OPTICS & PHOTONICS International Congress

OPIC 2020

20-24 April 2020

Congress Program

Plenary Session

Joint Sessions

Specialized International Conferences

- ALPS 2020 : The 9th Advanced Lasers and Photon Sources
- BISC 2020 : The 6th Biomedical Imaging and Sensing Conference
- HEDS 2020 : International Conference on High Energy Density Science 2020
- LDC 2020 : Laser Display and Lighting Conference 2020
- LEDIA 2020 : The 8th International Conference on Light-Emitting Devices and Their Industrial Applications
- LSC 2020 : Conference on Laser and Synchrotron Radiation Combination Experiment 2020
- LSSE 2020 : Laser Solutions for Space and the Earth 2020
- OMC 2020 : The 7th Optical Manipulation and Structured Materials Conference
- OPTM 2020 : Optical Technology and Measurement for Industrial Applications 2020
- OWPT 2020 : Optical Wireless and Fiber Power Transmission Conference 2020
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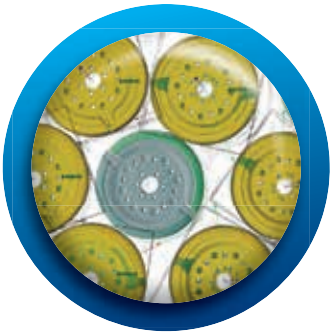

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Date: Monday 20 - Friday 24 April 2020

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Welcome to OPIC 2020

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The Optics and Photonics International Council (Japan) has organized the Optics and Photonics International Congress (OPIC) and the Optics and Photonics International Exhibition (OPIE) annually at Pacifico Yokohama since 2012. OPIC historically includes more than 10 technical conferences in related technology areas. It is extremely important to hold different optics-related technical conferences at one place at the same time because laser sources, light detection, and light active control are common elemental technologies. Sharing the supply and demand from each technical conference accelerates the development of these technologies and their applications.

OPIC is now one of the largest international conferences, suitable to efficiently attract the latest advanced science and technology information of optics, photonics, and their applications. OPIC 2020 is co-chaired by Yoshiaki Kato (Graduate School for the Creation of New Photonics Industries), Christopher P. J. Barty (University of California, Irvine), Reinhart Poprawe (Fraunhofer Institute for Laser Technology), and Ruxin Li (Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences).

OPIC 2020 was originally composed of 15 technical professional conferences, covering the fields of lasers and photon sources, biomedical imaging and sensing, high energy density science, nano-photonics and nano-optoelectronics, IoT enabling sensing/network/AI, laser display and lighting, light-emitting devices and their industrial applications, laser and synchrotron radiation combination experiment, laser solutions for space and the earth, optical manipulation and structured materials, optical technology and measurement for industrial applications, optical wireless and fiber power transmission, laser damage, smart laser processing, and x-ray optics and applications.

However, due to the rapid world-wide spreading of the new coronavirus (COVID-2019), we decided to hold OPIC 2020 not as an in-person conference as originally planned, but as an online virtual conference. The health and safety of OPIC conference attendees is always of primary importance. Although we cannot communicate directly as at in-person meetings, this online conference has several advantages: you can focus on the specific presentations you are interested in on your pc, you can attend presentations at various sessions without conflict or overlap in parallel session timing.

The steering committee of each technical professional conference intensively discussed to find the best adjusted scheme for the community supporting the conference. Unfortunately, four technical professional conferences decided to cancel their meeting. OPIE, one of the largest exhibitions in Japan specializing in photonics, also gave up to hold in this year was also forced to cancel. But, the rest of eleven remaining OPIC 2020 conferences have decided to hold an online virtual meeting.

With a few exceptions, all presentation videos will be uploaded to YouTube and Youku at “unlisted” property during the week of OPIC 2020 (during 9:00 of April 20 – 17:00 of April 24, Japan time). All registered participants will have access to all archives from the registration accounts page, including presentations at conferences other than the one they registered for (more on this later). The presentation archives are protected from downloading but all registered participants can access and download the full abstracts of OPIC 2020.

The OPIC 2020 plenary session will also be held with video presentation. Two prominent scientists are invited to give the plenary lectures: Prof. Gérard Mourou (École Polytechnique, recipient of 2018 Nobel Prize in Physics) and Dr. Berthold Schmidt (CTO, TRUMPF Lasertechnik GmbH).

The organizer would like to thank all who have submitted the papers and also the invited speakers who have agreed to make presentations at OPIC 2020. Since we made every effort to make this conference very useful to all participants, we hope you will bring back many fruits from OPIC 2020 and strengthen our communication in spite of this difficult situation.

The OPI Council sincerely appreciates the authorized support of the Ministry of Education, Culture, Sports, Science and Technology (MEXT), the Ministry of Economics, Trade and Industry (METI), the Ministry of Agriculture, Forest and Fishery (MAFF), the Ministry of Health, Labor and Welfare (WHLW), the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), and Keidanren (Japan Business Federation). We appreciate cooperation with the societies and agencies in Japan, USA, Germany, Taiwan, and Korea. Also, we would like to thank the founding organizations and companies for their strong support of OPIC 2020.

The organizer hope that we will get together again in OPIC 2021 and celebrate overcoming the virus infection.

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Plenary Session

Plenary Speech

PASSION EXTREME LIGHT

Gérard Mourou
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Abstract

Extreme-light laser is a universal source providing a vast range of high energy radiations and particles along with the highest field, highest pressure, temperature and acceleration. It offers the possibility to shed light on some of the remaining unanswered questions in fundamental physics like the genesis of cosmic rays with energies in excess of 1020 eV or the loss of information in black-holes. Using wake-field acceleration some of these fundamental questions could be studied in the laboratory. In addition extreme-light makes possible the study of the structure of vacuum and particle production in "empty" space which is one of the field's ultimate goal, reaching into the fundamental QED and possibly QCD regimes.

Looking beyond today's intensity horizon, we will introduce a new concept that could make possible the generation of attosecond-zeptosecond high energy coherent pulse, de facto in x-ray domain, opening at the Schwinger level, the zettawatt, and PeV regime; the next chapter of laser-matter interaction.

Professor Gérard Mourou is Professor Haut-Collège at the École polytechnique. He is also the A.D. Moore Distinguished University Emeritus Professor of the University of Michigan. He received his undergraduate education at the University of Grenoble (1967) and his Ph.D. from University Paris VI in 1973. He has made numerous contributions to the field of ultrafast lasers, high-speed electronics, and medicine. But, his most important invention, demonstrated with his student Donna Strickland while at the University of Rochester (N.Y.), is the laser amplification technique known as Chirped Pulse Amplification (CPA), universally used today. CPA revolutionized the field of optics, opening new branches like attosecond pulse generation, Nonlinear QED, compact particle accelerators. It extended the field of optics to nuclear and particle physics. In 2005, Prof. Mourou proposed a new infrastructure ; the Extreme Light Infrastructure (ELI), which is distributed over three pillars located in Czech Republic, Romania, and Hungary. Prof. Mourou also pioneered the field of femtosecond ophthalmology that relies on a CPA femtosecond laser for precise myopia corrections and corneal transplants. Over a million such procedures are now performed annually. Prof. Mourou is member of the U.S. National Academy of Engineering, and a foreign member of the Russian Science Academy, the Austrian Sciences Academy, and the Lombardy Academy for Sciences and Letters. He is Chevalier de la Légion d'honneur and was awarded the 2018 Nobel Prize in Physics with his former student Donna Strickland.

Plenary Speech

Market Perspectives and Applications driven by Laser Intensity and Functionality

Dr. Berthold Schmidt
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Abstract

The industrial laser market for laser sources and integrated systems continuous to grow despite the current slowdown in certain areas. Exceeding the market size for lasers in telecommunication the increasing field of high-power applications is an important industrial factor not only in the field of metal processing [1]. Broadening the scope of laser applications, e.g. by evolving traditional CO_2 lasers to ultra-high-power laser systems powering EUV light generation is just one more recent example for this trend. To create a sustainable customer value, enhancements in laser system functionality are of similar importance such as driving cw lasers to higher powers, more efficiency, compactness, robustness and reliability. In parallel, ultra-short pulsed (USP) lasers based on thin disk, fiber and slab amplification gain growing interest from industry due to their higher average power levels, increasing pulse energies, more flexible repetition rates and pulse durations. To keep up with this development TRUMPF serves this market with a broad portfolio of new lasers e.g. ns-pulsed high-power lasers in combination with line beam focusing optics for laser lift-off applications, while TRUMPFs enlarged USP laser portfolio enables applications ranging from transparent material processing to the control of lightning with Joule level femtosecond laser pulses at kHz repetition rates utilizing chirped-pulse amplification (CPA).

Content

TRUMPF's laser systems portfolio starting in 1985, traces key elements of the industrial laser development and is therefore an interesting subject to reflect the path from early CO_2 lasers to the latest generation of diode pumped short pulse (SP) thin disk laser (TDL) with more than 720 W average power at 343 nm wavelength. Today, TRUMPF's advanced laser sources enable novel applications such as EUV light generation, laser lift-off for production of OLEDs, surface annealing of functional glass substrates and the installation of secondary sources. Upcoming industrial applications and a dramatic improved productivity of established processes are driven by a further increase in brilliance resulting from ever-higher output powers at highest beam quality.

Following the intensity increase of cw laser hardening ($I > 10^4$ W/cm^2) and laser metal deposition ($I > 10^5$ W/cm^2) become possible at first, succeeded by heat conduction welding ($I > 10^6$ W/cm^2), keyhole welding ($I > 10^7$ W/cm^2) and with the highest intensity demand laser cutting of metal ($I > 10^7$ W/cm^2).

Although the named applications can in generally be accomplished by simple "low cost" beam sources, important additional attributes, such as flexible but robust beam shape control by means of TRUMPF's BrightLine technology, synchronized scanner optics and in-situ process monitoring e.g. by OCT [2] are required to warrant high-quality, stable processes in industry. A capability of TDLs, which is of increasing industrial interest, is the optional cavity internal frequency conversion with an optical-to-optical efficiency of ~45 % [3] for generation of a green (515 nm), high brightness laser beam mainly for copper welding, a prerequisite for manufacturing battery powered electric cars of the future [4].

In contrary, micro processing application related to the consumer and semiconductor industry are often addressed with SP and USP lasers as shown in Fig.1. The development of industrial grade USP lasers has significantly progressed over the past years. While pulse energy together with beam quality is the determining factor to enable specific applications, a

further rising average power remains the strongest driver towards higher productivity. The tremendous increase of intensity to the focal point is realized by enhanced laser concepts, such as slab amplifiers, TDL based regenerative amplifiers optional with subsequent multi-pass amplification [5].

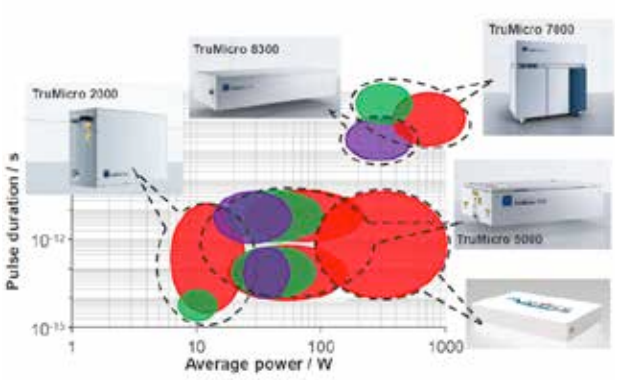

Figure 1. Overview of TRUMPF's SP and USP laser family in dependence of pulse duration (s) and average output power (W). Colors indicate the commercially available wavelengths 1030nm, 515nm and 343nm.

In combination with CPA [6] highest laser intensities can be generated enabling e.g. nonlinear absorption even in transparent materials like glass or sapphire. Special optical elements such as TRUMPF's TOP Cleave or TOP Weld optics yield laser intensity profiles with a constant intensity along the propagation line. In combination with USP lasers this enables glass separation ($I \sim 10^{13}$ W/cm^2) with a thickness of up to 12 mm in a single shot [7] or direct welding of glass or sapphire to metal ($I > 1.7\ 10^{14}$ W/cm^2) [8].

When reaching pulse energies of 700 mJ with 900 fs pulse duration, intensity levels are already achieved far beyond what is required for micro material processing. However, these high power USP lasers enable new exciting applications such as the control of lightning [9], by opening a plasma channel of higher electrical conductivity in air to control the propagation of electrical discharge. Targeting lasers with even higher intensities e.g. > 500 mJ at 30 fs pulse duration, so called laser driven electron secondary sources become feasible.

Emission from these secondary sources can be x-rays ($I > 10^{14}$ W/cm^2), electrons ($I > 10^{18}$ W/cm^2) as already stated, ions or neutrons ($I > 10^{20}$ W/cm^2) as shown in Fig. 2. The generation process itself is multifold and originates from interrelations of the laser beam with a well-prepared target [11].

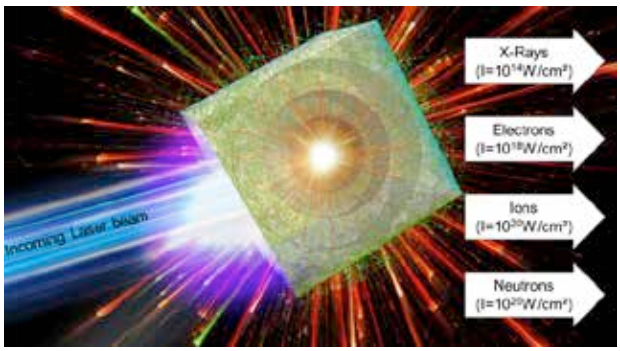

Figure 2. Artistic illustration [10] of an incoming laser beam hitting on a target. Depending on the laser intensity due to the interaction with the target different secondary beams like x-rays, electrons, ions and neutrons are generated.

Depending on the type of radiation, these secondary sources have potential applications ranging from novel scientific fields to metrology in semiconductor industry, nondestructive testing all the way to cancer therapy.

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Dr. Berthold Schmidt is CTO of the TRUMPF Laser Technology GmbH, Germany. Earlier he was CEO and President of TRUMPF Photonics Inc., the production center for III-V high power diode lasers and subsystems located near Princeton, NJ as well as Head of Corporate Research establishing the basis of the TRUMPF Venture GmbH to promote disruptive technologies in early startup companies. Before joining TRUMPF, he was

CEO of Intense Ltd. in Scotland, UK and active in various management roles at Bookham, Switzerland. He received his PhD from the Technical University of Munich (TUM), the "Diplom" from the Julius-Maximilians-University in Würzburg, Germany and the MSc from SUNY Albany, USA. From 2005 to 2016 he supported the Swiss Commission for Technology and Innovation (CTI) in the field of micro and nano technologies as technical expert.

OPIC 2020

Specialized International Conferences

Conference Chairs' Welcome Letters & Committees

The 9th Advanced Lasers and Photon Sources ALPS 2020

Sponsored & Organized by
The Laser Society of Japan

Conference Chair **Hitoki Yoneda**

Institute for Laser Science, University of Electro-Communications

We are delighted to welcome you to the 9th Advanced Lasers and Photon Sources Conference (ALPS 2020), Japan.

The ALPS aims to provide a fruitful opportunity to exchange information and discuss recent progress in lasers and photon sources, and related basic research and industrial applications. The ALPS conference is organized as part of the OPTICS & PHOTONICS International Congress (OPIC 2020), which consists of fifteen optics-related scientific conferences. In the ALPS 2020, we will have 25 excellent invited talks and more than 100 contributed papers, which cover novel optical materials, high average power lasers, high peak power lasers, novel solid-state, fiber, diode lasers, shorter wavelength light sources, terahertz devices, novel optical devices, optical frequency combs, quantum optics, and their applications.

The world is in harsh trouble because of the COVID-19, but we are holding ALPS 2020 in a new form: an online conference. We encourage you to actively participate in all aspects of the Congress and hope that you will find these interactions to be beneficial.

We hope that you enjoy your time at the conference.

The 6th Biomedical Imaging and Sensing Conference BISC 2020

Sponsored by
SPIE, The International Society for Optics and Photonics

Conference Chair **Toyohiko Yatagai**

Center for Optical Research and Education, Utsunomiya University

On behalf of the organizing committee and program committee, it is our great pleasure that the 6-th Biomedical Imaging and Sensing Conference in Yokohama is going to open, within the framework of the OPTICS & PHOTONICS International Congress (OPIC 2020). Unfortunately, due to spreading of COVID-19, the conference this year is performed as a digital conference via an internet system.

In biomedical optics and photonics, optical tools are employed for understanding and treatment of diseases, from the cellular level to macroscopic applications. At the cellular level, highly precise laser applications allows the manipulation, operation or stimulation of cells, even in living organisms or animals. Optical microscopy has been revolutionized by a thorough understanding of the different markers and their switching behavior. marker-free microscopy, like SHG or THG-microscopy is spreading into multiple biological and clinical imaging applications. OCT is continuously broadening its clinical applicability by even higher resolution, higher speed and more compact and the use of Doppler and polarization sensitivity for functional imaging.

In the field of optics and photonics, biomedical imaging and sensing areas are most quickly progressing and expanding. Techniques developed in these areas could bring us great steps in advances of physical, engineering and biological knowledge as well as optics and photonics technology. This Conference aims at covering several aspects from the fundamental studies at cellular level to clinical applications of various optical technologies.

Finally we hope the 6-th Biomedical Imaging and Sensing Conference contributes to the progress in this field and we hope you enjoy fruitful discussions in the Conference.

International Conference on High Energy Density Science 2020 HEDS 2020

Conference Co-Chair
Ryosuke Kodama
Osaka Univ., Japan

Conference Co-Chair
Sebastien Le Pape
Ecole Polytechnique, France

We are delighted that you have joined us in Yokohama to share your latest research achievements in the fields of high energy density science realized with high power apparatus, especially high-power laser, in 2020. This conference is organized with the international co-chair Prof. Le Pape from Ecole Polytechnique in France.

This is the 9th International Conference on High Energy Density Sciences (HEDS 2019) within the framework of OPICS & PHOTONICS International Congress (OPIC 2020), which consists of 15 Optics-related scientific conferences. The HEDS 2020 will focus on significant progress in high-energy-density sciences including inertial fusion physics, laboratory astrophysics, high-pressure science, laboratory astrophysics and planetary sciences, laser-driven radiation source development, atomic and nuclear physics.

In HEDS 2020, we will collaborate with Conference on Advanced Laser and Photon Sources (ALPS 2020) and the International Conference on X-ray optics, detectors, sources, and their applications (XOPT 2020) to hold the special joint session on high power lasers including XFEL and their applications.

We hope that you enjoy your time during the conference and that you will also take this opportunity to explore the rest of Yokohama.

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Laser Display and Lighting Conference 2020
LDC 2020

Sponsored by
The Optical Society of Japan

Conference Co-chairs
Prof. Kazuo Kuroda
Utsunomiya Univ.

Conference Co-chairs
Prof. Hiroshi Murata
Mie Univ.

Welcome to the 9th Laser Display and Lighting Conference, LDC 2020!

The LDC is an international conference on laser displays, laser lighting, and related technologies. The 1st, 2nd, 4th, and 6~8th LDC were held in Yokohama, Japan in 2012, 2013, 2015, and 2017~2019, respectively, the 3rd in Taichung, Taiwan in 2014, and the 5th in Jena, Germany in 2016. The 9th LDC, LDC 2020 is being held from 21st to 24th April 2020 at Pacifico Yokohama, Yokohama, Japan. LDC 2020 is sponsored by the Optical Society of Japan, in cooperation with several academic societies and associations, and is operated by the Laser Display Research Group, the Optical Society of Japan.

LDC 2020 is intended to provide a central forum for the update and review of scientific and technical information on laser display and lighting covering a wide range of fields from fundamental research to systems and applications.

A total of 50 papers will be presented during the 4-day conference, consisting of 3 key-note talks, 22 invited papers (including joint sessions), and 25 contributed papers. Two exciting special sessions entitled 'Laser Technology for Automotive Applications -Phosphor Light Source & Systems-' are also being held with a number of distinguished speakers on 24th April. In these special sessions, the state-of-the-art laser technology including excellent laser headlamps, advanced lidar, and new challenge for automotive, will be presented and discussed. After all the technical sessions, a ceremony for the LDC Best Paper Award and the LDC Student Award will be held for exceptional papers commended for their outstanding achievement.

We would like to extend our sincere thanks to all the presenters and participants of LDC 2020 for their contribution to the success of the conference. We also express our sincere thanks to the Takano-Eiichi Hikari-Kagaku-Kikin (Optical Science Foundation), the Japanese Society of Applied Physics, for the financial support. We hope that all the attendees enjoy the conference.

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The 8th International Conference on Light-Emitting Devices and Their Industrial Applications LEDIA 2020

Sponsored by
Akasaki Research Center (ARC), Nagoya University

Steering Committee, Chair, LEDIA 2020 **Gen-ichi Hatakoshi**

Faculty of Science and Engineering, Waseda University

Welcome to the 8th International Conference on Light-Emitting Devices and Their Industrial Applications (LEDIA 2020), which is one of the specialized international conferences in OPTICS and PHOTONICS International Congress 2020 (OPIC 2020). LEDIA 2020 is sponsored by Akasaki Research Center (ARC), Nagoya University and in corporation with several academic institutes and technical associations.

Since 2013, LEDIA has been designed to provide a platform for active scientists and engineers to present and discuss progress and future trends in science and technology challenges of growths, fabrications, and characterizations of light-emitting diodes/laser diodes, and their industrial applications.

This year, LEDIA 2020 decided to cancel the oral presentation meeting in Pacifico Yokohama, due to a rapid spread of the coronavirus (COVID-19). Extended abstracts will be distributed to the people who registered for the LEDIA 2020.The publication of the abstract will be officially regarded as the presentations by registered speakers. For detail, please refer to the LEDIA 2020 official site (https://www.riam.kyushu-u.ac.jp/reme/ledia/).

We sincerely hope that the whole world can overcome the difficulty.

Conference on Laser and Synchrotron Radiation Combination Experiment 2020 LSC 2020

Co-Sponsored by
PHOTON BEAM PLATFORM
Institute of Laser Engineering, Osaka University

Conference Chair **Hiroki Wadati**

University of Hyogo, Japan

We are pleased to welcome you to the Conference on Laser and Synchrotron Radiation Combination Experiment (LSC) 2020.

As part of the OPTICS & PHOTONICS International Congress (OPIC), LSC aims to converge all scientists and engineers who are working on laser and synchrotron experiments all over the world.

The conference features invited talks and presentations on the recent developments, activities, and trends in lasers and synchrotron sources, instrumentation, experimental techniques, and applications. Especially we will focus on the rapid development of new experimental techniques such as ultrashort pulse lasers and X-ray free electron lasers, which made the study of sub-picosecond dynamics more accessible. A breakthrough, which has not been possible just by studying static properties of materials, is expected to occur by studying sub-picosecond dynamics. Given the current state of this research field, cooperation between laser and synchrotron is getting more and more important. We hope that you will find all the LSC and OPIC activities interesting, engaging, and beneficial. We are very grateful for your participation, and we hope you will enjoy via video conferencing.

Laser Solutions for Space and the Earth 2020
LSSE 2020

Sponsored & Organized by
The Executive Committee of Laser Solution for Space and the Earth

Conference Chair **Toshikazu Ebisuzaki**

RIKEN, Japan

We are pleased that you have joined in Yokohama to attend to Laser Solutions for Space and the Earth (LSSE 2020).

This is the 5th conference of LSSE organized as a part of the OPTICS & PHOTONICS International Congress (OPIC 2020). The aim of "Laser Solutions for Space and the Earth" is to discuss the application of emerging laser technologies to solve various problems for sustainable developments of space and the Earth.

We consider rapidly growing fields, such as, "Agri-Photonics (Smart agriculture, Laser plant factory and Laser sense organ)", "Infrastructure (Non-destructive Testing and Laser-Induced Breakdown Spectroscopy)", "Active Remote Sensing (Extreme Condition and Industrial Application)" and "Space Technology (Laser Debris Deorbit and UV imaging)", as the featured topics of the year 2020. Fortunately, we will have keynote lectures of two distinguished scientists: Prof. Gerard Mourou (Ecole Polytechnique, France) for the Laser Debris Deorbit, Prof. Shigenori Maruyama (ELSI Tokyo Institute of Technology, Japan) for the Extreme Condition. Poster session is prepared for various industrial applications with OPIE activities.

We hope you could enjoy the inspiring discussions in the many research fields in our conference, as we did in the last three conferences. We are looking forward to seeing you at Yokohama, Japan in April.

The 7th Optical Manipulation and Structured Materials Conference OMC 2020

Sponsored by
SPIE.
JSPS KAKENHI in Scientific Research on Innovative Areas "Nano- Material Optical-Manipulation"

OMC 2020 Conference Chair **Takashige Omatsu**

Chiba Univ.
omatsu@faculty.chiba-u.jp

Since the first demonstration of an optical tweezer based on optical radiation forces (scattering and gradient forces) created by a tightly focused laser beam, optical tweezers have been widely investigated in a variety of research fields, including biology, physics, and chemistry. In fact, Dr. A. Ashkin was awarded Nobel Prize in Physics, for contributing to a pioneering work of optical manipulation, 2018.

Conventional optical tweezers have been mostly adopted to dielectric particles with a dimension range from hundreds of nanometers to tens of micrometers. However, they do not always enable us to efficiently trap nanosacle-sized dielectric particles as well as metallic particles.

In recent years, plasmonic tweezers based on enhanced radiation forces owing to surface plasmon polaritons in metallic nanostructures have been successfully demonstrated to efficiently trap and manipulate both nanosacle-sized dielectric and metallic particles.

Also, structured lights, such as higher order Laguerre-Gaussian and Bessel beams carry optical angular momenta, and they provide unique tweezing abilities, for instance, for inducing an orbital motion of the trapped particles without employing mechanical systems.

Since 2014, the OMC has been successfully collecting more than 80 participants from home and abroad. The OMC 2020 conference aims to present and discuss up-to-date scientific subjects, new technologies, and applications related to the fields of optical and plasmonic tweezers, the manipulation of nanostructures, structured optical fields and their satellite topics.

We hope that this conference will also facilitate scientific and professional networking as well as scientific inspiration through discussions.

Optical Technology and Measurement for Industrial Applications 2020 OPTM 2020

Sponsored by
SPIE.
The Japan Society for Precision Engineering (JSPE)

Conference Chair **Takeshi Hatsuzawa**

Laboratory for Future Interdisciplinary Research of Science and Technology (FIRST), Tokyo Institute of Technology

The first Optical Technology and Measurement for Industrial Applications Conference (OPTM) was held in Minatomirai, Yokohama JAPAN from 23 to 25 April 2019, as a part of the Optics and Photonics International Congress 2019, sponsored by the SPIE and Mechano-optics technical committee in the Japan Society of Precision Engineering. In the conference, 35 oral and 15 poster were presented, which is fairly a lot as a first time . The topics are full of variety ranging from profilometry, data acquisition, metrology, inspection etc., showing deep interests in this technical field.

The aim of the OPTM 2020 is to provide an international opportunity for introducing up-to-date technology in the filed of optical measurement and their applications for industries, at the same time, providing a networking opportunity among young researchers and students is another important role of the conference. Also in the venue, other optics related exhibitions and conferences will be hold, which will be a good chance to foster interest in different technical fields. We hope your visit to port of Yokohama will be a new departure in your technical and research carrier.

Optical Wireless and Fiber Power Transmission Conference 2020 OWPT 2020

Sponsored by
Optical Wireless Power Transmission Committee,
The Laser Society of Japan

Conference Chair **Tomoyuki Miyamoto**

Tokyo Institute of Technology

It is our great honor to welcome you to the 2nd Optical wireless and Fiber Power Transmission Conference (OWPT 2020).

The OWPT 2020 is the international conference which is intended to provide a central forum for updating and reviewing scientific and technical information on optical wireless power transmission and optical fiber power transmission by covering a wide range of fields from fundamental researches to systems and applications. The OWPT 2020 is organized as part of the OPTICS & PHOTONICS International Congress (OPIC 2020), which consists of 15 optics-related scientific conferences. The OWPT 2020 is sponsored by Optical Wireless Power Transmission Committee, the Laser Society of Japan in cooperation with several academic societies and associations. The OWPT 2020 consists of 1 plenary talk, 2 special talks, 8 invited talks, and more than 30 contributed papers aiming at great developments in the field covering novel devices and components, systems and subsystems, applications, and related topics.

On the other hand, due to the rapid worldwide spread of new coronavirus infections (COVID-19), the OWPT 2020 committee decided to scale down. The "scale down" means that OWPT 2020 is deemed to have been held by publication of the Technical Digest on April 21 (Tue.) to 23 (Thu.), 2020. The event of practical meeting at the conference venue is not taken place. These decisions basically follow those of the OPIC 2020. We would deeply appreciate your cooperation and understanding on our decision.

We hope that you get the latest activities and achievements of the scope of the OWPT 2020.

International Conference on X-ray Optics and Applications 2020 XOPT 2020

Co-Sponsored by
RIKEN SPring-8 Center
Research Center for Ultra-Precision Science & Technology. Osaka Univ.
Technical Committee for Ultraprecision Machining of JSPE

Conference Co-chairs
Tetsuya Ishikawa
RIKEN

Conference Co-chairs
Kazuto Yamauchi
Osaka University

We are pleased to host the International Conference on X-ray Optics and Applications (XOPT 2020) as part of the Optics and Photonics International Congress 2020 (OPIC 2020) in Yokohama, Japan.

X-rays have played a vital role in a number of breakthrough scientific discoveries in recent years. Continuous innovations in X-ray optics, methodologies, and beamline instruments have laid the foundation for these achievements. For this conference, we are inviting leading experts in these fields from around the world to share the latest status of X-ray technology and developments and to discuss their plans for the future. One important topic we would like to discuss is how state-of-the-art X-ray optics can contribute to exploring the potential of the DLSR (Diffraction-Limited Synchrotron Radiation) sources that are currently emerging.

This year, due to the recent Coronavirus outbreak, XOPT 2020 will be held at two locations in Tokyo and Osaka via Internet on April 22 (Wed) and April 23 (Thu). Details will be announced on the XOPT homepage.

We are happy to welcome you to participate in and enjoy the conference.

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OPIC 2020 Conferences Program

BISC & OMC

[JS4]
Joint Session BISC & OMC
Chairs: Takashige Omatsu
Chiba University
Osamu Matoba
Kobe University

JS4-01 *Plenary*

Identification of chiral interactions in the applications of structured light
David Leslie Andrews
Univ of East Anglia, United Kingdom
Structured light can convey orbital as well as spin angular momentum, imparting novel mechanisms for chiral interaction. Research extends from production and interrogation of chiral structures in material processing, to enhanced spectroscopic measurement of biomatter.

JS4-02 *Plenary*

Shaped Light and Sound: Advanced Trapping and Imaging for Biomedicine
Kishan Dholakia
University of St. Andrews
Optical imaging is advancing at an exceptional pace for biomedicine with new concepts in geometries and light collection. Here we describe approaches that combine trapping and manipulation with optical imaging opening up new studies for the biomedical arena. In particular using shaped light for tailored optical traps as well as acoustic traps leads to immobilizing cells, bacteria and larger organisms such as zebra fish for relevant studies in biomedicine.

ALPS

[ALPS-OP]
Opening Remarks
Chair: Hitoki Yoneda
The University of Electro-Communications

[ALPS1]
Novel optical materials/structure and applications 1
Chair: Masashi Yoshimura
Osaka University

ALPS1-01 *Invited*

Toward high light yield and high energy resolution in inorganic scintillators by defect engineering

Yuntao Wu
Shanghai Institute of Ceramics, Chinese Academy of Sciences

Inorganic scintillators as important radiation detection materials can emit light pulses with detectable wavelengths by photosensors when they are struck by ionizing radiation. Codoping has been regarded as a useful approach to engineer the critical performance of inorganic scintillators. In this talk, we will present our recent developments in inorganic scintillators by codoping.

ALPS1-02

Study on broadband Raman comb generation in silica rod microresonators

Shota Sota, Shun FUjii, Ryo Suzuki, Hajime Kumazaki, Tamiki Ohtsuka, Takasumi Tanabe
Keio University

We investigated Raman comb formation and revealed that due to a cascaded Raman process the center avelength of the generated comb changes, changing the pumping condition. We investigated the degree of coherence of Raman comb.

ALPS1-03

Transparent $MgAl_2O_4$ Ceramic by Reactive Sintering Method

Jian Zhang[1,2]
[1]Shanghai Institute of Ceramics, Chinese Academy of Sciences, [2]Center of Materials Science and Optoelectronics Engineering, University of Chinese Academy of Sciences

The reactive sintering method using commercial available raw materials are employed for fabricating highly transparent $MgAl_2O_4$ ceramic. The microstructure evolution, and its effects on optical properties of the sintered ceramics are experimentally disclosed.

ALPS1-04

Efficient 1062.78 nm Pulse Amplification Medium Toward Intense Lyman-alpha Generation

Yu Oishi[1,4], Norihito Saito[2], Takayo Ogawa[2], Yasuhiro Miyake[1,4], Masahiko Iwasaki[3], Satoshi Wada[2]
[1]Institute of Material Structure Science, KEK, [2]Center for Advanced Photonics, RIKEN, [3]Center for Accelerator-based Science, RIKEN, [4]Material and Life Science Division, J-PARC

Fundamental amplification property of a Nd:$Y_3Sc_{1.5}Al_{3.5}O_{12}$ceramic for 1062.78 nm lightwas investigated. The ceramic shows good potential not only for the amplification property but also productivity of a high quality large-diameter medium.

[ALPS2]
Novel optical materials/structure and applications 2
Chair: Shunsuke Kurosawa
Tohoku University

ALPS2-01 *Invited*

Growth and characterization of large aperture YCOB and Sm:YCOB crystals for application in high peak power lasers

Yanqing Zheng[1], Xiaoniu Tu[1], Kainan Xiong[1], Sheng Wang[1], Erwei Shi[1], Jingui Ma[2], Liejia Qian[2]
[1]Shanghai Institute of Ceramics Chinese Academy of Sciences, China, [2]Key Laboratory for Laser Plasmas, Ministry of Education, Shanghai Jiaotong University, Shanghai, China

YCOB and Sm:YCOB crystals up to 4 inches in diameter were grown both by Czochralski and Bridgman methods. The basic properties were characterized and the application in SHG and high efficiency OPCPA were demonstrated.

ALPS2-02

Growth of SrB_4O_7 crystal and its surface DUV laser-induced damage threshold

Yasunori Tanaka[1], Ryota Murai[2], Yoshinori Takahashi[2], Tsuyoshi Sugita[3], Daisetsu Toh[1], Kazuto Yamauchi[1], Sora Aikawa[4], Yuji Umeda[4], Yusuke Funamoto[4], Tomosumi Kamimura[4], Masayuki Imanishi[1], Yusuke Mori[1,5], Masashi Yoshimura[2,5]
[1]Grad. Sch. of Eng., Osaka Univ., [2]ILE, Osaka Univ., [3]Nikon Corp., [4]Dept. of Electronics, Info. and Comm. Eng., Osaka Inst. Tech., [5]SOSHO CHOKO Inc.

SrB_4O_7 (SBO) crystal has 4.3 times higher surface DUV laser-induced damage threshold (LIDT) than that of UV-grade synthetic silica glass. We have also successfully enhanced the surface LIDT of the SBO using catalyst-referred etching.

ALPS2-03

High-power 355 nm UV generation by using $CsLiB_6O_{10}$ crystal

Kuniaki Atagi[1], Ryota Murai[2], Yoshinori Takahashi[2], Yosuke Orii[3], George Okada[3], Masayuki Imanishi[1], Yusuke Mori[1], Masashi Yoshimura[2]
[1]Graduate School of Engineering, Osaka University, [2]Institute of Laser Engineering, Osaka University, [3]Spectronix Corporation

We demonstrate 355-nm ultraviolet generation in excess of 50 W in $CsLiB_6O_{10}$ by using narrow spectral picosecond pulsed laser at pulse repetition rate of 900 kHz. The conversion efficiency from the fundamental source is 33%.

ALPS2-04

Damage threshold and lifetime improvement on gold coated diffraction gratings in fs regime

Yann BERNARD[1], Gilles REY[2], Thomas MORBIEU[2], Alain PELLEGRINA[2], Benoit. BEAUREPAIRE[2], Sandrine RICAUD[2], Herve BESAUCELE[2], Olivier CHALUS[2], Amine BOUSSADI[1]
[1]Horiba France, [2]Thales LAS France SAS, (France)

We report on large LIDT and lifetime improvement of gold coated diffraction grating for 30 femtosecond pulses. The original test setup allowed to characterise bleaching threshold over large number of shots at 10Hz.

[ALPS3]
Wavelength diversity of coherent light sources
Chair: David Lancaster
The University of South Australia

ALPS3-01 *Invited*

Recent development of high power sesquioxide ceramic lasers at 2~3 μm

Deyuan SHEN[1,2], Fei Wang[1], Jinwen Tang[1], Enhao Li[2], Jun Wang[1], Dingyuan Tang[1]
[1]Jiangsu Normal University, [2]Fudan University

We report on power scaling of Ho^{3+} and Er^{3+} doped Y_2O_3 ceramic lasers based on home-developed highly-transparent ceramic samples, generating over 120 W and 4 W of output power at ~2 um and ~2.7 um.

ALPS3-02 *Invited*

High-power ultrafast thin-disk lasers for Terahertz science

Clara Saraceno, Yicheng Wang, Frank Meyer, Tim Vogel, Sergei Tomilov, Negar Hekmat, Martin Hoffmann
Ruhr Universitat Bochum, Germany

Table-top THz sources combining high field strength and high repetition rate are attractive tools for a wide range of applications. We will present our recent progress on THz generation driven by femtosecond modelocked thin-disk lasers.

ALPS3-03

Kerr-lens mode-locked Tm^{3+}:RE_2O_3 (RE=Lu, Sc) lasers

Anna Suzuki[1], Masaki Tokurakawa[1], Christian Kränkel[2]
[1]Institute for Laser Science,University of Electro-Communications, [2]Zentrum für Lasermaterialien, Leibniz-Institut für Kristallzüchtung

We report on Kerr-lens mode-locked Tm^{3+}:Sc_2O_3 single crystal laser and Tm^{3+}:Lu_2O_3 ceramic laser. To the best of our knowledge, this is the shortest pulse generation from Tm^{3+}:Sc_2O_3 and the first demonstration of KLM Tm^{3+}:Lu_2O_3 laser.

ALPS3-04

Acousto-optically *Q*-switched 4 μm Fe:ZnSe laser pumped by fluoride fiber laser

Hiyori Uehara[2], Shigeki Tokita[1], Takanori Tsunai[1], Bingyu Han[1], Ryo Yasuhara[2], Fedor Potemkin[3], Junji Kawanaka[1]
[1]Osaka University, [2]National Institute for Fusion Science, [3]M.V. Lomonosov Moscow State University

An actively *Q*-switched mid-infrared Fe:ZnSe laser was demonstrated using an acousto-optic modulator. High-repetition, nano-second pulses with kW-level peak power were obtained at 4 μm wavelength by continuous-wave fiber laser pumping.

ALPS3-05

Visible laser performance of Tb:$LiYF_4$ and $LiTbF_4$

Hengjun Chen[1], Hiyori Uehara[1,2], Hiroki Kawase[2], Weichao Yao[1], Ryo Yasuhara[1,2]
[1]National Institute for Fusion Science, Gifu, Japan, [2]SOKENDAI, Gifu, Japan

Visible laser operations of 15%Tb:$LiYF_4$ and $LiTbF_4$ have been demonstrated in yellow or/and green spectral region. The maximum slope efficiencies were found to be 63% and 45% at 544 nm, respectively.

[ALPS4]
Optical frequency combs / Frequency stabilized lasers and applications
Chair: Kana Iwakuni
UEC

ALPS4-01 *Invited*

Distributed fiber-optic sensing with ultra-high spatial resolution based on dual-comb interferometer

Xinyu Fan
Shanghai Jiao Tong University

Linear optical sampling is actually the time-domain representation of dual-comb interferometer. Distributed fiber-optic sensing based on linear optical sampling is demonstrated with a spatial resolution of 340 mm and a measurement range of 10 km.

ALPS4-02

Pico-second single-pulse three-dimensional imaging with an optical frequency comb

Takashi Kato[1,2], Hirotaka Ishii[1,2], Kazuhiro Terada[1,2], Tamaki Moritoh[1], Kaoru Minoshima[1,2]
[1]The Univ. of Electro-Communications (UEC), [2]JST, ERATO MINOSHIMA Intelligent Optical Synthesizer (IOS)

Using a 15-ps chirped pulse of an optical frequency comb, fully single pulse, 3D surface profile imaging is demonstrated, at 100-square-pixel resolution and μm-level uncertainty. Electric-field-induced picosecond transient 3D imaging is also demonstrated.

ALPS4-03

Digital-micromirror-device based Surface Measurement using Optical Frequency Comb

Guangya Xu
Tsinghua University

We demonstrate a digital-micromirror-device based surface measurement system using optical frequency comb. A three-step surface is reconstructed quickly and accurately.

ALPS4-04

Optical Frequency Comb Generation using Mach-Zehnder Modulators

Ardhendu Sekhar Patra
Sidho-Kanho-Birsha University

39 optical frequency comb lines (OFCL) with flatness less than 1dB, 49 OFCL with flatness less than 0.5dB are generated by single Mach Zehnder Modulator (MZM) and double MZMs theoretically.

ALPS4-05 *Invited*

Burst-mode dual-comb spectroscopy for time-resolved studies of laser induced plasma's

Jason Jones
The University of Arizona

We introduce a pulse burst mode form of dual-comb spectroscopy to enable time-resolved measurements of singular events. The time-resolved spectrum of from various samples is used to charzterize temperature and number density.

ALPS

[ALPS5]
Novel concept of laser sources
Chair: Deyuan SHEN
Fudan University

ALPS5-01 *Invited*

Chip laser based dual-frequency combs for sensing applications
David George Lancaster[1], Nicholas R. Phillips[2], Nicholas Bourbeau Hébert[2], Dale Otten[1], Philippe Guay[2], Jerome Genest[2]
[1]Laser Physics and Photonics Devices labs, Future Industries Institute, University of South Australia, 5095 Australia, [2]Centre d'optique, photonique et laser, Université Laval, Québec, QC, G1V 0A6, Canada
'Chip-scale' compact planar-waveguide lasers operate in the ~0.5 GHz to 10 GHz repetition rate regimes. Dual-frequency waveguide chip combs are realised by operating two mode-locked independent laser cavities using common optics. This paper will present results including the laser characteristics and common-mode properties of the dual-comb laser and demonstrate spectroscopic application.

ALPS5-02 *Invited*

Giant micro-photonics toward tiny integrated power lasers
Takunori Taira[1,2]
[1]RIKEN SPring-8 Center, [2]Institute for Molecular Science
Multiple thin-disk or micro-chip gain medium based on distributed face cooling structure allow us an excellent thermal management with high-gain toward tiny integrated high-power and high-field laser.

ALPS5-03

Full–Aperture Thermal-Lens Free HCAM Laser
Ken-ichi Ueda[1,2,3,4,5]
[1]University of Electro-Communications/ Institute for Laser Science, [2]Osaka University/ Institute of Laser Engineering, [3]JST SAKIGAKE, [4]Hamamatsu Photonics, [5]Celox Photonics Technology
The full aperture thermal lens free solid state laser is available by the effective thermal barrier between pumping volume to the no-pump and thermally isolated outer volume. The doping volume control will be discussed.

ALPS5-04

2 μm Watt-level single frequency fibre lasers based on the microresonators
Haotain Wang, Jiangning Zhang, Deyuan Shen
Jiangsu Normal University
We report on single frequency Tm-doped fibre lasers based on the high-Q silica microresonators. A maximum power of 0.9 W was extracted from the laser oscillator directly. Moreover, we also explore the tuning ability of the fibre lasers through exciting different modes in the microresonator selectively or injecting liquids of different refractive index into the microresonators. On the other hand, Fano resonance is used to improve the laser efficiency.

ALPS5-05

Mode analysis in multi-mode fiber laser by interference method
Taro Kakehashi, Akira Shirakawa
Institute for Laser Science, The University of Electro-Communications
We report mode analysis of a multi-mode fiber laser by an interferometry based on the Fourier transform method. Six modes were well resolved and the occupancy of LP_{11} modes decreases by bending as expected.

ALPS5-06

Observation of Soliton Collisions in NALM Fiber Laser
Shotaro Kitajima[1], Shigeki Tokita[1], Kenta Kohno[2], Seiji Shimizu[2], Junji Kawanaka[1]
[1]Institute of Laser Engineering, Osaka University, [2]Spectronix Corp.
The soliton collision, one of the characteristic behaviour of dissipative solitons, was observed in Yb-doped NALM fiber laser for the first time. Real-time temporal measurement with fast photo-diode confirmed the behaviour at the collision moment.

ALPS5-07

Sub-nano second pulse width tunable fiber laser of more than 100kW peak power.
Ryo Kawahara[1], Kyosuke Yamauchi[1], Jeffrey W. Nicholson[2], Shun-ichi Matsushita[1]
[1]Furukawa Electric Co., Ltd., [2]OFS laboratories
We demonstrated a tunable pulse width fiber laser from 100ps to 1ns by using a electrical modulated seed laser and a very large mode area fiber amplifier to obtain more than 100kW peak power.

[ALPS6]
Quantum optics and their applications
Chair: Masahiro Takeoka
NICT

ALPS6-01 *Invited*

Quantum optical synthesis of time-frequency entangled photons
Ryosuke Shimizu
The University of Electro-Communications
We present direct observation of entangled photon distributions in 2D time-frequency space and discuss the ability to tailor the temporal characteristics of light taking into account the entanglement in time and frequency degree of freedoms.

ALPS6-02 *Invited*

Satellite-based quantum communication and follow on
Yuan Cao[1,2], Juan Yin[1,2], Ji-Gang Ren[1,2], Sheng-Kai Liao[1,2], Cheng-Zhi Peng[1,2], Jian-Wei Pan[1,2]
[1]University of Science and Technology of China, [2]CAS Center for Excellence in Quantum Information and Quantum Physics
On August 16, 2016, the first quantum science satellite was launched successfully in China. Utilizing this satellite, we have completed a series of quantum communication experiments at space scale. In this presentation, I will introduce the recent satellite-based experiments we have achieved and our future follow on plans of realizing the global-scale quantum network.

ALPS6-03

Programmable Control of Multimode Squeezed State in the Frequency Domain
Aruto Hosaka[1], Akihito Omi[1], Yoshiaki Tsujimoto[2], Kentaro Wakui[2], Masahiro Takeoka[2], Fumihiko Kannari[1]
[1]Keio University, [2]National Institute of Information and Communications Technology
We experimentally demonstrate programmable control of multimode squeezed states in the frequency domain. We observe the squeezing level and the phase of a multimode squeezed state are flexibly controlled by pulse shaped pump laser pulses.

ALPS6-04

Infrared metrology with visible light
Anna Paterova, Hongzhi Yang, Dmitry Kalashnikov, Leonid Krivitsky
*IMRE A*STAR*
We propose a new method of IR metrology with visible light, based on features of quantum and nonlinear optics. The method allows to measure IR properties of media using only visible optics and detectors.

ALPS6-05

Fourier transform spectroscopy utilizing two-photon quantum interference
Hiroya Seki[1], Yuta Uchihori[2], Jun Ishihara[2], Kensuke Miyajima[2], Ryosuke Shimizu[1]
[1]The University of Electro-Communications, [2]Tokyo University of Science
As a practical example of Fourier transform spectroscopy using quantum interference, we observed two-photon interference patterns with photon pairs from biexciton and estimated biexciton spectrum from Fourier transform of the interference pattern.

[ALPS7]
High peak power lasers, high pulse energy lasers and applications 1
Chair: Hiromitsu Kiriyama
National Institutes for Quantum and Radiological Science and Technology

ALPS7-01 *Invited*

Advanced laser technologies for high-power energetic lasers
Denis Penninckx
CEA
One of the goals of the LEAP project is to develop new technologies for high power energetic lasers which are still based on neodymium-doped laser glass for amplification and flash lamps.

ALPS7-02

ELI-Beamlines: Readiness of High Energy, High Repetition Rate Laser Systems for User Experiments
Pavel Bakule[1], Bedřich Rus[1], Roman Antipenkov[1], Daniel Kramer[1], Jakub Novák[1], Jakob Andreasson[1], Josef Cupal[1], Lucie Koubíková[1], Daniele Margarone[1], František Batysta[1], Robert Boge[1], Jonathan Tyler Green[1], Zbyněk Hubka[1,2], Michael Greco[1], Lukáš Indra[1,2], Alexandr Špaček[1,2], Jack Alexander Naylon[1]
[1]Institute of Physics ASCR, ELI Beamlines, Dolni Brezany, Czech Republic, [2]Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Czech Republic
ELI Beamlines facility is gradually transitioning from construction phase to the user operation phase. We will review the readiness status of the L1 ALLEGRA and L3 HAPLS for regular user operation.

ALPS7-03

Optimizing high-order-harmonic generation by the relative phase between two-color, CEP-stable few-cycle laser fields
Shaobo Fang[1,2], Yabei Su[1], Zhiyi Wei[1,2]
[1]Institute of Physics, Chinese Academy of Sciences, [2]University of Chinese Academy of Sciences
Optimizing high-order harmonics generation (HHG) by the relative phase between two-color, few-cycle laser fields is demonstrated. The experimental and simulation results show how the plateau cutoff energies are manipulated by the relative phase.

ALPS7-04

Characteristics of a 100-J class Yb:YAG ceramics laser amplifier on 10-Hz operation
Masateru Kurata[1], Takashi Sekine[1], Yuma Hatano[1], Yuki Muramatsu[1], Takaaki Morita[1], Yuki Kabeya[1], Takuto Iguchi[1], Takashi Kurita[1], Yasuki Takeuchi[1], Yoshinori Tamaoki[1], Yoshinori Kato[1], Shigeki Tokita[2], Junji Kawanaka[2]
[1]Hamamatsu Photonics K.K., [2]Osaka University
Over 100 J of output pulse energy has been achieved with cryogenically cooled multi-disk Yb:YAG ceramics laser amplifier pumped by laser diodes. Its small signal gain and wavefront distribution have been measured at 10 Hz.

ALPS7-05

Optimization of electron beam from laser-driven micro metal wire and electron diffraction
Ye Tian
Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences
We present experimental optimization of electrons in the several hundred keV energy range originated from laser-irradiated wire targets. We demonstrate this scheme as a promising candidate for single-shot electron diffraction.

[ALPS8]
High peak power lasers, high pulse energy lasers and applications 2
Chair: Takashi Sekine
Hamamatsu Photonics K.K.

ALPS8-01 *Invited*

Design and Recent Progress of 10PW SULF Laser
Xiaoyan Liang, Yuxin Leng, Ruxin Li, Zhizhan Xu
Shanghai Institute of Optics and Fine Mechanics
Recently, the peak power of 12.9PW was achieved for SULF laser in Siom. At the repetition rate of one shot per 3 minutes, the amplified energy of 422J was measured. Meanwhile, the compressed pulse duration was 23.3fs with throughput efficiency of 71.3%.

ALPS8-02 *Invited*

Current status of 10PW class ATON laser commissioning in ELI-BL
Daniel Kramer[1], Roman Antipenkov[1], Pavel Bakule[1], Jan Bartonicek[1], Frantisek Batysta[1], Sandra Bruce[2], Gilles Cheriaux[2], Todd Ditmire[2], Gavin Friedman[1], Erhard Gaul[2], Jan Hubacek[1], Irena Majerova[1], Jack Alexander Naylon[1], Bedrich Rus[1], Pavel Trojek[1], Praveen Kumar Velpula[1], Stepan Vyhlidka[1]
[1]FZU AVCR v.v.i., Czech Republic, [2]National Energetics, Austin USA
The amplifier chain of the L4 ATON 10PW class laser system was successfully integrated into ELI-Beamlines facility and commissioned in CPA and non-CPA modes with high repetition rates.

ALPS8-03

Improvement of reflected wavefront with gold-coated SiC ceramics mirror
Yasuhiro Miyasaka, Kotaro Kondo, Hiromitsu Kiriyama
National Institutes for Quantum and Radiological Science and Technology
The ability of SiC ceramics substrate mirror for keeping high reflected wavefront quality is experimentally demonstrated under high thermal load. Compared with fused silica substrate mirror, the degradation of the reflected wavefront is greatly supressed.

ALPS

ALPS8-04

Stabilization of supercontinuum generated in bulk YAG using direct pulses from a regenerative amplifier centered around 2 µm

Seyed Ali Rezvani[1], Yutaka Nomura[2], Takao Fuji[1]
[1]Toyota Technological Institute, [2]Institute for Molecular Science

A supercontinuum covering 380 nm to 4 µm is generated in bulk YAG using pulses from a regenerative amplifier. Benefiting from the pump properties and through increasing pump spectral quality, stable supercontinuum pulses are achieved.

[ALPS9]
Novel optical devices, metamaterials, structure and applications 1
Chair: Takasumi Tanabe
Keio University

ALPS9-01 *Invited*

Optoplasmonic Resonators: Single, Chiral, and Bio Molecule Sensing.

Frank Vollmer
University of Exeter, UK

Single-molecule techniques continue to transform imaging, biophysics and, more recently, optical sensing. I will introduce a new class of label-free micro and nanosensors that are starting to emerge and that allow us to observe dynamic processes at the single molecule level directly with light, with unprecedented spatial- and temporal resolution, and without significantly affecting the natural and functional movements of the molecules.

ALPS9-02 *Invited*

Photonic-chip based soliton microcombs

Tobias Kippenberg
EPFL, Switzerland

Optical frequency combs1,2 provide equidistant markers in the IR, visible and UV and have become a pivotal tool for frequency metrology and are the underlying principle of optical atomic clocks, but are also finding use in other areas, such as broadband spectroscopy or low noise microwave generation.

ALPS9-03

Saturable absorption of CNT/PDMS coated high-*Q* microcavity

Keigo Nagashima[1], Rammaru Ishida[1], Riku Imamura[1], Shun Fujii[1], Sze Yun Set[2], Shinji Yamashita[2], Takasumi Tanabe[1]
[1]Keio University, [2]RCAST University of Tokyo

We developed a method for coating CNT/PDMS on a high-*Q* silica microcavity needed for building a mode-locked laser and measured its saturable absorption.

ALPS9-04

Surface Profilometry of Curved Optics Using a Shack-Hartmann Sensor

Reza Amani[1,2,3], Stanley Tang[2], Naveed Abbas[1], Claude Aguergaray[1,2,3], Neil G. R. Broderick[1,2,3]
[1]The University of Auckland, [2]The Photon Factory, [3]The Dodd-Walls Centre for Photonic and Quantum Technologies

We report surface profilometry of curved optics against a flat optical reference within a deformation of ~120 nm and repeatability of RMS 2.3 nm using a 150 µm-spatial-resolution Shack-Hartmann wavefront sensor.

[ALPS10]
High average power lasers and applications
Chair: Fumihiko Kannari
Keio University

ALPS10-01 *Invited*

272 nm deep-ultraviolet laser diode fabricated on high-quality AlN substrate

Chiaki Sasaoka[1], Ziyi Zhang[1,2], Maki Kushimoto[1], Tadayoshi Sakai[1], Naoharu Sugiyama[1], Leo John Schowalter[1,3], Hiroshi Amano[1]
[1]Nagoya University, [2]Asahi Kasei Corporation, [3]Crystal IS

A 272 nm laser diode was successfully fabricated. Non-doped distributed polarization doping of the p-side cladding layer and a high-quality AlN substrate were key to achieving current injection lasing.

ALPS10-02 *Invited*

Status update of the PEnELOPE laser system

Daniel Peter Konrad Albach[1], Markus Loeser[1], Mathias Siebold[1], Ulrich Schramm[1,2]
[1]Helmholtz-Zentrum Dresden Rossendorf e.V. (HZDR), [2]Technische Universität Dresden

We present a status update of the PENELOPE laser system currently under construction at the Helmholtz-Zentrum Dresden-Rossendorf. We show the first energetic activation of the first major amplification stage on the 10 Joule-level in order to benchmark the performance of the whole last two amplifier sections and the progress at the last amplifier section in order to achieve a first activation.

ALPS10-03

Power scalable 5.3 W Er:YAP laser at 2920 nm

Weichao Yao[1], Hiyori Uehara[1,2], Hiroki Kawase[2], Hengjun Chen[1], Ryo Yasuhara[1,2]
[1]National Institute for Fusion Science, [2]The Graduate University for Advanced Studies

A LD pumped Er:YAP laser with an output power of 5.3 W at 2920 nm was reported. The ability for further power scaling was analysed.

[ALPS11]
Novel optical devices, metamaterials, structure and applications 2
Chair: Takuo Tanaka
RIKEN

ALPS11-01 *Invited*

Perovskite-based Plasmonic Nanolasers

Yu-Jung Lu[1,2]
[1]Research Center for Applied Sciences, Academia Sinica, Taipei 11529, Taiwan, [2]Department of Physics, National Taiwan University, Taipei 10617, Taiwan

We report a novel plasmonic enhanced two-photon pumped nanolaser consisting of a Cl-doped MAPbBr3 nanocube in a plasmonic resonator. An ultralow lasing threshold of 200 nJcm^{-2} is achieved.

ALPS11-02

Ultrafast electron emission from a grating structure assisted by propagating surface plasmons using mid-IR fields

Tomoya Mizuno, Kengo Takeuchi, Keisuke Kaneshima, Nobuhisa Ishii, Teruto Kanai, Jiro Itatani
The University of Tokyo

Resonant-like ultrafast electron emission was observed from an aluminium grating when irradiated by mid-IR pulses. The mechanism is attributed to propagating surface plasmons that enhances the near field at the ridge.

ALPS11-03

Final focusing optics with UV excited ozone mixed gas grating for high power laser systems

Yurina Michine, Hitoki Yoneda
University of Electro-Communications

We show a final focusing system based on ozone mixed gas grating to solve the severe debris problems that often arise in high power laser applications.

ALPS11-04

Two Types of Deformable Mirrors for High-Power Lasers

Alexis Kudryashov[1,2], Vladimir Toporovsky[1,2], Vadim Samarkin[1], Alexey Rukosuev[1], Julia Sheldakova[1]
[1]Institute of Geosphere Dynamics Russian Academy of Sciences, [2]Moscow Polytechnical University

Paper presents the key parameters of two type of deformable mirrors – bimorph and stacked actuator ones and their application for the correction of high-power laser radiation.

[ALPS12]
Short wavelength light sources and applications
Chair: Hiroki Mashiko
NTT BRL

ALPS12-01 *Invited*

A complete solution and its physical mechanism for polarization control of high-harmnic attosecond pulses

Ming-chang Chen
Institute of Photonics, National Tsing Hua University

We provide a complete solution, together with its physical mechanism, to generate polarization-controllable, table-top, isolated attosecond pulses – that is realized by adjusting the ellipticity of counter-rotating few-cycle polarized fundamentals for non-collinear high harmonic generation.

ALPS12-02 *Invited*

Coherent Control of an EUV Emission Generated Through Frustrated Tunnelling Ionization

Kyung Taec Kim[1,2], Yang Hwan Kim[1,2], Hyeok Yun[1], Igor A. Ivanov[1], Sung In Hwang[1]
[1]Center for Relativistic Laser Science, Institute for Basic Science, [2]Department of Physics and Photon Science, Gwangju Institute of Science and Technology

We present that an EUV emission generated through frustrated tunnelling ionization (FTI) can be coherently controlled. The divergence of the EUV emission shows a strong dependence on the target position.

ALPS12-03

Extreme ultraviolet interferometry with isolated attosecond pulse

Akihiro Oshima[1,2], Hiroki Mashiko[1], Ming Chang Chen[3], Koji Asaga[1,4], Tadashi Nishikawa[4], Ikufumi Katayama[2], Jun Takeda[2], Katsuya Oguri[1]
[1]NTT Basic Research Laboratories, [2]Yokohama National University, [3]National Tsing Hua University, [4]Tokyo Denki University

We demonstrate a first-order interferometric autocorrelation of an isolated attosecond pulse (IAP) in the extreme ultraviolet (XUV) region. The XUV interferometry with IAP will be a powerful tool for characterizing ultrafast electronic motion of materials.

ALPS12-04

Development of Low Firing Voltage Electrodes Structure for Hg-Free UV-LAFi

Hitoshi Hirakawa[1], Kenji Awamoto[1], Takefumi Hidaka[1], Junichiro Takahashi[1], Tetsuya Makino[1], Masayuki Wakitani[1], Tsutae Shinoda[2]
[1]Shikoh Tech Co, Ltd., [2]Shinoda Plasma Co, Ltd.

Newly developed trigger electrodes had lowered the firing voltage and improved the emission efficacy of Hg-free UV-LAFi dramatically. UV-LAFi is now available for the power-saving and the battery-powered irradiation devices.

[ALPS13]
Optical devices and techniques for bio and medical applications
Chair: Masato Ohmi
Osaka University

ALPS13-01 *Invited*

Health-care system based on infrared spectroscopy using quantum cascade lasers and hollow optical fibers

Yuji Matsuura
Tohoku University

A blood glucose measurement system using mid-infrared QCLs and hollow optical fibers is introduced. The differential absorption between two specific wavelengths exhibits high correlation with the blood glucose level.

ALPS13-02 *Invited*

Optical-frequency-comb microscopy for spatio-temporal imaging with comprehensive optical information

Takeo Minamikawa[1,2,3,4], Takeshi Yasui[1,2,3]
[1]Institute of Post-LED Photonics, Tokushima University, [2]Graduate School of Technology, Industrial and Social Sciences, Tokushima University, [3]ERATO Intelligent Optical Synthesizer Project, Japan Science and Technology Agency (JST), [4]PRESTO, Japan Science and Technology Agency (JST)

We propose a novel optical microscopy employing optical-frequency-comb (OFC). The OFC microscopy enables spatio-temporal imaging with comprehensive optical information such as amplitude, phase and polarization based on mechanically-scanless Fourier transformation spectroscopy.

ALPS

[ALPS14]
Terahertz devices, nonlinear optics and applications 1
Chair: Takashi Notake
RIKEN

ALPS14-01 *Invited*

Real-time THz color scanner
Takeshi Yasui
Tokushima University
Real-time THz color scanner was proposed based on two-dimensional spatio-temporal THz imaging. The proposed system has the potential to expand the application scope of THz spectral imaging based on its rapid image acquisition rate.

ALPS14-02

Terahertz driven negative Kerr effect in liquid water
Liwei Song
Shanghai Institute of Optics and Fine Mechanics
Optical birefringence driven by intense terahertz pulses is observed in liquid water. The change of the refractive index is caused by the electronic polarizability modulated by the field-induced water molecular orientation.

ALPS14-03 *Withdraw*

[ALPS15]
Terahertz devices, nonlinear optics and applications 2
Chair: Ken Morita
Chiba University

ALPS15-01 *Invited*

Study of brain glioma in a mouse model using terahertz spectroscopy and imaging
Yuye Wang[1,2,3], Limin Wu[1,2], Degang Xu[1,2], Tunan Chen[3], Hua Feng[3], Jianquan Yao[1,2]
[1]Institute of Laser and Optoelectronics, School of Precision Instruments and Optoelectronic Engineering, Tianjin University, [2]Key Laboratory of Optoelectronics Information Technology (Ministry of Education), Tianjin University, [3]Department of Neurosurgery and Key Laboratory of Neurotrauma, Southwest Hospital, Third Military Medical University (Army Medical University)
We demonstrated that *in vivo* brain glioma in a mouse model using continuous wave terahertz reflection (TR) and attenuated total reflection (ATR) imaging systems. The tumor regions of *in vivo* brain tissues can be well distinguished by THz intensity images at the frequency of 2.52THz. The THz imaging results correlated well with those in visual and hematoxylin and eosin stained images.

ALPS15-02

Efficient 0.46-THz Difference Frequency Generation of Subnanosecond Near-Infrared Pulses in Lithium Niobate
Yuma Takida, Kouji Nawata, Takashi Notake, Hiroaki Minamide
RIKEN
Using idler pulses from a backward terahertz (THz)-wave parametric oscillator, efficient 0.46-THz difference frequency generation of subnanosecond near-infrared pulses in lithium niobite crystal was demonstrated for up-scaling the narrowband THz-wave pulse energy toward mJ-level.

ALPS15-03

Stable THz waves generation using laser chaos
Fumiyoshi Kuwashima[1], Takuya Shirao[1], Kazuyuki Iwao[1], Masahiko Tani[2], Kazuyoshi Kurihara[3], Kohji Yamamoto[2], Osamu Morikawa[4], Hideaki Kitahara[2], Makoto Nakajima[5]
[1]Fukui Univ. of Tech., [2]Research Center for Development of Far-Infrared Region, University of Fukui, [3] Fac. of Educ., Univ. of Fukui, [4]Chair of Liberal Arts, Japan Coast Guard Academy, [5]Institute of Laser engineering, Osaka Univ
Stable THz waves generation and detection are achieved using laser chaos. And this system applied to THz spectroscopy to distinguish water and oil.

ALPS15-04

Fabrication of Annealed Proton-Exchanged Waveguide in Periodically-Poled MgO:s-$LiTaO_3$ for High Power Second Harmonic Generation
Ryosuke Noro, Masahiro Uemukai, Tomoyuki Tanikawa, Ryuji Katayama
Graduate School of Engineering, Osaka University
In order to fabricate watt-class wavelength conversion devices, we fabricated a large-diameter MgO:s-$LiTaO_3$ waveguide by the annealed proton exchange technology. The guided mode $1/e^2$ diameter as large as 30 μm was achieved by long-time annealing.

ALPS15-05

Characterization of QPM quartz device fabricated by a stamp method
Hideki Ishizuki[1,2], Takunori Taira[1,2]
[1]RIKEN SPring-8 Center, [2]Institute for Molecular Science
We have proposed a polarity inversion of crystal quartz by QPM stamp method for realizing a QPM quartz device. Characteristics of the QPM quartz in second harmonic generation scheme is presented for initial evaluation.

[ALPS-CL]
Closing
Closing Remarks
Chair: Hitoki Yoneda
The University of Electro-Communications

[ALPSp]
Poster Session 1

ALPSp-01

First-Principles Study on Structural, electronic and Optical Properties of $CsPb(I_{1-x}Br_x)_3$ Perovskite Using PBE-GGA and mBJ-GGA Methods
Hamid Mansoor Ghaithan[1,2], Zeyad A. Alahmed[1], Saif M. H. Qaid[1], Mahmoud Hezam[3], Abdullah S. Aldwayyan[1,3]
[1]Physics and Astronomy Department, College of Science, King Saud University, P.O. Box 2455, Riyadh 11451, Saudi Arabia, [2]Physics Department, College of Education and linguistic, Amran University, Amran, Yemen, [3]King Abdullah Institute for Nanotechnology, King Saud University, P.O. Box 2454, Riyadh 11451, Saudi Arabia
The structural, electronic, and optical properties of $CsPb(I_{1-x}Br_x)_3$ were investigated using FP-LAPW using PBE-GGA and mBJ-GGA methods. The bandgaps calculated using the mBJ-GGA gives the best agreement with experimental values.

ALPSp-02

Difference between Experimental Value and Debye-Model in the Specific Heat of $Y_3Al_5O_{12}$
Yoichi Sato[1,2], Takunori Taira[1,2]
[1]RIKEN SPring-8 Center, [2]Institute for Molecular Science
The specific heat of $Y_3Al_5O_{12}$ was evaluated within the range from -150 °C to 200 °C. In order to express the specific heat of $Y_3Al_5O_{12}$ by Debye-model, we had to use the temperature-dependent Debye temperature.

ALPSp-03

Optical properties of sapphire/YAG ceramic composite materials by pulsed electric current bonding technique
Hiroyuki Tanaka[1], Yuki Koike[1], Hiroaki Furuse[1], Ryo Yasuhara[2]
[1]Kitami Institute of Technology, [2]National Institute for Fusion Science
We have demonstrated the sapphire/Nd:YAG ceramic composite materials with high optical quality and good laser characteristics by PECB. In order to know optimal bonding condition and improve their characteristics, we investigated detailed optical characteristics.

ALPSp-04

Thermal resistant of optical glass materials for high average power lasers.
Hidetsugu Yoshida, Noboru Morio, Shigeki Tokita, Junji Kawanaka
Institute of Laser Engineering, Osaka University
Due to relatively small absorption in the IR region, the optical glass materials usually possess a major thermal problem especially under the condition of few kW class average power. The temperature increase by laser irradiation of the optical glass and the small absorption by PAS (photo-acoustic signals) were measured.

ALPSp-05

Development of laser and optical system for charge exchange process in intense negative hydrogen ion beam
Aoi Fuchi[1], Yurina Michine[1], Hiroyuki Harada[2], Pranab Saha[2], Hitoki Yoneda[1]
[1]The University of Electro-Communications, [2]J-PARC center
The laser and interaction optical system for ion beam are being developed. In J-PARC accelerator, negative hydrogen ions from LINAC accelerator is converted to positive proton for matching between circulating ions and injected ions.

ALPSp-06

Stimulated Brillouin scattering phase conjugate mirror using solid medium for high power laser system
Seongwoo Cha, Hong Jin Kong
KAIST
A fused silica is employed as a medium of stimulated Brillouin scattering phase conjugate mirror for high average power laser. The calculated temperature change in the fused silica rod during 0.3 s is less than 0.008 K for the 10 J of input energy at 1 kHz repetition rate operation. The experiment using Kumgang laser system is on the progress.

ALPSp-07

10J/ 100Hz cryogenically-cooled Yb:YAG active-mirror amplification system
Jumpei Ogino[1], Shigeki Tokita[1], Shoutaro Kitajima[1], Li Zhaoyang[1], Shinji Motokoshi[2], Noboru Morio[1], Koji Tsubakimoto[1], Hidetsugu Yoshida[1], Kana Fujioka[1], Junji Kawanaka[1], Ken-ichi Ueda[3], Ryosuke Kodama[1]
[1]ILE, Osaka univ., [2]ILT, [3]ILS/UEC
We are developing the 10 J, 100 Hz cryogenically-cooled active-mirror amplifier. The system construction has been completed and demonstration experiments have started. We will report a overview and currently result.

ALPSp-08

Ionization characteristics of cesium plasma generated by irradiating resonance laser light
Yuki Mori, Norio Tsuda, Jun Yamada
Aichi Institute of Technology
The resonance photoionization characteristics of cesium plasma were investigated. As a result, the electric charge increased proportionally up to 5Pa. However, it was suppressed at higher vapor pressures.

ALPSp-09

The pursuit of Exawatt-class peak-power lasers with the hybrid technique of WNOPCPA and thin-film compression
Zhaoyang Li, Junji Kawanaka
Osaka University
By combining two techniques of the wide-angle non-collinear optical parametric chirped-pulse amplification (WNOPCPA) and the thin-film compression (TFC) together, the new hybrid-technique might support the generation of the Exawatt-class (10^{18} watt) peak-power lasers.

ALPSp-10

An Erbium Fiber Laser with Stable Single-Mode Output by Exploiting Feedback Rayleigh Backscattering
Jhao-Ren Chen[1], Wei-Yao You[1], Chien-Hung Yeh[1], Chi-Wai Chow[2], Jing-Heng Chen[1]
[1]Feng Chia University, [2]National Chiao Tung University
We present an erbium-doped fiber (EDF) laser with stable tunability and switchable single-longitudinal-mode (SLM) output by using self-injected feedback Rayleigh backscattering (RBS) technology. Here, 40-nm wavelength-tuning range from 1523.0 to 1563.0 nm is achieved.

ALPSp-11

Ti:sapphire laser pumped by 450-nm diode laser at low temperature
Yuta Shioya, Shogo Fujita, Fumihiko Kannari
Keio University
We examined output performance of continuous wave Ti:sapphire laser pumped by a 450-nm LD at cryogenic temperatures. We also investigated the temperature dependence of pump laser absorption and the pumping efficiency.

Program

ALPS

ALPSp-12

Distance measurement accuracy for a self-coupling type distance and velocity sensor using arbitrary waveform

Masanari Yamada, Tatsuya Ohba, Norio Tsuda, Jun Yamada
Aichi Institute of Technology

The distance measurement accuracy for simultaneous measurement sensor of velocity and distance by the self-coupling effect of the semiconductor laser was studied. The accuracy of distance measurement has been improved by using arbitrary triangular waveforms.

ALPSp-13

Study on self-coupling laser terminal voltage distance sensor using pulse modulation

Yuto Higuchi, Norio Tsuda, Jun Yamada
Aichi Institute of Technology

The self-coupling laser terminal voltage distance sensor using an array of LDs has been studied. A laser is operated by a pulse current modulation, and a self-coupled signal is obtained from the terminal voltage.

ALPSp-14

Basic investigation on automatic detection of displacement direction in self-coupling displacement sensor

Ryoya Iwamoto, Norio Tsuda, Jun Yamada
Aitch Institute of Technology

We have been made a displacement sensor using the self-coupling effect of a semiconductor laser, and have investigated the automatic detection of the displacement amount and displacement direction.

ALPSp-15

Development of yellow (575nm) laser by Dy^{3+}-doped double-clad structured waterproof fluoro-aluminate glass fiber

Natsuho Nashimoto[1], Kenta Takahashi[1], Yasushi Fujimoto[1], Osamu Ishii[2], Masaaki Yamazaki[2]
[1]Chiba Institute of Technology, [2]Sumita Optical Glass, Inc

We successfully drew a Dy^{3+}-doped double-clad structured waterproof fluoro-aluminate glass fiber and evaluated the fiber characters in order to develop a high-power yellow fiber laser.

ALPSp-16

1650 nm broad-stripe diode in-band pumped $Tm:Lu_2O_3$ ceramic laser

Non Kikuchi, Anna Suzuki, Masaki Tokurakawa
Institute for laser science, University of Electro-Communications

We report 1650 nm broad-stripe LD in-band pumped $Tm:Lu_2O_3$ ceramic laser. With an output coupler of 1%, a maximum output power of 194 mW was obtained at 2091nm under an absorbed pump power of 1.45 W.

ALPSp-17 *Withdraw*

ALPSp-18

Measurement of small signal gain in Pr-doped waterproof fluoride glass fiber

Takumi Ikeda, Tsukasa Kurosawa, Keisuke Ochiai, Hikaru Takahashi, Yasushi Fujimoto
Chiba Institute of Technology

We report a result of small signal gain property of Pr-doped fluoro-aluminate glass (Pr:WPFG) fiber. This result will provide the precise discussion of laser cavity design and power scaling of Pr:WPFG fiber laser.

[ALPSp] Poster Session 2

ALPSp-19

Mode-locked fiber laser aiming to phase-locked of multicore fiber laser

Tomonari Kawamura, Akira Shirakwa
Institute for Laser Science, University of Electro-Communications

We study mode-locked fiber laser in all-normal dispersion region by semiconductor saturable absorber with using Fabry-Perot type cavity. We plan to replace the gain fiber with MC-PCF in the next stage.

ALPSp-20

Numerical Analyses of All-Optical Decision Gate Using Cascade QPM-PPLN

Yutaka Fukuchi, Ryoichi Miyauchi
Tokyo University of Science

We propose a cascade PPLN. In the device, two crystals with different QPM wavelengths are connected. We numerically show that the device has an all-optical level-discriminating characteristic, thus enabling a compact and stable 3R repeater.

ALPSp-21

Single-shot THz wave measurement by spectral interferometry based heterodyne detection

Kazuki Takasawa[1], Ryota Iguchi[1], Takakazu Suzuki[1], Hirofumi Nemoto[1], Riku Watase[1], Dmitry S. Bulgarevich[2], Hideaki Kitahara[2], Masahiko Tani[2], Fumihiko Kannari[1]
[1]Keio University, [2]University of Fukui

We demonstrate single-shot terahertz wave measurement with high SNR by spectral interferometry between an EO sampling chirped pulse and a Fourier transform limited reference pulse using heterodyne detection.

ALPSp-22

Anisotropic, Frequency-Decomposed Emissions by a Micro-Helix Visualized in Terahertz Frequency Range

Takashi Notake[1], Tomokazu Iyoda[2], Chiko Otani[1], Hiroaki Minamide[1]
[1]RIKEN, [2]Doshisha Univ.

Real-time, two-dimensional electromagnetic responses of a three-dimensional micro-helix are visualized at THz frequency range. Once a micro-helix is excited by impulsive THz electromagnetic-wave irradiation, anisotropic emission can simultaneously occur with different frequency spectra.

ALPSp-23

Characterization of Every Second-Order Nonlinear Coefficient of N-Benzyl-2-Methyl-4-Nitroaniline Organic Crystal

Takashi Notake[1], Masahiro Takeda[1], Shuji Okada[2], Takuya Hosobata[1], Yutaka Yamagata[1], Hiroaki Minamide[1]
[1]RIKEN, [2]Yamagata Univ.

An ultra-high-precision lathe is applied to precisely process fragile organic BNA crystals. Then, all of second-order nonlinear optical coefficients of BNA can be measured accurately based on Maker fringe technique.

ALPSp-24

GPU based FDTD simulation of THz pulse generation using obliquely crossed optical pulses

Ken Morita, Hiroki Yahagi, Yuta Osumi, Takashi Kakue, Yoshihiro Ishitani
Chiba University

Terahertz pulse generation for the obliquely crossed optical pulses in optical rectification based on GPU is simulated by finite-difference time-domain method. We compare the conventional MATLAB implementation with the one implemented in C ++ using a GPU. The calculation speed is 50 times faster in C ++ using a GPU than using the MATLAB.

ALPSp-25

Microchip $Nd:YVO_4$ Lasers Pumped by Wavelength-Stabilized Single-Mode Laser Diode

Taku Saiki, Akira Tatebayashi, Masashi Ohmori
Kansai University

Wavelength stabilized LD was used for end-pumped microchip Nd:YAG and $Nd:YVO_4$ lasers. Higher conversion efficiency than using common LD and $Nd:YVO_4$ was obtained. The output laser power was stable upto LD temperature of 35 degs.

ALPSp-26

Optical switching using free carrier effect of silicon with high purity

Masaki Omori, Yukio Iida, Taku Saiki
Kansai University

Switching of signal light on basis of free carrier effect of silicon with high purity by irradiating control light was experimentally investigated. Attenuation of signal light was enhanced by reducing thickness of silicon.

ALPSp-27

Kerr frequency comb aligned with ITU-T grid for DWDM telecom applications in crystalline microresonators

Koshiro Wada[1], Shun Fujii[1], Hajime Kumazaki[1], Tamiki Ohtsuka[1], Shota Sota[1], Satoki Kawanishi[1], Yosuke Hashimoto[2], Yuta Kobayashi[2], Tomohiro Araki[2], Takasumi Tanabe[1]
[1]Keio University, [2]Japan Aerospace Exploration Agency

We demonstrated efficient Kerr comb generation in an ultra-high Q MgF2 microresonator with an output power of 0 dBm per channel of which wavelengths are aligned with a 25 GHz ITU-T.

ALPSp-28

Fractional CO_2 laser for enhancing skin delivery of siRNA to treat psoriasis-like plaque in mouse

Jia-You Fang[1], Woan-Ruoh Lee[2], Pei-Yin Liu[1]
[1]Chang Gung University, [2]Taipei Medical University

In this study, the fractional CO_2 laser–assisted approach was developed to describe siRNA permeation enhancement mediated by the created microchannels for silencing the gene to treat psoriasiform lesions.

ALPSp-29

Single-shot ultrafast 2D-burst imaging using integral field spectroscopywith a lenslet array

Shota Itoyama, Hirofumi Nemoto, Takakazu Suzuki, Kazuki Takasawa, Riku Watase, Fumihiko Kannari
Keio University

We propose a single-shot burst imaging of STAMP utilizing a lenslet array based integral field spectrograph (LA-STAMP) to achieve a high light utilization efficiency. Employing spectrally sweeping burst probe pulses, we demonstrated ultrafast imaging in a sub-nanosecond window.

ALPSp-30

Multimodal microscopy using the combination of optical coherence microscopy and multiphoton-excited fluorescence imaging in a third optical tissue window

Kentaro Harada, Masahito Yamanaka, Norihiko Nishizawa
Nagoya University

We developed a multimodal imaging system by using the combination of optical coherence microscopy and multiphoton excitation fluorescence microscopy in a third optical tissue window. The developed system enabled high-resolution multimodal imaging of thick specimens.

ALPSp-31

Rigid-endoscope OCT system with KTN optical scanner

Masato OHMI[1], Rena Kanagawa[1], Shogo Yagi[2]
[1]Osaka University, [2]NTT Advance Technology Corporation

We developed novel rigid-endoscope OCT system with KTN optical probe for a diagnosis in the orthopedic surgery fields. The present system demonstrates that biological image was measured by using KTN optical scanner for having degree of freedom in sample arm as OCT. The system was shown to have a resolution 14.2μm for biological tissue in few mm depth.

ALPSp-32

Dual-comb spectroscopy of dispersion properties in solid-state optical response

Takuto Adachi[1,2], Akifumi Asahara[1,2], Yusuke Odagiri[1,2,3], Masayuki Shirakawa[4], Chikako Ishibashi[2,3], Satoshi Hatano[2,3], Eiji Tokunaga[4], Kaoru Minoshima[1,2]
[1]The University of Electro-Communications, [2]Japan Science and Technology Agency (JST), ERATO MINOSHIMA Intelligent Optical Synthesizer (IOS) Project, [3]Neoark Corporation, [4]Tokyo University of Science

We developed a measurement method for the dispersion properties of the complex off-diagonal permittivity using dual-comb spectroscopy. With this technique, all parameters needed for the calculation can be acquired using only a single measurement.

ALPS

ALPSp-33

Development of Highly Coherent All-Polarization-Maintaining Dual-Comb Fiber Laser with Simple Mechanical Sharing

Yugo Kusumi[1,2], Yoshiaki Nakajima[1,2], Yuya Hata[1,2], Kaoru Minoshima[1,2]
[1]The University of Electro-Communications, [2]Japan Science and Technology Agency (JST), ERATO MINOSHIMA Intelligent Optical Synthesizer (IOS) Project

We developed a simple and robust dual-comb fiber laser system comprising two independent mode-locked fiber lasers with mechanical sharing scheme. The two frequency combs achieve a high relative stability without servo control owing to common-mode noise cancellation.

ALPSp-34

Diode Laser for Wavelength Stabilized LiDAR Transmitter Utilizing Coupled Cavity Scheme

Sunjak Choi[1,2], Sangheon Kim[2], Jieun Baek[2], Soonwook Kwon[2], Soo Jin Kim[1], Junho Lee[2]
[1]Korea University, [2]Korea Electronics Technology Institute

Wavelength stabilized diode laser utilizing coupled cavity scheme with volume bragg grating is developed to minimize wavelength and power drifting. It could be applied for laser source of LiDAR with precise and stable operations.

ALPSp-35

Hyperspectral Spatial Phase Detection of Optical Vortices using Single-pixel Imaging and Dual-comb Spectroscopy

Akifumi Asahara[1,2], Takuto Adachi[1,2], Seishiro Akiyama[1], Kaoru Minoshima[2,1]
[1]The University of Electro-Communications, [2]JST, ERATO MINOSHIMA Intelligent Optical Synthesizer

Characterization of optical vortex is demonstrated by combining dual-comb spectroscopy and single-pixel imaging. The proposed method will be used as a versatile tool for optical vortex study including optical communications and material researches.

ALPSp-36

Scalable and Programmable Linear Optical Quantum Circuit in the Frequency Domain

Kazuki Takahashi[1], Aruto Hosaka[1], Yoshiaki Tsujimoto[2], Yuta Yamagishi[1], Akihito Omi[1], Kentaro Wakui[2], Mikio Fujiwara[2], Yutaka Shikano[3,4], Masahiro Takeoka[2], Fumihiko Kannari[1,3]
[1]Department of Electronics and Electrical Engineering, Keio University, [2]Advanced ICT Research Institute, National Institute of Information and Communications Technology (NICT), [3]Quantum Computing Center, Keio University, [4]Institute for Quantum Studies, Chapman University

We report the improvement of frequency-domain Hong-Ou-Mandel interference. We also discuss the scalability in the number of quantum modes processed by a chirped-fiber-Bragg-grating-based frequency-domain linear quantum circuit.

ALPSp-37

Generation and Mixing of Multimode Quantum States with Dispersion Engineered Nonlinear Crystals in the Frequency Domain

Yuta Yamagishi, Akihito Omi, Aruto Hosaka, Kazuki Takahashi, Fumihiko Kannari
Keio University

We propose and experimentally demonstrate the method to control multimode quantum states in the frequency domain. We discuss the potential of the method as a platform of quantum information processing based on the experimental results.

ALPSp-38

Ultrafast Infrared Burst Imaging with Visible Light

Riku Watase, Aruto Hosaka, Takakazu Suzuki, Hirofumi Nemoto, Fumihiko Kannari
Keio University

We propose sequentially timed all-optical mapping photography in the infrared (IR) using a CCD camra by applying a quantum illumination method.

ALPSp-39

Topological superradiant phase transition in a shaken optical lattice induced by an optical cavity

Yanlin Feng[1], Jingtao Fan[2], Gang Chen[2], Yangjian Cai[1,3]
[1]Shandong Normal University, [2]Shanxi University, [3]Soochow University

Based on the steady state of Fermi atoms coupled to a shaken cavity field at half filling, we find that the shaken dynamical optical lattice produces interesting cavity-field-dependent long-range hoppings under the high-frequency limit. These long-range hoppings can change the band structures of the system and thus induce nontrivial topological superradiant phases, especially with a large winding number and four degenerate edge states.

BISC

[BISC1]
Invited Talks Session
Chair: Osamu Matoba
Kobe University

BISC1-01 *Invited*

Towards single-photon deep-tissue microscopy
Tom Vettenburg
University of Dundee, United Kingdom
Fluorescence light-sheet microscope enables long-term studies of intact biological specimens. However, autofluorescence and scattering of light limit its use to highly transparent and thin samples. Here, we show how autofluorescence can be eliminated effectively by relying on reversible photo-switching while we propose a way forward to study and control light propagation in optically-thick tissues.

BISC1-02 *Invited*

Single-molecule tracking reveals varying transport speed of IFT88 proteins at the base of mammalian primary cilia
Jiahui Wang[1], Jung-Chi Liao[2], T. Tony Yang[1]
[1]Graduate Institute of Biomedical Electronics and Bioinformatics, National Taiwan University, Taipei, Taiwan, [2]Institute of Atomic and Molecular Sciences, Academia Sinica, Taipei, Taiwan
An essential mechanism of ciliogenesis is intraflagellar transport (IFT). The IFT processes at the ciliary base were unknown based on the diffraction-limited kymograph. Here, we optimize single-molecule tracking localization microscopy to observe IFT88-mEOS4b in live human retinal pigment epithelial cells. We found IFT88 proteins switched gears multiple times from ciliary base to cilium, revealing region-dependent slowdown of IFT proteins.

BISC1-03 *Invited*

Adaptive Optical isoSTED Nanoscopy for Thick Specimen Imaging
Xiang Hao[1], Edward Allgeyer[3], Joerg Bewersdorf[2]
[1]Zhejiang University, China, [2]Yale University, [3]University of Cambridge
We have developed a nanoscope that, by utilizing an advanced adaptive optics strategy, achieves sub-50 nm isotropic resolution of structures such as neuronal synapses and ring canals previously inaccessible in tissue.

BISC1-04

Hyperspectral fluorescence imaging by using visible-wavelength two-photon excitation
Toshiki Kubo, Kenta Temma, Nicholas Isaac Smith, Lu Kai, Tomoki Matsuda, Takeharu Nagai, Katsumasa Fujita
Osaka University
We implemented visible-wavelength two-photon excitation to slit-scanning confocal microscope and demonstrated simultaneous multicolor imaging of HeLa cells. Linear un-mixing separated the distribution of multiple types of fluorescent proteins expressed at different intracellular structures.

BISC1-05

Fluorescence Sectioning Micro-endoscopy using Hybrid Illumination
Haw Hsiao[1], Chen-Yen Lin[2], Kuang-Yu Huang[1], Yuan Luo[2,3,4]
[1]Graduate School of Mechanical Engineering, National Taiwan University, [2]Institute of Medical Device and Imaging, National Taiwan University, [3]Molecular Imaging Center, National Taiwan University, [4]Yong-Lin Institute of Health, National Taiwan University
A widefield endoscope with optical sectioning capability using digital micro-mirror device (DMD) is proposed and demonstrated. HiLo algorithm is used to eliminate out-of-focus information. To verify the optical sectioning capability of the proposed system, 45μm fluorescent beads and mouse heart tissues were observed.

[BISC2]
OCT1
Chair: Yoshihisa Aizu
Muroran Institute of Technology

BISC2-01 *Invited*

Optical Coherence tomography-guided laser therapy for tumor identification and treatment monitoring
Wen-Ju Chen[1], Feng-Yu Chang[1], Meng-Tsan Tsai[1,2]
[1]Chang Gung University, Taiwan, [2]Chang Gung Memorial Hospital, Taiwan
In this study, an integrated theranostic system combining a CW laser diode with optical coherence tomography (OCT)/ angiography (OCTA) was utilized for tumor identification and treatment monitoring. To examine the effect of laser exposure on tissue scattering characteristics, the OCT backscattering intensities of non-ablated and ablated tissues were analyzed, and the effect on the skin microvasculature produced by laser ablation was quantitatively evaluated.

BISC2-02 *Invited*

Wavelength dependence of ultrahigh resolution optical coherence tomography using supercontinuum for deep imaging
Norihiko Nishizawa, Masahito Yamanaka
Nagoya University, Japan
Wavelength dependence of optical coherence tomography and microscopy (OCT/OCM) imaging using supercontinuum were investigated experimentally. Deep, high-resolution imaging of mouse brain was demonstrated using OCT/OCM at 1.7 um wavelength.

BISC2-03

Development of a catheter-based optical coherence tomography system for the early detection of cervical precancerous lesions
Meng-Shan Wu[1], Yi-Chun Wu[1], Ching-Yu Wang[1], Chuan-Bor Chueh[1], Ting-Yen Tsai[1], Ting-Hao Chen[1], You-Nan Tsai[1], Meng-Tsan Tsai[2], Chun-Chieh Wang[3,4], Hsiang-Chieh Lee[1]
[1]Graduate Institute of Photonics and Optoelectronics, National Taiwan University, Taipei 10617, Taiwan, [2]Department of Electrical Engineering, Chang Gung University, Taoyuan 33302, Taiwan, [3]Department of Medical Imaging and Radiological Sciences, Chang Gung University, Taoyuan, 33302 Taiwan, [4]Department of Radiation Oncology, Chang Gung Memorial Hospital at Linkou, Taoyuan, 33306 Taiwan
We have developed a catheter-based OCT system allowing volumetric imaging of the cervix. The rotary junction and catheter are custom-designed to tailor the aforementioned biomedical applications. Using a wavelength-swept laser with a central wavelength of 1310 nm and a swept rate of 100 kHz, the catheter-based OCT system can provide a volumetric scan range over a pullback length of 6 cm maximum with a 7.5 μm axial resolution and up to 3 mm imaging depth in tissue.

BISC2-04

Investigation of tissue architectures with a long-wavelength and multiscale optical coherence tomography imaging system
Ching-Yu Wang[1], Chuan-Bor Chueh[1], Ting-Yen Tsai[1], Jye-Chang Lee[2], Teng-Chieh Chang[1], Ting-Hao Chen[1], Yin-Peng Huang[3], Ming-Kai Pang[2], Hsiang-Chieh Lee[1]
[1]Graduate Institute of Photonics and Optoelectronics, National Taiwan University, Taipei, [2]Department of Pharmacology, College of Medicine, National Taiwan University, Taipei, [3]Graduate Institute of Networking and Multimedia, National Taiwan University, Taipei
We have developed a wide-field optical coherence tomography imaging system providing volumetric imaging of the biological tissue with multiscale imaging capability and operating in the long-wavelength regime. Once the specimen is placed on the 2D stage, wide-field tissue imaging could be achieved by using the mosaic scanning protocol. The vertical stage provides real-time adjustment of the focus position in the tissue due to the sample height variation.

[BISC3]
Bioimaging
Chair: Yasuhiro Awatsuji
Kyoto Institute of Technology

BISC3-01 *Invited*

Optimal voltage imaging of dendritic activity via single-photon excitation by scattered photons
Michael Lawrence Castanares, Hans Albert Bachor, Vincent Daria
The Australian National University, Australia
We use patterned light initiate oblique scattered photon excitation of voltage indicators that report changes in the membrane potential. Our proposed scheme reduces the excitation of voltage indicators elsewhere in the cell that constitutes the background signal and therefore enables us to amplify the detected fluorescence, which carries voltage information.

BISC3-02 *Invited*

Photoacoustic imaging as a bridge from medical imaging to bioimaging
Miya Ishihara
National Defense Medical College, Japan
Abstracts with approximately 120 words must be included. The basic structure of an abstract includes a topic sentence or hypothesis (rationale) of the work, a brief description of the methods, a summary of the results, and a conclusion. Literature citations and references to tables, figures, or equations found in the body of the manuscript should not be used.

BISC3-03 *Invited*

Live-cell imaging to illuminate the mechanism underlying high stem-cell formation ability in plants
Yosuke Tamada
Utsunomiya University
With live-cell imaging using fluorescent proteins, we identified first factor for the induction of stem cells which is conserved in both plant and animal kingdoms. We also adopt adaptive optics towards high-resolution live-cell imaging.

[BISC4]
Phase and Fluorescence Microscopy
Chair: Yusuke Ogura
Osaka University

BISC4-01 *Invited*

Morphological predictors of macrophage sub-populations based on digital holographic microscopy
Nicholas Smith, Nicolas Pavillon
Osaka University, Japan
Immune cells include a wide variety of functionally different but visibly similar cell types. Here we show how quantitative phase imaging can be used as a non-invasive and label-free assay to discriminate between different types of macrophages as well to determine characteristic features that correspond to the immunological activation state.

BISC4-02 *Invited*

Phase-contrast optical microscopy using active image processing
Masaki Hisaka
Osaka Electro-Communication University
A phase-contrast optical microscope using active image processing has been developed to visualize phase structure of living tissues. We reproduced phase-contrast images of biological samples and extended the technique to the phase-contrast scanning microscope.

BISC4-03 *Invited*

Fourier-domain lightfield microscopy: a new paradigm in 3D microscopy
Emilio Sanchez-Ortiga, Gabriele Scrofani, Manuel Martinez-Corral, Genaro Saavedra
3D Imaging & Display Laboratory, Universitat de València, E46100 Burjassot, Spain
Lightfield microscopy offers the possibility of capturing 3D information of samples after a single shot. This contribution is devoted to review a new paradigm in lightfield microscopy, namely, the Fourier-domain integral microscope (FiMic), that improves the capabilities of the technique, and to present recent advances and applications of this new architecture.

BISC

[BISC5]
Advanced Imaging and Sensors
Chair: Vincent R Daria
The Australian National University

BISC5-01

Multiline illumination Raman microscopy for rapid cell imaging

Kentaro Mochizuki[1,2], Yasuaki Kumamoto[1], Katsumasa Fujita[1,3,4]
[1]Osaka University, Graduate School of Engineering, [2]Kyoto Prefectural University of Medicine, Department of Pathology and Cell Regulation, [3]AIST-Osaka University, Advanced Photonics and Biosensing Open Innovation Laboratory, [4]Osaka University, Institute for Open and Transdisciplinary Research Initiatives, Transdimensional Life Imaging Division

Image acquisition rate in spontaneous Raman microscopy was accelerated by installing a multiple-line illumination technique and parallel spectral detection capability. Under this scheme, more than ten thousand of Raman spectra were detectable in an exposure, thus a high-resolution Raman image of living cells was available within a few minutes. Several biological applications were also performed with higher efficiency by using this scheme.

BISC5-02

High-throughput discrimination of cancerous and noncancerous human cell lines by high-speed spontaneous Raman microscopy

Yasuaki Kumamoto[1,2], Kentaro Mochizuki[1,2], Kosuke Hashimoto[2], Yoshinori Harada[2], Hideo Tanaka[2], Katsumasa Fujita[1,2]
[1]Osaka University, [2]Kyoto Prefectural University of Medicine

We used a narrow spectral range together with detector binning for high-throughput analysis of cancerous and noncancerous human cell lines by spontaneous Raman microscopy. Throughput improvement of the cell analysis reached at 20-folds, in comparison to use of unbinned, wideband spectra. With cellwise narrowband spectra, the cancerous and noncancerous cells were discriminated at the accuracy of 90.5%.

BISC5-03 *Withdraw*

BISC5-04

Transcutaneous monitoring of hemoglobin derivatives during methemoglobinemia using spectral diffuse reflectance imaging

Fahima Khatun, Izumi Nishidate
Tokyo University of Agriculture and Technology

We propose a non-invasive and non-contact imaging technique based on the diffuse reflectance spectroscopy to evaluate the concentrations of methemoglobin (metHb), oxygenated hemoglobin (HbO), and deoxygenated hemoglobin (HbR) simultaneously. Experiments with *in vivo* rat exposed to sodium nitrite ($NaNO_2$) shows the feasibility of the method for monitoring changes in metHb, HbO, and HbR concentrations during methemoglobinemia.

BISC5-05

Effective optical parameters of good and bad prognosis neuroblastoma

Y Le Nguyen[1,2], Nam Hoang Bui[1,2], Phuong Mai Truc Nguyen[1,2], Bao Chi Bui[3], Hai Thanh Le[4,2], Hung Quoc Phan[5], Hien Thi Thu Pham[1,2]
[1]School of Biomedical Engineering, International University, Ho Chi Minh City, Vietnam, [2]Vietnam National University Ho Chi Minh City, Vietnam, [3]Ho Chi Minh City University of Medicine and Pharmacy, Ho Chi Minh City, Vietnam, [4]Department of Mechanical Engineering, Ho Chi Minh City University of Technology, [5]Department of Mechanical Engineering, National United University, Miaoli 36063, Taiwan

Neuroblastoma has been considered as one of the most common extracranial solid tumors of childhood. In this study, we proposed a non-invasive diagnostic measurement in evaluating the malignant level of neuroblastoma utilizing the Mueller matrix decomposition to extract effective optical parameters. The results showed a significant difference in optical properties between good and bad prognosis neuroblastoma samples.

BISC5-06

Differential Mueller matrix formalism for reflectance configuration and high scattering medium

Quoc-Hung Phan[1], Wei-Ze Xiao[1], You-Rui Lai[1], Tzu-Hsiang Jian[1], Thi-Thu-Hien Pham[2], Chi-Hsiang Lien[1]
[1]National United University, [2]International University-Vietnam National University HCMC

A novel technique of differential Mueller matrix formalism for reflectance configuration and high scattering medium based on surface plasmon resonance is proposed. The feasibility of the proposed technique is performed by detecting the aqueous solution over the range of 0-500 mg/dL. The resolution of the measured results is approximate 16 mg/dL.

[BISC6]
Phase Imaing
Chair: Yosuke Tamada
Utsunomiya University

BISC6-01 *Invited*

Intelligent, High-speed, High-resolution, and Tomographic Phase Microscopy

Renjie Zhou
The Chinese University of Hong Kong

We have recently empowered quantitative phase microscopy with artificial intelligence, ultrahigh imaging speed, and 3D imaging capability. Using those developments, we achieved sorting complex cells and observing microscopic structures in 2D, 3D, and 4D.

BISC6-02

Preliminary experimental evaluation of microscopic imaging through thick biological tissues based on in-line phase-shift digital holography using near-infrared light

Manami Ohta[1], Shutaro Kodama[1], Kanami Ikeda[2], Yutaka Kano[1], Yoko Miyamoto[1], Wolfgang Osten[3], Mitsuo Takeda[4], Eriko Watanabe[1]
[1]The University of Electro-Communications, [2]Osaka Prefecture University, [3]University of Stuttgart, [4]Utsunomiya University

We report the evaluation of our microscopic imaging system for objects hidden behind scattering media using a near-infrared light source. A favorable microscopic image of the object behind the rat-skin sample of 912 μm-thickness was successfully reconstructed.

BISC6-03

Multi-wavelength digital holographic microscopy for bio-imaging and applications

Manoj Kumar[1], Osamu Matoba[1], Xiangyu Quan[1], Yasuhiro Awatsuji[2]
[1]Kobe University, [2]Kyoto Institute of Technology

A single-shot common-path off-axis multi-wavelength digital holographic microscopic system for phase imaging of biological specimens is proposed. The obtained experimental results corroborate the imaging capability of the proposed system. The proposed system may open new possibilities in bio-imaging and real-time simultaneous measurement of various parameters including the thickness, refractive index, etc.

[BISC7]
OCT2
Chair: Masaki Hisaka
Osaka Electro-Communication University

BISC7-01 *Invited*

Real-time functional optical coherence tomography imaging

Teng-Chieh Chang[1], Ting-Hao Chen[1], Ting-Yen Tsai[1], Chuan-Bor Chueh[1], Yin-Peng Huang[2], Meng-Tsan Tsai[3], Cheng-Kuang Lee[4], HSIANG-CHIEH LEE Lee[1,5]
[1]Graduate Institute of Photonics and Optoelectronics, National Taiwan University, [2]Graduate Institute of Networking and Multimedia, National Taiwan University, [3]Department of Electrical Engineering, Chang Gung University, [4]NVidia AI Technology Center (NVAITC), NVidia, [5]Molecular Imaging Center, National Taiwan University

Optical coherence tomography (OCT) is non-invasive biomedical imaging technique, which can provide volumetric imaging of the tissue architectural information. In this talk, I will briefly discuss the preliminary results of several ongoing works in my lab, including the quantitative analysis of the microvasculature with the animal model and investigation of the mouse cochlear anatomy.

BISC7-02

Bulk phase error correction for holographic signal processing of optical coherence tomography

Kensuke Oikawa, Shuichi Makita, Daisuke Oida, Yoshiaki Yasuno
University of Tsukuba

A numerical method to cancel the phase error caused by sample bulk motion from SD-OCT volume data is presented. This method first measures the vectorial gradient field of the phase error. The phase error is then estimated by path integration operation with non-standard integration paths. The performance of this method is validated by assessing the image quality of numerically refocused OCT images which is generated by complex holographic signal processing.

BISC7-03

Intensity-invariant scatterer density estimation for optical coherence tomography using deep convolutional neural network

Thitiya Seesan[1,2], Daisuke Oida[1], Kensuke Oikawa[1], Prathan Buranasiri[2], Yoshiaki Yasuno[1]
[1]Computational Optics Group, University of Tsukuba, Tennodai 1-1-1, Tsukuba, Ibaraki 305-8573, Japan., [2]Department of Physics, King Mongkut's Institute of Technology Ladkrabang, Chalongkrung Rd., Bangkok 10520 Thailand

A convolutional neural network (CNN) based scatterer density estimator for optical coherence tomography (OCT) is presented. In order to train the OCT, small patches of OCT speckle images were numerically generated. In this numerical image generation, the imaging parameters including the resolutions, probe power, signal-to-noise ratio, and scatterer density were randomly defined. So, CNN was trained to estimate the parameters from the generated OCT image.

BISC7-04

Comparison of vascular image quality with different sweep rate laser light source based on variable interscan time analysis in optical coherence tomography angiography skin imaging

Yi Chun Wu[1], Ting Hao Chen[1], Ting Yen Tsai[1], Teng Chieh Chang[1], Chuan Bor Chueh[1], Ching Yu Wang[1], Yin Peng Huang[2], Meng Tsan Tsai[3], Hsiang Chieh Lee[1,4]
[1]Graduate Institute of Photonics and Optoelectronics, National Taiwan University, [2]Graduate Institute of Networking and Multimedia, National Taiwan University, [3]Department of Electrical Engineering, Chang Gung University, [4]Molecular Imaging Center, National Taiwan University

Optical coherence tomography angiography (OCTA) identifies the presence of the microvasculature in the biological tissue due to the backscattered signal of the moving red blood cells. In this paper, we have developed a swept-source OCT system using two 1060 nm wavelength-swept lasers with a sweep rate of 100,000 and 200,000 A-scans/sec and reconstructed OCTA images by variable interscan time analysis (VISTA) algorithm to provide relative blood flow information.

BISC

BISC7-05

Quantification of ex-vivo tissue activity by polarization dynamics imaging using Jones matrix optical coherence tomography.

Pradipta Mukherjee[1], Arata Miyazawa[1], Larina Shen[2], Shinichi Fukuda[2], Toshiharu Yamashita[3], Yuki Oka[4], Ibrahim Abd El-Sadek[1], Shuichi Makita[1], Satoshi Matsusaka[2], Tetsuro Oshika[2], Hideaki kano[4], Yoshiaki Yasuno[1]
[1]Computational Optics Group, University of Tsukuba, [2]Faculty of Medicine, University of Tsukuba, [3]Graduate School of Comprehensive Human Sciences, University of Tsukuba, [4]Graduate School of Pure and Applied Sciences, University of Tsukuba

A new method for quantitative assessment of tissue dynamics and activity is presented. The method is based on polarization-sensitive optical coherence tomography. Temporal variance of birefringence and temporal polarization uniformity are used to assess the tissue dynamics. These methods are applied to hourly time-course evaluation of tissue activity of ex-vivo dissected mouse heart.

BISC7-06

RGB-spectroscopic OCT imaging using single-panel CMOS color camera

Yoshiaki Tanuma, Toshiaki Iwai
Tokyo University of Agriculture and Technology

We have developed one-shot RGB-spectroscopic FF-OCT. In this system, RGB lights are synthesized into the light incident and separated by a Bayer filter. We show the possibility of RGB-spectroscopic OCT imaging in the one-shot operation.

[BISC8] Imaging and Image Processing

Chair: Genaro Saavedra-Tortosa
Universitat de València

BISC8-01 *Invited*

Ghost imaging for weak light imaging by using arrival time of photon and deep learning

Yasuhiro Mizutani, Shoma Kataoka, Tsutomu Uenohara, Yasuhiro Takaya
Osaka University, Japan

This paper reports for high-sensitivity imaging based on Ghost imaging (GI), which is one of the single-pixel imaging. Although the GI is correlation-based imaging, there is an advantage in detecting weak light intensity. We focused on the arrival time of the first photon. Furthermore, to improve the detection time, we applied machine learning to reduce the measurement number. In this paper, we have proposed the principle and some experimental results.

BISC8-02

Spatial discrimination of cancer using circular polarization of light scattered by biological tissues

Nozomi Nishizawa[1], Shinya Kawashima[1], Bassam Al Qadi[2], Takahiro Kuchimaru[3], Hiro Munekata[1]
[1]Tokyo Institute of Technology, [2]Palestine Technical University, [3]Jichi Medical University

We investigate the spatial discrimination of cancer using circular polarized light scattered by biological tissues. In-plane resolution was investigated using experiments on biological tissues, which show a noticeable difference in polarization values between healthy and cancerous parts. The resolution in the depth direction is examined with the calculation method, which shows that the thickness of cancer can be estimated by detecting the polarization values.

BISC8-03 *Withdraw*

[BISCp] Poster Session

BISCp-01

Numerical jitter estimation for swept source optical coherence tomography

Lida Zhu, Arata Miyazawa, Pradipta Mukherjee, Ibrahim Abd El-Sadek, Kensuke Oikawa, Daisuke Oida, Yoshiaki Yasuno
University of Tsukuba

Due to asynchronization between the acquisition trigger and K-clock trigger in a swept source optical coherence tomography (SS-OCT) system, trigger jitter causes the spectrum a temporal shift in the spectral domain and thus corrupts the measurement. We study ternary distribution of the jitter signal by measuring TiO2 phantom using a SS-OCT system, and it shows one-pixel spectral shift in the spectral domain.

BISCp-02

Three-dimensional tracking of moving *Volvox* by parallel phase-shifting digital holographic microscope

Junya Inamoto[1], Yuki Takase[1], Kohei Arao[1], Tomoyoshi Inoue [1], Kazuki Shimizu[1], Kenzo Nishio[1], Osamu Matoba[2], Toshihiro Kubota[3], Yasuhiro Awatsuji[1]
[1]Kyoto Institute of Technology, [2]Kobe University, [3]Kubota Holography Laboratory Corporation

We report the three-dimensional trajectory of a *Volvox* moving in water was recorded by parallel phase-shifting digital holographic microscope providing 10X magnification. We successfully demonstrated the 3D tracking of curvedly moving *Volvox*.

BISCp-03

Reconstruction quality of digital holographic images using a holographic diffuser with different distances

Soichiro Tabata[1], Fumito Araki[1], Hidenobu Arimoto[2], Wataru Watanabe[1]
[1]Ritsumeikan University, [2]AIST

Lensless digital holography can reconstruct the intensity and phase of an object located behind a diffuser. In this paper, we reconstruct the object intensity by changing the distance between the sample and the diffuser.

BISCp-04

Single shot low-coherence digital interferometer with multi-reflection reference mirror for mearing long depth object

Quang Duc Pham[1,2], Yoshio Hayasaki[3]
[1]National Center for Technological Progress, 25 – Le Thanh Tong – Phan Chu Trinh – Hoan Kiem – Hanoi – Vietnam, [2]Vietnam Institute of Science Technology and Innovation, 38 Ngo Quyen, Hoan Kiem, Hanoi Vietnam, [3]Center for Optical Research and Education (CORE), Utsunomiya University 7-1-2 Yoto, Utsunomiya 321-8585, Japan

A new type of reference mirror constructed by a half mirror and a full reflective mirror was introduced for the low-coherence interferometer. It allowed reconstructing the profile of the object whose depth was many times longer than the coherence length of the light source in a single-short.

BISCp-05

Digital holographic microscopy using speckle patterns generated from a moving diffuser

Hideki Funamizu[1], Tatsuya Tokushima[1], Jun Uozumi[2], Yoshihisa Aizu[1]
[1]Muroran Institute of Technology, [2]Faculty of Engineering, Hokkai-Gakuen University

In this study, we report spatial resolution enhancement and image quality improvement of a digital holographic microscopy using speckle patterns generated from a moving diffuser.

BISCp-06

Shape measurement of a droplet using phase-shifting burst digital holography

Takumi Ujiie, Yoshio Hayasaki
Center for Optical Research and Education (CORE), Utsunomiya University

The phase-shifting digital holography with burst-imaging method is proposed for imaging a moving object. The phase-shifting digital holography at 460 μs is demonstrated by using a high-speed camera and a high-speed phase modulation based on a piezoelectric element.

BISCp-07

Phase imaging of radiated sound field by parallel phase-shifting digital holography

Yuki Takase[1], Kazuki Shimizu[1], Syogo Mochida[1], Tomoyoshi Inoue[1], Kenzo Nishio[1], Sudheesh K Rajput[2], Osamu Matoba[2], Toshihiro Kubota[3], Yasuhiro Awatsuji[1]
[1]Kyoto Institute of Technology, [2]Kobe University, [3]Kubota Holography Laboratory Corporation

We report imaging of a sound field radiated from a sound source by parallel phase-shifting digital holography. We have succeeded in observing the propagation of 40000 Hz sound by the technique.

BISCp-08

Isotropic quantitative differential phase contrast microscopy using deep neural networks

An Cin Li[1], Yu Hsiang Lin[2], Hsuan Ming Huang[1], Yuan Luo[1,3,4]
[1]Institute of Medical Device and Imaging, National Taiwan University, [2]Department of Power Mechanical Engineering, National Tsing Hua University, [3]Molecular Imaging Center, National Taiwan University, [4]YongLin Institute of Health, National Taiwan University

Isotropic quantitative differential phase contrast (iDPC) microscopy based on pupil engineering has made significant improvement in reconstructing phase image of weak phase objects. To further enhance acquisition speed for phase recovery in iDPC, we adapt deep neural networks to achieve isotropic phase retrieval from half-pupil based quantitative differential phase contrast (qDPC) microscopy.

BISCp-09

Implementation and Numerical Evaluation for Multiplicative Algebraic Reconstruction Techniques

Tomohiro Aoyagi, Kouichi Ohtsubo, Nobuo Aoyagi
Toyo University

Multiplicative algebraic reconstruction techniques (MART) is one of the method of projections onto convex sets (POCS) for solving a system of simultaneous equation. We apply the MART to image reconstruction problems in computer simulations.

BISCp-10

Virtual multi-focus optical-resolution photoacoustic microscope with extended depth of field using block DCT transform fusion

Xianlin Song[1], Jianshuang Wei[2], Xiaoquan Yang[2]
[1]Nanchang University, [2]Huazhong University of Science and Technology

Photoacoustic microscopy with large depth of focus is significant to the biomedical research. Here, we developed a virtual multi-focus optical-resolution photoacoustic microscope with extended depth of field by using block Discrete Cosine Transform fusion.

BISCp-11 *Withdraw*

BISCp-12

Improvement of signal-to-noise ratio in super resolution imaging using subdiffraction limited spots by additional digital signal processing

Riki Yamada[1], Yusuke Ogura[1], Takahiro Nishimura[2], Yosuke Tamada[3], Takashi Murata[4], Jun Tanida[1]
[1]Graduate School of Information Science and Technology, Osaka University, [2]Graduate School of Engineering, Osaka University, [3]Faculty of Engineering, Utsunomiya University, [4]National Institute for Basic Biology., National Institutes of Natural Sciences

We are studying about super-resolution microscopy based on parallel scanning of multiple subdiffraction-limited spots. This paper reports on improvement of signal-to-noise ratio (SNR) of super resolution images by additional digital signal processing. More specifically, the size of the digital pinhole is changed during reconstruction. Experimental results demonstrate that the SNR can be improved by using an appropriate pinhole size.

BISCp-13

Image reconstruction behind diffuser by deep learning and spatial filtering

Taichi Nishijima[1], Wataru Watanabe[1], Hidenobu Arimoto[2]
[1]Ritsumeikan University, [2]AIST

Deep learning has been used in recent years to reconstruct images behind scattering media. We investigate the effects of distance separating the diffuser from the lens and the iris diameter on deep learning and accuracy.

BISCp-14

Skin reflectance spectra with different parameter conditions in Monte Carlo simulation and agarose-gel phantom experiment

Kaustav Das[1], Takaaki Maeda[2], Izumi Nishidate[3], Tomonori Yuasa[1], Hideki Funamizu[1], Yoshihisa Aizu[1]
[1]Muroran Institute of Technology, [2]Kushiro National Collage of Technology, [3]Tokyo University of Agriculture and Technology

Similarity in skin reflectance spectra with different combination of absorption and scattering conditions makes erroneous estimation of parameters for any measured spectrum through the database containing simulated spectra. In this study, such similar reflectance spectra are investigated by Monte Carlo simulation and phantom experiment.

BISC

BISCp-15

Investigation on estimation of absorption and scattering parameters using skin spectral reflectance database

Tomonori Yuasa[1], Takehiro Ohya[1], Kaustav Das[1], Takaaki Maeda[2], Hideki Funamizu[1], Yoshihisa Aizu[1]
[1]Muroran Institute of Technology, [2]National Institute of Technology, Kushiro College

We investigated a method for estimating the absorption and scattering parameters by considering the effect of specific layers on the spectral band in the spectral reflectance database of human skin generated by Monte Carlo simulation.

BISCp-16

Monte Carlo simulation of super Gaussian beam in turbid media

Ying-Ju Tsai[1], Sunil Vyas[2], Kung-Bin Sung[1,3,4], Yuan Luo[2,3,5]
[1]Graduate Institute of Biomedical Electronics and Bioinformatics, National Taiwan University, 10617, Taiwan, R. O. C., [2]Institute of Medical Device and Imaging, National Taiwan University, 10051, Taiwan, R. O. C., [3]Molecular Imaging Center, National Taiwan University, Taipei, 10672, Taiwan, R. O. C, [4]Department of Electrical Engineering, National Taiwan University, 10617, Taiwan, R. O. C, [5]YongLin Institute of Health, National Taiwan University, Taipei, 10087, Taiwan, R. O. C

Understanding the interaction between light and biological tissues is one of the active area in biophotonics research. One of the most common modeling tool in laser tissue interaction is Monte Carlo simulation. Here, we present Monte Carlo simulation for the propagation of super-Gaussian beam and compared with the Gaussian beam. The effect of spatial distribution of photons on the energy deposition inside the medium for different optical coefficients are studied.

BISCp-17

Fluorescent sensing system for *ex vivo* and *in vivo* visualization and determination of molecules of neurotransmitters

Irina Veselova[1], Olesya Kapitanova[1], Anastasiya Mikhailova[1], Maria Makedonskaya[1], Tatyana Shekhovtsova[1], Dina Myasnikova[2], Junji Fukuda[2]
[1]Lomonosov Moscow State University, Faculty of Chemistry, [2]Yokohama National University, Faculty of Engineering

The solid-phase fluorescent sensing system for *ex vivo* and *in vivo* visualization and determination of markers neurotransmitter metabolism in blood plasma and neural cell structures *PC12* based on formation of intensely fluorescing ternary complexes of biogenic amines and their metabolites with europium and oxytetracycline (Eu^{3+}–OTC–BA/metabolite ternary complex) were developed. This study was financially supported by *RFBR* (19-03-00901a and 20-33-70264).

BISCp-18

Multimodal two-photon microscopy with electrical tunable lens

Takumi Noda[1], Xiangyu Quan[1], Sudheesh Rajput[1], Osamu Matoba[1], Yasuhiro Awatsuji[2]
[1]Kobe University, [2]Kyoto Institute of Technology

In this research, we have proposed a fast fluorescent volume imaging method by using electrical tunable lens. In order to speed up the imaging, the sectioning is realized by changing the focal power of an electrical tunable lens. The quantitative phase imaging is also combined to two-photon imaging system to obtain multimodal imaging.

BISCp-19

Improvement of the spatial resolution of ion imaging system using thinned sensor substrate

Wataru Inami, Kiyoshisa Nii, Satoru Shibano, Hikaru Tomita, Yoshimasa Kawata
Shizuoka University

We proposed an addressable potentiometric sensor for ion imaging using a focused electron beam. To realize high spatial resolution, the acceleration voltage of the electron beam and the film thickness of the sensor substrate were examined.

BISCp-20

Snapshot polarization bio-imaging for circular dichroism of living scarab beetles

Shuhei Shibata, Masayuki Suzuki, Nathan Hagen, Yukitoshi Otani
Utsunomiya University

We show the principles and example measurements of snapshot polarization bio-imaging of insects using our full-Stokes imaging polarimeter using two polarization cameras.

BISCp-21

***In situ* time-series quantitative evaluation of skin burn healing using second-harmonic-generation imaging and texture analysis**

Eiji Hase[1], Ryosuke Tanaka[2], Shu-ichiro Fukushima[2], Takeshi Yasui[1,2]
[1]Institute of Post-LED Photonics, Tokushima University, [2]Graduate School of Engineering Science, Osaka University

In this paper, we performed the quantitative evaluation of wound healing process in an animal model by a combination of *in situ* time-series second-harmonic-generation imaging and a texture analysis using the gray-level co-occurrence matrix.

BISCp-22

Application of Nanoplasmonic Based Multichannel Spectral Imaging in Pesticide Detection

Sheng Hann Wang[1], Shu Cheng Lo[1,2], Chia Wen Kuo[1], Yung Ju Tung[1], Yi Hsin Tai[1,3], Pei Kuen Wei[1]
[1]Academia Sinica / Research Center for Applied Sciences, [2]National Taiwan University / Institute of Applied Mechanics, [3]The University of Tokyo / School of Engineering

We present a surface plasmon resonance (SPR) based nanoplasmonic chip integrated with a multichannel spectral imaging system to detect ecosystem harmful pesticides which include imidacloprid, thiamethoxam, clothianidin, and fipronil.

BISCp-23

An Advance Real Time Detection of EC-SPR with Image-based Spectrometer

Shu-Cheng Lo[1,2], Chia-Wen Kuo[2], Pei-Kuen Wei[2]
[1]National Taiwan University, [2]Academia Sinica

Since the SPR sensor is metal thin film, it could be simply designed and used as the electrode. Combing the optical sensor with electrochemistry would be easily to be used EC-SPR, and the signal from electrode is real time measured by image-based spectrometer which could immediately observe the difference between two electrodes. In this work will demonstrate the diffusion of ions by the real time image-based spectrometer.

BISCp-24 *Withdraw*

[JS4]
Joint Session BISC & OMC
Joint session program p.25

Program

Several presentations are supposed to be withdrawn due to the conference shift from real to digital. This printed program was produced for the real conference. The latest program of the digital conference will be released on a website. We are very sorry for this confusion.

HEDS

[HEDS-OP]
Opening
Shinsuke Fujioka
ILE, Osaka University
Opening Remarks

[HEDS1]
High Intensity Laser
Chair: Shinsuke Fujioka
ILE, Osaka University

HEDS1-01

Plasma mirror performance optimisation

Graeme Scott
Lawrence Livermore National Laboratory

Building work showing that a finite plasma density gradient significantly enhances plasma mirror reflectivity, we introduce a technique where the sub-micron density scale length, collisionality and temperature of the plasma is measured and correlate this with PM optical performance. This leads to novel conclusions on the kinematic plasma expansion and compostion, which we will demonstrate provides avenues for investigation of plasma optic optimisation.

HEDS1-02

Evidence of enhanced laser-plasma coupling with compound parabolic concentrator targets

Shaun Kerr[1], David Alessi[1], Jeffrey Bude[1], Ginevra Cochran[1], David Fittinghoff[1], Alex Haid[2], Mathew Hamamoto[1], Andrea Hannasch[3], Rick Heredia[1], Matthew Hill[4], Daniel Kalantar[1], Andreas Kemp[1], Paul King[3], Otto Landen[1], Nuno Lemos[1], Andrew MacPhee[1], David Martinez[1], Michael Mauldin[2], Isabella Pagano[3], Arthur Pak[1], Matthew Prantil[1], Dean Rusby[1], David Schlossberg[1], Ganesh Tiwari[3], Scott Vonhof[2], Scott Wilks[1], Gerald Jackson Williams[1], Wade Williams[1], Kelly Youngblood[1], Andrew MacKinnon[1]
[1]Lawrence Livermore National Laboratory, [2]General Atomics, [3]The University of Texas at Austin, [4]AWE

Maximizing peak laser intensity puts steep demands on focal spot size, which increases facility cost & complexity. Compound parabolic concentrator (CPC) targets relax focusing requirements while achieving results consistent with high effective intensities. We measured the performance of CPC targets with laser conditions from 0.1 – 40 ps, 100 – 2600 J, and F/#'s of 10 – 60. CPC targets produced ~10x higher conversion to hot electrons & x-rays compared to flat targets.

HEDS1-03

Intense attosecond pulses carrying orbital angular momentum using laser plasma interactions

Jingwei Wang
Shanghai Institute of Optics and Fine Mechanics, CAS

We theoretically and numerically demonstrate that intense surface harmonics carrying orbital angular momentum are naturally produced by the intrinsic dynamics of a relativistically intense circularly-polarized Gaussian beam interacting with a target at normal incidence.

[HEDS2]
ICF measurement
Chair: Alex Zylstra
Lawrence Livermore National Laboratory

HEDS2-01

Density Measurements of the Inner Shell Release

Dan Haberberger, Alex Shvydky, Suxing Hu, James Knauer, Steve Ivancic, Valeri Goncharov, Dustin Froula
Laboratory for Laser Energetics, University of Rochester

In inertial confinement fusion implosions, the release of plasma off the inner surface of the target shell can reduce performance. Experiments on OMEGA EP at the Laboratory for Laser Energetics indicate that a decompression of the initial neutral CH shell results in an increased expansion of the plasma on the back side of the shell. This material is supported by the Department of Energy National Nuclear Security Administration under Award Number DE-NA0003856.

HEDS2-02

First direct and high-precision measurement of ne and Te evolution inside an ICF hohlraum

Zhichao Li
Laser Fusion Research Center, China Academy of Engineering Physics

First direct and high-precision measurement of ne and Te evolution inside an ICF hohlraum.

HEDS2-03

Neutron diagnostics on FIREX

Yasunobu Arikawa, Yuki Abe, Shoi Asano, Ayami Nakao, Takato Mori, Zechen Lan, Akifumi Yogo, Shinsuke Fujioka, Hiroyuki Shiraga, Mitsuo Nakai, Ryosuke Kodama
Institute of Laser Engineering, Osaka University

Nuclear diagnostics on fast ignition inertial confinement fusion experiments conducted on Gekko-XII and LFEX facility (FIREX project) is presented. Since a much larger amount of high energy X-ray generated at heating process than fusion neutron is inevitably detected before the neutron detection, the discrimination of the neutron signal among X-ray has been technically difficult. In this study time of flight neutron detectors were updated.

HEDS2-04

Assessment of the Time-dependent Drive Radiation Flux at the Center of a Gas-filled Cylindrical Hohlraum

Xufei Xie
Laser Fusion Research Center

Assessment of the drive flux on the capsule is very important in ICF. As the drive flux can not be measured directly, it is proposed that re-emitted flux from the capsule can be measured to be an important constraint for the simulation. Measurement of the re-emitted flux is combined with measurement of shock wave velocity, from the sample at the center of a cylindrical hohlraum. 2D LARED code is adopted for the data interpretation, and time-dependent drive flux is obtained.

[HEDS3]
Multi-picosecond interactions
Chair: David Neely
Central Laser Facility, UKRI

HEDS3-01

Manipulating Time-dependent Short-pulse Laser-particle Acceleration with Multi-ps Laser Pulse Shaping

Derek Mariscal[1], Joohwan Kim[2], Graeme Scott[1], Scott Willks[1], Andreas Kemp[1], Ginevra Cochran[1], Jaebum Park[3], Natsumi Iwata[4], Yasuhiko Sentoku[4], Tammy Ma[1]
[1]Lawrence Livermore National Laboratory, [2]University of California San Diego, [3]Colorado State University, [4]University of Osaka

In this work we examine the recent progress in understanding time-dependent particle acceleration dynamics from multi-ps drivers and examine the possibilities of laser pulse-shaping at the sub-ps level to precisely influence time-dependent laser-particle acceleration.

HEDS3-02

Plasma dynamics and particle acceleration under over-ps relativistic laser light irradiation

Natsumi Iwata
Institute of Laser Engineering, Osaka University

Kilojoule/ps intense lasers have an advantage in particle acceleration and high energy density plasma creation with large volumes. A theory for such large-scale laser-plasma interactions over picoseconds is proposed and substantiated by Particle-in-Cell simulations.

HEDS3-03

Scaling study of laser driven proton acceleration as a function of pulse duration in the multi-ps regime

Raspberry Simpson[1,2], Graeme Gordon Scott[1], Paul King[1,3], Dean Rusby[1], Elizabeth Grace[1,4], Mitchell Sinclair[5], Adeola Crown Aghedo[6], Isabella Mary Pagano[3], Chris Armstrong[7], Shaun Kerr[1], G. Jackson Williams[1], Nuno R.C. Lemos[1], Felicie Albert[1], Arthur Pak[1], Mario Manuel[8], Johan Frenje[2], Andrew Mackinnon[1], Andrew MacPhee[1], Scott Andrews[1], Brent Stuart[1], Stephen Maricle[1], Robert Costa[1], Brandon Fischer[1], Ken Charron[1], Robert Cauble[1], Derek Mariscal[1], Tammy Ma[1]
[1]Lawrence Livermore National Laboratory, [2]Massachusetts Institute of Technology, [3]Texas Petawatt Laser Facility, [4]Georgia Institute of Technology, [5]University of California at Los Angeles, [6]Florida A & M University, [7]Rutherford Appleton Laboratory, [8]General Atomics

A detailed scaling study was performed examining how maximum energies of laser-driven protons scale with pulse duration (0.6 – 20 picoseconds). This work demonstrates that the accelerated electrons do not follow the ponderomotive scaling [1] for pulse lengths in the multi-picosecond regime and also that the accelerating field is established by a population of super-ponderomotive electrons with inferred temperatures that are a strong function of pulse duration.

[HEDS4]
Magnetic Field Applications
Chair: Tammy Ma
Lawrence Livermore National Laboratory

HEDS4-01

Magnetising ICF Experiments on the National Ignition Facility: Simulated Changes to Perturbation Growth Rates

Chris A Walsh[1,2], Jeremy P. Chittenden[1], Aidan Crilly[1], Brian Appelbe[1], Sam O'Neill[1], Aidan Boxall[1], John Moody[2], Hong Sio[2], Brad Pollock[2], Dave Strozzi[2], Darwin Ho[2], Arijit Bose[3]
[1]IC, [2]LLNL, [3]MIT

A project has recently been funded to add magnetic fields to ICF implosions on the National Ignition Facility (NIF), with initial experiments scheduled for 2020. The physics case will be outlined in this talk, with magnetisation expected to decrease energy losses from the fuel, increasing yield and temperature. As a conductive hohlraum can prevent target magnetisation in short timescales, both directly and indirectly-driven configurations are being considered.

HEDS4-02

Magnetized Rayleigh-Taylor instabilities and particle separation in laser-induced plasma jets with transverse configuration of poloidal magnetic field

Evgeny Filippov[1,2], Sergey Makarov[2,3], Guilhem Revet[4], Simon Bolanos[5], Igor Skobelev[2], Sophia Chen[6], Marie Ouille[5], Oswald Willi[10], Benjamin Khiar[7,8], Andrea Ciardi[7], Konstantin Burdonov[1,5,7], Maria Safronova[1,5], Alexander Soloviev[1], Mikhail Starodubtsev[1], Jerome B'eard[9], Mirela Cerchez[10], Thomas Gangolf[5,10], Sergey Pikuz[2], Julien Fuchs[5]
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This work is devoted to the investigation of impact of magnetic field of a high strength (up to 30 T) on laboratory plasma flows propagating across the lines of magnetic field by means of optical interferomtery and x-ray spectroscopy. As a result, we observed that external transverse magnetic field confines the plasma into a rapidly expanding slab via a series of recollimating shocks.

HEDS

HEDS4-03

Strong Laser-Driven Magnetostatic Fields for Magnetized High Energy-Density Physics

Michael EHRET[1,2], Ch. Vlachos[3,1], M. Bailly-Grandvaux[1], C. Bellei[1], P. Forestier-Colleoni[1], S. Fujioka[4], L. Giuffridaa[1], J.J. Honrubia[5], G. Schaumann[2], E. d'Humières[1], Ph. Korneev[13,14], V.T. Tikhonchuk[1], D. Batani[1], R. Bouillaud[1], S. Borodziuk[10], T. Burian[12,11], M. Chevrot[6], T. Chodukowski[10], J. Cikhardt[15,11], J.E. Cross[7], R. Crowston[8], S. Dorard[6], J. Dostal[6], J.-L. Dubois[1,9], R. Dudzakc[11], S. Singh[12], N. Woolsey[8], A. Zaras-Szydłowska[10], Z. Zhang[4], J.J. Santos[1]
[1]Laboratoire CELIA, UMR 5107, Univ. Bordeaux, Talence, France, [2]Institut für Kernphysik, Technische Univ. Darmstadt, Darmstadt, Germany, [3]Centre for Plasma Physics & Lasers (CPPL), T.E.I. of Crete, Rethymnon, Greece, [4]Institute of Laser Engineering, Osaka Univ., Osaka, Japan, [5]ETSI Aeronáutica y del Espacio, Univ. Politécnica de Madrid, Madrid, Spain, [6]Laboratoire LULI, UMR 7605, Palaiseau, France, [7]Department of Physics, Univ. Oxford, Oxford, UK, [8]Department of Physics, Univ. York, Heslington, UK, [9]CEA, Saclai, France, [10]Institute of Plasma Physics and Laser Microfusion, Warsaw, Poland, [11]Institute of Plasma Physics of the CAS, Prague, Czech Republic, [12]Institute of Physics of the CAS, Prague, Czech Republic, [13]National Research Nuclear University MEPhI, Moscow, Russian Federation, [14]Fac. Nucl. Sci. & Phys. Engineering, Czech Technical Univ., Prague, Czech Republic, [15]Fac. Electrical Engineering, Czech Technical Univ., Prague, Czech Republic

We present studies and optimization prospects of a robust open-geometry platform for generation of ultra-strong magneto-static fields in an all-optical principle. A ns-laser pulse of several hundred Joule is tightly focused at 10^{17} W/cm^2 to drive a target discharge. The subsequently rising return current of up to hundreds of kA is guided by the coil-like target geometry and induces a strong magnetic field up to the order of kT.

HEDS4-04

Near-accelerator quality beams of high energy protons guided by intense-laser driven helical coils

Hamad Ahmed[1], Prokopis Hadjisolomou[1], Simon Ferguson[1], Stephanie Brauckmann[2], Domenico Doria[1], Aaron Alejo[1], Thomas Hodge[1], Rajendra Prasad[2], Mirela Cerchez[2], Oswald Willi[2], Marco Borghesi[1], Satyabrata Kar[1]
[1]School of Mathematics and Physics, Queen's University Belfast, [2]Institut für Laser-und Plasmaphysik, Heinrich-Heine-Universität, Düsseldorf, Germany

Laser-driven ion accelerators have been envisioned as a promising alternative to conventional sources, however, some of the shortcomings of the ion beams pose significant technical challenges to their applicative use. The helical coil targets in this context device a miniature and versatile setup for controlling effectively the spectral and angular properties of the proton beams, and delivering high energy beams of accelerator-quality.

[HEDS5]
Laser indirect drive ICF

Chair: Sebastien Le Pape
Ecole Polytechnique

HEDS5-01

Progress towards ignition at the NIF

Alex Zylstra[1], Omar Hurricane[1], Debbie Callahan[1], Annie Kritcher[1], Ben Bachmann[1], Kevin Baker[1], Laura Berzak Hopkins[1], Richard Bionta[1], Tom Braun[1], Dan Casey[1], Dan Clark[1], Eddie Dewald[1], Laurent Divol[1], Tilo Doeppner[1], Verena Geppert Kleinrath[2], Denise Hinkel[1], Matthias Hohenberger[1], Casey Kong[3], Shahab Khan[1], Otto Landen[1], Sebastien Le Pape[1], Brian MacGowan[1], Derek Mariscal[1], Kevin Meaney[2], Abbas Nikroo[1], Art Pak[1], Prav Patel[1], Louisa Pickworth[1], Joe Ralph[1], Neal Rice[3]
[1]Lawrence Livermore National Laboratory, [2]Los Alamos National Laboratory, [3]General Atomics

Record fusion yields on NIF were produced with designs that utilized high-density-carbon (HDC) capsules and low-gas-fill hohlraums. These campaigns explored design parameters including adiabat, velocity, and coast time, and simple scaling relations suggest that increasing the capsule size could be a favorable tactic to further increase performance. In this talk, we report progress towards increasing implosion performance on NIF using this approach.

HEDS5-02

Impact of localized radiative loss on ICF implosions

Arthur Pak[1], L. Divol[1], C. R. Weber[1], L. F. Berzak Hopkins[1], D. S. Clark[1], E. L. Dewald[1], D. N. Fittinghoff[1], V. Geppert-Kleinrath[2], M. Hohenberger[1], S. Le Pape[1], T. Ma[1], A. MacPhee[1], D. Mariscal[1], E. Marley[1], A. Moore[1], L. Pickworth[1], P. Volegov[2], C. Wilde[2], O. Hurricane[1], P. Patel[1]
[1]Lawrence Livermore National Laboratory, [2]Los Alamos National Laboratory

The degradation to fusion energy production from radiative loss is found to be linearly proportional to the fraction of the total emission that is associated with injected ablator material and that this radiative loss has been the primary source of variations, of up to 1.6X, in observed fusion energy production.

HEDS5-03

Laser Plasma Instability in Indirect-Drive Inertial Confinement Fusion on Shenguang Laser Facilities

Dong Yang
Laser Fusion Research Center, China Academy of Engineering Physics

A new experimental platform octuplet has been developed to study LPI under laser configurations close to the future.

[HEDS6]
Strong shock

Chair: Arthur E. Pak
Lawrence Livermore National Laboratory

HEDS6-01

Spherical Shock-Wave Experiments on the OMEGA Laser

John Ruby[1], James Ryan Rygg[1], David Alex Chin[1], Chad Forrest[1], Vladmir Glebov[1], Christian Stoeckl[1], Neel Kabadi[2], Patrick Adrian[2], Benjamin Bachmann[3], Yuan Ping[3], Jim Gaffney[3], Gllbert Collins[1]
[1]Laboratory for Laser Energtics, University of Rochester, Rochester, NY, USA, [2]Plasma Science and Fusion Center, Massachusetts Institute of Technology, Cambridge, MA, USA, [3]Lawrence Livermore National Laboratory, Livermore, CA, USA

The analysis of spherical shock wave experiment from the omega laser system using integrated models is presented. Self-emission data is used to constrain the energy balance of a spherical shock wave in different systems.

HEDS6-02

Laser-driven compression of water, ammonia, and C:H:N:O mixtures of interest for Icy Giants interiors

Alessandra Ravasio
LULI Laboratory

We will present the results obtained using laser-based compression schemes on water, pure ammonia and C:H:N:O mixtures. Mbar pressures and few 1000 K temperatures have been reached with decaying shocks, a double-shock technique and through the coupling of dynamic and static compression in DAC. These results will be of most importance for models of icy planets.

HEDS6-03

The role of hot electrons on ultrahigh pressure generation relevant to shock ignition conditions of inertial confinement fusion targets

Keisuke Shigemori[1], Koki Kawasaki[1], Yoichiro Hironaka[1], Yuto Maeda[1], Toshihiro Iwasaki[1], Norimasa Ozaki[2], Ryosuke Kodama[1,2], Dimitri Batani[3], Jocelain Trela[3], Phillipe Nicolai[3], Hideo Nagatomo[1]
[1]Institute of Laser Engineering, Osaka University, [2]Graduate School of Engineering, Osaka University, [3]Centre Lasers Intenses et Applications, University of Bordeaux

We performed an experiment on ultrahigh pressure generation with hot electrons produced by high-intensity laser plasma interactions.

[HEDS7]
Fast isochoric heating & ICF

Chair: Felicie Albert
Lawrence Livermore National Laboratory

HEDS7-01

Present status of plasma heating experiments by counter illuminating ultra-intense laser pulses

Yoshitaka Mori[1], Akifumi Iwamoto[2], Hiroshi Sawada[3], Katsuhiro Ishii[1], Ryohei Hanayama[1], Yoneyoshi Kitagawa[1], Takayoshi Sano[4], Natsumi Iwata[4], Yasuhiko Sentoku[4], Atsushi Sunahara[5], Yuito Ota[6], Itsuki Nakau[6], Yoshihiro Kajimura[6]
[1]The Graduated School for the Creation of New Photonics Industries, [2]National Institute for Fusion Science, [3]Univsersity of Nevada Reno, [4]Institute of Laser Engineering, Osaka University, [5]Center for Materials Under eXtream Environment (CMUXE)Purdue University, [6]National Institute of Technology, Akashi College

Present status of counter illuminating fast heating schemes using Ti-Sapphire laser system 0.8 J/100 fs are presented.

HEDS7-02

Direct observation of the fast electron transport in a pre-compressed core with the super-penetration scheme

Tao Gong[1,4], Hideaki Habara[1], Kohei Sumioka[1], Yasunobu Arikawa[1], Shinsuke Fujioka[1], Hiroyuki Shiraga[1], Mingsheng Wei[2], Kazuo A Tanaka[1,3]
[1]Osaka University, [2]University of Rochester, [3]ELI-NP, [4]Laser Fusion Research Center

The transport of fast electrons in a pre-compressed core was directly observed through the excited Cu Kα emission in an integrated experiment with the super-penetration scheme on GEKKO-LFEX laser facility at Osaka University. Our simulations well reproduced the experimental measurements, which indicated that about 1% of the short-pulse energy was deposited in the core with a radius of 70 μm.

HEDS7-03

Fast isochoric heating mechanism visualized with spatial-temporal-resolved x-ray imaging

Shinsuke Fujioka[1], Ryunosuke Takizawa[1], Mao Takemura[1], Yuki Abe[1], Baojun Zhu[1], Hiroki Morita[1], Kazuki Matsuo[1], King Fai Farley Law[1], Junyun Dun[1], Tomoyuki Johzaki[2], Hiroshi Sawada[3], Shuwang Guo[1], Naoki Higashi[1], Alessio Morace[1], Akifumi Yogo[1], Natsumi Iwata[1], Takayoshi Sano[1], Atsushi Sunahara[4], Hitoshi Sakagami[5], Tetsuo Ozaki[5], Kunioki Mima[6], Kohei Yamanoi[1], Koji Tsubakimoto[1], Shigeki Tokita[1], Yoshiki Nakata[1], Jyuunji Kawanaka[1], Mitsuo Nakai[1], Hiroyuki Shiraga[1], Hiroshi Azechi[1], Hideo Nagatomo[1]
[1]Institute of Laser Engineering, Osaka University, [2]Graduate School of Engineering, Hiroshima University, [3]Department of Physics, University of Nevada, [4]CMUXE, Purdue University, [5]National Institute for Fusion Science, [6]The Graduate School for the Creation of New Photon Industries

Here we report the mechanism of plasma heating by magnetized fast-isochoric (MFI) heating scheme. The mechanism was visualized experimentally by combining several spectroscopic and spatially- and temporally-resolved X-ray imaging techniques.

Program

HEDS

Program

HEDS7-04

Fast electron energy reduction triggered by dense plasma ablation in multi-picosecond relativistic laser plasma interaction

Naoki Higashi[1,2], Natsumi Iwata[2], Takayoshi Sano[2], Atsushi Sunahara[2,3], Kunioki Mima[2,4], Yasuhiko Sentoku[2]
[1]Department of Physics, Graduate School of Science, Osaka University, [2]Institute of Laser Engineering, Osaka University, [3]CMUXE, Purdue University, [4]The Graduate School for the Creation of New Photon Industries

A dense plasma ablation happens in the continuous plasma heating with a relativistic multi-picosecond laser light. The ablation plasma has an extremely pressure beyond the laser photon pressure, thus the laser-plasma interface is pushed backward resulting the fast electron energy reduction.

HEDS7-05

Achieving low fuel entropy in layered implosions on the National Ignition Facility

Brian Michael Haines
Los Alamos National Laboratory

Achieving ignition with 2MJ of laser energy requires reducing the fuel layer entropy to increase energy coupling to the hot spot. We use simulations of implosions that resolve mixing to study the impact of instability growth on implosion adiabat, which is increased by up to 30% over the design adiabat. The modeling of these processes brings the areal density inferred by simulation in line with experimental measurements. The results imply smoother capsules are needed.

[HEDS8]
High intensity laser physics
Chair: Keisuke Shigemori
ILE, Osaka University

HEDS8-01

Status of Extreme Light Infrastructure: Nuclear PhysicsStatus of Extreme Light Infrastructure: Nuclear Physics

Kazuo A. Tanaka, I Dancus, Marian Toma, Dan Stutman, Dimiter Balabanski, Ovidiu Tesileanu, Calin A Ur, N Victor Zamfir
Extreme Light Infrastructure: Nuclear Physics (ELI-NP)

Since the European Strategy Forum on Research Infrastructures (ESFRI) has selected in 2006 a proposal based on ultra-intense laser fields with intensities reaching up to 10^{22}–10^{23} W/cm^2 the construction has started at ELI-NP in 2012 based on the European Commission and the Romanian Government from Structural Funds via the European Regional Development Fund (ERDF).

HEDS8-02

Laser-plasma acceleration with superluminal laser pulses

Cedric Thaury[1], Clement Caizergues[1], Kosta Oubrerie[1], Slava Smartsev[2], Victor Malka[2], Julien Gautier[1], Jean-Philippe Goddet[1], Kim Ta-Phuoc[1], Amar Tafzi[1]
[1]Laboratoire d'Optique Appliquee, Ecole polytechnique - ENSTA - CNRS - Institut Polytechnique de Paris, 828 Boulevard des Marechaux, 91762 Palaiseau, France, [2]Department of Physics of Complex Systems, Weizmann Institute of Science, Rehovot 7610001, Israel

We propose a new acceleration concept, based on the use of diffraction-free superluminal laser pulses, which allows to cope with the three phenomena that limit the beam energy in a laser-plasma accelerator.

HEDS8-03

Electron- and Ion-Heating by Whistler Waves in Magnetized Overdense Plasmas

Takayoshi Sano[1], Masayasu Hata[1], Natsumi Iwata[1], Daiki Kawahito[2], Shinsuke Fujioka[1], Yoshitaka Mori[3], Kunioki Mima[1,3], Yasuhiko Sentoku[1], Ryosuke Kodama[1]
[1]Institute of Laser Engineering, Osaka University, [2]Center for Energy Research, University of California, San Diego, [3]The Graduate School for the Creation of New Photonics Industries

We have examined the plasma interaction with whistler waves by Particle-in-Cell simulations and demonstrated the whistler waves could be an efficient heating mechanism for overdense plasmas.

HEDS8-04

Laser driven sheath fields and associated MHz-THz

David Neely
Central Laser Facility, UKRI

The relationship between the escaping currents of relativistic hot electrons and the generation of GW power level THz pulses and strong EMP fields from ps duration laser driven solid targets is explored.

[HEDS9]
Laser particle acceleration
Chair: Natsumi Iwata
Osaka University

HEDS9-01

Recent Results and Future Prospects for High-Energy Density Laboratory Plasma Studies with NIF-ARC

Tammy Ma[1], Derek Mariscal[1], Felicie Albert[1], David Alessi[1], Hui Chen[1], Nuno Lemos[1], Graeme G. Scott[1], Dan Kalantar[1], Andreas Kemp[1], Shaun Kerr[1], Constantin Haefner[1], Mark R. Hermann[1], Sandrine Herriot[1], Mario Manuel[2], Andrew J. Mackinnon[1], Andrew G. MacPhee[1], David Martinez[1], Chris Mcguffey[3], Alessio Morace[4], David Neely[5], Dean Rusby[1], Riccardo Tommasini[1], Mingsheng Wei[6], Scott Wilks[1], G. Jackson Williams[1]
[1]Lawrence Livermore National Laboratory, [2]General Atomics, [3]University of California, San Diego, [4]Osaka University, [5]Central Laser Facility, Rutherford Appleton Laboratory, [6]Laboratory for Laser Energetics, University of Rochester

Large-scale, petawatt-class short-pulse laser facilities such as the Advanced Radiographic Capability (ARC) at the National Ignition Facility (NIF) open new frontiers in High-Energy Density Laboratory Plasmas (HEDLP). We will provide an overview of experimental results from NIF-ARC since its commissioning in 2015, and discuss future prospects in laser capabilities and HEDLP studies.

HEDS9-02

Continuous field acceleration of ions from multi-picosecond short pulse lasers to achieve high energy particles

Joohwan Kim[1], Scott Wilks[2], Tammy Ma[2], Andreas Kemp[2], Farhat Beg[1], Derek Mariscal[2]
[1]University of California San Diego, [2]Lawrence Livermore National Laboratory

In the new concept of ion acceleration, a sufficient hot electron population near the ion beam front continuously drives the significant electric field for a long time scale leading to further acceleration of ions. The details of computational studies will be presented.

HEDS9-03

Lateral confinement of high energy electrons in intense laser-thin foil interactions

Kunioki Mima[1], N. Iwata[2], Yasuhiko Sentoku[2], Andreas Kemp[3], Scott Wilks[3], Tammy Ma[3], Ming Chen[4]
[1]The Graduate School for the Creation of New Photonics Industries, [2]ILE, Osaka University, [3]Lawrence Livermor National Laboratory, [4]Shanghai Jaotong University

This paper will present the mechanism by which the sloshing high energy electrons are confined in the laser focal spot of the thin foil. The confinement is due to the random walk of high energy electrons scattered by the electromagnetic fluctuations in the thin foil. The lateral expansion velocity of high energy electrons is highly suppressed by the random scattering.

[HEDS10]
Ion acceleration
Chair: Alexander S. Pirozhkov
KPSI, QST

HEDS10-01

Ion acceleration and collimation driven by high intensity laser field from micro-tube target

Daiki Kawahito[1], Mathieu Bailly-grandvaux[1], Alexey Arefiev[1,2], Jposeph Strehlow[1], Farhat N Beg[1,2]
[1]Center for Energy Research, University of California, San Diego, [2]Department of Mechanical and Aerospace Engineering, University of California, San Diego

In response to the use of high laser intensities (>10^{21} W/cm^2) to enhance a high energy ion beam, there has been growing interest in using structured targets. We will present PIC simulation results of the ion acceleration mechanism from the micro-tube target and the optimization of the tube size and the laser parameters for the ion energy.

HEDS10-02

A new laser target that produces collimated and accelerated proton bunches

Matthieu Bardon[1], Julien Moreau[1], Christophe Rousseaux[2], Lorenzo Romagnani[3], Michel Ferri[1], Frederic Lefèvre[3], Mathieu Chevrot[3], Emilie Loyez[3], Daniel Farcage[4], Bertrand Etchessahar[1], Sébastien Bazzoli[2], Isabelle Lantuejoul[2], Witold Cayzac[2], Nathalie Blanchot[1], Benjamin Vauzour[2], Gaetan Sary[2], Antoine Compant-La-Fontaine[2], Laurent Gremillet[2], Jacques Gardelle[1], Olivier Cessenat[1], Emmanuel D'Humières[5], Vladimir Tikhonchuk[5,6]
[1]CEA-CESTA, [2]CEA-DIF, [3]LULI, [4]CEA-Saclay, [5]CELIA, [6]ELI-Beamlines

We present the results of the PACMAN 1 campaign carried out at the LULI2000 facility, in March 2019, where the pico2000 laser beam (70 J, 1 ps) irradiated gold foils attached to helixes of different diameters, lengths or pitches. The experimental data are compared to the results of numerical simulations carried out with the PIC code SOPHIE developed at the CEA.

HEDS10-03

Quasimonoenergetic protons driven by CSBA (converging shock-induced blow-off acceleration) in a micron-scale hydrogen cluster

Ryutaro Matsui[1], Yuji Fukuda[2], Yasuaki Kishimoto[1]
[1]Kyoto university, [2]Kansai Photon Science Institute (KPSI), National Institutes for Quantum and Radiological Science and Technology (QST)

We propose a new approach to produce highly-directional, highly-reproducible, impurity free, quasi-monoenergetic protons exceeding 200 MeV utilizing the micron-scale spherical hydrogen cluster.

[HEDS11]
High energy density hydrodynamics
Chair: Christopher A. Walsh
Imperial College London / Lawrenve Livermore National Laboratory

HEDS11-01

Plasma collision in a gas atmosphere

Sebastien Le Pape[1,2], L. Divol[1], G. Huser[3], J. Katz[4], J. R. Ross[1], R. Wallace[1], S. Wilks[1]
[1]Lawrence Livermore National Laboratory, CA 94550, USA, [2]2 LULI–CNRS École Polytechnique, CEA, Université Paris-Saclay, UPMC Univ Paris 06, Sorbonne Universités, F-91128 Palaiseau cedex, France, [3]CEA,DAM,DIF, Bruyeres-le-Chatel, F-91297 Arpajon, France, [4]Laboratory for Laser Energetics, University of Rochester, 250 East River Road, Rochester, New York 14623, USA

Plasma collisions are present in a large range of conditions which impact the characteristics of the collision. We present a study on the impact of a gas atmosphere on the collision of two counter propagating plasmas. We observe the interpenetration of the two plasma in the vacuum while they stay separated once helium is added. The presence of helium is enough to transition from an interpenetrating regime to a regime in better agreement with a hydrodynamic description.

HEDS11-02

Laboratory demonstration of inductive ion energization in Rayleigh-Taylor unstable plasma envelopes expanding in a magnetized ambient medium

Julien Fuchs[1], Guyot Julien[2], Revet Guilhem[1], Ciardi Andrea[2]
[1]CNRS-Ecole Polytechnique, [2]CNRS-Sorbonne Université

We will present the result of an experiment which used two collimated plasma jets propagating collinearly to a strong (20 T) magnetic field and which are made to collide within a low-density ambient gas. The collision triggers the heating of the colliding plasmas, inducing fast radial expansion of plasma into the ambient. The envelope at the edge of the expansion is unstable to the Rayleigh-Taylor instability, which drives the growth of plasma fingers within the ambient.

HEDS11-03

Unique regimes of hydrodynamic instabilities and mixing in high energy density settings

Bruce A Remington
Lawrence Livermore National Laboratory

The Rayleigh-Taylor (RT) instability is being studied experimentally, comparing classical with ablatively stabilized RT evolution using a soft x-ray drive. Rayleigh-Taylor instabilities have been studied in indirect drive, direct drive, with and without effects of laser imprinting, with radiative shock stabilization, with an embedded magnetic field, and with material strength stabilization. Examples from the above will be given.

HEDS

[HEDS12]
Laser produced x-ray & applications

Chair: Cedric Thaury
LOA - Insitut Polytechnique de Paris

HEDS12-01

X-ray Sources from Self-modulated Laser Wakefield Acceleration: Applications in High Energy Density Sciences

Felicie Albert
Lawrence Livermore National Laboratory

This work discusses the development of x-ray and gamma-ray sources based on laser-wakefield acceleration (LWFA) in the self-modulated regime. These sources are developed for probing high energy density (HED) science experiments at large-scale laser facilities.

HEDS12-02

Absolute yield and conversion efficiency in X-ray keV range of over dense Si PW laser plasma.

Sergey Nikolayevich Ryazantsev[1,2], Sergey Vasil'evich Popruzhenko[3], Artem Sergeyevich Martynenko[2], Mikhail Dmitrievich Mishchenko[1,2], Igor Yuryevich Skobelev[2,1], Tatiana Aleksandrovna Pikuz[4,2], Anatoly Yakovlevich Faenov[4,2], Philip Durey[5], Leo Doehl[5], Damon Farley[5], Chris Baird[5], Kate Lancaster[5], Chris Murphy[5], Paul McKenna[6], Ryosuke Kodama[7,8], Nigel Woolsey[5], Sergey Alekseevich Pikuz[2,1]
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Absolute values and angular distribution of keV X-ray source intensity created by PW-laser linearly polarized radiation in Si foils were obtained experimentally. It is shown ~0.5 J of the laser energy converts to x-rays with photon energies from1.65 to 2.75 keV. The angular distribution is strongly elongated along a laser radiation polarization axis and asymmetrical with respect to it.

HEDS12-03

Hard x-ray generation at intensity approaching 10^{22} W/cm^2

Alexander S. Pirozhkov[1], K. Ogura[1], C. Armstrong[2], D. Neely[2,3], T. Zh. Esirkepov[1], A. Sagisaka[1], T. Hayakawa[4], W. Yan[5], T.M. Jeong[5], S. Singh[5,6], P. Hadjisolomou[5], O. Finke[5], D. Kumar[5], G. Grittani[5], M. Nevrkla[5], C. Lazzarini[5], J. Nejdl[5], A. Velyhan[5], A. N. Shatokhin[7,8], E. A. Vishnyakov[7], A. O. Kolesnikov[7,8], E. N. Ragozin[7], T. A. Pikuz[9,10], M. A. Alkhimova[10], S. A. Pikuz[10], B. Gonzalez Izquierdo[1], Y. Fukuda[1], J. K. Koga[1], M. Ishino[1], Ko. Kondo[1]
[1]KPSI QST, [2]CLF RAL, [3]University of Strathclyde, [4]Tokai Quantum Beam Science Center, QST, [5]ELI-Beamlines, [6]Institute of Plasma Physics ASCR, [7]P.N. Lebedev Physical Institute, [8]Moscow Institute of Physics and Technology (State University), [9]Osaka University, [10]Joint Institute for High Temperatures

Efficient generation of ~MeV x-rays in the Gamma Flare regime in preplasma via the nonlinear Thomson/inverse Compton scattering mechanism is one of the most promising and expected high-power laser applications. We describe our experiment performed with the J-KAREN-P laser, with the emphasis on data from the hard x-ray spectrographs, and our efforts to distinguish the generation mechanism.

HEDS12-04

Recent development on Laser-produced MeV Positron Experiments

Hui Chen
Lawrence Livermore National Laboratory

Substantial progress has been made recently on laser produced relativistic electron-positron pair jets and plasmas, including the completion the first campaign on NIF ARC; positron acceleration on Gekko LFEX laser; pair yield on Omega EP lasers. This talk will review the new results and describe plans for future development. This work was performed under US DOE by LLNS, LLC, under Contract No. DE-AC52-07NA27344 and funded by LDRD 17-ERD-010.

[HEDS13]
X-ray and atomic physics

Chair: Julien Fuchs
Ecole Polytechnique

HEDS13-01

The role of atomic physics on the ionization and heating of laboratory photoionized plasmas

Roberto C. Mancini[1], D. C. Mayes[1], K. J. Swanson[1], G. P. Loisel[2], J. E. Bailey[2], G. A. Rochau[2], J. Abdallah, Jr[3], I. E. Golovkin[4], D. Liedahl[5]
[1]Physics Department, University of Nevada, [2]Sandia National Laboratories, [3]Los Alamos National Laboratory, [4]Prism Computational Sciences, [5]Lawrence Livermore National Laboratory

Ionization, x-ray heating, photoelectron thermalization, and the determination of plasma temperature are fundamental problems of photoionized plasmas. Guided by experimental observation we seek to test and establish what physics models are needed to address these issues.

HEDS13-02

Femtosecond observation on electron-hole equilibrium in warm dense copper using an XFEL

Jong-Won Lee[1,2], Gyoung Bo Kang[1,2], Min Ju Kim[1], Min Sang Cho[1], Min Seok Kim[3], Sam Vinko[4], Sang Han Park[3], Soon Nam Kwon[3], Byoung-Ick Cho[2,1]
[1]Gwangju Institute of Science and Technology, [2]Institute for Basic Science, [3]Pohang Accelerator Laboratory, [4]University of Oxford

We present a recent femtosecond x-ray absorption spectroscopy to investigate the electron-hole equilibrium processes during the nascent formation of warm dense copper. The experiment was performed at the Soft x-ray Scattering and Spectroscopy (SSS) station at the PAL-XFEL. In this presentation, we also introduce a fast modification of x-ray absorption in Cu d-band and detailed analysis based on DFT calculation.

HEDS13-03

In-situ X-ray diffraction measurements of shock-induced deformation in nano-polycrystalline diamond

Kento Katagiri[1], Leora Eve Dresselhaus-Cooper[2], Jon H. Eggert[2], Yuichi Inubushi[3], Tetsuo Irifune[4,5], Michel Koenig[6], Ryosuke Kodama[1,7], Takeshi Matsuoka[8], Kohei Miyanishi[9], Nishiyama Norimasa[10], Toshimori Sekine[11], Yusuke Seto[12], Keiichi Sueda[9], Yoshinori Tange[3], Tadashi Togashi[3], Yuhei Umeda[1], Makina Yabashi[9], Toshinori Yabuuchi[3], Norimasa Ozaki[1,7]
[1]Graduate School of Engineering, Osaka University, [2]Lawrence Livermore National Laboratory, [3]Japan Synchrotron Radiation Research Institute, [4]Geodynamics Research Center, Ehime University, [5]Earth-Life Science Institute, Tokyo Institute of Technology, [6]LULI, CNRS, Ecole Polytechnique, [7]Institute of Laser Engineering, Osaka University, [8]Open and Transdisciplinary Research Initiatives, [9]RIKEN SPring-8 Center, [10]Laboratory for Materials and Structures, Tokyo Institute of Technology, [11]Center for High-Pressure Science and Technology Advanced Research, [12]Graduate School of Science, Kobe University

A series of laser-shock experiments were performed to reveal the deformation pathway in nano-polycrystalline diamond (NPD). In-situ X-ray diffraction measurements were obtained to quantify the complex elastic-plastic deformation in NPD using the ultrafast high-intensity X-ray pulses generated by an X-ray free electron laser (XFEL).

HEDS13-04

Novel Approach to Schwinger Field and Mega-Tesla Magnetic Field by Microbubble Implosion

Masakatsu Murakami[1], Javier Honrubia[2], Katheleen Weichman[3], Alex V. Arefiev[3], Sergey V. Bulanov[4]
[1]ILE, Osaka University, [2]ETSI, Universidad Politecnica de Madrid, [3]University of California San Diego, [4]Institute of Physics ASCR, ELI BEAMLINES

We propose a new principle to generate ultrahigh magnetic fields of the order of mega-Tesla. First, we prepared a hollow cylindrical target surrounded by a solid material, which is then irradiated by ultrashort ultraintense laser pulse. As a result, ultrahigh magnetic fields ~ 1-2 mega-Tesla have been demonstrated by the open source code EPOCH-2D.

[HEDSp]
Poster Session

HEDSp-01

Laser driven magnetic reconnection experiment with double wire target.

Daniil Olegovich Golovin[1], Yogo Akifumi[1,2], Binghe Shi[1], Yuki Abe[1], Yuki Honoki[1], Keisuke Koga[1], Seyed Reza Mirfayzi[1], Takato Mori[1], Keisuke Okamoto[1], Satoru Shokita[1], Yasunobu Arikawa[1], Anatoly Yakovlevich Faenov[1,3], Tatiana Aleksandrovna Pikus[1,3], Ryosuke Kodama[1,3]
[1]Institute of Laser Engineering, Osaka University, [2]PRESTO, Japan Science and Technology Agency, [3]Graduate School of Engineering

In this work we use specially designed target consist of aluminum foil and two copper wires attached to it rear side to investigate the possibility of MR in the region between the wires.

HEDSp-02

Effects of Laser and Plasma Parameters on Electron Beam Quality in Ionization Injection Laser Plasma Acceleration

Driss Oumbarek Espinos[1,2], Yasuhiko Sentoku[1], Amin Ghaith[2], Charles Kitégi[2], Mourad Sebdaou[2], Alexandre Loulergue[2], Fabrice Marteau[2], Frédéric Blache[2], Mathieu Valléau[2], Marie Labat[2], Alain Lestrade[2], Eléonore Roussel[4], Cédric Thaury[3], Sébastien Corde[3], Guillaume Lambert[3], Olena Kononenko[3], Jean Philippe Goddet[3], Amar Tafzi[3], Victor Malka[3,5], Ryosuke Kodama[1], Marie Emmanuelle Couprie[2]
[1]Graduate School of Engineering, Osaka University, [2]Synchrotron SOLEIL, [3]Laboratoire d'Optique Appliquée, Ecole polytechnique, [4]Universite Lille, [5]Weizmann Institute of Science

We report here on the effects of plasma (density, different gas ratio) and laser parameters (beam profile, peak intensity) on the electron beam quality, by means of 1D PIC simulations using PICLS code. We also present electron spectrometer and imager measurements of Ionization injection produced electrons beams obtained in the Free Electron Laser experiment COXINEL and compare with the simulation results.

HEDSp-03

Picosecond Laser-Driven Transient Electromagnetic Fields for High Energy-Density Beam Tailoring

Michael EHRET
CELIA UMR5107, Univ. Bordeaux, France & IKP, TU-Darmstadt, Germany

Transient electromagnetic fields are driven by ultra-intense sub-ps laser pulses of several tens of Joule at 10^{19} W/cm^2 from thin solid density targets. Laser interaction leads to target discharge and subsequent pulsed propagation of the potential following the target geometry. An interplay of this discharge wave and rising return currents induces magnetiv fields of several tens of Tesla and electric fields on the order of GV/m.

HEDS

HEDSp-04

PIC simulation for dense high Z plasma formation with ultrashort petawatt laser including radiation processes

Kaoru Sugimoto[1,2], Naoki Higashi[1,2], Natsumi Iwata[2], Atsushi Sunahara[3], Takayoshi Sano[2], Yasuhiko Sentoku[2]
[1]Department of Physics, Graduate School, Osaka University, [2]Institute of Laser Engineering, [3]Center for Materials Under eXtrem Environment, School of Nuclear Engineering, Purdue University

We simulated laser-plasma interaction between a silver foil target and petawatt laser using PIC code PICLS including radiation processes. The highly charged silver plasma with pressure ~ 10 petapascal have been formatted by irradiating a petawatt laser with peak intensity 10^{21}W/cm^2 in 30 femtoseconds. The energy stored in the hot silver plasma is released as hard x-rays photons in a few picosecond time scale with radiation intensity of 10^{17} W/cm^2.

HEDSp-05

Ab-initio Calculation for Electrical Conductivity of Warm Dense Gold

Hiroki Morita[1], Tadashi Ogitsu[2], Suxing Hu[3], Shinsuke Fujioka[1], Frank Graziani[2]
[1]Institute of Laser Engineering, Osaka University, [2]Lawrence Livermore National Laboratory, [3]Laboratory for Laser Energetics, University of Rochester

We calculated the electrical conductivity of the warm dense gold at the solid density with *ab-initio* calculation. The results showed that the conductivity of the warm dense gold takes a constant value of 10^6 S/m in the several eV regime in the temperature. Further, it was found that the conductivity of WDM strongly depends on the atomic configuration.

HEDSp-06

"Nuclear Photonics" Activities in ILE

Akifumi Yogo
Institute of Laser Engineering, Osaka University

We are exploring Nuclear Photonics by using a laser-driven neutron source (LDNS) exhibiting two outstanding characteristics, compactness (5 mm) and short duration (1 ns), which are unique compared to conventional neutron sources. Here, we have generated 2×10^{11} neutrons in the range of MeV energy in a single laser shot.

HEDSp-07

Designing for the beam transport system with Laser-driven ion beam using 3D PIC code WARP

Tatsuhiko Miyatake[1], Hironao Sakaki[2], Kotaro Kondo[2], Mamiko Nishiuchi[2], Sadaoki Kojima[2], Takayuki Sako[3], Shinya Matsuda[3], Yukinobu Watanabe[1], Toshiyuki Shirai[2], Masaki Kando[2], Kiminori Kondo[2]
[1]Kyushu University, [2]QST, [3]Toshiba Energy Systems & Solutions Corporation

QST aims to develop a small ion injector using a laser-driven ion acceleration mechanism. In order to use this mechanism as an injector, it is necessary to design the characteristics of the beam to match the accelerator at the subsequent stage. Therefore, we are preparing for the benchmarking of 3D PIC code (WARP) by laser-driven ion acceleration, and report the progress.

HEDSp-08

Denoising technique of an in-line electron energy spectrometer based on feature filtering

Hironao Sakaki[1,2], Keiichiro Shiokawa[2], Tatsuhiko Miyatake[2], Mamiko Nishiuchi[1], Kotaro Kondo[1], Nicholas Peter Dover[1], Hazel Frances Lowe[1], Akira Kon[1], Masaki Kando[1], Yukinobu Watanabe[2]
[1]National Institutes for Quantum and Radiological Science and Technology, [2]Kyusyu University

We developed new denoising technique for the electron spectrometer at experiment of laser-driven ion acceleration.This technique is the feature filtering based on Deep-Learning. We show the denoising performance of the feature filtering compared with "Median filter" which is generally used for filtering of radiation noise.

HEDSp-09

Dense Material Heating by Relativistic Electrons Generated in Multi-Pico-Seconds Relativistic Laser-Plasma Interactions Under Converging Magnetic Field

Tomoyuki Johzaki[1,2], Shijuro Takeda[1], Masaya Hino[1], Wookyung Kim[1], Takuma Endo[1], Shinsuke Fujioka[2], Hideo Nagatomo[2], Yasuhiko Sentoku[2], Atsushi Sunahara[3,4]
[1]Hiroshima University, [2]Osaka University, [3]Purdue University, [4]Institute for Laser Technology

Material heating properties by laser-accelerated electron beam are numerically evauated. To intensify the electron beam with large divergence, we consider use of kilo-tesla-class converging magnetic field. In addition to the intensification effect, we observed the confinement of fast electrons inside of the target due to the mirror field reflection and the kick-back by the multi-ps laser pulse. Both effects enhance the heating efficiency drastically.

HEDSp-10

High-resolution radiography of Rayleigh –Taylor instabilities induced by high-power-laser pulses

Tatiana Pikuz[1,3], Gabriel Rigon[2], Bruno Albertazzi[2], Paul Mabey[2], Victorien Bouffetier[4], Norimasa Ozaki[5], Tommaso Vinci[2], Emeric Falize[7], Yoshinori Inubushi[8,9], N Kakimura[5], Kento Katagiri[5], Sergey Makarov[3,10], Mario Manuel[2,11], Kohei Miyanishi[9], Sergey Pikuz[3,12], Olivier Poujade[7], Yuhei Umeda[5], K Sueda[9], Takeshi Matsuoka[1], Tadashi Togashi[8,9], Makino Yabashi[8,9], Toshinori Yabuuchi[8,9], Gianluca Gregori[13], Ryosuke Kodama[5,6], Alexis Casner[4], Michel Koenig[2]
[1]Institute for Open and Transdisciplinary Research Initiative, Osaka University, Suita, Osaka, Japan, [2]LULI, CNRS, CEA, Ecole Polytechnique, UPMC, Univ Paris 06: Sorbonne Universites, Institute Polytechnique de Paris, Palaiseau, France, [3]Joint Institute for High Temperature RAS, Moscow, Russia, [4]Univerité de Bordeaux-CNRS-CEA, CELIA, Talence, France, [5]Graduate School of Engineering, Osaka University, Suita, Osaka, Japan, [6]Institute of Laser Engineering, Osaka University, Suita, Osaka Japan, [7]7CEA-DAM, DIF, Arpajon, France, [8]Japan Synchrotron Radiation Research Institute, Hyogo, Japan, [9]RIKEN SPring-8 Center, Hyogo, Japan, [10]Lomonosov Moscow State University, Moscow, Russia, [11]General Atomics, Inertial Fusion Technologies, San Diego, USA, [12]National Research Nuclear University (MEPhI) Moscow, RUSSIA, [13]Department of Physics, University of Oxford, Oxford, UK

Dynamics of Rayleigh-Taylor instabilities up to turbulence stage investigated with spatial resolution ~ 1 micron in the field of view greater than square mm by means of radiography based on XFEL beam and LiF detector.

HEDSp-11

Optimization of a cone-inserted target implosion for fast ignition with non-uniform laser irradiation

Hideo Nagatomo[1], Toshinori Matsukawa[1], Masayasu Hata[1], Tomoyuki Johzaki[2]
[1]Osaka University, [2]Hiroshima University

In the fast ignition of laser fusion, the compression of the DT fuel using implosion with cone-inserted target is important, which is strongly affected by the optimization of the second phase, ignition dynamic. We will show the optimum method for the compression.

HEDSp-12

Energetic ion beam dynamics in focusing devices and application to FIREX-I

Alessio Morace[1], Javier Honrubia[2], Yuki Abe[1], Derek Alexander Mariscal[3], Yasunobu Arikawa[1], Tomoyuki Johzaki[4], Tammy Ma[3], Natsumi Iwata[1], Yasuhiko Sentoku[1], Kunioki Mima[1], Akifumi Yogo[1], Shota Tosaki[1], Sadaoki Kojima[1], shohei sakata[1], SeungHo Lee[1], kazuki Matsuo[1], Yoshiki Nakata[1], takayoshi Norimatsu[1], Junichi Kawanaka[1], Shigeki Tokita[1], Noriaki Miyanaga[1], Hiroyuki Shiraga[1], Youichi Sakawa[1], Mitsuo Nakai[1], Hiroaki Nishimura[1], Hiroshi Azechi[1], Shinsuke Fujioka[1], Ryosuke Kodama[1]
[1]Institute of laser engineering, [2]Universidad Politecnica de Madrid, P.za del Cardenal Cisneros 3, Madrid, Spain, [3]Lawrence Livermore National Laboratory, 7000 East Avenue, Livermore, United States, [4]Hiroshima University, 1-3-2 Kagamiyama, Higashi Hiroshima, Japan

Studying the guiding and focusing [1] of energetic ion beams and their subsequent transport in dense plasmas [2] is important for the development of the ion based FIREX project as well as for applications to high energy density science.

HEDSp-13 *Withdraw*

HEDSp-14

Dependence of heating efficiency on pulse duration in magnetized fast ignition scheme

Ryunosuke Takizawa[1], Yuki Abe[1], Mao Takemura[1], Hiroki Morita[1], Baojun Zhu[1], Shuwang Guo[1], Jinyuan Dun[1], King Fai Farley Law[1], Kazuki Matsuo[1], Ayami Nakao[1], Shoui Asano[1], Chang Liu[1], Naoki Higashi[1], Natsumi Iwata[1], Noriaki Miyanaga[1], Tomoyuki Johzaki[1], Hiroshi Sawada[1], Yuki Iwasa[1], Sadaoki Kojima[1], Masayasu Hata[1], Takayoshi Sano[1], Hideo Nagatomo[1], Atsushi Sunahara[1], Alessio Morace[1], Akifumi Yogo[1], Mitsuo Nakai[1], Hitoshi Sakagami[2], Tetsuo Ozaki[2], Kohei Yamanoi[1], Takayoshi Norimatsu[1]
[1]Osaka University, [2]National Institute for Fusion Science

LDC

[LDC-0P]
Opning
Sunao Kurimura
NIMS
Opening Remarks

[LDC1]
Keynote 1
Chairs: Sunao Kurimura
NIMS
Kazuo Kuroda
Utsunomiya University

LDC1-01 *Keynote*

AR/VR based technologies and their applications
Jyrki Saarine
Univ. of Eastern Finland
AR/VR based technologies and their applications will be discussed.

LDC1-02 *Keynote*

Recent advances of InGaN laser diodes for high power applications
Stephan Haneder
OSRAM Opto Semiconductors
The paper introduces OSRAM Opto Semiconductor laser portfolio and describes the recent progress for blue high power GaN lasers with focus on design optimization to improve lifetime for single emitters and efficiency and output power for laser bars.

[LDC2]
AR, MR, VR, ... XR technologies 1
Chair: Norihiro Ohse
Sony

LDC2-01 *Invited*

Finnish flagship programme for Photonics
Juha Purmonen[1,2,3]
[1]Photonics Finland, [2]Institute of Photonics, [3]University of Eastern Finland
The Finnish Flagship Programme provides a new, unique way of doing R&D&I in Finland. The Programme promotes active collaboration between research, business and society in the field of each Flagship. Photonics Research and Innovation platform focusing on light-based solutions from scientific excellence to industrial and societal impact. PREIN partners are worldwide leaders in photonics that changes the world.

LDC2-02 *Invited*

Changing World: What is the impact of VR/AR nowadays and in the future?
Shun Kubota
Mogura Inc.
Nowadays VR/AR technologies starts adopting in the society. As VR/AR specific journalist, I describe how VR/AR is changing the society, industry, daily life and how fast the adoption is in this early stage of adoption. Also I describe the future of these technologies.

LDC2-03 *Invited*

Glass for see-through head-mounted display -High refractive index/High transparency glass wafer-
Satoko Konoshita[1], Hiroshi Sawasato[2], Shunsuke Fujita[1], Takashi Murata[1]
[1]Research Div., Nippon Electric Glass Co., Ltd., [2]Display Glass Div., Nippon Electric Glass Co., Ltd.
High index and high transparency glass with ϕ300mm and 0.3mm has developed for the see-through head-mounted display. This glass will realize a wider FOV and higher brightness as a light guide in AR/MR glasses.

LDC2-04

FOV Expanding of Computer Generated Holograms with a Holographic Waveguide Combiner
Shao-Kui Zhou[1,2], Wen-Kai Lin[1,2], Bor-Shyh Lin[1], Wei-Chia Su[2]
[1]National Chiao Tung University, [2]National Changhua University of Education
The field of view of computer-generated – hologram from spatial light modulator is expanded by using a holographic waveguide combiner. The aberration of the diffraction images at 50 cm behind the waveguide is analysed and then are compensated. Through experimental verification, virtual images with larger FOV can be obtained without aberrations.

LDC2-05

Overcoming the limitations of Spatial Light Modulators for holographic near-eye displays
Michal Makowski, Rafal Trybus, Szymon Fiderkiewicz, Joanna Starobrat
Warsaw University of Technology
Among the limitations of Spatial Light Modulators for computer holography there are regular pixel arrays, causing the formation of spurious higher diffractive orders. We address this problem by two-dimensionally tilted SLM configuration and by pixel-level engineering involving apodizing masks and irregular sampling. We show the experimental cancellation of higher orders.

[LDC3]
AR, MR, VR, ... XR technologies 2
Chair: Masafumi Ide
MagicLeap

LDC3-01 *Invited*

Optical See-Through AR HMD with Spatial Tracking
Hiroshi Mukawa, Hiroyuki Aga, Atsushi Ishihara, Koichi Kawasaki
Sony Corporation
An optical see-through AR HMD prototype with a small temporal registration error between virtual and real objects was developed. The prototype employs micro-OLED displays to achieve high image quality despite the challenge to reduce the temporal registration error. Our latency compensation technique can minimize the temporal registration error small enough for practical use.

LDC3-02 *Invited*

MEMS system for AR HMDs
Ran Gabai, Gil Cahana, Dan Nabel, Meni Yehiel, Avi Leibushor, Gady Yearim, Matan Naftali
Maradin LTD
MEMS-based projectors are attractive to use for AR HMDs for their high-resolution, small-footprint, and low-power properties. High dynamics capabilities are required to achieve the desired image quality. These achieved by a combination of innovative mechanical design with break-through feedback control. Key design points of such MEMS devices are presented.

LDC3-03 *Invited*

Why Light Field is an Important Fundamental Technology for Future XR Displays
Takafumi Koike
Hosei University
Light field is a concept that describes light by position and direction. At present, the light field is an important concept for displays and computer graphics. I describe why the light field is important also for AR and VR.

[LDC4]
Imaging / Lighting -Speckle-
Chair: Hiroshi Murata
Mie University

LDC4-01 *Invited*

Efficient speckle reduction using volume scattering crystals
Shigeo Kubota, Koji Suzuki, Hisashi Masuda, Keisuke Nakagome, Yutaka Anzai
Oxide Corporation
Volume scattering diffusers are overwhelmingly efficient in speckle reduction in laser displays than surface scattering diffusers. We report a eutectic crystal is potential stationary diffuser for speckle reduction using the volume scattering, based on simulations and experiments.

LDC4-02

Speckle reduction within nanosecond-order pulse widths for flash lidar applications
Fergal Shevlin
DYOPTYKA
Our innovative deformable mirror technology is shown to be effective for the reduction of speckle contrast within pulse durations of approximately 6 ns. It can be used to improve the spatial and temporal resolution of flash lidar distance measurements.

LDC4-03

Error Analysis of Speckle Contrast by Image Subtraction Method
Makio Kurashige, Kazutoshi Ishida, Shumpei Nishio
Dai Nippon Printing Co., Ltd.
Measurement error of speckle contrast was analysed in terms of the size of measurement field and imaging condition. The images from the different area of the original image were subtracted to check the randomness.

LDC4-04

Improved Visual Resolution Measurement for Laser Displays Based on Eye-diagram Analysis of Speckle Noise
Junichi Kinoshita[1], Akira Takamori[1], Kazuhisa Yamamoto[1], Kazuo Kuroda[2], Koji Suzuki[3], Keisuke Hieda[4]
[1]Osaka Universitry, [2]Utsunomiya University, [3]Oxide Corporation, [4]HIOKI E.E.CORPORATION
Visual resolution measurement method under the effect of speckle noise is improved by considering eye-diagram analysis. Measurement is carried out using a raster-scan mobile laser projector. The speckle effects can be expressed more clearly.

LDC4-05

Study on Projection Screen and Speckle Contrast in Laser Display Technology
Yuwei Fang, Linxiao Deng, Chun Gu, Lixin Xu
University of Science and Technology of China
We have promoted and demonstrated a relationship between speckle contrast and the fluctuation of the screen surface. We used the step profiler to measure the height and surface topography of 12 kinds of screens and meanwhile built a speckle testing platform to simulate human eye.

[LDC5]
Imaging / Lighting -Display Technologies-
Chair: Satoshi Ouchi
Hitachi

LDC5-01 *Invited*

A laser backlight liquid crystal display achieving a BT.2020 wide color gamut
Koichi Okuda, Shinichi Komura, Ken Onoda, Hiroaki Kijima
Japan Display Inc.
The developed laser backlight liquid crystal display covers 98% of the color gamut of BT.2020. In addition, the speckle problem is solved by applying an AC voltage to the laser diodes.

LDC5-02 *Invited*

Aerial Display Opens a New Field of Biology
Hirotsugu Yamamoto[1,2], Erina Abe[1], Masaki Yasugi[1,2], Eiji Watanabe[3], Hideaki Takeuchi[4]
[1]Utsunomiya University, [2]JST, ACCEL, [3]National Institute for Basic Biology, [4]Tohoku University
This paper introduces our developments on aerial displays. We have realized an omni-directional aerial display with aerial imaging by retro-reflection. The developed display is utilized for behavioral biology experiments, such as optomotor reaction.

LDC5-03 *Invited*

Near-eye CGH display with Holographic Waveguide Element
Wei-Chia Su[1], Wen-Kai Lin[2], Shao-Kui Zhou[2], Bor-Shyh Lin[2]
[1]Nat. Changhua Univ. Edu., [2]College of Photonics, National Chiao Tung University
The near-eye holographic display systems based on waveguide type holographic combiners are analyzed. The astigmatism aberration will be induced by the holographic waveguide combiner. The astigmatism performance can be predicted with the ray-tracing technology and it can be verified experimentally. Astigmatism induced by the holographic waveguide element is corrected by using an improved iteration CGH algorithm.

LDC5-04

Effective Speckle Reduction Method Based on a Rotating Ball Lens
Linxiao Deng, Yuwei Fang, Yuhua Yang, Tianhao Dong, Chun Gu, Lixin Xu
University of Science and Technology of China
A novel design for speckle reduction based on a rotating ball lens is investigated. In addition, a standardized speckle measurement method is also developed and the parameters mainly accord with characteristics of human eyes. This method could open up an avenue to the practical speckle measurement application.

LDC

[LDC6]
Keynote 2
Chair: Tetsuya Yagi
Mitsubishi Electric.Co.,

LDC6-01 *Keynote*

Indication of current-injection lasing from an organic semiconductor
Chihaya Adachi, Toshinori Matsushima, Fatima Bencheikh, Shinobu Terakawa, William J. Potscavage, Chuanjiang Qin, Takashi Fujihara, Kenichi Goushi, Jean-Charles Ribierre
Kyushu University
We demonstrate the lasing properties of 4,4'-bis[(N-carbazole)styryl]biphenyl (BSBCz) thin films under electrical pumping. The device incorporates a mixed-order distributed feedback SiO_2 grating in an organic light-emitting diode structure and emit blue lasing.

[LDC7]
Light sources and components 1
Chair: Tetsuya Yagi
Mitsubishi Electric.Co.,

LDC7-01

Speckle Contrast Generated by 638-nm Broad Area Laser Diodes
Kyosuke Kuramoto[1], Takuma Fujita[1], Takehiro Nishida[1], Tetsuya Yagi[1], Akira Takamori[2], Kazuhisa Yamamoto[2], Masahiko Kondow[3]
[1]Mitsubishi Electric Corporation, [2]Institute of Laser Engineering, Osaka University, [3]Graduate School of Engineering, Osaka University
Experimental investigation on speckle contrast generated by 638-nm broad-area laser revealed that increasing the emitter number reduced the speckle contrast, i.e. the triple emitter was better than dual one in the viewpoint of speckle reduction.

LDC7-02

Monolithic single-mode diode lasers at 633 nm with high coherence and reliability for holographic printing
Katrin Paschke, G. Blume, J. Pohl, B. Sumpf, D. Feise, P. Ressel, A. Sahm, N. Werner, J. Hofmann
Ferdinand-Braun-Institut
We will present redemitting DBR-tapered-diode-lasers at 633-nm which provide 200-300mW of optical power with coherence lengths of about 0.5m for more than 10,000h, which is suitable for holographic printing, interferometry or various types of spectroscopy.

LDC7-03

High-direction and low-coherence semiconductor laser with dumbbell-type cavity
Linhai Xu, Yufei Wang, Yufei jia, Wanhua Zheng
Institute of Semiconductors, CAS
We reported an electrically pumped dumbbell-type semiconductor laser with low-coherence and high-direction, which exhibits great potential application value in laser display.

[LDC8]
Light sources and components 2
Chair: Tatsushi Hamaguchi
Sony

LDC8-01 *Invited*

Progress in semipolar GaN-based VCSELs
Jared A Kearns[1], Joonho Back[2], Nathan C Palmquist[1], Daniel A Cohen[1], Steven P DenBaars[1,2], Shuji Nakamura[1,2]
[1]Materials Department University of California, Santa Barbara, [2]Department of Electrical and Computer Engineering, University of California, Santa Barbara
Semipolar vertical-cavity surface-emitting lasers with ion-implanted apertures and buried tunnel junction apertures are compared. The effect of changing the out-coupling mirror reflectivity is calculated to project the potential effect on output power.

LDC8-02

High Power Static Phosphor Light Source for Cinema Projectors
Kenneth Li
Optonomous Technologies Inc.
This paper describes a compact static phosphor system in which the static phosphor plate could be mounted on traditional heat sinks by which the heat can be removed effectively. The effective emission area is increased by a lightweight rotating optics scanning for focused spot onto the phosphor plate while maintaining the original etendue of the focused spot. The resulting high output can be used for cinema projectors and other high power applications.

LDC8-03

Interference Pattern Generation of Multi-wavelength Yellow-Orange Lasers Using Chi$^{(2)}$ Nonlinear Photonic Crystals
Bai-Wei Wu[1], Kai-Hsun CHANG[1,2], Safia Mohand Ousaid[2], Azzedine BOUDRIOUA[2], Hiroyuki YOKOYAMA[3], Chih-Ming Lai[4], Lung-Han Peng[1,2,3]
[1]National Taiwan University, [2]Université Paris 13, [3]Tohoku University, [4]Ming Chuan University
We report tri-wavelength 580, 590, and 600nm yellow-orange lasers based on PPLT nonlinear photonic crystals composed of double-slit OPOs and chirped SHG structures. It enables coherent interference of SHG with a green to yellow-orange conversion slope efficiency > 8% and an interference pattern with visibility of 0.61.

LDC8-04

High-Frequency Modulation of RGB Semiconductor Lasers for High-Resolution Scanning Displays
Kiyoshiro Yamanaka[1], Hiroshi Murata[1,2], Junichi Kinoshita[2], Kazuhisa Yamamoto[2]
[1]Mie University, [2]Osaka University
Digital signal modulation characteristics of RGB pig-tailed laser modules were measured. Eye opening ratios over 80% were obtained in the frequency range of 100-600 MHz, which meet demands for the applications to 4-Mega-pixel displays.

LDC8-05

645 nm lasers with a low vertical divergence angle for laser display
Yufei Jia, Yufei Wang, Linhai Xu, Wanhua Zheng
Institute of Semiconductors, CAS
We design the 645 nm laser with a narrow vertical divergence. The measured vertical far-field divergence can be reduced from 18.3° to 14.7° (FWHM) without degrading the laser performance. In addition, the low coherence laser with 4% speckle contrast is presented for laser display.

[LDC9]
Novel and emerging technologies and applications 1
Chairs: Hirotsugu Yamamoto
Utsunomiya University
Shiro Suyama
Tokushima University

LDC9-01 *Invited*

Warp Square: A 360-degree Visual Experience in 4K Ultra-short-throw Projector Cave
Norihiro Ohse
Sony Corporation
We have developed Warp Square, a 360-degree projector cave using 4K ultra-short-throw projectors and a contrast screen. It has high spatial efficiency and delivers high-quality images with a high contrast ratio. This system has been applied to various multi-person VR experiences. We expect that it will eventually be installed in all homes in the future.

LDC9-02 *Invited*

Trends and Prospects of Systems and Applications of Wireless Power Transmission Using Laser Light
Tomoyuki Miyamoto
Tokyo Institute of Technology
Optical wireless power transmission is attractive because of long-distance transmission, small size and light weight, and no electromagnetic interference. Applications for IoT terminals, consumer equipment, and mobilities are expected. The current status of features, systems, and applications will be reported, focusing on the author's results.

LDC9-03

Evaluation of the chromaticity of tricolor laser displays under the laser wavelength shifts depending on the operating currents
Keisuke Hieda, Tomoyuki Maruyama, Fumio Narusawa
HIOKI E.E. CORPORATION
The wavelengths of red, green and blue laser diodes were measured while changing their operating currents. The wavelengths shifts observed in this experiment cause unintended color shifts in tricolor laser displays. To make the best use of tricolor laser displays, the wavelength shifts must be considered in their color management.

LDC9-04

Forming Aerial Signage in front of LED Panel by Use of Retro-Reflector with Square-Shaped Holes
Daiki Nishimura[1], Masaki Yasugi[1,2], Hirotsugu Yamamoto[1,2]
[1]The University of Utsunomiya, [2]JST, ACCEL
We propose an optical system to form aerial signage over an LED panel. A beam splitter is placed in front of the LED panel that is covered with retro-reflector with square-shaped holes. The aerial image is formed in front of the LED panel, which is suitable for a large-scale installation.

[LDC10]
Novel and emerging technologies and applications 2
Chairs: Masato Ishino
Osaka University
Norihiro Ohse
Sony

LDC10-01 *Invited*

Large and Long-Viewing Distance DFD (Depth-Fused 3D) Display by using Transparent Polyethylene Screens and Short-Focus Projectors
Shiro Suyama, Haruki Mizushina
Tokushima University
We have developed large and long-viewing-distance DFD (Depth-fused 3D) display with deep 3D image by using transparent polyethylene screens with adequate transmittance and scattering and short-focus projectors. Blurring front image can successfully enlarge 3D-image depth.

LDC10-02

Subjective Super-Resolution by Use of High-Speed Multi-Color LED Display
Kojiro Matsushita[1], Toyotaro Tokimoto[1,2], Hirotsugu Yamamoto[1,3]
[1]Utsunomiya University, [2]DaoApp Technology Company Limited, [3]JST, ACCEL
We have developed a novel multi-color LED display. The developed LED display shows images at a high frame rate to perform subjective super-resolution, which makes viewers perceive a higher resolution than the number of actual LED lamps. We have confirmed that subjective super-resolution effect is evoked in multi-color images.

LDC10-03

Improvement of Visibility of Aerial Image in See-Through AIRR by Cutting Off Ambient Light Using Polarization Modulation
Kengo Fujii[1], Masaki Yasugi[1,2], Hirotsugu Yamamoto[1,2]
[1]Utsunomiya University, [2]JST ACCEL
An aerial image can be superimposed and displayed on the real world by using a see-through structure by AIRR. In this paper, we improve the visibility of aerial images in see-through AIRR.

LDC10-04

Fabrication of SiO_2-based Binary Diffractive Lens with Controllable Focal Distribution for High-Power Laser Applications
Atsushi Motogaito, Kazuki Matsuo, Kazumasa Hiramatsu
Mie University
A binary diffractive lens with controllable focal distribution owing to the adjustable zone radius and interval was fabricated by electron beam lithography and reactive ion etching. The measured intensity distribution was consistent with the simulation.

LDC

[LDC11]
Laser Technology for Automotive Applications - Phosphor Light Source-
Chair: Masaru Kuramoto
Stanley Electric

LDC11-01 *Invited*

AlInGaN laser diodes for automotive applications
Takashi Miyoshi, Masanobu Tanaka, Shin-ichi Nagahama
Nichia Corporation
GaN-based multi-mode blue laser diodes (LDs) were fabricated on c-plane GaN substrates. The wall plug efficiency was 40.7 % at 2.3A. These LDs were integrated to white LDs with luminous flux and luminance over 1300 lm and 700 cd/mm^2.

LDC11-02

Laser Light Sources for Automotive Front Lighting Applications
Meng Han, Julian Carey, Paul Rudy
SLD Laser
Progress in development of blue laser diodes and their integration with phosphors enabled a new category of solid state light sources for automotive lighting. In this paper, a dynamic laser light module consisting of blue laser diode, a MEMS scanner and remote phosphor for adaptive driving beam and future intelligent lighting will be introduced.

LDC11-03

Design parameters for light engines with static ceramic luminescent converter assemblies
Volker Hagemann, Albrecht Seidl
SCHOTT AG
Laser pumped phosphor light sources overcome the luminance limit of LEDs, that restricts the use of solid state lighting in etendue limited applications such as digital projection. This paper investigate static converter properties such as light diffusion and temperature dependence of the irradiance limit that is necessary to fully utilize the benefits of these components in optimized light engines.

LDC11-04

Ce:YAG composite ceramic phosphors for laser lighting
Kenta Yagasaki, Hisashi Minemoto, Kana Fujioka, Hiroshi Fuji, Kazuhisa Yamamoto
Osaka University
We succeeded in suppression for thermal-quenching of phosphors using AlN-Ce:YAG composite ceramics for the first time. The ceramics have excellent thermal conductivity, so that the generated heat by the focused beam of a Laser Diode (LD) diffuses efficiently. This technology contributes to the improvement of a high-power head lamp.

[LDC12]
Laser Technology for Automotive Applications - Systems-
Chair: Satoshi Ouchi
Hitachi

LDC12-01 *Invited*

Automotive Laser Headlamps using DMD Technologies
Kenneth Li[1], Yung Peng Chang[2]
[1]Optonomous Technologies Inc., [2]Taiwan Color Optics, Inc.
This paper presents a laser excited phosphor automotive headlight combining the high efficiency of the white LEDs and the high intensity spot of the laser, producing a non-uniform, hot spot intensity profile on the DMD. The output intensity profile on the roadway can be controlled providing the low beam, high beam, ultra-long-range spot light, and controlled dimming for various detected objects from a single DMD.

LDC12-02 *Invited*

Sokuiki-Sensor (LiDAR) System and Applications
Keisuke Inoue, Katsumi Kimoto, Naohiro Shimaji, Masanori Hino, Toshihiro Mori
Hokuyo Automatic co., ltd.
The authors have developed various types of Sokuiki-sensors that is fundamental technology for autonomous robots, autonomous driving car. In this paper, we have introduced the structure and application of such Sokuiki-sensors.

LDC12-03 *Invited*

Wide Angle Multi-Shift Stereo Camera with Monocular Detection
Masayuki Kobayashi[1], Kazuyoshi Yamazaki[1], Felipe Gomez Caballero[2], Takuma Osato[2], Takeshi Endo[2], Masayuki Takemura[2], Takeshi Nagasaki[3], Takeshi Shima[3]
[1]Central Research Laboratory, Hitachi Ltd., [2]Hitachi Research Laboratory, Hitachi Ltd., [3]Hitachi Automotive Systems Ltd.
The developed stereo camera system combines stereo and monocular vision for far-distance detection and wide-angle FOV. Moreover, we improved detection accuracy by compensating the monocular vision with the road disparity calculated from the stereo vision.

[LDC13]
Visible light communication (VLC) technologies and systems
Chair: Hidekazu Hatanaka
Ushio

LDC13-01 *Invited*

Location-based Services using Visible Light Communication
Shinichiro Haruyama
Keio University
Visible light communication can be used for location-based services by sending location information from visible light sources. Typical light sources of visible light communication are LED lights, but we proposed the use of DMD (Digital Micromirror device) projectors to send different data in different directions. Combinations of different types of transmitters and receivers are shown with various location-based services.

LDC13-02 *Invited*

Laser-based LiFi for 6G: Potential and Applications
Volker Jungnickel, Julian Hohmann, Dominic Schulz, Peter Hellwig, Jonas Hilt, Christoph Kottke, Ronald Freund
Fraunhofer Heinrich Hertz Institute
LiFi uses the light for mobile communications. Advantages of laser-compared to LED-based LiFi systems are better energy efficiency and higher modulation bandwidth, yielding enhanced mobility, higher data rates, more precise positioning and reduced latency in promising 6G applications like mobile backhaul, secure meeting rooms and industrial or medical wireless.

LDC13-03 *Invited*

The Future Prospects of Robot-Photonics:Visible Light Communication and Sensing with the Plasmonic Mirror
Kensuke Murai
National Institute of Advanced Industrial Science and Technology
Photonics are essential for present robot systems. Photonic devices are more important not only for distance and image but also for environmental communication and sensing. The plasmonic mirror with the metal-insulator-metal (MIM) structure has the potential to sense such information with the LED/LD driven white light.

[LDC14]
Smart Systems
Chair: Junichi Kinoshita
Osaka University

LDC14-01 *Invited*

Vertical View Human Action Recognition from Range Images
Akinobu Watanabe, Keiichi Mitani
Hitachi, Ltd.
We developed the human joints' position estimation technique and the person tracking technique from looking-down-view range image of TOF sensor, and confirmed the correct prediction ratio of hands' position is 97%, upper-front view angle is suitable for hands' position estimation, and confirmed the person tracking error is reduced to 1/7.

LDC14-02 *Invited*

High-Speed Projection for Augmenting the World
Yoshihiro Watanabe
Tokyo Institute of Technology
This paper introduces the progress of high-speed projection technology and how this technology opens new possibilities of augmenting the world based on dynamic projection mapping.

LDC14-03

Color LiDAR using RGB visible laser diodes
Tomoyuki Ohashi, Masato Ishino, Kazuhisa Yamamoto, Kana Fujioka
Institute of Laser Engineering, Osaka University
We propose color LiDAR using RGB visible LDs that can obtain color information as well as position information. From results of the Time-of-Flight(ToF) measurements and received light characteristics for color chart, the feasibility of the color LiDAR was verified.

[LDC15]
Post Deadline and Closing
Sunao Kurimura
NIMS
Closing Remarks

[LDCp]
Short Presentation for Poster Paper
Chair: Satoshi Ouchi
Hitachi

LDCp-01

Reforming of Computer Generated Hologram Pattern through Angular Spectrum Domain Computation
Chang Joo Lee[1], Woo Young Choi[1], Joong Ki Park[2], Kwan Jung Oh[2], Kee Hoon Hong[2], Ki Hong Choi[2], Seung Yeol Lee[1]
[1]Kyungpook National University, [2]Electronics and Telecommunication Research Institute (ETRI)
In this paper, we propose a hologram image resizing method through zero padding and cutting in spatial frequency domain for reducing computation time. This method is much faster than conventional CGH calculation method for reforming.

[LDCp]
Poster Session

LDCp-01

Reforming of Computer Generated Hologram Pattern through Angular Spectrum Domain Computation
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In this paper, we propose a hologram image resizing method through zero padding and cutting in spatial frequency domain for reducing computation time. This method is much faster than conventional CGH calculation method for reforming.

LEDIA

[LEDIA-0P]
Opening Remarks
Gen-ichi Hatakoshi
Waseda University

[LEDIA2]
LED and Laser I
Chair: Tetsuya Takeuchi
Meijo University

LEDIA2-02 *Withdraw*

LEDIA2-03

Fabrication Process of InGaN High-Order Deeply Etched DBR Laser
Akihiro Higuchi, Daiki Tazuke, Masahiro Uemukai, Tomoyuki Tanikawa, Ryuji Katayama
Osaka University
An InGaN quantum well single-mode laser using a high-order deeply etched DBR grating was fabricated. We report a simple fabrication process with simultaneous formation of an active channel and the deeply etched DBR grating.

[LEDIA3]
Keynote I
Chair: Ryuji Katayama
Osaka University

LEDIA3-02 *Withdraw*

LEDIA3-03

Fabrication process of GaInN/GaN honeycomb array nanocolumn LEDs for integration of surface plasmonic resonance scheme
Akihiro Ueno[1], Gyo Imamura[2], Keigo Yoshida[1], Keiji Takimoto[2], Ichirou Nomura[2], Rie Togashi[2], Tomohiro Yamaguchi[1], Tohru Honda[1], Katsumi Kishino[2]
[1]Kogakuin University, [2]Sophia University
Nanocolumn (NC) LEDs with GaInN/GaN NC honeycomb arrays, which are suitable for integration of surface plasmon resonance scheme, were successfully fabricated. The device process for depositing a plasmonic Au film on NC sidewalls was established.

LEDIA3-04 *Withdraw*

[LEDIA4]
Crystal Growth
Chair: Rie Togashi
Sophia University

LEDIA4-02

Regrowth of Li-free layer on GaN substrate produced by the Na-flux-sapphire-dissolution technique
Takumi Yamada, Masayuki Imanishi, Kosuke Murakami, Kosuke Nakamura, Masashi Yoshimura, Yusuke Mori
Osaka University
In Na-flux-sapphire-dissolution technique for fabricating freestanding GaN substrates, incorporation of Li impurity in crystals can't be avoided. We successfully obtained Li-free regrown layer on GaN substrate produced by the technique.

LEDIA4-03

Correlation between Etch Pit Size and Threading Dislocation Propagation Habit in GaN Substrate Observed by Multiphoton-Excitation Photoluminescence
Mayuko Tsukakoshi, Tomoyuki Tanikawa, Masahiro Uemukai, Ryuji Katayama
Osaka University
Three-dimensional characterization of threading dislocations in GaN was performed using multiphoton-excitation photoluminescence. Propagation habit of threading dislocations was different by their type. This result will lead to the novel nondestructive characterization technology.

LEDIA4-04

Control of the lattice relaxation of the InGaN layer grown on patterned sapphire substrates using Tri-Halide Vapor Phase Epitaxy
Kentaro Ema, Ryohei Hieda, Hisashi Murakami, Akinori Koukitu
Tokyo University of Agriculture and Technology
The relaxation behavior of thick InGaN layers grown on patterned sapphire substrates (PSSs) by THVPE was investigated. The relaxation ratio of the InGaN epilayer could be controlled by changing the thickness of GaN intermediate layers grown on PSSs.

LEDIA4-05 *Withdraw*

[LEDIA5]
Industrial Application I
Chair: Takeo Kageyama
QD Laser, Inc

LEDIA5-02

A High-Speed Light-Emitting Diode with Bandwidth > 1GHz based on InGaN/GaN Quantum Dots Active Region
Lei Wang[1], Chien-Ju Chen[2], Lai Wang[1], Kai-Chia Chen[2], Zhibiao Hao[1], Yi Luo[1], Meng-Chyi Wu[2], Changzheng Sun[1], Yanjun Han[1], Bing Xiong[1], Jian Wang[1], Hongtao Li[1]
[1]Tsinghua University, Beijing, China, [2]National Tsing Hua University, Hsinchu, Taiwan, China
A blue light-emitting diode (LED) with single-layer active region of InGaN/GaN quantum dots is grown and fabricated to micro-LED of 75-μm diameter. The bandwidth of this LED can reach 1.3GHz at the current density of 528.5 A/cm^2.

LEDIA5-03

A 15 Gb/s widely tunable directly modulated DBR laser for 5G fronthaul application
Daibing Zhou, Song Liang, Dan Lu, Lingjuan Zhao, Wei wang
Institute of Semiconductors, Chinese Academy of Sciences
An InP based tunable distributed Bragg reflector (DBR) laser is reported. 15 Gb/s data transmissions at up to 30 km are demonstrated. The wavelength tuning range of the device is larger than 10 nm.

LEDIA5-04

Improvement of photosensitivity of AlGaN/GaInN/GaN-based HFET photosensor by using short optical p-GaN gate
Yuya Yamada[1], Ryo Fujishima[1], Motoaki Iwaya[1], Tetsuya Takeuchi[1], Satoshi Kamiyama[1], Isamu Akasaki[1,2]
[1]The University of Meijo, [2]Akasaki Reserch Center, Nagoya Univ.
We investigated the increase in photosensitivity by shortening the optical p-GaN gate length of an AlGaN/GaInN/GaN-based HFET pthotosensors. The photocurrent increased approximately 3 times by shortening the gate length from 2 μm to 200 nm.

LEDIA5-05

Design of AlN Doubly-Resonant Waveguide Microcavity SHG Device
Soshi Umeda, Takumi Nagata, Masahiro Uemukai, Tomoyuki Tanikawa, Ryuji Katayama
Graduate School of Engineering, Osaka University
In order to realize a compact and practical deep ultraviolet light source consisting of a blue semiconductor laser and a wavelength conversion device, AlN waveguide microcavity SHG device was designed taking diffraction loss into account.

[LEDIA6]
Short Presentation
Chair: Hisashi Murakami
Tokyo University of Agriculture and Technology

LEDIA6-01

Structural characterization of BGaN films grown on AlN layer
Yuhki Shimizu[1], Yuto Ohta[1], Yuri Takahashi[1], Narihito Okada[2], Yoku Inoue[1], Takayuki Nakano[1,3]
[1]Department of Electronics and Materials Science, Shizuoka University, [2]Graduate School of Sciences and Technology for Innovation, Yamaguchi University, [3]Research Institute of Electronics, Shizuoka University
In BGaN epitaxial growth on AlN, high B composition BGaN growth is expected due to the effect of lattice constant. In this study, BGaN film on AlN was fabricated and evaluated.

LEDIA6-02 *Withdraw*

LEDIA6-03

Simultaneous Growth of Multi-Color Micro LEDs Based on Super Thin Micro-Platelets with Various Surface Areas
Wentao Cai[1], Maki Kushimoto[1], Manto Deki[2], Atsushi Tanaka[2,3], Shugo Nitta[2], Hiroshi Amano[2,3,4,5]
[1]Department of Electronics, Nagoya University, [2]IMaSS, Nagoya University, [3]NIMS, [4]ARC, Nagoya University, [5]VBL, Nagoya University
An approach to simultaneously grow multi-color micro LEDs is presented in this work. 440 to 478 nm emitting wavelength shifting was achieved based on super-thin micro platelet structure with a varying diameter of 2.5-9.0 μm.

LEDIA6-04

Theoretical approach to carbon concentration on GaN(0001) and (000-1) surfaces during MOVPE
Daichi Yosho[1], Yuya Inatomi[1], Yoshihiro Kangawa[1,2,3]
[1]Kyushu University, [2]RIAM, Kyushu University, [3]IMaSS, Nagoya University
Carbon concentration on GaN(0001) and (000-1) surfaces during MOVPE was theoretically investigated. The difference of growth orientation and influence of V/III ratio and carrier gas ratio were discussed.

LEDIA6-05 *Withdraw*

LEDIA6-06

Growth of β-Gallium Oxide via $GaCl_3$-O_2-N_2 system
Kentaro Ema[1], Kohei Sasaki[2], Akito Kuramata[2], Hisashi Murakami[1]
[1]Tokyo University of Agriculture and Technology, [2]Novel Crystal Technology, Inc.
Homoepitaxial growth of β-Ga_2O_3 by tri-halide vapor phase epitaxy (THVPE) using $GaCl_3$-O_2-N_2 system was performed. The β-Ga_2O_3 layer with good surface morphology was obtained and maintained almost the same crystalline quality as the β-Ga_2O_3 substrate.

LEDIA6-07 *Withdraw*

LEDIA6-08

Fabrication of lattice-relaxed thick $Al_{0.6}Ga_{0.4}N$ films on annealed sputtered AlN formed on a-plane sapphire substrates
Moe Shimokawa[1], Sho Iwayama[1,2], Shohei Teramura[1], Sayaka Ishizuka[1], Tomoya Omori[1], Kazuki Yamada[1], Syunya Tanaka[1], Kosuke Sato[1,3], Motoaki Iwaya[1], Tetsuya Takeuchi[1], Satoshi Kamiyama[1], Isamu Akasaki[4], Hideto Miyake[2]
[1]Meijo University, [2]Mie University, [3]Asahi Kasei Co., [4]Nagoya University
High quality $Al_{0.6}Ga_{0.4}N$ films were obtained by growing three-dimensionally on the annealed sputtered AlN on a-plane sapphire. The dislocation density of $Al_{0.6}Ga_{0.4}N$ estimated from the cathodeluminescence dark spot was 7.4×10^8 cm^{-2}.

LEDIA6-09

Suppression of the step bunching in GaN crystal using purified Na in the Na-flux method
Hyoga Yamauchi, Takumi Yamada, Masayuki Imanishi, Yusuke Mori
Osaka University
In GaN crystal grown by the Na-flux method, inclusions were often observed. In this study, we suppressed the step bunching during growth to reduce the formation of inclusions by using purified Na.

LEDIA6-10

Thermodynamic analysis of metalorganic vapor phase epitaxy of group-III sesquioxides
Saori Matsugai[1], Nami Tanaka[1], Sakiko Yamanobe[1], Nao Takekawa[1], Ken Goto[1], Yoshinao Kumagai[1,2]
[1]Department of Applied Chemistry, Tokyo University of Agriculture and Technology, [2]Institute of Global Innovation Research, Tokyo University of Agriculture and Technology
Thermodynamic analyses on MOVPE of group-III sesquioxides (Ga_2O_3, Al_2O_3 and In_2O_3) were performed. The results clarified growth conditions for high temperature growth at and above 1000 ºC.

LEDIA

LEDIA6-11

Inductively Coupled Plasma Reactive Ion Etching of GaN Films Maintaining Surface Flatness for Surface Activated Bonding

Naoki Yokoyama, Ryo Tanabe, Takaya Morikawa, Yasufumi Fujiwara, Masahiro Uemukai, Tomoyuki Tanikawa, Ryuji Katayama
Osaka University

Effect of ICP-RIE conditions on surface flatness of GaN films was investigated. Addition of Ar gas to Cl_2 gas was effective in reducing chloride-based by-products that hinder uniform etching.

LEDIA6-12 *Withdraw*

LEDIA6-13 *Withdraw*

LEDIA6-14

Effect of N radical irradiation on InN film for surface modification

TSUTOMU ARAKI, Faizulsalihin Bin Abas, Shinichiro Mouri, Yasushi Nanishi
Ritsumeikan University

In-situ surface modification of InN film by N radical beam irradiation was investigated using different substrate temperature, plasma power and irradiation time. The surface morphological changes and electrical properties of irradiated InN templates were studied.

LEDIA6-15

Optical characteristics of high–Indium–content GaInN MQWs grown on different templates by RF–MBE

Ryosuke Yoshida, Hiroki Hirukawa, Kaigo Tahara, Tomohiro Yamaguchi, Takeyoshi Onuma, Tohru Honda
Kogakuin University

GaInN multi–quantum–wells (MQWs) with GaInN barriers were grown on GaInN templates. Those optical characteristics are discussed. Especially, the characteristics were compared with those of MQWs with GaN barriers.

LEDIA6-16

Thermodynamic study of $(Al_xGa_{1-x})_2O_3$ ternary alloy growth by metalorganic vapor phase epitaxy

Nami Tanaka[1], Saori Matsugai[1], Sakiko Yamanobe[1], Nao Takekawa[1], Ken Goto[1], Yoshinao Kumagai[1,2]
[1]Department of Applied Chemistry, Tokyo University of Agriculture and Technology, [2]Institute of Global Innovation Research, Tokyo University of Agriculture and Technology

Growth of $(Al_xGa_{1-x})_2O_3$ ternary alloy using metalorganic vapor phase epitaxy (MOVPE) was thermodynamically investigated. The results revealed a linear vapor-solid distribution relationship at 1000 ºC even under a high interaction parameter of 10000 cal/mol.

LEDIA6-17

Growth promotion of GaN point seed with lithium addition in the Sodium flux method

Kazuma Hamada, Takumi Yamada, Kosuke Nakamura, Kosuke Murakami, Masayuki Imanishi, Masashi Yoshimura, Yusuke Mori
Osaka University

For the fabrication of low-dislocation GaN substrate, the use of small diameter point seed is effective. The difficulty to grow on extremely small-diameter point seed was overcome by adding lithium in the sodium flux.

LEDIA6-18

Structural analyses of a-In_2O_3 grown on a-Al_2O_3 substrates by Mist CVD

Yuka Hayakawa[1], Soichiro Ohno[1], Tomohiro Yamaguchi[1], Takanori Kiguchi[2], Hirokazu Yokoo[1], Takeyoshi Onuma[1], Tohru Honda[1]
[1]Kogakuin University, [2]Institute for Materials Research, Tohoku University

Structural analyses by transmission electron microscopy (TEM) of a-In_2O_3 grown on (0001) a-Al_2O_3 by Mist CVD were carried out. The space distribution of edge and screw dislocations were observed in a-In_2O_3.

LEDIA6-19

Fabrication of μ-LED pixels and evaluation of luminescent characteristics

Hiroyoshi Chikui[1], Shoma Takeda[1], Kota Sato[1], Takeyoshi Onuma[1], Tomohiro Yamaguchi[1], Mitsuaki Shimizu[2], Tokio Takahashi[2], Tohru Honda[1]
[1]Kougakuin University, [2]National Institute of advanced Science and technology

Approximately 20 μm × 20 μm size μ-LED pixels were fabricated using ICP-RIE with Ni metal mask. Evaluation using monochromatic cathodoluminescence measurements showed that n-GaN contact layer was well exposed by the etching.

LEDIA6-20 *Withdraw*

LEDIA6-21 *Withdraw*

LEDIA6-22

Growth of AlGaN films on AlN template by RF-plasma assisted molecular beam epitaxy

Mari Hashimoto, Naozumi Tachibana, Tohru Honda, Tomohiro Yamaguchi, Takeyoshi Onuma
Kogakuin University

100-430-nm-thick $Al_xGa_{1-x}N$ thin films with x=0.77-0.83 were grown by RF-plasma-assisted molecular beam epitaxy on c-plane AlN on Al_2O_3 templates. Root mean square roughness of 0.61 nm was obtained for 100-nm-thick $Al_{0.83}Ga_{0.17}N$ thin film.

LEDIA6-23 *Withdraw*

LEDIA6-24 *Withdraw*

LEDIA6-25 *Withdraw*

LEDIA6-26 *Withdraw*

LEDIA6-27 *Withdraw*

[LEDIA7]
AlN and UV Laser
Chair: Yoshinao Kumagai
Tokyo University of Agriculture and Technology

LEDIA7-03 *Withdraw*

[LEDIA8]
LED and Laser II
Chair: Tomohiro Yamaguchi
Kogakuin University

LEDIA8-01

Highly Efficient AlGaN UVB LEDs using Graded Mg-doped p-type Multi-Quantum-Barrier Electron Blocking Layer (Grad p-MQB-EBL)

Muhammad Ajmal Khan[1,2], Noritoshi Maeda[1], Masafumi Jo[1], Yukio Kashima[3], Yoichi Yamada[4], Hideki Hirayama[1,2]
[1]RIKEN Cluster for Pioneering Research (CPR), [2]RIKEN Center for Advanced Photonics (RAP), [3]Marubun Corporation, Chuo, Tokyo 109-8577, Japan, [4]Yamaguchi University

In this work of AlGaN-based (290nm-310nm)-band UVB LEDs, when the Al-graded Mg-doped p-type (Grad p-MQB-EBL) plus 50% relaxed buffer were used, the light power as well as external-quantum-efficiency, respectively, were enhanced from 17 mW and 5.6% to a record value of 42 mW and 9.1% on bare wafer. Similarly, in the 310nm UVB LED, where the maximum L was greatly improved up to 29 mW with EQE of 4.9%.

LEDIA8-02

Workfunction control of CNT films by doping for UVLED's electrode

Yuta Furusawa, Orysia Zaremba, Yutaka Ohno, Yoshio Honda, Hiroshi Amano
Nagoya university

We investigated the work function control of carbon nanotube network film by doping for UVLED's electrode. Photoelectron measurement showed work function was changed from 4.84 to 5.13~5.95 eV.

[LEDIA9]
Characterization
Chair: Tomoyuki Tanikawa
Osaka University

LEDIA9-03 *Withdraw*

LEDIA9-04

Theoretical model for oxygen incorporation during step flow growth of GaN on vicinal m-GaN by MOVPE

Daichi Yosho[1], Fumiya Shintaku[1], Yoshihiro Kangawa[1,2,3], Jun-Ichi Iwata[4], Atsushi Oshiyama[3], Kenji Shiraishi[3], Atsushi Tanaka[3], Hiroshi Amano[3]
[1]Kyushu University, [2]RIAM, Kyushu University, [3]IMaSS, Nagoya University, [4]AdvanceSoft Corporation

Oxygen incorporation mechanism in GaN grown on vicinal m-GaN by MOVPE was theoretically investigated. Both ab initio-based approach (statics) and diffusion equation-based approach (dynamics) were used for theoretical modeling.

[LEDIA10]
Keynote II
Chair: Yoshio Honda
Nagoya University

LEDIA10-01 *Withdraw*

[LEDIA-CL]
Closing Remarks
Yoshio Honda
Nagoya University

[LEDIAp]
Poster Session

LEDIAp-01

Structural characterization of BGaN films grown on AlN layer

Yuhki Shimizu[1], Yuto Ohta[1], Yuri Takahashi[1], Narihito Okada[2], Yoku Inoue[1], Takayuki Nakano[1,3]
[1]Department of Electronics and Materials Science, Shizuoka University, [2]Graduate School of Sciences and Technology for Innovation, Yamaguchi University, [3]Research Institute of Electronics, Shizuoka University

In BGaN epitaxial growth on AlN, high B composition BGaN growth is expected due to the effect of lattice constant. In this study, BGaN film on AlN was fabricated and evaluated.

LEDIAp-02 *Withdraw*

LEDIAp-03

Simultaneous Growth of Multi-Color Micro LEDs Based on Super Thin Micro-Platelets with Various Surface Areas

Wentao Cai[1], Maki Kushimoto[1], Manto Deki[2], Atsushi Tanaka[2,3], Shugo Nitta[2], Hiroshi Amano[2,3,4,5]
[1]Department of Electronics, Nagoya University, [2]IMaSS, Nagoya University, [3]NIMS, [4]ARC, Nagoya University, [5]VBL, Nagoya University

An approach to simultaneously grow multi-color micro LEDs is presented in this work. 440 to 478 nm emitting wavelength shifting was achieved based on super-thin micro platelet structure with a varying diameter of 2.5-9.0 μm.

LEDIAp-04

Theoretical approach to carbon concentration on GaN(0001) and (000-1) surfaces during MOVPE

Daichi Yosho[1], Yuya Inatomi[1], Yoshihiro Kangawa[1,2,3]
[1]Kyushu University, [2]RIAM, Kyushu University, [3]IMaSS, Nagoya University

Carbon concentration on GaN(0001) and (000-1) surfaces during MOVPE was theoretically investigated. The difference of growth orientation and influence of V/III ratio and carrier gas ratio were discussed.

LEDIAp-05 *Withdraw*

LEDIAp-06

Growth of β-Gallium Oxide via $GaCl_3$-O_2-N_2 system

Kentaro Ema[1], Kohei Sasaki[2], Akito Kuramata[2], Hisashi Murakami[1]
[1]Tokyo University of Agriculture and Technology, [2]Novel Crystal Technology, Inc.

Homoepitaxial growth of β-Ga_2O_3 by tri-halide vapor phase epitaxy (THVPE) using $GaCl_3$-O_2-N_2 system was performed. The β-Ga_2O_3 layer with good surface morphology was obtained and maintained almost the same crystalline quality as the β-Ga_2O_3 substrate.

LEDIAp-07 *Withdraw*

Program

LEDIA

LEDIAp-08

Fabrication of lattice-relaxed thick $Al_{0.6}Ga_{0.4}N$ films on annealed sputtered AlN formed on a-plane sapphire substrates

Moe Shimokawa[1], Sho Iwayama[1,2], Shohei Teramura[1], Sayaka Ishizuka[1], Tomoya Omori[1], Kazuki Yamada[1], Syunya Tanaka[1], Kosuke Sato[1,3], Motoaki Iwaya[1], Tetsuya Takeuchi[1], Satoshi Kamiyama[1], Isamu Akasaki[4], Hideto Miyake[2]
[1]Meijo University, [2]Mie University, [3]Asahi Kasei Co., [4]Nagoya University

High quality $Al_{0.6}Ga_{0.4}N$ films were obtained by growing three-dimensionally on the annealed sputtered AlN on a-plane sapphire. The dislocation density of $Al_{0.6}Ga_{0.4}N$ estimated from the cathodeluminescence dark spot was 7.4×10^8 cm^{-2}.

LEDIAp-09

Suppression of the step bunching in GaN crystal using purified Na in the Na-flux method

Hyoga Yamauchi, Takumi Yamada, Masayuki Imanishi, Yusuke Mori
Osaka University

In GaN crystal grown by the Na-flux method, inclusions were often observed. In this study, we suppressed the step bunching during growth to reduce the formation of inclusions by using purified Na.

LEDIAp-10

Thermodynamic analysis of metalorganic vapor phase epitaxy of group-III sesquioxides

Saori Matsugai[1], Nami Tanaka[1], Sakiko Yamanobe[1], Nao Takekawa[1], Ken Goto[1], Yoshinao Kumagai[1,2]
[1]Department of Applied Chemistry, Tokyo University of Agriculture and Technology, [2]Institute of Global Innovation Research, Tokyo University of Agriculture and Technology

Thermodynamic analyses on MOVPE of group-III sesquioxides (Ga_2O_3, Al_2O_3 and In_2O_3) were performed. The results clarified growth conditions for high temperature growth at and above 1000 ºC.

LEDIAp-11

Inductively Coupled Plasma Reactive Ion Etching of GaN Films Maintaining Surface Flatness for Surface Activated Bonding

Naoki Yokoyama, Ryo Tanabe, Takaya Morikawa, Yasufumi Fujiwara, Masahiro Uemukai, Tomoyuki Tanikawa, Ryuji Katayama
Osaka University

Effect of ICP-RIE conditions on surface flatness of GaN films was investigated. Addition of Ar gas to Cl_2 gas was effective in reducing chloride-based by-products that hinder uniform etching.

LEDIAp-12 *Withdraw*

LEDIAp-13 *Withdraw*

LEDIAp-14

Effect of N radical irradiation on InN film for surface modification

TSUTOMU ARAKI, Faizulsalihin Bin Abas, Shinichiro Mouri, Yasushi Nanishi
Ritsumeikan University

In-situ surface modification of InN film by N radical beam irradiation was investigated using different substrate temperature, plasma power and irradiation time. The surface morphological changes and electrical properties of irradiated InN templates were studied.

LEDIAp-15

Optical characteristics of high–Indium–content GaInN MQWs grown on different templates by RF–MBE

Ryosuke Yoshida, Hiroki Hirukawa, Kaigo Tahara, Tomohiro Yamaguchi, Takeyoshi Onuma, Tohru Honda
Kogakuin University

GaInN multi–quantum–wells (MQWs) with GaInN barriers were grown on GaInN templates. Those optical characteristics are discussed. Especially, the characteristics were compared with those of MQWs with GaN barriers.

LEDIAp-16

Thermodynamic study of $(Al_xGa_{1-x})_2O_3$ ternary alloy growth by metalorganic vapor phase epitaxy

Nami Tanaka[1], Saori Matsugai[1], Sakiko Yamanobe[1], Nao Takekawa[1], Ken Goto[1], Yoshinao Kumagai[1,2]
[1]Department of Applied Chemistry, Tokyo University of Agriculture and Technology, [2]Institute of Global Innovation Research, Tokyo University of Agriculture and Technology

Growth of $(Al_xGa_{1-x})_2O_3$ ternary alloy using metalorganic vapor phase epitaxy (MOVPE) was thermodynamically investigated. The results revealed a linear vapor-solid distribution relationship at 1000 ºC even under a high interaction parameter of 10000 cal/mol.

LEDIAp-17

Growth promotion of GaN point seed with lithium addition in the Sodium flux method

Kazuma Hamada, Takumi Yamada, Kosuke Nakamura, Kosuke Murakami, Masayuki Imanishi, Masashi Yoshimura, Yusuke Mori
Osaka University

For the fabrication of low-dislocation GaN substrate, the use of small diameter point seed is effective. The difficulty to grow on extremely small-diameter point seed was overcome by adding lithium in the sodium flux.

LEDIAp-18

Structural analyses of a-In_2O_3 grown on a-Al_2O_3 substrates by Mist CVD

Yuka Hayakawa[1], Soichiro Ohno[1], Tomohiro Yamaguchi[1], Takanori Kiguchi[2], Hirokazu Yokoo[1], Takeyoshi Onuma[1], Tohru Honda[1]
[1]Kogakuin University, [2]Institute for Materials Research, Tohoku University,

Structural analyses by transmission electron microscopy (TEM) of a-In_2O_3 grown on (0001) a-Al_2O_3 by Mist CVD were carried out. The space distribution of edge and screw dislocations were observed in a-In_2O_3.

LEDIAp-19

Fabrication of μ-LED pixels and evaluation of luminescent characteristics

Hiroyoshi Chikui[1], Shoma Takeda[1], Kota Sato[1], Takeyoshi Onuma[1], Tomohiro Yamaguchi[1], Mitsuaki Shimizu[2], Tokio Takahashi[2], Tohru Honda[1]
[1]Kougakuin University, [2]National Institute of advanced Science and technology

Approximately 20 μm × 20 μm size μ-LED pixels were fabricated using ICP-RIE with Ni metal mask. Evaluation using monochromatic cathodoluminescence measurements showed that n-GaN contact layer was well exposed by the etching.

LEDIAp-20 *Withdraw*

LEDIAp-21 *Withdraw*

LEDIAp-22

Growth of AlGaN films on AlN template by RF-plasma assisted molecular beam epitaxy

Mari Hashimoto, Naozumi Tachibana, Tohru Honda, Tomohiro Yamaguchi, Takeyoshi Onuma
Kogakuin University

100-430-nm-thick $Al_xGa_{1-x}N$ thin films with x=0.77-0.83 were grown by RF-plasma-assisted molecular beam epitaxy on c-plane AlN on Al_2O_3 templates. Root mean square roughness of 0.61 nm was obtained for 100-nm-thick $Al_{0.83}Ga_{0.17}N$ thin film.

LEDIAp-23 *Withdraw*

LEDIAp-24 *Withdraw*

LEDIAp-25 *Withdraw*

LEDIAp-26 *Withdraw*

LEDIAp-27 *Withdraw*

LSC

[LSC1] Time-resolved measurements

LSC-OP
Opening Remarks

LSC1-01 *Invited*
Development of laser-based soft x-ray attosecond pulse sources and their application to transient absorption spectroscopy in gaseous media

Nobuhisa Ishii[1], Nariyuki Saito[2], Teruto Kanai[2], Jiro Itatani[2]
[1]Kansai Photon Science Institute, National Institutes for Quantum and Radiological Science and Technology, [2]The Institute for Solid State Physics, The University of Tokyo

We present the development of an intense, few-cycle infrared light source and its applications to soft x-ray high harmonic generation and to transient absorption spectroscopy in gases at the nitrogen K edge around 400 eV. After the photo-ionization of nitric oxide by 1600-nm infrared pulses, we observe the electronic dynamics of both neutral and ion molecules, the molecular dynamics of the nitric oxide ions, and the rotational motion of the neutral molecules.

LSC1-02 *Invited*
Role of the ultrafast structural dynamics for developing photoinduced phase transition (PIPT) materials

Shinya Koshihara[1], Tadahiko Ishikawa[1], Yoichi Okimoto[1], Kou Takubo[1], Masaki Hada[2]
[1]School of Science, Tokyo Institute of Technology, [2]Faculty of Pure and Applied Sciences, University of Tsukuba

In this talk, brief history of the challenging experimental works for developing photo-induced phase transition (PIPT) phenomena will be introduced. In addition, recent development for realizing Quantum PIPT materials utilizing ultrafast light technologies including femtosecond electron diffraction will be discussed.

LSC1-03 *Withdraw*

LSC1-04 *Invited*
Time-resolved ARPES of sub-10-fs intraband electric redistribution in graphite

Katsuya Oguri, Keiko Kato, Hiroki Mashiko
NTT Basic Research Laboratories, NTT Corpporation

We report an observation of the photoexcitation and the primary relaxation process in the strongly nonequilibrium electron system of graphitebased on our sub-5-fs probe time- and angle-resolved photoemission spectroscopy technique.

[LSC2] New facilities, new techniques

LSC2-01 *Invited*
High-Resolution Resonant Inelastic Soft X-ray Scattering Research at NSRRC

Jun Okamoto
National Synchrotron Radiation Research Center

High-resolution resonant inelastic X-ray scattering researches in soft X-ray region have been promoted at NSRRC for these two decades. Research results and status of newly constructed system at 3-GeV ring TPS beamline 41A are presented.

LSC2-02 *Withdraw*

LSC2-03 *Invited*
Photo-induced Magnetization dynamics observed with synchrotron radiation and free electron lasers

Kohei Yamamoto[1], Hiroki Wadati[2]
[1]Institute for Molecular Science, [2]Graduate School of Material Science, University of Hyogo

In order to capture the ultrafast photo-induced spin dynamics with x-rays, we developed time-resolved x-ray magneto-optical effect measurement appratuses using a synchrotron radiation and an x-ray free electron laser.

[LSC3] New facilities, new techniques

LSC3-01 *Invited*
Ultrafast valence dynamics of $EuNi_2(Si_{0.21}Ge_{0.79})_2$ probed by time-resolved soft X-ray absorption spectroscopy

Kohei Yamagami[1], Yujun Zhang[2], Kohei Yamamoto[3], Hiroki Ueda[4], Urs Staub[4], Sang Han Park[5], Soonnam Kwon[5], Kojiro Mimura[6], Takayuki Uozumi[6], Akihiro Mitsuda[7], Hirofumi Wada[7], Hiroki Wadati[2]
[1]The University of Tokyo, [2]Mater. Sci., Univ. of Hyogo, [3]IMS, [4]PSI, [5]PAL-XFEL, [6]Grad. Sch. Eng., Osaka Pref. Univ., [7]Dep. of Phys., Kyushu Univ.

Valence transition phenomena originating from the hybridization between 4*f* and conduction electrons are strongly related to the quantum critical phenomena of the strongly correlated rare-earth compounds. We performed Eu *M*-edge time-resolved X-ray absorption spectroscopy for $EuNi_2(Si_{0.21}Ge_{0.79})_2$ by using 800 nm laser and X-ray free electron laser and observed femto-second photon-induced valence transition of Eu ions.

LSC3-02 *Invited*
Molecular Interactions in Liquids Probed by Soft X-ray Absorption Spectroscopy in Transmission Mode

Masanari Nagasaka
Institute for Molecular Science

We have developed a liquid cell for soft X-ray absorption spectroscopy of liquids in transmission mode. From the precise energy shift analyses, we discuss molecular interactions in several liquids such as concentration dependence of aqueous pyridine and acetonitrile solutions and temperature dependence of liquid benzene.

LSC3-03 *Withdraw*

[LSC4] Material science

LSC4-01 *Invited*
Various topological states of quasi-one-dimensional bismuth halides revealed by angle-resolved photoemission spectroscopy

Takeshi Kondo
The University of Tokyo

The three-dimensional topological insulator (TI) is classified as either “strong” or “weak”. In contrast to the strong TI, the weak TI has eluded experimental verification. In my talk, I will provide evidence for the weak TI state in β-Bi_4I_4 obtained by angle-resolved photoemission spectroscopy. I will also demonstrate the first experimental realization of a higher-order TI by investigating Bi_4Br_4; bismuth halides are thus capable of selecting various topologies.

LSC4-02 *Invited*
Unusual photoacoustic phenomena in transition-metal dichalcogenide

Kyoko Ishizaka
The University of Tokyo

Controlling acoustic phonons, the carriers of sound and heat, has been attracting great attention. Here we investigate an unusual photo-acoustic effect occurring in a transition-metal dichalcogenide VTe_2, coupled to the electron system via charge-density-wave. Ultrafast electron microscope imaging and diffraction measurements reveal the generation and propagation of unusual acoustic waves in the nanometric thin plate.

LSC4-03 *Invited*
Observation of Non-linear Conductivity Phenomena by Synchrotron X-ray Spectroscopy

Daiki Ootsuki
Graduate School of Human and Environmental Studies, Kyoto University, Japan

To understand the electronic structure in non-equilibrium situation and clarify the origin of the non-linear conductivity phenomena, the photoemission and absorption experiments under electric field were performed using the synchrotron x-ray sources.

[LSC5] Material science

LSC5-01 *Invited*
Magnetic anisotropy and anisotropic electronic structures studied by angle-dependent XMCD

Goro Shibata
Tokyo University of Science

For a better understanding of the microscopic mechanism of magnetic anisotropy in thin films, we have performed angle-dependent XMCD measurements on ferromagnetic thin films of $La_{1-x}Sr_xMnO_3$ and $L1_0$-type FePt. We have revealed the anisotropic electronic structures in both samples through the measurements of magnetic dipole moment M_T.

LSC5-02 *Withdraw*

LSC5-03 *Invited*
Ultrafast quantum path interferometry using phase-locked femtosecond pulses

Kazutaka Nakamura[1], Yosuke Kayanuma[1,2]
[1]Tokyo Institute of Technology, [2]Osaka Prefecture University

The ultrafast quantum path interferometry using phase-locked femtosecond pulses has formulated with a quantum theory based on two-electronic levels with harmonic phonons and confirmed with the coherent control experiments on optical phonons in GaAs.

[LSC6] New facilities, new techniques

LSC6-01 *Withdraw*

LSC6-02 *Invited*
Laser-SR synchronization for laser seeding to generate monocycle FEL radiation at NewSUBARU

Yoshihito Tanaka[1], Sumiyuki Okabe[1], Keisuke Kondo[1], Yuichiro Kida[2], Ryota Kinjyo[2], Tadashi Togashi[3], Hiromitsu Tomizawa[3], Satoshi Hashimoto[4], Shuji Miyamoto[4], Takashi Tanaka[2]
[1]Graduate School of Material Science, University of Hyogo, [2]RIKEN SPring-8 Center, [3]JASRI/SPring-8, [4]LASTI, University of Hyogo

The timing synchronization of a femtosecond pulse laser and an electron bunch in the storage ring of NewSUBARU has been achieved for laser seeding to generate monocycle FEL radiation.

LSC6-03
Advanced Gamma ray Generation by High Power Laser and High Brightness Electron Beam at UVSOR

Heishun Zen
Kyoto University

Gamma rays having many attractive features can be generated by colliding high power laser with high brightness electron beam. Present status and future plan of gamma-ray beamline in UVSOR will be presented.

[LSC7] New facilities, new techniques

LSC7-01 *Withdraw*

LSC7-02 *Invited*
Topological physics explored by ultracold ytterbium atoms in an optical lattice

Nobuyuki Takei
Kyoto University

We experimentally reveal the competition and interplay between topological quantum phenomena and disorder in a setting of topological Thouless pumping under controllable quasi-periodic disorder using ultracold Fermi gases of ytterbium atoms in an optical lattice.

LSC7-03
Ultrafast structural dynamics of nanoplasmas probed by time-resolved X-ray diffraction

Akinobu Niozu
Kyoto University

We examined the structural evolution of nanoplasmas induced by intense near-infrared (NIR) laser pulses by means of time-resolved X-ray diffraction using an XFEL.

LSC

[LSC8] Material Science

LSC8-01 *Invited*

Optical investigations of APLF glass co-doped with Pr^{3+} and Ce^{3+}

Toshihiko Shimizu[1], Yuki Minami[1], Jacque Lynn Gabayno[1,2], Verdad C. Agulto[1], Youwei Lai[1], Melvin John F. Empizo[1], Kohei Yamanoi[1], Nobuhiko Sarukura[1], Akira Yoshikawa[3], Takahiro Murata[4], Malgorzata Guzik[5], Yannick Guyot[6], Georges Boulon[6], John A. Harrison[7], Marilou Cadatal-Raduban[1,7]
[1]Institute of Laser Engineering, Osaka University, [2]Mapua University, [3]Tohoku University, [4]Kumamoto University, [5]University of Wroclaw, [6]Université Claude Bernard Lyon 1, [7]Massey University

The optical properties of APLF80 grass co-doped with Pr^{3+} and Ce^{3+} was investigated. This grass has an interesting emission process and has a potential for a new fast and intense scintillator with a good tenability.

LSC8-02 *Invited*

Time resolved attenuated total reflection spectroscopy on photo catalyst $[Re(CO)_2(bpy)\{P(OEt)_3\}_2](PF_6)$

Hiroshi Watanabe[1], Phuong Ngoc Nguyen[1], Yusuke Tamaki[2], Osamu Ishitani[2], Shin-ichi Kimura[1]
[1]Osaka University, [2]Department of Chemistry, Tokyo Institute of Technology

We measured time development of THz spectra on $[Re(CO)_2(bpy)\{P(OEt)_3\}_2](PF_6)$ using time-resolved attenuated total reflection terahertz spectroscopy method. We observed the peak shifts and peak intensity changes of the 1.35 THz peak corresponding to the inter molecular vibration mode. These results indicate the not only the electron transfer between Re complex and the reducing agent but also its precursor phenomena.

LSC8-03 *Invited*

VUV spectroscopy of Nd^{3+}-doped $20Al(PO_3)_3$-80LiF glass as a potential scintillator material

Melvin John Fernandez Empizo[1], Marilou Cadatal-Raduban[2], Yuki Minami[1], Kohei Yamanoi[1], Toshihiko Shimizu[1], Takahiro Murata[3], Akihiro Yamaji[4], Akira Yoshikawa[4], Malgorzata Guzik[5], Yannick Guyot[6], Georges Boulon[6]
[1]Osaka University, [2]Massey University, [3]Kumamoto University, [4]Tohoku University, [5]University of Wrocław, [6]Université Claude Bernard Lyon1

By leveraging the fast VUV emission lifetimes of Nd^{3+} ions and the high Li content of APLF glass, we report the VUV spectroscopy of 1.0 mol% Nd^{3+}-doped APLF glass as a potential scintillator material.

[LSC9] Material Science

LSC9-01 *Withdraw*

LSC9-02 *Withdraw*

LSC9-03 *Invited*

Photo-induced phase transitions and Floquet engineering in solids

Kazuaki Takasan
University of California, Berkeley

Application of strong laser light to solids drives the motion of the electrons and the ions and realizes the excited states. This excitation can transiently induce a new "phase" macroscopically distinguishable from the original state.

LSC-CL

Closing Remarks

[LSCp] Poster Session

LSCp-01

Numerical investigation of laser-induced damage in optical material based on percolation model

Jacque Lynn Ferranco Gabayno[1,2], Akira Sasaki[3], Susumu Kato[4], Nobuhiko Sarukura[1]
[1]Institute of Laser Engineering Osaka University, [2]Mapua University, [3]Kansai Photon Science Institute, National Institutes for Quantum and Radiological Science and Technology, [4]Electronics and Photonics Research Institute, National Institute of Advanced Industrial Science and Technology

We present a numerical model of laser-induced damage (LID) based on percolation theory and known properties of an optical material. The threshold behavior and change in electrical property of a material was investigated using a stochastic approach to photoionization.We show the spatio-temporal evolution of optical damage, its critical dependence on laser conditions, and establish quantitative agreement between our simulation results and experiments.

LSCp-02

Investigation of Cu-doped ZnO microrods using photoluminescence spectroscopy and x-ray absorption near-edge structure spectroscopy

Verdad Canila Agulto[1], Melvin John F Empizo[1], Kloudene A Salazar[2], Keito Shinohara[1], Kohei Yamanoi[1], Toshihiko Shimizu[1], Vallerie Ann I Samson[3], Roland V Sarmago[2,1], Nobuhiko Sarukura[1]
[1]Osaka University, [2]University of the Philippines Diliman, [3]Department of Science and Technology of the Philippines

This study presents the photoluminescence properties of Cu-doped ZnO microrods fabricated using hydrothermal growth method and confirms the successful incorporation of Cu^{2+} dopants in the ZnO lattice.

LSCp-03

X-ray absorption spectroscopy analysis of Fe-doped ZnO

Kloudene Salazar[2], Vallerie Ann Samson[1], Jonah Micah Inguito[2], Nobuhiko Sarukura[3], Melvin John Empizo[3], Verdad Canila Agulto[3], Pinit Kidkhunthod[4], Suchinda Sattayapornttayaporn[4], Roland Sarmago[2]
[1]Philippine Nuclear Research Institute, [2]National Institute of Physics, University of the Philippines-Diliman, [3]Institute of Laser Engineering, Osaka University, [4]Synchrotron Light Research Institute

Zinc oxide is a promising base material for opto-electronic devices because of its efficient UV emission and room temperature luminescence. Doping with transition metals such as Fe offers a way to modify the optical properties of ZnO. In order to completely understand the role of dopant atoms in the optical emissions of ZnO, XANES and EXAFS measurements were performed.

LSCp-04

Grazing incidence x-ray diffraction spectroscopy of non-irradiated and D-ion plasma-irradiated bulk ZnO single crystals

Melvin John Fernandez Empizo[1], Erick John Carlo De Guzman Solibet[2], Myles Allen Hermoso Zosa[1], Verdad Canila Agulto[1], Yuki Minami[1], Kohei Yamanoi[1], Toshihiko Shimizu[1], Allan Abraham Bustria Padama[3], Vallerie Ann Innis Samson[4], Armando Soriano Somintac[2], Roland Villano Sarmago[2], Arnel Angud Salvador[2], Nobuhiko Sarukura[1]
[1]Osaka University, [2]University of the Philippines Diliman, [3]University of the Philippines Los Baños, [4]Department of Science and Technology

To better understand radiation-matter interaction and the possible interaction of ions on the surface, we investigate the specific effects of D-ion plasma irradiation on a bulk ZnO single crystal using grazing incidence x-ray diffraction spectroscopy.

LSSE web-meeting room *https://zoom.us/j/8393451683*

LSSE

Tuesday, 21 April

[LSSE1] 11:00-12:10
Opning & Keynote1
Chair: Akio Kanai
Institute for Advanced Biosciences
Keio University

LSSE-0P 11:00
Opening Remarks

LSSE1-01 11:10 ***keynote***
The origin and evolution of life: System evolution of the universe and the Earth
Shigenori Maruyama
ELSI, Tokyo Institute of Technology
The habitable planet Earth was born as a dry rocky planet, and atmospheric/oceanic components were secondary accreted through the ABEL bombardment during 4.37-4.20Ga. Including this scenario, there are about 50 conditions to be a habitable planet with civilization.

[LSSE2] 13:30-14:30
Microorganism, Environmental measurement of Fukushima
Chair: Akihiko Nishimura
Japan Atomic Energy Agency

LSSE2-01 13:30 ***Invited***
Microbial genome analysis: from basics to frontiers
Akio Kanai
Keio University
In my talk, I am going to divide my presentation into two parts. The first half will explain the very basics of genome analysis of microorganisms. In the latter half, I would like to mention especially the latest topics in this field that became clear as a result of metagenome analysis.

[LSSE3] 15:30-17:00
Microorganism, Radiation measurement
Chairs: Akihiko Nishimura
Japan Atomic Energy Agency
Akio Kanai
Institute for Advanced Biosciences
Keio University

LSSE3-01 15:30
Development of Radiation Distribution Sensing Method using One-Dimensional Optical Fiber for Fukushima Daiichi NPS Decommissioning
Yuta Terasaka[1,2], Kenichi Watanabe[2], Akira Uritani[2], Yuki Sato[1], Tatsuo Torii[1], Ikuo Wakaida[1]
[1]Japan Atomic Energy Agency, [2]Nagoya University
We will introduce the R&D activities about the radiation distribution sensing method using one-dimensional optical fiber for the decommissioning of the Fukushima Daiichi Nuclear Power Station. A novel radiation distribution sensing method which focused on the wavelength information of the emitted spectrum was developed for the high dose rate measurement.

LSSE3-02 15:50
Introduction to Multi Cubic high energy gamma-ray spectrometer
Masaaki Kaburagi[1], Kenji Shimazoe[2], Yutaka Otaka[2], Mizuki Uenomachi[2], Kei Kamada[3], Kyoung Jin Kim[3], Masao Yoshino[3], Yasuhiro Shoji[3], Akira Yoshikawa[3], Hiroyuki Takahashi[2], Tatsuo Torii[1]
[1]Collaborative Laboratories for Advanced Decommissioning Science, Japan Atomic Energy Agency, [2]The school of Engineering, The University of Tokyo, [3]New Industry Creation Hatchery Center, Tohoku University
We developed a high energy gamma-ray spectrometer using a small cubic $CeBr_3$ scintillator, and verified that the spectrometer had the energy resolution at 1333 keV are 3.95% at 790 mSv/h.

LSSE3-03 16:10 ***Invited***
Cell and bacteria analysis by scanning electron microscopy using neodymium chloride: rapid, informative, insightful
Oleg Gusev
Riken
The quality of electron microscopy (EM) visualization of biological objects is constantly improving, primarily with the usage of more complex technologies, such as serial block- face scanning electron microscopy (SEM), focused ion beam scanning electron microscopy, and array tomography. Here we suggest a new rapid method of whole cell sample preparation for scanning EM using neodymium chloride treatment followed by staining with lead acetate.

LSSE3-04 16:40
Risk Reduction with Prolonged Decommissioning for Fukushima Daiichi Nuclear Power Plant
Akihiko Nishimura[1,2], Akio Kanai[3], Minoru Yoshida[4]
[1]Japan Atomic Energy Agency, [2]University of Fukui, [3]Keio University, [4]HAKUSAN
Effective risk reduction associated with prolonged decommissioning for Fukushima Daiichi NPP (1F) is an urgent issue. Here are eight directions for the fundamental R&D themes.

Wednesday, 22 April

[LSSE4] 9:00-10:30
Environment, Conservation and Energy
Chair: Akio Kanai
Institute for Advanced Biosciences
Keio University

LSSE4-01 9:00 ***Invited***
Conversion of Radioactive Waste into Clean and Sustainable Energy
Hiroshi Uechi[1], Akihiko Nishimura[2]
[1]Osaka Gakuin University, [2]University of Fukui
We propose the concept to convert nuclear radioactive wastes from nuclear plants into clean and sustainable energy through mechanoelectric energy generations (MEG) and energy-harvesting technology.

LSSE4-02 9:30 ***Invited***
Microbial Uranium Immobilization: Could it give a solution for controlling radionuclide dispersal for Fukushima Daichi Nuclear Disaster?
Yohey Suzuki
The University of Tokyo
Microbes play key roles in transformation of mobile uranium into its immobile forms via reduction, sorption and intracellular uptake. In addition to direct interactions, microbial uranium immobilization is known to occur via incorporation and/or agglomeration into calcium phosphate and calcium carbonate. In this presentation, recent advances will be summarized to seek a solution for controlling radionuclide dispersal for Fukushima Daichi Nuclear Disaster.

LSSE4-03 10:00 ***Invited***
Selective laser ionization for the reduction of radioactive wastes
Tohru Kobayashi
RIKEN Institute of Advanced Photonics
Based on the transition selection rule, we have developed both efficient and selective photoionization schemes for palladium and zirconium, which will contribute to the reduction of high-level nuclear wastes.

[LSSEp] 11:00-12:15
Poster Session (Oral)

LSSEp-01 11:00
Influence of plastic deformation in laser resonance frequency analysis for metallic anchorage bolt
Katsuhiro Mikami, Hiroaki Nishikawa
Kindai University
Laser vibration spectra of fastened metallic anchorage bolts with different torque were investigated by laser resonance frequency analysis to reveal influence of the plastic deformation.

LSSEp-02 11:15
Electric-field induced second-harmonic generation in atmospheric air using high intensity femtosecond laser pulses
Takashi Fujii[1], Masahiro Sato[1], Shin Nakamura[1], Akiko Kumada[1], Megumu Miki[2], Yuji Oishi[2]
[1]The University of Tokyo, [2]Central Research Institute of Electric Power Industry
The intensity of second harmonics of femtosecond laser pulses increased quadratically versus electric field with laser energy of 3 mJ, suggesting the electric field can be measured with the laser energy above optical breakdown threshold.

LSSEp-03 11:30
Thermal Blooming Measurement in Gas with Near-Infrared Laser Beam
Naoto Sakaki[1], Tomohiro Tsukihana[1], Toshikazu Ebisuzaki[1], Masashi Iwashimizu[2], Takuya Noritake[2], Shingo Nishikata[2], Hiroyuki Daigo[2], Yoshikatsu Kuroda[2], Masayuki Fujita[3], Seiji Taniguchi[3], Shinji Motokoshi[3]
[1]RIKEN, [2]Mitsubishi Heavy Industries, Co., Ltd., [3]Institute for Laser Technology
It is important to understand thermal blooming effect which distorts the propagation of Laser beam for application like energy transmission. We have started a laboratory experiment to evaluate the effect.

LSSEp-04 11:45
Improving the moisture permeability of structural plywood using laser drilling
Koichi Sakai[1,2], Kazuhisa Fujita[1], Kunioki Mima[1]
[1]The Graduate School for the Creation of New Photonics Industries, [2]LIHITO.Inc
Laser drilling in structural plywood improved moisture permeability by 37%, compared with normal screw drilling. It comes from barrel shape of the inner surface of the hole drilled by laser.

LSSEp-05 12:00
Promotion of Thermal Energy Plants and Decommissioning NPPs
Akihiko Nishimura[1], Toru Okazaki[2], Hiroshi Uechi[3]
[1]University of Fukui, [2]Institute of Applied Energy, [3]Osaka Gakuin University
The best way to reduce waste in decommissioning nuclear power plants is reuse for energy security. We propose to modify them as thermal storage plants.

[LSSE5] 13:30-15:30
Laser application for newclear power
Chair: Noboru Hasegawa
QST

LSSE5-01 13:30 ***Invited***
Fundamentals of laser peening and applications to life-extension of infrastructure with palmtop-sized handheld lasers
Yuji Sano[1,2]
[1]Institute for Molecular Science, National Institutes of Natural Sciences, [2]Institute of Scientific and Industrial Research, Osaka University
Laser peening was developed and has been applied to nuclear power reactors since 1999. Ultra-compact high-power pulse lasers developed in ImPACT will extend the application to maintenance of infrastructure.

LSSE5-02 14:00 ***Invited***
Production of fine particles and fragments emitted from laser ceramic and concrete interactions
Hiroyuki Daido[1], Tomonori Yamada[2], Chikara Ito[2], Masabumi Miyabe[2], Takuya Shibata[2], Hiroyuki Furukawa[1], Shuichi Hasegawa[3]
[1]Institute for Laser Technology, [2]Japan Atomic Energy Agency, [3]The University of Tokyo
We present fine particle and fragment production from a laser irradiated ceramics and concrete samples during a laser processing as a fundamental study for the debris retrieval for the decommissioning of the Fukushima Dai-ichi Nuclear Power Station.

LSSE web-meeting room *https://zoom.us/j/8393451683*

LSSE

Wednesday, 22 April

LSSE5-03 14:30 *Invited*

Developments in Laser Cutting for Combined Materials of Steel and Concrete

Mitsuhiro Sato[1], Eisuke John Minehara[2]
[1]HAZAMA ANDO Corporation, [2]LDD Corporation

We have been developing a laser cutting technique. In full scale mockup experiments, laser cutting has achieved of combined materials in one process. Results indicate that optical fiber core size and efficiency of assist gas largely affect the cutting speed.

LSSE5-04 15:00 *Invited*

Summary of environmental radiation monitoring around the Fukushima Daiichi Nuclear Power Station

Yukihisa Sanada
Japan Atomic Energy Agency

Immediately after the Fukushima Dai-ichi Nuclear Power Station accident, many radiation monitoring data have been acquired by various government organizations. In this paper, the current situation of environmental radiation monitoring is summarized.

Thursday, 23 April

[LSSE6] 11:00-12:30
Space debris 1
Chair: Marco Capitanio
University of Florence

LSSE6-01 11:00 *Invited*

Removal of non-functional spacecraft by satellite-mounted laser

Tadanori Fukushima[1], Daisuke Hirata[1], Jun Yamada[1], Yuki Itaya[1], Takayo Ogawa[2], Katsuhiko Tsuno[2], Satoshi Wada[2], Toshikazu Ebisuzaki[2], Hiroshi Ueno[3], Takashi Hiramatsu[3], Akihiro Sasoh[4], Yusuke Nakamura[4], Toshiya Hanada[5], Yuri Matsushita[5]
[1]SKY Perfect JSAT Co., Ltd., [2]RIKEN, [3]JAXA, [4]Nagoya University, [5]Kyushu University

SKY Perfect JSAT Co. has launched a new mission, which removes non-functional spacecraft by laser ablation from a satellite-mounted laser with keeping a safe distance, in order to achieve space sustainability in collaboration with RIKEN, JAXA, Nagoya Univ., and Kyushu Univ. Laser ablation takes advantage in control the attitude of tumbling objects. And recent progress of laser technology has increased the feasibility to mount such lasers on small satellite.

LSSE6-02 11:30 *Invited*

Impulse Measurement of Laser Induced Ablation in Vacuum

Katsuhiko Tsuno[1], Satoshi Wada[1], Takayo Ogawa[1], Tadanori Fukushima[2], Daisuke Hirata[2], Jun Yamada[2], Yuki Itaya[2]
[1]RIKEN, [2]SKY Perfect JSAT

The new impulse measurement system based on a simple pendulum is developed. The system has temporal resolution of <1sec and sensitivity of ~10^{-7}Ns to measure individual laser induced ablation events. The momentum coupling factor of ~20 μNs/J is observed over the fluence of 4~40J/cm^2 for aluminum alloy target.

LSSE6-03 12:00 *Invited*

National Science Foundation ZEUS*: A laser-driven mid-scale science facility for studies in the QED regime with R&D history of high peak power laser systems in CUOS

John Nees
Gérard Mourou Center for Ultrafast Optical Science, University of Michigan

NSF has sponsored the Zetawatt Equivalent Ultrashort pulse laser System (ZEUS), a 3PW multi-beam mid-scale facility to explore relativistic plasmas, nonlinear quantum electrodynamics, and extreme high-field science.

[LSSE7] 13:30-15:00
Space debris 2
Chair: Toshikazu Ebisuzaki
RIKEN

LSSE7-01 13:30 *Invited*

Ground-based optical observation of space debris at Bisei Spaceguard Center.

Tokuhiro Nimura, Kota Nishiyama, Tomoko Fujiwara, Shin-ichiro Okumura, Seitaro Urakawa, Nariyasu Hashimoto, Atsuo Asami
Japan Spaceguard Association (JSGA)

We introduce about current states and future of observation systems and analysis method for space debris at Bisei Spaceguard Center (BSGC).

LSSE7-02 14:00 *Invited*

Monitoring the low earth orbit using opcical fence

Toshifumi Yanagisawa, Koki Kamiya, Hirohisa Kurosaki
Japan Aerospace Exploration Agency

Optical sensors such as CCD and CMOS will be the power tool to monitor the low earth orbit compensating current radar technology. We developed the proto-type using CMOS sensors.

LSSE7-03 14:30 *Invited*

Study of Debris identification using Mini-EUSO detector on board the International Space Station

Marco Casolino[1], Toshikazu Ebisuzaki[1], Lech Wiktor Piotrowski[1], Naoto Sakaki[1], Yoshiyuki Takizawa[2]
[1]RIKEN, Computational Astrophysics Lab, [2]RIKEN, Ultrahigh Precision Optics Technology Team

We will report on observations of Mini-EUSO, a UV telescope observing the Earth from the ISS since 2019 that can detect the transit of debris in space. We are also developing a Mini-EUSO-like larger ground telescope with 1m lenses to test the principle of detection of moving objects and Laser shooting. Work supported by Innovative Science and Technology Initiative for Security, ATLA Japan.

[LSSE8] 15:30-17:00
Active remote sensing
Chair: Takashi Fujii
The University of Tokyo

LSSE8-01 15:30 *Invited*

In-situ Robotic Raman Spectroscopy for Nuclear Decommisioning

David Megson-Smith, Tom Scott, John Day, Sam White
Interface Analysis Center, HH Wills Physics Laboratory, Tyndall Avenue,Bristol, BS8 1TL, United Kingdom

Aside from the radioactive characteristics of nuclear waste it is imperative that chemical composition is also assessed. To this end, a range of fibre coupled Raman sensors for remote inspection of extreme enviroments are presented, including; endoscopic-contact, short working distance and stand-off sensors. Examples of their operation whilst deployed on various robotic platforms are given.

LSSE8-02 16:00 *Invited*

Industrial applications of LIBS technology

Yoshihiro Deguchi[1,2], Zhenzhen Wang[2,1], Minchao Cui[3,1]
[1]Tokushima University, [2]Xi'an Jiaotong University, [3]Northwestern Polytechnical University

Long and Short Double-Pulse LIBS was applied to molten steel samples to demonstrate the quantitative detection ability for the advanced monitoring and control methods in iron and steel making processes.

LSSE8-03 16:30 *Invited*

Measurement of resonance Raman excitation profile for realization of hazardous substance remote sensing technology

Ippei Asahi, Sachiyo Sugimoto, Yuji Ichikawa, Masakazu Ogita, Ayako Hoshino
Shikoku Research Institute Inc.

We conduct a research on trace substance detection based on the resonance Raman effect in order to realize a technology for safely measuring hazardous substances remotely. In this presentation, we measure the resonance Raman excitation profile of SO2 and NO, which are air pollutants, and evaluate the feasibility of remote measurement.

[LSSE9] 17:10-18:10
Keynote 2
Chair: Toshikazu Ebisuzaki
RIKEN

LSSE9-01 17:10 *keynote*

Coherent Amplification Network

Gerard Mourou
Ecole Polytechniue

LSSE web-meeting room *https://zoom.us/j/8393451683*

LSSE

Friday, 24 April

[LSSE10] 11:00-12:30
Agri-photonics 1
Chair: Satoshi Wada
RIKEN

LSSE10-01 11:00

The effect of laser irradiated on the stem of the Mikania Micrantha
Yuan Chung Hsu, Yu Pin Lan
National Chiao Tung University
Here we observed mortality of the different laser energy and laser beam area irradiated on the stem of the Mikania micrantha.

LSSE10-02 11:30 *Invited*

Plant chemical biology research going toward the future agriculture
Takeshi Nakano
Kyoto Univ.
Chemical biology is a new research field that are trying to elucidate unknow mysteries in biology by chemicals as research tools. If we are able to find novel compounds that positively regulate plant growth, it will be useful tool, which can clarify unknown molecular mechanism of plant growth, and it will be used for applied plant science as agriculture. We are trying to identify novel plant growth genes and chemicals, and to apply them for agriculture of rice and sugarcane.

LSSE10-03 12:00 *Invited*

Prediction of optimal conditions for maximising yields of metabolites with a dynamic pathway simulator
Yu Atsumi
SyntheticGestalt
We have developed a dynamic simulator of plant cell metabolic pathways based on enzymatic reactions and reaction rates. This simulator enables us to predict the relationship between a genetic intervention and the monosaccharide production ratio, which is useful for yield maximization.

[LSSE11] 13:30-15:10
Agri-photonics 2
Chair: Norihito Saito
RIKEN

LSSE11-01 13:30 *Invited*

Weather Predictability and Data Assimilation: Perspectives Toward Prediction and Control in Agriculture
Takemasa Miyoshi
RIKEN
Numerical weather prediction (NWP) is probably the most successful prediction made by modern science. Here, predictability and data assimilation are the key. The knowledge obtained in NWP may be useful in different areas including agriculture.

LSSE11-02 14:00 *Invited*

Application of agri-photonics for regulation of plant-light interactions in crops
Hironori Itoh
National Agriculture and Food Research Organization
Crops use light information to adapt to environmental fluctuations, but their responses are sometimes undesirable and uncontrollable. I will introduce the utility of LEDs for genetic improvement of cereal crops.

LSSE11-03 14:30 *Invited*

Effects of growth humidity and light quality on keeping freshness in lettuce
Y. Saito[1], Y. Hara[1], M. Nagata[2], M. Asai[2], N. Nakamura[2], K. Kato[3], K. C. Yamada[3], T. Iwaki[3], S. Wada[1]
[1]RIKEN Center for Advanced Photonics, [2]Food Research Institute, National Agriculture and Food Research Organization, [3]Agri Open Innovation Institute
The purpose of this study was to clarify the effects of cultivation environment, especially relative humidity and light quality, on the maintenance of freshness after harvest in lettuce.

LSSE-CL 15:00

Closing Remarks

LSSE web-meeting room
https://zoom.us/j/8393451683

OMC

[OMC1]
Angular momentum of light
Chair: Masaaki Ashida
Osaka University

OMC1-01

Spin-orbit Laguerre-Gauss beam shaping
Etienne Brasselet
University of Bordeaux, CNRS
The advent of micro/nanofabrication technologies nowadays offer novel opportunities to exploit the spin-orbit interaction of light for shaping the complex amplitude of light. Here we discuss how phase and amplitude could be spatially shaped in order to achieve Laguerre-Gauss modal beam shapers. This requires to account for the effects of both dynamic and geometric phase.

OMC1-02

Picosecond optical vortex induced chiral structures of azo-polymers via two photon absorption
Ami Shiraishi[1], Keigo Masuda[1], Katsuhiko Miyamoto[1,2], Takashige Omatsu[1,2]
[1]Chiba University, [2]Molecular Chirality Research Center, Chiba University
We demonstrate the formation of chiral surface relief of azo-polymers by irradiation of picosecond 1-μm optical vortex with a pulse width of 8ps via two-photon absorption. Optical vortex induced TPA enables us to create the chiral surface structures only within an extremely narrow defocusing tolerance with high three-dimensional (longitudinal and transverse) spatial resolution beyond the diffraction limit and without undesired outer rings of Airy pattern.

OMC1-03

Optical Gradient Force on Chiral Nanoparticles
Junsuke Yamanishi[1], Hyo-Yong Ahn[1], Shun Hashiyada[1,2], H. Okamoto[1]
[1]Institute for Molecular Science, [2]Innovative Photon Manipulation Research Team, RIKEN Center for Advanced Photonics
It is expected that the gradient force depending on the circular polarization (CP) acts on particles with chiral structures. Here, we investigate the CP-dependent gradient force on the chiral gold nanoparticles. We found that the amplitude (dispersion of the position of the Brownian motion) depends on the handedness of the incident light in both cases of D- and L-form particles.

OMC1-04

Orbiting of dielectric particles around a single-mode ultrathin fiber waveguide
Georgiy Tkachenko[1], Ivan Toftul[2], Viet Giang Truong[1], Sile Nic Chormaic[1]
[1]Okinawa Institute of Science and Technology Graduate University, Onna, Okinawa 904-0495, Japan, [2]Department of Physics and Engineering, ITMO University, Kronverkskiy prospekt 49197101, Saint-Petersburg, Russia
We experimentally demonstrate light-induced orbiting of isotropic, dielectric microspheres around a single-mode ultrathin fiber waveguide. In accordance with the theoretical results, the observed orbiting frequency is proportional to the helicity parameter, which is controlled by the degree of circular polarization of the light coupled to the fiber.

OMC1-05

Quantum vortex visualization in superfluid helium
Yosuke Minowa, Kensuke Kokado, Shota Aoyagai, Masaaki Ashida
Osaka University
We demonstrated the visualization of quantum vortices in superfluid helium. The nanoparticles in superfluid helium are trapped at the core of the quantum vortices. By imaging the scattered light, we visualized the quantum vortex motion.

[OMC2]
Photothermal & plasmon trapping
Chair: Ryuji Morita
Hokkaido University

OMC2-01

Laser-heated microswimmers: thermal forces on active particles
Alois Wurger
Universite de Bordeaux
In recent years various experiments reported translational and rotational motion of laser-heated Janus colloids, including steering through feedback and collective effects. We discuss optical actua- tion and swimming mechanisms, in terms of the underlying thermal surface forces and slip velocities, the latter providing hydrodynamic boundary conditions.

OMC2-02

Manipulation of mica flakes using photothermally generated microbubbles
Kyoko Namura, Ryuta Matsumura, Samir Kumar, Motofumi Suzuki
Kyoto University
We experimentally investigated the manipulation of mica flakes coated with iron silicide using photothermally induced microbubble. The bubble was generated by focusing laser at multiple spots on to the flake immersed in degassed water.

OMC2-03

Photothermal energy conversion in plasmonic nanogap antennas: Application to localized ZnO growth for nanophotonics
Christophe Pin[1], Hideki Fujiwara[2], Tatsuro Suzuki[1], Keiji Sasaki[1]
[1]RIES, Hokkaido University, [2]Hokkai-Gakuen University
We engineer plasmonic nanoantennas to achieve controlled localization and enhancement of both the electric field and the heat generation. We demonstrate localized growth of ZnO in the antenna nanogap by plasmon-assisted hydrothermal synthesis.

OMC2-04

Molecular Manipulation by Plasmon Induced Optical Force at Solid-Liquid Interface under Ambient Condition
Nobuaki Oyamada, Hiro MINAMIMOTO, Kei Murakoshi
Hokkaido University
It has been expected that the gradient force in the electric field induced by the localized surface plasmon resonance could retard the molecular Brownian motion. In this study, we have attempted to observe the optical molecular manipulation through electrochemical surface-enhanced Raman scattering measurements. It has been found that the control of the electrochemical potential of the metal nanostructures realized the molecular selective manipulation.

OMC2-05

Enhancement of electrocatalytic oxygen reduction reaction on Au-Ag nanorings by plasmon excitation
Tatsuya Kameyama, Kosuke Sasamoto, Tsukasa Torimoto
Nagoya University
Ring-shaped colloidal Au-Ag nanoparticles were successfully synthesized via galvanic replacement of Ag nanoplates as a template. The thus-obtained nanorings showed a intense localized surface plasmon resonance (LSPR) peak at 680 nm. The Au-Ag nanorings exhibited an electrocatalytic activity for oxygen reduction reaction in an O_2-saturated KOH aqueous solution at negative potential than +0.8 V vs. RHE, the activity being enhanced by the photoexcitation of LSPR.

[OMC3]
Structured light 1
Chair: Takashige Omatsu
Chiba University

OMC3-01

Spin/Orbital Angular Momentum conversion at a nano scale
Jingbo Sun[2,1], Natalia M Litchinitser[1]
[1]Duke University, [2]Tsinghua University
In this work, we perform in-depth theoretical study on the Spin/Orbital Angular Momentum conversion at the nanoscale when a radially polarized vortex beam is ideally focused by a so called-hyperlens. Radially polarized optical vortex beam was used as an input and from the output side, a beam with circular polarization was observed from the hyperlens, which enabled a unique Spin/Orbital Angular Momentum conversion at the extremely tight focal spot of the hyperlens.

OMC3-02

Vector beam induced mass transport in azo-polymer films
Manuel Francisco Ferrer[1], Yousef Alvandi[2,1], Yingwen Zhan[1,3], Ebrahim Karimi[1,2,3]
[1]University of Ottawa, [2]Institute for Advanced Studies in Basic Sciences, [3]National Research Council of Canada
We have performed calculations of the induced-force density due to structured optical beams onto a dispersive-absorptive medium, such an azo-polymer surface, at two different regimes: paraxial and non-paraxial beams.

OMC3-03

Fractional optical vortex creates a curved "spin-jet"
Haruki Kawaguchi[1], Kei Umesato[1], Keisaku Yamane[2], Katsuhiko Miyamoto[1,3], Takashige Omatsu[1,3]
[1]Chiba University, [2]Department of Applied Physics, Hokkaido University, [3]Molecular Chirality Research Center, Chiba University
We discover an entirely novel phenomenon, so-called the formation of curved "spin-jet", in which an irradiated fractional optical vortex provides a donor film non-axisymmetric torque to form a "spin-jet" with a curved trajectory.

OMC3-04

Microscale perovskite crystal creation by optical vortex laser induced forward transfer
Haruki Kawaguchi[1], Kei Umesato[1], Ken-ichi Yuyama[2], Katsuhiko Miyamoto[1,3], Takashige Omatsu[1,3]
[1]Graduate School of Engineering, Chiba University, [2]Research Institute for Electronic Science, Hokkaido University, [3]Molecular Chirality Research Center, Chiba University
We demonstrate the creation of a microscale lead halide perovskite crystal by employing optical vortex laser induced forward transfer (OV-LIFT) technology. The created microscale crystals exhibit efficient visible fluorescence with a lifetime of ~7 ns.

OMC3-05

Ultrafast azimuth rotation of linearly polarized beam by use of a chirped optical pulse pair
Rin Sasaki[1], Keisaku Yamane[1], Kazuhiko Oka[2], Yasunori Toda[1], Takashige Omatsu[3,4], Ryuji Morita[1]
[1]Hokkaido University, [2]Hirosaki University, [3]Chiba University, [4]Molecular Chirality Research Center, Chiba University
We demonstrated that ultrafast azimuth rotation of linearly polarized beam by use of a chirped optical pulse pair, and the rotational frequency of sub-THz was realized.

[OMC4]
Optical manipulation 1
Chair: Keiji Sasaki
Hokkaido University

OMC4-01

A Versatile Fiber-Optic Platform for Optical Transport of Solid Particles and Liquid Droplets
Kyunghwan Oh, Hyeonwoo Lee, Junbum Park
Yonsei University
All-fiber platforms specially designed for optical manipulation of solid particles and liquid droplets are reviewed in terms of the physical principles, waveguide structures, and optical manipulation techniques.

OMC4-02

Transmission spectral and diffraction pattern study on optical trapping and assembling of dielectric nanoparticles at solution/glass interface
Tetsuhiro Kudo, Ching-Shiang Tseng, Abdullah Kamit, Hiroshi Masuhara
National Chiao Tung University
Optical trapping dynamics of dielectric nanoparticles at glass/solution interface, forming a single large disk-like assembly, was studied by transmission spectral and diffraction pattern measurements and ascribed to optical scattering and propagation of trapping laser.

OMC4-03

The Trapping of a Single Chloroform Microdroplet in Water Using Optical Tweezers
Mohd Farid Mohamad Yusof, Shahrul Kadri Ayop
Sultan Idris Education University
Most organic solvents have a higher refractive index than water. Therefore, they can be optically trapped in the form of microdroplet. We report our attempt to trap a single chloroform microdroplet in water.

OMC

OMC4-04

Optical micromanipulation using nonliner photo-responses

Syoji Ito, Shinya Nakamura, Mizuki Hayasaka, Masafumi Koga, Kenji Setoura, Hikaru Sotome, Hiroshi Miyasaka
Osaka University

We have detected multiphoton absorption force acting on microparticles due to simultaneous two-photon absorption. A polymer microparticle including dye molecules was optically trapped with femtosecond pulse pairs with time-interval Δt. The two-photon absorption force increased by decreasing Δt to overlap the pulse pair. The particles were pushed in the direction of light propagation and the displacement increased with decreasing Δt.

OMC4-05

Nanoparticle Trapping using Plasmonic Metamaterials Tweezers

Domna G. Kotsifaki[1,2], Viet Giang G. Truong[1,2], Sile Nic Chormaic[1,2]
[1]Okinawa Institute of Science and Technology Graduate University, [2]Light-Matter Interactions for Quantum Technologies Unit

We experimentally demonstrate, a Fano resonant optical tweezers for multiple nanoparticle trapping based on plasmonic metamaterials. We achieve optical trapping of 20 nm diameter polystyrene particles with low incident trapping intensities (~ 0.65 mW/μm^2) at near resonant frequencies.

[OMC5]
Optical maniputaion 2
Chair: Satoshi Ashihara
University of Tokyo

OMC5-01

Coherent oscillations of a birefringent microsphere in vacuum optical traps

Yoshihiko Arita[1,2], Stephen H. Simpson[3], Pavel Zemanek[3], Kishan Dholakia[1,2,4]
[1]University of St Andrews, [2]Chiba University, [3]The Czech Academy of Sciences, Institute of Scientific Instruments, [4]Yonsei University

We report an experimental observation that when a birefringent microsphere is held in a linearly polarised Gaussian optical trap in vacuum, spontaneous oscillations emerge that grow rapidly in amplitude and become increasingly coherent as the air pressure is reduced.

OMC5-02

Revisit of Azimuthal Doppler Shift for Transverse Flow Measurement by Using an Optical Vortex Beam

Miki Kitazawa, Haruhiko Himura, Kyoko Kitamura
Kyoto Institute of Technology

We revisit the pronciple of transverse ion flow measurement by using an optical vortex beam (OVB). Then we consider its feasibility by using the OVB emitted by surface-processed photonic-crystal laser.

OMC5-03

Chirality Induced Single-Layer Achiral Structures for Spin-Selective Absorption/Reflection

Hafiz Saad Khaliq, Kashif Riaz, Muhammad Zubair, Aima Zahid, Taimoor Naeem, Muhammad Qasim Mehmood
Information Technology Univ of the Punjab, Lahore, Pakistan

This paper presents a novel all-dielectric single-layer chiral mirror based on achiral structures. Such mirror enables us to engineer an optical device for a combination of reflection and absorption in visible regime.

OMC5-04

High-pressure microscopy for manipulating bionanomachines in living cells

Masayoshi Nishiyama
KINDAI University

High-pressure microscopy is one of the powerful techniques that manipulate molecular machines working in cells. We successfully developed a new high-pressure microscope that is optimized both for the best image formation and for stability under high hydrostatic pressure. The techniques described here could be extended to study various biological samples, including molecules, cells and individuals.

OMC5-05

Neuronal electrical activity induced by optical trapping of neurotransmitter receptors on neuron

Tatsunori Kishimoto[1,2], Suguru N. Kudoh[2], Takahisa Taguchi[3], Chie Hosokawa[1,4]
[1]Osaka City University, [2]Kwansei Gakuin University, [3]NICT, [4]AIST

AMPA-type glutamate receptor (AMPAR) is one of neurotransmitter receptors at excitatory synapses in neuronal cell. Here, we demonstrate simultaneous measurement combined optical trapping and fluorescence analysis with patch-clamp recordings to evaluate the neuronal electrical activity. The relationship between optical trapping dynamics of QD-AMPARs located on neuronal cells and the neuronal electrical activity was discussed.

OMC5-06

Spatio-temporally-controlled synthesis of lead halide perovskite crystals by laser trapping

Ken-ichi Yuyama[1,2], Islam Md Jahidul[2], Vasudevanpillai Biju[1,2]
[1]Research Institute for Electronic Science / Hokkaido University, [2]Graduate School of Environmental Science / Hokkaido University

We demonstrate crystallization of lead halide perovskites under the focused laser irradiation in the unsaturated precursor solutions. Upon the irradiation onto the air/solution interface, a perovskite crystal is formed from the focus. The formed crystal dissolves after the laser turns off, which is due to unsaturated condition of the surrounding solution. The mechanism of the crystallization is discussed from the viewpoints of laser heating and laser trapping.

[OMC6]
Nonlinear phenomenon

OMC6-01 *Invited*

Light-induced biological waveguides

Anna Bezryadina[1], Rekha Gautam[2,3], Nicolas Perez[1], Tobias Hansson[4,5], Yinxiao Xiang[2,6], Josh Lamstein[2], Benjamin Wetzel[4,7], Roberto Morandotti[4], Zhigang Chen[2,6]
[1]California State University Northridge, [2]San Francisco State University, [3]Vanderbilt University, [4]Institut National de la Recherche Scientifique, [5]Linköping University, [6]Nankai University, [7]University of Sussex

By using light, living cells can be manipulated to form long waveguide structures in biological suspensions due to nonlinear self-trapping and self-guiding effects. Formed waveguides can provide effective guidance for weaker light through scattering bio-soft-matter.

OMC6-02

Spinning twin-mode generation in a bacteriorhodopsin suspension

Keigo Masuda[1], Taiki Yoshizawa[1], Junhyung Lee[1], Masataka Shinada[1], Yoshiko Okada-Shudo[2], Takeshi Murata[1,3], Kohei Toyoda[1,3], Katsuhiko Miyamoto[1,3], Takashige Omatsu[1,3]
[1]Chiba university, [2]The University of Electro-Communications, [3]MCRC Chiba university

We report on a spinning twin-mode generation in biomaterial suspension pumped by an optical vortex. The spinning direction of the twin mode is reflected on the handedness of the incident optical vortex.

OMC6-03 *Invited*

Light-matter interactions in engineered turbid media

Natalia M. Litchinitser[1], Jingbo Sun[1,2], Danilo Gomes Pires[1,3], Ulviya Bunyatova[1,4], Wiktor Walasik[1], Wenhao Li[1]
[1]Duke University, Durham, North Carolina, USA, [2]Tsinghua University, Beijing, China, [3]Instituto de Fisica, Universidade Federal de Alagoas, Brazil, [4]Baskent University, Ankara, Turkey

Propagation of light beams in turbid media such as underwater environments, fog, clouds, or biological tissues finds increasingly important applications in science and technology, including bioimaging, underwater and free-space communication technologies, and weather control.

OMC6-04

Optical Trapping–Raman Spectroscopy for Small Plastics Characterization in the Marine Environment

Domna G. Kotsifaki[1], Christina Ripken[1,2], Sile Nic Chormaic[1]
[1]Light- Matter Interactions for Quantum Technologies Unit, Okinawa Institute of Science and Technology Graduate University, Onna-son, Okinawa, 904-0495, Japan, [2]Marine Genomics Unit, Okinawa Institute of Science and Technology Graduate University, Onna-son, Okinawa, 904-0495, Japan

In this work, we employ an optical trapping-Raman spectroscopy technique for concurrent characterization and monitoring of the physical and chemical properties of single micro-and/or nano-plastics in a seawater environment.

[OMC7]
Structured light 2
Chair: Kyoko Kitamura
Kyoto Institute of Technology

OMC7-01 *Invited*

Controlling orbital angular momentum in microscopic and topological systems

Daryl Preece[1], Zhiwei Shi[2], Zhigang Chen[2], Halina Rubinsztein-Dunlop[3]
[1]University of California, [2]San Francisco State University, [3]University of Queensland

Many experiments involve the application or measurement of beams with orbital angular momentum. We discuss the applied optical torque, distortion and rotation of such beams. Finally, we will discuss their application in topological insulators.

OMC7-02

Correction to spatial mode transformation in a modified interferometer

Yoko Miyamoto[1], C T Samlan[1], Surya Gautam[2], Dinesh N. Naik[2], Nirmal K. Viswanathan[3]
[1]The University of Electro-Communications, [2]Indian Institute of Space Science and Technology, [3]University of Hyderabad

The action of a modified interferometer that transforms optical modes can be generalized in the form of a pair of twisting operators. The theory can be adjusted with correction for higher order mode inputs.

OMC7-03

Broadband terahertz single pixel imaging system

Adam Valles[1,2], Jiahuan He[1], Taisei Ookawa[1], Seigo Ohno[3], Katsuhiko Miyamoto[1,2], Takashige Omatsu[1,2]
[1]Chiba University, [2]MCRC Chiba University, [3]Tohoku University

We report a simple single pixel imaging (SPI) scheme with high singal-to-noise ratio (SNR) in an entire THz frequency region (1-15 THz) by employing a metallic ring with a series of random masks directly perforated. This SPI scheme allows us to reconstruct high-resolution images (320 x 320), offering potentially advanced THz imaging technologies, such as non-invasive assignment of biomaterials.

OMC7-04

Multidimensional spatial entanglement transfer through our existing fiber optic network

Adam Valles[1], Isaac Nape[2], Jun Liu[3], Qianke Wang[3], Jian Wang[3], Andrew Forbes[2]
[1]Chiba University, [2]Wits University, [3]Huazhong University

We transport multi-dimensional spatial entangled states down conventional single-mode fiber (SMF). We achieve this by entangling the spin-orbit degrees of freedom of a bi-photon pair, passing the polarization (spin) photon down the SMF while accessing multiple orbital angular momentum (orbital) sub-spaces with the other, thereby realizing multi-dimensional spatial entanglement transport.

OMC7-05

Bond-breaking and adsorption of molecules at plasmonic hot-spots initiated by infrared vibrational excitation

Ikki Morichika, Satoshi Ashihara
Institute of Industrial Science, The University of Tokyo

We demonstrate that plasmonic near-fields of temporally-shaped mid-infrared pulses induce vibrational ladder climbing and the resulting bond-breaking of metal-carbonyl compounds. The observed new band indicates that the compounds are adsorbed on gold surfaces after vibrationally-mediated bond-breaking.

OMC

[OMC8]
Optical manipulation 3
Chair: Takashige Omatsu
Chiba University

OMC8-01 *Invited*

Enhanced Optical Trapping

Une G. Butaite[1], Graham Gibson[1], Ying-Lung Ho[2], Mike Taverne[2], Jonathan Taylor[1], David Phillips[3]
[1]University of Glasgow, [2]University of Bristol, [3]University of Exeter

We extend the capabilities of holographic optical tweezers by employing optically trapped objects to manipulate the surrounding fluid, thus having hydrodynamic control of the freely diffusing particles submerged within it.

OMC8-02

Optical transport and sorting of fluorescent nanodiamonds inside a tapered glass capillary

Christophe Pin, Ryohei Otsuka, Keiji Sasaki
RIES, Hokkaido University

In order to overcome nanoparticle diffusion during optical sorting experiments, we investigate the use of tapered glass capillaries as optofluidic waveguides. We demonstrate size-dependent optical transport of fluorescent nanodiamonds inside a tapered capillary. Nanoparticle sorting is also demonstrated by balancing the optical transport of the nanodiamonds with a liquid flow in the opposite direction.

OMC8-03

Development of achromatic flat-surface gradient index microlenses

Ryszard Buczynski[1,2], Adam Filipkowski[1], Hue Thi Nguyen[1,2], Dariusz Pysz[1], Ryszard Stepien[1], Adrew J. Waddie[3], Mo R. Taghizadeh[3], Rafal Kasztelanic[1,2]
[1]Lukasiewicz - Institute of Electronic Materials Technology, [2]University of Warsaw, [3]Heriot-Watt University

A development of microlenses achromatically corrected for near infrared range is reported. Internal nanostructurization of microlens allows to obtain an effective parabolic gradient index profile. A standard stack-and-draw method was used to fabricate the component. They have a nearly wavelength-independent working distance of 35 µm over the wavelength range of 600-1550 nm.

OMC8-04

Silicon (111) chiral structures fabricated by the illumination of optical vortex

Ablimit Ablez[1], Kohei Toyoda [1], Katsuhiko Miyamoto[1,2], Ryuji Morita[3], Takashige Omatsu[1,2]
[1]Chiba University, [2]MCRC, [3]Hokkaido University

We investigate the structures on a silicon (111) substrate produced by illumination of optical vortices. The fabricated structures on silicon (111) exhibit polycrystalline properties associated with a rather complicated 7×7 constructed surface.

OMC8-05

Orbital analysis of single nanoparticle in-plane motion driven by an optical vortex

Kichitaro Nakajima, Tempei Tsujimura, Kentaro Doi, Satoyuki Kawano
Osaka University

An orbital of nanoparticle motion driven by the Laguerre-Gaussian beam is visualized using a nanofluidic channel. From a particle tracking analysis, we estimate the trapping stiffness and driving force of the orbital motion.

[OMC9]
Theory & novel approach for optical manipulation

OMC9-01

Observation of Mie scattering from a superconducting micro-particle

Shota Sasaki[1], Jun Naoi[1], Masato Takamune[1], Daisei Kondo[1], Mitsutaka Kumakura[2], Masaaki Ashida[3], Yoshiki Moriwaki[1]
[1]University of Toyama, [2]University of Fukui, [3]Osaka University

A spherical superconducting micro-particle generated by laser ablation in superfluid helium is trapped in a quadrupole magnetic field. Utilizing the property that the particle is isolated in space, observation of the Mie scattering from this particle has been carried out. Analyzing the results, information on the optical properties of superconducting microparticle and their shapes at helium temperature have been deduced.

OMC9-02

Numerical simulation of micro- and nanoparticles orbital motion driven by an optical vortex

Tetsuro Tsuji[1], Satoyuki Kawano[2]
[1]Kyoto University, [2]Osaka University

Micro- and nanoparticles under the irradiation of an optical vortex are considered using a mathematical model based on fluid mechanics. In particular, we consider the case of plural particles trapped in the orbit of the optical vortex. The inter-particle interaction includes the forces arising from a hydrodynamic effect. The numerical simulation of the model shows that the orbital speed of the particles increases as the number of particles in the orbit.

OMC9-03

Theory of Optical Response Measurement of Dimer Molecules by Photoinduced Force Microscopy

Hidemasa Yamane[1], Nobuhiko Yokoshi[1], Hajime Ishihara[1,2]
[1]Osaka Prefecture University, [2]Osaka University

We theoretically analyzed Photoinduced force microscopy (PiFM) measurement on dimer molecules, using discrete dipole approximation. We obtained PiFM images of a dimer molecule for allowed and forbidden optical transitions. The PiFM images reflect the spatial structure of the localized electric field vectors. This study shows that PiFM provides multifaceted information based on the microscopic interaction between nanomaterials and light.

OMC9-04

Plasmon-induced transverse optical torque on nanostructures

Ryoma Fukuhara, Yoshito Tanaka, Tsutomu Shimura
Institute of Industrial Science, the University of Tokyo

We report that LSPR can induce an optical torque perpendicular to the optical axis on nanostructures depending on the incident polarization state, and it can provide a new degree of freedom for nanoparticles manipulation.

OMC9-05

Isotopic Hydrogen Evolution Reaction by Plasmonic Electrochemistry

Hiro Minamimoto, Daiki Sato, Kei Murakoshi
Hokkaido University

In this study, plasmon-induced hydrogen evolution reaction system has been successfully established by the combination of the plasmonic metal nanostructures with the p-type GaP semiconductor electrode. Through various photoelectrochemical measurements, it was confirmed that the present system showed the unique surface molecular process which is originated from the effect of the field localization.

OMC9-06

Metal sphere separation in glass by the two laser beam illumination

Taichi Imazeki, Hirofumi Hidai, Souta Matsusaka, Akira Chiba, Noboru Morita
Chiba University

The authors reported that laser illumination to a metal sphere in glass migrated the metal sphere toward the light source. The migration was caused by interfacial tension gradient. In this presentation, we demonstrate the metal sphere separation by the two laser beam illumination from opposite direction. The metal sphere separation was not explained by the interfacial gradient and suggested the existence of pulling force to the light source side.

[OMCp]
Poster Session

OMCp-01

Controlling the propagation of Surface plasmon polaritons by geometric phases

Feng Lin
Peking University

We used a scanning near-field optical microscope to observe the near-field distribution of surface plasmon polaritons (SPPs) from a ring-shaped metasurface under illumination of circularly polarized light. It was found that with an additional degree of freedom of the geometric phase provided by the regularly arranged metamolecules, control over the near-field interference of the SPPs can be achieved.

OMCp-02

High Thickness Uniformity and Maximum Growth Rate of Silicon Dioxide Layer via Wet Oxidation

Mukhzeer Mohamad Shahimin[1,2], K. C. Ang[3], M. H. A. Wahid[3], N. A. M. Ahmad Hambali[3], Vithyacharan Retnasamy[3]
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In this paper, we have proposed and demonstrated an optimised fabrication step of 1.8µm-2µm thick silicon dioxide layer on wafer with high thickness uniformity and maximum growth rate.

OMCp-03

Development of Cascaded Voltage Doubler Rectifier for RF Energy Harvesting

I. Adam[1,2], M.N.M. Yasin[1,3], A.R. Khan[1], N.A.M. Ahmad Hambali[4], Mukhzeer Mohamad Shahimin[5,6]
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This paper presents the design and development of cascaded voltage doubler. Operated in ISM band, step by step of rectifier design is demonstrated in details.

OMCp-04

FPGA based Quantum Key Distribution Electronic System for Multipurpose Optical Setup and Protocols

N.S.M. Aseri[1], N. Ali[1,2], S.A. Aljunid[2], R. Endut[2], N.A.M. Ahmad Hambali[1], Mukhzeer Mohamad Shahimin[3,4]
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The FPGA electronic control system for Quantum Key Distribution has been realized to improve the analog electronic system in optoelectronic conversion. The main conversion of optical laser signal and optical detector signal has been improved with Mezzanine FPGA board that reduce noise errors during transmission and receiving signal.

OMCp-05

Fluorescence correlation spectroscopy for analysis of atto-liter space using three-dimensional super-resolution microscopy

Yoshinori Iketaki
Olympus

We applied three-dimensional super-resolution microscopy (3D-SRM) to fluorescence correlation spectroscopy (FCS). This method can provide a spherical fluorescence spot area with atto-liter (10^{-18}/) volume, which is much smaller than that given by conventional FCS. This result means that the effective fluorescence spot size becomes shrunken owing to 3D-SRM. This spot enables us to analyze diffusive motion of highly concentrated molecules in a small volume.

OMC

OMCp-06

Fast iterative phase retrieval in holographic data storage

Xiao Lin, Jianying Hao, Kun Wang, Yuhong Ren, Xiaodi Tan
Fujian Normal University

A fast iterative non-interferometric phase decoding method in holographic data storage is proposed. This method can not only avoid phase ambiguity issue with interferometric, but also make system more compact and stable.

OMCp-07

Non-interferometric phase retrieval in collinear holographic data storage

Jianying Hao, Xiao Lin, Kun Wang, Yuhong Ren, Xiaodi Tan
Fujian Normal University

A non-interferometric phase retrieval method in collinear holographic data storage (HDS) is proposed. Code rate of collinear method is increased by 2 times compared with off-axis HDS.

OMCp-08

Effect of photo-sensitizer and thermo-initiator concentrations on holographic recording performance of PQ/PMMA photopolymer

Chen Yuxin Chen
Fujian Normal University

In this paper, we experimentally investigated the effect of photo-sensitizer and thermo-initiator concentrations on holographic recording performance of PQ/PMMA photopolymer and obtained a relatively relatively suitable concentration balance.

OMCp-09

Manipulation of CdSe/ZnS quantum dots in room-temperature fluid with an inhomogeneous electric field and optical excitation

Mitsutaka Kumakura, Takayuki Shimomura, Riki Asano, Goro Nozue, Kiroku Yamamoto, Takeshi Moriyasu
University of Fukui

We report on the experimental realization of manipulation for CdSe/ZnS quantum dots with a laser beam and an electric field. Trapping potential enhanced by optical excitation is discussed in comparison with conventional dielectrophoresis.

OMCp-10

Observation of structural color in random Au nano-islands fabricated on dielectric nanopillars

Young-Gyu Bae[1], Taehyun Kim[2], Jongsu Lee[2], Eui-Sang Yu[2], Yong-Sang Ryu[2], Seung-Yeol Lee[1]
[1]School of Electronics Engineering, Kyungpook National University, [2]Sensor System Research Center, Korea Institute of Science and Technology

We have devised inexpensive colorful structural coloring device using random Au nano-islands and CYTOP nano-pillar. The device has color tunability at the both front and back side by liquid solution which infiltrate into the device.

OMCp-11

Study on the Causes of Bubbles in PQ / PMMA Optical Holographic Storage Materials

Haiyang Song, Yuxin Chen, Xi Chen, Xiao Lin, Xiaodi Tan
Fujian Normal University

This paper focuses on the causes of bubbles in the fabrication of holographic storage materials phenan-threnequinone(PQ)/ polymethyl methacrylate(PMMA).

OMCp-12

A general method for evaluation of effective Raman wavefront and phase shift in atom interferometry

Yukun Luo[1,2], Jie You[1,2], Yingying Li[1,2], Qingqing Hu[1,2], Mingxiang Ma[1,2], Jie Wang[1,2], Fufang Xu[1,2]
[1]National Innovation Institute of Defense Technology, Academy of Military Sciences PLA China, [2]Beijing Academy of Quantum Information Sciences

Atom interferometry is an advanced optical manipulation tool of atoms in precision measurement. Raman wavefront aberration is one of the major obstacles impeding the improvement of measurement accuracy. We present a general method using optimal estimation theory for evaluating the effective Raman wavefront and the corresponding phase shift. The results provide strong support on analytical and numerical reference for wavefront error compensation.

[JS4]
Joint Session BISC & OMC
Joint session program p.25

OPTM

OPTM1-01

Annular subaperture stitching interferometry with planar reference wavefront for measurement of spherical and aspherical surfaces

Markus Schake, Gerd Ehret
Physikalisch Technische Bundesanstalt

An interferometric line sensor in a Michelson configuration without a transmission sphere is employed for annular subaperture stitching interferometry to measure spherical and aspherical surfaces. The misalignments between the subapertures, which are caused by positioning error induced wavefront aberrations, are corrected employing a machine learning based Zernike polynomial fitting in the overlapping regions.

OPTM1-02 *Invited*

Nano Optical Measurement for Next-Generation Nano/Micro Manufacturing based on Localized Light Energy Control

Satoru Takahashi
The University of Tokyo

Keywords: optical measurement, far-field optics, near-field optics, evanescent light, super resolution.

OPTM1-03

Displacement measuring interferometer using sinusoidal frequency modulation and phase-locked loop on arbitral modulation index

Masato Higuchi, Dong Wei, Masato Aketagawa
Nagaoka University of Technology

Applying a phase-locked loop (PLL) to sinusoidal frequency modulation interferometer, a systematic error appears depending on a modulation index. In this paper, we discuss a correction process for the PLL in the real-time measurement.

OPTM2-01 *Withdraw*

OPTM2-02 *Withdraw*

OPTM2-03

An optical frequency domain angle measurement based on second harmonic generation of a mode-locked laser

Hiraku Matsukuma, Masaru Nakao, Wijayanti Dwi Astuti, Yuki Shimizu, Wei Gao
Tohoku University

We propose an optical frequency domain angle measurement using characteristics of second harmonic generation (SHG). The angular displacement of target non-linear optical crystal is determined by the optical frequency change of the second harmonic wave.

OPTM2-04

Refractive index measurement system based on maximum phase difference of total internal reflection

Ju-Yi Lee[1], Tzu-Yang Weng[1], Chia-Yu Chiang[1], Jing-Heng Chen[2]
[1]National Central University, [2]Feng Chia University

A refractive index measurement system based on the maximum phase difference of the total internal reflection is proposed. By analyzing the maximum value of the phase difference between the vertical and horizontal polarization states, the refractive indices of the material can be obtained. The experimental results demonstrate that the measurement resolution can be better than 0.0025.

OPTM2-05

Optical and Stress Properties of Flexible Nb_2O_5/SiO_2 Multi-layer Films Deposited by E-gun Evaporation with Ion-beam Assisted Deposition

SHENG-BIN CHEN, Hsi-Chao Chen, Chun-Hao Chang, Yu-Ru Lu, Wei-Lin Chen
National Yunlin University of Science and Technology

The high & low refractive index $(Nb_2O_5/SiO_2)^2$ multi-layer films were deposited by E-gun evaporation with ion-beam assisted deposition (IAD) on flexible PET substrate. The optical property and anisotropic residual stress were investigated. The residual stress of each layer film was measured step by step with self-made shadow moiré interferometer.

OPTM2-06

Electromagnetic simulation model of microscopic scattering dark-field imaging for optical components surface defect detection

Weimin Lou[1], Pin Cao[2], Haotian Hu[1], Zichen Lu[1], Yongying Yang[1]
[1]Zhejiang University, [2]Hangzhou Zernike Optical Technology Co., Ltd

An electromagnetic simulation model of microscopic scattering dark-field imaging was built based on the finite difference time domain (FDTD) method. The scattered light distribution of different defect's size was obtained. Results show the span of distribution curve and the distribution peak are relative to the defect's width and depth respectively. The results in this paper can provide instructive reference for the defect's size inversion.

OPTM3-01 *Withdraw*

OPTM3-02

Design of SiN waveguide reference wave source for point diffraction interferometer

Yuankai Chen, Yongying Yang, Chen Wang, Yao Li, Zijian Liang, Hongyang Zhao, Shengan Liu, Jian Bai
Zhejiang University

Point diffraction interferometer uses the reference wave source (RWS) to generate the ideal spherical wave. A new RWS based on the silicon nitride waveguide is now proposed, aimed at providing a spherical reference wave with high NA and high accuracy. The generated reference wave has sub-nanometer accuracy and its NA reaches up to 0.58. In addition, the maximum light transmittance of this RWS could reach 24%.

OPTM3-03 *Withdraw*

OPTM4-01

Testing mid-spatial frequency wavefront error of large aperture and long-focal-length lens with computer-generated hologram

Jian-Peng Cui, Ning Zhang, Jie Liu, Di-Long Wu, Hua Xu, Ding-Yao Yan, Ping Ma
Chengdu Fine Optical Engineering Research Center

We present a method of using CGH to test mid-spatial frequency error of 440mm×440mm large aperture long-focal-length lens. Experiments and error analysis indicate this test approach is feasible and measurement accuracy can reach 0.8510nm RMS.

OPTM4-02

Iodine-stabilized laser for telecom applications

Kohei Ikeda[1,3], Sho Okubo[2,3], Masato Wada[2,3], Ken Kashiwagi[2,3], Kazumichi Yoshii[1,3], Hajime Inaba[2,3], Feng-Lei Hong[1,3]
[1]Yokohama National University, [2]National Metrology Inst. of Japan, AIST, [3]JST, ERATO MINOSHIMA Intelligent Optical Synthesizer

We demonstrate the third harmonic generation of a 1542-nm laser using a dual-pitch periodically poled lithium niobate waveguide. The generated 514-nm light is used for saturation spectroscopy of molecular iodine and laser frequency stabilization.

OPTM4-03

Simulation design of dark-field imaging scene for optical spherical surface imperfection based on raytracing

Pengfei Zhang, Yongying Yang, Danhui Zhang
College of Optical Science and Engineering, Zhejiang University

A method to simulate and design the dark-field imaging scene for optical spherical surface imperfection is proposed based on raytracing. Image function is solved by raytracing and Monte Carlo integration of luminous flux.

OPTM5-01 *Withdraw*

OPTM5-02 *Invited*

Design of a spectroscopic imaging ellipsometer

Lianhua Jin[1], Makoto Uehara[1], Takashi Iwao[1], Yuki Iizuka[1], Eiichi Kondoh[1], Bernard Gelloz[2]
[1]Univ.Yamanashi, [2]Nagoya University,

Imaging ellipsometry (IE) possesses characteristics of both single-point measurement ellipsometry and optical microscopy. To obtain quantitative measurement, it is very important for design of the spectroscopic imaging ellipsometer to employ a correct imaging system, solve non-uniformities of optical components. Here, we introduce a reflection imaging system, measurement noises due to non-ideal optical components, and describe solutions of problems.

OPTM5-03

Large scale thin film thickness uniformity extraction based on dynamic spectroscopic ellipsometry

Daesuk Kim, Vamara Dembele, Inho Choi, Sukhyun Choi, Saeid Kheiryzadehkhanghah, Chung Song Kim
Chonbuk National University

This paper describes a new approach for large-scale thin film thickness mapping based on dynamic spectroscopic ellipsometry. The proposed system can provide a real time thin film uniformity measurement capability with high precision. We expect the proposed scheme can be applied for various large-scale thin film deposition process applications such as roll to roll manufacturing where real time process uniformity monitoring becomes crucial.

OPTM5-04

Calibration methods for snapshot Mueller matrix spectropolarimetry

Nathan Hagen, Yukitoshi Otani
Utsunomiya University

We show how to expand the calibration methods of Stokes vector channeled spectropolarimetry for the more difficult Mueller matrix spectropolarimetry case, and give preliminary measurements.

OPTM5-05

Birefringence Influence on Polarization Changes and Frequency on Optical Fiber Sensors

Martin Kyselak[2], Jan Maschke[2], Marco Panasci[2], Karel Slavicek[3], Otto Dostal[3], David Grenar[1], Milan Cucka[1], Miloslav Filka[1]
[1]Brno University of Technology, [2]University of Defense, [3]Masaryk University

The article deals with the exact measurement of wavelength intensities. A functional polarizing fiber optic temperature sensor is used as the measuring element, and the frequency variations are induced by a birefringence change in the fiber retaining polarization due to temperature changes. Different speed of light propagation in the two polarization planes of the polarization-maintaining optical fiber was used to excite the birefringence.

OPTM5-06

Fringe polarimetry enabled by the geometric phase: preliminary theory

Luis Garza
Tecnologico de Monterey

We developed the preliminary theory that relates visibility of fringes and geometric phase. Our results enable the implementation of a fringe polarimetry technique, i.e., we can infer the polarization properties of the test sample through visibility measurements.

OPTM6-01 *Withdraw*

OPTM6-02

An actuation and measurement system with pico-meter mechanical step displacement using single phase-locked loop, heterodyne interferometer, and piezoelectric driving stage

Dong Thanh Nguyen, Dong Wei, Masato Aketagawa
Nagaoka University of Technology

In this paper, we set up an actuation and measurement system using a modified heterodyne interferometer with the single phase-locked loop (PLL) and a piezoelectric driving stage, which is capable of attaining a 10-picometer-order mechanical step displacement measurement. The result shows that the actuation and measurement system can accomplish mechanical displacement measurements with steps of 38 pm and 11 pm.

OPTM6-03 *Withdraw*

OPTM6-04

Projection deflectometry – a novel approach to the measurement of specular surfaces

Rainer Tutsch, Marcus Petz, Dan Linnert
Technische Universitaet Braunschweig, Institut fuer Produktionsmesstechnik

A new approach to the measurement of reflecting surfaces is presented as projection deflectometry, which is based on a combination of techniques that are established in fringe projection and deflectometry.

OPTM7-01 *Withdraw*

OPTM

OPTM7-02

Ghost Imaging with probability estimation using convolutional neural network

Shoma Kataoka, Tsutomu Uenohara, Yasuhiro Mizutani, Yasuhiro Takaya
Department of Mechanical Engineering, Osaka University

Convolutional neural network estimates the existence probability of the signal at each pixel from a noisy image obtained by ghost imaging with fewer measurements. A high-quality image can be obtained by mapping estimated probability.

OPTM7-03

Deep learning based method for phase analysis from a single closed fringe

Peihang Li, Mingfeng Lu, Jinmin Wu, Chenchen Ji, Gang Yu, Ran Tao
Beijing Institute of Technology

A deep learning based method for analyzing phase from a single closed fringe pattern is proposed that can predict the phase quickly and estimate the curvature radius of spherical surface accurately.

OPTM7-04

Image-free fast moving objects detection and tracking by using a single-pixel detector

Zibang Zhang, Qiwen Deng, Jingang Zhong
Jinan University

Detecting and tracking a high-speed moving object has many important applications in various fields. We report an image-free method which only uses one single-pixel detector and a spatial light modulator for spatial information acquisition. The technique provides new insights on how to efficiently acquire spatial information via spatial light modulation.

OPTM7-05

Modeling and Reconstructing Light Multiple Scattering Problems using Markov Chain Approximation

Shangning Wang, Shangze Yang, Shuyi Qiu, Mingli Cui, Xuesong Li
Shanghai Jiao Tong University

A transition-matrix-based Markov Chain method in predicting the characteristics of transmitted and reflected photons through a plate-parallel turbid slab is introduced. This method can accurately predict scattered photon angular distribution with a precision of less than 1% compared with Monte Carlo simulation with a feasible computational cost.

OPTM7-06

The method of intelligent computer simulation of laser gyros behavior under vibrations to ensure their reliability and cost-effective development and production

E.V. Kuznetsov[1], Y.D. Golyaev[1], Y.Y. Kolbas[1], Y.N. Kofanov[2], N.E. Kuznetsov[1], Tatiana Soloveva[1], A.I. Kurdybanskaia[1]
[1]"POLYUS" Research Institute of M.F. Stelmakh", JSC, [2]National Research University Higher School of Economics

Paper presents the computer simulation of laser gyros behavior under vibrations at the designing early stages. It allows for savings on repetitive tests and re-designing, finally improves reliability and economic efficiency of development and production.

OPTMp-01 *Withdraw*

OPTMp-02 *Withdraw*

OPTMp-03

Bi-frequency 3D Ghost Imaging with Haar Wavelet Transform

Mengjia Xi, Hui Chen, Yuan Yuan, Gao Wang, Jianbin Liu, Huaibin Zheng, Zhuo Xu
Xi'an Jiaotong University

We introduce Haar wavelets as illuminating patterns into ghost imaging. This can highly reduce the sampling rate and the requirement of high dynamic range of detectors, enabling high-resolution 3D ghost imaging.

OPTMp-04 *Withdraw*

OPTMp-05 *Withdraw*

OPTMp-06 *Withdraw*

OPTMp-07 *Withdraw*

OPTMp-08

RGB-D Image based Pallet Detection for Warehouse Robots

Yanxin Ma, Jiahua Zhu, Fuyin Wang, Hu Chen, Min Zhu, Xiaoqian Zhu
National Universty of Defense Technology

RGB-D image based pallet detection is proposed in this paper which fuses color and depth information. Firstly, color information based segmentation is used to obtain a whole pallet. Then, normal information is used to segment different planes. Finally, the pallet area is obtained using mathematical morphological filtering methods. Experimental results show that the proposed method achieves a high recognition rate and a strong robustness to complex illumination.

OPTMp-09

Self-calibration method using the orientation- and scale-covariant features in planar scene

Qingkai Hou, Yanxin Ma, Qiong Yao, Min Zhu, Xiaoqian Zhu, Shuidong Xiong
National University of Defense Technology

A self-calibration method for camera using two views of unknown-structure planar scene is introduced. Firstly, two orientation- and scale-covariant features, provided by the SIFT feature detectors, are used to estimate the homography of two views. Then the homography is decomposed into the camera parameters. Finally, the camera parameters are optimized with a non-linear parameter optimization using the inliers of two views.

OPTMp-10 *Withdraw*

OPTMp-11

A robust matching algorithm for shape recognition based on geometric consistency

Wei Wang, Bing Lei, Jianhua Shi, Jin Liu
National University of Defense Technology

A shape recognition algorithm is proposed based on the geometric consistency between shapes. Each shape pair is represented as a node in a graph and the weights of edges are computed while R-histogram is adopted.

OPTMp-12

Digital holographic microscope with a close set of two wavelengths

Hiroyuki Ishigaki[1], Takahiro Mamiya[2], Ikuo Futamura[2], Yoshio Hayasaki[3]
[1]CKD Corporation, Utsunomiya University, [2]CKD Corporation, [3]Utsunomiya University

New type of optical system for low-coherence digital holography with a close set of two wavelengths is proposed to measure a shape measurement of a curved surface object with a height of several-tens micrometer.

OPTMp-13

Acetylene photo-thermal spectroscopy using an optical heterodyne interferometer based on a double-pass acousto-optic frequency shifter

Pin Wei Huang, Che Chung Chou, Tyson Lin, Sheng Hua Lu
Feng Chia University

We demonstrate the photo-thermal (PT) spectroscopy of a 1.53-μm acetylene line using an optical heterodyne interferometer (OHI). A double-pass acousto-optic modulator is used as the frequency shifter and beam splitter in the OHI. Due to the nearly equal path length of the OHI scheme, we can observe the PT signal without using feedback control to maintain the path difference of the OHI arms.

OPTMp-14

Method to Improving Spot Overlap in Wide-Angle Patterns Generated by Diffractive Optical Elements for Structured-Light 3D Sensing

Wei-Feng Hsu, Yin-Lun Huang, Cheng-Kai Liu, Shih-Hsiang Lu
National taipei University of Technology

We proposed a method to increase the resolution of the diffraction pattern using the scaled DOE to prevent the loss of sampling points in correction of distortion in wide-angle patterns produced by diffractive optical elements.

OPTMp-15

Investigation of Retroreflector Characteristics using Computer-Vision Method

Huayang He[1], Wenying Su[1], Yingqi Xue[2], Xiaokun Han[2]
[1]Research Institute of Highway Ministry of Transport, [2]National Center of Metrization for Equipments of Roads and Bridges

The RAW data output from a camera has a linear association with the luminous flux on the surface of retroreflectors, which can be used to calculate the coefficients of retroreflection and the chromaticity coordinates.

OPTMp-16

Fast 3D measurement system using generalized phase-shifting method for deformation measurement of human hand

Shusuke Kobayashi, Nobukazu Yoshikawa
Saitama University

Fast fringe projection 3D measurement system using a generalized phase-shifting method with a continuous fringe scanning scheme is proposed. We conduct experiments on measurement of small deformation in muscle tendon of human hand during mouse operation.

OPTMp-17

Spatial resolution improvement of single pixel camera using the motion of an hole-array mask

Yujiro Ito, Tomoyuki Kurosawa, Yoshio Hayasaki
Center for Optical Research and Education (CORE), Utsunomiya University

An implementation method for increasing the number of pixels in single-pixel camera based on hole-array masks is developed. The implementation has an important advantage of no exaxt positioning of the masks in addition with the advantages of the hole-array masks, because the masks are captured by taking a picture. In this research, an imaging of the target sample was performed at near infrared, and then the masks were captured at visible range.

OPTMp-18

Reducing the thermal processes influence on the Zeeman laser gyro bias stability

Vladimir Vladimirovich Abaturov, Mikhail Grushin, Evgenii Kuznetsov, Alexey Medvedev, Igor Savelyev, Konstantin Skopin
JSC "Research Institute "Polyus" of M.F. Stelmakh"

The possibilities of reducing the temperature of self-heating and temperature gradients of the Zeeman laser gyro to increase the bias stability of its output characteristic are considered. By means of experiments and thermal model it is confirmed that reduction of gas discharge length and current in non-reciprocal device coils leads to decrease laser gyro bias and improve its stability.

OPTMp-19

A new ellipsometry scheme by modulating vectorial polarization optical field and digital image processing

Bing Lei, Chao Gao
National University of Defense Technology

We proposed a new ellipsomerty scheme by modulating the vectorial polarization optical field and processing the digital image. Its working principle is provided and some numerical analyzing studies are carried out to validate the feasibility.

OPTMp-20

Novel moiré approach to measure the object surface profile

Kun-Huang Chen, Jing-Heng Chen, Chien-Hung Yeh, Chia-Hung Tsai, Chih-Hsiung Lin
Feng Chia University

This paper proposes a method to measure the object surface profile. It's based on the moiré and FFT analysis. To validate the proposed approach, a coin was measured, yielding a height error of 8.5 mm.

OPTMp-21

Experimental investigation of multicore fiber Bragg grating's crosstalk for curvature sensing

Naohiro Sonoda, Tetsuya Abe, Yosuke Tanaka
Tokyo University of Agriculture and Technology

We performed experimental investigation of the intercore crosstalk of a multicore fiber Bragg grating (MCFBG) and then conducted curvature sensing using MCFBG and two-photon absorption process in Si-APD.

OPTM

OPTMp-22

Development of collimator adjustment technology used for large aperture space telescopes

Chiayen Chan[1], Poming Lin[1], Chunchieh Lien[1], Powen Hwang[2]
[1]Taiwan Instrument Research Institute, National Applied Research Laboratories, [2]Department of Aerospace and Systems Engineering, Feng Chia University

A novel method for adjusting the collimation of a collimator used for large aperture space telescopes has been proposed in the study. The method integrates the interferometer measurement, optical simulation and coordinate measuring machine measurement as well as a high-precision theodolite and self-made chart pattern to perform the collimation measurement.

OPTMp-23

Reflected light intensity characteristics of linear cat's eye retro-reflected modulator array

Huayan Sun, Laixian Zhang, Jianying Ren, Ruifeng Liu
Space Engineering University

the matrix optics is used to decompose the cat's eye retro-reflected beam propagation process, and the retro-reflected light intensity propagation formula is derived by using the Collins diffraction integral formula and the hard-edge pupil window function method.

OPTMp-24

Failure analysis of Flexible OLED Display Film by Raman Imaging Microscopy

Hyo Kim, Wonbo Cho
Dongduk Women's University

The impurities in flexible organic light emitting diode (OLED) display films were measured using Raman imaging and photoluminescence (PL). A multi-layer film of polyethylene terephthalate (PET) and polyimide (PI) with an adhesive is a key component of flexible structures that replace rigid glass substrates. Recently, laser cutting is the most common method for the processing of multi-layer polymers.

OWPT

[OWPT1] Plenary Talks

OWPT1-01 *Plenary*

Photovoltaic Power Converters and Application to Optical Power Transmission

Simon Fafard
Broadcom

High-performance multi-junction Optical Power Converters enable new applications. Broadcom's VEHSA design exhibit the highest conversion efficiencies. PT4 and PT6 products have been deployed for various ~808nm applications. Multi-junction are taking over single junction devices due to their benefits, e.g. their optimal load is more manageable. It can be advantageous to work at longer wavelengths and Broadcom is now extending its PT6 to the 980 nm range.

[OWPT2] Progress and Extension of OWPT

OWPT2-01 *Special*

Lessons Learnt from Past Experiments on the Optical Wireless Power Transmission for Drones

Nobuki Kawashima[1,2]
[1]Ninovatech Inc., [2]Kindai Univ.

Past optical wireless power transmission experiments to kite plane and drone are reviewed and lessons learnt from them are discussed. Demand for a long time flight capability appears to be not strong for most drone users. An application of this technology to a rescue effort for failured drones and robots is proposed.

OWPT2-02

Long-Range, Integrated, Safe Laser Power Beaming Demonstration

Thomas Nugent[1], David Bashford[1], Thomas Bashford[1], Thomas J. Sayles[1], Alex Hay[2]
[1]PowerLight Technologies, [2]Photon Manufactutring Inc.

Previous laser power beaming demonstrations have focused on specific performance metrics. PowerLight has integrated power and active safety into an enclosed, easy-to-use laser transmitter and photovoltaic receiver package. This system was tested and demonstrated both indoors and outdoors, delivering of hundreds of watts over hundreds of meters. Laser eye protection was not required for demonstration attendees.

OWPT2-03

Power Beaming for Deep Space and Permanently Shadowed Regions

Jonathan Grandidier[1], Malcolm W. Wright[1], Dimitri Krut[2], Bill J. Nesmith[1], John R. Brophy[1]
[1]NASA Jet Propulsion Laboratory, [2]Boeing Spectrolab Inc.

Power beaming involves the wireless transfer of power, and could provide a revolutionary new way to power spacecraft and vehicles operating in difficult to access regions. Power beaming has the potential to represent an alternative solution to power spacecraft and landers where sunlight is unavailable. It could provide a source of power to robotic systems in permanently shadowed regions or power landers and rovers from orbiting spacecraft.

[OWPT3] Light Sources and Eye-Safety

OWPT3-01 *Withdraw*

OWPT3-02

High Efficiency Operation of 9xx-nm Broad Area Laser Diode and its Cavity Length Dependency

Ryozaburo Nogawa[1], Kyohei Yoshida[1], Yoshikazu Kaifuchi[2], Toshiyuki Kawakami[1], Yuji Yamagata[1], Masayuki Yamaguchi[1]
[1]Fujikura Ltd., [2]Optoenergy Inc.

Improvement of PCE of single emitter 9xx-nm LD is experimentally studied by vertical design optimization. Newly designed LD achieves the high PCE of 73.6%. By research of dependence of PCE on cavity length, with the newly designed vertical structure LD is expected to be applied to various applications by adopting reasonable cavity length.

OWPT3-03

Photovoltaic Laser Power Converter for O-Band Wavelengths around 1310 nm

Henning Helmers, Alexander Franke, David Lackner, Oliver Höhn, Frank Dimroth
Fraunhofer Institute for Solar Energy Systems ISE

Photovoltaic cells for conversion of wavelengths around 1310 nm are developed. Excellent performance with an efficiency of 51.1% is demonstrated with a InGaAsP based cell grown lattice matched on InP. GaInAs based cells grown with a metamorphic approach on GaAs substrates are realized with impressive material quality similar to that of lattice matched cells on InP.

OWPT3-04

Design of LED-based Optical Wireless Power Transmission for Long Distance Operation and Increased Output Power

Yuhuan Zhou, Tomoyuki Miyamoto
Tokyo Institute of Technology

Optical wireless power transmission technology is still at the initial stage. Considering the relatively loose regulation and other merits, researching on LED-based optical wireless power transmission system is imperative. In this research, LED-based optical wireless power transmission system that realizes up to 3m power transmission and LED-array system which can achieve over watts output power is shown and discussed.

OWPT3-05 *Withdraw*

[OWPT4] Solar Cell Technology 1

OWPT4-01 *Withdraw*

OWPT4-02

GaAs Based Engineered Substrates for Lattice Matched Epitaxial Growth on Lattice Constants between GaAs and InP

Henning Helmers, Alexander Franke, Jens Ohlmann, Frank Dimroth, David Lackner
Fraunhofer Institute for Solar Energy Systems ISE

We present engineered substrates based on metamorphic buffer structures grown on GaAs that serve as growth templates for epitaxial growth on lattice constants between GaAs and InP. These engineered substrates allow to grow optimal photovoltaic absorber materials for many common near infrared wavelength (such as 980 nm, 1064 nm, 1310 nm, 1550 nm), as well as to realize other devices such as LEDs, lasers, detectors, or transistors on III-V compound semiconductors.

OWPT4-03 *Withdraw*

OWPT4-04

Laser Power Conversion at 977 nm using InGaAs/GaAsP Multi-Quantum-Wells

Matthew M Wilkins[1], Hsiang-Hung Huang[2], Hassanet Sodabanlu[2], Masakazu Sugiyama[2], Karin Hinzer[1]
[1]Department of Physics, University of Ottawa, [2]Department of Electrical Engineering and Information Systems, Graduate School of Engineering, The University of Tokyo

We demonstrate multi-quantum-well InGaAs/GaAsP devices for use in laser power conversion at 977 nm. We show that with proper optical design, this material system has excellent performance (E_g-V_{oc} < 0.35 V). In a 5-junction Fabry-Perot structure, as few as 15 quantum wells per junction are needed. As a result, performance is much higher than in a comparable solar cell which would require >100 quantum wells.

OWPT4-05

Crystal Growth and Evaluation of GaP Based Photovoltaic Devices for Blue Laser Light Receiver

Masakazu Arai, Kensuke Hiwada, Shinnosuke Tsuboyama, Keisuke Oishi, Koji Maeda
University of Miyazaki

We investigated the growth condition of GaP layer and compared between p-side up and n-side up photovoltaic devices. We successfully confirmed high open circuit voltage (1.56 V) under blue laser irradiation.

[OWPT5] Solar Cell Technology 2

OWPT5-01 *Invited*

Trapping Light Incident into and Emitted from Photovoltaic Cells using Dielectric Multilayers

Yasuhiko Takeda[1], Kazuo Hasegawa[1], Tomoyoshi Motohiro[2]
[1]Toyota Central Research and Development Laboratories, Inc., [2]Nagoya University

We demonstrated a significant light trapping effect of a combination of an angular selective filter on the front surface and a diffuse reflector on the rear surface of a photovoltaic cell under laser illumination incident from limited directions.

OWPT5-02

Characterizations of $CsPbBr_3$ Optical Power Converter under Blue LED Illumination

Ayuki Murata, Shinsuke Miyajima
Tokyo Institute of Technology

We developed a $CsPbBr_3$ optical power converter for OWPT using blue light source such as blue laser or light emitting diode (LED). The fabricated device was characterized using blue LED illumination at a wavelength of 453 nm.

OWPT5-03

Monochromatic Photovoltaic Characteristics of Wide Bandgap Perovskite Solar Cells

Ryousuke Ishikawa[1], Takuya Kato[2], Ryotaro Anzo[2], Ayuki Murata[3], Nozomu Tsuboi[2], Shinsuke Miyajima[3]
[1]Tokyo City University, [2]Niigata University, [3]Tokyo Institute of Technology

We have developed $CH_3NH_3PbBr_3$ solar cell which is a wide bandgap perovskite material for OWPT application, and succeeded in obtaining a very high output voltage of V_{oc} = 1.41 V by adding lithium treatment of perovskite layer. Over 20% of conversion efficiency under 455 nm monochromatic LED light was achieved.

OWPT5-04

Conversion Efficiency Measurements for Optical Devices, Especially Receivers, Based on Calorimetric Method

Terubumi Saito, Shigeki Tsuchiya, Muneaki Tatsuta, Yamato Abe, Hidetaka Abe
Tohoku Institute of Technology

We have succeeded in solar cell conversion efficiency measurements based on a calorimetric method employing a negative feedback control to maintain a constant temperature. The technique can be used for conversion efficiency measurements for sources as well.

[OWPT6] Beam Fluctuation and Stable Output

OWPT6-01 *Withdraw*

OWPT6-02

Dynamic Output Power Characteristics of Optical Wireless Power Transmission from Air to Underwater

Jiaying Li, Tomoyuki Miyamoto
FIRST, IIR, Tokyo Institute of Technology

Optical wireless power transmission (OWPT) has attracted a lot of attention, and underwater optical wireless power transmission will become an important application of OWPT. In this report, to analyze the output power of solar cells, we discussed about the light intensity distribution under the influence of 1D and 2D water waves and found the piece of solar cell where the light intensity is weakest.

OWPT6-03

Two Dimensionally Connected Photorecepto-Conversion Scheme (2DPRCS) for High Efficiency Solar Cells and Optical Wireless Power Transmission

Akira Ishibashi, Nobuo Sawamura
Hokkaido University

A novel waveguide that both harvests and conveys photons can be realized with carefully designed spatial asymmetry. The 2D-connected photoreception-photoconversion, or photorecepto-conversion, scheme would serve as a key technology for high efficiency solar cells as well as for robust optical wireless power transmission.

OWPT6-04

Optical Wireless Power Transmission with Light-Switching Boost Converter Using On-Chip Phototransistor

Koji Kotani
Akita Prefectural University

Optical wireless power transmission system with "light-switching" boost converter using on-chip phototransistor is proposed. In addition to a CW mode laser light for power transmission, a pulse-modulated laser light is delivered to the receiver and it drives an on-chip phototransistor acting as a current switch in the boost converter mechanism. -0.5 V of solar cell output voltage can be boosted up to -1 V or more. 51.5% of boost converter efficiency has been achieved.

OWPT

[OWPT7] Applications of OWPT

OWPT7-01 *Special*

Progress and Prospects of Vehicles Equipped with Photovoltaic Solar Panels and Their Application for Wireless Charging

Taizo Masuda[1], Kenji Araki[2], Masamori Endo[3], Akinori Sato[1], Masafumi Yamaguchi[2]
[1]Toyota Motor Corporation, [2]Toyota Technological Institute, [3]Tokai University

This paper reports the benefits of utilizing solar power as an energy source for future vehicles. Since the strict CO_2 emissions limit for passenger cars has been set by many countries, it is essential to develop an alternative power source for future cars. Our theoretical and experimental studies show that installing photovoltaic solar panels on passenger cars has the ability to reduce CO_2 emissions by 63%.

OWPT7-02

Investigation of Flying Condition of Small Drone Powered by Optical Wireless Power Transmission using VCSEL

Jiahe Zhang, Tomoyuki Miyamoto
Tokyo institute of Technology

Optical wireless power transmission (OWPT) has been well-known as a new technology to transmit power and takes a role to replace the conventional power transmission methods under some circumstances. In this research, a method based on OWPT to supply powers for small drone was investigated, its basic structure and experimental configuration were described and a mothed to improve efficiency was discussed.

OWPT7-03

Reporting Power Beaming Demonstration Characteristics

Paul Jaffe Jaffe
U.S. Naval Research Laboratory

Many compelling demonstrations of power beaming have been performed. A meaningful basis for the assessment of their readiness for practical applications has yet to become widespread. This paper endeavors to lay out such a basis.

[OWPT8] Data Transmission and Fiber Power Transmission

OWPT8-01 *Invited*

A Design Guide for Power-by-Light Systems

Christos Klamouris[1], Kai Worms[1], Frans Wegh[2], Wilhelm Stork[3]
[1]Fibergy GmbH, [2]Hasa-Computer-Elektronik GmbH, [3]Karlsruhe Institute of Technology (KIT)

In this paper we present a design guide for the development of Power-by-Light systems. General technical considerations necessary for engineers to choose the most appropriate components for their applications and methods to reduce cost and increase reliability are described.

OWPT8-02

Operation of a 6 W Optical Power Over Fiber System with Smart Power Management

Henning Helmers, Moritz von Ravenstein, Cornelius Armbruster, Leonhard Probst, Christian Schöner
Fraunhofer Institute for Solar Energy Systems ISE

We demonstrate operational characteristics of a 6 W power over fiber system with integrated optical communication. A smart power management scheme controls the laser power and minimizes it while the demand of an arbitrary electrical load profile is still met. Thereby system efficiency is maximized and the components lifetimes are prolonged.

OWPT8-03

Trade-Off between Energy Harvesting and Wireless Communication towards a 1 Gb/s Laser and Photovoltaic Data Link

John Fakidis[1], Henning Helmers[2], Harald Haas[1]
[1]The University of Edinburgh, [2]Fraunhofer Institute for Solar Energy Systems ISE

We study the trade-off between power and data transfer for a two-meter wireless laser and gallium-arsenide photovoltaic-based optical link. The use of orthogonal frequency-division multiplexing with adaptive bit and power loading results in a peak data rate of 997 Mb/s. The receiver is shown to offer simultaneous power harvesting with 39.3% efficiency under the irradiance of 0.41 W/cm2 and a data rate of 743 Mb/s.

OWPT8-04

Demonstration of Hybrid Optical Wireless Power Transmission and Free Space Optical Communication System using Dichroic Mirrors

Alexander William Setiawan Putra, Hirotaka Kato, Takeo Maruyama
Kanazawa University

Hybrid Optical Wireless Power Transmission (OWPT) and free space optical communication system is a technology which allows power and data transmission simultaneously to remote electronic devices through air. In this research, hybrid OWPT and free space data transmission using dichroic mirrors and two lasers with different wavelengths has been successfully demonstrated.

OWPT8-05

Optimization of Data and Power Transfer Efficiency in Visible Light Simultaneous Data and Power Transfer System

Yohei Nakamura[1], Yun Li[1], Yohtaro Umeda[1], Yusuke Kozawa[2]
[1]Tokyo University of Science, [2]Ibaraki University

The optimum conditions for the maximum data and power transfer efficiency in visible light simultaneous data and power transfer system using a solar cell as a photodetector.

OWPT8-06 *Invited*

Light Beam Scanning and Spatial Transmission using Visible Lasers - LiDAR, Spot-Lighting and Power Feeding -

Masato Ishino, Tomoyuki Ohashi, Akira Takamori, Kazuhisa Yamamoto
Osaka University/Institute of Laser Engineering

To realize multifunctional smart lighting, technologies of beam scanning and spatial transmission using a visible semiconductor laser (LD) is investigated. In the research, we have realized LiDARs using a visible LD, high efficiency light transmission. In addition, by using a hybrid spot-lighting system integrated with a visible LiDAR, light illumination to the target solar cell and power generation have been successfully demonstrated.

[OWPT9] Consumer Applications

OWPT9-01 *Withdraw*

OWPT9-02

Oblique Incidence Characteristics of Solar Cells with Controlled Color and Scattering Appearance for OWPT

Yu Liu, Tomoyuki Miyamoto
FIRST, IIR, Tokyo Institute of Technology

Color filters and frosted glass can change the black surface characteristics of the solar cell to impressive appearance. The oblique incidence and the direction of polarization also could change the appearance and efficiency of OWPT. Detailed experiment and numerical calculation of oblique incidence as well as roughness of the applied frosted glass were investigated for clarifying the conditions of both efficient power transmission and appearance design.

OWPT9-03

Proposal and Demonstration of Optical Wireless Charging for Battery Operating Small Electronic Devices

Naomi Uchiyama, Hirohito Yamada
Tohoku University

Optical wireless charging for battery operating small electronic devices such as wireless keyboards and mice, laser pointers and/or various remote controllers was studied and demonstrated. In each device, the power consumption was about 200 mW or less. The crystalline Si (c-Si) solar cells and power storage device incorporated in small electronic devices enable optical wireless charging system using infrared LED light, and can eliminate to use dry butteries.

OWPT9-04

Design and Build of OWPT System with Multiple Light Sources

Jing Tang, Kenta Takahashi, Jiahe Zhang, Tomoyuki Miyamoto
Tokyo Institute of Technology

Multiple light source system is attractive for OWPT. As one of advantages, high efficiency and large charging area can be obtained by multiple light sources. In addition, other efficient transmission path to overcome blocking problem can be prepared. In this research, we proposed and constructed an OWPT system with multiple light sources and solar cell recognition module so that the beam can be transmitted under efficiently controlled switching in real time.

[OWPTp] Poster Session

OWPTp-01

Solar Pumped Fiber Laser for Energy Harvesting Applications

Kai Aoyagi[1], Taizo Masuda[2], Stephan Dottermusch[3], Ian A. Howard[3,4], Bryce S. Richards[3,4], Masamori Endo[1]
[1]Department of Physics, Tokai University, [2]S-frontier Division, Toyota Motor Corporation, [3]Institute of Microstructure Technology, Karlsruhe Institute of Technology, [4]Light Technology Institute, Karlsruhe Institute of Technology

Solar-pumped lasers (SPLs) are promising candidate for energy harvesting. We propose a fully-planar solar-pumped laser that could drastically simplify the construction and operation of SPLs. The wireless power transmission and catalytic hydrogen generation are discussed.

OWPTp-02

Analysis of $CsPbBr_3$ Optical Power Converter for Optical Wireless Power Transmission using Device Simulation

Hirofumi Shimizu, Ayuki Murata, Shinsuke Miyajima
Tokyo Institute of Technology

Cesium lead bromide ($CsPbBr_3$) is one of the candidates of the light absorbing material for optical power converter in optical wireless power transmission system. One dimensional device simulations of $CsPbBr_3$ optical power converters were carried out to investigate the causes of the conversion efficiency losses. These results suggest that a highly defective region exists near the CsPbBr3 / P3HT interface.

OWPTp-03

Optical Wireless Power Transmission using GaInP Solar Cell with Distributed Bragg Reflector

Yuki Komuro, Fumiaki Tanaka, Shinya Honda, Ryota Warigaya, Kazuki Kurooka, Shiro Uchida
Chiba Institute of technology

By introducing distributed Bragg reflector (DBR) structure into the GaInP solar cell, for the first time, the conversion efficiency was improved to be 45.4%, which was about 4% higher than the cell without DBR.

OWPTp-04

Effect of Surface Electrode Area of GaAs Single-Junction Solar Cell for an Optical Wireless Power Transmission

Kazuki Kurooka, Fumiaki Tanaka, Shinya Honda, Yuki Komuro, Ryota Warigaya, Daiki Morita, Shiro Uchida
Chiba Institute of Technology

The electrode area dependence of the conversion efficiency of GaAs solar cells irradiated with 830 nm laser was investigated. The lager electrode area led to the higher efficiency in the higher power irradiation over 200mW.

OWPT

OWPTp-05

Characteristics of InGaAs Solar Cell with a DBR Structure under 1550nm Laser Irradiation

Shinya Honda[1], Fumiaki Tanaka[1], Yuki Komuro[1], Kazuki Kurooka[1], Ryota Warigaya[1], Kouichi Akahane[2], Shiro Uchida[1]
[1]Chiba Institute of Technology, [2]National Institute of Information and Communications Technology

By introducing a distributed Bragg reflector (DBR) structure into the InGaAs solar cell,the conversion efficiency under 1550nm laser irradiation became 20.1%,which was about 3% higher than the reference cell without DBR.

OWPTp-06

Crosstalk Evaluation of Simultaneous Data Signal and Feed Light Transmission at 1.55-μm Band for Power-over-Fiber Using a Double-Clad Fiber

Hikaru Mamiya, Hayato Nomoto, Tadanobu Higuchi, Motoharu Matsuura
The University of Electro-Communications

This paper presents power-over-fiber (PWoF) using double-clad fibers (DCFs) at low-loss wavelength band to improve the power transmission efficiency. We evaluate the transmission performance of downlink- and uplink transmitted data signals by tuning the wavelength at around 1.55-μm band. In this evaluation, it is found that good transmission performance of the signals is obtained as long as the wavelengths of the feed light and the signal do not overlap.

OWPTp-07

Flight Control of Power-over-Fiber Drones Using Optical Fibers for Airborne Base Stations

Natsuki Shindo, Ryo Yazawa, Ryuichi Kobayashi, Motoharu Matsuura
The University of Electro-Communications

In this paper, we present flight control of power-over-fiber (PWoF) drones using optical fibers for airborne base stations. To show the controllability of PWoF drones, we connect an entry-type drone and the remote controller with a 10-m optical fiber and show the flight demonstration by controlling the drone without using wireless control signals from the remote controller.

OWPTp-08

Power Supply Efficiency of Optical Wireless Power Transmission Systems Using Visible LEDs and Silicon Solar Cells

Haruka Yokoyama[1], Tomohiro Yamaguchi[1], Yasuhisa Ushida[2], Hiroki Hirukawa[1], Takeyoshi Onuma[1], Tohru Honda[1]
[1]Kogakuin University, [2]Nagoya University

The power supply efficiency of visible OWPT using visible LEDs and Si solar cell was investigated. The power supply efficiency was found to be mostly determined by multiplied by each place efficiencies. The highest power supply efficiency was obtained when the blue LED were used as a light source.

OWPTp-09 ***Withdraw***

XOPT

Wednesday, 22 April

9:00-9:15
Opening Remarks
Tetsuya Ishikawa
RIKEN

9:15-10:30
X-ray Optics (I)
Chair: Satoshi Matsuyama
Osaka University

9:15
Progress on development of zoom optics based on deformable mirrors at the Advanced Photon Source
Lahsen Assoufid
Argonne National Laboratory

9:45
Mirror–based hard X-ray optical systems for the next generation synchrotron radiation sources
Kazuto Yamauchi
Osaka University

10:15
Precise wavefront measurement using grating interferometer for sub-10 nm XFEL focusing system
Nami Nakamura
Osaka University

-----Break 10:30-10:45-----

10:45-11:30
Soft X-ray Optics
Chair: Hidekazu Mimura
The University of Tokyo

10:45
Development of ultra-short Kirkpatrick-Baez mirror system for nano-focusing of soft X-rays
Takenori Shimamura
The University of Tokyo

11:00
Two-stage reflective focusing system for soft X-rays at BL25SU of SPring-8
Yoko Takeo
The University of Tokyo

11:15
Development of copper electroforming process for non-magnetic soft x-ray mirrors
Gota Yamaguchi
The University of Tokyo

11:30-12:15
X-ray Imaging
Chair: Hidekazu Mimura
The University of Tokyo

11:30
Development of X-ray multiscale tomography
Kentaro Uesugi
JASRI

12:00
X-ray nanofocused beam scan using refractive prism and focusing mirrors
Jumpei Yamada
RIKEN

-----Lunch Break 12:15-13:30-----

13:30-14:15
X-ray Optics (II)
Chair: Alfred Baron
RIKEN

13:30
Development of Multi-Beam X-ray Optics for High-Speed Tomography
Wolfgang Voegeli
Tokyo Gakugei University

13:45
Development of adaptive X-ray focusing system based on the combination of concave mirror and convex mirror
Yuka Nishioka
Osaka University

14:00
Ultraprecise fabrication of X-ray mirrors for XFEL sub-10 nm focusing system based on Wolter type III geometry
Takato Inoue
Osaka University

14:15-15:00
XFEL (I)
Chair: Alfred Baron
RIKEN

14:15
Surface processing of a μ-channel-cut crystal monochromator for reflection self-seeding of hard X-ray free-electron laser
Shotaro Matsumura
Osaka University

14:30
Controlling pulse duration of X-ray free-electron lasers with rotated-inclined crystals
Shota Nakano
Osaka University

14:45
Exploring new frontiers in online spectrometry at SwissFEL
Pavle Juranic
Paul Scherrer Institut

-----Break 15:00-15:30-----

15:30-16:45
XFEL (II)
Chair: Makina Yabashi
RIKEN

15:30
Pump-probe holographic imaging with femto-second FEL pulses of laser-induced cavitation bubbles
Malte Vassholz
University of Goettingen

15:45
Recent results and future perspectives in materials science at SACLA
Yuya Kubota
RIKEN

16:15
Shortening pulse duration of X-ray free-elecron laser via saturable absorption
Ichiro Inoue
RIKEN

16:30
Intensity Autocorrelation Measurement at Angstrom Wavelength
Taito Osaka
RIKEN

16:45
Closing Remarks
Kazuto Yamauchi
Osaka University

NOTE

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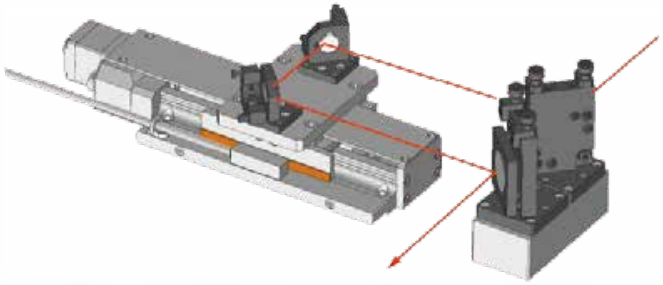

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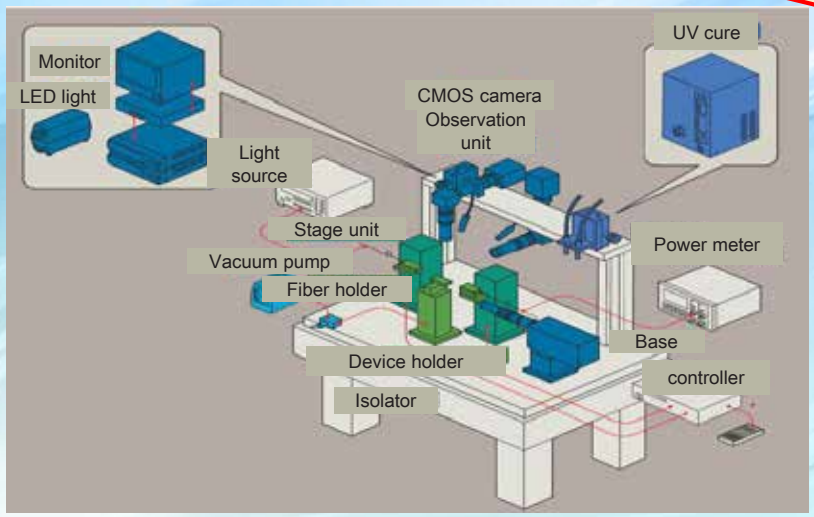

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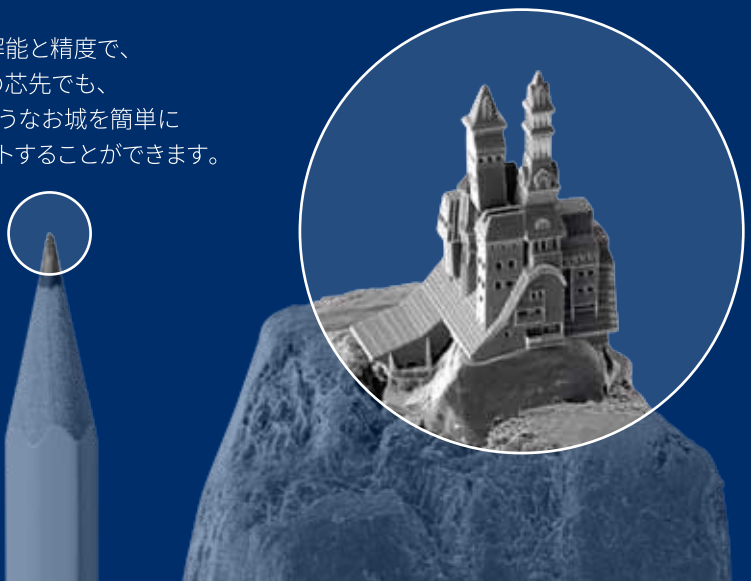
組み合わせた初めてのシステムです。
高分子マイクロパーツやメソオブジェクトの生産現場に、
これまでにない可能性を提供します。**

塔部分の階と
階をつなぐ16本の
柱の直径はわずか1ミクロンに至りません。
これは人間の髪の毛の100分の1の太さです。
この驚くべき建築物は、
わずか6分以内でプリントされたものです。

高分解能と精度で、
鉛筆の芯先でも、
このようなお城を簡単に
プリントすることができます。



素敵なこのお城から伸びる二本の塔をご覧ください。
特に、右側の塔には中空構造の柱が連立する
驚くべき構造を持っています。

マイクロでも、メソでも対応

NanoOne®プリントシステムは、部品の幾何学的形状と分解能に応じて、レーザスポットサイズを設定します。このレーザスポットが、最小重合可能容積を定義するボクセルサイズを決定します。
複雑な構造やマイクロスケールの部品については、高NAの対物レンズを使用し、サブミクロンのレーザスポットとボクセルサイズを実現します。 メソスケール構造はadaptive resolutionモードで作られます。レーザスポットサイズは、部品の要件に従って調節されます。

nanoONE

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