MMC
2006 5
MICRONANO



MMC Activities

# Overview of MMC's Activities in Fiscal 2005

## I. Basic Objectives of Activities

The basic objectives of MMC activities are, firstly, to establish basic micromachine technologies and increase utilization of micromachines through promoting research and investigation of micromachines (MEMS and other minute machines and systems), collection and provision of micromachine information, and exchange and cooperation with worldwide organizations; and secondly, to contribute to the further development of Japan's industrial economy and to international society.

MMC's basic objectives in Fiscal 2006 are, as in the previous fiscal year, to promote the industrialization of micromachines/MEMS and to strive for the establishment of next generation basic micromachine and NEMS technologies in accordance with trends in cutting-edge technological fields such as biotechnology, nanotechnology, and IT.

Furthermore, a MEMS Council comprising MEMS-related businesses will be established in April. The council will aim to provide support for the further development of MEMS industries and contribute to the strengthening of the international competitiveness of Japanese industry.

## II. Description of Primary Activities

### 1. National/NEDO Project-related Activities

To enable the establishment of basic micromachine technologies, MMC is mobilizing the strengths of industry, academia, and government bodies to proactively promote national government/NEDO R&D projects. In Fiscal 2006, the MMC plans to continue to promote the MEMS Open Network Engineering System of Design Tools Project as well as begin work on the new High Integration/Combination MEMS Production Technology Development Project.

#### (1) MEMS-ONE: MEMS Open Network Engineering System of Design Tools Project (NEDO-commissioned project)

The MMC will cooperate with the 7 companies and 13 universities participating in the project as well as the National Institute of Advanced Industrial Science and Technology (AIST) to promote the project, now in its final year, developing and completing a an open network engineering system of design tools for MEMS that is easy for researchers in other fields and the uninitiated to use. Efforts will focus on: (i) the collection of intellectual data of universities, corporate researchers and technicians that have a track record in world-class cutting-edge MEMS research and development and data on material properties from a diversity of materials businesses in Japan; and (ii) under the guidance of the project leader and sub-leader, playing a management role in overseeing the promotion and progress of the project overall to ensure that the ultimate goals specified for the project are realized.

#### (2) Studies on MEMS-ONE Propagation Activities (NEDO-commissioned project)

In parallel with the MEMS-ONE project, frameworks for the promotion of MEMS-ONE diffusion after completion of the MEMS-ONE project will be constructed during Fiscal 2006 and preparation made so that operations can begin smoothly after April 2007. To this end, further study will be conducted regarding such issues as conceptualization of the operating system for MEMS-ONE system maintenance, how best to approach researchers and technicians (the anticipated users of MEMS-ONE), technological and legal preparation for beginning system operations, and creation of an economic foundation for operations. The MMC plans to undertake these tasks in collaboration with software companies involved in the MEMS-ONE project.

#### (3) High Integration/Combination MEMS Production Technology Development Project (Planned project)

NEDO will be calling for participants in this National Project for Fiscal 2006. In this project, the MMC plans to prepare a high integration/combination MEMS knowledge database that collects, organizes, and arranges knowledge information related particularly to 3 issues in the development of concentration/combination MEMS: (i) combination of MEMS and nano functions, (ii) integration of MEMS and semiconductors, and (iii) MEMS and MEMS high integration unification. The MMC also intends to provide support for the overall management of the project.

### 2. Activities of the MEMS Council (Policy Proposals, Industry Exchange, Revitalization Activities)

In April a special committee, the MEMS Council, will be established for the purpose of providing further support for the MEMS industry. Comprising MEMS-related businesses, the MEMS Council aims to promote policy proposal, industry activities, and revitalization activities, thus contributing to the strengthening of the international competitiveness of the MEMS industry in Japan.

#### (1) Policy Proposals

Through exchanges of opinion between MEMS Council members and representatives of the government and MEMS-related industries at MEMS Council Promotion Committee meetings, as well as by holding MEMS forums, the MMC will proactively present proposals concerning MEMS policies.

#### (2) Coordination with Industry and Academia

Interested business members will gather together for study groups on particular topics. In order to encourage the development of bedrock state-of-the-art micro/nano technologies, we need a place where information about new technologies can be exchanged, and topics for further research and study identified. The "Micro/Nano Cutting Edge Technology Exchange", which will be held once again this year, will provide a forum to meet these needs. The MMC intends to further raise the number and quality of these exchange meetings in Fiscal 2006.

#### (3) Preparation of an Infrastructure for MEMS Development

(i) Expansion and Strengthening of a Foundry Network System

Foundries are vital to the industrialization of MEMS. In order to improve these facilities, we will undertake the establishment of a system to improve services through a network comprising members of the Foundry Service Industry Committee, who represent businesses either involved in or related to the provision of foundry services.

(ii) Promoting the Diffusion of MEMS-ONE

The MMC will promote the diffusion of MEMS-ONE (MEMS Open Network Engineering System of Design Tools) services, due to begin from Fiscal 2007, and support the efficiency of MEMS design and development environments.

(iii) Strengthening of Coordination between Public Foundries in Each Region and Regional Clusters

Cooperation with public research institutions and regional clusters throughout Japan that proactively support MEMS development will be strengthened.

(iv) Promotion of Human Resource Training

The MMC will support the training of people involved in MEMS development through the implementation of MEMS lectures and internship support (creating a notice board of companies offering internships, etc.)

#### (4) MEMS Business Exchange in Japan and Abroad

(i) Establishment of an MEMS Mall

A "MEMS MALL" (tentative name; will be combined with the Council website) website introducing the activities of MEMS Council members as well as new products and technologies will be established on the Internet with the aim of providing support for MEMS businesses.

(ii) Mega Event: The 2006 International Micromachine/Nanotech Symposium

In order to promote industrial exchange in the MEMS field, Micro/Nano 2006: the 2006 International Micromachine/Nanotech Symposium (partly sponsored by the Japan Auto Racing Association) will be held in November at the Tokyo International

Forum. In addition to the Micromachine Exhibition and Symposium held every year, this mega event will also include the Presentation of MEMS-ONE Results, MEMS Forum, and other special events.

(iii) Participation in the 12th Micromachine Summit

MMC will participate in the 12th Micromachine Summit in Beijing, China, taking part in discussions of a wide range of topics, including worldwide trends in micromachine technology and its fields of application.

(iv) Creation of an International Network of Affiliates

The MMC will create a network of affiliates for the MEMS Council comprising micro/nano-related organizations and research institutions both in Japan and abroad, establishing a system in which the Council ca function as a hub for micro/nano industrialization. In addition to relevant organizations in Japan, affiliations will be established with micro/nano-related organizations and research institutions in Europe, the United States, and Asia and support provided with regard to information exchange, distribution of newsletters, and events.

(v) International Exchange and Dispatch of Researchers

A group will be dispatched overseas to promote the exchange of information and opinions with micromachine-related research institutes in universities and similar institutions. This group will also participate in international symposiums and academic meetings held overseas. MMC will further promote exchange by inviting experts in the field from America and Europe and by sending our experts and researchers overseas.

## 3. Survey Research Activities

Planned activities in the field of micromachine/MEMS technology, which is becoming a key technology for the manufacturing industry, are aimed towards gaining a clear understanding of the trends in micromachine technologies and industries and conducting investigations of and research on new technological issues regarding the fusion of micro- and nano-technologies.

**(1) The MMC will conduct survey research of future devise technology that can be realized through the technological integration of nano and bio (nano-fusion) and other technologies that will have a revolutionary impact on society in 20 years from now, expanding on the results of the long-term vision round-table conference held in Fiscal 2005 to survey research on future devise technology (application submitted to the Mechanical Social Systems Foundation as a commissioned project) arising from nano-fusion – the frontier of MEMS technology. Working groups will be set up to investigate 3 target fields – environment/energy (green devices), health/medicine (white devices), and safety/security (blue devices) – and process integration.**

**(2) Studies on R&D Trends for Micromachine Technology in Japan and Abroad**

These studies aim to identify and analyze the latest trends in the field of micromachine technology, which is progressing at a remarkable pace, and micromachine R&D in Japan and abroad; and to develop basic technological data to aid in developing micromachine technologies.

**(3) Survey Research on the MEMS Market**

Using the MEMS market survey methods established with the “Survey Research on the Analysis of the Current Conditions in MEMS-related Markets and Japan’s Competitiveness” conducted in Fiscal 2003,the MMC will conduct rolling research concerning MEMS market trends and future predictions, with particularly detailed analysis of products containing MEMS.

**(4) Enhancing the Micro/Nano Database**

The MMC website database will be further enhanced to enable supporting members to search for publicly disclosed documents and survey reports, research center maps, mini-research reports, and other information.

## 4. Standardization of Micromachines

In cutting-edge technological fields such as micromachine/MEMS, standardization is being promoted as international initiatives are being taken.

**(1) Research on MEMS Standardization Roadmap**

With regard to survey research on a roadmap for MEMS standardization, the MMC will develop a roadmap for MEMS standardization that enables strategic and ongoing efforts in fields in which Japan can likely achieve a competitive edge in order to maintain and strengthen the international competitiveness of our MEMS industry.

**(2) Response to International Standardization Activities Overseas**

In response to the rapidly increasing number of MEMS international standardization proposals by the ROK and other countries, the MMC will consider Japan’s approach (particularly concerning RF-MEMS, splicing, and packaging).

**(3) Promotion of the International Standardization of Tensile Testing Methods for MEMS Thin Film Materials**

In addition to continuing to follow up the situation regarding tensile testing methods, which are currently at the CDV (Committee Draft for Vote) stage, in April the MMC will also submit a NP (New Proposal) regarding fatigue testing. The MMC will also aim to submit new standardization proposals through round robin tests with a view to the international standardization of life testing and other testing methods.

**(4) Standardization of Micromachine Terminology**

The micromachine terminology adopted last fiscal year as an IEC standard will be considered for JIS approval.

## 5. Dissemination of Information and Education about Micromachines

By issuing and distributing quarterly magazines and by holding exhibitions, we hope to disseminate information on micromachines extensively in order to educate as many people as possible.

Furthermore, information and documents on micro/nano-machine use in universities, industries, and public organizations in Japan and overseas will be collected, combined with survey results and MCC-produced documents, and made freely available in the MMC library. At the same time, information will be disseminated widely, both domestically and internationally, through the MCC website.

**(1) Improved Dissemination and Exchange of Information through the MCC Website**

Utilizing the MCC website, efforts to exchange and disseminate information will be made proactively. Website content aimed at supporting members will be enhanced.

**(2) Publication of a Micro/Nano Public Relations Magazine**

A public relations magazine will be published periodically and distributed to those in or connected with the field; it will also be made available on the Internet through the Center's home page. The magazine’s title will change from the April 2006 edition from “Micromachine” to “Micro/Nano”.

**(3) Publication of a Monthly Newsletter**

Information concerning research and governmental trends related to micro- and nano-machines is distributed monthly via the “MMC/MIG News” to supporting members, MEMS Council members, and other interested individual and organizations.

**(4) Provision of Information through the MicroNano Express Newsletter**

Through the MicroNano Mailing list, information concerning micro/nano-machine events or industry-academia-government collaboration is distributed as required via the “MicroNano Express” newsletter to supporting members, MEMS Council members, and other interested individual and organizations.

**(5) Maintaining and Upgrading the MMC Library by Expanding the Literature Abstract Database**

“Micromachine Index,” an information magazine containing abstracts of technical documents and information on materials, is issued on a regular basis and provided to supporting members and organizations concerned with micromachines. Collected technical documents and materials are stored and maintained in the MMC library and made available to the general public.

**(6) Micromachine Exhibitions**

The 17th Micromachine Exhibition and other events will be held to present the latest research achievements, as well as the latest cutting-edge micromachine/MEMS industry-related products and product materials, as part of the 2006 International Micromachine/Nanotech Symposium. The venue for this year’s symposium has changed from the Science Museum, Tokyo, to Tokyo International Forum. The symposium is to be held from November 7 (Tue.) to 9 (Thu.), 2006.

***Upcoming Event Announcement***

***The 2006 International Micromachine/Nanotech Symposium***

**Venue: Tokyo International Forum (Yurakucho, Tokyo)**

**1. The 17th Micromachine Exhibition**
November 7 (Tue.) – 9 (Thu.), 2006

**2. MEMS Forum**
November 7 (Tue.), 2006

**3. The 12th International Micromachine/ Nanotech Symposium**
November 8 (Wed.), 2006

**4. Presentation of MEMS-ONE Results**
November 9 (Thu.), 2006

*** The International Conference on Miniaturized Systems for Chemistry and Life Science (μTAS2006) will also be held.**

# Overview of the Keynote Address at the 11th International Micromachine/Nanotech Symposium

## Strategies for Further Development of MEMS Industries and Emerging Applications

**Hiroyuki Fujita**
Professor, Institute of Industrial Science, the University of Tokyo

MEMS R&D began with pressure sensors in the 1970s and by the latter half of the 1990s had spread to applications in such fields as optics, radio frequency, biotechnology, and $\mu$-TAS. At its current level of maturity, MEMS technology for microspaces enables us to freely create and operate devices at the research and development level while gradually producing tangible products. In the future, we plan to expand R&D on applications in nanospaces and to build an infrastructure for the MEMS industry by producing end products with technologies that have been perfected. At this symposium, we discussed strategies for vitalizing the MEMS industry by categorizing MEMS products in terms of their market scale and the amount of added value MEMS gives to the products.

**Fig. 1** shows the results of our efforts to categorize MEMS products. The inkjet printer head is an example of a great success because MEMS technology is indispensable for its production and the inkjet printer head is a mass-produced product. Therefore, the printer head was positioned in the upper right of the graph. Accelerometers occupy the bottom right of the graph since they can be replaced with mechanical means. Digital micromirror devices (DMD) employed in projectors are now competing fiercely with liquid crystal devices and are thus positioned in the center of the graph. Optical MEMS switches are also products that could not be produced without MEMS technology. However, since they are produced in low quantities, the switches have been placed in the upper left of the graph. Hence, MEMS products can be divided into three categories: (1) mass-produced MEMS products, (2) products unique to MEMS in which the system functions as a consequence of MEMS, and (3) indispensable MEMS products that could not be realized without MEMS. Products in Fig. 1 above the solid line are successful products. In the future, we anticipate the development of such new MEMS products as tire sensors and such consumer products as accelerometers and gyroscopes for category (1); products for medical diagnosis including biochips for analyzing DNA in category (2); and scanning probe microscopes and devices for manipulating objects at the atomic/molecular level in category (3).

The success and failure of MEMS products depends on the market scale and the degree of MEMS added value. One strategy we can draw upon for MEMS products is mass-production in category (1) aimed at reducing costs, as in the example of semiconductor chips. However, in addition to mass-produced products, opportunities for MEMS may lie in key components of high added-value systems in categories (2) and (3). Therefore, we examined problems and solutions in commercializing product groups for which small quantities of numerous varieties are inevitably produced.

Despite their small production, these MEMS products require expensive production equipment. There is also a shortage of high-level designers that possess sufficient knowledge related to the MEMS manufacturing process. However, by utilizing a MEMS foundry service, customers who possess no such expensive manufacturing equipment can manufacture products using the foundry's expensive equipment and processing technologies. As the network of MEMS foundries grows, it will be possible to obtain a variety of services at one location.

A lot of time and expense is required for developing MEMS products, as many design modifications and much trial production is necessary for producing an optimal product. However, with advances in computer-aided design, it will be possible to view the final structure of a MEMS product virtually so that the amount of trial production can be minimized, thereby greatly reducing the time and costs for development. Further, all too often manufacturers do not make full use of MEMS properties due to an insufficient knowledge of MEMS. However, we hope to resolve this issue by providing a knowledge database containing extensive data accumulated by universities and research institutes over a twenty-year period, and equipped with an excellent search engine.

In conclusion, we hope to construct a foundry network, a computer-aided design environment, and an infrastructure facilitating technical transfer from universities and research institutes through collaboration among foundry businesses, equipment and material suppliers, software vendors, research institutes at universities, and government agencies. By doing so, we are confident that we can accelerate the industrialization of various applied fields requiring small numbers of diverse products, as well as the industrialization of mass-produced products.

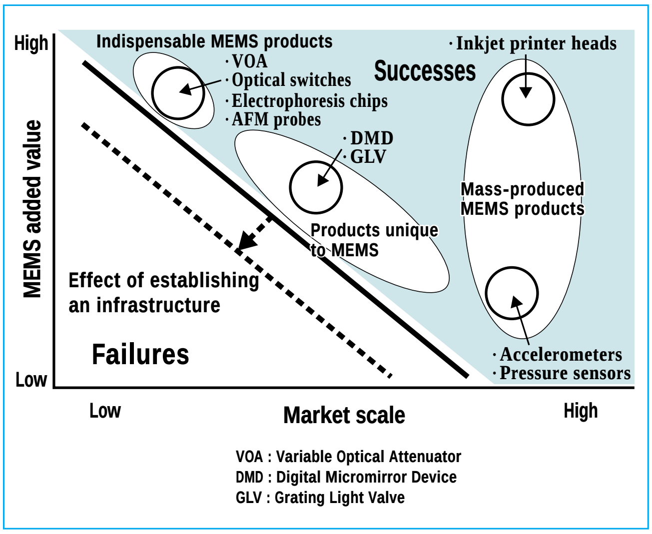


**Fig. 1 A map of MEMS products**

# MEMS Foundry Service Industry Committee

**Takuji Keno**
Matsushita Electric Works, Ltd.
Former Chairman of the MEMS Foundry Service Industry Committee

## 1. Overview

Highly anticipated as the next cornerstone of industry, Micro-Electro-Mechanical Systems (MEMS) is the integration of mechanical, optical, and fluid elements with electronic circuits through microfabrication. Initially, MEMS products were developed by a handful of companies who possessed the necessary infrastructure. However, commercial MEMS foundry services began to appear gradually in Japan around the end of the 90s. Based on a survey of foundry networks developed in the West, the MEMS Foundry Service Industry Committee (FSIC) was established in June of 2002 to construct such a network in Japan.

The Committee, whose membership has increased to eleven organizations at present, conducts seminars and other activities. Below I will outline the activities of the FSIC.

## 2. Activities of the MEMS FSIC

Companies now offering MEMS foundry services have expanded their business to provide such services to external customers, using facilities that were employed for many years to produce in-house products. However, in the interest of expanding the prototyping and mass-production services available to users, it will be necessary to link company resources organically over a network in order to utilize resources more effectively and to resolve common issues facing foundries.

It is for this purpose that the MEMS foundry companies shown in **Fig. 1** have formed this committee around the Micromachine Center and have initiated activities to construct such a network. The committee activities involve the following issues.

1) Promotional activities for expanding MEMS users (workshops, activities for introducing the foundries, etc.)
2) Identifying problems in network management
3) Identifying common problems facing MEMS foundries and determining demand for design and analytical tools
4) Approaches for facilitating MEMS usage for customers, process standardization, consulting, etc.
5) Discussing common problems for users and examining business guidelines


**Fig. 1 Members of the MEMS FSIC**

In view of these issues, the FSIC has performed the following activities to date.

(1) In order to promote the network and expand its user base, we have launched a Web site (http://fsic.mmc.or.jp) detailing services offered by the various companies and event information. We have also given presentations and joint seminars at the Micromachine Exhibition.
(2) Through joint discussions with industry, government, and academia on promoting the MEMS industry, we have clarified the importance of inexpensive and user-friendly design tools and the need for a reliable material database in order to help users initiate new projects.
(3) We have provided a help desk on the FSIC Web site entitled MEMStation. Beginning services on July 1, 2005, MEMStation provides a relatively easy approach to choosing a suitable foundry business.

## 3. Conclusion

MEMS enables the microfabrication of devices and modules merging precision mechanical, optical, and fluid parts with electronic circuits, and we are confident that MEMS will raise Japan's level of competitiveness in the mechatronics industry. We believe that by constructing a network of MEMS companies, each with their own field of expertise, the FSIC can provide optimal solutions to users wishing to develop and mass-produce MEMS devices.

# Databases for Supporting the MemsONE Project

**Yoshiharu Suizu,** Planning Director, MEMS System Development Center, The Micromachine Center

## 1. Significance of the MemsONE Databases

The objective of the MEMS Open Network Engineering System of Design Tools (MemsONE) is to provide software support for engineers and researchers in a wide variety of fields, facilitating access to information in the field of MEMS with the aim of furthering the promotion and growth of the MEMS industry in Japan. To this end, our goal is to provide a system that not only supports advanced MEMS R&D, but also provides newcomers to the field of MEMS and researchers and engineers having less experience in this field with ready access to material-related information and knowledge possessed by veteran MEMS researchers.

**Fig. 1** shows a functional breakdown of the MemsONE system currently under development to achieve the goals described above. MemsONE is configured of three functional sections including a GUI section referred to as framework software (within the yellow border in **Fig. 1**), a simulator section for computer-aided studies on various structural designs and manufacturing processes (within the blue border in **Fig. 1**), and a database section providing support to novice users (within the red border in **Fig. 1**).

The database section has both a knowledge database and a material and process database and functions in the background to support first-time and novice users. Although possessing different content and designed for different uses, these two databases are packaged together.

Next, the database section will be described in detail.

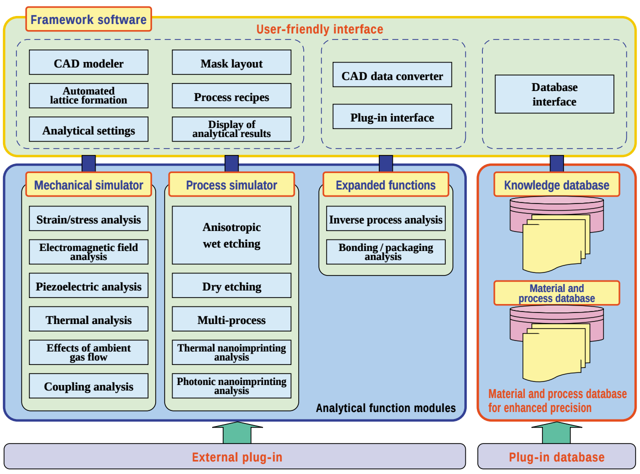


**Fig. 1 Breakdown of the MemsONE functions**

## 2. Goals and Features of the Knowledge Database

One of the databases supporting the MemsONE project is the knowledge database (see **Fig. 2**). In order to aid newcomers to the MEMS field in MEMS design, the knowledge database stores a wealth of data (such as knowledge, expertise, and examples) possessed by some of the leading researchers at university and company research centers, providing a user-friendly database for first-time and novice users.

The data accumulated in the knowledge database is broadly divided into the four categories of devices, processes, material properties, and analyses. These categories are further divided into two levels of subcategories. The database allows users to freely search and reference the data and to add additional entries at any time.

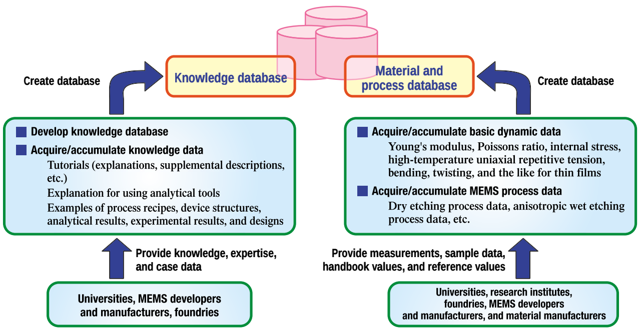


**Fig. 2 Structure of the MemsONE database**

## 3. Goals and Features of the Material and Process Database

The other database supporting the MemsONE project is the material and process database (see **Fig. 2**). The material and process database systematically accumulates various experimental data (mechanical properties of thin film materials, process data, etc.) and all data required for the numerical analysis of various MEMS structural designs and manufacturing processes that have been developed by MEMS engineers and researchers, providing a database to aid first-time users and the like in MEMS design. Material data including such mechanical properties as the breaking strength, Young's modulus, Poisson's ratio, and residual stress of thin film materials and process data including various data on dry etching and wet etching (etching rate, etc.) have been either acquired or collected through collaborations with universities, research institutes, and foundries to construct a useful database for foundries.

Data accumulated on the mechanical properties of materials and process data provide important parameters that influence the precision of numerical analyses. Accordingly, we are placing an emphasis on acquiring precise data under a wide range of conditions. We are also listing measuring instruments and conditions with newly measured data and collected data as auxiliary data in order to complement fluctuations in measurement values found for thin film materials that are due to the measuring instruments, conditions, and the like. This auxiliary data will be provided as factors for determining usage.

## 4. Conclusion

As mentioned earlier, the objective for the knowledge database and material and process database is to construct user-friendly databases that can aid new users in the field. Consequently, data structure, usage specifications, and the expansion of accumulated data are issues of the databases that must be addressed. At present, the issues of data structure and usage specifications have been substantially resolved. To complete the system, we will next focus on the acquisition and accumulation of data.

After its completion, the MemsONE system is expected to see extensive use by novices in the field, who can take advantage of the system's core databases. Their participation should help expand the nation's base of MEMS engineers and stimulate the promotion and growth of the MEMS industry in Japan.

**Column**

# MEMS-Enabling Technologies

**Norihisa Miki**, Assistant Professor,
Department of Mechanical Engineering, Faculty of Science and Technology, Keio University

I joined the Department of Mechanical Engineering at Keio University as assistant professor and launched the "Miki Laboratory," the only laboratory for the field of MEMS in the department, in April 2004. Currently we have nine graduate students and five senior undergraduate students, and are becoming a full-fledged laboratory.

When launching the new laboratory, I struggled first and foremost on determining the direction of our research. Before coming to Keio University, I was a research engineer in the Department of Aeronautics and Astronautics at the Massachusetts Institute of Technology where we researched a button-sized micro-engine and a micro-rocket in the MIT Microengine Project. I was primarily involved in the manufacturing of and experimentation with devices and, in particular, studied Deep Reactive Ion Etching (DRIE) and wafer bonding technologies that require rigid manufacturing precision. I might be able to continue the work here at Keio University, but a change in location is also a good opportunity to change the subject of study. Therefore, emulating the researchers in US, who customarily change their research themes every 3–5 years, I decided to tackle a new topic of research for the new laboratory at Keio.

When considering new topics of research, I remembered a term used by Dr. Senturia, a former professor at MIT and now the CTO at Polychromix: "MEMS-enabling technologies." In his lectures, Dr. Senturia suggested that we should not sell only MEMS devices but technologies that are made possible through the MEMS devices; that is, entire systems that incorporate the MEMS devices. (One can derive from this meaning that MEMS devices alone may not be discriminated against the competitors given their low cost accounting for only a few percent of the overall system.)

Hence, we searched not for MEMS devices, but for MEMS-enabling technologies, i.e., technologies that would benefit dramatically from MEMS and micromachining technologies. As one example, we introduce a pupil-tracking and line-of-sight (LOS) detecting technology. The LOS detecting technology has numerous promising applications in the fields of medical care, information technologies, and safety and security. For example, the severely disabled who are capable of moving only their eyes can utilize LOS to communicate with others. LOS can be a novel input tool replacing the mouse and keyboard. Detecting the LOS of pedestrians, in particular, children, and drivers helps the effective display of hazard signs. Most of today's LOS detecting systems, however, employ a stationary camera or a helmet with a camera mounted in the front to track the subject's pupil, which obstructs the subject's movement and field of vision and, most importantly, affects the subject psychologically.

In light of these issues, we have been developing transparent pupil-tracking devices that can be fabricated on eyeglasses, as shown in **Fig. 1**. We employed dye-sensitized devices, which are currently studied as solar cells, as transparent optical sensors to detect differences in reflected light between the whites of the eyes and the pupils and thus derive the position of the pupils. Since these devices can be worn as glasses, they do not obstruct the subject's movement or field of vision and have a negligible psychological impact, thereby resolving the issues of today's LOS detecting devices. Hence, this technology will contribute to the rapid implementation of the promising applications of LOS detection mentioned above. Since the device has no movable parts, it is not a MEMS device in the strict sense of the term. However, patterning of arrayed electrodes, and processes to encapsulate pigments and electrolytes are made possible through MEMS manufacturing technologies. Thus the proposed system is an MEMS-enabling technology. To date, we have succeeded in detecting the movement of a pupil using a single dye-sensitized device (patent application no. 2006-018591).

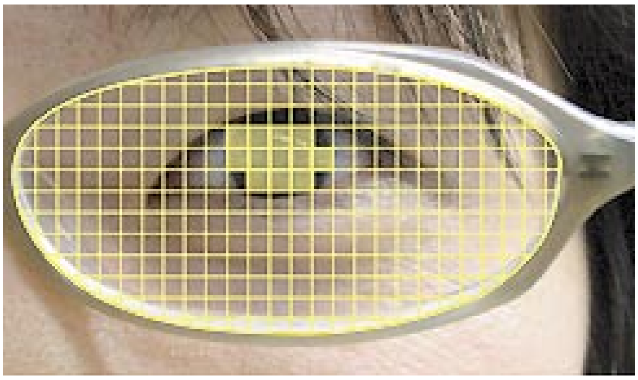

**Fig. 1 A mounted transparent pupil tracking device**

When studying MEMS-enabling technologies, I believe it is vital that we make full use of the resources at the Faculty of Science and Technology of Keio University. MEMS-enabling technologies are, in effect, technologies of other fields that can make remarkable advances with the help of MEMS. Hence, the key for establishing a research theme lies in how we can discover the potential needs in other fields. In this regard, the Faculty of Science and Technology at Keio University has been a blessing. Owing partially to the rather compact Yagami Campus at the university, we have enjoyed lively intercourse with diverse researchers in the eleven departments of our faculty. Miki Laboratory is currently conducting collaborative research with six other laboratories in four departments.

As you know, MEMS development is highly dependent on expensive equipment. Miki Lab currently has equipment capable of performing basic photolithography, but we do not possess expensive DRIE or sputtering devices, nor do we have measuring instrumentation. Fortunately, however, our Faculty of Science and Technology has the Central Service Facilities for Research complete with measuring instruments and analyzers (http://www.sfr.st.keio.ac.jp/), and a laboratory equipped with a deposition system. Hence, we have endeavored to share the use of this equipment as much as possible. At the same time, we have made our facilities at Miki Lab available to other laboratories having an interest in MEMS. In the future I would like to establish an open MEMS laboratory at the Faculty of Science and Technology.

However, sharing resources in this way leads all too frequently to some laboratories monopolizing the equipment, establishing rules of usage that are too strict, and accidents caused by inexperienced users. We are currently drawing up management guidelines to eliminate these problems while studying the systems used at MITs Microsystem Technology Laboratories and MEMS laboratories in Japan. We are actively engaged in implementing a research environment to facilitate MEMS-enabling technologies, i.e., "a research environment enabling MEMS-enabling technologies" in our Faculty of Science and Technology.

Overseas Trends

# Report on the MEMS 2006 International Conference in Istanbul

The 19th International Conference on Micro Electro Mechanical Systems (MEMS 2006) was held over a period of five days, January 22–26, 2006. This year, the venue was in Istanbul, the former capital of three successive empires—Roman, Byzantine, and Ottoman—and a city that is still captivating today.

Despite the unfortunate weather that visited Istanbul during the conference, the total 646 participants was on a level with previous years. The conference also received many participants from Japanese universities and companies. The number of abstracts submitted this year was a record-setting 789 (750 were submitted the previous year), while the percentage of accepted presentations was typically low, at 30%. The 239 selected presentations were characterized with much originality and included 3 talks by invited speakers, 42 oral presentations, and 194 poster presentations. Despite the heavy snowfall, the conference was enveloped in an air of enthusiasm.

Countries that gave the largest number of presentations this year were the United States with 80 (107 the previous year), Japan with 59 (47 the previous year), South Korea with 24 (16 the previous year), Taiwan with 22 (4 the previous year), and Germany with 16 (9 the previous year). By region, 82 presentations were given by North America (108 the previous year), 47 by Europe (35 the previous year), and 51 by Asian countries other than Japan (28 the previous year). Hence, nearly half of presentations were given from Asian countries. Of particular surprise was the daunting increase in the number of Taiwan presentations.

Among research institutes that gave the largest number of presentations, the University of Tokyo (Japan) gave 21 presentations; the University of Michigan (USA) and the University of Freiburg (Germany) gave 10 each; the National Tsing Hua University (Taiwan) gave 8; Ritsumeikan University (Japan), Stanford University (USA), Korea Advanced Institute of Science and Technology (South Korea), and the University of Illinois (USA) each gave 7; and the Georgia Institute of Technology (USA) and the University of California at Los Angeles (USA) each gave 6. Presentations from other universities in Japan included 4 each from Kyoto University, Nagoya University, and Tohoku University; and 3 from the University of Hyogo.

Broadly dividing the presentations into fundamentals and applied devices/systems, the former occupied 42% of all presentations and the latter 58%. Hence, applied research remains on top. By field, fluidic, biological, and physical (sensors) applied fields increased in number, while the fundamental fields showed increased research on fabrication technologies (non-silicon) and actuators (electrostatic, piezoelectric, etc.). Japan also showed a dramatic increase in fluidic and biological research, as well as optics, and Asia in general showed a striking increase in fluidic and biological research. The United States had an increase in physical (sensors) and biological research, although research on fluidics and RF-MEMS, while still high, decreased from the previous year. Europe gave many presentations on physical (sensors) and fluidic fields.

Although 92% of all presentations were given by research institutes of universities and the like, there were also many interesting research reports from businesses. For example, Philips Research Laboratories gave a fascinating presentation on “Electrowetting-Based Displays: Bringing Microfluidics Alive On-Screen” regarding a technique employing electric voltage to control the surface tension of droplets in displays, while Analog Devices gave a memorable presentation entitled “A MEMS Condenser Microphone for Consumer Applications” on producing a low-cost silicon microphone with MEMS technology. These presentations tied ideas in fundamental research to commercialization.

During the conference, a gala banquet was held in a magnificent palace facing the Bosphorus that survives from the closing years of the Ottoman Empire. The banquet featured festive belly dancing and other traditional dance in which conference attendees also participated. The ring of dancers that continued to grow late into the night will not soon be forgotten.

The MEMS 2006 conference sponsored this year by IEEE has so far been held in Nara, Oiso, Nagoya, Miyazaki, and Kyoto. It is only fitting that the next conference, MEMS 2007, which will mark the 20th conference, should be held in Kobe. The conference dates are January 21–25, 2007. I encourage you all to attend.

**Members' Profiles**

# Seiko Epson Corporation

Director and General Administrative Manager
of Production Engineering & Development Division
**Minoru Usui**

## 1. The Challenge of Micromachine Technology

Using some of the most advanced technologies in the world, Seiko Epson provides products and services in the fields of information-related equipment, electronic devices, and precision products that bring us a rich, high quality of life based on harmony with the environment. Major business activities of the corporation involve the development, production, sales, and service of information-related equipment, including computers and peripherals (printers, scanners, etc.) and imaging equipment (LCD projectors, etc.); electronic devices including semiconductor devices, displays, and quartz devices; precision products including watches, corrective lens, and factory automation equipment; and other products.

We have developed our own micromachine technologies to produce devices that we have incorporated in various products. One of our foremost products is an inkjet print head employed in inkjet printers.

## 2. Development of Micromachine Technology

Here, I will introduce some representative products and R&D activities we have performed on related technologies to date.

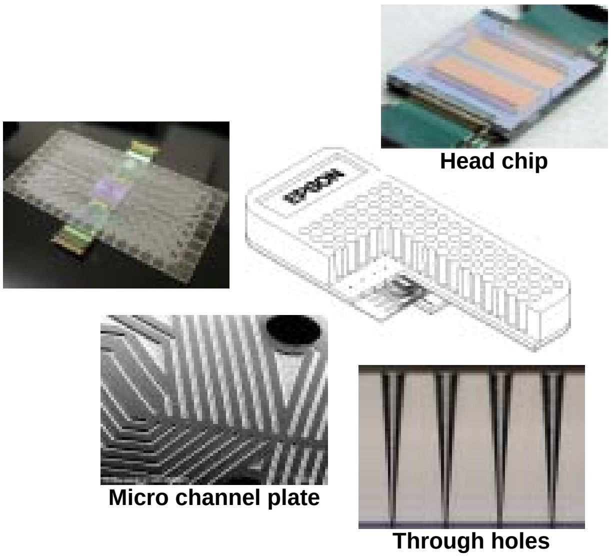


**Fig. 1 Overall view and enlarged photos of a head chip for biotechnology applications**

### (1) Inkjet print head

Printers in our Colorio series are equipped with inkjet heads having micromachined ink channels. We have also applied our own micromachine technologies to developing biotechnology applications for assisting medical diagnoses (**Fig. 1**).

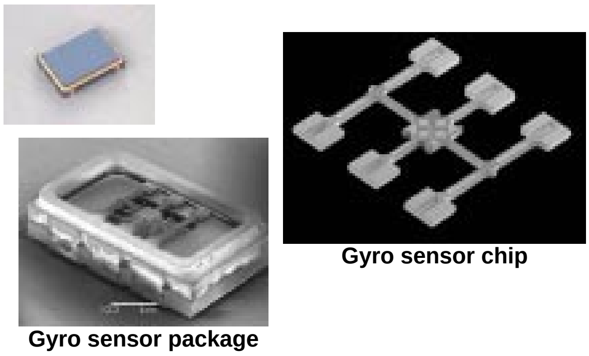


**Fig. 2 Overall view and enlarged photos of a gyro sensor**

### (2) Electronic devices

We have incorporated micromachine technology in electronic devices and have succeeded in producing high-sensitivity micro-crystal resonators and ultra-miniature vibration gyro sensors (see **Fig. 2**). We are also conducting R&D on potential value-added products incorporating optical elements or integrated circuits and micromachined devices on a single chip.

## 3. Future Challenges

We are working to evolve our original ultrafine machining technology from micro- to nanotechnology in order to create innovative devices. We hope to maintain our base of satisfied customers by continuing to provide advanced products and services that are in harmony with the environment.

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