MMC

MICROMACHINE

2005 1



# View on Year 2005 at the Beginning of the Year

**Tamotsu Nomakuchi, Chairman**
Micromachine Center

As we welcome the beginning of 2005, I would like to take this opportunity to wish you all a happy New Year. On this occasion, allow me to give a New Year's address with my view on the state of Japan and our industry.

Last year was one in which Japan's economy finally got back on track toward recovery and we glimpsed some good omens for the manufacturing industry, as efforts in reform began to bear fruit.

According to the economic report recently released by the Cabinet Office, an increase in domestic demand will continue to spur economic recovery in the current year.

However, although Japan's manufacturing industry has already developed global production, sales, and services, it must also heed sudden increases in crude oil prices and fluctuations in foreign exchange and must try to be more competitive globally, standing on the advancement of the East Asian economic partnership agreement (EPA), which is now being referred to as a global factory.

Amid global competition that becomes fiercer every day, Japan's government, industry, and academia are asked to collaborate in the strategic fields stated in the government's Science and Technology Basic Plan, including information technology, nanotechnology, materials, and manufacturing technologies. Japan is striving to create more sophisticated innovations by actively promoting R&D.

Fortunately, Japan has managed to preserve an international edge through individual achievements in functional parts, exceptional for the use of special synthesized materials and precision micromachining. The manufacturing industry of East Asia is growing with Japan's advanced parts and materials industry at its nucleus.

By fusing micromachines and MEMS with semiconductor micromachining technology, applied research and development research of these fields have advanced rapidly, attracting much attention domestically and overseas as key technologies for developing new products in automotive fields, information and telecommunication fields, and medical treatment and welfare.

The Micromachine Center has conducted business operations aimed at concentrating the efforts of government, industry, and academia in order to establish and commercialize basic technologies in micromachines and MEMS. Last year, after conducting several studies on the industrialization of MEMS in a joint investigation and research project, we came up with proposals for measures aimed at developing an industrialization foundation and reinforcing the functions of the MEMS foundry. At the same time, we launched the MEMS-ONE project designed to construct a sophisticated, user-friendly software infrastructure for improving the efficiency of MEMS design and development. Together with the foundry service project designed to develop the hardware infrastructure, this project is expected to function like the wheels of a car in helping develop the MEMS industry and restoring Japan to its place as a leading manufacturing nation.

While continuing to base its efforts on trends in such advanced fields as biotechnology, nanotechnology, and information technology, the Micromachine Center plans to explore other technology frontiers with the aim of establishing new basic technologies for next generation micromachines (fine MEMS, nano-microsystems, etc.).

I wish you all continued happiness and prosperity in 2005. Happy New Year, everyone!

# The 10th International Micromachine / Nanotech Symposium

The 10th International Micromachine / Nanotech Symposium, subsidized by the Japan Motorcycle Racing Organization and supported by METI and NEDO, was held on November 11 (Thursday), 2004, at the Science Museum in Kitanomaru Park, Tokyo. The themes for this symposium were “Micromachine technology for safe and secure advanced information societies”, “New MEMS/ systems and technology”, and “Policy trends of MEMS research and development”; 15 lectures were presented by invited speakers, 4 from overseas and 11 from within Japan. The symposium welcomed 359 participants altogether, including general attendees from both within Japan and overseas, speakers, invited guests, and members of the media. This number represents an increase of more than 20% over last year's attendance and includes the highest number of participants from within Japan to date. The symposium was a roaring success, with morning sessions in particular so packed there was barely standing room.

In Session 1, “Opening”, an opening address was given by Dr. Tamotsu Nomakuchi, Chairman of the Micromachine Center, followed by a guest speech by Mr. Yoshinori Komiya, Director of the Industrial Machinery Division, Manufacturing Industries Bureau, METI. This was followed by a special lecture entitled “New progress of integration and fusion in MEMS – expectations for new industry creation”, presented by Prof. Susumu Sugiyama of Ritsumeikan University. The input/output of LSI – the development of which enabled the realization of today's information society - is limited by electronic signals; MEMS, however, has the potential to input/output a diversity of signals - electronic, mechanical, optical, magnetic, chemical, and even biological. By combining MEMS with the remarkable technological innovation that is nanotechnology, it is anticipated that this field will bring about tremendous dreams for human society.

In Session 2, “Micromachine technology for safe and secure advanced information societies”, speakers active at the forefront of the commercialization of cars, information equipment, and medical equipment presented lectures on the relationship between MEMS and these various products. Brimming as these product-focused lectures were with practicality, the already overflowing lecture hall took on an added air of excitement. Today micromachine (MEMS) technology is a key technology supporting a safe and secure highly information-orientated society. Thanks to MEMS technology and nanotechnology, such innovations as the ultimate safe car; the impressively creative, ultimate computer display; and the safe, reassuring, highly efficient, ultimate therapeutic capsule endoscope are no longer dreams.

Session 3, “New MEMS/ systems and technology”, began with 3 lectures (2 by speakers from overseas and 1 by a speaker from within Japan) on the relationship between ubiquitous networks and MEMS. These were followed by 2 lectures (1 each by speakers from overseas and within Japan) on the application of MEMS in biomedicine. Various other lectures on timely topics were presented, including the smart skin for turbulence confrd insplred by dolphins skin, the integrated MEMS that examined the example of infrared image sensors, and the nanoimprinting technology. which enables micro and nano machining innovations with a view to moving away from the semiconductor process. From these it is clear that MEMS can potentially be applied and expanded in a vast array of fields. However, for this to be realized, R&D of new production technologies that considers cost reductions is also an important challenge for the future.


Session 4, “Policy trends of MEMS research and development” featured such lectures as one on market trends for MEMS that showed an expansion of the MEMS market from 450 billion today to 1.35 trillion in 2010 and another on the METI/NEDO MEMS design and analysis support system development project (MEMS-ONE Project) - launched in an industry-academia consortium by the Micromachine Center – that highlighted the activities of the Micromachine Center. Furthermore, a lecture on systematic approaches in material research necessary to MST (Micro System Technology), launched by a European industry-academia consortium showed how global R&D is progressing overseas also.

Lasting from just after 9:00 a.m. until 6:00 p.m., the long program packed in 15 lectures, beginning with the special lecture, and the lecture hall was filled with an air of excitement. A sense of the enormity of the potential of micromachines and MEMS, and tremendous expectations for their future was palpable. Responses to the symposium included many favorable comments from participants, such as “I was able to learn about new trends and could see the direction in which commercialization is heading” and “MEMS-ONE is a highly desirable experiment; I hold high expectations for it,” and some of the information presented in lectures was taken up and reported favorably by the media. Thanks to the efforts of our speakers, both from within Japan and overseas, who presented such topical information, and of the members of the program committee, who worked so hard to organize the program, this year’s symposium was a resounding success.

The next symposium, The 11th International Micromachine / Nanotech Symposium, is planned for November 10 (Thursday), 2005, again at the Science Museum in Kitanomaru Park, Tokyo (located near the Imperial Palace), in conjunction with The 16th Micromachine Exhibition.

# The 15th Micromachine Exhibition: "Micromachine 2004"

The 15th Micromachine Exhibition, "Micromachine 2004," was held in conjunction with The 10th International Micromachine/Nanotech Symposium at the Science Museum in Kitanomaru Park, Tokyo, for 3 days from November 10 to 12, 2004, and was a roaring success.

The theme for this year's exhibition was "Limitless Business Fields Opened up by Micro/Nano Technology: International Exhibition on Micro-Ultraprecision/Microfabrication, MEMS, Nanotechnology, and Biotechnology".

In addition to the Micromachine Center and 11 of its supporting member organizations, generous cooperation in the arrangement of exhibitions was also provided by private businesses, universities, and independent public organizations. A total of 247 displays (352 booths) were exhibited by representatives of various businesses, academic groups, universities, and research organizations. France's National Center for Scientific Research (*Centre National de la Recherche Scientifique*) and six other organizations from abroad also presented exhibits.

In accordance with the increased number of exhibitors, the Micromachine 2004 exhibition occupied, for the first time, the entire first floor hall space and preparation room, a part of the lounge, and a part of the second floor, of the Science Museum.

Furthermore, a total of 77 businesses and academic groups took part in the exhibition, including 2 companies participating from abroad for the first time, and a wide range of new technologies and products in the fields of nano-technology and micromachines were presented.

Thanks in part to the exhibition being held in conjunction with the 10th International Micromachine/Nanotech Symposium, an attendance of 8,213 people was achieved over the three days of the event. Researchers, engineers, and administrators from the frontlines of various technological fields accounted for a large number of these attendees, and through the exchange of ideas and sharing of research information with colleagues from other fields, the exhibition provided an ideal opportunity for discussion of the possibilities for new technologies and to resolve a wide range of developmental issues.

The main products displayed at the exhibition included micromachines, their associated components and application systems, MEMS-related systems, nano-technologies and materials, technologies related to micro-ultraprecision fabrication and production, equipment, biotechnology and medical systems, evaluation and measurement devices, and software. In this regard, Micromachine 2004 was ideally suited to researchers, engineers, designers, manufacturers, and managers from fields such as mechanisms and precision machinery; electrical devices and electronics, medicine; information technology; automobiles and transportation; biology, physics, and chemistry; architecture; metallurgy; space aviation; and shipping and oceanography.

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

On its opening day, the exhibition was visited by Mr. Sakae Takahashi, Executive Director of NEDO (independent administrative organization), who spoke at the reception that was held following the exhibition. On the second day, it was also visited by Mr. Yoshinori Komiya, Director of the Industrial Machinery Division, Manufacturing Industries Bureau, METI.

**Micromachine 2005 will be held from November 9 (Wednesday) to 11 (Friday), 2005 at the Science Museum, Kitanomaru Park, Tokyo.**

**Inquiries:** Mesago Messe Frankfurt Corporation
**Tel:** 03-3262-8441
**Fax:** 03-3262-8442
**Email:** info@micromachine.jp
**URL:** http://www.micromachine.jp

**The exhibition hall, packed with attendees.**

**Attendees at the post-exhibition reception.**

# Hitachi MEMS Foundry Service

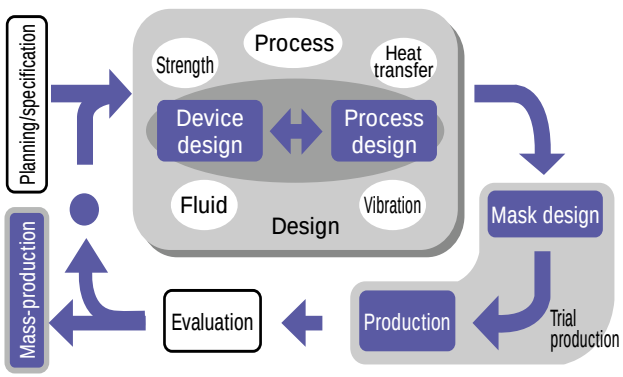
**Akira Koide**
MEMS Project
Mechanical Engineering Research Laboratory
Hitachi, Ltd.

## 1. Outline

In i-engineering, an integrated market of its manufacturing technologies, Hitachi, Ltd. supports technicians engaged in research and development, design, production, and inspection. Although Hitachi's MEMS foundry service was launched three years ago with services covering design, processing, and trial production, many customers have expressed a wish for the foundry service to handle the entire process up to and including mass-production. Therefore, beginning this year, we are offering services through mass-production in cooperation with foundry companies in Hitachi Group. We also assist customers in MEMS R&D and the construction of production lines and are providing wide-ranging solutions for MEMS development, from the selection of utilities and manufacturing and inspection equipment to clean room construction required.

## 2. Hitachi MEMS

Much of the technology supporting MEMS at Hitachi came into being as a result of technologies fostered since the 1970s for developing power devices, optical communications, semiconductor sensors, and other such devices. Applied fields for these technologies have expanded to include biotechnology, micro-chemical processing, and RF-MEMS. These processing technologies originate from the anisotropic etching of single-crystal silicon. Hitachi has worked hard to develop a multi-stage etching process employing a simulator for predicting etching configurations and has used this process to develop many products. For more than ten years now, Hitachi has continually expanded the range of applied fields for MEMS technology and has actively engaged in the development of micromachining and assembly technologies for thin films, glass, metals, and synthetic resins and has applied these technologies to device development in the various fields.




**Flow of processes in Hitachi's MEMS foundry service**

In this way, processing technologies have become more versatile, and, as advancements of each technology have led to increasing specialization, Hitachi has engaged in the building of a framework capable of effectively utilizing these processing technologies in device development. In one such example, Hitachi has created an environment for linking device design to process development in which process developers can easily analyze the strength and heat flow of devices while seated. Accordingly, robustness that accounts for variations in each process under development by specialists can be easily reflected in the device design, providing efficient device development that enables a smooth transition from trial production to mass-production.

## 3. Features of Hitachi's MEMS Foundry Service

Hitachi's MEMS foundry service has developed into a broad service for supporting the individual circumstances of our customers, from simple questions related to MEMS to device design, trial production, and mass-production. These services are founded on knowledge that Hitachi has accumulated through years of research and development on devices and their design and processing. Our objective is to further strengthen our MEMS R&D system and to provide a richer array of services.

In order to broaden the range of services it provides, Hitachi is strengthening relationships with other companies in Hitachi Group. Two representative examples of companies in Hitachi Group that have developed foundry services independently are Hitachi Metals, Ltd. (http://www.hitachi-metals.co.jp/index.html) and Hitachi Haramachi Electronics Co., Ltd. (http://www.haraden.co.jp/). Both companies have differing fields of expertise that complement one another and disclose the features of their technologies on their corresponding Web sites.

In summary, Hitachi continually develops the array of services offered through its MEMS foundry service through reinforcement of its MEMS R&D system and collaboration with companies in Hitachi Group. It is our hope that these services will contribute to future MEMS development.

For further information, see the i-engineering Web site for Hitachi's integrated market of manufacturing technologies:
http://www.i-eng.hitachi.co.jp/

Overseas Trends

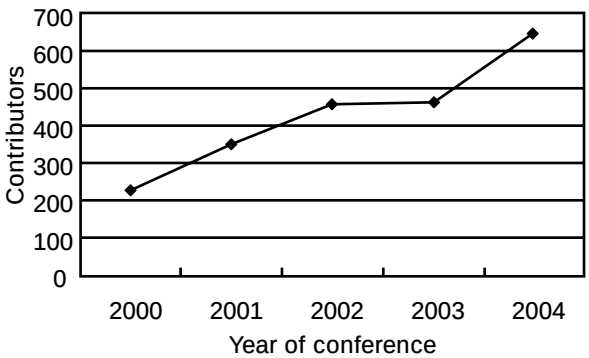
# μTAS 2004, Sweden (September 26–30)

The 8th International Conference on Miniaturized Systems for Chemistry and Life Sciences (μTAS 2004) was held at the Malmö Exhibition and Convention Center in Malmö, Sweden on September 26–30, 2004.

Since the first of these conferences was held in 1994 as a workshop in Enschede, Holland, the numbers of contributors and participants have increased each year.

The latest conference received 655 contributions of which 430 were accepted. This is a large increase over the 462 contributions and 325 acceptances of the previous year, proving that research in this field continues to grow. Viewing the number of contributions by country, we can see that Japan contributed 175, the U.S. 132, Sweden 78, and Denmark 57, indicating that Japan, America, and Northern Europe are the leading countries and regions in this field. Among research institutions, the University of Tokyo submitted 46 contributions, the Technical University of Denmark 26, the Research Association of Micro Chemical Process Technology 13, and Lund University 13, indicating that the University of Tokyo is very active in this field. At last count, the conference attracted about 735 participants, of which more than 200 were from Asia.

The conference featured presentations on such basic technologies as microfluidics, MEMS and nanotechnology, and materials, as well as their applications in chemistry, biotechnology, medicine, and the like. It seemed that the conference was able to assemble a vast array of data in the field. Poster presentations, also reflecting the organizer's intention, were given on application systems, MEMS technology, and other technologies on the verge of practical applications. As many as 356 presentations were given during the three days of the conference. The conference also provided a venue for researchers to engage in direct intercourse.




Overall the presentations seemed to shift in content from single-step chemical processes to system research envisioning applications in chemistry, biotechnology, and medicine.

The first half of the presentations seemed to focus on nanotechnology, in which Japan is strongest, while the second half focused more on cellular tissue and analysis, which area is led by Europe and America. Conspicuous among these was the presentations on cells that included reports on the proposals and trial production of new systems from such perspectives as positioning, culture, and lysis or from points of view at which these overlap, resulting in a multifaceted presentation overall. Many presentations on MEMS processes covered chips and MEMS structures using polymers (PMMA, SU8/PDMS, etc.). There was also a presentation on two-layer processes that tried to drive home the stability and commercial potential for these processes.

The poster session was a great success. Presenters and participants used all the time allotted for the session to exchange opinions directly on applications, MEMS technology, fluid devices, and nanotechnology.

Next year, μTAS 2005 will be held in Boston, Massachusetts, U.S.A. on October 9–13, 2005.


**Malmö Exhibition and Convention Center**

**View of a conference room**

# Aisin Cosmos R&D Co., Ltd.

**Yoshihiro Naruse**
**Director**

## 1. Introduction

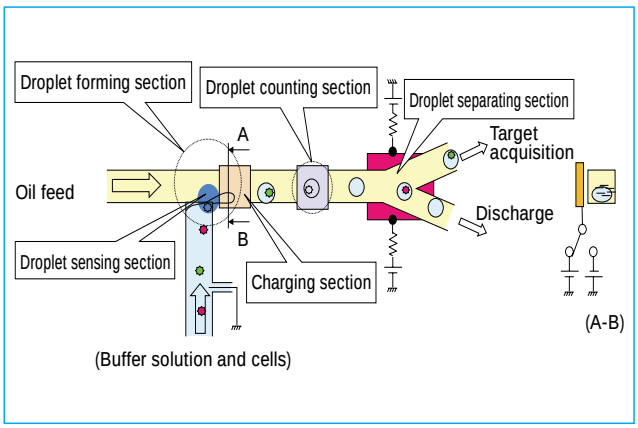
Aisin Cosmos R&D Co., Ltd. was founded in Kariya City in Aichi Prefecture in October 1992 as an R&D company under Aisin Seiki Co., Ltd. Since its establishment, the company has focused its energies on fields in which great strides are expected in the 21st century, such as biotechnology, micromachine technology, and medical equipment. In addition, we are developing technologies that may become feasible in the coming generations, such as an antigen-antibody reaction sensing technology using a technique for exhaustively analyzing genes and the surface plasmon resonance principle, and microfluid devices such as micropumps and microsorters.

In today's information society, which is experiencing rapid growth in technology, we are concerned with people's health and destruction of the environment. In our research, we are striving to link our developed technologies to devices that can provide security and peace of mind to the average citizen.

## 2. Endeavors in Micromachine Technology

Our endeavors in micromachine technology began in 1990, inspired by a micromotor having a diameter of 100 μm that first emerged around 1989, drawing much attention. However, in terms of the scaling, heat and viscosity become more dominant in micromachine functions than in conventional designs. Therefore, we made it a point to begin developing micropumps comprising heat actuators. We also participated in the former Micromachine Project organized by METI (formerly MITI), at which time we conducted R&D focusing on microfluid control technology in micro-region. We are currently focusing on using our developed technologies in the biotechnology field.

Fig. 1 shows a photo of a micro cell sorter developed using our microfluid control technology. In this device, cells are entrapped in droplets that are formed in the channel, with prescribed cells being made fluorescent to aid in sorting and separation. By performing everything from droplet formation to sorting and separation within the channels, the system is airtight and should prevent contamination and improve operability. Currently we have achieved a droplet formation/separation rate of 5,000 droplets/second in experiments that entrap fluorescent beads in the droplets.



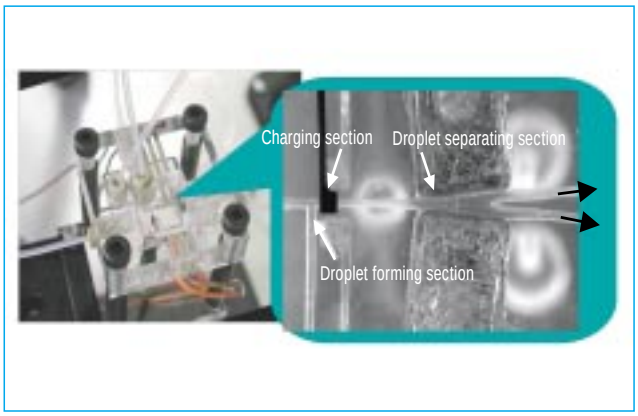




**Fig. 1 Photo of a microsorter with an enlarged view of the sorter section**

## 3. Future Prospects for Micromachine Technology

For the past ten years or more, micromachine technology has developed significantly in the fields of MEMS and μTAS. While MEMS has shown steady progress toward practical use in the fields of information and sensors, it is thought that μTAS, based on micromachine technology, must be somehow matched with biotechnology or chemical technology on a nanotechnology base to achieve practical applications.

Worldwide R&D

# Department of Applied Chemistry, Graduate School of Science and Engineering, Specializing in Chemical Engineering and Advanced Crystallization Engineering Research, Waseda University

**Izumi Hirasawa**, Professor

A crystal is a solid having a regular arrangement of atoms and molecules. By creating crystals with a desired quality, it is possible to achieve high purity that can be kept stable for a long period of time and that can be freely controlled with complex functions. Hence, we are striving to develop an environmental friendly crystalline product of a desired quality as a 21st century material for biotechnological and environmental use. To make crystals in a solution (known as crystallization), the concentration of the solution is made higher than their solubility (supersaturated state) to produce seeds of a crystal (crystal nuclei). These seeds are grown to cultivate large crystals. By controlling the number of seeds and their growth rate during this process, it is possible to control the size, shape and structure of the crystals. We have witnessed the instant at which molecules and atoms in the solution become crystals. The solution begins to quiver and the crystals are born among the oscillations. While crystals are inanimate, they appear like living organisms that are born as seeds and grow as if they are alive.

Today we are conducting research for producing desired crystalline products while attempting to better understand basic crystallization phenomena. We have organized projects on pharmaceuticals and organic crystals, nano-crystals, environment and recycling, and heat storage (storing heat in the form of crystals). Topics of our research are discussed in greater detail below.

## Environment and recycling

We are constructing processes that are capable of not only removing but also recovering substances that have adverse affects on the environment, including such nutrients as nitrogen and phosphorous and such industrial emissions as fluorine and metal ions. In collaboration with industry and academia, we are advancing R&D aimed at establishing optimal operations and processes for the removal and recovery of these targeted substances in the form of crystals. The resulting process for removing and recovering fluorine and phosphate ions is being implemented with full-scale equipment and is contributing to the recovery of unused resources. While fine crystals tend to be generated in the crystallization process, we have obtained coarse spherical crystals by efficiently conducting supersaturation formation, attachment of fine crystals, and agglomeration. Further, through collaboration with other companies, we have conducted successful research on recovering nickel ions in the form of nickel metal (more than 99% pure) from a used bath of electroless nickel plating in the presence of a reducing agent. We believe that this research will help in the recovery of other rare metals and the creation of nano-size metals.

## Creation of Nano-Crystals

Crystals in the nano-size ($10^{-9}$ m) range have a large surface area per gram and exhibit functions that are not seen in larger crystals. We are trying to produce a crystal of this size in a highly supersaturated region. In order to produce functional crystals (such as those that emit blue or red fluorescence or those with a confined distribution of nano-size particles), we are attempting to produce nano-size crystals, focusing on crystallization with polyelectrolytes (see photo), controlling nucleation with the presence of heterogeneous crystals, and nucleation induced by ultrasonic waves.

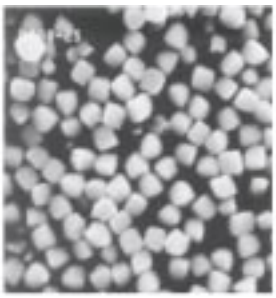
## Pharmaceuticals and Organic Crystal Control

Many crystalline products in pharmaceuticals are hydrophobic and, hence, cannot be dissolved or absorbed in the human body efficiently. Accordingly, it is important to obtain crystals having a desirable solubility and nano-size crystals. We are conducting research aimed at creating such crystals.

## Heat Storage Process

Latent heat storage is a method for storing heat in the form of crystals. Our laboratory is working to recover waste heat of various temperatures using hydrated salt crystals. Joint research is being conducted with other companies on ice storage, and a new heat storage system is currently operating at the Minato Mirai 21 District Heating and Cooling Service Co., Ltd. located in Minato Mirai 21 district, Yokohama. Our know-how for creating crystals is thus applied in the effective use of thermal energy.

http://www.sci.waseda.ac.jp/research/



**Nano-size lead sulfate produced through reaction crystallization in a polyelectrolyte environment**

**MICROMACHINE No. 50**

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

Keiichi Aoyagi, Executive Director, Micromachine Center (MMC)
MBR99 Bldg., 6F., 67 Kanda Sakumagashi, Chiyoda-ku, Tokyo 101-0026, Japan
Tel : +81-3-5835-1870, Fax : +81-3-5835-1873
Internet Home Page http://www.mmc.or.jp/
Date of Issue : January 21, 2005