NMIJ Newsletter
No.14, November 2021

Greetings from Director of RIMCM

Dr. GONDA Satoshi
Director of RIMCM

The main mission of the Research Institute for Material and Chemical Measurement (RIMCM) is to establish and supply measurement standards that contribute to the development of the chemical and materials industries and the safety and security of life and health. In addition to developing and disseminating certified reference materials that support the basics of chemical analysis, we are also conducting research and development on chemical measurement, analysis, and evaluation technologies. Typical certified reference materials include pH standard solutions and elemental standard solutions, which support the basis of chemical analysis; biological or composition-based reference materials, which are indispensable to ensure safety of our life and foods; and reference materials for advanced materials used in the development and production of high-quality industrial products. These reference materials are indispensable for determining the measured values in chemical measurement such as calibration of analytical instruments and evaluation of analytical methods. We are also working on the development of primary measurement methods for guaranteeing quality by assigning values accurate and traceable to the International System of Units (SI) for these reference materials, and the development of measurement and analysis methods equivalent to them. The developed measurement standards are supplied as certified reference materials and calibration services, etc. In addition, we are promoting multiple collaborative development of measuring equipment and technology, activities aimed at improving analytical skills at actual analysis sites by utilizing the research and development capabilities and knowledge related to accurate analysis and evaluation. At the same time, comprehensive databases with stated reliability, which are useful in the field of materials, metrology, and evaluation technologies, are provided, and their improvement is being pursued.

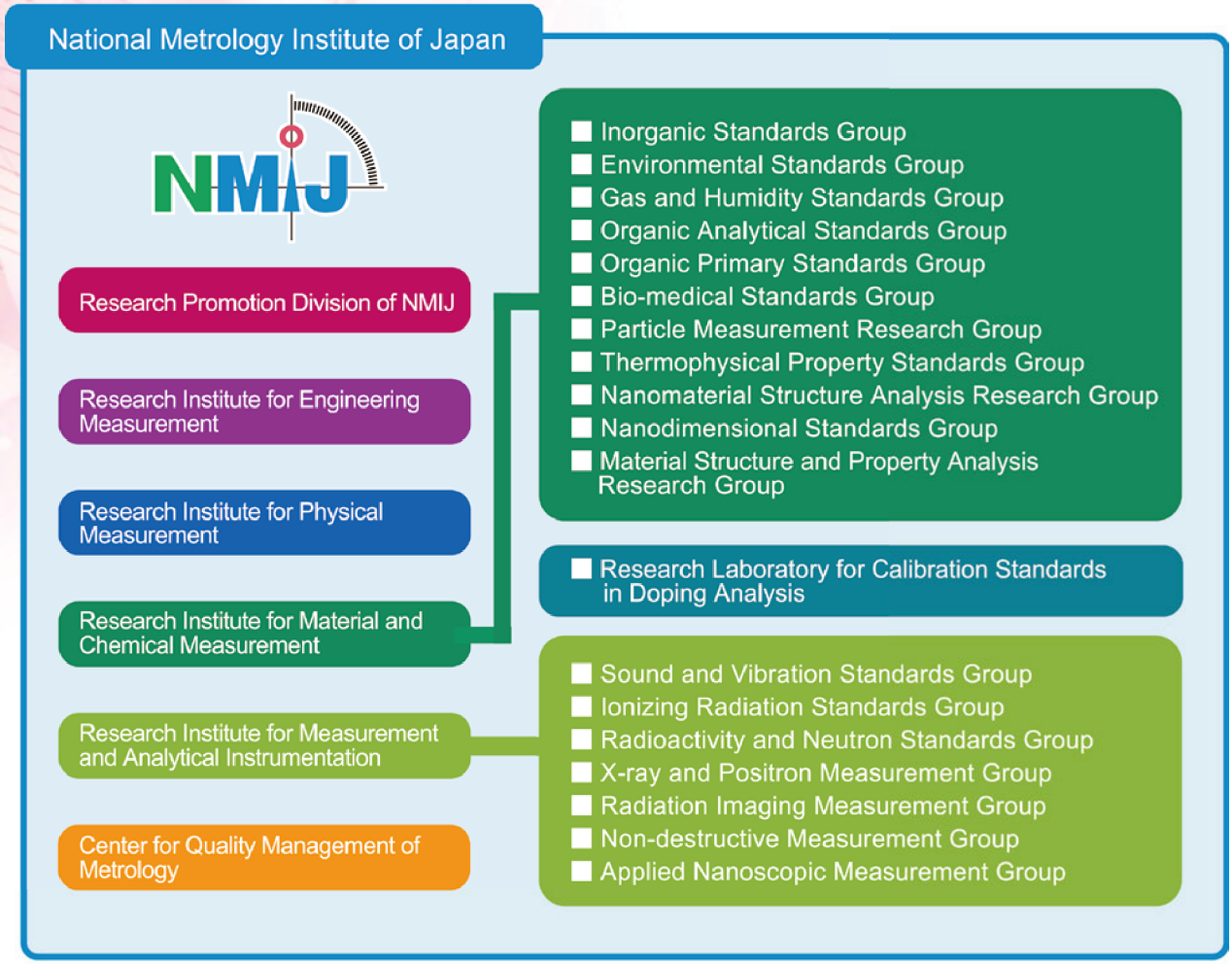
Greetings from Director of RIMA

Dr. ISHII Juntaro
Director of RIMA

The Research Institute for Measurement and Analytical Instrumentation (RIMA) consists of seven research groups with around sixty researchers and has multiple roles in the NMIJ. The first role is to develop and disseminate the national measurement standards for ionizing radiation, radioactivity, neutron, acoustics, and vibration which are supplied to users in a wide range of industries and medical fields. We have recently developed an IoT-adopted wearable radiation dosimeter. It has a built-in LCD which indicates measured radiation dose in real-time. We are intensively investigating standardized neutron technologies for novel boron neutron capture therapy (BNCT), which is attracting attention as an effective treatment for cancer. Characterization of acoustic noise emitted from unmanned aerial vehicles (drones) is also currently under earnest study in our institute. The second is to research and develop advanced analytical methods and instruments, such as a positron annihilation lifetime technique for advanced material science. In 2020 we started operating a new type of neutron beam facility, Analytical facility for Industrial Science and Technology using Accelerator-based Neutron Source (AISTANS) for the non-destructive analysis of advanced materials. The third is to research non-destructive diagnostic techniques with X-ray imaging as well as optical methods for structural inspections and to implement these technologies into industry for addressing a social challenge of aging infrastructures. In addition, we are actively involved in training young researchers through various programs, such as Nanotech Career-up Alliance and Nuclear Researchers Exchange Program.

We hope to tackle the challenges that face all of us through nationally and internationally networked research activities.

Organization Chart of RIMCM and RIMA



Introduction of RIMCM

The RIMCM, composed of 11 research groups, develops and disseminates reference materials of various kinds such as high-purity systems, composition systems, biological systems, and advanced materials systems that contribute to the chemical and materials industries, and conducts research and development on related measurement and evaluation technologies. We are also developing technologies for precision measurement of shape, structure, electronic state, and physical property that contribute to the development of next-generation advanced materials and devices using various probes such as X-ray, electron beam, laser light, and atomic force.

■ Inorganic Standards Group

Our group is responsible for the development and supply on pH and metal or non-metal ion standard solutions as national primary standards for Japan Calibration Service System (JCSS), as well as high-purity inorganic standards and electrolytic conductivity standard solutions, to satisfy domestic needs in the field of inorganic analysis in Japan. This group is also engaged in the enhancement and the application studies on primary methods of measurement for the standards and the standard solutions.

■ Environmental Standards Group

To maintain a safe and comfortable life and food safety, it is essential to ensure the reliability of chemical analysis in conformity inspection with safety standards. We have established reliable analytical techniques. Using these techniques, we are promoting the development and sophistication of inorganic measurement technologies such as analytical technology for each chemical form of elements and solid particle/cell analysis technology, and the development and supply of matrix-type reference materials. We also provide programs for analysts in testing laboratories to help them improve their skills.

■ Gas and Humidity Standards Group

We develop and supply standard gases that are traceable to the International System of Unit (SI), and humidity standards in the range from trace moisture at the nmol/mol level to high humidity with a dew point of 95 °C. Our research activities include preparation methods for standard gases based on highly accurate mass measurement, a high-sensitivity and high-precision measurement method for trace amounts of water based on cavity ring-down spectroscopy (CRDS).

■ Organic Analytical Standards Group

Our group is working on analytical methods and techniques for high-accuracy (good trueness and high repeatability) quantification of trace organic compounds. We develop and supply highly reliable certified reference materials (CRMs) which can be used for calibration of instruments, method validation, and evaluation of personal skill. We mainly focus on extraction and clean up procedures followed by chromatographic analysis. Furthermore, we are also researching other topics such as water content at ultra-trace level and are contributing to standardization in the field of Raman spectroscopy.

■ Organic Primary Standards Group

To assay purities and concentrations of organic reference materials (high-purity materials and standard solutions) with the traceability to the SI, we are developing and improving analytical techniques such as freezing point depression method, titrimetry, and quantitative nuclear magnetic resonance spectroscopy (qNMR). Using these developed techniques, we contribute to the supply of reliable organic reference materials for calibration of analytical instruments by developing certified reference materials (CRMs) and providing calibration services. Users are expected to obtain reliable analytical results by using the reference materials supplied by our activities.

■ Bio-medical Standards Group

We are working on the development of analytical methods that can accurately determine the purity and concentration of various biological substances, from small molecule compounds such as steroid hormones and amino acids to high molecular compounds such as proteins and nucleic acids. And by using such methods, we are developing and supplying reference materials. We are also working to ensure the reliability of bioanalysis and clinical analysis through activities such as participation in international comparisons.

■ Particle Measurement Research Group

Our group focuses on the measurement of particles, powders, and polymers, and develops metrological standards for those materials. In recent years, a certified reference material of polystyrene latex particles with the nominal diameter of 100 nm and a certified reference material of carbon black with the nominal specific surface area of 20 m^2/g were developed in 2020 and 2021, respectively. In the past few years, we have been actively participating in interlaboratory comparisons in CCQM and EURAMET on number concentration of airborne particles.

■ Thermophysical Property Standards Group

We are developing reliable technologies for measuring thermophysical properties of advanced solid materials, for example, thermal expansion coefficient, thermal diffusivity, thermal conductivity and specific heat capacity, and heat-related quantities. Developed measurement technologies can be applied to various material characterization and are useful to solve energy problems related to the realization of energy saving and a low carbon society. We are also developing and supplying reference materials intended for use in the calibration and validation of instruments for measuring thermophysical properties.

■ Nanomaterial Structure Analysis Research Group

We are conducting research and development of measurement and analysis techniques for the internal, surface, and interfacial conditions of nanostructured and functional materials with high sensitivity and high spatio-temporal resolution by using various probes (X-ray, electron beam, positron, light, etc.). We also supply reference materials related to nanostructures and functional materials and provide calibration services.

■ Nanodimensional Standards Group

Nanodimensional standards group is mainly engaged in research and development of nanodimensional standards required in advanced industries such as semiconductor technology industries. Development and calibration service of metrological atomic force microscopes (metrological AFM) traceable to the International System of Units (SI), development of certified reference material for image sharpness evaluation of scanning electron microscope, development of magnification calibration technology of transmission electron microscope, and development of operando dynamics measurement technology using AFM have been in progress.

■ Material Structure and Property Analysis Research Group

Our group develops precise measurement techniques related to material structures (X-ray CT, crystallography, X-ray diffraction analysis, solid state nuclear magnetic resonance (NMR)) and material properties (thermal diffusivity of thin films, thermal resistance at interfaces, liquid viscosity at high pressures) for advanced materials. We also provide high quality and large-scale databases related to spectra for organic compounds, thermophysical properties, and solid-state NMR spectra, which are open to the public through the internet.

■ Research Laboratory for Calibration Standards in Doping Analysis

The NMIJ has led the world in practical application of quantitative nuclear magnetic resonance spectroscopy (qNMR) as a technology for measuring the purity of reference materials. The laboratory has been established for this purpose and will further enhance qNMR and develop technology that achieves both prompt and accurate analysis of prohibited substances to build an analytical infrastructure that is traceable to the SI. The technology developed by the laboratory will be provided to inspection and analytical organizations as certified reference materials and calibration services from the NMIJ.

Research Topics of RIMCM

Line edge roughness (LER) measurement for evaluating semiconductor lithography technology

KIZU Ryosuke, MISUMI Ichiko, HIRAI Akiko, and GONDA Satoshi

In semiconductor lithography technology, nanoscale line patterns are fabricated on a silicon wafer. One of the indicators of lithography-process performance is line edge roughness (LER). Since the edges of a line pattern, which are straight in design, actually have roughness, LER is used as an indicator of the degree of roughness. LER affects device performance and manufacturing yields and is a performance index of process technologies and resist materials. Conventional LER measurement by scanning electron microscopy (SEM) suffers from errors by noise and the inability to measure the 3D shape of the pattern sidewall.

NMIJ has developed a LER measurement technique using a metrological tilting-atomic force microscope (metrological tilting-AFM). The metrological tilting-AFM is equipped with laser interferometers and a tip-tilting mechanism, which enables accurate and low-noise shape measurement and 3D measurement of the pattern's vertical sidewall. A unique LER analysis enables LER evaluation of the sidewall profile in the longitudinal direction of the line pattern with a height resolution of 1 nm. Since it does not cause electron beam damage to the sample in contrast to SEM, it is expected to be applied to not only hard material (such as silicon) but also photoresist. The metrological tilting-AFM technique enables the highest precision in the measurement of 3D sidewall and LER, thus it is useful for evaluating lithography technologies, which use LER as a performance index.

Reference: Kizu et al., J. Micro/Nanolith. MEMS MOEMS 19, 014003, 2020.

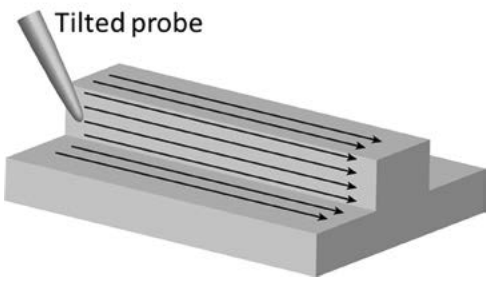
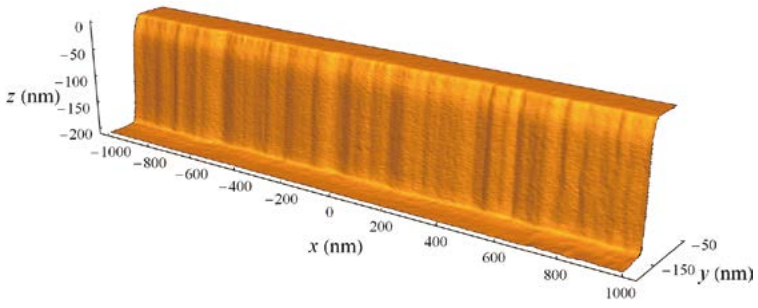


Illustration of the probe scan by metrological tilting-AFM.



Measurement example of silicon line pattern sidewall.

Application of supercritical fluid extraction (SFE) for the determination of pesticide residues in food

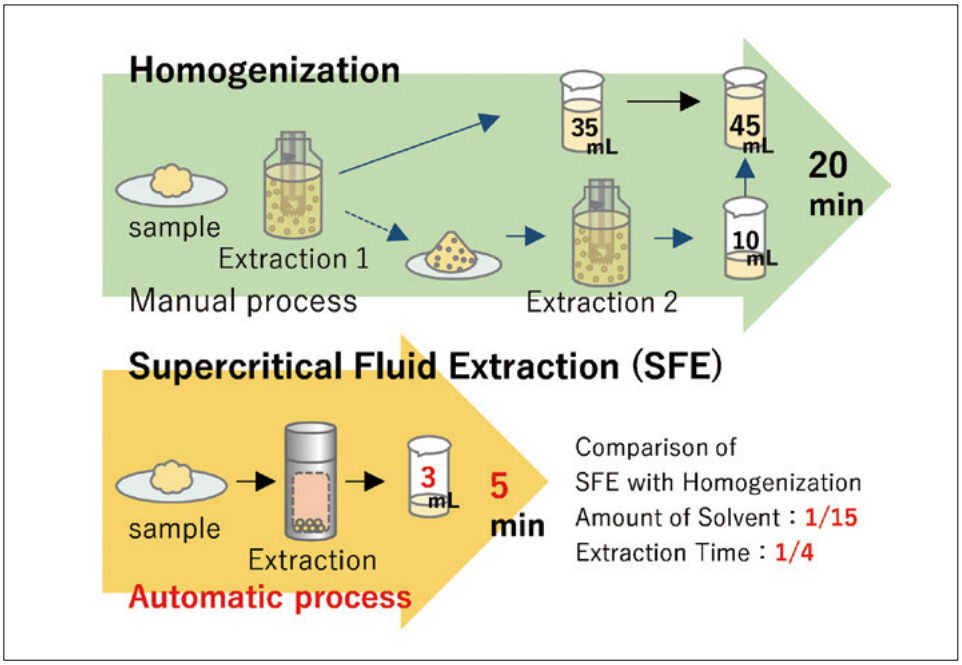
NAKAMURA Keisuke, OTAKE Takamitsu, and HANARI Nobuyasu

Pesticides are routinely used to maintain a stable food supply. Unfortunately, pesticides may be potentially harmful to human health and the environment. Thus, the accurate analysis and monitoring of residual pesticides in food are essential for the proper assessment of the relationship between human health risks and pesticides exposure through food.

Although analysis of trace amount of pesticide residues involves several steps (extraction, clean-up, and instrumental measurement), extraction step can be marked as the most critical one. Solid-liquid extraction using a homogenizer (homogenization) and hand shaking extraction are employed in official multiresidue method in Japan, USA, and EU, etc. to achieve monitor pesticide residues in a range of food samples. However, these methods are somewhat troublesome and time consuming. There is a need for automating the extraction technique to improve laboratory productivity for pesticide residues analysis. Supercritical fluid extraction (SFE) is the automatic extraction method which is used for the analytical method of organic pollutants. Despite their widespread use, SFE is not adequately applied for the extraction of pesticide residues in food, because strict setting of SFE condition is required to extract different type of pesticides having different properties, such as thermal degradability and water/octanol partition coefficient, etc., respectively.

We have optimized SFE for the determination of pesticide residues in food. Optimized SFE was evaluated by comparison with homogenization method. The analytical values of the pesticides obtained by optimized SFE were in good agreement with homogenization, and we successfully achieved the drastic reduction of operating time and the amount of solvent for the extraction compared to homogenization method (see the figure). This technique will be contributory to the automation of whole analytical method for pesticide residues in food.

Reference: K. Nakamura et al., J. Environ. Sci. Health Part B, 55, 604, 2020.



Comparison of optimized SFE and homogenization method.

Introduction of RIMA

The RIMA develops and disseminates national measurement standards and related measurement techniques in the fields of ionizing radiation, radioactivity, neutron, acoustics, and vibration, to ensure the reliability and safety of medicine, analysis, and inspection. The RIMA also develops various advanced techniques for measurement, analysis, evaluation, and inspection, including infrastructure diagnosis and evaluation of advanced materials by using quantum beams.

■Sound and Vibration Standards Group

In order to ensure the reliability of high-sensitivity sensors that contribute to disaster prevention and mitigation, our group focuses on establishing low-frequency acoustic and vibration standards through the development of evaluation systems equipped with a laser interferometer. High-sensitivity sensors need to be evaluated precisely to ensure the observation of low-frequency sound that propagates far away from the event of a volcanic eruption or tsunami, the observation of microtremors and long-period earthquakes, and structural health monitoring.

■ Ionizing Radiation Standards Group

Radiation dosimetry standards are used in various fields such as radiation protection, medicine, industry, and advanced science. Our group develops, maintains, and disseminates standards for radiation protection and for radiotherapy. Recently, we have been developing absorbed dose to water standards for proton and carbon beams used for the cancer treatment, and dose standards of the eye lens for radiation protection. Furthermore, we are developing the high dose standards using Alanine/ESR (Electron Spin Resonance) dosimetry system.

■ Radioactivity and Neutron Standards Group

As for radioactivity and neutron metrology standards, we develop radioactivity standards for radiopharmaceuticals in cancer therapy, radiation protection in workplace, contamination survey and others, as well as neutron standards and measurement technology for a wide energy range of more than 12 orders of magnitude, from the thermal range (10^{-3} eV) to GeV (10^{9} eV), which are required in fields such as nuclear industries and medical applications.

■ X-ray and Positron Measurement Group

Our group studies the development and application of advanced measurement technology using quantum beams such as X-rays, positrons, and neutrons in order to contribute to the development of high-performance materials and the realization of a safe society. For example, the distribution of atomic vacancies and intermolecular voids near the surface of advanced materials is visually evaluated using a positron probe microanalyzer that can acquire a two-dimensional positron lifetime map using a scanning positron microbeam.

■ Radiation Imaging Measurement Group

We conduct research and development of non-destructive diagnostic techniques for aging infrastructures and in-situ monitoring techniques for laser-processing materials by using quantum beam such as X-ray and ultrashort pulse laser. We also develop quantum-beam generation techniques, for example, a high-current electron gun, and detection and imaging techniques such as a large-area X-ray two-dimensional detector and a gas electron multiplier (GEM) for detecting neutron and heavy particle beams.

■ Non-destructive Measurement Group

Our group focuses on research and development related to non-destructive evaluation by optical and ultrasound waves measurement technology such as Moiré imaging & AI techniques and ultrasonic sound. We promote three research themes: full-field measurement technology, ultrasonic visualization, and evaluation of high-temperature properties of carbon-based materials. Besides, we have recently focused on developing deflection measurements for drone aerial photography and non-destructive inspection technology for aircraft composite materials. We will also challenge ourselves to link these research results to social implementation.

■ Applied Nanoscopic Measurement Group

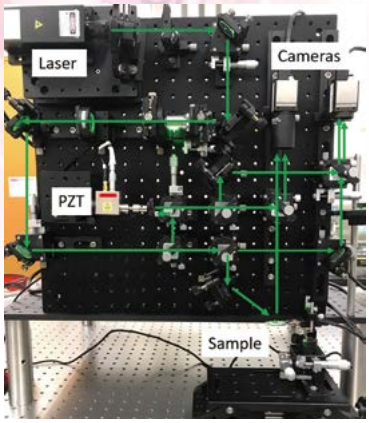
We conduct research and development of mass-spectrometry related technologies with probes such as laser beams and ion beams, and structure analysis technologies with mass spectrometry, for analyzing surfaces, interfaces, and thin films of nanomaterials. We also conduct research and development of technologies for measuring and evaluating the process of nanomaterial production (e.g., ozone oxidation) and technologies for diagnostics and monitoring of biological bodies by tomographic imaging with light interference.

Research Topics of RIMA

Three-dimensional dynamic measurement based on digital holography

XIA Peng, RI Shien, and WANG Qinghua

In recent years, there has been a growing need for high-precision three-dimensional (3D) dynamic measurement in various fields such as industrial inspection, biotechnology, and medicine. Confocal microscope and AFM can achieve high-precision 3D surface measurement, but it is challenging to measure dynamic objects due to the long mechanical scanning time.



The calibrated phase-shifting digital holography system.

NMIJ has been developing various 3D dynamic measurement techniques using digital holography, such as calibrated phase-shifting digital holography (CPSDH) with wide bandwidth, and single-shot digital holography (SSDH) for fast-moving objects. We have successfully used the CPSDH to achieve nanometer-order dynamic 3D measurements of thermal deformation of electronic devices, as well as high-precision shape measurements of live cells. The digital holography is capable to obtain both amplitude and phase information of the object, so that it is a powerful technique for measuring the transparent objects. The density distribution of a transparent gas sprayed at high speed was successfully measured with an SSDH system. By adjusting the magnification of the optical system, objects ranging in size from dozens of micrometers to dozens of centimeters can be measured, while recording speeds of tens of frames per second can be achieved.

Reference: P. Xia, et al., Opt. Express, 26, 12594, 2018.

Neutron measurements for boron neutron capture therapy (BNCT)

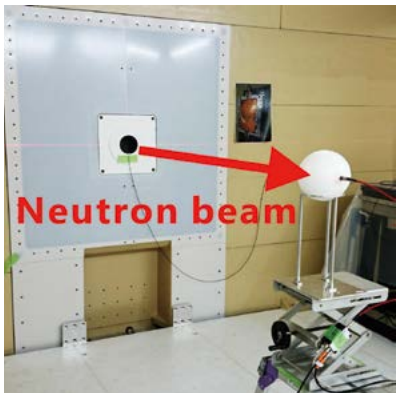
MASUDA Akihiko, MATSUMOTO Tetsuro, MANABE Seiya, and HARANO Hideki

Boron neutron capture therapy (BNCT), a kind of radiation therapy using neutrons, recently became utilized and expected to spread, by the contribution of compact accelerator-based neutron sources that can be installed in the ordinary hospitals. Novel neutron measurements are required to ensure the effectiveness and safety of the treatment.

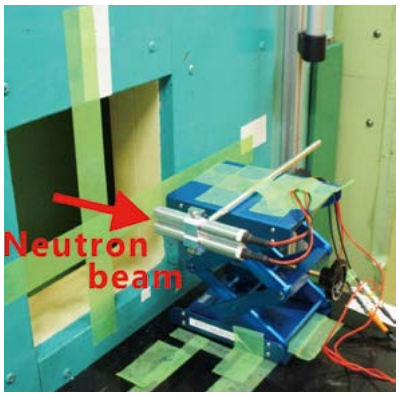
We have already achieved a characterization measurement of an accelerator-based neutron source for BNCT developed by the collaborator and successfully verified that it has the expected neutron energy distribution.

We are improving neutron detectors and measurement methods to make the characterization techniques adaptable to general BNCT facilities which have different characteristics due to the neutron generation method and various facility conditions. Expected achievements will also be beneficial for calibrating BNCT detectors because the calibration results given at the calibration facility must be used in the hospitals with some correction factors arisen from the facility-dependent differences. Furthermore, we are developing real-time neutron intensity monitors to be used during the actual treatment to enhance treatment accuracy.

Improvements of neutron detection sensors and signal acquisition are necessary to solve the common technical problem of intensity of the therapy-level neutron beam. We are working with domestic and international academic societies and organizations related to BNCT to make our achievements suitable to the field of BNCT.



Neutron spectral fluence measurements at a BNCT facility.



Experimental evaluation of developed detectors at a BNCT facility.

Featured Events

Survey on Impact of COVID-19 Pandemic

AKOSHIMA Megumi

The pandemic caused by the novel coronavirus infectious disease has had a great impact on the world. The activities of NMIs have also been affected. A survey was conducted to collect information about the impact caused by the pandemic so far and the foreseeable effect it will have on the activities and challenges of NMIs in the post-pandemic world.

The survey was conducted online or via email in the period between 5th August and 10th September 2021, targeting NMIs and related institutes of the Member States and Associates to the Metre Convention. More than 45 responses were collected from various countries and regions. The survey consisted of two parts: questions about the impact of COVID-19 and questions for the post pandemic. Part one asked whether NMIs were affected by COVID-19 and if so, when and what was affected. The impact and response in facilities and equipment, calibration services, public relations and dissemination activities, and activities of CIPM and RMO were also asked. Other questions touched upon the research activities required to respond to the pandemic and the role of NMIs in a pandemic. Part two asked questions on what NMIs would like to prioritize and what would be expected from NMIs in the post-pandemic world. The results show that most of the respondents were affected by COVID-19 in the first half of 2020. Many institutes experienced a significant reduction in their activities to less than 25% of their pre-pandemic levels, particularly when severely affected. Some institutes reported that their activities had recovered to more than 50% of their pre-pandemic levels as of July 2021. Since the benefits of online meetings and online screenings have become apparent, NMI activities will be implemented not only in-person but also online and digitally.

The detailed results of this survey are to be reported at the workshop of the 21st meeting of NMI Directors and Member State Representatives on 21–22 October 2021. We hope that the survey will provide insight for future NMI activities, in consideration of future pandemics and disaster preparedness.

ESW2021 (Emerging Scientist Workshop 2021)

Online laboratory tour

The sixth ESW was held online for two days on 5th and 6th July 2021. A total of 52 young researchers participated in the workshop from NMIJ (Japan), KRISS (Korea), and NIM (China). On Day 1, 30-minute research talks were presented by each institute, followed by one-minute self-introduction by the participants, and discussion in seven groups. Afterwards, some groups had virtual lab tours and shared their interests to conclude the day. Day 2 started with the COVID-19 session where the results of the preliminary survey among three institutes were introduced by NMIJ and the impact of the pandemic on each institute and their efforts to address it were shared in turn. Then, participants had another group discussion session on four different themes and summarized their outcomes. Although the workshop was held online due to the COVID-19 pandemic, it was a significant event with active discussions and enthusiastic exchange of views.

Participants of ESW2021

Outline of the Third Term "Intellectual Infrastructure Development Plan"

KOBATA Tokihiko

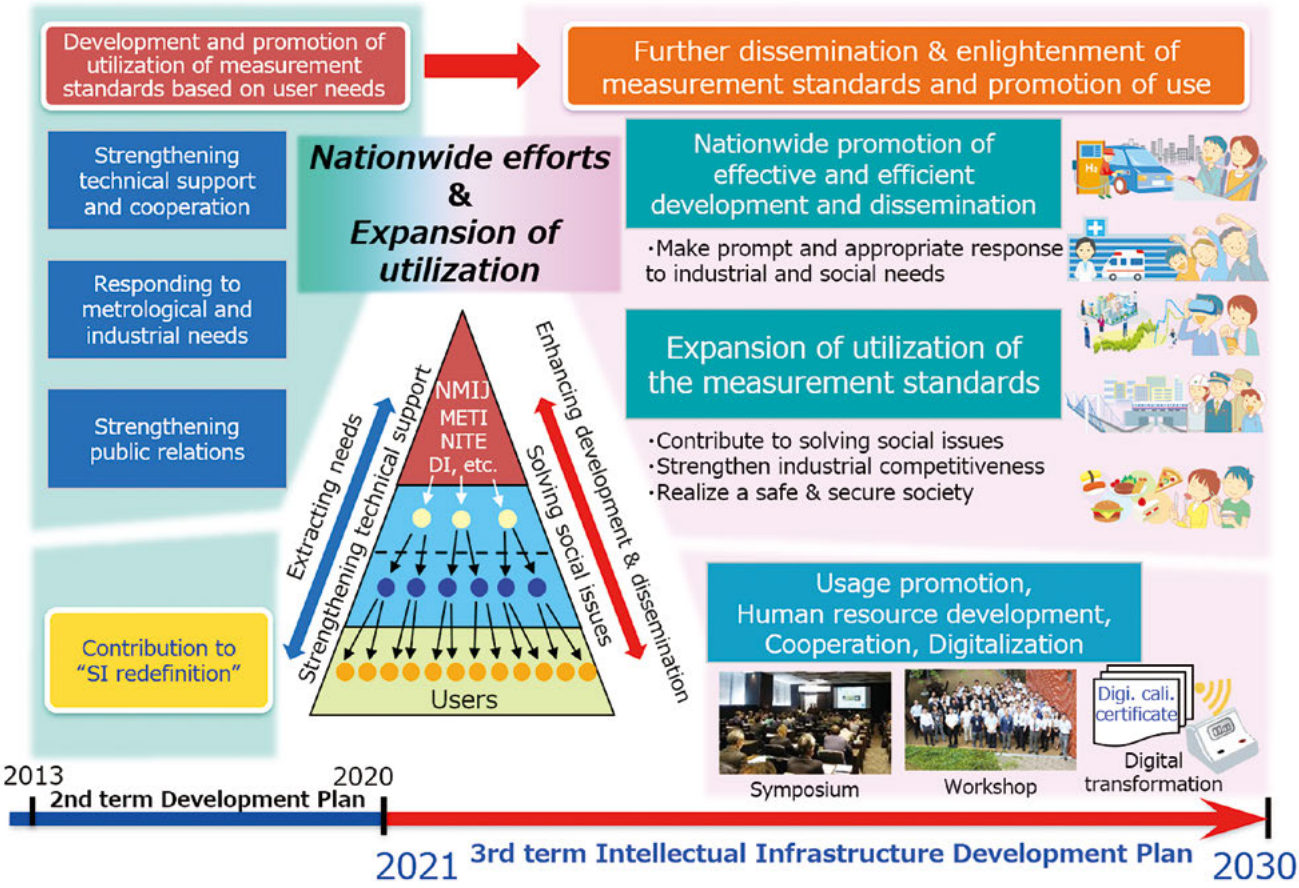
Since 2001, intellectual infrastructure such as measurement standards has been recognized as an important infrastructure in Japan, and such infrastructure has been developed in accordance with the intellectual infrastructure development plans designed by the Ministry of Economy, Trade and Industry. In the field of measurement standards, various measurement standards and reference materials have been developed and provided to a wide range of users over the past two decades.

As a result of a new deliberation, the third term "Intellectual Infrastructure Development Plan" with a planning period up to 2030 was formulated and was published on the website of the Ministry of Economy, Trade and Industry on 31st May 2021.

In the field of measurement standards, focus was placed on "Nationwide promotion of effective and efficient development and dissemination" and "Expansion of utilization of the measurement standards." Achievement goals and tasks for 2050 are set for each social issue and common platform such as health & longevity, food & culture, environment, resources & energy, disaster prevention & security. In addition, cross-sectional tasks are individually set for the issues including response to small and medium-sized enterprises and regions, digitalization, inter-ministerial cooperation & domestic cooperation, international cooperation, human resource development & dissemination, and enlightenment.

In line with the new development plan, NMIJ, which is the main implementing organization in the field of measurement standards, will continue to steadily develop "measurement standards," promote their dissemination and utilization, and make efforts to contribute widely to solving social issues through technology and innovation in Japan.

Outline of the Third Term "Intellectual Infrastructure Development Plan"



Online IMEKO2021 Held Successfully

KOBATA Tokihiko

The International Measurement Confederation (IMEKO) XXIII World Congress (IMEKO2021) titled "Measurement: sparking tomorrow's smart revolution" was held from 30th August to 3rd September 2021, co-organized by Science Council of Japan (SCJ) and the Society of Instrument and Control Engineers (SICE). Over 460 people have registered from 39 countries/economies around the world. IMEKO2021 was held online as the first World Congress for IMEKO to ensure the safety of participants, presenters and exhibitors. IMEKO2021 provided participants with various events such as plenary/invited lectures, technical sessions, workshops and exhibitions through on-demand video presentations. The field of measurement science and engineering, which is covered by IMEKO, is a cutting-edge specialized field that promotes the advanced technological society of the future, and more than 300 technical presentations were made by researchers and engineers in academia and industry related to measurement and metrology. Thank you for your interest and cooperation in IMEKO2021.

NMIJ-INMETRO Online Meeting
(Future collaboration plans based on the MOU)

A meeting was held online between NMIJ and Instituto Nacional de Metrologia, Qualidade e Tecnologia (INMETRO, Brazil) on 21st May 2021 to discuss further collaboration based on the current MOU. The International Cooperation Office of NMIJ and the International Affairs Office of INMETRO discussed procedures to be taken to identify strategic fields that both institutes would like to focus on and to select liaison researchers. They explored the possibility of collaboration under this pandemic situation. They also exchanged views on the COVID-19 measures taken by each institute and the future Digital Transformation.

Upper left: attendees from International Cooperation Office, NMIJ
The rest: attendees from INMETRO

NCSLI Workshop & Symposium 2021

NCSLI* Workshop & Symposium 2021 was held from 21st to 26th August in Orlando, Florida, USA. Last year, the exhibition was cancelled and the 2020 Workshop & Symposium was conducted online, due to the COVID-19 pandemic. As the international travel guidelines have not changed with the ongoing difficult conditions, NMIJ exhibited posters at this year's event, but sent no staff.

*NCSLI : National Conference of Standards Laboratories International

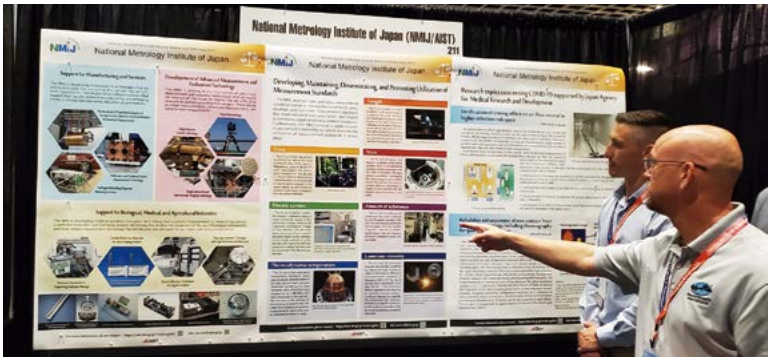


Photo Credit: NCSLI Orlando 2021

Designation of the National Prototype of the Kilogram of Japan as an Important Cultural Property

- A great contribution to the modernization and industrial development of Japan as the national mass standard -

KURAMOTO Naoki

On 15th October 2021, the Council for Cultural Affairs submitted a report to the Minister of Education, Culture, Sports, Science and Technology proposing that the National Prototype of the Kilogram of Japan and related prototypes kept by the NMIJ/AIST be given the status of Important Cultural Properties on the basis of the deliberations and decisions of the Subdivision on Cultural Properties of the Council for Cultural Affairs held on the same day.

For about 130 years from 1889 to 2019, the kilogram, the unit of mass, was defined as the mass of the International Prototype of the Kilogram. The National Prototype of the Kilogram of Japan kept by the NMIJ/AIST is one of the copies of the International Prototype of the Kilogram. In 1891, the National Prototype of the Kilogram of Japan was set as the national mass standard, and a unit system in conformity with the international metric system was established on the basis of the conventional unit system, where the unit "shaku" (one shaku is approximately 30.3 cm) and the unit "kan" (one kan is approximately 3.75 kg) had been used.

Furthermore, in order to monitor the mass fluctuation of the National Prototype of the Kilogram, Japan received additional copies of the International Prototype of the Kilogram from the Bureau international des poids et mesures (BIPM) and used them as the secondary prototypes. Japan also received the Prototypes of the Kan to use them as the practical standards for the kan. The internationalized unit system played an important role as an intellectual infrastructure to introduce Western knowledge and technology when Japan was moving toward modernization. The National Prototype of the Kilogram of Japan continued to play a role as a national mass standard for about 130 years until 2019 and greatly contributed to the modernization and industrial development of Japan.

On the other hand, the National Prototype of the Meter of Japan was the national length standard for about 70 years until 1960, and it has already been designated as an Important Cultural Property. The definition of the kilogram was revised in 2019 and is now based on the Planck constant. In response to this redefinition, the historical and academic values of the National Prototype of the Kilogram of Japan, the Secondary Prototype of the Kilogram, the Prototypes of the Kan and the certificate of the National Prototype of the Kilogram issued by the BIPM in 1889 were evaluated, and they are to be additionally designated as Important Cultural Properties.

National Prototype of the Kilogram of Japan which was used as the national mass standard for about 130 years.

Upper center: National Prototype of the Kilogram of Japan
Upper left: Secondary Prototype of the Kilogram
Lower left and right: Prototypes of the Kan

International Activity Data

The following numbers show international activities implemented by NMIJ from April to October 2021. Due to the coronavirus pandemic, all peer reviews during this period were conducted online.

International comparisons (piloted by NMIJ in FY2020) - 25
Dispatched peer reviewers - 12 Invited peer reviewers - 7

Selected Research Reports

1) Y. Tanaka, K. Hattori, Y. Harada, "Micro-cantilever testing of microstructural effects on plastic behavior of Ti–6Al–4V alloy," Materials Science & Engineering: A, 823, 2021, 141747, DOI:10.1016/j.msea.2021.141747

2) Y. Kano, N. Kuramoto, "Gaseous density calculation by means of relative permittivity measurement," Measurement: Sensors, 18, 2021, 100111, DOI:10.1016/j.measen.2021.100111

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