MMC

2005 8

MICROMACHINE

MMC Activities

Activities of the Micromachine Center in Fiscal 2004

OVERVIEW

The Micromachine Center undertook the following activities regarding research and study about micromachines (MEMS and other minute machines and systems), the collection and provision of micromachine information, and exchange and cooperation with domestic and worldwide organizations. The aim was to establish basic micromachine technologies and promote their industrialization, thus contributing to the further development of Japan's industrial economy and to international society.

1. Research and Investigation of Micromachines

Research activities were aimed at 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 nanotechnologies, as well as making adjustments appropriate for the multidirectional expansion of micromachine technology.

(1) Microanalysis/Production System Project (recommissioned NEDO project and contract)

The MMC participated in the national government/NEDO-sponsored Microanalysis/Production System Project and is working on the construction of a document database system. Specifically, the MMC attended μTAS2004 and MEMS2005 and examined a total of 480 microchemistry-related documents, classifying the content of each and compiling a database accordingly.

(2) Studies on the future prospects of micromachine/ MEMS technology

The MMC not only held six next-generation project meetings attended by key figures in industry, academia, and government, but also undertook joint research commissioned by the Mechanical Social Systems Foundation, proposing a next-generation MEMS project to begin in fiscal 2006 aimed at meeting the requirements and expectations of industry regarding MEMS and trends in MEMS technology.

(3) Studies on R & D trends for micromachine technology in Japan and abroad

The Subcommittee on Trends in R&D for Micromachine Technology in Japan and Abroad (Chairman: Prof. Shuichi Shoji, Waseda University)met three times, conducting exploratory analysis of the latest situation regarding the rapid expansion, both domestically and internationally, of micromachine technology and research trends and of basic technological data that contributes to the advancement of micromachine technology; and compiled the results of investigations on technological trends into the 2004 report on the investigation into trends by category.

(4) Studies on MEMS reliability assessment technology(project commissioned by the Japan Machinery Federation)

The Subcommittee on Trends in Reliability Assessment Technology was established and met five times. The subcommittee investigated the current situation of and issues for MEMS reliability assessment technology using related academic literature, and compiled the recommendations regarding policies for strengthening approaches in this field into the 2004 report on the investigation into MEMS reliability assessment.

(5) Studies on micro/nanosystem-related processing and assembly/measurement and assessment/handling technology(project commissioned by the Mechanical Social Systems Foundation)

A report was compiled of the results of investigations aimed at exploiting MEMS characteristics and enhancing their potential as an integrated technology through the integration of third-generation microprocessing technology and nano-and other disparate cutting-edge materials. In cooperation with the "Studies on the future prospects of micromachine/MEMS technology" described above in (2), the MMC made proposals for a next-generation MEMS project.

(6) Joint survey research activities concerning the industrialization of MEMS

As measures to promote the expansion and strengthening of MEMS foundry operations, the a subcommittee comprising three foundry manufacturers considered two issue-standardization of specialized MEMS terminology, and methods of response to MEMS foundry users-and made recommendations to the Foundry Service Industry Committee. These recommendations are to be implemented in fiscal 2005.

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

The MMC has organized an industry/academia cooperative research consortium (comprising nine businesses, ten universities, one research institute, and one organization). In June 2004, the center was commissioned to act as representative for MEMS-ONE (MEMS Open Network Engineering System of Design Tools Project), a national government/NEDO project, to oversee development for a three-year period until March 2006.

Specifically, the MMC oversees a total of six committees, including the Project Promotion Committee, and ensured that the project overall proceeded according to plan in the first stage.

The MMC also took part in the construction of the MEMS-ONE knowledge database and materials/process database, collecting and compiling information from academic literature and data provided by universities.

(8) Studies on the ripple effect and diffusion of MEMS-ONE(NEDO-commissioned project)

The MMC and Mizuho Information & Research Institute, Inc. jointly conducted a NEDO-commission project with the aim of promoting the diffusion of MEMS-ONE. Specifically, a written and, in some cases, aural survey of potential MEMS-ONE users (domestic organizations) was conducted, as was a market/needs survey aimed towards diffusion.

2. Collection and Provision of Micromachine Information

Information and documents on micromachines in universities, industries, and public organizations both in Japan and overseas have been collected and, along with MCC-produced survey results and documents, maintained and not only made freely available in the MMC library, but also disseminated widely, both domestically and internationally.

(1) Improved dissemination and exchange of information through the MCC website

The MMC Internet homepage was revised and thoroughly overhauled.

(2) Publication of a micromachine periodical (*"Micromachine Index"*)

A micromachine periodical entitled *Micromachine Index* gathering together abstracts of important documents was published and distributed to interested parties (fiscal 2004: Nos. 92-99 issued [8 volumes]).

(3) Publication of a newsletter

Information concerning research and governmental trends related to micromachines was distributed monthly to supporting members.

(4) Maintaining and upgrading the MMC library

Documents on micromachines in universities, industries, and public organizations both in Japan and overseas have been collected and combined with survey results compiled and documents produced by MMC and made available in the MMC library (48 books collected in fiscal 2004, making a total of 1,100 books as of March 31).

3. Exchange and Cooperation with Micromachine-related Organizations Worldwide

To promote affiliation, exchange and cooperation with related organizations in and outside Japan, the MMC involved itself in such activities as participating in the Micromachine Summit, holding the International Micromachine/Nanotech Symposium, and inviting to Japan and sending overseas researchers and experts in the field.

(1) Participation in the 10th Micromachine Summit

The 10th Micromachine Summit was held over three days, from May 3 to 5, 2004, in Grenoble, France. The event was attended by 108 participants representing 23 countries and regions. A delegation of four and three observers attended from Japan, and presentations were made by Isao Shimoyama (professor, the University of Tokyo), Toshiro Shimoyama (Honorary Chairman of MMC), Takayuki Hirano (MMC Technology Adviser), and Kunihiko Hara (Executive Director, Nippon Soken Inc.)

(2) Holding the 10th International Micromachine/Nanotech Symposium (partially subsidized by activities promoting the machine industry)

The 10th International Micromachine/Nanotech Symposium was held on November 11 at the Science Museum in Kitanomaru Park, Tokyo, with the aim of promoting micromachine technology and educating a wider public audience. The event was well attended, with a total of 359 participants including speakers, invited persons and media representatives.

(3) International exchange and dispatch of researchers

A fact-finding mission visited Taiwan and Singapore over six days, from September 6 to 11, 2004. In Taiwan, the group visited the Industrial Technology Research Institute (ITRI) and three companies, and in Singapore visited the Institute of Microelectronics (IME) and two companies; approaches to MEMS and nanotechnology were discussed. To summarize, Taiwan is planning the foundry industrialization of MEMS and promoting the use of large diameter wafers on the same level as semiconductors; Singapore is focusing on nanotechnology research.

(4) Building a MEMS foundry network system

To further the industrialization of MEMS, the MMC has established and operates a foundry network comprising businesses that provide foundry services. In addition to the 10 foundry business members, the National Institute of Advanced Industrial Science and Technology (AIST) joined the network this year as an associate member. The Foundry Service Industry Committee met five times; strategies for expanding the network were considered; the MMC Internet homepage - a channel for providing information - was upgraded; and two MEMS lectures were held.

(5) Establishing a forum for the exchange of cutting-edge micro/nano technology

A forum for the exchange of cutting-edge micro-nano technology was held two times for supporting members with the aim of strengthening cooperation between industry and academia in the micromachine/MEMS field.

4. Promotion of Standardization of Micromachines

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

(1)Standardization of fatigue testing methods for micro-nano materials (application for sponsorship submitted to the Ministry of Economy, Trade and Industry)

Continuing on from last year, the MMC is conducting research on standard fatigue testing methods that enable evaluation of the mechanical properties of various thin film materials measuring less than 10μm wide and 100μm long, with the aim of international standardization.

(2) Standardization of tensile testing methods for thin film materials

With the support of the Japanese Standards Association, the MMC has prepared proposals for the international standardization of tensile testing methods for thin film materials and standard test pieces. The CD (Committee Draft) submitted to the International Electric Congress (IEC) was referred to each of the member countries and approved at the IEC meeting held in Seoul in October 2004. It was then decided to submit a CDV (Committee Draft for Vote), one more step closer to international standardization.

(3) Support for standardization of IEC terminology

At the IEC meeting held in Seoul in October 2004, the CDV proposed by Japan was approved. It was then decided to submit a FDIS (Final Draft International Standard). International standardization will thus be achieved in 2005.

(4) Research and investigation of micromachine standardization

Following the IEC international standardization of specialized terminology, it was decided to next proceed with Japan Industrial Standard (JIS). Now that the international standardization of specialized terminology, tensile testing and fatigue testing has been completed, an investigation is underway about what other areas require standardization.

5. Dissemination of information and education about micromachines

The MMC undertook a variety of activities aimed at disseminating information and providing education about micromachines, including in particular the issue and distribution of quarterly magazines and sponsorship of exhibitions.

(1) Publication of public relations quarterly magazine *"Micromachine "*

Volumes 47 to 50 were published in Japanese only. English versions are available on the MMC website.

(2) The 15th Micromachine Exhibition

The 15th Micromachine Exhibition was held from November 10 to 12 at the Science Museum in Kitanomaru Park, Tokyo. Altogether 247 companies, organizations, and other exhibitors - the largest number of exhibitors at any micromachine exhibition to date - participated (the total number of booths was 352), and the total number of visitors was 8,213.

(3) Administration of the Federation of Micromachine Technology

As secretariat for the Federation of Micromachine Technology, the MMC endeavored to enhance cooperation between and strengthen micromachine-related organizations.

Next-Generation Projectss

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Graduate School of Information Science and Technology
The University of Tokyo

The Micromachine Center created the Next-Generation Project Investigative Commission to study the future shape of MEMS. The following is a description of the findings of this study.

Characterized by miniaturization, MEMS has been developed as a major industry centered on monofunctional devices. MEMS products that have been marketed to date include pressure sensors, accelerometers, gyroscopes, inkjet print heads, DLP products, and microphones. According to a study conducted by the Micromachine Center, the market size for MEMS in Japan is expected to reach 1.36 trillion yen by 2010. Therefore, future high-density, complex MEMS, which will be smaller, more reliable, and more sophisticated, have become a major issue.

The Investigative Commission discussed the MEMS industry based on our recognition of this situation. In the future, there will be a strong demand for smaller, cheaper, more sophisticated, and more versatile electronic parts serving as key components in the telecommunication field, for which a surge in demand is anticipated, and the automotive field, which is competitive internationally. It will also be necessary to contribute to safety and security, sustainable energy, medical welfare, and other social needs. MEMS technology is the leading candidate among manufacturing technologies for meeting these needs.

Future MEMS business may develop in many shapes, including in-house-manufacturing businesses, businesses for supplying MEMS parts, foundry services, startup companies produced by spinouts, as well as design, simulation, and consulting businesses. However, MEMS R&D to date has required capital for relatively long periods, such as ten to twenty years or more. If this also proves to be a impediment in next-generation highly integrated, complex MEMS, the potential for the MEMS industry and its users will be low. Therefore, we must establish policies for the MEMS industry aimed at revitalizing the strength of Japan's manufacturing industry.

The Commission established the following four categories for technologies required for meeting our future needs through the development of high-density, complex MEMS that are smaller, more reliable, and more sophisticated.

(1) Technologies integrating MEMS and high-density semiconductors (MEMS + CMOS)

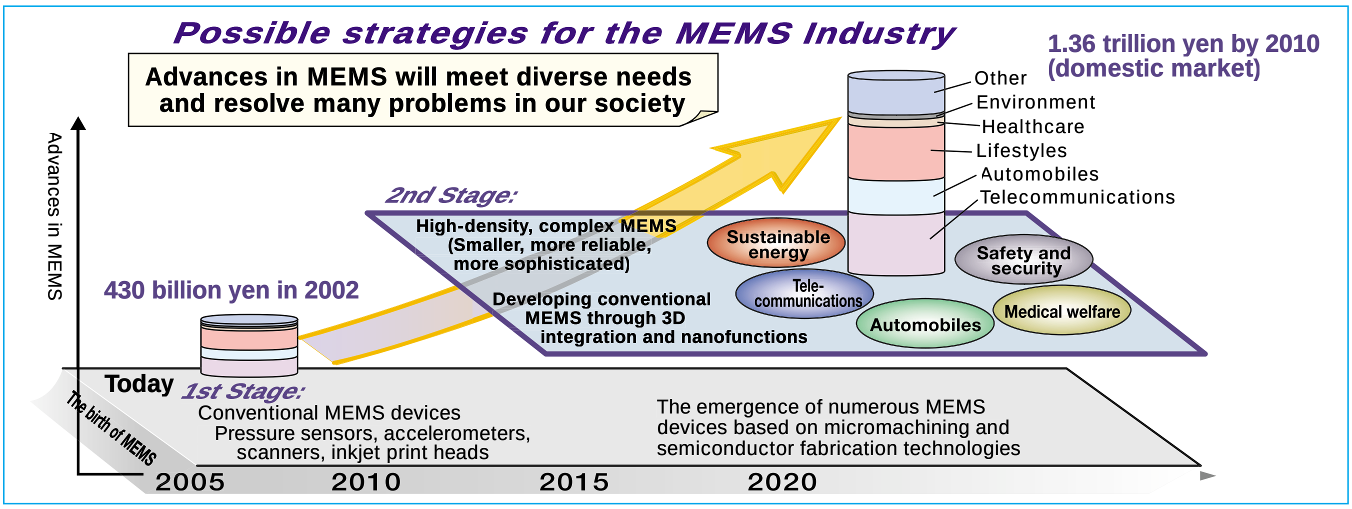
(2) Technologies for combining and increasing the density of multiple MEMS (MEMS + MEMS)

(3) Technologies for combining the functions of MEMS and nanotechnology (MEMS + NANO)

(4) Common base technologies

Of these categories, (1) involves the monolithic integration of MEMS and CMOS aimed at rapidly improving the functional capacity for knowledge accumulation; (2) involves the research and development of technologies for bonding and layering dissimilar materials and functions at the wafer level in order to combine functions, express new functions, and improve reliability; (3) involves the research and development of technologies for locally and selectively forming and expressing the functions of nanomaterials on MEMS with the aim of improving the performance of MEMS using functional expressions on the nanoscale; and (4) is aimed at constructing a common knowledge database primarily concerned with high-density, complex MEMS.

MEMS technology is our trump card for the future of the manufacturing industry. It has high added value and is supported by a strong technological strength difficult to replicate. It is our wish that the results of the Next-Generation Project Investigative Commission will be incorporated in future R&D for strengthening the competitiveness of our industry.



Possible strategies for the MEMS Industry

Fujikura's MEMS Foundry Service

Nobuyuki Sadakata, General Manager
Electron Device Laboratory, Silicon Technology Department
Fujikura Ltd.

1. Overview

Fujikura's MEMS technology is based on experiences in the downsizing and integration of sensors. The technology is backed by years of expertise on silicon micromachining, wafer bonding and packaging during our mass-production of semiconductor pressure sensors. By combining silicon planer processes, microcircuits formation on flexible printed circuit boards, and chip-on-film assembling technology, we have developed our wafer-level package (WLP) technology and launched a foundry service. Fujikura is actively pursuing research and development targeting a future MEMS packaging applying silicon through-hole interconnection technology.

2. Wafer-Level Packages

For portable electronic equipments, WLP, which enables real-chip-size IC package, is now becoming widespread. Fujikura has developed technologies for forming thick resin film, fine rule circuits, lead-free solder bumping on the whole wafer and reducing the chip-height by wafer-thinning. Also, building-up multi-layer circuits has been developed. Fujikura started its WLP foundry service in 2002, and now new mass-production line for 8-inch and 6-inch wafers at the Sakura Plant has brought into operation. Further, integrated passive devices for RF-MEMS of high-performance antennas and inductors on WLPs have been successfully developed. Fujikura will continue to contribute improving device performance with novel technology.

3. MEMS Packaging

Fujikura was among the first to focus on promising through-hole interconnects in silicon substrates. A photo-assisted electro-chemical etching (PAECE) process for forming through-holes and a molten metal suctioned method (MMSM) for conductor formation have been developed at early stage. Now by dry etching and by low-cost conductor filling processes, for instance, electroplating, we are pursuing R&D on various techniques for forming through-hole interconnects and wafer bonding that are appropriate for MEMS device packaging and system-in-package technologies.

The image-sensor package is one of the typical product applying these technologies. By embedding conductors in a chip using a through-hole interconnect, solder bumps can be formed on the opposite side of image-sensing area of the device on the optical lens side, achieving a small camera module for a high-density assembly. Combining this WLP technology with our expertise in packaging of pressure sensors with cavities, we are endeavoring to realize practical products by introducing our through-hole interconnects for the coming generation of interposers and wafer-level MEMS packages (WLMP).

4. Conclusion

Fujikura has assembled its wafer-level package foundry service and MEMS R&D at its Sakura Plant, intending to establish a MEMS production service as well as WLPs to meet our customer demands.

Contact
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Fig. 1 Wafer-level package

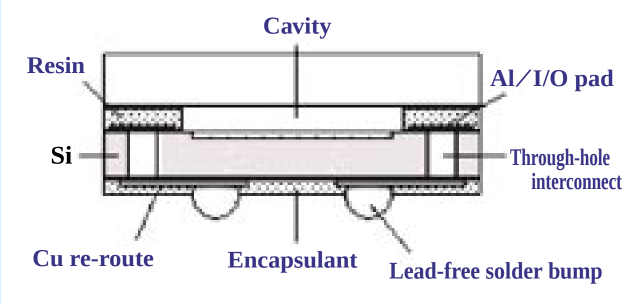


Fig. 2 Cross-sectional view of an image sensor

MEMS-ONE Project Data:Development of the Framework Software

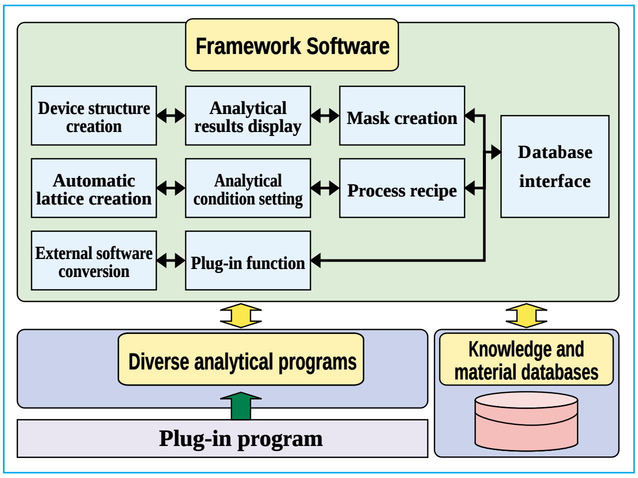
Yukihisa Maeda, MEMS Project Manager, Research and Development Department
Nihon Unisys Excelutions, Ltd.

1. Development Objectives

Nihon Unisys Excelutions is researching and developing framework software designed to implement integrated management of the MEMS Open Network Engineering System of Design Tools (MEMS-ONE). This framework software will have sophisticated functional integration with diverse analytical software and will establish an organic link with the knowledge database and material and process database.

2. State of Development

The framework, detailed in the following diagram, primarily functions to form device structures, create masks, set analytical conditions, display analytical results, set process recipes, automatically create lattices, convert data using external software, implement plug-ins, and interface with databases.



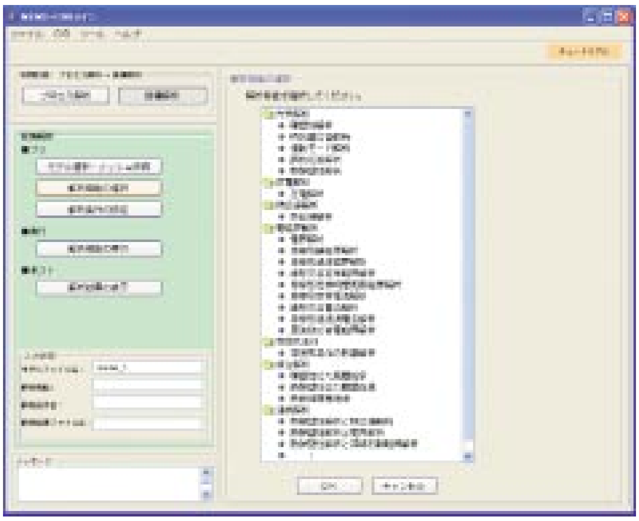
Functions in the framework for MEMS-ONE

The function for device structure formation includes a 3D modeling function. The function for mask creation includes a CAD function for creating mask layout data. The function for setting analytical conditions can set conditions for many diverse analytical programs. The function for displaying analytical results includes a function for visualizing analytical data. The process recipes include a function for combining processes in multiprocessing and a function for setting and modifying process conditions. The function for automatic lattice creation has a function for creating mesh data required for analytical programs employing the finite element method. The external software converter has a function for converting commercial CAD data and analytical data. The plug-in function has an open parts and data format so that the user's software can be incorporated into the present system. The database interface has a function for facilitating interface with the knowledge database and the material and process database.

Development of the MEMS-ONE project was begun last year with a target release date set for the end of 2006. We have begun development work on the program this year based on the studies implemented last year on specifications for the framework functions.

Below we present a draft of screen images for the MEMS-ONE framework functions (not the final version).

MEMS-ONE start-up screen



Selection window for the mechanical analysis program

Since the framework functions are responsible for the main interface with the user, we strove to create a user-friendly GUI simple enough for novices to use. Our goal is to complete the development early enough that the developmental results can be actively promoted at the Micromachine Exhibition and the like.

Column

Transitions in Bonding Technologies : from a Golden Mask to MEMS

Osamu Ohashi, Professor, Graduate School of Science and Technology
Niigata University

Throughout the history of humankind, technology has progressed slowly and, at times, rapidly. One technology that has advanced with the others is welding/bonding technology.

The history of bonding began with a golden mask that was discovered in the tomb of the Egyptian king Tutankhamen. The goldwork of the mask had been assembled around 1300 BCE using thermocompression. Bonding in Japan began with the repair of a bronze bell. Then in 747, the Daibutsu, or Great Buddha, of Nara was cast in block units and subsequently assembled using a brazing-like technique. Around 900, a technique for manufacturing Japanese swords was established. When guns arrived in Tanegashima in 1543, material processing techniques advanced so rapidly that guns could be manufactured domestically soon thereafter. These bonding and processing techniques were performed by combusting charcoal as a heat source, heating the materials in a reducing gas to prevent oxidation, and joining gold and iron alloys through forge welding and brazing with no melting.

When iron came to be produced in blast furnaces after the Industrial Revolution, iron and steel materials were bonded mechanically by forming holes in two iron plates and inserting rivets to join them together. This riveted construction can be seen in the Eiffel Tower, constructed in 1889, and the Komagata Bridge in Asakusa, Japan, shown in Photo 1. The heat source evolved from charcoal to electricity, then arcs, electron beams, and laser beams, as new heat sources were developed. These heat sources have been applied to welding/bonding techniques to develop a new fusion welding for melting the process points.

Recently, materials are gaining higher functionality; parts are being made smaller; and there is increasing demand for precision bonding and methods for joining dissimilar materials. There are numerous cases in which assembly is not possible with the conventional melt welding due to metallurgical problems. Thus, technologies have been sought and developed for joining materials in their solid phase without including a molten phase in order to decrease these metallurgical problems.

Fig. 2 shows a sample wound coil for use in a cell phone. The entire coil is smaller than a grain of rice. The coil is produced from a urethane-coated copper wire having a diameter of 30 μm, and this insulated copper wire is bonded to the silver electrode of a terminal by thermal compression.

Fig. 3 shows a sample microreactor having heat exchange circuits above and below the reactor circuit. A stainless steel leaf having a path no greater than 0.5 mm, is bonded using thermocompression (diffusion bonding) under a high vacuum so that the material does not deform.

The thermocompression in these bonding techniques was the same used to assemble Tutankhamen's golden mask, but remarkable advancements have been made in techniques for controlling the bonding process.

Various accelerometers have been manufactured in recent years. Many of these have been incorporated in automobiles and have helped improve riding comfort and safety. Accelerometers are parts formed by joining and assembling silicon and glass that have been micromachined according to photolithography. The method of bonding is anodic bonding, which employs electrostatic attraction in the glass interface that accompanies the migration of sodium ions. This method can be used at the relatively low temperature of about 300℃.

In addition to microreactors, devices having micromechanical structures (MEMS) include various accelerometers and optical switches. Assembled of micromechanical parts formed in silicon using photolithography, these devices have practical applications in combination with processing technologies from multiple fields.

I believe that complex micromechanical process and assembly technologies represented in devices having micromechanical structures should be one of Japan's focuses in the future.

Fig. 1 Rivet structure for the Komagata Bridge in Asakusa

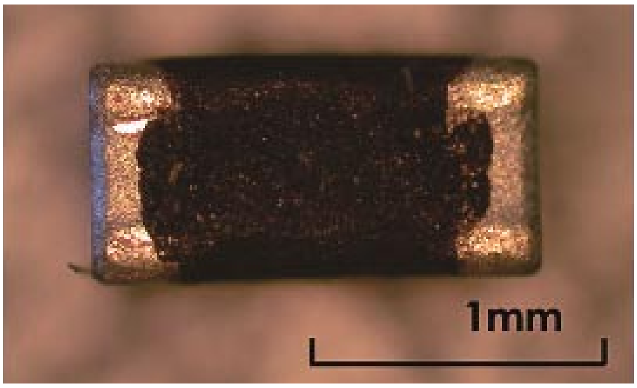


Fig. 2 Wound coil for a cell phone (manufactured by Taiyo Yuden)

Fig. 3 Layered heat exchanger cut to show the internal structure (manufactured by Yachida)

Overseas Trends

Report on the 11th Micromachine Summit

The 11th Micromachine Summit was held in Dallas, Texas, May 1-4, 2005. The Micromachine Center held the first Micromachine Summit in Kyoto, Japan in March 1995, inviting representatives from nine other countries active in the field of micromachines, including the United States, Australia, Canada, France, Germany, Italy, the Netherlands, Switzerland, and the United Kingdom. Now, ten years later, sixty-three representatives and thirty-three observers-for a total of ninety-six participants-attended the 11th Micromachine Summit in 2005. Including the countries mentioned above, the participants came from a total of twenty-four countries including Mexico, Argentina, China, South Korea, Taiwan, Singapore, India, Israel, Belgium, Greece, Denmark, Norway, Sweden, and Finland. Representatives from universities and research institutes and organizations accounted for three-fourths of the participants, while the remainder was made up of business reapresentatives. A total of nine people from Japan attended, including Chief Delegate Dr. Isao Shimoyama (professor, the University of Tokyo), Delegate Toshiro Shimoyama (chairman, the Micromachine Center and supreme advisor, Olympus Corporation), Delegate Hitoshi Ogata (director, the Micromachine Center and senior executive officer, Mitsubishi Electric Corporation), Delegate Keiichi Aoyagi (executive director, the Micromachine Center), Delegate Takayuki Hirano (executive advisor, the Micromachine Center), and four observers.

The conference proceeded in a roundtable format, with the delegates seated around the table and the observers encircling them. The first day of lectures consisted of country reviews, in which a representative from each participating country spoke about their country's micromachine- and nanotechnology-related endeavors. No other event provides the opportunity to hear about the micromachines activities of twenty-four countries under one roof. For Japan's review, Chief Delegate Shimoyama spoke on “MEMS Market Trends in Japan.” In this report, he predicted rapid growth in Japan's MEMS market and stressed the importance of producing fine MEMS through the development of (1) MEMS+CMOS, (2) MEMS+MEMS, and (3) MEMS+Nanotech in order to attain and expand this rapid growth.

On the second day of the Summit, twenty-three lectures were given during four sessions entitled (1) Techno-Historical, (2) Institutes and Companies, (3) Strategy, and (4) Industry Groups. Of particular interest were the success stories related by the host country's Texas Instruments on Digital Mirror Devices and Analog Device Inc. on the development of accelerometers. Delegate Aoyagi of Japan reported on the Micromachine Center's endeavors to date and future developments in a lecture entitled “Toward Industrialization of MEMS/Micromachine Technologies.” Delegate Shimoyama gave a visual presentation entitled “Technological Challenges toward Capsule Endoscopes,” in which he introduced through video Olympus' activities in Capsule Endoscopes. This year, Delegate Shimoyama was recognized by the Secretariat for the enormous contribution he has given to the Summit over the years. Also, in his lecture entitled “Micro and Nano Technologies at Mitsubishi Electric Corporation,” Delegate Ogata presented Mitsubishi Electric's work in nanotechnology centered on MEMS technology.

On the final day, participants were taken on a tour of Texas Instruments, Zyvex, and the University of Texas at Dallas, all located near the conference hall. Perhaps due to its location in this buoyant town of Texas, this year's Micromachine Summit had a light-hearted mood throughout. It was apparent during this Summit that the connection of micromachines and MEMS technology to nanotechnology is essential and that many countries are working to use this to create and develop new industries. The fruits of these activities are greatly anticipated. Finally, it was decided to append the subtitle “Micro/Nano Technology and Applications” to the original title “Micromachine Summit.”

The 12th Micromachine Summit: Micro/Nano Technology and Applications has been scheduled to be held in Beijing, China for three days on April 27-29, 2006. Hence, as new industries for micromachines and MEMS emerge and the number of Asian participants in the Summit increases, the Micromachine Summit will be departing from its salon-type roundtable meeting of several tens of people and is about to be reborn as a new conference that maximizes features different from other typical academic meetings on technology. The Micromachine Center will continue to lend its support to the Micromachine Summit.

Members' Profiles

Olympus Corporation

Haruo Ogawa
Division Manager, New Business Planning Division

1. Endeavors in MEMS Technology

Olympus launched its Semiconductor Technology Center in 1982 to develop special imaging sensors and peripheral ICs. This led to Olympus' involvement in MEMS in 1989, when Olympus began developing cantilevers for atomic force microscopes (see Fig. 1) using the semiconductor prototype production line. In the meantime, Olympus has actively engaged in research and development on charge modulation image sensors and all-purpose Bi-CMOS devices using electronic devices; various cantilevers, optical scanners (see Fig. 2), and other optical MEMS using MEMS; and various optical sensor modules combining photodiodes and micro-optical devices. Olympus also participated in the ten-year Micromachine Project, which began in 1991 and concluded in the spring of 2001. This project involved the development of small-diameter, active-bending microcatheters tipped with a heavy density of silicon piezoelectric MEMS pressure sensors, as well as piezoelectric diagnostic tactile sensors, helping to create base technologies for a variety of MEMS sensors. In addition, Olympus has conducted biotechnology-related R&D since the second half of the 1980s. In the latter half of the 1990s, Olympus began developing bio-MEMS (or microfluidics devices) in the form of preprocessing free-flow modules for separating DNA and proteins and micro-PCR (polymerase chain reaction) modules for amplification.

Fig.1 Cantilever

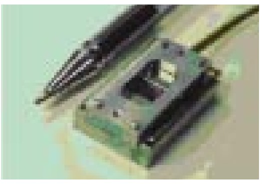


Fig.2 Optical scanner

2. Commercialization of MEMS Technology

After many years of accumulating research and development on MEMS technology, Olympus introduced the cofocal scanning laser microscope LEXT OLS3000 in November 2003 as a product capable of utilizing the features of MEMS devices. This microscope is equipped with an optical MEMS scanner and boasts the world's highest resolution among similar microscopes. In August 2004, Olympus introduced the nanosearch microscope LEXT OLS 3500 (see Fig. 3). This microscope is equipped with the functions of a scanning probe microscope using MEMS cantilevers that enable rapid super-wide range observations, from millimeters to nanometers. In April 2004, Olympus announced that, through collaboration with Kanazawa University professor Toshio Ando, it had developed a high-speed atomic force microscope capable of videotaping individual molecules in living proteins by applying soft cantilevers one-twentieth the size of their conventional counterparts. This microscope is expected to contribute widely to fields of basic research in nanobiotechnology, for example.

In November 2004, Olympus introduced a passive capsule observation endoscope (see Fig. 4), which is a culmination of its many years of research and development on micromachines. Now, MEMS has grown into a core technology at Olympus that differentiates its products.

Fig.3 Nanosearch microscope

Fig.4 Capsule endoscope

3. Creating Core Businesses based on MEMS Technology

Currently, Olympus is involved in the national MEMS Project to develop a high-precision fabrication technology for optical switches. As Olympus continues to acquire sophisticated optical MEMS technology, its MEMS foundry service is receiving an increasing number of inquiries. Although the foundry service has been in operation for just over three years, numerous prototypes of MEMS devices have been manufactured, some of which have now entered the mass-production phase. Quality assurance becomes of utmost importance in the mass-production phase, and the laser microscopes OLS3000 and OLS3500 sold by Olympus are ideal for evaluating MEMS devices. When commercial measuring instruments are not sufficiently inspected or assured, Olympus develops special evaluation equipment using its own microscope technologies, making every effort to assure quality.

MEMS is now being said to be vital for industry. Olympus is striving to build a relationship of trust with its customers through the MEMS foundry service and to create future core businesses according to a new business model.

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