

Hands-on Access for Fabrication Facility

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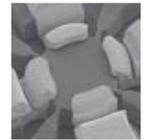
TOHOKU
UNIVERSITY

April, 2014

Requirement for MEMS R&D

- Development of design, process and evaluation in individual cases > No standard !
- Expensive facility (clean room) and equipment
- Trained engineer
- Much know-how
- Human network

Much time and cost



prototype

>> Open-access facility reduces the barrier for device prototyping and manufacturing.

Hands-on access fab., an open access facility at Tohoku Univ. 試作コインランドリ

The “[Hands-on access fab.](#)” is an open access facility that companies can easily access and utilize for their prototyping or small volume production. The fab. is shared with other users and managed with best efforts.

The fab. will not make contract development like MEMS foundry. Companies which have not own facility can dispatch their people to operate equipments by themselves.

The fab. is equipped with 4 and 6 inch facilities for semiconductor and MEMS. Companies pay fee depending on usage. The users can make investment small, because they are able to achieve prototyping of a device at appropriate cost. As a result, the users can reduce the risk in development, and can bridge R&D stage to manufacture stage more smoothly.

Companies can access accumulated know-how at Tohoku University.

Skilled engineer staffs coach the user.





Aobayama campus, Tohoku Univ.



Micro-nano Center
(20mm, 2inch for MEMS and LSI)



Hands-on-access fab. Nishizawa
Center (4 and 6 inch MEMS and
semiconductor)



MEMS lab. (20mm
for MEMS)

Tohoku University



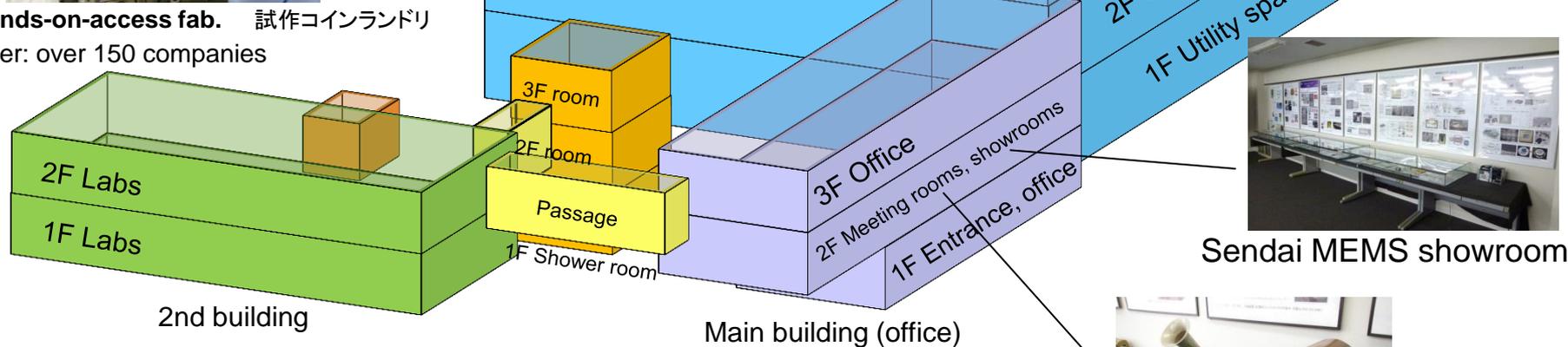
MNOIC, AIST
(8 and 12 inch for MEMS)

Jun-ichi Nishizawa Memorial Research Center

東北大学西澤潤一記念研究センター



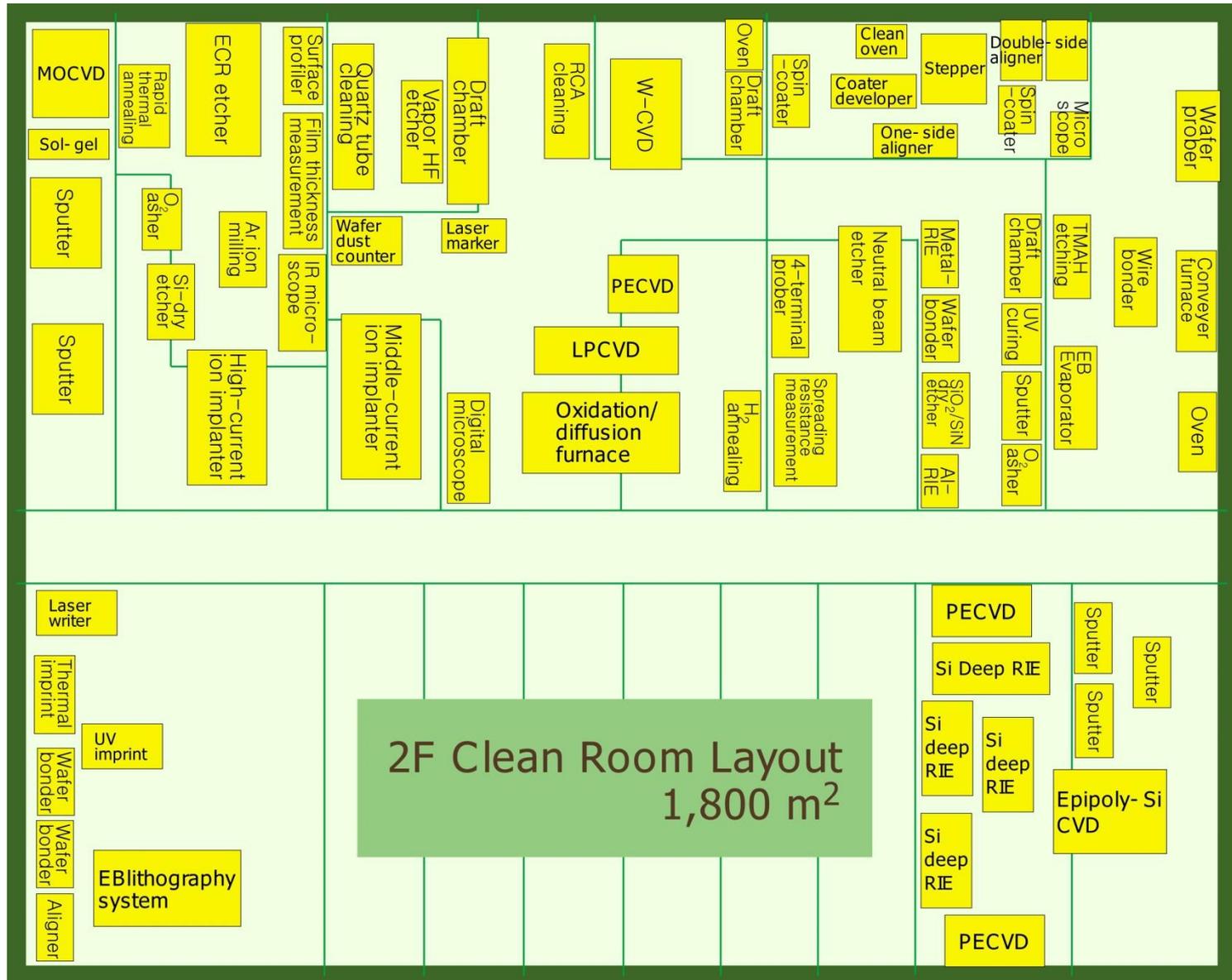
Hands-on-access fab. 試作コインランドリ
User: over 150 companies



Total area: 8,976m²

Historical museum of technology

Layout of the Hands-on access fab. (2nd floor of the Research Center)



Cleaning, drying



Draft chamber

HF/HNO₃/H₂SO₄/HCl etc.



Draft chamber

Organic solvent,
resist removing



Brush scrubber

Zenkyo
post polishing



Spin dryer

SEMITOOL PSC101



CO₂ critical point
dryer

SCFluids CPD1100



Inert oven

Yamato DN63H



Vacuum oven

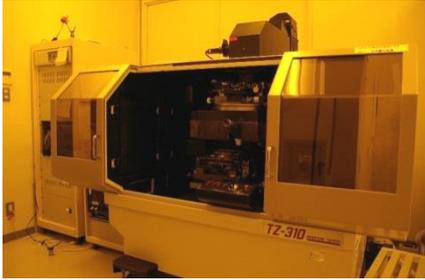
Yamato DP-31



Spin dryer

Toho Kasei

Photolithography



Pattern generator

NSK TZ-310
For emulsion / Cr mask
making, up to 7inch



Laser writer

Heidelberg instruments
DWL2000CE



Spin coater

Mikasa 1H-DXII etc.



Spin coater

Actes ASC-4000



Coater/developer

Canon CDS-630
For positive resist



Hot plate



Clean oven

Yamato DE62



Curing furnace

Yamato DN43H
For polyimide

Photolithography



Stepper

Canon FPA1550M4W
g-line, 0.65 μ m, 4inch



Double-side aligner
x 2

Suss Microtech
MA6/BA6



Single-side aligner

Canon PLA-501-FA



EB lithography

Raith 50
30nm, up to 3inch



Draft chamber

For development



UV curing

Ushio UMA-802



Spray developer

Actes ADE-3000S
-8 inch, vacuum/mechanical
chuck



EB lithography

Elionix ELS-G125S
Max130keV, 4nm, up to 6"

Oxidation, diffusion, ion implantation, annealing



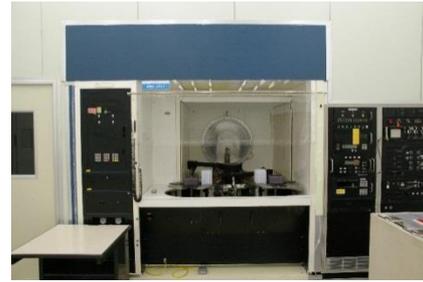
Oxidation/diffusion
furnace

TEL XL-7



Middle-current ion
implanter

Nissin ion NH-20SR
Max. 180keV, 0.6mA



High-current ion
implanter

Sumitomo eaton nova NV-10
Max. 80keV, 6mA



Annealing

AG Associates AG4100
1000°C



Metal diffusion furnace

Koyo lindberg Model270

Deposition (CVD, sputtering, evaporation, etc)



LP-CVD

Kokusai
SiN, Poly-Si, NSG



Thermal CVD

Kokusai
Epi-Poly Si, 1200°C



PE-CVD

Sumitomo MPX-CVD
SiN, SiO₂



PE-CVD

Sumitomo MPX-CVD
TEOS SiO₂



PE-CVD

JPEL VDS-5600
SiN, SiO₂



Sputtering

Anelva SPF-730
5inch target x 3



Sputtering

Shibaura CFS-4ESII x 2
3inch target x 3



Sputtering

Shibaura !-Miller
3inch target x 4

Deposition (CVD, sputtering, evaporation, etc)



W-CVD

Applied materials
Precision 5000



EB evaporation

Anelva EVC-1501



Automatic sol-gel
deposition

Technofine PZ-604



MOCVD

Wacom Doctor-T
PZT, up to 8inch

Etching



Si Deep-RIE
x 4

Sumitomo MUC-21



Dry etcher

Anelva DEA-506
For SiN, SiO₂ etching



Dry etcher

Anelva L-507DL
For Si etching



Al RIE

Shibaura HIRRIE-100



RIE

Ulvac RIH-1515Z
Cl₂, BCl₃, SF₆, CF₄, CHF₃, Ar, O₂, N₂



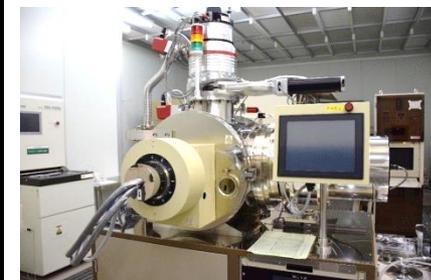
ECR etcher

Anelva ECR6001
3 inch GaAs



Asher

Branson IPC4000
13.56MHz, 600W



Ar ion milling

NS, Hakuto 20IBE-C

Bonding, packaging, imprinting etc.



Polisher

BN technology
Bni62



Polisher

BN technology
Bni52



Wafer bonder

Suss Microtech
SB6e



Dicer

Disco DAD522, DAD2H/6T



Wire bonder

West Bond
Al, Au



Reflow furnace

Shinko FB-260H/TE



Laser marker

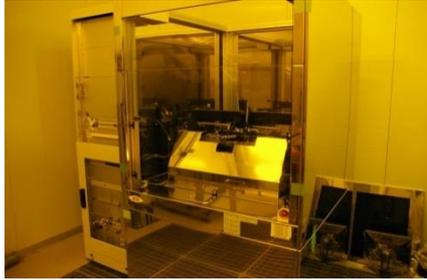
GSI WM-II



Sand bluster

Shinto

Bonding, packaging, imprinting etc.



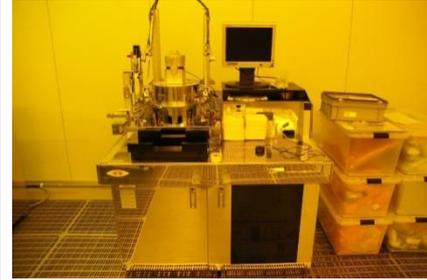
Wafer aligner

EVG Smart View



Wafer bonder

EVG 520



Epoxy injection chamber

EVG 520



UV imprinting

Toshiba machine ST50



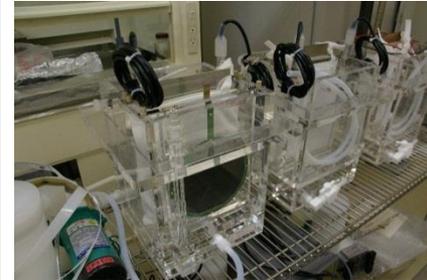
Thermal imprinting

Origin electric
Reprina-T50A



Excimer lamp cleaner

Dernaechste
EXC-1201-DN



Electroplating

Yamamoto
Cu, Ni, Sn, Au

Measurement



Wafer dust counter

Topcon WM-3



Film thickness measurement

Nanometric
NanoSpec 3000



Surface profiler

Dektak 8



Surface profiler

Tenchor AlphaStep 500



Depth measurement

Union Hisomet



4-terminal probe



Spreading resistance measurement

Solid State Measurements
SSM150



Wafer prober

Accretech EM-20A

Measurement



Laser/white light
confocal microscope

Lasertec
OPTELCIS HYBRID L3-SD



Digital microscope

Keyence and Kunoh



SEM

Hitachi S3700N
Max. 12 inch, EDX



FE-SEM

Hitachi S5000



X-ray micro CT

Comscan techno
ScanXmate D160TS110



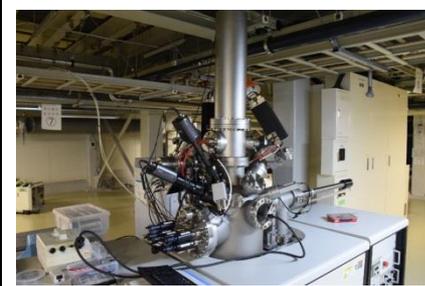
Ultrasonic microscope

Insight IS350



IR microscope

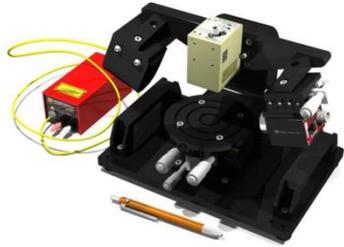
Olympus, Hamamatsu



TOF-SIMS

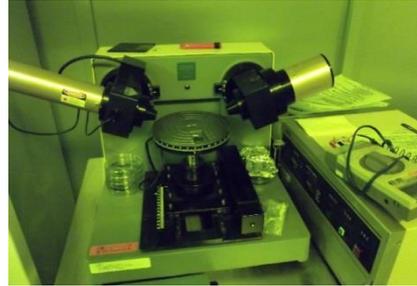
CAMECA TOF-SIMS IV

Measurement



Ellipsometry

Photonic Lattice SE-101



Ellipsometry

ULVAC



AFM

Digital Instruments
Dimension3100

How to use Hands-on access fab.

1. Consultation
2. Send application to the Univ.
3. Use facility at Hands-on access fab.
4. Receive bill from the Univ.
5. Payment



Fees

Facility (CR, office, etc.) usage fee : JPY 700 /h*

Technical assistant fee : JPY 5,565 /h (3,150/h)*

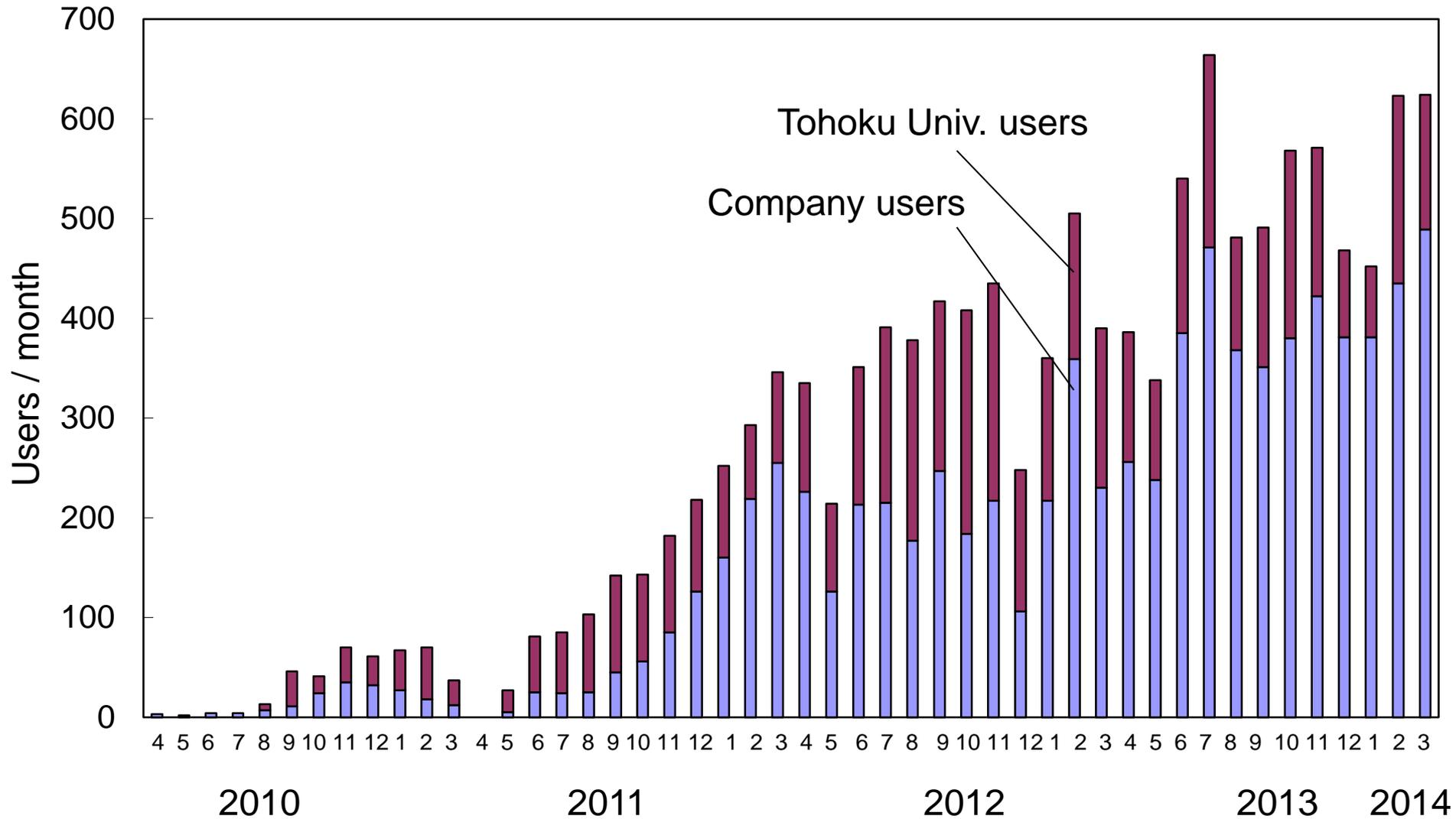
Equipment usage fee : max. JPY 10,000 /h

Materials cost

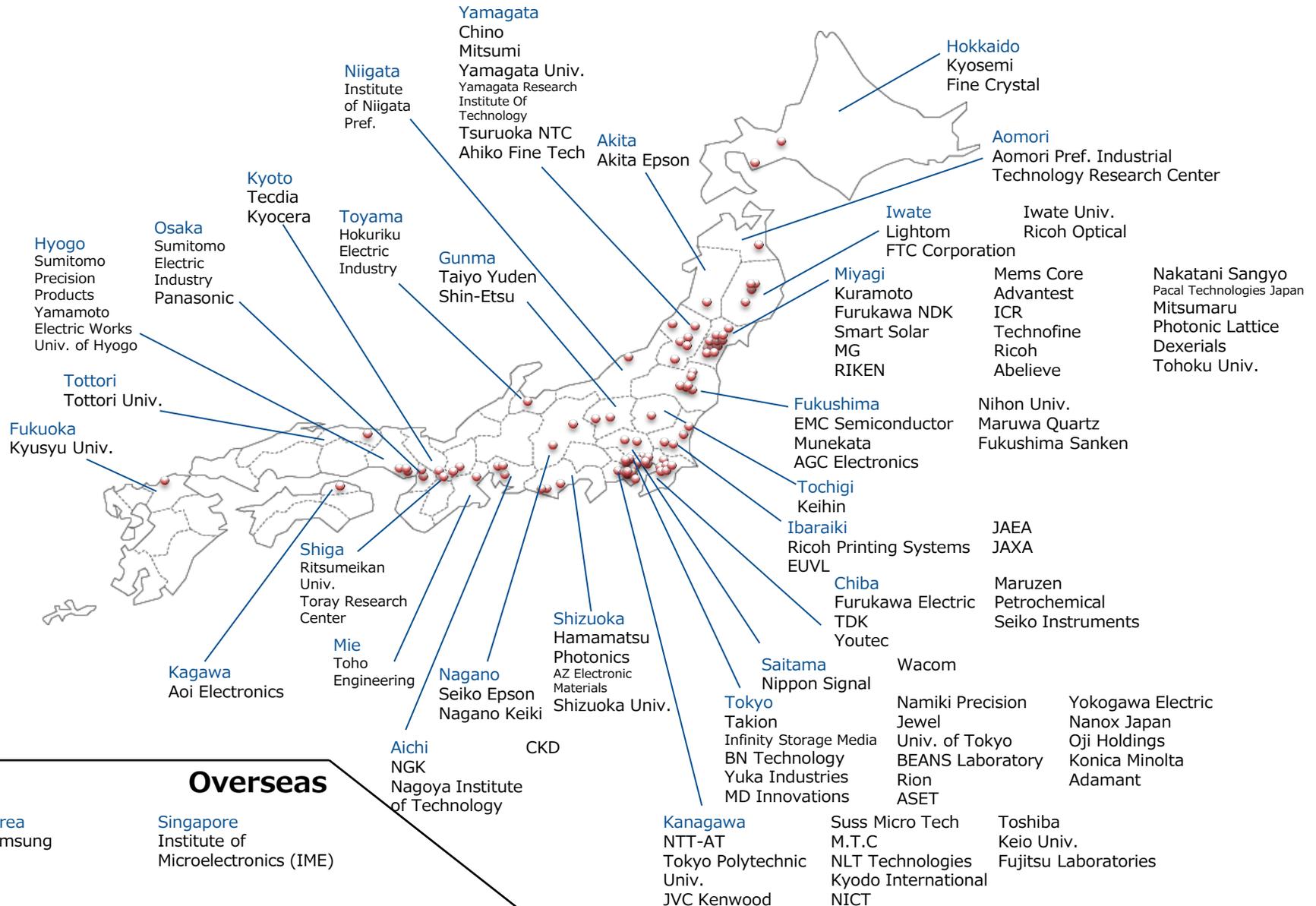
* Nanotechnology platform users

If a company uses the Hands-on-access fab for a week, the average payment will be JPY100,000. At the end of each month, the university calculates the fee for one-month usage of each company. Then in the middle of next month, the university sends a bill to each company.

Users



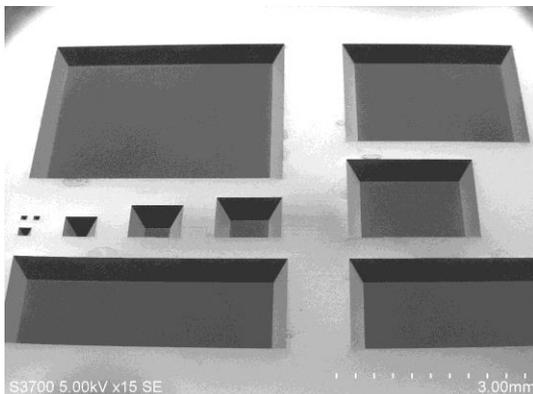
Users list (~150 companies)



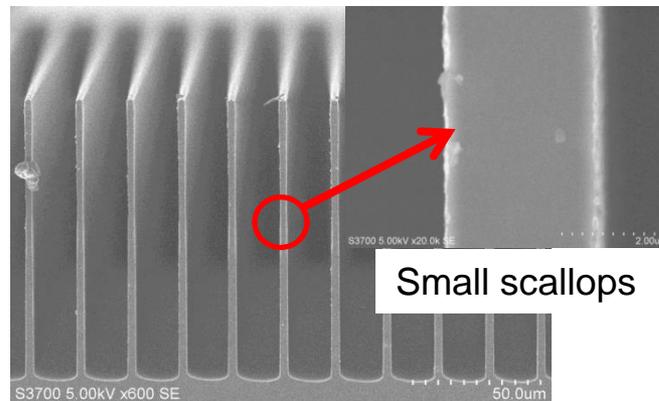
User cases

- Single process (deposition, etching, etc.)
- Total process (sensor, semiconductor, etc.)
- Evaluation (observation, measurement, etc.)
- Equipment manufacture's demo
- Training

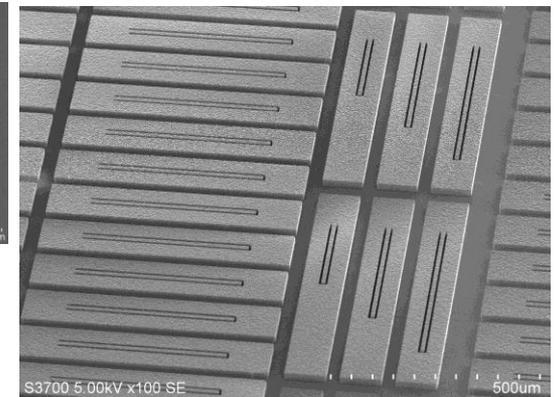
Si anisotropic wet etching



Si deep reactive ion etching

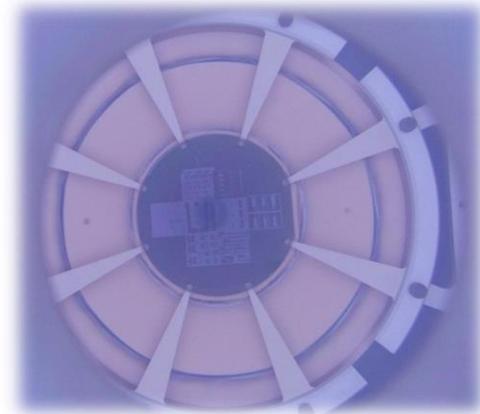


Epi Poly-Si over 20μm-thick

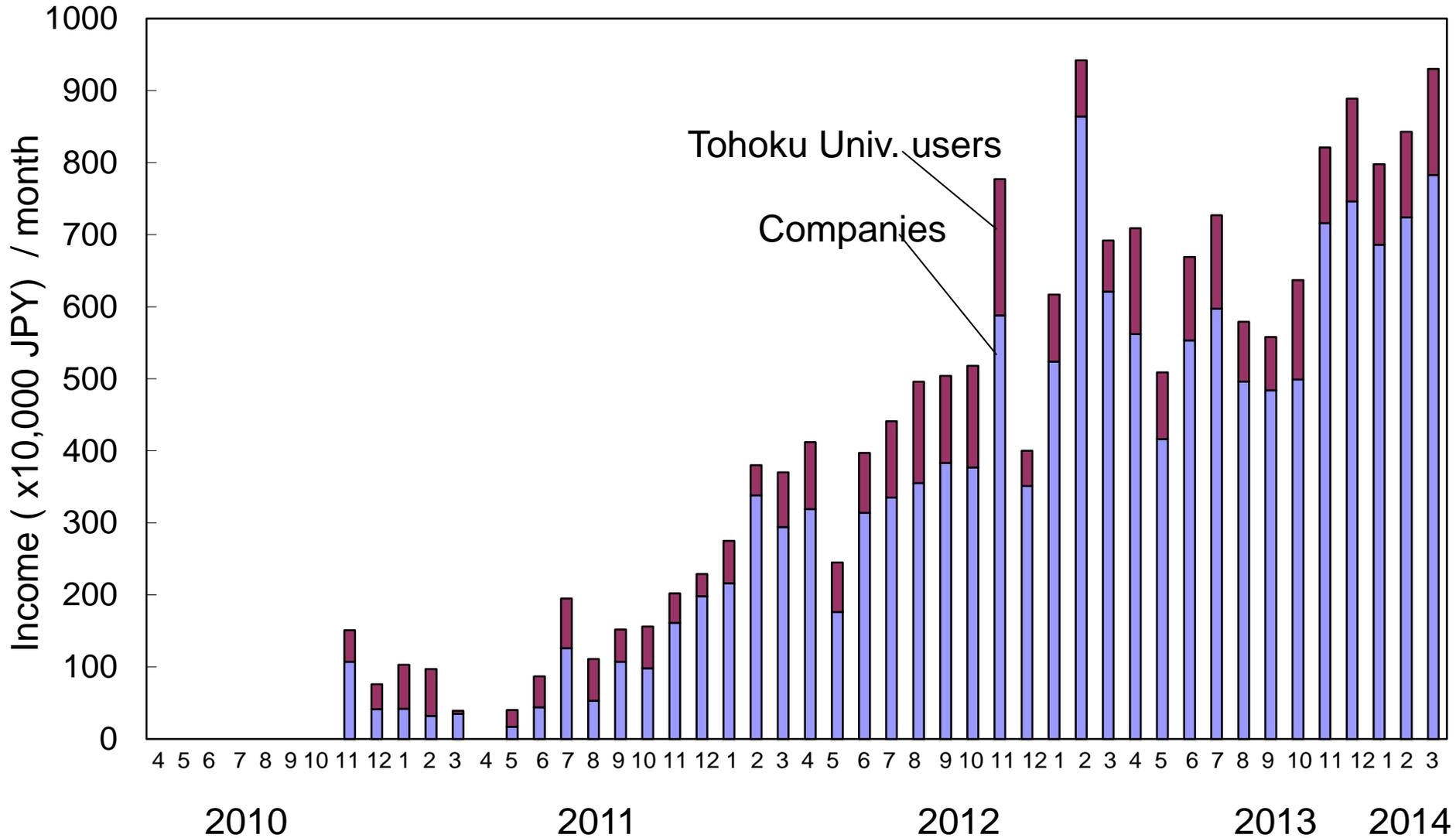


Device prototyping

- Acceleration sensor
- Pressure sensor
- Si microphone
- Magnetic sensor
- Gas sensor
- Photo diode
- Solar cell
- Quartz device
- Piezoelectric device
- Micromirror device
- Microfluidic device
- Radiation sensor(already commercialized)
etc.



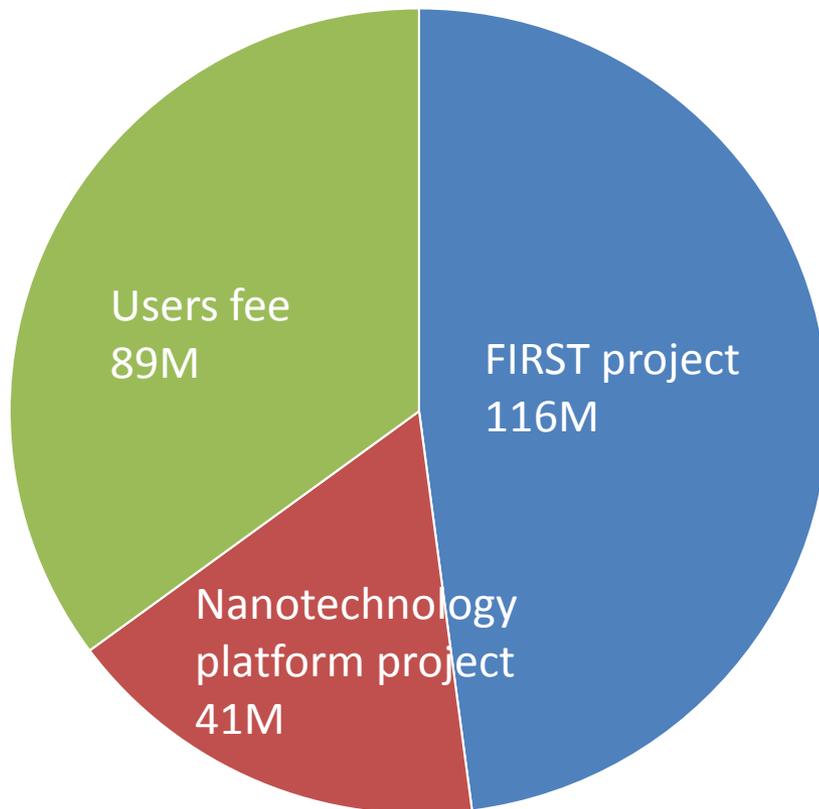
Income



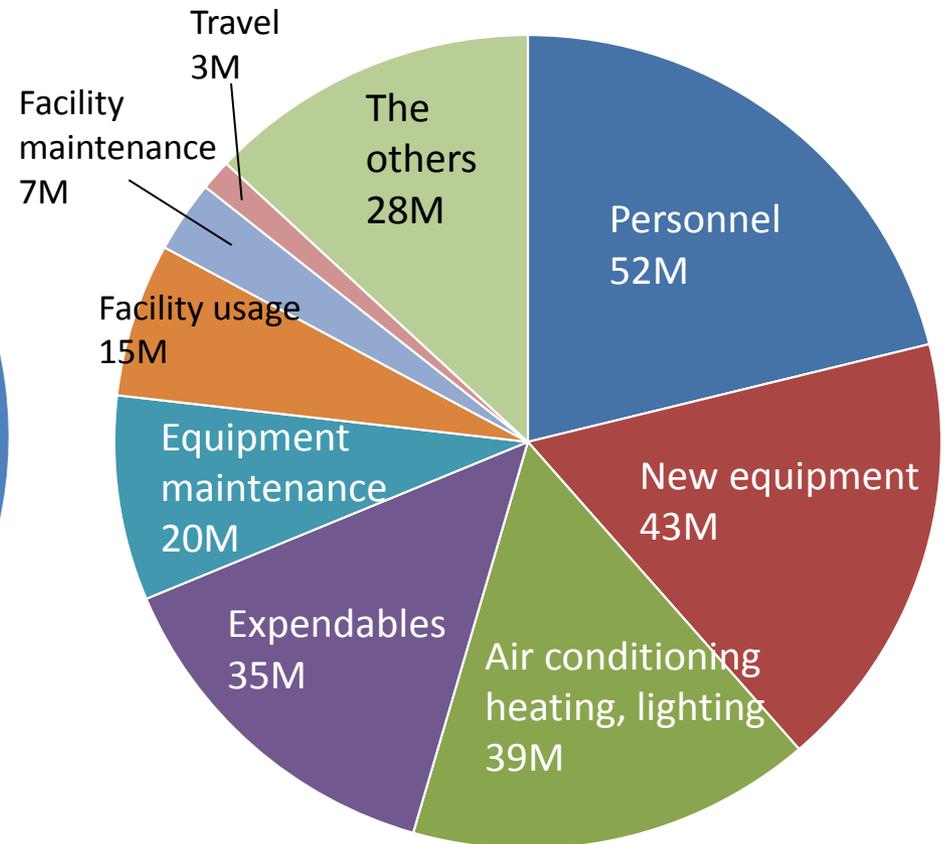
Revenue and expenditure (FY2013)

Total : JPY 246 M

Revenue



Expenditure



Activity

Providing the fab. service

Installation, modification and maintenance

Development of system including software

Booking system, information sharing, safety course

Process development

Fundamental technology (CVD, photolithography, etching, etc.)

New materials installation

Evaluation

Training

On the job training

Practical training program organized
by MEMS Park Consortium (3 months)

Training program for semiconductor
industry in Tohoku region



Thermal CVD for Epi Poly-Si



Power supply: 150kHz, 100kW

4" x 8" or 6" x 4"

Rotatable SiC susceptor

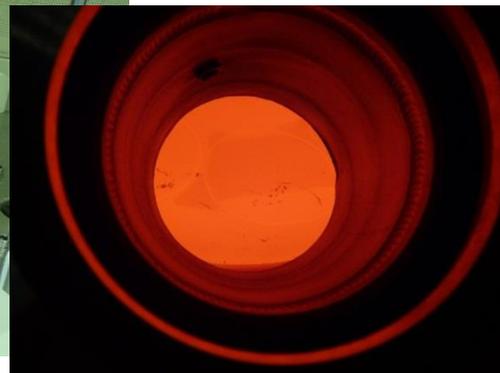
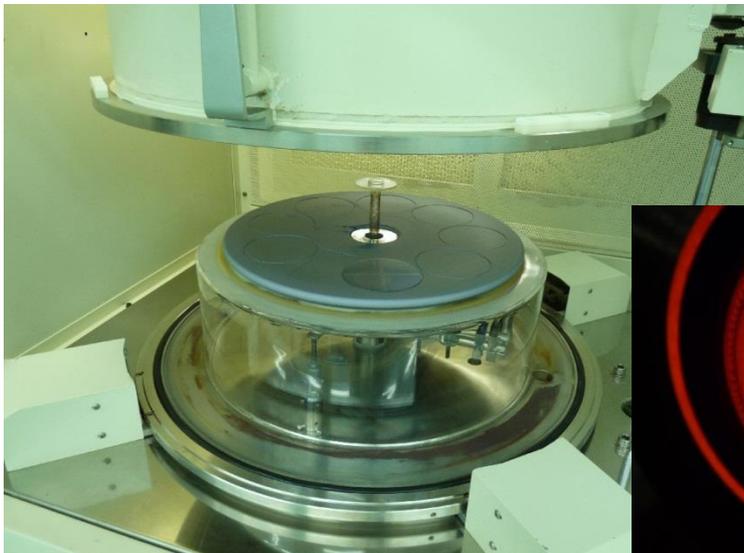
Max. temp. :1100°C

Source gas: SiH_2Cl_2

Doping gas: $\text{PH}_3(5\%)$

Carrier gas: H_2

Cleaning gas: HCl



Epi Poly-Si deposition

Thermal oxidation

SiO₂ 1μm



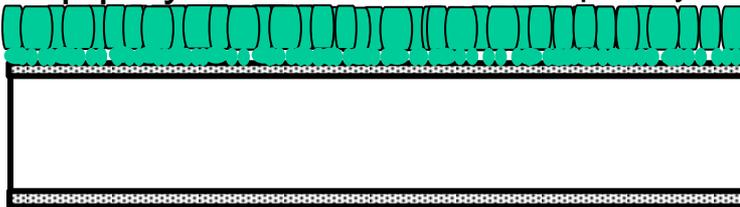
Poly-Si CVD, 800°C

Poly-Si 100nm



Epi poly-Si CVD

Epi Poly-Si

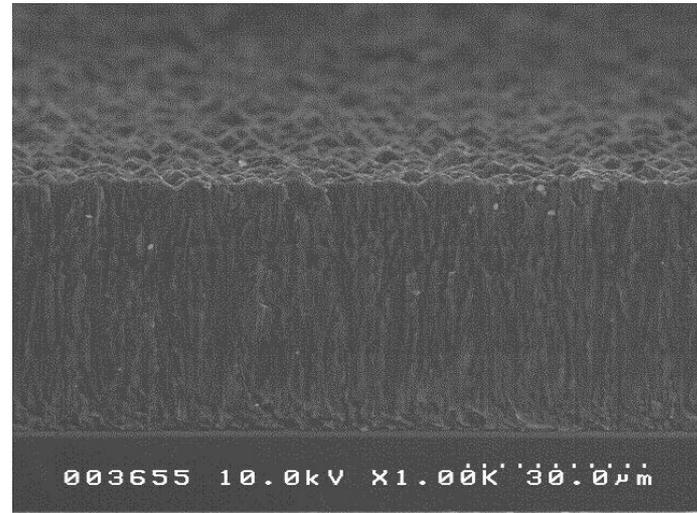
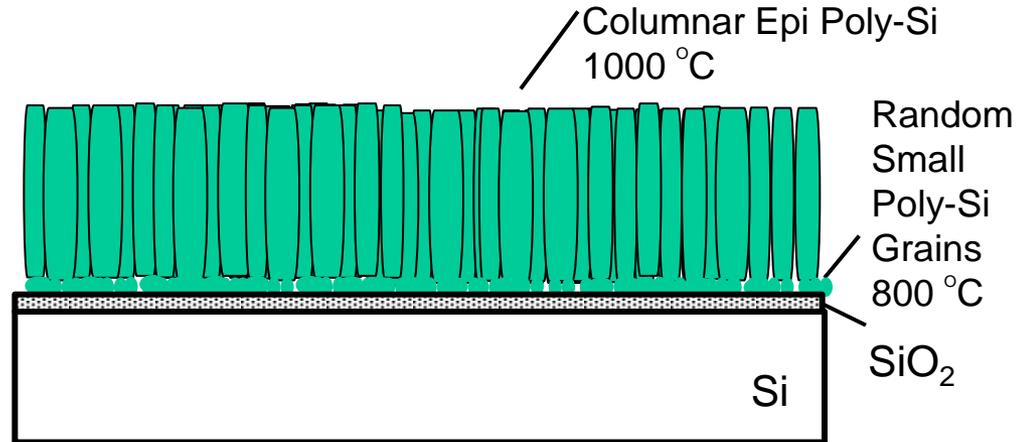


1000°C

SiH₂Cl₂: 200 sccm

PH₃(5%): 10 sccm

H₂ : 15 SLM

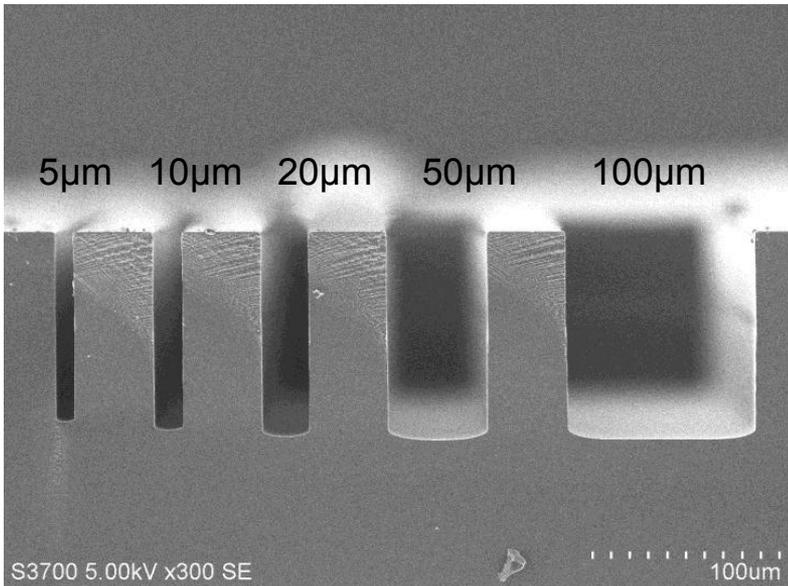


Deposition rate : 45 μm / 60min = 0.75 μm / min

Stress : 40MPa, compressive

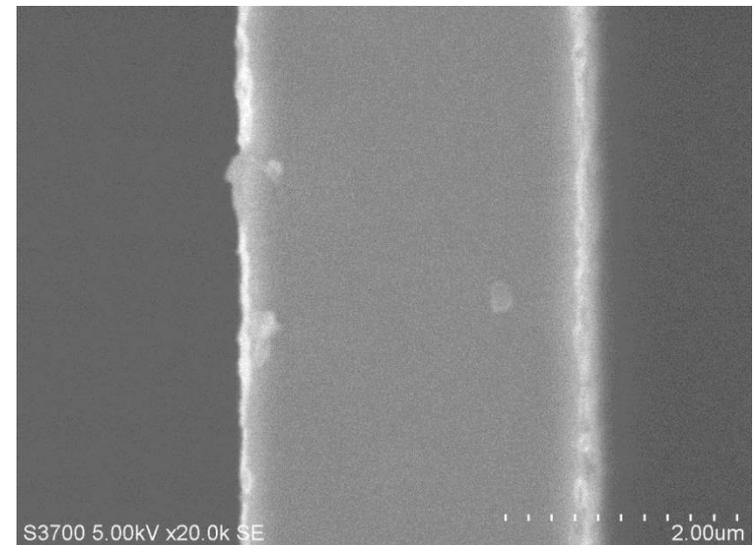
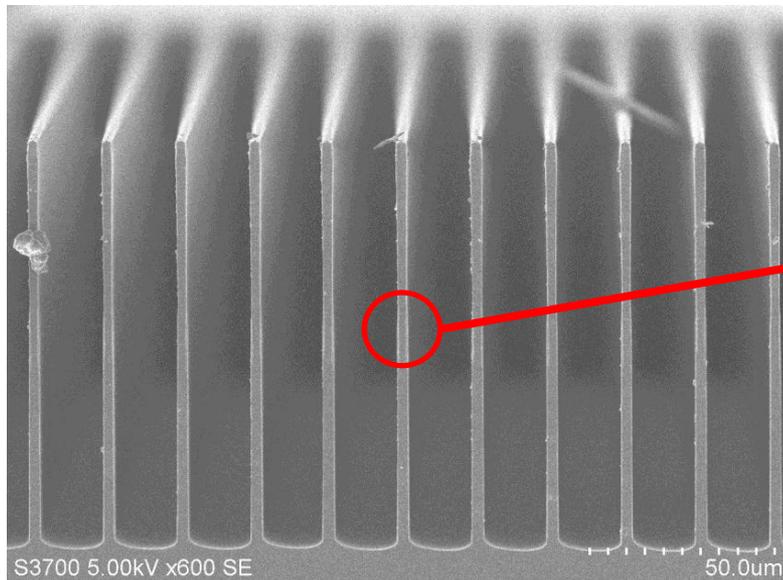
Resistivity : 0.002 Ω·cm

Si DeepRIE process development



Si etching rate: 2.5µm/min
Si/SiO₂ selectivity: 310

Small scallop

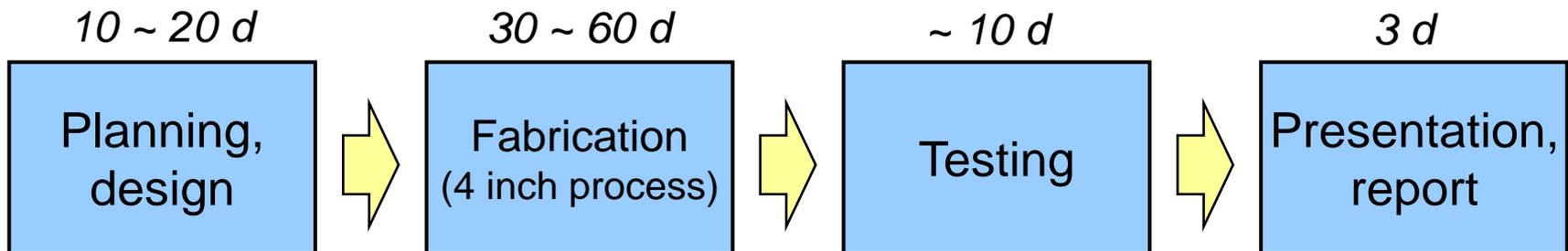


MEMS Training Program

- Originally started as a part of METI program in 2007 and operated by MEMS Park Consortium since 2008
- Comprehensive training program containing planning, design, fabrication, testing, report for MEMS R&D
- Practical training and lecture-based training
- The fee is approx. JPY 1M.



Ex. Capacitive 3-axis accelerometer



Participants:

RICOH, MEMS CORE, PENTAX, ADVANTEST, ALPS ELECTRIC, NIPPON DENPA, SYSTEC INOUE, YAMAHA, TOPPAN, KONICA MINOLTA, SEKISUI, MURATA, FUJI MACHINE, DENSO, AHIKO, YAMAMOTO ELECTRIC WORKS, JAXA

Product manufacturing

- Product manufacturing by company user is available since June 2013.
- The purpose of this production is
We prove University's R&D result as a product in the market and society.
Result or problem through production accelerates University's R&D and education.

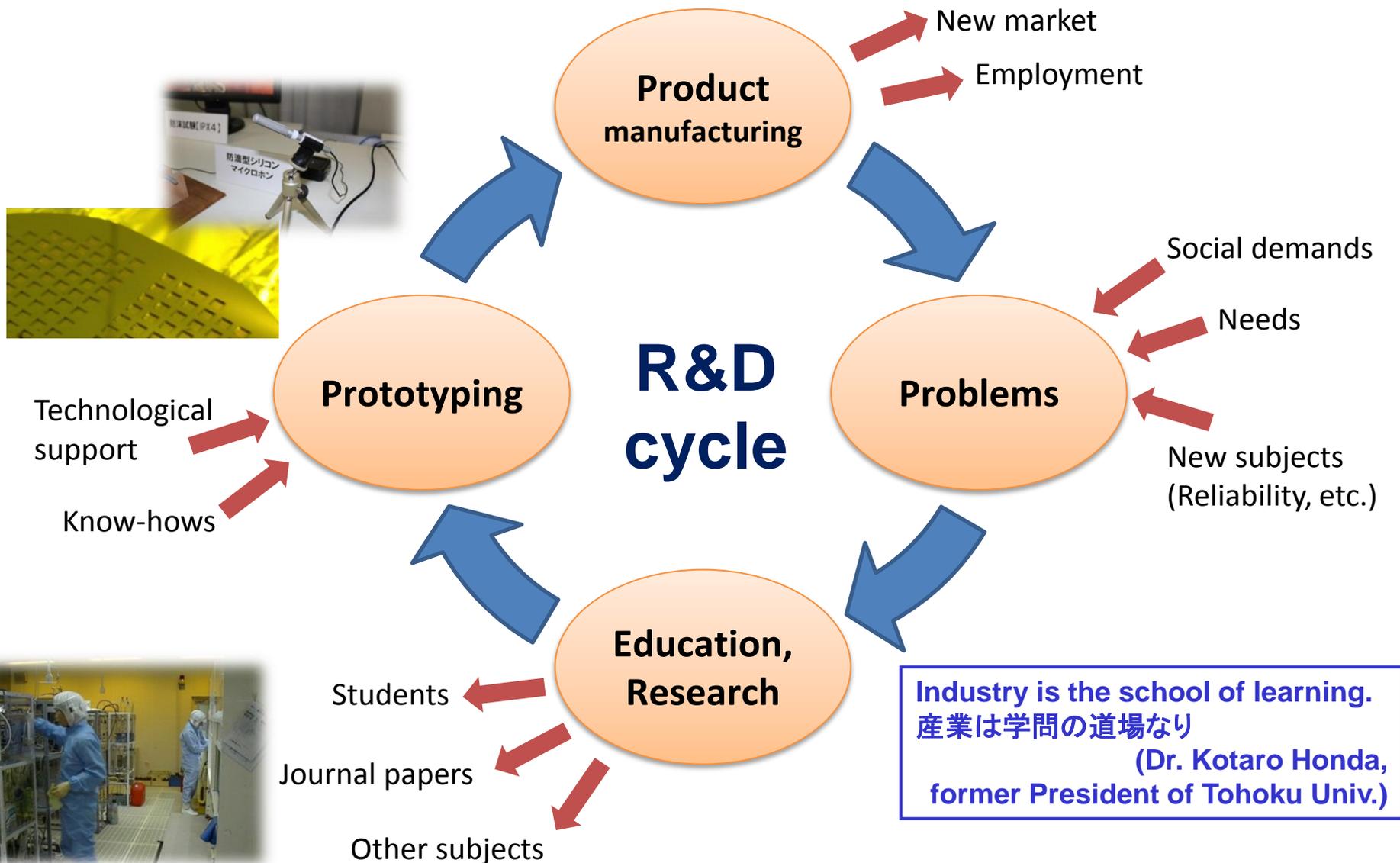
<Requirement>

- The device should be developed under University's cooperation, and should be continuously developed at the fab.
- Occupied area and time should be less than 5% of total capacity.
- A report to University is required every 6 months.
- Maximum period for one type of device production is 3 years.

<Note>

- University states exemption from responsibility.

R&D cycle model with product manufacturing



Challenge

Since starting of the Hands-on-access fab in April 2010, we re-start and modify old equipment, and install new equipment. Many company users have already accessed the fab. This result reveals that the hands-on system (open-access facility) is accepted by companies. We try to find out a sustainable model by making efforts to increase the number of uses. The fab continues supporting company to accelerate commercialization.

- Build up sustainable system
- Support new business, companies
- Develop and keep skillful engineers
- Improve and maintain quality of equipment
- Accumulate practical know-how



Hands-on-access fab, a part of your home facility

Acknowledgement

Equipment installation, operation, process development at the Hands-on-access fabrication facility are supported by following projects;

2010-2013

“Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST Program)” of the Japan Society for the Promotion of Science (JSPS), initiated by the Council for Science and Technology Policy (CSTP).

2012-

“Nanotechnology Platform” of the Ministry of Education, Culture, Sports, Science and Technology (MEXT).

2011-2012

“Innovation Center Establishment Assistance Program (corporate demonstration/evaluation facility development program)” of the Ministry of Economy, Trade and Industry (METI).

Hands-on-access fab. facility received “METI Minister Award 2013 for Industry-Academia-Government Collaboration Contribution”



