NMIJ Newsletter
No.11, May 2020

Greetings from Director General of NMIJ

Dr. USUDA Takashi *
Vice-President, AIST
Director General, NMIJ

Welcome to the 11th issue of NMIJ Newsletter.

First of all, I would like to send our best wishes to all colleagues in the international metrology community. Due to the COVID-19 pandemic, many NMIs are forced to suspend and reduce their activities. However, mutual cooperation among NMIs is essential in the metrology community at very such time. NMIJ is fully determined to continue our efforts and cooperation with other NMIs and contribute to the international metrology community.

NMIJ/AIST embarked on its 5-year-midterm plan from 1st April 2020 to 31st March 2025. The primary mission in this term is to solve social challenges. In recent years, Japan is facing such important challenges as energy and environmental constraints, an aging population, and reinforcement of national land and disaster prevention, all of which are unavoidable in the context of realizing a sustainable society.

In line with the new plan, NMIJ will attempt such new challenges as nondestructive inspection of infrastructure, usage of hydrogen energy and some other challenges. We of course keep developing, maintaining, disseminating the measurement standards and contributing to the international society. The realization and dissemination of the new SI after the redefinition of the SI base units are also big future tasks. We are unable to accomplish our goals without your help, and now, we kindly ask for your continued support and cooperation.

* Dr. USUDA was appointed to the Vice-President of AIST on 1st April 2020 concurrently with the Director General of NMIJ.

Organization and management team of NMIJ

The NMIJ is composed of six units including two administrative units and four research institutes. The Research Promotion Division (RPD) is the headquarter of NMIJ and plays a leading role in the activities of NMIJ. The four research institutes, Research Institute for Engineering Measurement (RIEM), Research Institute for Physical Measurement (RIPM), Research Institute for Material and Chemical Measurement (RIMCM), and Research Institute for Measurement and Analytical Instrumentation (RIMA), are conducting a variety of researches related to measurement standards. The Center for Quality Management of Metrology (CQMM) consists of six sections, providing administrative support for NMIJ.

Directors of RIEM, RIPM, RIMCM and RIMA were appointed on 1st April 2020.

Dr. FUJIMOTO Toshiyuki
Deputy Director General, NMIJ

Dr. OTA Akihiro
Director of RIEM

Dr. SHIMADA Yozo
Director of RIPM

Dr. GONDA Satoshi
Director of RIMCM

Dr. ISHII Juntaro
Director of RIMA

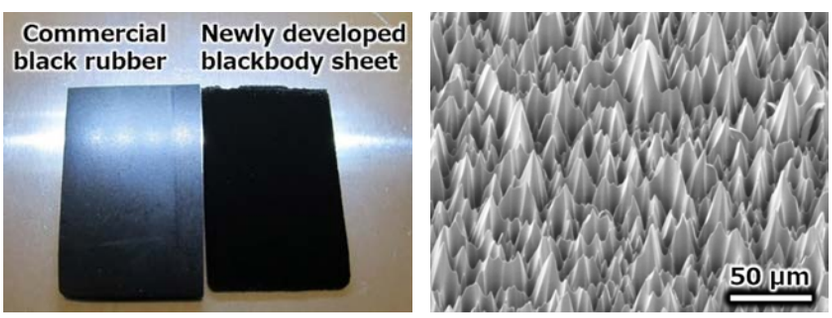
Dr. KOBATA Tokihiko
Director of CQMM

Research Topics

Perfect blackbody sheets from nano-precision microtextured elastomers

AMEMIYA Kuniaki, KOSHIKAWA Hiroshi*, IMBE Masatoshi, YAMAKI Tetsuya* and SHITOMI Hiroshi ****National Institutes for Quantum and Radiological Science and Technology (QST)***

We have developed a novel perfect blackbody sheet that absorbs all light with a finely microtextured surface. Black-surface materials have a wide range of applications from not only optical metrology and dark-level reduction, but also imaging, light harvesting, and decoration. In particular, black materials of nearly 100 % absorptance are required for the absorber of an absolute radiometer, or stray light elimination in high-end optics. However, most materials that absorb more than 99 % of light have poor durability and are difficult to use in the general environment. Herein, we have successfully developed an elastomeric perfect blackbody sheet having high durability and flexibility, by forming a surface microtexture where incident light is confined by multiple bounces. The surface microtexture template was fabricated on a polymer surface by ion beam irradiation from a cyclotron accelerator and chemical etching. The blackbody sheet was produced by replicating the template texture to silicone rubber. The resultant sheet absorbs more than 99.5 % of incident light in the entire range from ultraviolet light to visible light to infrared. We have succeeded to absorb the thermal infrared more than 99.9 %. This new black material would offer the unprecedented beautiful black finishing of consumer products, as well as the optical absorber of an absolute radiometer standard, the contrast enhancement in imaging, and so on. Stray thermal infrared reduction in thermography would be also expected.



The newly developed blackbody sheet (left). Even under the light illumination, the blackbody sheet exhibits almost no reflection. Electron microscope image of the fine surface microtexture of the blackbody sheet (right).

Reference: K. Amemiya et al., Journal of Materials Chemistry C, **7**, 5418-5425, 2019.

Intense positron beam facility for advanced material analysis

MICHISHIO Koji, Brian E. O'Rourke and OSHIMA Nagayasu

Atomic/molecular-scale voids in materials affect the macroscopic properties of the materials such as mechanical strength, electrical characteristics and functionalities. Therefore, in the development of advanced materials, evaluating the structure and state of the voids is essential, together with the manufacturing technology. In particular, since functionalities of a number of recent advanced materials are expressed by surface modification and composite technologies, analysis techniques of the extremely small voids in near-surfaces and local areas were demanded.

The positron, the antiparticle of the electron, is a sensitive probe of voids owing to its unique characteristic, in which positrons can be captured by voids and then annihilate into gamma-rays. This process takes place with an intrinsic lifetime depending on the nature of the void. The techniques based on this positron annihilation spectroscopy (PAS) provide valuable information on the void structure and state. However, in conventional methods, it was often difficult to apply the methods for various advanced materials due to the limited spatial resolution (e.g. 1 cm) and measurement speed.

Slow positron beam facility at NMIJ: a depth-resolved positron annihilation spectroscopy system and a scanning positron microscope.

We have developed a positron beam facility at NMIJ (see figure) for material analysis employing an intense positron beam generated by an electron linear accelerator. The beam is applied to depth-resolved PAS measurements for the analysis of thin films and a novel scanning positron microscope. The positron microscope enables us to perform localized scanning and two-dimensional imaging of the void-size distribution with a spatial resolution of less than 100 µm, and measurements outside vacuum under controlled atmospheric conditions. These powerful tools developed in the facility are open to external users and support the development of advanced materials.

New certified reference materials for reliable doping tests

NUMATA Masahiko, YAMAZAKI Taichi, KUROE Miho, SAITO Naoki, SHIMIZU Yoshitaka and IHARA Toshihide

To keep fairness of sport competitions, accurate anti-doping analysis is required and reliable certified reference materials (CRMs) are essential for this purpose. In March 2020, NMIJ issued two CRMs as requested by the World Anti-Doping Agency (WADA) to support doping test regimes for the upcoming Tokyo Olympic and Paralympic Games.

In addition to the prohibited substances that are listed more than 300 substances by WADA, metabolites of such substances are also important as one of the objectives of doping tests.

CRMs for doping test (standard solutions of 4-hydroxy-clomifene, left, and 3β, 4α-dihydroxy-5α-androstan-17-one, right)

The new CRMs are standard solutions of 4-hydroxy-clomifene and 3β, 4α-dihydroxy-5α-androstan-17-one which are metabolites of the prohibited substances, namely Clomifene and Formestane. Their certified values (concentrations of the target compounds) have been accurately determined by quantitative nuclear magnetic resonance spectroscopy (qNMR), and combination of qNMR and liquid chromatography.

Starting 24th March 2020, these CRMs are distributed to WADA accredited laboratories. The SI-traceable CRMs for calibration of analytical instruments such as liquid chromatograph/mass spectrometer (LC/MS) will work effectively to improve the reliability of doping tests for international sporting events.

Installation of type approval test facilities for Automatic Weighing Instrument (AWI)

MIKURA Shinsuke

In Japan, the specified measuring instruments in 18 categories are used for transactions and certifications in legal metrology and they must be type-approved based on the Measurement Act. Outline of the type approval system was already introduced in NMIJ Newsletter No. 10 (October 2019).

NMIJ/AIST conducts type approval for most of the specified measuring instruments. In 2019, the cabinet order and ministerial ordinance supporting the Measurement Act were revised, and automatic weighing instruments (AWIs) were recently included in the specified measuring instruments. Following this revision, NMIJ/AIST has set up new test facilities for type-approval in the AIST campus in Tsukuba. In the type approval test of AWIs, the effects of the environment including temperature/humidity conditions and the immunity to electromagnetic interferences are evaluated in addition to the basic weighing performance.

Because AWIs are large, sufficient spaces must be provided for the temperature/humidity chamber for the environmental tests (Figure 1) and the anechoic chamber for immunity to radiated electromagnetic field (Figure 2). The size of the anechoic chamber is larger than a normal one for general use. The large chamber doors enable AWIs, whose sizes are 2 m × 2 m at maximum, can be loaded and unloaded smoothly.

In order to test an extremely large AWI, NMIJ uses a larger anechoic chamber with a size of 37 m (W) × 37 m (D) × 9.6 m (H) at FREA (Fukushima Renewable Energy Institute) of AIST located in Fukushima Prefecture. This chamber had been already used in FREA for other purposes. To utilize this facility for type approval under Measurement Act, a new device for immunity test has been installed.

With above developments in the facilities, NMIJ/AIST recently started a new type approval service for AWIs.

Figure 1: Temperature & humidity test chamber for static temperature & dump heat test
4.5 m (W) × 2.7 m (D) × 2.5 m (H)

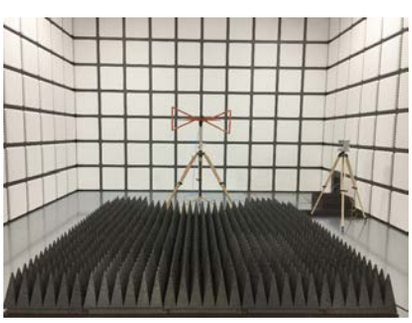


Figure 2: Anechoic chamber for radiated, RF, electromagnetic field immunity test
9.5 m (W) × 6 m (D) × 4.5 m (H)

Featured Events

Director of NIMT, Thailand visits NMIJ

Ms. Ajchara Charoensook, Director of National Institute of Metrology, Thailand (NIMT) and the delegates visited NMIJ in Tsukuba on 5th and 6th September 2019. On this visit, the delegates intended to exchange ideas with NMIJ especially regarding strategic plans to address the rapid growth of the latest technologies such as robotics and automation, medical hubs and energy efficiency. Three discussion groups were prepared and held in parallel. The first group was led by Dr. USUDA Takashi, Director General of NMIJ on the organizational strategy plan. The second and third were on-site technical discussions regarding the latest engineering and physical measurement technologies carried out while demonstrating the actual equipment and devices. Comprehensive but in-depth discussions accompanied by meaningful exchanges of information took place both at the discussion groups and at the summary session. The delegates also paid a visit to 12 representative laboratories including dimensional standards, storage battery evaluation, NMR spectroscopy and clinical linac.

NMIJ and NIMT have forged a long-standing relationship, marked by the success of JICA-NIMT project. On this occasion, both directors reaffirmed each other to continue and further strengthen this well-established partnership and collaboration.

NIMT and NMIJ director meeting

Laboratory visit on force and torque standards

Director of NIM, China visits NMIJ

Mr. Fang Xiang, Director of the National Institute of Metrology, China (NIM), and three other delegates visited NMIJ in Tsukuba from 17th to 19th September 2019. This was the second visit for Mr. Fang since May 2018.

A warm welcome from NMIJ to the delegates was represented by Dr. USUDA Takashi, Director General of NMIJ, followed by NIM and NMIJ director meeting. At the meeting, the directors made updates on the latest activities performed by each institution and exchanged opinions on some recent metrology and standards issues. They also agreed to strengthen the partnership and collaborations that have been conducted so far by extending the validity period of the MoU which will end in March 2020.

Former and new APMP Chairs and Secretariat members

On this occasion, the delegates also undertook the taking-over process of work duties of APMP Chair as well as APMP Secretariat since Mr. Fang serves as APMP Chair after Dr. TAKATSUJI Toshiyuki.

Mr. Fang also paid a visit to several laboratories of interest including bio-medical standards and quantum electrical standards.

The delegates of NIM and NMIJ

AIST-ITRI Joint Symposium 2019

The 7th joint symposium between AIST and the Industrial Technology Research Institute, Taiwan (ITRI) was held at AIST Tsukuba Center on 8th November 2019. The symposium was attended by 69 people from both institutes included Dr. Edwin Liu (President of ITRI), and Dr. CHUBACHI (then President of AIST). Parallel sessions of the symposium were mainly focused on areas expected for AIST-ITRI New Technical Discussion with Future Collaboration Action Plan. Dr. Peng of CMS/ITRI and Dr. USUDA of NMIJ/AIST organized a session on the theme of Metrology for particle metrology, angle metrology, and high temperature metrology. Speakers from ITRI for the session were Dr. Hsu, Dr. Yeh, and Dr. Chang.

Previously, on 7th November, CMS/ITRI members visited NMIJ labs focused on metrology fields of the symposium and discussed with NMIJ researchers. Three groups were prepared and discussions were held in parallel. These groups had a lab tour and on-site technical discussions regarding the recent research topics for the organized session theme, and research topics for silicon sphere (revision of kilogram definition), nebulizer (ultra fine mist nozzle), optical frequency comb, and 3D measurement (X-ray CT).

AIST-ITRI meeting and lab tour, 7th November

AIST-ITRI Joint Symposium 2019, 8th November

General Director of VNIIFTRI, Russia visits NMIJ

Prof. Dr. Sergey Donchenko, General Director of All-Russian Scientific Research Institute for Physical-Engineering and Radiotechnical Metrology, Russia (VNIIFTRI), Dr. Vladimir Dobrovolskiy, Head of VNIIFTRI Physico-Chemical and Electrical Measurements Department and two other delegates visited NMIJ in Tsukuba from 20th to 22nd November 2019.

On the first day, NMIJ-VNIIFTRI Director Meeting was held, beginning with remarks by Dr. USUDA Takashi, Director General of NMIJ, followed by the introductions of each institution. Potential cooperation between the two institutions for the future were discussed during the meeting.

The next two days, the delegates made a special visit to NMIJ Research Institute for Material and Chemical Measurement (RIMCM) to discuss detailed research activities on electrochemical measurements as well as key comparison plan for pH measurements.

A series of laboratory visits to the laboratories representing NMIJ and the laboratories related to material and chemical measurements were also arranged.

Dr. USUDA welcomed the visit of Prof. Donchenko and the delegates.

The 2019 APMP General Assembly and Related Meetings

The 2019 APMP General Assembly and Related Meetings were held in Sydney, Australia from 28th November to 6th December 2019 at the International Convention Centre Sydney.

National Measurement Institute, Australia (NMIA), Australian Nuclear Science and Technology Organization (ANSTO) and Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) co-hosted this big event.

It was the last meeting for Dr. TAKATSUJI Toshiyuki as the Chair to manage all meetings since his term of office was supposed to be terminated. At the same time, Dr. MORIOKA Takahiro, Executive Secretary also finished his term of office as the Secretariat in this meeting. The new Chair and Secretariat were transferred to Mr. Fang Xiang and Ms. Cai Ada Juan of National Institute of Metrology, China (NIM) respectively. A total of 375 participants attended the meetings and all meetings and workshops were completed successfully.

Prof. Ullrich gives a speech at the 15th NMIJ International Metrology Symposium

Prof. Dr. Joachim Hermann Ullrich, President of the Physikalisch-Technische Bundesanstalt, Germany (PTB), who also serves as a President of the Consultative Committee for Units (CCU) and Vice-President of the International Committee for Weights and Measures (CIPM), was invited by NMIJ to give a keynote speech at the 15th NMIJ International Metrology Symposium (the 17th Japan Metrology Forum Symposium) held on February 21st, 2020 at TKP GARDEN CITY PREMIUM Jimbocho, Tokyo. His speech entitled "The revised SI for innovation, science, and the second quantum revolution," was the latest important topics in metrology, right on target for the audience who were mostly involved in the fields of measurements and standards and would certainly be valuable information for them. The symposium is held annually, however, in this last five years has been focused on the redefinition of SI. The theme this time is a summary of the SI redefinition and its future prospects.

Prof. Ullrich gave a speech at the 15th NMIJ International Metrology Symposium

Upcoming Event

XXIII World Congress of the International Measurement Confederation (IMEKO 2021)

August 30 to September 3, 2021 in Yokohama, Japan

www.imeko2021.org

International Visitors / Guests

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
Dr. S. Pasakawee, Dr. V. Sittakul	National Institute of Metrology, Thailand	9th – 13th September 2019	Technical visit to Radio-Frequency Standards Group
Ms. A. B. A. Rahman	Tribology Precision and Machining, MJIIT-UTM, Malaysia	25th September - 29th October 2019	Study on advanced humidity standards and calibration system.
Mr. P. Rindhatayathon	Office of Atoms for Peace, Thailand	4th September - 22nd November 2019	Evaluation of correction factors using Monte Carlo simulation.
Dr. Z. Jia	Electromagnetic Division, National Institute of Metrology, China	15th October 2019 - 9th April 2020	Research collaboration on a programmable Josephson voltmeter for the quantum metrology triangle measurement
Dr. C. Massey Dr. A. Bella	National Physical Laboratory, UK	20th February 2020	Special talk on diversity and inclusion at NPL

Peer Reviewer Dispatch

The NMIJ dispatches peer reviewers to other NMIs on their requests (if available).

Name	Institute Reviewed	Visiting Date	Peer Review Field
Dr. KAJIKAWA Hiroaki	NMC/A*STAR, Singapore	10th - 11th December 2019	Pressure and Vacuum
Dr. KAJIKAWA Hiroaki	MUSSD, Sri Lanka	8th - 9th January 2020	Pressure

International Comparisons

The NMIJ has participated in the following international comparisons.

NMIJ Participant	KCDB Code	Field	Title	Pilot Lab	Start Date
Dr. SHITOMI Hiroshi	CCPR-K5.2019	Photometry and Radiometry, Properties of Materials	Comparison of spectral diffuse reflectance from 360 nm to 820 nm	MIKES	December 2019
Dr. UCHIDA Takeyoshi		Ultrasound	APMP research comparison on high ultrasonic power	NIM, NMIJ	8th October 2019
Dr. ITOH Hiroshi		Surface Chemical Analysis (VAMAS/TWA 2)	International round robin test for graphene layer number characterization by kelvin probe force microscopy (Project A12)	NIMS	5th February 2020
Dr. SASAJIMA Naohiko	APMP. T-S15	Thermometry, Pyrometry	Calibration on ear thermometers	NIM	16th December 2019

Selected Research Reports

1) H. Uchida, Y. Kayukawa, Y. Maeda, "Ultra high-resolution seawater density sensor based on a refractive index measurement using the spectroscopic interference method", Nature scientific reports, **9**, 15482, 2019, DOI: 10.1038/s41598-019-52020-z

2) K. Hattori, C. Wu, N. Tak, et al., "Final report of the key comparison of Vickers hardness: APMP.M.H-K1.b and APMP.M.H-K1.c", Metrologia, **57**, 07010, 2020, DOI: 10.1088/0026-1394/57/1A/07010

3) H. Nozato, W. Kokuyama, K. Hattori, et al., "An investigation on influence of mass inertia using primary calibration of back-to-back accelerometer by laser interferometry", Metrologia, **56**, 65006, 2019, DOI: 10.1088/1681-7575/ab3f61

4) Y. Kasai, H Yabuno, Y. Yamamoto, S. Matsumoto, "Ultra-sensitive minute mass sensing using a microcantilever virtually coupled with a virtual cantilever", Sensors, **20**, 1823, 2020, DOI: 10.3390/s20071823

5) Y. Takei, K. Arai, H. Yoshida, et al., "Development of an optical pressure measurement system using an external cavity diode laser with a wide tunable frequency range", Measurement, **151**, 107090, 2020, DOI: 10.1016/j.measurement.2019.107090

6) J. Zhu, T. Hayashi, A. Nishino, K. Ogushi, "Development of 2 N dead-weight type force standard machine", Measurement, **154**, 107463, 2020, DOI: 10.1016/j.measurement.2019.107463

7) S. Takada, H. Edlbauer, H. V. Lepage, et al., "Sound-driven single-electron transfer in a circuit of coupled quantum rails", Nature Communications, **10**, 4557, 2019, DOI:10.1038/s41467-019-12514-w

8) K. Ueda, S. Tanaka, R. Yamamoto, Y. Shimizu, et al., "Site dependence of Tb^{3+} luminescence in double perovskite-type alkaline earth lanthanum tantalates", The Journal of Physical Chemistry C, **124**, 854-860, 2020, DOI: 10.1021/acs.jpcc.9b09260

9) Y. Kato, A. Sanada, "Impedance-matching technique of metasurfaces generating evanescent fields for subwavelength focusing", IEEE Transactions on Microwave Theory and Techniques, **68**, 1401-1408, 2020, DOI: 10.1109/TMTT.2020.2966696

10) S. Yanagimachi, K. Harasaka, R. Suzuki, et al., "Reducing frequency drift caused by light shift in coherent population trapping-based low-power atomic clocks", Applied Physics Letters, **116**, 104102, 2020, DOI: 10.1063/1.5143377

11) Y. Kawamura, T. Nakano, "Evaluation of the triple point temperature of sulfur hexafluoride and the associated uncertainty at NMIJ/AIST", Metrologia, **57**, 14003, 2020, DOI: 10.1088/1681-7575/ab47e9

12) S. Asai, M. Ohata, Y. Hanzawa, et al., "Direct quantitation of ^{135}Cs in spent Cs adsorbent used for the decontamination of radiocesium-containing water by laser ablation inductively coupled plasma mass spectrometry", Analytical Chemistry, **92**, 3276-3284, 2020, DOI: 10.1021/acs.analchem.9b05161

13) M. Li, M. Akoshima, "Appropriate metallic coating for thermal diffusivity measurement of nonopaque materials with laser flash method and its effect", International Journal of Heat and Mass Transfer, **148**, 119017, 2020, DOI: 10.1016/j.ijheatmasstransfer.2019.119017

14) S. Takeya, M. Muraoka, S. Muromachi, K. Hyodo, A. Yoneyama, "X-ray CT observation and characterization of water transformation in heavy objects", Physical Chemistry Chemical Physics, **22**, 3446, 2020, DOI: 10.1039/C9CP05983K

15) K. Saikusa, D. Kato, A. Nagadoi, H. Kurumizaka, S. Akashi, "Native mass spectrometry of protein and DNA complexes prepared in nonvolatile buffers", Journal of the American Society for Mass Spectrometry, **31**, 711-718, 2020, DOI: 10.1021/jasms.9b00145

16) H. Yamawaki, "Viscosity measurements of high-pressure liquids via a quartz crystal fundamental resonance", Journal of Applied Physics, **127**, 094701, 2020, DOI: 10.1063/1.5143161

17) A. Honda, T. Yoshida, A. Shioda, K. Nomoto, K. Miyamura, "Cold crystallization of chiral schiff-base nickel (II) complex having alkyl chains and characteristic methyl group", Bulletin of the Chemical Society of Japan, **92**, 1853-1858, 2019, DOI: 10.1246/bcsj.20190166

18) P. Xia, Q. Wang, S. Ri, H. Tsuda, "Calibrated phase-shifting digital holography based on space-division multiplexing", Optics and Lasers in Engineering, **123**, 8-13, 2019, DOI: 10.1016/j.optlaseng.2019.06.022

19) D. Asakawa, H. Takahashi, S. Iwamoto, K. Tanaka, "Hydrogen attachment dissociation of peptides containing disulfide bonds", Physical Chemistry Chemical Physics, **21**, 26049, 2019, DOI: 10.1039/C9CP03923F

20) Q. Wang, S. Okumura, S. Ri, P. Xia, H. Tsuda, S. Ogihara, "Second-order moiré method for accurate deformation measurement with a large field of view", Optics Express, **28**, 7498-7514, 2020, DOI: 10.1364/OE.387997

21) A. Yunoki, Y. Sato, et al., "Report of APMP comparison of the activity measurements of Fe-59 (APMP.RI(II)-K2.Fe-59)", Metrologia, **57**, 06002, 2020, DOI: 10.1088/0026-1394/57/1A/06002

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