MICRONANO

Thoughts on the New Year

Tamotsu Nomakuchi
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As we greet the year 2009, I would like to wish everyone a Happy New Year, and to share some thoughts at the beginning of this new year.

The past year was a turbulent one for the Japanese economy. Increases in the price of crude oil and rare materials, which had been a concern for the past few years, continued apace. This put pressure on company operations and people's daily lives, and highlighted the all too well known fragility of the industrial infrastructure and lifeline of Japan, a country with a dearth of energy resources and raw materials. Then financial instability on a worldwide scale occurred, caused by the long-feared collapse of subprime loans in the United States. The resulting turbulence seems unlikely to be resolved easily. Viewing these trends, what I feel anew is the peril posed by an economy that is not tethered to reality. As an industry, Japan must have creative products with an appeal unrivaled by those of other countries, constituting an economic foundation that is based on actual circumstances.

The Micromachine Center (MMC) conducts a variety of activities aimed at establishing key technologies relating to micromachines, MEMS and other micro/nano fields and providing support for the continued growth of the MEMS industry, as well as strengthening the international competitiveness of Japan's domestic industry and contributing to the creation of the abundant society of the future.

The activities of the Micromachine Center during the past year as noted in the "Topics" section begin with the Project to Develop Next-generation Device Manufacturing Technologies that Fuse Different Fields, otherwise known as the Bio Electro-mechanical Autonomous Nano Systems (BEANS) Project. This major project is being conducted for the next five years through collaboration among industry, academia and government, with the goal of developing the technical infrastructure needed to create third generation MEMS devices. 18 companies, 12 universities, two research institutes and three other organizations are participating in the promotion of this project. An unprecedented research management organization has been established with "integration" and "openness" as its watchwords, in order to achieve what the Ministry of Economy, Trade and Industry calls an "Innovation Superhighway." In addition to future application fields, third generation MEMS devices are expected to find applications in a wide range of fields including the environment and energy, safety and security, and health and medical care. Third generation MEMS are expected to raise the level of the market and achieve market expansion through the creation of new devices that will support a multitude of industrial fields in Japan.

This year's annual combined exhibition, MicroNano 2008, was held July 29 to August 1 at Tokyo Big Sight. As in the case of last year's exhibition, the event attracted record attendance (14,000 attendees, a 13% increase over the previous year). This provides additional evidence of the tremendous interest in this field from various sectors.

With regard to activities to promote standardization in the MEMS field, Working Group 4 (WG4) of Technical Committee 47 (TC47, semiconductor devices) of the International Electrotechnical Commission (IEC), the organization charged with reviewing the issue of MEMS standardization, was upgraded to a subcommittee (SC47F) last June, and Japan became the organizing country. This increased the latitude for MEMS standardization activities at the IEC and established a climate that is expected to stimulate activity in this area. Japan's becoming the organizing country establishes the foundation that will enable the promotion of Japanese-led international standardization activities.

In terms of public relations, a new MEMS Mall has been opened on the Micromachine Center's website. The MEMS Mall introduces activities by various companies in the micromachine and MEMS fields as well as new products and technologies, and is designed to help stimulate business in these fields.

In addition to the examples noted above, the Micromachine Center has promoted a variety of successful projects. I would like to express my appreciation for your constant effort, cooperation and support, without which these achievements would not have been possible.

The Micromachine Center will continue to promote projects aimed at the establishment of key technologies and industries in the micromachine and MEMS field. I hope we can count on your continued understanding and support, and I hope that this year will be a rewarding one for you all.

Activities of MEMS Foundry Service

Fumihiko Sato, Omron Corporation / Chair, MEMS Foundry Service Industry Committee, MEMS Industry Forum

1. Introduction

Micro Electro Mechanical Systems (MEMS) are expected to grow to become a market rivaled in size only by the markets for flat panel displays (FPDs) and semiconductors. In recent years, full-fledged adoption of these systems in cellular phones and other consumer products has begun, and the scale of the market is growing rapidly. As applications for these systems have expanded, the technology has become increasingly diversified and Time To Market needs have also increased. As a result, the role of MEMS foundries in development and manufacture is becoming increasingly important.

The MEMS Foundry Service Industry Committee conducts activities to help expand the MEMS industrial base and increase competitiveness through the creation of a foundry network in Japan.

2. Activities of the MEMS Foundry Service Industry Committee

The MEMS Foundry Service Industry Committee membership comprises 11 companies and organizations relating to MEMS foundries, each with its own unique characteristics (**Fig. 1 and Fig. 2**).

Fig. 1 MEMS Foundry Service Industry Committee Members

	Design & Simulation	Testing & Prototyping	Product Development	Mass Production
ULVAC, Inc.		Machining of various types of MEMS through a combination of dry etching, vapor deposition polymerization and dielectric film formation technologies		
Oki Semiconductor Co., Ltd.		Silicon process integration MEMS		
Omron Corporation	Technologies for creating original dies for various types of MEMS manufacture, primarily for bulk micromachining, as well as proprietary technologies; manufacture of lenses, fine molds etc. using electroforming mass production technologies			
Olympus Corporation	Has a wealth of accumulated knowledge relating to optical MEMS and bioMEMS and offers services from design to mass production of various types of MEMS using precision bulk micromachining			
Hitachi, Ltd.	Assistance for research and development, primarily relating to bulk micromachining			
Fujikura, Ltd.			MEMS processing and through wiring on wafer level packages, silicon wafers, etc.	
Panasonic Electric Works Co., Ltd.	Sensors and actuators (silicon processes) / high-density packaging			
Mizuho Information & Research Institute, Inc.	Analysis services Simulator development			
UEL Corporation	Design / analysis support Software development			
Mathematical Systems, Inc.	Simulator and ECAD tool development and sale			
National Institute of Advanced Industrial Science and Technology (AIST)		MEMS device prototyping Micronano fabrication	(joint research only)	

Fig. 2 Service Areas of Member Companies

(1) Operating MEMS foundry service network

To simplify the process of approaching foundry companies for users who want to use MEMS foundries but do not know where to go to initiate the process, the Committee has established the MEMStation (http://fsic.mmc.or.jp) as a clearing-house for user inquiries.

(2) MEMS Seminars and other educational and joint publicity activities

To support the training of MEMS development personnel, the Committee plans and holds MEMS Seminars twice each year. Designed for novice and midlevel MEMS engineers, these seminars have met with a very favorable response.

(3) Activities to expand the MEMS industrial base

For many years, foundry companies have used equipment for manufacturing their own products and expand their business to users outside the company. As a result, in many cases the prototyping and mass production services that they are able to provide are limited to their own specific processes and materials. Investment in equipment and the development of custom processes for each customer require both time and money. So, it is not easy for small, medium-sized companies and venture firms to take university MEMS research achievement to the mass production and practical application stage.

The MEMS Foundry Service Industry Committee promotes the following activities in an effort to facilitate the use of foundries by users and expand the MEMS industrial base.

1. Expansion of the MEMS foundry network system

The Committee has studied the standard process recipes that would enable even users with little experience in or knowledge of MEMS manufacture to easily manufacture the MEMS they need. These recipes are ready-made processes that utilize the abundant manufacturing experience of foundry companies. Using these recipes for prototyping is expected to make it possible for customers to save both time and cost requirements.

In the future, the Committee will work to promote activities to expand the use of these standard process recipes, and will also study the possibility of setting up organization or centers for consulting and coordination of MEMS development activities.

2. Cooperative activities with public foundries and regional clusters in various locations

Working with domestic publicly-operated testing entities, regional clusters and nanofabrication companies the Committee is setting up an organic foundry network as a framework for providing support for MEMS project development and will promote activities aimed at expanding the MEMS industrial base.

Recent Trends in MEMS Standardization

MEMS international standardization will be essential to accelerate design and development, ensure compatibility and quality and enable mass production. In Japan, the Micromachine Center is playing a leading role in promoting MEMS standardization. Three international standards proposed by Japan have been published, and one more is currently under consideration. Recently South Korea has also become actively involved in international standardization activities; so far, one standard proposed by South Korea has been published, four are currently under consideration and two have been submitted as proposals.

International standards in the MEMS field have been prepared by Working Group 4 (WG4) of Technical Committee Meeting No. 47 (TC 47) (semiconductor devices) of the International Electrotechnical Commission (IEC). In October 2007, Japan proposed that this working group be upgraded to a subcommittee (SC) and offered to serve as secretariat. The status of activities of WG4 and Japan's achievements and contributions up to now were evaluated by the other countries, and in May 2008 the proposal was approved. Nine nations participated as regular members: China, Germany, France, Italy, Japan, South Korea, the Netherlands, Russia and the United States. The Micromachine Center became the domestic consideration organization for the new subcommittee, SC47F, and assumed the secretary.

The first international conference for SC47F was held October 28 - 30 at the Mita Kaigisho in Tokyo to coincide with the TC47 conference. The following table shows the status of individual documents, focusing on the content of the discussions at this conference.

Document	Proposed	Proposed By	Level	Status
IEC 62047-1; Terms and definitions	July 2002	Japan	IS	Published as an International Standard (IS) in September 2005. Published as a Japanese Industrial Standard (JIS C 5630-1) in March 2008.
IEC 62047-2; Tensile test method of thin film materials	July 2003	Japan	IS	Published as an International Standard (IS) in August 2006. Submitted as a draft Japanese Industrial Standard (JIS) to the Japan Standards Association in July 2008.
IEC 62047-3; Standard test piece for tensile tests	July 2003	Japan	IS	Published as an International Standard (IS) in August 2006. Submitted as a draft Japanese Industrial Standard (JIS) to the Japan Standards Association in July 2008.
IEC 62047-4; Generic specification	July 2004	South Korea	IS	Published as an International Standard (IS) in August 2008.
IEC 62047-5; RF MEMS switches	December 2005	South Korea	CD	Following comment and review of the second Committee Draft (CD) by individual countries, it was decided to prepare a third CD.
IEC 62047-6; Thin film material fatigue test methods	May 2006	Japan	CDV	The Committee Draft for Vote (CDV) was approved, and a Final Draft Industrial Standard (FDIS) reflecting the results of comment and review by individual countries was submitted. Expected to be published as an International Standard in FY 2008.
IEC 62047-7; FBAR filter	March 2007	South Korea	CD	A review of the comments from individual countries regarding the Committee Draft (CD) was conducted, and it was decided to prepare a second CD.
IEC 62047-8; Thin film bending test methods	March 2007	South Korea	CD	A review of the comments from individual countries regarding the Committee Draft (CD) was conducted, and it was decided to prepare a second CD.
IEC 62047-9; Wafer-to-wafer bonding strength measuverent	March 2007	South Korea	CD	A proposal from Japan to add a 3-point bending test method and a die shear test method to the test methods in the South Korean proposal was approved, and Japan prepared a draft. At South Korea's request, it was decided that Japan should also prepare the draft for the blister test.
IEC 62047-10; Micropillar compression test	August 2008	South Korea	NP	Currently on the ballot as a "New Work Item Proposal" (NP). Japan voted in favor of the proposal, attaching a comment regarding the purpose, scope and content of the standard based on the results of the domestic committee review.
IEC 62047-11; Test methods for MEMS material coefficient of thermal expansion	August 2008	South Korea	NP	Currently on the ballot as a "New Work Item Proposal" (NP). During the committee meeting, Japan expressed the view that consideration should be given to including other test methods for the coefficient of thermal expansion in the draft, but the South Korean side wanted these to be proposed separately. Accordingly, Japan voted in favor of the proposal on the condition that the document be given a narrowly focused title.

In addition, the draft international standards currently being prepared in Japan are shown in the table below. These will be proposed as “New Work Item Proposals” (NPs) around the end of the development period.

Topic	Development Period	Notes
Thin film material life acceleration test methods	FY 2006 - FY 2008	Establishes methods for life tests using resonant oscillation that are conducted for tiny mechanical structures used for micromachines
Standard materials for calibration	FY 2006 - FY 2008	Establishes the standard materials used for calibrating weight displacement for the material testers used to test microstructure materials
MEMS mechanism material bonding strength test methods	FY 2007 - FY 2008	Establishes methods for testing the strength of bonds between thin films and substrates between the microstructures that will become constituent members
MEMS gyro and electronic compass	FY 2008 - FY 2010	Defines (in matrix form) the passive and active sensitivity of tiny multi-axial gyros, and defines parameters for performance requirements and standardizes the methods to represent and measure these parameters. Also standardizes the properties and user interface (including coordinate system) for hexaxial electronic compasses.

Project Update

Construction of a Fine MEMS Knowledge Database (DB)

- Goal: utilization and dissemination as industrial infrastructure -

The Highly Integrated / Complex MEMS (Fine MEMS) Manufacturing Technology Development Project is a three-year project being conducted in FY 2006 - FY 2008. Commissioned and subsidized by the New Energy and Industrial Technology Development Organization (NEDO), this project aims to establish the technology that will enable the manufacture of highly integrated and complex MEMS devices that are compact, conserve energy and offer high performance and high reliability. The Fine MEMS Knowledge Database Construction Project is also being promoted in connection with this project, with the goal of organizing the achievements and knowledge gained through research and development in the Fine MEMS Project and information regarding international conferences and so on in database form to provide an environment that can be employed easily by researchers and engineers working to develop and manufacture fine MEMS.

To ensure that users are able to use the knowledge database easily, and to promote ongoing updating of the knowledge data in the database, it is essential to construct an environment that allows joint collaboration by multiple users at the same time and does not require special applications or knowledge of specialized nomenclature. As shown in Fig. 1, a major feature of the database system, is the introduction of a web browser / MediaWiki system – the same type of system as the Wikipedia free online dictionary – as the infrastructure for achieving this database, enabling data to be viewed and updated easily by anyone with an Internet connection. The basic premise of the system design is that, once information has been disclosed publicly on the Internet, it will be added to the MemsONE knowledge database to enable efficient use and dissemination.

By FY 2007, more than 1000 items of knowledge data had been registered to the MemsONE database, exceeding the target of 1,000 items. The stored data has been organized around four MemsONE categories (process, device, material properties, analysis) using keywords developed in this study. The knowledge data is also being augmented through the addition of laid-open patent data and Western patent analysis references corresponding to development topics. To enable users to quickly locate the information they need, a full text search function using a precision Japanese language search engine and various types of ranking display functions that allow visualization of the status of the data stored in the database have been provided. In the remaining six months of the database construction project, efforts have focused on improving the quality of the registered data, updating patent data, building a top page for general Web access and creating terms of use and guidelines, and the work is progressing at a fever pitch. The database will be made available on the Internet at the beginning of FY 2009, and activities to encourage ongoing improvement of the knowledge data will be conducted to enable the database to be used as a part of Japan's industrial infrastructure.

Fig. 1 Construction of an Internet-based Shared Collaboration Environment

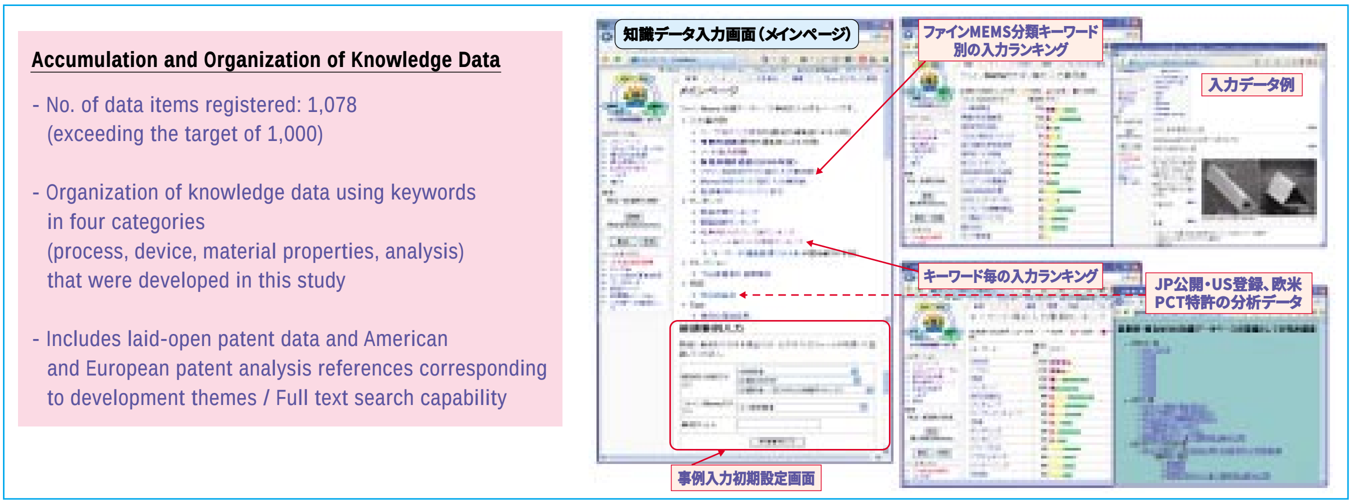


Fig. 2 Overview of Knowledge Database System and Upload Function

Column

MEMS in the Future: A Baby Boomer's Symbiotic Relationship with MEMS

On a clear autumn day in the year 202X, an elderly baby boomer (let's call him "Mr. A") went to the nearby botanical garden with digital camera in hand, intent on taking a seasonal photograph of autumn leaves to post on his blog (which is entitled "Boomer Avenue"). Not only was strolling around the botanical garden pleasant, the negative ions emitted from the trees made it a healthy "forest bathing" experience. Mr. A had lived this lifestyle for the past dozen years or so. Perhaps this was the reason that he remained in excellent health despite being almost in latter old age; he took pride in contributing in some small way to reducing the nation's overall medical care costs.

During the latter part of his career, Mr. A had been involved in the industrial development of MEMS (miniature sensors and other electromechanical devices).

Accordingly, in addition to photographs of natural scenery, Mr. A's blog also featured many posts on industrial technology relating to MEMS. For the benefit of those who have not read them, here are a few of the interesting posts on his blog.

(Date: _____)

More than a decade ago, around the beginning of the project to develop the technology to manufacture Bio Electro-mechanical Autonomous Nano Systems (BEANS), the MEMS of the future, a financial crisis precipitated by the U. S. subprime loan debacle spread throughout the entire world in the blink of an eye. This crisis dealt a major blow not only to the U. S., Great Britain and other developed countries but also to the economies of newly developing countries that up to that time had experienced overheated economic growth. It was many years before the world economy was once again stable.

Although the Japanese economy was of course affected, it did not sustain serious damage. This was partly due to the fact that it was not the direct epicenter of the financial crisis. But I feel it was also due to Japan's outstanding industrial technology such as MEMS. We had learned the lessons from the collapse of the "bubble" economy, and most Japanese companies had conducted sound management that placed great value on technology. The national government, too, had established a roadmap for industrial technology in key technical fields such as MEMS, nanotech materials, biotechnology and robots, and had provided technical development assistance.

The subsequent course of events demonstrated the strong international competitiveness of Japan's manufacturing sector, based on its firm technological footing. The Japanese economy recovered rapidly, and now other countries once again look to Japan to drive the world economy. As someone who has been involved in promoting technical development projects and providing assistance for industrialization in the MEMS field, this makes me very happy.

(Date: _____)

The development of MEMS in recent years has been nothing short of remarkable. Great strides have been made in the creation of fine MEMS such as various types of sensors and RF-MEMS for telecommunications. Vehicles, cell phones, information processing equipment and other units are now chock-full of highly integrated MEMS devices with advanced functions, and they have dramatically improved the convenience of our daily lives. Products equipped with fine MEMS devices bear a "MEMS Inside" sticker, and "MEMS Inside" is now a synonym for high performance and high quality.

My trusty digital camera also has a "MEMS Inside" sticker. The lens and other optical system components of the digital camera are still the same as before. But as soon as the camera is turned toward an object, all of the outstanding functions – blur prevention, autoface focus, macro photography and so on – are fully automated through the power of MEMS. This allows me to take one outstanding photo after another with next to no effort. As a result, even though I am older and not as steady as I used to be, I can still easily post stunning photographs of the seasons on my blog. This is a blessing beyond compare.

What's more, many other products are increasingly incorporating MEMS technology recently. To reduce energy consumption and environmental load in the product development process, the trend is toward the use of smaller and smaller electronic and mechanical components and three-dimensional IC chips, and MEMS ultra-fine processing technologies are increasingly being employed in these industrial fields as well.

Furthermore, the revolutionary BEANS technologies that were developed in the BEANS manufacturing technology project and are designed to help create the MEMS of the future have been provided by a patent pool agency administered by the MEMS Industry Forum. I understand that companies in the health and medical care field and various other industries are vying with one another to adapt BEANS technologies for product development. I can't wait to see what kind of new products appear in the months and years ahead. For me, the key thing will be to live as long as possible so I'll be around to see them.

After returning from his stroll in the botanical garden, Mr. A felt thoroughly refreshed in both body and spirit by the two hours of "forest bathing." But he was also a bit agitated. It was his custom to place his hand and ear against the trunk of an enormous tree in the botanical garden, in an effort to communicate with the tree. But this time he had felt as if he could actually hear some kind of message from the tree. Immediately he ordered a MEMS kit from the MEMS Mall (an online store for MEMS products). The kit was designed to make special recordings and was equipped with an automatic translation function. Using this kit would enable him to post his conversation with the tree on his blog. In this way, Mr. A, the boomer, seems likely to continue his symbiotic relationship with MEMS forever.

By Boomer, B

Overseas Trends

Overseas Mission from Micromachine Center / MEMS Industry Forum Attends the MEMS Executive Congress and Visits Micro-Nano Related Venture Firms in Silicon Valley

The MMC/MEMS Industry Forum dispatches overseas missions as one of its international interchange activities. At the beginning of November, an overseas mission attended the MEMS Executive Congress that was held in Monterey, California. The group also visited universities and companies in North America, particularly those in Silicon Valley in the MEMS and nanotech fields, in order to conduct a survey of current trends. The following is an overview of the overseas mission's activities.

◆**Date:** November 2 (Sunday) - 9 (Sunday), 2008

◆**Purpose:** To attend the MEMS Executive Congress in order to ascertain the latest trends in the MEMS field as viewed from a management standpoint and create a network of MEMS industry managers around the world, and to use the time before and after the Congress to visit micro/nano related companies, universities and other institutions in Silicon Valley in order to conduct a survey of technical trends and forge business relationships.

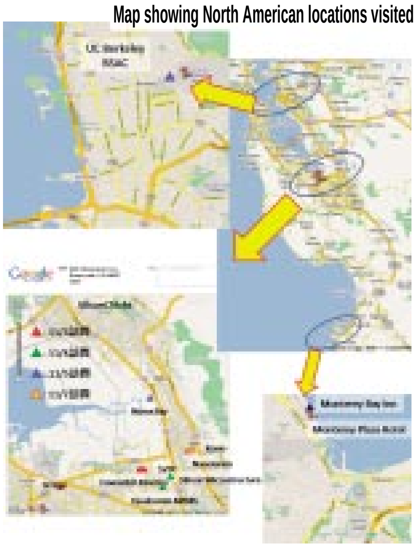
◆**Itinerary:**

November 2 (Sunday) Depart Japan; arrive San Francisco
November 3 - 5 (afternoon) (Monday - Wednesday) Visit relevant organizations
November 5 (evening) - 7 (morning) (Wednesday - Friday) Attend MIG MEMS Executive Congress
November 7 (Friday) Visit relevant organizations
November 8 (Saturday) Depart San Francisco
November 9 (Sunday) Arrive Japan

◆**Participants:**

Omron: Sato, Takahashi (Omron Silicon Valley)
Panasonic: Okamoto
Lintec: Nakata
MMC: Adachi

Map showing North American locations visited



Overseas Mission at SiTime

MEMS Executive Congress Dinner at the Monterey Bay Aquarium

◆MEMS Executive Congress

The MEMS Executive Congress is an annual conference held by the MEMS Industry Group (MIG), a MEMS Industry Forum overseas affiliate based in Pittsburgh, Pennsylvania. The conference is attended by executives of MEMS-related firms from around the world.

This year, the MEMS Executive Congress was held at the Monterey Plaza Hotel & Spa in Monterey, California. The 133 Congress attendees included four from Japan:

- Mr. Sekiguchi of Omron Corporation, an MIG member firm;
- Professor Esashi of Tohoku University (who also served as a panelist);
- Mr. Okamoto of Panasonic Electric Works Co., Ltd., one of the participating companies making up the overseas mission; and
- Mr. Adachi of the Micromachine Center.

The Congress program included the keynote addresses and panel discussions listed below. One of the most noteworthy features of the MEMS Executive Congress seems to be the long lunch and other break times, designed to encourage networking and the exchange of information among attendees.

Keynote Addresses

■ Sun Small Programmable Object Technology (Sun SPOTs) — Roger Meike, Sun Microsystems Laboratories
■ Towards New Paradigms of Sensing, Computing and Communication — Tapani Ryhanen, Nokia Research Center

Panel Discussions

■ Panel 1 : Convergence of MEMS in Consumer Electronics and Mobile Communications
■ Panel 2 : MEMS Inside: Enabling Low Power, Energy Monitoring and Conservation
■ Panel 3 : Investments in MEMS Leading to Liquidity Events – A VC Perspective
■ Panel 4 : MEMS Emerging Technology Outlook
■ Panel 5 : MEMS Market Analysis

Next year's MEMS Executive Congress will be held November 4 - 6 in Sonoma, California.

◆Company and university visits

The following is an overview of the locations visited in North America.

■Cavendish Kinetics: **Venture firm specializing in the development of CMOS-compatible MEMS**

The goal of Cavendish Kinetics is to provide memory, sensors and switches using a 100% CMOS-compatible process.

The basic technical concept is to control silicon-to-silicon adhesion and form cantilever structures by means of a CMOS-compatible process, creating memory, sensors and switches solely by changing the mask designs. The company has a business model under which it utilizes SVTC technologies in a fabless manner and licenses its technology.

■Kovio, Inc.: **Venture firm specializing in nanoink and printed electronics**

Kovio was founded in 2001 by Dr. Jacobson of the MIT Media Lab and has 51 employees. The company obtained USD $23.5 million in Series D funding; Japanese companies Yasuda Enterprise Development Co., Ltd., Mitsui Ventures, Panasonic Venture Group and Toppan Forms Co.have invested in the company. Kovio currently specializes in the development of silicon ink (synthesized using the wet method) and silicon ink printing technologies used for manufacturing RF-ID tag transistor circuits. The smallest circuit width is 10 μm with mobility of 70 - 80. These circuits have greater mobility and durability as compared to organic semiconductors.

■Nanochip, Inc.: **Venture firm specializing in cantilever memory development**

This fabless startup company, founded in 1996, developed prototype devices based on a concept similar to the Millipede project at the IBM research lab in Zurich. Nanochip has received funding since 2004. This company introduced the concept of creating memory through the combination of three layers: a CAP wafer (with a pocket for storing a magnet), a Mover wafer and a CMOS wafer. An electromagnetic system with high drive force in the X and Y directions is used to enable displacement of ± 100 μm, and an electrostatic system was adopted due to the low cantilever displacement of 0.4 μm.

■NanoGram Corporation: **Venture firm specializing in nanoparticle / nanoink and solar cell development**

Founded in Silicon Valley in 1996, this venture firm has received funding of USD $68.7 million from Yasuda Enterprise Development Co., Ltd., Mitsui Ventures, Inc, Nagase & Co., Ltd., Tokyo Electron Limited and other companies. It has 85 employees and offices in Japan and South Korea. A core technology of the company is a process through which a precursor is thermally decomposed using a laser beam and condensed into nanoparticles. Using this technology, NanoGram has generated numerous nanoparticles while maintaining control of particle size and composition. Currently the company's primary focus is on developing the technology to form multicrystal silicon foil (SilFoil) directly on substrates using the laser reaction deposition method, with the aim of producing solar cells. As this method enables large-area film formation in a non-vacuum environment, the cost is low as compared to conventional multicrystal silicon solar cells. Design of a 5 MW pilot line is currently underway.

■Qualcomm MEMS Technologies, Inc.: **MEMS display development company**

Qualcomm MEMS Technologies is a 100% subsidiary of Qualcomm, a company famous for its achievements in 3G CDMA technology. Qualcomm MEMS Technologies develops and manufactures reflective "IMOD" displays that reflect ambient light and output specific wavelengths. The principle is to use surface micromachining to form resonant structures that move individual pixels through electrostatic drive, using light interference to reflect RGB wavelength light to an external location. A black and white display product developed for use in Chinese cellular phones is being manufactured in Hsinchu, Taiwan. Development of a full color display for use as the display in MP3 music players is also progressing, and the initial customers for this product have already been secured. As the device is a reflective one, the screen is easy to see even in direct sunlight, and no backlight is required. Electrostatically driven hysteresis is used to maintain "off" status at low voltage, so power consumption is much lower than that of a liquid crystal display. On the other hand, as the screen is dark in indoor locations, a front light is used to improve visibility.

■Silicon Clocks, Inc.: **Venture firm specializing in Si resonator and MEMS/CMOS integration**

Dr. Howe of Stanford University serves as chief scientist for this startup firm. A new CEO has been brought on board to oversee a shift in the business model from the previous emphasis on silicon oscillator product development to the licensing of element IP ("MEMS on CMOS" integration process, wafer-level vacuum sealing, resonator and other device design, and analog circuit design). Silicon Clocks is currently seeking licensees and has shown great interest in Japanese firms. The company integrates MEMS resonators on CMOS using LPCVD polysilicon-germanium.

■Silicon Microstructures, Inc.: **MEMS development division (pressure sensors) of the German firm Elmos Semiconductor AG**

Founded in 1991, this company has 90 employees and is a specialty manufacturer of piezoresistance type MEMS pressure sensors (10 mbar - 10 bar). In 2001, it was acquired by and became a 100% subsidiary of the German firm Elmos Semiconductor AG (a manufacturer of automotive ASIC). Since 2004, Silicon Microstructures has manufactured pressure sensors on 6" lines for automotive use (TPMS, etc.) and for the medical care (blood pressure meters, etc.), industry and consumer markets. Its product line also includes absolute pressure sensors that utilize vacuum sealing.

■SiTime Corporation: **Venture capital firm specializing in Si resonator development**

The aim of this company is to create new markets by replacing crystal oscillators with its Si resonators, utilizing their properties of compact size, low cost, high reliability and CMOS compatibility. The 4" crystal oscillator achieved through joint research between Bosch and Stanford University professor Tom Kenny were expanded to an 8" process in 2005 by SVTC Technologies in order to shift to mass production. In the latter half of 2006, the achievements were transferred to Jazz Semiconductor, and a mass production system was put in place in 2007. This year, production of 2.5 million units was achieved. Future goals are to achieve a market shift from crystal oscillators amounting to JPY 1.7 trillion yen, and to develop new markets for these devices. The MEMS division has been consigned to Jazz Semiconductor and the CMOS divisions to TSMC, with packaging conducted through fabrication in Malaysia and Thailand.

■SVTC Technologies, LLC: **8" CMOS/MEMS process development foundry**

In the SVTC business model, ideas from users and concept models developed at the university laboratory level are brought in, and customers dispatch engineers to conduct process development using SVTC facilities (in some cases, the customer provides the equipment needed for process development). In this way, the company serves as a bridge to mass production. Major benefits include the fact that customers are able to use the process recipes accumulated by SVTC and own 100% of the intellectual property relating to the processes they develop. Fabrication is conducted using the R & D facility of Cypress Semiconductor, and facilities are currently being expanded. This year, SVTC acquired a company with a large fabrication plant in Texas, and the company also has a third center of operations in south San Jose that is dedicated to the fabrication of solar cells. Process development is conducted by users or by SVTC based on agreements with users. SVTC also conducts consulting relating to process development and provides engineering services to meet user needs.

■MEMS research by Berkeley Sensor & Actuator Center (BSAC), University of California at Berkeley

◆Case studies of nanotech research at BSAC presented by Dr. Javey

- Printable nanowire
- Nanocolumn GaAs solar cell
- High-strength adhesion by means of nanowire with polymer coating

◆Advanced MEMS Inc. – Endoscope equipped with MEMS mirror

This startup firm, founded by a U. C. Berkeley post-doctorate researcher, is developing the technology to integrate an electrostatically-driven MEMS mirror and laser light source at the tip of an endoscope in order to obtain images of areas beneath the surface of the skin using the light coherence tomography method. Information contained in 2mm^2 sectional slices are continually obtained at a resolution of 10µm, making it possible to quickly detect cancer cells that previously were difficult to discover through surface observations.

At the places we visited, the worsening economy resulting from the financial crisis has made it difficult to secure venture capital, even in Silicon Valley. As a result, some companies were switching from cost-intensive product manufacture and sale to a business model based on licensing, and some have even been forced to lay off some of their employees due to cash flow problems. Yet some companies were still doing well; for example, this year SiTime shipped 2.5 million MEMS resonators.

With attendance at an international conference and visits to 10 different companies in the space of five days, the overseas mission had a very busy schedule. However, the companies were located near one another in Silicon Valley, where MEMS related companies and universities are concentrated, and the weather was good. As a result, the trip was a resounding success, and the Micromachine Center would like to express its appreciation to those who participated.

The MEMS Industry Forum plans to dispatch overseas missions in the future as well. If there are any particular regions or companies that you think it would be instructive to visit, please let us know.

Members' Profiles

Furukawa Electric Co., Ltd.

1. Business Profile of Furukawa Electric Co., Ltd.

Founded in 1884 as a manufacturer of electric cables and nonferrous metals, Furukawa Electric has accumulated more than a century of expertise in the development of technologies and products aimed at reinforcing the foundation of our society and industry. Today companies in the Furukawa Group are active in such diverse industries as telecommunications, automobiles, energy, electronics, and construction, utilizing the strengths of a wide range of materials, including light, metal, and plastic. The following is a description of some of our signature products in these fields.

One of the core products in telecommunications is the optical fiber cable, which is indispensable for building optical communication networks that sustain our advanced information society. In 1974 Furukawa Electric became the first company in the world to successfully manufacture optical fiber cables. Today we are the world's second largest manufacturer of optical fiber cables and globally provide total solutions for optical parts, optical communication equipment, and optical systems essential to our optical information-oriented society.

Steering roll connectors, a major product in the automotive parts industry, function to transmit electric signals for activating an airbag built into the steering wheel of an automobile. Furukawa Electric has been developing and manufacturing these connectors for more than twenty years, bringing the company recognition for its development capabilities and earning the products praise for their low cost and reliability. Our connectors are used throughout the world, accounting for the highest share of the global market.

As China continues to grow, the country has been plagued with a chronic shortage of electric power. Furukawa Electric has established production centers in China for manufacturing ultra-high-voltage power cables and related components, and optical fiber composite overhead ground wires in order to supply these products throughout China. We have received high praise for our superior manufacturing capability and product quality and are the market leader in ultra-high-voltage power cables.

Furukawa Electric's signature product in electronic-related fields is the copper foil. Copper foils are used in printed wiring boards incorporated in computers, cell phones, and other communication equipment, collectors for lithium ion batteries, and electromagnetic interference shielding materials for plasma displays. From common to sophisticated foils, the company provides high-quality products backed by more than thirty years experience in producing electrodeposited copper foils.

By utilizing this wealth of material expertise and exploring the diverse applications, we will always strive to be a more profitable, innovation-oriented business group with a dynamic global presence. We will continue to develop technologies and products that enrich our society and offer these products not only in Japan, but also in countries throughout North and South America, Europe, and Asia.

2. New Product Development

2.1. Furukawa Electric's Distinctive Production Technology

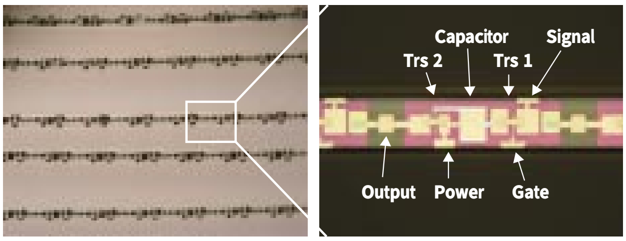
Since many of our products are long in dimension, such as the optical fibers, electric cables, copper foils, and plastic sheets, these products are produced using our continuous roll-to-roll processing technology. The elemental technologies used in this process include a thermal processing technique for maintaining an optimum process temperature, a processing technique to perform molding and extrusion continuously, and a sensing technique for monitoring product quality online. The sophisticated materials in our products are testament to how we have managed over the years to develop each elemental technology into our own distinctive technology. It would not be an exaggeration to say that the history of our product innovation is inseparable from the development of our continuous processing technology. Recently we have been working on developing new products made distinctive by this production technology.

2.2 One-Dimensional Substrate Technology

Using proprietary techniques in optical fiber manufacturing processes, Furukawa Electric is working on a project aimed at transforming fabrication based on an entirely new concept called ."one-dimensional substrate technology."

One dimensional substrate technology is the efficient, low-cost manufacturing of electronic devices on long and narrow film-like glass and metal substrates. A major feature of this technology is its conduciveness to fabricating devices using our roll-to-roll processing technique. Today displays, solar cells, and semiconductor substrates are predominantly produced through vacuum batch processes using two-dimensional silicon wafers and glass substrates. However, in order to increase the number of devices that can be produced from a single substrate and thus reduce costs, the size of the substrate has been increased, leading to a need for larger manufacturing equipment–an enormous investment. By using one-dimensional substrates in device fabrication, the production method can be changed from the vacuum batch process to an atmospheric-pressure continuous process to achieve lower production costs. Since it is also possible to localize the process area, we can employ more compact equipment and increase the processing speed. Hence, there is potential for transforming the semiconductor industry from the traditional model of increasing scale to an approach aimed at increasing processing speed.

Recognizing the potential for expanding one-dimensional substrate technology into a wide range of industrial products and the advantages of incorporating this technology as a new business, Furukawa Electric is currently engaged in development aimed at achieving commercial viability as early as possible.



TFT circuit formed on a one-dimensional substrate

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