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MICRONANO

New Year's Greetings

Tamotsu Nomakuchi
Chairman, Board of Directors,
Micromachine Center

It gives me great pleasure to offer greetings on the dawn of the year 2008, and to share some of my thoughts at the beginning of the year.

The Japanese economy had seemed to be recovering. However, according to the monthly economic report for last year announced by the Cabinet Office, the figures throughout the year were weaker across the board than comparable figures for the previous year. The continuing rise in the price of oil is a concern. In the 20th century, economic activity based on mass production and mass consumption propelled the Japanese economy. In the new century and in a global society, however, this must be reexamined in the light of the remarkable pace of economic growth in developing nations, the insufficiency and skyrocketing price of petroleum and other raw materials, the environmental issues that are becoming more serious on a global scale and so on. For this reason, studies are underway in an effort to determine how human beings can create sustainable development that achieves a balance between environmental concerns and economic activity. Various proposals have been offered, including a report entitled "The Key to Creating Innovation and the Promotion of Eco-Innovation" released by the Ministry of Economy, Trade and Industry.

The Micromachine Center is currently engaged in research and development of microelectromechanical systems (MEMS). Up to now, the Center has produced first-generation sensors and other single-function devices that focus on miniaturization and increased reliability, as well as second-generation devices (fine MEMS) with even more advanced functions. This year marks the start of the Project to Develop Technologies for the manufacture of Next-Generation Devices that Fuse Different Fields. The goal of this project is to create third-generation MEMS devices (named Bio Electro-mechanical Autonomous Nano Systems, or "BEANS"). BEANS are expected to find applications in a variety of new fields in addition to existing application fields, including environment and energy, safety and security, health care and medical treatment and so on. It is hoped that BEANS will lead to technologies that can support the sustainable development of humanity.

The MEMS market in Japan is expected to expand at a rapid pace. According to a study commissioned by the New Energy and Industrial Technology Development Organization (NEDO) and conducted by the Micromachine Center, the MEMS market was JPY 440 billion yen in 2005 when first-generation MEMS devices were the driving force. By 2010, when the second-generation MEMS devices appear on the market, the market is expected to grow to JPY 1.17 trillion yen. And in 2015, when third-generation MEMS devices will hold sway, the market is expected to grow further to JPY 2.4 trillion yen.

The Micromachine Center pursues research and development with a view to the future, in order to achieve progress for the MEMS industry. The Center works diligently at a variety of activities aimed at supporting MEMS industry growth and stimulation. One such activity that is important in terms of strengthening international competitiveness is international standardization. Last year, the Micromachine Center initiated activities as an advisory group in Japan in the MEMS industry. As a result, the role and responsibilities of the Micromachine Center in the industry is expected to become even more important.

The Micromachine Center will continue to pursue activities aimed at establishing basic technologies for micromachines and MEMS and achieving industrialization.

On behalf of the Micromachine Center, I hope we can count on your further understanding and support. It is our heartfelt wish that this year will be a rewarding one for you all.

"Boomer Avenue"

This was my first dream of the new year of 2008. It is my fervent hope that this dream is prophetic.

On a certain day during the decade 2030-2039, an elderly gentleman sits dozing in front of his computer. The very comfortable living room is brightly lit by the sunlight streaming through the trees on the virtual screen set in the wall of the house. This gentleman is a member of the so-called "baby boomer" generation, and he prides himself on the central role that his generation had continued to play in Japan's economic development. However, one by one his friends have all passed away, and inevitably his generation's influence on society has declined as that role has passed to the younger generation. Now, however, he has considerable time on his hands, and so recently he started a blog entitled "Boomer Avenue" in which he writes down his recollections.

He's asleep right now, so let's take a peek at the computer screen to see what he has written.

(Date: ________)

Today I have a deep sense of satisfaction. What makes me so content this morning is that the Project to Develop Technologies for the Manufacture of Next-Generation Devices that Fuse Different Fields (BEANS Project; 2008 - 2012) that we all began in 2008 was a resounding success. The success of the project spurred individual companies to move ahead with the marketing of specific BEANS (Bio Electro-mechanical Autonomous Nano Systems) devices. As a result, BEANS is everywhere around us, a part of our everyday lives.

For instance, there is a BEANS "spacecraft" (an advanced endoscope capsule) right inside my own body. Each day, it patrols my body and works to prevent illness. I can tell it where and how to patrol, but that's too much trouble, so I have it on autopilot. Today I have the feeling it's somewhere around my large intestine. It's like the parasite-like thing often seen when I was young that had the side benefit of almost completely eliminating my allergic constitution. This, too, makes me happy. Many people use these BEANS "spacecraft" to maintain their health. This has greatly reduced health care costs for the nation as a whole, helping to improve our financial health as well.

The "spacecraft" has just issued a warning message that it's almost out of gas. I guess I'll have to refuel it with an evening drink of that special "Bean-Scent" Japanese premium sake that I was finally able to get.

(Date: ________)

Today I'll continue with my thoughts about BEANS. Last time I wrote about the BEANS "spacecraft" that lives in my body. But BEANS are present in the outer world as well. They play a major role in maintaining the air and water and other aspects of the global environment. Today I'll talk about water.

At the beginning of the 21st century, the economies of China and India grew at an astonishing pace. However, both countries experienced serious water problems, which has been a limiting factor for further economic development. Also in Japan, water is insufficient in the Shikoku region and northern Kyushu region almost every summer. Although there is a practically limitless quantity of seawater covering the surface of the earth, there was a dramatic insufficiency of fresh water suitable for use as drinking water and water for industrial production. In recent years, however, BEANS for turning seawater into freshwater have appeared, and these promise to become our salvation in terms of resolving the problem of insufficient water. These tiny freshwater conversion BEANS, which look like peas, will be spread like gravel on the filtration equipment. The BEANS have a three-dimensional nanostructure that incorporates biological membranes. This structure enables them to efficiently filter large quantities of seawater. Individual homes will be able to filter the next day's drinking water at night while the occupants sleep. Moreover, the sea salt that is a byproduct of the filtration process is absolutely delicious. Supposedly it goes very well with the flavor of (real) boiled beans.

There seems to be no limit to the memories of this elderly gentleman concerning BEANS. After all, the achievement of Innovation 25 – the societal goal at the time – was given a great boost by the practical application of BEANS. This explains his great sense of satisfaction.

We were on the point of leaving, not wanting to disturb his pleasant sleep, when we glanced at the computer screen once more and this time saw an image on the screen. The "thought switch" was left on, and so it appeared that we were looking at the dream he was having at that moment. It was extremely interesting. The basic content of the dream was as follows.

Jack planted beans (Internet BEANS) in a field. Instantly, the beans sprouted into a tree that grew high into the sky. Jack climbed the tree, up into the clouds, and discovered a towering pile of "knowledge" - the crown jewels of human knowledge. Amidst this knowledge, he discovered MEMS Peadia (a database of MEMS-related knowledge). For some reason, Jack was deeply moved. Looking around, he saw the same type of bean plants sprouting out all over the place, and these began to connect up with one another. And they began to come in contact with clumps of knowledge everywhere. Through the BEANS network that the Internet had evolved, "knowledge" gushed from springs like water and spread to every corner of the earth.

The dream of this elderly gentleman may very well be prophetic. Speaking for myself, I plan to buy some Internet BEANS and secretly plant them in my garden. Hopefully, I will soon be able to take a stroll in the heavens.

Toward the Popularization of Foundry Services and the Broad-Based Expansion of MEMS Industries

Kazushi Tomii, Matsushita Electric Works, Ltd.
Chair, Foundry Service Industries Committee, MEMS Industry Forum

1. Introduction

MEMS industries are currently in transition, moving from their period of initial start-up to a period of expansion. From now on, greater and greater speed will be required for product development and creation along with the expansion of the market for MEMS products. As a result, foundries will play an even more important role from the stage of initial development through mass production.

For the past five years, the Foundry Service Industries Committee in the MEMS Industry Forum has actively worked to create a unique Japanese network, with the aim of expanding MEMS industries through foundry services. This article will introduce the achievements of these activities and discuss issues that remain to be resolved.

2. Activities of the Foundry Service Industries Committee

The Foundry Service Industries Committee began its activities in 2002 within the Micromachine Center. The Committee has held regular discussions on common issues faced by MEMS foundries, and its activities have centered on public relations targeting MEMS foundry users. At present, the Committee is made up of 11 diverse companies and organizations involved with MEMS foundries. (**Fig. 1**)

Fig. 1 Members of the Foundry Service Industries Committee

Below are the major activities that have been conducted, centering on the Foundry Service Industries Committee:

(1) Common liaison for foundry services
(2) Educational activities (MEMS workshops, etc.) and joint PR activities
(3) Activities to promote MemsONE (MEMS design and analysis tool)
(4) Study for the purpose of broad-based expansion of MEMS industries

Of these, **(1)** common liaison plays the role of contact point between the users and foundries, leading to increased foundry use on the part of users. In terms of **(2)** publicity and educational activities, workshops are held twice a year, and these have been particularly well received by engineers who have had little experience with foundry services. We will continue to hold these workshops and update their content.

The Committee is also helping to promote the MemsONE design and analysis tool in **(3)**, in order to create an environment in which it is easier to use foundries from a process perspective. With regard to **(4)**, studies into the creation of a mechanism to enable rapid, low-cost prototyping are underway, with the aim of achieving broad-based expansion of MEMS industries.

3. Future challenges and efforts

Through these activities, the Committee had been able to provide users with a certain amount of information from foundries, increasing the level of user awareness with regard to foundries. Future efforts will aim to further increase use in order to achieve a broad-based expansion of MEMS industries overall. However, there are thought to be limits to the company-centered efforts that have been conducted up to now. This is because, unlike semiconductors, there is no standardized process and design environment for MEMS., As a result, mismatches are produced between users and manufacturers in terms of specifications, costs and so on. This occurs particularly when small and medium-sized companies and venture companies pursue development and prototyping. In order to resolve this problem, a mechanism to link users and foundry companies is thought to be needed in order to provide a smooth path to mass production. In a survey of MEMS foundries conducted in the past by the Micromachine Center, too, many respondents expressed the opinion that the national government should work to build a network to accelerate the process from development to commercial application.

The Committee has just initiated a study of the possibility of creating ready-made processes and common guidelines on the foundry side, as one phase of the effort to promote the dissemination of MemsONE. The Committee also plans to actively pursue the exchange of information with public research institutions and local publicly-run trials in order to form a MEMS network. If this mechanism can function on the practical level as a network system, it will accelerate the process of creating new MEMS on the part of small and medium-sized companies and venture companies, from the development and prototyping stage to the mass production stage, resulting in broad-based expansion of MEMS industries.

MemsONE Dissemination and Use

MEMS System Development Center

The MemsONE Project was initiated in FY 2004 with the goal of creating a software infrastructure to support the promotion and development of MEMS industries. The project ended in FY 2006 with the achievement of a beta version of MemsONE. An effort was made to ensure widespread dissemination of MemsONE throughout Japan during the term of the project.

Accordingly, a project to disseminate the achievements of the MemsONE Project was commissioned by the New Energy and Industrial Technology Development Organization (NEDO). The project has been renewed for this fiscal year as well and is currently underway. In order to establish an infrastructure for dissemination, the project is placing special emphasis on the following four efforts:

1) Activities to disseminate the MemsONE beta version

Widespread distribution of the MemsONE beta version (achieved by the MemsONE Project) to users in Japan, in order to secure users, determine user needs and the status of use, and reflect the results in future dissemination activities

2) Improvement and enhancement of MemsONE functions

Improvement and enhancement of those functions whose improvement is a matter of particular urgency, based on the results of the dissemination study and the evaluation survey of the alpha version (the version distributed as the midterm project achievement)

3) Achievement dissemination and user support activities

Provision of user assistance in the form of hands-on regular workshops and seminars, held primarily in major metropolitan areas

(User assistance regarding operational and technical aspects of the beta version is seen as essential for the dissemination of project achievements.)

4) Study activities for purposes of dissemination

Establishment of foundry services as manufacturing centers that can take the place of manufacturing equipment (which entails a large initial investment burden) in order to achieve widespread dissemination of MemsONE and effect a broad-based expansion of MEMS industries

With regard to topic **1)**, distribution of the beta version began in early June, and the beta has been introduced to companies, universities and research institutions and in publicly-run trials and so on. So far, more than 400 licenses are in use. To distribute the beta version, various types of email messages were sent to relevant entities. In addition, the beta was released on the Committee's website and was exhibited at Exhibition Micromachine / MEMS and the International Robotics Exhibition. A video was also used to introduce MemsONE functions, and the beta version was further publicized through the use of panel exhibitions and the distribution of pamphlets. As a result, the goal of at least 450 licenses is expected to be achieved.

With regard to topic **3)**, technical support for users with regard to operational procedures and analysis is thought to be indispensable in order to ensure widespread dissemination of MemsONE throughout Japan. The most effective type of user support is the holding of workshops with an environment in which the beta version is already installed on multiple PCs. This beta version installed on actual PCs is used to provide guidance to users regarding GUI operations and analysis procedures. It is hoped that such hands-on workshops will help disseminate the project's achievements. In order to hold these workshops, a classroom with at least 30 PCs was needed, and this was made possible through the provision of classrooms at the University of Tokyo and Kyoto University. Three courses were prepared – a basic course and Applied A and B courses – and the courses have been held since July; plans call for the courses to be held six times at the University of Tokyo and four times at Kyoto University. The courses so far have been attended by 130 persons, and judging from survey results the courses seem to have been effective. Moreover, in addition to these regular workshops, two workshops have been held at the request of other institutions in which the students (60 in all) brought their own PCs, and this has also helped to expand the number of MemsONE beta version users.

It is hoped that the promotion of these topics will have a beneficial impact on future product development. Accordingly, the topics will be promoted with care and energy.

For inquiries regarding MemsONE, please contact the MemsONE Support Center:

TEL (+81) 3-5835-1870
Email mems1-user@mmc.or.jp

Micromachine Exhibition

Hands-On Workshop (held at The University of Tokyo)

MEMS-LSI Chip Lateral Interconnects (High-Density Mounting Technology with Low-Temperature Chip Stacking)

Mitsumasa Koyanagi, Professor, Graduate School of Engineering, Tohoku University

We are conducting research aimed at developing a new mounting technology using low-temperature chip stacking for the high-density integration of heterogeneous devices and electronic parts, such as LSI chips, MEMS chips, optical devices, and passive elements. This new technology fuses IC, MEMS, mounting, and micro-optic technologies comprising 1) a technique for high-density mounting of MEMS and LSI chips on a flexible printed circuit board using self-assembly, 2) a technique for high-density formation of microbumps on a flexible printed circuit board, 3) a technique for forming crossover interconnects over chips mounted on a substrate, and 4) a technique for forming passive elements on chips, such as resistors, capacitors, inductors, and coils. Here, I will present our findings from investigations into MEMS-LSI mounting using self-assembly and the formation of crossover interconnects.

MEMS-LSI Mounting Using Self-Assembly

Numerous MEMS and LSI chips can be densely mounted together on a flexible printed circuit board using the surface tension of liquid droplets. When mounting the chips facedown on a hydrophobic flexible printed circuit board, as shown in **Fig. 1**, the underside surfaces of the multiple MEMS and LSI chips forming a plurality of microbumps are made hydrophilic and coated with an aqueous solution or liquid organic matter. At the same time, hydrophilic areas are formed on the surface of the substrate for temporarily holding the chips. These areas are also coated with an aqueous solution or liquid organic matter. The plurality of chips whose underside surfaces are coated with the aqueous solution or liquid organic matter are flipped so that their underside surfaces are facing downward and are simultaneously lowered onto the surface of the substrate so that the aqueous solution or liquid organic matter on the underside surfaces merges with that on the surface of the substrate. The chips are aligned on the substrate through self-assembly owing to the surface tension of the liquid and are bonded in place. This technique enables the chips to be positioned with an accuracy of ±1 μm within one second.

Crossover Interconnects

We are developing a technique to form high-density lateral interconnects that cross over MEMS and LSI chips mounted on a flexible printed circuit board through self-assembly. With this technique, it is important to form the copper interconnect patterns over the high chips so that the side surfaces of the chips are well coated, as shown in **Fig. 2**. To achieve this, we studied various techniques on insulating layer formation, hot lithography, and copper electroplating. We succeeded in forming crossover interconnects with widths of 5–10 μm and a pitch of 10 μm.

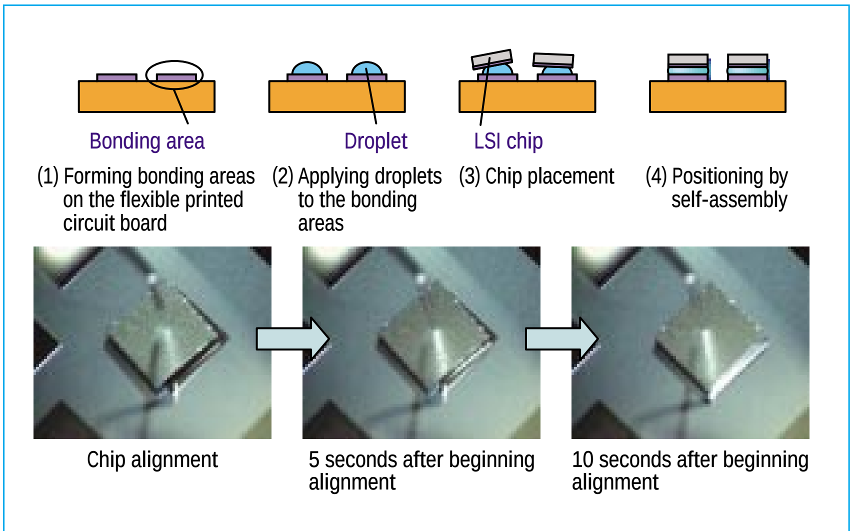

Fig. 1 MEMS-LSI mounting technology using self-assembly

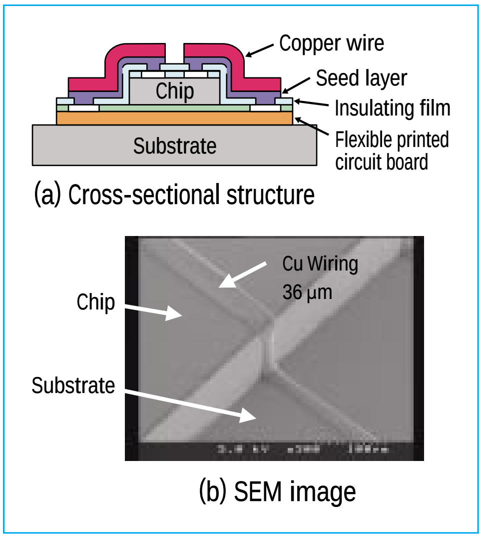

Fig. 2 Crossover interconnect

Column

Frontiers of Future MEMS Devices: Process Integration

Nobuyuki Moronuki, Professor, Faculty of System Design, Tokyo Metropolitan University

Previous columns have introduced green, white, and blue devices as applications of MEMS devices we could have twenty years from now. The processing technologies needed to support these applications will require severe specifications, such as the manufacturing of microstructures in units of nanometers over a range on the order of meters. This may be difficult to achieve through a simple top-down approach based on the “copying principle” applied to cuthing, for example. While it may be possible to manufacture nanometer-order structures according to processes applying the principle of self-assembly and the like, developing such structures directly into meter-order structures will not likely be easy.

Therefore, our workgroup has been studying the development of technologies fusing manufacturing and assembly that can be applied seamlessly across both of these orders by merging a top-down process with a bottom-up process, as shown in **Fig. 1** (members of the workgroup are listed in **Table 1**). While conventional machining and energy beam machining can conceivably be combined for larger structures, it would be necessary to control the temperature and other aspects of the environment to ensure precise positioning, for example.

In addition, imprinting or other transfer techniques would be essential to attain high-throughput, low-cost manufacturing. Device designs themselves may also be affected when one considers the possibility of further developing the framework of simple shape transfers to the transfer and assembly (integration) of specific functional materials and molecules, as well as biotechnological devices.

A self-assembly process, i.e., a bottom-up approach, will likely be required for dimensional scales on the order of nanometers or less. Moreover, rather than producing uniform monolayers, we can imagine techniques for fixing and orienting molecules based on their location. The following are three features of this process.

(1) Technology for manufacturing three-dimensional nanostructures

The so-called 2.5-dimensional structures (columns, etc.) are produced through a combination of lithography and etching. Of course, higher resolutions will be in demand. However, existing technologies are not likely sufficient to support demands for three-dimensional processing, such as the formation of tapers and free-form surfaces. It will also be necessary to develop techniques for machining periodic three-dimensional microstructures on nanometer scale.

(2) Large surface areas

Printing technologies must be applied to large surface area applications of a poster size scale, enabling high-speed mass-production. On the other hand, the printing technology most suited to smoll lot production is inkjet technology. While throughput is lower, this technology is promising for processes supporting individual, customized product designs. There remains much room for research on materials used with this technology. It is conceivable that future processes may be able to deposit actual MEMS devices containing biomaterials.

Scale extension is another important issue.

(3) Interface control

Self-assembly can be performed location-selectively by modifying the wettability at specific locations on a solid surface. For example, we expect to be able to fix functional devices to only hydrophilic portions of a substrate simply by drawing the substrate up from water in which the functional devices are dispersed. It will be necessary to develop many techniques including surface modification in order to control the assembly of a variety of functional devices. To achieve this in resolutions at the molecular level, extremely preoke interface control will be required.

As can be seen from the above issues, it will not be easy to implement comprehensive process integration. However, we believe these technologies are critical for implementing various applications and will produce a great ripple effect.

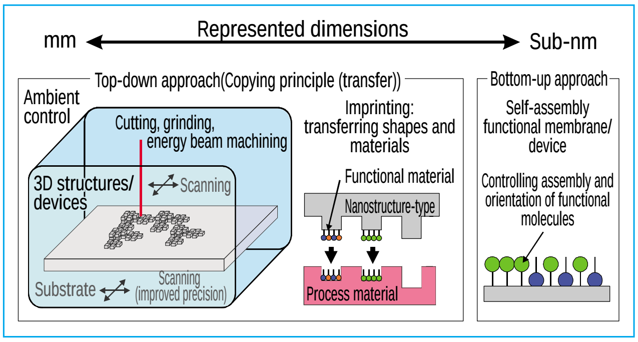

Fig. 1 Next-generation processing

Table 1 Members of the process integration workgroup

Nobuyuki Moronuki	Tokyo Metropolitan University
Kiwamu Ashida	National Institute of Advanced Industrial Science and Technology (AIST)
Gen Hashiguchi	Shizuoka University
Seiji Samukawa	Tohoku University
Harutaka Mekaru	National Institute of Advanced Industrial Science and Technology (AIST)
Ko Fuwa	ULVAC, Inc.
Yasuhiro Igarashi	Oki Electric Industry Co., Ltd.
Chieki Mizuta	Mathematical Systems Inc.
Koichi Tanaka	Sony Corporation
Nobuaki Kawahara	DENSO Corporation
Takayuki Masunaga	Toshiba Corporation
Hirokazu Hashimoto	Fujikura Ltd.
Masatsugu Tomotaka	Fuji Electric Systems Co., Ltd.
Masao Kubo	Matsushita Electric Works, Ltd.
Kazuo Asaumi	Mizuho Information & Research Institute, Inc.

Overseas Trends

Study of International MEMS Industry Trends

- Study of MEMS Foundries in Asia -

As one phase of the Study of MEMS Industry Trends and the NEDO-commissioned "Project to Disseminate the Achievements of the MEMS-ONE Project," a group from the Micromachine Center visited foundry companies and relevant research institutions in Taiwan and Singapore, two of the centers for MEMS foundries in Asia, from December 5 through December 12, 2007. The group held discussions regarding the current state of foundry business and issues that must be resolved, as well as efforts to accommodate MEMS for integration and other future deployment.

The group visited the following companies and institutions:

◆Taiwan

- **tMt (Touch Micro-system Technology):** Foundry
- **apm (Asia Pacific Microsystems):** Foundry
- **ITRI (Industrial Technology Research Institute):** MEMS Research Institution

◆Singapore

- **MEMS Technology:** Foundry
- **IME (Institute of Microelectronics):** MEMS Research Institution
- **SIMTech (Singapore Institute of Manufacturing Technology):** MEMS Research Institution
- **IMRE (Institute of Materials research and Engineering):** Micro-nano Research Institution
- **ANF (Asia Nano Forum):** Small Tech & Nanotech Industrialization Support Institution

MEMSTECH

tMt

apm

Participating in the study were Isao Shimoyama, Professor of Tokyo University and Chair of the Industrial Trends Study Committee and International Interchange Committee; Masaharu Takahashi of the National Institute of Advanced Industrial Science and Technology (AIST) who is also a member of the Foundry Service Industries Committee and MEMS Personnel Training Committee, and Masao Arakawa of Matsushita Electric Works, Ltd. who is a member of the International Interchange Committee (with the latter two individuals participating in the Singapore study only). Participating from the MMC were Shunichi Adegawa and Junji Adachi. Mr. Arakawa is currently stationed at Panasonic Electric Works Asia Pacific Pte. Ltd. in Singapore, and he provided support for the study activities in Singapore.

The results of the study were reported as follows:

– The number of MEMS foundries in Taiwan declined from six in 2001 to three in 2007.

– apm, the largest foundry company in Taiwan, entered a capital alliance in 2006 with UMC, a CMOS foundry. The company is currently focusing exclusively on foundry business.

– Chip Sense, an affiliated company of UMC, was absorbed by apm in 2007.

– tMt is involved in both joint development with a Taiwanese company and foundry service business. In 2007, tMt became a member of the Walsin Group as a 100% subsidiary of Walsin.

– CMOS/MEMS integration is the current trend. In Taiwan, alliances with MEMS foundries have been initiated or explored, beginning with those of UMC and TSMC.

– MEMSTECH, the only MEMS foundry in Singapore, is pursuing device business as well. The company is currently focusing on the development and marketing of silicon microphones.

– MEMSTECH's foundry business is focused on fields in which the processes for the principal devices (sensors and microphones) can be used.

Members' Profiles

Alps Electric Co., Ltd.

1. Company Profile

Under the corporate philosophy "Alps creates new values that satisfy stakeholders and are friendly to the earth," Alps Electric has been developing and manufacturing products focused on five business divisions, while being true to its business domain of "perfecting the art of electronics."

The Mechatronic Devices Division supports the electronic industry with diverse product lines including switches, potentiometers, sensors, and connectors. These products are the result of condensing many years of experience in molding, machining, plating, and mechatronics technologies and have received high praise for their performance and reliability.

By introducing advanced technologies into its proprietary onboard electronic systems, the Automotive Products Division has developed various devices and systems that enhance automobile safety and comfort while reducing environmental impact. These systems include the Haptic Commander®, which uses a tactile feedback technology, as well as steering modules, and instrument panel operation units.

Amid the dramatic changes in the communications industry, the Communication Devices Division has used its high-frequency circuit technology and other proprietary technologies to develop tuners compatible with broadcasting systems in various countries, communication modules for next-generation information terminals, and transceiver units for mobile phones. This division is also engaged in the development of lenses and modules for optical communications, and camera modules for mobile phones.

The Peripheral Products Division develops devices serving as interfaces between people and equipment. This division develops input devices such as GlidePoint™ touchpads for laptop computers, display-related devices such as highly transparent and responsive touch panels making use of our micromachining technology, and output devices such as compact photo printers and thermal printers.

The Magnetic Devices Division provides a wide array of products incorporating magnetic materials, drawing on our expertise in magnetic materials and thin-film manufacturing and processing technologies cultivated through many years of developing magnetic heads. These products include magnetic sensors incorporating magnetic sheets developed with our proprietary Liqualloy™ material, and high-precision magnetic elements. This division strives to develop products contributing to advanced functions and performance in a variety of equipment ranging from compact digital devices to automotive products.

2. SENSORING™

One of the product lines Alps Electric is currently focusing its attention on is sensors. We currently develop resistive sensors, capacitive sensors, magnetic sensors, and piezoresistive sensors. Setting our sights on the continually evolving sensor industry, we have begun developing a business referred to as "SENSORING™", combining the base "sensor" with the progressive form "ing," expressing innovation and a desire to take on the industry.

Resistive sensors take advantage of our company's expertise on resistors excelling in long lifetime and robustness that we accumulated through the development of potentiometers. Our resistive sensors are widely used in not only consumer electronics, but also automobiles, in which high-reliability in extreme environments is essential.

We have also developed capacitive pressure sensors, which are characterized by low power consumption and high sensitivity. Hence, these sensors are suitable for such applications as automotive Tire Pressure Monitoring Systems (TPMS) and instruments used to measure blood pressure.

The magnetic sensors use highly reliable magnetic elements. Because our sensors offer a wide detection range and low performance deviation even at high-sensitivity levels, they allow greater freedom in circuit board design and sensor layout. Moreover, with their low power consumption and stable operating temperature, these sensors expand the application possibilities in such broad fields as cell phones, personal computers, household appliances, and automobiles.

Piezoresistive sensors are suitable for compact pressure detectors and have been used to perform high-resolution detection by optimizing the digital circuit and temperature compensation circuit. These sensors have potential application ranging from portable navigation devices to white goods.

Hence, Alps Electric has developed diverse sensors with wide-ranging uses and applications. To create these products, MEMS technologies will be indispensable.

3. MEMS Technologies at Alps Electric

Anticipating a future trend toward smaller and thinner products having higher performance and functionality, our initial approach toward MEMS technology has been based on the belief that the size and precision required in molding technologies will evolve from millimeters to micrometers and from micrometers to nanometers, and that it will be necessary to dramatically increase the degree of freedom in machining shapes. In MEMS processing, we have pursued a fusion of MEMS processing with precision machining cultivated through our switch development and manufacturing. The technologies born from this fusion have enabled us to form dies with a high aspect ratio and a high degree of freedom in sidewall inclination, while allowing an extensive range of machining dimensions (see **Fig. 1**). This MEMS technology is based on the micromachining technologies we cultivated when developing magnetic heads.

While to date we have developed MEMS technology as one means of die machining, we also hope to develop applications for MEMS in manufacturing the various sensors described above. Using our own technologies, we have implemented feed-through electrode formation on glass capable of producing hermetically sealable electrodes and hope to continue making contributions toward meeting the compact high-performance requirements of sensors.

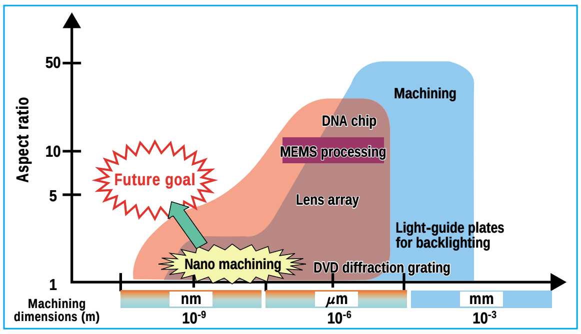

Fig. 1 Machining levels targeted through the fusion of precision machining and MEMS technologies

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