MMC

MICROMACHINE

2006 2

New Year's Greetings

Tamotsu Nomakuchi, Chairman
Micromachine Center

I would like to take this opportunity to extend my best wishes to all for a happy and prosperous 2006, as well as express a few thoughts at the start of a new year.

The Japanese economy is currently in a period of gradual recovery centered on private-sector demand. This year – hailed as the year Japan's economy will finally and without fail emerge from the long period of stagnation that has ensued since the economic bubble burst – will also be the year of an "offensive revolution" that will reshape Japan's manufacturing industry anew.

In the 1980s, the United States worried over the twin concerns of budget and trade deficits as the EU and Japan caught up with then overtook its manufacturing industries. This period saw rising demand in the US from the manufacturing world, represented by the Young Report, for measures to strengthen international competitiveness. Various strategies undertaken by the government put American competitiveness on the road to recovery. The Palmisano Report, "Innovative America" – a report claiming that fostering innovation was imperative for America to maintain its competitive advantage – was then released in December 2004.

As the rapid economic growth in various Asian countries enabling them to catch up with Japan, Japan today is now facing the same situation as once faced by the US when Japan caught up economically with it. In particular, the formulation of measures to address intensifying competition with China and other emerging innovation regions –known as the "emerging tigers" – is an important task Japan now faces.

The Third Science and Technology Basic Plan beginning this fiscal year, gives "the importance of human resource training and creating a competitive environment" (from things to people) as the principle that should underlie science and technology policy and the national position to aim for. The Ministry of Economy, Trade and Industry also announced last year "The New Industry Creation Strategy, 2005" devising action plans in seven important fields for the creation of new industries in addition to training and recruiting workers to support competitiveness, creating a common infrastructure to support priority fields, building up advanced material industries that will serve as a foundation for competitiveness in new cutting-edge industrial fields, and establishing policies for high-risk research and development.

Because of their reputation as small, high-precision, low-energy, high-added-value devices key to a diversity of industrial fields such as information and telecommunications, medicine, biotechnology, and automotives, micromachines/MEMS (Micro Electro Mechanical Systems) – the technologies promoted by the MMC – are regarded as vital for strengthening the international competitiveness of major areas within Japan's manufacturing industry today.

Against this background, it has been decided to establish within the MMC in April this year a MEMS Council comprising MEMS-related businesses for the purpose of providing support for the further development of MEMS industries and contributing to the strengthening of the international competitiveness of Japanese industry.

This council will promote activities such as the support of business revitalization through the expansion and strengthening of policy recommendation activities regarding basic issues in order to develop MEMS industries and a foundry service network for building an infrastructure for research group activities regarding important themes and MEMS development, as well as through the establishment of a website for introducing new products and technologies such as MEMS devices, foundries, and manufacturing equipment as a means of encouraging exchange between MEMS businesses.

Your participation in and cooperation with the council and its activities would be highly welcomed and appreciated.

At the MMC, we will continue with our activities – mobilizing industry, academia, and government – with the aim of establishing basic technology for and the industrialization of micromachines/MEMS in order to contribute to the reshaping of Japan's manufacturing industry and to the strengthening and maintenance of Japan's international competitiveness.

In conclusion, I would like to again wish everyone all the best for a happy and prosperous 2006.

The Eleventh International Micromachine/Nanotech Symposium

On November 10 (Thursday) 2005, the Eleventh International Micromachine/Nanotech Symposium was held in the Science Hall of the Science Museum in Tokyo's Kitanomaru Park, sponsored by the Ministry of Economy, Trade and Industry and the New Energy and Industrial Technology Development Organization (NEDO), with assistance from the Japan Auto Racing Association. The symposium started with an opening address from Tamotsu Nomakuchi, Chairman of the Center, followed by a greeting from the guest of honor, Tetsuya Yamamoto, Director of the Machinery System Technology Development Dept. at NEDO. This time, before the lectures, a special session was planned with a keynote speech and panel discussion on the theme of "Towards development of the MEMS industry", followed by twelve lectures in the three sessions "The frontiers of the micromachine business", "Micromachine applications expected to blossom", and "The leading edge micromachine technologies". Three hundred and thirty-nine people from a range of specialist fields attended, from a number of companies, universities, and research institutions in the fields of electronics, equipment and machinery, automotive, materials and chemicals and so on, making the symposium a great success. This is a report of the symposium overall.

The special session was held to raise awareness of the MEMS Industry Group to be inaugurated by the Micromachine Center in April 2006 with the aim of promoting the further development of the MEMS industry in a situation where the market for MEMS devices and products is expanding, and to contribute to enhancing the international competitiveness of the Japanese MEMS industry. First Prof. Hiroyuki Fujita of Tokyo University gave a keynote speech entitled "The expansion of the MEMS industry and policies for developing new sectors", followed by a discussion of the themes "The direction of the MEMS industry" and "Policies for creating a new industry and driving development", mediated by Prof. Fujita with the six panelists Hitoshi Ogata (Senior Director of Development at Mitsubishi Electric Corporation, and MEMS Informal Committee Representative), Haruo Ogawa (Director of New Core Business Planning at Olympus Corporation), Hiroya Taguchi (Chairman of The Japan Society of Mechanical Engineers and Chief Engineer of the Hitachi Research and Development Center), Hiroshi Tsuchiya (Assistant Section Chief, Industrial Machinery Division, Manufacturing Industries Bureau of the Ministry of Economy, Trade and Industry), Tsuneyuki Miyake (Deputy Editor of Nikkei Microdevices), and Prof. Harri Kopola (Research Director, VTT Electronics), one of the lecturers.

Regarding "The direction of the MEMS industry", Mr. Ogawa and Mr. Ogata talked about the micro and nano strategies of their respective companies, while Prof. Kopola explained the efforts towards building a MEMS industry in Finland. It was very much apparent that companies both in Japan and overseas are focusing on MEMS and nanotechnology as core technologies. Mr. Miyake rounded off the discussion by talking about how there is no doubt that MEMS represents a third wave that is forming a significant market, with semiconductors as the brains, displays as the face, and MEMS devices as the limbs and the senses, and how major disparities will open up between companies depending on their strategies. Next, they discussed the topic "Policies for creating a new industry and driving development". Mr. Taguchi compared the MEMS research approaches of the Society of Mechanical Engineers and the Institute of Electrical Engineers, stressing the necessity for horizontal linkage between them for MEMS development. Then Mr. Ogata, the representative of the MEMS Informal Committee which is promoting the establishment of the MEMS Industry Group, talked about the need for exchanges within industry to promote the MEMS industry, introducing the MEMS Industry Group as the organization for fulfilling this role. Next Mr. Tsuchiya of the Ministry of Economy, Trade and Industry explained the strong policies of the Ministry in providing the best backup for raising MEMS technology, such as preparing new projects to meet the expectations for the MEMS industry. Finally the discussion was completed with the

The panel discussion

The keynote speech from Prof. Fujita

presentation of a video letter from MANCEF President, Dr. Kees Eijkel expressing strong support for the MEMS Council.

In Session 1, “The frontiers of the micromachine business”, there were presentations that strongly evoked the scene of work at the various companies, on the subject of inkjet printers from Mitsuro Abe of Seiko Epson, mobile phones from Kunihiko Nakamura of Matsushita Electric, and inertia sensors such as acceleration sensors and gyroscopes (angular velocity sensors) from Bob Sulouff of Analog Devices in the US. The printer heads at the heart of inkjet printers are one successful type of MEMS device, and the applications of printer heads are not limited to printers. Mr. Abe explained how recently, the development of applications is taking off with printer heads used as a tool for the manufacture of a range of devices such as LCD color filters, organic EL displays, organic TFTs, plasma display electrodes, biochips and so on, which was greeted with surprise. In order to achieve multiband mobile phones, further technological innovation is required. Among these innovations, there are expectations for the development of small, low-loss RF-MEMS switches and RF-MEMS filters, and it was explained that relevant research and development is taking place around the world. MEMS devices have been commercialized successfully in the form of inertia sensors such as acceleration sensors and gyroscopes (angular velocity sensors), and the wonderful success story of Analog Devices in the US which succeeded in breaking into the MEMS industry gave heart to everybody else involved in the same effort.

In Session 2, “Micromachine applications expected to blossom”, there were lectures introducing the frontiers of applied research in medicine, optics, energy, and space, in which MEMS technology is key. Prof. Yoshinobu Baba of Nagoya University gave a lecture on the medical applications of nanotechnology. Nanobiotechnology is making significant advances with microfabrication technology and molecular nanotechnology, making possible the development of methods for separating all sorts of biomolecules such as DNA, RNA, proteins and peptides, for applications in genomics, genetic information copying, protein science and the like, while applications in the treatment of cancer are also expected. In his lecture, Prof. Kopola of VTT Electronics explained that in future optoelectronics and optical communication systems, MEMS technology will be a key technology for miniaturization, integration, and low cost. Osamu Nakamura of Casio gave a talk on the development of subminiature, high-performance reforming fuel cells for use in mobile terminals. MEMS technology is the key technology for making the integrated miniature reformer, an essential part for generating hydrogen from a fuel alcohol such as methanol, and from which the power-generating cell extracts electrical energy. In his lecture, Dr. Thomas George who carried out research at NASA, explained that MEMS and nanotechnology, which achieve the ultralow volume, ultrasmall size, and ultralow energy consumption required in space development, are extremely useful. To round up the session, Prof. Isao Shimoyama of Tokyo University gave a lecture entitled “Fine MEMS”, talking of the need for combinations of MEMS and nanotech functions, integrated fabrication of MEMS and semiconductors, and the development of high integration composite MEMS technologies for high MEMS/MEMS integration, in order for MEMS to meet diversified needs. And although MEMS devices and components are incorporated in many products, the general public is largely unaware of them so he made the interesting suggestion that products containing MEMS should be labeled with a mark like that used by Intel.

In Session 3, “The leading edge micromachine technologies”, there were lectures about MEMS and materials, ultraprecision microfabrication and its applications, nanometrology, and the mechanical limits of structural thin-film materials and nanomaterials. Development of the basic technologies regarding materials, fabrication, measurement, and reliability are essential for MEMS development, and on this occasion, we encountered the leading edge of these basic technologies being pursued steadily at universities and the like, both here and overseas. Among these, Yoshimi Takeuchi of Osaka University talked about ultraprecision microfabrication and its applications. Although semiconductor microfabrication technologies tend to play a central part in MEMS fabrication technology, Mr. Takeuchi presented extensive fabrication data showing that machining at the nanolevel is possible not only superficially but on three-dimensional surfaces too. Finally Dr. Christopher Muhlstein of Pennsylvania State University spoke on the subject of understanding the mechanical limits of structural thin-film materials and nanomaterials. He explained how he analyzed the breakdown and fatigue behavior of thin film materials with the aim of improving the reliability of MEMS, and he showed a method of improving the mechanical characteristics of thin films with a protective coating on their surface based on those results. The reliability of thin film materials is an important research issue for commercialization of MEMS, and this topic was of great interest to the audience.

Starting after 9 and going on till 6 in the evening, it was a long event starting with the panel discussion in the special session followed by twelve lectures packed into a tight schedule. The venue was enthused by the palpable sense of potential and expectation surrounding micromachines and MEMS. It was apparent that MEMS technology, that was in its initial phase centered on research and development, is now becoming a functioning industry. Thanks to the timely topics provided by the speakers from Japan and overseas and to the efforts of the program committee, this symposium was a tremendous success.

The Twelfth International Symposium will be held on November 8 (Wednesday), 2006 at the Tokyo International Forum as part of Exhibition MICROMACHINE.

The 16th Micromachine Exhibition

The 16th Micromachine Exhibition was held in conjunction with The 11th International Micromachine/Nanotech Symposium at the Science Museum in Kitanomaru Park, Tokyo, over 3 days from November 9 to 11, 2005, and was a resounding success.

The theme for this year's exhibition was "Fields in the Spotlight - Micro/Nano Technologies Open up Next Generation Business: International Exhibition on Micro-Ultraprecision/Microfabrication, MEMS, Nanotechnology, and Biotechnology".

In addition to the Micromachine Center and 10 of its supporting member organizations, willing and generous cooperation in the arrangement of exhibitions was also provided by private businesses, universities, and independent public organizations. A total of 259 displays (362 booths) were exhibited by businesses, organizations, universities, and research organizations. France's National Center for Scientific Research (Centre National de la Recherche Scientifique) and 15 other organizations from abroad also presented exhibits.

As with the previous year's exhibition, Micromachine 2005 occupied the Science Museum's entire first floor hall space and preparation room, a part of the lounge, and a part of the second floor in keeping with the increased number of exhibitors.

Furthermore, with 38 companies (3 from overseas) and groups participating for the first time, the exhibition presented a wide range of new micromachine- and nanotechnology-related technologies and products.

Thanks in part to the exhibition being held simultaneously with the 11th International Micromachine/Nanotech Symposium and the MEMS-ONE Project Interim Report Presentation, a record attendance of more than 9,098 people was achieved over the three days of the event. With researchers, engineers, and administrators from the frontlines of diverse technological fields accounting for a large number of these attendees, another factor in the exhibition's huge success was its role as venue for the exchange of ideas and sharing of research information between researchers in different fields, providing an ideal opportunity for the discovery of new possibilities for technologies and solutions to a wide range of issues concerning technological development.

The main products displayed at the exhibition included micromachines, their associated components and application systems, MEMS (micro-electromechanical systems), MEMS manufacturing equipment/design tools, nano-technologies and materials, other materials, biotechnology and medical systems, evaluation and measuring instruments. In this regard, the micromachine exhibitions are becoming specialized events ideally suited for people working in R&D, technology, design, production/manufacturing, or management/administration in a diversity of fields, including mechanisms and precision machinery; electrical devices and electronics, medicine; information technology; automobiles and transportation; biology, physics, and chemistry; architecture; steel; space aviation; and shipping and oceanography.

Furthermore, the exhibition provided an excellent opportunity for the promotion of technologies, devices, and products by businesses in the field of micromachine R&D; for the presentation of the results of research by universities and other research organizations; and for the announcement of products and technologies by other newly participating businesses.

The 16th Micromachine Exhibition is to be held:
Dates: Nov. 7 (Tues.) – Nov. 9 (Thurs.), 2006
Venue: Tokyo International Forum
(Yurakucho, Tokyo)

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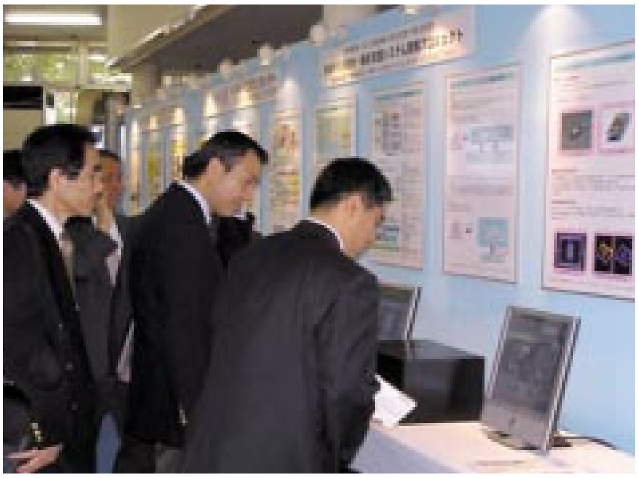


The exhibition hall, busy with attendees

The post-exhibition reception

ULVAC Inc.'s MEMS Foundry Services

Yoko Yamakawa, Managing Director,
Engineering Planning Officer,
Tsukuba Metamaterial Laboratory Director

1. ULVAC's approach to MEMS

ULVAC has developed equipment for MEMS and at the same time we have been developing the associated processes. For example, we are offering equipment that overcomes issues that were considered difficult in the past such as deposition and etching of functional materials like high-permittivity film and magnetic film, deep etching quartz and Si, or dry etching etch-resistant materials with low vapor pressure and so on. For example, equipment such as the SME-200 sputter machine for high-permittivity film and SAW device electrode formation; the CME-200 CVD machine for silicon oxide and nitride films; the NLD-6000 which demonstrates its power in deep etching quartz; and the NLD-Si that can deep-etch Si are evaluated highly in the field of MEMS.

In addition, besides giving polymer film itself the functionality of water repellency, hydrophilicity, biocompatibility, and antimicrobial properties, ULVAC's vapor deposition polymerization method can form a uniform polymer film even in the deep parts of minute structures. These properties are drawing attention to the method as a technology perfectly suited to MEMS. In parallel with the development of this machinery, ULVAC is aggressively pursuing challenging new development in the bio, fine mechatronics and fine chemicals sectors.

The MEMS foundry service, started in November 2003, is positioned to leverage these equipment and process developments for production of MEMS devices. In other words, as well as providing services incorporating ULVAC's technologies into processing as a foundry managed by an equipment manufacturer, we are leveraging our technology and know-how gained through development of equipment and processes. In this way we are expanding our mission by providing rapid service to meet our customers' requirements for new processes and equipment.

2. The features of ULVAC's MEMS foundry services

Since we started the foundry, the response has exceeded our expectations. Besides production of MEMS devices, requests have come in for single processes like deposition of single films or etching. We are making great efforts to upgrade our equipment and improve our processes in response to difficult orders, and we believe that as the foundry of an equipment manufacturer, we have a distinctive offering.

As a rule, for devices, we ask the customer to provide the design, while the foundry faithfully fulfills production. The basic philosophy of ULVAC's foundry service is to enable the customer to carry out the design freely without any preconceptions even when new processes are required, or when it is difficult to judge which material to use, then to pass the production baton to ULVAC whereupon we manufacture the product to specification and hand it back. Naturally, we work to ensure that there are pricing benefits too.

3. Introducing ULVAC's MEMS manufacturing

Here we provide an example of ULVAC's in-house device manufacturing. When we developed our MO-CVD equipment for LEDs, we produced a prototype blue LED to evaluate the equipment characteristics. Figure 1 shows an emission test (λ = 440.9 nm). The quantum well of the luminescent layer is formed of InGaN, sandwiched between p-AlGaN and n-GaN to form an LED.

Figure 2 shows an example of Si deep etching. This is a processing example of ULVAC's proprietary NLD-Si method. It achieves Si etching with a width of 0.2 μm, a depth of 6.5 μm, and an aspect ratio of 30 or more.

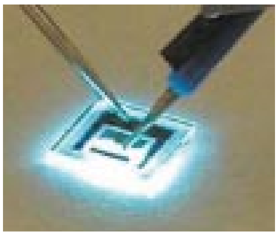


Figure 1. Blue LED

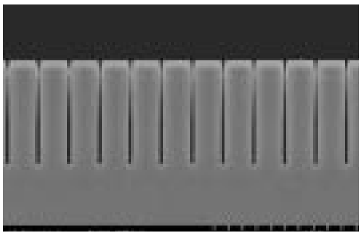


Figure 2. High aspect etching using the NLD-Si method

4. Future efforts

As we saw above, ULVAC's MEMS foundry aims to provide a wide range of processing technologies in a timely manner. We have a comprehensive range of lines, from deposition and etching to bonding and dicing, and we are currently augmenting our facilities. At our current scale of operations, we are accepting orders for small-lot production suited to R&D level manufacturing. For the future, we plan to expand into larger-scale processing. Besides integrated production for our own company, the ULVAC MEMS foundry also welcomes subcontracting orders in our area of specialization. In terms of quantity, we accept orders starting from one wafer. Please address enquiries to the Micromachine Center or through the ULVAC website.

http://www.ulvac.co.jp

Introducing process inverse problem analysis software

Yasunori Suzuki, Group Leader, Mathematical Systems, Inc.

Purpose

In designing MEMS devices, the design of the masks used in the processes is a major task, while at the same time, it involves very difficult problems. A skilled practitioner who has a thorough knowledge of MEMS can use their experience and knowledge to establish the necessary processes. However, for a beginner, it is very difficult to draw a MEMS pattern while thinking through the processes, and it is not unusual to draw patterns that are impossible.

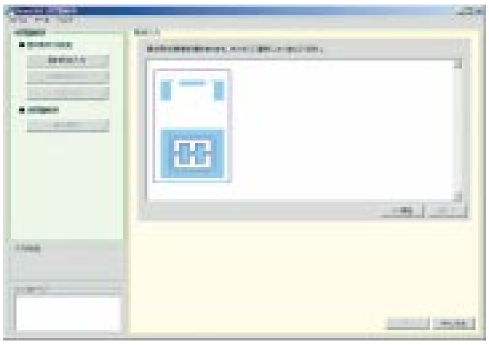
This software facilitates design by resolving the difficult problems of MEMS device design while providing the user with guidance, and it is expected to be an effective learning tool especially for MEMS beginners.

Functions

The software has the following functions for performing inverse problem analysis.

- Load MEMS device pattern (top, cross section) files
- Specify MEMS device pattern dimensions
- Set process conditions (equipment used, processes etc.)
- Inverse process guidance for MEMS device patterns
- Framework linkage
- Mask data file output (the format conforms to the framework)
- Process recipe file output (the format conforms to the framework)

To enable the user to perform analysis easily, the settings can be performed using a wizard (the screenshot shows a prototype).



State of development

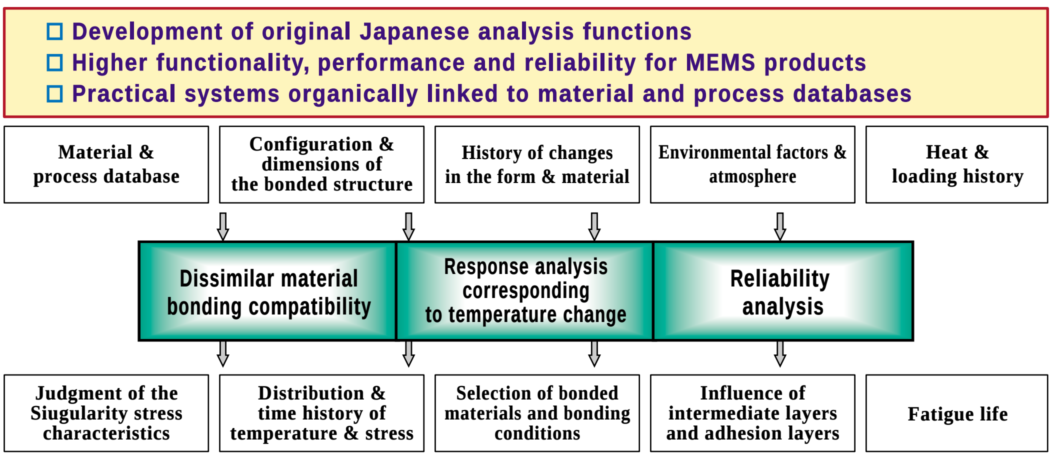
Following specification development last year, the software is now in the development phase. The first stage of development will be completed this year, and the α version is scheduled for release in 2006.

Introducing about package bonding analysis software

Yinsheng Li, Senior Manager, Social Technology Office
Engineering Services Department, Mizuho Information & Research Institute, Inc.

Bonding technology is a technology that is used for MEMS processes and packaging. When dissimilar materials are bonded, damage to the bonded interface and edges may occur due to the influence of differences in the physical properties of the dissimilar materials such as their Young's modulus, Poisson's ratio, coefficient of thermal expansion and so on, and the geometric configuration of the bonded edges, the materials and dimensions of the intermediate layers and other factors.

The package bonding analysis software supports the design and development of MEMS that may experience this kind of problem. It includes a material compatibility analysis function for evaluating the stress singularity at bonded edges, a function for analyzing the deformation and temperature history and inheritance arising from changes in the material and form, a reliability analysis function for evaluating bond strength.



Column

Merger of Integrated Circuits and MEMS

- At the Toyohashi University of Technology -

Makoto Ishida, Toyohashi University of Technology

Although sensor and MEMS technology are derived from integrated circuit (IC) technology, it is not a simple matter to fabricate sensors or MEMS and ICs on the same chip. Because the microfabrication of ICs has developed to the nm level, the barriers to this kind of merger are high. This is because ICs involve ultra high precision engineering, while sensors and MEMS involve precision engineering. Ultraprecision ICs basically are not amenable to further processing besides the manufacturing process. On the other hand, the requirements of sensors and MEMS include materials, structures, and fabrication processes that enable a range of further processing. Fulfilling these contradictory requirements is the key to merging the two. One method is to fabricate the sensors and MEMS after fabricating the IC. Another is to constrain the fabrication of the sensors and MEMS to the extent possible with IC processes. However, it is difficult to fabricate sensors and MEMS with the fullest capability, so compromises must be made somewhere. We faced the same conflicts at Toyohashi University in merging sensors and MEMS with integrated circuits, but we worked to ensure that both were satisfactory as far as possible. Here I will explain how we built a research and development environment at the University with the goal of merging integrated circuits with sensors and MEMS, and I will offer an example of smart chip development.

Twenty-six years ago now, there were very few universities in Japan that were actually producing integrated circuits from the design stage, while seriously pursuing teaching and research. The University of Technology was established in Toyohashi as the 88th national university, and the current President Tatau Nishinaga, the late Tetsuro Nakamura (from NEC), and Yukio Yasuda currently at Kochi University of Technology (from Toshiba) took the lead in starting unified semiconductor-related courses with the aim of building an environment where serious teaching and research, and fabrication of integrated circuits could be pursued in one place. The main equipment at first was a 2-inch line from the NEC Tamagawa Factory, and in the autumn of 1979, as the 4th year laboratory experiment (a 3-month experiment called the big experiment), students succeeded in fabricating a simple npn bipolar transistor, whereupon a great cheer went up in the clean room. This was the start of it all. The radio produced from these six transistors is still running in the VBL exhibition room. Roughly speaking, if you can make a basic transistor, you can make however complicated an IC. Then we received a request from Genyo Mitarai of the Research Institute of Environmental Medicine in Nagoya to develop an EEG IC chip for the cerebellum of carp for exploring space sickness in a space experiment, for which we pursued development as a Master's research theme. This chip was used in experiments on the Endeavor in 1992, when Mamoru Mohri went into space and when this chip first left the earth.

In the meantime, up to this year, a course with the same content as the big experiment has been held 25 times (25 years) for 1 week continuously during the summer holiday. (More than 400 people have taken part.) All the teaching staff participated and it was a tough business getting through the hot summer with the students, but besides maintaining the equipment in operation, it is an excellent opportunity for checking the machinery (since one member of the staff is an engineering official).

Currently a 4-inch CMOS, 1 micron process is possible using a stepper. In 1994, the department moved to the Electron Device Research Center from the original building where it was established, and in 2002 it was incorporated in the VBL (Venture Business Laboratory) facilities. A clean room where micro and nano processing is possible was set up on the first floor of the VBL, and MEMS processing was enhanced. We have fabricated many kinds of smart chips that merge sensors and MEMS with integrated circuits, but MEMS manufacture requires special process other than the CMOS process, so it has often become necessary to use the equipment separately. How to organize and manage this is a difficult matter, and success rests upon being able to adjust for the interests of both. It is necessary to have a relationship where both can allow compromise as far as possible. It is also necessary to design hitherto unknown processes.

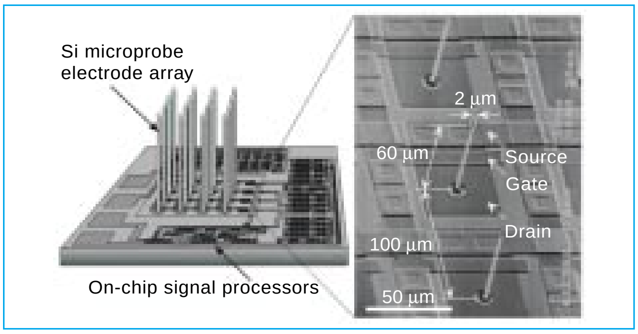


Figure 1 Conceptual diagram of a nerve potential sensor integrating a miniature electrode array and signal processing circuit, and electron microscope photograph of a prototype chip

My proposal for a nerve potential measuring smart chip with a silicon microprobe formed by crystal growth on an IC chip shown in Figure 1 is clearly one such example. This chip which was at first thought to be completely impossible probably met with many objections in the laboratory too. That's because if you give a reason why something cannot be done, any number of others can also be found. With this background, separate groups worked on the crystal growth and integrated circuit processes so that a system was achieved for assessing the problems and limitations of each process, and for pursuing solutions by pooling the knowledge of each group. As a result we were able to develop the chip to a state where it detected a signal from living cells which had been our ambition at the start of last year. [1] In this way we have proposed or prototyped many smart microchips that incorporate sensors and MEMS with ICs, but in order to raise the level of these chips further, we are proceeding through discussion of the problems involved in merging ICs with sensors and MEMS.

1) T. Kawano et.al "Three-dimensional multichannel Si microprobe electrode array chip for analysis of the nervous system", IEDM 2004, pp.1013-1016

Overseas Trends

Survey of Trends in the Industrialization of MEMS in Europe

From November 21 to 25 a study tour of foundries, research institutions, and companies which have successfully set up MEMS businesses in Europe – a leading region in the promotion of MEMS industrialization – was conducted with the aim of contributing to the promotion of MEMS industries and the development of a foundry service network in Japan.

The tour visited companies and research institutions; at each location, after explaining the situation regarding the promotion of MEMS industrialization in Japan and receiving explanations of the activities of the company/institution, problems involved in promoting MEMS industrialization and methods for their resolution were discussed. Consequently, we were able to gather practical, up-to-the-minute information from the frontline in this field.

The following locations were chosen to ensure that the tour broadly covered the spectrum of MEMS industrialization and include MEMS foundries, MEMS device manufacturers, MEMS/nanotechnology research institutions, and organizations supporting MEMS industrialization.

<Locations Visited>

Locations visited

◆ **VTT Technical Research Centre of Finland**
- Finland's national research institution; conducts contracted research
- R&D of MEMS/nanoelectronics

◆ **MST factory Dortmund**
- Incubator for microsystem technology
- Supports raising the success probability of setting up MEMS businesses through reduction of costs and product development time

◆ **IVAM**
- Microtechnology association comprising 165 member businesses and research organizations based mainly in Europe
- Supports MEMS industrialization that builds bridges between businesses and users

◆ **X-FAB Semiconductor Foundries**
- Representative United States/European semiconductor company
- Also promotes MEMS foundry activities

◆ **Robert Bosch, Automotive Electronics Division**
- Largest manufacturer of in-car MEMS sensors
- MEMS process development

◆ **ST Microelectronics**
- Major semiconductor manufacturer; also manufactures MEMS sensors for consumer appliances

The study tour enabled the exchange of opinion on the situation in Europe regarding the promotion of MEMS-related projects, trends in foundry activities and MEMS device development, and industrialization support and provided valuable information with regard to the future course of this field. In particular, interest in Japan as a market for consumer-use MEMS was high, with discussions at each location focusing on the possibility of market participation and/or business collaboration.

In addition to interaction between businesses, interaction between Japan and Europe in the area of industrialization support is sure to flourish in the future.

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