NATIONAL
INSTITUTE FOR
MATERIALS
SCIENCE

NIMS NOW International

No. 2
2013 MARCH

Materials Manufacturing and Engineering Station

Engineer *for* Science

Engineers Creating Advanced Research

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At many plants that produce industrial products,
mechanization and automation are underway.
As a matter of fact, in semiconductor production and certain other industries,
manufacturing is performed virtually without human intervention.
In spite of this trend, the people known as engineers are still indispensable in
advanced materials research.
Why?
When producing materials, for example, metals are melted and rolled.
In this work, there are still many areas where digitization is not possible,
and technologies in these areas are accumulated in engineers as a kind of implicit knowledge.
The Materials Manufacturing and Engineering Station possesses
the integrated technologies of the actual manufacturing workplace,
from metal melting to welding,
and uses these technologies to support advanced research.
The engineers of this Station know what happens at the site where materials are produced,
and that is indispensable for transforming basic research into useful materials.

Engineering Work
–the Competitive Power of Materials Research

Shiro Torizuka,
Station Director, Materials Manufacturing and Engineering Station

The aim of the Materials Manufacturing and Engineering Station is to support materials research not only at NIMS, but in Japan as a whole. This station provides all types of research support, from preparing metal ingot through smelting to the manufacture of experimental equipment. Engineers must possess the high technological capabilities to make advanced proposals for research.

Torizuka(T): Although it has now been 6 years since the Materials Manufacturing and Engineering Station was launched, I feel that the importance of engineering work is increasing. Even though the Station has equipment for processes such as melting, plastic working, laser welding of metals, and mechanical working, this alone is not enough; our work is only possible thanks to the technical skills of our outstanding engineers. Recently, although they have advanced equipment, people who can do engineering work that requires high safety technology at universities and other research institutions has decreased. Because NIMS consciously maintains the necessary environment, we now receive a number of requests from universities and companies.

—— What is necessary for that?

T: We must continue to pass on existing technologies to the younger generation, while also introducing state-of-the-art equipment, and train human resources in line with this. We do very advanced work here, for example, levitation melting, and we also create new experimental systems. Grinding and polishing of metal is a good example. In the past, it was enough to remove flaws, but now it must be possible to observe the crystal orientation of the sample structure. To achieve this, we must produce a strain-free surface. Engineers are expected to have a deep knowledge of these material manufacturing and engineering techniques, understand the aims of researchers, and be able to offer proposals.

—— So research support that utilizes human capabilities is essential?

T: Semiconductor manufacturing technology, which by nature should be an advanced technology, was lost to other countries in a relatively simple manner. On the other hand, Japan has maintained strong competitiveness in metals and materials. I often think about the reasons for this, but I feel that in fact, engineering is deeply related. This is because all the manufacturing technology and know-how of individual engineers cannot be incorporated in the equipment.

In reality, the phenomena that occur in product manufacturing processes are quite complex. For example, in rolling, the friction coefficient is different, depending on whether there is an oxide film (scale) on the material surface or not. If there is, the rolling method will be different. This still can't be predicted by a computer, but an engineer will know what will happen in a certain case, based on implicit knowledge possessed by that individual. With steel strips, it is difficult to control the internal structure and produce an ultra-fine grained product, but it is also very difficult to roll strips to the required thickness. Nevertheless, that is the "product". In fact, the things that we take for granted are extremely difficult.

—— It seems that things that can't be quantified are important.

T: Ilmplicit knowledge becomes known and is automated. Although this is wonderful, there are still many, many things at the production site where this is not possible. Actually, this in itself is a source of Japan's competitiveness. Since this is also a source of materials research, I believe that attaching importance to engineering work that requires high-order technologies will contribute to maintaining Japan's competitiveness in materials-related fields.

—— What are your dreams for the future?

T: To become a hub supporting materials research in Japan. I hope people will come to NIMS when they have a problem. If so, we can also collect information and understand what the next technologies will be. That is one dream. As another dream, I would like to contribute to the development of innovative new materials using our technologies as a base. Ultrasteel screws, which are developed by NIMS, have now reached practical application and are used in smart phones. However, I also want to contribute to the next practical application. This Station performs work beginning with melting and rolling, as well as welding and preparation of specimens and observation of structures. Organizationally, we have integrated technologies for materials manufacturing, extending to the design and manufacture of experimental equipments utilizing glass work and machining work. I would like to maintain and increase that strength of having highly advanced universal technology and unique original technology in the future.

—— Do you have any advice for young people?

T: If you understand that you are a frontrunner of the world's most advanced technologies, I'm sure you'll think they are overwhelmingly interesting. However, since that's very hard, I hope you'll make steady efforts. I also hope that you'll ask for feedback from researchers to improve yourself. I hope you'll become people who can make proposals that only an engineer can provide. To do that, you have to understand research. We live in times that demand this kind of ability.

Engineers are waiting to do research with everyone!

Shiro Torizuka Ph.D. (Eng.) Completed the doctoral course at the School of Engineering, the University of Tokyo in 1993. Joined NKK (now JFE Steel Corporation) in 1985, and joined National Research Institute for Metals (NRIM; now NIMS) in 1996. Station Director of Materials Manufacturing and Engineering Station, and also Group Leader of Materials Processing and Reliability Group, Materials Reliability Unit, Environment and Energy Materials Division.

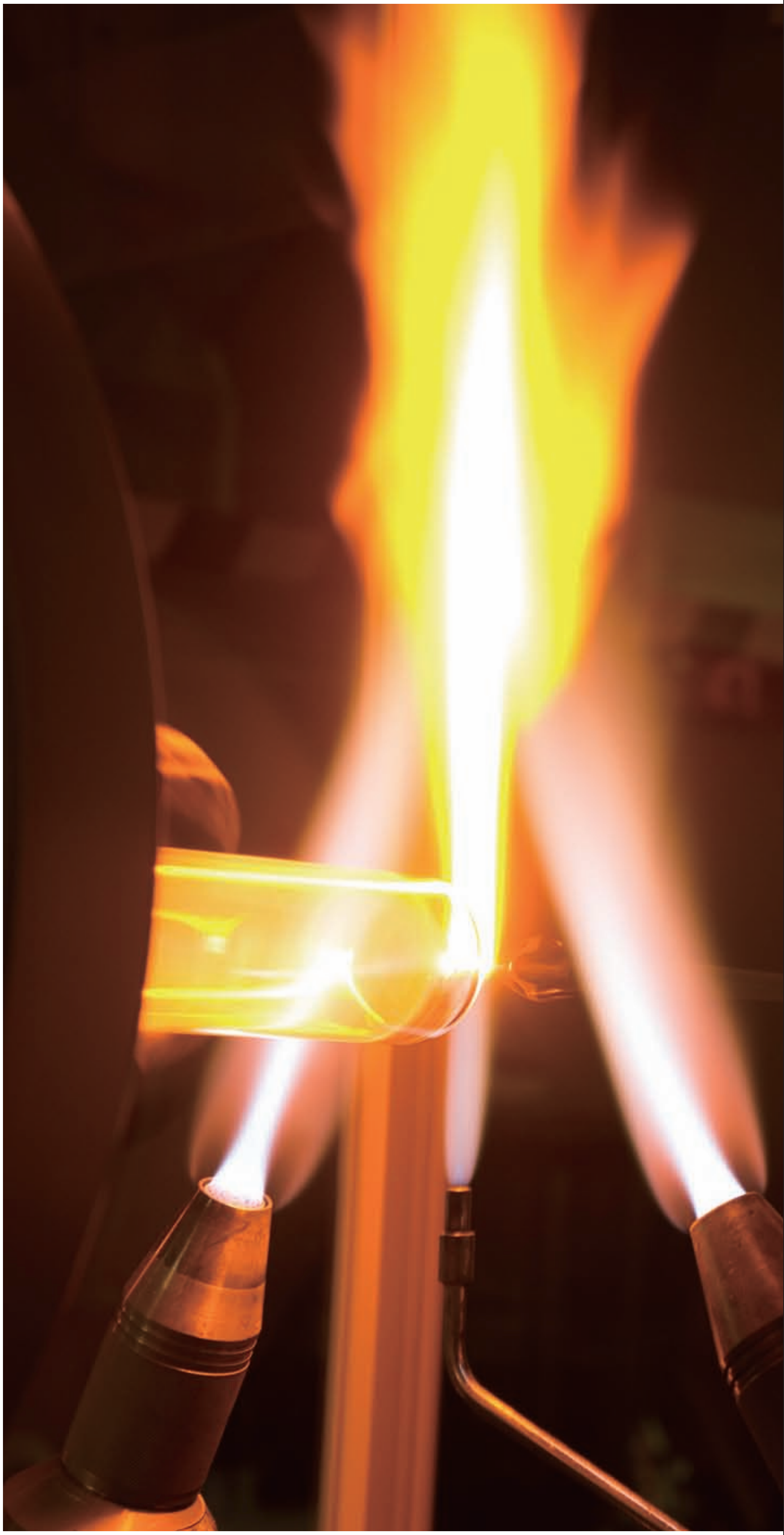
Glass Workshop

The Glass Workshop is responsible for a wide range of work, which includes design and manufacture of glass equipment/devices that are indispensable for advanced research and development aiming at practical application, as well as technical support for research, such as vacuum sealing and inert gas replacement sealing of sample materials, precision polishing, technical consultations, supply of raw materials, etc.

The main equipment of the Glass Workshop includes a glass lathe, high speed precision cutting machine, surface grinders and internal/external cylindrical grinders, an ultrasonic machining system, high vacuum exhaust device, and various types of burners. Using these equipments, the Workshop manufactures valuable glass implements, and also designs and trial manufactures advanced devices.

The photograph shows work with the glass lathe. A Pyrex glass tube (outer diameter: 65φ) is drawn by applying the high heat flame (approx. 1500°C) of an oxygen/hydrogen burner and then cut, after which the bottom is closed and flattened.

In this way, glass equipment for various types of experiments is fabricated by heating glass tubes with the high heat flame of a gas burner and then drawing and expanding the glass. Although the glass lathe is used in working of large-diameter hard glass and quartz glass, ultimately, the machine is only an aid. This is virtually all "hand work." Fabrication of these products is job in which the long experience and intuitions of engineers play a particularly large role.



Machine shop

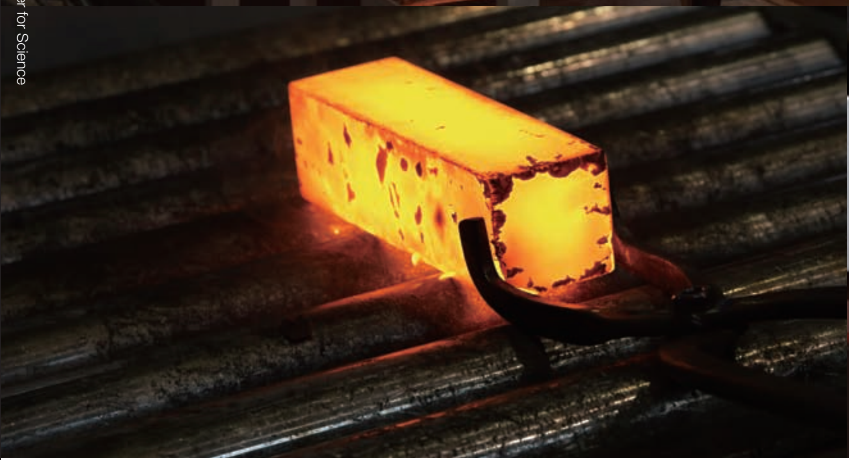
The Station has two machine shops, the Sengen Workshop, and the Namiki Workshop. These two workshops perform machining and processing upon request from researchers, and provide technological consultations and other services.

One distinctive feature of the Namiki Workshop is design and prototyping work using CAD. The Workshop is responsible for development of devices that are indispensable in research support, such as optical polishing devices, micro-tensile test piece polishing device, etc.

The Sengen Workshop performs machining and micromachining of test pieces using a complete range of equipment. The Workshop puts its full energies into various types of work, such as machining of tensile and compression test specimens using the CNC lathe, machining of micro-test pieces, masks for sputtering, and microelectrodes using the wire-electrical discharge machine, hard materials machining and micromachining by a laser machining system, etc. The Sengen Workshop also holds monthly safety and technology classes in English and Japanese to encourage use of its facilities by international researchers. The photograph shows a researcher, who obtained a license by taking classes, using the electrical discharge machine.

Metallogaphy Workshop

Observation and evaluation of the structure of materials is the first step in materials research. The Metallogaphy Workshop provides a platform that enables high-level integrated specimen preparation works from cutting, implantation, and polishing of various types of materials to corrosion testing, observation/hardness measurement, and surface evaluation. Using mechanical polishing and electrolytic polishing, the Workshop supports preparation of mirror finished surfaces of specimens. 3D observation is also possible. Among its representative equipment, the Workshop has 9 cutting machines of 6 different types, 6 implantation machines of 2 types, 17 automatic grinding machines, 9 manual grinding machines of 3 types, and 1 surface grinding machine. Recently, these facilities are used by many researchers working not only with metallic materials, but also with diverse other types of materials and with processing-resistant materials. The range of users is very wide, including 17 NIMS Units, 2 Stations, and 34 Groups. The total number of users now exceeds 6,000/year, and total working time is more than 9300 hours/year. The Workshop also supports short-term users and internships and experiential training to improve and disseminate basic knowledge/technology in connection with specimen preparation techniques, and plans and holds classes on sample preparation techniques. When necessary, it also provides individual consultations related to specimen preparation.

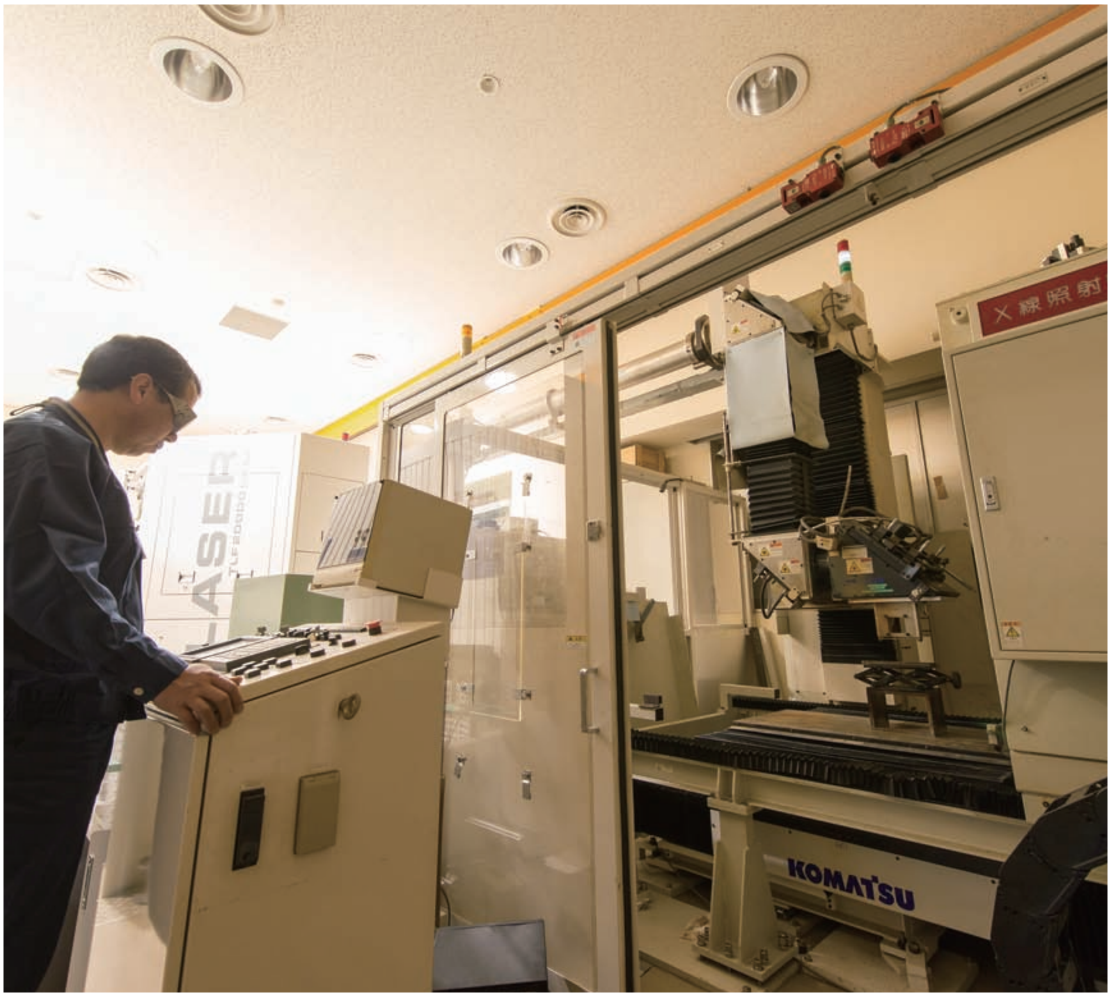


Metal Melting & Plastic Working / Forging & Rolling

In the field of melting & plastic working, we are responsible for melting and plastic working of metal materials. The 300t forging press on the cover of this newsletter is mainly used to form ingots produced by melting to the shape required by research purpose by compressing with dies from above and below. Forging makes it possible to produce raw materials with improved mechanical properties by refining and homogenizing their microstructure. Unlike closed die forging, free forming and compression are possible, but conversely, the skill of an engineer is necessary.

In addition, this Workshop also handles many diverse rolling requests, such as production of steel bars and ultra-thin steel sheets from thick materials by hot, warm, and cold rolling. The purpose of rolling processes is not simply to produce a sheet or bar shape; the effect of rolling on the grain size and material properties of the rolled material is also a key research issue. Even though this requires a rich variety of materials and numerous experimental conditions, this Workshop realizes rolling experiments for a wide range of research, from basic to

applied research. In particular, grain refinement rolling based on multidirectional and large strain working in the warm temperature region is actively used in various fields of research.

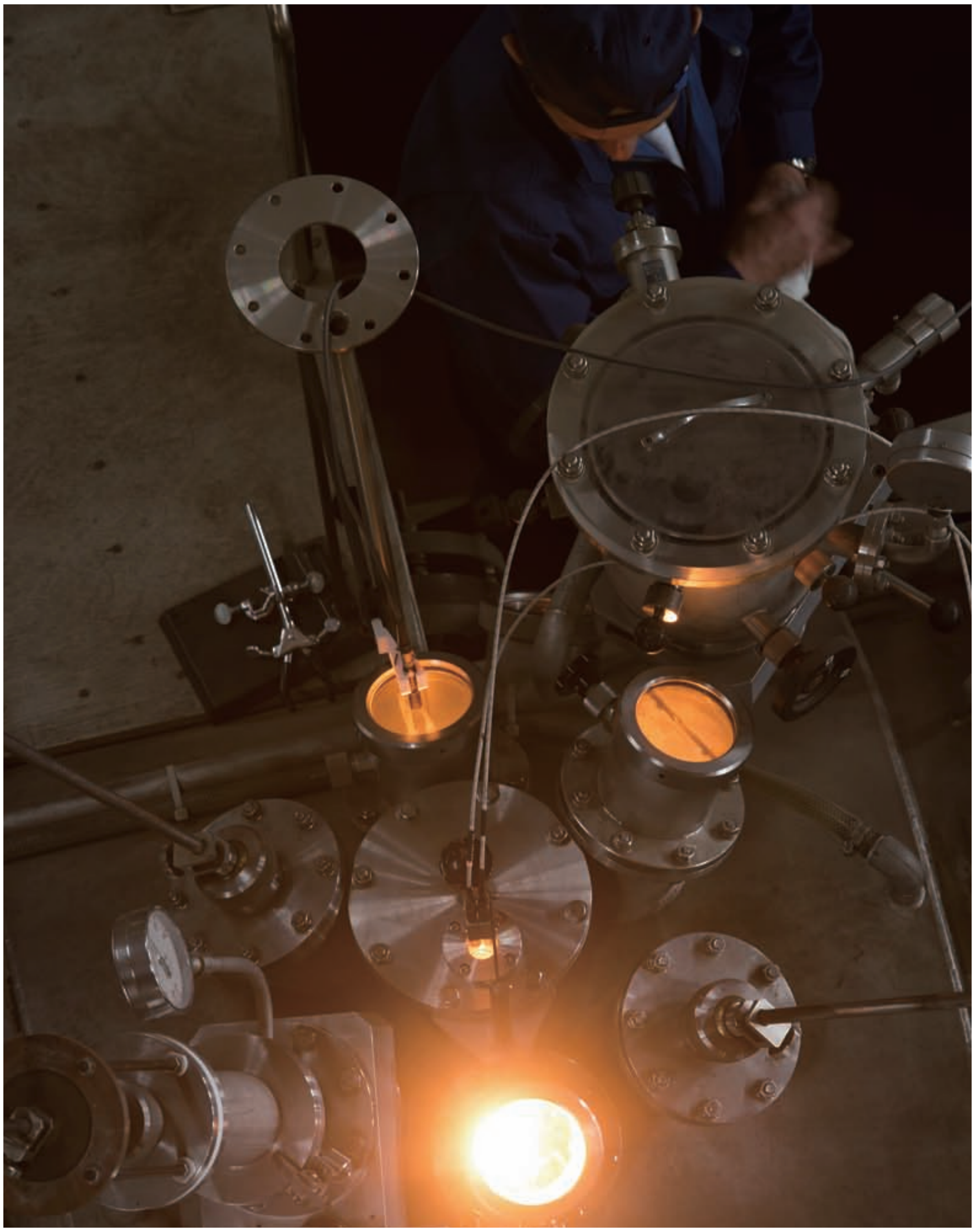


Welding

We perform welding with high energy density beam. Devices include a CO_2 gas laser welding system (maximum laser output: 20kW, continuous wave (CW) and pulsed oscillation (0.1-100kHz)), micro-focus fluoroscopic device (maximum tube voltage: 225kV, maximum tube current: 1mA, maximum penetrating power for Fe materials: approx. 20mm), and an electron-beam welding system (accelerating voltage: 70kV, beam current: 500mA).

Because laser welding forms a long, narrow cavity called a keyhole (keyhole welding; arc welding is heat conduction-type welding), it is the only heat source that enables deep weld penetration under an ordinary air atmosphere, high welding speed, and a fine weld bead. For this reason, the heat affected zone (HAZ) is narrow and has a minimal effect on the microstructure of the base metal. The keyhole behavior in laser welding can be observed using the micro-focus fluoroscope.

Making full use of these devices, we respond to wide-ranging needs, from support for welding research by researchers to joining in fabrication of test specimens.

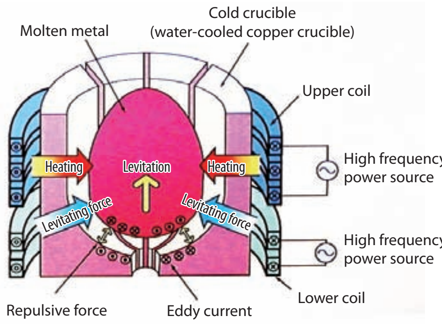


Metal Melting & Plastic Working / Levitation Melting

The equipment in this field features a perfect levitation-type metal melting device using CCLM (Cold Crucible Levitation Method) melting. CCLM melting is a method in which metals are levitated by the repulsive force of an eddy current, which causes repulsion between a molten metal and the water-cooled copper cold crucible, and the metal is also heated and melted by high frequency induction heating.

As shown in the figure, using 2 high frequency power sources, this device enables melting of 100% of the metal in a state of perfect levitation by a combination of a high frequency power source of several kHz in the lower coil, where priority is given to the levitating force, and a high frequency power source of several 10kHz in the upper coil, where heating capacity is important. In the general melting technology for metals, high frequency melting is performed using crucible made of oxidized material such as alumina. However, this levitation melting technology enables melting without contact with the crucible.

As features of this technology, high speed melting is possible, high purity and high melting point metals like Nb and chemically active metals like Ti can be melted, the refining reaction can be promoted using the active stirring force of the melt by magnetic force, thereby producing alloys with a homogeneous composition, and fluxes with various compositions can be used because there is no reaction between the melt and the crucible. Removal of impurities by the inclusion aggregation effect due to the difference in electric conductivity is also a feature which is not found in other melting methods.



Principle of cold crucible levitation melting

NIMS NEWS

1 nano tech 2013

(Jan. 30 – Feb. 1, 2013) NIMS exhibited at "nano tech 2013 – The 12th International Nanotechnology Exhibition and Conference," which was held at the Tokyo Big Sight International Exhibition Center. The main subject this year was "'Life & Green Nanotechnology' 10^{-9} Innovation" continuing from year 2012. A total of approximately 47,000 persons visited the exhibition over the 3-day period. NIMS exhibited posters showing 21 research achievements and also presented mini-lectures by researchers. At the poster exhibit, research on fuel cell catalysts, high performance thermoelectric materials, and single electron devices attracted particular attention.

NIMS booth

2 Report of MANA International Symposium 2013

(Feb. 27 – Mar. 1, 2013) The International Center for Materials Nanoarchitectonics (MANA) held the MANA International Symposium 2013 at the Tsukuba International Congress Center (Epochal Tsukuba). This symposium is held each year to present the results of research at MANA. This year's event was the 6th in the series. At sessions, oral presentations were given by Researchers of MANA, and 19 Invitational Lectures were presented by front-line scientists from Japan and other countries who are active in the field of nanotechnology. During the symposium, two Nobel Prize Laureates, Professor Emeritus Akira Suzuki of Hokkaido University and Dr. Georg Bednorz, delivered Special Invitational Lectures to room full of listeners.

3 Visitors to NIMS

(Jan. 29, 2013) Prof. Pairash Thajchayapong, Chairman of the Executive Board of The National Nanotechnology Center (NANOTEC) Thailand, accompanied by Prof. Sirirurg Songsivilai, Executive director of NANOTEC paid a visit to NIMS President Prof. Ushioda.

(Feb. 14, 2013) H.E. Dr. Sid Ali Ketrandji, Algerian Ambassador to Japan paid a visit to NIMS President Prof. Ushioda.

(February 20, 2013) Mr. Louis Schwaitzer, the Special Representative of French Minister of Foreign Affairs for French-Japanese Partnership, accompanied by Ambassador of France to Japan, H.E. Mr. Christian Masset and Counselor for Science and Technology, Dr. Florence Rivière-Bourhis, made a visit to NIMS.

With Prof. Thajchayapong from NANOTEC

Discussion with H.E. Dr. Sid Ali Ketrandji

Mr. Louis Schwaitzer at lab tour

Hello from NIMS

Dear NIMS NOW readers,

About two and a half years ago, I visited Japan for the first time to attend a conference. That time, I was realizing my childhood dream. After that contact with different research centers, I decided to go beyond my dream: why not living in Japan? And since September 2011 I have been working as a visiting researcher at NIMS. It has been fantastic to work with leading scientists, using very well equipped laboratories, and experiencing challenging research projects. MANA has welcomed me very well, and everything I have learned here will be extremely valuable to my scientific career. Besides, my wife, Viviane Abreu, and I have enjoyed a lot our lives in Tsukuba. We both came from Brazil, and although Japan and our country have different cultures, our adaptation was very quick. Japanese people are really friendly, and their politeness is unique. My wife and I have traveled to some places in Japan, like Sendai, Nikko and Tateyama; it is really amazing that each place or city in Japan has always astonished us in some way. Also, we should say the Japanese cuisine is wonderful. After this time living here, we can conclude that moving to Japan was the best experiences in our lives.

My wife and I at Sensoji Temple, Asakusa

At Nikko, experiencing the coldest day in our lives

Alex Aparecido Ferreira (Brazil)
From September 2011- present
Visiting researcher,
pi-Electronics Research Group, MANA

NIMS NOW International 2013 vol.11 No.2
National Institute for Materials Science
http://www.nims.go.jp/eng/publicity/nimsnow/

cover image: 300t forging press

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