NMIJ Newsletter
No.16, November 2022

Greetings from Director General of NMIJ

Dr. USUDA Takashi
Director General

First of all, I would like to express my gratitude for your cooperation in the activities of NMIJ/AIST. Although the opportunities to meet you in person are limited due to the Coronavirus Disease (COVID-19) pandemic, I am delighted to have a chance to share our latest updates with you through this newsletter.

International equivalence is extremely important for measurement standards. Under the Metre Convention, we, the communities of National Metrology Institutes (NMIs), have steadily made progress towards ensuring international equivalence. Our efforts include the integration of units, global understanding of their definitions, and international comparisons based on the CIPM Mutual Recognition Arrangement (CIPM MRA), for which mutual cooperation among NMIs is indispensable.

Now in the third year of the pandemic, we are establishing a new normal for ensuring international equivalence by utilizing online methods in holding meetings and conducting peer reviews.

Meanwhile, the geopolitical developments originated in the eastern Europe are about to change the world order with great uncertainty. In addition, we are facing critical long-term issue such as climate change even though their short-term effects are hard to see. To steer those issues, NMIs should cooperate each other even more closely.

This December, NMIJ and DIs in Japan will host the General Assembly of APMP under the slogan of “Beyond All Limits.” We would like to offer a new style of international conferences in the post-pandemic world and make it a place where mutual cooperation among NMIs can be fortified. I am looking forward to meeting you either in person or online.

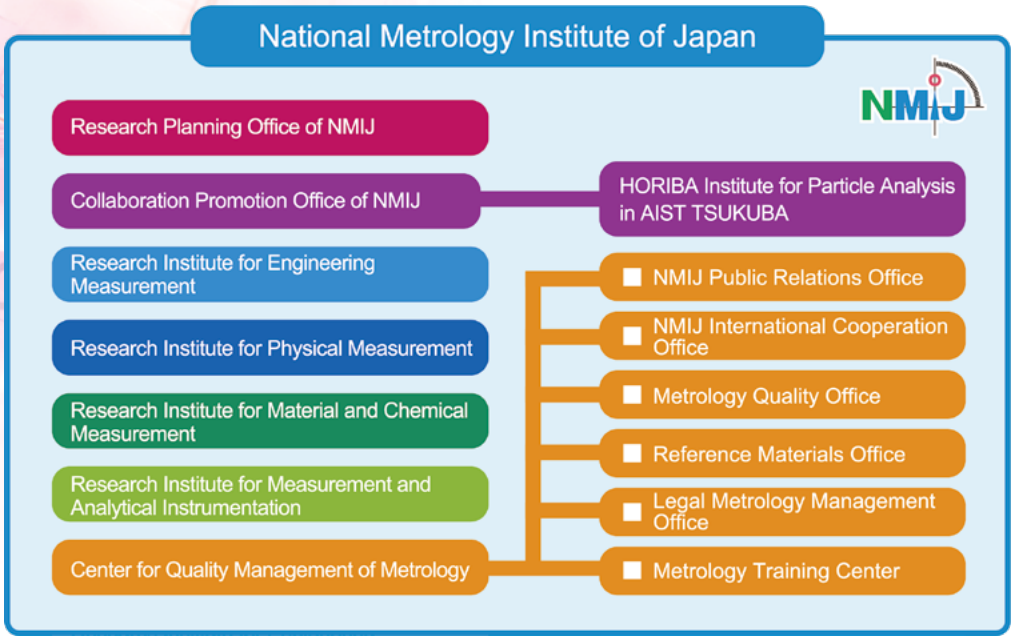
Greetings from Deputy Director General of NMIJ

Dr. KOBATA Tokihiko
Deputy Director General

Greetings to all our Newsletter readers. It has already been two and a half years since the outbreak of COVID-19. I would like to express my deepest sympathies to those who have suffered from COVID-19. All NMIJ employees have been making vigorous efforts in our work to appropriately respond to the present and post-pandemic society while taking necessary measures to prevent the spread of infection.

On 1st April 2022, NMIJ launched its new organizational structure in line with the reorganization of the AIST’s research promotion scheme. The new structure is shown on the next page. At present, NMIJ consists of the following units: Four Research Institutes for developing and supplying measurement standards; the Center for Quality Management of Metrology for undertaking administrative support tasks; and the Research Planning Office of NMIJ and the Collaboration Promotion Office of NMIJ for planning and collaboration. We all work in unison to carry out various activities both domestically and internationally. As the National Metrology Institute of Japan, NMIJ will continue to focus on developing measurement standards and measurement techniques, promoting their dissemination, providing legal metrology services and fostering human resources. Lastly, I am looking forward to seeing you again in person as soon as possible.

Organization Chart of NMIJ



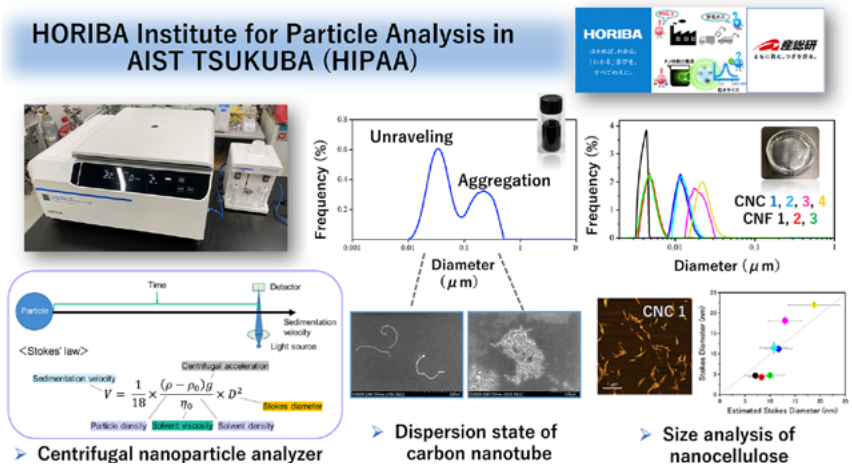
NMIJ's organizational structure has been renewed since 1st April 2022.

Introduction of Research Planning Office of NMIJ and Collaboration Promotion Office of NMIJ

To fulfill AIST's mission, **the Research Planning Office of NMIJ (RPO/NMIJ)** decides on research policies and strategies, and then creates research projects and formulates their budgets. The RPO/NMIJ also serves as a liaison with other AIST research departments, the Ministry of Economy, Trade and Industry (METI), other national research and development agencies, universities, and other related organizations working together with the Collaboration Promotion Office of NMIJ.

The Collaboration Promotion Office of NMIJ (CPO/NMIJ) plans collaboration between NMIJ and companies, etc., and promotes and supports technology transfer to companies. The CPO/NMIJ also supports the research and development of the Cooperative Research Laboratory. The Innovation Coordinators in charge of collaboration and the Intellectual Property Officer in charge of technology transfer work together to promote organized collaboration with industry.

HORIBA Institute for Particle Analysis in AIST TSUKUBA (HIPAA)



Principle of the centrifugal sedimentation method and the dispersion state of carbon nanotubes and nanocellulose.

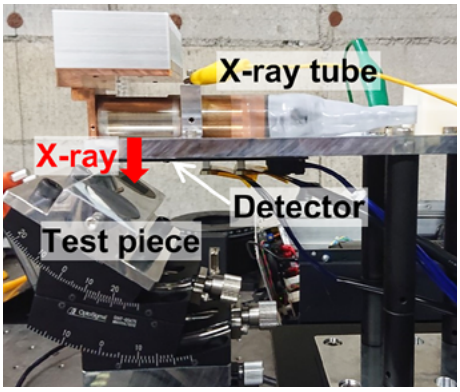
Analytical methods and applications using the centrifugal sedimentation method are developed in HIPAA. Centrifugal sedimentation enables us to measure target particles with broad size distribution due to the high resolution separation in high centrifugal forces. The size distribution and dispersion state of carbon nanotubes and nanocellulose are mainly analyzed to establish the evaluation system for the advanced nanomaterials.

Research Topics

A compact X-ray inspection instrument for high-thruput, in-situ X-ray residual stress measurement

KATO Hidetoshi, SUZUKI Ryoichi

In order to evaluate the quality of machine parts and to characterize the condition of infrastructure, there is a need for technologies to measure residual stress, which is an important material property indicator, at high speed and in-situ. Non-destructive and contactless residual stress measurement using X-rays is available, but its typical measurement time is long, making it unsuitable for total inspection. Therefore, we have developed a high-thruput and high-precision X-ray residual stress measurement device combining NMIJ's compact X-ray source technology and the cosα method developed by Kanazawa University. By using a coniferous carbon nano-structure (CCNS) electron source, the X-ray tube can be made compact (25 mm in diameter and 84 mm in length). In addition, the device is battery-operated and has a fast start-up time, which is suitable for in-situ measurement. With this device, a residual stress measurement which conventionally required several minutes can be performed in around one second. In the future, we will develop compact light-weight portable devices for various inspection uses.



X-ray residual stress measurement device.

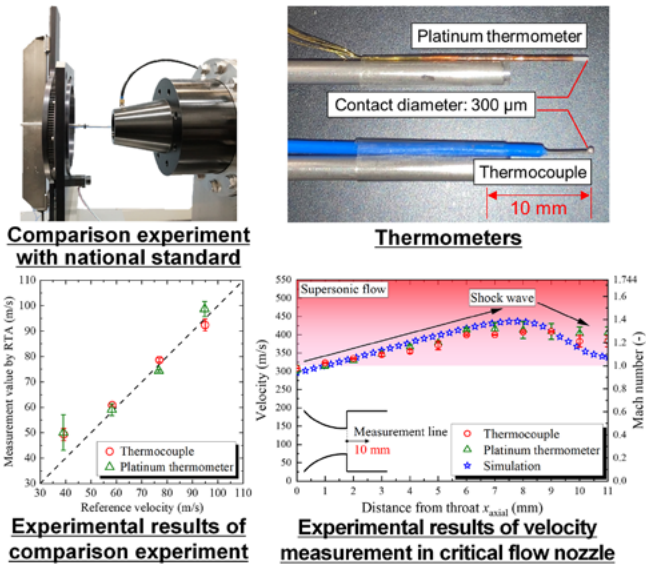
Flow velocity measurement in a critical flow nozzle using a small thermometer and advancement of gas flow standard

TAKEGAWA Naoki

In Japanese gas flow standards, critical flow nozzles, which can generate stable flow rates by providing differential pressure, are commonly used as transfer standards to ensure traceability. Although improvements are being made to promote the use of critical flow nozzles in ISO 9300, there are still issues to be addressed regarding the design of a reasonable shape due to the difficulty of measuring flow velocity in the nozzle.

In this study, we worked on the development of a method for measuring flow velocity using small thermometers (RTA, Recovery Temperature Anemometry). First, experiments were conducted to evaluate RTA based on a national standard for flow velocity, and it was confirmed that the difference between RTA and the velocity standard was within 5 % in the flow velocity range of 60 m/s to 95 m/s. Furthermore, as a result of measuring the flow velocity inside the critical flow nozzle using RTA, the supersonic flow inside the nozzle measured by RTA was in good agreement with the numerical simulation results.

It is noteworthy that low-disturbance and high-spatial-resolution velocity measurements over a wide velocity range were achieved with existing inexpensive small thermometers. In addition, since the measurement principle of RTA is based on a physical model, it is of great social significance in that RTA requires little calibration effort and is easy to use. By understanding the detailed flow field inside the critical flow nozzle and designing a reasonable geometry, it will be possible to generate stable flow at a smaller differential pressure. In other words, large-scale flow facilities can be more efficient and compact, contributing to the supply of sustainable flow standards.



Measurement of flow velocity in a critical nozzle using a small thermometer.

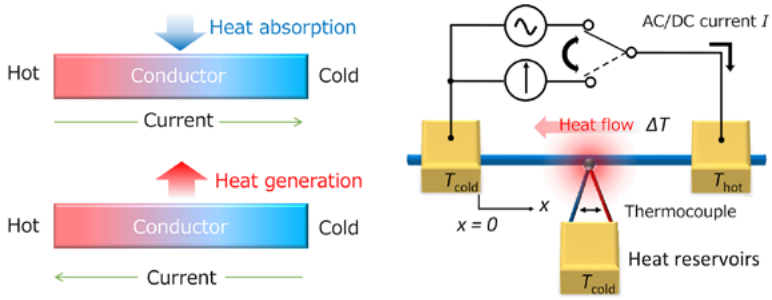
Reference: N.Takegawa et al., Scientific Reports, **11**, 23778, 2021, DOI: 10.1038/s41598-021-02877-w

New principle for precisely measuring the thermoelectric "Thomson effect"

AMAGAI Yasutaka, SHIMAZAKI Takeshi, OKAWA Kenjiro, FUJIKI Hiroyuki, and KANEKO Nobu-Hisa

The physics and engineering of thermoelectric coolers and power generators have been studied intensively. The operating principle of these devices is based on the Seebeck and Peltier effects that convert heat into electricity and vice versa. Meanwhile, the Thomson effect is the only thermoelectric effect that occurs in a single and homogeneous conductive substance. Thus, it can be utilized to determine the absolute scale of thermoelectricity, which serves as a foundation for almost all the subsequent thermocouple-based experiments. However, the heat loss from the sample limits its accuracy and the variety of samples that can be measured. To address this issue, NMIJ has developed a new principle for measuring the Thomson effect which avoids this heat loss. A crucial idea is that most of the heat loss that occurs during the measurement of the Joule and Thomson heats can be compensated for by calculating the ratio of the two signals. Therefore, the ratio between the Joule and Thomson heats will be insensitive to the absolute amount of the heat loss. We successfully measured the Thomson effects of a fine wire and a thin film on a glass substrate with high thermal resistance, which were difficult to measure using a conventional method. This demonstrated that precise and versatile measurements were possible regardless of the shape of the sample.

Reference: Y. Amagai et al., Appl. Phys. Lett. **117**, 063903, 2020, DOI: 10.1063/5.0018593

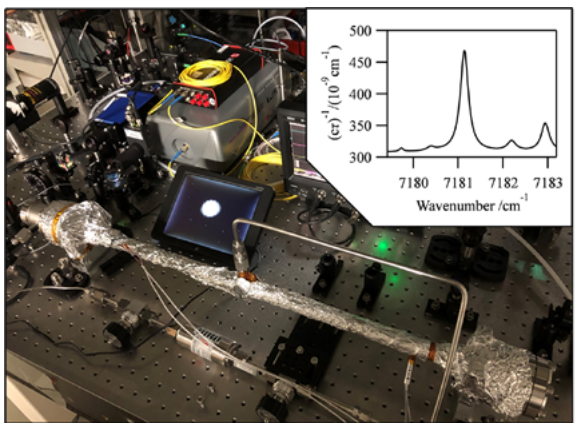


Thermoelectric Thomson effect (left) and measurement principle for the Thomson effect developed at NMIJ (right).

High-sensitivity detection of trace moisture in gas using wavelength-meter-controlled cavity ring-down spectroscopy

HASHIGUCHI Koji

There is an increasing demand for accurate measurement of trace water vapor (trace moisture) in gases in technology-intensive industries. Therefore, NMIJ has developed measuring instruments for measuring trace moisture using cavity ring-down spectroscopy (CRDS). In CRDS, an optical cavity consisting of highly reflective mirrors is used as a sample cell to extend the effective optical path length. However, it becomes more difficult to transmit a probe laser through the cavity if we use higher reflectivity mirrors. To solve this issue, we developed a simplified technique for laser control in CRDS, referred to as the "wavelength–meter–controlled" technique, and acquired the absorption spectra of H_2O with good long-term stability. In wavelength–meter–controlled CRDS, first, resonant frequencies of the cavity are stabilized with reference to the frequency of a helium-neon (He-Ne) laser. Then the frequency of the probe laser is controlled to adjust to one of the stabilized resonant frequencies using a high-resolution wavelength meter. By following these steps, we enabled the use of highly reflective mirrors. With this new technique, we were able to acquire the absorption spectra of trace moisture near 7180 cm^{-1} at atmospheric pressure with parts-per-trillion sensitivity, which is the highest level of detection sensitivity for trace moisture measurement in the world. In addition to the development of the measurement device, we are aiming at achieving precise measurement of trace moisture by evaluating the optimal line shape profiles for fitting the absorption spectra.



The wavelength-meter-controlled cavity ring-down spectroscopy. Inserted graph on the upper right corner is the absorption spectrum of trace moisture.

Reference: K. Hashiguchi et al., Jpn. J. Appl. Phys. **61**, 012003, 2022, DOI: 10.35848/1347-4065/ac3724

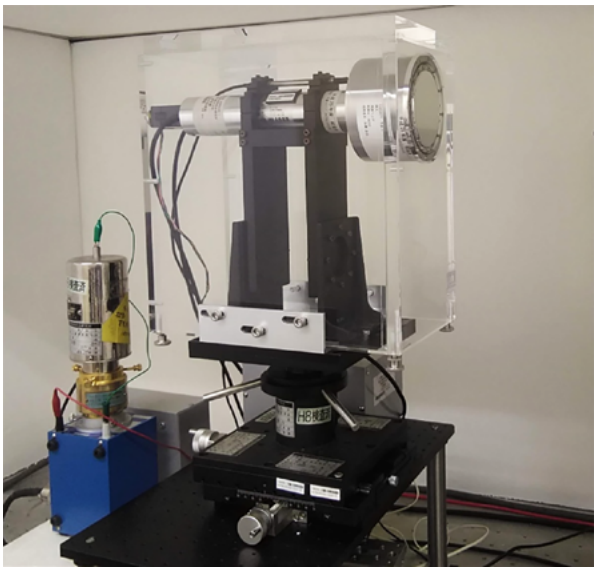
Beta-particle dosimetry standards for the dose management of the lens of the eye

KATO Masahiro

Radiation workers who handle radiation, such as medical workers, nuclear power plant workers and researchers, use dosimeters to manage the dose of radiation so that the adverse effects of radiation exposure do not occur on the body. Recent studies have improved the understanding of radioactive cataracts in the lens of the eye, and the International Commission on Radiological Protection has advised that more precise management is required. Therefore, new dose management has been put in place for exposure to the eyes.

NMIJ has developed the standards for the personal dose equivalent at the depth of 3 mm, $H_p(3)$, required for calibration and testing of eye lens dosimeters for beta particles, which are radiations that may badly affect the lens. Using an extrapolation chamber as the primary standard, the $H_p(3)$ has been determined for beta-particles from the Sr-90/Y-90 source which is widely used and the Ru-106/Rh-106 source emitting the beta-particles of high energy. The extrapolation chamber is a radiation measuring instrument specialized for beta dosimetry.

The method of performing calibration and testing based on the standards for $H_p(3)$ provided by NMIJ is adopted in the guidelines for the dose monitoring of the lens of the eye published by the Japan Health Physics Society and is used for ensuring the reliability of commercially available dosimeters. NMIJ is currently participating in the EURAMET supplementary comparison (Project No. 1398: Comparison of personal dose equivalent at 0.07 mm and 3 mm depth, $H_p(0.07)$ and $H_p(3)$, for beta radiation), and is working to establish the international consistency of the primary standards.



Extrapolation chamber for beta-particle radiations.

Featured Topics

Partnership agreement with CERI for dissemination of reference materials

ASAKAI Toshiaki

The National Metrology Institute of Japan, the National Institute of Advanced Industrial Science and Technology (NMIJ/AIST) and the Chemicals Evaluation and Research Institute, Japan (CERI) signed the partnership agreement for the development and the dissemination of reference materials on 1st August 2022.

A meeting for the partnership agreement at CERI Tokyo.

Reference materials are widely used for chemical analyses as standards. CERI produces national standards under the Measurement Act in Japan, and calibrates them with the metrological traceability to the property values of certified reference materials produced by NMIJ/AIST. The national standards with the SI traceability are acceptable throughout the world.

NMIJ/AIST and CERI accelerate the development of reference materials, and establish the reliable and efficient dissemination scheme under the agreement.

The Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology

The Young Scientists' Award

ASAKAWA Daiki

Dr. ASAKAWA Daiki, Chief Senior Researcher of Applied Nanoscopic Measurement Group, Research Institute for Measurement and Analytical Instrumentation, has received the 2022 Young Scientists' Award, the Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology for his achievement on "Research on the gas-phase radical fragmentation process of proteins." The research provides the academic community with a new research perspective from a chemical theory on the fragmentation of gas-phase ions that occurs in mass spectrometers, facilitating the development of more accurate analytical methods and reference materials for biomolecules.

Reference: D. Asakawa et al., "Hot Hydrogen Atom Irradiation of Protonated/Deprotonated Peptide in an Ion Trap Facilitates Fragmentation through Heated Radical Formation", J. Am. Chem. Soc. **144**, 3020,
DOI: 10.1021/jacs.1c11081

The Award for Creativity

SUGAYA Miyuki

Dr. SUGAYA Miyuki, Senior Researcher of Legal Weighing Metrology Group, Research Institute for Engineering Measurement, has received the 2022 Award for Creativity, the Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology for his achievement on "Improvement of high-performance testing device for heat meters." Heat meters are used as measuring instruments to measure the amount of heat consumed by hot water system and floor heating at home, which are in great demand due to the increase in district heating in smart cities. As an organization providing type approval tests based on the Measurement Act, NMIJ/AIST should conduct tests which comply with the new technical standards for the electromagnetic type heat meters using a new measurement principle. Dr. SUGAYA made improvements to the structure of the testing device and the temperature control, and realized highly accurate and stable evaluation.

NCSLI International Workshop & Symposium 2022

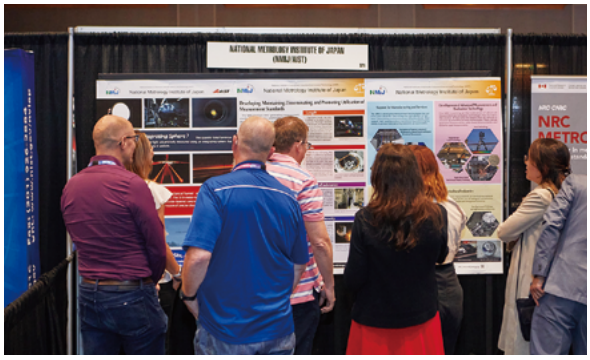


Photo credit: NCSLI Grapevine 2022

The NCSL International Workshop & Symposium titled "Nourishing Metrology Professionals" was held on 20-24 August 2022 at the Gaylord Texan Hotel & Convention Center in Grapevine, Texas, USA. Like last year, no NMIJ staff could attend the physical event, but three posters were exhibited in the NMIJ booth at the exhibition hall.

*NCSLI: National Conference of Standards Laboratories International

The 38th APMP General Assembly and Related Meetings will be held in Odaiba, Tokyo, Japan from 28th November to 2nd December 2022.

As of October 2022

<table>
<tr><td>Date/Time</td><td>7~25 Nov.</td><td colspan="2">Monday
28 Nov.</td><td>Tuesday
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<tr><td>Morning</td><td rowspan="2">TC
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Workshop</td><td>EC-CC</td><td>EC-CC</td><td>Handover meeting (Chairperson& Secretariat)</td><td>Lab tour</td></tr>
<tr><td>Afternoon</td><td>EC</td><td>TCC</td><td>NMI Directors' Workshop</td><td>APMP Symposium</td><td rowspan="2">GA</td><td>GA</td></tr>
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https://www.apmp2022.jp/

APMP Symposium on "Metrology Underpinning a Sustainable Society"

Concurrently with the General Assembly and related meetings of the APMP 2022, the APMP symposium on "Metrology underpinning a sustainable society" will be held at AIST Tokyo Waterfront on 30th November 2022 and online as well. Presentations are held in English and simultaneous interpretation service (English to Japanese) is available. We look forward to your participation!

Photo copyright : TCVB

Symposium on

"Metrology Underpinning a Sustainable Society"

Date: Wednesday, 30th November 2022
14:00-16:30 (JST) 5:00-7:30 (UTC)

Place: AIST Tokyo Waterfront (onsite and online)

- **Report of survey on the pandemic impact to NMI activities, 2020-2021**
  AKOSHIMA Megumi, NMIJ/AIST, Japan
- **Development of novel inspection and long-life technologies for infrastructures toward a sustainable society**
  TSUDA Hiroshi, NMIJ/AIST, Japan
- **Standard and measurement of trace moisture in gases**
  ABE Hisashi, NMIJ/AIST, Japan, TCT Chair
- **Activities of MMFG and new challenges**
  DING Xiang, NIM, China, MMFG Chair
- **APMP Energy Efficiency Focus Group - Engaging with energy sector and showcasing measurement -**
  BUDOVSKY Ilya, NMIA, Australia, EEFG Chair
- **Metrological activities related to Climate Change and Clean Air in the Asia-Pacific region**
  KAI Fuu Ming, NMC A*STAR, Singapore, CCCAFG Chair

Registration:
Open until Tuesday, 22nd November 2022
Onsite participation: Limited to the first 50 people who register.
Please register at APMP 2022 ***https://unit.aist.go.jp/nmij/english/***

Selected Research Reports

1) Y. Tanaka, K. Hattori, Y. Harada, "Nanoindentation and micro-cantilever testing for understanding cold-dwell sensitivity of heat-resistant titanium alloys," Materials Characterization, **190**, 112055, 2022, DOI: 10.1016/j.matchar.2022.112055

2) K. H. Cheong, R. Doihara, N. Furuichi, M. Nakagawa, R. Karasawa, Y. Kato, K. Kageyama, T. Akasaka, Y. Onuma, T. Kato, "Optimum Pressurization Mechanism for a Non-Electrical Piston-Driven Infusion Pump," Applied Sciences, **12**, 8421, 2022, DOI: 10.3390/app12178421

3) S. Wada, N. Furuichi, "Applicability evaluation of the ultrasonic pulse-train Doppler method on the disturbed flow in a pipe," Flow Measurement and Instrumentation, **87**, 102225, 2022, DOI: 10.1016/j.flowmeasinst.2022.102225

4) K. Shirono, H. Tanaka, M. Koike, "Economic optimization of acceptance interval in conformity assessment: 2. Process with unknown systematic effect," Metrologia, **59**, 045006,2022, DOI: 10.1088/1681-7575/ac6fa2

5) M.Tanabe, "Spectral nonlinearity of an inverse-layer-type silicon photodiode under over-filled illumination," Optics & Laser Technology, **153**, 108248, 2022, DOI: 10.1016/j.optlastec.2022.108248

6) K. Hattori, T. Konno, Y. Miura, S. Takasu, D. Fukuda, "An optical transition-edge sensor with high energy resolution," Superconductor Science and Technology, **35**, 095002,2022, DOI: 10.1088/1361-6668/ac7e7b

7) T. Arakawa, T. Oka, S. Kon, Y. Niimi, "Microwave Dynamical Conductivity in the Quantum Hall Regime," Physical Review Letters, **129**, 046801, 2022, DOI: 10.1103/PhysRevLett.129.046801

8) Y. Okazaki, T. Tanaka, N. Saito, N. Kaneko, "Subfemtoampere Resolved Ionization Current Measurements Using a High-Resistance Transimpedance Amplifier," IEEE Transactions on Instrumentation and Measurement, **71**, 2002508, 2022, DOI: 10.1109/TIM.2022.3164155

9) A. Takagaki, S. Nakamura, S. Ashimura, M. Yoshida, J. T. Song, M. Watanabe, S. Hayashi, T. Ishihara, "Mixing nitrogen-containing compounds for synthesis of porous boron nitride for improved porosity, surface functionality, and solid base catalytic activity," Applied Catalysis A: General, **638**, 118635, 2022, DOI: 10.1016/j.apcata.2022.118635

10) N. Hanari, Y. Aoyagi, Y. Orihara, "A reference material (NMIJ RM 4076-a) for the determination of short-chain chlorinated paraffins," Environmental Science and Pollution Research, **29**, 46273–46281, 2022, DOI: 10.1007/s11356-022-19120-2

11) T. Miura, A. Wada, "Precise Purity Analysis of High-Purity Lanthanum Oxide by Gravimetric Analysis Assisted With Trace Elemental Analysis by Inductively Coupled Plasma Mass Spectrometry," Frontiers in Chemistry, 888636, 2022, DOI: 10.3389/fchem.2022.888636

12) T. Kinumi, K. Saikusa, M. Kato, R. Kojima, C. Igarashi, N. Noda, S. Honda, "Characterization and Value Assignment of a Monoclonal Antibody Reference Material, NMIJ RM 6208a, AIST-MAB," Frontiers in Molecular Biosciences, 842041, 2022, DOI: /10.3389/fmolb.2022.842041

13) Q. Wang, S. Okumura, S. Ri, P. Xia, S. Ogihara, "Stereo sampling moire method for three-dimensional deformation mapping with a stereomicroscope," Optics Express, **30**, 29310-29328, 2022, DOI: 10.1364/OE.464574

14) D. Asakawa, K. Saikusa, "Characterization of the Internal Energy of Ions Produced by Electrospray Ionization Using Substituted Benzyl Ammonium Thermometer Ions," Journal of The American Society for Mass Spectrometry, **33**, 1548–1554, 2022, DOI: 10.1021/jasms.2c00116

15) D. Asakawa, T. Hosokai, Y. Nakayama, "Experimental and Theoretical Investigation of MALDI In-Source Decay of Peptides with a Reducing Matrix: What Is the Initial Fragmentation Step?," Journal of The American Society for Mass Spectrometry, **33**, 1011–1021, 2022, DOI: 10.1021/jasms.2c00066"

16) T. Shimoda, W. Kokuyama, H. Nozato, "Precise sinusoidal signal extraction from noisy waveform in vibration calibration," Metrologia, **59**, DOI: 10.1088/1681-7575/ac6cba

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National Institute of Advanced Industrial Science and Technology (AIST)
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