MMC

MICRONANO

2007 5

MMC Activities

Overview of Project Planning for Fiscal 2007

I. Basic Objectives of Activities

The Micromachine Center works to establish basic technologies relating to the micromachine, Micro Electro Mechanical Systems (MEMS) and other micro-nano fields. The Center actively promotes relevant technical development projects of the national government and the New Energy and Industrial Technology Development Organization (NEDO). At the same time, the Center is also actively engaged in environmental improvement activities aimed at the industrialization of the micro-nano field (including policy proposal projects, industry interchange and stimulation projects, research projects, projects to promote standardization and publicity projects) in order to promote dissemination and industrialization of these basic technologies and thus make a contribution to both the growth of Japanese industry and the international community.

In 2007, the Micromachine Center will continue to actively promote the High Integration/Combination MEMS Production Technology Development Project. (nicknamed the Fine MEMS Project), a three-year project that began last year. The Center will also build a support organization for the MEMS Open Network Engineering System of Design Tools Project (nicknamed the MEMS-ONE Project), for which development was completed in March 2007, and will shift to publicizing the achievements of this project. With regard to activities to improve the environment for industrialization, beginning with policy proposal activities and industry interchange/stimulation projects on the part of the MEMS Industry Forum that was established last year, the Center will continue to actively promote projects from last year including research projects, projects to promote standardization and publicity projects.

II. Description of Primary Activities

1. National/NEDO Project-related Activities

In order to establish basic technologies relating to micromachines and MEMS, the Center has actively promoted research and development projects led by the national government and NEDO, combining the capabilities of industry, government and academia. In 2007, the Center will vigorously promote the High Integration/Combination MEMS Production Technology Development Project (Fine MEMS Project), a three-year project initiated in 2006. The Center will also actively promote dissemination of MemsONE, the research and development achievement of the MEMS Open Network Engineering System of Design Tools (MEMS-ONE Project), a national government/NEDO project that was concluded in March 2007.

(1) High Integration/Combination MEMS Production Technology Development Project (Fine MEMS Project) (NEDO)

The Center will continue to promote this project, initiated in 2006 as a national project, and carry out the 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: (1) combination of MEMS and nano functions, (2) integration of MEMS and semiconductors, and (3) MEMS and MEMS high integration unification. A web-based database system in particular will make it easy for researchers participating in the project to enter data, and this will help to increase the number of database entries and make the content more complete. In addition, the Center will continue to assist in overall management of this project in cooperation with NEDO, and will actively publicize midterm achievements using opportunities such as this year's Exhibition MICROMACHINE.

(2) Dissemination of MemsONE

The MEMS Open Network Engineering System of Design Tools (MemsONE) Project was concluded in March 2007. The Center will establish a MemsONE Support Center to promote MemsONE – the research and development achievement of the MemsONE Project. The MemsONE Support Center will vigorously publicize MemsONE in cooperation with the MEMS Industry Forum.

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

The MEMS Counsil was established in April of last year 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 promote development of the bedrock state-of-the-art micro-nano technologies for which wide-ranging applications are anticipated, the "Micro/Nano Cutting Edge Technology Exchange" will be once again held this year (as last year) as venues for the exchange of information and in order to stimulate joint research. The MEMS Council will also work with the Standardization Committee to promote standardization activities.

(3) Preparation of an Infrastructure for MEMS Development

(i) Expansion and Strengthening of a Foundry Network System
(ii) Promoting the Diffusion of MemsONE
(iii) Strengthening of Coordination between Public Foundries in Each Region and Regional Clusters
(iv) Promotion of Human Resource Training

(4) MEMS Business Exchange in Japan and Abroad

(i) Establishment of an MEMS Mall
(ii)Hosting "MicroNano 2007"

To promote industry interchange in the micromachine/MEMS field, as last year, a series of events entitled "MicroNano 2007" will be held. The events will comprise Exhibition MICROMACHINE, a trade show for micro/MEMS and nanotechnologies; the MEMS Forum; the International Micromachine/Nanotech Symposium; and the Presentation of National Government/NEDO Project Results. The series of events will be held July 25 - 27, 2007 at Tokyo Big Sight.

(iii) Participation in the 13th World Micromachine Summit

The Center will participate in the 13th World Micromachine Summit, which will be held in the Italian city of Venice from

April 25 - 29 this year, taking part in discussions of a wide range of topics, including worldwide trends in micromachine technology and its fields of application.
(iv) Building of an International Network of Affiliates
(v) Dispatch of overseas missions and exchange of researchers

3. Survey Research Activities

The Center conducts research relating to micromachine and MEMS technologies that are gradually becoming key manufacturing technologies, in order to accurately determine technical and industry trends and study new technical issues in domains in which these technologies are fused with nanotechnology.

(1) Implementation of research relating to the BEANS Project

The Center will establish a BEANS Project Review Committee with the aim of making the Bio & Electro-mechanical Autonomous Nano Systems (BEANS) Project a national project. BEANS was the achievement of a MEMS frontier project implemented in 2006 to study future device technologies that are expected to be created through fusion with nano-bio technologies. The Committee will study the project scheme, organization, research topic content and so on.

(2) Study of national and international technical trends

This year as well, the Center will determine, from a fixed perspective, the technical and research trends in the micro-nano fields that are experiencing dramatic technical progress both at home and abroad. In addition, work will continue on the compiling of a database that is basic to, and critical for, future process in micromachine technologies.

(3) Survey of industry trends

The Survey Research on the Analysis of the Current Conditions in MEMS Related Markets and Japan's Competitiveness was implemented last year. This year, an exchange of views will be held with overseas affiliates in the MEMS Industry Forum regarding the MEMS market, and a study of last year's market trends and the current status as well as future prospects will be completed. Information-gathering and analysis will also be conducted with regard to various issues relating to future technical development.

(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. Projects to promote standardization

International initiatives to promote standardization in the micromachine/MEMS technology field will be pursued.

(1) Study of standardization

In 2006, a road map for standardization was established to serve as a guide for international standardization and normalization, which will be needed to strengthen MEMS international competitiveness and international deployment based on this competitiveness. In 2007, efforts will focus on basic common fields and device fields in accordance with this road map, and detailed study leading to the creation of draft standards will be conducted.

(2) Research and development to authenticate the criteria for proposing international standards

In 2006, accelerated life testing of the mechanisms and materials for MEMS devices was initiated, in addition to research and development of calibration materials for characteristic evaluation tests of MEMS mechanisms and materials with the objective of standardization. In 2007, the primary focus will continue to be on acquiring basic data for establishing draft standards.

(3) Follow-up for proposed Thin Film Material Fatigue Test Method

Follow-up activities aimed at international standardization will be conducted for the NP (New Work Item Proposal) fatigue test proposed in 2006.

(4) Study of overseas standards

A study will be conducted to determine how Japan can accommodate the rapidly increasing number of proposed MEMS standards in Korea and other overseas countries (relating to RF-MEMS, bonding and packaging).

(5) Creation of JIS standard for thin film material tension test method

A study will be conducted with the objective of creating a JIS standard for the tension test method and standard test specimens for which IEC standards were established in 2006.

5. Publicity projects

Efforts will be made to achieve wide-ranging dissemination and education regarding micromachines and MEMS through the publication and distribution of brochures, the holding of exhibitions and so on. 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.

(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) Hosting "Exhibition MICROMACHINE/MEMS"

The 18th International Trade Show for Micro/MEMS & Nanotechnologies will be held as part of a series of events entitled "MicroNano 2007." The trade show will feature exhibits of state-of-the-art products, manufacturing materials and so on relating to the micromachine and MEMS industry, and it will also serve as a forum for presenting the latest research achievements. Due to venue scheduling circumstances, this year the venue will change from Tokyo International Forum to Tokyo Big Sight. The series of events will be held from Wednesday, July 26, 2007 to Friday, July 27, 2007.

"MicroNano 2007" Events

1. Exhibition MICROMACHINE: The 18th International Trade Show for Micro/MEMS & Nanotechnologies
July 25, 2007 (Wednesday) - July 27, 2007 (Friday)
Tokyo Big Sight (West Hall 3 & 4)

2. 2nd MEMS Forum
July 25, 2007 (Wednesday)
Tokyo Big Sight (West Hall 3 & 4)

3. 13th International Micromachine / Nanotech Symposium
July 26, 2007 (Thursday)
Tokyo Bay Ariake Washington Hotel (Iris)

4. National Government / NEDO Project Achievements
July 27, 2007 (Friday)
Tokyo Big Sight (West Hall 3 & 4)

Toward the Achievement of 3rd Generation MEMS: Bio & Electro-mechanical Autonomous Nano Systems (BEANS)

Keiichi Aoyanagi, Executive Director, Micromachine Center

MEMS: The "Beans" of Industry

In recent years, Micro Electro Mechanical Systems (MEMS) have become a key part of industry. These devices are incorporated into a wide variety of final products and provide high added value. Examples of development efforts and products include mirror devices for optical switches used in the field of optical communications and so on, cantilevers used in atomic force microscopes, pressure sensors and acceleration sensors used in automobile components and the like, and radio frequency (RF) MEMS switches used in wireless communication systems.

In Japanese, the expression *sangyo no kome* (literally "the rice of industry") is used to indicate a key element of industry, such as steel manufacture during Japan's period of rapid economic growth or the semiconductor chips that are now core devices used in many products. MEMS devices have been called not the rice but the "beans" of industry. This is because, although tiny, MEMS are a source of vitality and provide outstanding utility and functions to the products in which they are incorporated.

The beans metaphor is applicable in other ways as well. There are many different types of beans (soybeans, adzuki beans, peanuts, green beans etc.), and they are used to make many bean products (natto, miso, tofu, soy milk, adzuki bean paste etc.). Similarly, there are many different types of MEMS devices, and they are used in many different types of products.

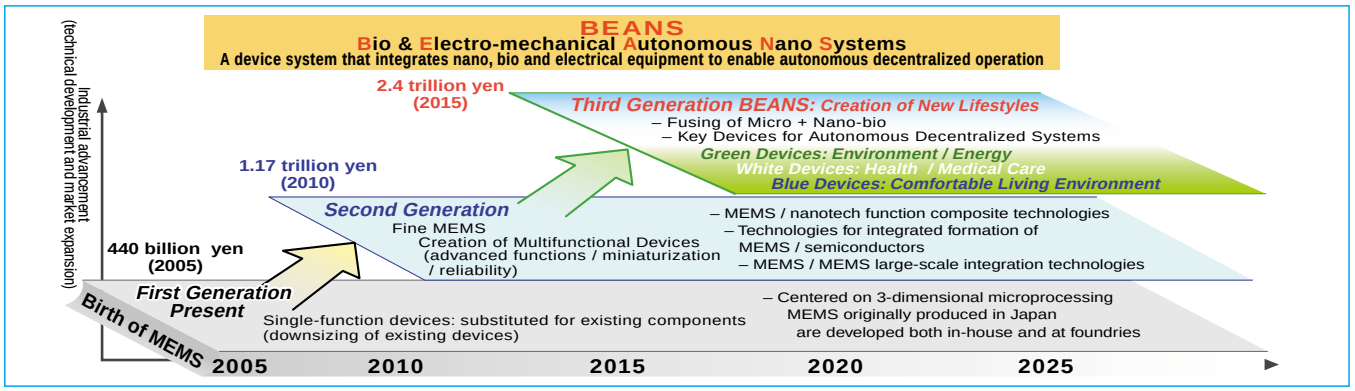
Development of MEMS

The first generation single-functional MEMS devices – those used primarily to replace existing single-function components due to their compact size – are currently in development. These products constitute an enormous market and include pressures sensors, acceleration sensors, inkjet printer heads and so on. These first generation MEMS devices constitute most of the domestic market that is estimated at JPY 440 billion yen.

However, in order to respond to the future needs of the automobile, information and telecommunications, safety and security, environment, medical care and other fields, second generation multifunctional MEMS devices (fine MEMS) that are ultra-compact and offer advanced functions and high reliability will be needed. For this reason, a three-year fine MEMS technical development project was initiated in fiscal 2006. The purpose of this project was to support the development of these second generation fine MEMS devices through research into (1) complex technologies to implement nanofunctions, (2) integrated construction with semiconductor chips, and (3) methods to connect MEMS components in a highly integrated manner. Practical application of fine MEMS technologies is expected in five to ten years.

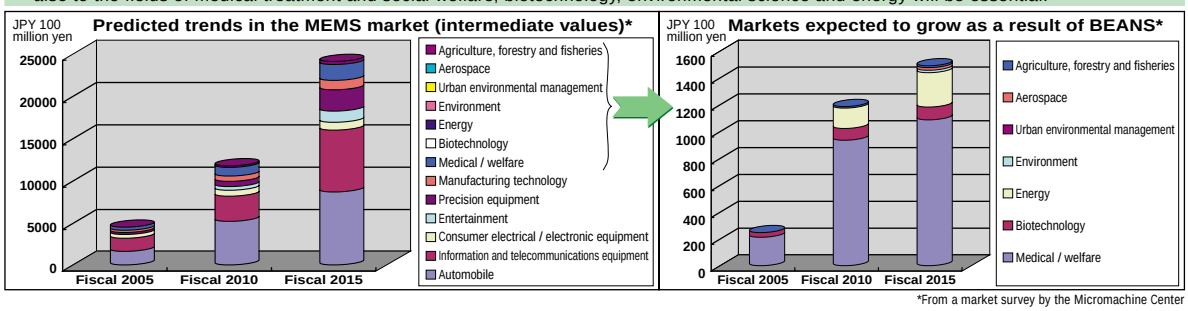
Expectations for BEANS (technologies of the future that will create new lifestyles)

MEMS technologies hold great promise for the society of the future 20 years from now. In order to realize this promise, further advances in MEMS technology are needed, as well as the fusion of this technology with nanotech materials technology and biotechnology to create third generation MEMS (future devices on the frontier of MEMS research) that will create new lifestyles and have a revolutionary impact on society. Efforts must be made now to establish the technical infrastructure that will enable the creation of these future devices. Accordingly, based on the results of a study conducted by the Micromachine Center (MMC) at the behest of the Mechanical Social Systems Foundation, MMC has called for a project to develop the technical infrastructure to fuse nanotechnology and biotechnology with electrical and mechanical systems, in order to create autonomous devices and systems called Bio Electro-Mechanical Autonomous Nano Systems (or BEANS). With the support of the Council on Competitiveness Nippon (COCN), MMC is asking relevant parties to help make this a national / NEDO project beginning in fiscal 2008.



MEMS Industry & MEMS Technology Road Map

– Since 2000, the MEMS market in Japan has grown rapidly, reaching JPY 440 billion yen in 2005. In 2010, this market is expected to increase to 1.17 trillion yen, and in 2015 it is expected to reach 2.4 trillion yen.*
– In order to achieve further expansion, application to not only the existing major fields of automobile and information/telecommunications but also to the fields of medical treatment and social welfare, biotechnology, environmental science and energy will be essential.



*From a market survey by the Micromachine Center

MEMS Market Trends

Publicizing of MemsONE (beta version)

The MEMS Open Network Engineering System of Design Tools (MEMS-ONE)Project was a three-year (2004 – 2006) development project commissioned by the New Energy and Industrial Technology Development Organization (NEDO). The project culminated in the achievement of a beta version of the MEMS design and analysis software “MemsONE”. Distribution of this version will be begun at the beginning of June.

At the end of February, the evaluation version (alpha version) of the software distributed since the end of last November had approximately 400 licensed users. 70% of these users provided feedback regarding functions, price, support and expectations. Modifications will be made based on this feedback and all of the issues encountered during project development will be incorporated into the beta version release. We hope the software will prove useful in product design and development at companies as well as in research projects, teaching materials and so on at universities.

1. Project objectives and system features

The objective of this project was to develop a system that would enable stress-free use of advanced MEMS knowledge and data by not only people such as MEMS researchers and engineers who are familiar with cutting-edge research in the field but also researchers and engineers in other fields who are first-time or inexperienced users, thereby achieving broad-based expansion of the MEMS industry.

The MemsONE system was developed jointly by three software developers (each handling its own field of specialty), five companies engaged in projects relating to MEMS devices (each of which contributed its experience and achievements to create specifications and conduct evaluations), 13 university researchers (who provided their state-of-the-art knowledge and wisdom), and one research institution (which provided the measurement technologies that it had accumulated over a long period of time).

The analytical functions needed for MEMS design were provided in all-in-one fashion. The most significant feature of the software is its Japanese language response capability, making it easy for beginners to use (see figure below).

Functions provided by the software include standard analysis and design, unique “inverse design” in which masks and processes are designed from the final structure, evaluation of bonding and packaging (which is involved for resolving many problems in the MEMS development phase), nanoimprinting analysis (which is becoming a focal point for cutting-edge technical trends in the MEMS field), and integrated analysis of MEMS devices and circuits. The software also includes a knowledge database containing more than 1,700 entries and a material database containing approximately 170 entries including data acquired through the process line.

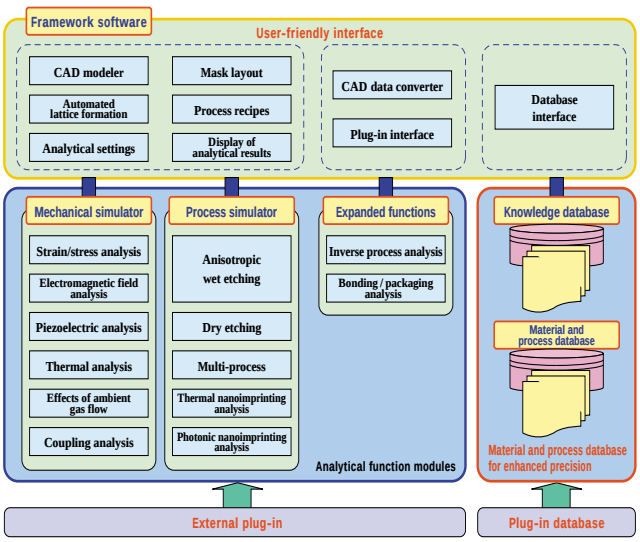
2. Activities aimed at dissemination

Last year a major publicity campaign was initiated to encourage dissemination of the MemsONE software. Events included the Sensors and Micromachines and Applied Systems symposium of the Institute of Electrical Engineers, the 9th Kansai Design and Manufacturing Solutions Exhibition, the Exhibition MICROMACHINE and the conference held concurrently to announce the achievements of the project, and the Nanotech 2007 exhibition.

As a result of this publicity campaign, the number of registered members in the MemsONE Club rose to approximately 800 persons. As MemsONE Club members are potential MemsONE users, Information disclosure and service activities will be focused on them in the future as well.

3. Beta version distribution schedule

– Publicity: Information regarding the beta version distribution will be provided on the website, and through the media, at the beginning of May.
– Distribution cost: The cost will be approximately JPY 10,000 yen per license.
– Use environment: Details will be posted on the website.



Fine MEMS Pj

Initiation of Fine MEMS project and Compiling of Knowledge Database

The Highly Integrated / Complex MEMS Manufacturing Technology Development Project was initiated in 2006 as a project commissioned and subsidized by the Ministry of Economy, Trade and Industry and the New Energy and Industrial Technology Development Organization (NEDO). The objective of this project was to use the technology for the manufacture of Micro Electro Mechanical Systems (MEMS) – key devices that will make a major contribution to miniaturization and performance enhancement of electronic devices and components in diverse fields that include information and communications, medical treatment, biotechnology, automobile manufacture and so on – in order to achieve breakthroughs in resolving development problems such as those shown in **Fig. 1** through complex technologies to implement nanofunctions, integrated construction with semiconductor chips, and methods to connect MEMS components in a highly integrated manner, in order to achieve further miniaturization, reduction of power requirements, and enhanced performance and reliability, as the next stage in MEMS development. This new stage has been nicknamed "fine MEMS." (**Fig. 1**)

The Micromachine Center was commissioned to handle one of the issues relating to development: the compiling of a database of fine MEMS knowledge. The Center gathered information relating to manufacturing technologies that had been fostered in the course of the project, with the aim of making it available for widespread use by MEMS researchers and engineers in Japan to stimulate and achieve broad-based expansion of MEMS manufacturing technology in Japan.

Basic knowledge and data relating to MEMS are contained in the knowledge database for the MEMS-ONE analysis and design support system completed in 2006. However, the Fine MEMS Knowledge Database will be an additional collection of knowledge relating to complex technologies to implement nanofunctions, integrated construction with semiconductor chips, methods to connect MEMS components in a highly integrated manner, and other knowledge relating to highly integrated and complex MEMS, and therefore it will have higher requirements for quality and number of records stored. The leader of the project, Professor Isao Shimoyama of Tokyo University, was keenly aware of the importance of the project, and he spearheaded the effort to determine specific methods to accomplish its objectives. Entries were collected from companies involved in the project, and research and development activities for knowledge relating to this project were consigned exclusively to five university research centers that had a detailed knowledge of development issues relating to the project. In addition, information regarding international conferences, patents and so on was gathered by MMC researchers in an effort to ensure that the content would be as complete as possible. As shown in **Fig. 2**, a web-based "Media Wiki" system was also introduced to enable collaboration and exchange of information among researchers participating in the project in order to improve the quality even further.

The project is scheduled for completion at the end of 2008. The achievements of the project will be publicized throughout Japan. (**Fig. 2**)

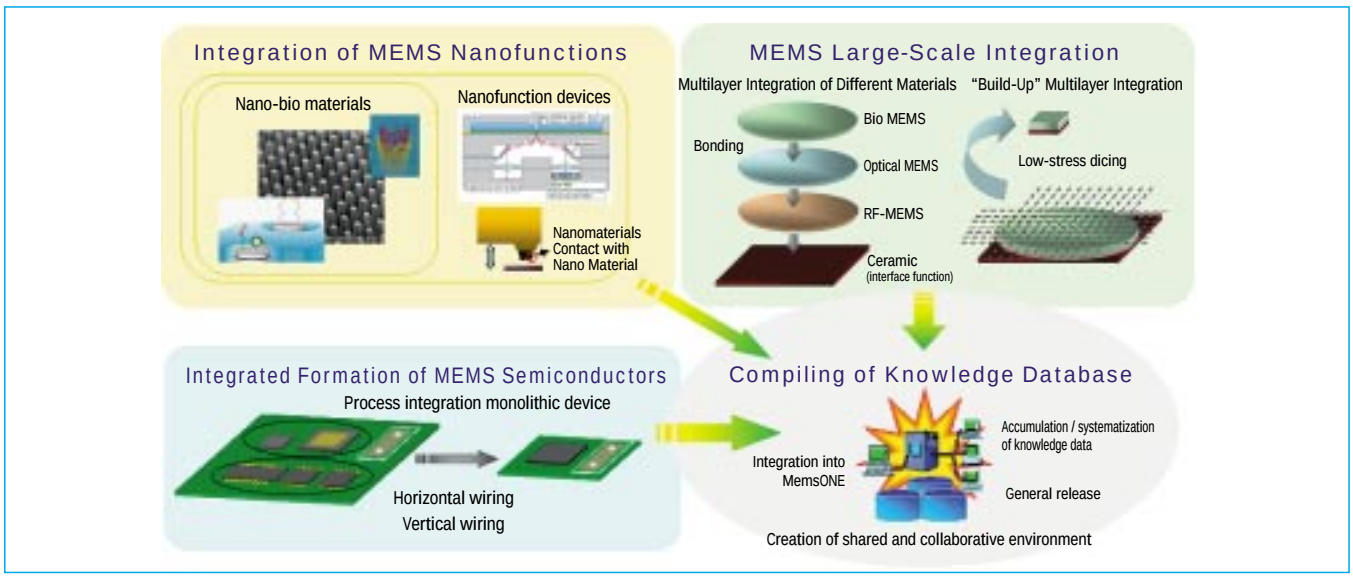


Fig.1 The Four Development Categories for Fine MEMS

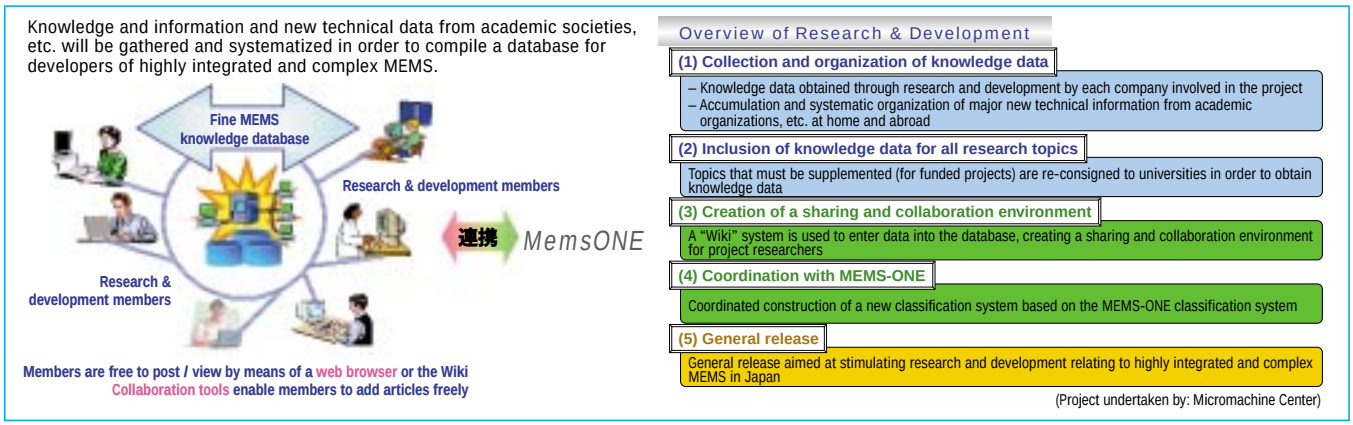


Fig.2 Compiling of Knowledge Database for Highly Integrated / Complex MEMS

Column

"Green" Devices: Future Devices on the Frontier of MEMS Research

Norihisa Miki, Associate Professor / Lecturer, Department of Mechanical Engineering, Keio University

With the promotion of the Highly Integrated / Complex MEMS Manufacturing Technology Development Project that began in 2006, even greater growth in the MEMS field is anticipated. At the same time, many innovative achievements are being produced in new fields such as nanotechnology and biotechnology. To see if fusing MEMS technologies with these achievements in the nano-bio field would produce sporadic innovation, in 2006 the Mechanical Social System Foundation commissioned the Micromachine Center to conduct a study entitled "Future Device Technologies Created through Fusion with Nano-bio Technologies as the Frontier of MEMS Research." The future devices targeted by this study are defined as "devices based on MEMS technology, produced by fusing nano-bio materials with MEMS, that will create new lifestyles and have a revolutionary impact on society 20 years from now." As shown in Fig. 1, these future devices will be achieved using, as an infrastructure technology, process integration that fuses microfabrication (a top-down process) with nano-bio processing (a bottom-up process). The devices will be used in three domains that are expected to be critical issues in the society of 20 years from now: environment / energy, health / medical care and safety / security. For this study, the future devices in each of these domains were named "Green" Devices, "White" Devices and "Blue" Devices, respectively, and – together with Process Integration – four working groups (WG) were formed and activated. In this column, I will discuss green devices based on the study conducted by the Green Devices WG, for which I served as chairperson.

Table 1 shows the membership of the Green Devices WG. The WG studied the green devices that are expected to have a major impact on the environmental and energy fields in the society of 20 years in the future. Discussions in the working group were conducted from two approaches: the qualities that these green devices of 20 years in the future should possess (needs) and the achievements that can be accomplished 20 years from now by combining nano-bio technologies with present-day MEMS technology (seeds). Ultimately, the Working Group proposed the following three green devices. In each case, the "localized, on-site" quality of MEMS is utilized to achieve both high performance and advanced functions in combination with nano-bio technologies.

(i) Energy harvesting

Light, heat, vibration, biotechnology and other heretofore unused sources of environmental energy will be used effectively to provide energy. For example, this technology will enable on-site supply of power to sensors distributed in a network. Medical devices implanted into the human body will not require battery replacement, leading to improved patient quality of life. Other anticipated devices include ultra-high efficiency organic solar cells created by means of three-dimensional nanopillar structures, ultra-high efficiency thermoelectric conversion elements created using nanocomposites and nanoporous structures, and high-performance storage battery devices that obtain energy from the environment and store it until it is needed.

(ii) On-site environmental cleanup

Substances such as carbon dioxide emitted by automobiles and water heaters and wastewater from homes are difficult to collect and clean up once they have been discharged, due to their extremely low concentrations in the environment. These substances will be purified on-site at the source, where they are still at high concentrations. Nanoporous filters that separate out pollutants, microorganisms to purify toxic substances and other biotechnology solutions are expected to be applied.

(iii) Ultra-sensitive environmental substance detection devices

These devices are capable of on-site detection of extremely small quantities of environmental substances with great sensitivity. Measuring systems will be compact and will form nodes in a distributed sensor network. For example, Surface Enhanced Raman Scattering (SERS) that uses nanostructures of gold, silver, etc. are anticipated.

Discussions regarding future devices that will be developed 20 years from now are necessarily somewhat lacking in specifics. Progress in research will give us a clearer picture of such devices. Green devices and the other future devices on the frontiers of MEMS research will form the foundation of MEMS technology. At the same time, such devices will no longer be MEMS devices. For this reason, the working group also proposed a new name for these devices: Bio Electromechanical Autonomous Nano Systems (BEANS). I am confident that this new term will soon be in widespread use in many industries.

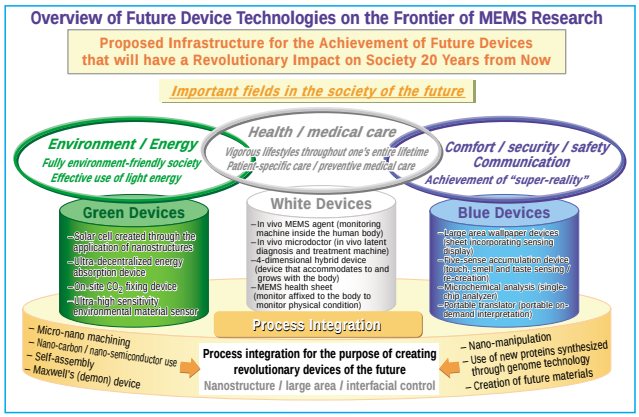


Fig 1 Future Devices on the Frontier of MEMS Research

Table 1 Members of the Green Device WG

Norihisa Miki	Keio University, Faculty of Science and Technology
Koji Miyazaki	Kyushu Institute of Technology, Graduate School of Life Science and Systems Engineering
Chihaya Adachi	Kyushu University, Center for Future Chemistry
Isao Shimoyama	Tokyo University, Graduate School of Information Science and Technology
Takao Ishida	Advanced Industrial Science and Technology (AIST)
Kazuyoshi Furuta	Seiko Instruments Inc.
Akihiro Koga	Toshiba Corporation
Ryo Miyake	Hitachi, Ltd.
Yuji Saisho	Matsushita Electric Works, Ltd.
Hitomichi Takano	Matsushita Electric Works, Ltd.
Junji Adachi	Micromachine Center (MMC)
Hiroshi Fukumoto	Mitsubishi Electric Corporation
Nobuhiro Tsukada	Hitachi, Ltd.

A Survey of China's Research Trends in Micro / Nanosystems

We conducted a survey on Chinese research trends in micro- and nanosystems by attending the International Conference on Integration and Commercialization of Micro and Nanosystems (Micro/Nano China 2007) held in Sanya, China on January 10-13, 2007. The conference was co-organized by the American Society of Mechanical Engineers (ASME) and the Chinese Mechanical Engineering Society (CMES). This academic conference on the integration of nanosystems has been held by the ASME Nanotechnology Institute in the United States since 2001. This year for the first time the conference was held outside of the United States–in Sanya, China–and was cosponsored by ASME with CMES and MANCEF. In addition to the cosponsorship by mechanical engineering societies from both countries, the conference was likely held in China because of the increased activity in MEMS-related R&D in China and the focus on Chinese MEMS researchers active in America.

We participated in this conference at the request of our overseas affiliate in MEMS conferences, MANCEF, to present the state of Japan's MEMS development and industrialization as a guest speaker, but we also participated with the following objectives.

- **To study trends in MEMS R&D and industrialization in China, where such R&D has become more active in recent years and will likely influence Japan's MEMS industry in the future**
- **To study the condition of Sino-American research collaboration**

The conference was held in the relatively new resort of Sanya, located at the southern tip of Hainan Island. Presentations given at the conference consisted of 108 oral and 260 poster presentations. **Tables 1 and 2** below give a breakdown of the topics in the oral and poster sessions and the countries that participated in each.

The following information was obtained based on the content of presentations and discourse at the conference.

- **Based on the oral presentations and the exchange of information among participants at the conference, it is apparent that China, Taiwan, South Korea, and other Asian countries recognize the high quality and substantial accomplishments Japan has made in MEMS industrialization through collaboration among industry, government, and academia.**
- **Overall picture of research trends in China**
- **Trends in MEMS-related research**
  - •Total number of groups conducting MEMS-related research: 140 (researchers: 3,000)
  - •Groups focusing on MEMS research: 50 (researchers: 1,452)
  - •North China: Tsinghua University, Peking University, CAS, and CETC (13 locations)
  - •East China: SIMIT, and Shanghai Jiao Tong University
  - •Northeast China: Dalian University of Technology, and Harbin Institute of Technology
  - •Other regions: Chongqing University, Xi'an Jiaotong University, and ChinaUniversity of Technology
- **•Micro and nano fields are a focus in long-term strategies for R&D in 2006-2020**
- **•Trends in Industrialization**
  - •MEMS commercialization has begun in Beijing, Shenyang, Taiyuan, Hangzhou, Wuxi, Chongqing, and others
  - •There is no movement at present to establish a system for supporting industrialization
- **•Sino-American research collaboration**
  - •The NSF is playing a central role in promoting Sino-American research collaboration
  - •Office established in Beijing (May 2006)
  - •NSF invests in U.S.-China program
  - •Approximately 150 projects underway
  - •15 million U.S. dollars invested (not including investments in collaborative research)

China is strengthening cooperation with Chinese researchers residing in the United States. There is potential in China for immense improvements in research sophistication and for advances in industrialization in macro and nano fields and, hence, the situation should be continually monitored.

	Oral presentations	Keynote speeches	Industrialization	MEMS / NEMS	Energy transfer	Processes and microfabrication	Micro/nano fluids	Micro/nano mechanics	Measurement and Control
Total no.	108	10	14	31	12	15	6	6	14
China	45	2	1	14	5	7	1	2	13
Taiwan	8	1		5	1	0		1	
USA&Canada	33	4	7	8	4	6	2	2	
Europe	8	2	4	1		1			
Japan	4		1		1	1	1		
Korea	3						1	1	1
Australia	2	1	1						
India	0								
Singapore	0								
China / USA	3			2			1		
China / Europe	1			1					
China /Japan	1				1				

Table 1 Analysis of Oral Presentations by Topic and Country

	Posters	Systems	Devices	Energy transfer	Processes and microfabrication	Micro / nano fluids	Micro / nano mechanics
Total no.	260	35	67	31	83	23	21
China	189	24	52	22	62	13	16
Taiwan	6		5				1
USA&Canada	28	7	3	8	8		2
Europe	8	1			1	6	
Japan	5		1		1	2	1
Korea	6	1	1	1	3		
Australia	1		1				
India	8	1	2		3	1	1
Singapore	1	1					
China / USA	6		2		4		
China / Europe	1					1	
China /Japan	1				1		

Table 2 Analysis of Poster Presentations by Topic and Country

Members' Profiles

Mathematical Systems Inc.

Managing Director
Chieki Mizuta

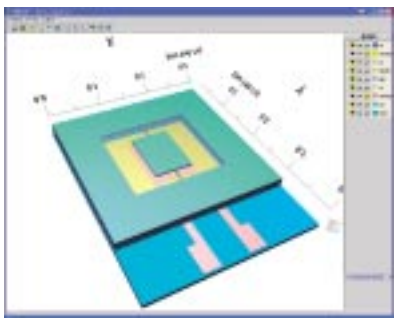
Company Overview

Since its foundation more than twenty years ago, Mathematical Systems Inc. (MSI) has consistently worked to develop technological software, and in particular design tools for semiconductor-related simulations, such as development of a device/process simulator and a circuit simulator and parameter optimization design and tolerance design using these simulators. We currently have a strong interest in the potential of the MEMS field and are working on developing new tools by making use of and expanding on our knowledge and techniques developed through the years. To address circuit integrated MEMS formed on the same substrate as an LSI, we are currently nearing completion of a 3D process simulator for simultaneously generating computer-aided MEMS design and LSI design and a circuit integrated MEMS simulator capable of simultaneously performing structural analysis and electronic circuit analysis. We also develop MEMS-related tools on commission and offer consulting services. With our own optimization software, data mining software, and statistical analysis tools, we offer a wide range of solutions to meet the customers' needs.

Related Products

ParadiseWorld-2

ParadiseWorld-2 is an all-in-one simulator for MEMS/LSI 3D processes (structures) with an optional capacitance/resistance simulator. Through continuous simulation, this software can produce smooth 2D and 3D structures from masks (GDS-II) and process recipes with high accuracy and unprecedented speed.



A micro-mirror structure produced with ParadiseWorld-2

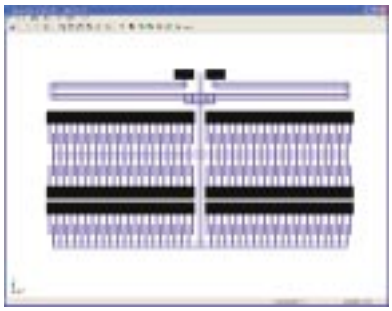
Inverse Problem Solving Tool for MEMS Processes

When a desired MEMS structure is inputted, this tool will produce a process and mask of inverted orientation for generating the structure (an achievement of the MemsONE project).

Process for generating a mirror device

Circuit Integrated MEMS Simulator

This simulator simultaneously performs coherent operations of MEMS mechanical elements and the operations of the electronic circuits that drive or control these elements. The user-friendly GUI makes even complex comb-drive actuators simple to produce (an achievement of the MemsONE project).



Creating a comb-drive actuator with the GUI (in reality, this is analyzed together with an electronic drive circuit)

Other Products

LiCRSIM: an ultrafast, large-scale linear simulator
Thyme: SPICE Netlist Reduction Tool
NUOPT: optimization software
Visual Mining Studio: data mining software
Text Mining Studio: text mining software
S-PLUS: statistical analysis software

To learn more, please refer to our Website at http://www.msi.co.jp.

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