MEMS Innovation at Tohoku University

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TOHOKU UNIVERSITY Sendai, Japan

The 100th Anniversary of Tohoku University in 2007

Tohoku University was founded in 1907 as the 3rd National University

Fundamental Policies

1. “Research-intensive University” as its mission
2. “Have University’s doors open to the World and Community” as its principle
3. “Development of Leading Human Resources” as its educational goal

TOHOKU UNIVERSITY Sendai, Japan

Major Research institutes with our tradition of “Practical Science”
- Institutes for Materials Research
  - KS steel by Dr. Kotaro Honda
- Research Institute of Electrical Communication
  - Yagi Antenna by Dr. Hidetsugu Yagi
- Semiconductor Research Institute, Semiconductor Research Foundation
- Research Institute for Electric and Magnetic Materials

Forerunner of University Ventures before the Second World War
- Tohoku Metal Industries Co., Ltd. (present: NEC TOKIN Corporation)
- Yagi Antenna Co., Ltd. (present: Hitachi Kokusai Electric Inc.)

Overview of TOHOKU UNIVERSITY

Research and Education Organization

From Tokyo to Sendai: 96 min
Population of Sendai: 1 million
Result of popularity vote in 2004:
1st: Sapporo, 2nd: Shizuoka, 3rd: Sendai, 4th: Tokyo

Bullet train “Shinkansen”

Nature, 2006

Yagi-Uda Antenna(1929)
Magnetoron(1927)
Magnetic recording system (1932)

A congratulatory message on the establishment of “Tohoku Metal Industries Co., Ltd” by Dr. Kotaro Honda

Institutes for Materials Research
- Institute for Development, Aging and Cancer
- Institute of Fluid Science
- Research Institute of Electrical Communication
- Institute of Multidisciplinary Research for Advanced Materials
- Biomedical Engineering Research Organization (TUBERO)
- University Collaborating Institutions

Administration Bureau
University Library(s)
University Hospital
Faculties and Institutes
- Arts and Letters
- Education
- Law
- Economics
- Science
- Engineering
- Agriculture
- Dentistry
- Pharmaceutical Sciences
- Veterinary
- Graduate School

Graduate Schools
(15)
(10)
Professional Graduate Schools
(3)
School of Public Policy
School of Accountancy
Law School
School of Public Policy
School of Accountancy

Inter-Department Institute for Education and Research
Biomedical Engineering Research Organization (TUBERO)
Overview of TOHOKU UNIVERSITY

Liaison and Overseas Offices

As of July 2007

University of Cambridge
Moscow State University
Syracuse University
Royal Institute of Technology
Institute National des Sciences Appliquees de Lyon
The University of New South Wales
Tohoku University US Office
Stanford University

Resource: ISI Essential Science Indicators

Overview of TOHOKU UNIVERSITY

Research Paper Citations

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<tr>
<th>National Ranking</th>
<th>International Ranking</th>
<th>Field</th>
<th>Citations</th>
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<td>All Fields</td>
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MEMS: Micro Electro Mechanical Systems

Tiny system combining electrical and mechanical components

ex.) Gyroscope, TOKIMEC, Japan

2-axis angular velocity and 3-axis acceleration
Mechanical part: 4mm silicon rotor
Electrical part: Electrostatic levitation control
rotation speed: 12,000 rpm

working as “the heart” or “the key” in a system

MEMS products from Tohoku Univ-Industry collaboration

Niki-Sango (Dec. 12, 2003) Catheter pH, PCO2 monitor (Nippon koden) Portable pH sensor (Shindengen)

Topcon (Nippon koden) Diaphragm vacuum gage (Canon anelva)
MEMS microphone (NKH, Panasonic)

Toyota motors (Ad vantest) Resonating gyroscope (Tokimec)
MEMS relay for LSI tester (Advantest)

Rockwell (Nippon signal) Electrostatically levitated rotational gyroscope (Tokimec)

Pyrite detector (Nippon signal)

Resource: ISI Essential Science Indicators

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MEMS R&D at Tohoku Univ ~over 30 faculties~

Prof. Esashi MEMS
Prof. Hane Optical MEMS
Prof. Kuwano Nano-system Sensor system
Prof. Yamaguchi Magnetic, RF MEMS
Prof. Mura MEMS fracture analysis
Prof. Nakazawa MEMS
Prof. Kobayashi LSI-Bio fusion, Packaging
Prof. Arai Bio, Medical MEMS
Prof. Shikama Plasma nano-processing
Prof. Haga Medical MEMS
Prof. Yuge Micro energy source

MEMS: M sensor (JTEKT) (Canon anelva) (NHK, Panasonic) (Nippon signal)
Working as “the heart” or “the key” in a system

Integrated capacitive pressure sensor (JTEKT)
Diaphragm vacuum gage (Canon anelva)
MEMS microphone (NKH, Panasonic)

Pyrite detector (Nippon signal)

MEMS relay for LSI tester (Advantest)
Sacificial dry etcher (Chemtronics)
**MEMS R&D facility at Tohoku University**

- 120 m² MEMS clean room
- 400 users and 40 laboratories registered
- 2 cm x 2 cm, 2 and 4 inch facilities
- More than 100 companies dispatched their researchers (full time)

**National project on MEMS at Tohoku University**

- Special Coordination Funds for Promoting Science and Technology supported by MEXT (Japanese Ministry of Education, Science, culture, sports)
- Formation of Innovation Center for Fusion of Advanced Technologies on; **Tohoku University R&D Center of Excellence for Integrated Microsystems**
  - Term: 2007~2016 (Max.)
  - Budget: ~$70M

**Concept**

- R&D center based on open innovation
  - Next generation industry-university linkage system
  - Human resource development beyond several fields
  - Seeds of next generation industry
  - Integrated microsystem technology

- Creative space for intelligent production
- Safety space for automobile
- Required technology Microsystem process for MEMS-LSI integration

**R&D Center of Excellence for Integrated Microsystems**

(Formation of Innovation Center for Fusion of Advanced Technologies sponsored by Ministry of Education...) 2007~2009 (2016)

**MEMS + LSI (SoC(System on Chip) & SiP(System in Package))**

- Arrayed MEMS, Capacitive sensors, RF integrated MEMS, Disposable devices
- Realize MEMS having good mechanical property on advanced small feature size LSI

**Problems to be solved:**
- Low temperature processes (bonding or deposition) for MEMS having good mechanical properties for micromechanical resonator, switch etc..
- Damage-free and compatible processes (temperature, etching, electrostatic discharge etc.)
- Packaging, Test, Interconnection and so on.

**Structure**

- RICOH
  - Core company
  - Member company
  - TOYOTA
  - PIONEER
  - SUMITOMO PRECISION
  - KITAGAWA
  - NIPPON SIGNAL
  - COPAL
  - NDK
  - MEMSAS

- Toyota motors
- Pioneer
- Nippon signal
- Kitagawa machine works
- Sumitomo precision
- Nippon densan copal
- Nippon denpa
- MEMSAS
- Tohoku Univ.

**Shuttle service shared in project**
- Low temperature additive MEMS process
- (MEMS core)

**Shuttle service shared in our project**
- + Low temperature MEMS process
Next generation wireless system group
Esashi, Yamaguchi, Yugami, Tanaka, Ono
Toppan TDC, Pioneer, Nippon Denpa Kogyo, Ricoh, NICT

Wireless sensor, Ultra-Sensitive sensor group
Mura, Kumano, Esashi, Ono, Tanaka, Nogawa
Kitagawa, Sumitomo precision
Product, Toyota motor, Nidec copal electronics

Optical microsystem group
Hane, Kanamori, Totou, Kawai
Ricoh, Nippon

Biomedical Microsystem group
Matsue, Nishizawa, Abe, Haga
MEMSAS

Fabrication Test Equipment group
Samukawa, Miura, Yamaguchi, Ono, Kumano
Ricoh, MEMS

Technology Society System group
Ueyama, Kumano, Totsu, Takahashi

BioMedical Microsystem group
Matsue, Nishizawa, Abe, Haga
MEMSAS

Blood pressure sensor
Bio sensor

Fabrication Test Equipment group
Samukawa, Miura, Yamaguchi, Ono, Kumano
Ricoh, MEMS

Technology Society System group
Ueyama, Kumano, Totsu, Takahashi

MEMS CORE Co., Ltd
MEMS manufacturing services

FREESCALE SEMICONDUCTOR JAPAN Ltd
Sendai R&D design Center

TOHOKU SEMICONDUCTOR CORPORATION
Accelerometer, pressure sensor

SiS MICRO PARTS LTD
Micro battery

ADVANCE ORPHER CORPORATION
RF-MEMS (high-frequency switch)

RICOH TOHOKU RESEARCH CENTER
Applied researches of MEMS

MEMS activity in Sendai area

“Science Park” Plan
Creation of new academic integration and integrated field of Industry-University-Government relations
Bases for Personal exchange and for creation of new technology/industry

University opened up to the region and the world
Tohoku University
Science Park
Industry

Providing Melting Pot

• Large scale innovative Joint R&D center
• Middle size innovative Joint R&D center
• Incubator, Cooperative research building
• Center building, Collective research building

Groups of Domestic overseas industrial cluster
• Venturing firms
• Supporting industry

Other Universities
Suggestion for Needs
Seeds

New Aobayama campus framework plan
(new campus in orange, existing campus in black)

The Aobayama campus will be extended by some 81 hectares and part of the new site will be available for the science park.

As a result, Tohoku University hopes to entice about 50 companies to the park. It will provide various support infrastructures for the park’s tenant companies, including access to existing research facilities at the university, and an opportunity for new business. Foreign companies are welcome!

Thank you for your attention!!
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