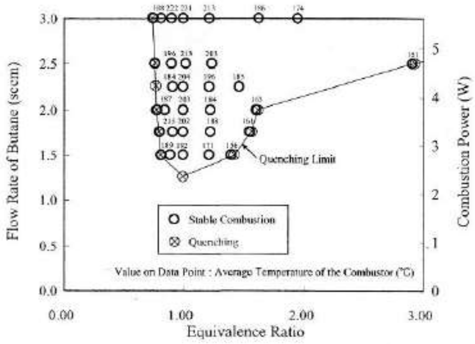


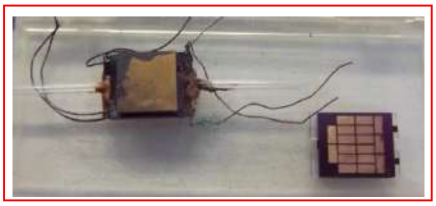


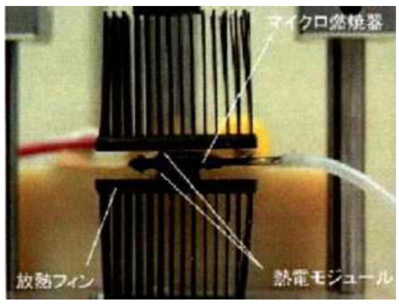
Si air-turbine with radial-inflow type journal bearing

Reference : S.Tanaka, Y.Miura, P.Kang, K.Hikichi and M.Esashi, MEMS-based Air Turbine with Radial-inflow Type Journal Bearing, Trans. on Electrical and Electronic Engng. 3 (2008) pp.297-304





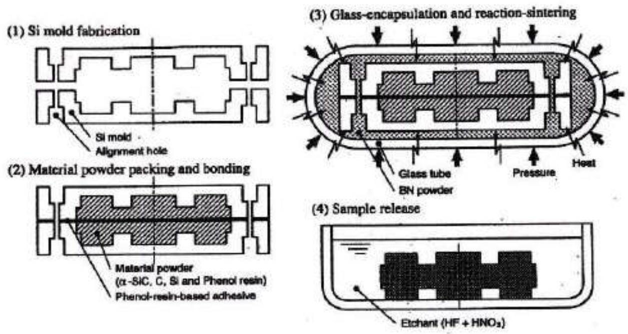




Thermoelectric generator

Reference : K.Yoshida, S.Tanaka, S.Tomonari, D.Satoh and M.Esashi, High-Energy Density Miniature Thermoelectric Generator Using Catalytic Combustion, J. of Microelectromechanical Systems, 15 (2006) pp. 195-203

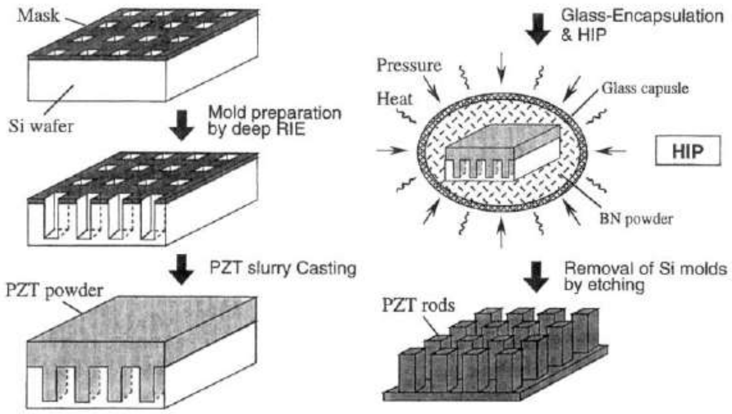
F3 # SiC and PZT by lost-mold process, Si_3N_4 by reaction sintering

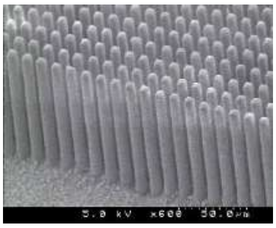


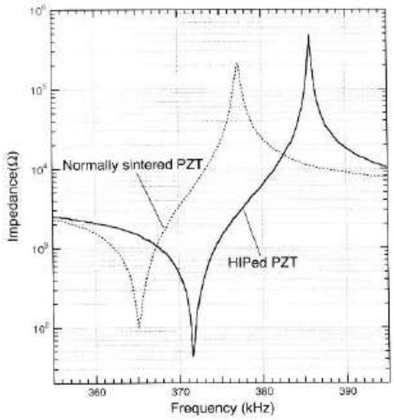
Fabrication Si mold SiC microstructure

SiC microstructure by lost mold process

Reference : S.Tanaka, S.Sugimoto, J.F.Li, R.Watanabe and M.Esashi, Silicon Carbide Micro-Reaction -Sintering Using Micromachined Silicon Molds, J. of Microelectromechanical Systems, 10 (2001) pp.55-61

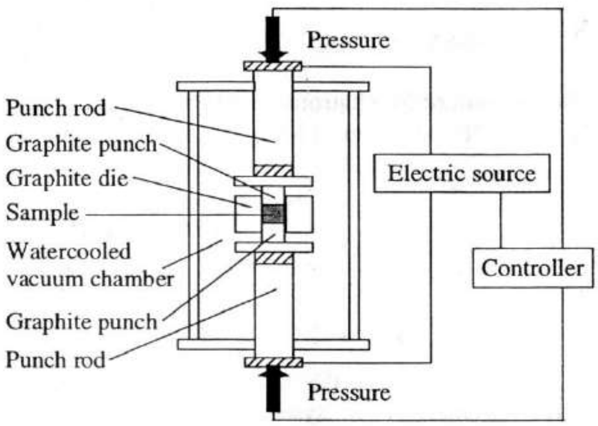


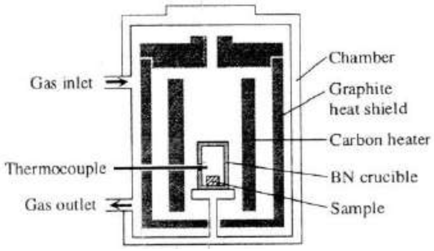




PZT microstructure by lost mold process

Reference : J.-F.Li, S.Wang, K.Wakabayashi, M.Esashi and R.Watanabe, Properties of Modified Lead Zirconate Titanate Ceramics Prepared at Low Temperature (800° C) by Hot Isostatic Pressing, J.American Ceramic Soc., 83 (2000) pp.955-957



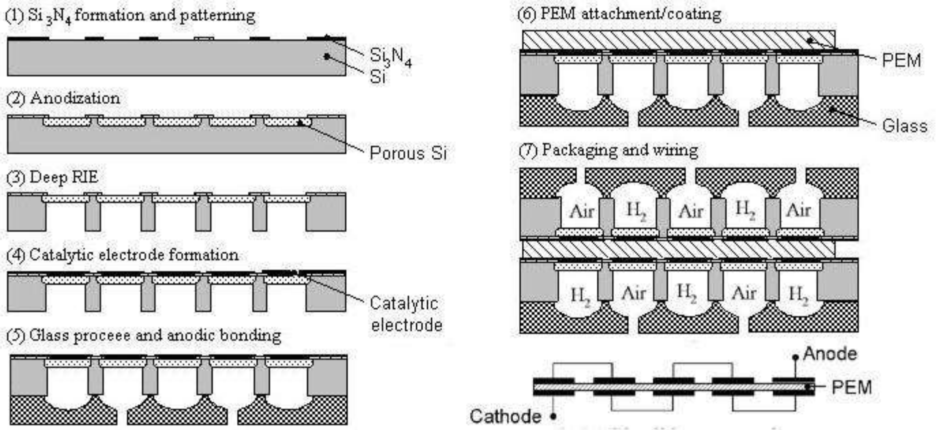


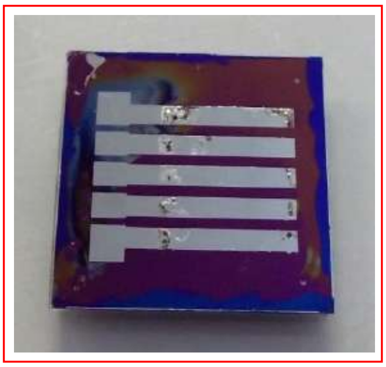
Spark plasma sintering of Si powder Mechanical shaping Sintering at 1400℃ in N_2 to form Si_3N_4

Si_3N_4 structure by sintering in N_2 of porous Si made by spark plasma sintering of Si powder and mechanical shaping

Reference : S.Sugimoto, S.Tanaka, J.-F.Li, T.Yamada, R.Watanabe and M.Esashi, Three-Dimensional Micromachining of Silicon Nitride for Power Microelectromechanical Systems, Technical Digest of the Transducers' 01 (2001) pp.1140-1143

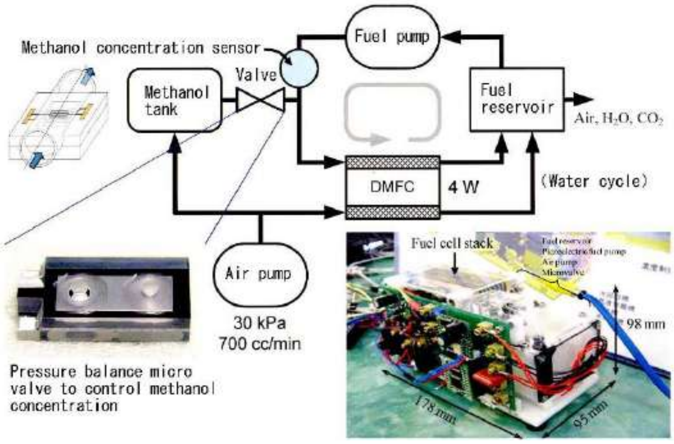
Micro fuel cell



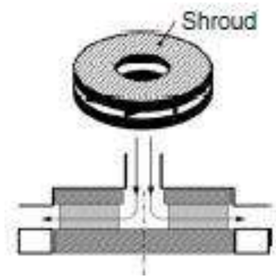


Polymer Electrolyte Membrane (PEM) fuel cell using porous Si as gas permeable membrane

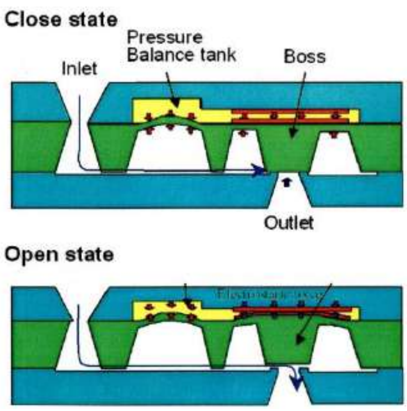
Reference : K.B.Min, S.Tanaka and M.Esashi, MEMS-Based Polymer Electrolyte Fuel Cell, Electrochemistry, 70 (2002) pp.924-927

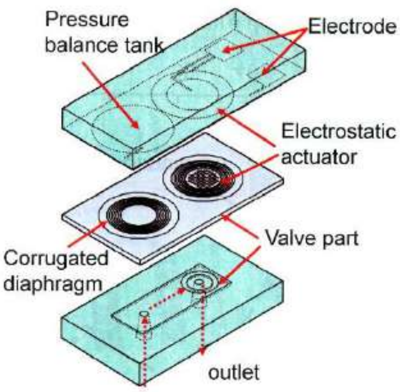


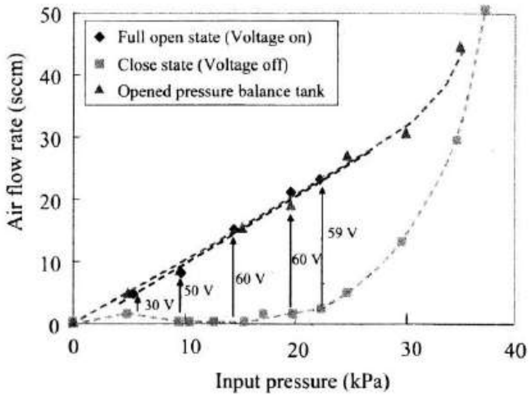
Direct methanol micro fuel cell system
(Tohoku Univ. – Matsushita Electric Works)



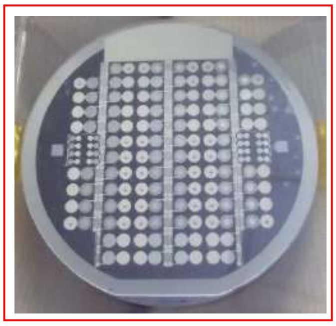
Turbo air pump with SU-8 impeller
(Tohoku Univ. – Nippon Kayaku)





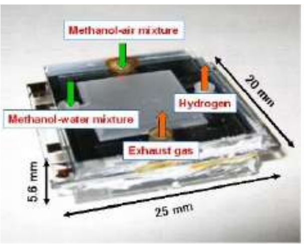


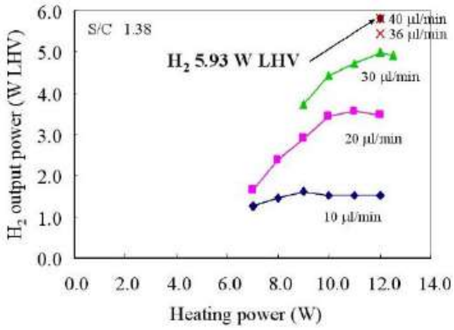
Pressure balance type micro valve (Tohoku Univ. – Matsushita Electric Works)

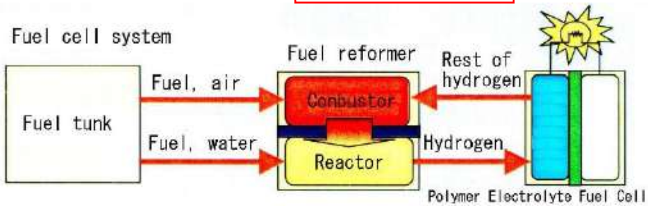


Reference :
S.Tanaka, K.-S.Chang, K.-B.Min, D.Satoh, K.Yoshida and M.Esashi, MEMS-based Components of a Miniature Fuel Cell/fuel Reformer System, Chemical Eng. J., 101 (2004) pp.143-149
K.Yoshida, S.Tanaka, Y.Hagihara, S.Tomonari and M.Esashi, Normally Closed Electrostatic Microvalve with Pressure Balance Mechanism for Prtable Fuel Cell Application, Sensors and Actuators A, 157 (2010) pp.290-298
R.Hino, M.Esashi and S.Tanaka, Antisymetric-mode Lamb Wave Methanol Sensor with Edge Reflectors for Fuel Cell Applications, Technical Digest MEMS 2010 (2010) pp.871-874
A.Nakajima, P.Kang, N.Honda, K.Hikichi, M.Esashi and S.Tanaka, Fabrication and High-speed Characterization of SU-8 Shrouded Two-dimensional Microimpellers, J.of Micromech. Microeng., 17 (2007) pp.S230-S2

F5 Micro fuel reformer

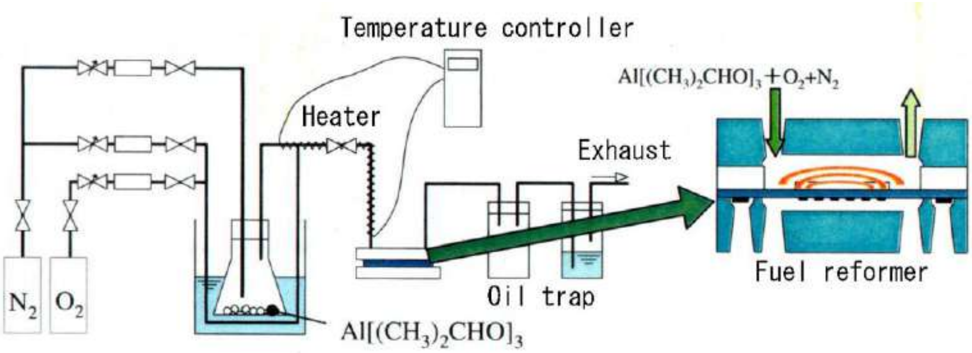


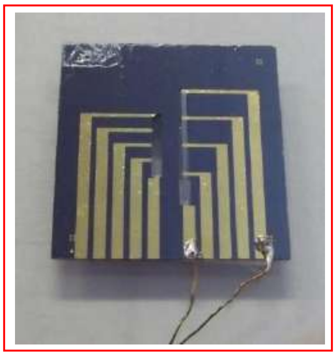


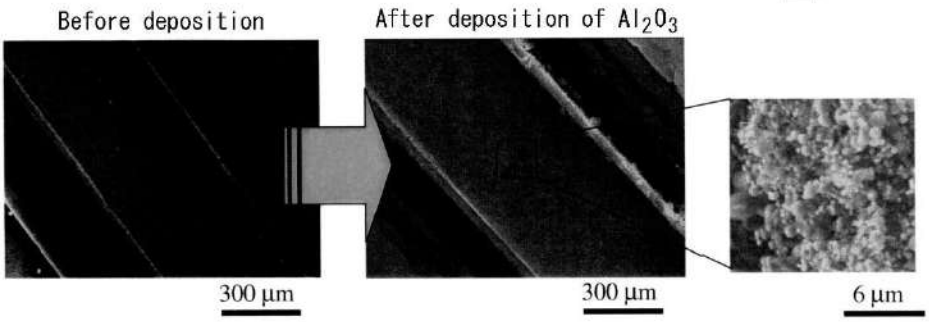


Micro fuel reformer (Tohoku Univ. – Matsushita Electric Works)

Reference : K.Yoshida, S.Tanaka, H.Hiraki and M.Esashi : A Micro Fuel Reformer Integrated with a Combustor and a Microchannel Evaporator, J.of Micromech. Microeng., 16 (2006) pp.S191–S197

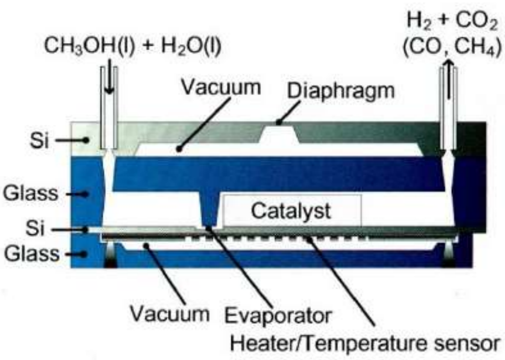


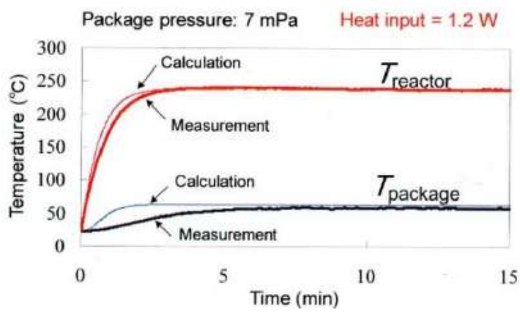


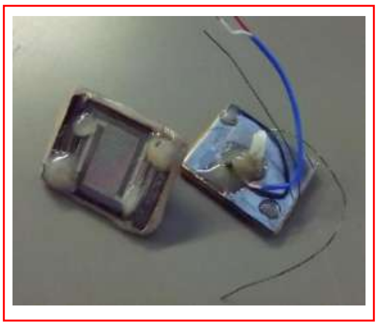


In Situ CVD of catalyst for fuel reformer

Reference : T.Takahashi, S.Tanaka and M.Esashi : Development of an in Situ Chemical Vapor Deposition Method for an Alumina Catalyst Bed in a Suspended Membrane Micro Fuel Reformer, J.of Micromech. Microeng., 16, (2006) pp.S206–S210



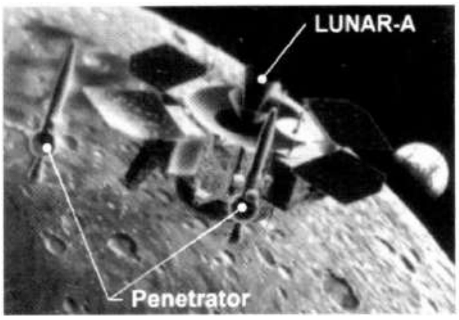




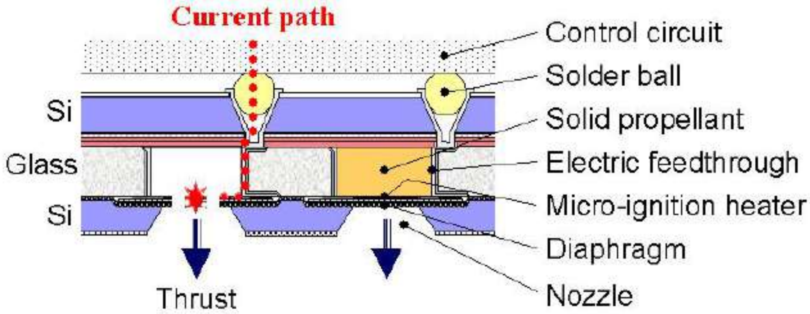
Vacuum-packaged micro fuel reformer

Reference : A.Kasuga, S.Tanaka and M.Esashi, Design and Fabrication of a Vacuum-packaged Micro Fuel Reformer, Technical Digest, Power MEMS 2007 (2007) pp.35–38

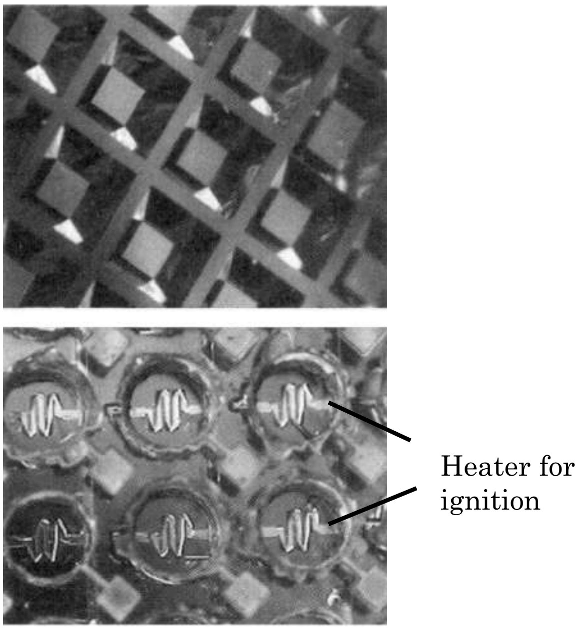
F6 Digital micro thruster (solid rocket engine array)



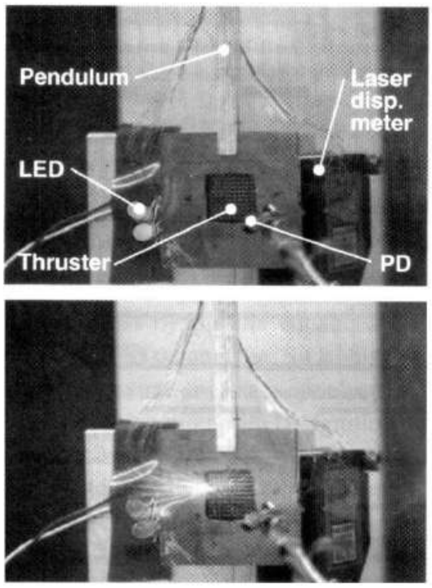
Purpose



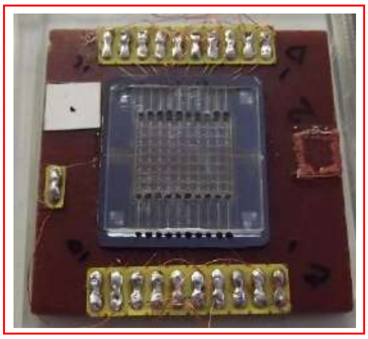
Structure



Top and bottom sides

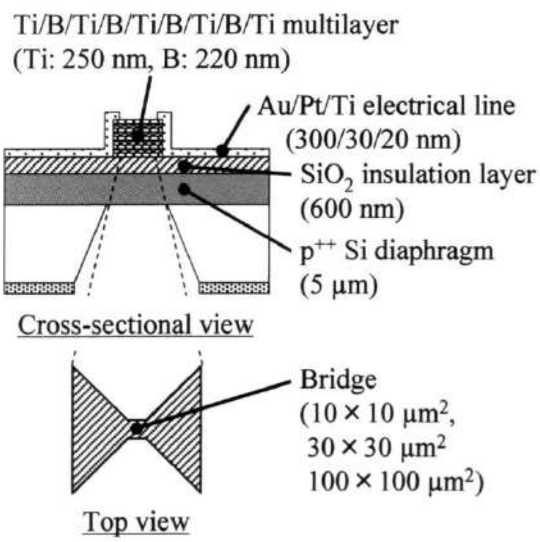


Measurement of thrust force

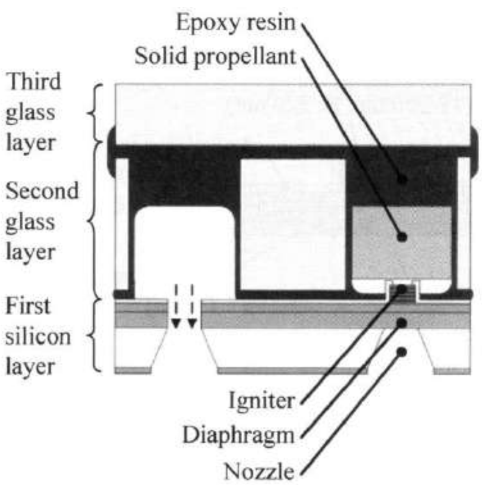


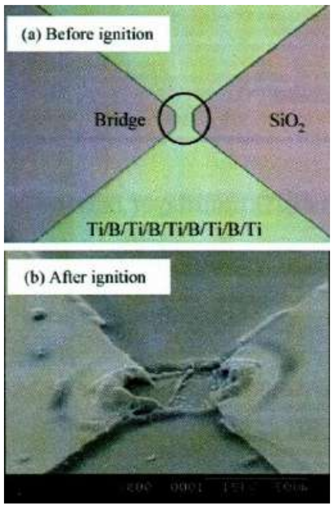
Digital micro thruster (Tohoku Univ. – JAXA)

Reference : S.Tanaka, R.Hosokawa, S.Tokudome, K.Hori, H.Saito, M.Watanabe and M.Esashi, MEMS-Based Solid Propellant Rocket Array Thruster with Electrical Feedthroughs, Trans. Japan Soc. Aero. Space Sci., 46 (2003) pp.47-51



$2B + Ti \rightarrow TiB_2 + 1320$ cal/g.

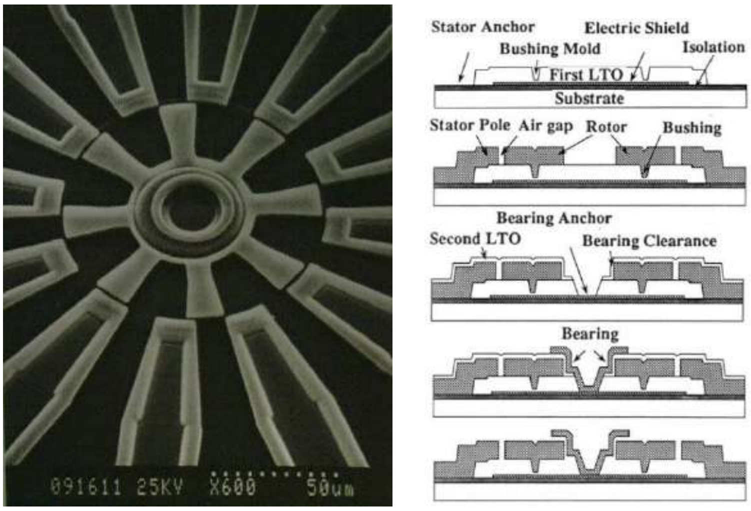




Igniter using a reaction of Bi / Ti (Tohoku Univ. – JAXA)

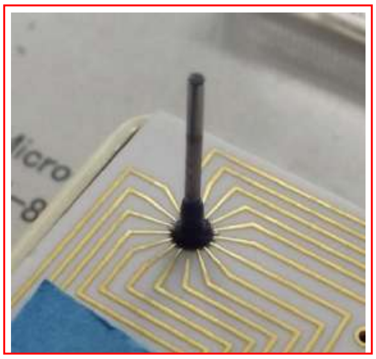
Reference : S.Tanaka, K.Kondo, H.Habu, A.Itoh, M.Watanabe, K.Hori and M.Esashi, Test of B/Ti Multilayer Reactive Igniters for a Micro Solid Rocket Array Thruster, Sensors and Actuators A, 144 (2008) pp.361-366

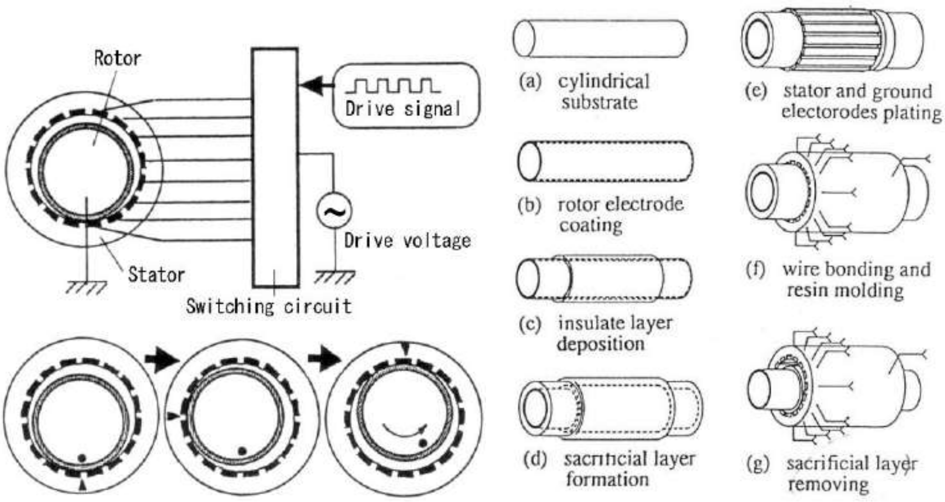
Electrostatic micro motor, actuator



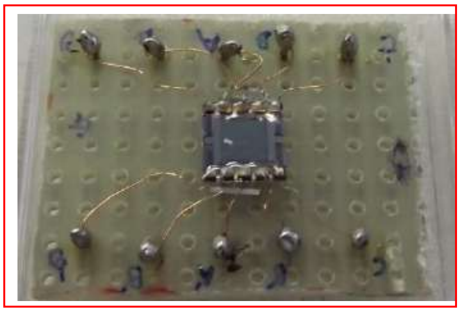
Electrostatic micro motor (MIT USA)

Reference : M.Mehregany, P.Nagarkar, S.D.Senturia and J.H.Lang, Operation of Micro-fabricated Harmonic and Ordinary Side-driven Motors, IEEE MEMS'90 (1990) pp.1-8

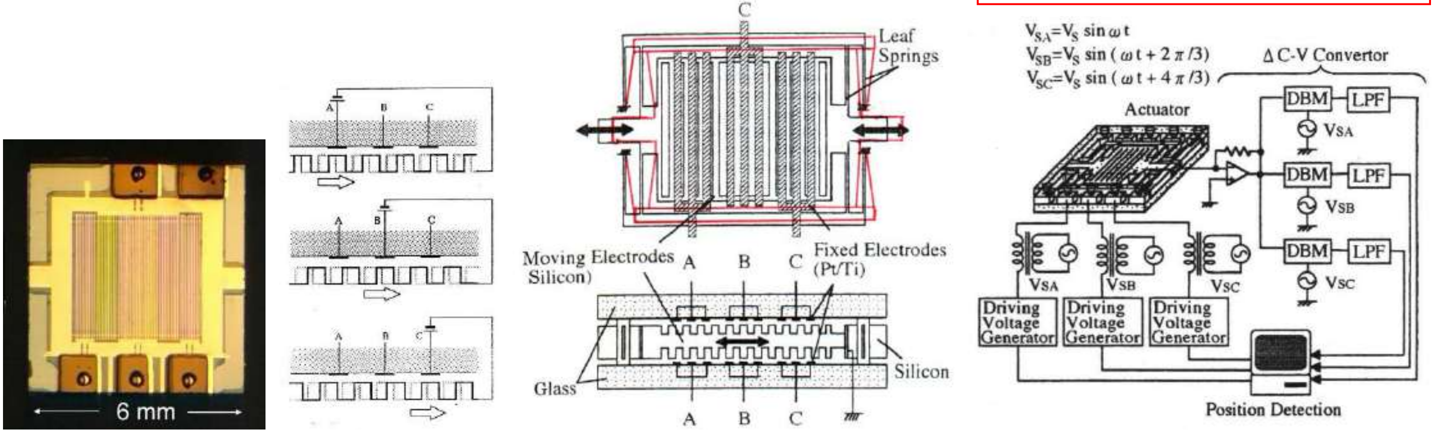




Electrostatic wobble motor (Panasonic Research Institute)



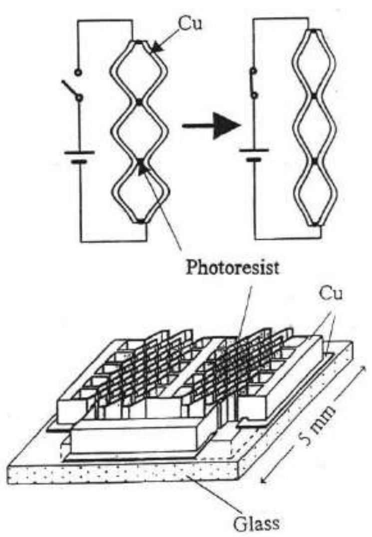
Reference : S.Aoki, H.Ogura, K.Nakamura, A.Ono, A Conventric Build-up Process to Fabricate Practical Wobble Motors, Procedings IEEE MEMS'94 (1994) pp.114-118

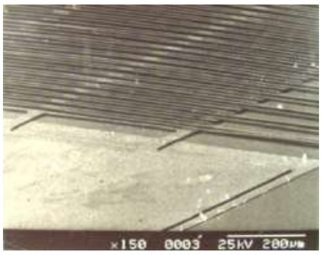


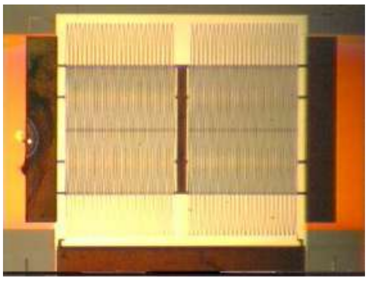
Packaged stepping electrostatic microactuator

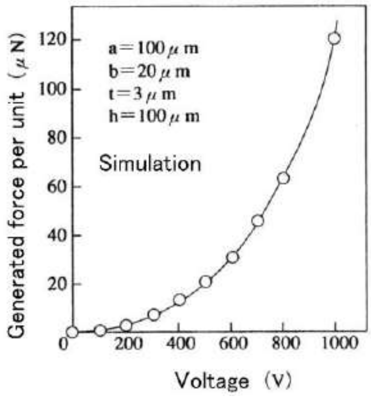
Reference : T.Matsubara, M.Yamaguchi, K.Minami and M.Esashi, Stepping Electrostatic Microactuator, Digest of Technical Papers Transducers'93 (1993) pp.50-53

F8 Distributed electrostatic micro actuator

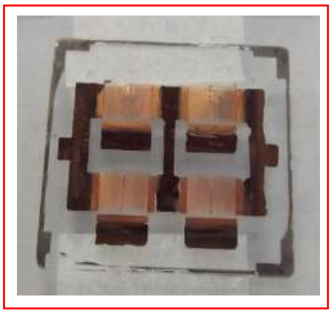




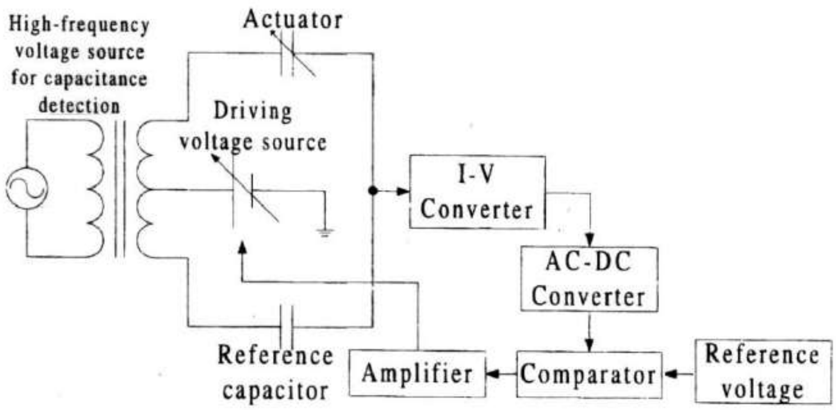


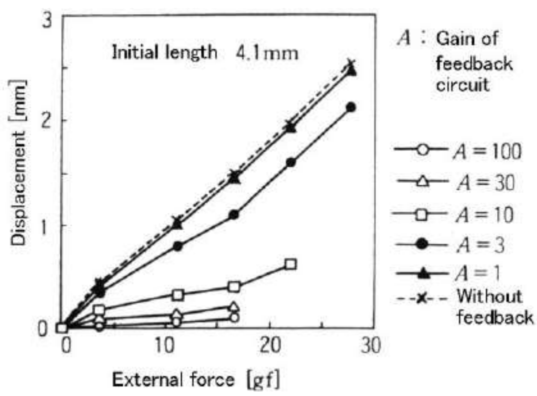


Distributed electrostatic micro actuator



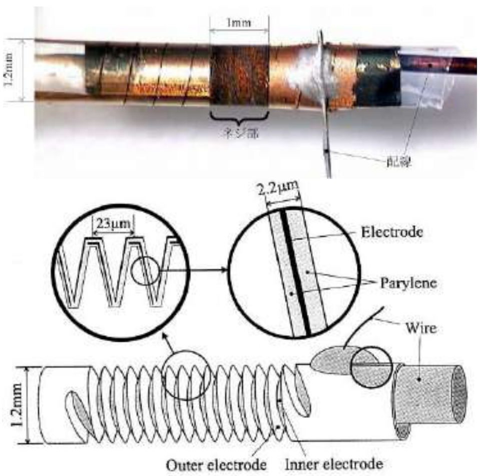
Reference : K.Minami, S.Kawamura and M.Esashi, Fabrication of Distributed Electrostatic Micro Actuator, IEEE Journal of Micromechanical Systems, 2 (1993) pp.121-127

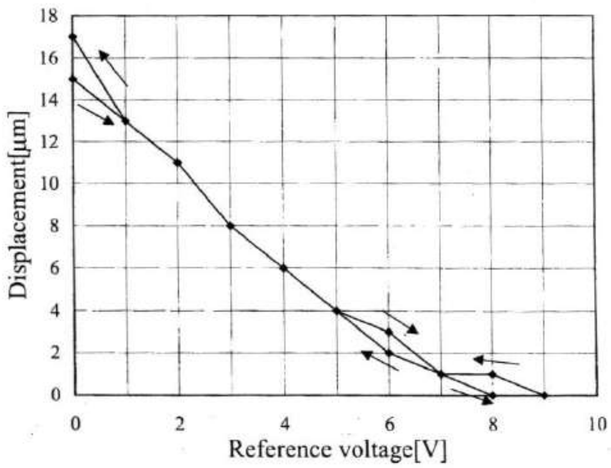




Compliance control of distributed electrostatic microstructure

Reference : M.Yamaguchi, S.Kawamura, K.Minami and M.Esashi, Control of Distributed Electrostatic Microstructures, Journal of Micromechanics and Microengineering, 3 (1993) pp.90-95

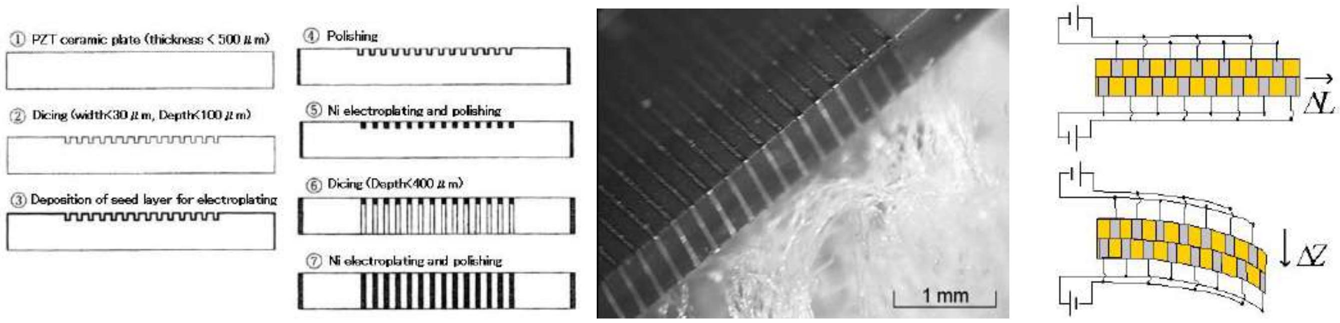




Bellows-shape electrostatic microactuator

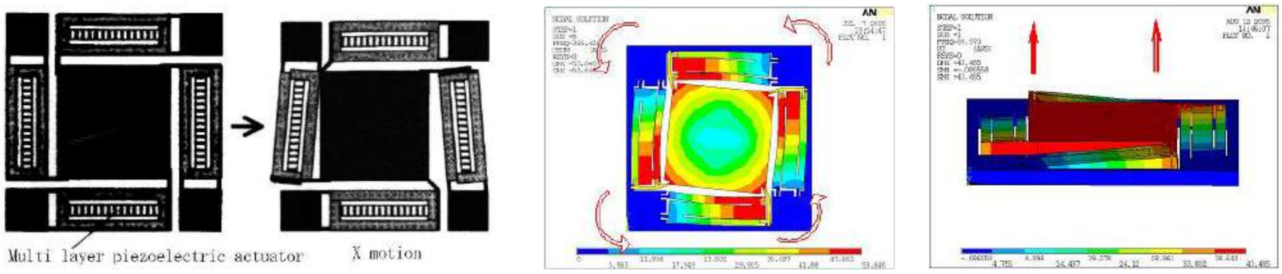
Reference : K.Minami, H.Morishita and M.Esashi, A Bellows-shape Electrostatic Microactuator, Sensors and Actuators, 72 (1999) pp.269-276

F9 Piezoelectric micro stage



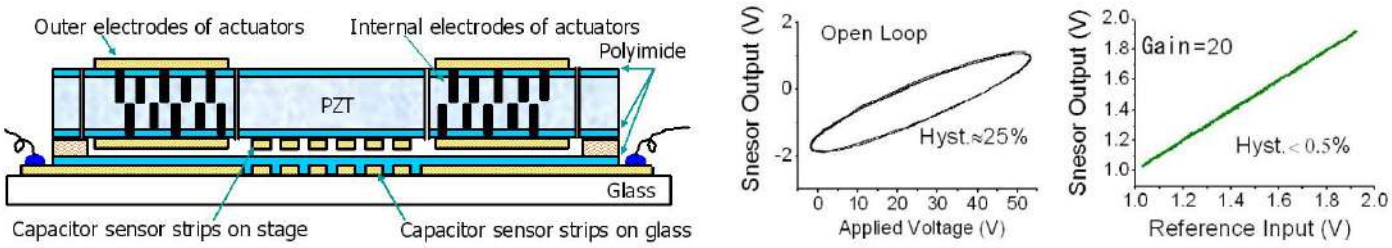
Multi-layer actuator by dicing PZT ceramic plate and filling the groove with electroplated metal

Reference : G.Suzuki and M.Esashi, Planer Fabrication of Multilayer Piezoelectric Actuator by Groove Cutting and Electroplating, Proc. of the Micro Electro Mechanical Systems'2000 (2000) pp.46-51



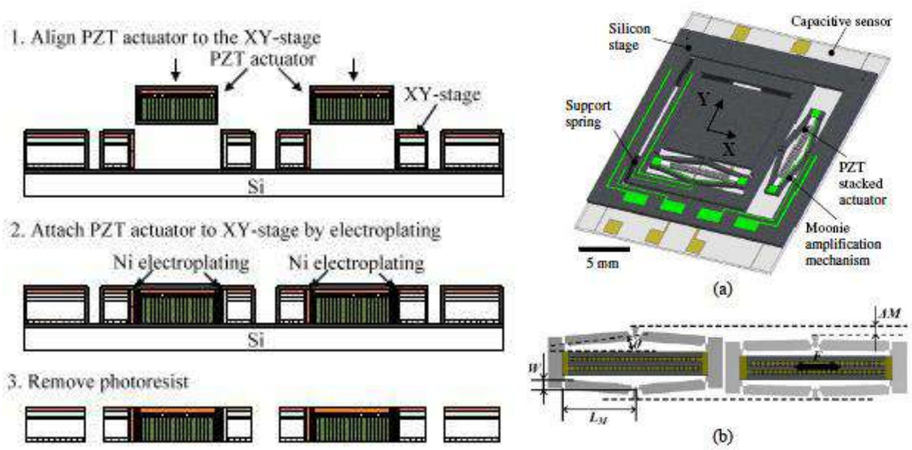
XYZ θ stage made of PZT ceramic plate

Reference : D.Zhang, C.Chang, T.Ono and M.Esashi, A Piezodriven XY-microstage for Multiprobe Nanorecording, Sensors and Actuators, A 108 (2003) pp.230-233

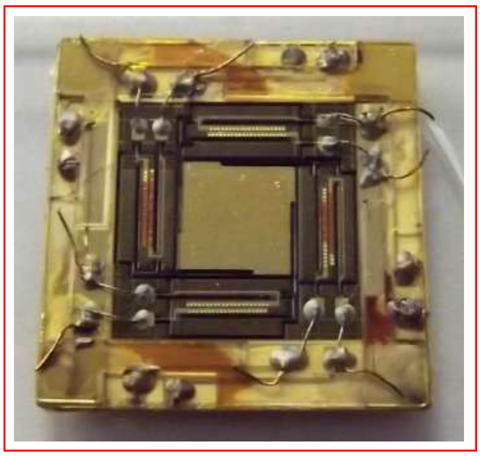


Feedback position control using capacitive position sensor

Reference : H.G.Xu, T.Ono and M.Esashi, Precise Motion Control of a Nanopositioning PZT Microstage Using Integrated Capacitive Displacement Sensors, J.of Micromech. Microeng., 16 (2006) pp.2747-2754

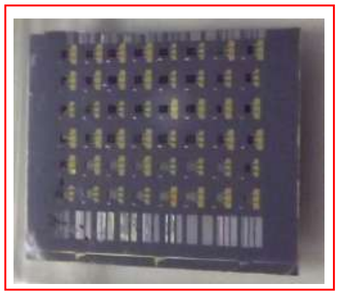


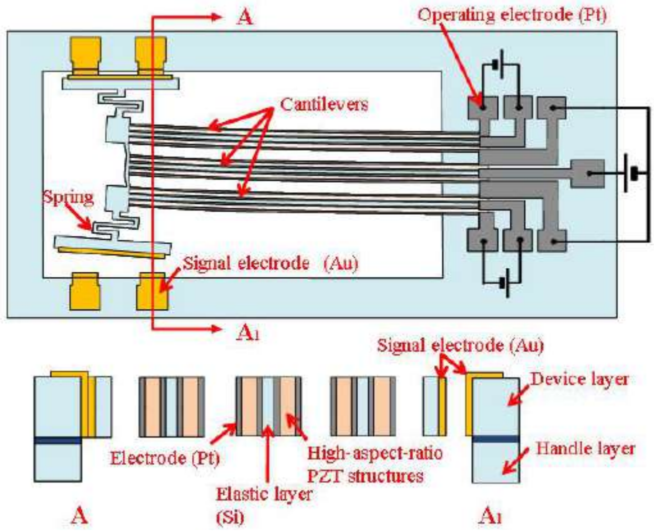
Si stage with multi-layer PZT actuators



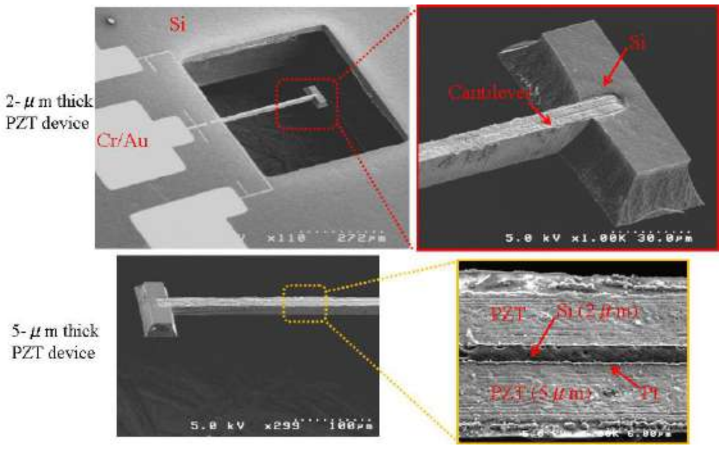
Reference : M.Faizul M.Sabri, T.Ono and M.Esashi, Modeling and Experimental Validation of the Performance of a Silicon XY-microstage Driver by PZT Actuators, J.of Micromech. Microeng., 19 (2009) 095004(9pp)

F10 Lateral motion piezoelectric microactuator

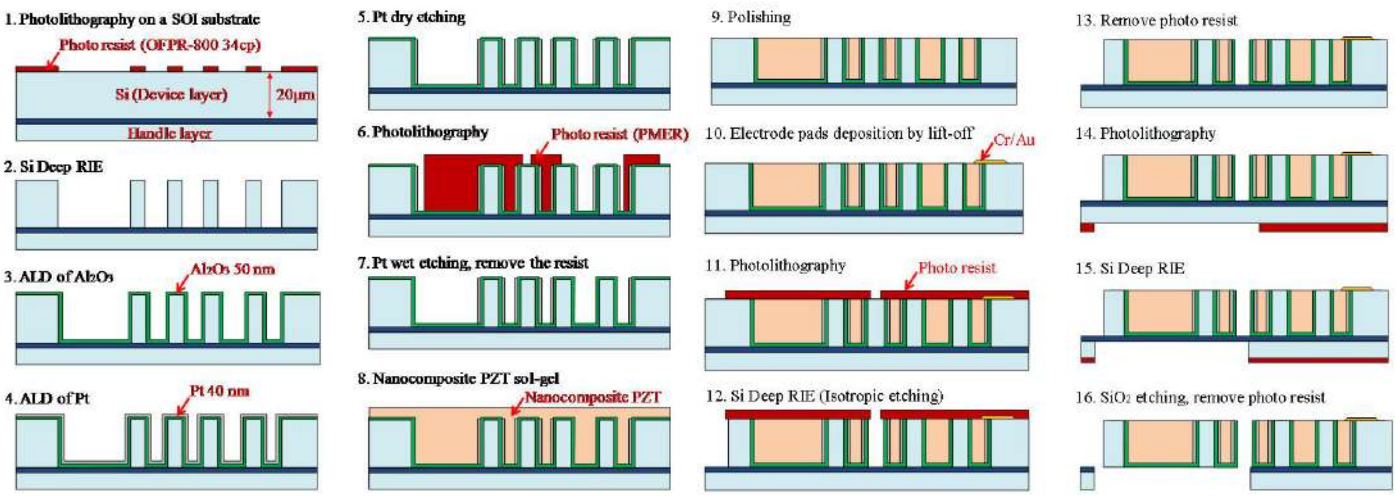




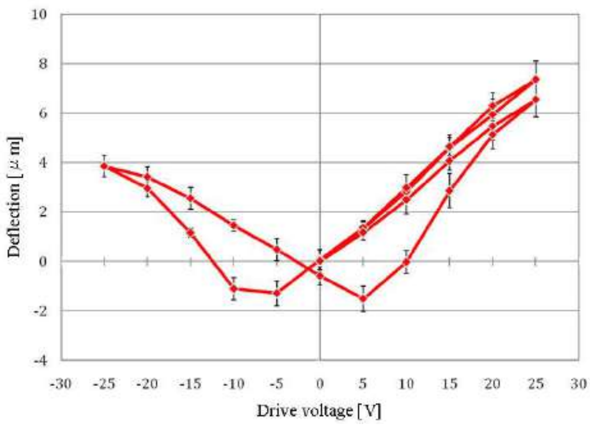
Structure

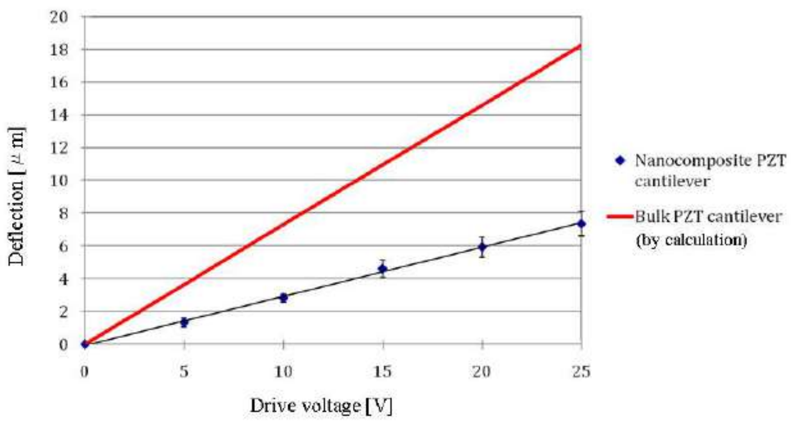


Photograph



Fabrication



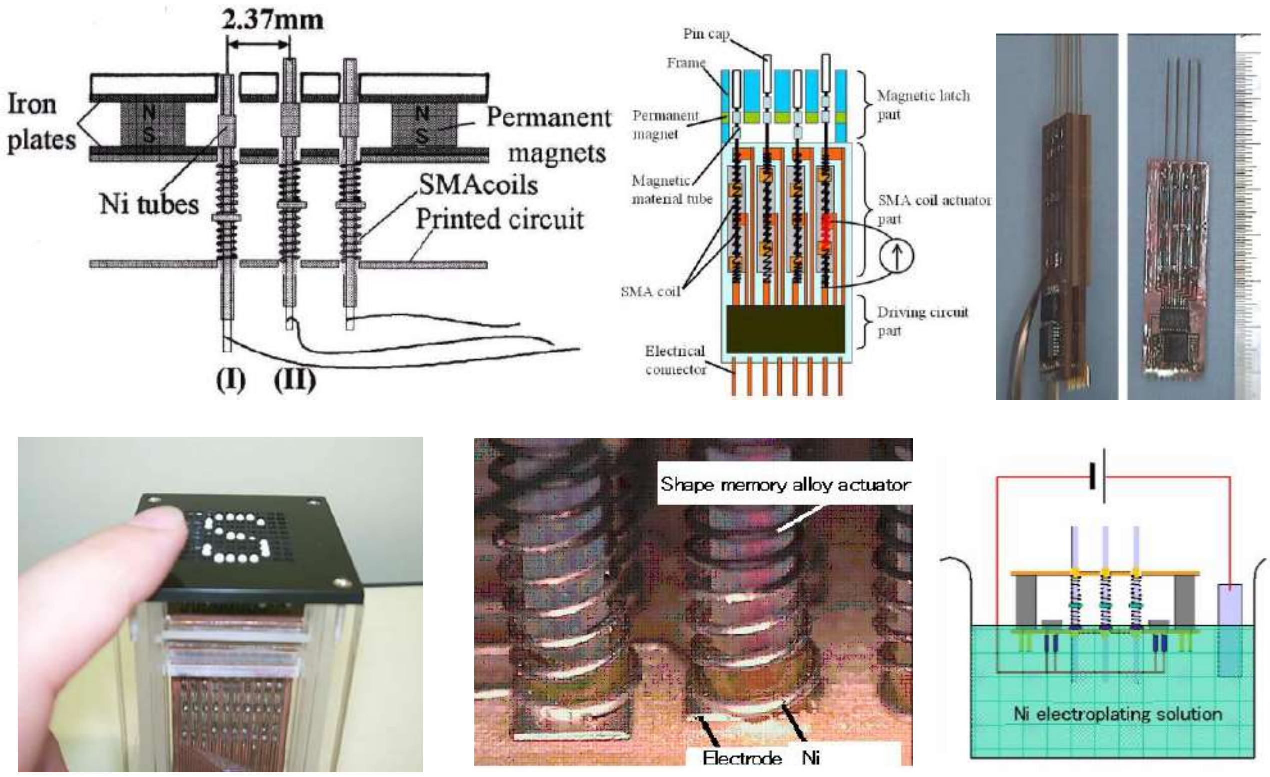


Displacement versus voltage

Lateral motion piezoelectric microactuator

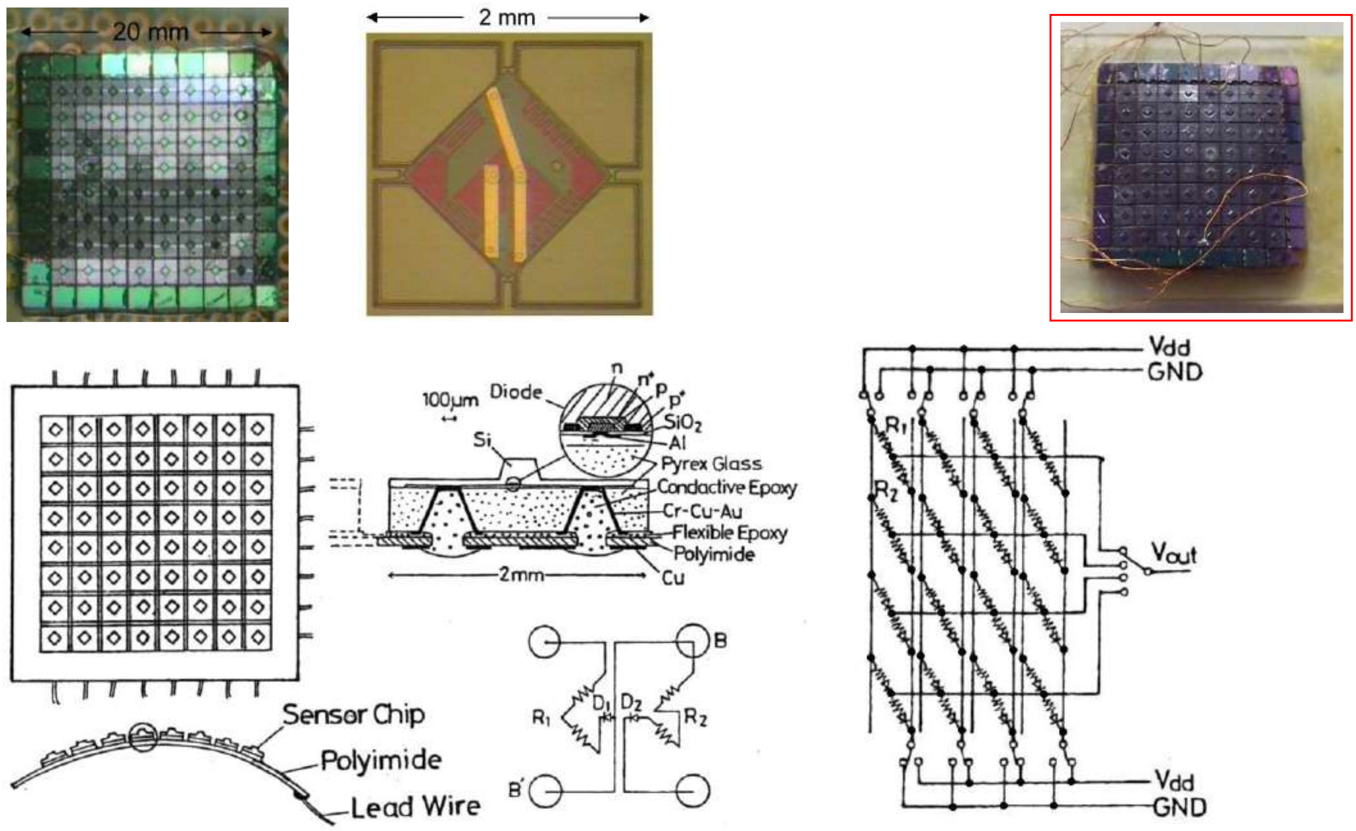
Reference : N.Wang, S.Yoshida, M.Kumano, Y.Kawai and M.Esashi, Fabrication of High-aspect-ratio PZT Structure by Nanocomposite S0l-gel Method for Laterally-driven Piezoelectric MEMS Switch, 2012 7th IEEE Intnl. Conf. on Nano/Micro Engineered and Molecular Systems (IEEE NEMS 2012) (2012) pp.321-326

Tactile display and tactile imager



Tactile display

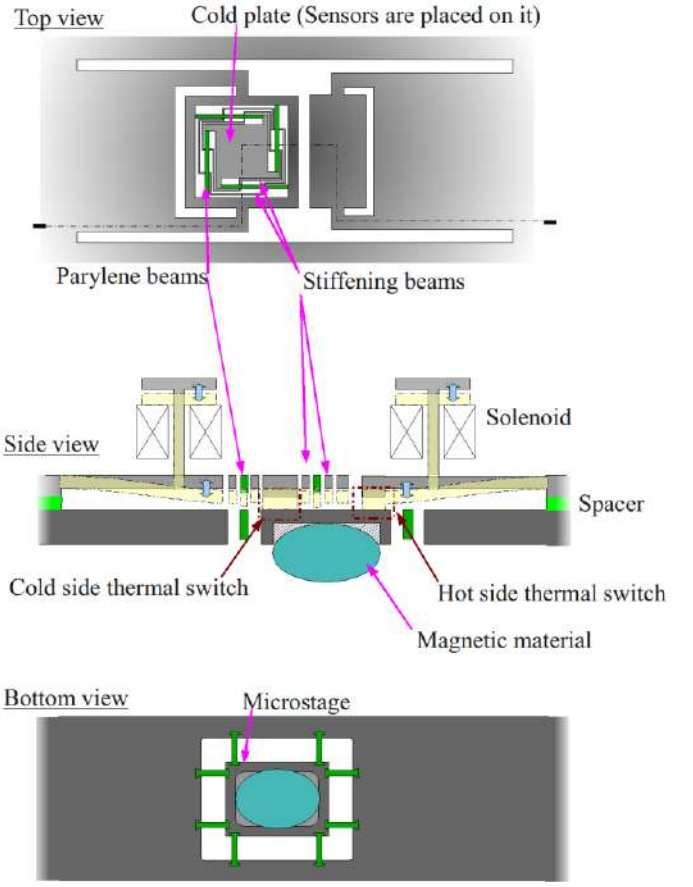
Reference : Y.Haga, W.Makishi, K.Iwami, K.Totsu, K.Nakamura and M.Esashi : Dynamic Braille Display Using SMA Coil Actuator and Magnetic Latch, Sensors & Actuators A, 119 (2005) pp.316-322



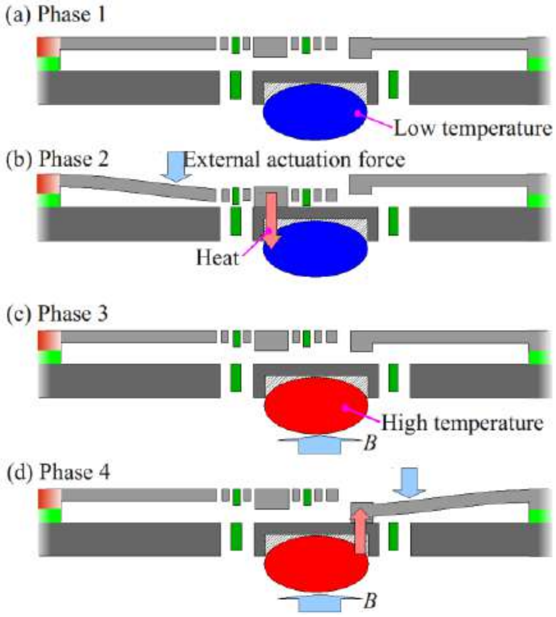
Tactile imager

Reference : M.Esashi, S.Shoji, A,Yamamoto, and K.Nakamura, Fabrication of Semiconductor Tactile Imager, Electronics and Communications in Japan, Part 2, 73 (1990) pp.97-104

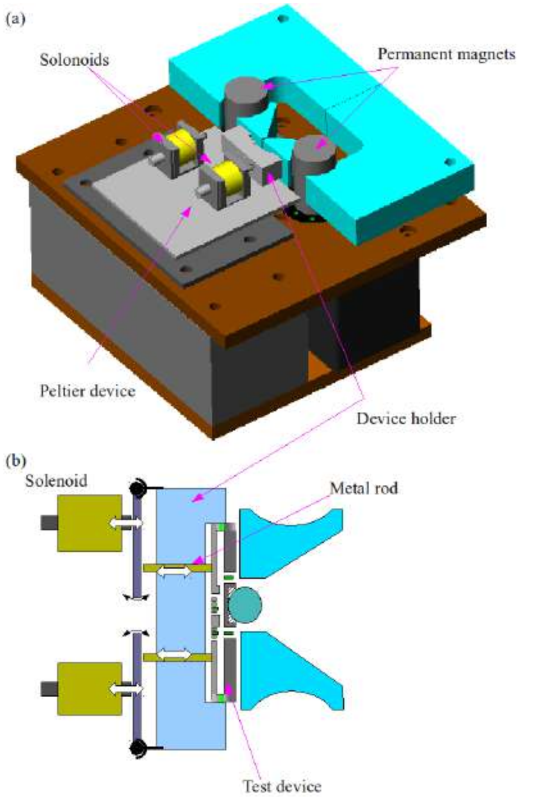
Micro refrigeration system



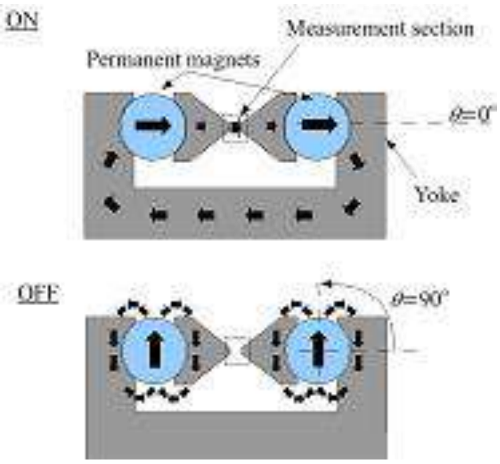
Micro magnetic refrigerator for cooling of micro devices



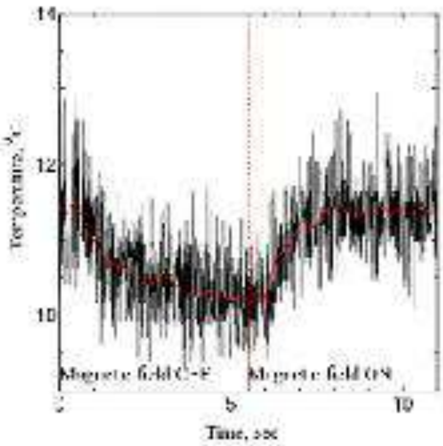
Refrigeration cycle (a)Adiabatic demagnetization (b)Heat dissipation from cold plate (c)Adiabatic magnetization (d)Heat dissipation to ambient.

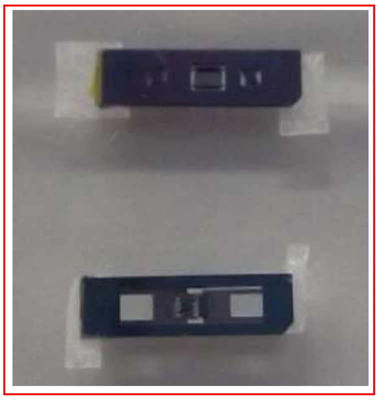


Refrigeration system



Rotating permanent magnets generate modulated magnetic field

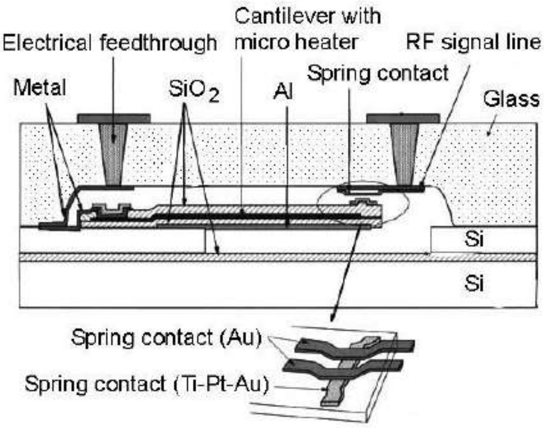


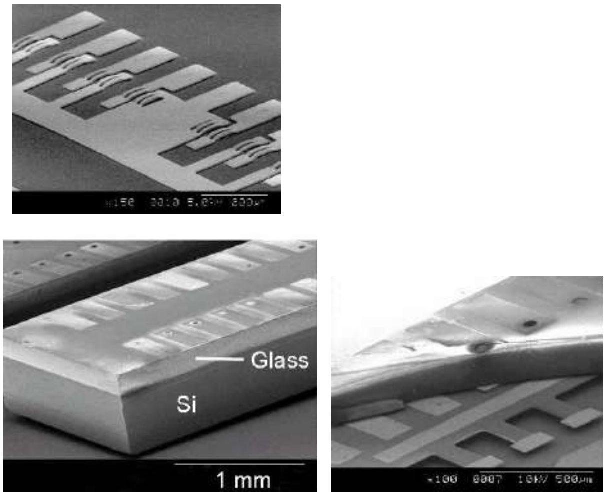


Magnetic field induced temperature change of the magnetic material

Reference : T.Tsukamoto, M.Esashi and S.Tanaka, A Micro Thermal Switch with a Stiffness-enhanced Thermal Isolation Structure, J.of Micromech. Microeng., 21 (2011) 104008(6pp)

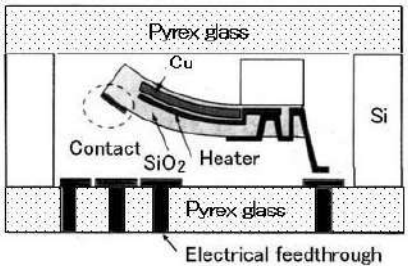
F13 Thermal MEMS switch

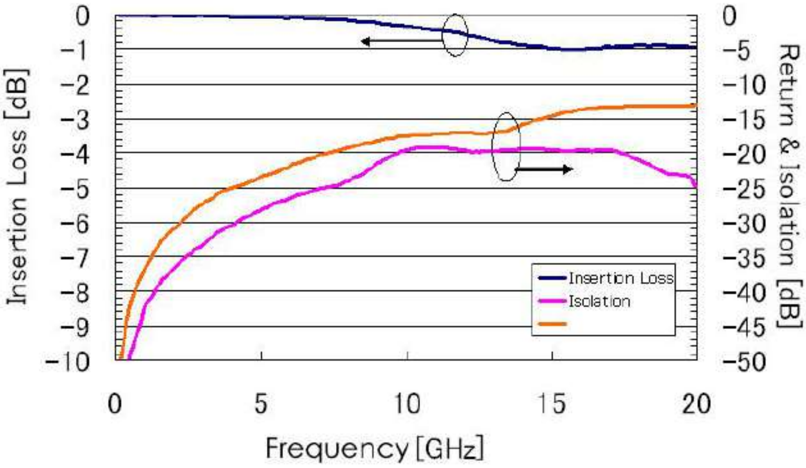




Thermal MEMS switch

Reference : Y.Liu, X.Li, T.Abe, Y.Haga and M.Esashi, A Thermomechanical Relay with Microspring Contact Array, Technical Digest IEEE Micro Electro Mechanical Systems'2001 (2001) pp.220-223





Advantages of conventional mechanical switch

- Imune to high voltage
- Excellent isolation at high frequency

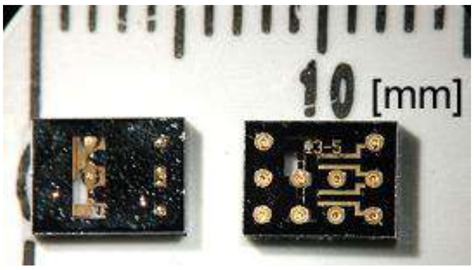
Advantages of small size and integration

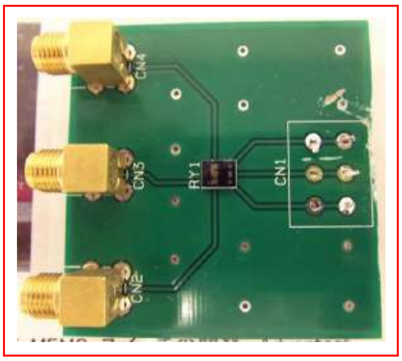
- Wide frequency range

RF MEMS switch

- Imunity to electrostatic discharge : 1000V
- Frequency range : DC – 10GHz

Drive power	<160mW (6V)
On resistance	<0.3 Ω (initial)
Switching speed	<3ms
Cotact life	8000 times (3V-15mA dry)



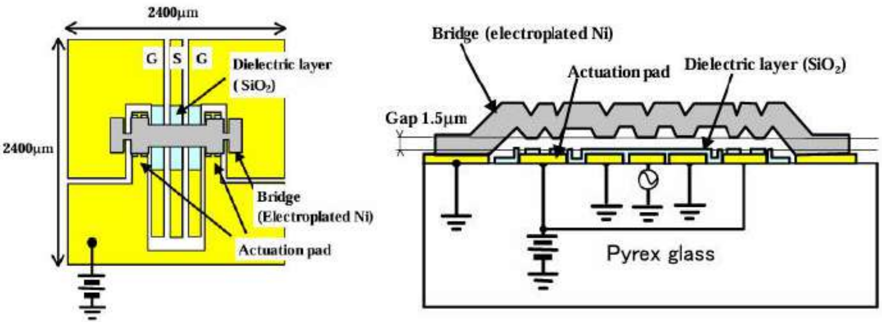


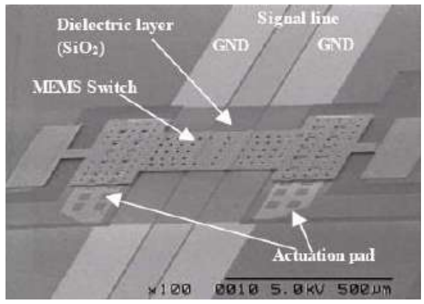
SoI test system T2000

LSI tester using the thermal MEMS switch and Advantest component producing the MEMS switch in Sendai

Reference : K.Nakamura, F.Takayanagi, Y.Moro, H.Sanpeo, M.Onozawa and M.Esashi : Development of RF MEMS switch, Advantest Technical Report, 22 (2004) pp.9-16

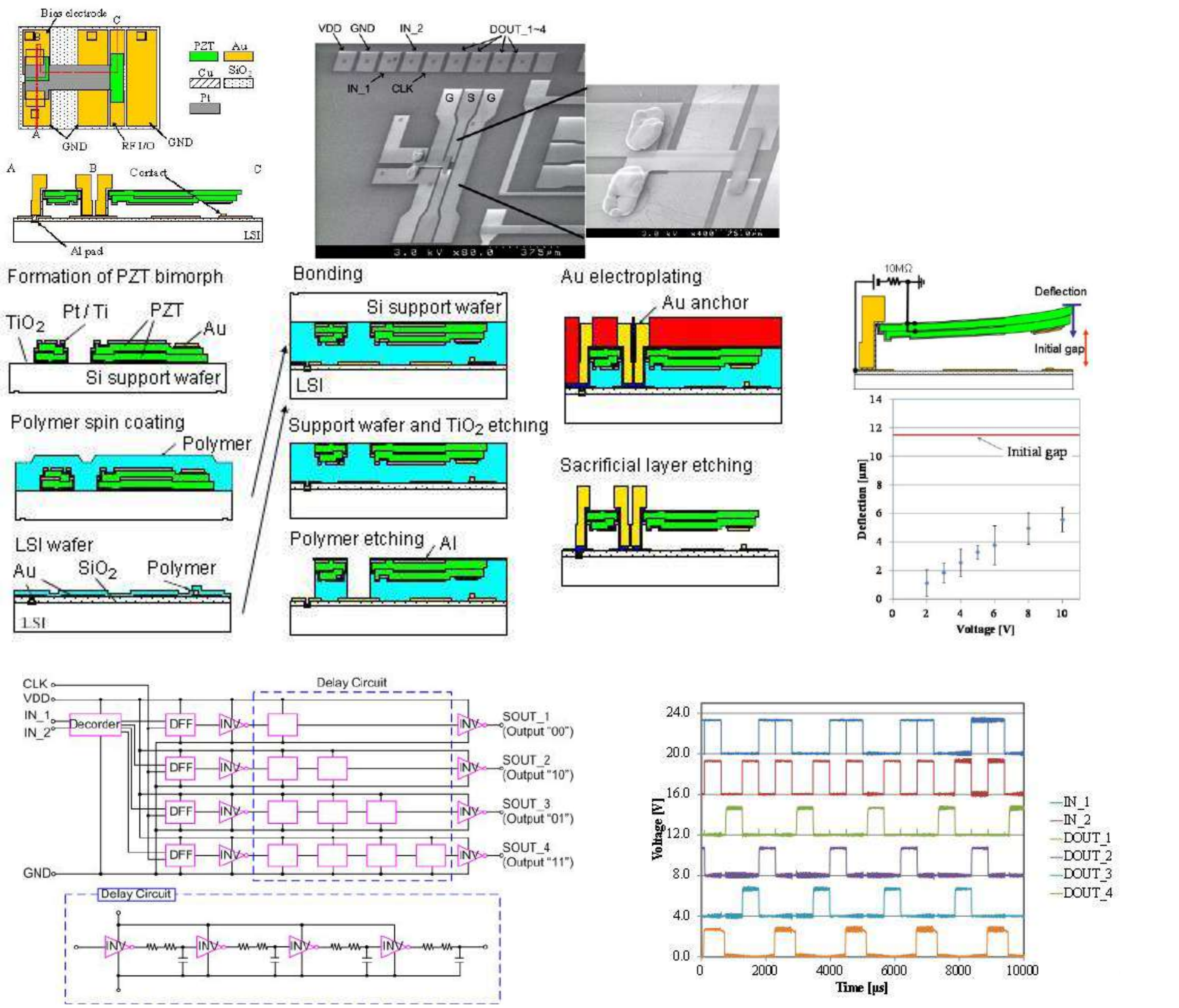
F14 Electrostatic and piezoelectric MEMS switch





Electrostatically actuated capacitive switch

Reference : T.Yuki, J.H.Kuypers, S.Tanaka and M.Esashi, Capacitive RF Switch Fabricated by Low-temperature Surface Process and Packaged Using Dry Film Resist, Proc. of the 24th Sensor Symp. (2007) pp.37-40



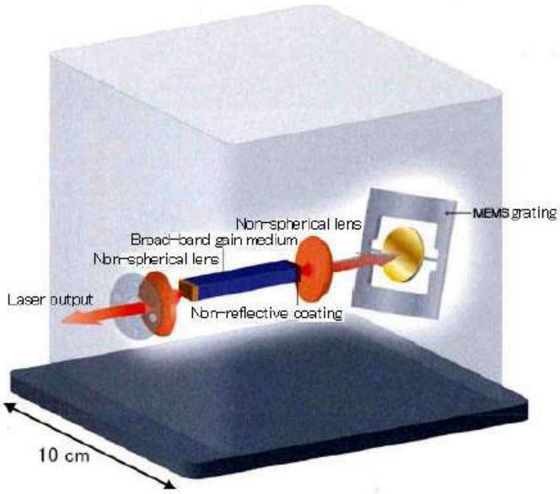
MEMS switch using piezoelectric thin film

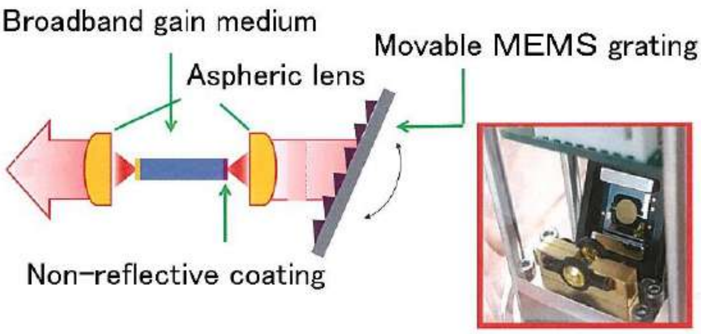
Reference : K.Matsuo, M.Moriyama, M.Esashi and S.Tanaka, Low-voltage PZT-actuated MEMS Switch Monolithically Integrated with CMOS Circuit, Technical Digest IEEE MEMS 2012 (2012) pp.1153-1156

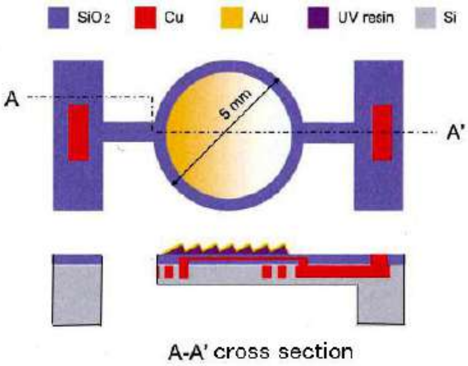
G1 Wavelength swept pulsed quantum cascade laser (EC-QCL)

(Hamamatsu Photonics K.K.)

Pulsed quantum cascade laser (EC-QCL) which can scan wide wavelength by using external resonator was commercialized by Hamamatsu Photonics K.K. using movable MEMS grating which was fabricated using the hands-on access fabrication facility in Nishizawa center. This enable remote, noncontact and high throughput middle infrared spectrometry.

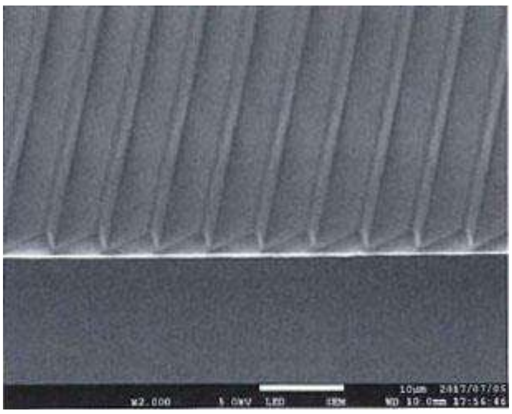


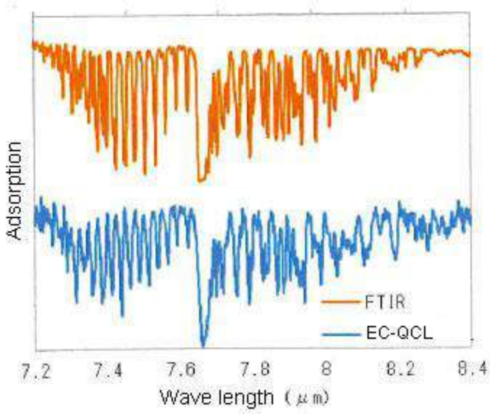




Structure

Movable MEMS grating





SEM image of MEMS grating

Measured IR spectrum of methane gas

Hamamatsu Photonics K.K. www.hamamatsu.com Tel. 053-459-1113

Melt Pressure & Temperature Sensor

Rev.1

KF10 NEW

長野計器

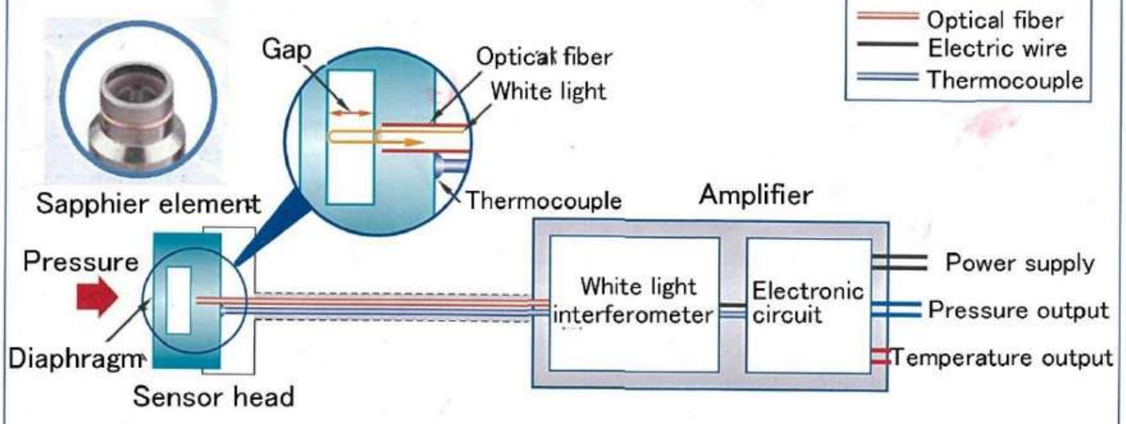
Optical Melt Pressure & Temperature Sensor

Improved durability using monocrystaline sapphire diaphragm head

Measurement of high pressur at 400℃ with ±0.5% F.S.

Princeple of optical pressure sensor

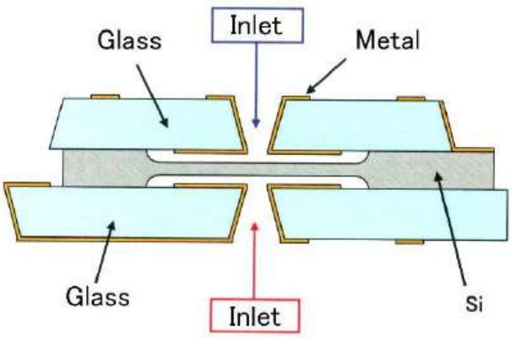
Gap in sapphier element is changed by pressure and is measured by white light interferometer. Temperature is measured by using thermocouple.



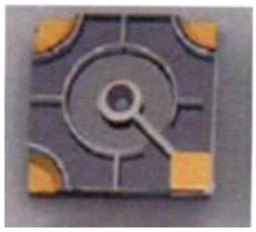
長野計器 NAGANO KEIKI
長野計器株式会社
本社／〒143-8544 東京都大田区東馬込一丁目30番4号 代表TEL 03(3776)5311 FAX 03(3776)5320
●お問合せは下記フリーコールをご利用ください。 ホームページ URL：
コールセンター／0120-10-8790 https://www.naganokeiki.co.jp/

G3 Capacitive high sensitive differential pressure sensor "MANOSTAR" (Yamamoto Electric Works Co. Ltd)

MANOSTAR digital differential pressure sensor QDP33 was developed in the "MEMS human resource training program (MEMS Park Consortium)" using the "Hands-on-access fabrication facility".



Cross section



Chip photo

Assembly

仕 様

圧力レンジコード

QDP33 N 1 D 500 (例)

レンジ	最大値（±レンジは±も記入）	
単位	D	Pa
	E	kPa
アナログ出力	1	4～20 mA
	4	1～5 V
比較出力	N	NPN トランジスタ
	P	PNP トランジスタ

圧力レンジコード	定格圧力レンジ	LCD表示
D 50	0 ～ 50 Pa	0 ～ 50.0
D 100	0 ～ 100 Pa	0 ～ 100.0
D 200	0 ～ 200 Pa	0 ～ 200
D 300	0 ～ 300 Pa	0 ～ 300
D 500	0 ～ 500 Pa	0 ～ 500
D 1000	0 ～ 1000 Pa	0 ～ 1000
E 1	0 ～ 1 kPa	0 ～ 1.00
E 2	0 ～ 2 kPa	0 ～ 2.00
E 3	0 ～ 3 kPa	0 ～ 3.00
E 5	0 ～ 5 kPa	0 ～ 5.00
D +-50	-50 ～ 50 Pa	-50.0 ～ 50.0
D +-100	-100 ～ 100 Pa	-100.0 ～ 100.0
D +-200	-200 ～ 200 Pa	-200 ～ 200
D +-300	-300 ～ 300 Pa	-300 ～ 300
D +-500	-500 ～ 500 Pa	-500 ～ 500
E +-1	-1 ～ 1 kPa	-1.00 ～ 1.00
E +-2	-2 ～ 2 kPa	-2.00 ～ 2.00
E +-3	-3 ～ 3 kPa	-3.00 ～ 3.00
E +-5	-5 ～ 5 kPa	-5.00 ～ 5.00

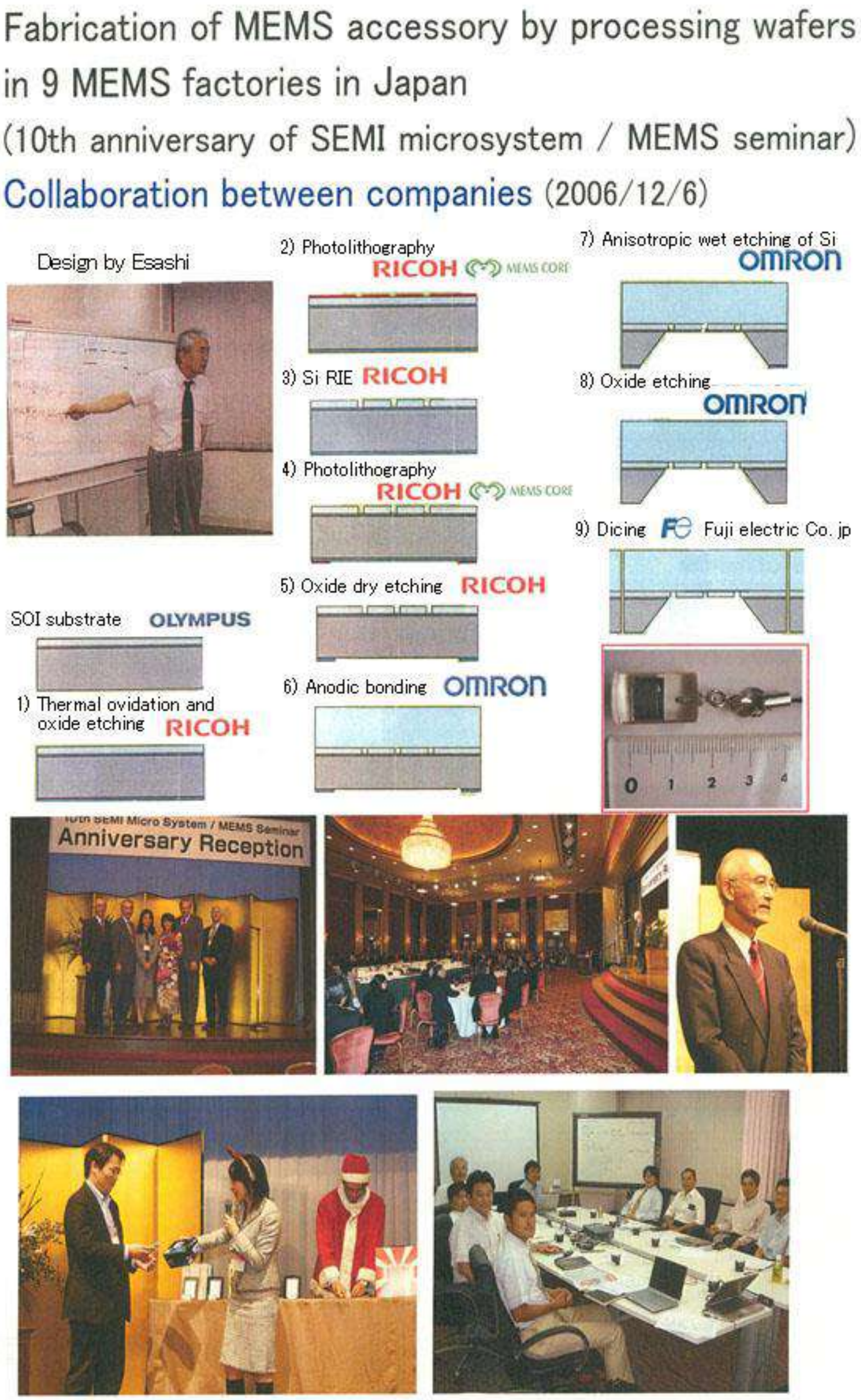
製品に関するお問い合わせ

▷ お電話でのお問い合わせ　▷ メールでのお問い合わせ

078-621-7000　eigyou@manostar.co.jp

製造元 株式会社 山本電機製作所
〒653-0031 神戸市長田区西尻池町一丁目2番3号
TEL: (078)-631-6000 FAX: (078)-631-6020
http://www.manostar.co.jp/

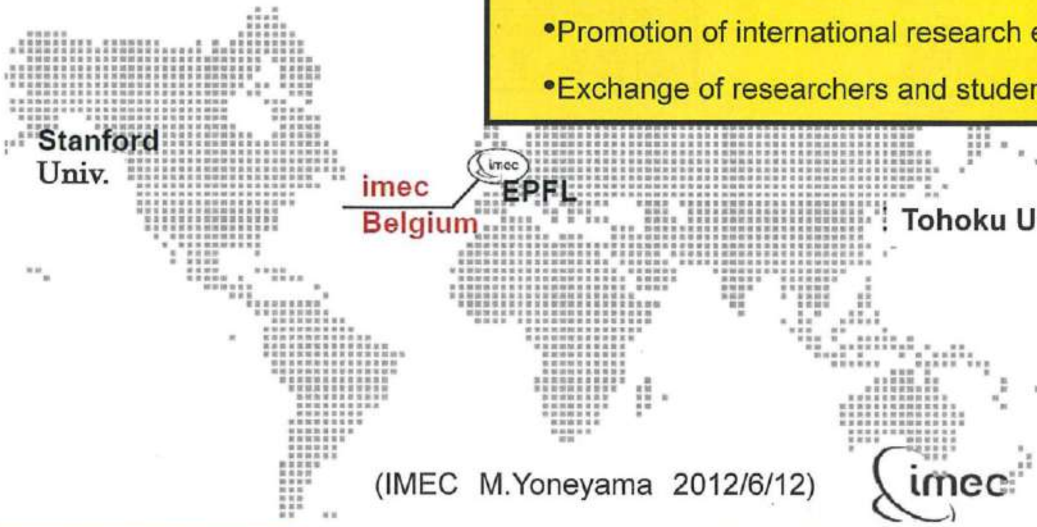
G4 10th anniversary of SEMI MEMS seminar



Tohoku Univ. and Belgium IMEC (Interuniversity Micro Electronics Center)

Strategic Partner

- One university from each region, Japan, USA and Europe
- Promotion of international research exchange
- Exchange of researchers and students



←Hiroshi Kazui (Director, Tohoku Univ.) and Luc Van Den Hove (IMEC president)

Signing ceremony (2012/6/11) →

Joint Seminar in IMEC (2012/6/21) Alternative annual meeting in IMEC and Tohoku University

H2 Poly-SiGe for MEMS sensor applications

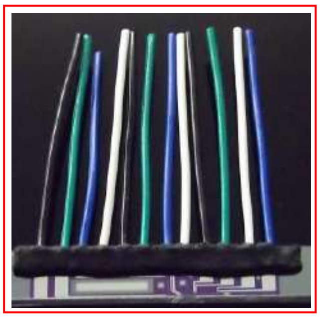
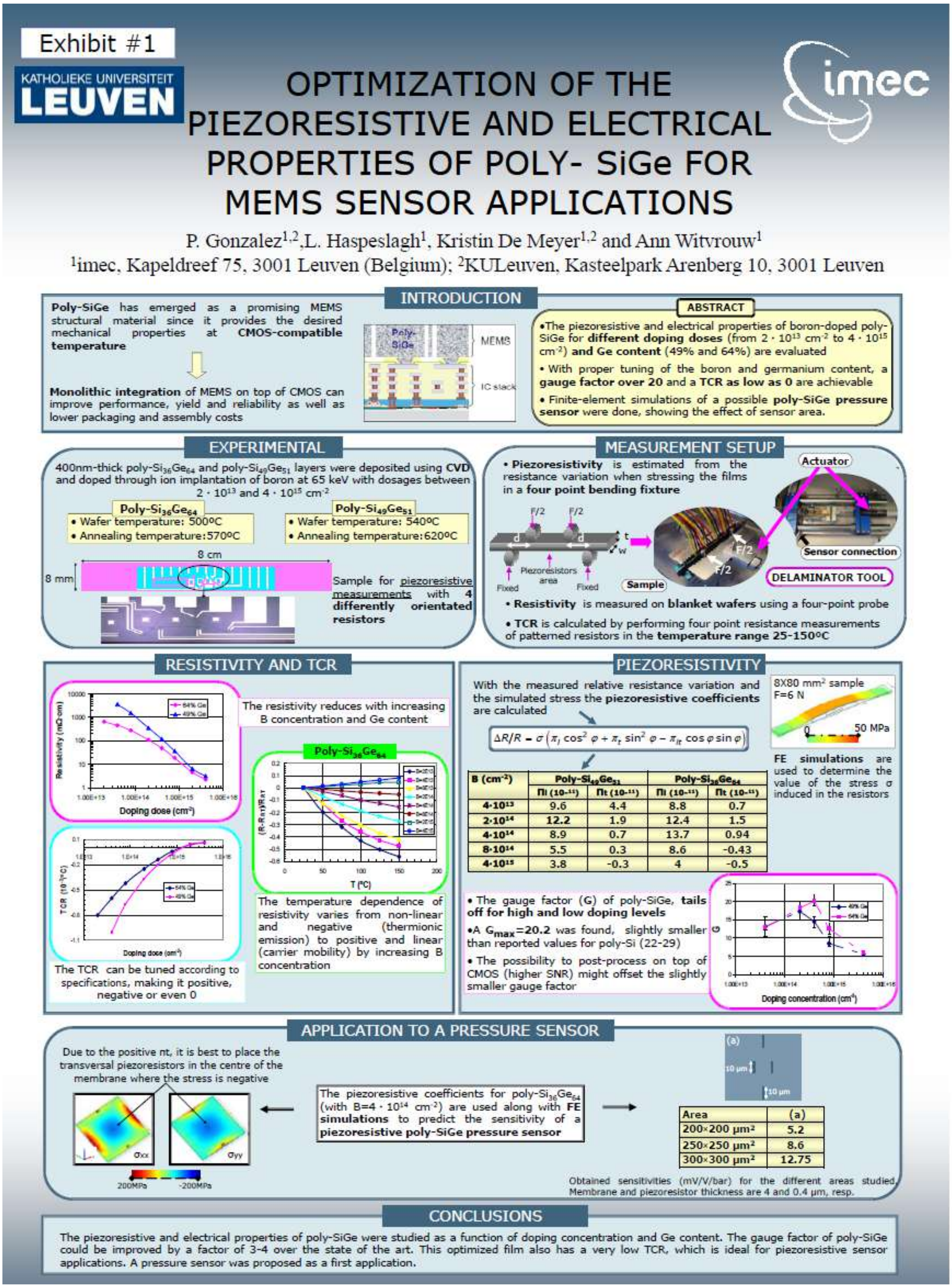


Exhibit #1: Sample to determine the piezoresistivity of a poly-SiGe layer by measuring the resistance changes during 4-point bending tests.



H3 MEMS gyroscope on CMOSIC using poly−SiGe

ISSCC 2005 / SESSION 4 / TD: MIXED-DOMAIN SYSTEMS

4.7 Processing of MEMS Gyroscopes on Top of CMOS ICs

A. Witvrouw[1], A. Mehta[1], A. Verbist[1], B. Du Bois[1], S. Van Aerde[2], J. Ramos-Martos[3], J. Ceballos[3], A. Ragel[3], J. M. Mora[3], M.A. Lagos[3], A. Arias[3], J. M. Hinojosa[3], J. Spengler[4], C. Leinenbach[5], T. Fuchs[5], S. Kronmüller[5]

[1]IMEC, Leuven, Belgium, [2]ASM, Leuven, Belgium, [3]IMSE-CNM, Sevilla, Spain, [4]Philips, Böblingen, Germany, [5]Bosch, Gerlingen-Schillerhöhe, Germany

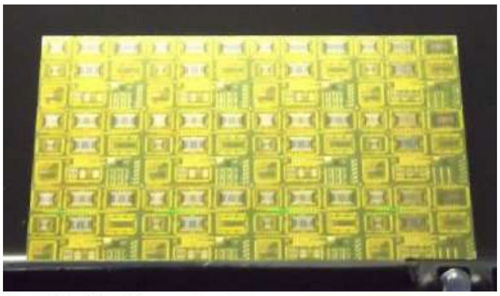
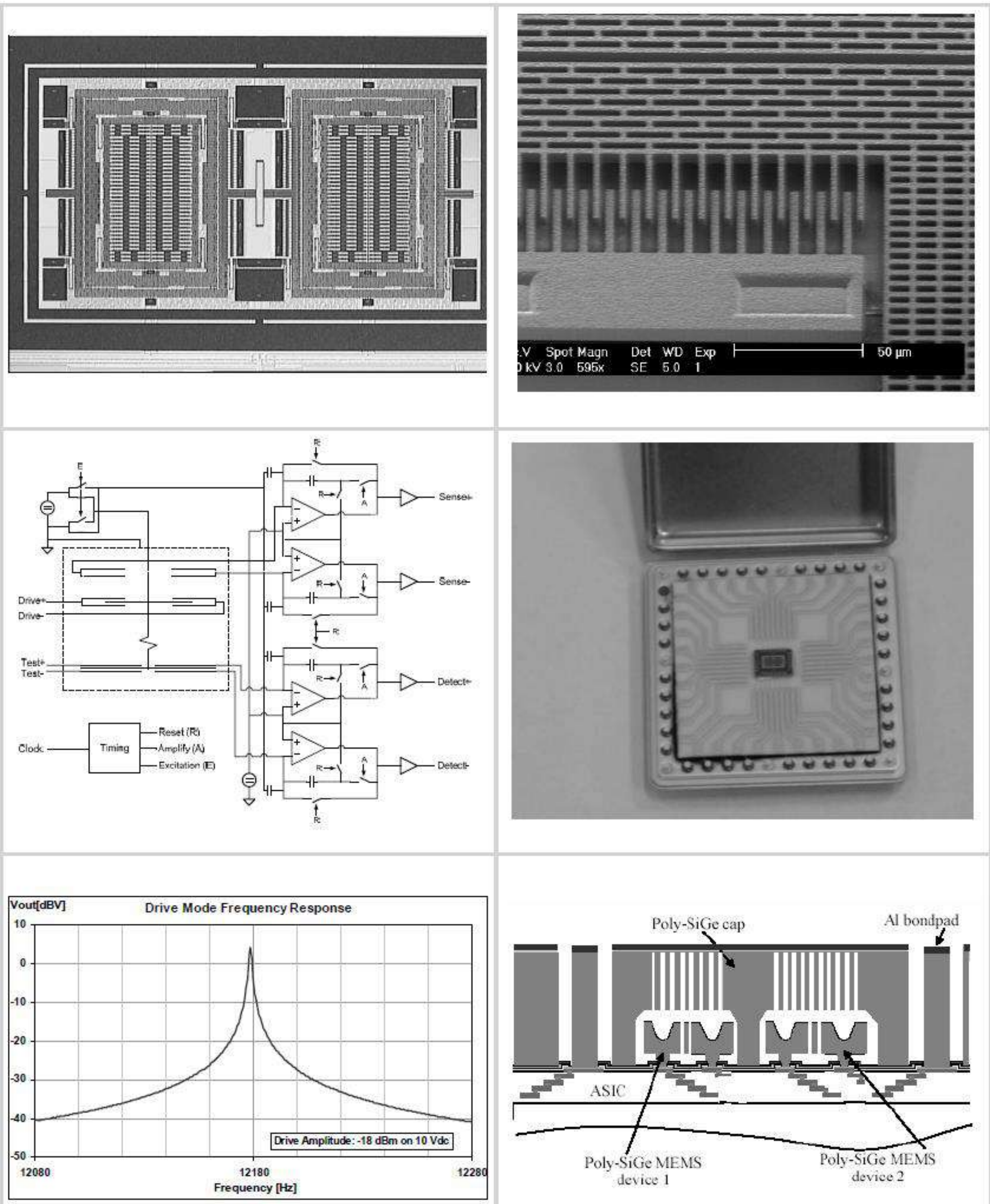


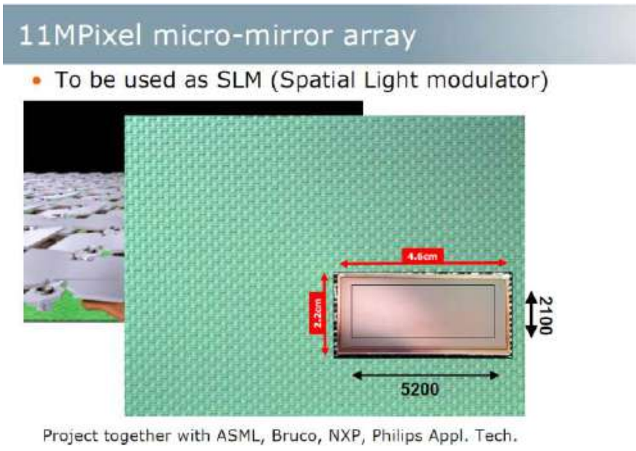
Exhibit #2: First poly-SiGe above-CMOS integrated gyroscope. The CMOS technology used is a standard 0.35 μm technology with 5 interconnect levels.

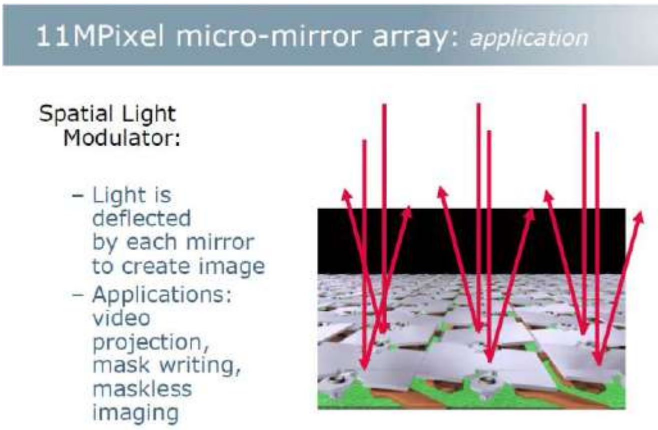


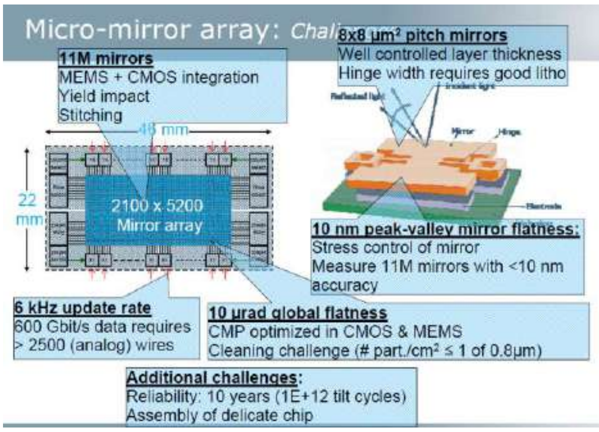
H4 # SiGe micro-mirror array on CMOS IC

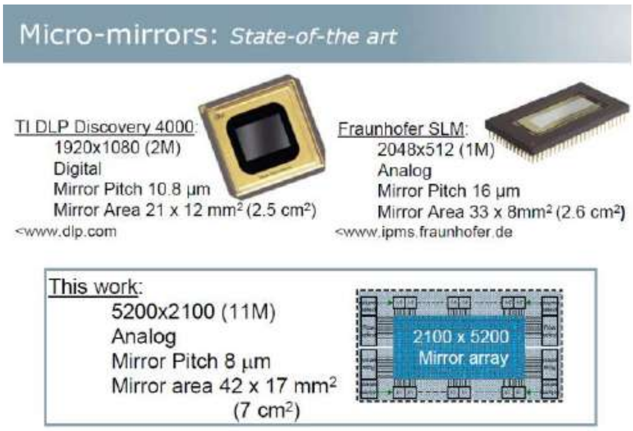
Ann Witvrouw

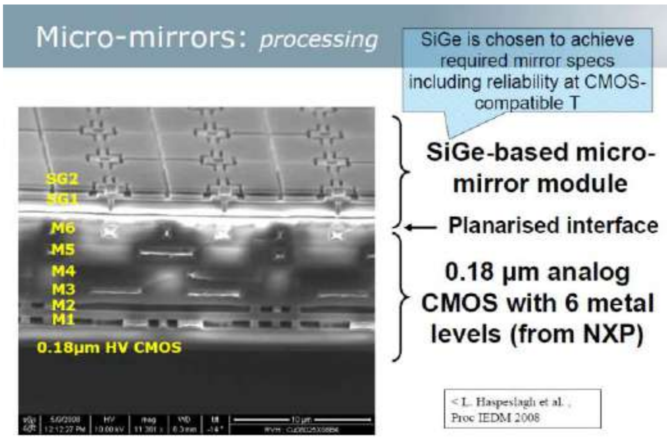
Exhibit #3: 11 megapixel micro-mirror array with 8 μm pitch made in poly-SiGe above standard 0.18μm analog-CMOS wafers fabricated by NXP, featuring 6 interconnect levels.

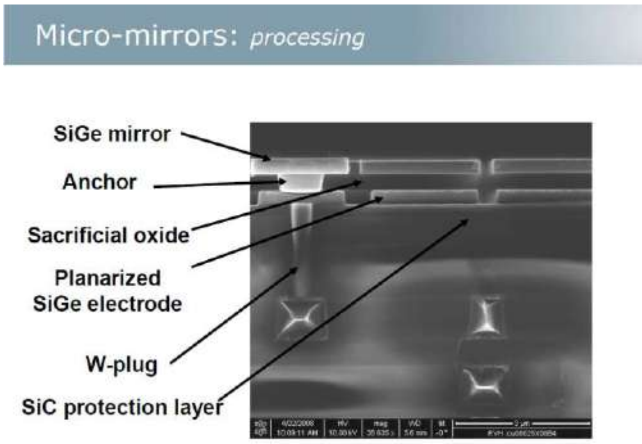


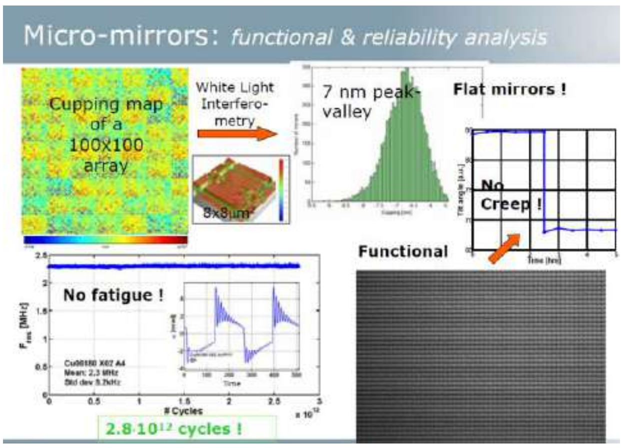


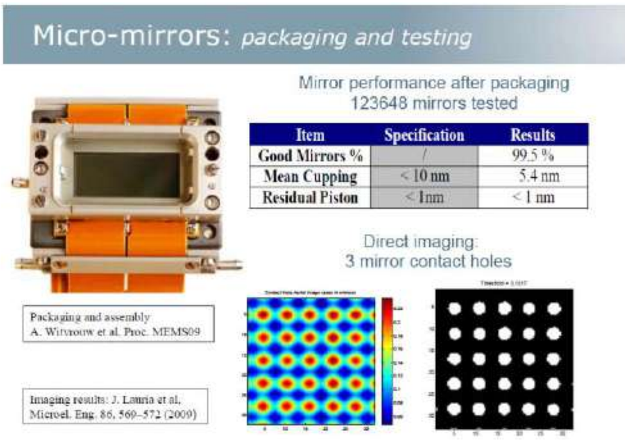












Item	Specification	Results
Good Mirrors %	/	99.5 %
Mean Cupping	< 10 nm	5.4 nm
Residual Piston	< 1nm	< 1 nm

CMORE SiGeMEMS mluti project wafer

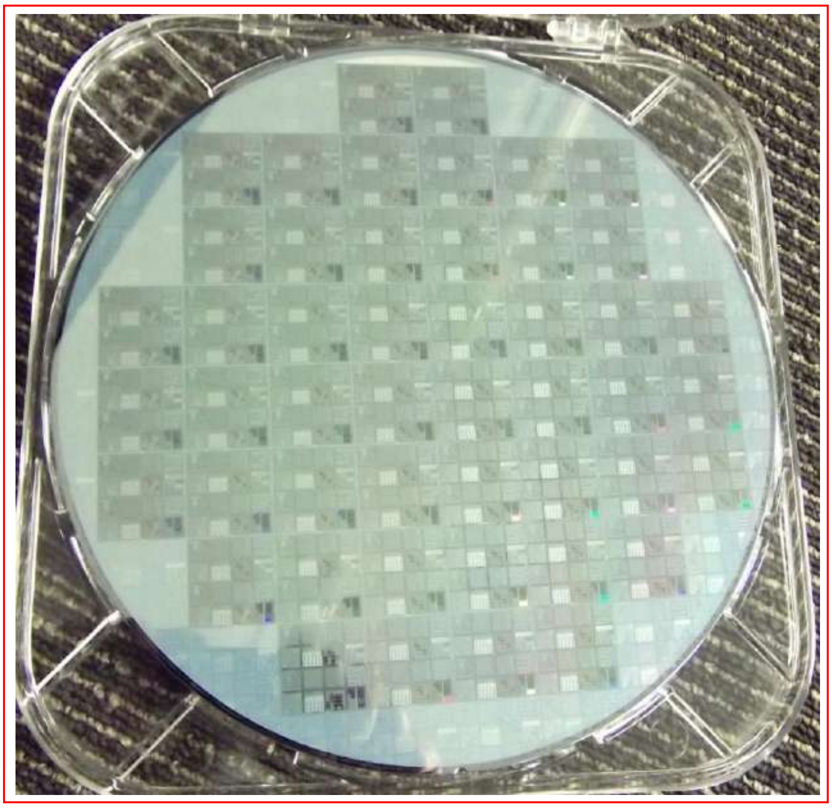


Exhibit #4: Poly-SiGe MEMS MultiProject Wafer (MPW) from the first SiGeMEMS MPW run organized by Europractice in 2011.

EUROPRACTICE IC SERVICE

imec

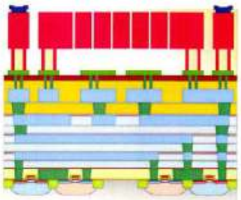
imec CMORE SiGeMEMS MPW

EUROPRACTICE IC Service offers Multi-Project Wafer Services in imec's CMORE SiGeMEMS standalone and SiGeMEMS/CMOS integrated technology:

Imec's **CMORE Silicon Germanium MEMS** platform technology, referred to as **SiGeMEMS**, is developed to enable monolithic integration of CMOS and MEMS. Systems integrating MEMS devices with the driving and readout electronics on the same die lead to better performances in terms of signal to noise ratio through reduced interconnect parasitic resistance and capacitance, allow for smaller die size and package, and also for lower power consumption. SiGeMEMS is based on a MEMS-last approach which allows state-of-the-art CMOS foundries to be employed.

Technology

The SiGeMEMS process, belonging to imec's CMORE service platform, is very versatile. Thanks to its flexible and modular approach, allowing application-specific tuning and optimization, it addresses a large number of applications like gyro's, switches, µmicrophones, µspeakers, CMUTs, T-sensors, P-sensors, ... and array type devices like µmirrors, probe-based memories, and arrays for µfluidics and µpower generation...



EUROPRACTICE now offers a fixed baseline SiGeMEMS process in a Multi-Project Wafer Service. This unique baseline process consists of MEMS structures defined by an electrode layer and a 4µm-thick SiGe-mechanical layer on top of a TSMC 0.18um CMOS wafer. Nanogaps of 500nm will allow fabrication of extremely small features. A standalone MEMS version, identical but processed on a wafer with a single metal layer, will be available for initial prototyping.

Europractice-imec SiGeMEMS MPW runs in 2012

imec CMORE	2012											
	J	F	M	A	M	J	J	A	S	O	N	D
SiGeMEMS MEMS-only								20				
SiGeMEMS/TSMC 0.18µm CMOS (CV018LD 1.8/3.3/32V)						10				25 [1]		

Note: 1) This run is preliminary and can be updated during 2012

Price

Technology Version	Standard Price	EU-Discounted Price
MEMS-only	4250 €	4000 €
CMOS integrated	28500 €	27000 €

EU-Discounted Price only applies to EUROPRACTICE registered (who paid their annual full membership fee) Academic and Research Members from all 27 EU countries and Norway, Iceland, Liechtenstein, Israel, Croatia, Serbia, Macedonia, Albania, Montenegro, Bosnia&Herzegovina, Switzerland, Turkey who submit designs for educational or *publicly funded research use only.*

Standard Price normal price for universities and research institutes not belonging to previous category. (Companies should contact imec CMORE at www.imec.be/cmore to take advantage of additional extensions and services.

Prices and conditions may change at any time without prior notice.

For more information : epmems@imec.be

www.europractice-ic.com

EUROPRACTICE IC SERVICE

imec

imec CMORE SiGeMEMS MPW

Principle

Imec's CMORE SiGeMEMS technology offered through the EUROPRACTICE IC MPW service is aimed at creating, characterizing and evaluating test structures prior to further specific development and production projects. By gathering the designs of multiple customers on the same masks set, MPWs allow to fabricate test structures and prototypes of devices at a low cost.

Advantages of SiGeMEMS

Monolithic integration with IC :

- Very compact
- Best solution for applications that are very sensitive to parasitics
- High intrinsic system reliability: less components, less interconnections

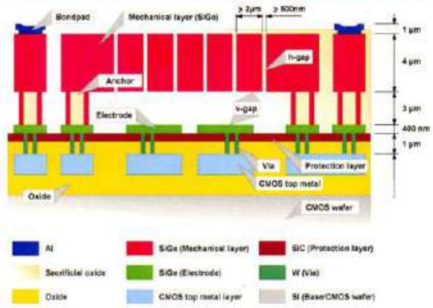
MEMS last above CMOS :

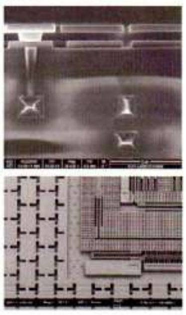
- Most flexible with respect to choice of CMOS technology
- Extremely well suited for MEMS array applications
  - very high-density and massively parallel interconnections possible → large arrays of MEMS (e.g. µmirror arrays)

Poly-SiGe :

- High performance: low parasitics
- Good mechanical properties & reliability
  - better than Al: higher strength and Q factor
  - better than Al: less creep and fatigue

Summary of SiGeMEMS main features and dimensions





General conditions :

EUROPRACTICE SiGeMEMS MPW Service is accessible for universities and research institutes. (EUROPRACTICE registered members) → more info at www.europractice-ic.com

Companies can have additional extensions to take advantage of the versatile, flexible and modular technology:

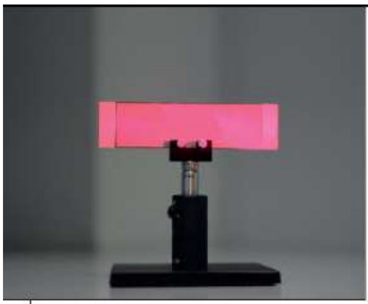
- Variable layer thicknesses
- Application specific optimization of layer & material properties
- Application specific functional add-on layers

Companies should contact imec CMORE at www.imec.be/cmore

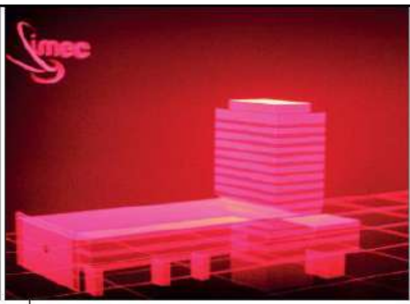
For more information : epmems@imec.be

www.europractice-ic.com

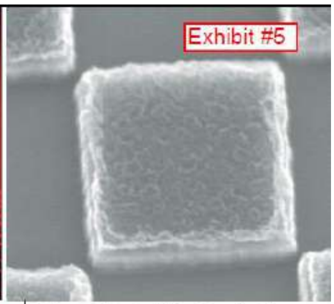
H6 Holographic displays



Set-up for holographic display technology



Holographic image demonstrator



SEM-image of sub-wavelength binary holographic pixel

DIGITAL DIFFRACTIVE OPTICS

PATH TO HIGH-QUALITY HOLOGRAPHIC DISPLAYS

Vision

Imagine having a meeting. You and your guests sit around the table arguing, discussing or presenting data. Just like any meeting you have today, only for one detail: some of the people around the table are 3D images – dynamic holograms – of people sitting in an office thousands of miles away. You will look them in the eye, feel their hesitations, and see their body language. Unlike with today's displays, you won't miss a cue.

Holographic visualization promises to offer a natural 3D experience for multiple viewers, without the undesirable side-effects of current 3D stereoscopic visualization (uncomfortable glasses, strained eyes, fatiguing experience). Imec's vision is to design the ultimate 3D display: a holographic display with wide viewing angle and a high-definition visual experience.

Challenges

Building a high-quality, real-time holographic display requires several breakthroughs from today's holographic prototypes. The challenges are threefold:

– To achieve high image quality, millions of light-diffracting elements are needed. These must all be individually controlled.

– To achieve a wide viewing angle, the light-diffracting elements should be sized close to or below the wavelength of the visible light, i.e. as small as a few hundred nanometers.

– To achieve real-time imaging, massive computing power is needed.

Technology

Imec is scaling its MEMS technology to meet these challenging demands. Our prototypes show promising results, setting the path to high-quality displays.

Imec aims for system-level solutions utilizing a unique combination of its multi-disciplinary teams with strong competences in:

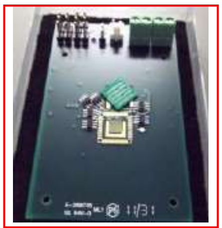
- Advanced lithography
- Silicon processing
- SiGe MEMS processing platform
- MEMS design & prototyping
- Computational holography
- Holographic (lens-less) imaging
- Sub-wavelength diffractive optics
- Embedded system design
- Parallel computing platforms

Our longer-term goal is to create a display system for computer-generated holography with billions of sub-wavelength diffractive elements, delivering high-definition 3D visual experience.

imec

www.imec.be

Imec, The Netherlands



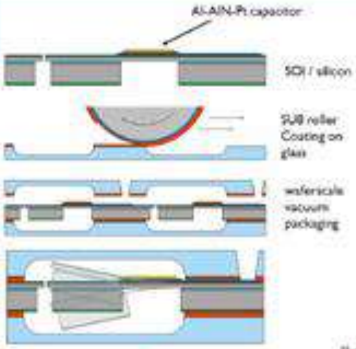
MEMS FOR ENERGY HARVESTERS & ELECTRONIC NOSE

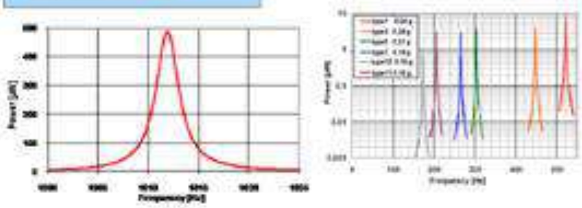
Background

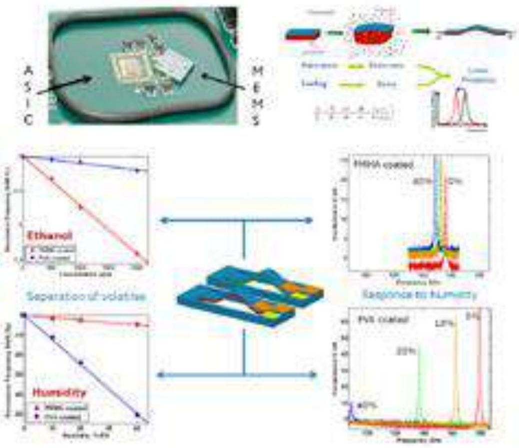
Wireless sensor nodes are able to operate autonomously, for extended periods of time, provided they are equipped with Ultra Low Power components, and their energy is supplied by energy harvesters. For both the sensors as well as the harvesters, MEMS fabrication by bulk machining is an enabling technology.

Energy Harvesting

The **Piezo Vibration Harvester** is processed on SOI wafers. An Al-AlN-Pt is deposited and subsequently the beam and mass are defined using DRIE. The devices are vacuum packaged with two glass wafers with a cavity. Roller coating is used for this process. Several devices have been designed, each with their own resonance frequency (between 200Hz and 1 kHz). The maximum power output has been 489μW at an input acceleration of 4.5g.







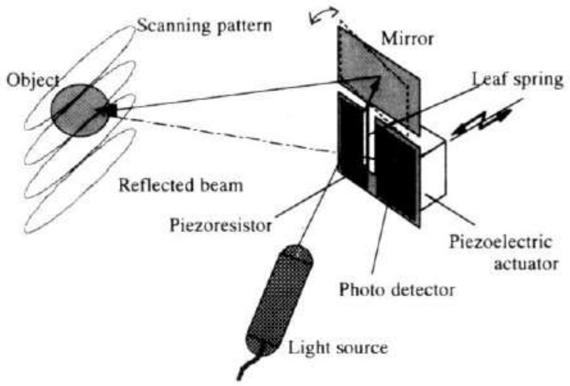
Ultra Low Power Electronic Nose

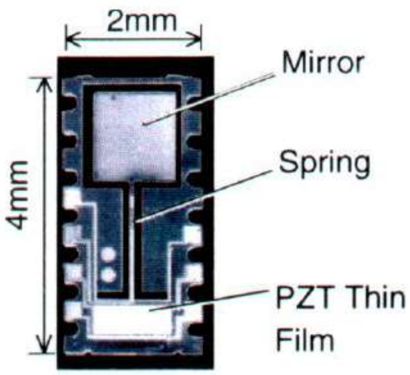
MEMS cantilevers are traditionally used for mass based (bio-)sensing as the resonance frequency shifts when molecules adsorb.

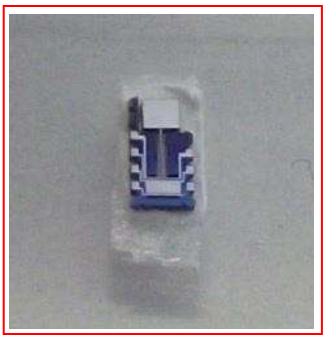
Here, an electronic nose based on the response of an array of MEMS resonators is developed, where each resonator is coated with a different polymer and thus reacts differently when exposed to the environment. This approach, where swelling of the polymers gives a stress induced resonance shift, is significantly more sensitive (~300x compared to mass based sensing), thus enabling detection of low-mass volatiles with a scalable MEMS array. Additionally, a dedicated ASIC is developed that actuates the device through a piezo-electric patch, and tracks the resonance frequency.

Holst Centre

I1 Piezoelectric and electrostatic optical scanners

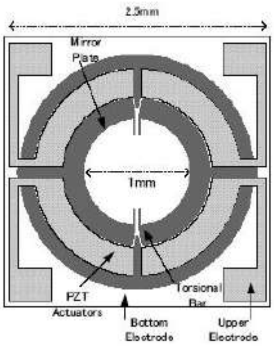


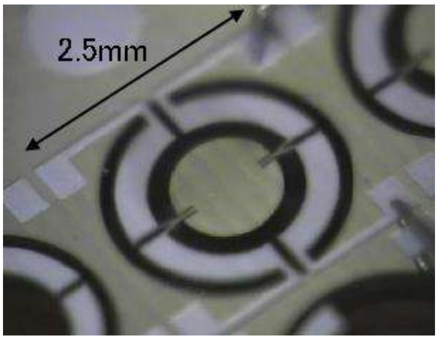


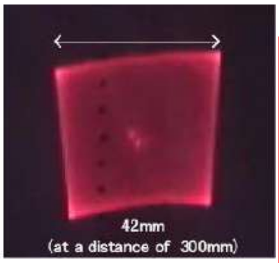


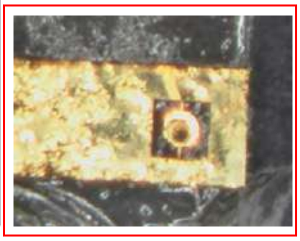
Piezoelectric 2 axis optical scanner (Omron)

Reference : T.Kawabata, M.Ikeda, H.Goto, M.Matsumoto and T.Yada, The 2-Dimensional Micro Scanner Integrated with PZT Thin Film Actuator, Transducers' 97 (1997) pp.339-342



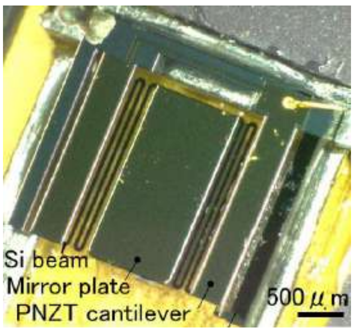


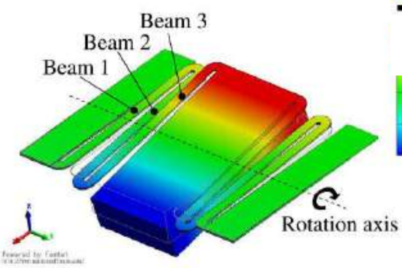


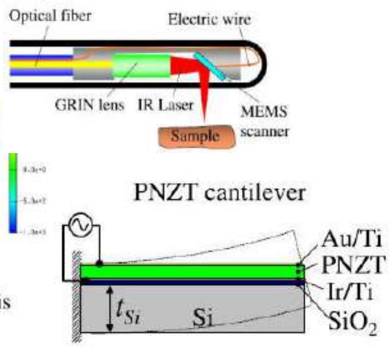


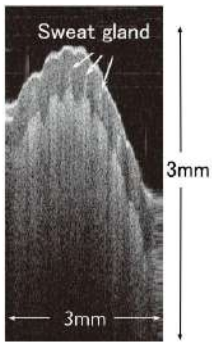
2 axis optical scanner using piezoelectric thin film for laser projector

Reference : H.Matsuo, Y.Kawai and M.Esashi, Novel Design for Optical Scanner with Piezoelectric Film Deposited by Metal Organic Chemical Vapor Deposition, Jap. J. Appl. Phys., 49, 6 (2010) 04DL19





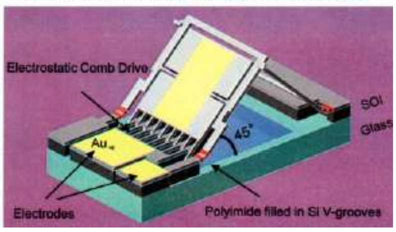


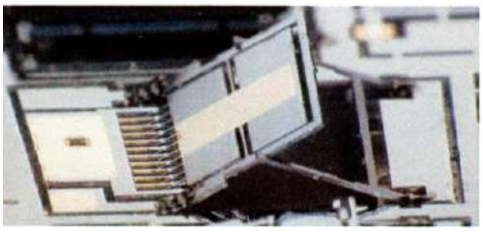


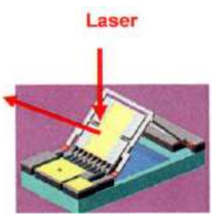
Large scan angleoptical scannerusing PNZTfilm (Tohoku Univ.-Fuji Film)　　Application to OCT (Finger skin))

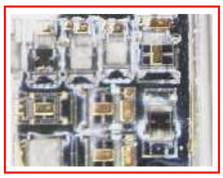
Reference : T.Naono, T.Fujii, M.Esashi and S.Tanaka, Large Scan Angle Piezoelectric MEMS Optical Scanner Actuated by Nb Doped PZT Thin Film, J. Micromech. Microeng. 24, 1 (2014) 015010(12))

ポリイミドの熱収縮を利用してミラーを45° 立ち上げた構造



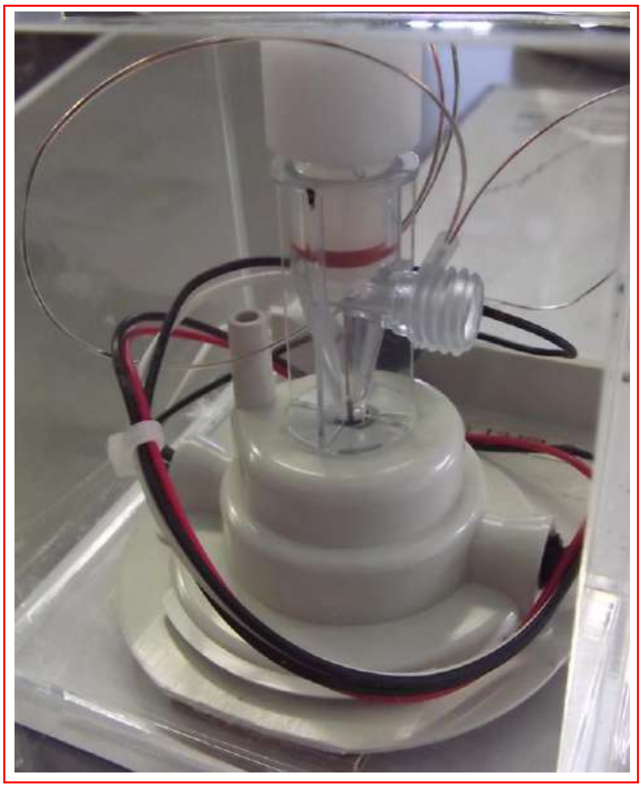


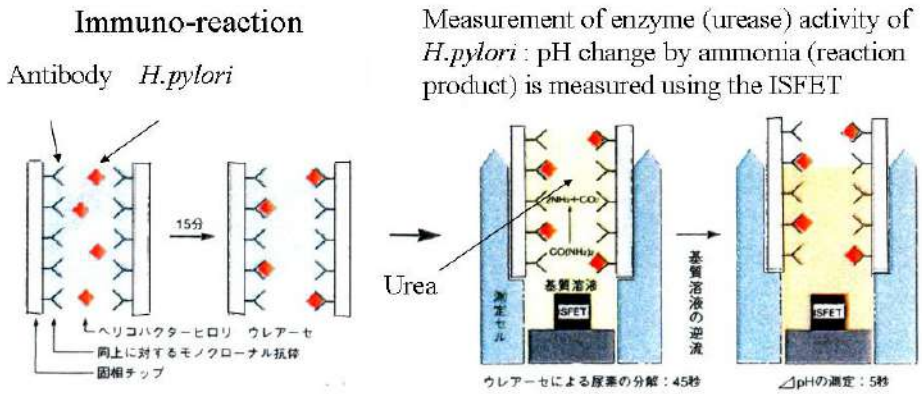


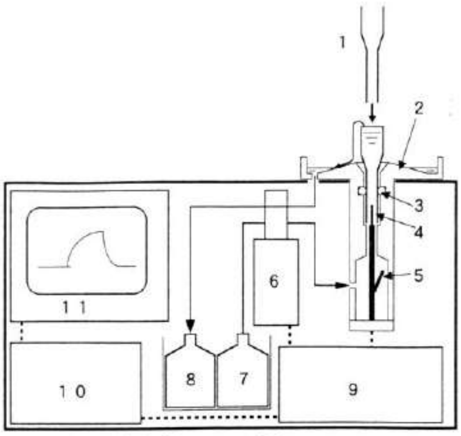


Electrostatic optical scanner for barcode reader (Tohoku Univ. - Optoelectro nics)

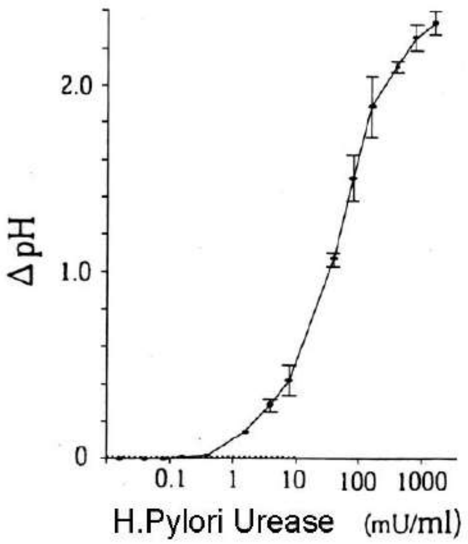
I2 Immunological analyzer of Helicobacter pylori's urease





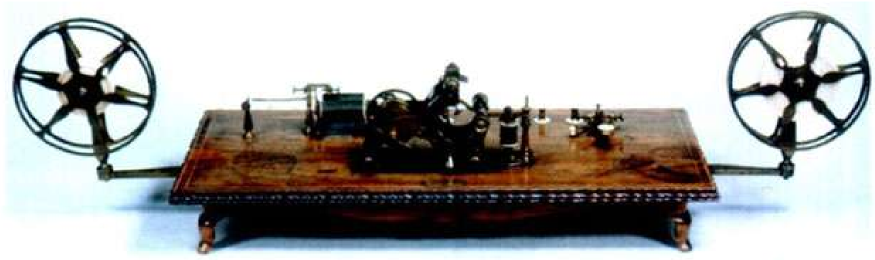


The block diagram of the present system. 1, solid-phase capillary tube ; 2, pH-measuring cell ; 3, o-ring ; 4, pH-FET ; 5, reference electrode ; 6, pelista pump ; 7, bottle of substrate solution ; 8, bottle for waste solution ; 9, electronic circuit for operating pH-FET and for controlling pump ; 10, CPU ; 11, display.

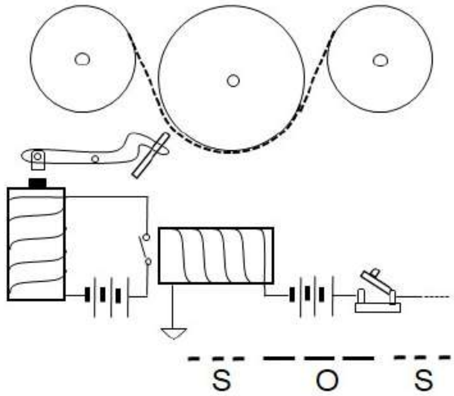


Reference : Y.Kohli, T.Kato, S.Ito, H.Miyazi, T.Azuma, K.Nagata, H.Tsuruta, S.Matsui, K.Oka and M.Nakamura, Diagnostic System for Helicobacter pylori Urease Based on a pH-sensitive Field Effect Transistor, Digestive Endoscopy, 7 (1995) pp.27-34

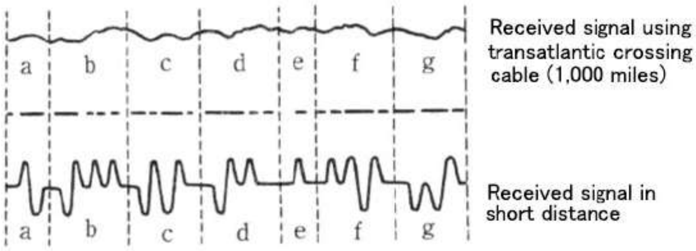
J1 Telegraph using electric wire in bottom of ocean



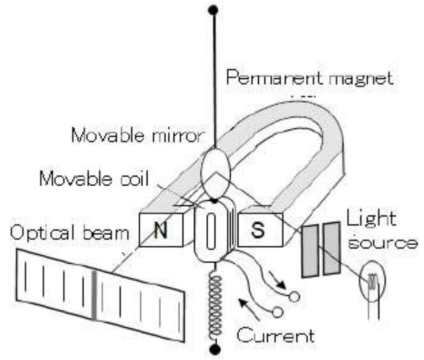
Enboshing Morse telegraph machine donated when Perry arrived in 1854

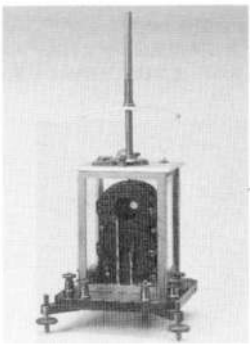


Enboshing Morse telegraph machine (POSTAL MUSEUM JAPAN)

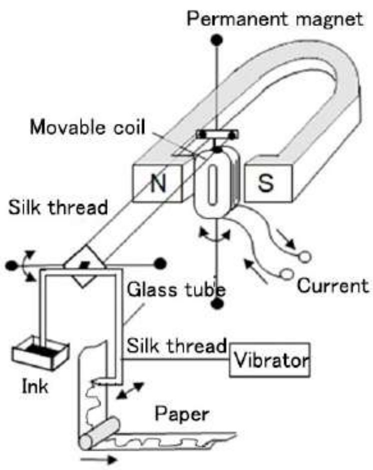


Distortion of received telegraph signal using electric cable in the sea





Kelvin type (optical) mirror galvanometer



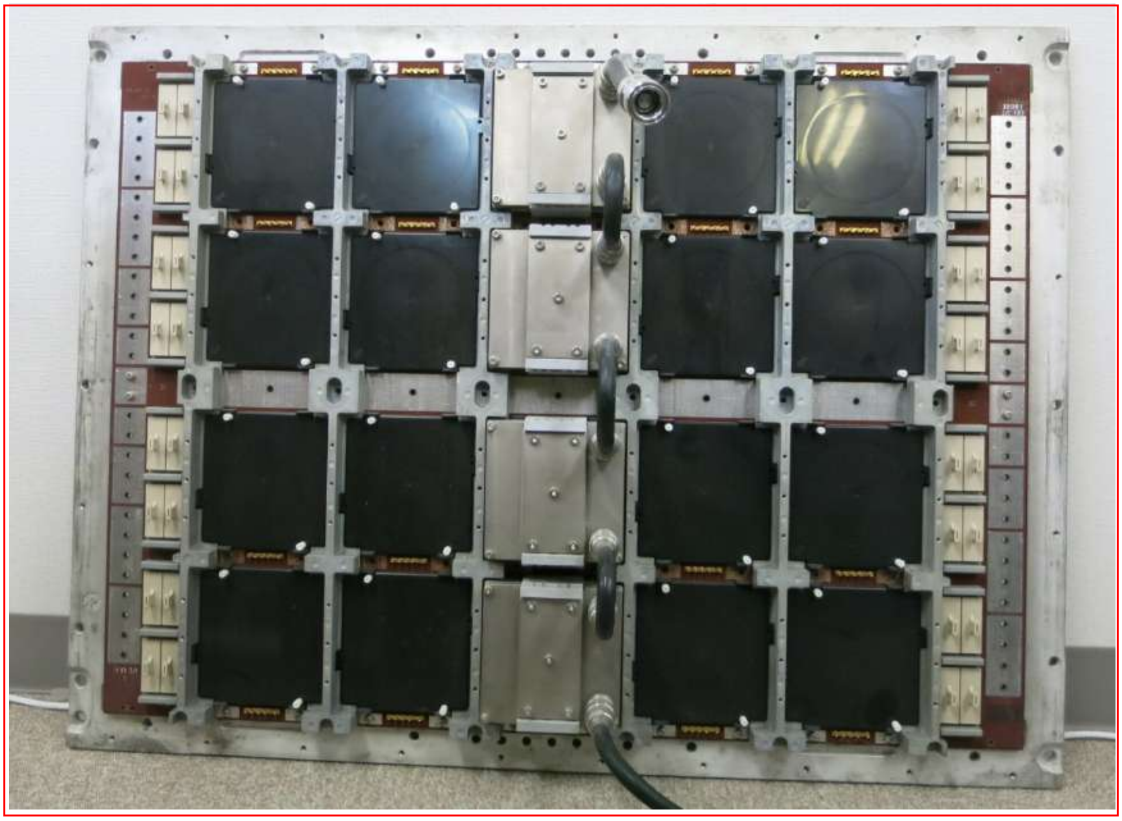
Siphon recorder

Submarine electrical cable through straits of Dover was installed in 1850. The Great Britten tried to install the submarine cable in all over the world. Transatlantic crossing cable was planned in 1957 and it was once linked in 1858/8. Queen Victoria and President Buchanan exchanged congratulatory telegram. The telegram from the queen Victoria took 67 minutes to send 102 words at that time, which was 2 words per 1 minute.

The received waveform was distorted. This is because the electrical resistance is increased by long distance and the capacitance is increased in submarine. Slow transmission was needed to solve this problem at that time. Kelvin type optical mirror galvanometer show left was used to receive the signal. The mirror was tilt by the received signal electromagnetically and reflected light was observed. Two person was needed for reading the signal and for keeping the record. This was hard work. Siphon recorder shown in lower left was invented to solve this problem and this could record the electrical signal by using pen and ink.

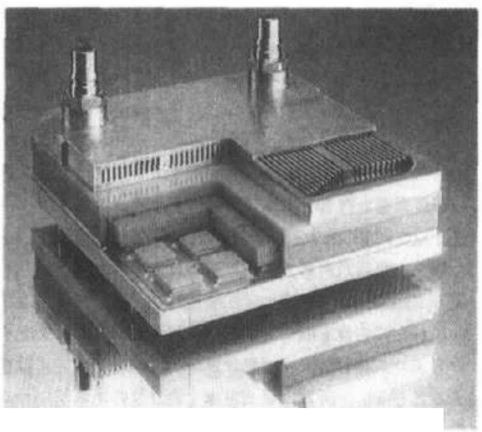
(Eiju Matsumoto : Submarine telegraph and Galvanometer, Measurement and Control, 38, 8 (1997) p.505) in Japanese

J2 CPU board for super computer (large computer)

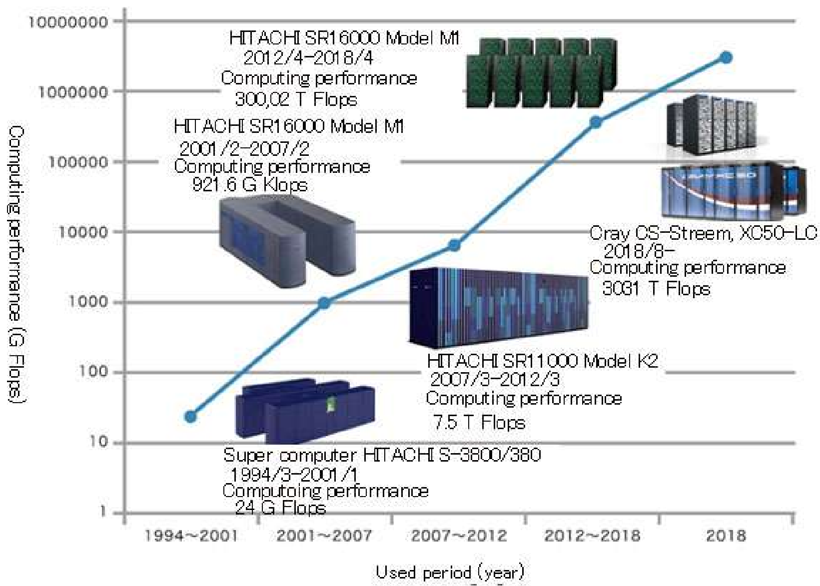


TCM (Thermal conduction module) for cooling CPU (Central processor Unit) (central part having no cover correspond to photograph shown below) (donated by Yoshiyuki Kawazoe)

(Ref) A. J. Blodgett and D. R. Barbour : Thermal conduction module : a high-performance multilayer ceramic package, IBM Journal of Research and Development, 26, 1 (1982) pp.30-36, https://doi.org/10.1147/rd.261.0030



Flipchip package MCM (HITAC M-880)

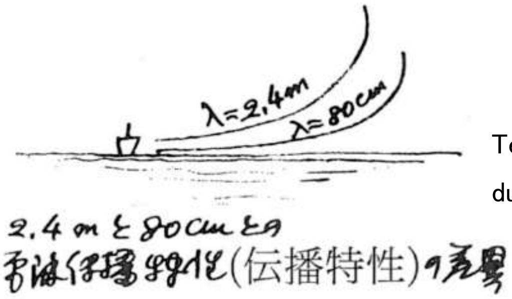


(Tadakatsu Nakajima : Cooling technology for 66, 8 (1997) 21-25) (in Japanese)

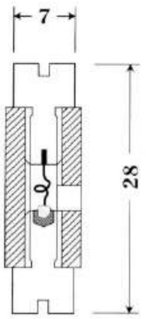
Super computer in Center of Mathematical Science in Inst. for Materials Research in Tohoku Univ.

(https://www.sc.imr.tohoku.ac.jp/center/successive.html)

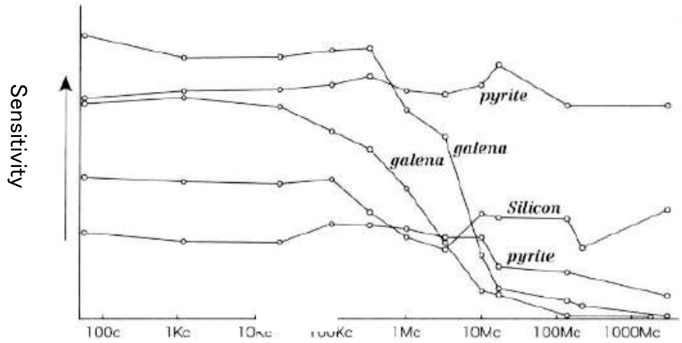
J3　Microwave radar using anode split magnetron



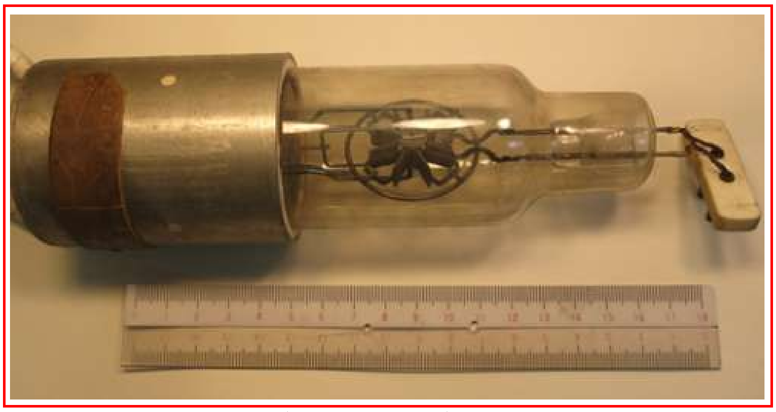
Technical transfer material from Germany during the 2nd world war (O plus E (2011/6)

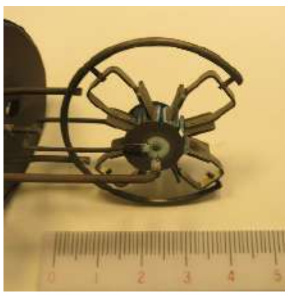


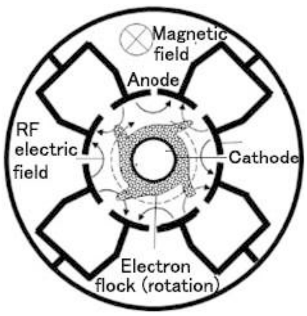
Cristal detector using pyrite



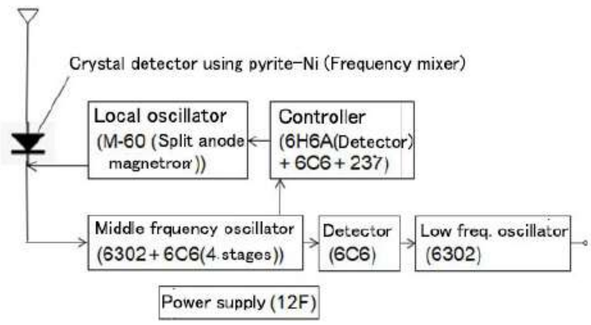
requency response of crystal detector with different crystals

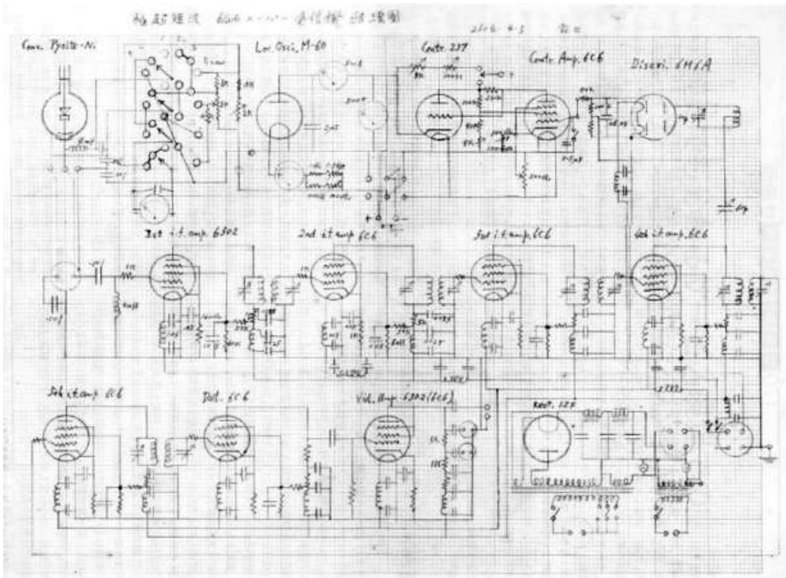






Anode split magnetron (Kinjiro Okabe)





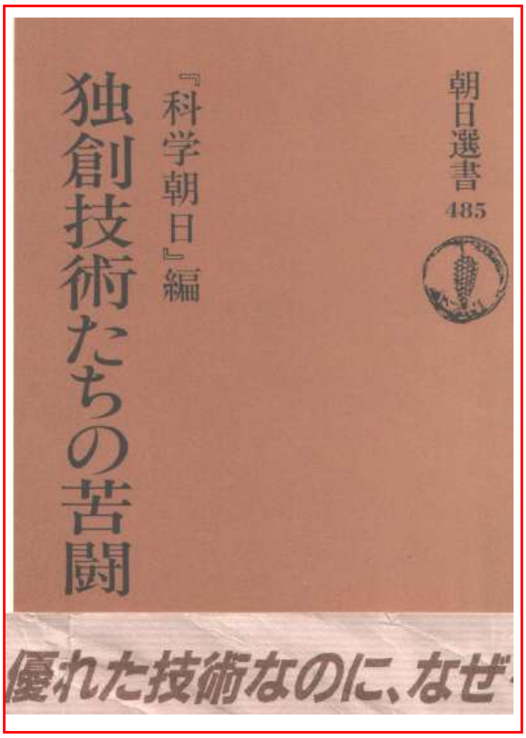
Receiver circuit of microwave radar (Koichi Shimoda : Development of domestic microwave radar, O plus E, **33**, 10 (2011) 1044–1052)

J4 Shimada laboratory in which high power anode split magnetron was developed before the end of war (Z project)

Shimada laboratory in which many scholars participated

Shimada laboratory in Shizuoka (6,600 m^2) was built in 1943 May. The director (part time) was Prof. Yasushi Watanabe in Tohoku Imperial Univ.. He was an acquaintance of Yoji Ito in Navy. Vise director was Shoichiro Mizuma. He gathered following full time staffs. They are Yanami Masao (Navy research center), Sohzabro Yamazaki and his supporting staff (Japan Radio Co. Ltd.), Yuzuru Watanabe (Associate Prof. in Kikuchi Lab. in Osaka Imperial Univ..), Zenuemon Abe (Associate Prof. in Watanabe Lab. in Tohoku Imperial Univ.), and Iwao Takao (Prof. in The Ryojun Engineering College, former engineer in Navy), Advisers from Tokyo Imperial Univ. were Prof. Masao Kotani (Physics), Prof. Yusuke Hagiwara (Astrophysics) and Prof. Sanichiro Mizushima (Chemistry). Prof. Shinichiro Tomonaga (Physics) in Univ. of Literature and Science Tokyo Imperial Univ. participated as well. They participated with their assistants as Minoru Ogawa (The director of The Institute of Physical and Chemical Research (RIKEN) now).

Many students in science and engineering were conscripted as supporters. Total number of staff were approximately 1,000 when it started. Many famous scholars participated as part-time staff, They are Masashi Kikuchi (Osaka Imperial Univ.), Yoshio Nishina (RIKEN), Fushimi Kohji (Osaka Imperial Univ.), Takeo Nagamiya (Osaka Imperial Univ.), Iwao Sato (Tohoku Imperial Univ.), and Juichi Hino (Tohoku Imperial Univ., Medicine).



Shimada laboratory in Shizuoka

Murder ray

The navy “Z project” has revived as microwave oven

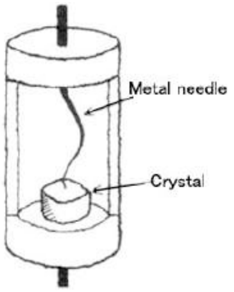
Yasuzo Nakagawa

Absurd concept to shot down B29
Wave length 20 cm, output 100 kW magnetron

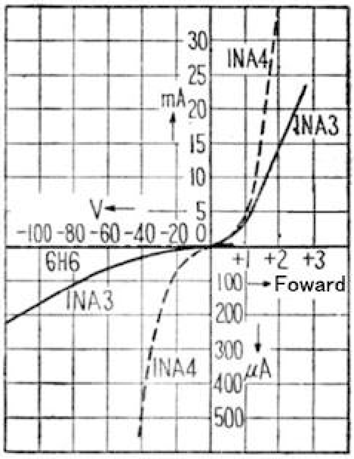
(Asahi sensho 485 “Struggle of creative technology”)

Dr. Shinichiro Tomonaga participated the Z project

J5 Crystal detector and point contact transistor



Principle of crystal detector

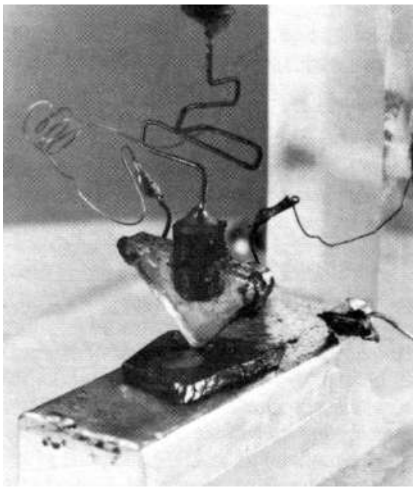


Characteristic

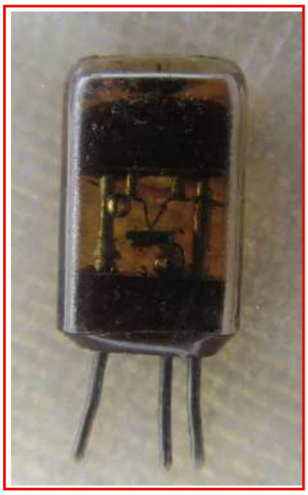
Inventor J.C. Bose

Displayed crystal detector

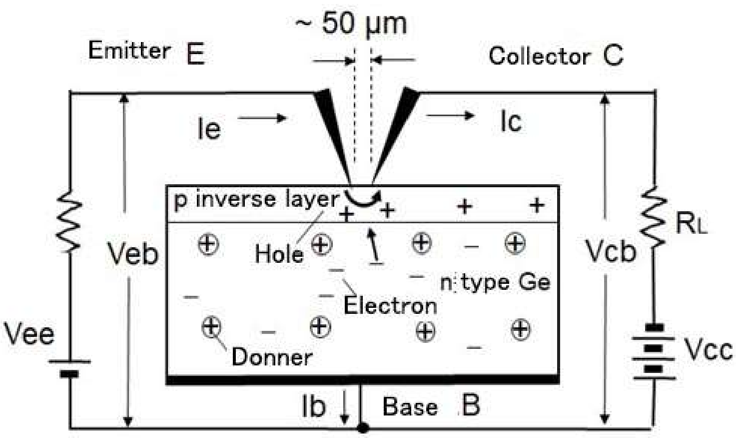
Crystal detector (point contact diode) (J.C. Bose : On the selective conductivity exhibited by certain polarizing substances, Proc. of the Royal Soc. London, vol.LX (1897) 433–436)

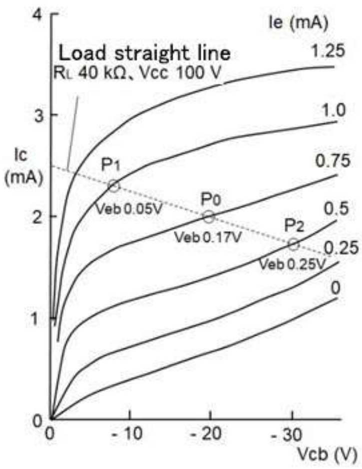


Photograph of point contact transistor and inventors



Point contact transistor(Western electric Inc.)

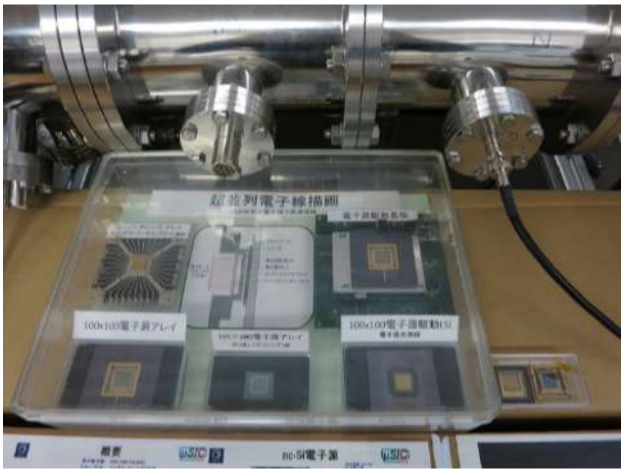




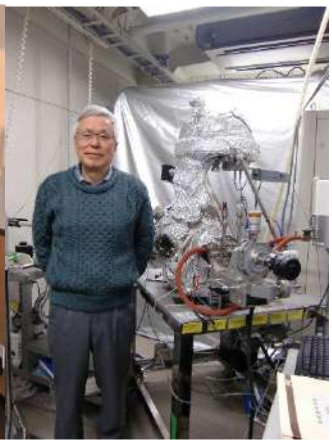
Principle and characteristics of point contact transistor

J. Bardeen and W.H. Brattain : Physical principles involved in transistor action, Physical Review, **75**, 8 (1949) 1208–1226.

J6 Massive parallel electron beam write

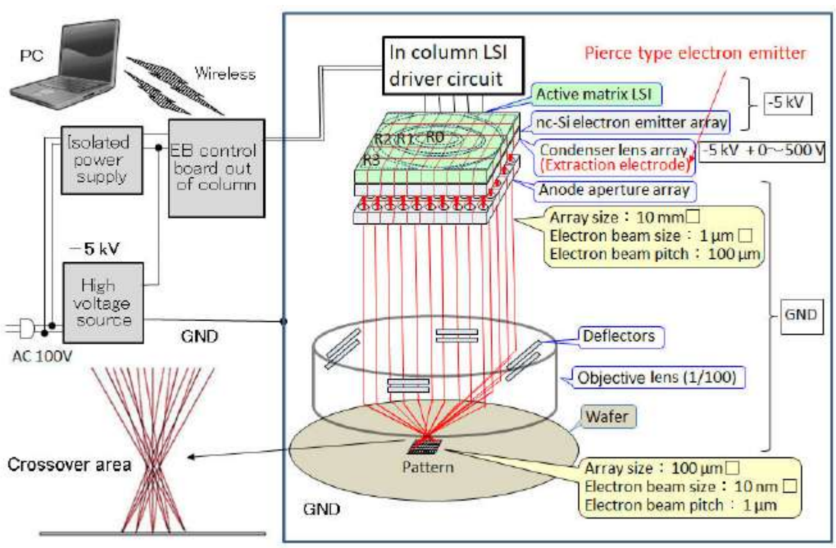


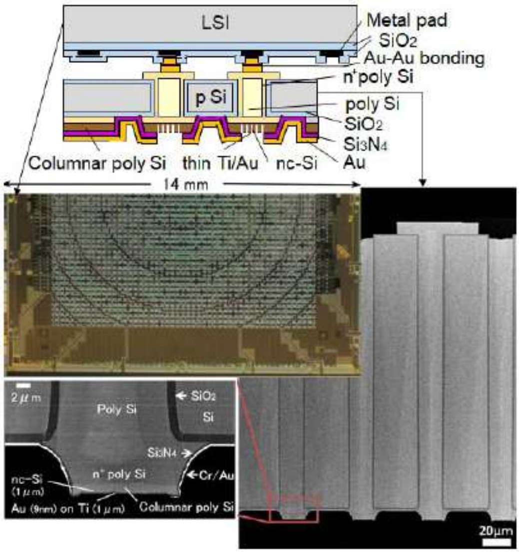
Massive parallel electron beam write using 100×100 active matrix electron sources (right)



Development member (2009 – 2016) Development of massive parallel electron beam write system

(Miyaguchi, Esashi, Kogima, Ikegami, Ohi, Sugata and Koshida (authors of the book)) Tohoku Univ. Press (2018)

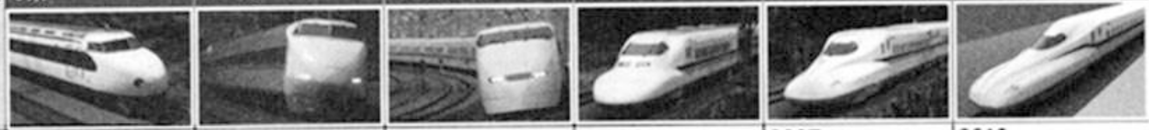




EB write System Active matrix nano crystal Si i(nc-Si) electron source

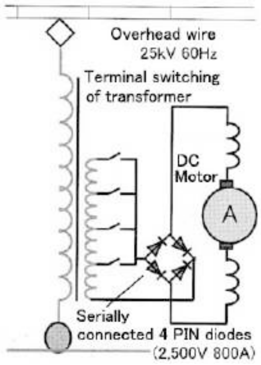
M. Esashi, H. Miyaguchi, A. Kojima, N. Ikegami, N. Koshida, and H. Ohyi : Development of a massively parallel electron beam write (MPEBW) system: aiming for the digital fabrication of integrated circuits, Jap. J. of Applied Physics 61, SD0807 (2022) 1–19

J7 Transitions of power devices used in Shinkansen

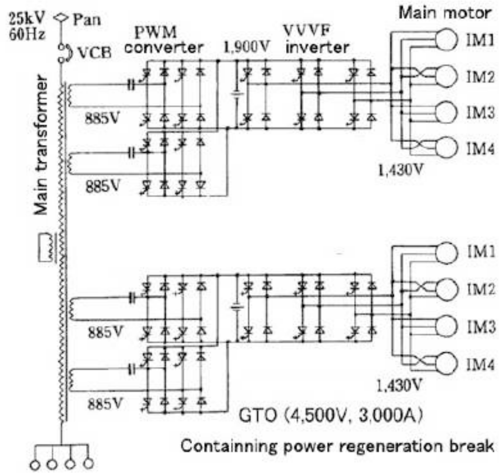


Veicle of Shinkansen	0系	100系	300系	700系	N700系/N700A	N700S
Completion year	1964	1985	1992	1999年	2007	2018
Used power devices	Diode	Thyrister	GTO	IGBT	low loss IGBT	SiC.
Cooling method	Forced air cooling				Travelling wind cooling power device	
Motor	DC motor		4 poles 3 phase induction motor			6 poles 3 phase induction motor

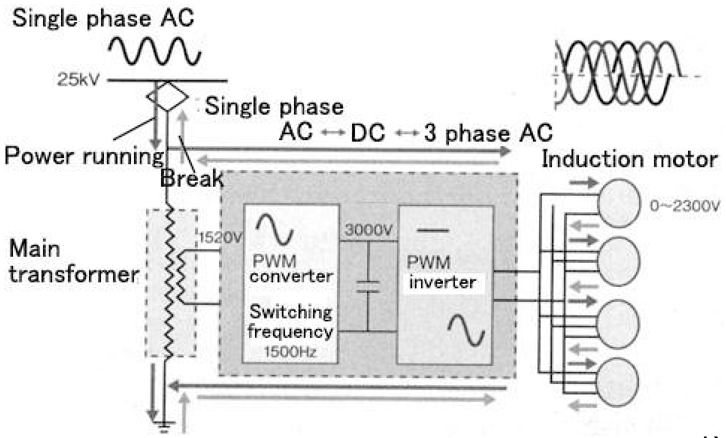
Transition of power devices and motors in Shinkansen

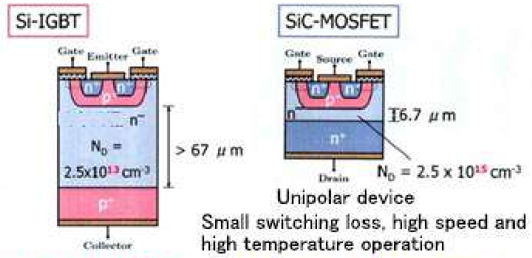


Main circuit of 0 type Shinkansen vehicle



Main circuit of 300 type Shinkansen vehicle

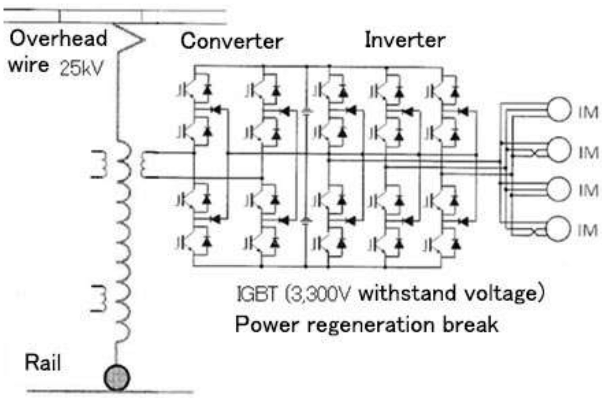




1kV Si-IGBT 1kV SiC-MOSFET

(Tokyo Inst. of Technology, Prof. Hirofumi Akagi)

(Sakae Ishikawa, Ⅱ.Induction motor drive system which fruited in "Nozomi", Transaction of Electrical Eng, Japan D, 114, 6 (1994) pp.604-607) in Japanese



Main circuit of 700 type Shinkansen vehicle

(Tetsuo Uzuka, Electrical train and power devices, SEAJ J., No,159 (2017/11) 18-21) in Japanese

Main motor : Squirrel cage 3 phase induction motor

Control : VVVF inverter control using SiC

Maximum speed : Tokaido (285 km/h (curve +25 km/h)

Sanyo : 300 km/h, West kyushu : 250 km/h

Train : 16 trains (Tohkaido, Sanyo),6 trains (West kyushu)

Year of manufacture : Prototype 2018. production 2020

Manufacturing plant : Hitachi Kasado plant

Nihon sharyo seizo Toyokawa plant (except Y type)

Production quantity : 830 set (at 2024/10/1)

N700S type Shinkansen which used SiC devices

(Masayuki Ueno, Nikkei electronics, (2017) 9 (p107), 10 (p.101))

J8　Electromagnetically levitated lamp

Lamp by Flyte Ltd. in Sweden. The lamp is electromagnetically levitated by permanent magnet in the lamp and electromagnetic coil in stage. Wireless power supply for the lamp is carried out by electromagnetic coupling.
https://www.plywood.jp/36321001

Set the light bulb free

Flyte is a levitating light which hovers by magnetic levitation and is powered through the air. With Flyte, we've set the light bulb free.

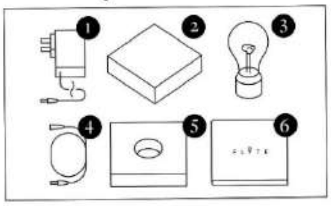
» About levitation

Achieving levitation will require some practice. If it is your first time, expect that it may take numerous attempts. As you gain experience, you will be able to levitate your Flyte Bulb every time effortlessly. If it is your first time levitating Flyte, use the Flyte Co-Pilot, a tool designed to make the levitation process even easier.

» You are about to defy gravity

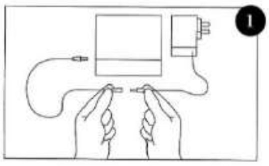
Levitation is achieved when the center of your Flyte Bulb is lowered directly over the center of your Flyte base. The challenge is to find the specific balancing levitation point.

» The Flyte kit includes :

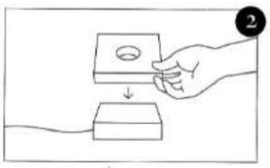


1. AC Adapter
2. Flyte Base
3. Flyte Bulb
4. Textile Cable
5. Flyte Co-Pilot (Setup tool)
6. User Manual / Warranty

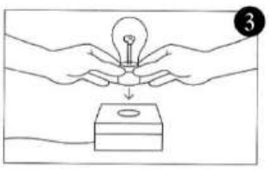
» Setting up your Flyte with Co-Pilot



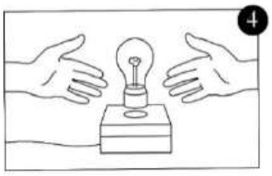
Place your Flyte Base on a flat non-metallic surface. Connect the textile cable to the Flyte Base. Connect the other end of the textile cable to the AC Adapter. Plug it into the outlet.



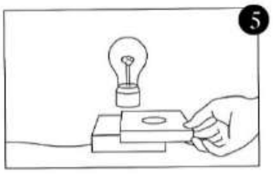
Place your Flyte Co-Pilot directly on top of the Flyte Base. This will act as target to the specific levitation balancing point.



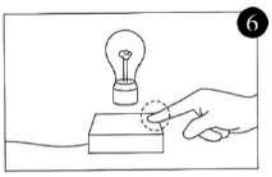
Start from a height of about 15cm/ 6 inches above the Flyte Base. Swiftly lower your Flyte Bulb with both hands directly over the center of the Flyte Base, keeping it level until you feel the upward magnetic force supporting the weight of the Flyte Bulb.



When you feel the magnetic force supporting the weight of the Flyte Bulb, gently let go keeping it centered and level. If it falls, simply lift the bulb by the cap and try again. Expect that it will take numerous attempts and may require some practice to master.



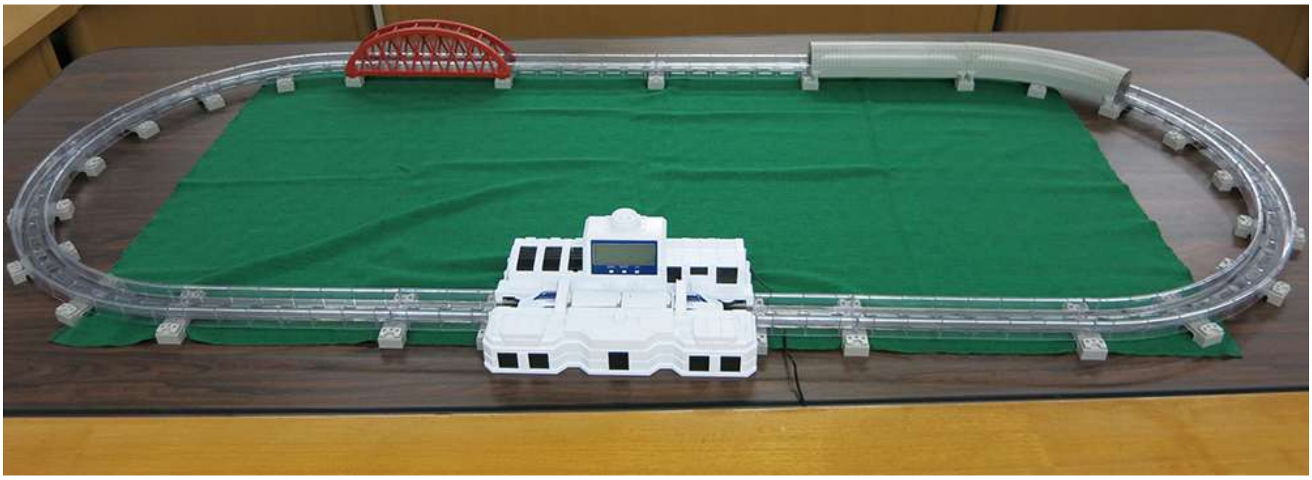
Once you have achieved levitation, remove the Flyte Co-Pilot. Each attempt to levitate your Flyte should last no longer than 5 seconds. After each attempt, start over once more by raising the Flyte Bulb at least 15cm/ 6 inches above the Flyte Base.



Gently tap the corner of your Flyte Base to turn On/Off the LED Light. The LED light will turn On/Off while levitation will remain intact. The touch sensitive corner is located diagonally across from the AC adapter jack.

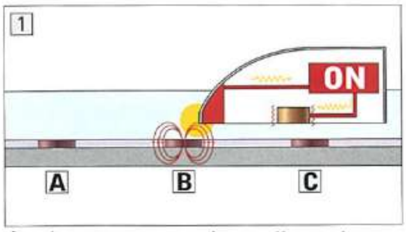
**To remove your Flyte Bulb lift the Bulb by the cap, and place it back in the foam container for storage.*

J9 Model railway of magnetically levitated linear liner (Tomy Co., Ltd.)

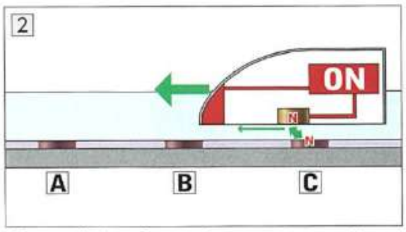


Principle of motion

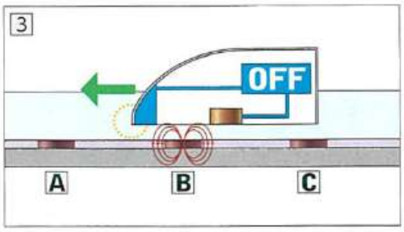
Foward magnetic field is detected by a high speed magnetic field sensor and magnetic field is generated by current in the coil on viecle. Repulsive force generated between the magnetic field by the coil on the viecle and that by the magnet on the rail moves foward the train.



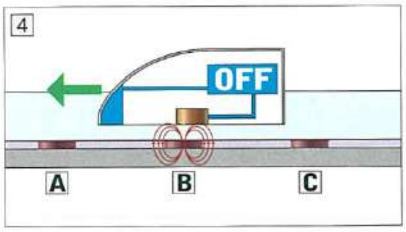
Apply current to the coil on the vehicle responding to the magnetic field generated by the front side magnet on the rail.



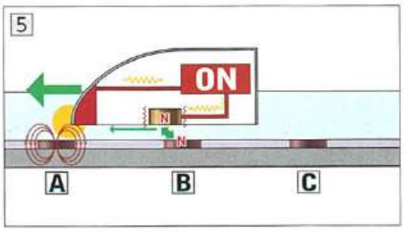
Propulsive force is generated by repulsive force between magnetic field by the coil and magnet on rail.



When the front side magnetic field is not detected, the current to the coil is cut off.



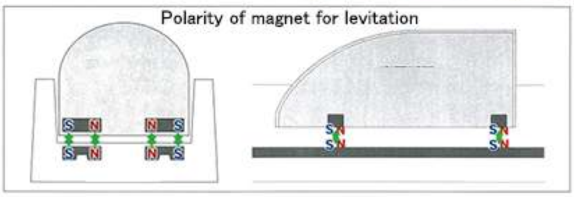
The viecle move forward by inertia.

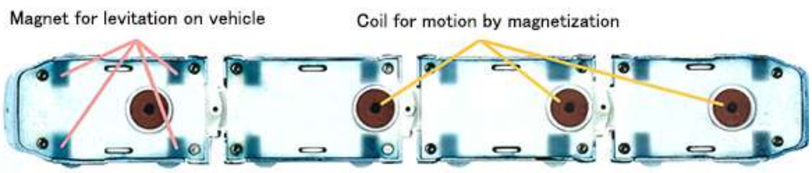


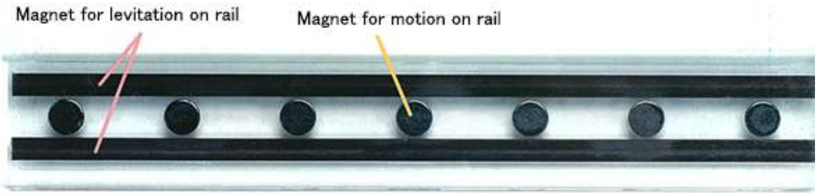
When magnetic field is detected in front side, current is applied to the coil on the vehicle again. These are are repeated for the motion of the viecle.

Principle of magnetic levitation

Magnet like belt on rail and 4 magnets on corners of vehicle cause repulsive which levitate the vehicle about 4mm.

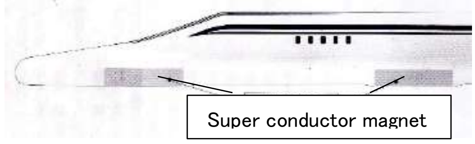




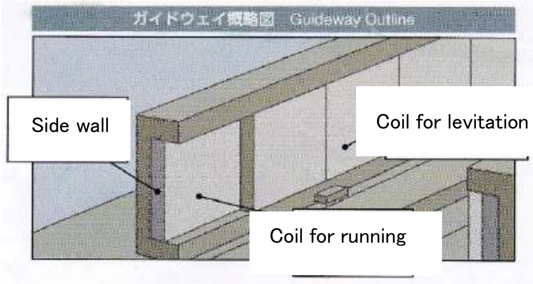


(Linear liner magazine (Tomy Co., Ltd.)) (in Japanese)

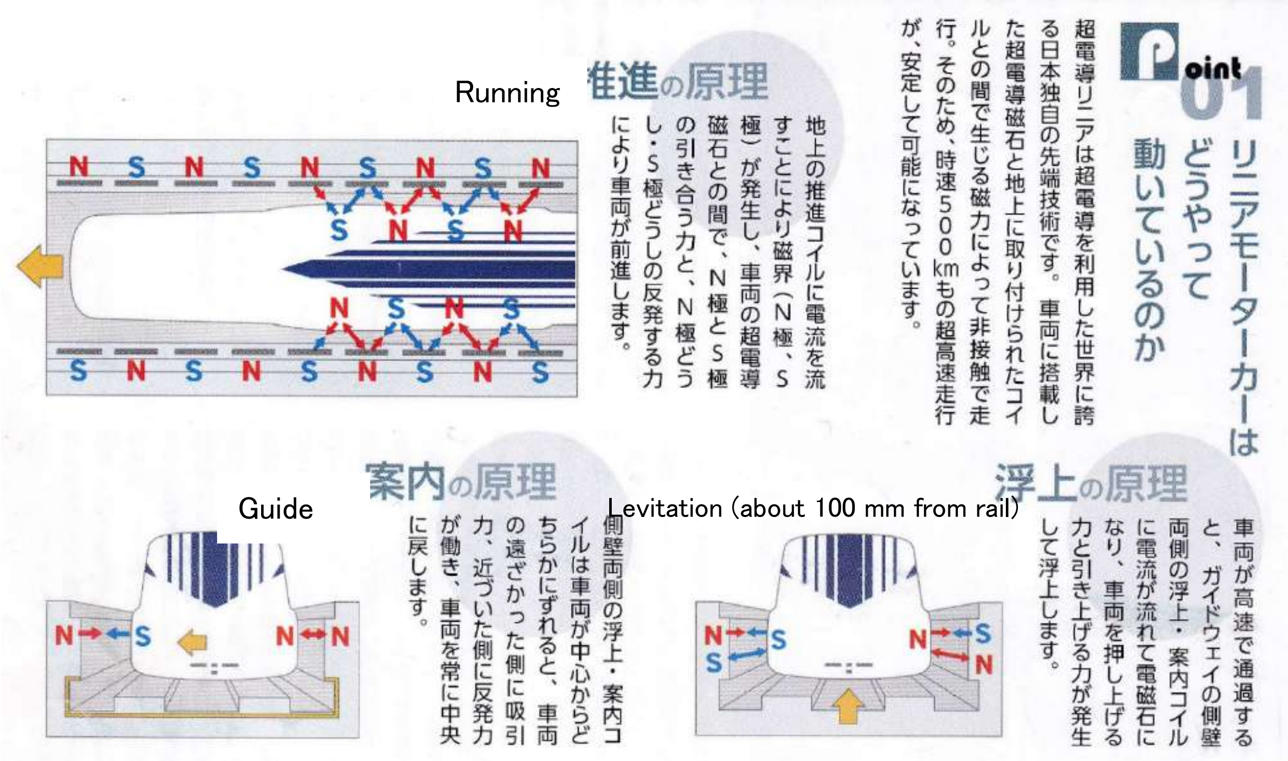
J10 Linear Chuo Shinkansen using superconductivity and its model railway



−269℃ Nb-Ti alloy



Linear Chuo Shinkansen (https://ja.wikipedia.org/wiki/%E4%B8%AD%E5%A4%AE%E6%96%B0%E5%B9%B9%E7%E7%)



Principle of running, levitation and guide (Linear liner magazine (Takara tommy))

Model railway of magnetically levitated linear liner using super Conductor (the rail has 3,600 Nd-Fe magnet)

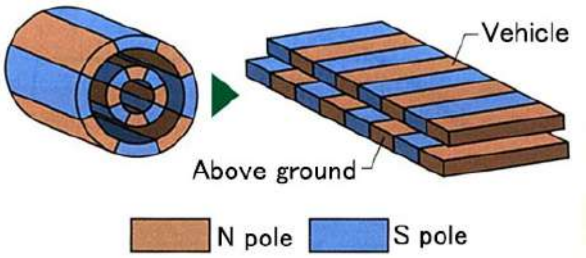
Cooling of the linear liner in liquid nitrogen (77K)

Kensuke Nakajima Lab. (Graduate school of Sci. and Eng., Yamagata Univ.) http://nakajima-lab.yz.yamagata-u.ac.jp/

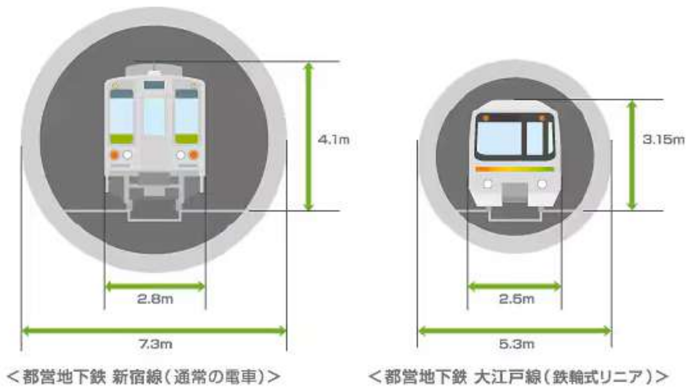
J11 Linear subway (Linear metro) travelling on wheels

“リニアメトロ方式” 地下鉄路線一覧

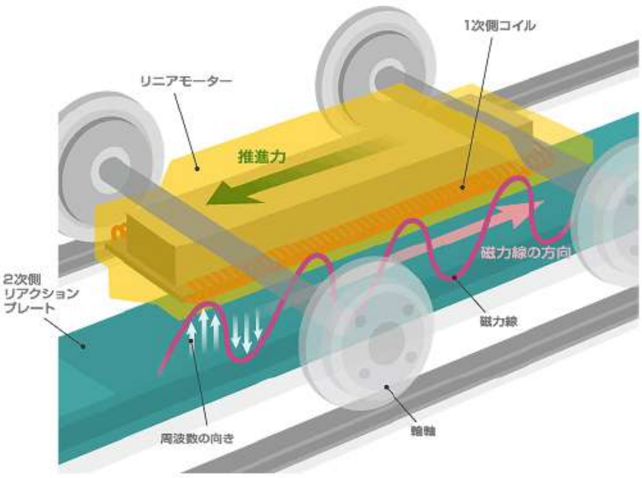
都　市	路線名	区　間	距　離
福岡市	七隈線	橋本～天神南	12.0km
神戸市	海岸線	新長田～三宮・花時計前	7.9km
大阪市	長堀鶴見緑地線	大正～門真南	15.0km
	今里筋線	井高野～今里	12.1km
横浜市	4号線（グリーンライン）	日吉～中山	13.1km
東京都	大江戸線	都庁前～光が丘	40.7km
仙台市	東西線	動物公園～荒井	14.4km



物理図鑑　視覚でとらえるフォトサイエンス、数研出版（2022）



通常の電車と鉄輪式リニアの車体寸法の比較



都営大江戸線などの鉄輪式リニアの原理

TDK　https://www.tdk.com/ja/tech-mag/knowledge/160

東西線（仙台市交通局）

「リニアメトロ」が、仙台の新たなまちづくりを支えます

仙台市では、自動車交通に過度に依存せず、軌道系交通機関を基軸とした集約型の都市構造を目指し、地下鉄東西線を建設しました。東西線の路線は、市南西部の八木山動物公園付近から東北大学等のある青葉山を経由し、都心部を経て、流通業務が集積する東部地区に至るルートです。導入したリニアモーター式地下鉄は、トンネル断面積が南北線の3分の2程度と小さく、建設費の低減が可能であることに加え、曲線半径を小さくでき、登坂能力にも優れており、勾配が大きいという東西線の路線特性に適合しています。
2015年12月に八木山動物公園～荒井間13.9kmで開業した東西線は、南北線との両線とで本市を東西南北に貫く十文字の骨格交通軸を形成し、仙台都市圏の基幹交通機関として重要な役割を担っています。

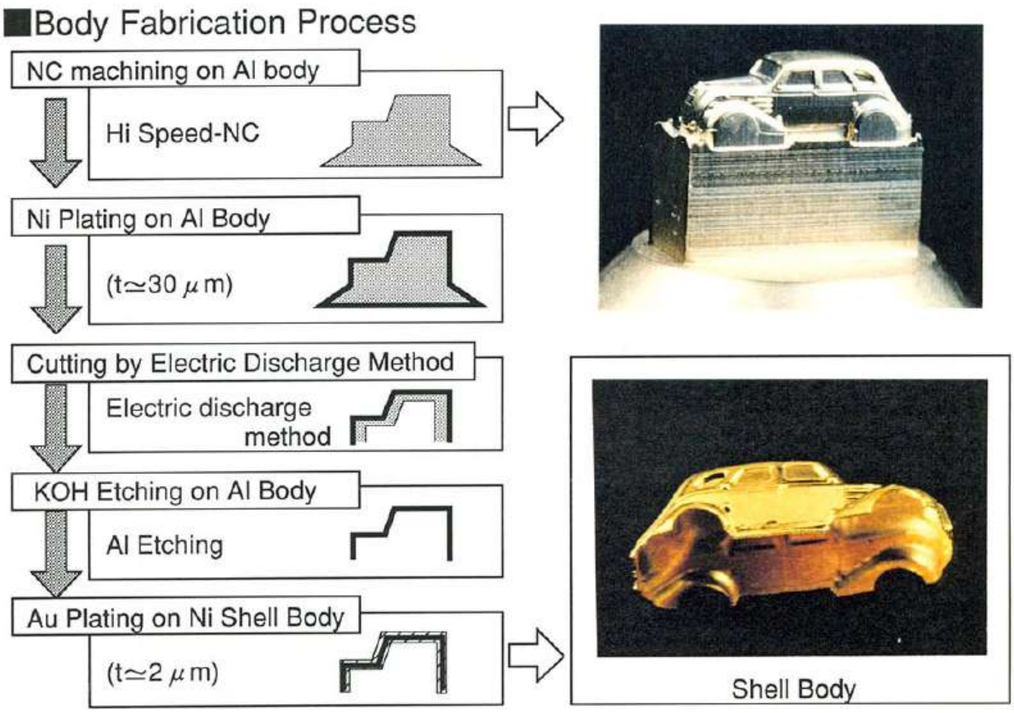
●車体長:先頭車16m/両
●車体幅:2.49m
●車体高さ:先頭車3.15m
●車両編成:4両

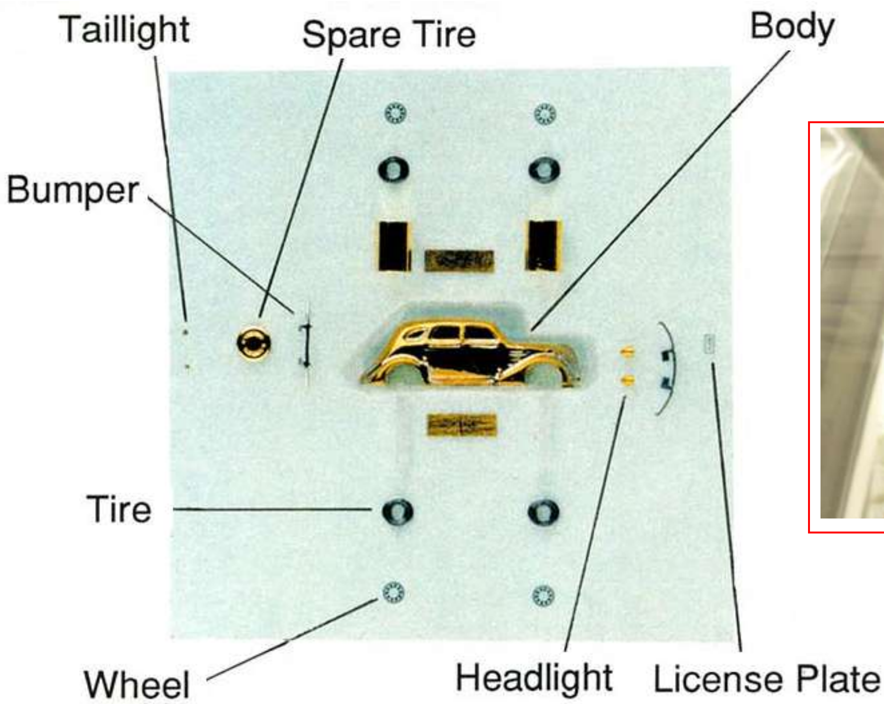
Above ground part of linear

Linear metro (Tozai line in Sendai)　http://www.jametro.or.jp/linear/touzai.html

J12 Micro car (Denso Corp.)

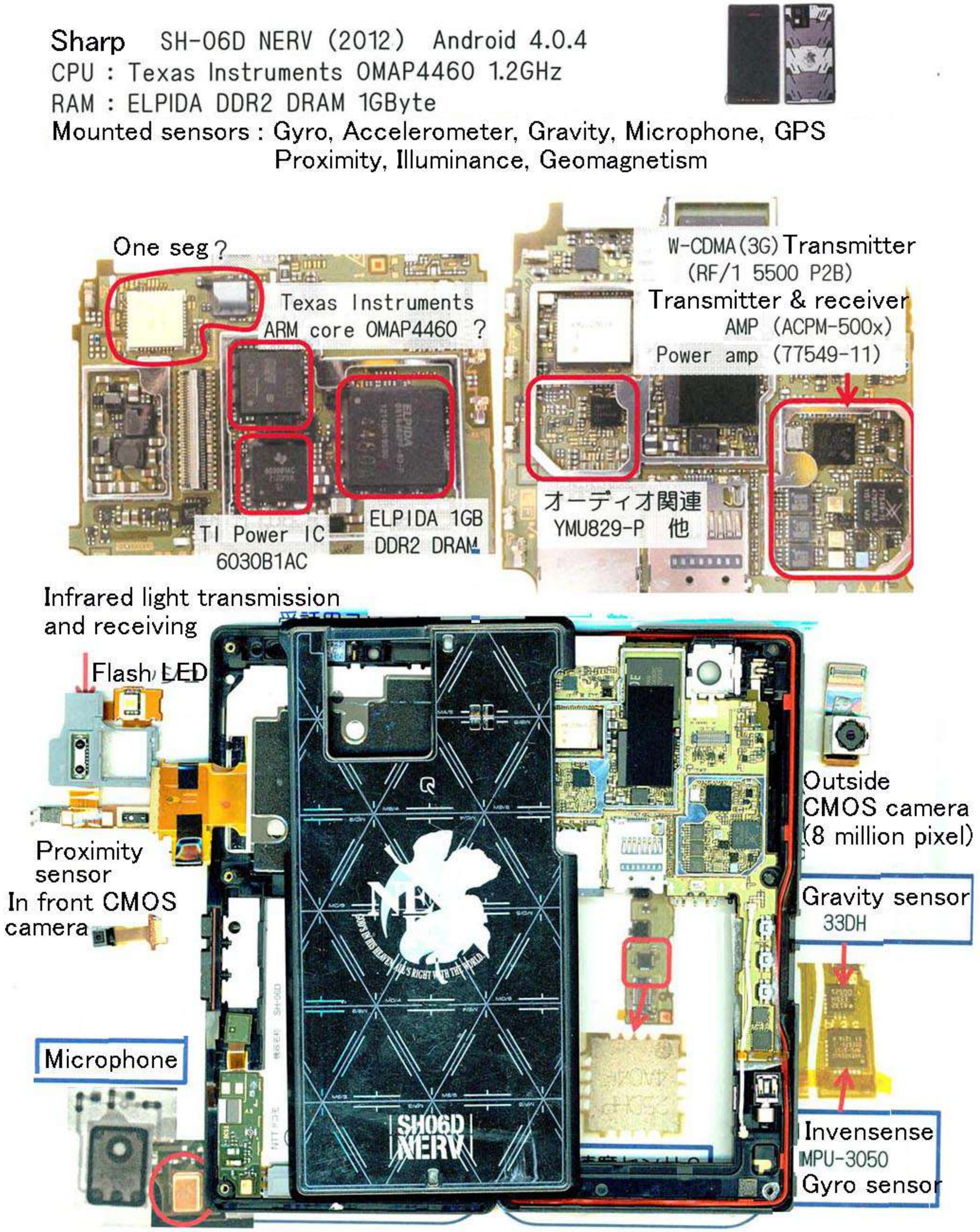
1/1000 size model of Toyota AA model (1936) (62 mg、24 parts)



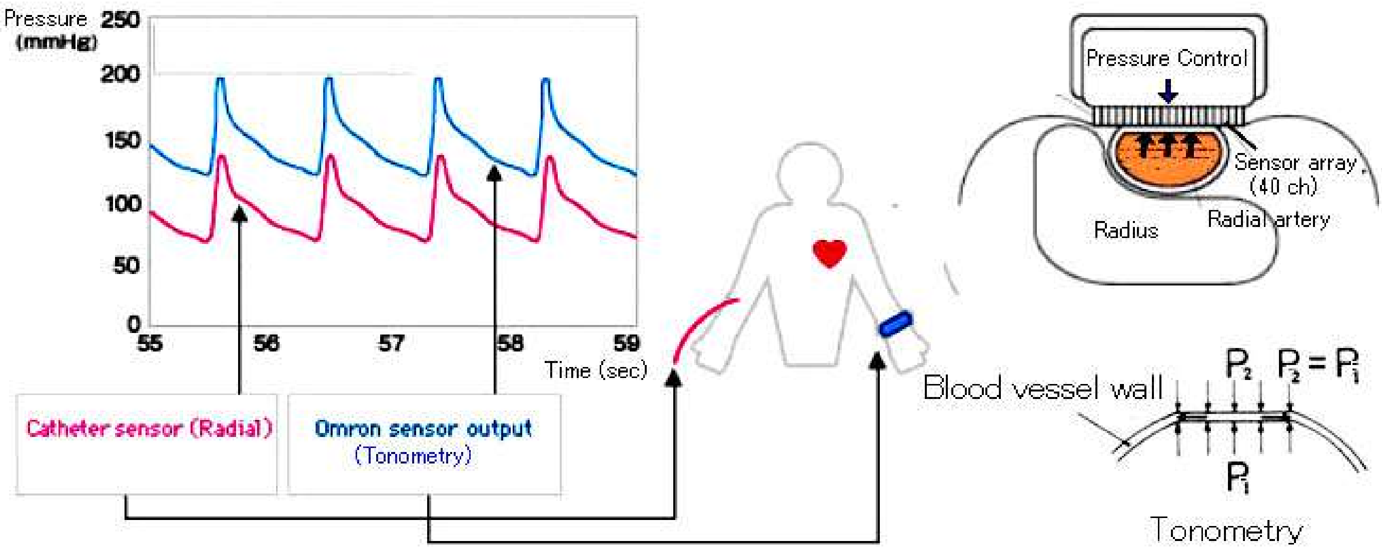


Disassembly of FOMA (3G) smartphone

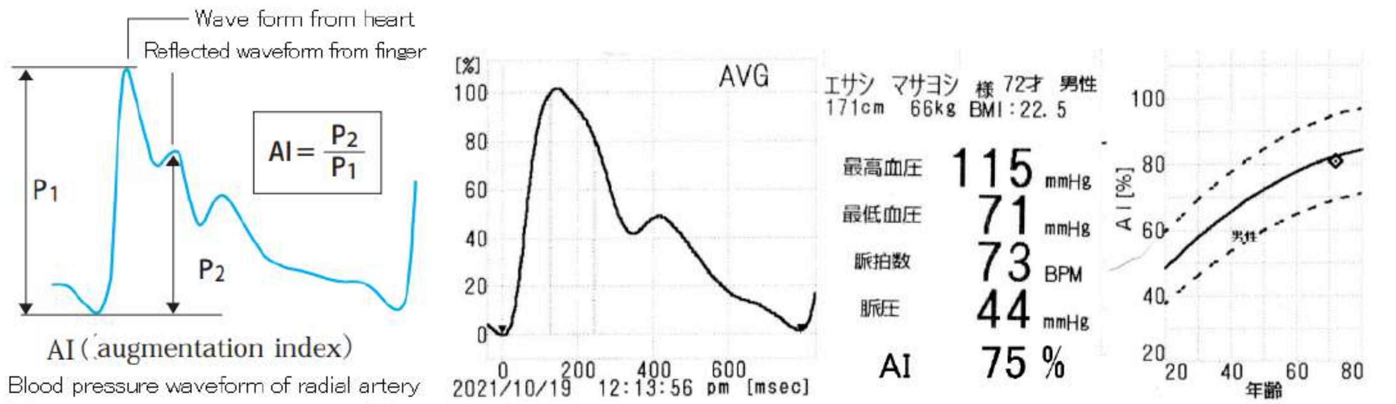
Sharp SH-06D NERV (2012) Android 4.0.4
CPU : Texas Instruments OMAP4460 1.2GHz
RAM : ELPIDA DDR2 DRAM 1GByte
Mounted sensors : Gyro, Accelerometer, Gravity, Microphone, GPS
Proximity, Illuminance, Geomagnetism



J14 Continuous arterial pressure waveform with Tonometry (OMRON HEM-9000AI)



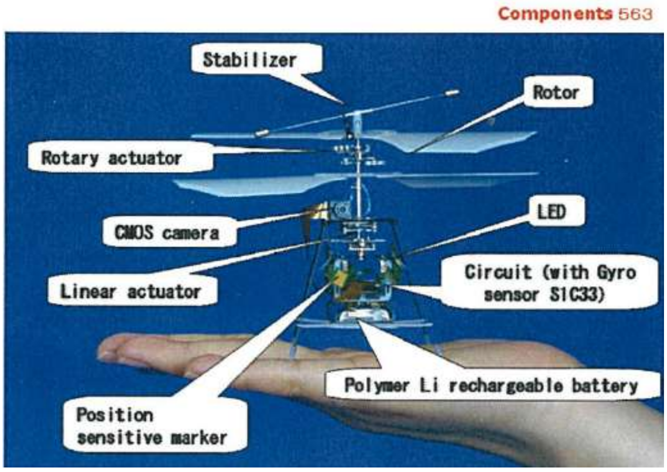
Comparison of pulse wave by catheter and tonometry

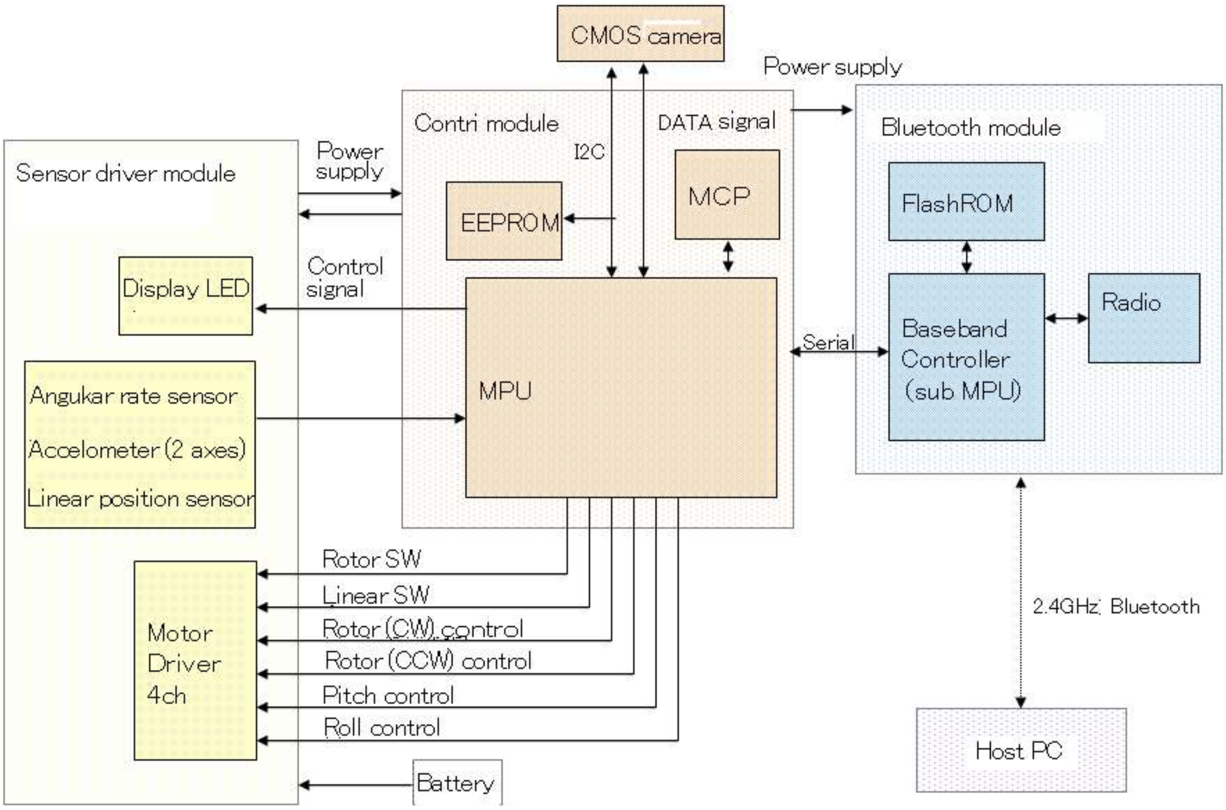


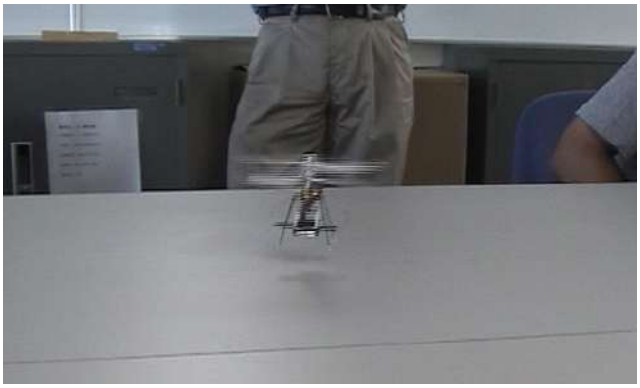
Measured pulse wave and AI value (Arterial Distensibility Index)

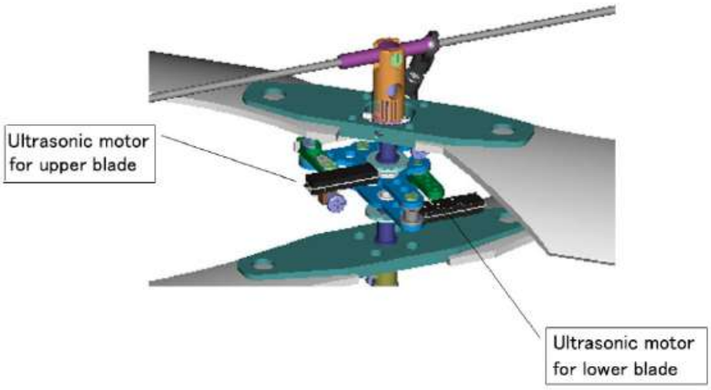
稲垣孝 (オムロンヘルスケア): トノメトリ法による橈骨動脈波形の AI 測定-オムロン血圧脈波検査装置 HEM-9000AI- Arterial Stiffness 動脈壁の硬化と老化, No.9 (2006)

J15　Micro Flying Robot（μFR）(Seiko Epson Corp.) (2003)









First flight of　μFL　　　　　　　　　　Ultrasonic motor for blade

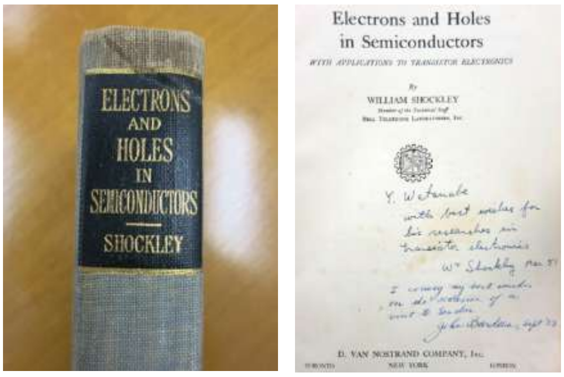
https://www.jstage.jst.go.jp/article/micromechatronics/50/194/50_KJ00004320100/pdf/-char/ja

(Seiko Epson Corp.　Osamu Miyazawa)

J16 Topics related to collected books

Books related to history of technology

Books related to Tohoku Univ. and companies



A book of return gift from W. Shockley to Nishizawa's paper which was send by his professor (Yasushi Watanabe).

ATTENTION-PLEASE COLUMN

不遇の天才に手をさしのべた東北大学
理科大学への招聘計画

東北大学は一九一一年(明治四十四年)、現在の理学部の前進である理科大学を開設しました。実は、この理科大学へ、アインシュタイン博士を本学最初の外国人教師として迎えようという計画がありました。

この計画は、当時ミュンヘンに留学中であった理科大学助教授・石原純が、初代総長沢柳政太郎へ相談をしたことから、始まりました。

アインシュタインは、その頃、スイスのチューリッヒで生活していました。ブラウン運動、特殊相対性理論に関する三つの論文を次々と発表し、学界の注目を集めていたものの、後の世界的名声を得るには至っていませんでした。

石原は、早くからこれらの論文を読み、その優れた理論ぶりを高く評価。博士が不遇な生活を強いられているのは、ユダヤ人ゆえかと心苦しく思っていたのです。そこで、「あえて救済という意味ではなく、東北大学の誇りのためにこの理学界の大天才を迎えては…」と、沢柳総長へ話を持ちかけたのでした。

当時、沢柳総長が石原へ宛てた手紙に、アインシュタインを迎える際の年俸や当初の期限三カ年と書いていることから、かなり具体的に計画を進めたようです。

この計画は、結局、実現しませんでした。その頃になって、次第にドイツでも博士の学才を認めるようになったからです。

後に、沢柳総長が、「ヨーロッパの人々がユダヤ人を迫害することは想像できないが、博士がそれに耐えて研究の不便さをしのぎ、その天才を発揮したことに敬服せざるをえない。もしか、博士が我が大学の教授であったならば…」と回想したそうです。

それにしても、東北大学の学問に賭ける自由闊達なフロンティア精神、また優秀な研究者への温情の片鱗が、この計画に表れていると言えます。

初代総長 沢柳政太郎

ATTENTION-PLEASE COLUMN

アインシュタインの強力な理解者
石原純との交流

石原純(当時は理科大学助教授・帰国後に教授昇格)は、ミュンヘン留学へ赴いた折、スイスのチューリッヒ工科大学のアインシュタイン教授の下で、新進研究者として半年を過ごしました。一九一三年(大正二年)のことです。

この時期のアインシュタインは、一般相対性理論の端緒である万有引力論を唱え、他の教授との激しい論争を展開。石原は、この厳しい一般相対性理論の形成期を目の当たりにし、戦列へ加わっていったのです。

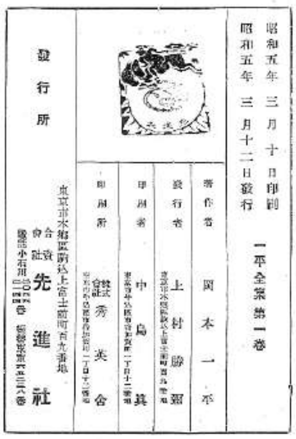
この縁で、出版社「改造社」がアインシュタインを日本へ招きたいと、石原に紹介状を依頼したのでした。石原はこれに協力して、博士との交渉にあたりました。アインシュタインはこれを受けて、「この機会を逃したら、日本を訪れることはできない」と四ヶ月にも及ぶ船旅への決断をしたのでした。

一九二二年(大正十一年)、アインシュタインが乗った北野丸が神戸港へ到着。船内でノーベル賞受賞のニュースを聞いた博士を迎えたのは、カメラのフラッシュと大きな歓声をあげてどよめく群集。博士は、初めて凱旋将軍のような歓迎を受けたのでした。

旅の目的は、観光と学術交流の二つでした。そのため、アインシュタインは、全国各地を巡り、京都大学、東京大学、東北大学などで、相対性理論の講演を行いました。この時、同行し、講演の通訳を行ったのが石原でした。石原は、物理学者として相対論や量子論の論文をいくつも書き上げ、帝国学士院から第九回恩賜賞を受けていました。それだけに、博士は、石原の的確な理解力と通訳ぶりを高く評価したそうです。

石原 純

Book "Manabinomori" (2006) on the relationship between Jun Ishihara and Albert Einstein



昭和五年三月十日印刷
昭和五年三月十二日發行

一平全集第一卷

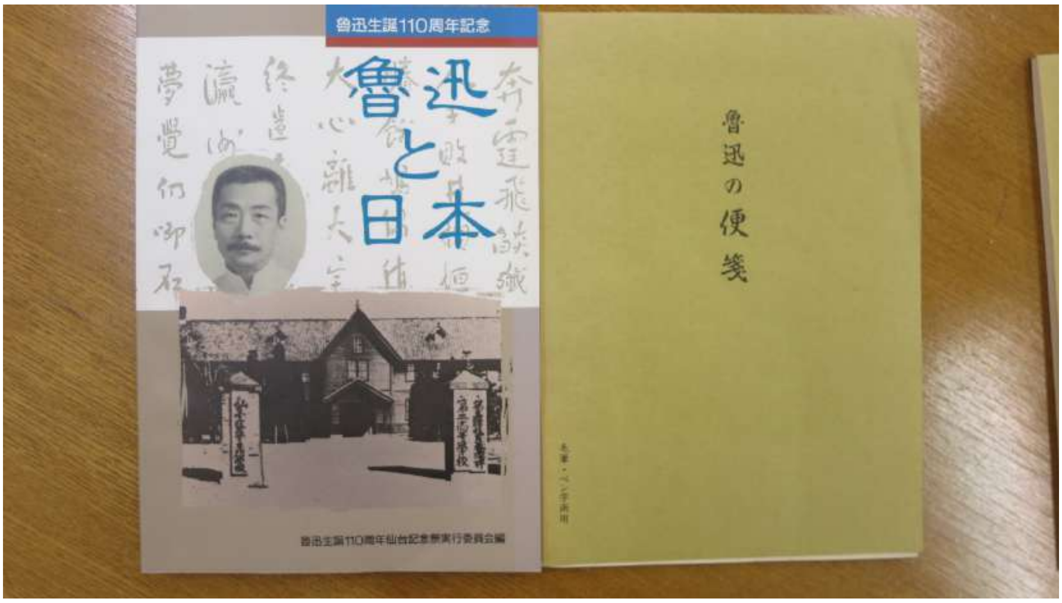
著作者 岡本一平
發行者 上村勝彌
印刷者 中島
印刷所 秀英舍
發行所 合資會社 先進社

アインスタイン博士の人間味

Book on Albert Einstein's visiting Sendai (1930)

Book written by Jun Ishihara (1942)

J17 Documents on Kohtaro Honda and Lu Xun

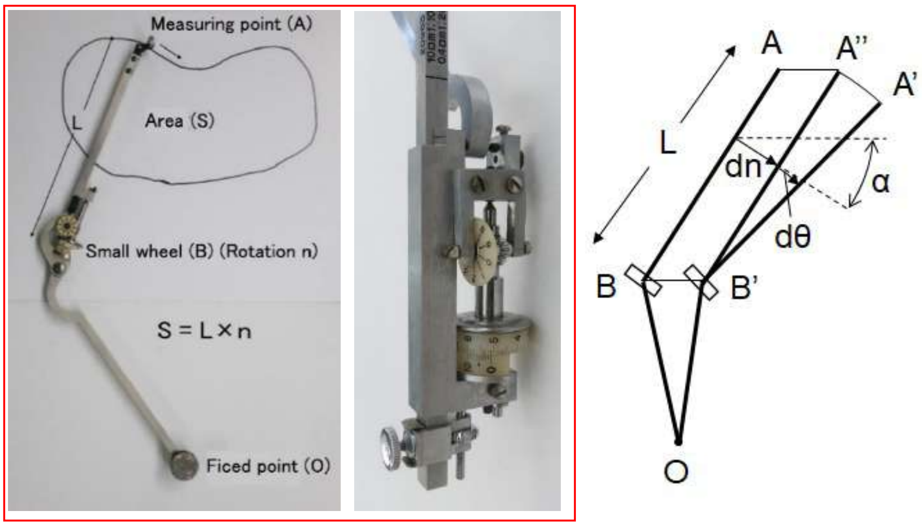


J18 Planimeter (area meter) and proportional compass

Photograph and principle of the planimeter (area meter) is shown in the figure (a). Small wheel is located at the bending point (B) of 2 rods. One rod rotates around the fixed point (O). Measuring point (A) of the other rod (length (L)) is moved around the area ((area (S)). The small wheel moves perpendicularly to the rod and the area (S) is obtained using the rotation (n) as $S = L \times n$.

The principle will be explained in the following using the figure (b). When the measurement point moves from A to A' the small wheel moves from B to B'. The movement of A to A' is composed of parallel movement AA"and rotation A"A'. The area covered by parallel movement of the bar is Ldn where dn is the rotation of the small wheel. The dn is BB' cos α where α is the angle between the direction of small wheel rotation and that of the parallel motion (AA") of the bar. The area covered by the rotation is $L^2 d\theta/2$. From these, the area (dA) covered by the movement of the bar AB is expressed as $Ldn + L^2 d\theta/2$. The area (S) by the closed motion of the measurement point is obtained by integrating dA as follows, where integrated value of the closed loop ($\oint L^2 d\theta/2$) is zero.

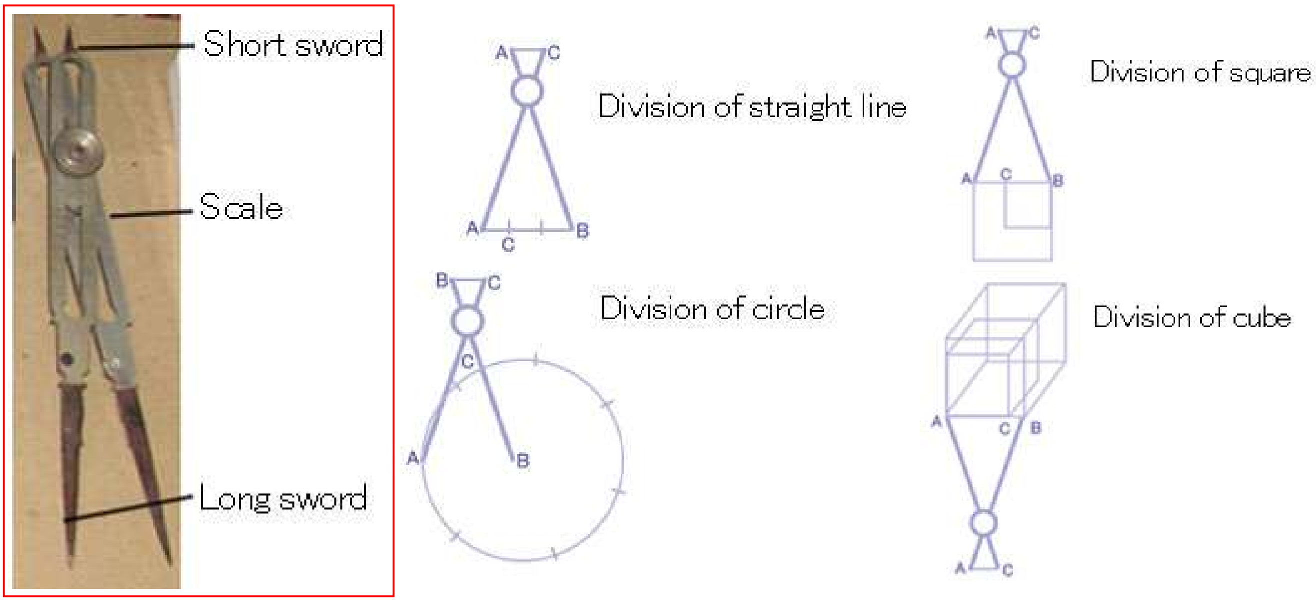
$$S = \oint dA = \oint Ldn + \oint L^2 d\theta/2 = L \times n$$



(a) Photograph and principle (b) Small wheel (c) The relationship between movement of A and B

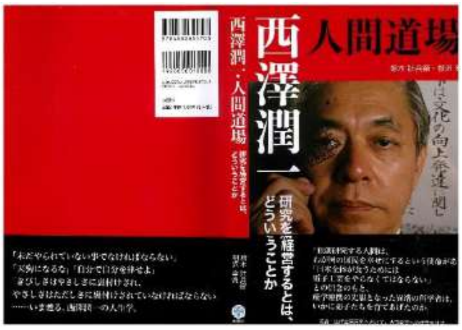
Figure Planimeter

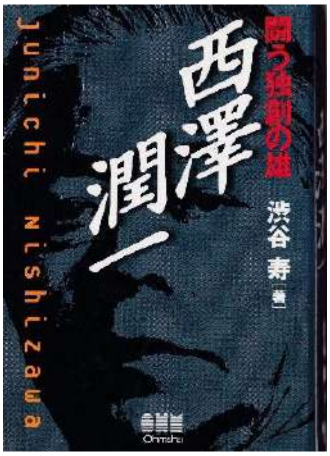
Ref. Yutaka Nishiyama : Area measurement, https://yutaka-nishiyama.sakura.ne.jp/math2010j/measuring_j.pdf



Proportional compass http://okadaenoguten.o.oo7.jp/ditail_desain3.html (Donated by Prof. Emeritus Yakichi Higo))

K1 Books, photograph and 0ther materials about Prof. Jun-ichi Nishizawa





The illumination for Xmas trees in Semiconductor Research Institute was extended to Pageant of light in Sendai

When Prof. Nishizawa visited Marmottan Monet museum in Paris, he pointed out that picture "Water lily" by Monet is displayed upside down. New Sunday art museum (NHK edu,TV 2007/6/10) "Trajectory of light image" which scientist saw.

河北新報 2024年(令和6年)11月17日(日曜日)

「ミスター半導体」素顔に迫る

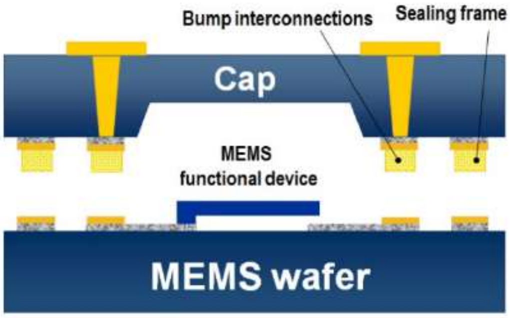
人生を一生懸命に

浮かび上がる人間味あふれる姿

絵画に独自の解釈

L1 Hermetic seal bonding at low temperature with sub-micron Au particles

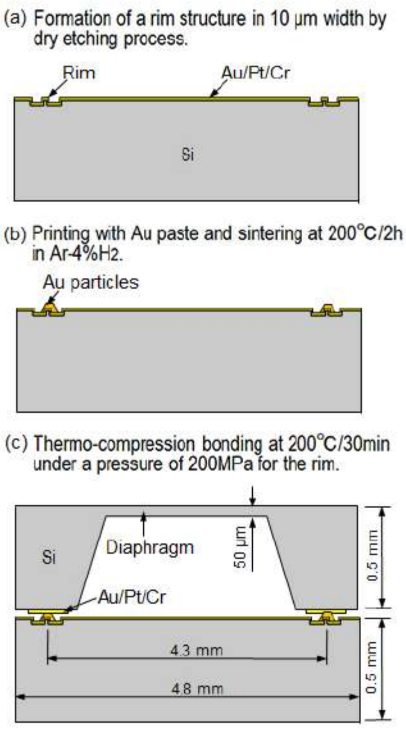
(TanakaKikinzoku Kogyo K.K., T. Ogashiwa)



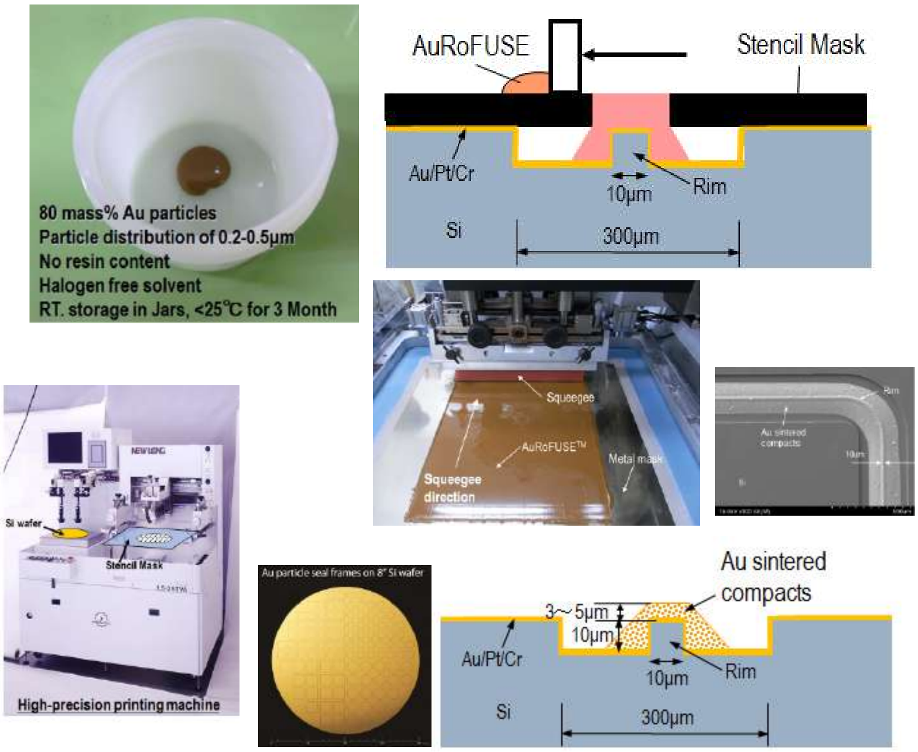
Structure packaged with Au particle

Wafer level hermetic sealing technology was developed using Au particles which cause compressed deformation at 200℃. Getter free packaging technology is aimed.

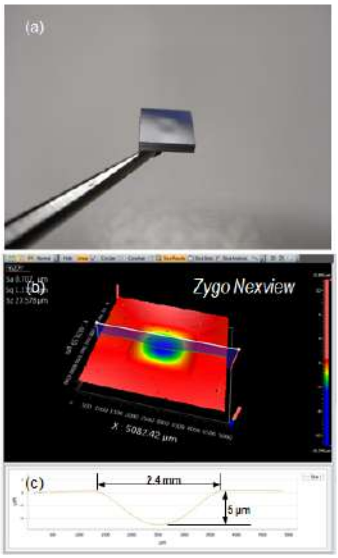
T. Ogashiwa, K. Totsu, M. Nishizawa, H. Ishida, Y. Sasaki, M. Miyairi, H. Murai, Y. Kanehira, S. Tanaka, M. Esashi, "Hermetic Seal Bonding at Low-temperature with Sub-micron Gold Particles for Wafer Level Packaging", in Proc. of 48th Interbational Symposium on



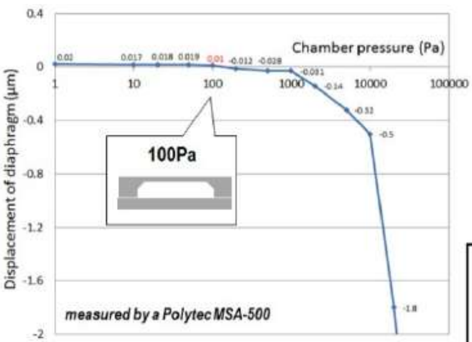
Wafer level packaging process



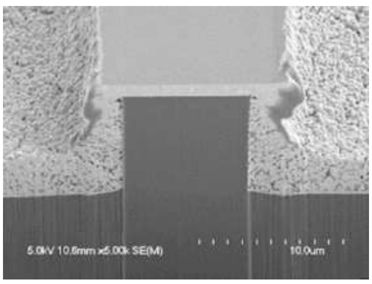
Formation of Au sintered compacts by stencil printing (AuRoFUSE™)



Bonding of Wafer with a thin diaphragm



Displacement of Diaphragm Measured at Different Chamber Pressures



Cross-sectional SEM image of hermetic rim joint

(Pa・m³/s)

Exposure time in He	Before exposure	After exposure ＜Dwell time＞		
72 hours 0.617MPa(abs)	2.91E-15	1.52E-12 ＜17 min＞	1.99E-13 ＜392 min＞	1.09E-14 ＜1706 min＞
Empty chamber	4.82E-15	4.97E-14	2.46E-14	5.37E-15

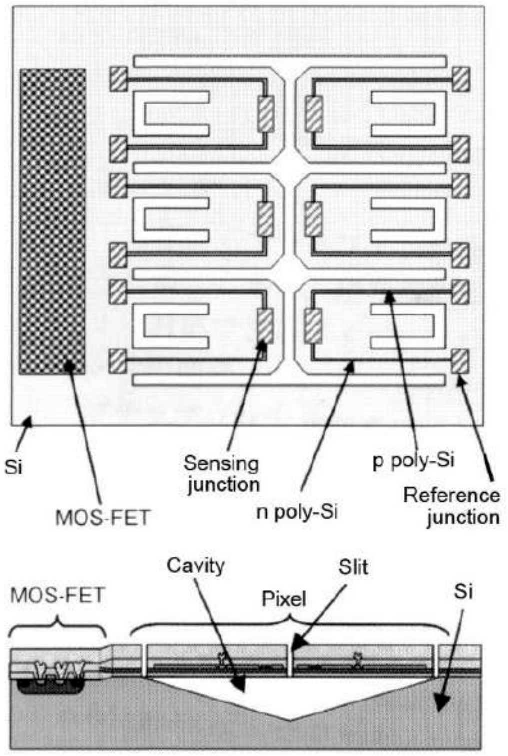
He leak rate : 10^{-14} Pa·m³/s (He)

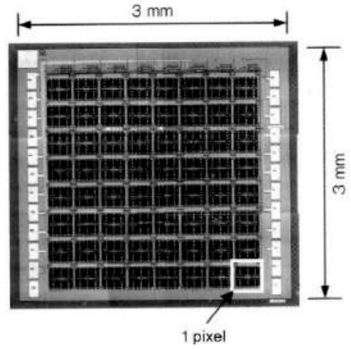
Measurement of He leakage

M1 Five - storied pagoda made of glass

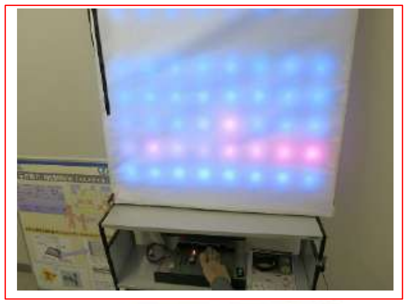
Fabricated by Zenjiro Matsumura (Donated by Katsufumi Kumano) Displayed at entrance of Jun-ichi Nisizawa memorial research center

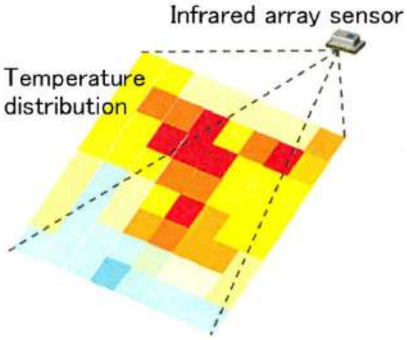
N1 # Infrared array sensor (Panasonic)

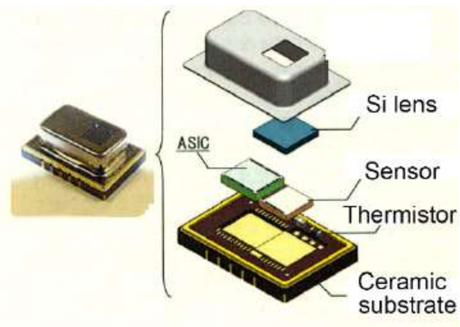




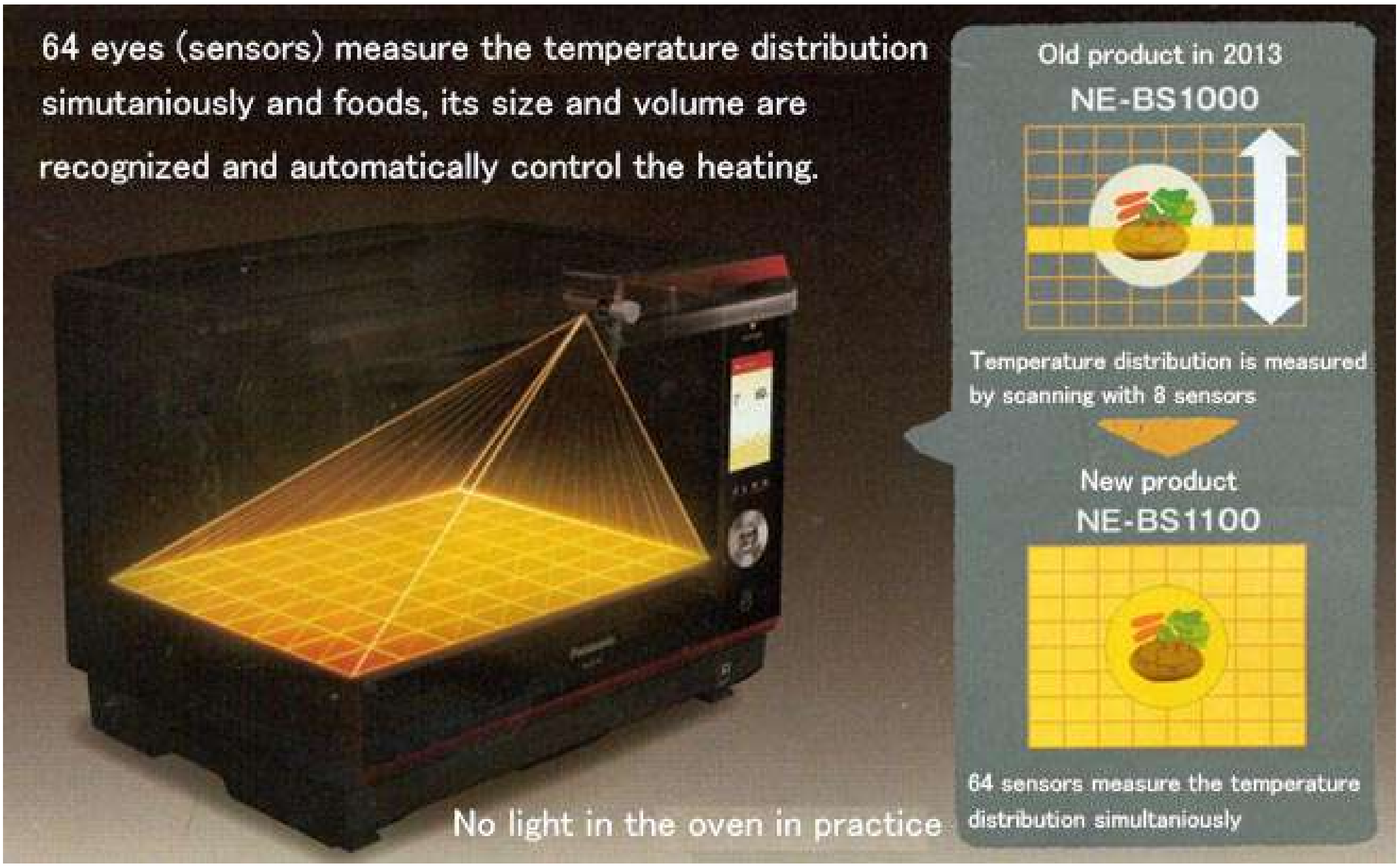
Structure





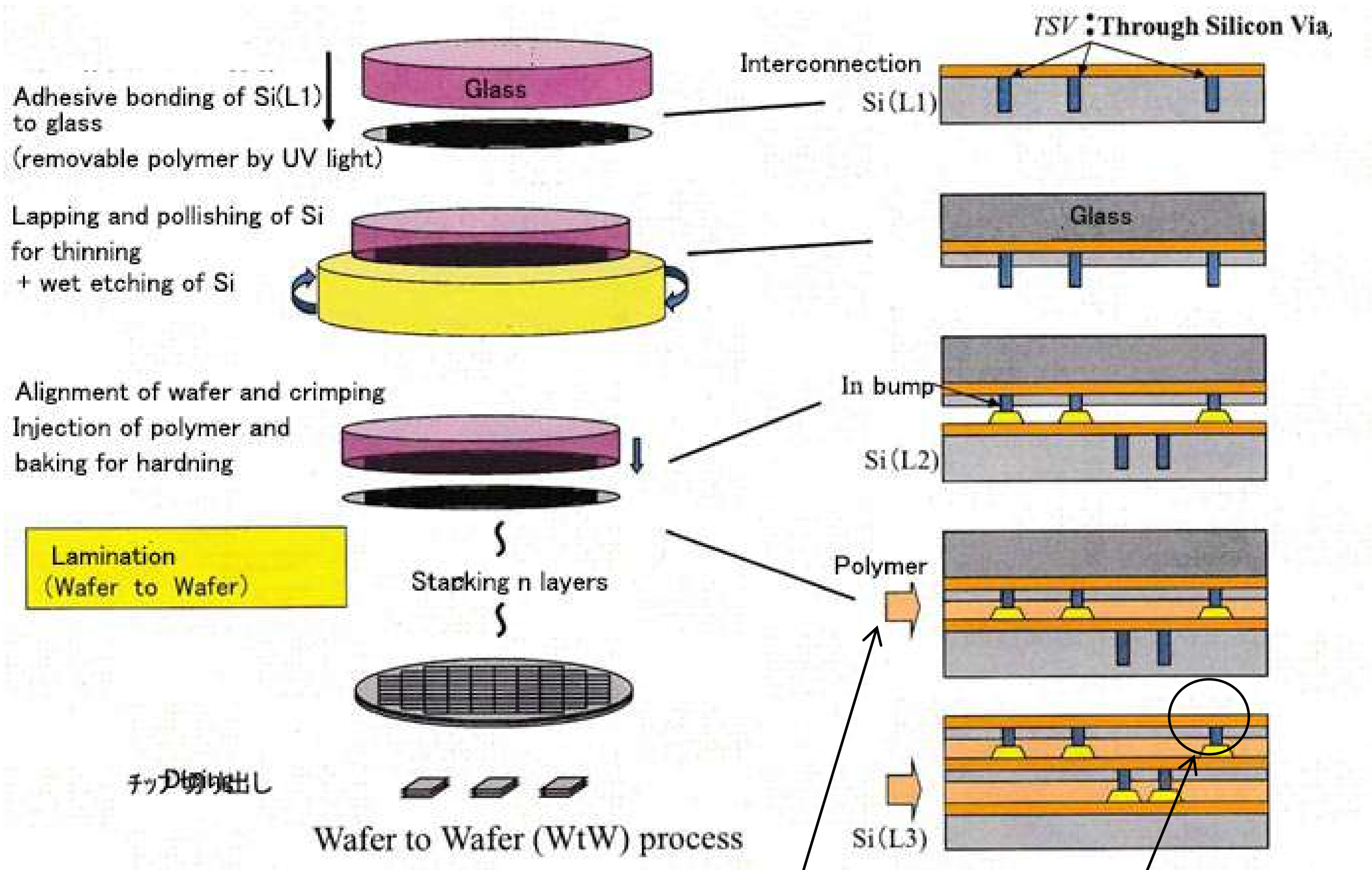


Applications

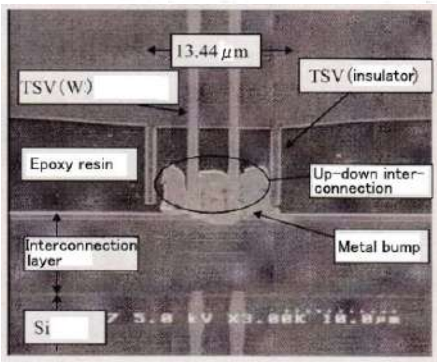


Measurement of temperature distribution in microwave oven

N2 3D LSI (Honda Research Institute, N. Miyakawa)

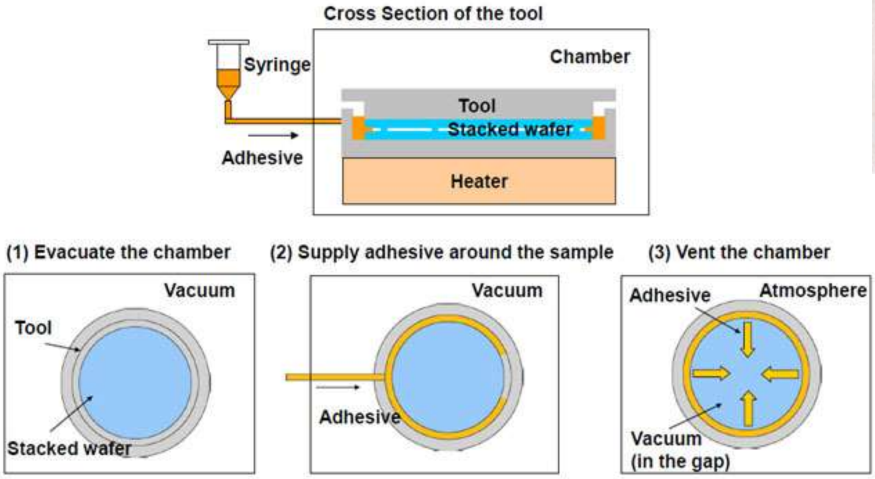


Process for stacked layers

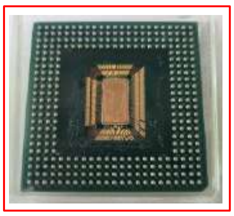


Cross section photo of TSV

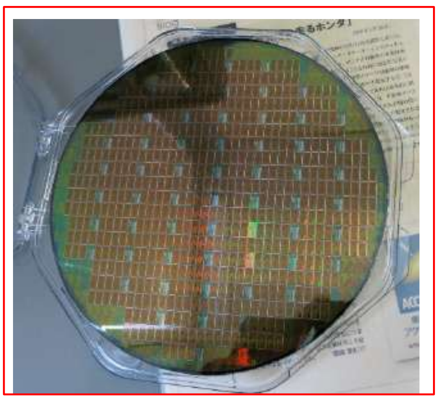
Evacuate in a gap between the Stacked wafer, and then an adhesive is injected in the tool. The adhesive is injected in the gap after the vacuum in the chamber is changed to a atmosphere.



Adhesive injection method



3D LSI chip



3D LSI wafer (8 inch)

(Nobuaki Miyakawa et.al . Multilayer stacking Technology using wafer-to-wafer stacked method, ACM J. on Engineering Technologies in Computing Systems, Vol.4, No.4 (2008):)

N3 Remote control switch using energy harvester （EnOcean GmpH）

Remote control switch

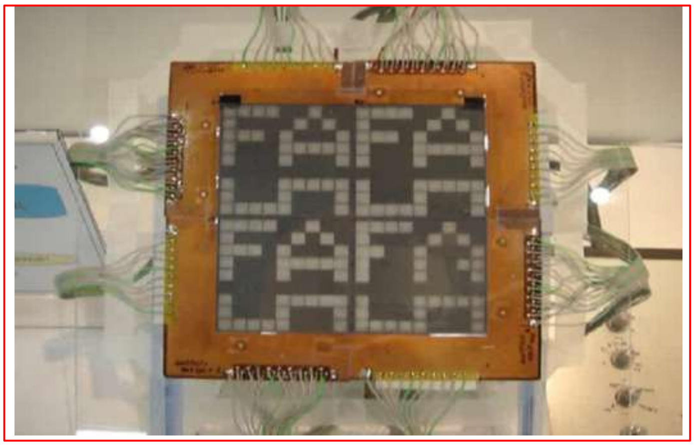
Energy harvester for the switch

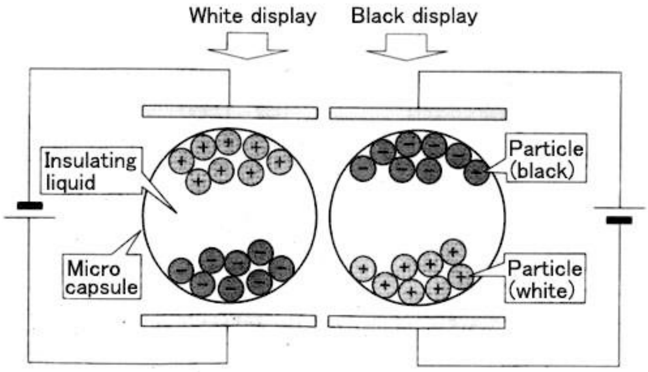
https://www.enocean.com/en/product/eco-260/?ts=1696510449

Application of the remote switch for bus in London

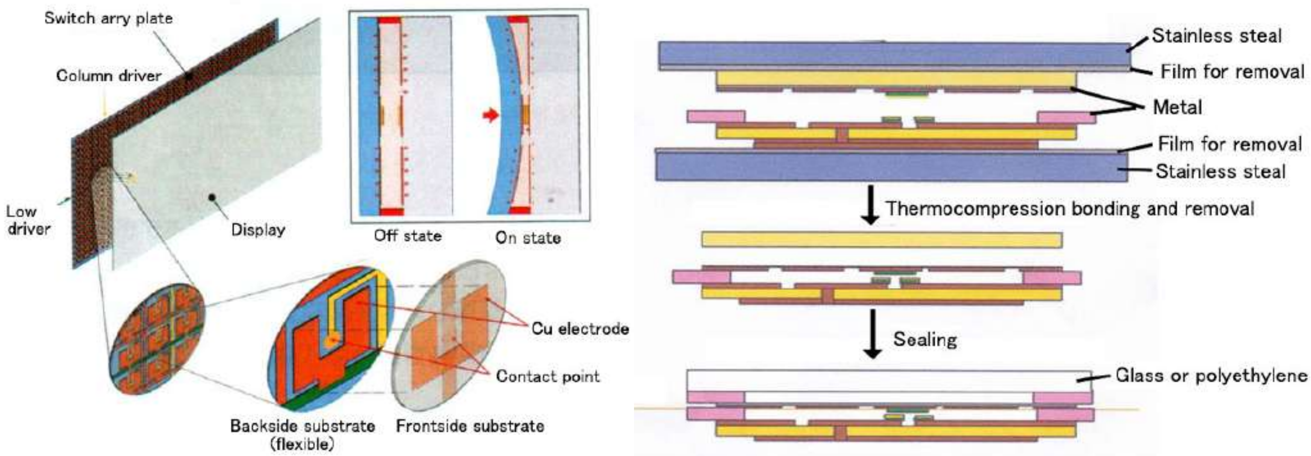
(Kazumi Itagaki (enocean alliance) : Battery-less wireless switch and sensor by energy harvesting and applications of MEMS devices, 2012/9/20 Research meeting on microsystem fusion)

N4 Membrane switch array for electrophoresis display and oscillometric blood pressure monitor (E-paper, Tokyo Sanyo Electric Co. Ltd, K. Senda)





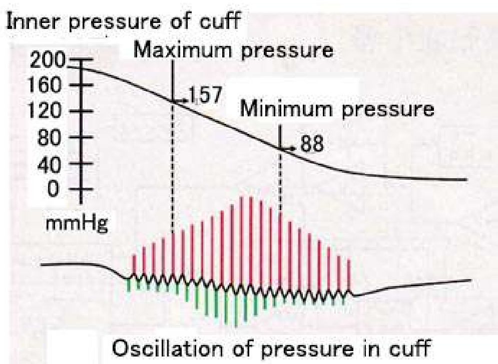
Photograph and principle of electrophoresis display



Principle of electrostatic switch and fabrication process

(K.Senda, B.S.Bae and M.Esashi : MEMS Membrane switches Backplane for Matrix Driven Large Sign Display [The 15th Internl. Display Workshops (IDW'08), Niigata (2008, Dec.4) 1349-1353]

(K. Senda, M. Esashi : Application of membrane switch array on polymer plate to MEMS display, 25th Sensor micromachine and system application symposium, Late news, Okinawa (2008/10/23) 121.



Holter oscillometric blood pressure monitor