

Collaboration with Chemnitz

Wafer-level transfer by adhesive bonding for integrated MEMS



Masayoshi Esashi

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Director, Micro/Nano Machining Research & Education Center

Tohoku University, Sendai, Japan

Fraunhofer Project Center from April 2012



 **Fraunhofer**
ENAS

FRAUNHOFER INSTITUTE FOR ELECTRONIC NANOSYSTEMS ENAS



**Fraunhofer Project Center
NEMS/MEMS Devices and
Manufacturing Technologies
at Tohoku University**

FhG Project Center signboard on the main door of S. Tanaka Laboratory

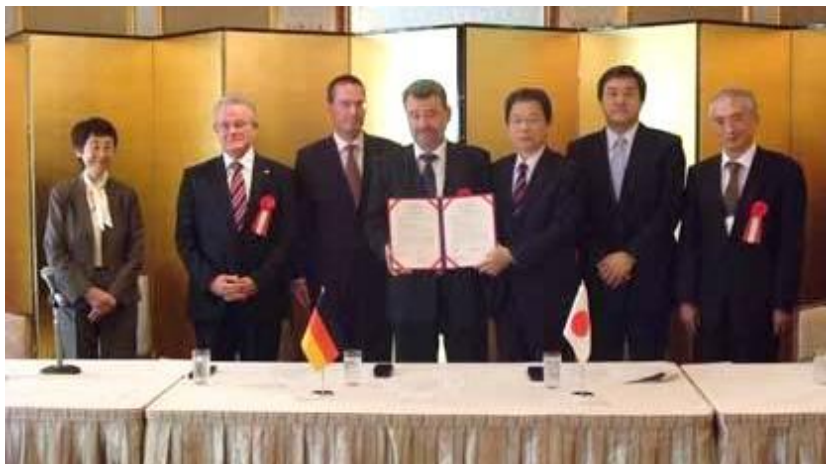
Official Collaboration since 2005



Fraunhofer Germany – Sendai City partnership signing ceremony in Munich (July 15, 2005)



1st Fraunhofer Symposium in Sendai “Doing Worldwide Business via MEMS Technology” (October 19, 2005)
The symposium is held every year.



Fraunhofer – WPI-AIMR Tohoku University partnership signing ceremony in Sendai (November 8, 2011)

Strong partnership established by Prof. Geßner and Prof. Esashi

Persons in Sendai

FhG Project Center members
staying in S. Tanaka Laboratory



Visiting Researcher
Jörg Frömel



Research Associate
in WPI-AIMR
Mai Phuong Nguyen



Visiting Researcher
Marco Haubold



Visiting Researcher
Frank Roscher



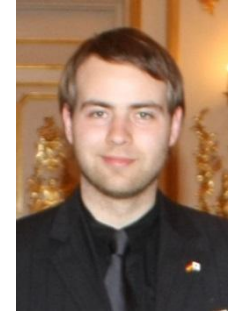
Visiting Researcher
Chenping Jia



Visiting Student
Felix Gabler



Visiting Student
Yu-Lang Chu



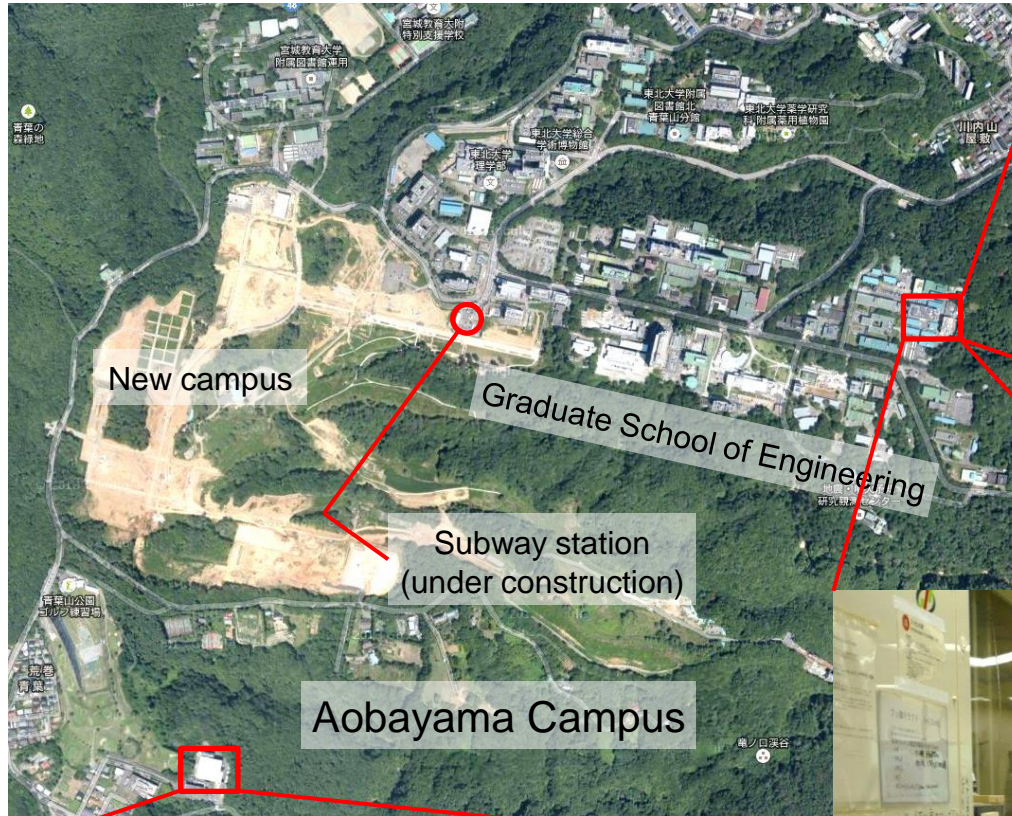
Visiting Student
Florian Kurth



Visiting Researcher
Klaus Vogel

Past visiting members
from **Prof. Geßner's** group
in Chemnitz

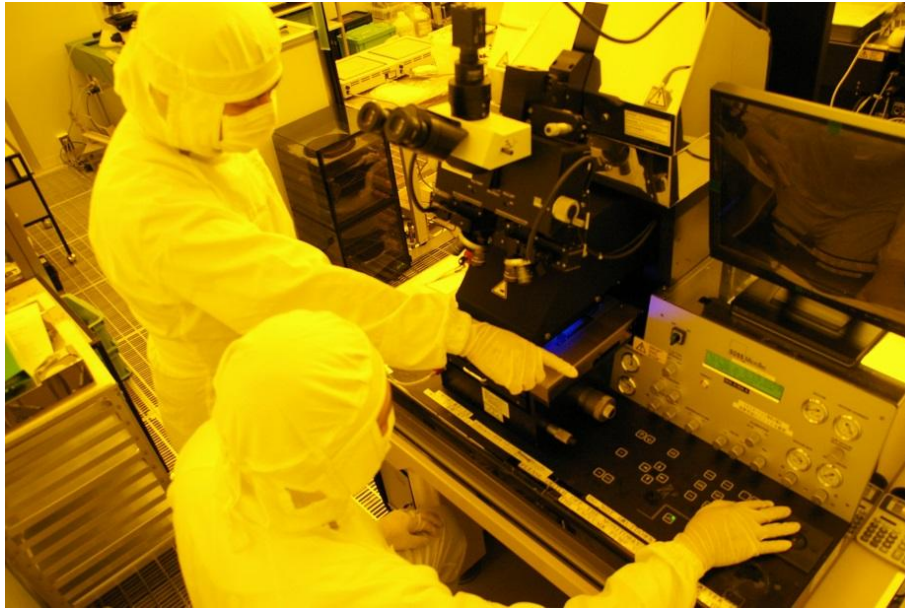
Tohoku University Aobayama Campus



Micro/Nano-Machining Research and Education Center (MNC)



Open Facilities for MEMS



1800 m² clean room

Over 150 user companies

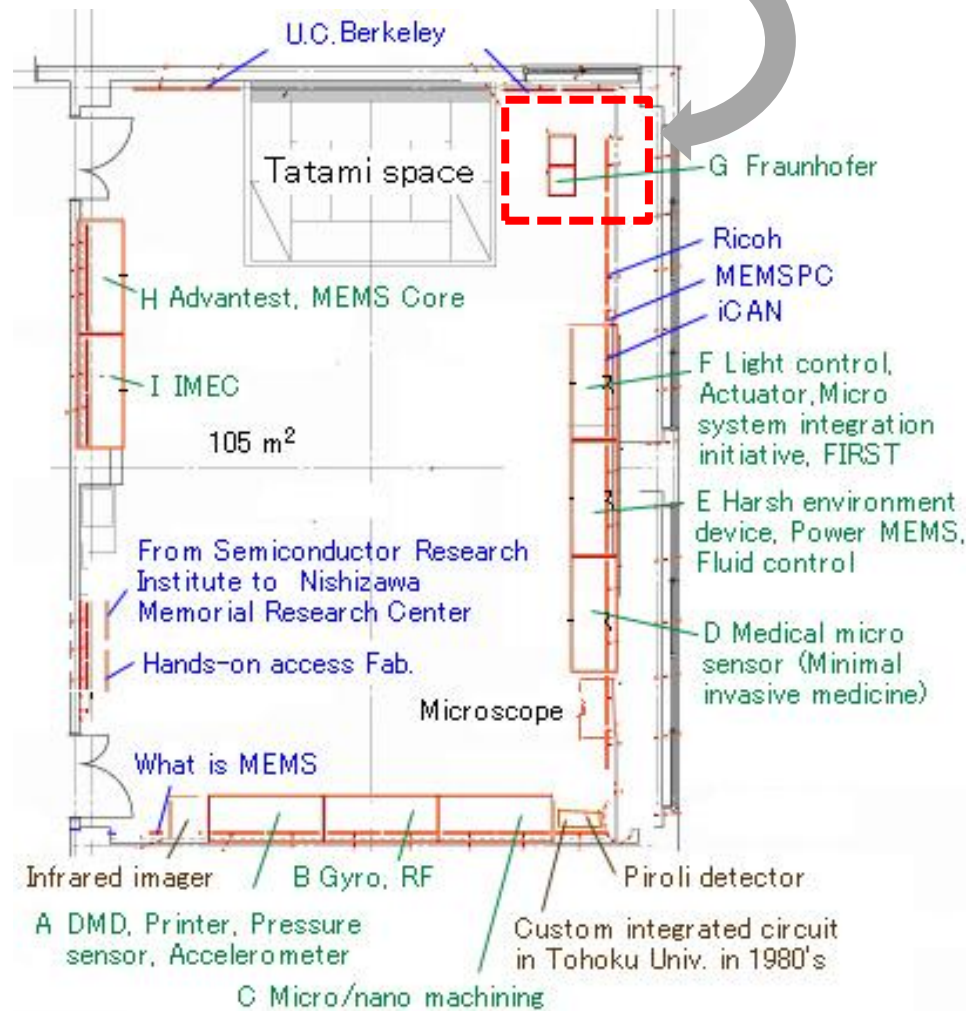


“Hands-on-Access Fab”
in Microsystem Integration Center
(Director: [Prof. Masayoshi Esashi](#))

MEMS Show Room and FhG Corner



Opening ceremony



Tactile Sensation on Whole Robot Body



Care robot

“RIBA”, Riken



Pet robot

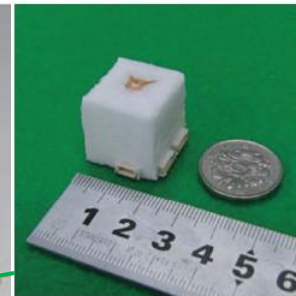
“Paro”, Intelligent Systems

Tactile sensor network for home and medical robots enables:

- Contact detection for collision safety
- Body contact communication



Robot skin



Bus-connected tactile sensor

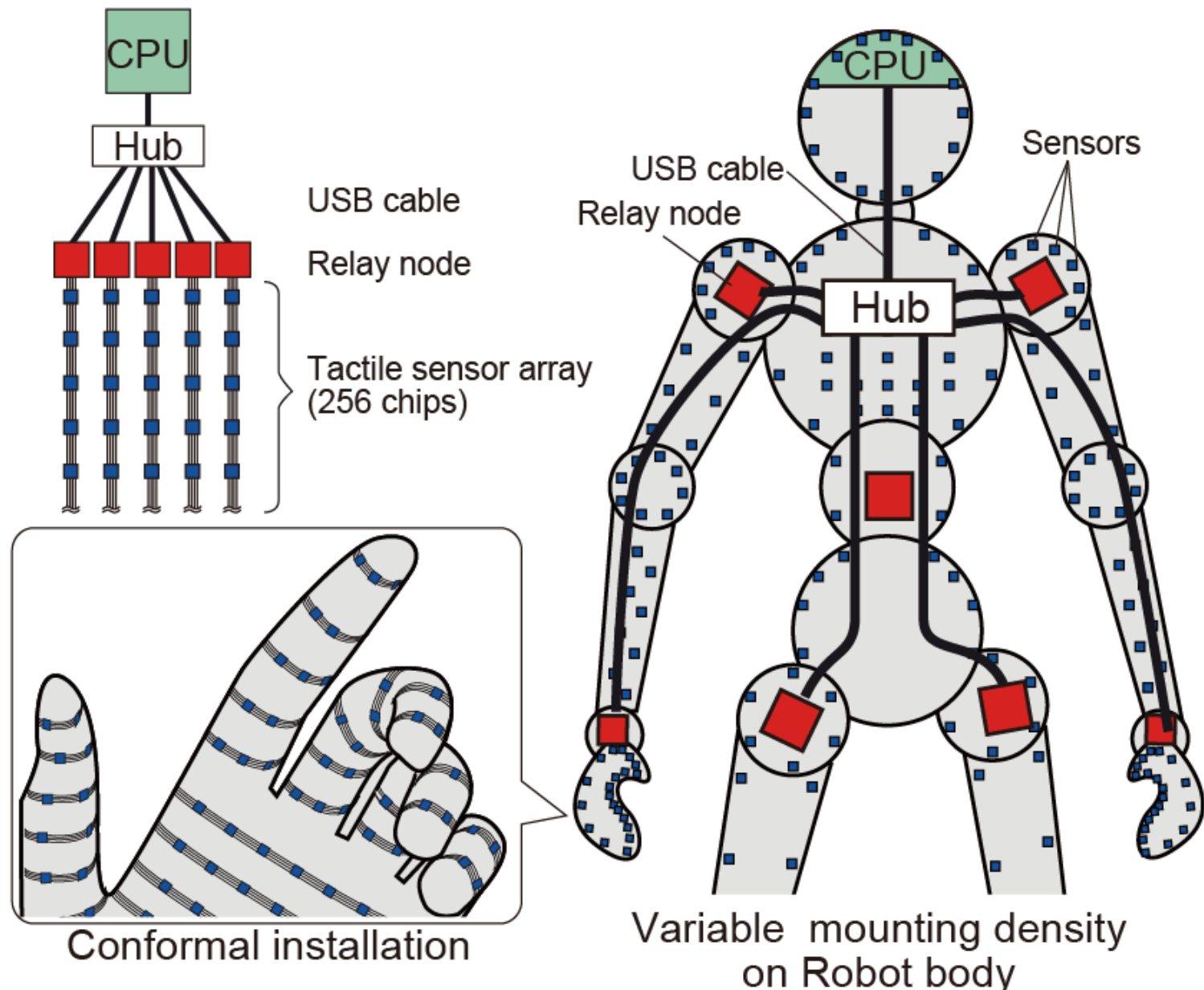


Parallel connection between brain and 10^7 of tactile receptors

How to imitate or replace nerve network?

I. Kumagai *et al.*,
IEEE/RSJ'12 (2012)

Tactile Sensor Network on Robot



MEMS-on-CMOS Integrated Tactile Sensor

M. Makihata, S. Tanaka *et al.*, Sensors & Actuators A (2012)

M. Muroyama *et al.*, Smart Systems Integration 2014

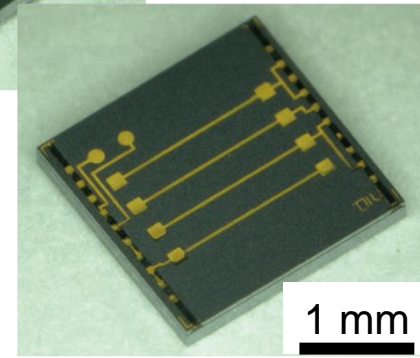
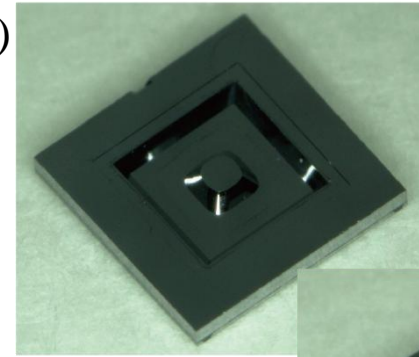
Capacitive sensing electrode

BCB polymer

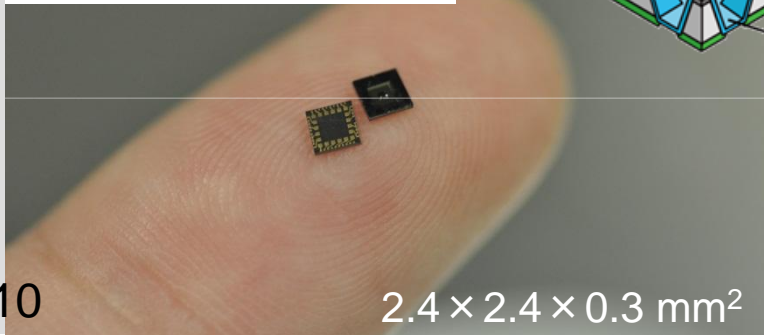
Thinned CMOS wafer

I/O pad

Through-silicon



1 mm

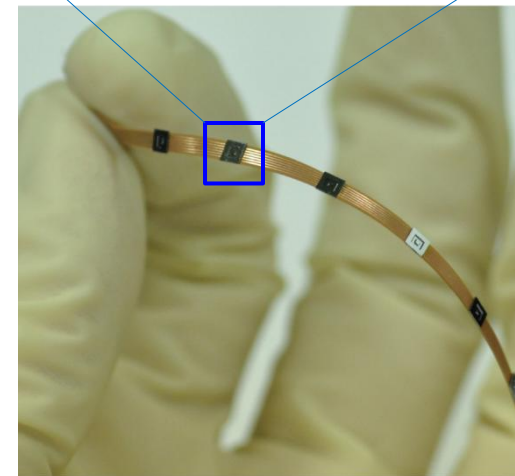
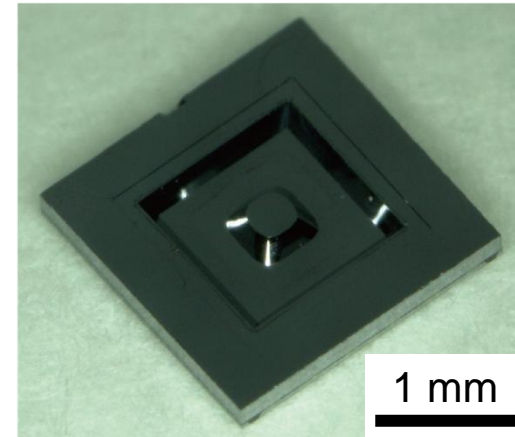
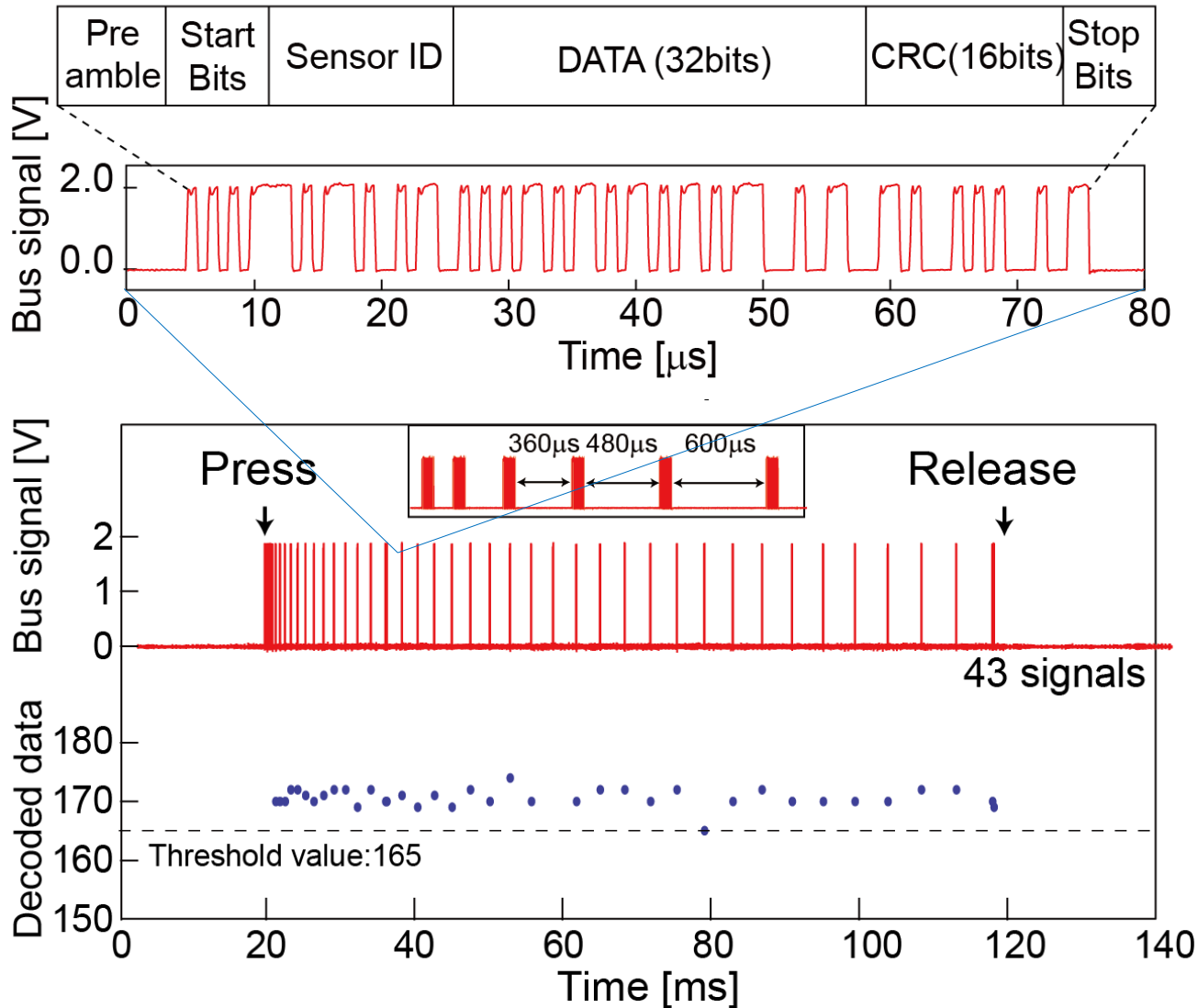


2.4 × 2.4 × 0.3 mm²



Data from Integrated Tactile Sensor

M. Makihata, M. Muroyama, S. Tanaka *et al.*, 2012 MRS Spring Meeting



Threshold & Adaption operation

Sensor Network for Infrastructure Safety



I-35W Mississippi River bridge (constructed in 1964) suddenly collapsed on August 1, 2007



Metropolitan expressway Haneda #1 (constructed in 1963)

Wireless sensor antenna

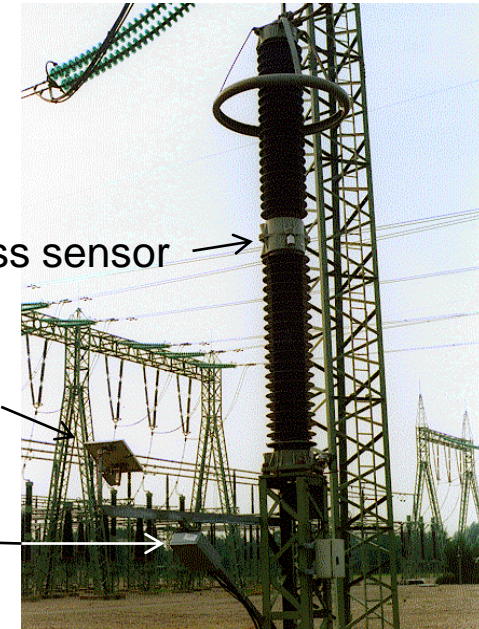


Train wheel

Wireless sensor

Antenna

RF unit



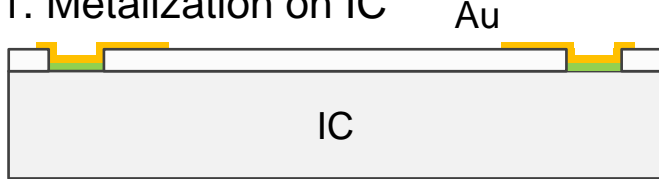
Sensor network expected for the monitoring infrastructures

Wireless technology and frequency control devices are getting more important!

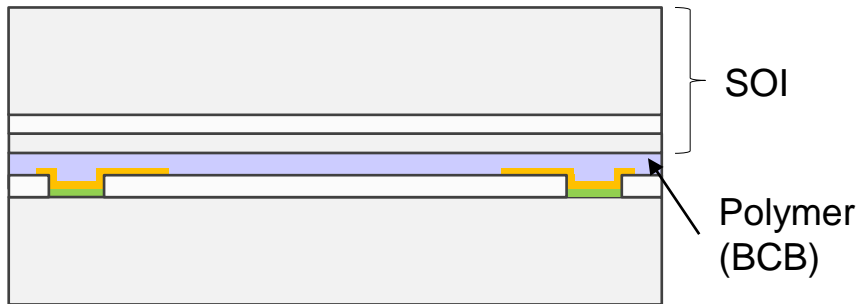
MEMS Clock Resonator Integrated with LSI

A. Kochhar *et al.*, 2012 IEEE Intl. Ultrason. Symp., Best Student Paper Award

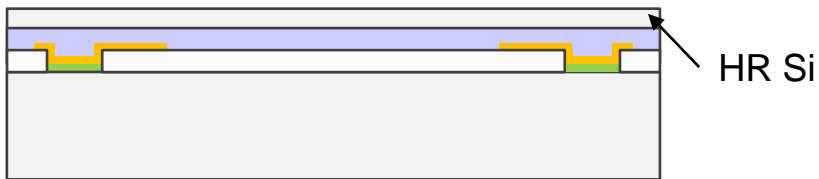
1. Metalization on IC



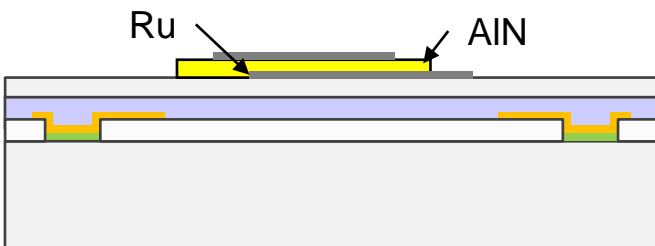
2. IC-SOI wafer bonding via polymer



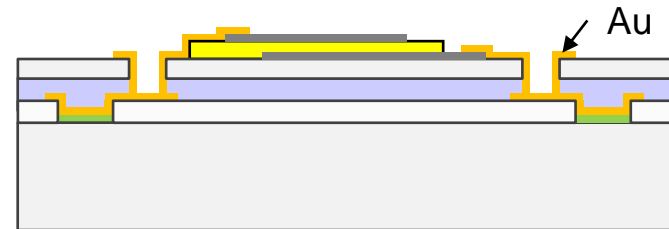
3. Removal of handle and BOX layer



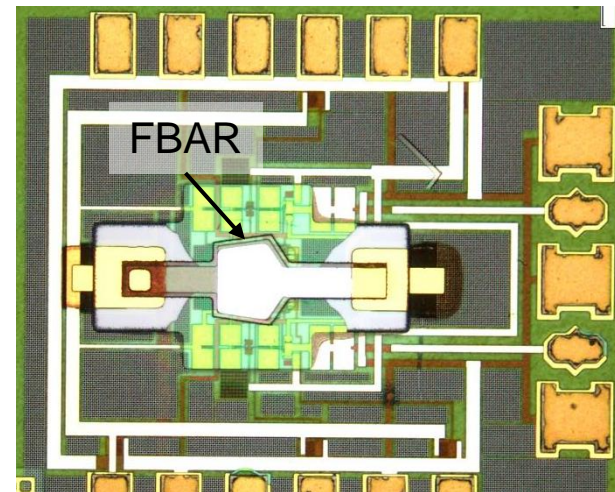
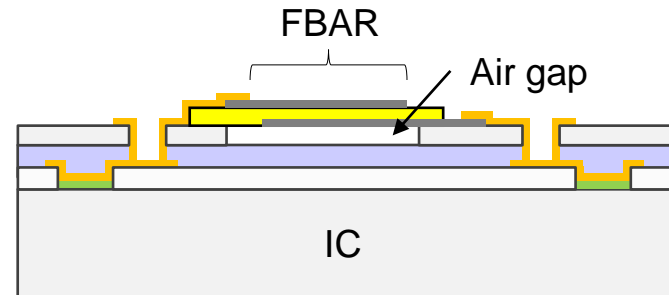
4. Fabrication of AlN transducer



5. Interconnection between IC and FBAR

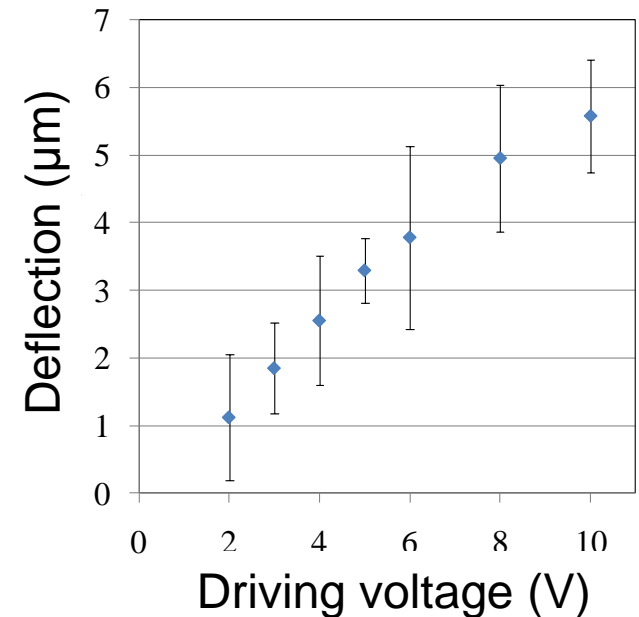
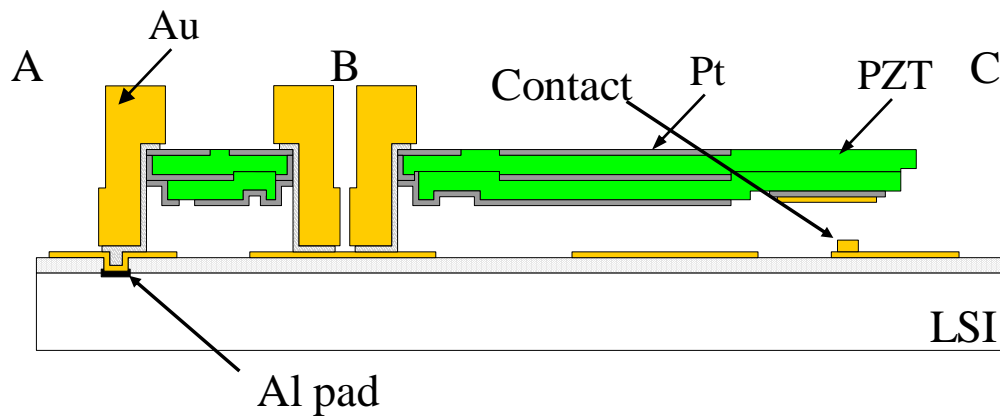
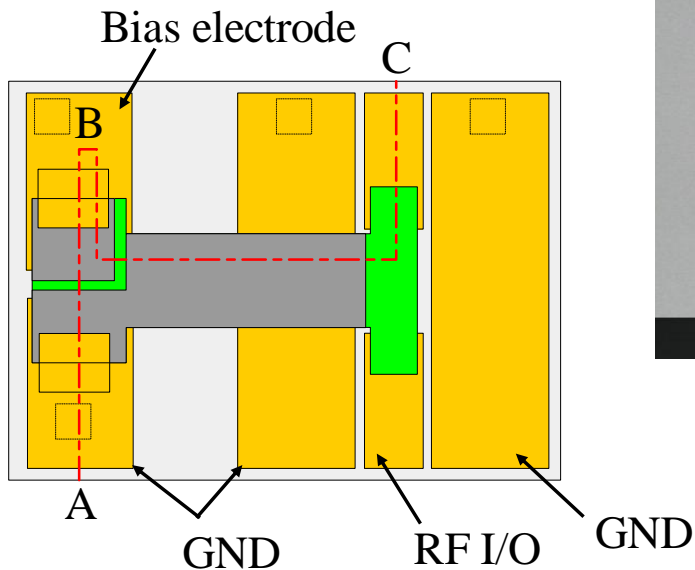
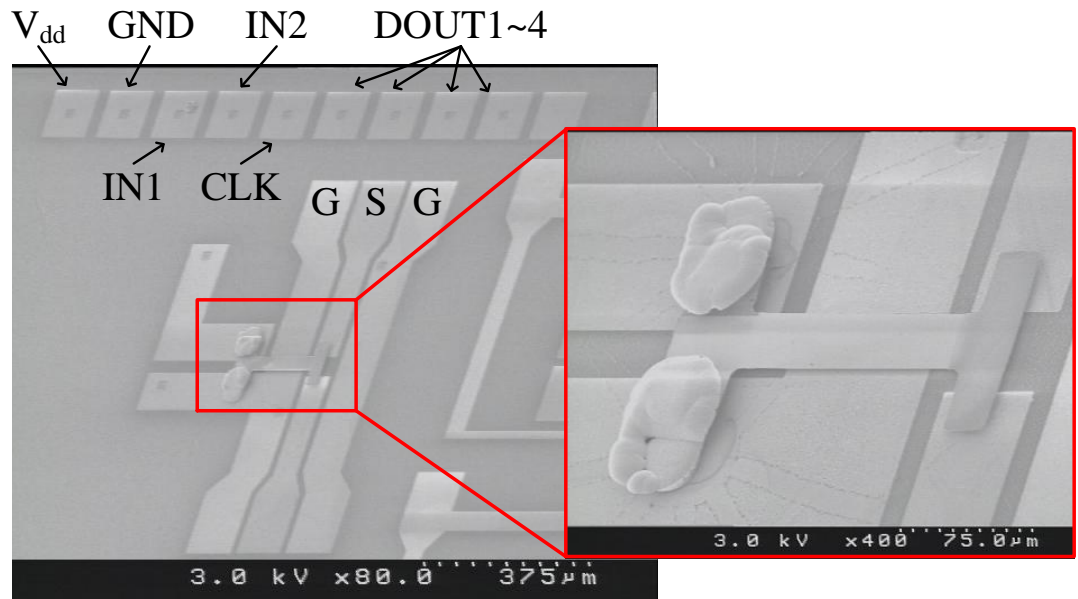


6. XeF₂ etching of sacrificial Si under FBAR



PZT-Actuated MEMS Switch on CMOS

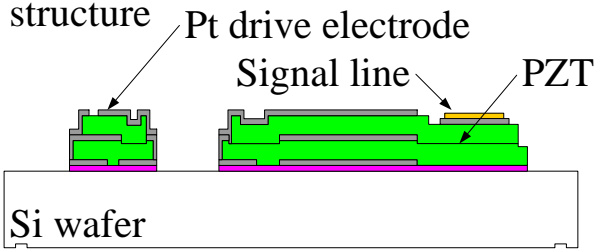
Matsuo, Moriyama, Esashi,
Tanaka, IEEE MEMS 2012



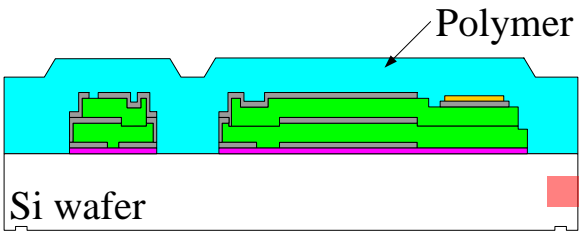
PZT-Actuated MEMS Switch on CMOS



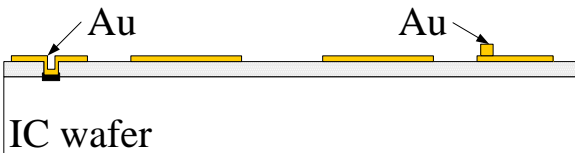
A-1. Fabrication of PZT MEMS structure



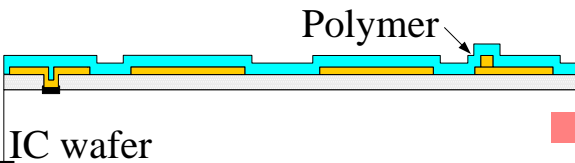
A-2. Polymer spin-coating



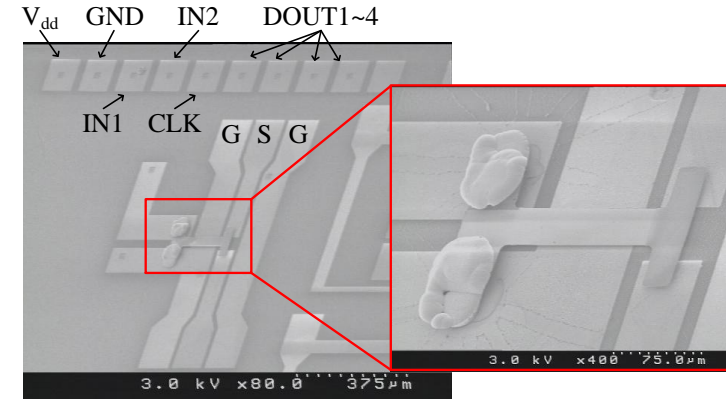
B-1. Fabrication of electrodes and pads on IC



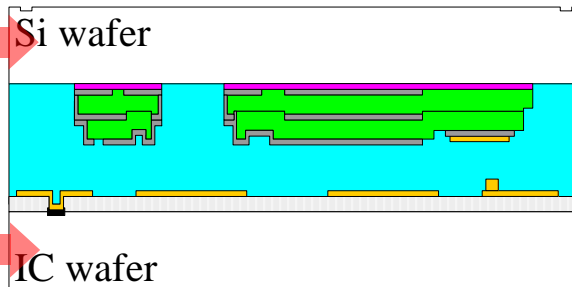
B-2. Polymer spin-coating



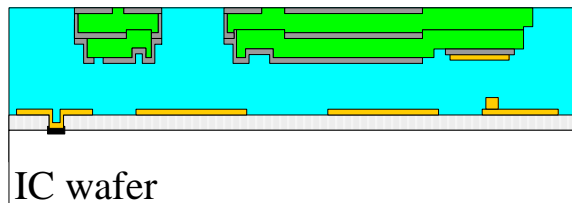
Matsuo, Moriyama, Esashi, Tanaka, IEEE MEMS 2012



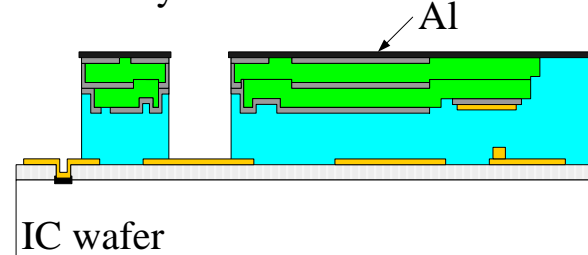
C-1. Bonding (A-2 and B-2)



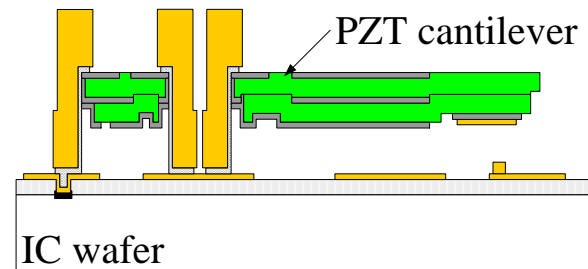
C-2. Etching of Si wafer and TiO₂ (Transfer of MEMS structures)



C-3. Polymer RIE

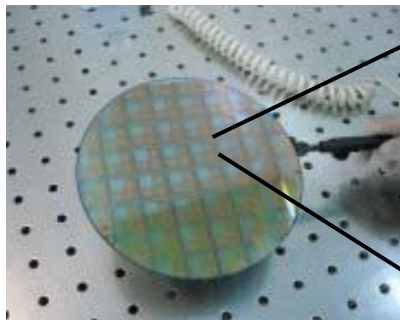


C-4. Sacrificial polymer etching

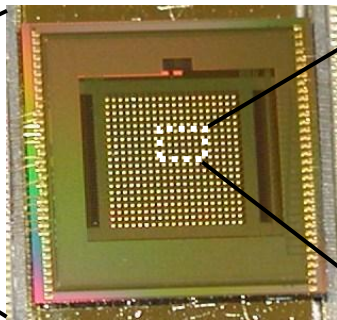


Electrochemical Biosensor Array

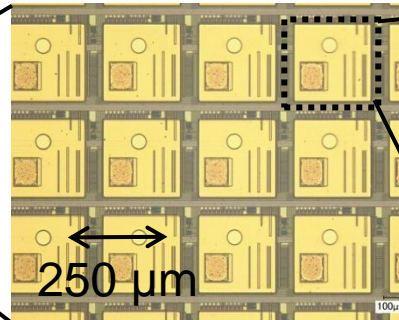
Multi-project wafer



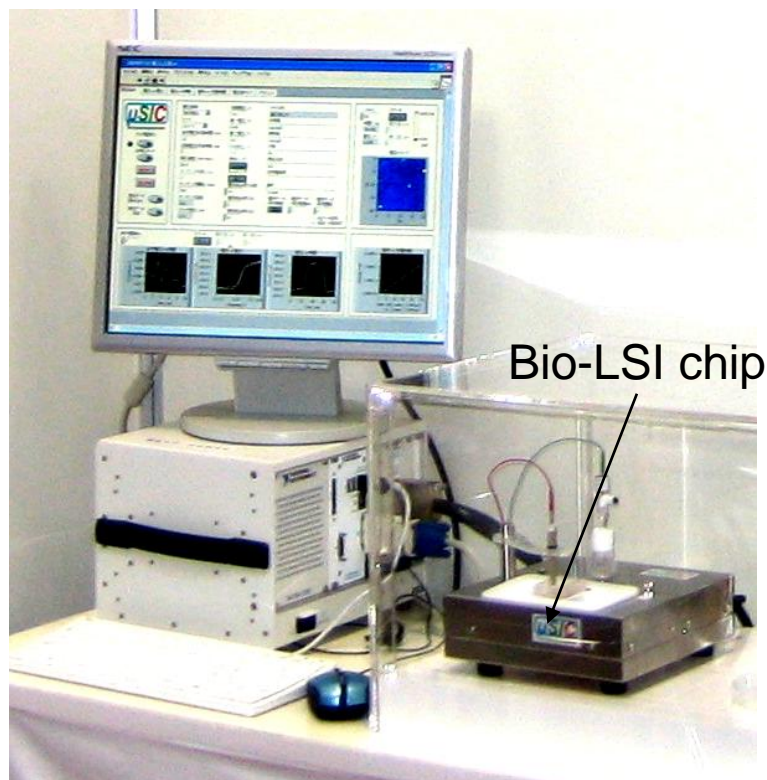
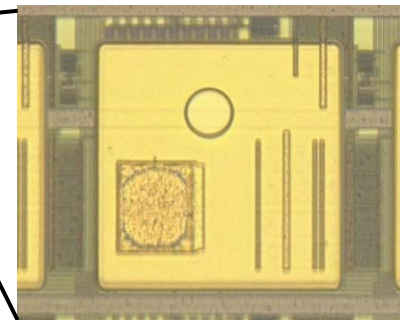
LSI chip



Electrode array

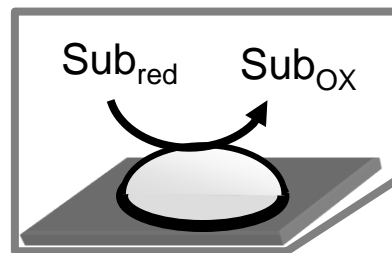


Electrode

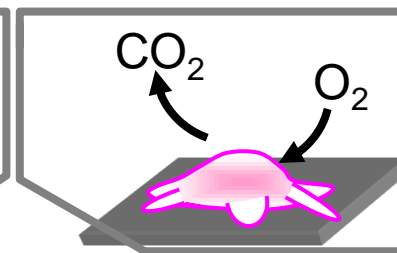


Bio-LSI chip

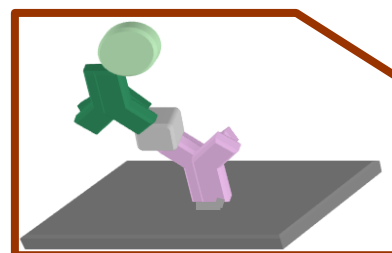
Enzyme kinetics analysis



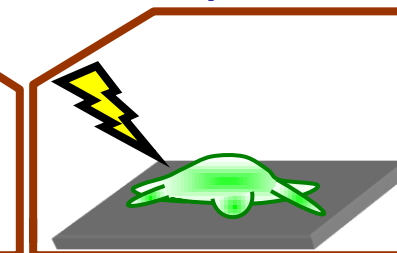
Cell respiration activity



Electrochemical bio-activity sensing



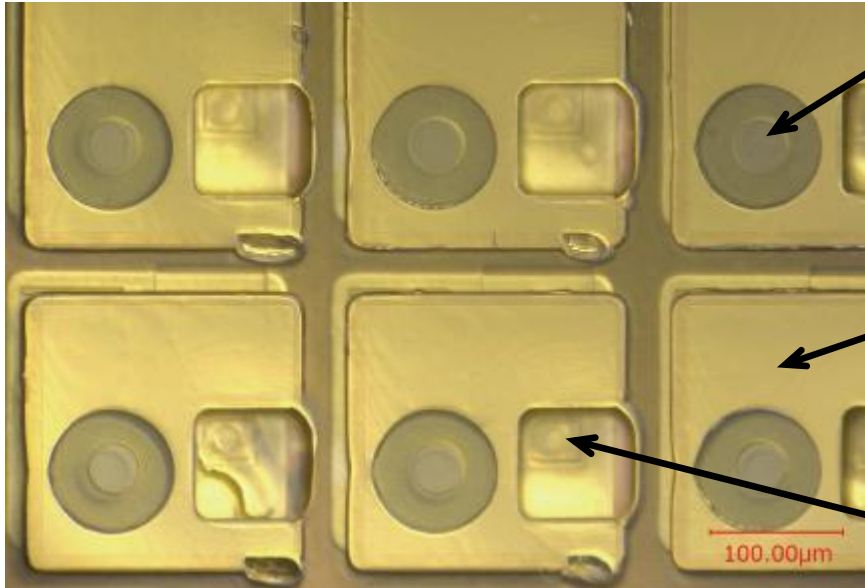
Immunoassay for diagnostics



Cell-based assay for environmental monitoring

Bio-Electrochem LSI with Diamond Electrode

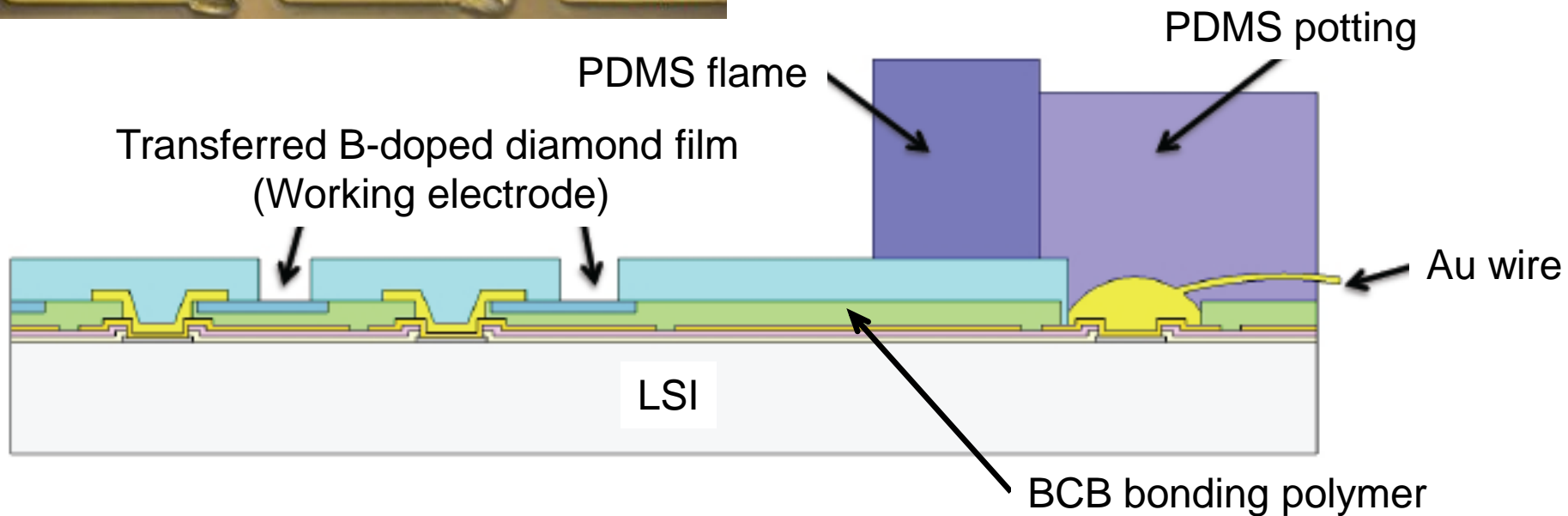
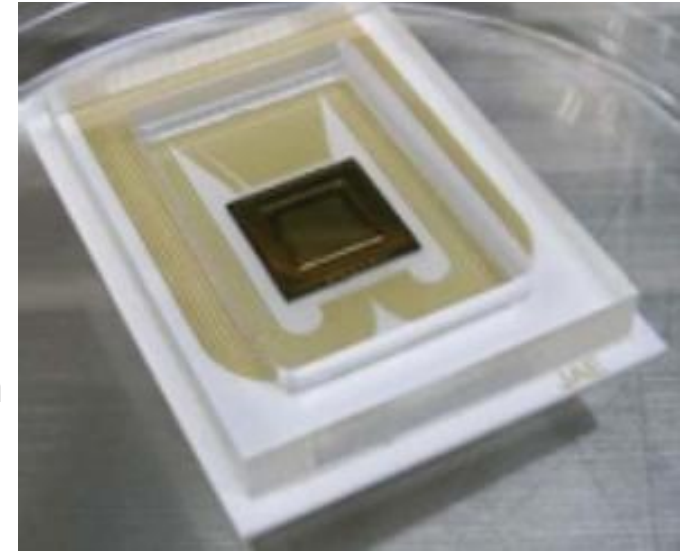
T. Hayasaka, S. Yoshida ... M. Esashi, S. Tanaka, IEEE MEMS 2014, pp. 322-325



Diamond electrode

Au inter-connection

LSI pad



PDMS potting

PDMS flame

Transferred B-doped diamond film
(Working electrode)

Au wire

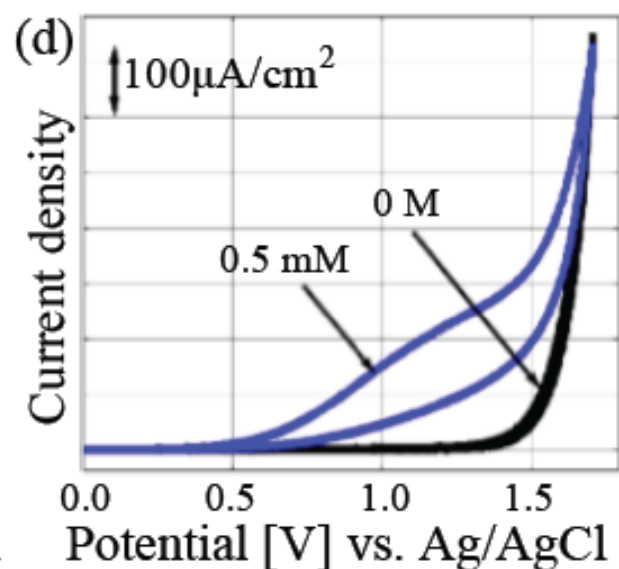
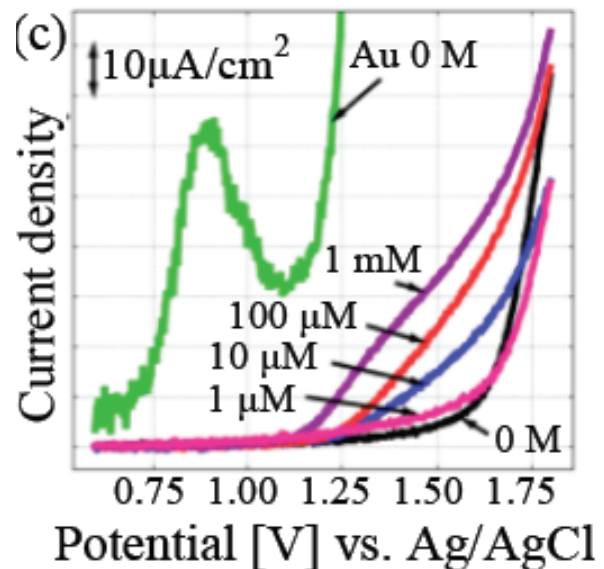
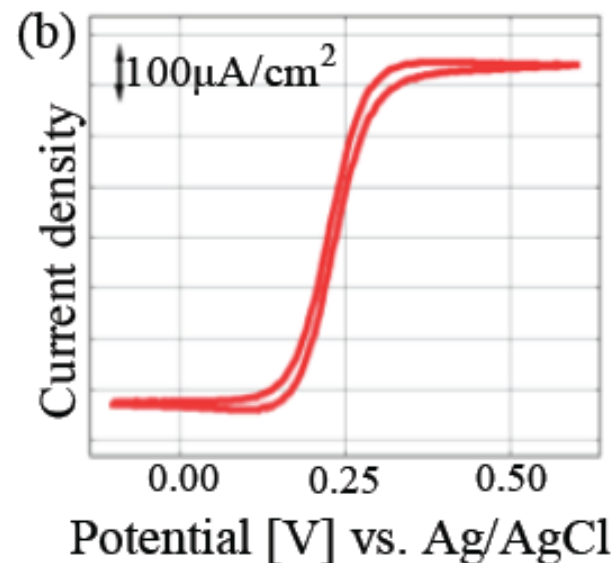
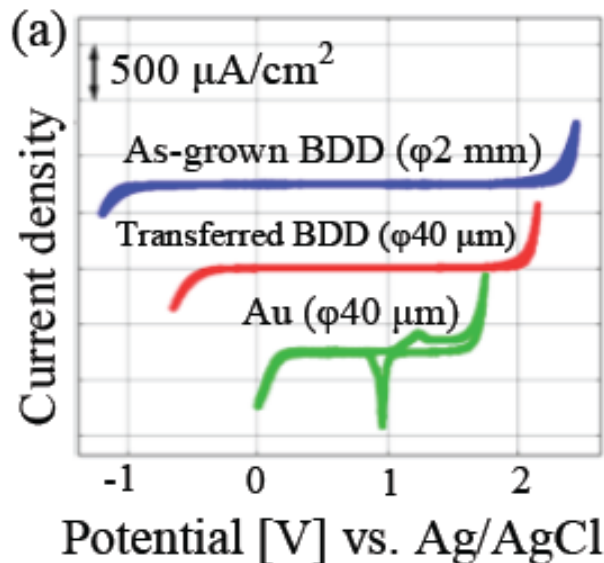
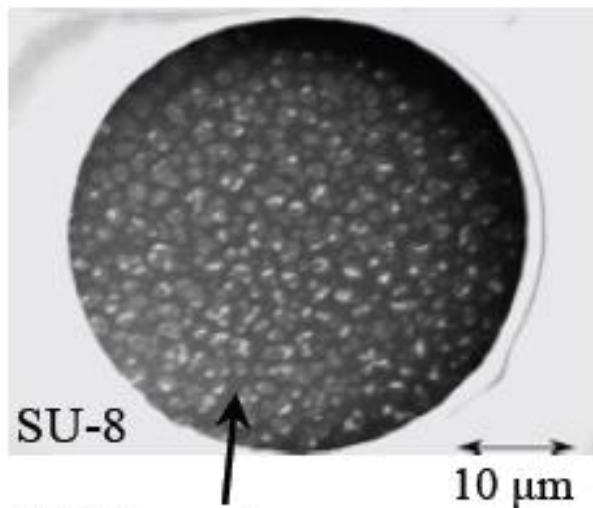
LSI

BCB bonding polymer

Bio-Electrochem LSI with Diamond Electrode

T. Hayasaka, S. Yoshida ... M. Esashi, S. Tanaka, IEEE MEMS 2014, pp. 322-325

→
Wide potential window
by boron-doped
diamond electrodes

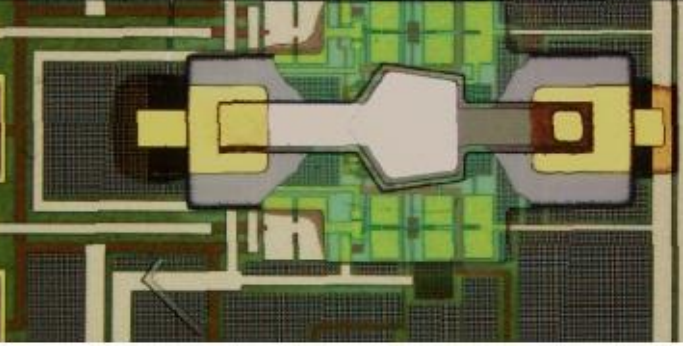


Please visit S. Tanaka Laboratory website
at http://www.mems.mech.tohoku.ac.jp/index_e.html



Home Research Members Facilities Links Access [Japanese]

役に立つこと、それが我々の誇りと喜び。



Tanaka Shuji laboratory

Blog Student Page
学生のブログ

研究室の技術小史
History of Lab

Internet Archives
インターネット記事

ALUMNI PAGE
同窓生のページ

MEMS WIKI
学内専用ページ

Lecture Page
講義のページ
Password required



Research and Development of Micro-Nanodevices for
Healthcare, Safety, Energy Saving, Advanced
Communication etc.

Our core competence is MEMS technology!
Students from other universities and foreign countries are welcome.
Please join our laboratory regardless of your experience in MEMS field.
Click for futher information on S. Tanaka Laboratory.

Information

Alumni page has been created. Please

mems tohoku

検索