MMC
2002 8
MICROMACHINE

MMC Activities

The Research Reports under the 8th Micromachine Technology Research Grant

This research grant program started inviting applications in 1993 as a part of the independent activities of MMC. The purpose of the program is to assist college and university staff engaged in basic research on micromachines, and to promote further development of micromachine technology and communication between academics and people in the industrial world.

Among the themes selected for the eighth (2000) research grant, six 2-year research projects carried over from fiscal 1999 have been completed.

The following are the summaries of the research results.

No.	Subjects	Leader and Co-Worker	Affiliations	Period
Carried-Over Projects Granted for Fiscal 1999				
1	Development of noninvasive single cell manipulator utilizing temperature-responsive polymer	Dr. Masayuki Yamato	Assistant Professor, Institute of Advanced Biomedical Engineering and Science, Tokyo Women's Medical University	2 Years
2	Construction of micro-lens array by micro-fabrication of stimuli-responsive gel	Prof. Yoshihiro Ito, Dr. Eng.	Project Leader, Regenerative Medical Bioreactor Laboratory, Kanagawa Academy of Science and Technology	2 Years
3	Study of novel polymer micro-actuator powered by enzymatic reactions of biomolecules	Prof. Kazuhiko Ishihara, Dr. Eng.	Professor, Department of Materials Science, Graduate School of Engineering, The University of Tokyo	2 Years
4	Catheter tip position sensing system using MI sensor	Dr. Yoichi Haga	Research Associate, Graduate School of Engineering, Tohoku University	2 Years
5	Electrical, thermal and mechanical properties of nano mechanical structures	Assoc. Prof. Gen Hashiguchi, Dr. Eng.	Associate Professor, Faculty of Engineering, Kagawa University	2 Years
		Prof. Hiroyuki Fujita, Dr. Eng.	Professor, Institute of Industrial Science, The University of Tokyo	
		Dr. Manabu Ataka	Assistant, Institute of Industrial Science, The University of Tokyo	
6	Integration of chemical systems toward artificial organ	Prof. Takehiko Kitamori, Dr. Eng.	Professor, Department of Applied Chemistry, Graduate School of Engineering, The University of Tokyo	2 Years
		Dr. Hideaki Hisamoto	Lecturer, Department of Applied Chemistry, Graduate School of Engineering, The University of Tokyo	

Development of a Noninvasive Single Cell Manipulator Utilizing a Temperature-Responsive Polymer

Masayuki Yamato, Assistant Professor, Institute of Advanced Biomedical Engineering and Science, Tokyo Women's Medical University

1. Introduction

Along with the recent miniaturization of physical objects in such fields as medicine, engineering, agriculture, and biology, there is an increased demand to establish methods for working in microscopic environments, such as operating and processing methods. With the developments in biotechnology over the past several years, there is an increasing need for cell microinjection and micromanipulation technologies in particular. The objective of this study is to provide an entirely new concept of micromanipulation aimed at greatly improving cell operability and achieving low invasiveness by developing a micromanipulation technique that uses temperature responsive polymers.

2. Temperature control for cell attachment and detachment

In this study, a temperature-responsive polymer, polyisopropylacrylamide (PIPAAm) was grafted onto the end surface of the manipulator. The properties of the polymer changes in response to temperature. By controlling temperature with a small Peltier device, the property of the PIPAAm was switched between hydrophilic and hydrophobic to control cell attachment and detachment (Fig. 1). The cell-trapping domain was ordered in an array by controlling the thickness of the temperature-responsive polymer layer on the order of nanometers and ablating the layer with UV excimer laser (Fig. 2).

3. Conclusion

It has been pointed out that cells can be damaged through single-cell traps and other manipulation using physical techniques, such as optical tweezers and electric fields. The technique for manipulating single cells used in the present study, using temperature changes to control the chemical nature of the manipulator surface, was found to be less invasive than existing methods. This technique is expected to have practical applications once the switching speed is improved.

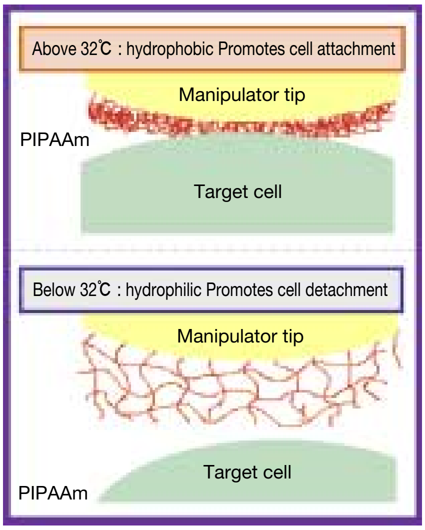

Fig. 1 Single cell manipulator employing a temperature-responsive polymer

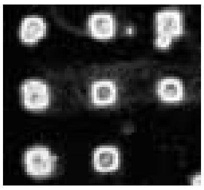

Fig. 2 Array of orderly arranged hepatocytes

Construction of Micro-Lens Array by Micro-Fabrication of Stimuli-Responsive Gel

Yoshihiro Ito, Project Leader, Regenerative Medical Bioreactor Laboratory, Kanagawa Academy of Science and Technology

A gel that expands and contracts in response to physical stimuli, such as thermal, electrical, and optical variations, and chemical stimuli, such as pH and chemical substances, has begun to attract much attention for its use as a soft functional material. Now we have discovered a method enabling micromachining of this type of stimuli-responsive gel. The objective of this study is to produce a compound-eye lens as an application of the gel. While the use of this gel for optical lenses has been considered before, the greatest weakness of this substance is its lengthy stimulation-response time. For example, a gel having a size of centimeters requires several hours to respond to stimulation. However, this response time can be shortened when reducing the size to micrometers. In this study, we designed a compound-eye gel micro-lens array with this gel, as shown in Fig. 1. We attempted to form the gel in a convex shape between micro-patterned ITO (indium tin oxide) transparent electrodes, controlling the thickness and focal length of the lenses individually by voltage. Micro-lenses having a diameter of about 500 micrometers were arranged at regular intervals. Variations in response to pH and electrical stimuli were observed within 1 second. Fig. 2 shows an image acquired using this micro-lens array. A toy dinosaur was used as the subject of imaging. Variations in focal length in response to stimuli were observed from pH 7 to pH 2.

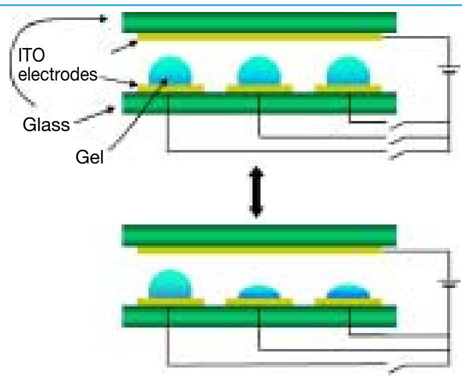

Fig. 1 Principles of the compound-eye system having an array of gel micro-lenses

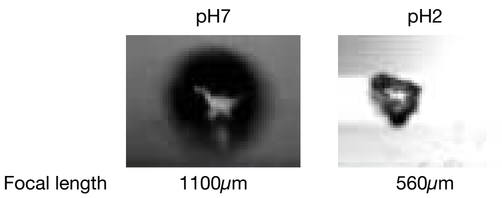

Fig. 2 An image taken by the compound-eye micro-lenses showing variations in focal length in response to pH stimuli

Study of Novel Micropolymer Actuator Powered by Enzymatic Reactions of Biomolecules

Kazuhiko Ishihara, Professor, Department of Materials Engineering, School of Engineering, The University of Tokyo

1. Introduction

The central issue in how to achieve autonomous operation of micromachines in a living organism is how to supply the energy that drives the micromachines. In such an extremely small environment, there is no space to allocate for a battery or the like, nor is it possible to supply energy from an external source. In this study, chemical substances existing in the living organism were employed as polymer actuators by varying their concentrations. The idea is to produce mechanical energy from the chemical substance, a process very similar to the mechanism that living system use to produce energy.

2. Developing a Polymer Gel that Responds to Alcohol

Phospholipid bilayers forming biomembranes have a thickness of 50 nm. Though they are extremely thin, they have many functions. Polymers with a phospholipid polar group in the side chain, 2-methacrylooyloxyethyl phosphorylcholine (MPC) polymers, show excellent properties as a new biomaterial. Further, it was discovered to control the volume of the polymer reversibly through changes in concentration based on the peculiar solvation effect of a phospholipid polar group (Fig. 1). The polymer was repeatedly swelled and deswelled by increasing and decreasing the alcohol concentration (Fig. 2). This indicates that it is possible to manipulate the volume of a bio-responsive polymer gel by causing a reaction with components in an MPC polymer gel to selectively fix enzymes that generate alcohol.

3. Enzymatic Reactions Produced by Alcohol and the Swelling Function of Gel

It was attempted to generate movement in an MPC polymer gel by combining enzymatic reactions using alcohol compounds that exist in the body. Using an EMP cycle, it was generated ethanol with pyruvic acid decarboxylase and alcohol deyhdrogenase using pyruvic acid generated from glucose as the initial substance. It was confirmed that the MPC polymer gel deswelled in this system. Hence, we achieved a polymer actuator capable of supplying chemical energy using the energy source of glucose was achieved.

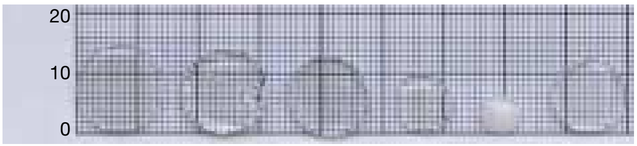

Fig. 1 Dependence of the volume of a cross-linked MPC polymer gel on alcohol composition Ethanol composition (from left): 0, 20, 40, 60, 80, and 100%

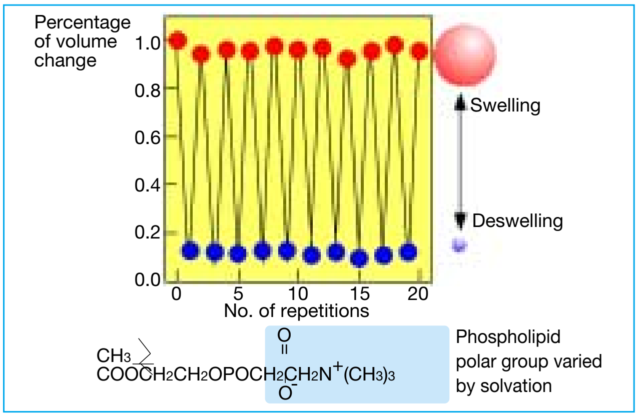

Fig. 2 Reversible volume changes of a cross-linked MPC polymer gel in an aqueous solution of pure water and 60% ethanol solution

Catheter Tip Position Sensing System Using MI Sensor

Yoichi Haga, Research Associate, Graduate School of Engineering, Tohoku University

1. Introduction

Minimally invasive examinations and treatments are performed by inserting a small instrument, such as an endoscope or catheter (a polymer tube having a diameter of about 0.3-3 mm) into the patient's body. While fluoroscopy is currently employed to determine the position of the catheter tip, this method provides only two-dimensional data, which makes for difficult determinations, and moreover produces inadequate image resolution. The capacity to determine the position and attitude (direction in which the tip is pointing) of the catheter tip three-dimensionally and in real time will benefit catheter navigation.

A practical tip position detecting system that employs micro-coils has already been developed. However, we are striving to develop a high-performance 3-axis micro-sensor that can be mounted on a catheter using micro-magnetic vector sensors. These sensors are based on a new principle of the magneto-impedance effect. The system detects exchange magnetic field emitted by an external coil and geomagnetism using three sensors mounted on the tip of the catheter, as shown in Fig. 1.

2. Developing a 3-axis MI Sensor System

In this sensor, a coil generating a bias magnetic field was wound around an amorphous wire having a diameter of 30μm. The sensor generates a voltage between the ends of the wire that varies according to the strength of the magnetic field. Three of the sensors were arranged orthogonally to one another in a 2-mm square column and achieved a positional resolution less than 1 mm and an angular resolution of about 1 degree at the point of position and attitude measurement. In order to combine the positions detected by the three sensors precisely, the sensors were mounted on a polymer which has an electrode patterns, as shown in Fig. 2.

To present 3-dimensional position and attitude data to the doctor, one could obtain and store three-dimensional blood vessel images in a computer prior to operation using contrast medium CT or the like and superimpose the three-dimensional position and attitude of the catheter tip onto the blood vessel images displayed on the screen. The current display system is configured of a three-dimensional blood vessel model image in a computer, as shown in Fig. 3. Measurement signals are input into the computer while calculations are performed to display superimposed position and attitude data in real time.

3. Conclusion

If we liken this sensor system to a car navigation system, the catheter tip corresponds to the car and the blood vessels to roads. By making this system practical, it is expected that minimally invasive therapy will become safer and more reliable, enabling us to perform examinations and treatment not possible before. Applying the system to an endoscope is also anticipated.

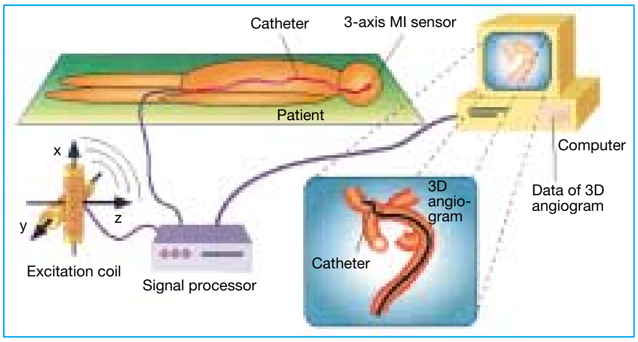

Fig. 1 A catheter tip position/attitude sensor system

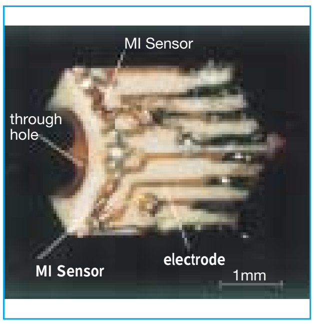

Fig. 2 3-axis micro-magnetic sensor

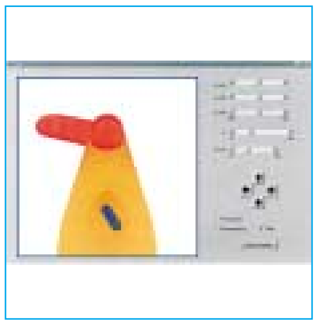

Fig. 3 Catheter tip position / attitude display system

Electrical, Thermal, and Mechanical Properties of Nano Mechanical Structures

Gen Hashiguchi, Associate Professor, Faculty of Engineering, Kagawa University
Hiroyuki Fujita, Professor, Institute of Industrial Science, The University of Tokyo
Manabu Ataka, Assistant, Institute of Industrial Science, The University of Tokyo

1. Introduction

To achieve practical nanotechnology, which has garnered much attention in recent years, it is essential to establish a method of evaluating small matter on the nano order. In this study, we investigated methods for measuring electrical, thermal, and mechanical properties of nano-size matter using micromachine technology. There are two conceivable methods for measuring the properties of nanostructures. One method integrally forms a nanostructure with an approachable electrode structure. The other method uses multiple nanoprobes to probe nanostructures. The following is a report of these two methods as studied in our research.

2. Four-Terminal Freestanding Silicon Nanostructure

We produced a four-terminal nanostructure for measuring the thermal response of silicon nanostructures. Fig. 1 shows an SEM photograph of this element. The cross-section of the wire is shaped as an isosceles triangle with a width of about 0.5 μm and a length of 4 μm. Fig. 2 shows the inverse relationship between input power and the resistance variations of the element. We can see there is a sharp peak in the resistance at a particular input power. Fig. 3 shows the properties of this element as a flow sensor and its frequency characteristics, illustrating that an air flow can be measured even by such a nano scale element.

3. Silicon Nanostructure Testing Device Using an Integrated Microactuator Element

We developed a process for integrally forming a silicon wire structure with an electrostatic actuator in order to study the mechanical properties of nanostructures. Fig. 4 shows an SEM photo of this device. This device is manufactured with a three-layer SOI wafer, wherein the electrostatic actuator is formed by the middle SOI layer and a nanostructure having an electrode terminal is formed by the top SOI layer. A special technique is implemented in this process to produce the nanostructure in freestanding form.

4. Conclusion

This was a report on nano-scale measurements using micromachining technology. The present study was limited to devices for measuring silicon nanostructures. However, there has recently been increasing interest in bio-nano objects, such as DNA, thereby necessitating a system capable of routinely measuring such objects. To aid in these measurements, we are developing integrated microactuator devices called nano-grippers and nano-testers. Please take a look at these devices, as well.

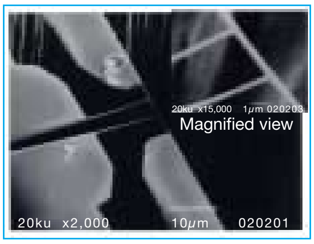

Fig. 1 SEM photo of a four-terminal free-standing silicon element

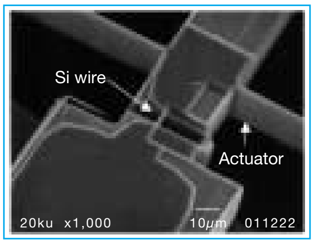

Fig. 4 An integrated electrostatic actuator type mechanical nanostructure testing device

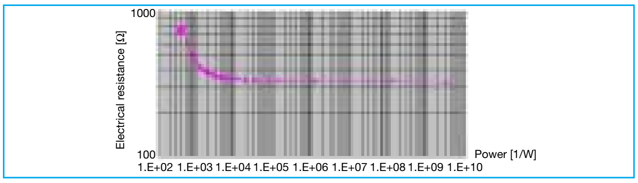

Fig. 2 Resistance variations in the free-standing nano wire

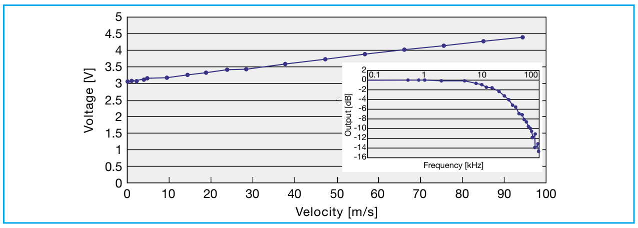

Fig. 3 Characteristics of a flow sensor employing a free-standing silicon nano wire

Integration of Chemical Systems toward Artificial Organs

Takehiko Kitamori, Professor, Department of Applied Chemistry, School of Engineering, The University of Tokyo
Hideaki Hisamoto, Lecturer, Department of Applied Chemistry, School of Engineering, The University of Tokyo

1. Introduction

It is believed that chemical conversion processes performed by organs, including metabolism, detoxification, and bio-synthesis, consist of cell response, enzymatic reactions, synthesis, and the like that progress very efficiently as a series of reactions within micro spaces, such as capillaries and cell surfaces.

We concluded that we could use microchannels, having a width of several tens to several hundreds of microns and manufactured on a microchip, in place of capillaries and accumulate elementary processes of organs, such as cell response, enzymatic reactions, and synthesis to achieve an efficient model of an artificial organ on a microchip, which would transcend a simple combination of macroscale reaction processes. The objective of this study was to detect multiple stage chemical conversion processes of sugar by integrating cell response, enzymatic reactions, and synthesis.

2. Integrating Modeled Chemical Reactions of an Organ on a Microchip

Fig. 1 shows our designed microchip, which comprises a cell culture bath, enzymatic reaction section, synthesis section, and sensing section. When lipopolysaccharide is introduced from an external source as a sugar and reacted with microphage, nitric oxide (NO) is produced. The generated NO is immediately converted into NO_2 and NO_3 by a reaction with water. Of these, NO_3 is converted into NO_2 by an enzyme introduced through a separate channel and subsequently generates a colored chemical species through a reaction with a mixing reagent introduced through the next channel. Hence, it is possible to confirm a series of chemical conversion processes by detecting this colored chemical species through a thermal lens microscope.

While it required half a day to detect the above series of reactions using a simple combination of macroscale reaction processes, the same series on a microchip only took 30 minutes. This indicates that by introducing a sugar into an artificial organ, such as a microchip, a colored chemical species is efficiently produced through various chemical processes.

3. Conclusion

The integration of elementary processes in a micro space, as described above, is extremely important to the realization of organ functions and other advanced biological functions on an artificial device. In the future we hope to be able to construct even more complex biological function mimicking devices by integrating many technologies, such as molecular fixation and a technique for fabricating functional separation membranes on a single chip. We also hope to apply this new knowledge to reproduction engineering and artificial organ development.

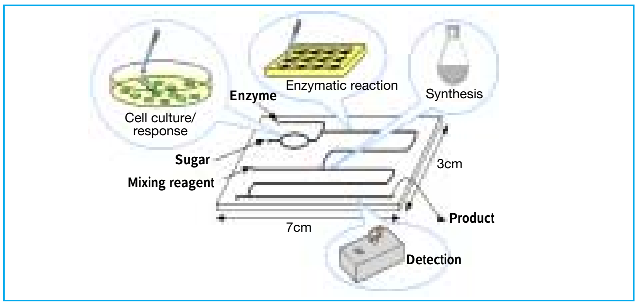

Fig. 1 Integrating Organ Chemical Reactions on a Microchip

Activities of the Micromachine Center in Fiscal 2001

I. Investigation and Research on Micromachines

1. R&D on a Micro-Fluid System for the High Speed Measurement of Dioxins (Commissioned by the New Energy and Industrial Technology Development Organization [NEDO])

This project applies a branch of micromachine technology called micro-fluid system technology to methods for analyzing dioxins in exhaust gas. The goal of the project is to develop micro-fluid element technologies. Research in Fiscal 2001 included the examination of micronized dioxin pre-treatment systems and micro-device specifications; and the testing and evaluation of unit operation devices (absorption, extraction, and condensation) and cooling and temperature distribution measuring devices (regarded as structural requisites in micro-fluid systems). R&D was also conducted in areas related to processing technology, such as microchannels and micro-fluid connectors.

2. Investigation and Research into the Applicability of Basic and Sprout Technologies in Other Fields to Micromachine Technology

This joint study between industry and academia is aimed at encouraging the establishment of theories in micro and nano science and engineering and probing for technological seeds necessary for promoting the merging and application of micro and nanotechnologies. Research on the following two themes was begun in 2001.

(1) Research Related to Cell Manipulation

Discussions will be held among specialists in a diversity of fields focusing on the methodology, significance, and future direction of cell manipulation, at the same time as technology streams are merged and integrated. Thus formulated, this new national research project proposal will aim to raise the curtain on nanotechnology, the next challenge in the field of micromachine technology.

(2) Research Related to the Field of Nano-Optics

A committee to examine research in the field of nano-optics was established and is ready to begin its investigative activities.

3. Research on Constructing a System for Evaluating the Micromachine Market

To upgrade statistics on micromachine technology based industries, a survey of market research, data/sampling, and evaluation methods was conducted.

4. Investigation of R&D Trends in Micromachine Technology in Japan and Abroad (Collation and Analysis of the Latest, Detailed Information from within Japan and Overseas)

5. Research into the Concept of Foundry Network System Micro-/Nano-Production Technologies (Commissioned by the Mechanical Social Systems Foundation)

This research forms the foundation for the industrialization of micro-/nano-technologies; thus, the potential of foundry network system micro-/nano-production technologies has been examined, an investigative committee established, and the following objectives achieved.

(1) Demonstration of the significance of micro-/nano-production technologies and the necessity for industrialization and foundry services.

(2) Survey of the situation regarding foundry services overseas and the industry-government-academia relationship in Japan

(3) Questionnaire conducted regarding demand for foundry services

(4) Reconfirmation of the primary purpose of foundries from the results of the survey on the current situation of foundries and issues identified.

(5) A concept proposed for a foundry network system (FNS) that is consistent with the current situation in Japan and which is also necessary if Japan is to continue leading the world in this field.

(6) Presentation of the practical roles required of industry, government, and academia in FNS.

6. Research Relating to Functional Expression and Process Technology in the Field of Micro-/Nano-Fusion (Commissioned by the New Energy and Industrial Technology Development Organization [NEDO])

In this research, surveys were conducted in relation to Micro-/Nano-Fusion Functional Expression Technology, a new technology for use in the new functional expression fields, such as process technology. As part of this research, a workshop, R&D in the Field of Micro-/Nano-Fusion, was held.

7. Research Related to the Creation of Systems Incorporating Next-Generation Micromachine Technology (Commissioned by the Mechanical Social Systems Foundation)

This research project was begun in Fiscal 2000. This survey has thus far shown that the application of micromachine technology in national projects conducted before and during Fiscal 2000 have enabled the achievement of significant results in the technological and industrial fields. In addition to focusing particular attention on certain fields, through this research we have been able to clarify the practical role required of government, academia, and industry and to formulate strategies for R&D in the micromachine technology field.

II. Collection and Provision of Micromachine Information

Information and documents on micromachines in universities, industries, and public organizations both in Japan and overseas have been collected, combined with survey results compiled and documents produced by MMC, and made freely available in the MMC library.

1. Maintenance and Expansion of the MMC Library
2. Publication of a Micromachine Periodical
3. Publication of a Newsletter
4. Database Construction and Data Management System Operations(indexed full-text retrieval)

III. Exchange and Cooperation with Worldwide Organizations Involved with Micromachines

1. Providing Research Grants for R&D on Micromachine Technology (3 new themes and six themes carried over from FY 2000)
2. Participating in the 7th Micromachine Summit and Holding Overseas Seminars

(1) Participated in the 7th Micromachine Summit (Freiburg, Germany: April 30 - May 2, 2001)

(2) Held European Seminars in Finland and Greece in June 2001

(3) The 7th International Micromachine Symposium (October 31 - November 1, 2001) held at the Science Hall, Science Museum in Kitanomaru Park, Tokyo

IV. Standardization of Micromachines

1. Research and Development for Standards "Standardization of Quality/Characteristic Measurement/Evaluation for Micromachine Materials" (Commissioned by the New Energy and Industrial Technology Development Organization [NEDO])

The three-year plan for the standardization of quality/characteristic measurement/evaluation for micromachine materials reached its final year in 2001. Round robin testing (RRT) was conducted in the tensile testing of various types of thin-film materials, which was the final objective of the project. This completed the R&D conducted to obtain the technological data required for submitting proposals for international standardization.

2. Investigation and Research into Micromachine Standardization

The Micromachine International Standardization Forum, organized mainly by the standardization committee, was established on the Internet as a method for promoting international standardization initiatives. As the standardization of evaluation standards for measurement WG has been promoted in the International Standardization Forum, an abstract (in English) is being prepared for inclusion in the MCC Technical Report "Measurement Evaluation Methods for Micromachine Technology." The specialist term WG was also coined following Forum discussions.

V. Dissemination of Information and Education about Micromachines

1. Publication of a Public Relations Quarterly Magazine "MICROMACHINE"
2. Transmission of Information via the Internet (website : http://www.mmc.or.jp/)
3. Organization of the 8th Micromachine Drawing Contest
4. Micromachine Seminars held in Japan (in Akita on September 14, 2001, and in Hiroshima on February 8, 2002)
5. Seminar presenting the results of "Research on the Applicability of Emerging Technology in Other Fields to Micromachine Technology in FY 2000" (held on July 16, 2001)
6. Workshop presenting the results of "Research Subjects for the 7th Micromachine Technology Research Grants (FY 1999)" on September 11, 2001
7. The 12th Micromachine Exhibition (October 31 - November 2, 2001) held at the Science Museum in Kitanomaru Park, Tokyo

TOPICS

The 8th Micromachine Summit

The 8th International Micromachine Summit was held for three days, from April 30 to May2, 2002, in Maastricht, the Netherlands, just near the border of the co-host nation, Belgium. The Summit, chaired by Professor Albert van den Berg from the University of Twente MESA + Research Institute and Mr. Kris Baert from IMEC Belgium, brought together high level experts from around the world to discuss the present status and future outlook for micromachine technology.

The common topics at the Summit were the fundamentals, the applications, the industrialization, and the education of micromachine technology. And this summit put particular emphasis' on technical transfer and industrial infrastructure, the rapidly advancing field of biotechnology and nanotechnology such as lab-on-a-chip.

The Summit presented major initiatives such as the CEA in France, a huge site which is hosting research facilities of industry, university, government and related institutions such as NEXUS and EURIMUS. The CEA is designed as the largest micro and nanotechnology "innovation center" in Europe based on the close interdisciplinary and industry-university-government cooperation in research and the synergic effects brought by these collective research. Participants also heard about large-scale ultra-clean rooms such as IMEC, set up by the government of Flanders in Belgium. IMEC boasts 24-hour, seven-day operation, and performs commercially-oriented joint research work based on the contract with over 450 private companies and research institutions worldwide.

The Japanese presentation discussed the set-up of the Council for Science and Technology Policy chaired by Prime Minister Koizumi. And the Council has taken up nanotechnology as one of the priority items to be industrialized effectively for new economy developments in Japan. And the Japanese delegation discussed that it will be needed to study a new technology called "micro-nano fusion area technology" which encompasses "top-down" development of micromachine technology that must be complemented by "bottom-up" development of nanotechnology.

The summit was attended by 74 delegates from 19 countries and regions, including three delegates and four observers from Japan. The 9th International Micromachine Summit will be held at the end of April, 2003, in Beijing, China.

The Eighth International Micromachine/Nanotech Symposium

Foundation of Industrial Technology in the 21st Century

1. Date : 14th Nov. 2002
2. Place : Science hall, Kagaku-Gijutsu-Kan, in Kitanomaru park, Tokyo
3. Entrance fee : 17,000 yen/person (Include Proceedings)
4. Acceptance of participants : (till) 31st Oct. 2002
5. Information window : Micromachine Center, International Exchange Dept.
Tel : 03-5835-1870 Fax : 03-5835-1873

❋❋❋❋❋❋❋❋❋❋❋❋❋❋❋❋❋❋❋❋ **PROGRAM** (Tentative) ❋❋❋❋❋❋❋❋❋❋❋❋❋❋❋❋❋❋❋❋

November 14, 2002

9:00 –	Registration	As of August 7th
Session 1 : Opening		**Chairman : Mr. T. HIRANO**
9:30 – 9:35	Opening Remarks	Mr. Toshiro SHIMOYAMA, Chairman, Micromachine Center
9:35 – 9:40	Guest Speech	Director-General,Manufacturing Industries Bureau, METI
9:40 – 10:20	Special Guest Speech: strategy towards Fusion of Nano and Micro systems	Prof. Isao SHIMOYAMA, Tokyo University
Session 2 : The Path to New Industries in the 21st Century		**Chairman : Prof. H. FUJITA**
10:20 – 10:45	International Standardization of MEMS	Dr. Kuniki OHWADA, International Standardization Engineering Laboratory
10:45 – 11:10	Standardization of Tensile Testing Method for Thin Film Material –Round Robin Test of Thin Film Specimen–	Toshiyuki TSUCHIYA, Toyota Central R&D LABS INC
11:10 – 11:35	MEMS in China, Especially in Shanghai Area	Prof. Yilong HAO, Peking University (to be confirmed)
11:35 – 12:00	MMC's Initiative towards Foundry Service Network	Foundry Service Industry Committee
12:00 – 13:00	❋❋❋❋❋❋❋❋❋ Lunch ❋❋❋❋❋❋❋❋❋	
13:00 – 13:30	The Sensibility of Scaling Recognition	Prof. Kazuo KAWASAKI, Nagoya City University Medical School
Session 3 : Innovative R & D		**Chairman : Prof. K. IKUTA**
13:30 – 14:00	Health care Chip	Prof. Yasuhiro HORIIKE, Tokyo University
14:00 – 14:30	Micro-fluidics for pre-process of Dioxin Measurement	Dr. Ryo MIYAKE, Hitachi Ltd.
14:30 – 15:00	Advanced MEMS Research in US	(to be decided)
15:00 – 15:30	Nano Photonics	Prof. Kobos KUIPERS, MESA
15:30 – 16:00	❋❋❋❋❋❋❋❋❋ Break ❋❋❋❋❋❋❋❋❋	
Session 4 : National Strategy for Micro/Nano Fusion domain		**Chairman : Prof. I. SHIIMOYAMA**
16:00 – 16:30	Strategy to enhance the application of micro @ nano-technology in France	Dr. Dirk BEERNAERT, European Commission
16:30 – 17:00	Cooperation Practice between Academy and Industry	Prof. Susumu SUGIYAMA, Ritsumeikan University
17:00 – 17:30	Bio Nano technology in 21st century, CELLOMIX	Prof. Teruo OKANO, Tokyo Women's Medical University
17:30 – 18:00	National Strategy on NEMS/MEMS in France	Dr. Constant AXELRAD, CRE
Session 5 : Closing		
18:00 – 18:10	Closing speech	Mr. Takayuki HIRANO, Executive Director, Micromachine Center

Members' Profiles

Moritex Corporation

Yukoh Morito
President and CEO

Moritex Corporation is developing projects in diverse fields, including fiber optic illumination, imaging, optical communications, bioscience, and new materials, based on such technologies as fiber optics, machine vision, automatic alignment of optical devices, bio-instrument automation, spheres, optical lenses, and software.

Moritex's involvement in the field of micromachines began shortly after its foundation when it began importing and selling microspheres manufactured by Duke Scientific Corporation. Ten years ago, Moritex joined forces with the Research Development Corporation of Japan (presently the Japan Science and Technology Corporation) to develop laser tweezers called a laser manipulator that uses optical radiation pressure. In 1998 Moritex participated in a photon control project for studying the measurement and processing of submicroscopic matter using light and began conducting research on optical fiber probes for observing near-field optics around objects in high-resolution, on the nano-meter order.

In October 2000, we began forming alliances with domestic and overseas manufacturers having their own processing technologies through commissioned production and sales of microstructure parts. Our company focused on processing using X-ray deep lithography as a departure from semiconductor fabrication. This technology is called a LIGA process. A feature of the LIGA process is its capability for manufacturing three-dimensional parts with a high aspect ratio using X-rays. This technology is one of the most anticipated for future micromachining because of its high precision processing capacity, including minimum dimensions on the order of submicrons and maximum dimensions of several ten micrometer or greater. Many of the processes performed by X-ray deep lithography are described below.

1) Processing resist material by lithography using an X-ray light source obtained by synchrotron radiation (SR)
2) Producing dies by electroforming (electroplating)
3) Processing microparts formed of various materials by precision molding (plastic molding)

Synchrotron radiation is an electromagnetic wave emitted when the paths of electrons accelerated near the speed of light by a synchrotron accelerator bend. The wavelength of synchrotron radiation spans from visible light to the X-ray region and is noted for a high brightness and sharp directivity comparable to laser light. Moritex uses small SR rings developed for industrial use as short electron path rings in the production of microparts. Use of these small SR rings allows us to eliminate the electroforming and precision molding processes and mass-produce (tens of thousands per month) PMMA (resist material) microparts at a low cost.

In addition to the LIGA process, Moritex sells microparts produced by the TIEGA process. This is a micromachining process that effectively uses radiation etching of Teflon (PTFE), which has a particularly high processing rate.

Moritex has already begun sales of LIGA-microspectrometers in conjunction with Germany's Microparts Co. The microspectrometers incorporate a diffraction grating produced through the LIGA process. Developments in our business have been focused on manufacturers of colorimeters, liquid densitometers, thin film measuring instruments, and the like. Currently we are engaged in research on molding technologies for ultrafine nonreflective constructions and glass chip microfabrication technology, and are undertaking commissioned production of micromachined components, including optical switches and VOA (variable optical attenuators), which are key devices for DWDM networks. Future plans call for assembling production equipment to develop our own products, including optical elements, microprisms, and lens arrays.

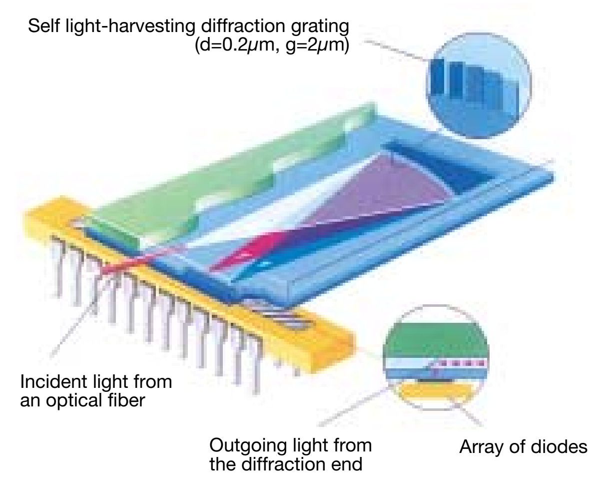

Fig. 1 LIGA-microspectrometer

Worldwide R&D

Nano Coordinate Measuring Machine and Nanoprobe

Kiyoshi Takamasu, Professor, School of Engineering, the University of Tokyo

One objective at our laboratory is to develop a three-dimensional measuring instrument called a Nano CMM (Nano Coordinate Measuring Machine) for measuring objects three-dimensionally with nanometer resolution. Currently, we can measure the three-dimensional surface of objects with nanometer resolution using STM and AFM. However, we are unable to truly measure three-dimensional shapes, such as the diameter of holes formed in the side of an object, surface direction, or related dimensions. We believe that a device for measuring three-dimensional sizes, positions, and other shapes on a nanometer order will be an indispensable basic tool in the future development of micromachines. The necessity for this research was first proposed at our laboratory, after which we began development. Recently, however, many other countries, including Germany, Holland, and UK, have been developing instruments for the three-dimensional measurement of objects on a nanometer order.

Fig. 1 shows the construction of a Nano CMM. This three-dimensional measuring instrument was made more compact for measuring three-dimensional shapes and dimensions in the automobile industry and the like. About 300 x 300 x 200 mm in size, this device has a measuring range of 10 x 10 x 10 mm and a resolution of 10 nm. The measuring device has a symmetrical construction with a double Vee groove guiding mechanism and employs a position sensing method using an optical scale to achieve high stability. Fig. 2 shows a prototype of the Nano CMM. When measuring the absolute shape and dimensions of objects on a nanometer order, the factor causing greatest error is temperature drift. When a 100-mm length of iron rises 1 degree in temperature, 1μm of thermal expansion occurs. This effect is directly reflected in the measured value. This prototype can restrain thermal drift of about 10 nm in an environment of about 0.1 degrees, as the entire mechanism is constructed of material having low thermal expansion and is designed to restrain the effects of temperature.

The most problematic point in Nano CMM research worldwide lies in the probing system. Numerous contact-type probing systems have been used in three-dimensional measuring devices in order to achieve stable measurements of three-dimensional positions and dimensions for objects formed of a variety of materials and having a variety of surface conditions. A contact-type Nanoprobe having two-dimensional or three-dimensional sensing capacity and resolution on the nanometer order is necessary for Nano CMM.

Fig. 3 shows the construction of a Nanoprobe and a prototype that we developed. The object to be measured is contacted by a small ball having a diameter of less than 0.5 mm. An optical sensor detects the movement of the ball. By combining a contact-type measuring instrument and optical sensor in this way, it is possible to construct a reliable Nanoprobe capable of high resolution.

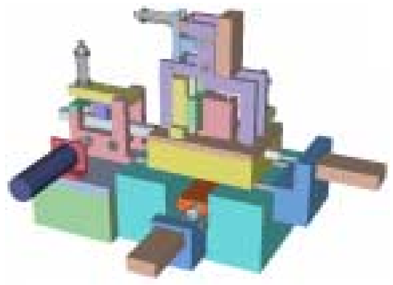

Fig. 1 Construction of a Nano CMM

Fig. 2 Prototype of the Nano CMM

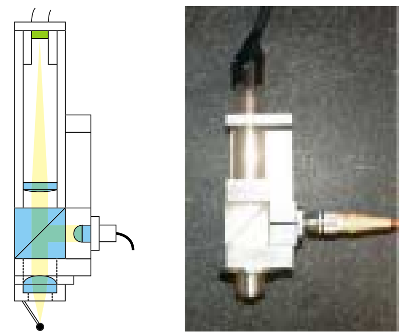

Fig. 3 Construction and prototype of a Nanoprobe

As described above, development is proceeding on Nano CMM and Nanoprobe, which will become basic tools for developing future micromachines. However, various issues remain before these devices can be put to actual use, such as the establishment of a method for calibrating the measuring instrument, as well as evaluations of the reliability and the durability of the device. Our laboratory hopes to continue leading the world in research on establishing Nano CMM.

MICROMACHINE No. 40

MICROMACHINE is published quarterly by Micromachine Center (MMC) to promote the international exchange of information related to micromachines, R&D and other technical topics, and is circulated free of change. Please send your comments about **MICROMACHINE** to the publisher :

Takayuki Hirano, Executive Director, Micromachine Center (MMC)
MBR99 Bldg., 6F., 67 Kanda Sakumagashi, Chiyoda-ku, Tokyo 101-0026, Japan
Tel : +81-3-5835-1870, Fax : +81-3-5835-1873
Internet Home Page http://www.mmc.or.jp/

Change of Address : Please send old address lebel and new address to the publisher.
Editorial and Production Management : Japan Technical Information Service (JATIS)
Date of Issue : August 22, 2002