“Trust and Coordinate” - Case Study in UTokyo Nanofabrication Site with Nanotechnology Platform

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Hello from UTokyo VDEC TakedaSCR

- Since 2004
  - By donation of Mr. Ikuo Takeda to VLSI Design and Education Center (VDEC) in 2001.

- Total 600m²
  - 200m² Federal Class 1 SuperCleanRoom
  - 245m² Federal Class 100 SuperCleanRoom
  - 155m² Federal Class 1000 CleanRoom

- 4 billions yens for construction
  + 3.5B¥ equipment (equivalent value)

Mita ➔
Class 100 part
… and the people! UTokyo Nanofab Platform Team

We address core problem and develop necessary environment…

… and share the environment and technologies through Nanotech Platform
We address Micro & Nanotechnology:

- **Scale:** (sub)cm down to nanometer
  - *In-plane:* cm to nm
  - *Out-of-plane:* mm to angstrom

- **Devices as well simple structures**
  - *Micro Electro Mechanical Systems*
  - – Structures

- **Variety of Materials**
  - *Silicon, Glass, Plastics, New Materials*
Big machine to draw Nano, over Large area

- ADVANTEST F7000S-VD02 (since 2015)
  - 3rd Generation Machine: Character Projection
  - 1Xnm-node top resolution over 8-inch wafer (any materials OK)

1. Gaussian
2. VSB
3. CP

J_{\text{max}} = 100 \text{A/cm}^2
I_{\text{max}} = 640 \text{nA}

11M US$
Seeing is believing – What does MEMS look like…

- Well explained in my textbook

Voltage applied

Electrostatic force generated

-> Mass moves
Seeing is believing – What does it look like…

- Well explained in my textbook
Machines used to take photos / videos

**Still Image:** Scanning Electron Microscope

**Entry Model:** $100k

**Mid-range Model:** $1M

**Video:** Micro System Analyzer

**Stroboscope Mode:** $400k

1 US$ = 100 yens
How to make that MEMS?

- “Standard” Lithography and Etching processes in cleanroom.
  - Class 1&100 Super Cleanroom in Hongo Main Campus
  - Direct Pattern Drawing with high-throughput Electron Beam writer
  - Deep Reactive Ion Etching with ICP plasma + Bosch process
  - Vapor HF acid etching in clean draft
  - Chip separation by Stealth Dicing
  - Wire Bonding on PCBoard

Design to Device: 1 day in UTokyo Site (superexpress)

Done!
So the common headache of researchers:

- Where is SUCH BIG Budget to buy apparatus?

Nowhere!

Clearly, we need some “strategy”
Strategy of Machines Acquisition in UTokyo Takeda

① Donation

② Annual National Budget allocated to Institution + users fee

③ (Occasional) Supplemental National Budget

④ Individual Research / Education Projects
   ① Big research project in of researcher
   ② Educational project of department

⑤ Collaboration with Company
   ① Free-of-charge rental

- 1onders
- 2nd EBW
- 1st EBW
- Building/CR
- 1ton/h DI water system
- VHF etcher
- SEM (small)
- Bonder
- LEWM
- Deep Etcher
- MSys.Analyzer
- Stealth Dicer
- Laser PWB

$40M
$11M
$1M
$50k
$100k
$50k
$11M
$1M
$11M
$1M

2012.03.27 Nanonet
Summary: my MEMS lecture Machine is jointly supported by:

1. **Donation**: $12M (+ $40M (building))
2. Annual National Budget allocated to Institution: $200k
3. Occasional Supplemental National Budget: $12M
4. Individual Research / Education Projects: $1.5M
   - Big research project in of researcher
   - Educational project of department
5. **Collaboration with Company**: $1.8M
   - Free-of-charge rental

Total: for $27.5M for machine sets plus $40M for building
Mita’s 10% strategy – to both ensure repairing and acquisition

- Rule of thumb: 10% of total budget fluctuates because of as unexpected breakage of machines.

  Then strategy is naturally...

- Take the “safe” budget management: take this 10% into account

  If we are lucky enough,

- In the end of financial year we end up with 10% of “surplus”

  If budget system is flexible

- We can buy new equipment in next financial year.
The machines that used such strategy

- Sputtering machine (medium-price, top-class demand)

Problem:
The financial system must admit “strategic use of risk management budget”:
- Freedom of purpose
- Somehow “pass over” financial year

$250k
Common headache of researches (bis):

- Where is SUCH BIG Budget to buy apparatus?

Nowhere!

Up to year 2000s over the world:
- Each PI acquired apparatus one-by-one,
- by “their own” research proposals.
- Common use of small (department level) “group use” was common also.
- End of budget = end of maintenance = end of machine.
Networked Nanofab Infrastructure Appeared

- National Nanotechnology Infrastructure Network (NNIN) and variants appeared worldwide since 2000s.
  - USA: NNIN (2001-): NSF Funded Research Infrastructure Project
    - 2nd phase (2016-): NN Coordinated Infrastructure (NNCI) 16 Unv.
  - France: RTB-RENATECH (2003-): Ministry of Higher Education Funded Project, CNRS Operated one = RENATECH.
    - 6 Big Research Institute Cleanroom (later merged to 5) + CEA LETI
    - Still continues now but budget is reduced since 2013.
    - 7 Universities & Public Research Institutes for Nano Fab. sites
    - 4th phase: MUST BE CONTINUED!!
  - Now (as of 2019) many countries have similar project.
    - EuroNanoLab Network
    - Indian Nanotechnology Center (such as IITB)
Many things changed

- **Before:** Only internal institute cooperation system
  - UTokyo: since 1979 (Pr Takuo Sugano)

- **After:** Institute started to learn that “external”s are important
  - User point: To mutualize the machine that does not exist in the institute,
  - Manager point: Not to have too much redundancy in machine investment plan by networking.
  - Institution point: The new opportunity (themes) comes automatically.
Nanotechnology Platform Nanofab. part

- Nanotechnology Platform: MEXT’s 10 years project
  - 2012-2021
  - 35 sites in total
  - in 3 layers

- Nanofab Platform
  - Coordinated network
  - 16 sites
  - 13 Univ. 2 national RI, 1 Public Institute

- Hokkaido U.  Tohoku U.  Toyota TI
- AIST  Toyota
- NIMS  Nagoya
- Tsukuba Univ.  Kagawa U.  Kyoto U.  Osaka U.
- Univ. of Tokyo  Hiroshima U.
- Waseda U.  Yamaguchi U.
- TITech  FAIS
EuroNanoLab received political support from 8 counties:

- France (lead partner) political and financial support
- Czech Republic political and financial support
- Norway
- Sweden
- The Netherlands
- Italy
- Spain
- Portugal

More countries will be included in the next phase.

Courtesy of Pr. M. de Labachereie
International Inter-Network Exchange

- RENATECH-Nanofab run exchange program
  - Delegates visit 2016
    - 13 persons
    - AIST (Tsukuba),
    - NIMS (Tsukuba),
    - U.Tokyo,
    - Kyoto U.
    - Joint workshop (continuing)

13 French delegates from 5 centrales
RENATECH delegates @ UTokyo VDEC Takeda Building

Pr. M. de Labacherrie, RENATECH/EuroNanoLab Coordinator
Open discussion in machine investment strategy was coordinated by RENATECH.

Outcome:

- Redundancy reduced: not to buy same equipment if expected usage is not too high
  - Now researchers know centrales are networked: started to trust others
- New technologies using same type of new machines
  - Strategically develop different technology on new machine: ALD

Nationwide Networking coordination is important and efficient

Pr. M. de Labacherrie

ça suffit souvent de faire circuler l’information

often it is sufficient to make the information circulated
Future Direction
The UTokyo Nanofab Strategy: Number is Power

- **Subscribed Groups: 361** (cf. FY 2012: 20)
  - 108 enterprises (85 big / 23 small)
  - 121 Externals (100 univ / 21 public)
  - 132 UTokyo (65 F.Eng / 56 others / 7 internal / 4 education)
  - 750 subscribed members (300 novices)

- **Active Groups: 139**
  - 43 Enterprises
  - 34 External Univ/Public
  - 62 UTokyo
  - 450 members used CR
Payments by user: lognormal

- FY2018: 77M yens (700k euros) paid by users
  - Including my group (the heaviest user)

![Payments Ranking (Logscale)](image)

Very light “charge” to researchers.
User Coverage: 30% operation cost

- Full Financial Expense 2018: 390M ¥
  - Operation Cost 240M ¥ + New Machines 150M ¥
    - Salaries 82M, Electricity 34M, Maintenance 66M, Consumables 31M, Indirect Cost 16M, Others 11M
    - User Fee 77M, Nanotech Platform 171M, VDEC support 75M, Permanent Staff 25M, Lab Project 22M, Tenant Fee 20M

Expenses 2018:
- Machines 38%
- Salaries 21%
- Electricity 9%
- Maintenance 17%
- Consumables 8%
- Indirect Cost 4%
- Others 3%

Incomes 2018:
- User Fee 20%
- Nanotech Platform 44%
- VDEC support 19%
- Permanent Staff 6%
- Lab Project 6%
- Tenant Fee 5%
Headache of the Manager…

- How to explore revenues *other than* user fee
  - In order to sustainably keep trial hurdle as low as possible

- Our policy: RI level trustiness:
  - Open² platform
  - Equal partnership
    - share everything

- Still “factor 3” remain
  - Between “affordable” and “necessary” operation cost: $\times 3$
  - Between “operation cost” and “machine investment”: $\times 3$
  - Summary: “affordable” $\times 3 = “operation”, \times 3 = “machine”

- My strategy to fill the 70% gap of operation…
  - Increase “Big users”
  - while keeping med-small users

Chance must evenly be given to everybody: the lower pay is the better

We will go altogether
for better or for worse (project)
for richer or for poorer (budget)
in sickness and in health (equipment)

Industrialization
Future Direction 1: Market Prototyping (or small-volume production)

- Allow users to keep using the same fab, and “sell” the fabricated device before the production can become “medium-size”.

### Nanotech 1.0

- Machine Sharing

### Nanotech 2.0

- Scientific / Technical Feasibility Study

### Nanotech 3.0

- Market Feasibility Study

### Open Competition

Some word in recommendation preferred.
Future Direction 2: “One Team” pass-and-run scheme

Taking Analogy of Nanofab Research to:

- RI A
- RI B
- RI C
- RI D
- RI E
- RI F

Start: Material → Device → Goal: Research Data

【Fabrication】 → 【Integration】

Traditional: SingleRI “try” the goal

New Model: “Pass and Run” to the goal
Summary: The Success cross

Number is power

Increase of users = increase of opportunity (+income for RIs)

Flexibility

RI should be ensured his flexibility to optimize the investment

“One Team” Coordinated Networking

Trust other institutes = remove redundancy + improve resilience + strategic technology development

Industrialization (in case of M&N fabrication sites)

Small-volume production must be not impeded any more, (under clear rule and accountability)

协调与金融支持是重要的

从“无处”到“现在这里”！
My last words...

- Research Infrastructure is “Infrastructure”
  - It must be there “before” research vehicles rides on
- Must be connected (no gap), and maintained forever
  - Policy may vary (more to countryside? city center?)
- Coordinated Infrastructure with mutual trustiness proved to be important
  - Top-down framework (government) + bottom-up coordination (Institutes)
Fair Currency Conversion Rate:

- **Burger King**
  - Whopper in Enschede: € 5.3
  - Whopper in Tokyo: ¥490
  - 1€ = 92.4¥

- **City Bus**
  - From Enschede CS to Twente Univ: € 2.3
  - From Ueno-Matuzakaya to Nezu: ¥200
  - 1€ = 71.2¥

- **University Faculty Lodge**
  - U Park Hotel Twin: €125
  - Faculty House Twin: ¥8,900
  - 1€ = 87.0¥

Should be: 1€ = 83.5¥; Today’s rate 1€ = 121.65¥
From Technology to Application

- Three layers configuration

Nanotech Platform not only work on level 1 but also on level 2. Nanotech platform team may do level 3 research as a user.