MICRONANO
2010 02
No.70

CONTENTS

MICROMACHINE CENTER
http://www.mmc.or.jp/

BEANS・TRA
http://www.beanspj.org/lab/

New Year's Greetings

Hisao Sakuta,
Chairman
Micromachine Center
BEANS Laboratory

As we welcome in 2010, 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.

Last year I was appointed chairman of both entities at the joint board meeting held on September 17 and assumed my duties on the following day. While I am deeply honored to receive such an important responsibility, at the same time I fully realize the magnitude of these duties. 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.

Forgive me for starting out the New Year on a somber note, but as you know the state of Japan's economy remains dire due in part to the failure of Lehman Bros. the year before last and the Dubai debt crisis this past fall. 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, we must double our efforts in technological development related to MEMS and other micro/nano fields, now considered important industrial technologies.

To do this, the BEANS Project to develop next-generation device manufacturing technologies that fuse different fields, which was established to develop core process technologies required for creating innovative next-generation devices and to build a platform for this development, has set its sights on 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.

The BEANS Project is now entering its third year, which is the interim evaluation year. In 2010, the achievements of the project will become more evident and will help us establish a roadmap for developing base technologies required to produce innovative next-generation devices. Therefore, I would like to thank you all in advance for your continued support and cooperation with regard to the activities of the BEANS Laboratory.

On another note, the Micromachine Center has entered its 18th year this January. However, after the three laws on reforming the public interest corporations system went into effect in December 2008, the Micromachine Center decided to shift from its current public interest status to a general incorporated foundation in order to maintain a level of freedom amid the rapidly fluctuating social environment and ensure a stable environment for conducting operations. Accordingly, we have submitted an application to the Cabinet Office for making this change. 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.

In regard to the activities of the MEMS Industry Forum under the Micromachine Center, this year we will continue working with all those involved in studies aimed at strengthening an infrastructure for the future creation of nanotechnology R&D centers. We ask for your continued support and cooperation in this matter as well.

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 2010

Research Studies and Standardization Activities

1. Study on Industrial Trends

MEMS technology is expected to progress from single-function devices produced through more advanced downsizing of existing parts to multifunction devices produced through the combination of MEMS and nano-devices, the integrated formation of MEMS with semiconductors, and the high integration of MEMS with other MEMS, as well as innovative devices developed through the fusion of nano-bio technologies.

With this background, the Industrial Trends Study Committee (chair: Isao Shimoyama, dean of the Graduate School of Information Science and Technology, the University of Tokyo) under the Micromachine Center is conducting a research study on (1) trends in devices employing MEMS technology (MEMS applications) and products incorporating these devices (MEMS-Inside), and (2) the leading companies in MEMS-related industries and their business profiles (company trends). This study is aimed at keeping track of developments in devices with added value owing to MEMS technology, industrial fields employing such devices, and MEMS-enabled products (MEMS-Inside) and at developing a roadmap for market expansion in the MEMS industry.

The study on MEMS-Inside is being conducted from two perspectives: trends from single-function MEMS toward highly integrated, complex MEMS, and trends in patent applications. Based on these perspectives, data on the future expansion of MEMS applications (MEMS-Inside) will be compiled into 13 industry-specific fields, such as information and communication equipment, automobiles, consumer electronics and appliances, and medical and welfare equipment.

The committee is also conducting a research study on sensor networks and service robots, two up-and-coming fields currently expected to yield further expansion of MEMS applications.

The committee studies trends of companies involved in MEMS-related industries by sorting all domestic companies conducting MEMS business according to the type of business and by determining the type of MEMS-related business or activities the company is conducting and the type of MEMS-related activities to which the company aspires. The committee also studies the organization of Japan's leading MEMS-related companies, the types of devices handled by MEMS device manufacturers and their applications, and the state of MEMS foundries in Japan based on data gathered from companies that participate in the Exhibition Micromachine/MEMS and that apply for MEMS-related patents, and the Micromachine Center's database of micro/nano-related documents.

The Industrial Trends Study Committee will summarize the current status and future outlook of MEMS-related industries in the "FY2009 Report on Industrial Trends" in March 2010 to provide feedback for those involved in the MEMS industry.

2. Standardization Activities

View of the Tel Aviv coastline

The Subcommittee on MEMS (SC47F) of the Technical Committee on Semiconductor Devices (TC47) under the International Electrotechnical Commission (IEC) is responsible for reviewing MEMS international standardization. On October 18–22, 2009, the SC47F was invited to the IEC General Meeting held in Tel Aviv, Israel for TC47-related committee meetings and working group conferences. Approximately one thousand people attended the opening ceremony, which featured an address by the IEC president, as well as spectacular entertainment imbued with sound and lights, videos, singing, and dancing.

The opening ceremony

A total of twenty-six people attended the international conference for SC47F, including ten from Japan, twelve from South Korea, and one each from China, Germany, the United States, and Brazil. The main agenda for this conference was to review the comments by all countries on the three approved New Work Item Proposals (NP) for which voting closed on October 9, 2009. The committee came to an agreement to accept nearly all comments and to prepare a new Committee Draft (CD) based on the results of this review. The approved proposals are as follows.

(1) Test method of measuring adhesive strength for MEMS structure (proposal from Japan)
(2) Micropillar compression test for MEMS material (proposal from South Korea)
(3) Test method for linear thermal expansion coefficients of MEMS material (proposal from South Korea)

Thereafter, South Korea submitted three NPs entitled "Forming limit measuring method of metallic film materials," "Test method for bond strength in PDMS/glass chip," and "Test method for residual stress measurement." The domestic committee is currently deliberating on Japan's voting position. Within the next six months, Japan plans to propose the two NPs "Bending test method of thin film materials" and "Standard data for assessing material characteristics."

The WG conference

Recent Activities of the MEMS Industry Forum

1. Overview of Plans for MicroNano 2010

The micromachine exposition MicroNano 2010 will be held at Tokyo Big Sight on July 28–30, 2010. Having reached a consensus on the basic concepts and goals for MicroNano 2010, the Micromachine Center, which is sponsoring the event, and the organizer Mesago Messe Frankfurt Corporation are now working in concert on preparations for the event.

The turnout for MicroNano 2009 was heavily affected by the poor economic conditions, and the event experienced its first decline in recent years in the numbers of exhibitors and visitors. While the economic climate for fiscal year 2010 remains uncertain, we hope to regain the momentum toward growth seen in previous years.

In an effort to attract more exhibitors and visitors, in 2010 the Exhibition Micromachine/MEMS will be held concurrently with ROBOTECH, an exhibition on manufacturing technologies for service robots utilizing MEMS sensors (an exhibition on surface technology, SURTECH, will also be held concurrently). The MEMS Industry Forum (MIF) is also considering adding more concurrent events, such as a workshop on Nanoimprint Technologies and a workshop for our international affiliates.

The MIF is conducting promotional activities leading up to MicroNano 2010, including participation in the International Robot Exhibition and addressing robot MEMS in our MEMS workshops. We are also working on plans to enhance the MMC concierge service at the Exhibition Micromachine/MEMS, as well as to provide the most valuable technical information, business information, and business opportunities in one location for exhibitors and visitors. Please consider participating in MicroNano 2010 as an exhibitor or visitor. This event is not to be missed!

2. Networking International Affiliates

The MIF actively pursues collaboration with its international affiliates. In addition to transmitting information from Japan and collecting the latest technical information from around the world, information exchange with international affiliates is directly linked to the concept of “open innovation” embodied in the formation of the Tsukuba Innovation Arena Nano (TIA-Nano).

In October 2009, a second joint workshop with CEA-LETI of France was held at AIST Tsukuba, where both parties gained a deeper understanding of robot MEMS, sensor networks, and 3D integration. We are currently exploring the possibilities for continued collaboration with LETI.

Taiwan’s Industrial Technology Research Institute (ITRI) became our 19th international affiliate on November 25. At the same time, we held a joint workshop at the University of Tokyo’s Komaba Campus to cultivate a better understanding with the ITRI and explore the potential for future collaboration.

In addition to these workshops, the MIF shared information with the Berkeley Sensor & Actuator Center (BSAC) and the MEMS Industry Group (MIG) of the U.S. and IMEC of Belgium, and discussed possibilities for intercourse with Canada and the Netherlands. It is hoped that these activities will eventually lead to business opportunities for the MMC’s supporting members and contribute to the formation of TIA-NMEMS.

Workshop with LETI

ITRI signing

3. Study on a human resource development Program

While the economy is at a standstill due to the recession, there is no doubt that the MEMS industry will continue to grow in the long-term. With the market for MEMS expected to grow to some 2 trillion yen, the need to develop skilled personnel to accommodate this market scale has become urgent.

The MIF is studying a new education and training program in which the Micromachine Center would play a pivotal role. While personnel training projects have been conducted at AIST and at public institutes in northern Kyushu and the Kansai area, this program is aimed at expanding the training projects nationwide in the next fiscal year through a subsidy from the Kanto Bureau of Economy, Trade and Industry. Entitled “the Innovative Micro/nano Personnel Training Program” (provisional title), the program would restructure and reform the current curriculum, including the addition of new courses, and would be aimed at developing not only experts in fabrication processes and device design, but also personnel capable of bridging the gap between technological seeds and market needs to produce commercial products.

4. Formation of the Tsukuba Nano-tech Innovation Arena N-MEMS

Creation of the Tsukuba Nano-tech Innovation Arena N-MEMS 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 endeavor has been gaining momentum with the June establishment of an executive council and a series of workshops held through the support of METI. The Micromachine Center is studying a draft on a strategy and organization aimed primarily at forming N-MEMS.

The BEANS Project and the research organization for GMEMS (high-performance sensor networks and low environmental impact fabrication processes), which has been proposed for a supplementary budget or the budget for the next fiscal year, are in position to make of the core of N-MEMS. We will continue to propose strategies for using Japan’s strengths to overcome our intense global competition and will conduct studies in cooperation with the Micromachine Center’s supporting members on forming N-MEMS.

Activities of the MEMS System Development Center

1. Subcommittee Meeting on the Fine MEMS Project (Post-project Evaluation)

In order to bring the Fine MEMS Project to a close, a NEDO research evaluation committee established to assess the R&D conducted over this three-year project held the 1st "Highly Integrated, Complex MEMS Production Technology Development Project" (Post-project Evaluation) Subcommittee Meeting at the WTC Conference Center on October 5, 2009.

Seven committee members participated in the subcommittee meeting, which was chaired by Kuniki Owada (professor at the Department of Information Science, the Faculty of Science and Engineering, Teikyo University). At the subcommittee meeting, the principal investigator Hajime Inuzuka of the Machinery System Technology Development Department (NEDO), which is overseeing the project, explained the significance and necessity of the project and the R&D management implemented. Isao Shimoyama, professor at the University of Tokyo and project leader, then gave an overview of the R&D achievements and prospects for commercialization.

These presentations were followed by a private session in which the heads of development for each company involved in the project presented their research achievements in the eight subsidized projects. In the ensuing public session, Susumu Sugiyama, a professor at Ritsumeikan University and Fine MEMS Project subleader, gave a report on the R&D achievements for seven commissioned projects (excluding the fine MEMS knowledge database and the integrated design platform projects). At the end of the public session, the MEMS System Development Center of Micromachine Center presented the results of compiling the knowledge database and developing the integrated design platform.

At the subcommittee meeting, there was a lively question and answer session among the evaluation committee members and other involved parties. The committee members recognized that the achievements produced in this project was some of the most original and cutting-edge in the world, and there were comments to the effect that the research results overall were outstanding.

The final evaluation of this project is expected to be completed by the end of January 2010 after deliberation by the NEDO research evaluation committee.

2. Report on the Third China & Japan Joint Seminar on Green MEMS and Sensor Networks

On November 24–25, 2009, Japan and China held a joint seminar at the Millenium Hotel in Wuxi, China on MEMS sensor networks, which are currently drawing attention as an area of research that must be pursued to meet future needs for low environmental impact, safety, security, and comfort. The seminar was organized by the National Institute of Advanced Industrial Science and Technology (AIST) (Dr. Ryutaro Maeda, prime senior researcher) and Peking University (Haixia "Alice" Zhang, professor). A total of thirteen speeches were given at the seminar, including seven from Japan and six from China.

Dr. Maeda described a general strategy for facility management in green MEMS, and discussed the importance of such management and the effects it would have on applications in MEMS networking. His speech drew questions and discussion on specific reductions for CO_2 gases. Prof. Zhang described the MEMS-related market and business activities in China and discussed the concept and importance of incorporating sensor networks in these activities. She also described plans to construct a green clean room at Peking University in order to demonstrate its efficacy and reported that network sensors may also be useful from a safety perspective, and not just a green perspective, as in motion sensors and optical sensors for monitoring human activity and RF and SIC pressure sensors, which are resistant to chemicals and high temperatures. Her speech sparked several questions, such as whether particle sensors were also being considered for use as network sensors in the clean room, and led to a more in-depth discussion that illustrated the high level of interest in sensor networks.

Toshihiro Ito of the AIST talked about a health monitoring system for chickens as one application of MEMS chips and sensor networks. Some felt that this would draw much interest from a marketing standpoint in China, since more than a billion chickens are raised in this country.

The China side also gave presentations on the environment for MEMS technology. Dr. Li Gang of Suzhou Microsensing Company reported on the climate for MEMS venture businesses in China, noting that the MEMS market is still underdeveloped, there is no support from MEMS foundries, few engineers have the necessary skills to develop MEMS, and MEMS industries are not growing. There was sentiment on the Japanese side that this situation presents an opportunity for foundry services.

Wang Hong of China Micro-Nano & Sensor Network Global Innovation Perk reported on activities in Wuxi related to MEMS and sensor networks. The city is trying to attract MEMS businesses and, toward that end, is proactively developing the necessary sites and infrastructure.

Lastly, Prof. Renshi Sawada of Kyushu University informed the participants of plans to hold the fourth seminar in Hokkaido the following August.

In conclusion, the seminar featured a wide variety of presentations on efforts to integrate industry, academia, and government, the core technologies necessary for MEMS research, the environment in China for MEMS, and efforts to develop applications for MEMS sensors, and the event proved to be of great interest to all participants.

Dissemination and Publicity Projects

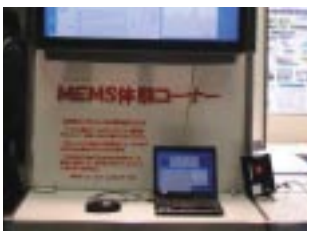
1. International Robot Exhibition 2009

The International Robot Exhibition 2009 organized by the Japan Robot Association and Nikkan Kogyo Shimbun, Ltd. was held November 25–28 at Tokyo Big Sight. The Micromachine Center (MMC) participated in the exhibition to introduce MEMS technology and the Center's activities.

In order to illustrate MEMS technology to both people involved in robotics and the general public, the MMC set up a trial corner for visitors to experience motion sensing. Here, an accelerometer and a gyroscope (angular velocity sensor), practical examples of MEMS-based sensors, were incorporated in a game controller. With many children and adults took turns trying out the controller throughout the exhibition, the trial corner helped illustrate how MEMS devices are already working for us in our everyday lives, as reflected in the expression "MEMS in your pocket."

In addition, the MMC booth featured presentations on the MEMS Mall, a service for introducing MEMS products over the Internet, and examples of practical applications produced from the METI's Micromachine Project, which laid the foundation for Japan's micromachine and MEMS technology in the 1990s. Both presentations were well received. We also announced the upcoming event MicroNano 2010 to be held July 28–30, 2010. The event, which is being sponsored by the MMC, will include ROBOTECH, Exhibition on Service Robot Manufacturing Technologies that is to be held concurrently with the Exhibition Micromachine/MEMS.

The MMC booth



The MEMS trial corner

2. The 2nd MemsONE Technology Forum in Tokyo

On November 27, 2009, the 2nd MemsONE Technology Forum in Tokyo was held at the MMC's Techno Salon. In an effort to publicize MemsONE to a wider group of people, the name of the forum was changed this year from the MemsONE User's Group so as to accept not only users, but also anyone interested in MemsONE, and participation in the forum was free. This year's event attracted a total of twenty people, including speakers, users, and the general public and created a hot discussion.

The following is a list of the lectures given at the 2nd MemsONE Technology Forum in Tokyo.

Special Lecture I : "R&D on microdevices for applications in regenerative medicine"; Hidetoshi Kotera, professor at Kyoto University

Special Lecture II : "An introduction to the MEMS Equivalent Circuit Generator"; Gen Hashiguchi, professor at Shizuoka University

Case Studies I : "Applying MemsONE circuit analysis to the design of a rotary stepper motor"; Junji Sone, associate professor at Tokyo Polytechnic University

Case Studies II : "Advanced mesh generating techniques with MemsONE"; Yukihisa Maeda, UEL Corporation

Demonstration on the features of version 3.0: the MemsONE Support Center

Prof. Kotera of Kyoto University

Prof. Hashiguchi of Shizuoka University

3. Publicizing MemsONE Nationwide

Previously, the MMC has disseminated information on MemsONE through exhibits, lectures, seminars, and workshops primarily in metropolitan areas. However, recently we began expanding our PR efforts through personnel training projects being conducted throughout Japan.

The MMC manned an exhibit at the 13th Tohoku CAE Konwakai held October 16 in Miyako City, Iwate. MemsONE was also used as the teaching material in intensive analytical courses held concurrently with the Forum for CAE engineers. To read more about the CAE Konwakai, please go to the Web site http://www.cae21.org/.

As part of the "Personnel training program for pioneering new innovative projects related to micro/nano mass production and applied device fabrication," a personnel training project conducted in 2009 through industry-academia collaboration, the National Institute of Advanced Industrial Science and Technology (AIST) organized a personnel training workshop entitled "MEMS design and simulation techniques." The workshop was held at Techno Plaza Okaya in Okaya City, Nagano on October 26 and featured MemsONE as the training material.

Announcing the release of MemsONE Version 3.0!!

More friendly (boundary element method and shape-defining function)

More powerfully (mesh generator, mask CAD)

Improved material and knowledge databases

See http://www.mmc.or.jp/mems-one/ for more information.

Achievements and Activities of the BEANS Project

At its five research centers (Life BEANS Center, Life BEANS Center Kyushu, 3D BEANS Center, 3D BEANS Center Shiga, and Macro BEANS Center) and its head office, the BEANS Laboratory has been conducting R&D on process technologies for integrating biomaterials, integrating organic matter, fabricating 3D nanostructures, fabricating 3D nanostructures for space applications, and large-area continuous manufacturing of micro/nanostructures, and has been building up of a knowledge database in heterogeneous technology convergence process development. In this fiscal year, we have so far presented our research achievements at domestic and overseas academic conferences, including the 26th Symposium on Sensors, Micromachines & Applied Systems (hereinafter "Sensor Symposium"), through forty-four presentations and eight paper submissions, and have additionally applied for sixteen patents. In order to further publicize the achievements of the BEANS Project, we held seminars at BEANS research centers (AIST on October 2 and the University of Tokyo on November 25), promoted technology exchange with LETI of France and ITRI of Taiwan, and participated in a panel discussion at the MEMS Executive Congress (held on November 4–6 and organized by the MEMS Industry Group) to introduce the activities of the BEANS Project.

This article describes our participation in the 26th Sensor Symposium, where we gave various presentations on the achievements of the BEANS Project as part of our activities.

1. The 26th Sensor Symposium

Sponsored by the IEEJ Sensors and Micromachines Society, the Sensor Symposium is the largest symposium in Japan on sensors, MEMS, and micromachines. At the 25th Sensor Symposium held in Okinawa in 2008, the first session on BEANS was held together with the Professional Committee of Micro-Nano Engineering of the Japan Society of Mechanical Engineers (JSME). However, a BEANS session was not included in the 26th Sensor Symposium, which was held October 15–16, 2009 at Tower Hall Funabori, Tokyo. Still, the 26th Sensor Symposium, which was held jointly with the 1st Symposium on Micro-Nano Engineering (hereinafter "Micro-Nano Symposium") organized by the Professional Committee of Micro-Nano Engineering of JSME and the Symposium on Integrated MEMS Technology organized by the Study Group of the Integrated MEMS of the Japan Society of Applied Physics (JSAP), lived up to its name as the largest symposium on sensors, MEMS, and micromachines.

The BEANS Project selected these symposia as the primary venues for presenting the achievements of the Project, giving nine presentations at the 26th Sensor Symposium and three at the Micro-Nano Symposium, for a total of twelve presentations. Since the 26th Sensor Symposium featured 153 presentations in all, including invited lectures, and the Micro-Nano Symposium 56 presentations, the BEANS Project accounted for 5.9% and 5.4% of the respective symposia, exceeding 5% overall.

Broken down by research center, six presentations were given by the Macro BEANS Center, three by the Life BEANS Center, two by the 3D BEANS Center, and one by the Life BEANS Center Kyushu, resulting in extensive publicity for the BEANS Project. The significance of the research conducted at the Life BEANS Center also received a boost in publicity when researcher Nobuo Misawa received the Igarashi Award for his presentation.

(1) Presentations by the Macro BEANS Center

- Thin film deposition technologies on fibers by inkjet (Akio Mimura senior researcher; Sensor Symposium)
- High speed thin film coating process on fiber-type substrates with die coater (Norihisa Shibayama, researcher; Sensor Symposium)
- Structual properties of Si films deposited by plasma enhanced chemical transport method under atomospheric pressure (Takaaki Murakami, senior researcher; Sensor Symposium)
- Ejection of microparticulate silicon using mist-jet technology (Yoshinori Yokoyama, senior researcher; Sensor Symposium)
- Flexible sheet device by weaving functional fibers (Takeshi Kobayashi, researcher; Micro-Nano Symposium)
- Microfabrication process of cellular structures in hollow fiber-shaped substrates (Sohei Matsumoto, senior researcher; Micro-Nano Symposium)

(2) Presentations by the Life BEANS Center

- A consideration on mechanisms of droplet formation in flow focusing devices (Yukihito Suzuki, researcher; Sensor Symposium)
- Multichannel chemical sensors using cells expressing olfactory receptors (Nobuo Misawa, researcher; Sensor Symposium)
- Subcutaneous implantable blood glucose sensors using glucose responsive fluorescent gel beads (Hideaki Shibata, researcher; Sensor Symposium)

(3) Presentations by the 3D BEANS Center

- Fabrication and control of InAlGaN quaternary quantum dots with deep-UV emission (Takayoshi Takano, researcher; Sensor Symposium)
- The analysis of a comb-drive actuator with the consideration of depletion layer (Shinji Ueki, researcher; Sensor Symposium)

(4) Presentations by the Life BEANS Center Kyushu

- Thermal properties of nano-structured materials and thermal measurements by MEMS (Koji Miyazaki, senior researcher; Micro-Nano Symposium)

Nobuo Misawa receiving the Igarashi Award

Research Centers under the BEANS Project (Part II)

1. Life BEANS Center Kyushu (Kyushu University)

The Life BEANS Center Kyushu is involved in the development of process technologies for integrating bio and organic materials. Organic semiconductor has been recognized as a key for developing the next generation of electronics. These days it is expected to develop optic and electronic devices with added value of flexibility and a large surface area with high quality that are difficult to achieve with conventional inorganic semiconductors. Our research team is developing organic semiconductor fabrication processes that provide an inexpensive solution to large-area nanostructure control, with the goal of expanding into optoelectric and thermoelectric energy conversion devices in the future.

The Life BEANS Center Kyushu collaborates with the Kyushu Institute of Technology, Lintec Corporation, and Panasonic Electric Works and operates in close coordination with research teams at the University of Tokyo and the National Institute of Advanced Industrial Science and Technology (AIST). We are striving to integrate such dissimilar fields as electronics, chemistry, and mechanics and are developing process technologies for integrating new bio-organic materials. A distinction of our Center is the large number of joint research projects that we are conducting with other centers in the BEANS Project, including a joint project with the 3D BEANS Center on ultra low-damage dry etching using a neutral beam, and a supercritical deposition technology. We have accelerated research on the neutral beam etching technology after installing equipment for etching organic film at the Life BEANS Center Kyushu. Supercritical deposition is also being studied to develop a technique for filling organic nanostructures fabricated at our Center. At the Life BEANS Center Kyushu, we are making steady progress toward the BEANS objective of hetero function integration which we hope will lead to the development of innovative devices.

2. 3D BEANS Center Shiga (Ritsumeikan University)

The 3D BEANS Center Shiga is involved in R&D on fabricating 3D nanostructures for space applications. Unlike the other research centers in the BEANS Project, 3D BEANS Center Shiga conducts R&D with the goal of applying micro/nanomachining to space applications. Based at the Biwako-Kusatsu Campus of Ritsumeikan University, Researchers from Ritsumeikan University, the Institute for Unmanned Space Experiment Free Flyer Foundation (USEF), the Japan Resources Observation System and Space Utilization Organization (JAROS), and Mitsubishi Electric Corporation conduct the research. The researches at the Center involve developing a technology for simulating subwavelength optical structures, developing micro/nanomachining technologies through anodic oxidation, developing optical and structural evaluation techniques for filters with 3D nanostructures designed for space applications, and studying an evaluation index on the applicability of 3D nanostructures for space applications.

3. Macro BEANS Center (AIST)

Based at AIST Tsukuba East, the Macro BEANS Center is engaged in the development of micro/nanostructure large-area continuous fabrication processes through collaboration among researchers in an AIST-Macro BEANS collaborative research group and researchers from Toshiba Machine Co.,LTD., The Furukawa Electric Co., LTD. and Mitsubishi Electric Corporation, and BEANS Laboratory.

We are working to produce meter-scale large-area energy harvesting devices for use in the fields of environment and energy and health and medical care at considerably lower cost and with higher performance using micro/nanostructures. We are also looking to develop new flexible sheet-like devices that can be mounted on a 3D free-form surface for use as wearable power generators, jackets designed for safety and security, and sheet-like health monitoring devices. However, continuing to employ fabrication techniques based on conventional semiconductor equipment to manufacture such devices has exposed problems such as limitations in the size of the vacuum process equipment and the surface area of the substrates. In order to reduce costs and increase performance of conventional meter-scale large-area devices, we must develop new fabrication process which deposits high-quality functional films having micro/nanostructures on meter-scale substrates without using vacuum process equipment. We must also develop a new fabrication technology that realizes meter-scale flexible sheet-type devices utilizing micromachining and weaving integration of fiber substrates instead of micromachining of large substrates.

To meet these needs, the Macro BEANS Center is conducting R&D on innovative next-generation non-vacuum processes based on techniques for coating functional materials, such as nano particles, that integrate a technique for activating nano functional materials through local control of ambient gas and temperature, and a technique for controlling the density and arrangement of nano functional materials. With these non-vacuum processes, we hope to develop a technology for the rapid and direct formation of high-quality functional films with micro/nanostructures on meter-scale large-area substrates. We are also conducting R&D on a technology for the continuous rapid formation of high-quality functional films on fiber substrates through a non-vacuum process, and a technology for increasing the functionality and surface area of this fiber substrate through a new weaving/integration process.

Researchers at the Macro BEANS Center

Members' Profiles

Toshiba Machine Co., Ltd.

1. Company Profile

Founded as a machine tool manufacturer in 1938, Toshiba Machine has since developed and produced a wide variety of product lines in response to the demands of the times. Now operating as the Toshiba Machine Group, the company is involved in the production and sale of diverse equipment including injection molding machines, die-casting machines, plastic extrusion machines, industrial robots, nanoimprint machines, high-precision machines, machine tools, and hydraulic equipment.

2. Nanoimprint Machines

Toshiba Machine entered the field of nanoimprint machines in 2004 to develop and manufacture press-type and roll-to-roll nanoimprint machines. In 2009 the high-precision machine business was consolidated with a new Nano Processing System Division launched to synergize nanoimprint lithography with ultraprecision machining.

(1) Application of Nanoimprint Lithography to MEMS

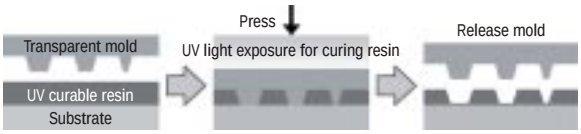
While semiconductor integrated circuit and LIGA fabrication technologies are generally used when manufacturing MEMS, equipment and running costs for these processes rise sharply as the pattern size becomes smaller. Nanoimprint lithography is a simple process for transferring a mold pattern onto a substrate and is thought to have great potential for reducing MEMS fabrication costs.

(2) Press-type Nanoimprint Machines

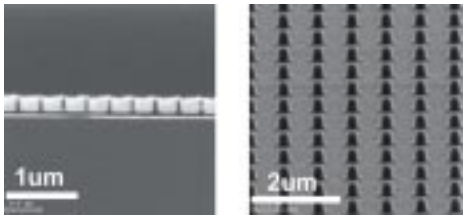
Toshiba Machine has developed a press-type nanoimprint machine (model No. ST50) with a maximum force of 50 kN. This machine supports UV imprinting, thermal imprinting, room-temperature imprinting, and micro-contact printing (soft lithography). Since it is necessary in nanoimprint lithography to provide flexible support for a wide variety of molds, patterns, and pattern-forming methods, we customize our machines for each customer to suit their desired imprint methods and mold structures.

A large number of the ST50 nanoimprint machines are being used in diverse research and development applications, including optical devices, storage media, biomedical applications, semiconductors, MEMS, and display devices. Recently we are developing nanoimprint machines capable of supporting mass production for such markets as high-brightness LEDs and discrete track media type hard disk drives.

Press-type nanoimprint machine ST50



UV nanoimprint lithography



Pattern transferred by a nanoimprint machine

(3) Roll-to-Roll Nanoimprint Machine

One obstacle in making nanoimprinting commercially viable is the need to support large-area applications. Toshiba Machine has developed and produced a roll-to-roll UV nanoimprint machine designed primarily for optical film applications. This machine applies the roll technology used in extrusion and printing systems, employing a gravure roll to mold UV curable resin coated on film. The applications of this machine are diverse and include optical sheets for flat-panel displays, biotechnological applications, solar cells, electronic paper, and wire-grid polarizers.

Roll-to-roll UV nanoimprint machine and transferred film

3. Toward the Mass Production of Nanodevices

Recently our customers' views toward nanoimprinting have changed from simply being content with good precision to wanting to perform prototype testing for the purpose of reducing costs in device mass production and enhancing the durability of the mold and mold-release layer. It is evident that the day is not far off when our system and machines will be used in production lines for a range of devices.

To realize device mass production with nanoimprint machines, it will be necessary not only to improve performance, but also to perfect the overall technology, including the mold, resin material, process design, and inspection required for implementing the entire manufacturing sequence. We are working tirelessly to develop these technologies as a total solution for our customers.

MICRONANO is published quarterly by Micromachine Center (MMC), BEANS Technical Research Association (BEANS·TRA) to promote the international exchange of information related to micromachines, R&D and other technical topics, and is circulated free of change. Please send your comments about **MICRONANO** to the publisher :

Keiichi Aoyagi, Executive Director, Micromachine Center (MMC)
MBR99 Bldg., 6F., 67 Kanda Sakumagashi, Chiyoda-ku, Tokyo 101-0026, Japan
Tel : +81-3-5835-1870, Fax : +81-3-5835-1873
Internet Home Page http://www.mmc.or.jp/
Date of Issue : February 22, 2010