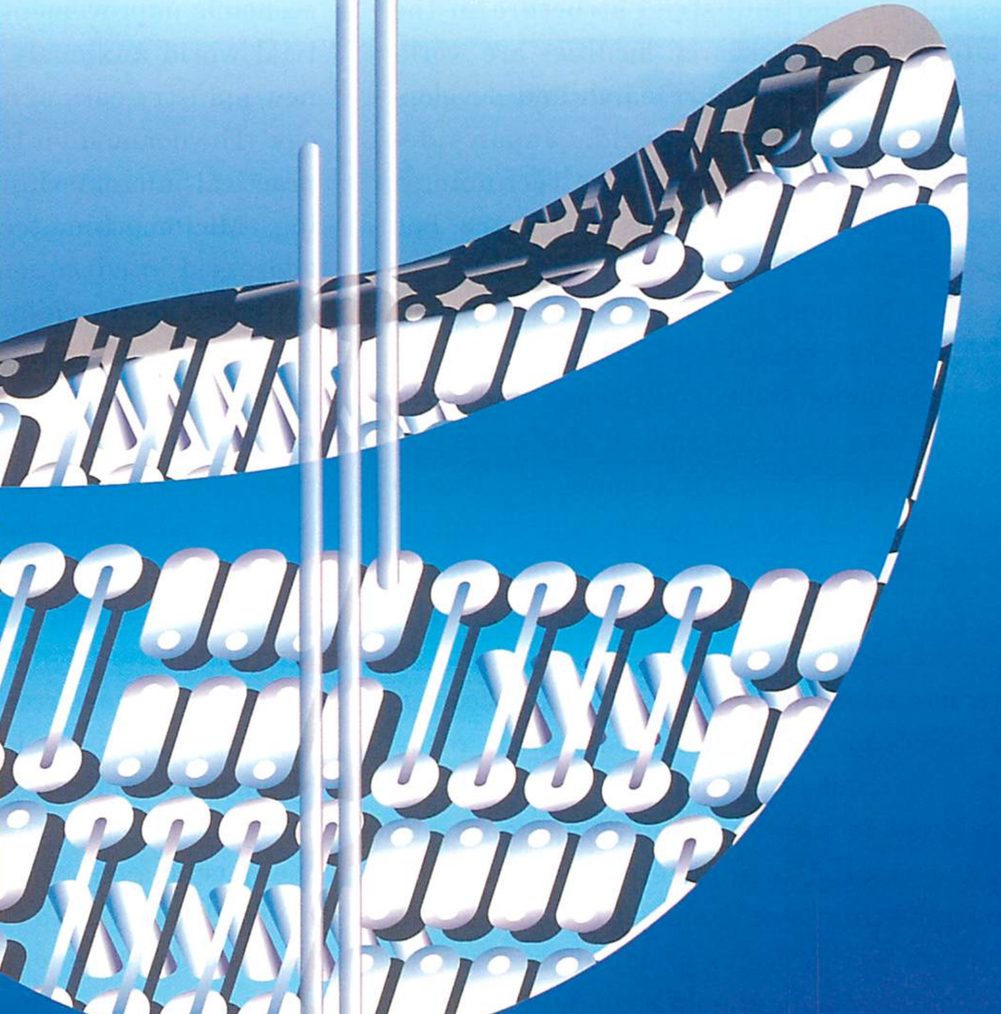
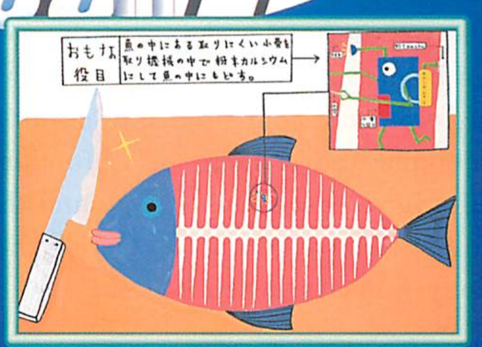
MMC Micromachine
マイクロマシン

May 1998

- Micromachines as a Vehicle for the Dreams of the 21st Century
- Res. at U. of Electro-Communications
- MMC's Act. in F.Y. 1998 / 5th Res. Grant / Okinawa Seminar / 4th Drawing Contest
- Members' Profiles : TERUMO / JET
- Foreign View
- Topics
- Introductory Course Portable Micromachine Exhibits (I)
- Events





No. 23

MICROMACHINE CENTER

Essay

Micromachines as a Vehicle for the Dreams of the 21st Century

Dr. Tsuneo Ishimaru
Chairman, Micromachine Center

It is anticipated that micromachine technology will be one of the keys to a richer social life and industrial structure in the future. Today, research facilities are working on micromachine research and development throughout the world. Japan's development of micromachine technology, spanning a variety of fields of research, has garnered worldwide attention.

The National Research and Development Project "Micromachine Technology" started in 1991 under Industrial Science and Technology Frontier Program of the Agency of Industrial Science and Technology. Due to the efforts of the companies and organizations involved, the project has made steady progress, and is now in its eighth year. The second phase of the project, which aims to realize micromachine systems, has been in progress for two years and is nearly ready for real trials of micromachine systems. As various technological developments are incorporated into ordered systems, the micromachine vision should become clearer, and issues concerning practical use of micromachine systems should be found.

Although the 21st century is near and scientific technology has been continually advancing, issues such as economic depression, environmental problems and crimes committed by young adults have cast shadows over the future. Against this backdrop, micromachine technology has attracted favorable attention in the mass media such as newspapers and television. Hoping for economic improvement, people of the industrial world anxiously await the birth of a new industry born of micromachine technology. The demand for the rapid realization of practical micromachines has been increasing. Micromachine technology is now being addressed in educational materials such as textbooks for the children who will be building our future. In this way, micromachines have become the focus of attention for many people, if not quite for the general population. We are now publicly demonstrating portable exhibits produced with the cooperation of supporting member companies for the visitors to various events and to the Micromachine Center. We hope that the progress in research & development of micromachine technology will be recognized by engineers and others alike.

We believe that the best way to promote the development and implementation of a new technology is to enable as many people as possible to understand the technology and its usefulness, and to encourage them to work together to make the vision a reality.

The Micromachine Center will continue to do its best to promote the establishment of fundamentals of micromachine technology and the popularization of micromachines across the nations and the generations.

Desktop Flexible Factory Utilizing Miniature Robots with Micro Tools and Sensors

Hisayuki Aoyama
Associate Professor, Dept. of Mechanical & Control Engineering
University of Electro-Communications, Tokyo, Japan

1. Introduction

In our laboratory (http://www.aolab.mce.uec.ac.jp), unique research is conducted with the goal of developing insect-sized robot armies capable of precision work on a sub-micrometer scale (1 μm = 1/1000 mm), remote control systems for those robots, and "Desktop Micro Factories" comprised of such robots and systems. We are also developing efficient integrated systems that combine these tiny robots and robots of conventional size, designing robots that operate in vacuum and under water. The leading-edge devices used to manufacture micromachine parts are very expensive and consume a great deal of energy. However, the minirobots to be introduced in our laboratory can be produced using normal machine tools. With the addition of alternative microsensors and actuators, their range of utility can be broadened even further.

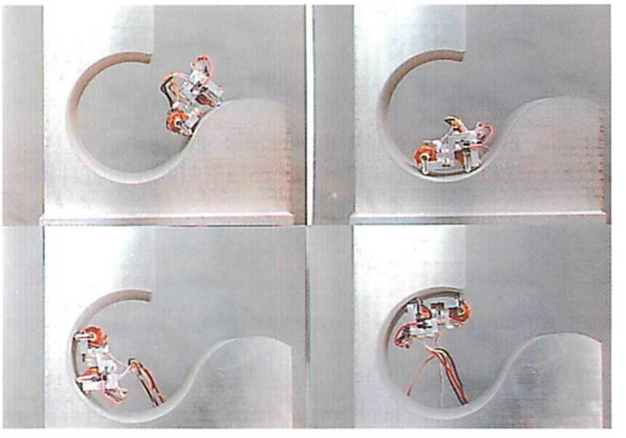


Fig. 1 Minirobot precisely navigating an 8-cm-diameter S-shaped surface

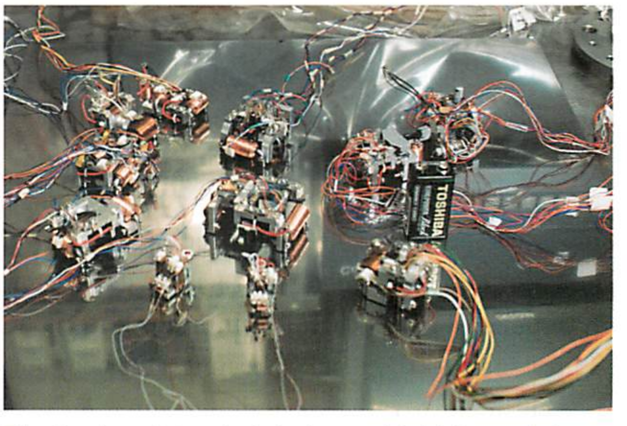


Fig. 2 A variety of minirobots with high-precision operational functions developed to date

2. Performance of Micro-locomotion

Fig. 1 shows micro-locomotion machines that are used in tandem in our research. With a size of around 3 × 3 × 3 cm and weight of about 50 g, they can be held in the palm of the hand. On each side of the machine unit are electromagnetic U-shaped legs, and a pair of piezoelectric elements is installed between each set of legs. When a 100-volt potential is applied to the piezoelectric elements, they expand and contract by a few micrometers. By coordinating the timing of the engagement of the electromagnets and the timing of the expansion and contraction of the piezoelectric elements, an "inchworm" effect is achieved, and precise movement becomes possible. If the surface on which the machine crawls is made of iron, it is possible to maintain a precise "stride" even across ceilings and walls. The degree of micro-locomotion can be made as small as 0.1 μm, and at a maximum degree of movement of 20 μm and a frequency of 100 Hz, movement at up to approximately 2 mm/s succeeded in the experiment.

3. Microrobot Families and Examples of Microproduction

Fig. 2 shows a microrobot family. These robots, developed at our lab, are capable of a variety of micro-operations. Using these robots, we have achieved extremely precise processing

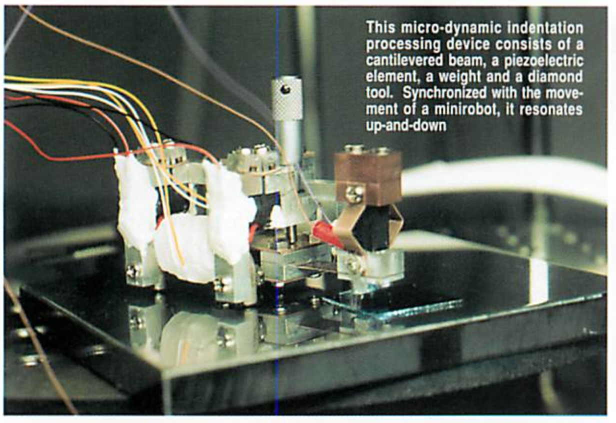


Fig. 3 Precision minirobot equipped with mechanical-resonance microhopping tool

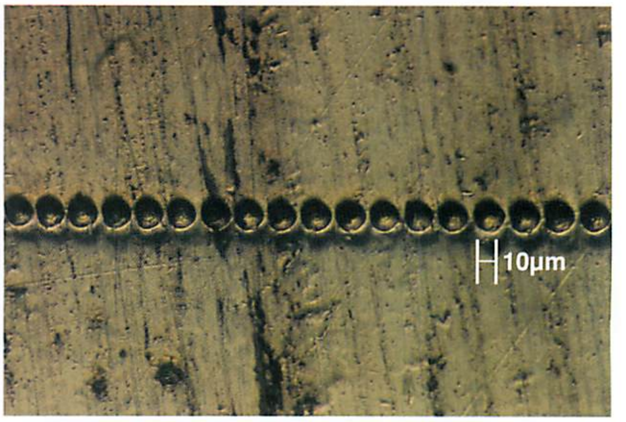


Fig. 4 Surface of material after dynamic indentation

and measurement. For example, Fig. 3 shows a minirobot equipped with microhopping tools. On the side of the minirobot, we have attached a beam that vibrates vertically, in mechanical resonance. On the end of this arm is a diamond tool with a diameter of 5 μm. Large vibrations achieved by moving the arms in resonance with the precise movement of the minirobot result in microindentation of the surface being traveled. As a result, tiny indentations can easily be created at precise intervals, as shown in Fig. 4. Fig. 5 shows a mechanism for the production of fine thin-film elements inside a vacuum deposition chamber. Within this mechanism are three minirobots. As the mask-carrying minirobot and the specimen-carrying robot determine their precise positions, they can freely create thin-film metal patterns.

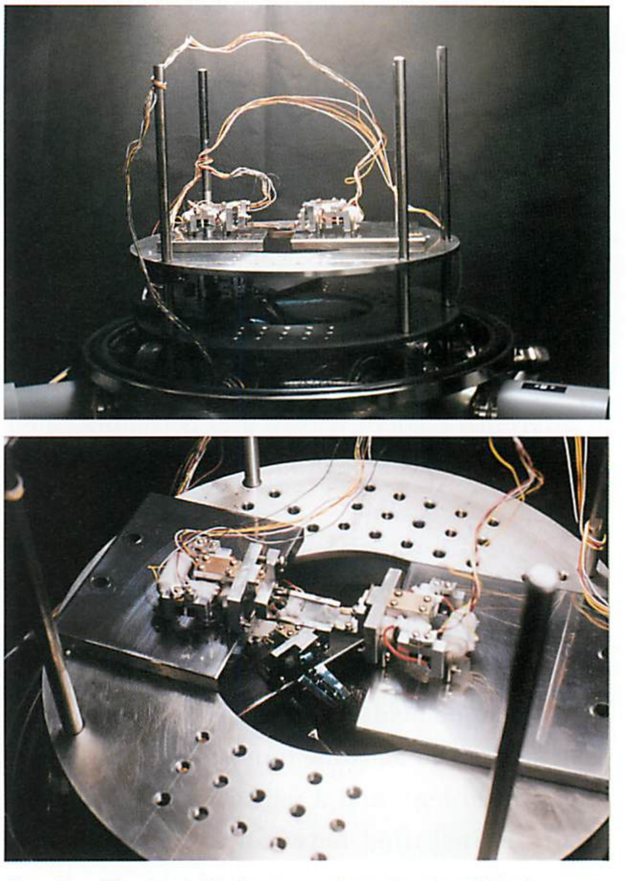


Fig. 5 Three minirobots performing localized control of a thin film in a vacuum deposition chamber

4. Conclusion

At the Department of Mechanical and Control Engineering at the University of Electro-Communications (http://www.mce.uec.ac.jp/), we are also researching and developing indoor garbage-collecting robots, construction-site robots, disaster-rescue robots, one-wheeled robots, robots for assisting the elderly, musical instrument performance robots, and other unique robots.

Overview of MMC's Activities in Fiscal 1998

In F.Y. 1998 the Micromachine Center (MMC) will implement the following five programs with the aim of establishing the basic technologies for micromachines and increasing utilization of micromachines.

① Investigations and research on micromachines,
② Collection and provision of micromachine information,
③ Exchange and cooperation with worldwide organizations involved with micromachines,
④ Promotion of standardization of micromachines,
⑤ Dissemination and education about micromachines.

I. Investigations and Research on Micromachines

The industrial Science and Technology Frontier Program of MITI's Agency of Industrial Science and Technology (AIST) has entered the third year of its second term. To achieve the goal of the basic plan for the R&D (Phase II), the R&D system will be further improved and research delegated to MMC will be actively promoted. Also MMC will exchange technical information with researchers in various countries and provide results of investigations and research for those concerned in and outside of Japan.

1. The AIST's Industrial Science and Technology Frontier Program "Micromachine Technology" (This project has been delegated to MMC by the New Energy and Industrial Technology Development Organization (NEDO).)

Based on the R&D results on fundamental device technology in the first phase, the ultimate purpose of this project is to establish technologies applicable to the realization of micromachine systems. These systems are mechanical systems composed of small functional elements that locomote within very narrow spaces in complicated equipment used at power plants and other facilities and inside of the human body. They can also perform intricate work autonomously, and produce small industrial products as a microfactory.

(1) Development of advanced maintenance technologies for power plants

① R&D of systematization technology (Experimental wireless micromachine for inspection on inner surface of tubes)

R&D of systematization technology will be conducted through production of an experimental system for a wireless micromachine. Inside a metal tube with a curved section, this micromachine will be able to move forward, backward, horizontally and vertically, stop optionally, and recognize its surroundings as well as detect defects of tubes.

R&D topics promoted are: realization of an experimental wireless micromachine for inspection on inner surface of tubes through developing a locomotive device and a microwave energy-supply/communication device as the main technology; and systematization of a microvisual device and an optical energy transmission device.

② R&D of systematization technology (Experimental chain-type micromachine for inspection on outer surface of tubes)

Systematization technology will be developed through production of an experimental micromachine system composed of a group of single machines capable of combining or separating according to the form of the object to be inspected.

R&D will promote the following topics: creation of an experimental chain-type micromachine for inspection on outer surface of tubes through developing a driving device to propel the machine; and systematization of reduction and traveling devices and a microconnector.

③ R&D on systematization technology (Experimental catheter-type micromachine for repair in narrow complex areas)

R&D on systematization technology will be conducted by producing an experimental micromachine system capable of entering the equipment of various structures and performing measurements or repairs of minute internal flaws.

R&D topics promoted are: creation of an experimental catheter-type micromachine for repair in narrow complex areas through developing a multi-degrees of freedom flexible pipe structure; and systematization of a position detection device and a monitoring device.

④ R&D of functional device technologies

R&D will be conducted to promote micronization, high performance, and multi-functionalization of functional devices that form the components necessary to realize future micromachine systems and highly advanced micromachine technology.

R&D will focus on creating the following: an artificial muscle, microjoint, low-friction suspension device, rechargeable micro-battery, optically driven free joint device, etc.

R&D will focus on creating the following: an artificial muscle, microjoint, low-friction suspension device, rechargeable micro-battery, optically driven free joint device, etc.

⑤ R&D of common basic technologies

R&D will be conducted on common basic technologies such as technologies for control, measurement, design, and evaluation necessary for realizing micromachine systems.

R&D will center on achieving: pattern forming technology for a group of distributed micromachines, hierarchical group control technology, measuring technology for micromachines, etc.

⑥ Comprehensive investigation and research

Comprehensive investigation and research on micromachine technology will be promoted including investigation and research to conduct the basic design of maintenance micromachines necessary for maintaining future power plants, and leading investigations and research on micromachine systems expected to be used for maintenance.

(2) Development of microfactory technology

① R&D of experimental processing and assembly technology

R&D will be conducted on systematization technology by producing an experimental system for processing and assembling capable of manufacturing models of small parts by integrating processing, assembly, conveyance, and inspection machines in a limited narrow space.

R&D topics promoted include: micro processing technology, micro assembling technology, micro fluid technology, micro optical driving technology, micro electric driving technology, micro conveyance technology, and micro inspection technology.

② Comprehensive investigation and research

Comprehensive investigation and research on micromachine technology will be promoted including: investigation and research on the influence of microfactories including problems such as electromagnetic interference caused when various devices are integrated or concentrated in a narrow space; leading investigation and research on micromachine systems that will be applied in the production field.

Also, we will analyze the economic efficiency of microfactories and conduct research on micro-vibration control of microfactory platforms together with the Mechanical Engineering Laboratory of AIST, and research on increasing the performance of micro-electron guns for beam processing jointly with the Electrotechnical Laboratory of AIST.

(3) Research and development of micromachine technology

① Research on micromachine systems

In the medical field, R&D on miniaturization and multi-functionality of micro-laser catheters and micro-tactile sensor catheters will be conducted. These catheters are the major functional components of a micro-catheter for diagnosis and treatment of cerebral blood vessels, an intraluminal diagnostic, and therapeutic system.

② Comprehensive investigation and research

Comprehensive investigations and research will be conducted on the future uses of micromachines in medical fields. With the Mechanical Engineering Laboratory of AIST, MMC will also conduct joint research on the basic design and manufacturing technologies for micromachines.

2. R&D of Micromachine Materials

Jointly with the Mechanical Engineering Laboratory of AIST, MMC will conduct ① research on the operating environments for micro functional elements, ② research on micromachine materials, and ③ feasibility studies on micromachine materials.

3. Investigation and Research on Fundamental Micromachine Technology (activities to help promote the machine industry)

To contribute to the promotion of micromachines and the dissemination of micromachines information, basic technology for the systematization necessary to construct various micromachine systems and promising technology in other fields will be explored and verified. This technology will be promoted jointly in the industrial and academic circles, and improvement of basic micromachine technology will also be undertaken. The following investigations and research will be conducted this fiscal year.

(1) Promising core technologies such as measuring methods for micro-objects and micro-control methods that are part of the basic technologies for micromachine systematization will be explored and verified.

(2) MMC will explore and verify those embryonic technologies that are not applied to micromachines directly at present, but that are likely to offer significant progress in micromachine technology through their fusion in coming years. These include promising technologies in other fields such as microorganism structures, high-dimensional complex structures and advanced functional structures.

4. Investigation and Research on Creation of New Industries by Micromachine Technologies (delegated activities to promote the machine industry)

There are high expectations for creating new industries through the application of micromachine technology, and there is a good prospect for practical applications in a large number of fields. MMC will identify changes in the industrial structure and develop future vision for creating new industries to disseminate micromachine technology. Specifically, MMC will continue the following investigation and research from F.Y. 1997, with the aim of increasing utilization and promoting micromachines in the future. ① Develop an image of new industries that will be created by fusing micromachine technology with other industries. ② Develop an image of the products created by micromachines that will substitute (better alternatives) for existing products. ③ Develop predictions on the economic effects and market size of the micromachine industry in the 21st century.

5. Study on Applications of Micromachine Technology

Building upon the results of research in F.Y. 1997, MMC will conduct a detailed study of technological possibilities for micromachine systems in people's lifestyles in the 21st century, and will define tasks related to new elemental technologies, and will investigate an effective framework for developing ripple effects in daily life. In this way, MMC will formulate the guidelines for developing micromachine technologies that can lead to significant improvements in everyday life and to vitalizing of the industry in the future.

6. Investigation on R&D Trends of Micromachine Technology in Japan and Abroad

MMC will analyze the current state of research and development on rapidly progressing micromachine technology in Japan and abroad, and develop a body of information on the basic technologies for developing micromachine technologies.

II. Collection and Provision of Micromachine Information

Information and documents on micromachines in universities, industry, and public organizations in Japan and overseas will be collected, combined with survey results and documents produced by MMC, and made freely available in the MMC library, as well as more broadly through the Internet.

III. Exchange and Cooperation with Worldwide Organizations Involved with Micromachines

To promote affiliation, exchange, and cooperation with related organizations in and outside Japan, MMC will implement the following: ① Provide research grants to research activities at universities for R&D on micromachine technology as part of its promotion of joint research with government, industry and academia. ② Invite authorities from other countries, and dispatch authorities from Japan, to promote overseas exchanges. ③ Dispatch researchers overseas. ④ Participate in the 4th Micromachine Summit. ⑤ Hold the 4th International Micromachine Symposium. ⑥ Hold joint seminars and workshops overseas.

IV. Standardization of Micromachines (partly delegated activity to promote the machine industry)

Based upon the F.Y. 1997 plan on standardization: ① Technical terms will be reviewed to achieve uniform usage worldwide, and these terms will be compiled in a glossary of terms in Japanese and English. ② Standardization will be promoted through individual detailed surveys of the instrumentation/evaluation methods. ③ To establish international standards at an early stage, cooperation with overseas standardization activities will be strengthened.

V. Dissemination of and Education about Micromachines

In order to achieve wider utilization of micromachines, MMC will implement the following: ① Publish and distribute public relations magazines. ② Hold the 5th Micromachine Drawing Contest and seminars on micromachines. ③ Hold the 9th Micromachine Exhibition. ④ Serve as the Federation of Micromachine Technology Secretariat.

The Research Subjects for the 5th Micromachine Technology Research Grant

The research subjects for the 5th Micromachine Technology Research Grant (for F.Y. 1997) were selected at the Board of Directors meeting held in March 1998. As a result of a rigorous screening and examination process, eight new research subjects and four ongoing research subjects (2nd year) were selected from a large number of applications, as shown in the appended table. A total of ¥19.7 million in financial assistance grants will be presented. This research grant program was started in F.Y. 1993 as an independent activity of the Micromachine Center, and provides financial assistance to researchers engaged in basic research on various aspects of micromachine technologies. It is aimed at providing support for further progress of micromachine technologies, and for promoting exchange and cooperation between industry and academia.

On March 25, 1998, a ceremony to award the research grants was held at the Tokai University Alumni Hall in the Kasumigaseki Building. Dr. Tsuneo Ishimaru, Chairman of the Micromachine Center gave the sponsor's greeting, Mr. Makoto Nakajima, Director, Industrial Machinery Division of MITI gave his guest speech, and Prof. Yoji Umetani, Chairman of the Industry-Academia Joint Research Committee of the Micromachine Center reported on the results of the screening. Financial assistance awards were presented to the twelve researchers who were selected. Prof. Katsutoshi Kuribayashi of Yamaguchi University spoke on behalf of the grant recipients. Later, each of the eight researchers on the new research subjects that were selected gave an overview on their respective research, followed by an informal discussion.

Applications for the F.Y. 1998 research grant program will be solicited and accepted from July to October of this year.

The new research subjects that were selected for the 5th Research Grant are summarized in the following pages.

Subjects for the 5th Micromachine Technology Research Grant

New Research Projects Granted for Fiscal 1997

Leader & Co-Worker	Affiliations	Subjects	Period
Dr. Yoshinori Matsumoto	Research Associate, Department of Electrical and Electronic Engineering, Toyohashi University of Technology	Teflon-like films for eliminating adhesion and friction for micromachines	1 Year
Dr. Toshihiro Itoh	Lecture , Research Center for Advanced Science and Technology, The University of Tokyo	Plasma etching using scanning probe microscope	2 Years
Assoc. Prof. Atsushi Suzuki	Graduate School of Engineering, Yokohama National University	Development of mesoscopic memory by light-sensitive polymer gels	1 Year
Prof. Shuichi Shoji, Ph.D. Dr. Osamu Tabata	School of Science and Engineering, Waseda University Associate Professor, Faculty of Science and Engineering, Ritsumeikan University	Fundamental study on microchip for DNA analysis	2 Years
Prof. Katsutoshi Kuribayashi, Dr. Eng.	Faculty of Engineering, Yamaguchi University	Development of pre-stretching method of SMA thin film actuator on Si wafer	2 Years
Prof. Tadashi Matsunaga, Dr. Eng.	Faculty of Technology, Tokyo University of Agriculture and Technology	Development of a nano-probe for detection of a cell surface protein	2 Years
Dr. Kenji Suzuki	Lecturer, Graduate School, Faculty of Engineering, The University of Tokyo	Measurement and control of friction in micromachines	2 Years
Prof. Shojiro Miyake, Dr. Eng.	Faculty of Systems Engineering, Nippon Institute of Technology	Formation of nanometer standard rules by mechanical processing	1 Year

Carried-Over Projects Granted for Fiscal 1996

Leader & Co-Worker	Affiliations	Subjects	Period
Prof. Takashi Miyoshi, Dr. Eng. Dr. Yasuhiro Takaya	Faculty of Engineering, Osaka University Faculty of Engineering, Osaka University	Fundamental study on the micromachining by using the laser radiation force controlled diamond grain	2nd Year
Assoc. Prof. Masaharu Kameda, Dr. Eng.	Faculty of Engineering, Tokyo University of Agriculture and Technology	On the development of a micro-jet-pump driven by the acoustic cavitation phenomena	2nd Year
Prof. Takeo Shinmura, Dr. Eng.	Faculty of Engineering, Utsunomiya University	A new precision mirror finishing for micromachine elements by the application of magnetic abrasive machining	2nd Year
Assoc. Prof. Masahiro Ooka, Dr. Eng. Prof. Yasunaga Mitsuya, Dr. Eng.	Faculty of Science and Engineering, Shizuoka Institute of Science and Technology School of Engineering, Nagoya University	Development of micro three-axis tactile sensor	2nd Year

Mr. Makoto Nakajima, Director of Industrial Machinery Division, MITI, gives his greeting.

Researchers who received research grants for F.Y. 1997.

Outline of the New Subjects for the 5th Micromachine Technology Research Grant

Teflon-Like Films for Eliminating Adhesion and Friction for Micromachines

Yoshinori Matsumoto
Toyohashi University of Technology

In micromachines, we cannot ignore the impact of factors such as surface energy and hydrogen combinations, etc., in relation to mass. Problems occur such as parts and substrates becoming stuck while being produced or during use. This research project will develop a plasma polymerization method and monomolecular film forming method with the aim of forming a Teflon-type film (which is the material with the smallest surface tension) on the micromachine, to reduce the surface tension and adhesion. Teflon-type film is effective for reducing friction, so micromachine's yield will improve, reliability can be achieved, and a longer life span can be expected.

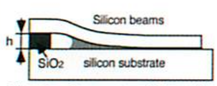


Fig. 1 Conceptual drawing of adhesion

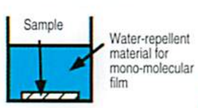


Fig. 2 Mono-molecular film formation method

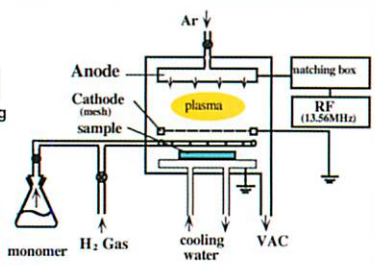
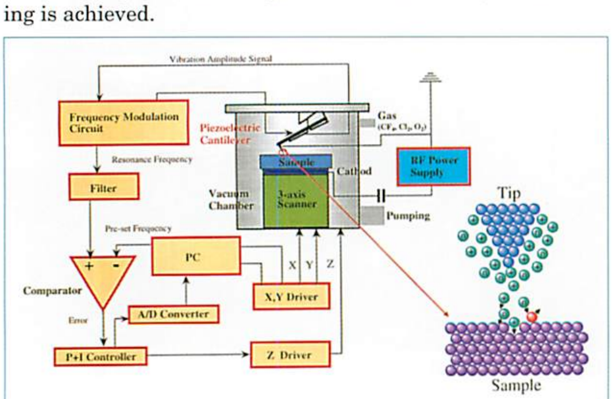


Fig. 3 Principles for plasma polymerization equipment

Plasma Etching Using Scanning Probe Microscope

Toshihiro Itoh
The University of Tokyo

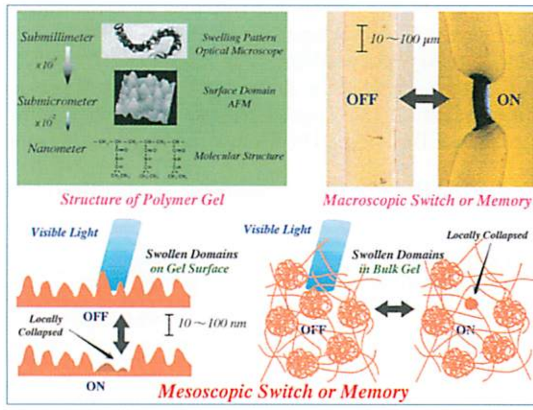
This is a research project on three-dimensional microprocessing of micromachine (semiconductor) materials such as Si and GaAs. We seek to achieve nanometer-scale microstructures by maskless-resistless direct processing using a scanning probe microscope at atomic scale resolution. Specifically, a reactive-type gas is introduced into a high-vacuum scanning probe microscope (a non-contact scanning atomic force microscope that uses conductive cantilever), and by applying direct-current or high-frequency voltage between the probe tip and the sample, nanometer-scale plasma etching is achieved.



Development of Mesoscopic Memory by Light-Sensitive Polymer Gels

Atsushi Suzuki
Yokohama National University

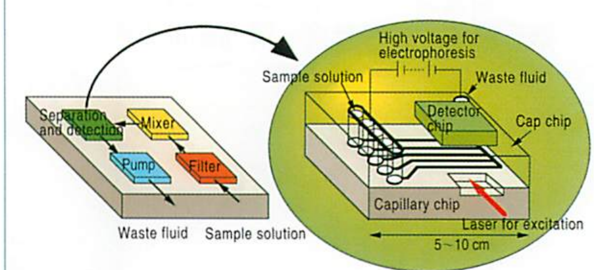
High polymer gel is a dilute solid with a complex structure. This soft, stimulus-responsive material of sub-millimeter size can be expected to be used as micromachine elements. In this research, we will use the unique characteristic of high polymer gel which responds to visible light and exhibits mass-phase transition. We will use the mesoscopic level domain structure of the gel surface and bulk, so that the switch memory function will become manifest, and explore the possibilities of gel as a nano-composite.



Fundamental Study on Microchip for DNA Analysis

Shuichi Shoji
Waseda University

Micromachine technology is expected to dramatically improve the precision and speed of gene diagnosis. In this research, we seek to develop the basic technology for the design and manufacture of fluid components that takes into account the handling and fluid characteristics of micro-sampling including genes in tiny areas, and as well as for sensitive detection of micro-samples. These are all common problems which micromachines that designed to deal with minute objects must overcome, and we believe that the results of this research can be applied to the micromachine technology broadly, beyond gene diagnosis.



Development of Pre-Stretching Method of SMA Thin Film Actuator on Si Wafer

Katsutoshi Kuribayashi
Yamaguchi University

An SMA thin film actuator has many advantages as a micro-actuator such as low-voltage drive power, flexibility, a large output force, etc. In order to form it on Si wafer, it is necessary to pre-stretch the thin SMA film. Since it is extremely difficult to pre-stretch it manually, it is necessary to develop a treatment process which can pre-stretch the film automatically. Specifically, as shown in Fig. 1 and Fig. 2, we will use a material with a large coefficient of thermal shrinkage such as polyimide, and develop a process with which we can use photolithographic technology.

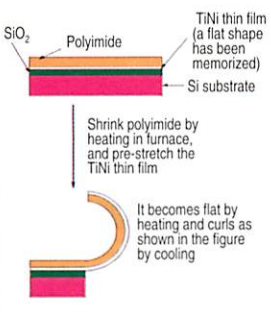


Fig. 1 Method of pre-stretching in an arc-like motion

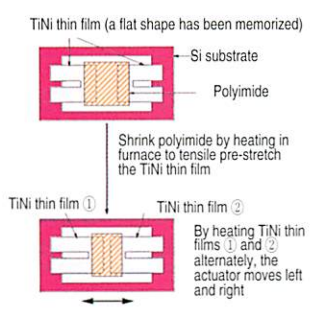
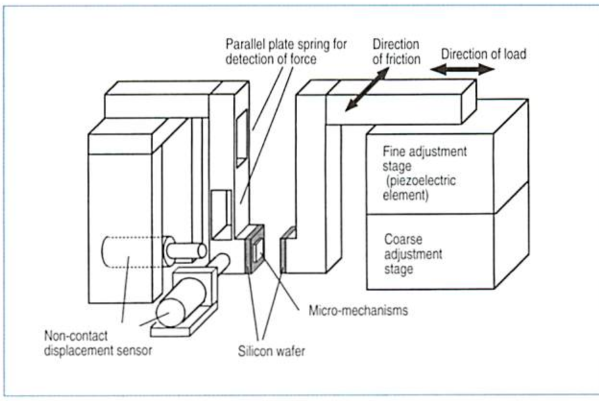


Fig. 2 Method of pre-stretching with linear movement

Measurement and Control of Friction in Micromachines

Kenji Suzuki
The University of Tokyo

The impact of frictional force generated by micromachine moving parts increases compared to the gravitational force and inertia. We also know that the mechanism of frictional force differs from conventional theory. This research project will study the frictional and adhesion forces on micromechanisms, as well as the impact of load, surface shape, humidity, etc., to clarify the mechanism of frictional force. Furthermore, by controlling the minute shapes and the distribution of electric charge on sliding surfaces, we aim to control friction. We expect to be able to develop new design guidelines that are appropriate for the minuscule scale, and address the problems of friction and lubrication.



Device to measure micro-frictional force and adhesion force

Development of a Nano-Probe for Detection of a Cell Surface Protein

Tadashi Matsunaga
Tokyo University of Agriculture and Technology

Using focus curve measurement with an atomic force microscope (AFM), it is possible to detect the interaction force between bio-molecules at molecular level. We will use protein with a bio-molecule recognition characteristic as an AFM probe, and examine its usefulness as a micro-detection system. In particular, we will use anti-bacteria antibody as the protein with a bio-molecule recognition, and develop a new probe for detecting living bacteria on single cell level. By establishing such technologies, we expect to be able to create an ultra-high sensitivity sensor.

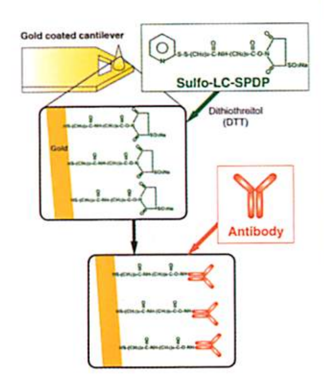


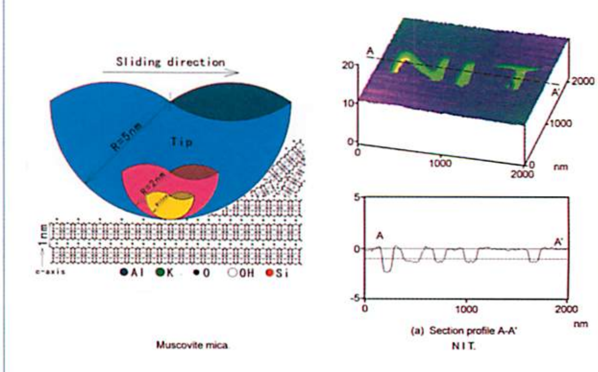
Fig. Schematic diagram for conjugation of antibody to the tip of probe

Formation of Nanometer Standard Rules by Mechanical Processing

Shojiro Miyake
Nippon Institute of Technology

Using an Atomic Focus Microscope (AFM) and an ultra-hard film chip as a tool, we will attempt to achieve nano-machining of layered crystal materials.

Specifically, we will use the difference of atomic bonding strength in layered crystallized materials to control the processing unit at layer-to-layer spacing. We will also apply removal processing at atomic level with the depth of one layer as the processing unit. Furthermore, using the results, we can form a high-precision grid of lines and spaces to a certain processing depth. By examining these points, we can expect to form a three-dimensional nanometer standard scale for length, along the surface atom image.



Okinawa Micromachine Seminar

The Okinawa Micromachine Seminar was held on January 30, 1998, under the sponsorship of the Micromachine Center, Okinawa Development Agency's Okinawa General Bureau, and the Okinawa Industry and Technology Promotion Association, with support and endorsement of the Center for Cooperative Research, University of the Ryukyus and the Okinawa Prefecture. The seminar was held at Kariyushi Urban Resort Naha in Naha City.

At this seminar, recent developments in the micromachine technology were explained, and four examples were described from the results of the Industrial Science and Technology Frontier Program "Micromachine Technology" (which is being promoted mainly by the Micromachine Center). During the break between lectures, portable exhibits of micromachine technologies were brought into the hall, and staff members of the Micromachine Center gave explanations of the "Micro Generator" (made by Mitsubishi Electric Corp.) and "Micro Pump with Low Surface Energy Processing" (made by Hitachi Ltd.). Thus, it was a good opportunity for the audience to learn more about the micromachine technology.

With Deputy Director Kenji Uehara of the Okinawa General Bureau as the moderator, speeches were given by Director-General Takahiro Fujii of the Okinawa General Bureau's International Trade and Industry Department, and MMC's Executive Director Takayuki Hirano. The lectures listed below were given thereafter.

As Okinawa Prefecture aims to develop itself as a leading base for international exchange and cooperation, the concentrated development of information and communications related industries has been adopted as a key industrial promotion policy. As Professor Tomomasa Sato stated in his talk, the hardware that handles information (which has no physical weight) is itself often required to be light-weight, highly precise and minute. There is much interest in Okinawa Prefecture on developments related to micromachine technology from the standpoint of developing the local manufacturing industry. The seminar was attended by 70 participants, including 21 from 13 businesses in Okinawa, 14 from the University of the Ryukyus (5 from the Faculty of Medicine and 9 from the College of Engineering), and 14 from public agencies, and it proved to be a very meaningful gathering.

Micromachine Center Activities

Takayuki Hirano (Micromachine Center)

Technical Lecture: Micromachines Are Truly Useful

Tomomasa Sato (Center for Research and Investigation of Advanced Science and Technology, The University of Tokyo)

The next four speeches described the results of the Industrial Science and Technology Frontier Project.

A Technology of Pattern Generation for Dispersing Micromachines

Keisuke Sasae (Kawasaki Heavy Industries, Ltd.)

Micro-Batteries (Materials for next-generation secondary batteries)

Tadashi Sugihara (Mitsubishi Materials Corp.)

In-Pipe Micro-Inspection Machine

Takuya Sasaya (Denso Corp.)

Micro-Manipulator Using SMA Plates

Shinji Kaneko (Olympus Optical Co., Ltd.)

A scene from the Okinawa micromachine seminar

Fourth Micromachine Drawing Contest Award Ceremony Held

The Micromachine Drawing Contest, which Micromachine Center (MMC) organizes for elementary school and junior high school pupils, has reached its fourth year. This time, with the support of the MMC's supporting members Kawasaki Heavy Industries, Ltd. and Hitachi Ltd., pupils from three elementary schools and two junior high schools participated.

There were 342 drawings entered the elementary school category, and 69 drawings entered the junior high school category.

The participating schools

Elementary Schools:

Iimori-nishi Municipal Elementary School (Nagasaki Prefecture)

Hanazono Municipal Elementary School* (Hyogo Prefecture)

Shimo-inayoshi Municipal Elementary School* (Ibaraki Prefecture)

Junior High Schools:

Futami Municipal Junior High School (Hyogo Prefecture)

Shimo-inayoshi Municipal Junior High School (Ibaraki Prefecture)

* School prize awarded.

From the artworks enlisted, seven winners were chosen in each category (elementary school and junior high school) by the jury listed below. The selected artworks are shown on the following pages.

Jury

Dr. Hirofumi Miura (Chief), Professor, The University of Tokyo

Dr. Yoshinori Nakazawa, Director-General, Mechanical Engineering Laboratory, Agency of Industrial Science and Technology, MITI

Dr. Keiko Nakamura, Deputy Director General, Biohistory Research Hall

Dr. Ryoze Yamashita, Associate Professor, Tokyo National University of Fine Arts and Music

Mr. Takayuki Hirano, Executive Director, Micromachine Center

Commemorative photograph of award winners

Miss Akiko Harada was awarded best entry prize in elementary school category.

The award ceremony was held on March 26 at the Tokai University Alumni Hall on the 33rd floor of the Kasumigaseki Building in Tokyo. There were more than 40 participants including the children receiving the awards, school staff, guests and the members of the jury.

At the award ceremony, Mr. Makoto Okazaki, Director for Machining and Aerospace R&D, AIST, MITI made a speech to the children. "R&D into micromachine has been carried on so as to be realized in near future. However, the results of R&D have to be useful to our daily lives and to make humankind happy. I am sure that in your drawings there are many important ideas to encourage such R&D."

Professor Miura, the Chief of the jury, reported on the judging process and commented on the work submitted. He said, "There are some incredible entries, so judging is always very difficult. This year, a professor from Tokyo National University of Fine Arts and Music joined the committee, and we were able to select work with not only great ideas but also aesthetic merit. If machines are going to be smaller, they will also differ in other ways from the machines that exist now. We adults do not know what will happen as a result. I am hoping that the flexible minds of elementary school and junior high school pupils will give us ideas."

Following the introduction of the selected drawings, testimonials and prizes were awarded to Miss Akiko Harada (5th grader of Shimo-inayoshi Municipal Elementary School in Ibaraki Prefecture) in the elementary school category and Mr. Masakazu Takahashi (2nd grader of Shimo-inayoshi Municipal Junior High School in Ibaraki Prefecture). Also, the two elementary schools with the most submissions received school awards.

Miss Harada said after receiving her award that she is looking forward to seeing realized micromachines in the 21st century and wished that she could create new technologies using her ideas.

After the ceremony, portable exhibits of micromachines were displayed. Children and teachers intently studied the micromachines, many of which they had never seen before.

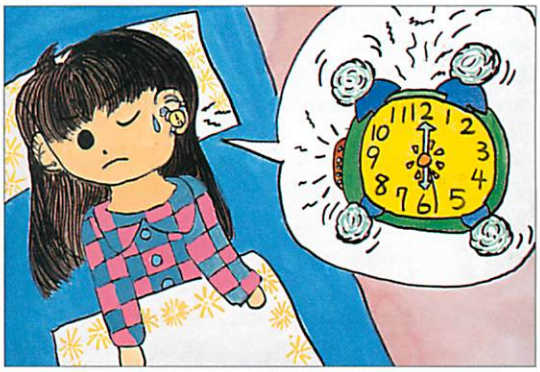
Winners of the Fourth Micr

Elementary School Category:

Best Entry Prize
Leave Mr. Droopy Flower to me!

Akiko Harada
Shimo-inayoshi Municipal Elementary School (5th grade)

First Prize
Tickle alarm



Asa Ueshima
Hanazono Municipal Elementary School (4th grade)

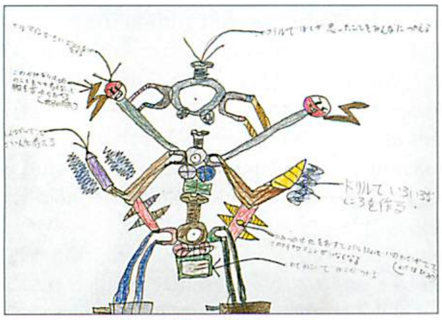
Second Prize
Micromachine in sand

Takamichi Nishijima
Hanazono Municipal Elementary School (5th grade)

Second Prize
The dream micromachine

Kana Okumura
Hanazono Municipal Elementary School (5th grade)

Third Prize
The micromachine that does everything I think



Yasuhiro Shimada
Iimori-nishi Municipal Elementary School (4th grade)

Third Prize
Sucky the robot

Kanako Yamazaki
Shimo-inayoshi Municipal Elementary School (5th grade)

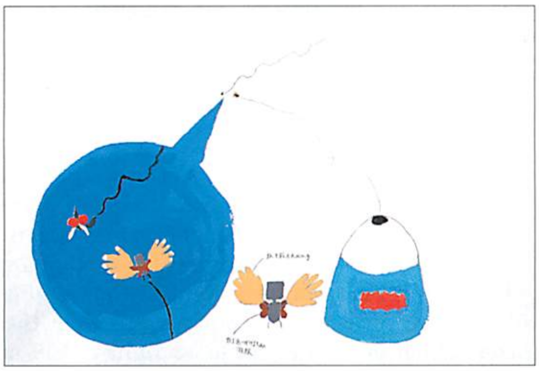
Third Prize
Now open miniature beauty salon

Satomi Miyamoto
Shimo-inayoshi Municipal Elementary School (5th grade)

machine Drawing Contest

Junior High School Category:

Best Entry Prize
Mosquito catcher



Masakazu Takahashi
Shimo-inayoshi Municipal Junior High School (2nd grade)

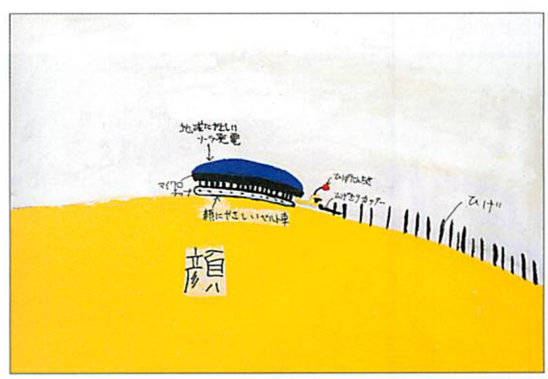
First Prize
Flower doctor

Hideaki Nakatani
Shimo-inayoshi Municipal Junior High School (2nd grade)

Second Prize
Mr. Green

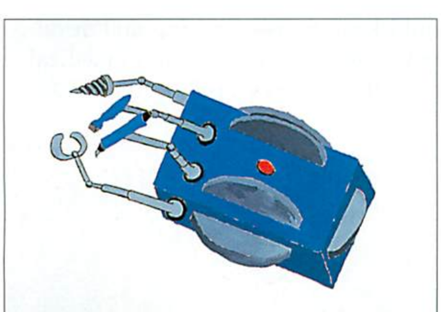
Rie Watahiki
Shimo-inayoshi Municipal Junior High School (2nd grade)

Second Prize
Mr. Microshaver



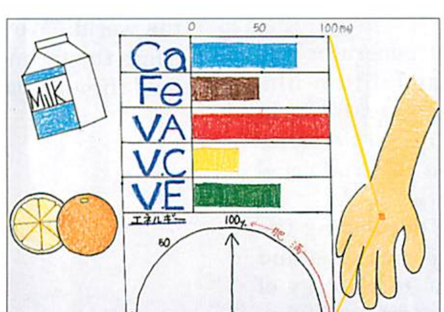
Norio Muramoto
Shimo-inayoshi Municipal Junior High School (2nd grade)

Third Prize
Mr. Everything Fixer



Nozomi Sakurai
Futami Municipal Junior High School (2nd grade)

Third Prize
Health barometer



Yuuka Murakami
Futami Municipal Junior High School (2nd grade)

Third Prize
Litterbug prevention sensor

Tomomi Nomura
Shimo-inayoshi Municipal Junior High School (2nd grade)

TERUMO Corporation

Akira Takahashi
Senior Managing Director
and Director of R&D Center

1. TERUMO's Stance on Micromachine Technology

In the recent medical field, taking an aging society and quality of life into consideration, the expectation for minimally invasive therapy (MIT) is getting high. Because it makes more safe surgery possible by the small cut. We have started on research and development of the micromachine technology in early years, as we consider that the technology is essential to MIT. And we participate the Industrial Science and Technology Frontier (ISTF) project conducted by the Ministry of International Trade and Industry in order to provide small and smart medical instruments that can enter any part of human body and treat affected part directly.

2. The Development of Micromachine Technology

Within the ISTF project, we have been developing two research topics. One is the optically-driven shape memory alloy (SMA) device which consists of a photo-current generator system and a thin film SMA actuator. By combining these two fundamental technologies, we fabricated a catheter-type laser scanning probe which has a photo-current generator (1.8 mm diameter light-receiving area) and a thin film mirror (7 μm thick and 0.3 mm × 1 mm area) (Fig. 1). These technologies are expected to be useful to realize a precisely controlled laser irradiation to an affected part of the internal organ.

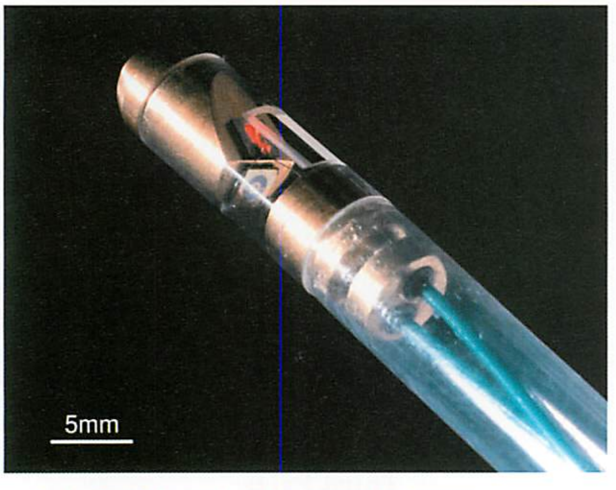


Fig. 1 Catheter-type laser scanning prove

For another topic, we have been developing the micro-laser catheter aiming to realize diagnosis and therapy in narrow blood vessel. The technology of forming flexible electric wiring on outside of a fine polymer tube and of mounting several sensing devices have been in research. In our recent study, we fabricated a catheter sample which have 10 spiral lines and 2 spiral grooves on the 1.5 mm diameter tube. Furthermore, we have been developed the micro-laser which can generate a laser light at the tip of a optical fiber. We fabricated a prototype model of the micro-laser which generate the laser light of 2.8 m wavelength (Fig. 2). Above mentioned technologies are expected to apply in surgical field of brain or heart treatment.

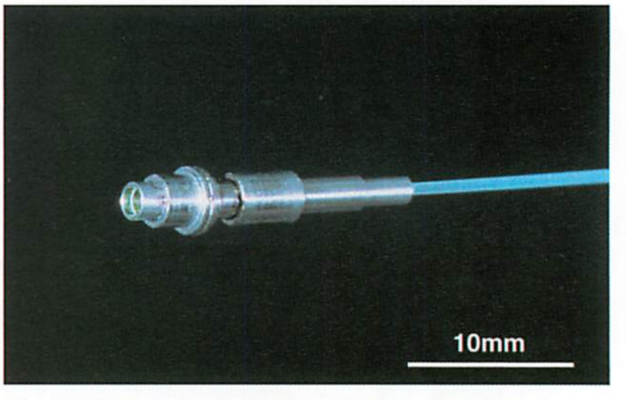


Fig. 2 Micro-laser generating 2.8 μm wavelength

3. For the Future

We consider that the micromachining will to be one of core technologies contributing to medical enhance. It is not just the technology to miniaturize the mechanical elements, if applied for MIT, we will be able to provide relief and safety for more people in the world. We would keep on researching and developing the technology in order to contribute to medical field through participating in ISTF project.

Japan Electrical Safety and Environment Technology Laboratories (JET)

Harumichi Saito
Executive Director

1. Micromachine Technology Involvement Policy

In recent years, international standards related to the electromagnetic compatibility (EMC) of electrical and electronic equipment have been revised. Japan Electrical Safety and Environment Technology Laboratories have been conducting research that includes immunity tests and emission measurement, in accordance with the latest international EMC standards.

In our current research on the microfactorization effect, we are aiming to establish electromagnetic compatibility in microfactories by clarifying the problems that arise in electromagnetic environments through large-scale integration of equipment.

2. Investigation of EMC Measurement and Evaluation Technology

In microfactories, sources of interference and parts that are easily affected by interference are located in close proximity. Since the attenuation of interference waves is small, electromagnetic interaction may occur easily. Therefore, testing within a small area becomes essential. Also, it can be assumed that conductive disturbances superimposed on power and signal lines occurs more easily than in the electromagnetic environment of larger production facilities.

Currently, attempts are being made to establish international standards for electromagnetic fields in manufacturing environments. However, for microfactories, any evaluation of the nature of electromagnetic fields must take into account the unique characteristics of such small-scale environments. In order to achieve this, collection of basic data and performance testing is necessary.

In our research, we are working to understand basic phenomena associated with electromagnetic fields, and to establish electromagnetic compatibility in microfactories. Subjects under consideration include:

(1) Conductive disturbances from power lines.
(2) Space-traveling disturbances by electromagnetic waves.
(3) Disturbances inducing electric current by line-frequency magnetic fields.

One means of measuring the radiation field level in a small area is a device called the electromagnetic wave obstruction probe. This device automatically scans the electric fields emitted from printed circuit boards and small machinery using a small electromagnetic field probe sensor in the X-Y direction, and measures peak levels of electric field strength in preset frequency ranges.

Fig. 1 shows the results of measuring the field emission from the CPU area of a personal computer (several millimeters) using the electromagnetic wave obstruction probe. This emission map can be used to represent field emission by three-dimensional characterization of levels and wavelengths.

Fig. 2 shows the external appearance of the GTEM Cell (Gigahertz Transverse Electromagnetic Mode Cell). This is a quadratic prism 4,500 mm in length, 2,500 mm in width and 2,200 mm in height that can be used to conduct immunity tests and emission measurement for small equipment. In other words, it can detect disturbances as the spatial propagation characteristics, and can be used to replace anechoic chambers and large-scale open sites. It can generate uniform electric fields in the frequency range of DC to 2 GHz for testing purposes.

Currently, we are considering assessment methods for small machinery immunity testing and emission measurement using this device.

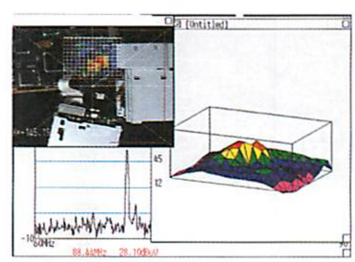


Fig. 1 Results of field emission measurement

Fig. 2 External appearance of GTEM cell

3. Further Involvement

We are planning to establish immunity testing methods and emission measurement in small areas for microfactory technology, and thereby gather test result data. Furthermore, through the assessment of the electromagnetic environment of a microfactory system to be produced on a trial basis, we are planning to achieve the integration of microfactory facilities into the international standards.

MEMS 98 Held in Heidelberg MMC's Investigation Mission Participates

The MEMS 98 (11th IEEE International Workshop) was held at the Convention Center "Stadthalle Heidelberg" in Heidelberg, Germany from January 25th (Sun.) - January 29th (Thu.). MMC's investigation mission (11 members) participated in this workshop during a visit to Europe.

There were 670 participants in MEMS 98 (442 people participated in MEMS 97 in Nagoya), marking a record attendance at the workshop.

There were 117 reports presented (refer to list below), and the presentation adoption rate was approximately 36%. From Japan, The University of Tokyo (7 reports), Nagoya University (5 reports), Tohoku University (4 reports), and Ritsumeikan University (2 reports) gave presentations, as well as the Mechanical Engineering Laboratory (MITI), Seiko Instruments Inc., Mitsubishi Electric Corp., Murata Mfg. Co. Ltd., NEC Corp., Seiko Epson Corp., Sumitomo Heavy Industries, Ltd., Matsushita Electric Works Ltd., Shimadzu Corp. and Joint Research Center for Advanced Stimuli Responsive Materials. There were two presentations in relation to the ISTF project.

Number of presentations for each nationality represented

Country	Oral	Poster
Switzerland	5	3
United States	19 (1)	15
Japan	11 (1)	18
Sweden	4	1
Germany	9 (1)	16
Korea	2	4
France	1	1
The Netherlands		2
Denmark		1
United Kingdom		1
Singapore	1	1
Belgium	1	
Canada	1	
Total	54 (3)	63

Remarks: Numbers in parentheses are for the invited talks.

This workshop was held in a large assembly hall, accommodating approximately 700 people, which was nearly full throughout the duration of the workshop. Since the number of oral presentations had increased to 57 (from 39 last year), each presentation was limited to 20 minutes (last year, each presentation was allowed 25 minutes). However, active discussion followed all the presentations.

A three-hour poster session took place on the afternoon of the 27th. The session was divided into two sections within the assembly hall, and active discussions took place in each presentation booth. The number of poster presentations on device topics related to heat and hydrodynamics was higher than last year.

MEMS 99 will take place in Orlando, Florida, USA, from January 17th through 21st, 1999. The application deadline for presentations is September 14, 1998. The next meeting will be held as a conference with parallel sessions rather than workshops, in order to accommodate the increase in the number of participants.

MMC's investigation mission joined the technical tour after the workshop to visit Forschungszentrum Karlsruhe and Hans-Schickard-Gesellschaft Institute of Micromachining and Information Technology (HSG-IMT). Upon completion of MEMS 98, they visited the University of Rome (in Italy), the University of Barcelona and CNM (Centro National de Microelectronica, both in Spain) and conducted investigation and discussions on topics related to micromachine technology.

MMC's investigation mission participated in MEMS 98

Japan-Switzerland Seminar

As part of JETRO's inter-industry exchange program, the "MICROMACHINE & MICROTECHNOLOGY IN JAPAN AND SWITZERLAND" seminar aimed at promoting technological exchange between Japan and Switzerland was held on February 24 (Tues.), in Interlaken.

Mr. Makoto Nakajima, Director, Industrial Machinery Division of MITI and others gave speeches on seven themes. Dr. Christoph von Arb, senior councelor in charge of the science and technology of the Swiss Federal Government gave a lecture on the "Present Situation of Research and Development in Switzerland," followed by five other speeches. More than 50 participants attended.

The presenters and titles of the lectures given by the Japanese obligation were as follows:

① Policy for Micromachine Development
by Makoto Nakajima, Director, Industrial Machinery Division, Machinery and Information Industry Bureau, MITI.

② Overview of Research and Development on the Micromachine Project
by Kazuhisa Yanagisawa, General Manager, Integrated Precision Technology Development Department, Olympus Optical Co., Ltd.

③ Development of Micromachine Technologies
by Norio Omori, Executive Managing Director, Denso Corporation.

④ Development of Decentralized Multiple Micromachine System Technologies
by Munehisa Takeda, Chief, Advanced Technology R&D Center, Mitsubishi Electric Corporation.

⑤ Development and Application of Micro-Pumps
by Takanobu Hori, President & Executive Director, Aisin Cosmos R&D Co., Ltd.

⑥ Development of X-Ray Deep-Lithography Technology
by Hiroshi Takada, General Manager of Harima Research Laboratory, Sumitomo Electrical Industries, Ltd.

⑦ Future Prospects for Micromachines
by Takayuki Hirano, Executive Director, Micromachine Center.

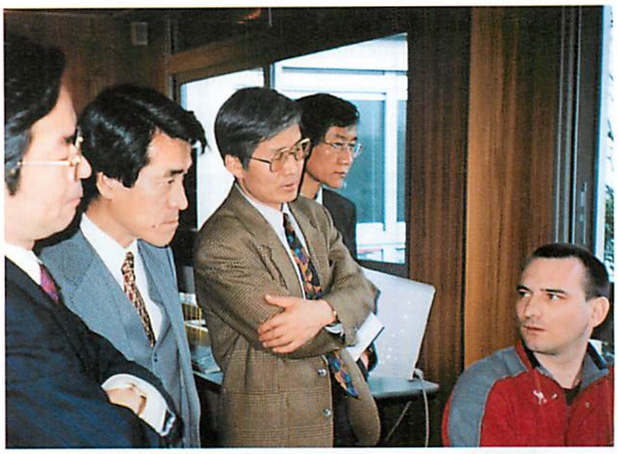
After the seminar, the Japanese representatives formed a study tour group led by President Takanobu Hori of Aisin Cosmos R&D Co., Ltd., and visited research institutes located in Toulouse and Sophia-antipolis in France on February 26 and 27.

In Toulouse, the group visited LAAS (Laboratorie d'Analyse et d'Architecture des Systems). LAAS is a national research institute which is part of what is regarded as the largest academic research organization in Europe, CNRS's Engineering Science Department. Here, the members investigated car-mounted pressure sensors using silicon technology, and microelectronics devices such as accelerometers.

In Sophia-antipolis, the study tour members visited the Science Park. The Science Park has an area about one half the size of Paris. There are about 1,100 research-related agencies and organizations such as advanced high-tech companies, research institutes, national universities, etc., and it comprises one of the key bases in all of Europe in terms of data processing, electronics, telecommunications, biotechnology, alternative energy and environment, and so on. The group members visited the Laboratory of Electronics Antennas and Telecommunications (LEAT) (microwave-related fields), Research Center for Hetero-Epitaxy and its applications (CRHEA) (blue laser, etc.), IMRA Europe S.A. (energy, information communication technology, etc.).

At the seminar hall in Switzerland as well as the research organizations that we visited in France, we encountered many enthusiastic questions, and comments from the local researchers, which communicated to us the high level of interest in micromachines in Europe.

Japan-Switzerland Seminar (Interlaken, Switzerland)



At LAAS (Toulouse, France)

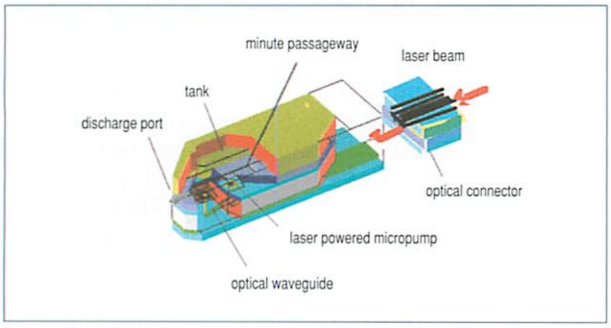
Portable Micromachine Technology Exhibits

In this and following three issues, we will introduce "Portable Exhibits" created with the cooperation of supporting members, with the aim of increasing understanding of the results of the Industrial Science and Technology Frontier Program "Micromachine Technology."

AISIN COSMOS R&D CO., LTD.
"Laser Powered Micropump"

1. Description of the Research

The AISIN COSMOS is developing a functional microdevice with laser as its energy source, as part of our research on systematization technology for microfactory systems. This device will be attached to the tip of a micro-manipulator, and serve as a micro-dispenser that can assemble tiny parts by discharging minute amounts of adhesive. In order to miniaturize the device, laser transmitted through optical fibers is used as the driving energy. It is necessary to develop not only a laser-powered micropump which serves as the center piece, but also, a method of supplying and discharging minute amounts of fluid, and a method of transmitting the laser into the pump.



Schematic drawing of laser powered microdispenser

2. Overview of the Portable Exhibit

[Significance of Creating the Exhibit]

One of the problems with micromachines has to do with viscosity and friction. The smaller the device, the larger the effect of the fluid viscosity, which makes it difficult for a micromachine to perform its designed tasks. This is especially important for micropumps and valves for which transfusion is a basic design requirement. Generally, a diaphragm-type pump is used for transfusion. In our case a number of diaphragms is arranged in a straight line to create a peristaltic motion, so that the stagnation of the fluid is kept to a minimum. The key points in this laser-powered micropump are the method of pumping and discharging minute amounts of transfusion liquid, and supplying of optical energy.

This portable exhibit shows how a minute amount of fluid is pumped and discharged, along with the actual movement of the diaphragms and it helps to understand of the mentioned problems.

Portable exhibit "Laser powered micropump"

[Explanation of the exhibit]

In this exhibit, compressed air is used as the driving power in the place of the laser, for safety reasons. Also, since we emphasize portability, the electrical power source, an arm (assumed to be a micro-manipulator), a micropump, a supply source of compressed air, moving stage, etc. all fit into a case measuring 330 × 240 × 120 mm. A tank for storing the fluid is placed at the rear of the micropump, so that the fluid can be supplied as needed during the demonstration. The micropump consists of a number of diaphragms that buckle up and down in two positions with gas pressure, a minute passageway and a discharging port made of stainless steel above them. Its size measures 4 × 6 × 22 mm.

By supplying positive and negative pulsating air pressure into each diaphragm with a phase difference of 72 degrees, fluid motion is achieved.

Enlarged picture of micropump

[Key points in the exhibit]

Research and development work on micropumps is being conducted in various countries such as the U.S., Netherlands and Germany. We adopted the peristaltic pump to reduce fluid resistance and stagnation in the flow channel. Also, we have produced diaphragms that are small in size, but with a large displacement, using the difference in thermal expansion coefficients between SiO_2 and Si. For instance a diaphragm of 800 × 800 μm has a peak-to-peak displacement of 40 μm. In the exhibit, the top of the flow channel is transparent so that the movements of the diaphragms can be seen.

3. Future applications

Devices for transfusion of minute amounts of fluid can be used in various fields, depending upon the type of fluid that is transfused. It can be used as a device to discharge adhesives for the assembly of minute parts as shown in this exhibit, or it could be used for continuous injection of minute amounts of lubricant or grinding fluid, or as a device for injection or transfusion of pharmaceutical solution or reagent in the pharmaceutical or biotechnological fields. Recently there are expectations for its application in biochemical analysis systems. It is becoming more important to further develop micro-fluid devices.

OLYMPUS OPTICAL CO., LTD.
"1-mm Diameter SMA Micro-Actuator"

1. Development of Micromachine Technology

We are researching on an experimental micromachine system which could enter complex equipment such as a power generation facility and perform light repair work (Fig. 1). This experimental system features performing work.

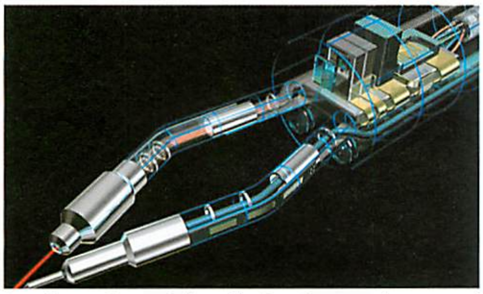


Fig. 1 Experimental catheter-type micromachine for repair in narrow complex areas

2. Overview of the Portable Exhibit

[Significance of Creating the Exhibit]

From the first phase of the Industrial Science and Technology Frontier Program, we have been developing a manipulator for working within narrow spaces, and this portable exhibit (Fig. 2) is one of its technological achievements.

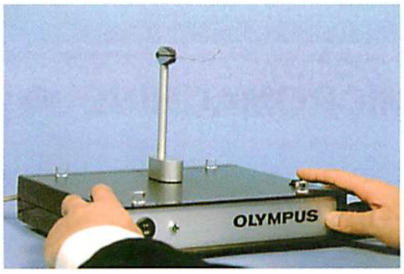


Fig. 2 1-mm diameter SMA micro-actuator

[Explanation of the exhibit]

We used shape-memory alloy (SMA) plates as the actuator that drives the manipulator. The reasons have to do not only with its large output force to volume ratio, but also, the fact that SMA has the characteristics of both a structural material and functional material.

In order to make the most use of its functional characteristic, we chose the structure shown in Fig. 3. The actuator is a pair of shape memory alloy plates that are arranged at a right angle, and this also serves as the basic structure as well. The shape memory alloy changes to its memorized curved shape by heating. The SMA used here is a plate which has been specially pre-processed with what is called on

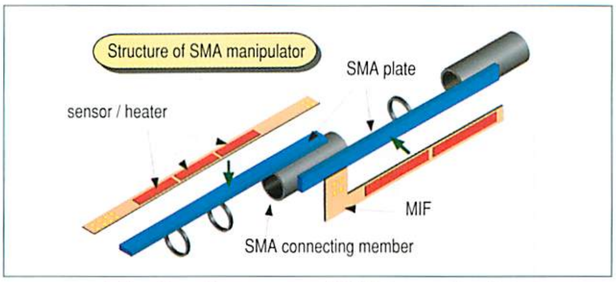


Fig. 3 Structure of SMA manipulator

reversible shape memory effect, so that it can change its shape on its own even at a low temperature. By changing the temperature in segments, it can access any position in a 3-dimensional space. The size of the SMA is 40 mm long, 0.5 mm wide, and 0.15 mm thick.

[Key points of the exhibit]

To function as a manipulator, this device must be capable of controlling its position with a high degree of precision. In order to cope with this problem, we developed a new device technology which we call Multi-function Integrated Film (MIF). All the necessary electrical elements such as heater-sensor wiring and an electrode for connecting to an outside lead line, are integrated in a flexible film that is about 10 microns thick. By attaching this film to the SMA plate, we were able to develop an SMA manipulator with a high degree of positional precision.

This manipulator is 1 mm in diameter and 80 mm long with 5 degrees of freedom and a curve angle of 40 to 70 degrees for each degree of freedom. Generally, with a heat-driven actuator such as SMA, there is a problem in terms of its response characteristics. But by reducing the heat capacity through miniaturization and improving the relative heat release efficiency, relatively good dynamic behavior has been exhibited. Also, with conventional SMA actuators, a high-level of positional control is very difficult due to the large hysteresis in the temperature-distortion characteristics. With this manipulator, however, by introducing an SMA continuous mathematical model, it is possible to achieve positional control to 0.2 mm for each degree of freedom. Also, with regard to the output force, the front tip can lift a weight of about 1 g.

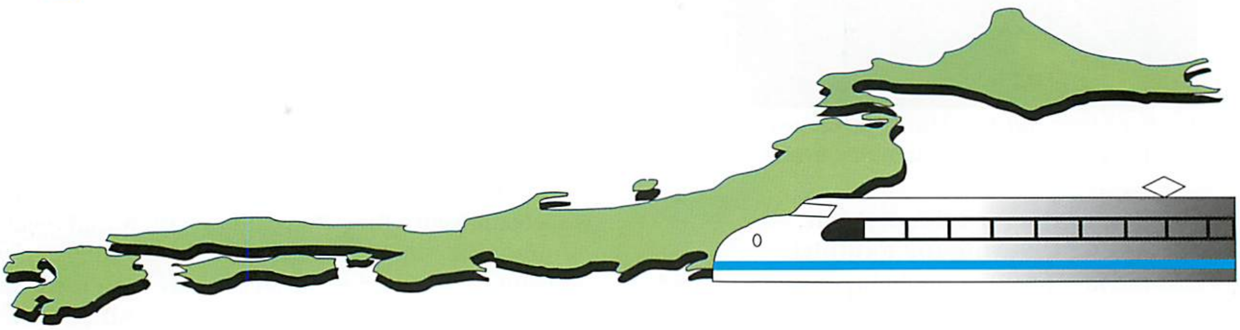
3. Future Applications

The actuator technology used in this manipulator is being modified for use in an experimental system for working inside equipment. Also, MIF technology integrates a film-type electronic device into the system, and we are doing research and development on applying this technology to high-density mounting technology for micromachines.

Preliminary Announcement

The 4th International Micromachine Symposium

October 29 and 30,1998
at Science Hall, Science Museum, Tokyo, JAPAN



Exhibition
MICROMACHINE '98

October 28 ▸▸ October 30,1998
at Science Museum, Tokyo, JAPAN

Exhibition
MICROMACHINE '98

The Detail will be announced later.

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