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CONTENTS

MICROMACHINE CENTER
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BEANS・TRA
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Topic

The MicroNano Exposition Returns to a Growing Trend with a Strong Showing in 2010

July 28–30, 2010 Tokyo Big Sight, East Hall 5/6
21st Exhibition Micromachine/MEMS ROBOTECH Exhibition on Next-Generation Service Robot Manufacturing Technologies
<Concurrent events> 16th International Micromachine/Nanotech Symposium, TIA-NMEMS Symposium, and more
(SURTECH 2010 Exhibition on Surface Technology held concurrently)

The micromachine exposition MicroNano 2010 was held at Tokyo Big Sight on July 28–30, 2010. This year's exposition welcomed more than 14,000 visitors over the three-day event, an increase of 15% over last year's total, and occupied 349 exhibit spaces, up approximately 10% over the previous year. With no let-up in the severe economic climate, this performance validates the great effort spent to recover from last year's decline in attendance.

MicroNano 2010 featured the first inclusion of ROBOTECH, an exhibition highlighting manufacturing technologies for service robots. The new addition attracted much media attention, enabling us to promote the feasibility of service robots as a promising field for MEMS applications.

The 16th International Micromachine/Nanotech Symposium adopted a theme on the link between MEMS technology and Green Innovation, while the TIA-NMEMS Symposium provided a venue to discuss the formation of a center in Tsukuba and to introduce the activities of the MEMS Industry Forum (MIF) toward this realization. The BEANS Project, facing interim evaluations with the passage of its first two years, held a seminar to present the achievements and outlook of the project. All seminars saw high attendance and realized our goal of offering comprehensive MEMS-related information at one venue, while also providing opportunities for business discussions.

Next year's exposition will be held on July 13–15, slightly earlier than in previous years. We hope to see many of you at the exposition, either as exhibitors or visitors.

ROBOTECH

Many advanced nations are facing a declining birthrate and aging population, as well as a declining workforce, critical issues that may be addressed by extensively incorporating service robots in our daily lives. The aim of the ROBOTECH exhibition is to assemble MEMS devices and other key elements for developing these service robots in order to promote promising applications for MEMS. (METI Senior Vice Minister Tadahiro Matsushita is shown here at ROBOTECH.)

The ROBOTECH Theme Zone showcased operations and functions of actual robots developed by robot-related companies in Osaka and Kanagawa, as well as university-related institutes, and drew much attention at the exhibition.

Next Year's MicroNano 2011 To Be Held
July 13–15 (Wed-Fri), 2011 at Tokyo Big Sight, East Hall

TIA-NMEMS Symposium

The TIA-NMEMS Symposium was held in MicroNano Conference Area A on July 30 as one of the concurrent events. This symposium was established to present some of the activities in the works for implementing a Tsukuba nanotech center.

The Tsukuba Innovation Arena NMEMS (TIA-NMEMS) is an R&D center for the field of micro-/nano-electromechanical systems, which is one of the six core domains of the Tsukuba nanotech center. It is hoped that TIA-NMEMS will fill an important role in helping to make Japan's MEMS industry more competitive internationally.

Although the symposium was scheduled for a timeslot just thirty minutes after the doors of the hall were opened, the 210-seat conference area was fully occupied. All of the speakers were people occupying positions of responsibility, including METI Senior Vice Minister Tadahiro Matsushita and AIST President Tamotsu Nomakuchi (pictured above), which likely raised the profile of the symposium. In his lecture, Nomakuchi talked about efforts being conducted to improve Japan's system of developing intellectual property in order to distinguish domestic research institutes from their counterparts overseas. Representatives from other companies expressed high expectations for the R&D projects carried out at TIA-NMEMS to bolster their own company's competitiveness.

Research Studies

1. First Semester Survey of Industrial Trends

In order to conduct a survey of industrial trends in the field of MEMS, we attended the Microtech/Nanotech Conference & Expo 2010 (June 21–24, Anaheim, CA), which is held annually in the U.S. At the conference, we studied trends in technological development and industrialization in MEMS-related businesses.

With the goal of promoting exchange among businesses and between companies and universities, the conference featured many distinctive sessions that included companies giving presentations, universities publicizing their acquired patents, major firms describing solicitations for joint research with universities and venture businesses, venture capital firms giving informative presentations, and a presentation on government funding.

The conference featured a series of vibrant presentations by companies, centered on guest speeches from STMicroelectronics and others who have produced results in the MEMS industry. Throughout the conference, presenters offered common viewpoints: that the fields of MEMS applications and the MEMS market will expand dramatically in the future, and that innovative technological development and suitable business strategies will enhance business opportunities considerably.

One trend in MEMS technology is the development of devices that integrate multiple functions, such as monolithic CMOS multi-axis motion sensors, many of which are already on the market. Developers are also actively working on reducing the size and cost of such devices.

There are an increasing number of startup companies in the fields of RF-MEMS, silicon oscillators, and electronic compasses, which are the latest industrial trends in new applications. It is apparent that these startups work in groups applying a horizontal specialization model, or a slightly modified version called a semi-horizontal specialization model, as a business strategy for competing with the major companies. Some of the most common aspects of the venture companies giving presentations were as follows: developing and patenting new technologies that are superior to conventional technologies is a minimum requirement; their applications target growing fields rather than niches; the preferred business model is horizontal specialization; and they compete against major companies through speed. In contrast, the MEMS industry in Japan is mostly configured as branches of major companies employing a vertical specialization model. It is not possible to conclude straight away that one model is better than the other, as successful cases of both can be seen throughout the world.

In the second semester of this fiscal year, we will continue surveying industrial and technological trends at home and abroad, analyze these trends, and compile proposed courses of action for Japan's MEMS industry. For more information, please visit http://beanspj.cocolog-nifty.com/mems/ (Japanese only).

2. First Semester Survey of Technological Trends at Home and Abroad

Our survey of technological trends in the first half of 2010 focused on the Asia-Pacific Conference on Transducers and Micro-Nano Technology (APCOT) 2010. APCOT is an international conference held biannually in the Asia-Pacific region to present R&D findings in MEMS and nanotechnology fields. APCOT 2010, the fifth meeting in the conference's history, took place in Perth, Australia on June 6–9, 2010.

The 253 papers submitted to this conference marked a radical drop from the 589 papers submitted to the previous conference held in Taiwan. Of these total submissions, 240 papers were selected for presentation. Fig. 1 breaks down the numbers of presentations given by country.

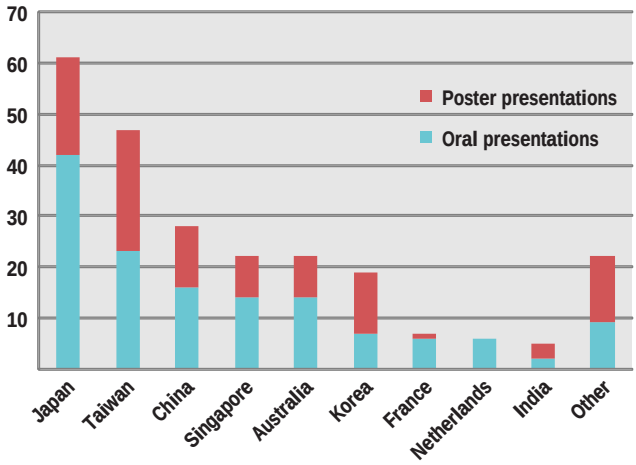


Fig. 1 Numbers of presentations by country

Fig. 2 illustrates the numbers of presentations broken down by field. Two of the more prominent fields are Radiation/Material Substance Sensors and Optical.

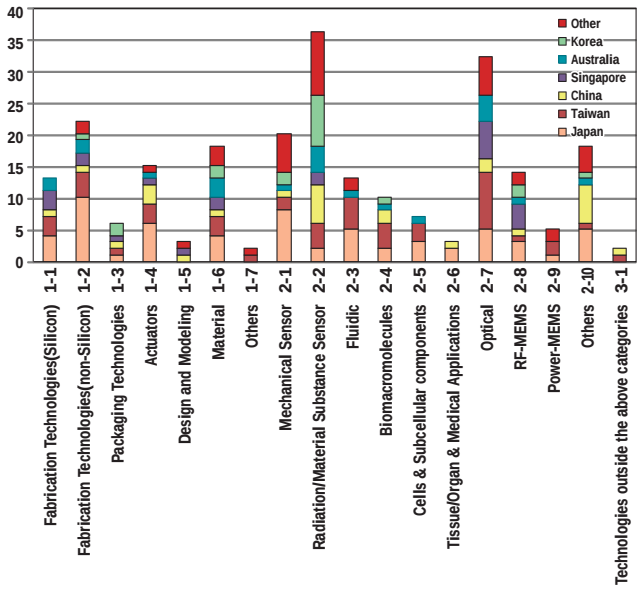


Fig. 2 Numbers of presentations by field

Activities of the MEMS Industry Forum

1. 16th International Micromachine/Nanotech Symposium ~MEMS World~

The 16th International Micromachine/Nanotech Symposium was one of the current events held at MicroNano 2010. The Symposium took place on July 28, 2010 (Wed) in Micro/Nano Conference Area A of Tokyo Big Sight, East Hall 5. The audience filled most of the seats in the conference area and contributed to a lively Q&A session.

In order to allow visitors sufficient time to attend the Symposium and still take in the exhibitions, the Symposium was limited this year to an afternoon program, rather than running the entire day, and featured six lectures including the keynote speech.

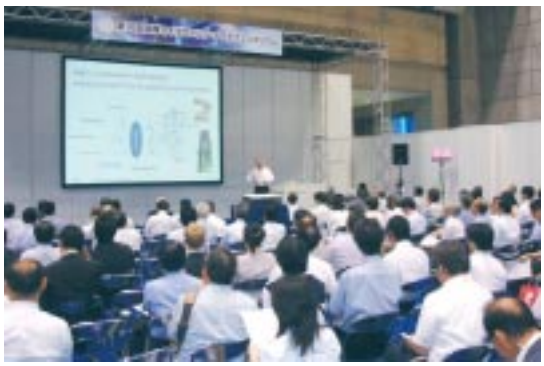
The 16th International Micromachine/Nanotech Symposium adopted the theme "Green Innovation Explored by Ambient Devices" and included presentations from international research institutes overseas detailing their latest results in the field of sensor networks, which is attracting a lot of attention and relates to the G-device Project. For the keynote speech, we turned to Isao Shimoyama, professor in the Graduate School of Information Science and Technology at the University of Tokyo and chairman of the International Exchange Committee established by the MEMS Industry Forum (MIF). As in previous years, simultaneous interpretation was provided.

Other lectures were given by representatives of the following member organizations.

- IMEC-NL of the Holst Centre (the Netherlands)
- CEA-LETI (France)
- Fraunhofer ENAS (Germany)
- BSAC (America)
- Dalsa Semiconductor (Canada)

According to a questionnaire distributed to audience members, most respondents indicated that they were either "mostly satisfied" or "satisfied" with the contents of the lectures, and the evaluations were thought to be consistent. There were also a few requests in the questionnaires from respondents who wished to continue the discussion in a separate room after the symposium in order to ask questions in greater depth, which is a matter to be considered for subsequent events.

We will work to incorporate your suggestions in a timely manner in order to provide a productive program next year.



Speech given by an IMEC researcher

2. MEMS Industry Forum Workshop

The MIF Workshop was held on July 30 (Fri) as Part II of the TIA-NMEMS Symposium. The Workshop offered an opportunity to distribute information on the activities of the MIF and to promote an exchange of opinions.

This year's Workshop was given the subtitle "Preparatory Activities for Implementing a Micro/Nano R&D Center" and served to introduce the MIF's various activities within the context of TIA-NMEMS. The MIF reported on industrial trends and trends in international R&D and international standardization, as well as its efforts to promote MEMS industrialization including activities related to personnel training, foundry services, and the MemsONE design tool. As with Part I of the Symposium, the conference area was substantially full for the Workshop, reflecting a heightened interest in the MEMS industry, trends in MEMS R&D, and efforts to build the R&D center at Tsukuba.

3. International Exchange: Visits to LETI and Fraunhofer and Participation in Nano Korea

As part of its efforts to promote international exchange, the MIF visited France's LETI and Germany's Fraunhofer ENAS and IPMS in June to participate in an exchange of views on the MEMS industry. In addition, the MIF participated as an exhibitor at the Nano Korea exhibition held in Korea in August this year.

The Nano Korea exhibition hall

4. Investigative Committee for an Open Innovation Center

This fiscal year, the MIF established the Investigative Committee for an Open Innovation Center under the Industrial Exchange Committee. The Investigative Committee initiated discussions on the best course of action for implementing a nanotech center at Tsukuba in order to strengthen Japan's international competitiveness in the MEMS industry. The Investigative Committee will also serve as the TIA-NMEMS Working Group that participates in the Executive Council for the Tsukuba nanotech center so that the results of discussions conducted in the Investigative Committee are reported directly to the Executive Council.

The first Investigative Committee meeting held in July and a subsequent council meeting revealed some specific challenges to implementing the center. We intend to continue this thorough investigation in order to help make the Tsukuba nanotech center a reality. Progress in the investigation will be reported on the MMC's Web site (Japanese only).

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

In order to sustain growth in the MEMS industry, it will be essential to establish a systematic strategy for cultivating the personnel required to support the expanding industry. This year, the MEMS Industry Forum (MIF) established a Committee for the Promotion of Human Resources Development (Chair: Ryutaro Maeda, Director of the AIST's Research Center for Ubiquitous MEMS and Micro Engineering) to implement the "Micro/Nano Innovator", Program for Human Resources Development. The Committee comprises representatives of the National Institute of Advanced Industrial Science and Technology (AIST), the Kitakyushu Foundation for the Advancement of Industry, Science and Technology (FAIS), the New Industry Research Organization (NIRO) in Hyogo Prefecture, the MEMS Park Consortium in the Tohoku region, and the Micromachine Center (MMC), who are working together to establish a high-quality national program for developing human resources in MEMS fields. Please visit the MIF's Web site on this program (http://mmc.la.coocan.jp/business/innovator/) for a detailed description of the offered training courses and the enrollment procedure.

Below are some of the training courses that are scheduled for the coming months. It is our hope that businesses will incorporate these courses into their personnel training strategy.

<FAIS>

Introductory course on manufacturing processes: manufacturing peripheral circuits for MEMS

November 15–18 (now accepting enrollment)
Category: process/device/system innovator Level: basic
"The design and manufacture of op-amps"
Place: the Semiconductor Center (Collaboration Center Building 2), Kitakyushu Science and Research Park
Length: 4 days Capacity: 5 participants
Course fee: 25,000 yen

Advanced applications course: introduction to optical MEMS

Category: device innovator Level: applied/advanced
"Optical device technology learned by developing micro-mirrors, etc."
Place: Ito Campus of Kyoto University
Length: 3 days Capacity: 5 participants
Course fee: 25,000 yen

Advanced applications course: introduction to MEMS sensors

Category: process/device innovator Level: applied/advanced
"Basic technological training for the trial manufacture of MEMS sensors (lecture)"
Place: the Semiconductor Center and elsewhere
Length: 4 days Capacity: 10 participants
Course fee: 15,000 yen

Advanced applications course: MEMS sensor applications

Category: process/device innovator Level: applied/advanced
"Sensor device technology learned by developing odor sensors (hands-on training)"
Place: the Semiconductor Center and elsewhere
Length: 4 days Capacity: 5 participants
Course fee: 25,000 yen

<MEMS Park Consortium>

MEMS Human Resources Development Project, introductory course

Category: process/system/device innovator Level: basic

MEMS Human Resources Development Project, hands-on trial manufacturing

<MMC>

Advanced applications course: the 15th MEMS Seminar, October 27 (now accepting enrollment)

Category: system/device innovator Level: applied/advanced
"New MEMS technologies (design, processing, and assessment) and products applying these technologies"
Lectures by Professors Hiroyuki Fujita and Isao Shimoyama and company representatives related to
"Green Innovation Made Possible with Next-Generation MEMS"
Place: Chuo University, Surugadai Memorial Hall (Ochanomizu)
Time: 13:00–18:00 Capacity: 20 participants
Course fee: 10,000 yen (includes costs of course materials and meals/refreshments)

Introductory course on MemsONE, November 18 and 19 (now accepting enrollment)

Category: process/system/device innovator Level: basic
"Introductory course on MEMS analysis using MemsONE"
Place: MMC Techno Salon
Length: 2 days Capacity: 5 participants
Course fee: 16,000 yen for the general public and 6,000 yen for university students and faculty

Techniques for promoting MEMS commercialization, December 15 (now accepting enrollment)

Category: system innovator Level: applied/advanced
"A study of basic tools for commercializing MEMS-related products, with an instructive look at case studies"
Place: MMC Techno Salon
Length: 1 day Capacity: 20 participants
Course fee: 20,000 yen (includes costs of course materials and meals/refreshments)

<AIST Tsukuba>

Advanced process training: nanoimprint training

Category: process innovator Level: applied/advanced
"Lectures on nanoimprint technology by the AIST, with hands-on training"
Place: AIST Tsukuba East
Length: 2 days Capacity: very limited
Course fee: 40,000 yen

Completion of the BEANS Project Interim Evaluation

A subcommittee meeting for interim evaluations of the NEDO-sponsored BEANS Project was held at Otemachi Sunsky Room (Room E) from 10:30 to 17:30 on September 10, and members of the evaluation committee assessed the activities and R&D achievements produced over the first two and a half years of the project. Since NEDO will announce the results of the interim evaluation at a later date, this article will serve to describe the proceedings of the meeting and the significance of the BEANS Project summarized for purposes of the interim evaluation.

1. Overview of the Interim Evaluation Subcommittee Meeting

A total of 39 people attended the subcommittee meeting for interim evaluations. These attendees comprised 7 subcommittee members including the chair of the subcommittee, Professor Kazuo Sato of Nagoya University; 8 personnel from METI and NEDO in charge of promoting the project; 10 members of the BEANS Project in charge of implementing the project, including President Atsushi Yusa; 12 members of the subcommittee meeting secretariat; and 2 participants from the general public.

The morning session, which was open to the public, was used to give an outline of the project and to answer any questions. Hideaki Watanabe, the principal investigator from NEDO, and President Yusa, the BEANS Project Leader, gave a 50-minute presentation based on the project's records, and subsequently fielded questions from subcommittee members. The questions were primarily concerned with the outline and R&D management of the project and led to a particularly lively Q&A session between the BEANS Project members and the subcommittee members regarding the appropriateness of the project's priorities and goals, as well as the best method of expanding on the project's achievements. Consequently, the morning session ran well past the scheduled ending time of 12 o'clock.

In the afternoon session, which was closed to the public, each of the center directors in the BEANS Project gave detailed reports on research findings covering all eight themes of the project. The subcommittee members showed great interest in the latest hot topics of BEANS research. Perhaps for this reason, the afternoon session had a different mood from the morning session, evolving into a meaningful discussion with various specialists giving a wide range of views on the academic significance of the research findings and their value as industrial technologies.

The final segment of the meeting, which was once again open to the public, featured questions and comments throughout. Notably, all of the subcommittee members expressed a high regard for the project's achievements and creative activities. There was also a request to further clarify the objectives and direction of the project in order to disseminate and expand on the project's achievements and to study scenarios in which the achievements of the project could contribute to the growth of MEMS technology in Japan and help strengthen the nation's international competitiveness in industry. Following this discussion, the meeting was adjourned.

2. Significance of the BEANS Project

In preparation for the interim evaluation, we summarized the significance of the project's achievements thus far from the following perspectives: 1) academic significance, 2) market expansion/creation brought about by the achievements, 3) generation of achievements that are the world's first or highest level, 4) potential for pioneering new technological fields, and 5) versatility of the achievements. Each of these aspects of the project's significance is described briefly below.

1) Academic significance

As indicated by the name of the project, the academic significance of BEANS lies in the integration of dissimilar fields to create devices with novel functions. The following three points may be considered the substance of this heterogeneous integration.

i) Integrating different scales from nanometers to meters
ii) Integrating different processes employing bottom-up and top-down approaches
iii) Integrating different materials from biomaterials to semiconductors

2) Market expansion/creation brought about by the achievements

Process innovation created through the BEANS Project enables the manufacture of unprecedented innovative devices that will provide us with novel methods for dealing with national issues twenty years from now in such fields as energy and the environment, medical care and welfare, and safety and security. Such innovations are hoped to enrich people, lifestyles, and the Earth and to enable us to expand into a wide range of markets and to create new markets. At the meeting, we provided several examples to illustrate how the achievements of the BEANS Project can enrich people, lifestyles, and the Earth.

3) Generation of achievements that are the world's first or highest level

In the BEANS Project, we researched and developed new technologies that are only now possible through heterogeneous integration. Our presentation at the subcommittee meeting noted that, to date, the BEANS Project has produced a number of achievements that are considered the world's first or highest level, including nine such achievements from R&D item 1 on bio/organic materials integration processes, twelve from R&D item 2 on 3D nanostructure fabrication processes, and eight from R&D item 3 on large-area continuous micro/nanostructure fabrication processes.

4) Potential for pioneering new technological fields

Achievements of the BEANS Project that are expected to pioneer new technological fields were divided into the following three categories.

i) Achievements through heterogeneous integration (9)
ii) Achievements through technologies based on new concepts (9)
iii) Achievements through technological advancements (5)

5) Versatility of the achievements

An objective of the BEANS Project is to build a process platform for inventing next-generation devices through development in R&D items 1–3, and research has been carried out while envisioning target devices in each of the R&D items. However, the processes used in development were selected for their versatility. For the subcommittee meeting, devices other than the target devices that were thought to have application potential were summarized in a table.

Achievements and Activities of the BEANS Project

The research organs of the BEANS Project, currently comprising four research centers (Life BEANS Center, Life BEANS Center Kyushu, 3D BEANS Center, 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, and large-area continuous micro/nanostructure fabrication processes and have been developing a knowledge database on hetero-functional integrated device technology. This fiscal year, the G-device Cooperative was added to the BEANS Project for the purpose of developing an advanced sensor network system and environmentally friendly fabrication processes. Thus far this year, the BEANS Laboratory has published its research findings at national and international academic conferences such as μTAS 2010 through approximately 60 presentations and has completed applications for 8 patents. In order to further publicize the achievements of the BEANS Project, we participated as an exhibitor in the 21st Exhibition Micromachine/MEMS and held the 4th BEANS Project Seminar, both of which took place at MicroNano 2010 on July 28–30. Some of the BEANS achievements were also published in newspapers, journals, and other print media and covered on television.

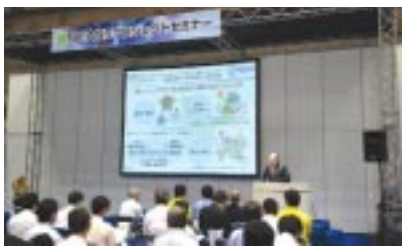
1. MicroNano 2010 at Tokyo Big Sight

(1) 21st Exhibition Micromachine/MEMS

The exhibition provided a venue for each BEANS research center to showcase its R&D achievements through posters and actual demonstrations. Since this year's exhibition coincided with the project's interim evaluation year, our objective for the exhibit was not simply to attract the attention of passersby, but to introduce our research achievements in exhaustive detail. Therefore, the exhibit space that surrounded the lone beanstalk rising upward at the booth's entrance was densely packed with the following exhibits: (1) futuristic devices the BEANS Project is working to make a reality with the aim of contributing to people, lifestyles, and the Earth, (2) an introduction to our efforts at creating intellectual property, (3) Japan's first public showing of fiber-like large-area pressure sensors, research on nanostructured fiber substrates, and a simulation of non-vacuum deposition , (4) photographs depicting low-damage neutral beam etching, models for elucidating the mechanism of supercritical films, trench capacitors, patterning using peptides, and true 3D machining, and (5) actual glowing microbeads related to a hybrid cell doll created from hydrogel beads and a glowing ear that reflects changes in blood sugar level. During the exhibition, visitors were often seen asking questions and enthusiastically engaging the attendants in conversation.

(2) The 4th BEANS Project Seminar

The seminar was held in MicroNano Conference Area B on July 29 (Thursday). Following greetings by Tomio Suzuki, executive director at NEDO, and Atsushi Yusa, president and project leader of BEANS, Sub Project Leader Hiroyuki Fujita, a professor at the University of Tokyo, gave a lecture entitled "The Shape of BEANS Revealed." Thereafter, the center directors (Associate Professor Shoji Takeuchi, Professor Chihaya Adachi, Associate Professor Masakazu Sugiyama, Professor Masaaki Kimata, and Group Leader Toshihiro Ito) gave clear and concise presentations on research achievements at their respective centers to date. After a brief recess, the invited lecturer Yoshihiro Shibuya, a director at INPIT, talked about the expectations for BEANS from an intellectual property perspective. While the seminar lasted a considerably long time, the assembled audience of approximately 300 people, many of whom were standing, remained in the conference area throughout.



2. Media Coverage

(1) An article entitled "Developing Robots with a Sense of Smell" by the Life BEANS Center's Shoji Takeuchi, professor at the University of Tokyo, was published in the Proceedings of the National Academy of Sciences (PNAS) of the U.S.A. The story was also picked up by Japanese television on August 24, beginning with the NHK's morning show *Good Morning, Japan* and later on the evening news, and on the same day was published in eight major national newspapers and trade journals, who mentioned the Center's previous press release issued in June of last year and entitled "Is Your Ear Glowing?! Developing a Blood Sugar Sensor That Glows Under the Skin." The foreign press was particularly enthusiastic in its coverage of this latest story, and related articles were also posted on science and technology Web sites and published in the journal *Nature Materials*. The BEANS Project was once again in the spotlight when the PNAS picked up the article on the glowing blood sugar sensor. Some of the foreign press also recorded video footage of the BEANS Project booth at the Exhibition Micromachine/MEMS held in July that appeared on the online news site DigInfo TV and in a health-related segment during America's ABC network news program.

(2) On August 27, 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."

Activities of the G-device Project

Under the guidance of Ryutaro Maeda, director of the Research Center for Ubiquitous MEMS and Micro Engineering (UMEMSME) under the National Institute of Advanced Industrial Science and Technology (AIST), G-device Center Kansai (center director Susumu Sugiyama) was established at Ritsumeikan University as a NEDO-sponsored project. The Center conducts joint research with Kyoto University and collaborates with four companies in MEMS-related industries, while aggressively promoting the project's development.

One of the most important activities implemented by the Ministry of Economy, Trade and Industry (METI) in its efforts to promote new growth strategies is "green innovation." Steps necessary for realizing green innovation include determining how to conserve resources in the manufacturing processes themselves by utilizing innovative next-generation devices and determining how to reduce environmental impact by implementing more efficient manufacturing processes. To this end, G-device Center Kansai is conducting R&D on high-performance MEMS sensors and developing a network system with these sensors in order to demonstrate that clean rooms used in MEMS fabrication can be made eco-friendly. The following is a detailed description of activities conducted in the G-device Project.

1) Development of a Sensor Network System

G-device Center Kansai is developing a wireless sensor network system configured of wireless MEMS sensors. The system is designed to allow a flexible layout of sensor nodes and to monitor multiple environmental conditions.

The Center will identify system requirements for acquiring detailed measurements at multiple points aimed at maintaining a consistent environmental quality and requirements for energy conservation control and will conduct basic and component studies of the control system. Plans call for experimental demonstrations to be conducted in a new MEMS clean room established at AIST Tsukuba East. The effectiveness of the system design will be verified through controlled operations and visual control of temperature, humidity, and particles, with the goal of reducing CO_2 emissions from energy use in clean rooms to 60% of 1990 levels.

2) Development of High-Performance Sensor Modules

The Center will also study sensor node platforms for a sensor network system comprising high-performance sensor modules arranged at multiple points.

The network system is provided with sensors for monitoring temperature, humidity, pressure, acceleration, and other conditions, with the sensors designed in the form of replaceable modules in order that the system may be adapted to different applications. Each module is configured of a sensor unit, battery, signal-processing circuit, wireless transmitting circuit, and antenna. With this construction, the module has functions for sensing ambient conditions influencing the air quality in a clean room, such as temperature, humidity, airflow, acceleration, and pressure, acquiring a signal from the sensor, and converting the signal to data that can be exchanged with a server through wireless communications. While a battery is used for powering circuits in this project, we hope to develop a self-reliant high-performance sensor module employing a vibration-based power generator or a wireless power supply system, for example. Each sensor module will be contained in a 30x30x10mm package and used as a network node in the system. One of the major objectives in developing sensor modules has been to create a concept of low power consumption in order to construct network nodes employing battery-free, self-reliant wireless sensors. To this end, we will study principle models for optimizing the sensor sampling rate, number of sensing categories, wireless data transfer rate, wireless communication protocol, and AD conversion rate in the signal processing circuit, with consideration for designing the sensor to be ultra-small, inexpensive, and highly sensitive.

3) Contaminant Gas Sensors

Currently clean rooms waste a lot of energy in draft ventilation because clean air is also being exhausted. Energy consumed when exhausting clean air can be reduced through real-time monitoring of fluctuations in contaminant gas. Specifically, the Center will develop MEMS sensors using a metal oxide semiconductor material, such as tungsten trioxide (WO_3) to produce a self-reliant, energy-efficient gas sensor for detecting ammonia (NH_3) and other inorganic gases.

4) Principles of Sensor Node Localization

While it will be important to develop an on-demand multi-point sensor network system capable of discovering the distribution of particulate in a clean room in real-time, today particle sensors are too expensive to equip a system with the number needed to achieve sufficient results. Therefore, the Center is working on an alternate method of developing principles of localization for wirelessly powered sensors that can be attached to workers' shoes, for example.

5) Functional Thin Films for Sensitive Temperature Sensing

The sensor network will require highly sensitive temperature sensors for determining the distribution of body temperatures and equipment temperatures over time, and self-reliant power-generating devices to implement a wireless network. In order to improve the performance and functionality of the temperature sensors, we will work to develop materials (including lead-free materials) and processes for forming functional thin films with pyroelectric/piezoelectric properties.

6) Development of Environmentally Friendly Processes for Polymer Sensor Integration

We are developing polymer sensors with biocompatibility (superior hemocompatibility) using polymer processes that are superior to the conventional silicon processes in exploiting the specific functions of bio/organic materials such as synthetic organic molecules and biomolecules. More specifically, the Center is manufacturing MEMS actuator prototypes (mirror devices) and evaluating their reflectance and surface roughness properties.

Members' Profiles

Taiatsu Techno Corporation

1. Introduction

Taiatsu Techno is engaged in the design, manufacture, and sales of pressure vessels for equipment used in research and development. Our company is unique in that all its design and manufacturing departments are concentrated at the Taiatsu Engineering Laboratory in Saitama City of Saitama Prefecture, allowing for close communication between designers and engineers in the machining department and enabling us to incorporate various user requirements for advanced technological development in tangible products. We have a product line of pressure vessels that employ glass in the structure. With much experience in manufacturing these pressure vessels and through an accumulation of various tests, we have succeeded in developing a window seal mechanism – for which we obtained a patent (No. 3354886) – that allows for internal observations and optical measurements under high temperatures and pressures. We believe our long track record and accumulated technologies on pressure vessels will provide reliable assistance for users conducting advanced technological development in the fields of high-pressure instruments and equipment.

2. Expanding into Instruments for Researching Supercritical Fluids

Taiatsu Techno first became involved in supercritical fluids more than fifteen years ago while designing vessels for withstanding high temperatures and high pressures. Today we develop and design a wide range of vessels and systems suitable for supercritical applications from the demanding conditions of maintaining a water in a supercritical state to the relatively milder temperature and pressure conditions required for maintaining carbon dioxide in a supercritical state. Through input from our customers and tests conducted with actual equipment, we understand that the materials and seal packing used in the body of vessels designed for supercritical fluids must be treated differently from those in common reactors. We have incorporated this knowledge into our equipment designs and have accumulated much expertise through the years in manufacturing supercritical instruments.

In response to requests from our customers, we began to develop vessels and cells with windows that allow direct observation of supercritical media, hiring dedicated technicians for this purpose. As a result, we established and acquired a patent for a window seal mechanism that is reliable under high temperatures and pressures and that facilitates setup and operations. Many users have adopted instruments employing our window seal mechanism, and it is our hope that the capability to visualize supercritical fluids under harsh conditions with such systems will continue to contribute to research on supercritical fluids.

In addition to responding to customer demands for visual observation, we hope to provide sound solutions for customer issues through integrated management of our knowledge and expertise on the design and manufacture of supercritical instruments. We understand that there are a large number of possible combinations of pressures, temperatures, fluids, and control methods in supercritical fields required by our customers. Therefore, our efforts in R&D are not merely focused on the body of the pressure vessel, the centerpiece of the research equipment, but also on peripheral equipment and how to propose optimum combinations and systems.

Cell system for visual observation of supercritical mixtures
(jointly developed with Takafumi Aizawa, senior research scientist at AIST Research Center for Compact Chemical System)

We also introduced a compact process vessel designed for supercritical experiments on carbon dioxide. The vessel can be used prior to installing an actual system as an initial step for assessing the research potential of the supercritical fluid. Once provided with a rough description of the experiment and its objectives, we can select the necessary peripheral equipment and advise the customer on the need for any new purchases other than the compact process vessel, enabling the customer to begin conducting experiments on a relatively low budget.

We continue to develop products to meet all our customers' needs in research on supercritical fluids, from entry level to advanced, and are engaged in the design and manufacture of pressure vessels that are safer and easier to use.

3. Conclusion

Taiatsu Techno believes that safety issues must be thoroughly addressed, even in relatively small pressure vessels designed for testing and research. Through conformance to regulations pertaining to pressure vessels and repeated verification of operation and handling procedures, we are striving to create a safer environment for users of high-pressure vessels. Furthermore, we are constantly studying improvements to the clamp mechanism and exploring other systems for improving the safety of the temperature control system without a loss in operability in an effort to design and develop instruments that strike the best balance between safety and user-friendliness.

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