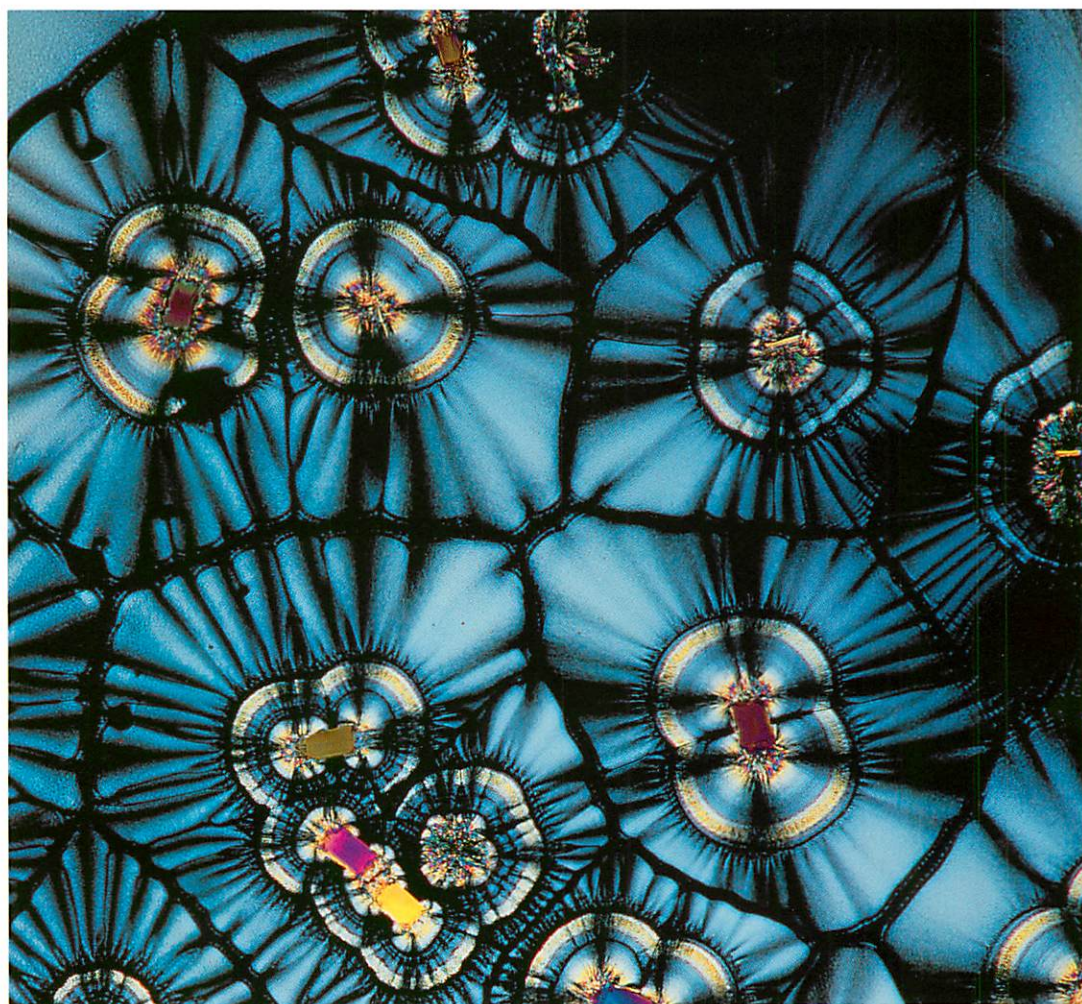




# MICROMACHINE

Feb. 1993 **No. 1**

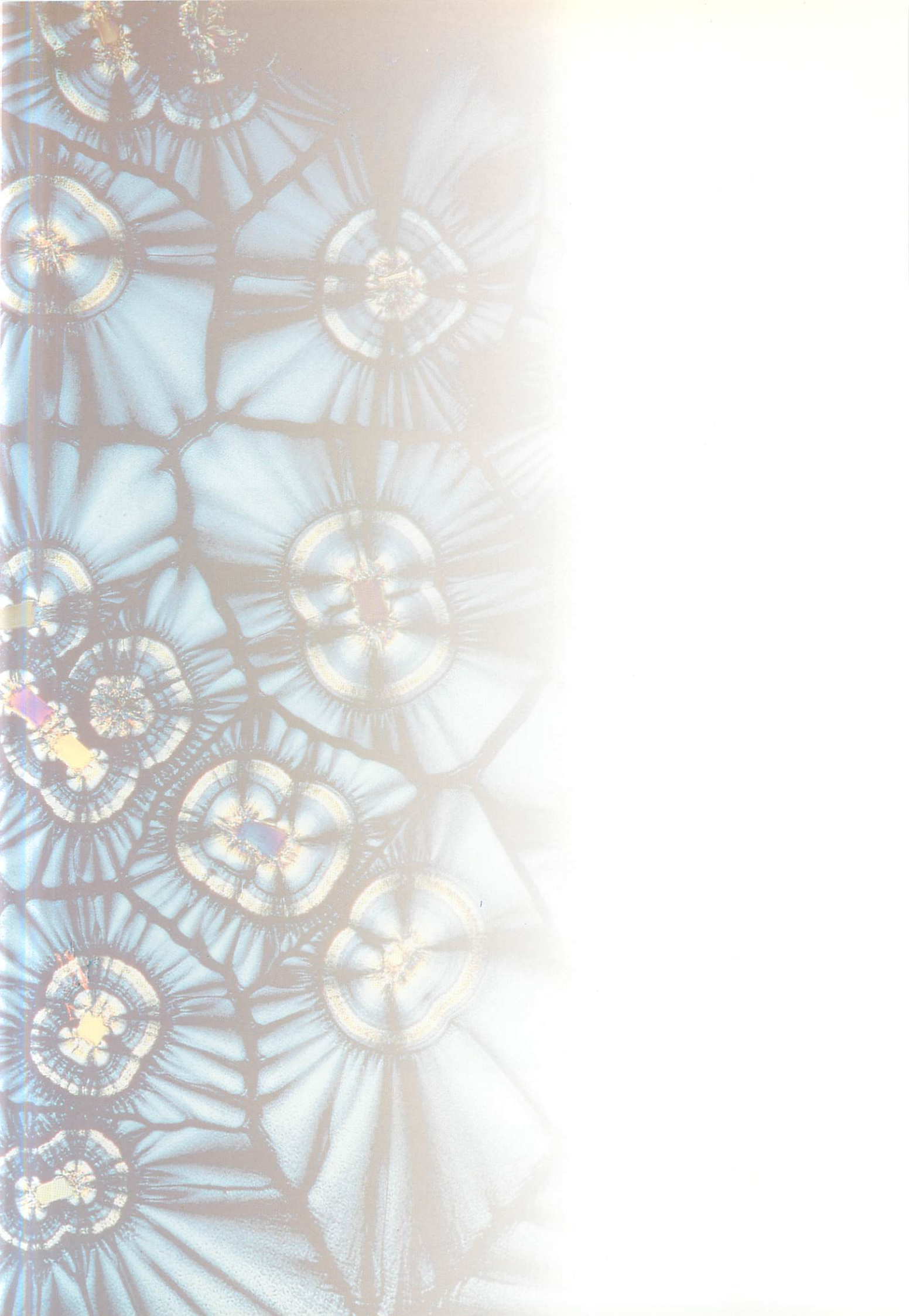


- At the Start of MICROMACHINE
- Activities of MMC
- Worldwide R&D of Micromachines

- Topics, Events
- Applications for Membership

**Micromachine Center**





## Message on the occasion of the inauguration of **MICROMACHINE**



**Seiueemon Inaba**  
Chairman  
MICROMACHINE CENTER

The Micromachine Center (MMC) was founded in January 1992, to carry out surveys and research into micromachines (minute devices a few millimeters in size capable of performing complex and microscopic tasks), to gather and supply information, and to promote exchange and cooperation with related organizations in Japan and overseas. By achieving these purposes, the center seeks to establish basic micromachine technology, encourage the spread of micromachines, and thereby contribute to industrial development in Japan and to the international community.

As readers are well aware, the main demands in the field of micromachines nowadays are for advanced, detailed maintenance technology to handle the increasingly complex and precise machine systems and for advanced, detailed medical techniques that cause minimal discomfort to patients.

Micromachines are extremely innovative—the machines of the twenty-first century, as they have been called—and their realization will require various breakthroughs in existing technology.

To achieve this end, the Micromachine Center will carry out a range of activities for the promotion of micromachines, including the large-scale research project called “Micromachine Technology” delegated by the government’s Agency of Industrial Science and Technology, joint research by the government, industrial, and academic circles, and exchange and tie-ups with other related organizations in Japan and overseas.

It is my sincere hope that this exchange of information and cooperation, especially with related organizations overseas, will be further deepened through this **MICROMACHINE** newsletter, an information journal relating to micromachines that the center will publish from now on.



# Activities of the Micromachine Center

## 1. Objectives of the Micromachine Center (MMC)

Micromachines only a few millimeters in size can conceivably perform complex microscopic tasks. Consequently, many people worldwide want to use these minute devices to cope with increasing demand for advanced maintenance technology for plants and machinery and for medical techniques that employ complex and precise mechanical systems.

Micromachines have many potential uses. In industry, the devices could provide sophisticated and delicate maintenance for many kinds of industrial plants and machinery. In medicine, micromachines would cause minimal discomfort to patients undergoing advanced medical techniques. These and other uses of micromachine technologies should have far-reaching effects.

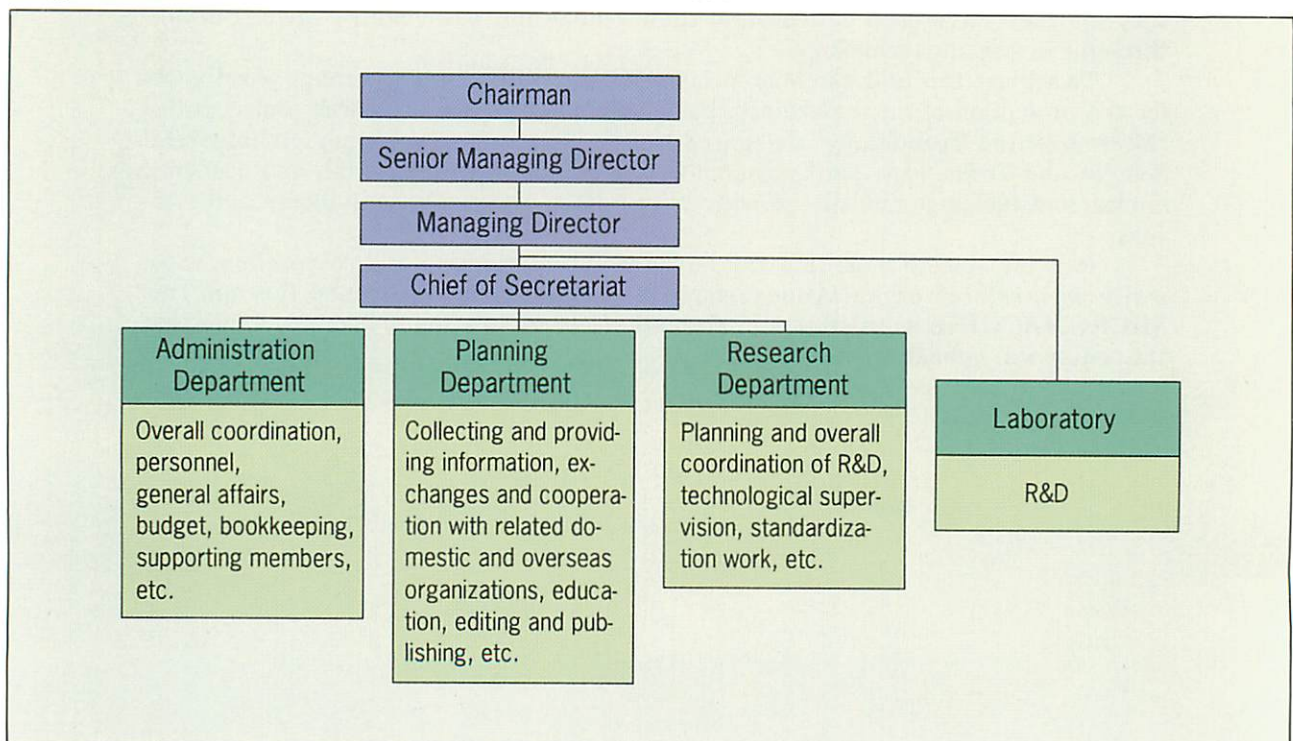
However, prior to realizing micromachines' potential applications, many basic technologies must be developed, including methods

for processing the microscopic and intricate parts of these devices and for providing energy supply and control mechanisms.

Another urgent task is to prepare a forum for international exchanges about new micromachine developments overseas. Information exchanges are important in promoting the development of micromachines and ensuring a central role for this technology as it spreads into economic and social sectors. People from industry, government, and academia should interact with ease as the research and development into micromachines accelerates at corporations, universities, and research institutions.

The Micromachine Center (MMC) was established January 24, 1992, with the approval of the Ministry of International Trade and Industry (MITI). Its purpose is to conduct R&D into micromachines, collect and provide information, and foster exchanges and cooperation with organizations in Japan and abroad. In this way, the center will establish

## Organization of the Micromachine Center



basic micromachine technology and disseminate micromachines in society, thereby contributing to the development of domestic industry and the international community.

## 2. Organization

- ① Date of establishment: January 24, 1992
- ② Endowment: an estimated 700 million yen as of the end of fiscal 1992
- ③ Officers: 26 directors and 2 auditors
- ④ Supporting members: 34 companies and organizations

## 3. Activities of MMC

To establish basic technologies and lead the dissemination of micromachines in economic and social sectors, the Micromachine Center mainly

- ① Investigates and researches micromachines
- ② Collects and provides information on micromachines
- ③ Engages in exchanges and cooperation relating to micromachines with organizations in

Japan and abroad

- ④ Promotes micromachine standardization
- ⑤ Provides and disseminates education on micromachines

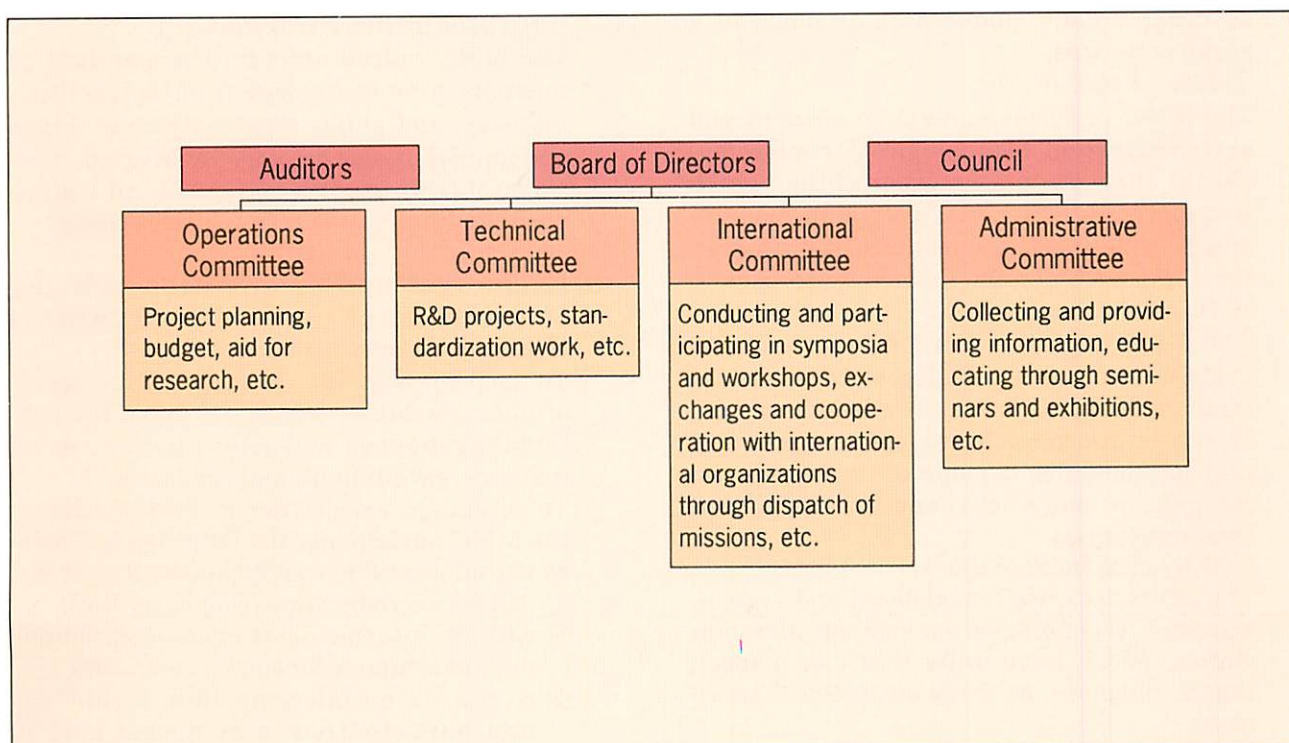
## (1) Investigation and research activities

The New Energy and Industrial Technology Development Organization (NEDO) has entrusted MMC with a large-scale project known as "Micromachine Technology"—the 10-year project begun in 1991 by MITI's Agency of Industrial Science and Technology (AIST). The MMC's role is to investigate and conduct research on micromachines.

NEDO delegated micromachine R&D to the MMC under the National Research and Development Program (Large-Scale Projects). The MMC conducts its R&D with 23 domestic companies, one domestic organization, and three overseas members.

## 1) R&D objectives

The need for micromachines is growing. These minute devices can quickly and easily





maintain increasingly advanced and complex industrial systems and can be used in the sophisticated medical techniques to minimize discomfort to patients.

Responding to this need, MITI's AIST began an R&D project on micromachines in fiscal 1991, as part of the agency's Large-Scale Projects.

The micromachine project involves researching and developing devices able to move in very fine tubing to inspect and repair complex systems, such as power generation stations, and to examine or operate inside the human body.

## **2) R&D period**

Five years from fiscal 1991 (10 years for the overall plan)

## **3) R&D funds**

About 10 billion yen (gross budget: 25 billion yen)

## **4) R&D areas**

### **① Microcapsule R&D**

The MMC studies element technology for floating type wireless micromachines as well as systematization technology. Based on the progress of these technologies, the MMC studies applications to conduct R&D on capsule type micromachines, which can function as independent modules or as parts of a group of devices.

### **② Mother ship R&D**

The MMC undertakes R&D on element and systematization technologies for micromachines that serve as mother ships, which transport inspection and operation modules and provide a communications link between the micromachines and outside controllers.

### **③ Inspection module R&D**

The MMC performs R&D on element and systematization technologies for wireless micromachines that move inside tubes. Wireless micromachines are composed of multiple modules capable of environmental recognition, movement, energy supply, and communications.

### **④ Operation module R&D**

The MMC does R&D on element and systematization technologies for cabled micromachines, which have units that can inspect, repair, diagnose, or carry out medical treatment.

### **⑤ Total system research**

In addition to defining complete micromachine systems, the MMC investigates and researches valuable ways of using micromachines.

## **5) Long-term development plans**

### **① Studies of the trends of micromachine R&D in Japan and abroad**

The MMC studies organizations capable of micromachine development and the state of development in Europe, the United States, and Japan.

### **② Studies on materials**

The MMC studies the needs for material technology in the fields in which micromachines are to be introduced and conducts experimental studies on the feasibility of applying this material technology to micromachines.

### **③ Studies of industrial ownership rights**

The MMC investigates industrial ownership rights to micromachines in Japan and abroad.

### **④ Joint research facilities**

The MMC studies the establishment of joint facilities for micromachine research and the provision of these facilities to researchers.

## **(2) Activities to gather and provide micromachine information**

The MMC collects information and data on micromachine technology from universities, industry, and public organizations in Japan and abroad. It also catalogs reference materials on its own studies and makes all materials in its library available to participants.

## **(3) Exchanges and cooperation relating to micromachines with organizations in Japan and abroad**

To keep up with international development of micromachines, the MMC plans international exchanges and joint studies among industry, government, and academia.

To encourage cooperation on micromachines, the MMC implements the following technology exchange and research support activities:

### **① Aid for micromachine technology R&D**

### **② Aid for international exchanges among micromachine technology researchers**

### **③ Symposia on micromachine technology and participation in symposia held in Japan and abroad**



- ④ Workshops on micromachine technology and participation in workshops held in Japan and abroad
- ⑤ Dispatch of missions to the United States, Europe, and other countries, thereby fostering exchanges and tie-ups with universities, research laboratories, and other institutions involved with micromachines

#### (4) Promotion of micromachine standardization

The MMC works with relevant organizations to promote the standardization of the terms, units, and measurement methods for micromachines.

#### (5) Provision and dissemination of micromachine information

The MMC engages in the following activities to provide and disseminate micromachine information:

- ① Periodically publishes and distributes a public relations document about micromachines
- ② Holds annual seminars on micromachines in Tokyo and other places
- ③ Holds exhibitions on micromachines once a year along with a symposium, scheduled for April 1994

### Long-Term Research and Development Plan

R&D item	Fiscal Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1. Microcapsule											
2. Mother ship											
3. Inspection module											
4. Operation module											
5. Total system											
6. Micromachine technology applied to medicine											

	Survey of technology					Interim evaluation					General evaluation
1. Microcapsule		←	Prototype making, testing, research	→			←	Research for sophistication and verification	→		
2. Mother ship		←	Prototype making, testing, research	→			←	Research for sophistication and verification	→		
3. Inspection module		←	Prototype making, testing, research	→			←	Research for sophistication and verification	→		
4. Operation module		←	Prototype making, testing, research	→			←	Research for sophistication and verification	→		
5. Total system		←	Investigation and research	→			←	Investigation and research	→		
6. Micromachine technology applied to medicine		←	Prototype making, testing, research	→			←	Research for sophistication and verification	→		



# Worldwide Research and Development of Micromachines

**Yoshitaka Tatsue**

Director, Machinery Department,  
Mechanical Engineering Laboratory,  
Agency of Industrial Science and Technology,  
Ministry of International Trade and Industry

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## 1. Introduction

Inasmuch as micromachine R&D is being vigorously conducted worldwide by researchers and engineers who are receiving enthusiastic support, this new publication is an appropriate way to follow the zealous, long-term development of this technology and to promote information exchanges.

At present, while micromachine R&D should be done as freely as possible, it is important to accurately document in a timely manner who is researching what and where. Here, I would like to frankly express my impressions and understanding of the current status of micromachine R&D, and I look forward to an article in the future issues that will introduce the R&D in detail.

## 2. Status of micromachine R&D

All R&D challenges the unknown, but usually the basic topography of the research area is known to some extent. However, I say without exaggeration that micromachine R&D has started with a blank map. From now on, we must earnestly construct the framework for researching this technology.

Research subjects tend to be taken up with relative ease in most countries. Yet no established research pattern exists for micromachines similar to the earlier example of conventional machinery for which the basic ideas were conceived in Europe, developed in the United States, and commercialized and matured in Japan. However, Japan, Europe, and the United States, though technologically advanced, have not established vectors for the development of a technology specific to each area.

I believe, therefore, it is important to introduce in this technology series the status of micromachine R&D in Japan and abroad.

Moreover, since the image of micromachines differs depending on the understanding and

interpretation of each individual concerned with this technology, a willingness to “try everything” emerges. This attitude is natural because micromachine researchers must construct a technological system comparable to that established for machinery by the sublimation of previous technology and the creation of new technology.

Micromachine R&D subjects will vary from sensors and simple actuators (soon to be realized) to energy sources, control mechanisms, and whatever is seriously studied henceforth. Basic research efforts will also cover broad technologies for materials, design, and processing and assembly.

To perform this wide range of research, we must make full use of existing advanced mechanical, electronic, optical, and biological technologies and know-how. We must not rely only on industrial research but also emphasize creative scientific research.

Again, let me emphasize that many people in Japan and abroad are engaged in various kinds of R&D work, including micromachines, to foster their dreams. The situation is like bamboo shoots sprouting everywhere.

Except for a few technologies like the semiconductor and LIGA processes, micromachine research is doable to a considerable extent using comparatively small-scale facilities. At the laboratory level, broad research areas can be covered quickly and interesting study themes emerge in rapid succession. In extreme cases, research work that attracts attention today may be regarded differently tomorrow.

Micromachine technology will certainly not be established in one day, so to speak. As micromachines pass through the development and application stages, their concepts and basic structures will be established, and their design, manufacturing, and application technologies will accumulate steadily.

While it is difficult to accurately assess how



micromachine R&D is conducted in Japan and abroad, typical examples of the starting point technologies and related research institutions are shown in Table-1. The general classifications of mechanism, processing, and system and control are for convenience only. Also included in each category are common technologies; technologies that are apparently the same but, in fact, differ substantially; and other unclassified technologies because, at present, no interdisciplinary boundaries exist.

### 3. Toward the future

Micromachines inspire many people's dreams and hopes and give a glimpse of a new world. This phenomenon is the same in every country. That is why people must talk to each other and share and enlarge their dreams.

MICROMACHINE's articles will play an important role in leading the search for ways to accurately exchange timely information and, based on this information, to determine what cooperative R&D is possible.

After the Micromachine Center (MMC) achieves common international understanding about micromachines, I would like the MMC to be the first step in efforts to direct the R&D and to show how these devices can be used commercially in commerce and industry.

At the time of this publication's first issue, the great expectations for micromachine technology make clear the importance of exploring the basic elements of this new field. This subject is too wide to be fully covered by one article in a public relations magazine. I wish it great success.

**Table-1. Typical Micromachine Research Institutions**

	Japan	United States	Europe
Mechanism-related technology Sensors, actuators, energy sources, designs, etc.	Tohoku University, Tokyo Institute of Technology, The University of Tokyo, Nagoya University, Kyushu Institute of Technology, MITI's Mechanical Engineering Laboratory, MITI's National Research Laboratory of Metrology, (many companies), etc.	UC-Berkeley, MIT, University of Utah, Stanford University, AT&T, NOVA, etc.	Fraunhofer-Institut, University of Twente, Philips, LETI, Siemens, etc.
Process-related technology Addition, reformation, removal, assembling, etc.	The University of Tokyo, Tohoku University, Mie University, Seikei University, MITI's Mechanical Engineering Laboratory, (many companies), etc.	MIT, University of Wisconsin, etc.	Fraunhofer-Institut, Messerschmidt, KfK, STEAG, Imperial College, etc.
System and control-related technology Autonomous distribution, telemetry, cooperative control	The University of Tokyo, MITI's Electrotechnical Laboratory, MITI's Mechanical Engineering Laboratory, etc.	University of Michigan, MIT, IBM, etc.	University of Neuchâtel, etc.
	As the image of micromachine systems becomes clearer, the number of research institutions should increase.		



## French Mission to Japan Exchanges Opinions

Leading authorities on micromachines from France visited the Micromachine Center in late June 1992, and, along with visits to other research centers arranged by MMC, participated in an active exchange of opinion among Japanese and French researchers.

The mission members, Dr. Daniel Hauden, director of the Laboratory of Physics and Meteorology; Dr. Jean-Pierre Goure, director of the Laboratory of Signal Processing Instrumentation; Dr. Françoise Rousseaux, director of X-ray Lithography at the Microelectronic Research Center of the National Science Agency (CNRS); Michel Froelicher, director of the Horology Industry Center in Besançon; and Philippe Delansay of the Optoelectronic Industry and Technology Development Association of the French Embassy, visited companies and laboratories in various cities.

Among the highlights of the mission were visits to Hitachi, the Electrotechnical Laboratory and the Mechanical Engineering Laboratory of the Ministry of International Trade and Industry (MITI), Tohoku University, Toyota Central Research and Development Laboratories, Nagoya University, Mitsubishi Cable Industries, Mitsubishi Electric, Kyushu Institute of Technology, Yaskawa Electric, Toshiba, University of Tokyo, and Nippon Telegraph and Telephone.

During the visits, where active exchange of opinion was encouraged, the mission was able to deepen its understanding of the current position of micromachine research and development in Japan and participate in a critical comparison of where such activities are headed in both countries.

Among the major impressions of the mission members were:

- Major interest in Japanese national R&D projects such as the Large-Scale Project systems
- Japan's active pursuit of practical targets
- Less interest by Japanese researchers than European ones in pursuing study of the LIGA process
- Sensor development is the major focus of current French development activity.

The mission members also asked the researchers at the place they visited to attend the first Japanese-French Congress of Mechatronics, which was held in Besançon over three days from October 20 last year.

To mark the mission activities in Japan, the members presented copies of "Recherches en Microtechniques: Réalités et Perspectives" (Report on World Micromachine Research Trends Based on Review of Papers), published in January last year, to MMC and the institutions visited.

The 438-page report, in French, is available for reading at MMC.

(Hideaki Shirai, Mitsubishi Cable Industries, Ltd.)



*The French mission members and Japanese colleagues*

## Imperial College Researchers Visit MMC

Dr. E. M. Yeatman and Dr. R. R. A. Syms of the Imperial College, Britain, who play an important role in the research and development of micromachines, visited the Micromachine Center on April 13, 1992 to exchange information with their Japanese counterparts.

The Imperial College is planning afoot to establish a micromachine research center in the Britain, and the timely presentation of a review of commissioned research projects undertaken by MMC and planned promotion of researcher exchanges and future publications were seen as especially helpful to the British visitors.

Yeatman and Syms outlined trends in Britain in current micromachine research and briefed MMC staff on the broad range of technology being studied at the Imperial College where four professors supervise the overall technical studies. The new system is a marked change from previous activity at the college where technical studies were carried out on individual bases with little overall coordination.

They also briefed the MMC on Britain's plans for a similar center and said that at least six private enterprises and 10 institutions are laying the groundwork for a research center likely to specialize in micromachine medical applications.

MMC suggested that it would be most willing to establish a cooperative relationship with the planned British institute once it is established.



## U.K. Trade Ministry Official Visits MMC

A. R. Holmes, chief of the Third Section (micromachine duty), Manufacturing Technology Division of the Department of Trade and Industry of Great Britain, visited the Micromachine Center in May last year to exchange research ideas and visit Japanese laboratories.

Guided by MMC Managing Director Takayuki Tsunemi and Project Leader Kiyoshi Aritome of the New Energy and Industrial Technology Development Organization (NEDO), Holmes examined the purpose behind the setting up MMC, its relationship with the Agency for Industrial Science and Technology's Large-Scale Project and research work commissioned by NEDO.

During discussions, it was noted that the Imperial College is leading a full effort in the field of micromachines. Holmes remarked that Britain is looking forward to the center's comprehensive programs to bring about exchange with foreign organizations through participation in foreign symposia, the sending of missions abroad, and promoting the exchange of researchers.

## EC Official Visits MMC

Karl-Heinz Robrock, an officer in Directorate-General XIII (telecommunications, information industries, and innovation) of Commission of the European Community visited the center in June last year while here in Japan to attend the CIM (Computer Integrated Manufacturing) Conference. Robrock said he became interested in MMC after hearing about it through an MMC report on Research and Development on Micromachine Technology at the workshop of International Advanced Robotics Program (IARP) in May 1992.

Robrock said that EC is planning to research on micromachine technology, and a report is expected soon that could lead to the creation of a micromachine project. He said he will inform MMC when the project is created within six months or so. At the end of his visit, MMC promised to mail him the quarterly MICROMACHINE so that the exchange of ideas may continue in the future.

While in Japan, Robrock also visited the Electrotechnical Laboratory of the Agency of Industrial Science and Technology and Seiko Instruments Inc.

## Invitation to Join the General Supporting Membership

Micromachines are minute devices capable of performing complex, microscopic operations, despite being composed of functional elements less than a few millimeters in size. It is believed micromachines have strong potential use across many industrial spectra, particularly in areas requiring sophisticated, advanced maintenance technology in response to increasingly complex and precise machine systems and in medical services where sensitive, advanced medical technology is required, but with minimal discomfort to patients.

The Micromachine Center (MMC) was established on January 24, 1992, with the approval of the Minister of International Trade and Industry. Its objective is to promote the dissemination of micromachine technology in Japan, and contribute to the development of Japan's industry, economy, and the advancement of international communities.

MMC promotes research and development work under the Large-Scale Project "Micromachine Technology," a 25-billion-yen mega-project begun in 1991, delegated by the Ministry of International Trade and Industry's Agency of Industrial Science and Technology.

The center will also engage in independent research, promote cooperative research involving industry, government, and academia, and organize international symposia on micromachine research and development.

(Please refer to page 4 for a Center profile)

MMC would like to invite your interest and support for its projects and activities—and call for your direct support through membership in MMC itself.

Membership privileges include:

1. Participation in surveys and research undertaken by MMC, and use of the results.
2. Use of delegated survey, research and development results not classified as secret.
3. Participation in study groups and other activities of the center.
4. Use of MMC's data bank.
5. Receipt of publications.

To apply for membership, please fill in the designated application forms and submit them to the secretariat.

Membership requires an initial payment of ¥ 4 million and annual dues of ¥ 2 million.

For further information, please contact the General Affairs Department of the Micromachine Center.



# EVENTS

The following are some of the events scheduled to take place in 1993.

## • Fourth International Micromachine Fair

Date: April 20 (Tues.)—22 (Thurs.), 1993  
Exhibition Hall: Science Museum  
(Kitanomaru Park, Chiyoda-ku, Tokyo)  
Organized by: Micromachine Center (MMC)  
Micromachine Society  
MESAGO Japan Corp.  
Supported by: Ministry of International Trade and Industry (to be confirmed)  
Sponsored by: Japan Industrial Robot Association, and other associations  
For more information, please contact MMC (Tel. 03-5443-2971)

## • Fifth Micromachine Symposium

Date: April 20 (Tues.)—22 (Thurs.), 1993.  
Exhibition Hall: Science Museum  
(Kitanomaru Park, Chiyoda-ku, Tokyo)  
Organized by: Micromachine Center (MMC)  
Micromachine Society  
Supported by: Ministry of International Trade and Industry (to be confirmed)  
Sponsored by: Japan Industrial Robot Association, and other associations  
For more information, please contact MMC (Tel. 03-5443-2971)

## Preview of Future Issues

It is our ultimate goal to continue to improve future issues.

Among the expected contents are as follows.

1. Essay (2 pages)
  - Micromachine development makes dreams come true (presented by a renowned researcher)
  - Micromachines and their future
  - Micromachines found in the nature
2. Worldwide R&D (2 pages)
  - Introduction of R&D activities
3. MMC Activities (2 pages)
4. Member Company Profiles (2 pages)
  - Introduction of supporting members (2 enterprises)
5. Topics (2 pages)
  - Reports on symposia, missions, etc.
6. Events (1 page)
  - Announcement of exhibitions, etc.

## MICROMACHINE No. 1

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