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New Year’s Greetings

Hisao Sakuta, Chairman
Micromachine Center
BEANS Laboratory

As we welcome in 2011, it gives me great pleasure to wish you all a happy New Year and to offer some thoughts on this new beginning. First, I would like to express my gratitude to all who have given their cooperation and support to the Micromachine Center and the BEANS Laboratory.

Approximately one year and three months have passed since September 2009, when I assumed the post of chairman for both entities. During this period, Japan’s economy has begun to show some signs of recovering from the failure of Lehman Bros. and the Dubai debt crisis, but the state of Japan’s industry has not yet stabilized due in part to financial crises in Greece, Ireland, and other EU countries, the effects of a strong yen, and increased competition in manufacturing industries from emerging nations such as China. In order to break out of this situation, it is essential that we intensify our efforts in technological development, which is the key to keeping Japan’s industries internationally competitive. For this reason, it remains vital for us to continue intensifying our efforts in technological development related to MEMS and other micro/nano fields, now considered important industrial technologies. As chairman I will strive to continue our efforts in developing micromachines, MEMS, and other micro/nano fields, and I shall be grateful for your support.

To accomplish this, the BEANS Project (the Hetero-functional Integrated Device Technology Development Project) was launched in 2008 to develop core process technologies required for creating innovative next-generation devices and to build a platform for this development, with the aim of developing applications in a wide range of fields that include energy and the environment, safety and security, and health and medical care, as well as in traditional fields of application. We hope to increase and expand the market for micro/nano devices by creating new devices to support Japan’s industry across diverse fields. It gives me great pleasure to announce that we have received high marks through the first half of the project. For the remaining two years, we will concentrate all of our efforts toward implementing the BEANS Project, focusing on research activities aimed at producing results that will lead to commercialization.

The previous year also marked the beginning of the G-device Project aimed at developing an advanced sensor network and environmentally friendly manufacturing processes. Through this project, we installed advanced manufacturing equipment at AIST Tsukuba for fabricating 8-inch MEMS devices and began preparing the groundwork for the Tsukuba Innovation Arena NMEMS in close cooperation with the MEMS Industry Forum of the Micromachine Center and AIST.

In addition to constructing TIA-NMEMS, the Micromachine Center has continued working to create a better environment for MEMS industrialization in Japan by promoting international standardization in MEMS fields and performing activities aimed at industrial exchange and vitalization, for example.

Further, in response to the three laws on reforming the public interest corporations system, the Micromachine Center submitted an application to the Cabinet Office for changing its current public interest status to that of a general incorporated foundation.

In the event that our application is approved, we will reevaluate our roles and responsibilities as a general incorporated foundation and will continue our activities in the hope of contributing to Japan’s international competitiveness in industry and to the creation of a future affluent society.

Finally, on behalf of the Micromachine Center and the BEANS Laboratory, I would like to offer you all my sincerest wishes for a fruitful year. Thank you and Happy New Year!

January 2011

Column

New Expectations for MEMS Devices

Isao Shimoyama, Professor
Department of Mechano-Informatics
Graduate School of Information Science and Technology
The University of Tokyo

Vietnamese Exchange Students and Japan's Aging Society

There are three Vietnamese students working in our laboratory, and all of them are excellent at their work. In fact, all three had papers selected for presentation at the international conference MEMS 2011, which will be held in Cancun, Mexico in January this year.

According to *The University of Tokyo Guidebook*, the number of foreign students accepted at the University of Tokyo in 2010 accounted for 250 of the total 14,172 undergraduate students and 2,084 of the total 13,820 graduate students, and the numbers increase each year. After graduating from high school in Vietnam, the three students in my lab passed the entrance examination for the University of Tokyo and entered the undergraduate program as international students sponsored by the Japanese government. All three continued on to graduate school and are now enthusiastically conducting research in our lab.

Students in countries of East Asia and Southeast Asia receive a rich education in fundamental subjects, such as mathematics and physics. This has proven to be an advantage for the Vietnamese students, even after entering the University of Tokyo. Further, there are no barriers to the wealth of information on the Internet for students who have no problems with the English language. Using information available over the Internet gives these students a capacity to perform advanced simulations that appears to surpass that of the average Japanese student at the University of Tokyo.

The ability to attract capable young people with such enthusiasm from overseas may benefit Japan, for which the declining birthrate and proportion of elderly in the population is expected to increase, as they may play an important role in helping to reform our social system and to improve its efficiency through science and technology. Because Japan's declining birthrate and aging population is advancing faster than the rest of the world, I believe that it is the country best-suited to proposing and popularizing new lifestyles.

The Role of MEMS Devices in Our Coexistence with Machines and Robots

In order to maintain our international competitive edge despite our aging society, we will have to make efficient use of our environment, resources, and labor force, and optimize traffic logistics, for example. Collaborative work among people and industrial robots is increasing at factories, and the popularization of service robots and household robots, not necessarily humanoid in form, has begun to appear a reality. As was reported in an article in the *Mainichi Shimbun* on January 2, 2011 entitled "2010 Traffic Death Toll at 4,863, with Half Aged 65 and Above," safety is a vital issue in taking measures to produce an efficient transportation system for our aging society. Yet this problem applies to the younger generation as well as the elderly.

MEMS devices serve as a core technology for improving the reliability and safety of machines that coexist with humans. These devices can accurately detect the circumstances at points of contact between machines and humans and the surrounding environment. With a low volume of information, it is difficult to remove all uncertainty, even with intelligent processing of the information. However, if the quantity and quality of information is improved using MEMS devices to acquire more data, safety and reliability of machines can be improved.

Here, I will describe some concrete uses for MEMS devices.

Tactile Sensing

In settings where humans and machines coexist, humans sometimes touch or ride on the machines. By sensing the state of forces exerted when industrial robots and humans work together to assemble parts, or by detecting whether a passenger riding in a personal mobility vehicle is sitting in the seat and is in contact with the backrest, such machines can be precisely controlled, properly accelerated and decelerated, and used without incident on stairways and elevators. We may be able to predict when a vehicle could slip on a road surface by detecting the frictional forces and coefficient of friction between the tires and road surface. It can be said that MEMS provides us with new functions by enabling us for the first time to detect forces that humans and machines exert on each other and the distribution of force vectors produced through contact between humans and machines.

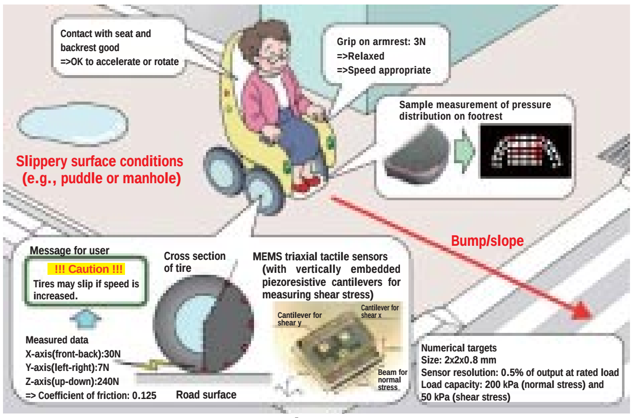
Increasing Sensitivity and Reducing Drift in Physical Sensors

Industrial robots, service robots, and personal mobility vehicles are constructed by assembling together rigid bodies. Encoders attached to the joints of the rigid bodies detect the angle of rotation between bodies in order to calculate the position and orientation of the links. Links are usually heavy in order to preserve rigidity, making the overall robot stiff and heavy. However, through the combined use of accelerometers and gyrosensors, the states of the links and robot fingers can be accurately learned, even when the links are flexible, making it possible to produce much lighter robots. Therefore, a new challenge facing R&D in robotics is to maintain the sensitivity of existing MEMS accelerometers and to reduce drift in gyrosensors.

Environmental Awareness

Measurements using light are effective in robots, automobiles, and personal mobility vehicles for detecting the state of objects in the vicinity. Currently laser rangefinders are being used to determine the distance to an object by emitting a laser pulse and measuring the time that the pulse takes to reflect off the target and return. However, in order for laser rangefinders to gain popularity, they must come down in both size and price.

As illustrated in the above examples, MEMS excels at adding new functionality, improving the performance of existing devices, and making things smaller, lighter, and less expensive, and MEMS devices are indispensible for operating machines in the same settings as humans. When listening to the Year-end Grand Song Festival on New Year's Eve, I heard the group AKB48 sing a song that included the lyrics "Are we dreaming?" and "Don't open someone else's map" and thought that I would like to pursue the dream in the former and the originality in the latter while researching MEMS devices in 2011.



Figure

Research Studies and Standardization Activities

1. Survey of Industrial Trends

In the current fiscal year, the Micromachine Center (MMC) has conducted surveys on trends in MEMS applications and trends in MEMS-related businesses for the purpose of studying trends in the MEMS industry.

As part of its efforts to research trends in businesses, the MMC visited some prominent MEMS-related companies in the U.S. in November of last year. A comparison of the MEMS industries in Japan and America reveals that in Japan MEMS business is generally handled by one branch of a large general company, while in the U.S. numerous venture companies are emerging alongside the large manufacturers to handle the commercialization of MEMS. The goal of this survey was to identify problems in Japan's MEMS industry by analyzing factors in the success of these venture companies and comparing how large companies in Japan and the U.S. approach MEMS.

The MMC visited the following companies for this survey: A.M. Fitzgerald & Associates, a MEMS product development consultant; SiTime Corporation, a venture company for MEMS oscillators; WiSpry, a venture company for RF-MEMS; Freescale Semiconductor, Inc., a large manufacturer of automotive sensors; Issys Sensor Systems, a venture company for MEMS and microfluidics applications; Sand9, Inc., a venture company for MEMS oscillators; and DALSA Corporation, a large MEMS foundry.

This survey covered all the traditional steps in product development from the initial idea to the final product, including research, technological development, prototyping, and commercialization. Only those products that clear all the hurdles encountered in the above steps reach commercialization. When examining the development steps employed at the companies we visited for this survey, it is clear that their approaches differ in many aspects, but a few of the venture companies shared common approaches and methods of exploiting the infrastructure. During the idea and research stage, the companies first conducted sufficient research to identify and predict market needs before designing a suitable product based on these needs. In the steps from technological development to prototyping, the companies require development funds and an infrastructure for device trial production, but it is not difficult to obtain assistance in the form of government funding or venture capital. In the U.S., venture companies can take advantage of the infrastructure in place at universities, where they can find MEMS trial production lines suitable for prototyping (taking the form of indirect assistance from state and federal governments). These companies also have access to the wealth of accumulated technologies at the universities.

Similarities were also seen in the approaches of major corporations in Japan and the U.S. For example, major firms tend to develop applications based on the element technologies that they have accumulated over the years and to form alliances with other companies in order to develop new businesses.

The details of this survey will be compiled in the FY2010 Report on Industrial Trends to be issued at the end of this fiscal year. For a brief report on the survey's findings, please visit the Web site "http://beanspj.cocolog-nifty.com/mems/2010/11/h22mems-a6dc.html."

2. Standardization Activities

The Subcommittee on MEMS (SC 47F) of the Technical Committee on Semiconductor Devices (TC 47) under the International Electrotechnical Commission (IEC) is responsible for reviewing MEMS international standardization. The SC 47F was invited to the IEC General Meeting held in Seattle from October 6 to10, 2010 for TC 47-related committee meetings and working group conferences.


View of Seattle

A total of twenty-five SC 47F-related participants attended the General Meeting, including eleven from Japan, eight from Korea, two from China, and one each from Germany, the United States, Finland, and Brazil. Some key members from China were not present because their visas were not issued in time.

Four drafts of standard were up for review by the subcommittee. The subcommittee members determined that the "bend- and shear-type test methods of measuring adhesive strength for MEMS structures" proposed by Japan would proceed to CDV (Committee Draft for Vote), after reaching agreement on a revised draft in response to fifteen additional comments from Korea. The subcommittee discussed comments on the second CD (Committee Draft) on "test method for linear thermal expansion coefficients of MEMS materials" proposed by Korea, including one comment from Germany, thirty-six from Japan, and ten from Korea. However, since the allotted time was insufficient for presenting a revised draft in response to the comments, it was decided that a third CD would be drawn up. The subcommittee reviewed fifteen comments from Germany, eighteen from Japan, and eight from Korea regarding the CD on "forming limit measuring method of metallic film materials." Revisions incorporating the comments were approved, and the document was advanced to CDV. A New Work Item Proposal (NP) on "bulge test method for measuring mechanical properties of thin films" received thirty-two comments from Japan and five from Korea. The document was advanced to the CD stage after revisions incorporating the comments were approved.

During the SC 47F conference, Korea gave a presentation on two future work items: a method of measuring Poisson's ratio of thin films, and a test method for measuring thin film properties on a flexible substrate.

At the TC 47 conference, the committee discussed a proposal from Korea to establish an incubation working group aimed at studying standardization for new fields, such as energy harvesting and human body communication interfaces. The committee agreed to establish an incubation advisory group.


Conference Room

Activities of the MEMS Industry Forum

1. Overview of Plans for MicroNano 2011

The micromachine exposition MicroNano 2011 (including the Exhibition Micromachine/MEMS and concurrent events) will be held at Tokyo Big Sight on July 13–15, 2011. Preparations for the event are being undertaken jointly by the Micromachine Center (MMC), which is sponsoring the event, and the organizer Mesago Messe Frankfurt Corporation.

We are pleased to note that attendance for MicroNano 2010 returned to its original trend of growth, due in part to improvements in the economic climate and the addition of ROBOTECH, an exhibition on manufacturing technologies for service robots utilizing MEMS sensors.

With the proliferation of fabless and fab-lite business models, the MEMS Industry Forum (MIF) is working on improving the convenience for visitors to MicroNano 2011 through effective zoning, e.g., providing a MEMS outsourcing zone for foundry services and analytical outsourcing, and a zone for sensor networks, which are anticipated to improve energy management and the safety and security of a company's infrastructure. In addition, we are discussing plans to accommodate diverse interests through a wider variety of symposiums, seminars, and other concurrent events.

The MIF is also working on plans to provide the most valuable technical information, business information, and business opportunities in one location for exhibitors and visitors. Please consider participating in MicroNano 2011 as an exhibitor or visitor. This event is not to be missed!

2. Program for Human Resources Development: "Micro/Nano Innovator"

The "Micro/Nano Innovator" program for human resources development is a nationwide, self-reliant program being developed under the Committee for the Promotion of Human Resources Development newly established this year, in cooperation with the National Institute of Industrial Science and Technology (AIST) and the Kitakyushu Foundation for the Advancement of Industry, Science and Technology (FAIS), among others. The MMC has conducted various training courses for this program, including "Advanced applications course: the 15th MEMS Seminar" held in October, "Introductory course on MemsONE" held in November, and "Techniques for promoting MEMS commercialization" held in December. All of the courses were extremely popular, indicating high interest in the field of MEMS and a persistent need for MEMS human resource development.

15th MEMS Forum

Course on techniques for promoting MEMS commercialization

3. Formation of the Tsukuba Innovation Arena NMEMS

Formation of the Tsukuba Innovation Arena NMEMS (TIA-NMEMS) at AIST Tsukuba is an endeavor aimed at the promotion of advanced research requiring a high capital investment that individual companies generally cannot afford, and the enhancement of design and trial production capabilities needed for pioneering MEMS applications. The MEMS Industry Forum (MIF) established the Investigative Committee for a Micro/Nano Open Innovation Center (MNOIC) to consider an organization and implementation schedule for best utilizing TIA-NMEMS.

After a fourth council meeting, the 2nd MNOIC Investigative Committee meeting was held in December. The meeting was filled with lively discussion on such topics as how to arrange participation by each company and how best to implement the center, including lab tours of the advanced 8-inch and 12-inch MEMS-related equipment being installed in clean rooms by the G-devices program and the Funding Program for World-Leading Innovative R&D on Science and Technology. The MNOIC Investigative Committee also serves as the TIA-NMEMS Working Group, one of eight working groups established under the Executive Council for promoting TIA-NMEMS.

2nd MNOIC Investigative Committee meeting

Installing state-of-the-art equipment

4. International Exchange: a Survey on MEMS Industrial Trends in North America

In early November, the MIF dispatched a mission led by Isao Shimoyama, professor at the University of Tokyo, to North America in order to ascertain trends in the MEMS industry. The group visited seven MEMS-related companies and participated in the MEMS Executive Congress organized by America's MEMS Industry Group (MIG).

The group came away with an overall impression that the consumer market in North America has become saturated with accelerometers and other sensors, and that venture companies and other businesses are working vigorously at developing products for the next promising market amid declining prices and fierce competition. There were also many sensor network and high-frequency applications for smartphones, and medical applications emphasizing performance and function over cost. It was quite clear that the market in North America develops dynamically, with existing major companies and venture companies sometimes collaborating and sometimes competing.

Freescale Semiconductor, Tempe, AZ (USA)

Dalsa Semiconductor, Bromont, Quebec (Canada)

Release of MemsONE Version 4.0

Upon the release of version 1.0 of MemsONE (Computer Aided Engineering System for MEMS) in February 2008, the Micromachine Center initiated activities to disseminate MemsONE throughout Japan. For the past three years, we have kept up these dissemination activities using such catchphrases as “an analytical tool providing powerful support for MEMS design and manufacturing processes” and “a tool suitable both for experts and novices with little experience in MEMS.” During this period, versions 1.1, 2.0, and 3.0 of the product were released, each release offering enhanced and more powerful functions with greater stability.

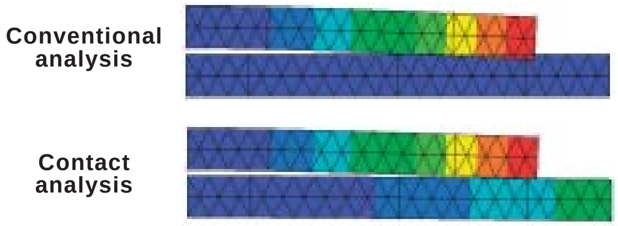
Version 4.0, anticipated for release in February of this year, will have even more improvements in analysis capabilities, user-friendliness, and the operating environment. The following are some of the improvements and enhanced features in version 4.0.

(1) Added support for Windows 7

MemsONE can now be used in the Windows 7 environment. The program was tested on various models of notebook and desktop computers to identify any issues. Recommended computer specifications are clearly noted in the product.

(2) Improved and strengthened the analytical functions

a. Added a contact analysis function for the large deformation problem in elastoplastic analysis and thermal elastoplastic analysis. This function enables analysis of the following contact state.



b. Included process recipes for company-supplied multiprocess emulators

c. Improved and strengthened the MEMS circuit simulator

- Added a function for extracting a macro model to generate MEMS elements from results of structural analysis.
- Added the ability to adjust the number of nodes on a rigid plate.
- Enabled pull-in analysis of gap elements.
- Improved the editor function and strengthened the post-process functions.

(3) Improved and strengthened the feature for setting analytical conditions

a. Enhanced the functions for browsing the material database in the conditional settings for mechanical analysis and enabled the inclusion of matrix data.

b. Added a time history table to the boundary conditions for electric potential in piezoelectric analysis.

c. Integrated the number of output steps with the number of computational steps.

(4) Enhanced functions and expanded data in the material database

a. Enhanced the function that allows characteristic data of specified materials to be referenced and recorded together in a table.

b. Added supplemental characteristic data for piezoelectric materials (particularly matrix data) required for piezoelectric analysis.

(5) Improved and enhanced pre-process functions

a. Added a function to compute mass properties (area and volume).

b. Improved user-friendliness of operations for setting local subdivisions in hexahedral mesh division.

c. Made it possible to specify the number of divisions in hexahedral mesh division.

d. Relaxed restrictions on the inheritance and data quantity for input parameters in the command “Sweep shell elements.”

(6) Improved and enhanced post-process functions

a. Resolved the issue of small text being difficult to read in the display of analytical results.

b. Improved the post-process function so that the rotated state in the CAD modeler is reflected in the display of analytical results.

(7) Upgraded the installation environment

a. Reduced the number of installation steps and improved messages displayed for suggesting measures required to resolve problems that occur during installation.

b. Eliminated virtual drive R, using only drives P and Q while MemsONE is executing.

(8) Added a network license function

Added a function that enables multiple users, within the number specified in the license agreement, to use MemsONE simultaneously on computers connected to a LAN.

Through the improvements and enhancements described above, version 4.0 of MemsONE is anticipated to be a more complete tool with remarkable advances in the quality and user-friendliness of its features. Sales and distribution of version 4.0 will begin in February 2011, and the MMC is committed to product dissemination. At the same time, will be offering user assistance through training courses and technology forums, for example, and will work to attract new users and expand our regular user base.

Activities of the BEANS Laboratory

Recent Media Coverage on the BEANS Project

This article focuses on activities in the BEANS Project that have been covered by newspapers, journals, and other media since the summer of 2010. The Japanese and foreign press have shown interest primarily in our achievements in biotechnology. The work by Associate Professor Shoji Takeuchi, director of the Life BEANS Center, on robots with a sense of smell and implantable blood sugar sensors has been making the rounds through various media outlets this past autumn. The following is some of the media coverage that we at the head office have noted thus far.

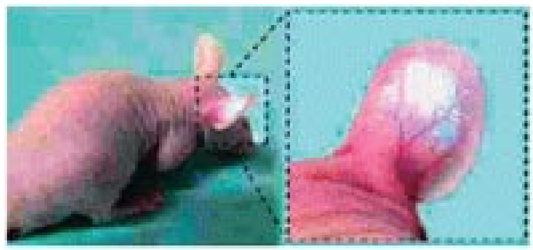
Research Achievements

Incorporating cell-based olfactory sensors in robots: an achievement of Shoji Takeuchi, associate professor at the University of Tokyo and director of the Life BEANS Center, researcher Nobuo Misawa, et al. An article on this achievement was published in the prestigious Proceedings of the National Academy of Sciences (PNAS) of the United States of America and was covered extensively in Japan. A list of the media coverage for the achievement is given below.

1) NHK TV, *Good Morning, Japan*, 9/24/2010; 2) NHK TV, NHK's six o'clock news, 9/24/2010; 3) TV Tokyo, *World Business Satellite*, 9/10/2010; 4) *Nihon Keizai Shimbun*, 8/24/2010, morning edition; 5) *Nikkei Sangyo Shimbun*, 8/24/2010, morning edition; 6) *Nikkan Kogyo Shimbun*, 8/24/2010, morning edition; 7) *Tokyo Shimbun*, 8/24/2010, morning edition; 8) *Yomiuri Shimbun*, 8/24/2010, evening edition; 9) *Mainichi Shimbun*, 8/24/2010, evening edition; 10) *Asahi Shimbun*, 9/3/2010; 11) *The Chemical Daily*, 8/24/2010; 12) Online article: *Medical Design and Manufacturing Technology*, Canon Communications; 13) Foreign press: *TechNewsDaily*; 14) Foreign press: *Reuters*; 15) Foreign press: *New Scientist Tech*; 16) Foreign press: the Brazilian newspaper *Folha De S. Paulo*, 8/24/2010; 17) Overseas scientific journal: *Nature Materials*, 8/23/2010, Research Highlights; 18) Overseas scientific journal: *Nature Materials*, October 2010, Vol. 9, p.78, "Oocytes as Sensors," PNAS, 107, 15340–15344 (2010); 19) Overseas scientific journal: the article "Olfactory Sensor" was selected for *Popular Science's* Best of What's New 2010 under the "Security" category, 11/22/2010; 20) Radio broadcast: *NHK World Radio Japan*, 9/20/2010, 14:10–14:30; 21) General magazine: *DIME*, no. 21, October 2010 (Shogakukan).

Developing an implantable blood sugar sensor: Shoji Takeuchi, associate professor at the University of Tokyo and director of the Life BEANS Center, et al. After its announcement in January 2010, this blood sugar sensor caught the attention of the foreign press at Exhibition Micromachine/MEMS and became prominent in the news once again when the achievement was covered in America's PNAS.

1) YouTube, *DigInfo* video news, 7/29/2010; 2) *Nihon Keizai Shimbun*, 10/5/2010, morning edition; 3) *Nikkei Sangyo Shimbun*, 10/5/2010; 4) Overseas scientific journal: *Royal Society of Chemistry NEWS*, October 2010; 5) Foreign press: America's *ABC News*, "Glowing Beads," October 2010; 6) Online article: *Medical Design and Manufacturing Technology*, Canon Communications.



The glowing microbeads can easily be seen through the skin of the mouse ear

© Proc. Natl. Acad. Sci. USA

Research achievements at the Life BEANS Center: the University of Tokyo and Mitsubishi Chemical Medience reported on the Center's success in developing a technique for fabricating bile canaliculi, p.11 of *Nikkei Sangyo Shimbun*, 12/6/2010.

On August 27, 2010, *Nikkei Sangyo Shimbun* published an article linked to Koji Miyazaki, associate professor at the Kyushu Institute of Technology and member of Life BEANS Kyushu, entitled "Thermoelectric materials that generate electricity through a small temperature difference, and their applications in wearable electronics."

Intellectual Property

The BEANS Project was recognized by *Nikkan Kogyo Shimbun* on 9/17/2010 for its pioneering efforts in the creation of intellectual property in an article entitled "Supporting intellectual property through cooperation among different disciplines."

Researchers

Two non-Japanese female researchers involved in the BEANS Project were profiled in the media.

•Khumpuang Sommawan, a researcher at Macro BEANS Center, was profiled in *Nikkan Kogyo Shimbun* October 15, 2010 in an article entitled "New technology research that transcends borders." After completing her undergraduate degree at Chiang Mai University in Thailand, Sommawan obtained a master's degree at the University of Bristol and a doctorate at Ritsumeikan University. She also worked at the University of Freiburg in Germany prior to participating in the BEANS Project.

•Heo Yun-Jung, a researcher at Life BEANS Center, received an excellent paper award for young researcher at the 27th Sensor Symposium on Sensors, Micromachines, and Applied Systems. Yun-Jung graduated from the Korea Advanced Institute of Science and Technology (KAIST) in South Korea and received her doctorate at the University of Tokyo.

Khumpuang Sommawan

Heo Yun-Jung

Activities of the G-device Project

Since April of last year, the G-device Center of the BEANS Laboratory, sponsored by the New Energy and Industrial Technology Development Organization (NEDO), has been working toward the development of an advanced sensor network system and environmentally friendly processes. In December of last year, the Center completed installation of a smart clean room and front/back-end advanced 8-inch MEMS lines (TKB812-F/B) at the Research Center for Ubiquitous MEMS and Microengineering, housed in the research base, Tsukuba East of the National Institute of Advanced Industrial Science and Technology (AIST Tsukuba East).

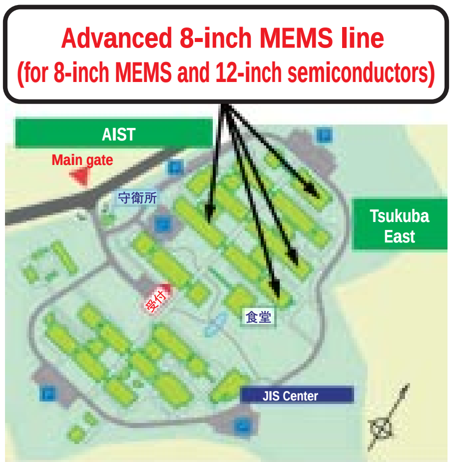
The smart clean room (area: 150 m^2) is designed for low-power consumption and low environmental impact. The clean room is targeted to achieve clean-on-demand control using a sensor network system to monitor temperature, humidity, particles, power consumption, and other environmental conditions, and a dedicated smart air conditioning system.

The MEMS lines form a coherent fabrication line that supports 8-inch and 12-inch wafers and includes a front-end processing line (TKB812-F) and a back-end processing and evalutation line (TKB812-B). The front-end line installed in a clean room at AIST (area: 350 m^2) covers everything from wafer cleaning to lithography, oxidation, diffusion, deposition, and etching. The back-end line installed in the smart clean room is equipped to handle chip/wafer-to-wafer bonding and wiring as well as evaluations of the processed wafer profiles and the electrical properties of devices, for example.

These production lines support microfabrication at a line width of 0.35 μm, as well as three-dimensional micromachining, enabling us to produce everything from sensors and other time-tested MEMS devices to advanced devices. In our NEDO-sponsored R&D work, the MEMS lines will be used in the trial production and evaluation of test element groups (TEGs) used for verifying processes developed in the BEANS Project, and TEGs of sensor network elements.

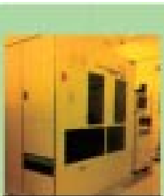
Our goal is to bridge the “commercialization gap” by using these facilities to provide development support in MEMS prototyping and pilot production aimed at mass production, which areas have been considered a weakness in Japan to date. At Tsukuba’s R&D center for NMEMS (TIA-NMEMS), these facilities are also expected to serve as the core of an R&D platform for operations of the future Micro/Nano Open Innovation Center (MNOIC).

Overview of the advanced 8-inch MEMS line



Installation site	Process	Process and evaluation equipment
Front-end clean room (TKB 812-F)	Cleaning/drying	12" wafer cleaning system (RCA cleaning)
		Organic draft chamber, IPA vapor dryer, water purifier
	Lithography	12" DMD maskless exposure system, mask aligner, i-line stepper
		12" coater/developer, 12" oxygen plasma asher
	Deposition	Oxidation furnace, boron diffusion furnace, 12" low-temperature TEOS plasma-enhanced CVD system for forming silicon dioxide films
		Silicon nitride LPCVD furnace
		Phosphorus-doped polysilicon LPCVD furnace
		3-chamber sputtering system for depositing metal, piezoelectric (AlN), and insulating layers
	Etching	12"/8" silicon DRIE system
		ICP dry etcher for metal, ICP dry etchers for silicon dioxide/nitride films
		Silicon anisotropic wet etcher
		Dry sacrificial layer etcher
Back-end clean room (TKB 812-B)	Bonding/packaging	Chip-to-wafer (12") bonding system, wafer-to-wafer surface-activated bonding system
		12" electron beam evaporator, vacuum annealing furnace
		Laser stealth dicer, 12" blade dicer
	Evaluation	Wafer prober, noncontact-type film stress measurement system, 12" X-ray CT scanning system
		12" SEM (elemental analysis, crystallographic analysis), CD-SEM
		12" spectroscopic ellipsometer, contact-type surface profiler, optical microscope, wafer surface particle analyzer

Major equipment in the MEMS line


i-line stepper
8-inch


TEOS-CVD system
8/12-inch


Silicon DRIE system
8/12-inch


Dry sacrificial layer etcher
8-inch


Wafer-to-wafer bonding system
8-inch


3D X-ray CT scanning system
8/12-inch

Members' Profiles

ROHM Co., Ltd.

1. Company Profile

ROHM Co., Ltd. is a manufacturer of semiconductor devices and electronic components and is involved in the development of systems in a wide variety of fields, including consumer electronics, mobile phones and communication devices, and automotive devices. While its headquarters are in Kyoto, ROHM utilizes a development and sales network that has expanded globally to provide LSIs and discrete semiconductor products with superior quality and reliability.

Moore's Law suggests that technological innovation in semiconductors will come through refinements in manufacturing processes. ROHM, on the other hand, is pursuing improvements in performance through new concepts, as reflected in its motto "More than Moore." We are meeting new demands in the industry by exploring diverse technological innovation that transcends the traditional measuring stick of "refinement," while developing or integrating element technologies in a wide range of fields, such as new materials, MEMS, biotechnology, and optical technology.

Among its efforts in the field of MEMS, ROHM manufactures high-performance MEMS accelerometers and high-performance products suitable for sensor networks employing MEMS devices. The latter is achieved through the utilization of our core technologies, including low power consumption, miniature packaging, digital-analog mixed-signal ICs, and wireless communications. We've also completed the development of a microvolume blood analyzing chip, a concept realized by integrating biotechnology with MEMS.

2. Activities in Bio-MEMS

Nearly a decade has passed since ROHM began R&D in biotechnology. Our R&D efforts have been oriented primarily toward self care products. During this time, we have been developing μTAS (micro total analysis system) technology as a core technology. Owing to the decrease in population in recent years coupled with a rapid decline in birthrate and an aging population, we anticipate a surge in users of health and welfare, medical care, and nursing services. Indeed, the age of home care and point of care testing (POCT) has arrived.

The field of biotechnology, of which we have only just begun to scratch the surface in our R&D activities, is currently showing promise as a candidate for company-wide development under one of our three concepts of business expansion aimed at the next fifty years: health and medical care, safety and security, and the environment. Based on our concept of "More than Moore," we are now working toward the fusion of biotechnology with semiconductor and optical technology, which we have gained over the years, and are developing compact medical and bio systems.

As an example of our progress in biotechnology, ROHM has developed a POCT product called Banalyst®, a microvolume blood testing system employing a μTAS chip. This system can perform tests on just a drop of blood and in less than ten minutes, outperforming large analyzing equipment. The entire test reaction is made possible by constructing a micro reaction space in the biochip using μTAS technology and performing flow control for a reagent that has been pre-encapsulated in the chip.

Compact systems using μTAS are expected to flourish in a variety of medical settings for tasks that were previously unheard of, such as bedside examinations in clinics and examinations for health care in remote areas.

The microvolume blood testing system Banalyst employing μTAS

The microvolume blood testing system Banalyst employing μTAS

3. Conclusion

In addition to bio-MEMS devices, we will be working on technical development of MEMS devices for application in sensor networks and energy harvesting systems. To this end, we believe it necessary to engage in strategic government-industry-academy collaboration in order to combine our fields of specialty. We hope that such close collaboration and the exchange of ideas will lead to rapid development of novel products.

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