Experiences of common facility and open collaboration for MEMS
MEMSのための共有施設とオープン･コラボレーション

M.Esashi

Tohoku University, The World Premier International Research Center Advanced Institute for Materials Research (WPI-AIMR), Director of Micro System Integration Center (μSIC)

Experiences of MEMS･IC research and construction of common facility

1. Chemical sensor & prototyping facility (graduate student) (1970-1975)
2. Biomedical micro sensors (Research Associate) (1976-Sept.1981)
3. Development of custom CMOS IC (Assoc. Professor) (Oct.1981-1990)
4. Integrated MEMS & industrialization (Professor) (1991-)

Open collaboration

5. Common facility for prototyping
6. Accumulation and utilization of knowledge
7. Supporting industry
8. Education for students who are eager to be useful

Summary

April 20, 2015, MEF

1971 ISFET (Ion Sensitive FET) (Graduate school (Electronic Eng.))
20mm process facility

1976 Medical sensors (Research associate in Electronic Eng.)
Common facility for micromachining

1981 CMOS LSI (Associate professor in Communication Eng.)
LSI design, process, testing facility

Prof. T.Matsuo studied in Stanford Univ. (Prof. J.Mindle's Lab.) with Research Associate Dr. K.D.Wise in 1971

1990 (Integrated)MEMS (Professor in Precision Eng.)
1995 Venture business laboratory
(2006~ Micro-Nanomachining research and education Center (MNC))

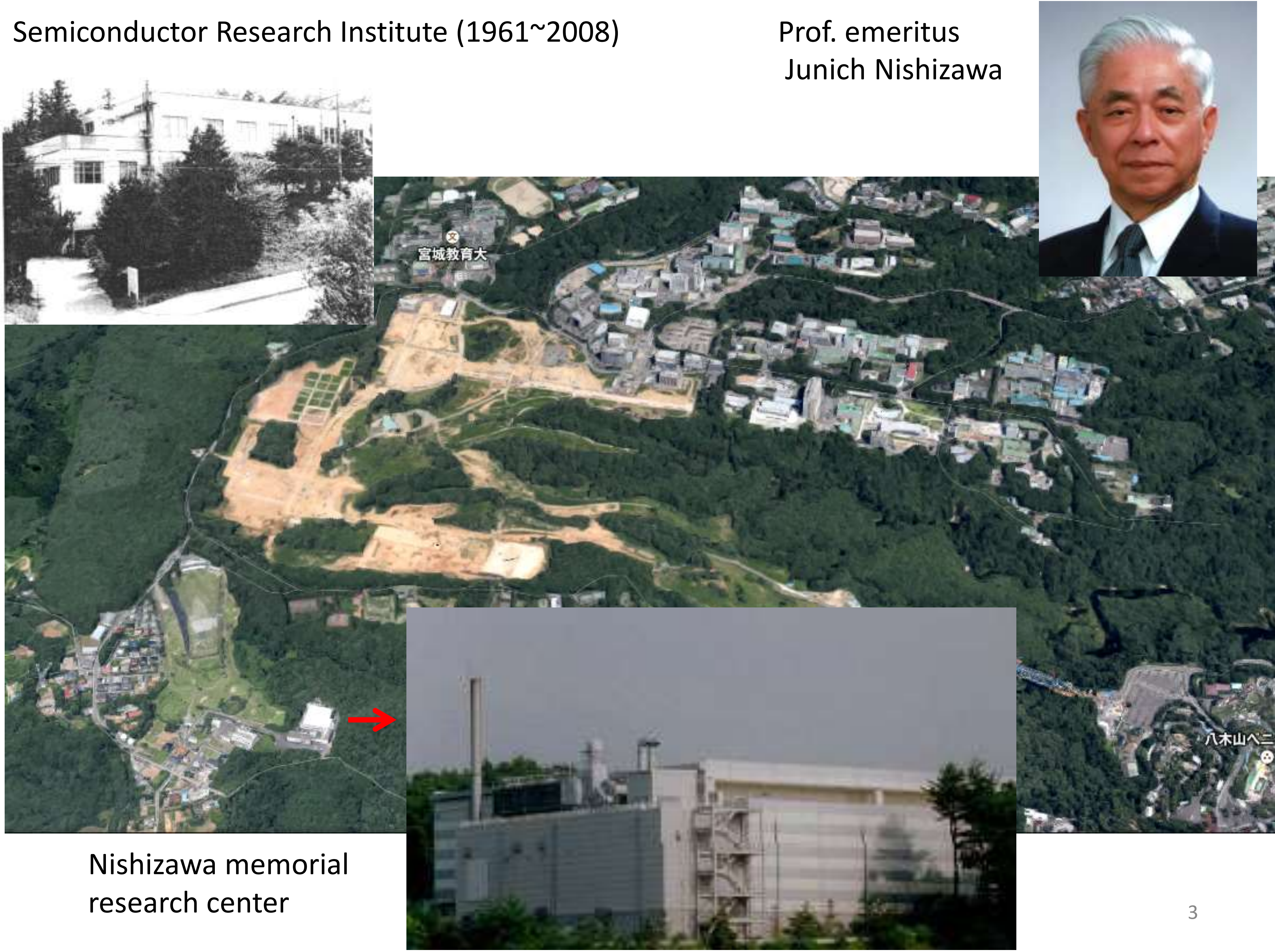
2007 Professor in WPI-AIMR (Concurrently in Graduate school of Eng.)
2007 Innovation centers for advanced interdisciplinary research areas program
2008 Closing of Semiconductor Research Institute
(→ J. Nishizawa memorial research and development center in Tohoku Univ.)
2009 Establishment of μSIC
2009 Funding Program for World-Leading Innovative R&D on Science and Tech. (FIRST)
2010 Hands-on access fabrication facility
2013 Retirement from Graduate school of Eng. (Successor : Prof. S.Tanaka)
2014 FIRST close
(2017 Closing of Innovation centers for advanced interdisciplinary research areas program)

WPI-AIMR : The World Premier International Research Center Advanced Institute for Materials Research
μSIC : Micro System Integration Center

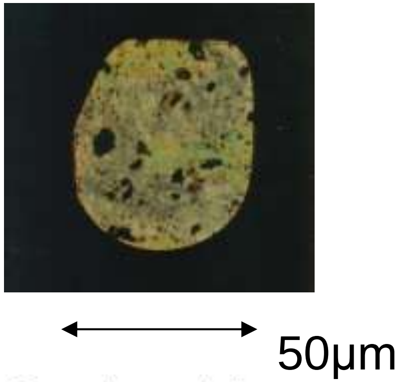
Common facility for fabrication

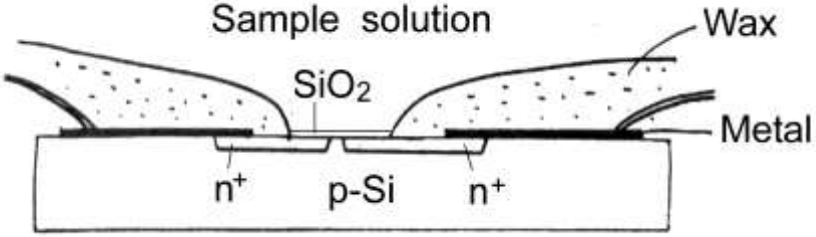
Semiconductor Research Institute (1961~2008)

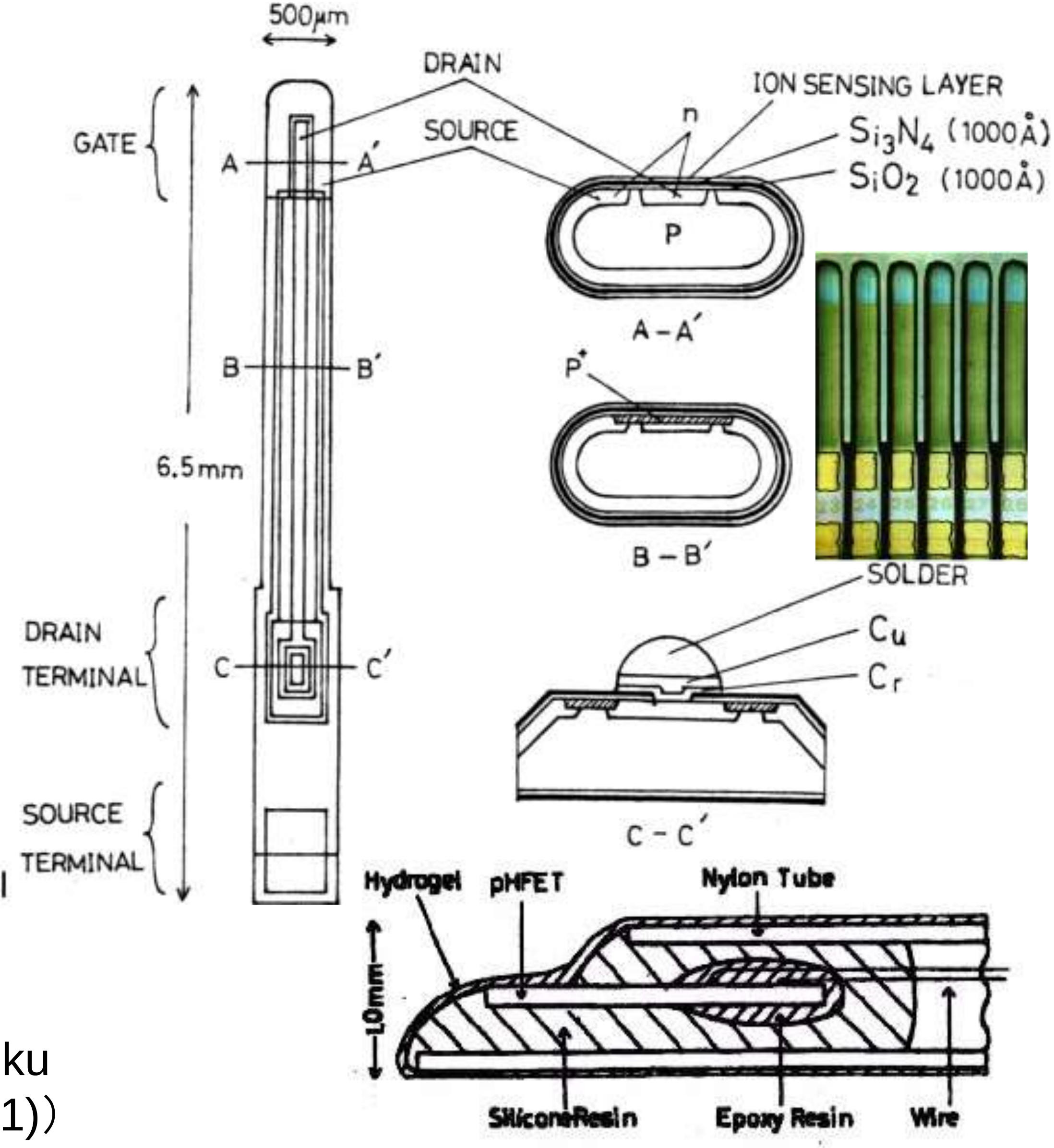
Prof. emeritus
Junich Nishizawa



Nishizawa memorial
research center





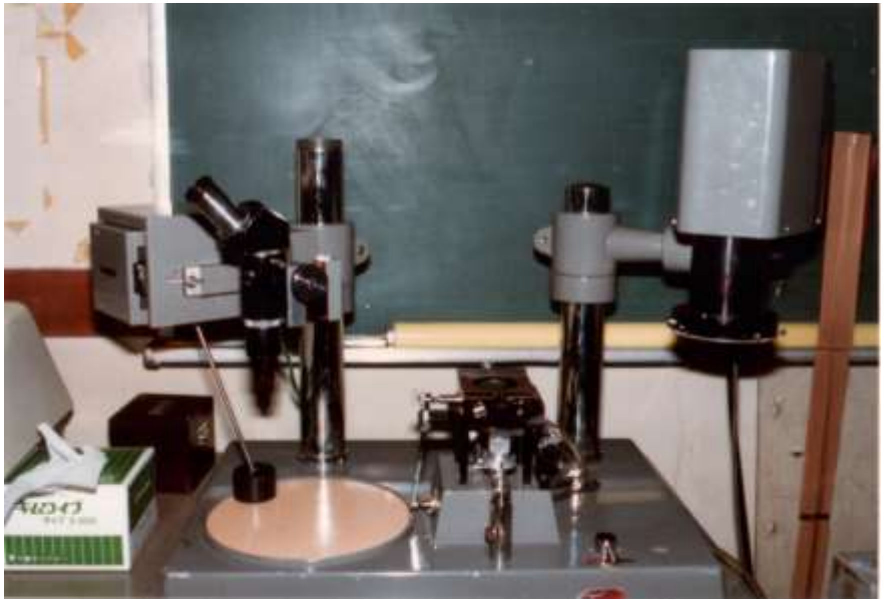


（T.Matsuo, M.Esashi, K.Iinuma, Tohoku region meeting of Electrical Eng.(1971)）

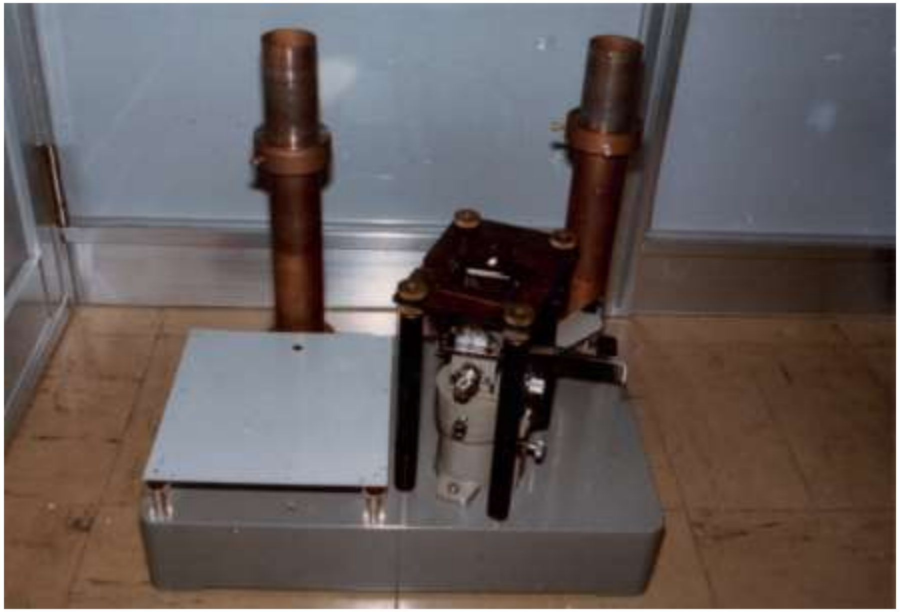
ISFET (Ion Sensitive Field Effect Transistor)

(wafer process for reliable assembly)

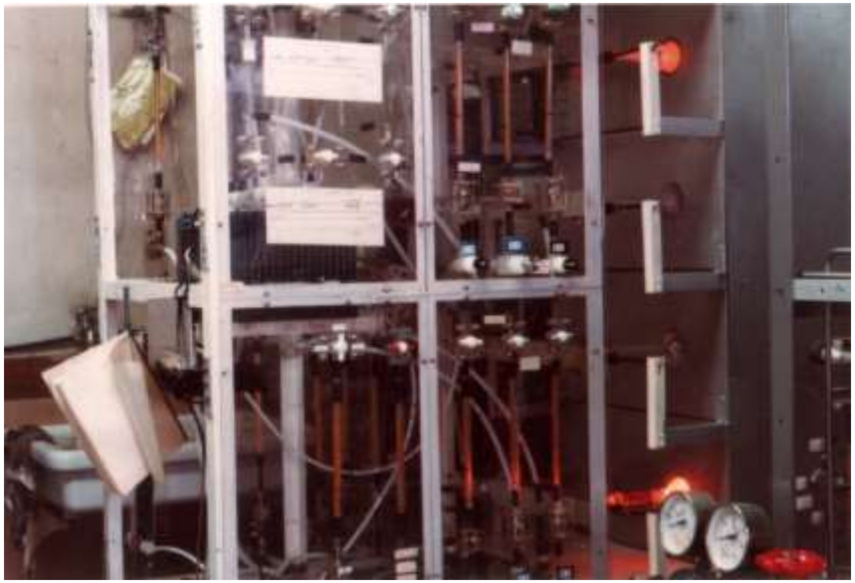
(M.Esashi & T.Matsuo, Supplement to the J.J.A.P.,44 (1975) 339)



Mask aligner bought by Grant-in-aid for Scientific Research

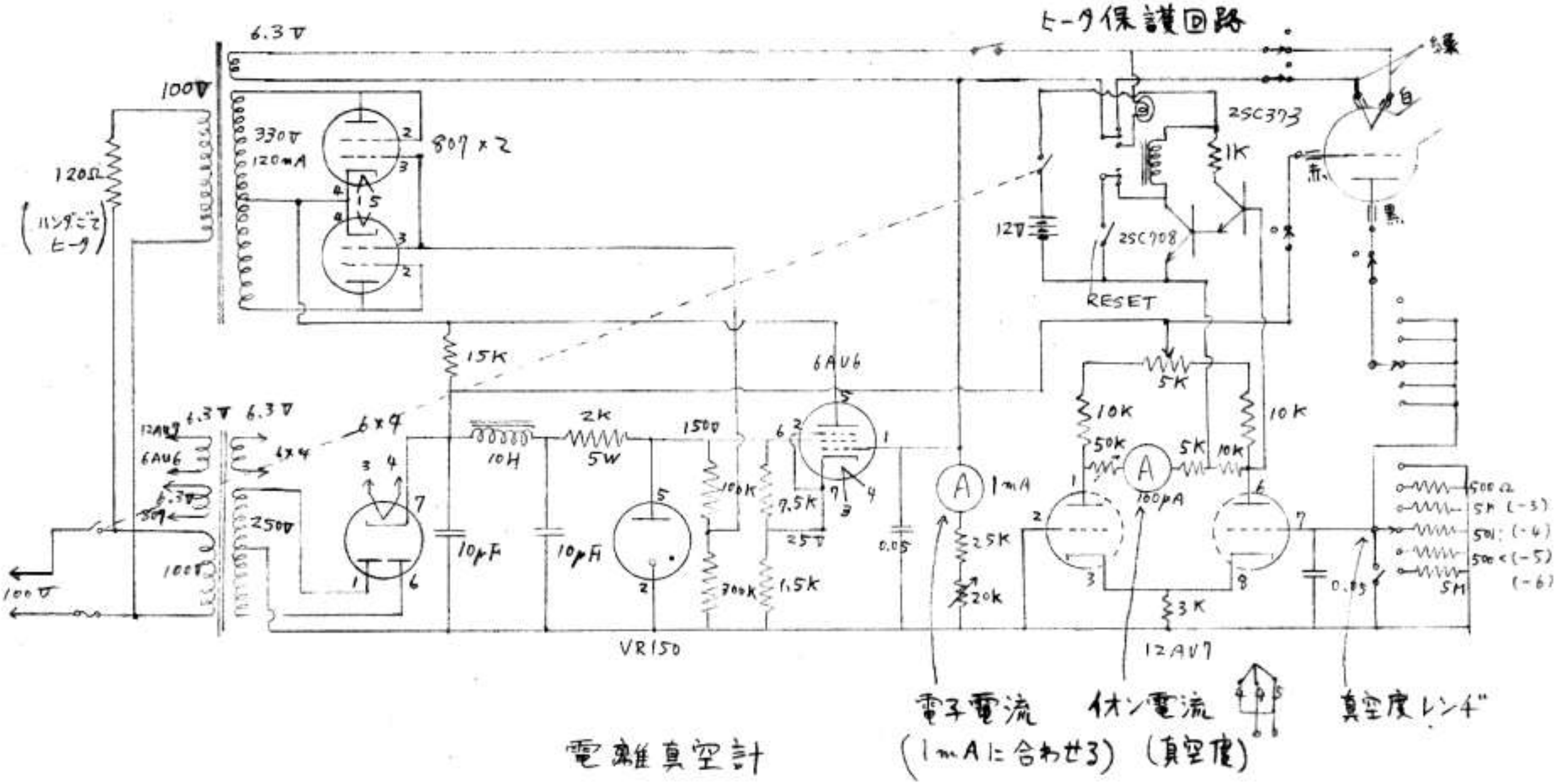


Double side mask aligner made in house



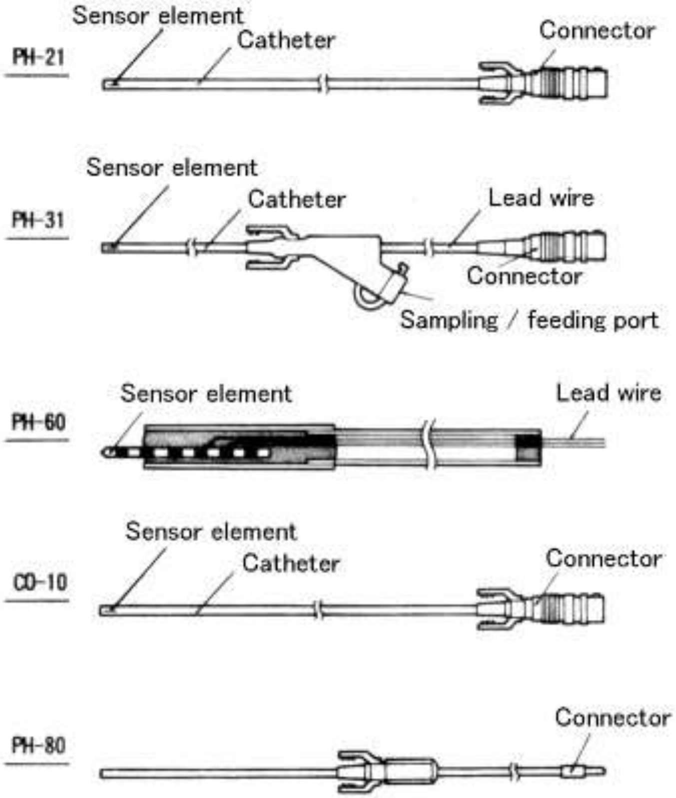
Oxidation and diffusion furnace

Etcher



Vacuum measurement system (ionization gage meter) made in house using vacuum tubes

(K. Shimada (Kurare), M. Esashi and T. Matsuo et.al.: Application of catheter-tip I.S.F.E.T. for continuous in vivo measurement, Med. & Biol. Eng. & Comput., Vol.18, No.11, pp.741-745 (1980))



NIHON KOHDEN

Type	Application	No	Catheter (mm)		Monitor	Note
			Length	Diameter		
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

Catheter pH, PCO_2 monitor (Kurare, Nihon Kohden) (1980)

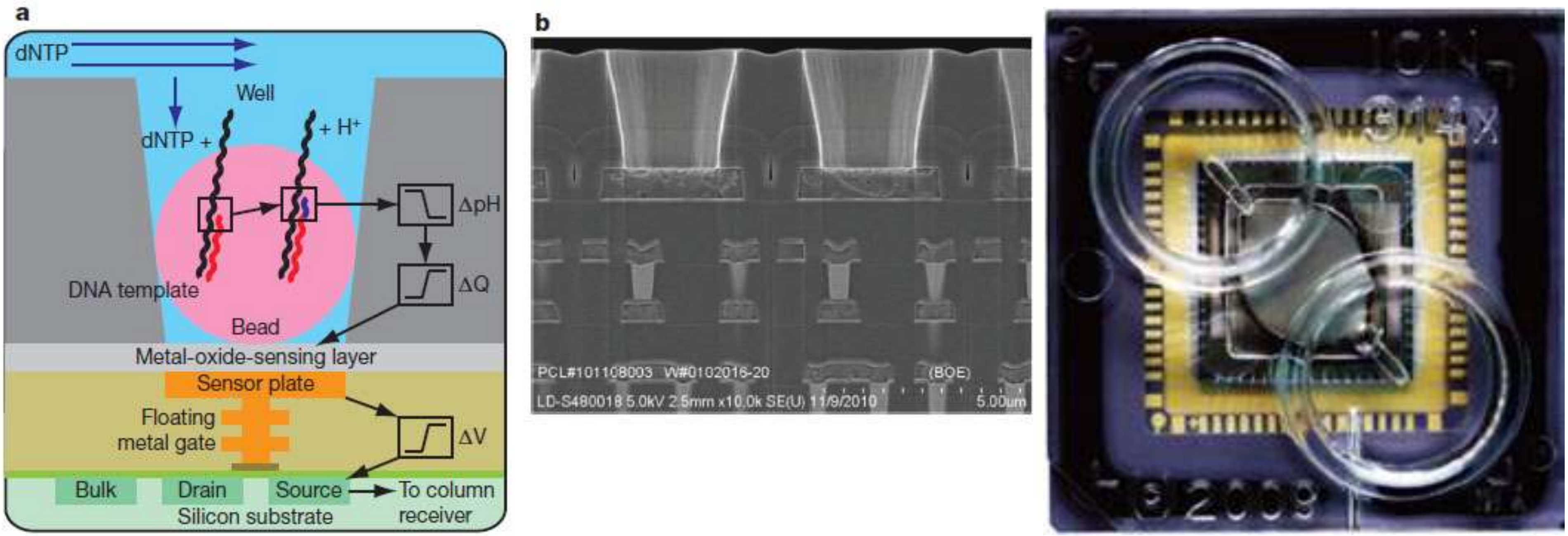


Figure 1 | Sensor, well and chip architecture. **a**, A simplified drawing of a well, a bead containing DNA template, and the underlying sensor and electronics. Protons (H^+) are released when nucleotides (dNTP) are incorporated on the growing DNA strands, changing the pH of the well (ΔpH). This induces a change in surface potential of the metal-oxide-sensing layer, and a change in potential (ΔV) of the source terminal of the underlying field-effect transistor. **b**, Electron micrograph showing alignment of the wells over the ISFET metal sensor plate and the underlying electronic layers. **c**, Sensors are arranged in a two-dimensional array. A row select register enables one row of sensors at a time, causing each sensor to drive its source voltage onto a column. A column select register selects one of the columns for output to external electronics.

Small fragment of single strand DNA attached in beads in each well generates hydrogen ion during binding with nucleotides (A-T, G-C) and double strand DNA is synthesized. The pH change is measured by changing a nucleotide solution.

3 chips all DNA sequencer using 165 million ISFETs on a chip

(J.M.Rothberg (Ion Torrent Life Technologies) et al. : An integrated semiconductor device enabling non-optical genome sequencing,, Nature, 475 (2011/7/21) pp.348-352)

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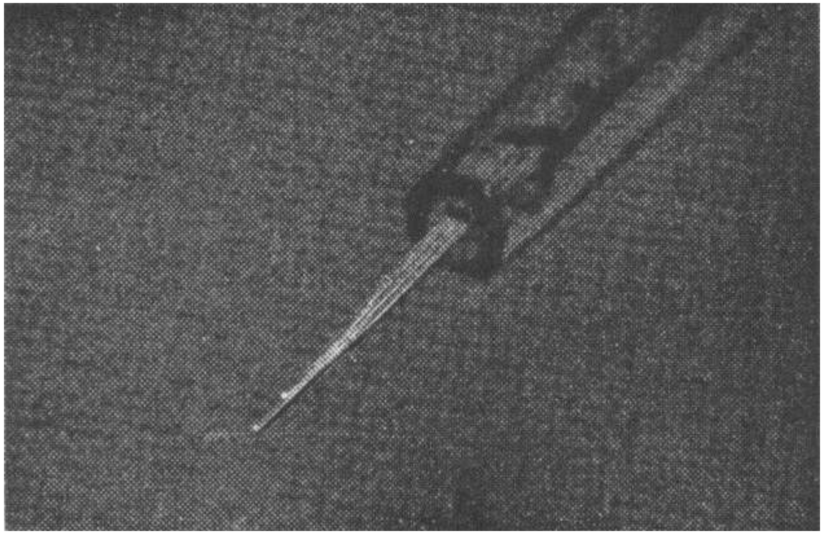
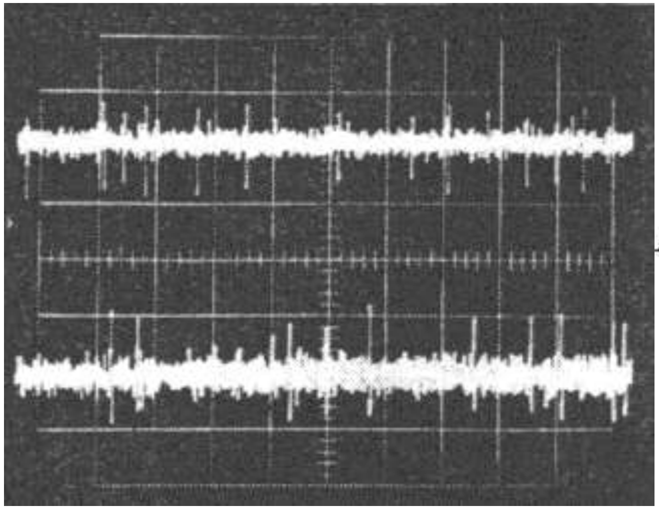
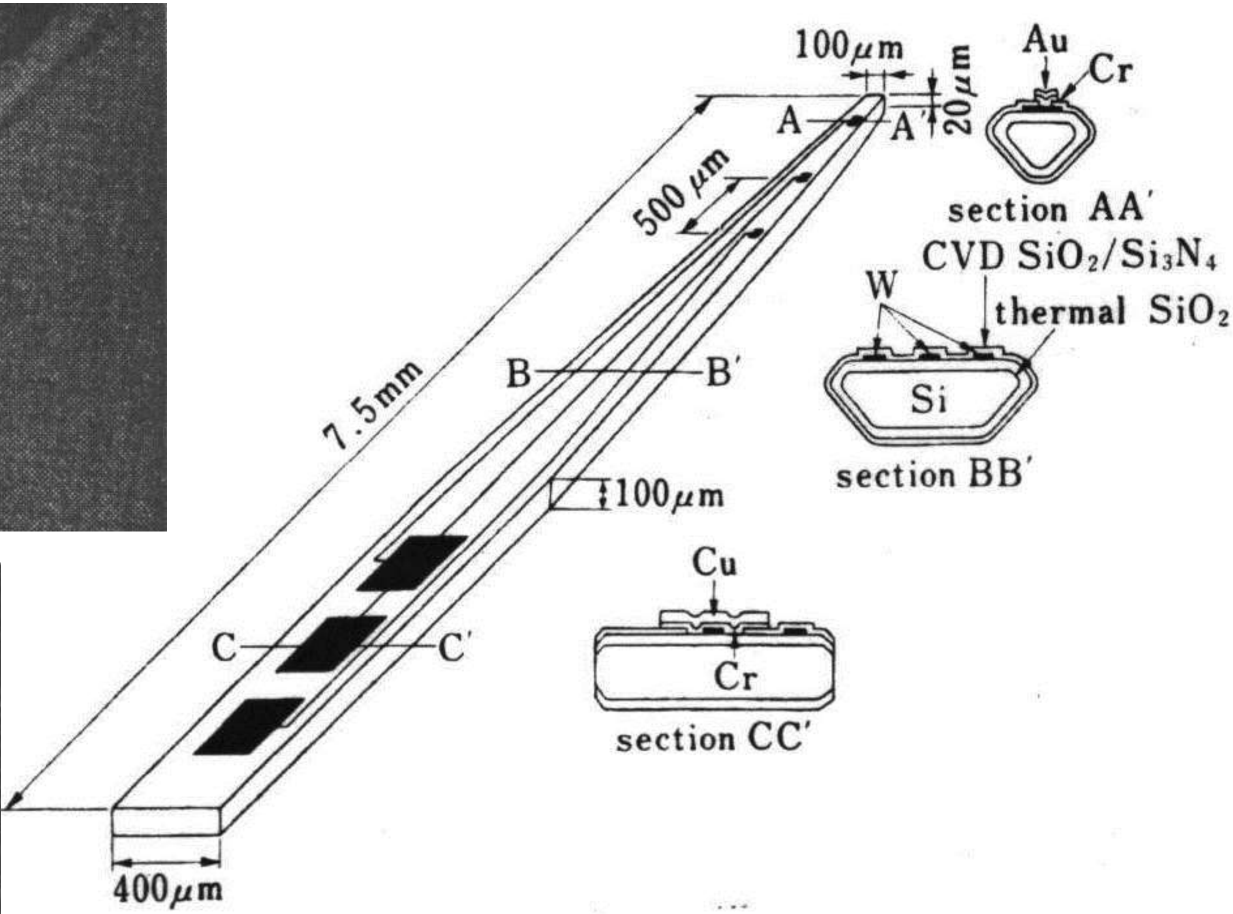
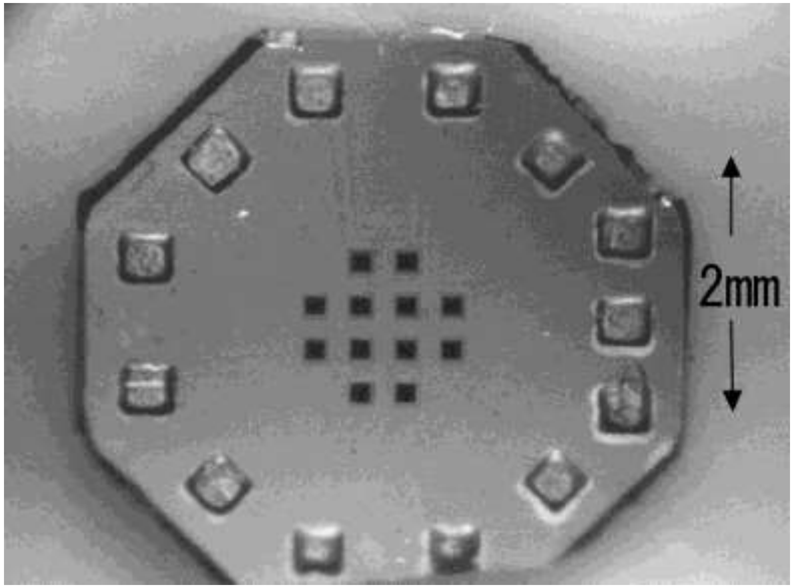


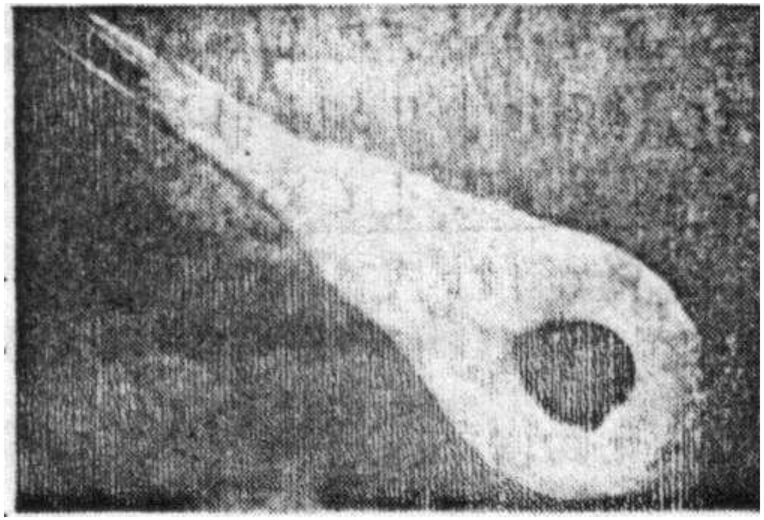


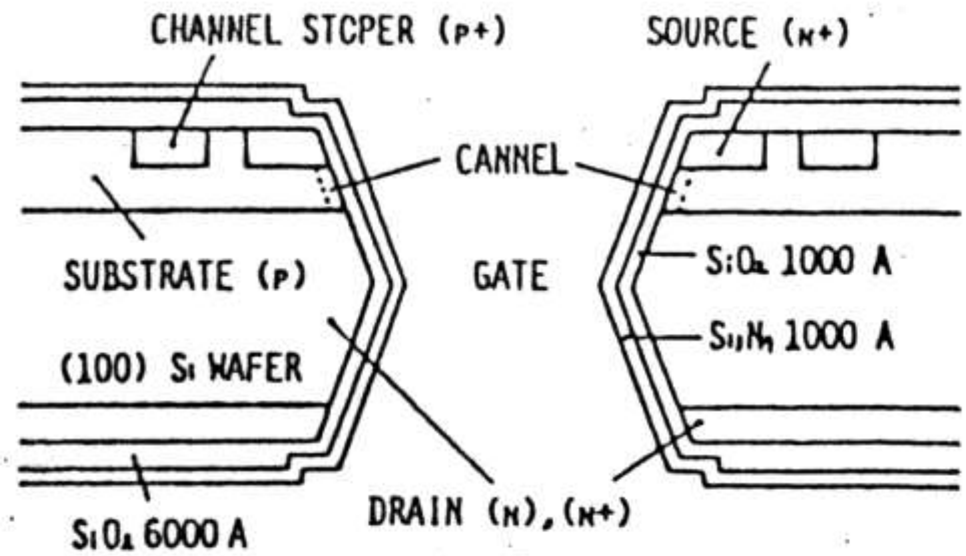


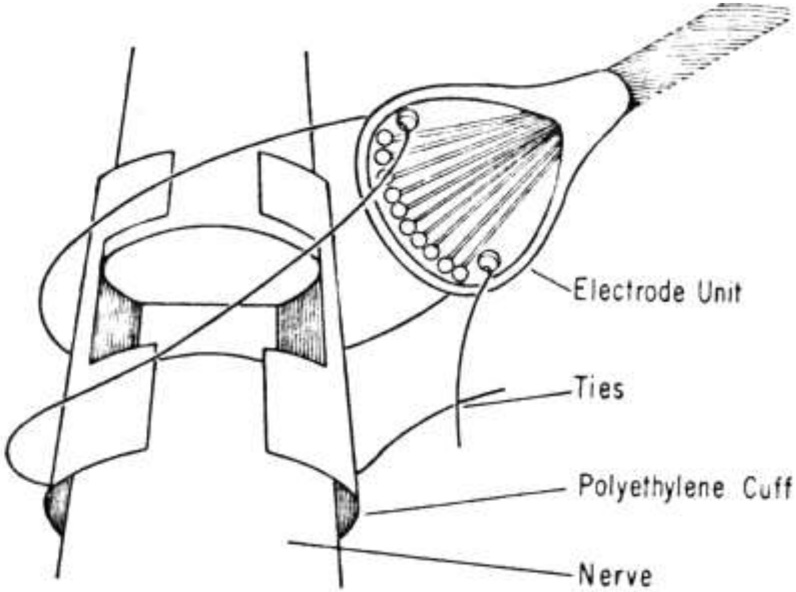
Multi-micro electrode to detect nerve impulse

(Y.Ohta, M.Esashi, T.Matsuo, Medical and Biological Eng., 19, 2 (1981) p.106)









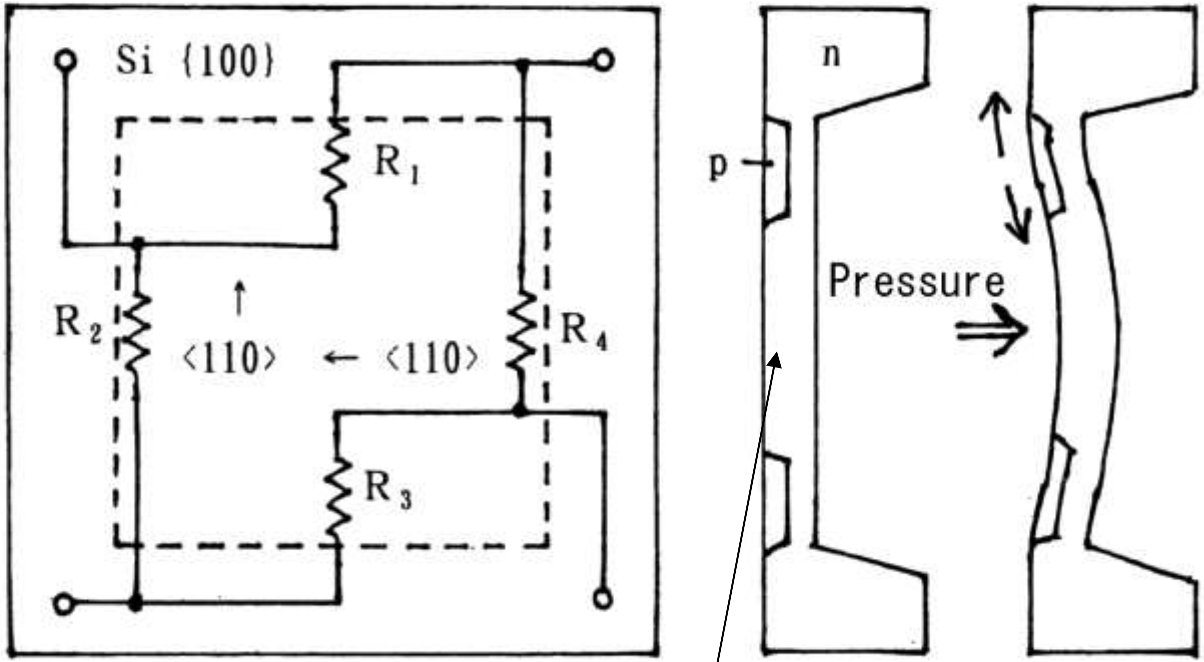
Idea of regenerating electrode

Regenerating transistor electrode

(Yamaguchi, Esashi,17th Convention of Bed.& Biological Eng.,(1978) 261）

(A.Mannard, Science (1974) 547)

Dr. I. Igarashi
(Toyota central
research lab.)



Silicon diaphragm with piezoresistors

1954 Piezoresistive effect of Si & Ge
C.S.Smith (Bell Lab.), (Phy.Rev. 94 (1954) 42)

1963 Silicon diaphragm piezoresistive pressure sensor
O.N.Tufte (Honeywell), J.of Applied Physics, 33 (1962) 3322),
I.Igarashi (T.C.R.L.)

1980’s Commercialized for engine control to reduce exhaust gas pollution

Piezoresistive pressure sensor

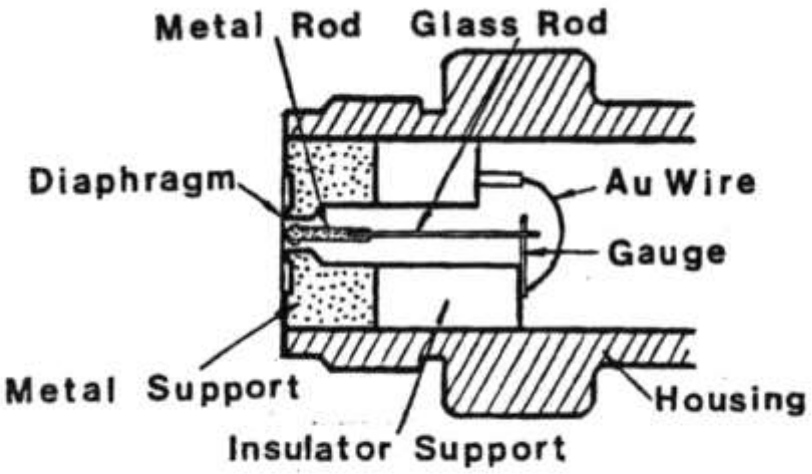


Fig-1 Schema of Blood Pressure Transducer

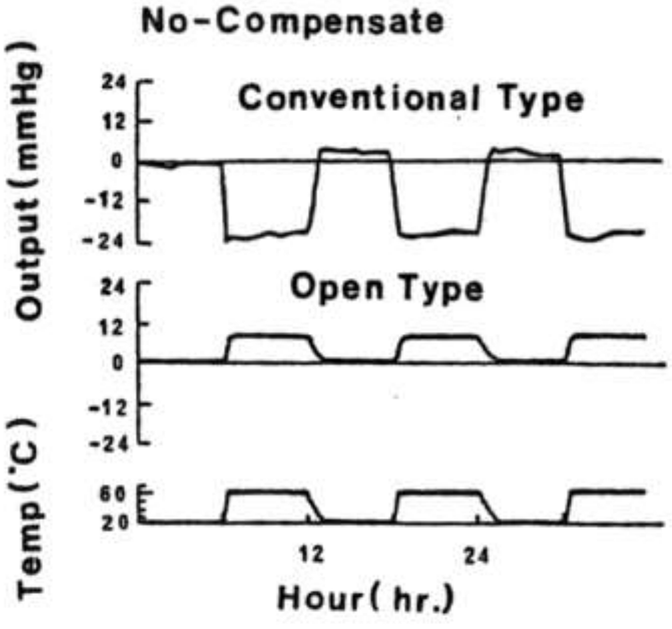
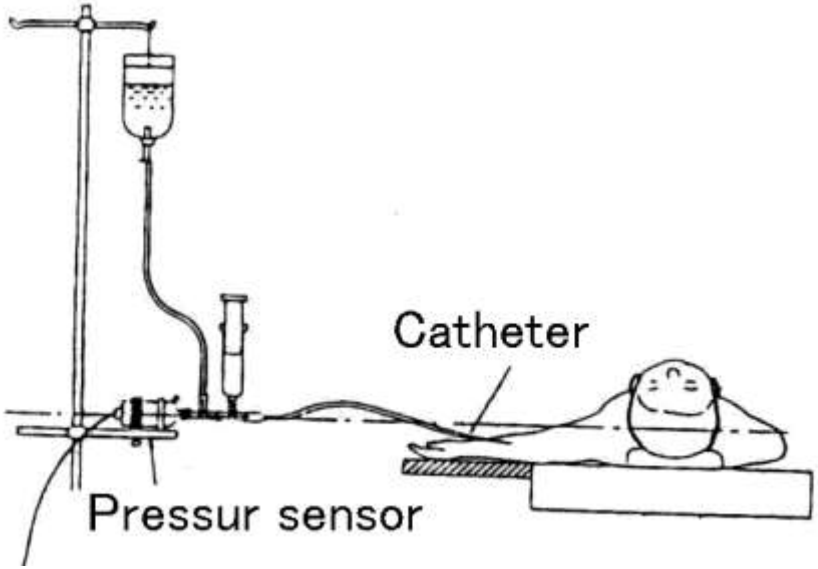


Fig-2 Thermal Drift of Zero



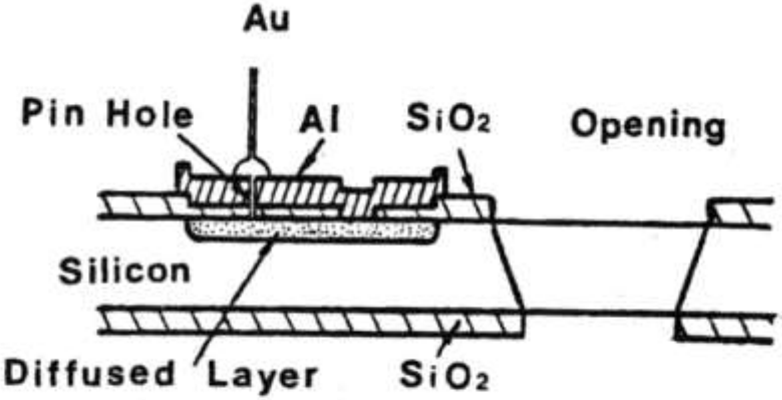
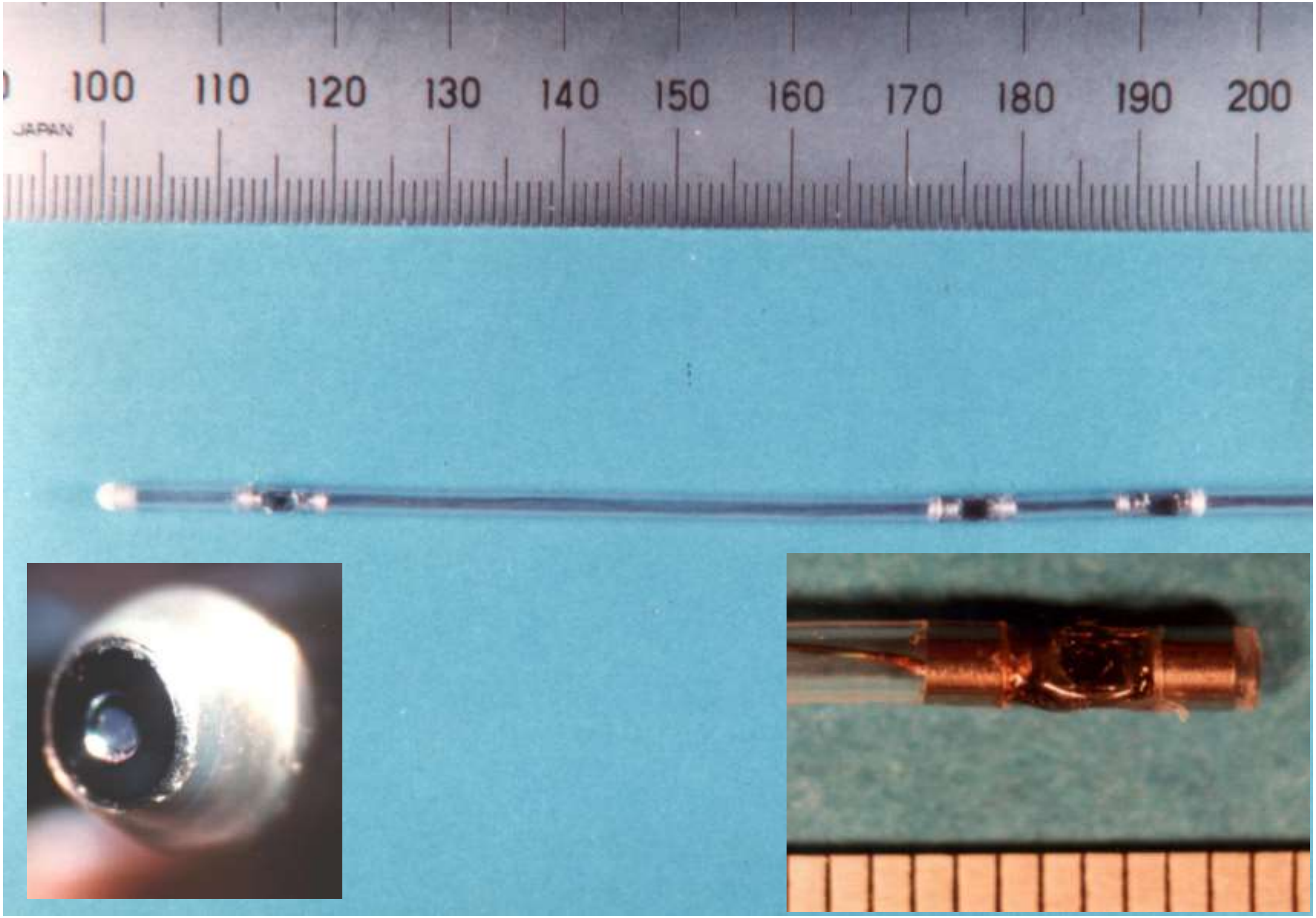


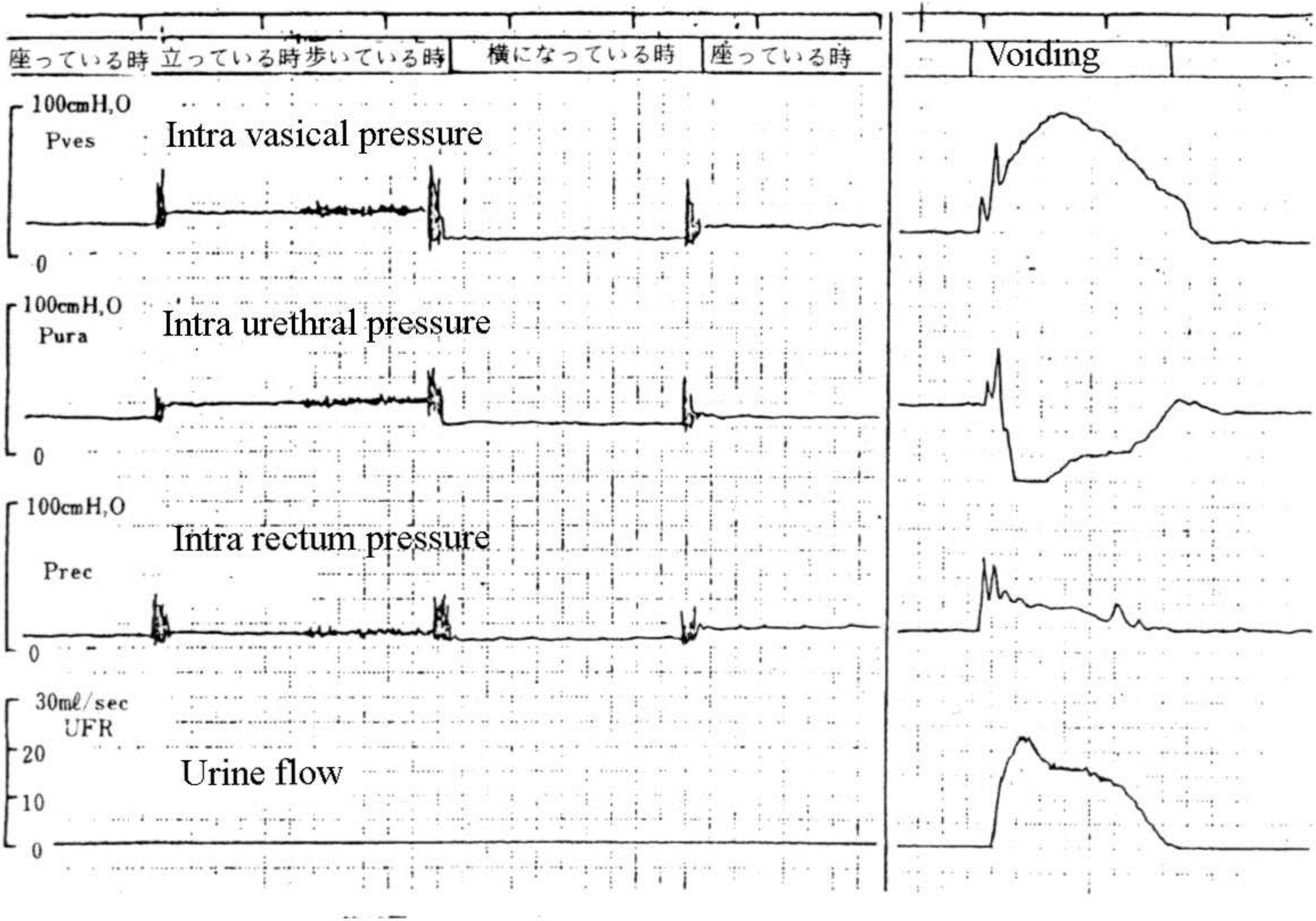
Fig-3 Section of Open Type Gauge

External blood pressure sensor using catheter

(H.Ozawa, M.Esashi, Med.& Biological Eng., 24(special issue) (1986))



Multi piezoresistive pressure sensor catheter
(M.Esashi et.al.: IEEE Trans. on Electron Devices, ED29, (1982) 57)



Clinical application of multi-pressure sensor catheter

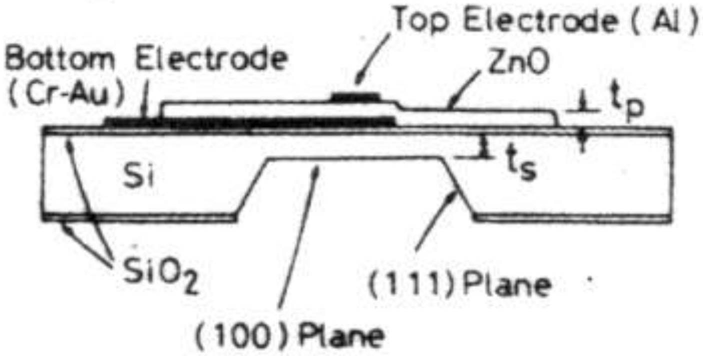
(M.Esashi et.al.: IEEE Trans. on Electron Devices, ED29, (1982) 57)

Proceedings of 1st Symposium on Ultrasonic Electronics, Tokyo, 1980
Japanese Journal of Applied Physics, Vol. 20 (1981) Supplement 20–3, pp. 111–114

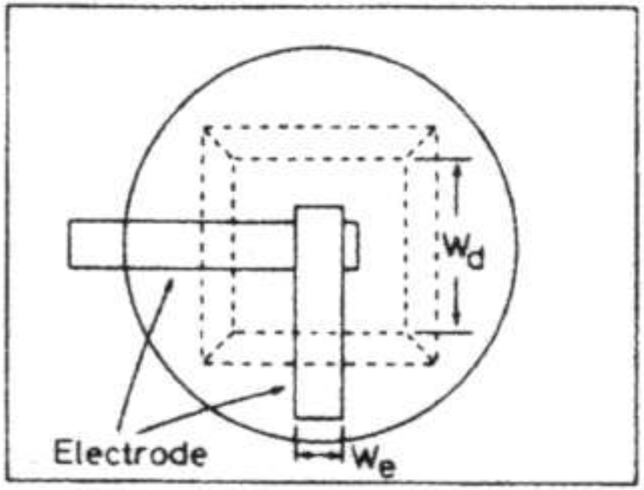
A Piezoelectric Composite Resonator Consisting of a ZnO Film on an Anisotropically Etched Silicon Substrate

Kiyoshi NAKAMURA, Hiromasa SASAKI and Hiroshi SHIMIZU

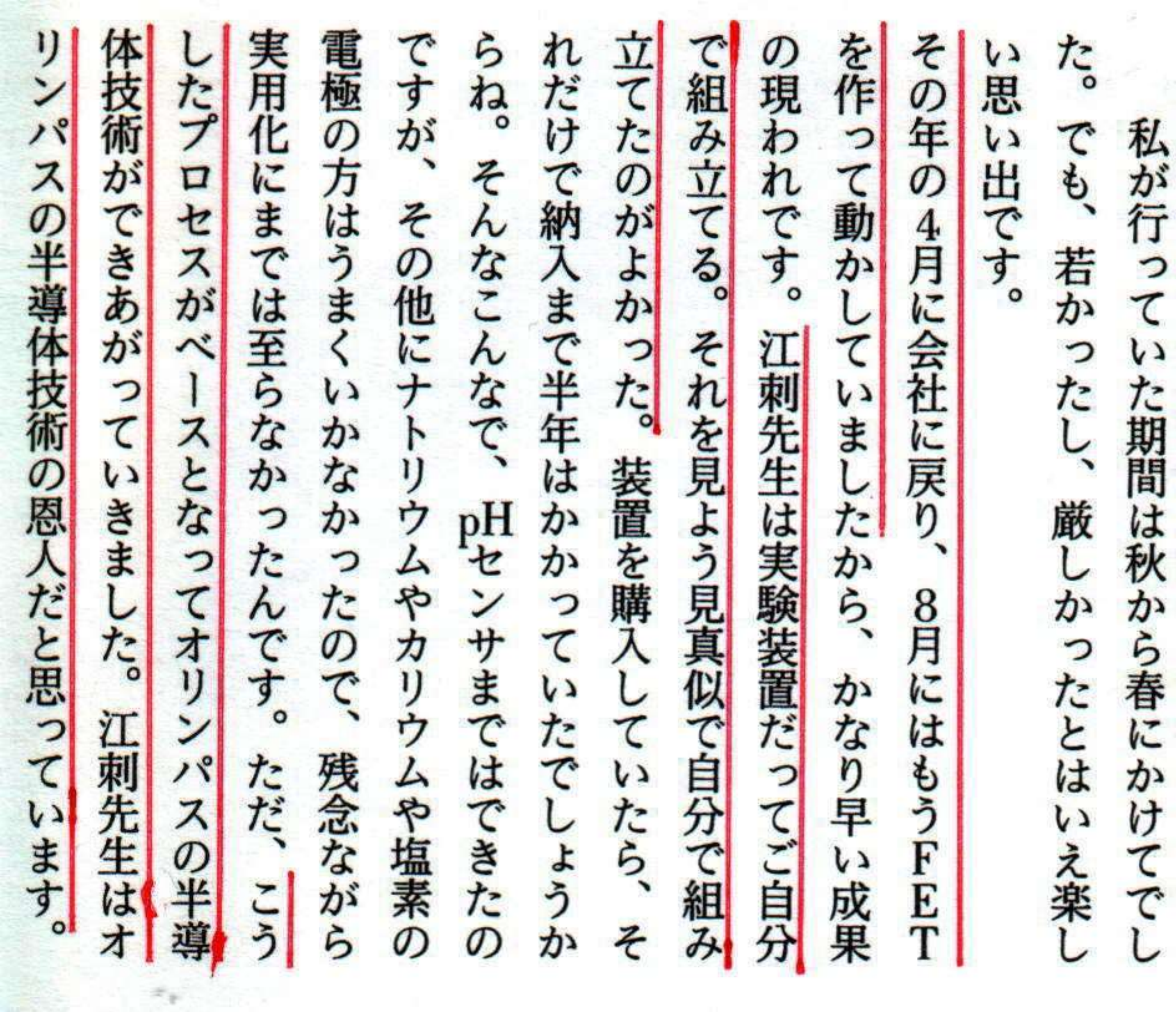
ngineering, Tohoku University, Sendai 980



and Dr. J. Kushibiki for their valuable suggestions on ZnO deposition, and Dr. M. Esashi for his helpful advice on anisotropic etching. They also wish to thank Mr. H. Watanabe and Mr. M. Uriuhara for their technical contributions.



First Film Bulk Acoustic Resonator (FBAR) (1980)



私が行っていた期間は秋から春にかけてでした。でも、若かったし、厳しかったとはいえ楽しい思い出です。その年の4月に会社に戻り、8月にはもうFETを作って動かしていましたから、かなり早い成果の現われです。江刺先生は実験装置だってご自分で組み立てる。それを見よう見真似で自分で組み立てたのがよかった。装置を購入していたら、それだけで納入まで半年はかかっていたでしょうからね。そんなこんなで、pHセンサまではできたのですが、その他にナトリウムやカリウムや塩素の電極の方はうまくいかなかったので、残念ながら実用化にまでは至らなかったんです。ただ、こうしたプロセスがベースとなってオリンパスの半導体技術ができあがっていきました。江刺先生はオリンパスの半導体技術の恩人だと思っています。

1977

Training of dispatched researchers who have experiences of all the process steps (Olympus)

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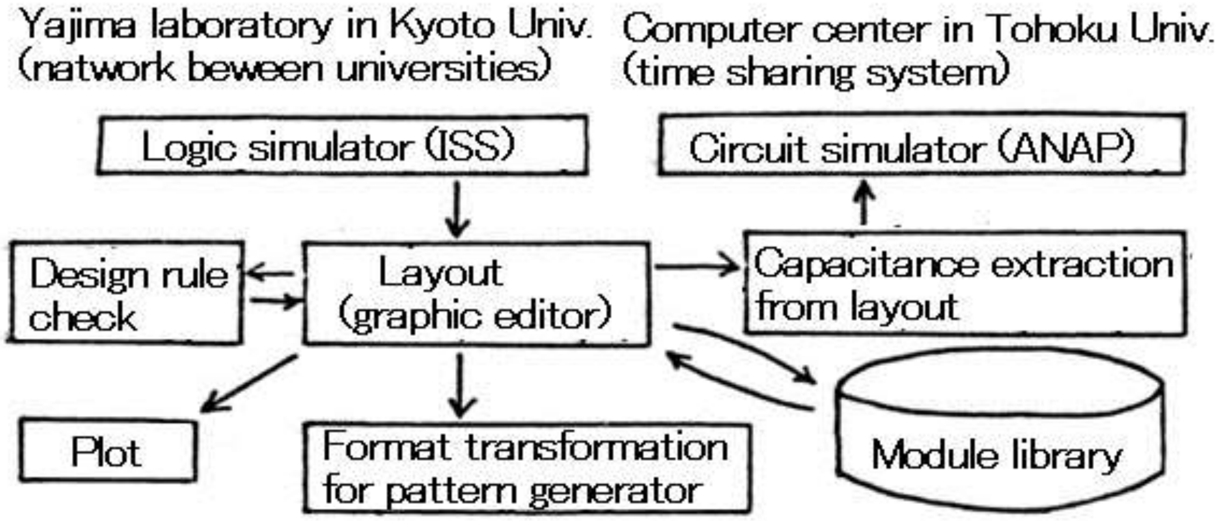
Summary

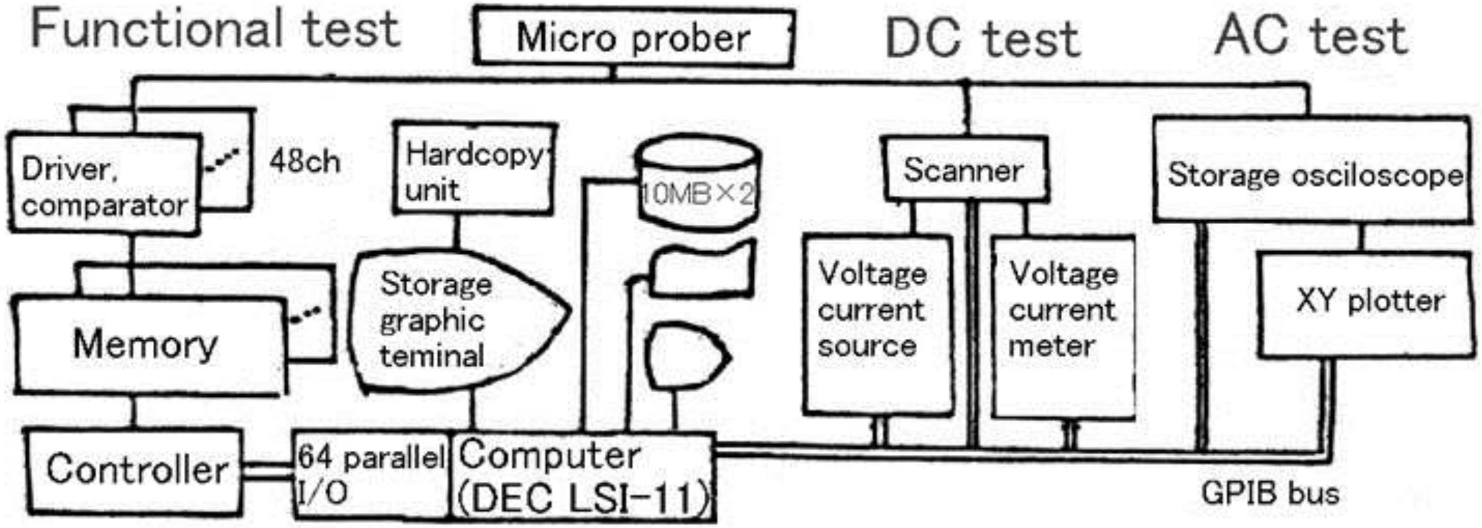
LSI design, testing facility



Design flow using CAD programs

Graphic editor programed by Esashi

(M.Esashi, Experiences of LSI design, prototyping and education, Convention of IEEJ (1984))



LSI test system

(M.Esashi & M.Ohtomo, Fabrication of functional tester for LSI, Tohoku convention of IEEJ (1984))

Mask pattern data (magnetic tape)

↓

Print out of mask pattern
(279mm × 354mm film)

↓

1/5 reduction to
3 inch glass plate

Enlarge (× 4) for
mask check

↓

1/10 reduction (step &
repeat) 2 inch glass plate

↓

Working mask
(2 inch Cr mask)

Mask making process

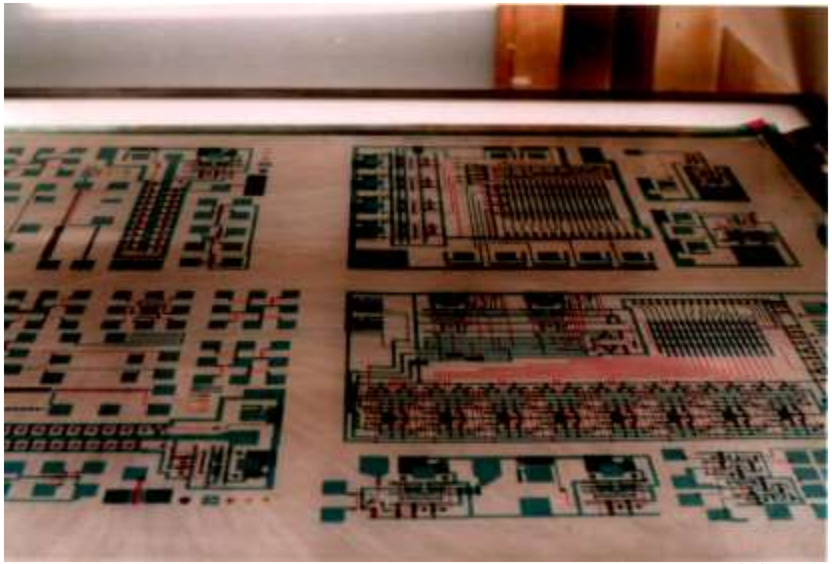

半導体工学シリーズ ❼

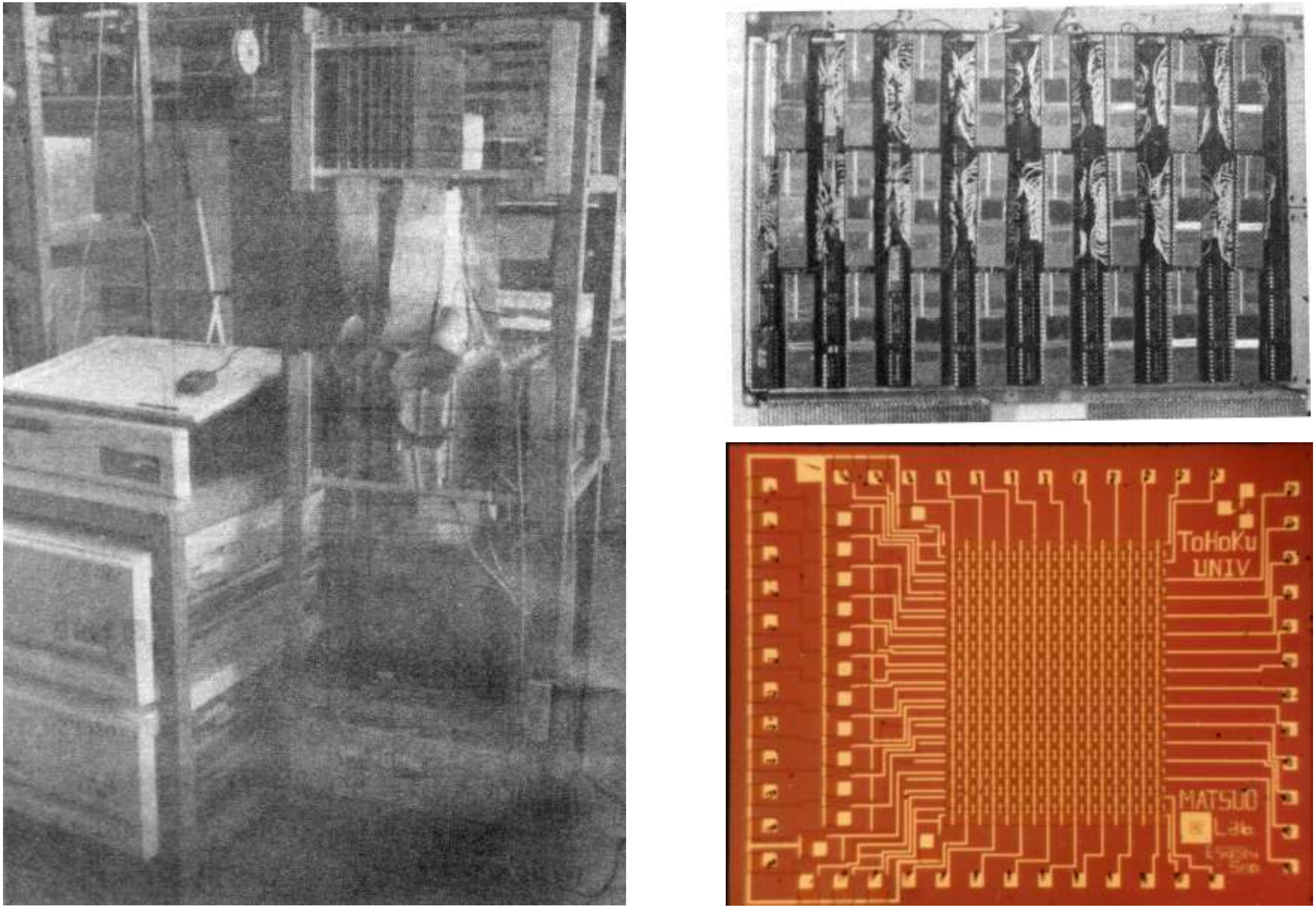
半導体集積回路設計の基礎

西澤潤一編　江刺正喜著

培風館

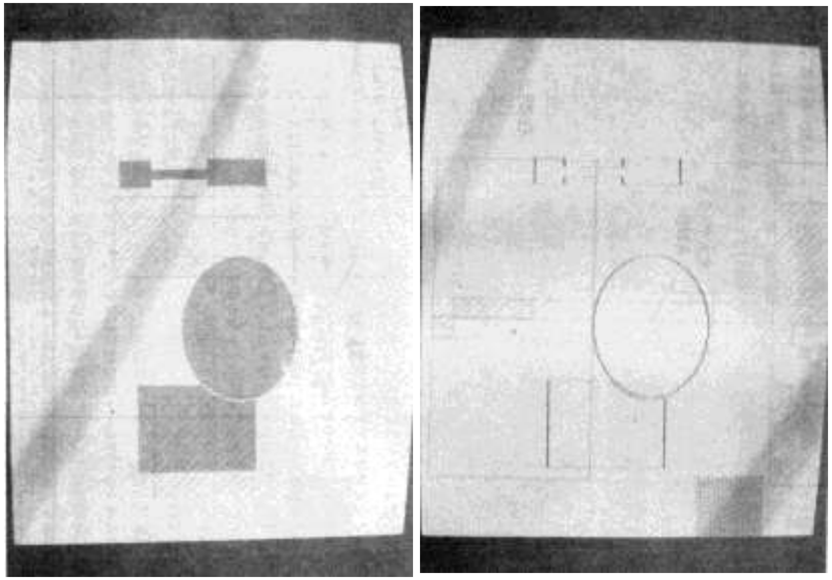
Text book, M.Esashi “Fundamentals of integrated circuit design” (1986)





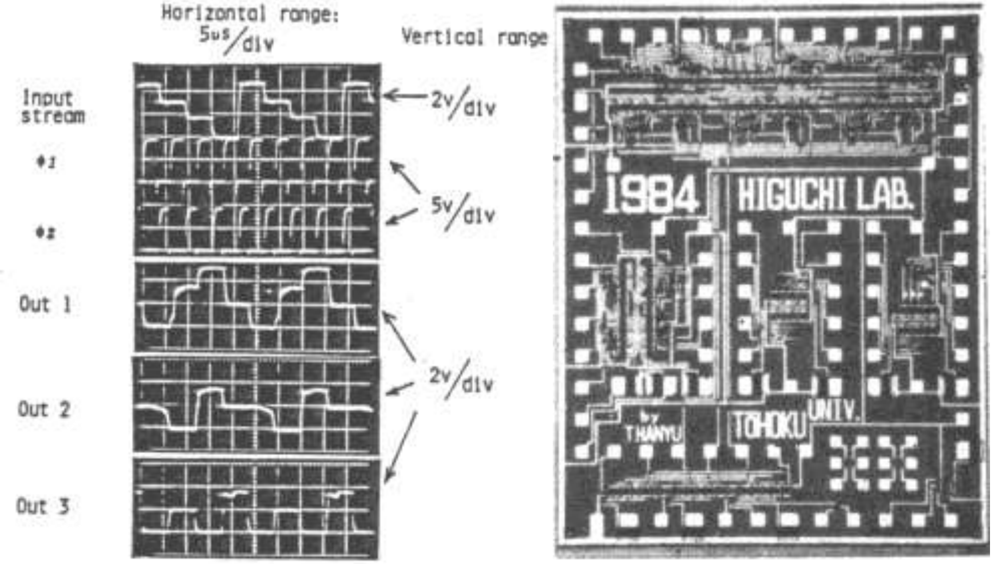
Parallel image processor using custom made IC for 2D barrel shifter

(M.Esashi et.al., Technical report on semiconductor and transistor, IEC,SSD85-51, (1985))



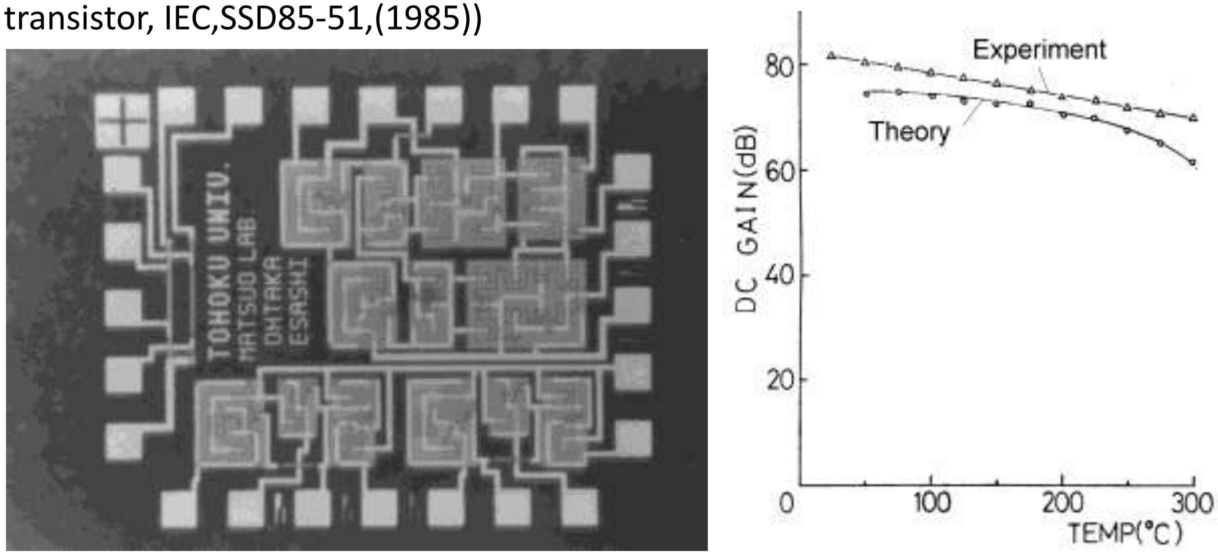
Example of parallel image processing

(M.Esashi et.al., Technical report on semiconductor and transistor, IEC,SSD85-51,(1985))



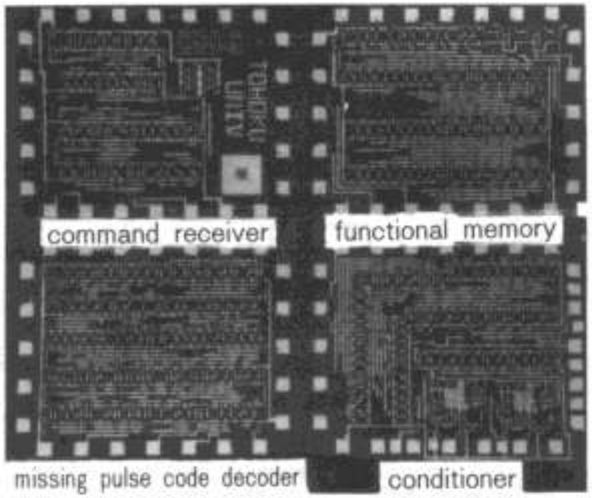
NMOS pipelined image processor using quaternary logic

(M.Kameyama, T.Haniyu, M.Esashi and T.Higuchi, ISSCC (1985) 86)



High temperature operational amplifier

(M.Esashi, S.Ohtaka and T.Matsuo, Technical report on semiconductor and transistor, IEC, SSD86-57 (1986))



Implantable telemetry CMOSIC

(H.Seo, M.Esashi and T.Matsuo, Frontiers of Medical and Biological Engineering, 1 (1989) 319)

20mm process facility for LSI and MEMS (1995)

Second-hand ion implanter used in Tokyo Sanyo Ltd

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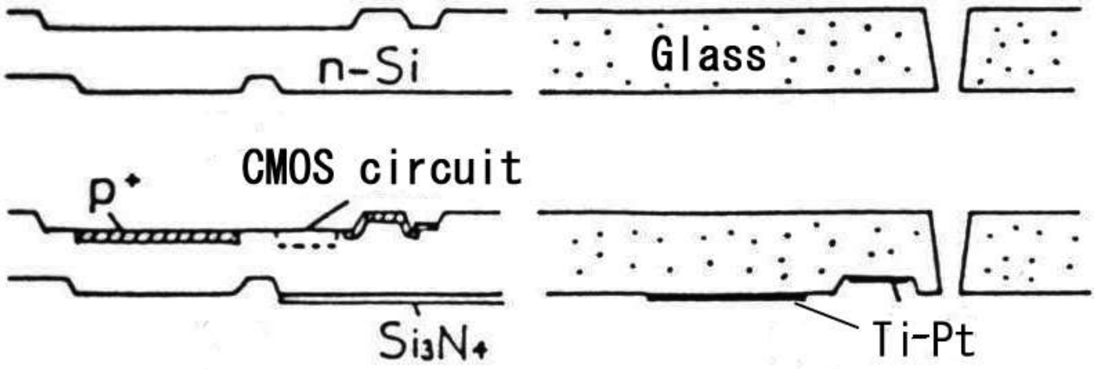
Unique facility like toy for MEMS prototyping

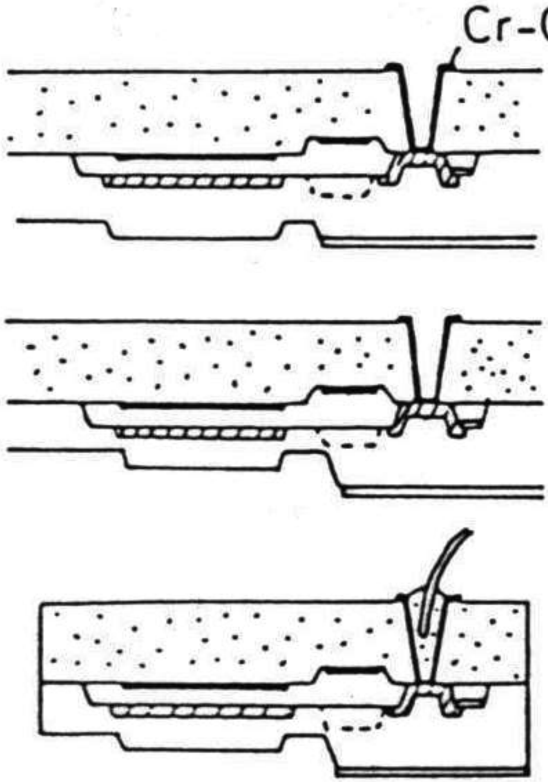
MEMS process facility for 20 mm wafer

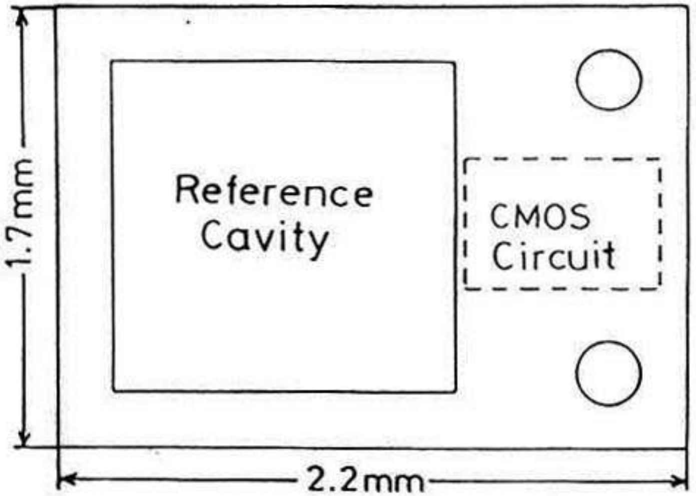
Many process equipments have been made in house.

Simple and basic equipments are suitable for training people who have experiences of all the process and for developing new devices taking advantages of process flexibility.

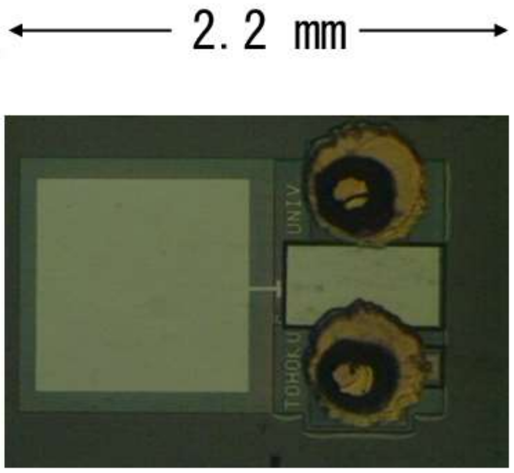
The facility has been shared by many laboratories. More than 100 companies dispatched researchers (full time, 2years).

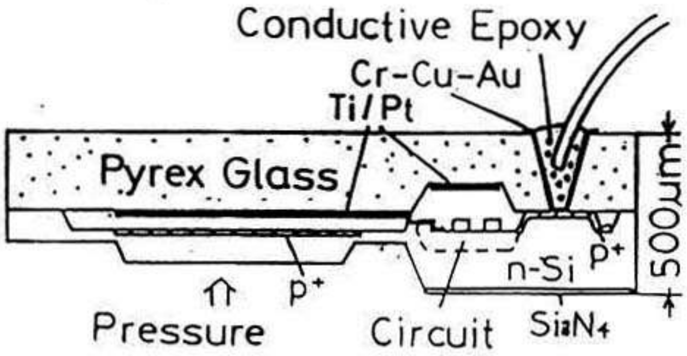






Wafer level packaging

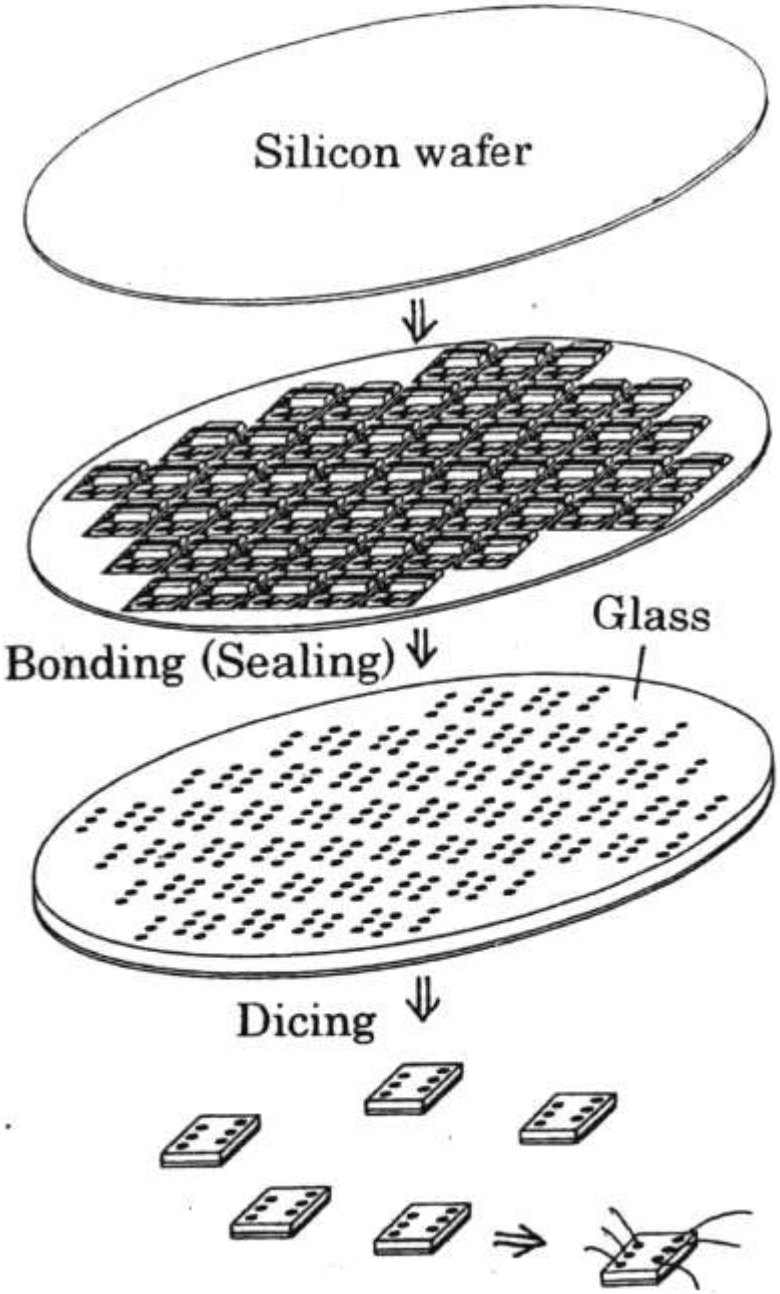




TOYODA

Integrated capacitive pressure sensor

(Y.Matsumoto, S.Shoji, M.Esashi, 22nd Conf. on Solid State Devices and Materials (1990) 701)



MEMS have moving parts

→ Direct molding with plastics can not be done.

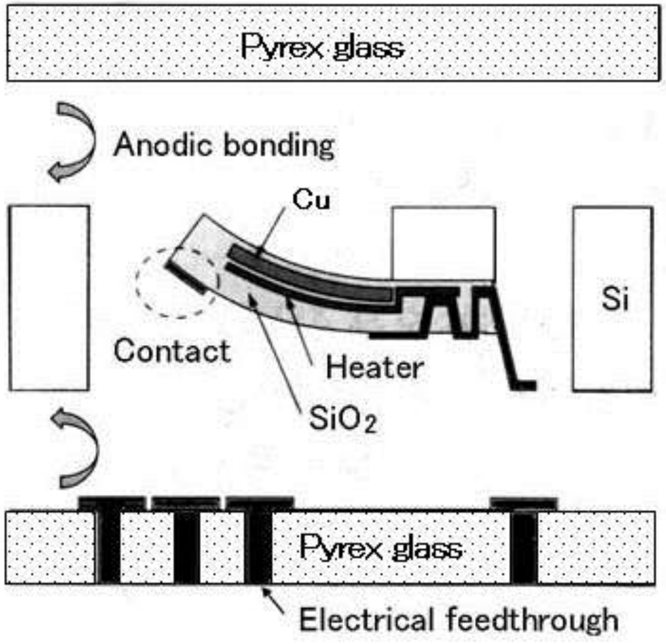
→ small size (chip size encapsulation, suitable for surface mounting)

→ high yield (protection of MEMS structures during dicing)

→ high reliability (hermetic sealing)

→ low cost (minimal investment for assembly, no use of expensive ceramic packages etc)

Wafer level packaging



アドバンテスト社製
半導体試験装置
T2000 シリーズ

半導体デバイスの性能や動作を試験して
良品だけを世の中に送り出しいるのが
アドバンテストの半導体試験装置

アドバンテスト
コンポーネント社製

半導体試験装置を支える
キーデバイスを提供

Immune to electrostatic discharge up to 1000V
Wide frequency range (DC~10GHz)

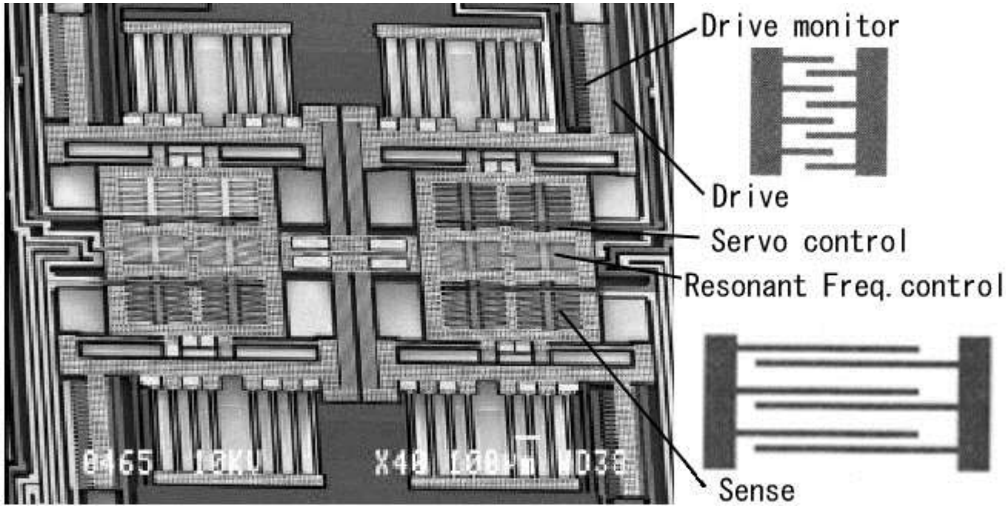
MEMS switch for LSI tester

(A.Nakamura et.al.,Advantest Technical Report, 22 (2004), 9-16)

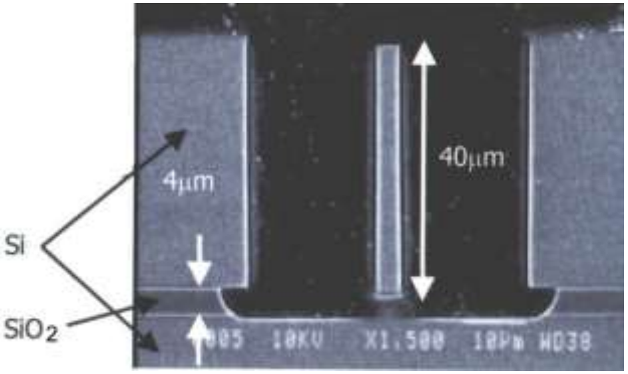
MEMS switch factory
(Advantest components (Sendai))

TOYOTA

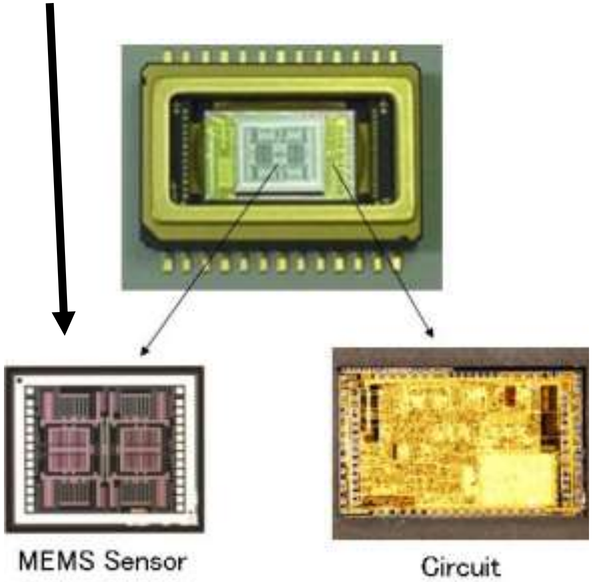
半導体式ヨーレートセンサーを搭載したクラウン(2003年12月発売)



1992-1997
Two researchers from Toyota stayed in Tohoku University for collaborative development of vibrating gyroscope

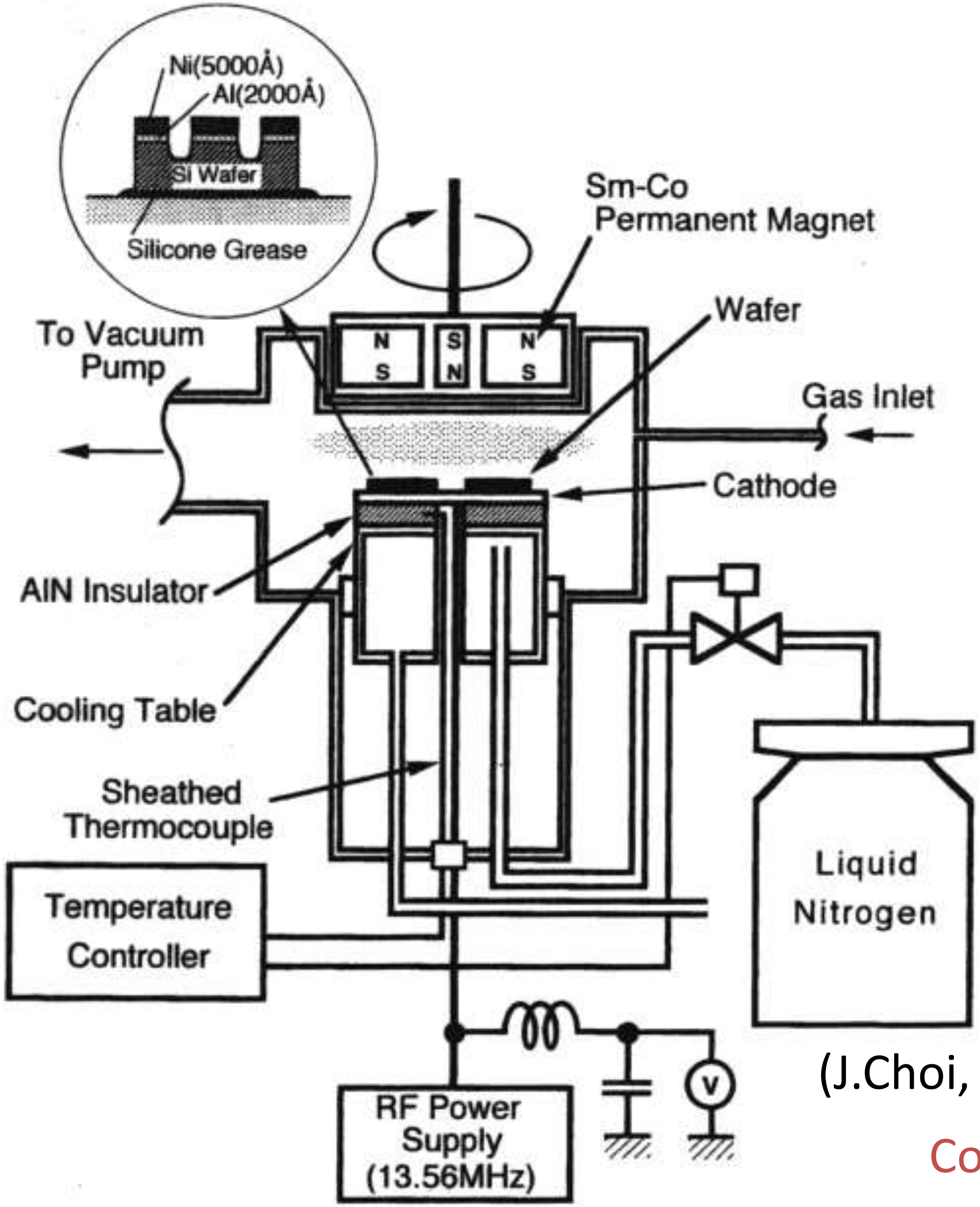


Yaw rate sensor has been produced in Toyota since 2003 and used in more than 1 million cars.



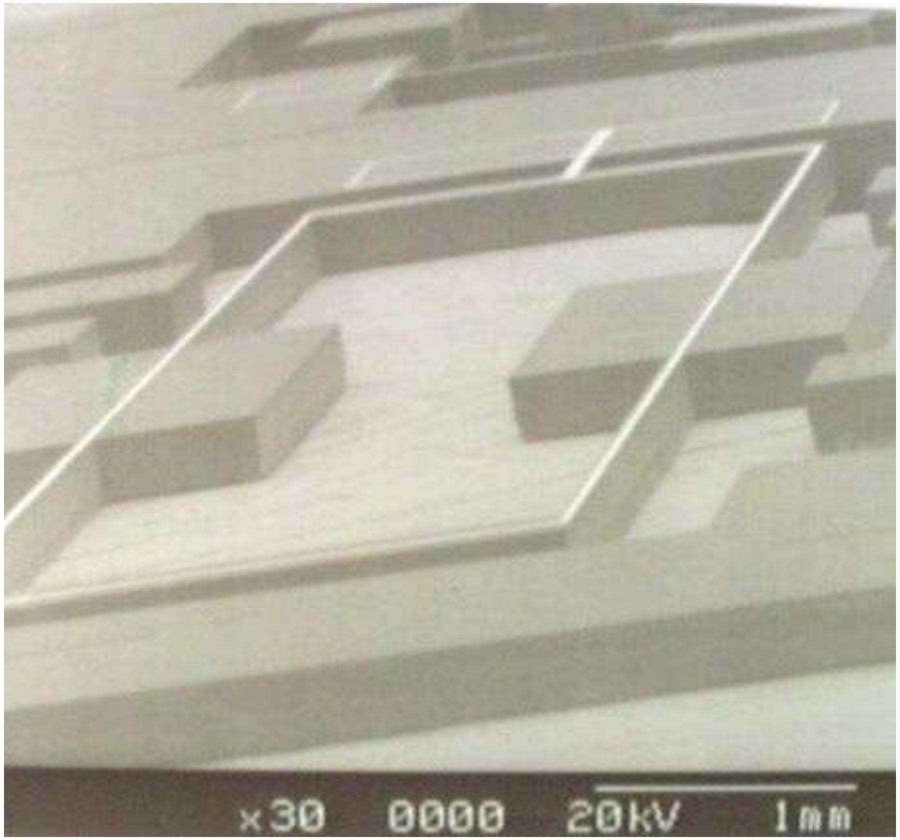
Resonating gyroscope (yaw rate sensor) and accelerometer for vehicle stability control

(M.Nagao et.al.,SAE World Congress, Detroit, (2004) 2004-01-1113)



Si deep RIE system

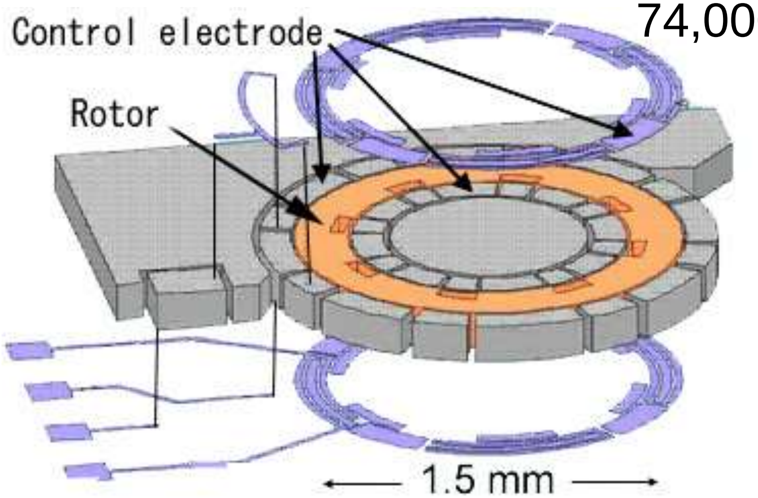
(M.Takinami, 11th Sensor Symposium, (1992) p.15)



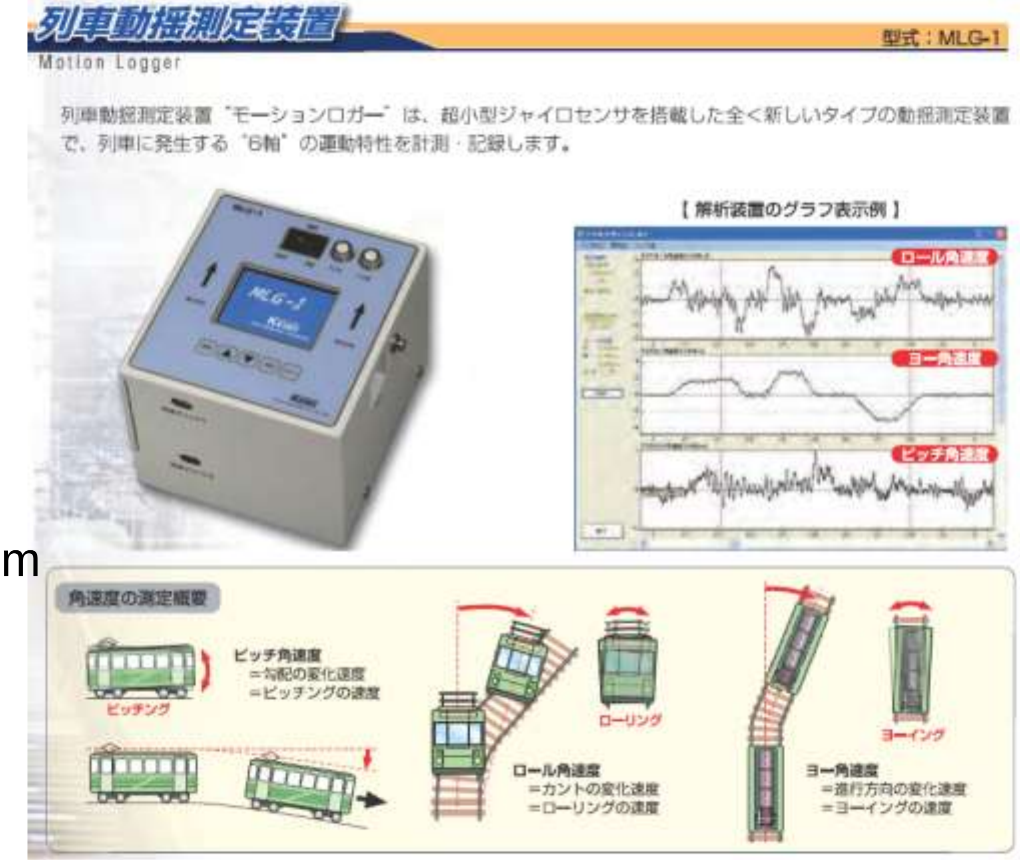
Resonating gyroscope fabricated using Si deep RIE

(J.Choi, Microsystem Tech., 2 (1996) p.186)

Commercial deep RIE system became available since 1996



74,000rpm



列車動揺測定装置

型式：MLG-1

Motion Logger

列車動揺測定装置“モーションロガー”は、超小型ジャイロセンサを搭載した全く新しいタイプの動揺測定装置で、列車に発生する“6軸”の運動特性を計測・記録します。

【解析装置のグラフ表示例】

角速度の測定概要

ピッチ角速度
=勾配の変化速度
=ピッチングの速度

ロール角速度
=カントの変化速度
=ローリングの速度

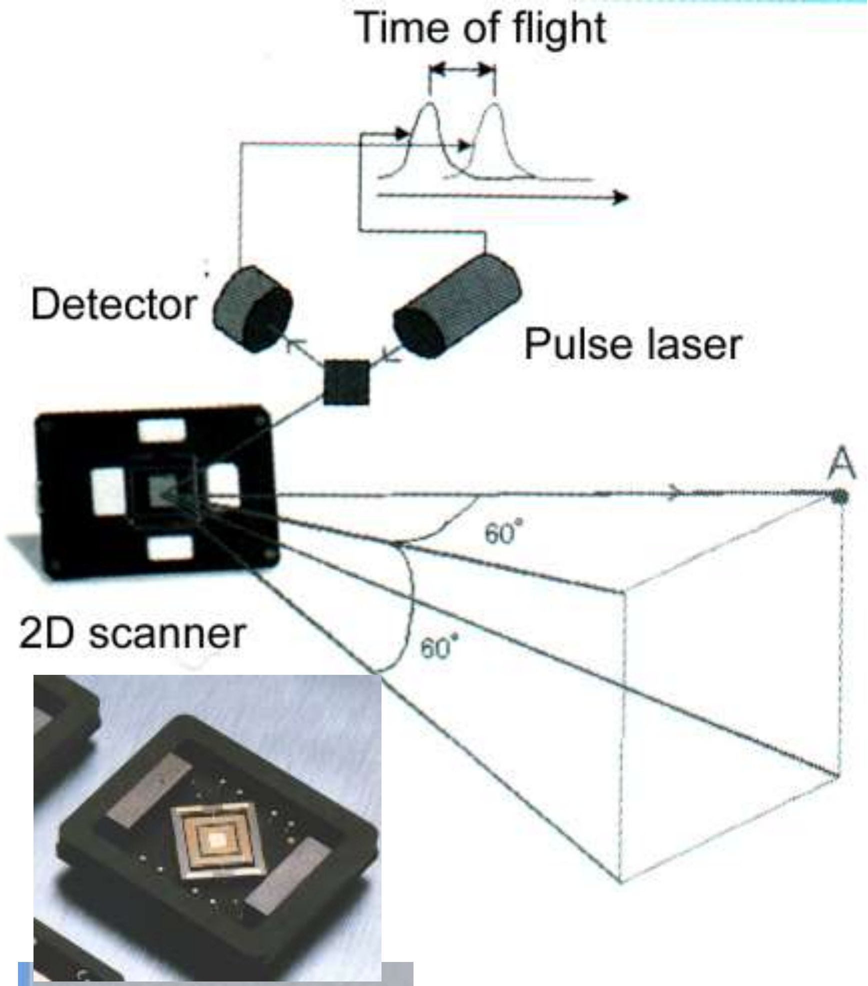
ヨー角速度
=進行方向の変化速度
=ヨーイングの速度

Application of the electrostatically levitated gyro to motion logger used for subways in Tokyo

Electrostatically levitated rotational gyroscope

(Simultaneous measurement of 2 axes rotation and 3 axes acceleration)

(T.Murakoshi et.al. : Jpn. J. Appli. Phys., 42, Part1 No.4B (2003) p.2468)



NIPPON SIGNAL

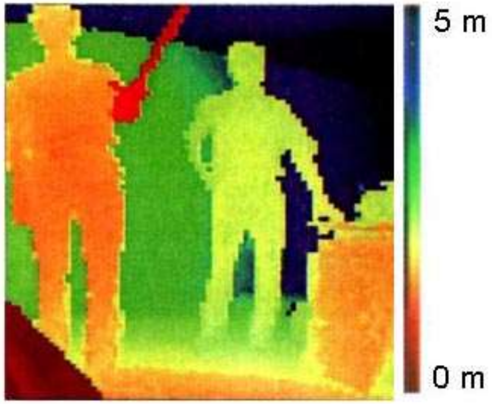
ECO SCAN

MEMS技術を利用した共振ミラー"エコスキャン"

2D Optical scanner

(N.Asada et.al., IEEE Trans. on Magnetics, 30 (1994) 4647)

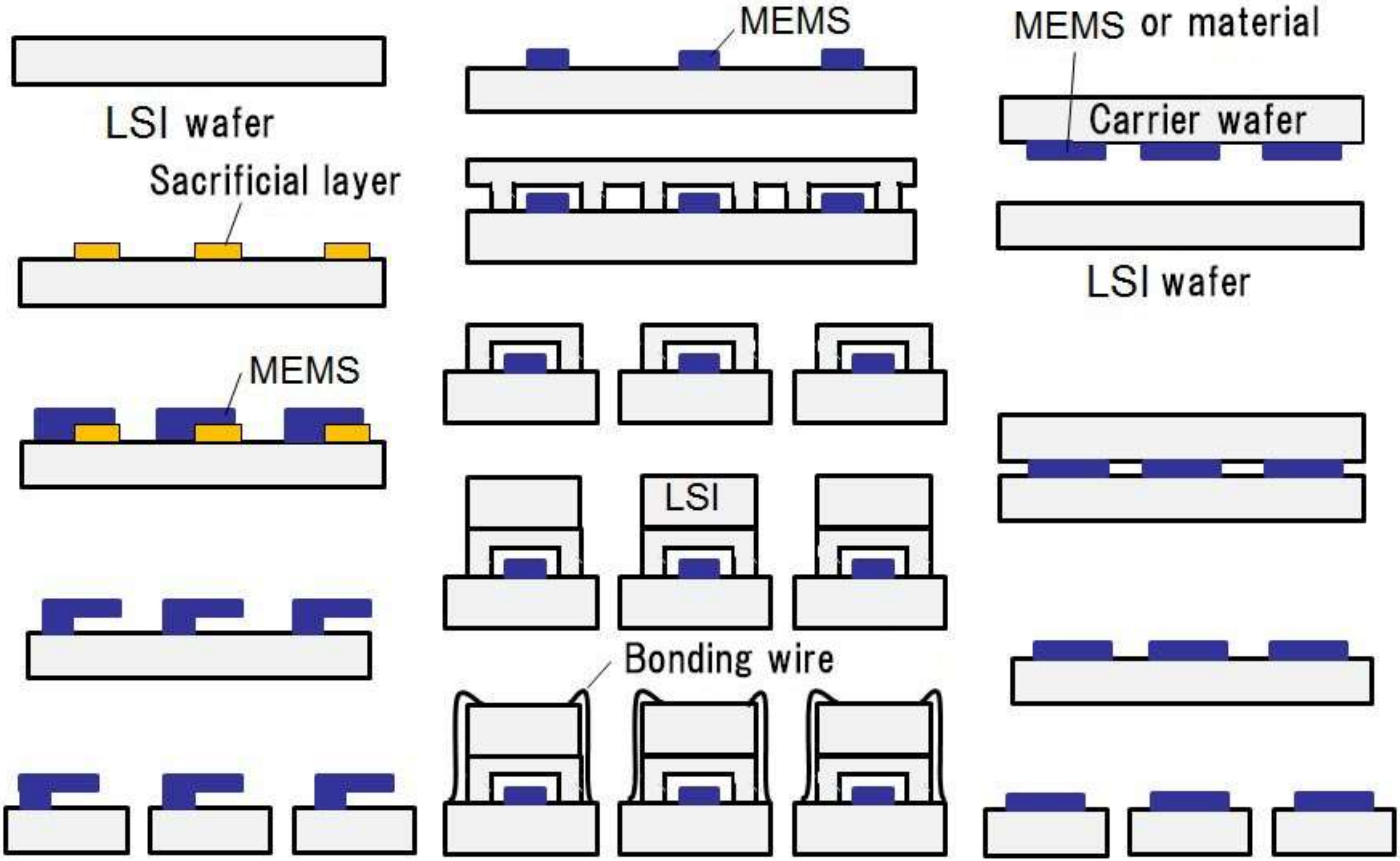
Ebisu station (platform doors using the ranging imager)



Color correspond to the distance

Ranging imager for safety systems and other applications

(T.Ishikawa,H.Inomata : Japan Signal Technical Report, 33, 1 (2009) 41)

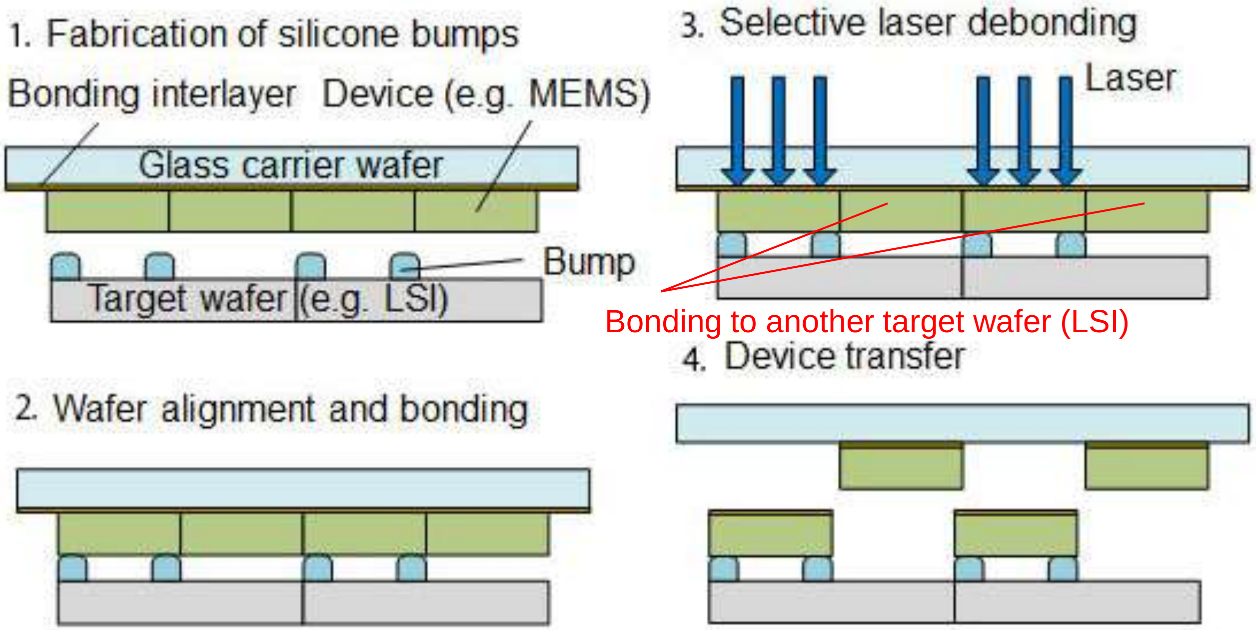


(a) Surface micromachining (Limitation of MEMS process)

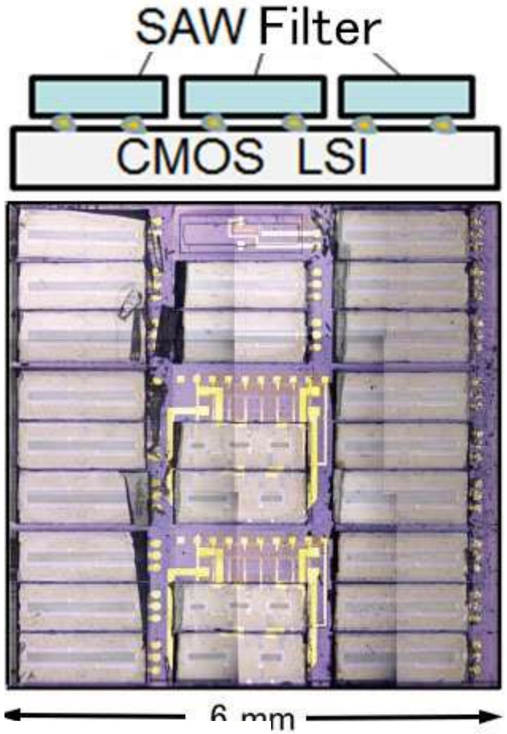
(b) Assembly of packaged MEMS and LSI (Limitation in interconnection)

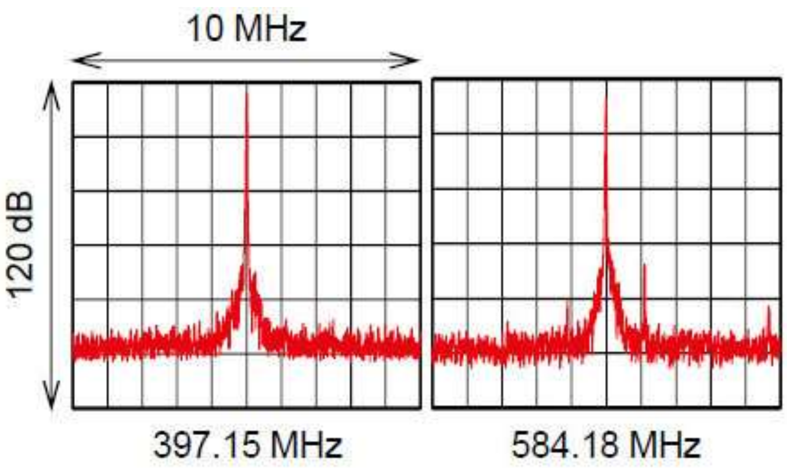
(c) Transfer of MEMS on LSI (no limitation)

Hetero integration

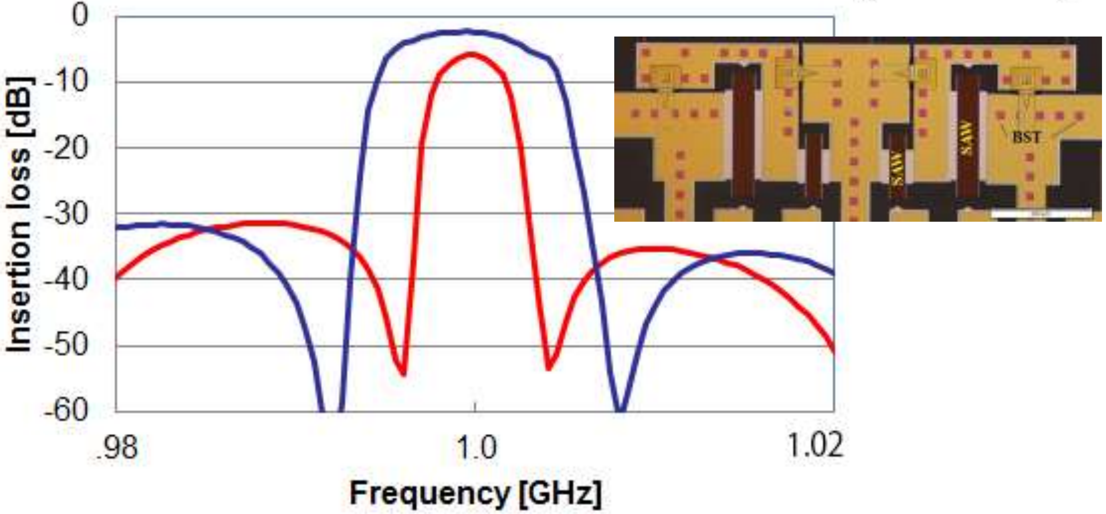


Selective transfer process by laser debonding



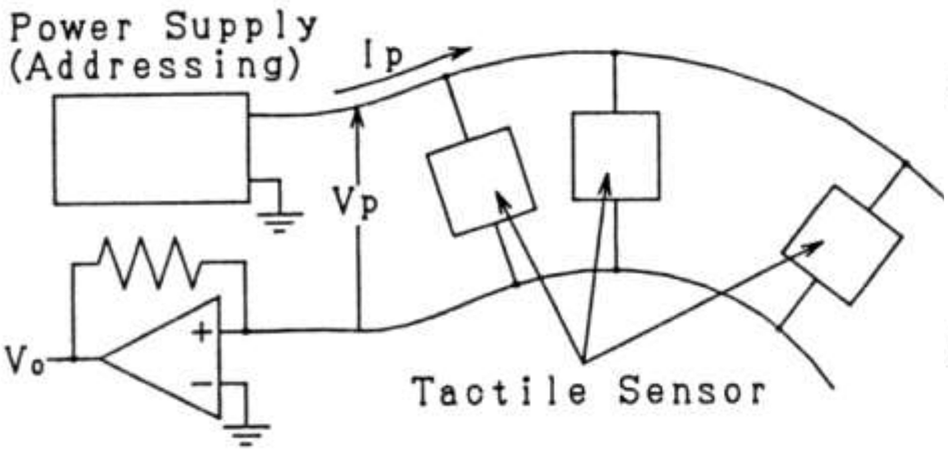


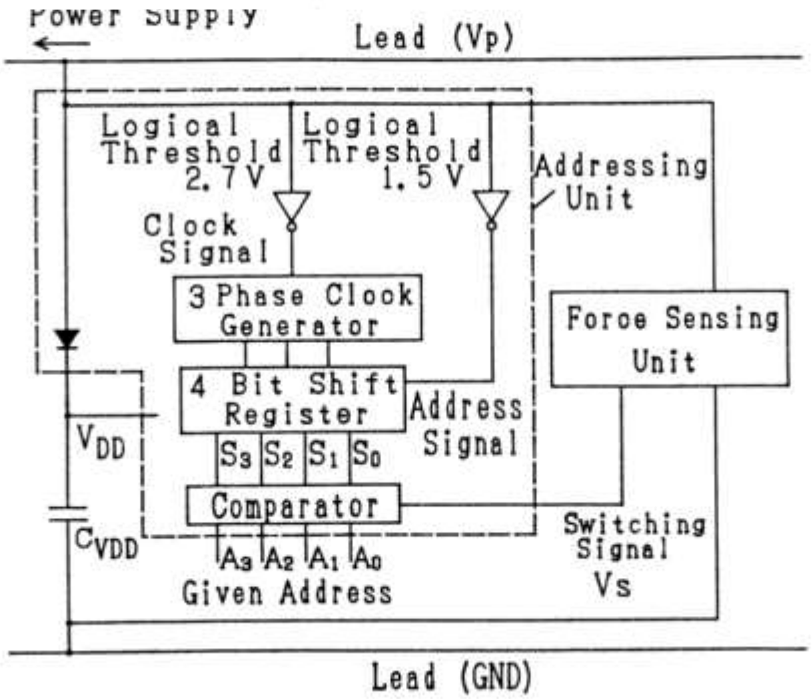
Multi SAW filters on LSI

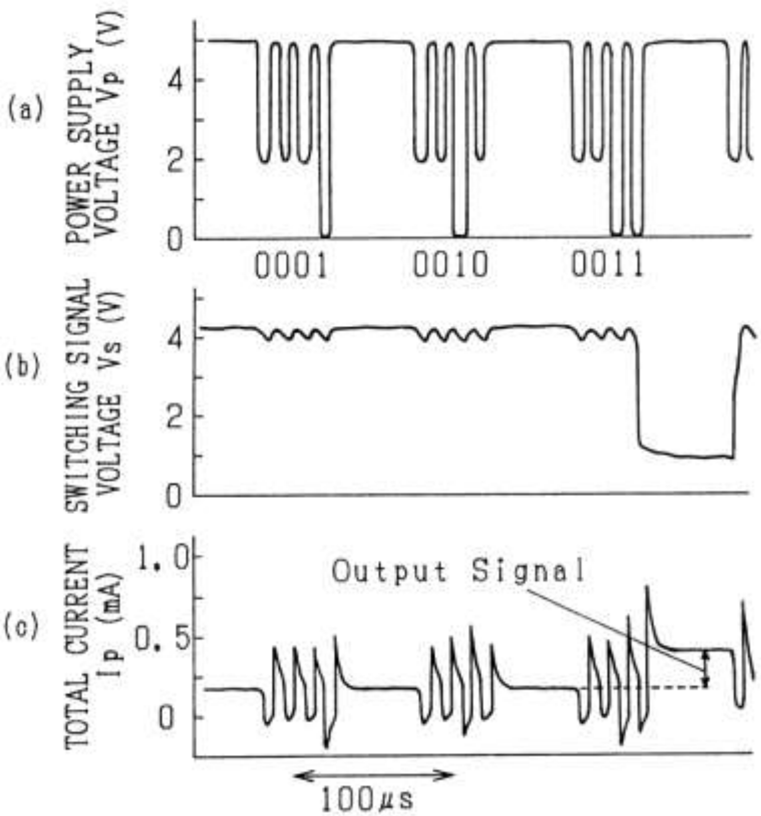


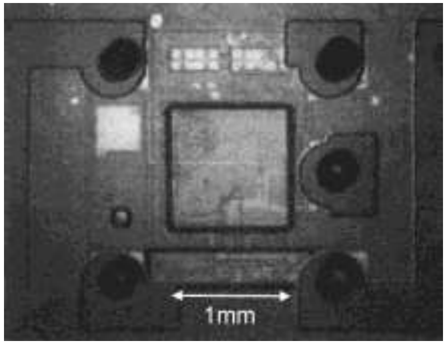
Tunable SAW filter using ferroelectric varactor

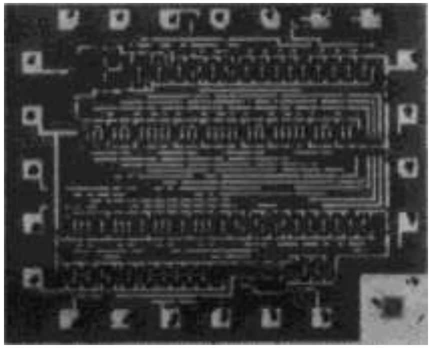
(S.Tanaka, M.Yoshida, H.Hirano , M.Esashi, 2012 IEEE Internl. Ultrasonics Symp. (2012) 1047).







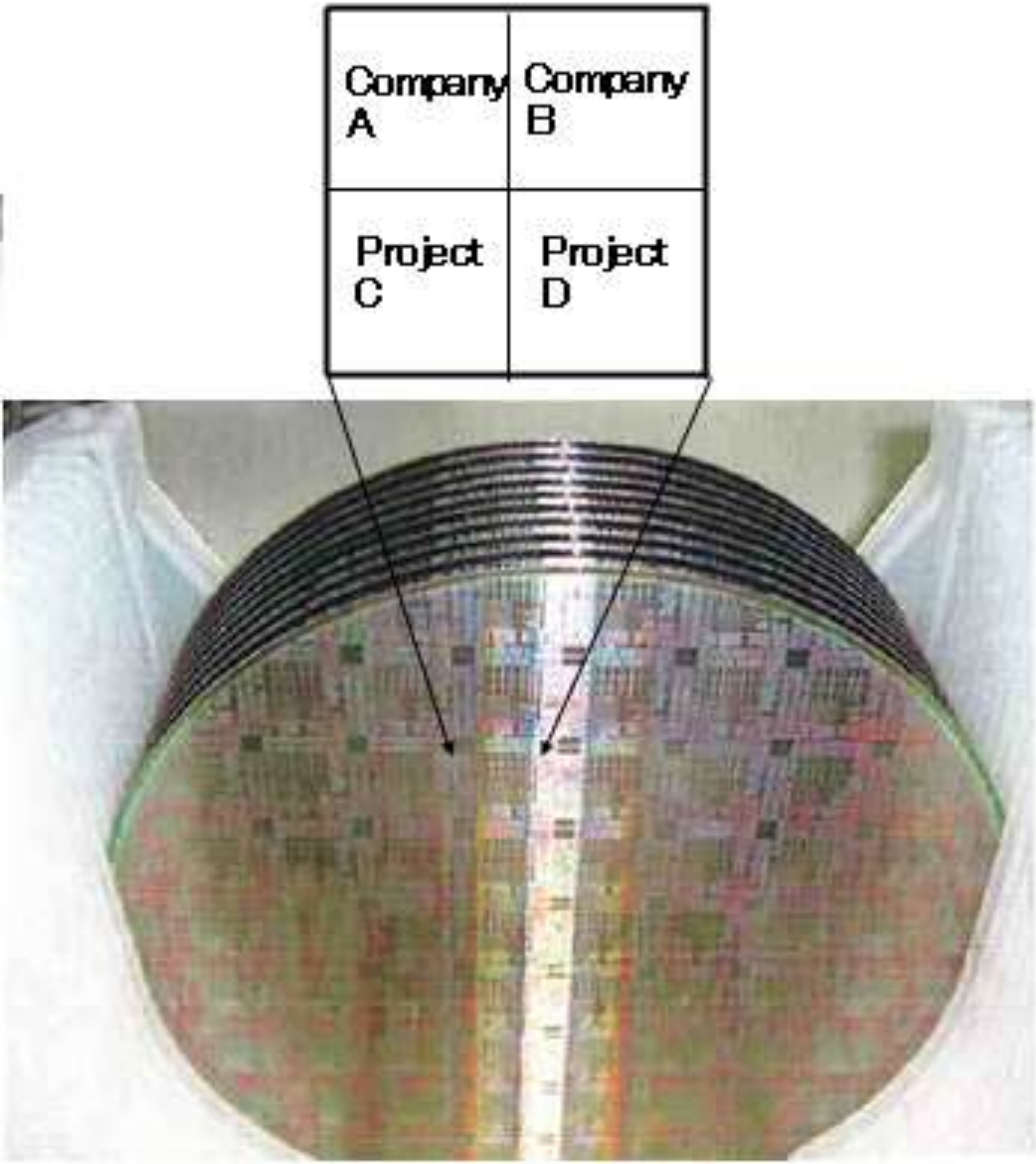




(1,000 Tr./chip in our lab., 1,000,000 Tr./chip in company, 10,000,000,000 Tr/chp now)

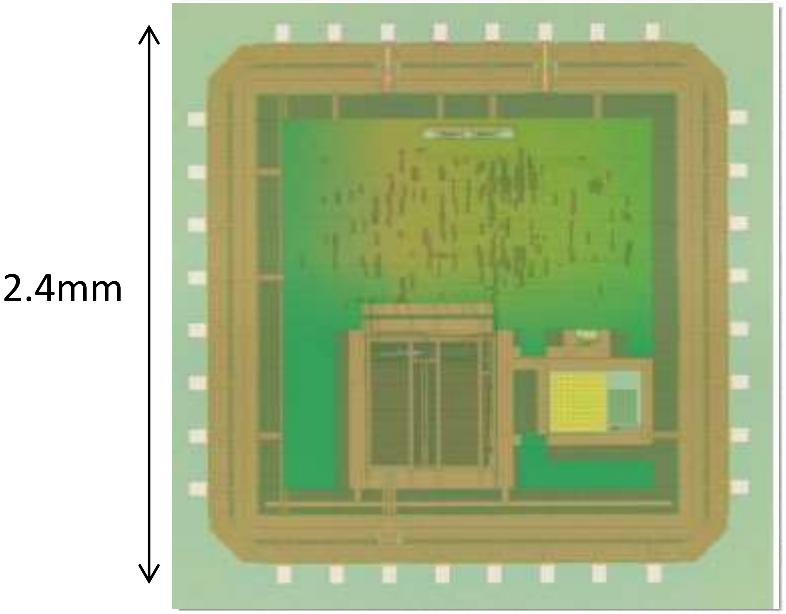
Common 2 wires tactile sensor array (polling type)

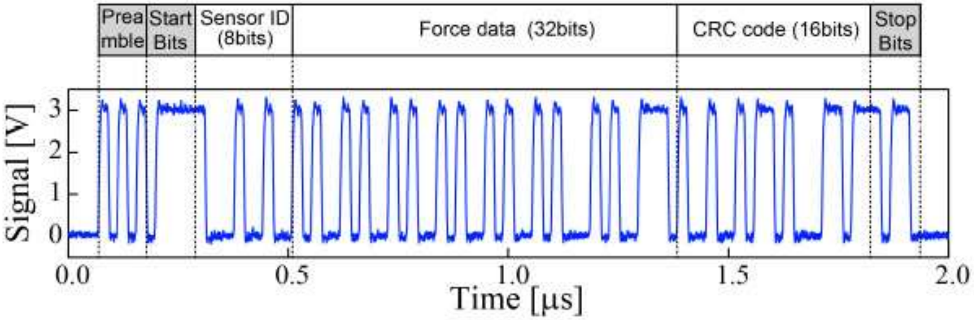
(S.Kobayashi & M.Esashi, Technical Digest of the 9th Sensor Symposium,(1990),137)

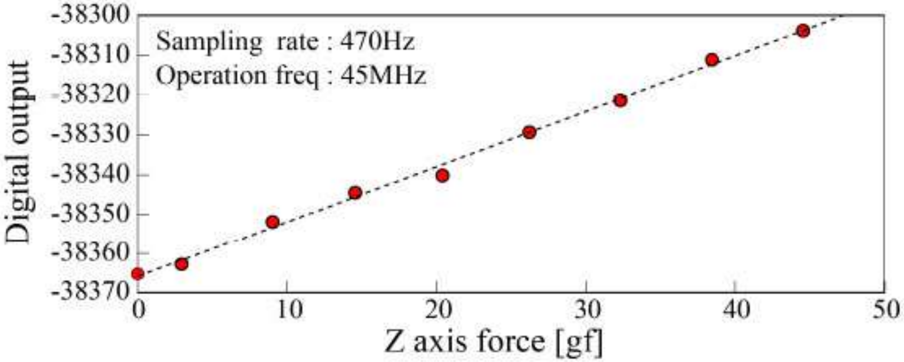


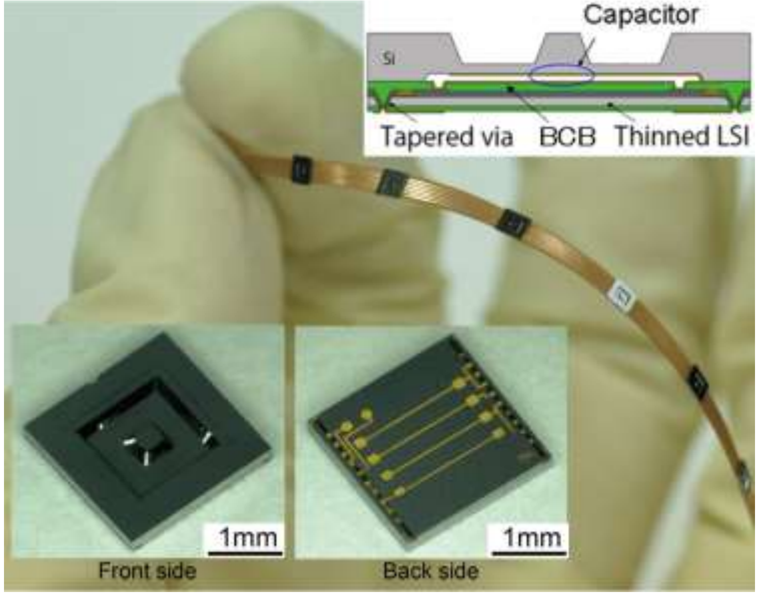
Shared CMOS LSI wafer

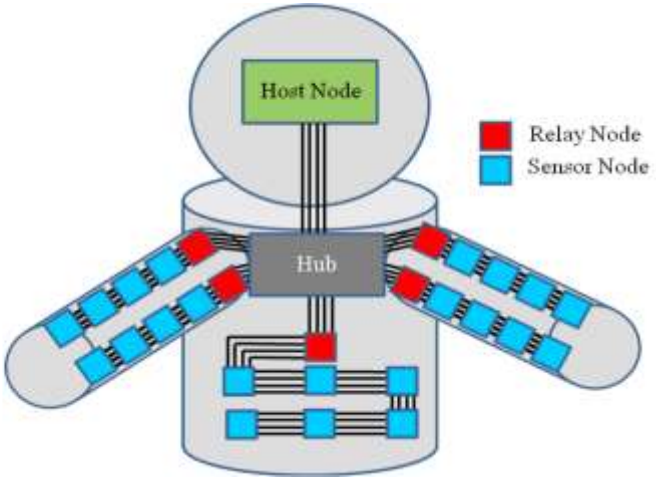
Ricoh,
Toyota motor,
Pioneer,
Nippon signal,
Toppan TDC,
Kitagawa iron works,
Sumitomo precision, NIDEC COPAL elec. Nikko,
Toyota central R&D lab,
Nippon dempa kogyo, Japan aviation elect. Ind., MEMS core,
MEMSAS,
Furukawa Electric,
Denso
Laboratories in Tohoku Univ.





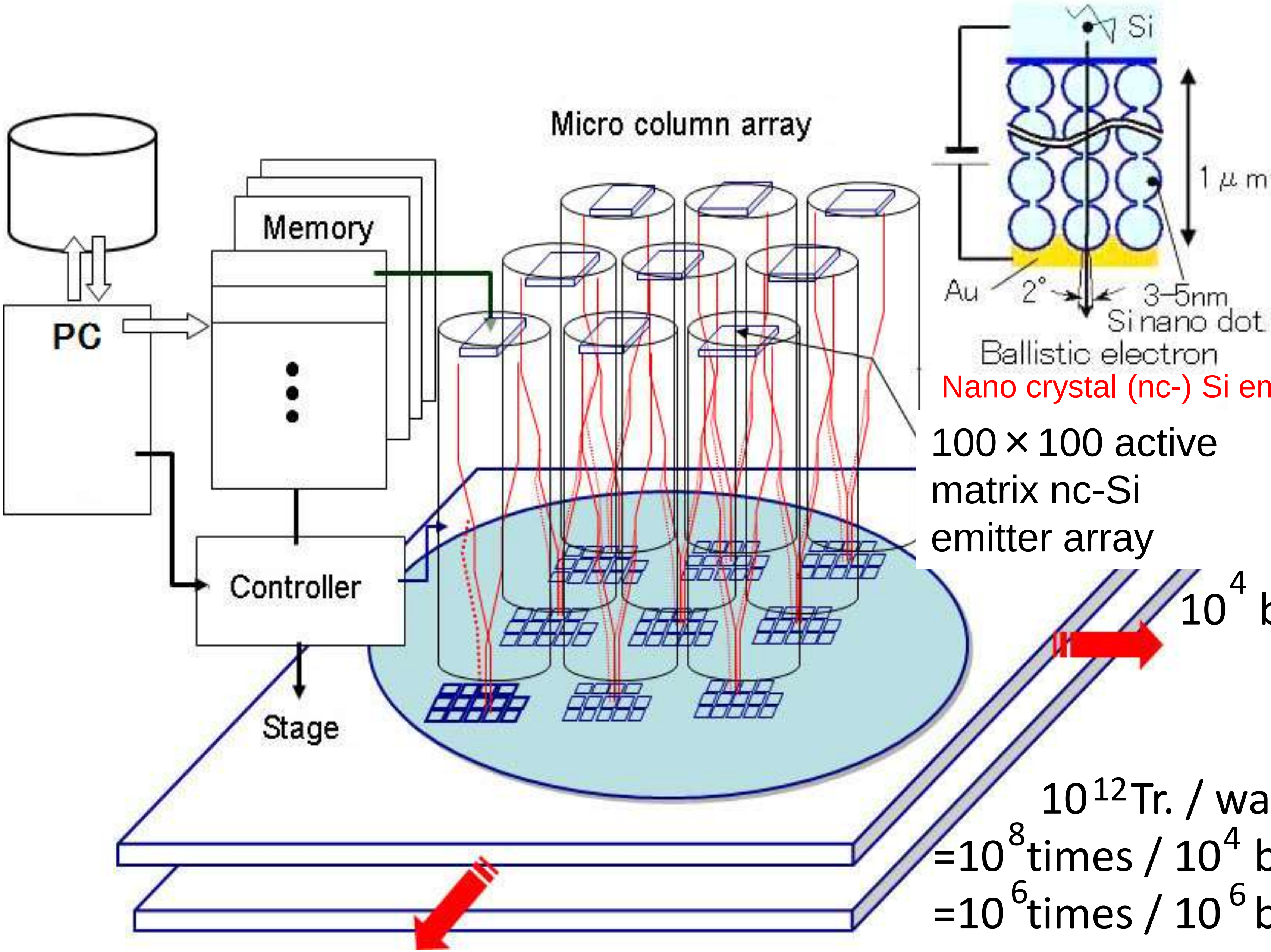






Tactile sensor network for robot (event driven type)

(M.Muroyama, M.Makihata, M.Esashi et al., Smart Systems Integration (SSI) 2014, (2014))



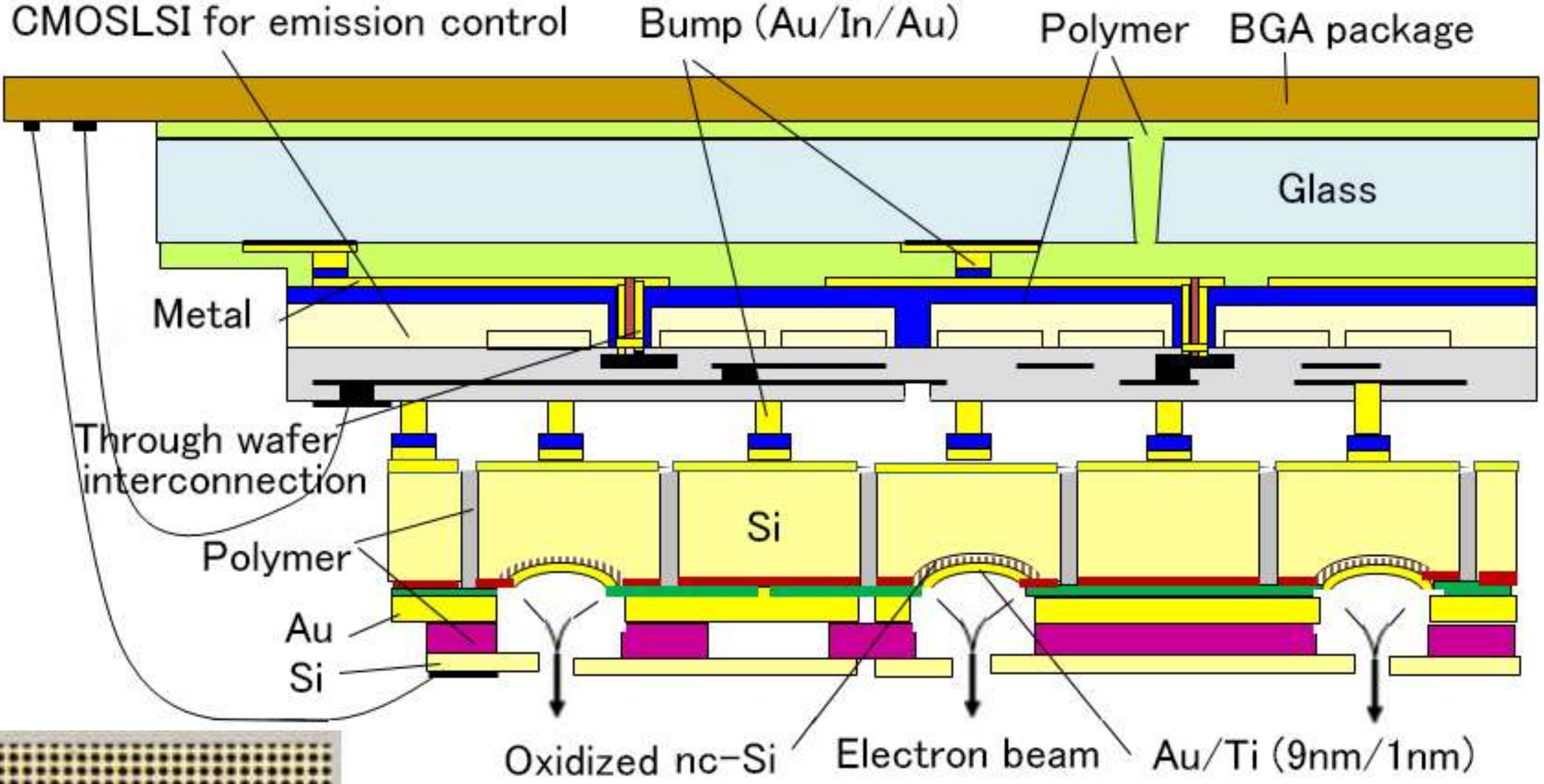
Nano crystal (nc-) Si emitter

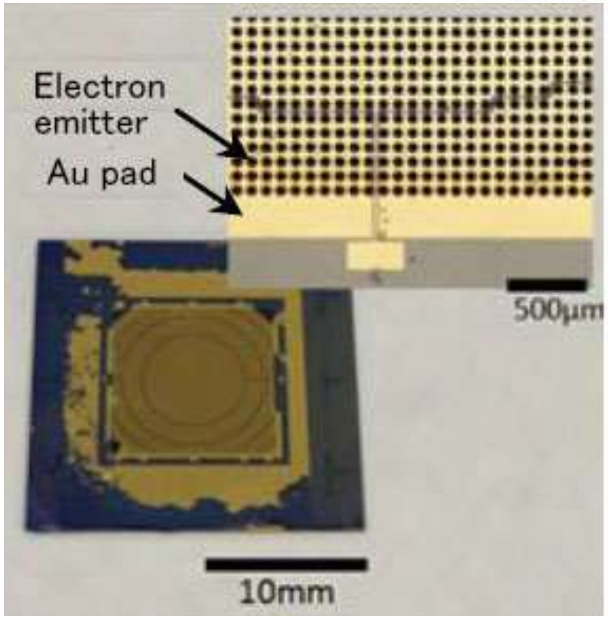
100 × 100 active matrix nc-Si emitter array

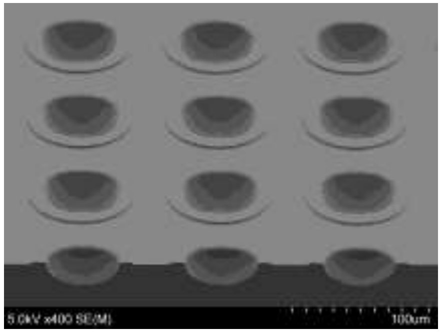
10^{4} beams

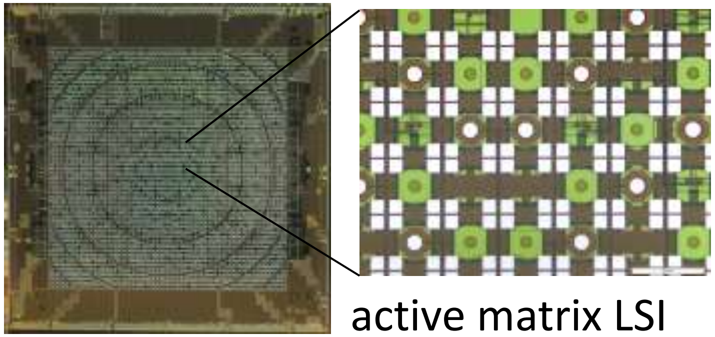
10^{12} Tr. / wafer
$=10^{8}$ times / 10^{4} beams
$=10^{6}$ times / 10^{6} beams

Concept of massive parallel electron beam exposure system using nc-Si emitter





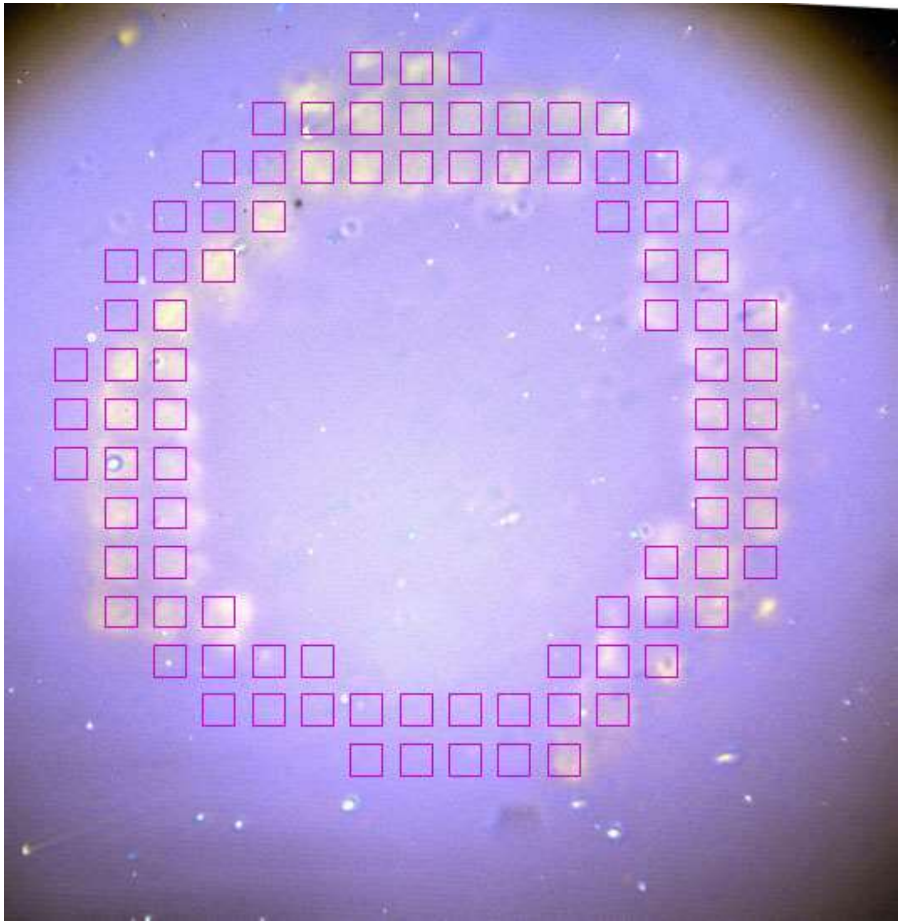



active matrix LSI

Structure of 100 × 100 active matrix nc-Si emitter

(H.Nishino, S.Yoshida, A.Kojima, N.Ikegami, N.Koshida, S.Tanaka and M.Esashi, Technical Digest IEEE MEMS 2014 (2014) 467-470)

Experimental setup for 1/100 and 1/1 exposure test.



Exposed patter on a resist using 1:1 projection system with 15×15 planer type nc-Si 40electron source (Electron source pattern is superimposed in the right photograph)

(N.Koshida et al., SPIE Advanced Lithography , San Jose, 2015/2/25)

Experiences of MEMS･IC research and construction of common facility

1. Chemical sensor & prototyping facility(graduate student) (1970-1975)
2. Biomedical micro sensors (Research Associate) (1976-Sept.1981)
3. Development of custom CMOS IC (Assoc. Professor) (Oct.1981-1990)
4. Integrated MEMS & industrialization (Professor) (1991-)

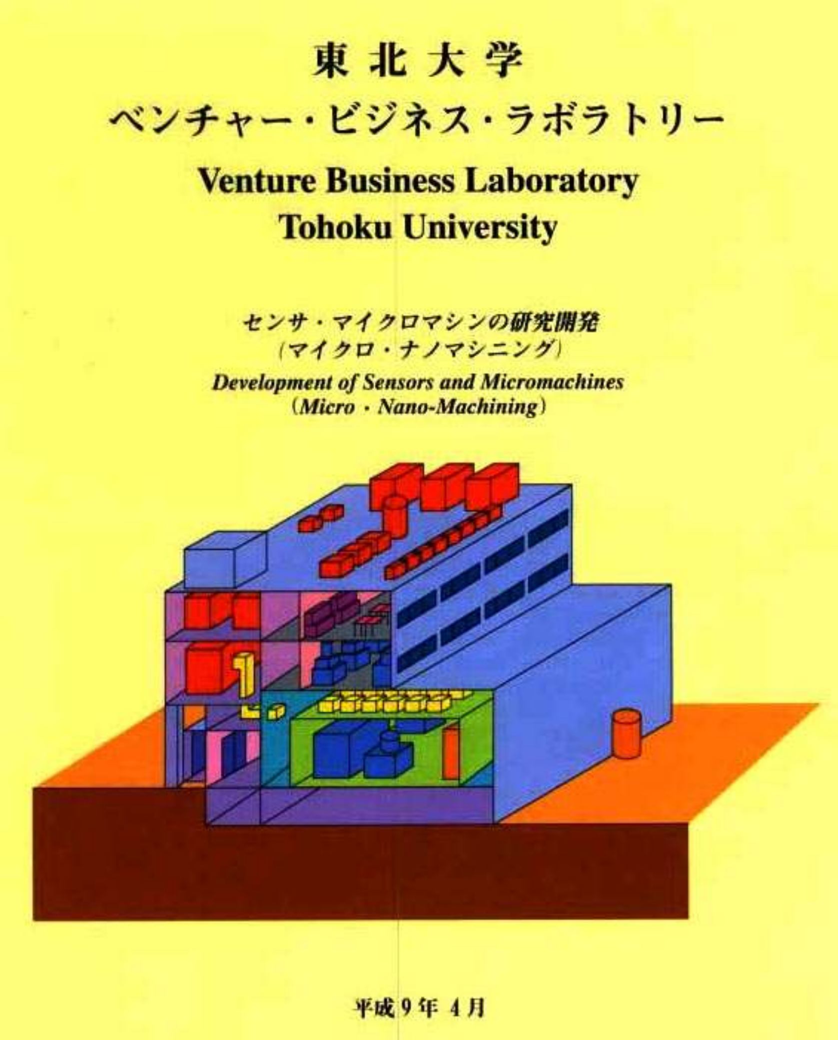
Open collaboration

5. Common facility for prototyping
6. Accumulation and utilization of knowledge
7. Supporting industry
8. Education for students who are eager to be useful

Summary

Instructions are directly written on the panel to prevent wrong usage

Shared facility (Micromachining room) in the building of Electrical group proposed by Esashi and Niitsuma (research associate) in 1980.
Auger electron spectroscopy bought by grant-in aid for scientific research and equipments for mask making, assembly etc. were commonly used.
Accumulation of knowhow for the common use



東北大学
ベンチャー・ビジネス・ラボラトリー
Venture Business Laboratory
Tohoku University

センサ・マイクロマシンの研究開発
（マイクロ・ナノマシニング）
Development of Sensors and Micromachines
（Micro・Nano-Machining）

平成9年4月

Micro / Nanomachining Research & Education Center (MNC) (2007-)
(Director Prof.S.Tanaka)

Venture Business Laboratory (VBL)(1997-2006)

Clean room for 2 inch process ($600m^2$)

ベンチャーラボ利用の皆様へ

Message to VBL users

Director M.Esashi1998.2.6

ベンチャーラボを利用して頂いている皆様へ、私がどのような考えで運営していきたいかということをご理解いただき是非協力をお願いしたい・・・・・

内部的な調整にエネルギを費やし自己満足しているような状態でなく、効率を上げて外部に役立つ研究成果を生み出していける・・・

第一は、ユーザの立場になって利用法を決めるということです。多くの場合に管理の都合からルールを決めるために無駄が多くなっています。例えば講習会を受けた利用者しか使えないとか、何週間か前に申し込むことなどということです。実際の研究では先の見通しなどは立たないもので、急に使う必要が生じるものです。装置を使っている時に一緒について使い方を習ってもらうことにしました。教える人はできるだけ詳細にまで教えてほしい。面倒なので代わりにやってあげるということになりがちですが、メンテナンスなども含めてついていてもらい、その人に手伝ってもらうつもりでやって下さい。

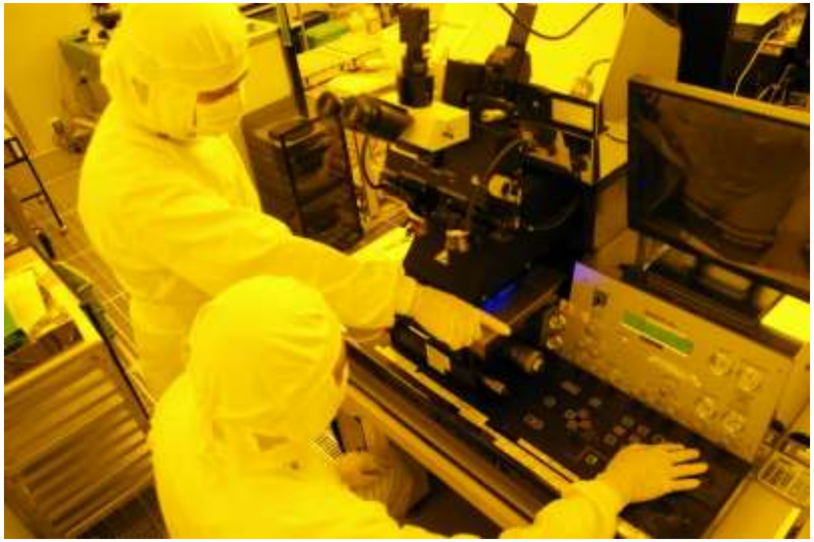
装置の維持は最も使う人(研究室)にやって頂きます。受益者負担の考え方に立ち、できるだけ負荷を分散し、皆様が自分の研究をできるようにと考えています。

第二は、いかにすれば自主性を保ち・・・

第三は、透明で開放的にし、情報へ効率よくアクセス・・・

User should learn not only the operation but also maintenance from the person who is using the equipment.

The management and maintenance of equipment should be done by the person (laboratory) who uses it most frequently (not by the owner laboratory) etc.

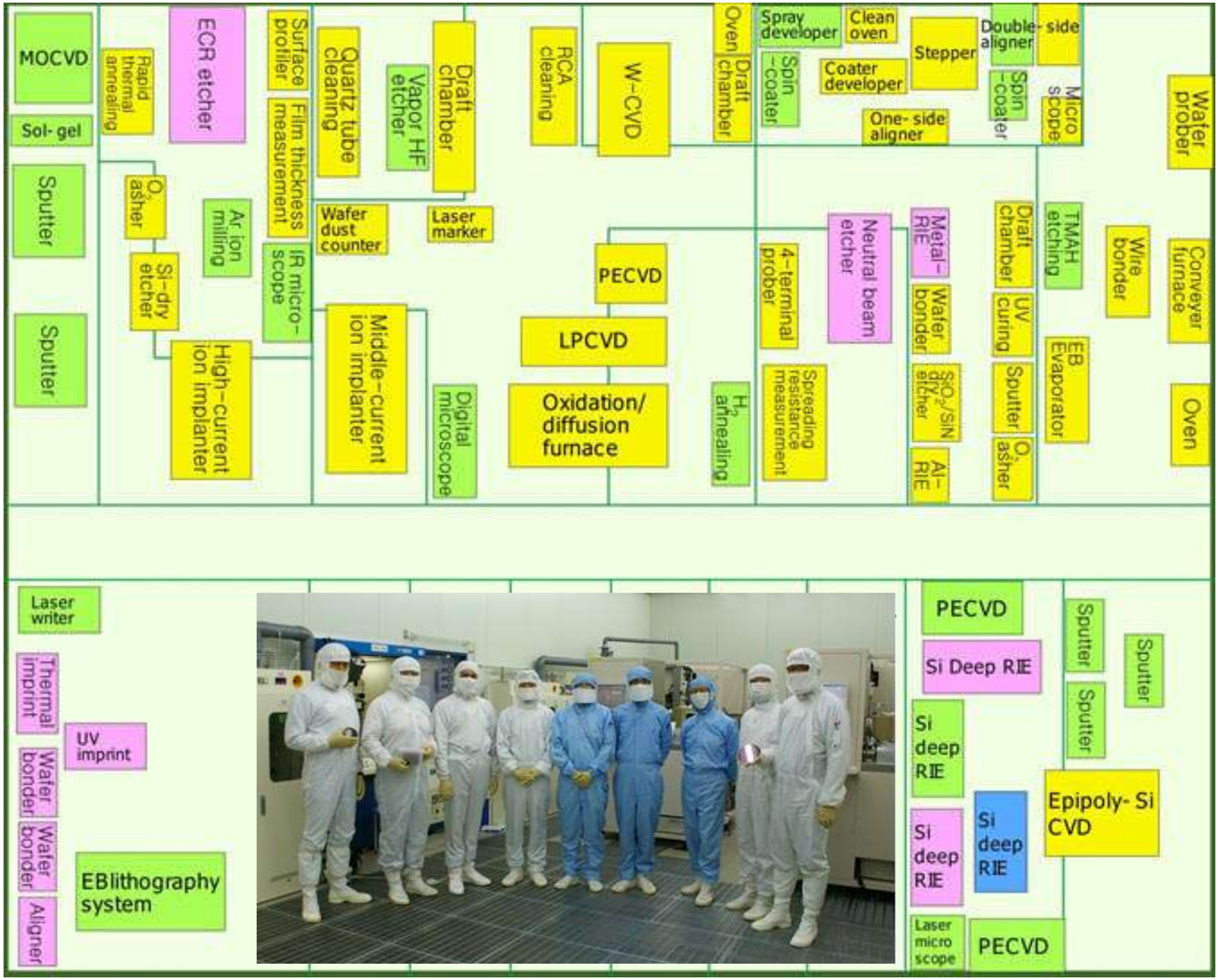


Companies which can not prepare their own facility dispatch their employees to operate equipments by themselves for development and small volume production.

Shared facility for industry to prototype MEMS devices (4 / 6 inch)

Hands-on-access fab. (Nishizawa memorial research center in Tohoku Univ.)

Contact person : Assoc. Prof. Kentaro Totsu totsu@mems.mech.tohoku.ac.jp



4 inch fab for power transistor production until 2008

- 🟨 Succeeded by Univ. in 2008
- 🟩 Newly installed since 2010
- 🟪 Donated by industry
- 🟦 Transferred from other lab

Equipments on other floors

1F-CR

- W-thermal SEM
- X-ray CT
- FE-SEM
- EB lithography system
- TOF-SIMS

3F-CR

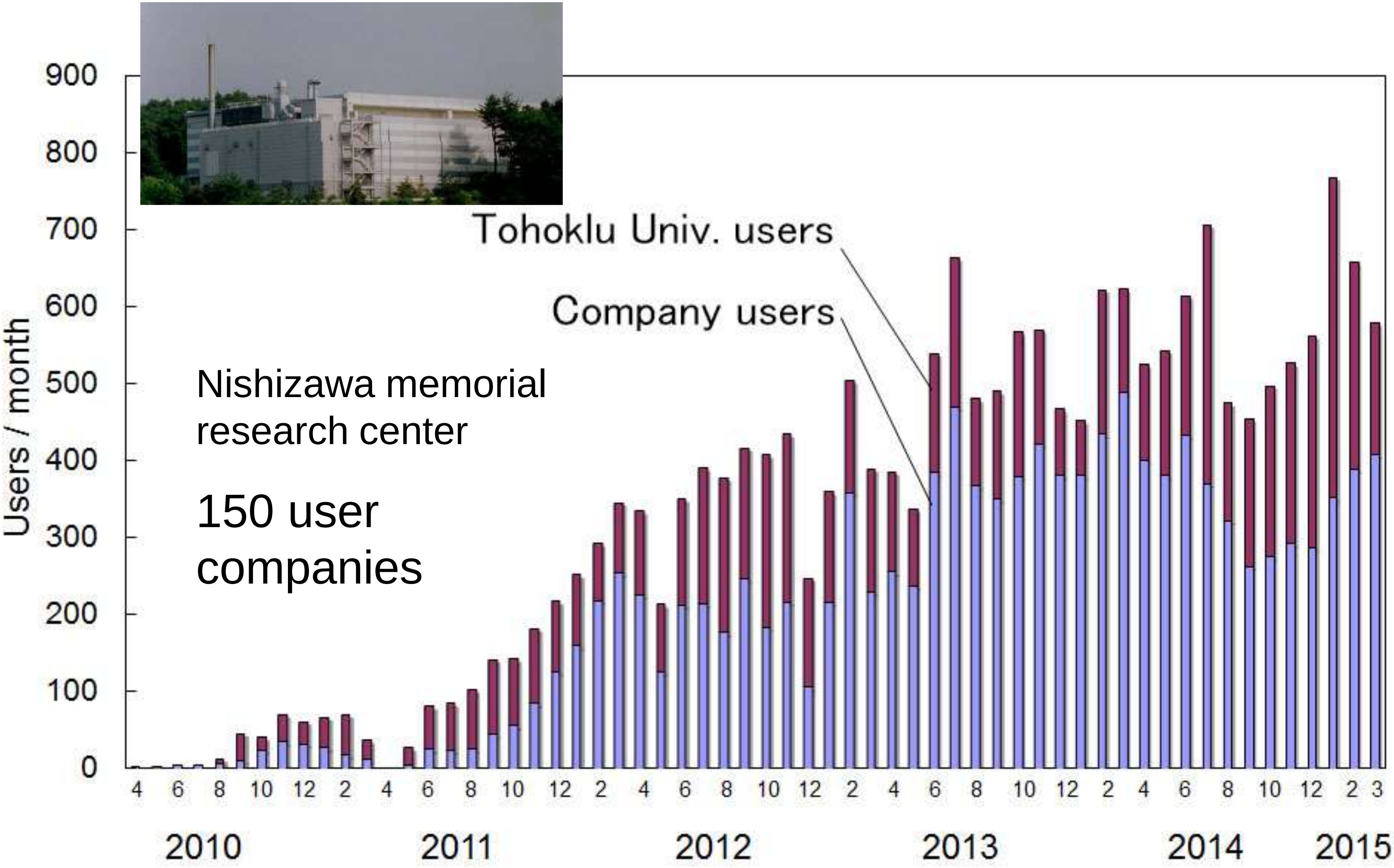
- Electroplating
- Q-mass
- CO2 critical point dryer
- Ultrasonic microscope
- KOH etching
- Wet station
- Pattern generator
- Sputter
- Ozone ashing
- Dicer

No.2 build. 1F

- Sand bluster

Layout of the Hands-on access fab. for 4/6 inch wafer

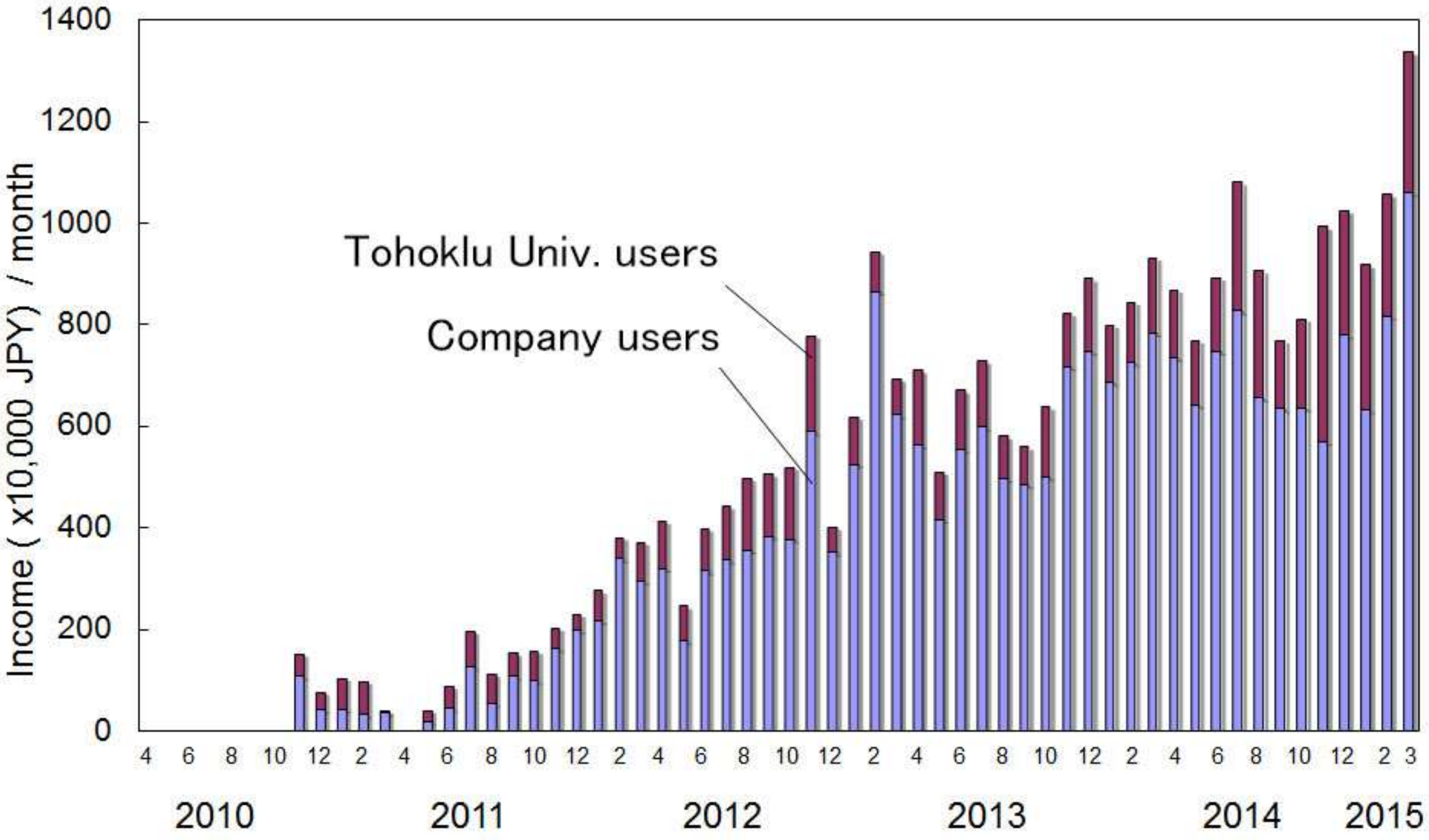
Companies are allowed to sell MEMS devices produced in the “Hands-on-access fab.” (2013/7 ~)



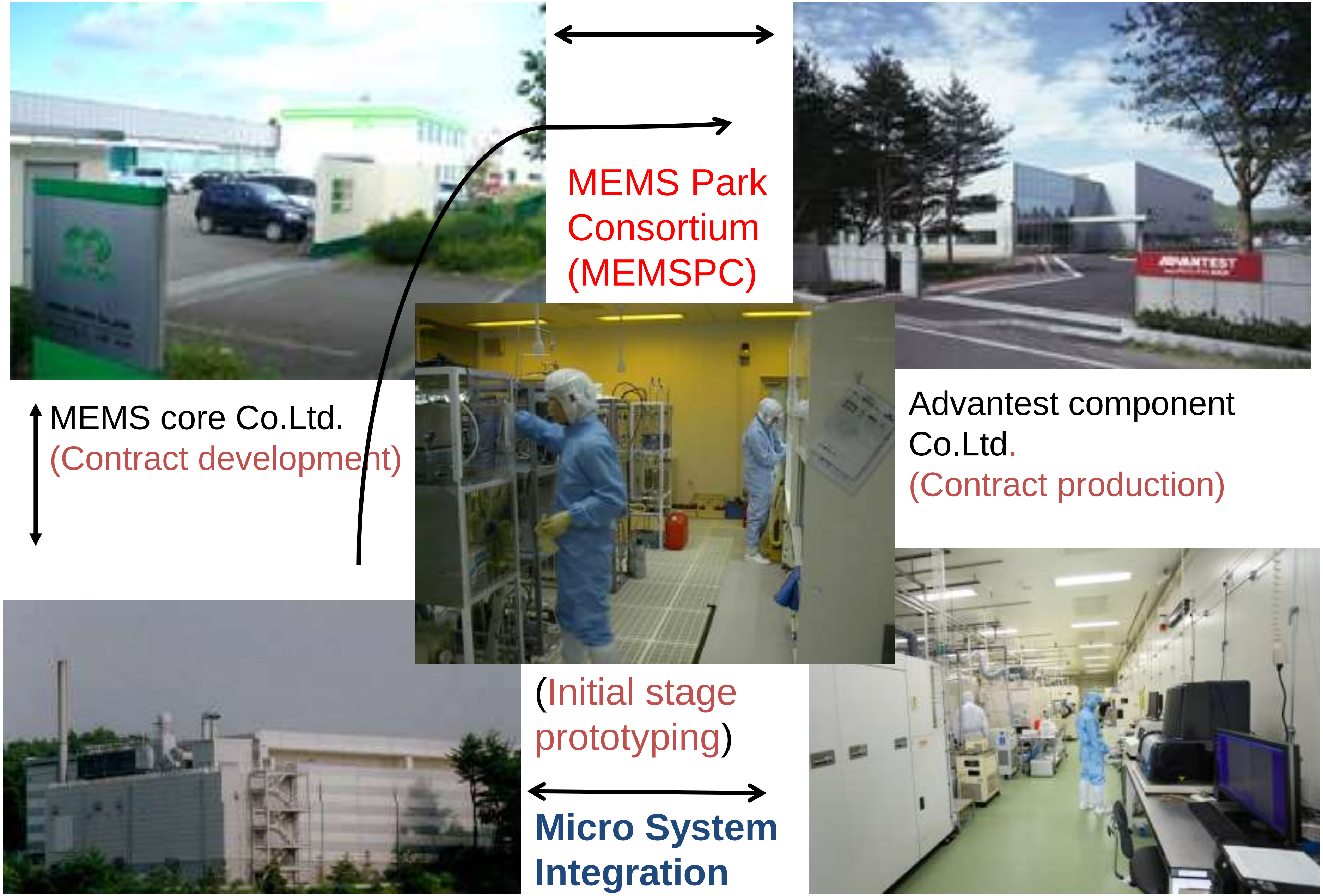
Nishizawa memorial research center

150 user companies

Users of the Hands-on-access fab.



Income of the Hands-on-access fab.



MEMS Park Consortium (MEMSPC)

MEMS core Co.Ltd.
(Contract development)

Advantest component Co.Ltd.
(Contract production)

(Initial stage prototyping)

Micro System Integration Center (μSIC), Tohoku Univ.

Nishizawa center, (Tohoku Univ.)
(Hands-on access fab.)

AIST (Tsukuba)
(Production stage prototyping)

Experiences of MEMS･IC research and construction of common facility

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2. Biomedical micro sensors (Research Associate) (1976-Sept.1981)
3. Development of custom CMOS IC (Assoc. Professor) (Oct.1981-1990)
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Summary

FhG Germany – Sendai city partnership signing ceremony in Munich (July15,2005)

FhG Germany – WPI-AIMR Tohoku Univ. partnership signing ceremony in Sendai (Nov. 8, 2011)

1st Fraunhofer Symposium in Sendai “Doing Worldwide Business via MEMS technology” (Oct.19, 2005)

10st Fraunhofer Symposium in Sendai (Nov.26, 2014)

FhG Project center in WPI-AIMR, Tohoku Univ. (April 1, 2012)

Collaboration with FhG (Fraunhofer Institute) in Germany

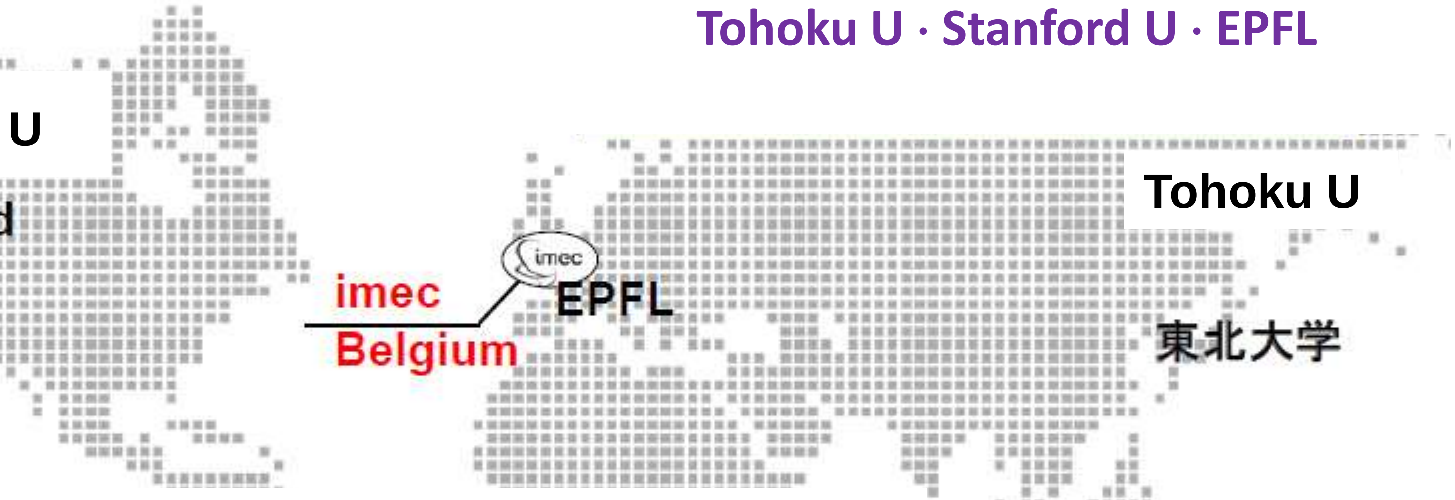
2012/6/21 Seminar at IMEC

2013/11/8 Seminar in Sendai

2014/11/12 Seminar at IMEC

Strategic Partner

Tohoku U · Stanford U · EPFL

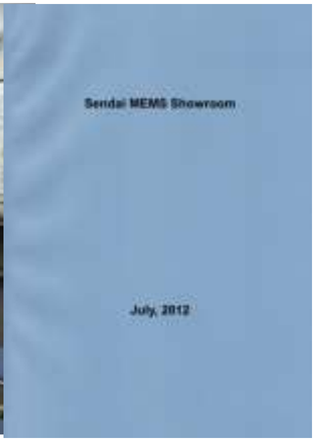


Signing ceremony (2012/6/11)

Hiroshi Kazui (Tohoku Univ.)
and Luc Van Den Hove (IMEC)

“your lab and imec are very complimentary”
Rudy Lauwereins, Vice-President of IMEC

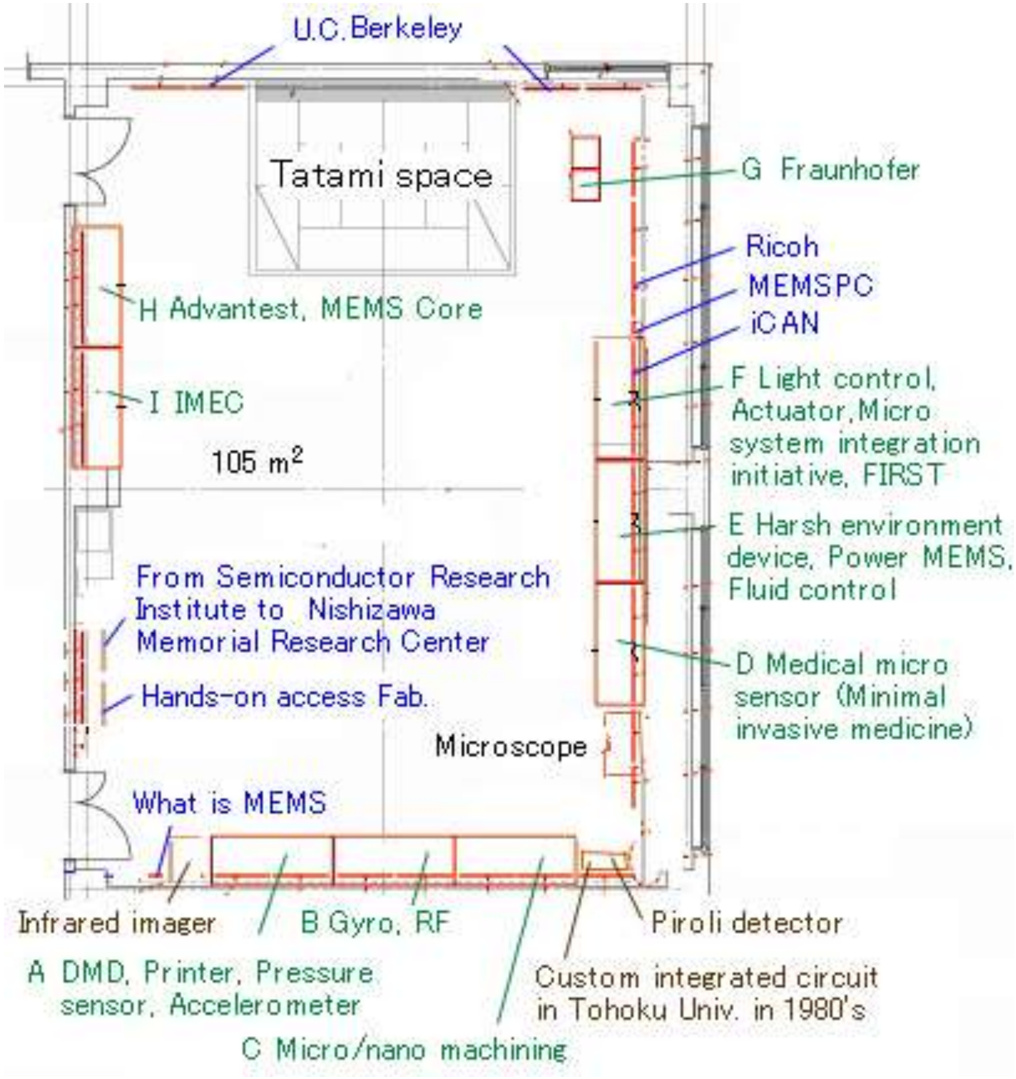
(IMEC M.Yoneyama
2012/6/12)



Sendai MEMS Showroom

July, 2012

Catalog



Efficient way to access accumulated knowledge is important for heterogeneous integration

Sendai MEMS showroom (2012/5/16 renewal opening)

http://www.mu-sic.tohoku.ac.jp/showroom/index.html (Japanese)

http://www.mu-sic.tohoku.ac.jp/showroom_e/index.html (English)

Efficient development for heterogeneous integration

Information from universities

（MEMS park consortium http://www.memspc.jp）

Free MEMS Seminar in Tokyo (Aug. 23-25, 2006) 280 attendees

Free MEMS Seminar in Sendai (Aug. 22-24, 2007) 75 attendees

Free MEMS Seminar in Fukuoka (Aug.20-22, 2008) 150 attendees

Free MEMS Seminar in Nagoya (Aug.4-6, 2009) 100 attendees

Free MEMS Seminar in Tsukuba (Aug.5-7, 2010) 211 attendees

Free MEMS Seminar in Kyoto (Aug.9-11, 2011) 175 attendees

Free MEMS Seminar in Tokyo (Aug.22-24, 2012) 226 attendees

Free MEMS Seminar in Tsukuba Univ.(Aug.7-9,2 013) 110 attendees

Free MEMS Seminar in Osaka (Aug.5-7, 2014) 140 attendees

Free MEMS Seminar in Toyohashi U.T. (Aug.5-7, 2015)

High-tech. small volume production

Efficient utilization of facilities

MEMS seminar

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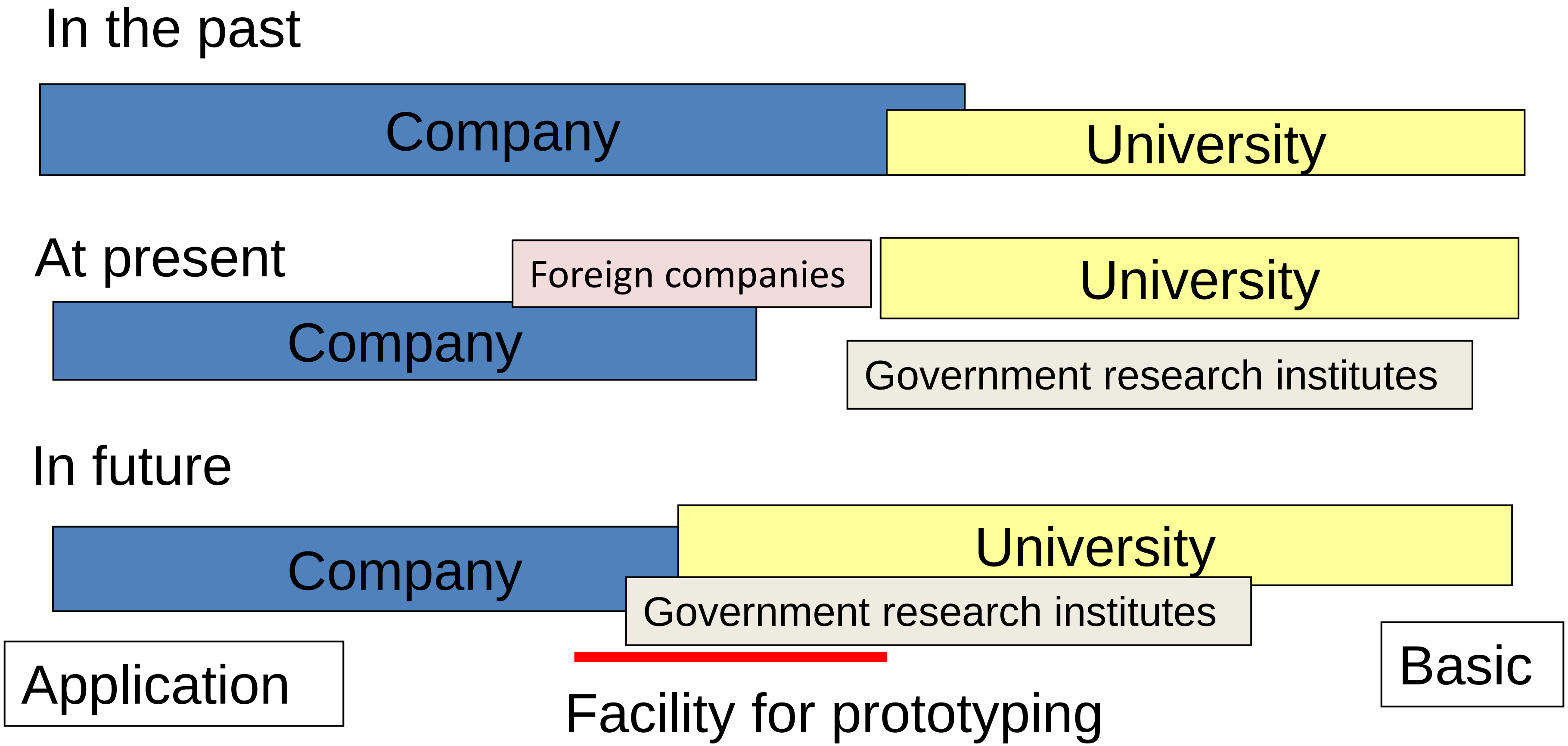


Rohm ← Kionics (USA) [Accelerometer]

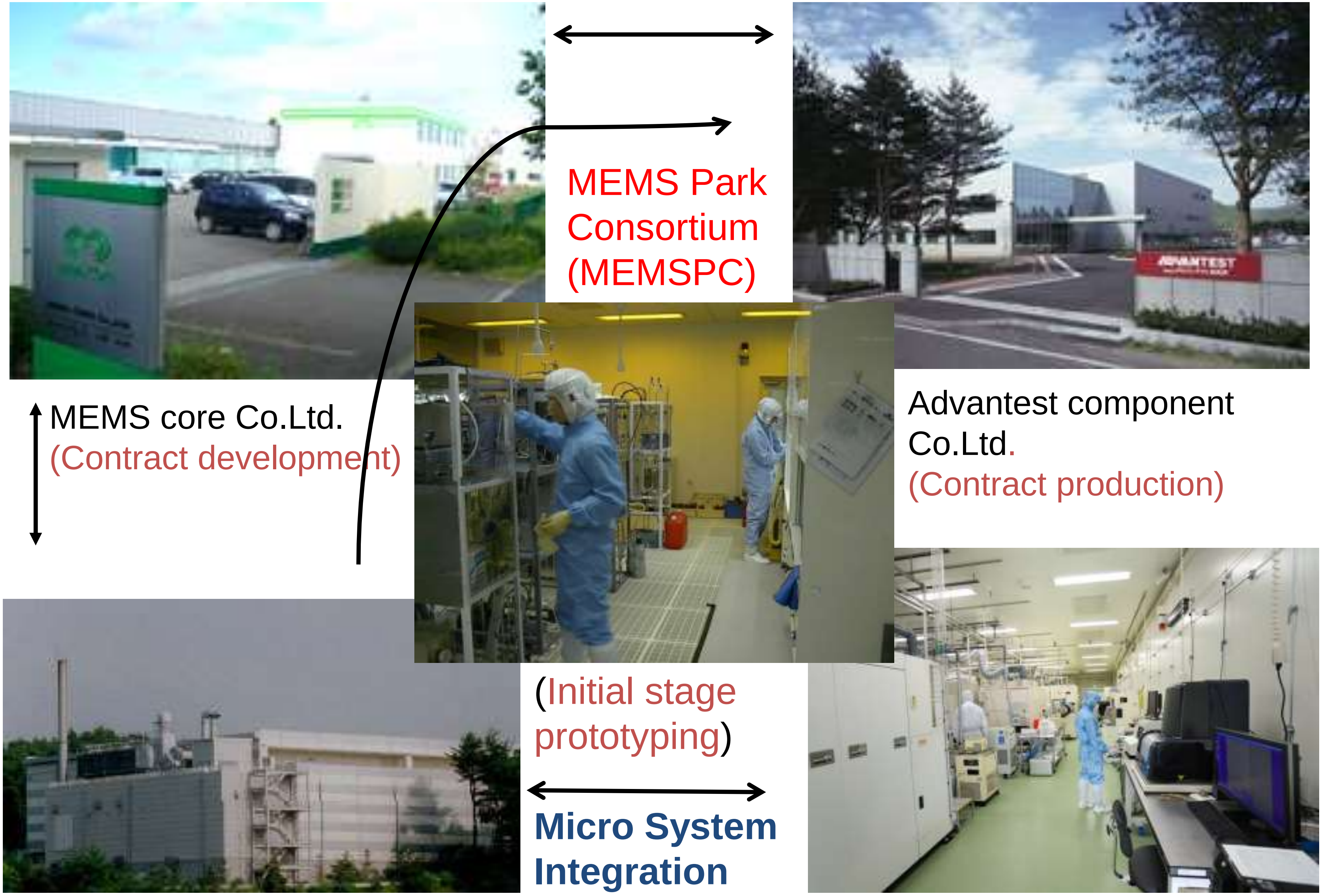
Murata manufacturing ← VTI (Finland) [Accelerometer]

TDK ← EPCOS (Germany) [RF components]

Megachips ← SiTime (USA) [MEMS oscillator]

Alps ← Qualtre (USA) [Bulk acoustic gyro]

Sharp ← Pixtronix (Qualcomm) (USA) [Display]



MEMS Park Consortium (MEMSPC)

MEMS core Co.Ltd.
(Contract development)

Advantest component Co.Ltd.
(Contract production)

(Initial stage prototyping)

Micro System Integration Center (μSIC), Tohoku Univ.

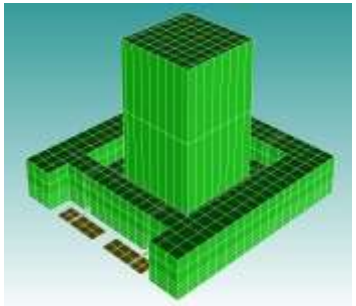
Nishizawa center, (Tohoku Univ.)
(Hands-on access fab.)

AIST (Tsukuba)
(Production stage prototyping)

3 months

10 ~ 20 d — Planning, design → *30 ~ 60 d* — Fabrication (4 inch process) → *~ 10 d* — Testing → *3 d* — Presentation, report

Lectures on Internet School of Tohoku University



Design

Training of Fabrication

Ex. Capacitive 3-axis accelerometer

MEMS Training Program in Sendai MEMS park consortium

Since Apr.2007. Fee 1 million yen. Trainee participate with own subject.

15 companies participated.

ADVANTEST

ADVANTEST CORPORATION

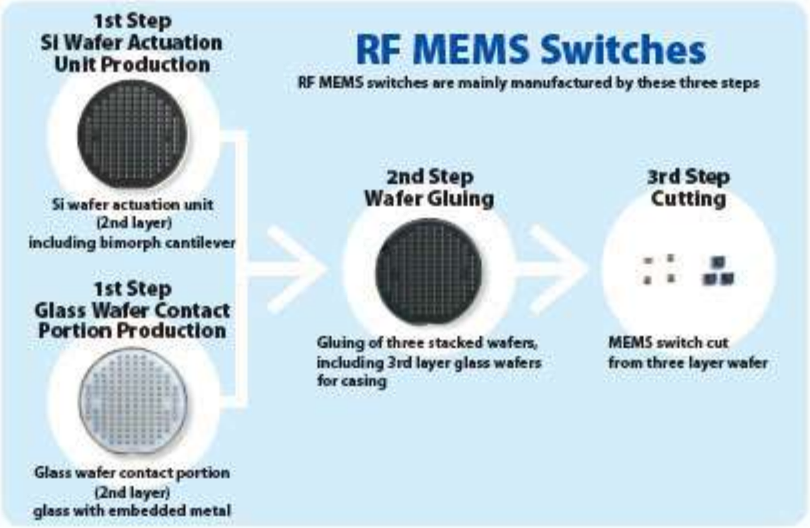
High-Frequency, Low Power Consumption MEMS Relay

Advantest's high-frequency MEMS relay utilizes piezoelectric actuation to achieve low power consumption and high reliability. Via Advantest's proprietary deposition technology, the relay features a piezoelectric film only 1 micron thick, making low actuation voltage possible. The relay also has high reliability, using contact-point control technology honed in Advantest's semiconductor testing equipment, and it can handle up to 20 GHz high-frequency transmission, using Advantest's high-frequency measurement technology.

MEMS Relay Applications

Semiconductor Testing Equipment, High-Speed Communications Devices, High-Frequency Measurement Equipment

MEMS Relay Production Process



RF MEMS Switches

RF MEMS switches are mainly manufactured by these three steps

1st Step
Si Wafer Actuation Unit Production

Si wafer actuation unit
(2nd layer)
including bimorph cantilever

1st Step
Glass Wafer Contact Portion Production

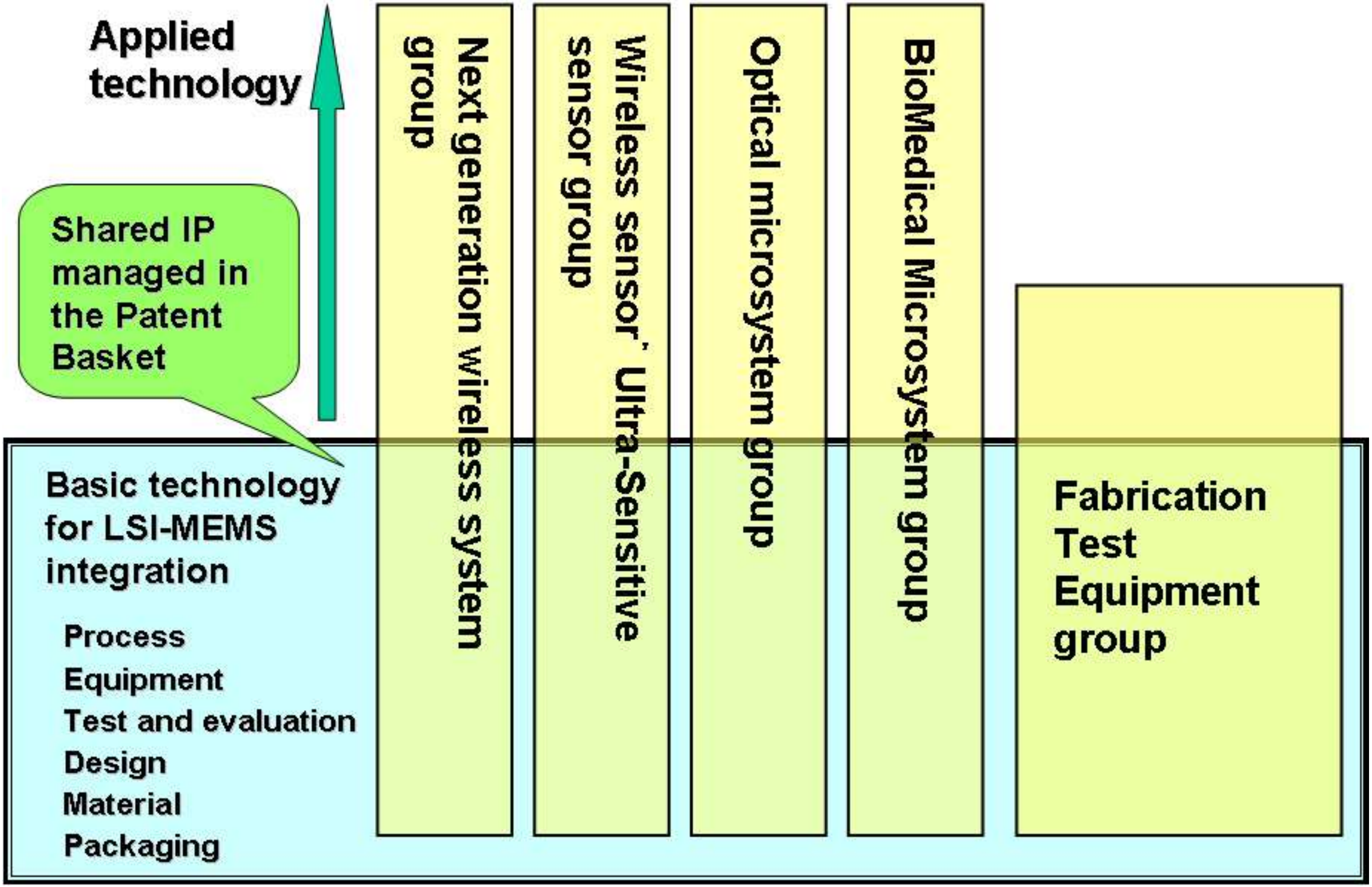
Glass wafer contact portion
(2nd layer)
glass with embedded metal

2nd Step
Wafer Gluing

Gluing of three stacked wafers, including 3rd layer glass wafers for casing

3rd Step
Cutting

MEMS switch cut from three layer wafer



Applied technology

Shared IP managed in the Patent Basket

Next generation wireless system group

Wireless sensor、Ultra-Sensitive sensor group

Optical microsystem group

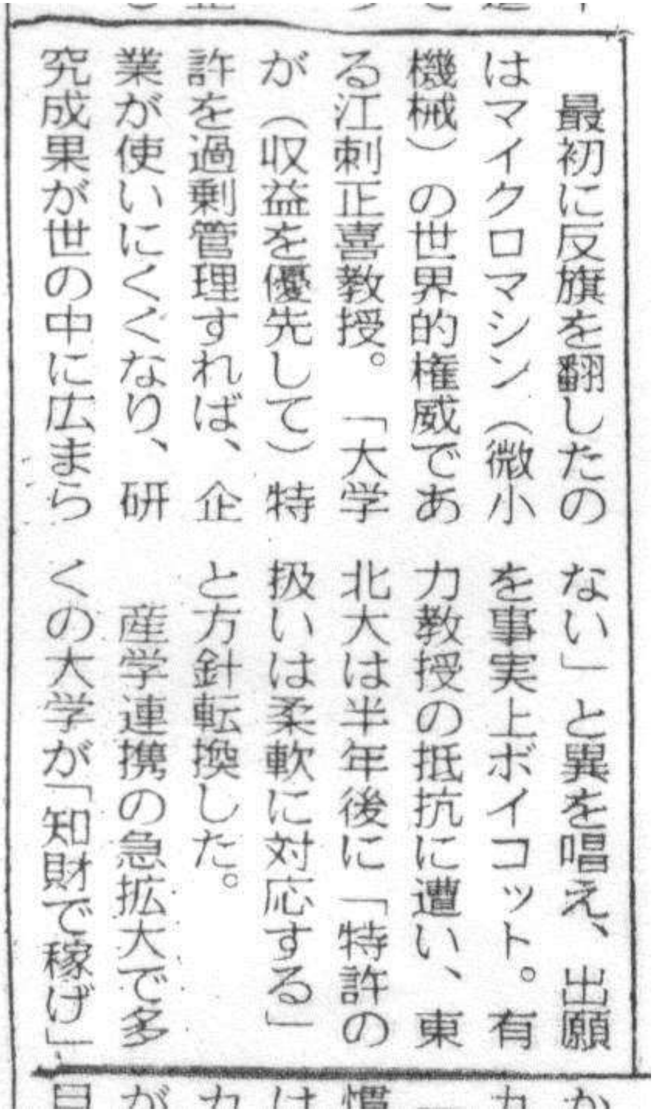
BioMedical Microsystem group

Fabrication Test Equipment group

Basic technology for LSI-MEMS integration

- **Process**
- **Equipment**
- **Test and evaluation**
- **Design**
- **Material**
- **Packaging**

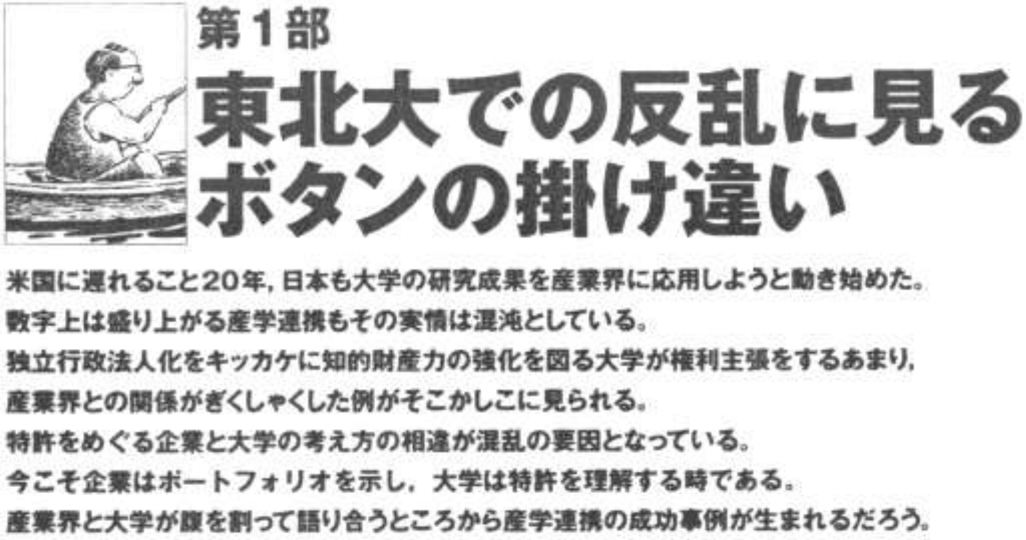
Shared IP managed in the Patent Basket



最初に反旗を翻したのはマイクロマシン（微小機械）の世界的権威である江刺正喜教授。「大学が（収益を優先して）特許を過剰管理すれば、企業が使いにくくなり、研究成果が世の中に広まらない」と異を唱え、出願を事実上ボイコット。有力教授の抵抗に遭い、東北大は半年後に「特許の扱いは柔軟に対応する」と方針転換した。

産学連携の急拡大で多くの大学が「知財で稼げ」

2005/7/19 Nihon Keizai Shinbun (first page)

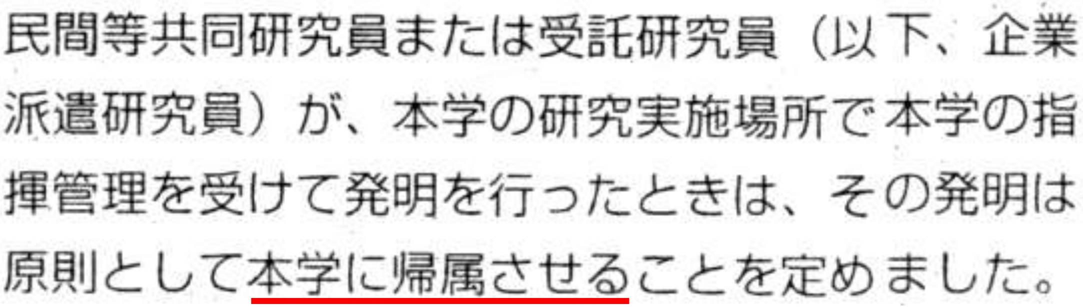


第1部

東北大での反乱に見るボタンの掛け違い

米国に遅れること20年，日本も大学の研究成果を産業界に応用しようと動き始めた。
数字上は盛り上がる産学連携もその実情は混沌としている。
独立行政法人化をキッカケに知的財産力の強化を図る大学が権利主張をするあまり，
産業界との関係がぎくしゃくした例がそこかしこに見られる。
特許をめぐる企業と大学の考え方の相違が混乱の要因となっている。
今こそ企業はポートフォリオを示し，大学は特許を理解する時である。
産業界と大学が腹を割って語り合うところから産学連携の成功事例が生まれるだろう。

Nikkei Electronics (2005.1.31)



民間等共同研究員または受託研究員（以下、企業派遣研究員）が、本学の研究実施場所で本学の指揮管理を受けて発明を行ったときは、その発明は原則として本学に帰属させることを定めました。

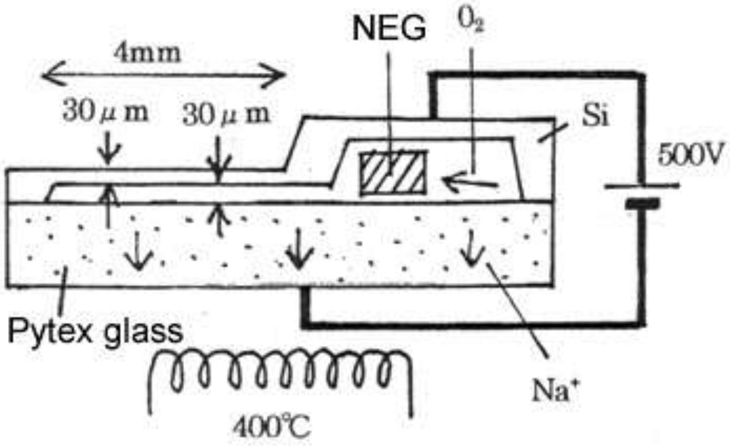
↓

Patent by dispatched researcher was owned by Tohoku University (before revolution)

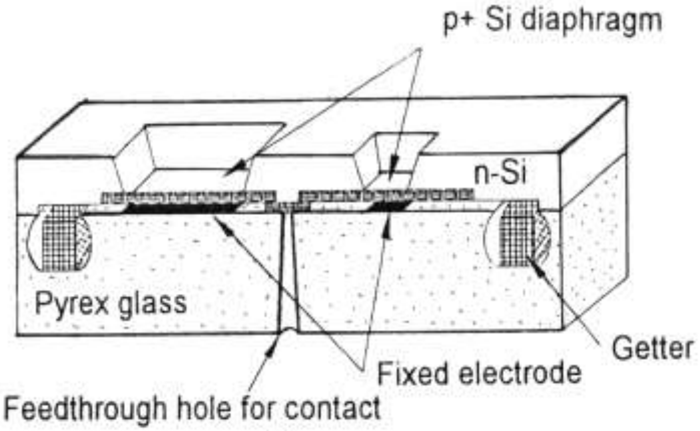
(Our laboratory) Patent shared with company is paid by company. Exclusive license is given to the company but opened if not commercialized.

Revolution against IP rules in Tohoku University

Efficient utilization of IP (example : capacitive vacuum sensor)



(H.Henmi (RIKEN), Sensors and Actuators A, 43 (1994) p.243)



(K.Hatanaka (ULVAC), Technical Digest of the 13th Sensor Symposium, (1995) p.37)

Two patent

Development

(ANELVA technical report , 11 (2005) p.37)

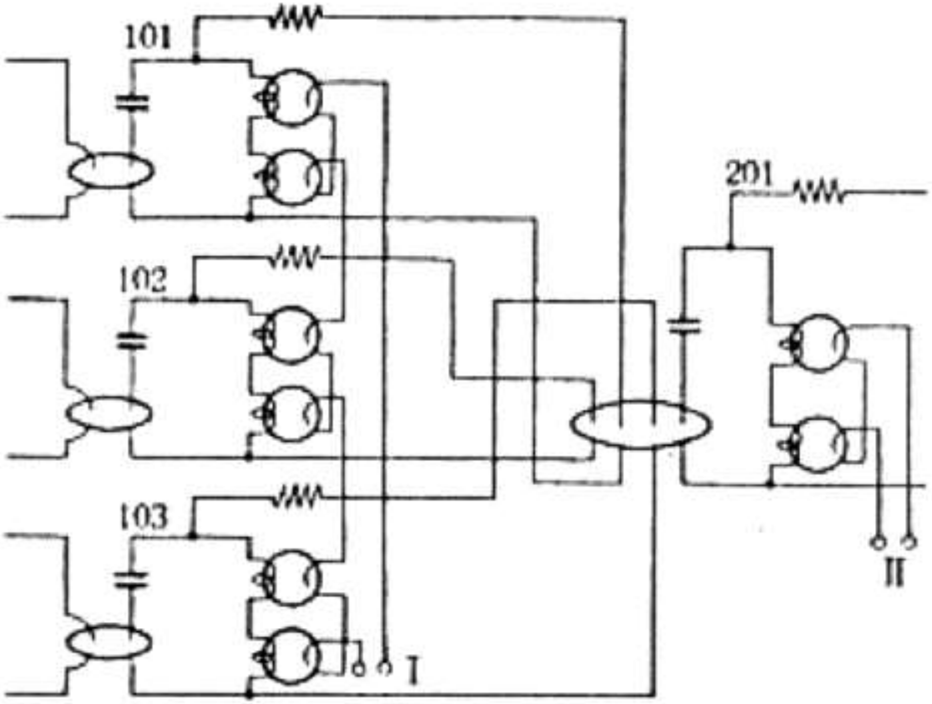
Experiences of MEMS･IC research and construction of common facility

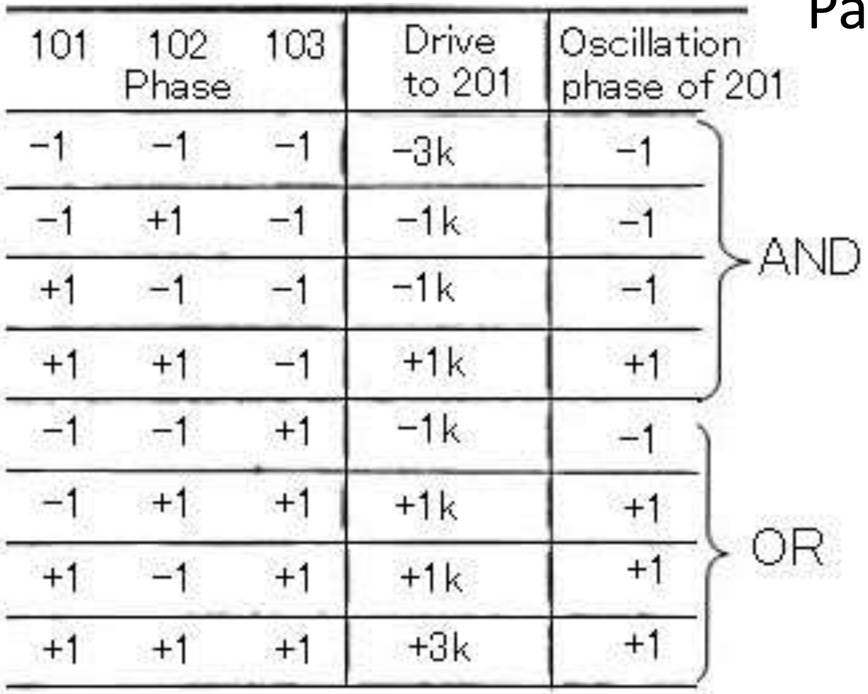
1. Chemical sensor & prototyping facility(graduate student) (1970-1975)
2. Biomedical micro sensors (Research Associate) (1976-Sept.1981)
3. Development of custom CMOS IC (Assoc. Professor) (Oct.1981-1990)
4. Integrated MEMS & industrialization (Professor) (1991-)

Open collaboration

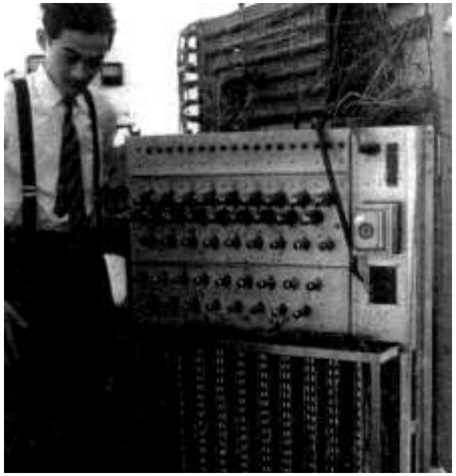
5. Common facility for prototyping
6. Accumulation and utilization of knowledge
7. Supporting industry
8. Education for students who are eager to be useful

Summary





101	102 Phase	103	Drive to 201	Oscillation phase of 201	
−1	−1	−1	−3k	−1	AND
−1	+1	−1	−1k	−1	
+1	−1	−1	−1k	−1	
+1	+1	−1	+1k	+1	
−1	−1	+1	−1k	−1	OR
−1	+1	+1	+1k	+1	
+1	−1	+1	+1k	+1	
+1	+1	+1	+3k	+1	



E.Gotoh : Inventor of Parametron computer (Graduate student in the Univ. of Tokyo in those days)

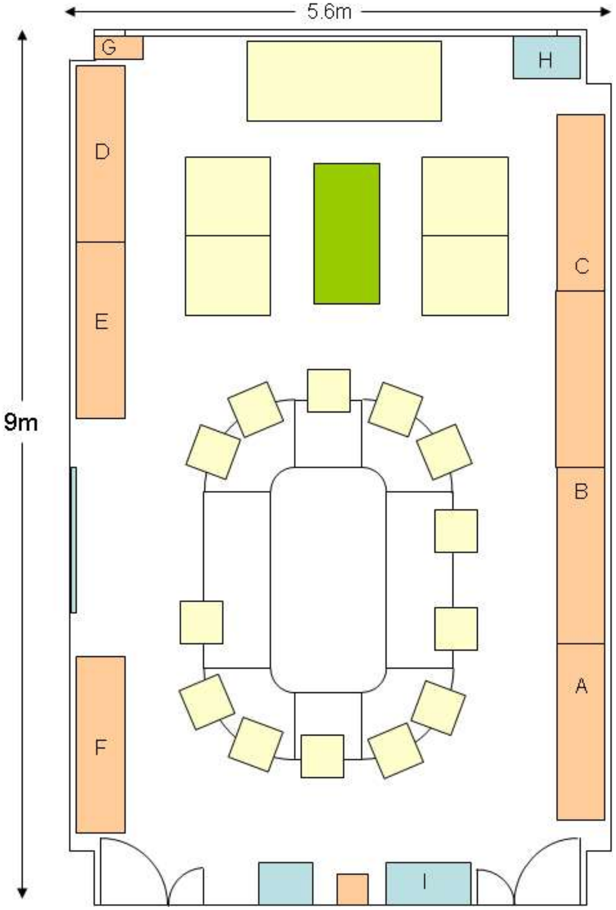
Parametron computer

(K.Nagamori, Electronics (1958, March) p.918)

平成 24 年度
近代技術史学

東北大学 原子分子材料科学高等研究機構
江刺 正喜

History of technology



A1 Electrical measurement : Potentiometer, Galvanometer

A2 Wired communication : Microphone, Headphone

A3 Wireless communication : Vacuum tube and transistor radio

B1 Recording : phonograph (Edison), Vacuum tube magnetic tape recorder

B2 Computer : Mechanical computer, calculator

C1 Vacuum tube : Various vacuum tubes, Vacuum tubes for take-out, Manuals

C2 Transistor･IC : From vacuum tube to transistor and LSI

C3 Haggerty's forecast (1964)

D1 Optical Instruments (1) optical measurement : Microscope, Radiation thermometer, D2 Optical Instruments(2) camera : Analog recording camera, 8mm movie

E1 Hobby : Mechanical doll, Aibo, Micro flying robotand computer controlled model car

E2 Automobile : Model T Ford、Model A Fordmanual etc.

F1Measure gause : Balance, Thermometer, Hygrometer

F2 Clock : Pendant camera, motor camera, tuning-fork camera

F3 Typewriter : Portable typewriter

H Probe card by Kiyota

G Books on the history of technology

I Materials related to Tohoku Univ. and companies

Historical Museum of Technology

http://www.mu-sic.tohoku.ac.jp/museum/

教員や学生らの手で、修復作業が続くT型フォード

Yomiuri shinbun, Feb.20, 2009

Ford Model T (donated by Mr.T.Tawara (Optoelectronics))

TEMS（Talking Equipment from Manual Sign）iCAN’11 winner, Kyoto Univ.

5th International Contest of Application in Nano / micro technologies (iCAN'14）
July 20, 2014 in Sendai (for high school and university students)

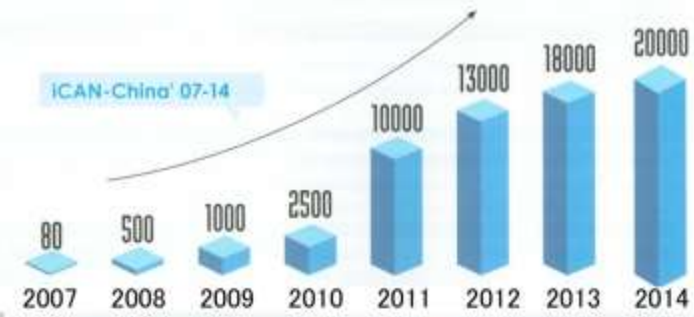
TU DARMSTADT, Germany
SMART PROTECTION GOGGLES

Fukushima prefectural Koriyama-kita technical high school, Japan
Pro ROBO -Robot to protect the safety of family

At the Institute of Electromechanical Design at TU Darmstadt smart protection goggles were developed to increase the safety at workplaces where the use of goggles is mandatory. The goggles detect when they are properly worn and send this information to a wireless receiver. This signal is used for different applications, for example to toggle a warning light thus alarming the user.

iCAN History

- iCAN-China'07-14 / 07, Shanghai / 08, Shenzhen / 09, Haerbin / 10-14, Wuxi
- iCAN'10 / Xiamen, China / 2010.1.20-22
- iCAN'11 / Beijing, China / 2011.6.5-7
- iCAN'12 / Beijing, China / 2012.7.6-9
- iCAN'13 / Barcelona, Spain / 2013.6.16-18
- iCAN'14 / Sendai, Japan / 2014.7.19-21
- iCAN'15 / Alaska, USA / 2015.6.21-25



20,000 attendee in the China domestic contest in 2014

Summary

- Common facility with versatile equipments and its effective utilization. Slim equipments made in-house for easy maintenance.
- Accumulation and reconstruction of knowledge from the past to the latest. Provide high quality knowledge delivery services.
- Answering to the needs and educating ourselves by studying heterogeneous knowledge and culture (international, different sectors etc.), Successful experience of practical contribution motivates us.
- Do not depend on outsourcing just for shortcut. Real experiences rather than virtual ones.
- Good subjects, effective advices and environment for enabling for student. Don't compare students.
- Think from basic. How useful outputs are is more important than the number of papers. Achieve results with minimum expense using second hand equipments. Patent is to protect products. Collaborative rather than competitive.

日経産業新聞　2003年（平成15年）12月12日（金曜日）

江刺研究室（東北大）評価1位

産学連携特別調査

江刺正喜教授の研究室はMEMS研究の草分け（東北大学）

理科少年シリーズ

検証 東北大学・江刺研究室 最強の秘密

江刺正喜

本間孝治
出川通

なぜ江刺研究室は、
世界中の企業から支持されるのか？

最先端技術MEMSの世界的権威が語る
人材育成、近代技術史と先端技術、勝つ戦略
キーワードは「理科少年」

江刺正喜教授の「理科少年」時代
江刺研究室の「強さ」
近代技術史と先端技術MEMS
MEMSビジネス

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