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.

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.
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 \(^{28}\text{Si}\)-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 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
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 NMII/AIST; Dr. Toshiyuki Fujimoto, Deputy Director General of NMII; and Dr. Toshiyuki Takatsuji, Director of Research Institute for Engineering Measurement (RIEM) of NMII.

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 Takatsui, Director of Research Institute for Engineering Measurement, NMII as a new APMP Chair and NMII served as secretariat. More than 300 participants from about 35 economies including 40 researchers and staffs from NMII 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 NMII led this course as coordinators. During this two-week course, the participants visited NMII, 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.

APLMF Service Award for a NMII 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 NMII 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.
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.

<table>
<thead>
<tr>
<th>Name</th>
<th>Affiliation</th>
<th>Visiting Date</th>
<th>Visiting Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Steven Westwood</td>
<td>BIPM, France</td>
<td>31 Jan. 2018</td>
<td>Discussion of MOU between BIPM and NMIJ, qNMR, and IUPAC purity project</td>
</tr>
<tr>
<td>Dr. Michael Nelson</td>
<td>NIST, USA</td>
<td>01 Feb. 2018</td>
<td>Discussion about qNMR and NIST’s statistical approaches for CCQM data</td>
</tr>
<tr>
<td>Dr. Michael Fasolka, Dr. Nicholas Barbosa, Dr. Christopher Soles, Dr. Carlos A. Gonzalez, Dr. Michael J. Winchester</td>
<td>NIST, USA</td>
<td>16 Feb. 2018</td>
<td>Discussion about CRMs</td>
</tr>
</tbody>
</table>
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.

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

Selected research reports


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


