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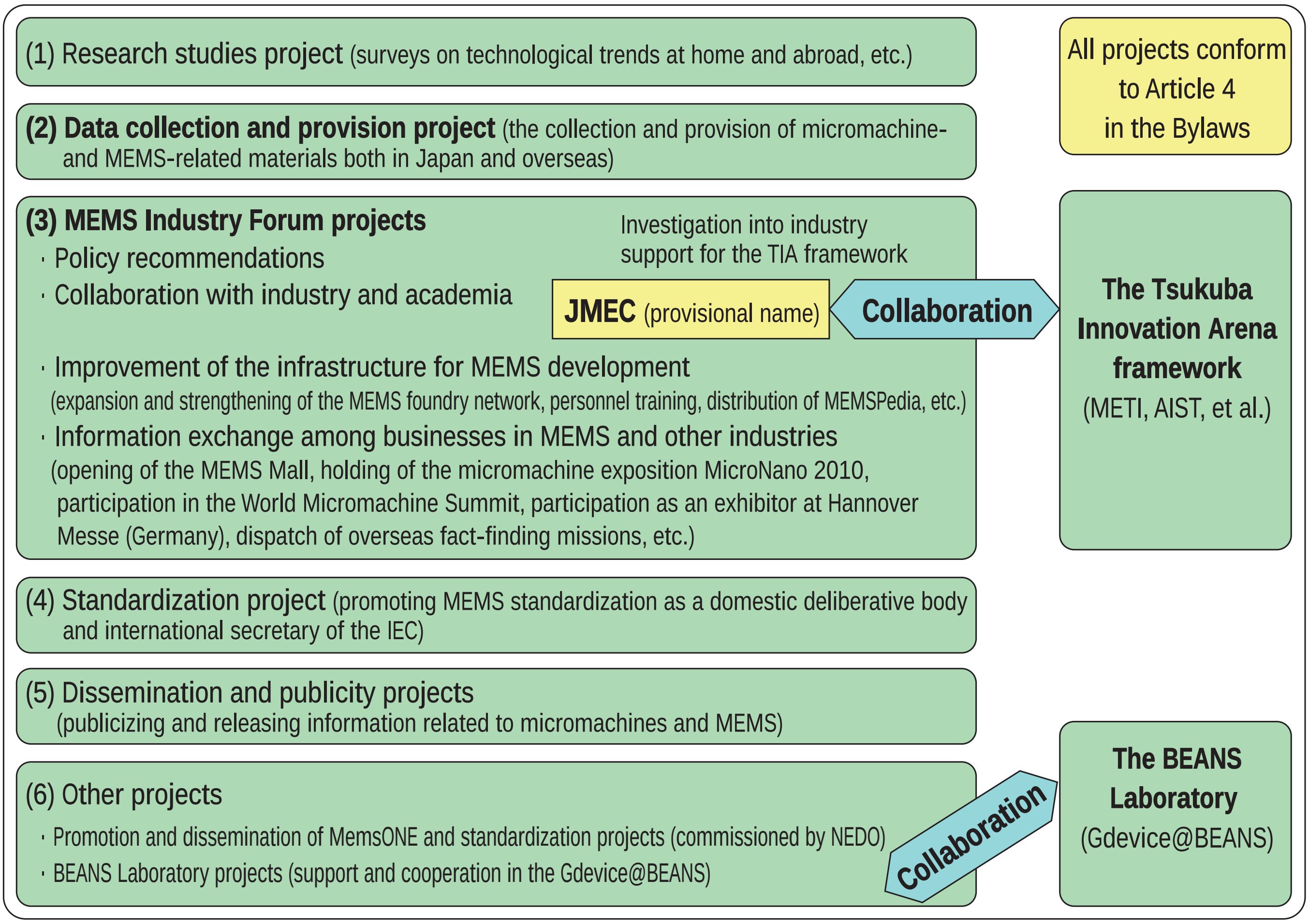
Topic

The Micromachine Center An Overview of FY 2010 Project Planning

In FY 2010, the Micromachine Center (MMC) intends to continue its contributions to the development of Japan's industry through activities for establishing basic technologies related to micromachines, MEMS, and other micro/nano fields and activities designed to improve the environment for developing industrial fields. Plans for FY 2010 projects were approved at meetings of the Council and Board held in March. Based on these plans, the MMC will be improving and intensifying its activities in various projects including research studies on micro/nano fields, data collection and provision, the promotion of domestic and international standards, the promotion of exchange and collaboration among businesses in MEMS and other industries, activities to improve the infrastructure for MEMS development, and dissemination and publicity activities.

Among the new activities added to this year's schedule are plans to develop micro/nano personnel training programs nationwide and to inaugurate the Japan MEMS Enhancement Consortium (JMEC; provisional name) that will coordinate with the Tsukuba Innovation Arena (TIA) framework. We are also committed to strengthening our support and cooperation for the BEANS Laboratory as a member of this organization, including its research project Gdevice@BEANS, newly added this year for the development of a high-sensitivity sensory network and processes having low environmental impact.

The diagram below lists major projects slated for this fiscal year.



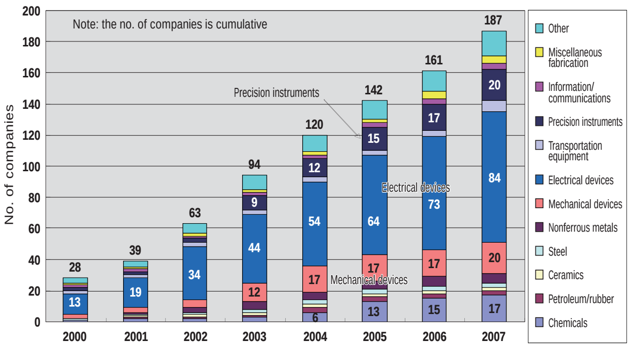
Overview of the Micromachine Center's FY 2010 Project Planning

Research Studies and Standardization Activities

1. Survey of Industrial Trends

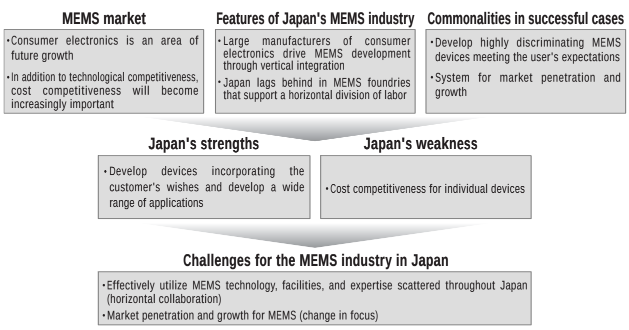
The Industrial Trends Study Committee is continuing its study begun last fiscal year on the types of tools employing MEMS technology (MEMS-Inside) and the uses for these tools (MEMS applications), as well as the state of affairs for MEMS-related businesses. The Committee compiled this information into its 2009 report on challenges and strategies for the expansion of Japan's MEMS industry.

MEMS has already been incorporated as a practical technology in numerous products, including such recognizable devices as airbag sensors for automobiles, print heads, controllers for game consoles, and image stabilizers for digital cameras, and many more applications are anticipated. Further, as illustrated in the following graph, the types of companies making up the MEMS industry are expanding into diverse sectors of business.



Japan's MEMS industry is configured of a group of dominant companies that follow a vertical integration model, as opposed to the horizontal division of labor employed in overseas groups, such as STMicroelectronics and foundries for analog devices and MEMS. Japan's model is less efficient because its technology, expertise, and facilities are scattered, and Japan does not conduct sufficient activities aimed at market penetration and growth for MEMS devices. Thus, in terms of cost competitiveness, which will be an important factor in the future of industrial competitiveness, Japan's model may be inferior to that used overseas.

To strengthen the MEMS industry in Japan, we must effectively utilize our technology, expertise, and facilities through collaboration between public institutions and businesses. It would also be ideal to have activities choreographed by industry and public institutions to facilitate Japan in changing its focus from technological and applied development through standardization to market growth and mass production.



2. Survey of Technological Trends at Home or Abroad (Second Semester)

In the second half of the FY 2009 survey of technological trends at home or abroad, the Committee conducted a survey of MEMS 2010 (the 23rd IEEE International Conference on Micro Electro Mechanical Systems). The 23rd conference was held in Hong Kong on January 24–28 2010.

MEMS 2010 drew 885 abstract submissions, which is the largest number in the history of the conference. By region, Asian had the most submissions with 425, accounting for 48%, or approximately half, of the total. From the submitted abstracts, 298 papers were accepted for an acceptance rate of 34%. By region, North America had 130 papers accepted for an acceptance rate of 46%, Asia had 113 accepted for a rate of 27%, and Europe had 55 accepted for a rate of 31%.

Fig. 1 shows the numbers of presentations by country over the past five years. Of particular note are the sharp rise in America's number of presentations and the steady increase in presentations from Taiwan and China.

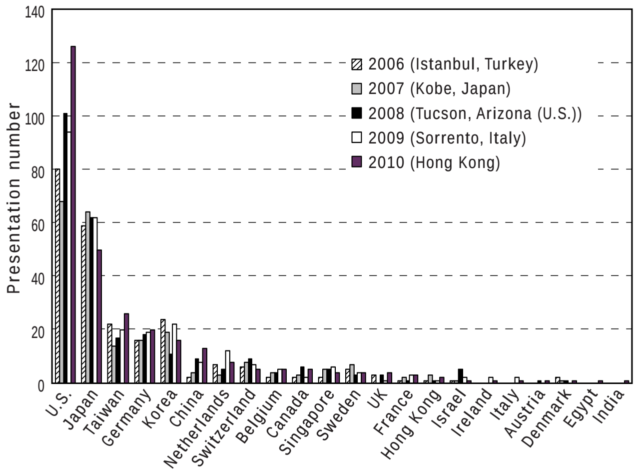


Fig. 1 Number of presentations by country over the past five years

Fig. 2 shows the numbers of presentations broken down by specific technological field. As can be seen in the graph, the three most popular fields were fabrication technologies (non-silicon), fluidic, and mechanical sensors.

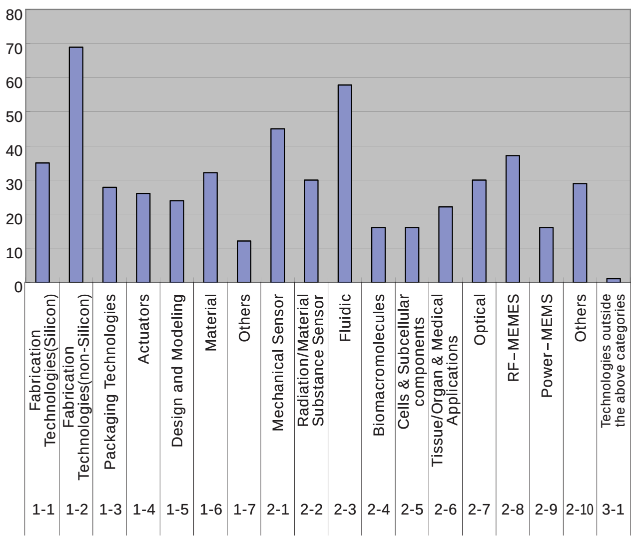


Fig. 2 Numbers of presentations broken down by field

Activities of the MEMS Industry Forum

1. Preparations for MicroNano 2010

The micromachine exposition MicroNano 2010 will be held at Tokyo Big Sight on July 28–30, 2010. The MEMS Industry Forum (MIF) and the organizer Mesago Messe Frankfurt Corporation are currently finalizing plans and arrangements for the exhibits, seminars, and other concurrent events. The following is a schedule for the major seminars.

- International Micromachine/Nanotech Symposium: July 28, afternoon, Conference Area A
- BEANS Project Seminar: July 29, Conference Area B
- ROBOTECH Seminar: July 30, Conference Area B

As with last year's exposition, there are also plans to hold the MEMS Industry Forum Workshop as a venue for the MIF to disseminate information, and the Workshop on Industry and University Cooperation focusing on information presented by universities promoting industry-academia collaboration. We would like to encourage any institution looking for an opportunity to introduce their activities, particularly in the latter forum, to contact us.

2. The Committee to Promote the MEMS Industry Forum

The 2nd Committee to Promote the MEMS Industry Forum (Chair: Kazuo Kyuma, senior managing executive officer at Mitsubishi Electric Corporation, Advanced Technology R&D Center) was held on January 29, FY 2009 at the Shoko Kaikan (Kasumigaseki), 6th floor conference room. The committee meeting was attended by representatives of eleven member companies, the Ministry of Economy, Trade and Industry (METI), and the New Energy and Industrial Technology Development Organization (NEDO), as well as Isao Shimoyama, vice-chair of the MIF and professor of the University of Tokyo. Among the features of this meeting were a report on the current fiscal year's activities and achievements by the MIF, a discussion of the future approach for advanced R&D projects such as BEANS, and a lively exchange of opinions on the MEMS R&D center at the Tsukuba Innovation Arena.

Member companies expressed their expectations for the BEANS Project, the Gdevice@BEANS project that was selected this year through a public invitation from NEDO to utilize the results of the BEANS Project, and the Tsukuba Innovation Arena N-MEMS (provisional title JMEC) being promoted by industry, academia, and government. Some attendees noted the significance of becoming competitive internationally as individual companies by concentrating research at a national research center, as well as the importance of promoting both international collaboration that includes Asia, and open innovation.

Representatives from METI and NEDO expressed a hope for utilizing national projects and research centers, while distinguishing between applications for concentrated in-house resources and applications for external resources. Additionally, the organizations requested information related to application in demand.

We hope to continue providing such a venue to bring together industry, academia, and government for an exchange of opinions and to incorporate the results of these meetings in the activities of the MIF.

The 2nd Committee to Promote the MEMS Industry Forum (Jan. 29)

3. Participation in the 5th Tsukuba Innovation Workshop

The 5th Tsukuba Innovation Workshop was held on February 15 and 16 at the auditorium of AIST Tsukuba Central to discuss the requirements for making the Tsukuba Innovation Arena (TIA) genuinely effective. The 5th Workshop was attended by leaders from noted overseas R&D centers involved in nanotechnology (IMEC, LETI, Fraunhofer, et al.) and featured lectures on management and networking, as well as a panel discussion. During the N-MEMS session on the second day, the Micromachine Center gave an overview of the Japan MEMS Enhancement Consortium (JMEC; provisional name) currently under consideration.

Representatives from Berkeley Sensor & Actuator Center (BSAC) and LETI shared their expertise and philosophy on how to implement research projects to get the best results and described their related activities at Korea's National NanoFab Center and in Singapore. We were impressed with how candidly the speakers from overseas were in relating their own experiences and offering advice, and felt the workshop was very meaningful and rewarding.

4. Nationwide Expansion of the Personnel Training Program

It is our belief that favorable industrial growth can be achieved through the systematic implementation of personnel training required for MEMS-related industries. In the next fiscal year, the MIF plans to establish a committee for promoting personnel training built around members of organizations in all parts of Japan that are involved in collaboration among industry, academia, and government; to formulate a master plan for the personnel training program; and to provide coordination among research centers.

The New Industry Research Organization in Hyogo Prefecture, the Kitakyushu Foundation for the Advancement of Industry, Science, and Technology, and an organization for promoting collaboration among industry, academia, and government at Tohoku University will serve as head offices for operations in their respective regions, while AIST Tsukuba will function to implement a portion of the courses and to act as an overall advisor. The MMC will serve as the secretariat for these committees and plans to bear the role of head office for operations in the Kanto region and Japan overall. Since there has been a large demand for personnel training nationwide, we ask you all for your support and cooperation in this project.

Dissemination and Publicity Projects

1. The 14th MEMS Seminar

The 14th MEMS Seminar on "New MEMS technologies (design, processing, and evaluation) and their product applications" was held on February 5 this year at the Hyogo Prefecture Citizens' Hall in Kobe, Japan. A total of thirty-seven people participated in the Seminar, which was organized by the Foundry Service Industry Committee (FSIC; chair: Fumihiko Sato of Omron Corporation) under the Micromachine Center (MMC).

Through the support of the New Industry Research Organization, this year's MEMS seminar featured lectures by representatives of MEMS-related companies in Hyogo Prefecture and its neighboring prefectures, as well as a catalog exhibition during an ensuing technical forum. The program given below illustrates the rich variety of events included at the 14th MEMS Seminar.

(1) "Advances in MEMS integration and fusion and expectations for the creation of new industries," Susumu Sugiyama, professor of Ritsumeikan University

(2) "Micronano molding technologies for MEMS devices," Tadashi Hattori, professor of the University of Hyogo

(3) Presentations by the FSIC (machining and joining technologies)
ULVAC, Omron, Olympus, National Institute of Advanced Industrial Science and Technology, Panasonic Electric Works, and Hitachi

(4) An introduction of technologies by MEMS companies in the Hyogo area
Sumitomo Precision Products, Silicon Sensing Products

(5) MEMS device evaluation technologies
Daiichi Kagaku, Oki Engineering

(6) Presentations by the FSIC (design and analysis technologies, etc.)
Nihon Unisys Excelutions, Mizuho Information & Research Institute, Mathematical Systems Inc., and the committee chair, Fumihiko Sato

(7) Technical forum
FSIC, Silicon Sensing Systems Japan, Kasen Nozzle Mfg. Co.

The following topics were discussed at the 14th MEMS Seminar.

In his lecture entitled "Micronano molding technologies for MEMS devices," Prof. Hattori pointed out the need for personnel training and drastic cost reductions in manufacturing processes in order to ensure the market success of products employing MEMS technologies, and explained how a molding technology using micro-molds will be a key technology.

Progress toward establishing and standardizing an evaluation technology for MEMS devices is lagging behind that for semiconductor devices, but this element technology is of utmost importance for developing products that incorporate MEMS. Highly reliable MEMS devices and products will be attainable by using the results of prototype evaluations as feedback in device design. On this topic, we heard lectures on technologies and equipment for controlling the local environment of microdevices with great precision and technologies and services for diagnosing MEMS-specific processes and analyzing failure modes.

The technical forum that followed the MEMS seminar involved guest exhibitors and stimulated an enthusiastic exchange of technological information. Afterward, the venue was changed to more relaxed surroundings for an informal gathering, where committee members of the FSIC, lecturers, and other participants engaged in a lively exchange of ideas.

The 14th MEMS Seminar

2. The Release of MemsONE Version 3.0

January 20 of this year marked the release of MemsONE version 3.0, a design and analysis support system for MEMS. Developed by an industry-academia joint research consortium comprising nine businesses, thirteen universities, one research institute, and one association, MemsONE is Japan's first software tool aimed at providing support for efficient MEMS design and development. MemsONE is not only a useful tool for the most sophisticated MEMS researchers and engineers, but also eliminates the stress for researchers and engineers in other areas who are novices or less experienced in the field of MEMS in accessing the most advanced MEMS-related data and know-how.

The following are some of the enhanced features included in this latest release.

(1) Added the boundary element method to electric field analysis
(2) Added an all-in-one setup for boundary conditions in thermal nanoimprint analysis
(3) Expanded the analysis scale for dynamic systems
(4) Improved the hexahedral mesh generator
(5) Improved the mask CAD
(6) Added a function for generating solids (comb-fingers and meander beams)
(7) Enhanced the function for adding analytical models in the MEMS circuit simulator
(8) Upgraded the knowledge database from 1,700 to 3,400 items
(9) Upgraded the material database from 203 to 388 items

Details of the latest version are provided in the MemsONE Corner of the MMC's Web site. To access this page, please visit the URL http://www.mmc.or.jp/mems-one/ (Japanese only).

Activities of the BEANS Laboratory

An Overview of Projects Planned for 2010

First administered directly by the Ministry of Economy, Trade and Industry in 2008, the Hetero-functional Integrated Device Technology Development Project (the BEANS Project) was converted last year to a commissioned project under the New Energy and Industrial Technology Development Organization (NEDO). The BEANS Project is now entering its third year, which is the interim evaluation year. We will be implementing the following R&D projects (1)–(4) in order to achieve our interim goals. Owing to a supplementary budget carried forward from last year, we have also added a fifth R&D project, but the details of this project will be provided in the next issue.

1. R&D Project (1): Development of bio/organic material integration processes

1A) Bio/nano interface treatment

We will develop a process for forming lipid bilayers that function stably for more than two hours in order to establish a research foundation for future implantable devices and ultrasensitive molecular measuring devices. Based on the results of forming molecular imprinted interfaces through electron beam-induced polymerization, and molecular surface modification of biocompatible polymers, we will select materials and techniques for forming biocompatible interfaces. We will further evaluate high multistage reactivity based on microbial models using carbon dioxide fixation, for example.

2A) Biomaterial higher-order structure formation

In order to create a foundation for future pharmacokinetic screening and artificial organ research, we will conduct experiments to implement glucose-responsive fluorescent gel beads in mice and verify the effectiveness of the beads to find a suitable implanting location. We will also acquire guidelines on selecting a technique for inducing the formation of billiary canaliculi by controlling the spatial organization of cells.

1B) Organic/nano interface treatment

We will narrow the organic nanostructure formation processes by means of nanoimprint lithography and the filling process in order to create a research foundation for highly sensitive and efficient organic devices using synthetic organic materials such as future organic semiconductors. We will also study a new technology for crystal growth control, wherein organic materials are filled using nano-marking. In addition, we will propose device designs making use of orientation, create functional devices with unique light and electronic properties, and verify the effectiveness of the processes.

2B) Organic material higher-order structure formation

In order to create a research foundation for highly sensitive and efficient organic devices using synthetic organic materials such as future organic semiconductors, we hope to establish processes for forming self-assembled nanostructures such as organic molecular nanopillar structures having a less than 50 nm diameter, organic molecular nanoporous structures with uniform pores of less than 100 nm diameter, and mesh or linear structures having a less than 100 nm line-and-space (L/S) pattern.

2. R&D Project (2): Development of novel fabrication technology for 3D nano structures

1) Top-down fabrication of monolayer-flat, defect-free 3D structure

In addition to achieving defect-free silicon nanostructures with an aspect ratio of 30 or greater using neutral beam etching, we will also control the sidewall inclination and isotropic/anisotropic nature of etching. We will demonstrate the superiority of ultra-low-damage etching in producing MEMS structures to conventional techniques. We also hope to improve the speed and selectivity for the formation of 3D structures through nano-domain modification with a femtosecond laser.

2) Bottom-up-technology for heterogeneous integration of materials and functions on 3D platform

As an example of highly conformal supercritical-fluid deposition on 3D nanostructures, we will form functional film through conformal deposition of oxide film, metal film, and organic film on the surface of microchannels having an aspect ratio of 30 or greater, or complex 3D surfaces. We will also develop a technology for site-selective formation of functional nanostructures, such as nanoparticles, nanodots, and nanotubes, on probe arrays or pillar arrays.

3) 3D nano-fabrication for aerospace applications

Since our interim objectives of developing a basic technology for the optimal structural design of filters for multiband observation from space, element and basic processing technologies, and basic evaluation techniques were met last year ahead of schedule, this fiscal year we will branch off and study practical applications of these technologies.

3. R&D Project (3): Development of large-area continuous process of micro/nano structure

1) Non-vacuum, large-area deposition techniques of high-quality nano/micro materials

We will install and set up a gush-type atmospheric pressure plasma deposition apparatus and develop a basic process for forming films with electronic functions and films with mechanical functions. We will also clarify the specifications for equipment capable of covering larger areas by studying scanning techniques. We will also develop a large-area nanomaterial coating technology capable of depositing a uniform film thickness within $\pm 10\%$, with a patterning resolution no greater than 200 μm.

2) Continuous nano/micro-machining and integration process for fiber substrates

We will develop a film coating process for fiber substrates employing a die coater with a high speed of 10 m/min or greater. We will also establish a 3D patterning technology for the curved surfaces of fiber substrates, a reel-to-reel imprinting technology having a high feeding speed of 5 m/min or greater, and a 3D hollow fiber formation technology. In addition, we will develop a basic weaving integration process for weaving heterogeneous fiber substrates.

4. R&D Project (4): Building up of a knowledge database for hetero-functional integrated device technology development

Functions and categorization considered by the Knowledge Database Compilation Committee will be incorporated in the knowledge database system. We will also upgrade the functions of the database system and continue to accumulate more data from the BEANS centers and the four working groups to enrich the database.

Achievements and Activities of the BEANS Project

The five research centers of the BEANS Project (Life BEANS Center, Life BEANS Center Kyushu, 3D BEANS Center, 3D BEANS Center Shiga, and Macro BEANS Center) and the head office of the BEANS Laboratory have been conducting R&D on biomaterial integration processes, organic material integration processes, 3D nanostructure fabrication processes, 3D nanostructure fabrication for aerospace applications, and large-area continuous micro/nanostructure fabrication processes and have been developing a knowledge database on hetero-functional integrated device technology.

Through FY 2009, the BEANS Laboratory publicized its research findings at national and international academic conferences through 100 presentations and completed applications for 23 patents. In just the fourth quarter of FY 2009 (i.e., from January through March 2010), our organization gave presentations at such international conferences as the 23rd IEEE International Conference on Micro Electro Mechanical Systems (MEMS 2010 held in Hong Kong on January 24–28) and the 3rd International Symposium on Micro/Nano Technology (held at Seoul National University on March 21–24). Some of the major conferences in Japan at which we presented the achievements of the BEANS Laboratory included the 24th Japan Institute of Electronics Packaging (JIEP) Annual Meeting (held at Shibaura Institute of Technology on March 10), the 2010 Japanese Society for Precision Engineering (JSPE) Spring Meeting (held at Saitama University on March 16), the 57th Spring Meeting, 2010 sponsored by the Japan Society of Applied Physics (held at Tokai University on March 17–20), the 9th Congress of the Japanese Society for Regenerative Medicine (held at the International Conference Center Hiroshima on March 19), and the Society of Chemical Engineers, Japan (SCEJ) 75th Annual Meeting (held at Kagoshima University on March 18–20).

The BEANS Laboratory gave three presentations at MEMS 2010, an international conference held in Hong Kong this year. The MEMS conference is the principal event on micro/nano technology in the world and is held annually, while being rotated among the regions of America, Europe/Africa, and Asia/Oceania. The 23rd installment was held in Hong Kong since it was the Asia/Oceania region's turn to host the event. A total of 75 oral presentations and 223 poster presentations were selected for the conference for an overall acceptance rate of 33.7%.

The Hong Kong Convention and Exhibition Centre, the venue for MEMS 2010

Presentations for the BEANS Project given at MEMS 2010 were (1) "MEMS-based exposure module for continuous lithography process on fiber substrates" given by the Macro BEANS Center, (2) "Core-shell gel wires for the construction of large area heterogeneous structures with biomaterials" given by the Life BEANS Center, and (3) "Transplantation of a neurospheroid network onto the rat brain" also given by the Life BEANS Center.

The achievements of the BEANS Project have been generating much interest, often receiving coverage on television and in newspapers and trade and business journals. Recently, Shoji Takeuchi, associate professor at the University of Tokyo, and Chihaya Adachi, professor at Kyushu University, were interviewed several times about their research activities for an article in the January 2010–and final–issue of *Nikkei Microdevices*. The title of the article is "Generating Demand for a Supernatural World That Transcends Nature through Device Technology. "

The most important goal of R&D in the BEANS Project is the creation of intellectual property. In fact, all researchers in the project are assigned a quota for the number of patents or ideas they must produce. We have been applying a new type of IP management within our collaborative system of businesses, universities, and national research institutes, and recently had the opportunity to introduce this management system to a group of Japanese and foreign professionals in intellectual property at the International Patent Licensing Seminar 2010. Organized by the National Center for Industrial Property Information and Training (INPIT), a well-known organization in the field of IP management, this international conference was held at Hotel Nikko Tokyo on January 25–26. During a panel discussion on the "Current situation and future issues for IP management in the R&D consortium," a panelist from the Interuniversity Microelectronics Center (IMEC) of Belgium representing Europe, a panelist from the Center for Information Technology Research in the Interest of Society (CITRIS) of Northern California representing the U.S., and a panelist from the BEANS Project representing Japan introduced their styles of IP management and anticipated future challenges. Since the topic was relevant to present-day research consortia, there were many enthusiastic questions from the standing-room-only audience of more than 400 attendees, making the seminar extremely rewarding.

Hotel Nikko Tokyo, the venue for the International Patent Licensing Seminar 2010

The Launch of Gdevice@BEANS

In response to a call for research proposals from the New Energy and Industrial Technology Development Organization (NEDO), the Hetero-functional Integrated Device Technology Development Project (the BEANS Project) added a new R&D project entitled “Research and development of an advanced sensor network system and environmentally friendly processes,” which was launched in FY 2009 and will be pursued through FY 2010. The research project is divided according to content into a part submitted in response to the call for research proposals and a part made possible by the accelerated pace of the BEANS Project. The BEANS Project proposal sent to NEDO was adopted on March 10.

With problems of the environment and energy resources now acknowledged as global issues, there is strong pressure on every country and industry to implement more eco-friendly measures. Specifically, it is vital to conserve resources and work toward high efficiency and low environmental impact in order to reduce greenhouse gas emissions by 25%. With this backdrop, the newest BEANS R&D project is aimed at developing a sensor network system capable of monitoring energy usage in real-time, controlling the air conditioning system, and the like. The project calls for constructing a clean room as a testing ground and installing an 8-inch MEMS production line therein. Numerous high-performance MEMS sensor modules will then be arranged in the clean room to provide detailed information. Wireless communications will be essential for installing sensor chips freely within the network. Therefore, we will attempt to identify any technical issues such as what type of integrated MEMS sensor chip will be compatible with wireless communication LSI and can be configured of a large number of multifunctional sensors while being microsized inexpensively.

Concurrently, we will be developing environmentally friendly MEMS fabrication technologies, such as the use of an alternative gas for deep etching and low-temperature wafer-level packaging. Further, in order to develop and manufacture prototypes for hetero-functional integrated devices and integrated sensor devices more effectively and efficiently, we will be formulating high-quality processes for an 8-inch MEMS production line, gathering process recipes to support new materials and new structures, improving the design technology for controlling process machinery, and researching and developing technologies for processing environmentally friendly, biocompatible polymers.

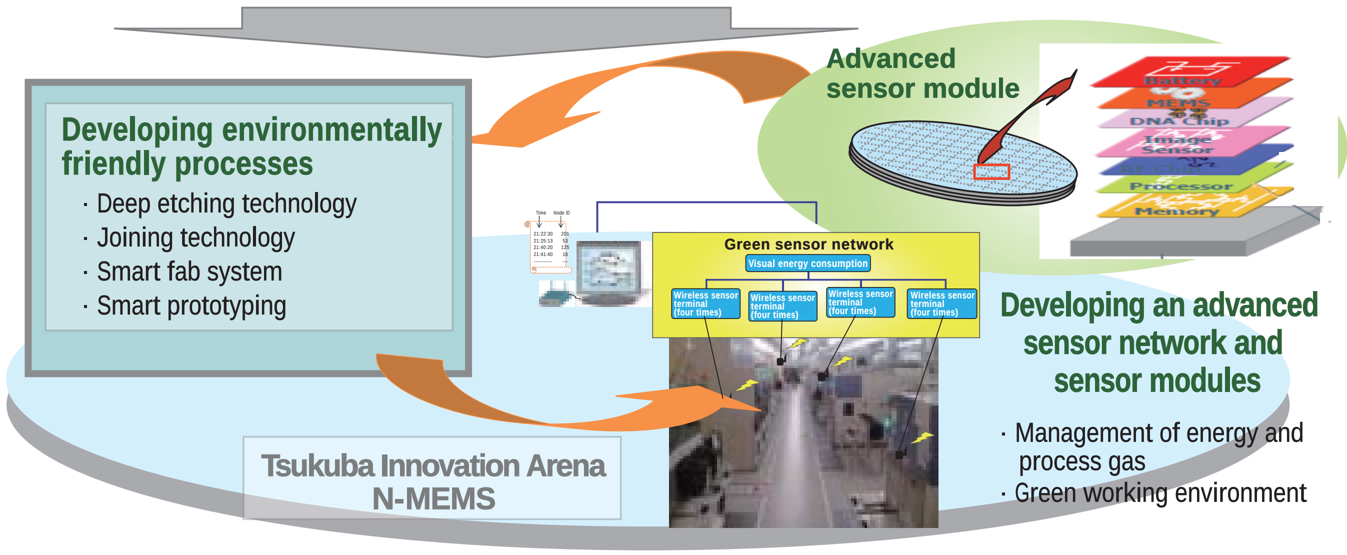
The BEANS Laboratory has adopted a spirit of open innovation. By making use of the infrastructure in place at the Tsukuba Innovation Arena N-MEMS aimed at the development of new technologies and industries and establishing a research center at Ritsumeikan University, we can take advantage of these assets to carry out more efficient and effective R&D. Please follow our progress in this project, as we intend to get the best results possible during this one-year period.

1. Development of an advanced sensor network system

- Produce a prototype of a sensor network system for sensing energy consumption, temperature, pressure, air volume, foreign particles, gas, etc. in a MEMS clean room for large-diameter wafers in order to analyze the effects on energy savings and reducing carbon content.
- Formulate new sensing principles aimed at the development of advanced integrated sensor chips capable of wireless communications with a wireless-independent power supply and having a small size and low profile and a highly sensitive sensing capacity.

2. Development of environmentally friendly processes

- Develop an efficient etching process for deep etching of silicon that has low environmental impact through an alternative gas to SF_6.
- Integrate various heterogeneous devices at the wafer level.
- Use polymer MEMS to reduce the environmental impact of processes and devices.
- Improve yield, quality, and throughput by designing and prototyping devices and processes using large-diameter test element groups, sharing information between the design and inspection stages, and providing design feedback from the inspection and measurement data.
- Implement information sharing at the design stage with consideration for environmental impact.



Members' Profiles

Mechanical Engineering Research Laboratory, Hitachi, Ltd.

1. Introduction

The Mechanical Engineering Research Laboratory (MERL) is one of six research laboratories belonging to Hitachi, Ltd. With about 380 researchers, MERL utilizes its basic mechanical systems technology to support a wide array of products, from large-scale infrastructure installations, such as high-speed rail cars and large-capacity high-speed elevators, to compact information equipment, such as magnetic and optical disks.

Hitachi's first involvement with micromachines came when its Central Research Laboratory and Hitachi Research Laboratory began developing semiconductor sensors in the 1970s. MERL began working with micromachines in earnest in 1991 when it participated in the Micromachine Project headed by the Micromachine Center. During this project, MERL worked on developing micro-sized pumps and other mechanisms, challenging the limits of conventional micromachining that simply reduced the size of traditional mechanical structures. Today, we are committed to R&D on 3D micromachining aimed at producing mechanical elements through semiconductor micromachining technology. We are also designing unique micromachined structures capable of emulating the functions of conventional machinery. Thus, machining technology and design technology are essential to our R&D activities. The next section will outline our efforts in research and development.

2. R&D Activities

As we approach the twentieth year of our R&D activities on micromachines at MERL, the direction of our research has shifted. The general focus of research in the micromachine field is said to have changed from determining how to make them, to determining what to make. Similarly, MERL's focus in R&D has changed from developing micromachine technology to developing applications for this technology. However, in order to verify the applications, it is vital to have our base machining technologies in place to be able to develop key micromachined parts quickly. Our micromachine room is approximately 585 m^2 and equipped with various production facilities that we work hard at maintaining and expanding. One feature of these facilities is that they allow us to implement 3D micromachining on a variety of materials, including silicon, glass, metal, and resin. We have this capacity because different materials are needed for the different business areas that the Hitachi Group handles, such as silicon and semiconductor thin films used in the fields of sensors and actuators, glass and resin used in biotechnology and medicine, and metal and glass used in chemosynthesis.

MERL is also conducting R&D on wafer-level bonding technologies for assembling micromachines formed on various substrates and possesses the facilities to support such technologies as diffusion bonding, eutectic bonding, fusion bonding, and anodic bonding. Our packaging equipment can replicate actual environments of use by forming wiring to 3D structures and connections to interposers as a means of interfacing between prototype micromachines and the physical world.

MERL evaluates the functions of packaged micromachines in fluidic devices using a microfluidic system to perform actual analysis and chemosynthesis. For sensors and actuators, we evaluate their dynamic characteristics using our various test facilities. We are also capable of conducting reliability tests on micromachines using our expertise cultivated in electronic devices.

Thus, MERL has prepared an R&D environment that allows us to carry out the entire process of prototyping, packaging, and evaluation necessary for proceeding smoothly in the development of applications.

Lastly, I will give a brief description of MERL's design technology. In micromachines, the design must be sufficiently reliable to avoid numerous repetitions of trial production and evaluation. To achieve such reliability, it is important from the design stage to carry out development that considers not only links between known micromachine structures and manufacturing processes, but also how such micromachine structures can be used. To this end, MERL is developing techniques for linking structural designs and package designs for micromachines. As always, it is easier said than done, but we will continue working toward this goal while drawing on our twenty years of accumulated experience.

3. Conclusion

At MERL we have worked on the development of various micromachine-related technologies and are now conducting a support service to provide consulting outside of the company on well-established micromachine technologies. For more information on Hitachi's integrated support service, please visit the i-engineering Web site below.

http://www.hitachi.co.jp/rd/i-engineering/contents4.html

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