

Greeting from Director of RIMA

We, the Research Institute for Measurement and Analytical Instrumentation (RIMA) aim to solve issues on the R&D and production sites by maintaining, and disseminating the national primary standards and by using advanced measurement and analysis techniques. For science, technology, and industries "measurement" is the basic technique which is essential for all kinds of events including discovery of new phenomena and materials, characterization of material properties, evaluation of product performance, and verification of the accuracy and repeatability.

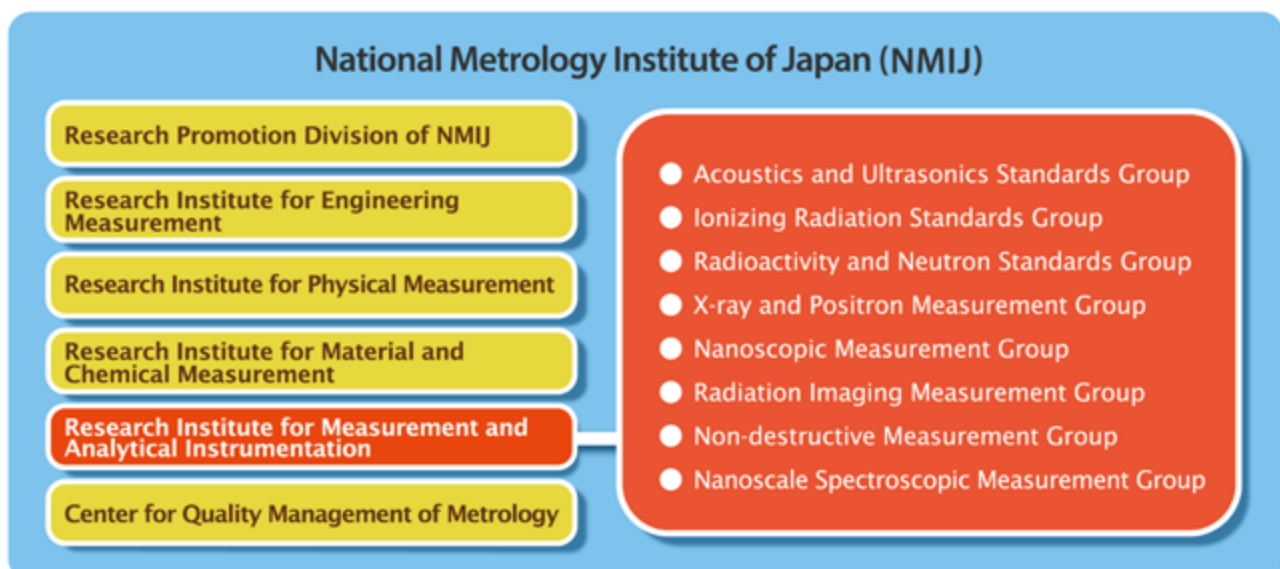
We develop, maintain, and disseminate the national primary standards especially for the industrial areas of ionizing radiation, radioactivity and neutrons, acoustics and ultrasonics. The standards include the absorbed dose in water for high energy photons from a clinical linac, a certified reference material consisting of brown rice mixed with a determined amount of Cs-134 and Cs-137 for radioactivity measurement of food, and a standard of sound power levels for evaluation of environmental noise. By supplying accurate and reliable scales to sound and radiation, these standards help to ensure a safe environment, and support the public trust in the safety of modern technology especially in the medical analysis and testing industries. We also carry out R&D of advanced measurement, analysis, characterization, and testing systems using positrons, X-rays, laser light, and ions as probes. The developed systems, which are in general either open to external users on site at AIST or put into commercial production through collaboration with companies, have a wide range of research applications including characterization of nano-materials and nondestructive inspection of finished products and facilities. By encouraging broad use of standards and advanced measurement techniques and systems in the analysis and testing industry we contribute to the establishment of a more affluent and safer society.



Dr. Hidehiko Nonaka
Director of RIMA

Introduction of RIMA

The Research Institute for Measurement and Analytical Instrumentation consists of eight research groups with the three devoted to standards and the five to measurement. Recent research topics and activities of each group are introduced as below. (continued to the next page)



● Acoustics and Ultrasonics Standards Group

Development, dissemination and maintenance of primary acoustic and ultrasonic standards, and development of precise measurement technology based on the standards.

1. Development of sound power level standards

Precise calibration technique of reference sound source for evaluating sound power level of office automation apparatus etc.

2. Development of primary ultrasonic pressure standards

Precise calibration technique of hydrophone sensitivity for evaluating ultrasonic medical apparatus.

3. Development of quantitative measurement technique on ultrasonic cavitation

Quantitative measurement technique on ultrasonic cavitation for evaluating high-power ultrasonic cleaning equipment.

● Radioactivity and Neutron Standards Group

Development of activity and neutron standards and their calibration services.

Research and development of measurement techniques of activity and neutron.

1. Development of activity measurement techniques and standards

We are developing various standards for activity measurements. We have developed a brown rice reference material for radioactive cesium analysis. It is widely used in measuring institutes for improving their capabilities.

We are assisting their activities by conducting proficiency tests continuously.

2. Development of neutron measurement techniques and standards

We are developing neutron calibration fields to test or calibrate various neutron detectors being used in nuclear, medical and other industrial fields for securing their reliabilities.

● Nanoscopic Measurement Group

Research development of measurement technologies in nanoregion using electron beam and ion beam as probes.

1. New elemental technologies on microscopy and mass-spectroscopy

We are developing new measurement technologies including a dual-probe near-field scanning microscope, a cluster ion gun for SIMS, and a new mass analysis technique for structural analysis of biomolecules.

2. Development the electron microscopy technique for risk assessment of nanomaterials

We are developing the measurement technique required for risk assessment and adequate control of nanomaterials using electron microscopes.

3. International standardization of measurement technique for nanomaterials

We promote the international standardization of nanomaterial measurement methods through the activities of ISO/TC210 (Surface chemical analysis) and ISO/TC229 (Nanotechnology).

● Non-destructive Measurement Group

Development of advanced measurement systems for non-destructive evaluation of critical structures in the society. The group has a strong record in both fundamental research and real-world applications.

1. Development of innovative optical imaging method for 3-D shaping by using sampling/scanning Moiré methods and phase-shifting digital holography

We apply the method to the deformation measurement of a wide variety of materials and structures from infrastructure like large bridges to micro electronic devices.

2. Development of cutting-edge ultrasonic inspection system using pulsed laser scanning

We combine the method with AI-enabled automatic data interpretation for non-destructive evaluation of infrastructure, automotive and aircraft structures.

3. Development of advanced testing method for characterizing mechanical properties of carbon fibers and high temperature properties of industrial carbon materials

We provide the technical data obtained by the method after analysis to the use for design of composites and for optimization of their application conditions as well.

● Ionizing Radiation Standards Group

Development of national dosimetry standards and relevant measurement technologies.

1. Development of dose standards for medical radiological equipments

We are developing measurement standards for radiation therapy, such as high energy photon beams and electron beams from a clinical linac, Ir-192 brachytherapy, and carbon ion beams.

2. Development of dose standards for eye lens

We are developing standards on 3 mm dose equivalent for beta-rays and low energy X-rays, which are important for the evaluation of dose in eye lens.

3. Development of measurement technology required for the Fukushima accident

We are developing the technique to measuring environmental radiation, calibration technique for low level dose rate, and so on.

● X-ray and Positron Measurement Group

Development of measurement technologies based on X-rays and positrons.

1. Characterization of materials using positrons

Making use of intense, pulsed, variable energy slow positron beams, we are developing new methods for the characterization of advanced materials.

2. Development of portable X-ray sources

Using nano-structured carbon field emitter cathodes, we are developing compact and powerful X-ray sources for non-destructive testing.

3. Development of radiation dosimeters

We have developed battery operated personal radiation dosimeters with a battery lifetime of more than one year.

● Radiation Imaging Measurement Group

Quantum Radiation Measurement and Radiation Imaging technology.

1. Nondestructive inspection of social and industrial infrastructure

Development of X-ray backscatter imaging technique using 0.9 MeV C-band X-ray generator for nondestructive imaging of roadbed and bridge.

2. Measurement methods and system

Development of advanced radiation detection method and measurement system for ultraviolet light, soft and hard X-rays, gamma-rays, and neutrons.

3. Application of ultra-short pulse laser

Laser plasma electron acceleration, laser-Compton scattering X-rays, terahertz generation and measurement using ultra-short pulse laser.

● Nanoscale Spectroscopic Measurement Group

R&D of optical and spectroscopic measurement technology in the nanoscale region using a laser beam or other light sources.

1. Absorption of light: Development of a highly space- and time-resolved laser spectroscopy and its application to material analysis

We are developing a transient absorption spectroscopy using absorption of a highly-intense and ultra-short pulsed light, applying it to the analysis of change in the state of functional materials, and developing ionization techniques and photoelectron spectroscopy with multi-photon absorption.

2. Reflection of light: Development of infrared imaging technology with its processing

We successfully developed a night vision camera capable of shooting a motion picture in color, by realizing visualization of an invisible space with infrared reflection and image processing of its spectral characteristics.

3. Interference of light: Advancement of a tomographic imaging technology

Controlling intensity correlation and optical wave front, we are aiming to establish imaging technology in a deeper region with more high-definition.

Research Topics

Backscatter X-ray imaging for nondestructive inspection of social infrastructure

Hiroyuki Toyokawa and Takeshi Fujiwara

Today, maintaining aged social infrastructures in Japan is becoming a serious issue. For instance, there are more than 700 thousand road bridges, and about 20 % of them were built 50 years ago. Moreover, their proportion goes up to 40 % in next 10 years, and 70 % in next 20 years. Fatal incidents of aged concrete structures sometimes stem from degradation of mechanical strength of reinforcement steel bars and wires in concrete.

X-ray imaging is a powerful tool for nondestructive inspection of reinforcement bars and wires in concrete structure with fine resolution. However, since such a concrete structure is usually too large for the use of a conventional X-ray transmission imaging system, then a prime candidate would be a backscatter X-ray imaging system. Nevertheless, the X-ray energy and the detection efficiency for conventional backscatter X-ray imaging system available on the market are not sufficient for inspecting heavy concrete structures, while the high-energy X-ray system is too large and fragile for the nondestructive inspection onsite.

Thus, we developed a backscatter X-ray imaging system for nondestructive inspection of concrete structure using a compact high-energy X-ray generator (see the figure at right) and a novel backscatter X-ray detection device, and were able to obtain an X-ray image of reinforcement bar in concrete structure at cover depth of 9 cm. A table-top compact electron accelerator system and novel radiation measurement technology have opened the way to our success.

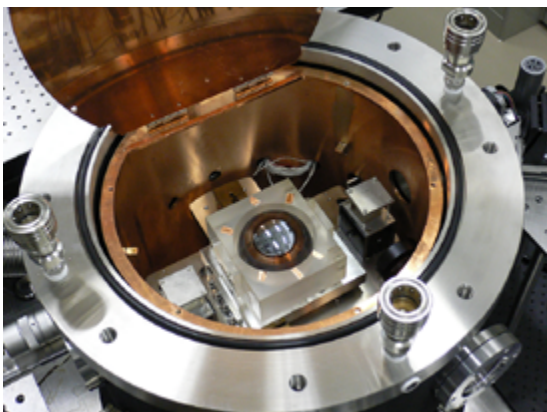


Compact high-energy X-ray generator

Contribution to the determination of the Planck constant to be used in the new definition of the kilogram

Kenichi Fujii, Naoki Kuramoto, Shigeki Mizushima and Lulu Zhang

In order to revise the present definition of the kilogram, which is the only SI base unit still defined by a material artifact, the Planck constant h has been determined accurately by using ^{28}Si -enriched crystals. The X-ray crystal density (XRCD) method was used to measure the Avogadro constant N_A . In this method, the density, molar mass and lattice constant of the crystals had to be measured with best uncertainties available in the world. For this purpose, NMIJ developed an optical interferometer to measure the diameters of 1 kg



Optical interferometer for Si spheres to measure their diameters with an uncertainty of sub-nanometer region

Si spheres with an uncertainty of sub-nanometer region. Accurate surface evaluation technologies for the Si spheres using the X-ray photoelectron spectrometry (XPS) and spectroscopic ellipsometry (SE), and a precise vacuum mass comparison technique were developed also at NMIJ. The measured values of N_A were converted to h using accurately known values of the fundamental physical constants. Using the data from NMIJ, PTB, INRiM and some other results from the Kibble (watt) balance method, the CODATA Task Group on Fundamental Constants published a fixed value of h to revise the present definition of the kilogram, which was defined in 1889. NMIJ thus contributed to the determination of the Planck constant to be used in the new definition of the kilogram.

Reference: [N. Kuramoto et al., Metrologia, 54, 716-729, 2017](#)
[K. Fujii et al., Metrologia, 55, L1-L14, 2018](#)

Featured events

Participation in the 6th ITRI-AIST Joint Symposium



On 31st October 2017, the 6th ITRI-AIST Joint Symposium was held at the Industrial Technology Research Institute of Taiwan (ITRI). The symposium was attended by about 100 researchers from both institutes including Dr. Ryoji Chubachi, President of National Institute of Advanced Industrial Science and Technology (AIST); Dr. Takashi Usuda, Director General of NMIJ/AIST; Dr. Toshiyuki Fujimoto, Deputy Director General of NMIJ; and Dr. Toshiyuki Takatsuji, Director of Research Institute for Engineering Measurement (RIEM) of NMIJ.

Dr. Usuda delivered a keynote speech on the topic "Mission and Strategy of AIST, and Impact of Metrology on Industry", which was followed by parallel sessions on the theme "Smart Manufacturing", "Printing Technology", "Sustainable Environment", and "Metrology". These parallel sessions were mainly focused on areas expected for future collaboration.



The 33rd APMP GA and Related Meetings

The 33rd Asia Pacific Metrology Programme General Assembly (APMP GA) and Related Meetings were held in New Delhi, India, hosted by National Physical Laboratory India from 24th November to 1st December 2017. This was the first GA chaired by Dr. Toshiyuki Takatsuji, Director of Research Institute for Engineering Measurement, NMIJ as a new APMP Chair and NMIJ served as secretariat. More than 300 participants from about 35 economies including 40 researchers and staffs from NMIJ attended the meetings. Dr. Takashi Shimada (TCFF), Dr. Ryuzo Horiuchi (TCAUV) and Dr. Kazumi Inagaki (TCQM) had been approved by the GA as new chairs of each TC. Also, since this year is the APMP's 40th anniversary of its foundation, the Anniversary Symposium was delivered. Dr. Martin J.T. Milton, Director of Bureau International des Poids et Mesures (BIPM), gave a talk and the detailed history of the APMP were introduced in it.



AOTS Training Course on Metrology in 2017

Ministry of Economy, Trade and Industry (METI) and Association for Overseas Technical Cooperation and Sustainable Partnerships (AOTS) have provided many training programs for years to support developing countries and emerging economies. Among them, a training course "Social and Industrial Infrastructure in Metrology" was conducted on 4th-15th December 2017 in the Tokyo metropolitan area. A total of 13 participants attended from 13 countries in the Asia-Pacific Region. Mr. Shigeru Horii of Japan Measuring Instruments Federation (JMIF) and Dr. Tsuyoshi Matsumoto of International Metrology Office of NMIJ led this course as coordinators. During this two-week course, the participants visited NMIJ, Tokyo Metropolitan Inspection Institute of Weights and Measures (TMII), Japan Electric Meters Inspection Corporation (JEMIC), Japan Quality Assurance Organization (JQA) and five manufacturers/calibration laboratories supporting the national infrastructure in metrology. On the final day, all participants provided summary reports and submitted action plans to be achieved after going back to their countries.



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APLMF Service Award for a NMIJ Member

The 24th Forum Meeting of Asia Pacific Legal Metrology Forum (APLMF) was held in Siem Reap, Cambodia on 25th-27th October 2017. Dr. Tsuyoshi Matsumoto of NMIJ and other four members received a Service Award from Mr. Stephen O'Brien, the APLMF President. Dr. Matsumoto had chaired WG on Quality Measurement of Agricultural Products since 2007. During this period, he coordinated three workshops on agricultural measurements (Thailand in 2007, PR China in 2008 and Viet Nam in 2009) and four training courses on rice moisture measurement (Indonesia in 2012, Thailand in 2014, Cambodia in 2015 and Malaysia in 2017). At this forum meeting, he handed over the position of WG chair to Mr. Surachai Sungzikaw of Central Bureau of Weights and Measures (CBWM) of Thailand.



BIPM Director visits Japan



Dr. Martin J.T. Milton, Director of BIPM, visited Japan on 22nd-26th January 2018 for promotion of redefinition of SI base units and lectured on "The future of the International System of Units (SI)" in Kyoto and Tokyo.

On 22nd January, he visited Mr. Fumikazu Sato, Deputy Director-General, Industrial Science and Technology Policy and Environment Bureau of METI, and had fruitful discussions on the research activities of NMIJ and BIPM.

In Kyoto, on 23rd January, as an invited speaker of Kyoto AIST Measurement and Analysis Fair, he spoke to the participants from measurement-analytical manufacturers in the Kansai area. He also talked

with AIST President, Dr. Ryoji Chubachi in Kyoto as a courtesy call.

On January 24th, he moved to Tokyo, and attended the 13th International Metrology Symposium as an invited speaker too. The symposium was held by the Japan Metrology Forum and NMIJ aiming to impart the benefits provided by redefinition of SI base units. The audience included the press and educational publishers too.

In both of his lectures, the overview of the redefinition based on fundamental constant was introduced and the impact of the redefinitions was described.

On the final day, on 25th January, he visited NMIJ in Tsukuba and discussed with NMIJ fellow researchers about the future of the SI Units.



Activities on SI Redefinition

To explain the redefinition of the SI and the contribution of NMIJ in a comprehensive way, CG animation movie is currently in production. Part of the movie has been provided to the international SI Promotion Task Group for sharing with overseas NMIs.

As a part of the domestic promotional activities, the 14th NMIJ International Metrology Symposium titled "A new age in base metrology units — Redefinition of the ampere and the prospect for future" was held in Tokyo on 25th April 2018. Dr. Gert Rietveld from VSL, President of Consultative Committee for Electricity and Magnetism (CCEM), as an invited speaker gave a keynote lecture "Impact of the SI Redefinition on electrical metrology".



Visitors

Many foreign guests visited NMIJ for technical discussions and a series of training. Ongoing and future collaborations were discussed with the guests listed below.

Name	Affiliation	Visiting Date	Visiting Topic
Ms. Mary Ness Idelfonso Salazar, Ms. Sarah Jane Talan Digay	ITDI, Philippines	23-27 Oct. 2017	Training on pressure calibration techniques
Dr. Steven Westwood	BIPM, France	31 Jan. 2018	Discussion of MOU between BIPM and NMIJ, qNMR, and IUPAC purity project
Dr. Michael Nelson	NIST, USA	01 Feb. 2018	Discussion about qNMR and NIST's statistical approaches for CCQM data
Dr. Michael Fasolka, Dr. Nicholas Barbosa, Dr. Christopher Soles, Dr. Carlos A. Gonzalez, Dr. Michael J. Winchester	NIST, USA	16 Feb. 2018	Discussion about CRMs

Peer review and international comparisons

The NMIJ dispatches peer reviewers to other NMIs on their requests (if available). On 6th-8th March 2018, Dr. Akiko Takatsu visited MSA Singapore as an on-site peer reviewer. Also, NMIJ has participated in the following international comparisons.

NMIJ Participants	KCDB Code	Field	Title	Pilot Lab
Dr. N. Furuichi	CCM.FF-K1	Water flow	Key comparison of water flow	PTB
Dr. A.Oota, Dr. W. Kokuyama and Dr. H. Nozato	CCAUV.V-K5	Vibration, from 10 Hz to 20 kHz	Magnitude and phase of the complex sensitivity of accelerometers from 10 Hz to 20 kHz	PTB
Dr. N. Itoh	CCQM-K146	Mole, Organic analysis	Low-polarity analyte in high fat food: Benzo[a]pyrene in olive oil	NIM
Dr. A. Yunoki, Dr. T. Miura, Dr. Y. Unno, Ms. R. Furukawa	CCRI(II)-S13	Radionuclide activity	Measurement of an activity per unit mass of Cs-134 and Cs-137 in wheat flour	NMIJ

Selected research reports

- 1) S. Wada, N. Furuichi, T. Shimada, "Application of partial inversion pulse to ultrasonic time-domain correlation method to measure the flow rate in a pipe", *Measurement Science and Technology*, **28**, 115302, 2017
- 2) T. Shirasawa, T. Masuda, W. Voegeli, E. Arakawa, C. Kamezawa, T. Takahashi, K. Uosaki, T. Matsushita, "Fast structure determination of electrode surfaces for investigating electrochemical dynamics using wavelength-dispersive X-ray crystal truncation rod measurements", *Journal of Physical Chemistry C*, **121**, 24726, 2017
- 3) M. Yasuda, T. Tanabe, T. Kobayashi, D. Akamatsu, T. Sato, A. Hatakeyama, "Laser-controlled cold ytterbium atom source for transportable optical clocks", *Journal of the Physical Society of Japan*, **86**, 125001, 2017
- 4) S. Ishidoya, K. Tsuboi, S. Murayama, H. Matsueda, N. Aoki, T. Shimosaka, Hiroaki Kondo, and K. Saito, "Development of a continuous measurement system for atmospheric O₂/N₂ ratio using a paramagnetic analyzer and its application in Minamitorishima Island, Japan", *SOLA*, **13**, 230–234, 2017
- 5) I. Misumi, K. Sugawara, K. Takahata, K. Takahashi, and K. Ehara, "Size measurements of standard nanoparticles using metrological atomic force microscope and evaluation of their uncertainties", *Precision Engineering*, **51**, 691-701, 2018
- 6) T. Hayashi and K. Ueda, "Miniaturization of a 50 N tuning-fork type force transducer by adopting a simplified Roberval mechanism", *Measurement*, **114**, 203–207, 2018
- 7) H. Iida, M. Kinoshita, "Amplitude calibration in terahertz time-domain spectroscopy using attenuation standards", *Journal of Infrared Millimeter, and Terahertz Waves*, **39**, 120-129, 2018
- 8) K. Yamada, H. Takahashi, R. Horiuchi, "Availability of reference sound sources for qualification of hemi-anechoic rooms based on deviation of sound pressure level from inverse square law", *IEICE Transactions on Fundamentals of Electronics, Communications and Computer Sciences*, **E101.A**, 211-218, 2018
- 9) H. Nozato, M. Shimizu, S. Nakao, S. Chiba, A. Ota, W. Kokuyama, K. Hattori, "A comparison of low-shock and centrifuge calibrations using piezoresistive accelerometers", *Metrologia*, **55**, S13-S22, 2018
- 10) N. Hanari, N. Itoh, R. Iwasawa, Y. Aoyagi, M. Numata, "Certified reference material for the determination of perfluorooctane sulfonate in acrylonitrile-butadiene-styrene resin (NMIJ CRM 8155-a)", *International Journal of Environmental Analytical Chemistry*, **98**, 56-66, 2018
- 11) K. Ito, S. Yoshimoto, B. O'Rourke, N. Oshima, K. Kumagai, "Subnanopore filling during water vapor adsorption on microporous silica thin films as seen by low-energy positron annihilation", *Applied Physics Letters*, **112**, 083701, 2018