### Program at a Glance

#### Aug. 24 (Mon)

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**T01** Solid State, Fiber, and Other Laser Sources  
**T02** Ultrafast Phenomena and Nonlinear Optics  
**T03** Terahertz Technologies and Applications  
**T04** High Power, High Energy Lasers  
**T05** Plasmonics and Metamaterials  
**T06** Laser Processing and Innovative Applications  
**T07** Optical Metrology and Sensing  
**T08** Quantum Optics, Atomic Physics, and Quantum Information  
**T09** Nitrides, Other Widegap Semiconductors  
**T10** Micro and Nanophotonics  
**T11** Biophotonics and Medical Optics  
**T12** Semiconductor and Integrated Optoelectronic Devices  
**T13** Display, Storage, and Applications
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I. Greetings from the Conference Chair of CLEO Pacific Rim 2015

It is my great pleasure to welcome all of you to the 11th Conference on Lasers and Electro-Optics Pacific Rim (CLEO Pacific Rim 2015) which is being held from August 24 to August 28, 2015, at the BEXCO Convention Center in Busan, Korea.

CLEO Pacific Rim convenes for the eleventh time, and I would like to point out with much satisfaction that it has grown to be a world-best conference as a forum for exchanging up-to-the-date research results and views on future advances in all fields of lasers and electro-optics, serving not only the Pacific Rim region but also the entire worldwide technical community.

I am pleased to announce that the conference will showcase four plenary talks encompassing recent developments and glimpses into the future of optical sciences and technologies, including presentations on:

1) Optical Antennas; Spontaneous Emission Faster Than Stimulated Emission;
2) FTTH – Past, Present, and Future;
3) Coherent Ising Machine Based on Optical Parametric Oscillator Network; and
4) 5PW High Gain Large Aperture Ti: sapphire CPA Amplifier.

In addition, the conference will offer a wide range of technical activities including 3 short course lectures, 3 tutorials, 113 invited talks and a total of 608 contributed papers to be presented in both oral and poster sessions. (380 oral and 228 poster presentations)

Busan, the host city of this year’s conference, is the second largest city in Korea embracing the beautiful natural sceneries. In particular, the Haeundae Beach, located near the conference venue BEXCO, is very popular among Koreans, with millions of people spending their vacations there every summer. Busan is also the largest port in Korea, which serves as a main gateway for the entire Northeast Asian region as well as the Korean Peninsula.

Finally, on behalf of the Organizing Committee I would like to express my heartfelt gratitude to all of you as well as the various committee members who have generously contributed their time and effort to make the CLEO Pacific Rim 2015 a great success. We are all too aware that this would not have been possible without the enthusiastic participation by the dedicated scientists and engineers.

Thank you once again and welcome to the CLEO Pacific Rim 2015.

Yong Hee Lee
Conference Chair
II. Committee Members

Organizing Committee

Conference Chair
Yong Hee Lee (KAIST, Korea)

General Arrangement
Sang Bae Lee (KIST, Korea)

Technical Program Committee Chairs
Chil-Min Kim (DGIST, Korea)
Byoungho Lee (Seoul National University, Korea)

Publicity & Publication
Jung H. Shin (KAIST, Korea)

Treasury
Sun-Kyung Kim (Kyung Hee University, Korea)

Exhibition
Jae-Won Hahn (Yonsei University, Korea)

Local Arrangement
Han Seb Moon (Pusan National University, Korea)
Yeong Mun Yu (Pukyong National University, Korea)

Steering Committee

Fumio Koyama (Tokyo Institute of Technology, Japan), Chair
Yung Jui Chen (National Sun Yat-Sen University, Taiwan)
Benjamin Eggleton (University of Sydney, Australia)
Sang-Kook Han (Yonsei University, Korea)
Jian-Jun He (Zhejiang University, China)
Byoungho Lee (Seoul National University, Korea)
Sang Bae Lee (KIST, Korea)
Yong Hee Lee (KAIST, Korea)
Ai-Qun Liu (Nanyang Technological University, Singapore)
Yoshiaki Nakano (The University of Tokyo, Japan)
Chang Hee Nam (GIST, Korea)
Shu Namiki (AIST, Japan)
Takashige Omatsu (Chiba University, Japan)
Alex Wai (Hong Kong Polytech University, Hong Kong, China)
Bingkun Zhou (Tsinghua University, China)
The Technical Program Committee includes:

**T01. Solid State, Fiber, and Other Laser Sources**
Fabian Rotermund (Ajou University, Korea) Co-chair
Takashige Omatsu (Chiba University, Japan) Co-chair
Stuart Jackson (University of Sydney, Australia)
Yoonchan Jeong (Seoul National University, Korea)
Jiwon Kim (Hanyang University, Korea)
Jungwon Kim (KAIST, Korea)
Ju Han Lee (University of Seoul, Korea)
Arkady Majoy (University of Manitoba, Canada)
Akira Shirakawa (University of Electro-Communications, Japan)
Thomas Südmeyer (University of Neuchatel, Switzerland)
Fengqui (Frank) Wang (Nanjing University, China)
Pu Wang (Beijing University of Technology, China)

**T02. Ultrafast Phenomena and Nonlinear Optics**
Chang Hee Nam (GIST/IBS, Korea) Co-chair
Kaoru Yamanouchi (The University of Tokyo, Japan) Co-chair
Zenghu Chang (University of Central Florida, USA)
Hideki Hashimoto (Osaka City University, Japan)
Masayuki Katsuragawa (University of Electro-Communications, Japan)
Dong-Eon Kim (POSTECH, Korea)
Kyung Taec Kim (GIST/IBS, Korea)
Andy Kung (Institute of Atomic and Molecular Sciences, Taiwan)
François Légaré (INRS, Canada)
Zhi Heng Loh (Nanyang Technical University, Singapore)
Peixiang Lu (HUST, China)
Katsumi Midorikawa (RIKEN, Japan)
Parinda Vasa (IIT Bombay, India)
Zhiyi Wei (IOP, China)
Nan Ei Yu (APRI/GIST, Korea)

**T03. Terahertz Technologies and Applications**
Gun-Sik Park (Seoul National University, Korea) Co-chair
Sakai Kiyomi (NICT, Japan) Co-chair
Jaewook Ahn (KAIST, Korea)
Eunmi Choi (Ulsan National Institute of Science and Technology, Korea)
Haewook Han (POSTECH, Korea)
Jae-Hyung Jang (GIST, Korea)
Tae In Jeon (Korea Maritime and Ocean University, Korea)
Youngwook Jeong (KAERI, Korea)
Kodo Kawase (Nagoya University, Japan)
Pilhan Kim (KAIST, Korea)
Sangin Kim (Ajou University, Korea)
Chiko Otani (RIKEN, Japan)
Kyung Hyun Park (ETRI, Korea)
Joohiuk Son (University of Seoul, Korea)
Technical Program Committee

T04. High Power, High Energy Lasers
Yong-Ho Cha (KAERI, Korea) Co-chair
Kiminori Kondo (Japan Atomic Energy Agency, Japan) Co-chair
Xiaoyan Liang (Shanghai Institute of Optics and Fine Mechanics, China)
Changhwan Lim (KAERI, Korea)
Zhiwei Lu (Harbin Institute of Technology, China)
Yasuo Nabekawa (RIKEN Center for Advanced Photonics, Japan)
Liejia Qian (Shanghai Jiao Tong University, China)
Jae Hee Sung (GIST, Korea)
Dong-Il Yeom (Ajou University, Korea)
Hidetsugu Yoshida (Osaka University, Japan)

T05. Plasmonics and Metamaterials
Q-Han Park (Korea University, Korea) Co-chair
Hongxing Xu (Chinese Academy of Sciences, China) Co-chair
Wonshik Choi (Korea University, Korea)
Sergey Gaponenko (National Academy of Sciences of Belarus, Belarus)
Yuri S. Kivshar (Australian National University, Australia)
Hong-Gyu Park (Korea University, Korea)
Junsuk Rho (POSTECH, Korea)
Yung Doug Suh (KRICT, Korea)
Hong Wei (CAS, China)
Jeong Weon Wu (Ewha Womans University, Korea)

T06. Laser Processing and Innovative Applications
Jiyeon Choi (KIMM, Korea) Co-chair
Ya Cheng (SIOM, China) Co-chair
Sung Hak Cho (KIMM, Korea)
Sung Ho Jeong (GIST, Korea)
Sae-Chae Jeoung (KRISS, Korea)
Saulius Juodkazis (Swinburne University, Australia)
Dongsik Kim (POSTECH, Korea)
Yan-Qing Lu (Nanjing University, China)
Yoshiki Nakata (Osaka University, Japan)
Hong-Jin Park (LTS, Korea)
Martin Richardson (University of Central Florida, USA)
Koji SugioKa (RIKEN, Japan)
Xia Yu (SIMTECH, Singapore)
Technical Program Committee

**T07. Optical Metrology and Sensing**
Seung Kwan Kim (KRISS, Korea) Co-chair
Terubumi Saito (Tohoku Institute of Technology, Japan) Co-chair
Bo-Hun Choi (Dong-A University, Korea)
Haiyong Gan (NIM, China)
Jonghan Jin (KRISS, Korea)
Masashi Kuwahara (EPRI/AIST, Japan)
Dong-Hoon Lee (KRISS, Korea)
Tim J. Malthus (CSIRO, Australia)
Hyug-Gyo Rhee (KRISS, Korea)
Atsushi Sato (Tohoku Institute of Technology, Japan)
Dai Hyuk Yu (KRISS, Korea)
Akio Yoshizawa (EPRI/AIST, Japan)

**T08. Quantum Optics, Atomic Physics, and Quantum Information**
Yoon-Ho Kim (POSTECH, Korea) Co-chair
Christian Kurtsiefer (National University of Singapore, Singapore) Co-chair
Kyung Soo Choi (University of Waterloo, Canada)
Jianfeng Du (USTC, China)
Keiichi Edamatsu (Tohoku University, Japan)
Hyunseok Jeong (Seoul National University, Korea)
Dzmitry Matsukevich (NUS, Singapore)
Jian-Wei Pan (USTC, China)
Scott Parkins (University of Auckland, New Zealand)
Geoff Pryde (Griffith University, Australia)
Yoshiro Takahashi (Kyoto University, Japan)
Xiang-Bin Wang (Tsinghua University, China)

**T09. Nitrides, Other Widegap Semiconductors**
Jong-In Shim (Hanyang University, Korea) Co-chair
Satoshi Kaniyama (Meijo University, Japan) Co-chair
Jong Hyeob Baek (KOPTI, Korea)
Yong-Hoon Cho (KAIST, Korea)
Jen-Inn Chyi (National Central University, Taiwan)
Jung Han (Yale University, USA)
Hideki Hirayama (RIKEN, Japan)
Jong Kyu Kim (POSTECH, Korea)
Dong-Seon Lee (GIST, Korea)
In-Hwan Lee (Chonbuk National University, Korea)
Sung-Nam Lee (Korea Polytechnic University, Korea)
Tien-Chang Lu (National Chiao Tung University, Taiwan)
Yi Luo (Tsinghua University, China)
Hideto Miyake (Mie University, Japan)
Dong-Soo Shin (Hanyang University, Korea)
Xinqiang Wang (Peking University, China)
Chih Ching Yang (National Taiwan University, Taiwan)
Technical Program Committee

**T10. Micro and Nanophotonics**
Bumki Min (KAIST, Korea) Co-chair
Masaya Notomi (NTT Basic Research Laboratories, Japan) Co-chair
Hyunyong Choi (Yonsei University, Korea)
Muhan Choi (Kyungpook National University, Korea)
Ki-Hun Jeong (KAIST, Korea)
Young Chul Jun (UNIST, Korea)
Dong-Wook Kim (Ewha Womans University, Korea)
Jin Tae Kim (ETRI, Korea)
Zee Hwan Kim (Seoul National University, Korea)
Seungwoo Lee (Sungkyunkwan University, Korea)
Ding Ping Tsai (National Taiwan University, Taiwan)
Qihua Xiong (National University of Singapore, Singapore)

**T11. Biophotonics and Applications**
Dug Young Kim (Yonsei University, Korea) Co-chair
Chen-Yuan Dong (National Taiwan University, Taipei) Co-chair
Min Gu (Swinburne University of Technology, Australia) Co-chair
Jin U. Kang (Johns Hopkins University, USA)
Satoshi Kawata (Osaka University, Japan)
Byeong Ha Lee (GIST, Korea)
Qingming Luo (Huazhong University of Science and Technology, China)
Yuan Luo (National Taiwan University, Taiwan)
Yong Keun Park (KAIST, Korea)
Junle Qu (Shenzhen University, China)
David D. Sampson (The University of Western Australia, Australia)
Yoshiaki Yasuno (University of Tsukuba, Japan)
Andy Yun (Harvard University, USA)

**T12. Semiconductor and Integrated Optical Devices**
Kyoungho Ha (Samsung Electronics Co., Ltd., Korea) Co-chair
Kazumi Wada (University of Tokyo, Japan) Co-chair
Benjamin J. Eggleton (University of Sydney, Australia)
Norbert Grote (Fraunhofer HHI, Germany)
Il-Ki Han (KIST, Korea)
Jong-Moo Lee (ETRI, Korea)
Jifeng Liu (Dartmouth College, China)
Nobuhiko Nishiyama (Tokyo Institute of Technology, Japan)
Hyo-Hoon Park (KAIST, Korea)
Hyundai Park (Aurrion, USA)
Jin-Hong Park (Sungkyunkwan University, Korea)
Dongjae Shin (Samsung Electronics Co., Ltd., Korea)
Zhiping Zhou (Peking University, China)
### Technical Program Committee

**T13. Display, Storage, and Applications**

Jae-Hyeung Park (Inha University, Korea) Co-chair

Hirotugu Yamamoto (Utsunomiya University, Japan) Co-chair

Heejin Choi (Sejong University, Korea)

Munekazu Date (NTT, Japan)

Joonku Hahn (Kyungpook National University, Korea)

Yi-Pei Huang (National Chiao Tung University, Taiwan)

Hak-Rin Kim (Kyungpook National University, Korea)

Jung-Ho Kim (Kyounghee University, Korea)

Nam Kim (Chungbuk National University, Korea)

Seung-Cheol Kim (Kwangwoon University, Korea)

Osamu Matoba (Kobe University, Japan)

Daisuke Miyazaki (Osaka City University, Japan)

Yasuo Hiro Mizutani (University of Tokushima, Japan)

Tatsuhiko Muroi (NHK, Japan)

Tomoyoshi Shimobaba (Chiba University, Japan)

Xiaodi Tan (Beijing Institute of Technology, China)

Yongtian Wang (Beijing Institute of Technology, China)

Masahiro Yamaguchi (Tokyo Institute of Technology, Japan)

Changhe Zhou (SIOM, China)
III. Conference Information

1. General Information

Official Language
English is the official language of the conference and will be used for all the printed materials, presentations, and discussions.

Poster Session
- Date: August 26 (Wed) and 27 (Thu), 2015
- Time: 13:45 ~ 15:15
- Venue: Exhibition Hall, 1F

Post-deadline Paper (PDP) Session
- Date: August 27 (Thu), 2015
- Time: 18:00 ~ 19:30
- Venue: #101 (Room A), 1F
  The result of paper selection will be announced on the message board on Tuesday, August 25, 2015.

Insurance
The organizer cannot accept responsibility for accidents that might occur over the course of the conference period. Participants are expected to have purchased suitable form of travel insurance beforehand.

Electricity
Please be advised that the standard outlet voltage is 220 V in Korea.

Conference Venue “BEXCO”
- Address: #55 APEC-ro, Haeundae-gu, Busan
- Tel: 82+51-740-7300
- Website: http://www.bexco.co.kr/eng/Main.do
  * You can use Free WiFi. SSID is posted on the Message Board.
2. Floor Plan

**1F**
- Technical Session
- Exhibition
- Poster Session
- Registration Desk

**2F**
- Technical Session
- Short Course (201–3)
- 206: Preview Room
- 207: Committee Room
- Banquet
- APEC Hall
- Opening Ceremony
- Plenary Talk
- IYL Open Program
- Onsite Secretariat

**3F**
- Get-together Party
- Grand Ballroom
3. Official Program

**Get-together Party**
- **Date**: Monday, August 24, 2015
- **Time**: 18:30 ~ 20:00
- **Place**: Grand Ballroom Lobby, 3F
  All participants are invited. Light snacks and refreshments will be served. This party is supported by OSA.

**Opening Ceremony**
- **Date**: Tuesday, August 25, 2015
- **Time**: 08:40 ~ 09:00
- **Place**: #205, 2F

**Banquet**
- **Date**: Wednesday, August 26, 2015
- **Time**: 18:00 ~ 20:00
- **Place**: Grand Ballroom, 3F
  Banquet is included in Regular registration fee. Extra banquet ticket is KRW 66,000. It can be purchased at the registration desk.

4. Conference Facilities

**On-site Secretariat**
- **Place**: # C252
  The on-site secretariat will be open during the conference as follows.

<table>
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<tbody>
<tr>
<td>Time</td>
<td>08:30~19:00</td>
<td>08:30~18:00</td>
<td>08:30~19:00</td>
<td>08:30~18:00</td>
<td>08:30~12:00</td>
</tr>
</tbody>
</table>

**Preview Room**
- **Place**: # 206
  Authors and speakers can prepare their presentation in the preview room. This room is equipped with a laptop computer and wired Internet. The preview room will be open during the conference as follows.

<table>
<thead>
<tr>
<th>Date</th>
<th>Aug 25</th>
<th>Aug 26</th>
<th>Aug 27</th>
<th>Aug 28</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>09:00~17:00</td>
<td>09:00~17:00</td>
<td>09:00~17:00</td>
<td>09:00~11:00</td>
</tr>
</tbody>
</table>
5. Registration Information

If you could not register by July 22, please register at the on-site registration desk. The registration desk will be located in front of Room #104, #105 (1st floor) at BEXCO. All payments are to be made in KRW, either by cash or credit card.

The registration desk will be open during the conference as follows.

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Time</td>
<td>12:00~19:00</td>
<td>08:00~18:00</td>
<td>08:00~18:00</td>
<td>08:00~18:00</td>
<td>08:00~12:00</td>
</tr>
</tbody>
</table>

**On-site registration fee**

<table>
<thead>
<tr>
<th>Type</th>
<th>Fee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular</td>
<td>KRW 770,000</td>
</tr>
<tr>
<td>Student</td>
<td>KRW 385,000</td>
</tr>
<tr>
<td>Additional Banquet Ticket</td>
<td>KRW 66,000</td>
</tr>
</tbody>
</table>

(* KRW means Korean Won)

**Regular Registration Fee includes:**
Access to all technical sessions, admission to Exhibition, IYL Program, Get-Together Party, Banquet, and one copy of USB conference proceedings

**Student Registration Fee includes:**
Access to all technical sessions, admission to Exhibition, IYL Program, Get-Together Party, and one copy of USB conference proceedings

**Registration Receipt**
A receipt will be issued at the registration desk together with the name tag packages during the conference.

**Registration Bag (Conference KIT)**
Registration Bag will be distributed at the registration desk. Each bag will contain a name tag, conference program book, USB conference proceedings and other materials.
6. Transportation

CLEO-PR 2015 Conference Venue

Busan Metro Line Map

Centum City Station (BEXCO) (Exit 1)

Bus Stop

Home Plus (Centum City)

Airport Limousine

Lotte Department Store

Shinsegae Department Store

Bus Stop

Trump World Centum

Bus Stop & Exit

Bus Stop

Parking Lot

Bus Stop

City Tour Bus

Bus Stop

Busan City Social Sports Center

Busan Museum of Art Station (Exit 7)

CLEO-PR 2015 Conference Venue
IV. Conference Program

1. Plenary Talks
2. Short Courses
3. Tutorial Speakers
4. Invited Speakers
5. Oral and Poster Sessions
## 1. Plenary Talks

### Overview of Plenary Talk

<table>
<thead>
<tr>
<th>Date &amp; Time</th>
<th>Plenary Speaker</th>
<th>Session Chair</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 August (Tue)</td>
<td><strong>Optical Antennas; Spontaneous Emission Faster than Stimulated Emission</strong></td>
<td>Jung H. Shin (KAIST)</td>
</tr>
<tr>
<td>09:00~09:45</td>
<td>Prof. Eli Yablonovitch&lt;br&gt;University of California, Berkeley, USA</td>
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</tr>
<tr>
<td>Place: Summit Hall (#205), 2nd floor, BEXCO Convention Hall</td>
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<tr>
<td>25 August (Tue)</td>
<td><strong>FTTH – Past, Present, and Future</strong></td>
<td>Sang Bae Lee (KIST)</td>
</tr>
<tr>
<td>09:45~10:30</td>
<td>Prof. Yun C. Chung&lt;br&gt;Korea Advanced Institute of Science and Technology, Korea</td>
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<tr>
<td>Place: Summit Hall (#205), 2nd floor, BEXCO Convention Hall</td>
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<tr>
<td>27 August (Thu)</td>
<td><strong>Coherent Ising Machine Based on Optical Parametric Oscillator Network</strong></td>
<td>Yoon-Ho Kim (POSTECH)</td>
</tr>
<tr>
<td>09:00~09:45</td>
<td>Prof. Yoshihisa Yamamoto&lt;br&gt;Stanford University, USA / Japan Science and Technology Agency, Japan</td>
<td></td>
</tr>
<tr>
<td>Place: Summit Hall (#205), 2nd floor, BEXCO Convention Hall</td>
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</tr>
<tr>
<td>27 August (Thu)</td>
<td><strong>5PW High Gain Large Aperture Ti:sapphire CPA Amplifier</strong></td>
<td>Dong-Eon Kim (POSTECH)</td>
</tr>
<tr>
<td>09:45~10:30</td>
<td>Prof. Ruxin Li&lt;br&gt;Shanghai Institute of Optics and Fine Mechanics, China</td>
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<tr>
<td>Place: Summit Hall (#205), 2nd floor, BEXCO Convention Hall</td>
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</table>
Plenary Talk I: Optical Antennas; Spontaneous Emission Faster than Stimulated Emission

Prof. Eli Yablonovitch (University of California, Berkeley, USA)

Date & Time August 25 (Tue.) 09:00 ~ 09:45

Place Summit Hall (#205), 2nd floor, BEXCO Convention Hall

Biography
Eli Yablonovitch is Director of the NSF Center for Energy Efficient Electronics Science (E3S), a multi-University Center based at Berkeley.

After a career in industry and in Universities, he is now Professor of Electrical Engineering and Computer Sciences at UC Berkeley, where he holds the James & Katherine Lau Chair in Engineering.

He contributed the 4(n squared) light-trapping factor to solar cells, which is used commercially in most solar panels world-wide. He introduced the benefit of strained lasers, an idea which is employed in almost all Internet telecommunications. He is regarded as a Father of the Photonic BandGap concept, and he coined the term "Photonic Crystal".

Prof. Yablonovitch is a Fellow of the OSA, the IEEE, and the American Physical Society. He was elected as a Member of the National Academy of Engineering, the National Academy of Sciences, the American Academy of Arts & Sciences, and Foreign Member of the Royal Society of London. He has been awarded the Adolf Lomb Medal, the W. Streifer Scientific Achievement Award, the R.W. Wood Prize, the Julius Springer Prize, the IET Mountbatten Medal (UK), the IEEE Photonics Award, the Harvey Prize (Israel), and the Rank Prize (UK). He also has an honorary Ph.D. from the Royal Inst. of Tech., Stockholm Sweden, and the Hong Kong Univ. of Sci. & Technology.

Abstract
Antennas emerged at the dawn of radio for concentrating electromagnetic energy into a small volume $\ll \lambda^3$, allowing for nonlinear radio detection. Such coherent detection is essential for radio receivers, and has been used since the time of Hertz.

Conversely, an antenna can efficiently extract radiation from a sub-wavelength source, such as a small cellphone. Likewise, antennas can accelerate spontaneous emission from a small quantum dot or molecule, whose emission rate can become faster than stimulated emission. Antennas interact equally, with real electromagnetic fields, as well as the quantum zero point field fluctuations that are responsible for spontaneous emission.

Regrettably, antenna physics is hardly addressed within the Physics curriculum. Whether from Jackson, the Feynman Lectures, or Yariv, it’s hard to learn the true beauty of antenna science.

This talk will commence with a pedagogic description of the three most important parts of antenna physics:
1. The Radiation Resistance;
2. The Electromagnetic Capture Cross-Section;
3. The Wheeler Limit on antenna Q.

These properties are encapsulated in an antenna equivalent circuit that provides us with physical understanding. Since antennas are intended to work at frequencies well below the plasma frequency, plasmonic effects are usually a minor perturbation to antenna physics, only contributing some kinetic inductance to the underlying antenna properties.
Plenary Talk II : FTTH – Past, Present, and Future

Prof. Yun C. Chung (Korea Advanced Institute of Science and Technology, Korea)

Date & Time    August 25 (Tue.) 09:45 ~ 10:30
Place          Summit Hall (#205), 2nd floor, BEXCO Convention Hall

Biography
Yun C. Chung is Dean of KAIST Institute and Professor of Electrical Engineering at Korea Advanced Institute of Science and Technology (KAIST), which he joined in 1994.

From 1987 to 1994, he was with the Lightwave Systems Research Department at AT&T Bell Laboratories. From 1985 to 1987, he was with Los Alamos National Laboratory under AWU-DOE Graduate Fellowship Program.

His current research activities include high-capacity optical transmission systems and networks, optical performance monitoring techniques, WDM passive optical networks, and fiber-optic networks for wireless communications, etc.

He has published over 500 journal and conference papers in these areas and holds over 80 patents. He has been General Co-Chair of OFC, OECC, and APOC, and is currently serving as President of the Optical Society of Korea.

Prof. Chung is a Fellow of IEEE, OSA, Korean Academy of Science and Technology, and National Academy of Engineering of Korea.

Abstract
The first fiber-to-the-home (FTTH) trial started in 1978. However, high cost and uncertain service demand prevented widespread deployment until about 15 years ago.

FTTH is now experiencing fast growth with the number of global FTTH subscribers exceeding 143 million at the end of 2014.

This talk reviews the past history, current status, and future direction of FTTH networks with special emphasis on the results achieved at KAIST.
Plenary Talk III: Coherent Ising Machine Based on Optical Parametric Oscillator Network

**Prof. Yoshihisa Yamamoto** (Stanford Univ., USA / JST, Japan)

<table>
<thead>
<tr>
<th>Date &amp; Time</th>
<th>August 27 (Thu.) 09:00 ~ 09:45</th>
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<tr>
<td>Place</td>
<td>Summit Hall (#205), 2nd floor, BEXCO Convention Hall</td>
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</table>

**Biography**

Yoshihisa Yamamoto received his B.S. degree from Tokyo Institute of Technology and his Ph.D. degree from the University of Tokyo.

He is a program manager for Impulsive Paradigm Change through Disruptive Technologies Program (ImPACT) of the Council for Science, Technology and Innovation of Cabinet Office of Government of Japan.

He is currently a Professor (emeritus) of Stanford University and National Institute of Informatics, and NTT R&D fellow.

**Abstract**

Combinatorial optimization problems are ubiquitous in our modern life, but most of them belong to NP-hard or NP-complete class in the complexity theory.

Assuming the widely believed $P \neq NP$ conjecture, there is no efficient classical nor quantum algorithm for solving them.

The past 40 years in computer science are thus the history of devising approximation algorithms which return a reasonably accurate solution in polynomial time.

In this talk, we will present a novel optical network machine for solving NP-hard combinatorial optimization problems.

The proposed computing system takes an advantage of criticality at the degenerate optical parametric oscillator (DOPO) phase transition and maps a three-dimensional Ising model onto the loss of the DOPO network.

We will present the principle, performance comparison against standard approaches based on simulated annealing and semi-definite programming, and proof-of-concept experiments.
Plenary Talk IV: 5PW High Gain Large Aperture Ti:sapphire CPA Amplifier

Prof. Ruxin Li (Shanghai Institute of Optics and Fine Mechanics, China)

Date & Time  August 27 (Thu.) 09:45 ~ 10:30
Place        Summit Hall (#205), 2nd floor, BEXCO Convention Hall

Biography
Ruxin Li received his PhD degree in optical physics in 1995 from Shanghai Institute of Optics and Fine Mechanics (SIOM), Chinese Academy of Sciences.
Since 1998 he has been working at SIOM as a full professor.

He is currently the director of SIOM and the director of State Key Laboratory of High Field Laser Physics at SIOM. His research interests include ultra-high-intensity femtosecond lasers, laser acceleration of particles, high order harmonic generation and filamentation nonlinear optics.

He has published more than 120 papers in high quality research journals and delivered more than 50 invited talks in academic conferences. He was elected fellow of OSA in 2014.

He is currently the Vice President of Chinese Optical Society (COS); Chair of Laser Subcommittee of COS; Vice Chair of Division of Quantum Electronics and Optoelectronics, Chinese Society of Electronics. He is a Member of International Committee on High Intensity Lasers; Member of ELI-ALPS Scientific Advisory Committee; associate editor in chief of Chinese Optics Letters and Member of editorial board of Chinese Physics Letters.

Abstract
We reported the latest progress on developing a 10PW ultra-high-intensity laser facility at SIOM. Over 1PW at 800nm central wavelength output from a hybrid CPA-OPCPA laser system was demonstrated, showing the possibility of 10PW 30fs laser pulse output with a large aperture LBO crystal based OPCPA booster amplifier.

In the meantime, a high gain chirped pulse amplifier based on a 150mm in diameter Ti:sapphire crystal was demonstrated, with the highest output pulse energy of 192.3J when pumped with a 312J green laser pulse, corresponding to a pump-laser efficiency of 50.4%.

The amplified chirped pulse has a bandwidth of 50 nm at 800nm central wavelength. With the grating compressor of 72% efficiency and the 27fs long compressed pulse obtained at lower energy level, this Ti:sapphire amplifier could support a compressed laser pulse of 5PW peak power.
## 2. Short Courses

### Overview of Short Course

<table>
<thead>
<tr>
<th>Date &amp; Time</th>
<th>Speaker</th>
<th>Room</th>
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<tbody>
<tr>
<td>24 August</td>
<td><strong>Short Course I</strong></td>
<td></td>
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<tr>
<td>16:30~18:30</td>
<td><em>Metamaterial: Fundamentals and Applications</em></td>
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<tr>
<td></td>
<td>Prof. Namkyoo Park</td>
<td>#201</td>
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<td></td>
<td>Seoul National University, Korea</td>
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<td>24 August</td>
<td><strong>Short Course II</strong></td>
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<tr>
<td>16:30~18:30</td>
<td><em>Slow, Stored, and Stationary Light in Cold Atoms</em></td>
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<td></td>
<td>Prof. Ite A. Yu</td>
<td>#202</td>
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<td>National Tsing Hua University, Taiwan</td>
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<tr>
<td>24 August</td>
<td><strong>Short Course III</strong></td>
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<tr>
<td>16:30~18:30</td>
<td><em>Optical Frequency Comb and its Applications to Metrology</em></td>
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<td></td>
<td>Prof. Kaoru Minoshima</td>
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<td></td>
<td>University of Electro-Communications, Japan</td>
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</table>
Short Course I: Metamaterial: Fundamentals and Applications
Prof. Namkyoo Park (Seoul National University, Korea)

Date & Time
August 24 (Mon.) 16:30 ~ 18:30

Place
#201, 2nd floor, BEXCO Convention Hall

Biography
Prof. Park is currently a professor at the School of EECS at SNU, where he joined in 1997 after a Ph.D. degree from Caltech (Vahala group) and research / industrial experiences in Bell Labs (two years) and Samsung Electronics (one year).

He has authored 130 international journal publications (including Nature, Nature Photonics, Nano Letters, and PRL of 4,900+ total citations), and had worked as an associate editor for IEEE Photonics Technology Letters and OSA Optics Express for over 10 years.

Prof. Park was one of the four recipients of the Young Scientist Award conferred by the president of Korea in 2003.

He is currently leading a nationwide team of Electromagnetic Metamaterials under the larger program of Center for Advanced Meta-Materials (CAMM, Global Frontier Project), which started from 2014 and funded by the Ministry of Science, ICT and Future Planning.

Abstract
The general outcome of the wave propagation is ultimately determined by the properties of its medium, where the wave travels through. In order to achieve an extreme manipulation of the wave propagation, an accessibility to the unusual space of wave parameters are thus obligatory, including regimes not conventionally offered by the natural materials.

Wide variety of artificial, extreme wave parameters and their application have been witnessed for different types of waves and material systems in the name of metamaterials for last 10 years.

In this short course, I will expand the fundamental physics of metamaterial (MM), and list notable achievements / applications made so far, in this exciting field.

Topics to be covered will include: Principles of Electromagnetic MM, Negative index MM, Cloaking & Transformation Optics, Hyperbolic MM, Meta-Surfaces, High index & Zero index MM, Reconfigurable MM, and Acoustic Metamaterials (scope of the course will be adjusted depending on the audiences’ previous exposure to Metamaterials).

At the end of the talk, I will also briefly talk about the goals & strategies of Center for Advanced Meta-Materials (CAMM), which started in 2014 as the first nationwide team effort in Korea, dedicated to the development of metamaterial systems.
Short Course II : Slow, Stored, and Stationary Light in Cold Atoms
Prof. Ite A. Yu (National Tsing Hua University, Taiwan)

Date & Time
August 24 (Mon.) 16:30 ~ 18:30

Place
#202, 2nd floor, BEXCO Convention Hall

Biography
Education & Current Employment
Ph.D. in Physics, Massachusetts Institute of Technology (1993).
Professor of Physics, National Tsing Hua University.

Professional Services
Director of the Division of Academiny and the Executive Board Member, the Physical Society of R. O. C. Taiwan (2014/1-present).
Editor, Chinese Journal of Physics (2006/1-present).

Convener of the Physics Panel, the Ministry of Science and Technology, Taiwan (2011/1-2013/12).
Physics Panel Member, the Ministry of Science and Technology, Taiwan (2008/1-2010/12).

Honors and Awards
Fellow of the Physical Society of R. O. C. Taiwan.
Outstanding Scholar Award, Foundation for the Advancement of Outstanding Scholarship (2013).
Ministry of Science and Technology Outstanding Research Award (2012).
National Tsing Hua University Outstanding Mentor Award (2009).

Research Interests
EIT, slow light, light storage, low-light-level nonlinear optics, quantum memory, quantum optics, and quantum information manipulation.

Representative Publications

Abstract
The outline of the short course is listed below:
- Introduction.
- Electromagnetically induced transparency (EIT).
- Slow light and storage of light.
- Theoretical tool and experimental setup for the system of cold atoms.
- Low-light-level nonlinear optics.
- Stationary light.
- Interaction between two motionless light pulses.
- EIT-based quantum memory.
- Two-component or spinor slow light.
- Outlooks.
Short Course III: Optical Frequency Comb and its Applications to Metrology

Prof. Kaoru Minoshima (University of Electro-Communications, Japan)

**Date & Time**
August 24 (Mon.) 16:30 ~ 18:30

**Place**
#203, 2nd floor, BEXCO Convention Hall

**Biography**

Kaoru Minoshima is a Professor at the University of Electro-Communications (UEC), Tokyo, Japan. She is also the research director of Intelligent Optical Synthesizer Project, Exploratory Research for Advanced Technology (ERATO), Japan Science and Technology Agency (JST). She received her Ph.D. degree in science from the University of Tokyo in 1993, and joined the National Research Laboratory of Metrology (NRLM), Japan. She became a senior scientist at NRLM in 1997 and at the National Institute of Advanced Industrial Science and Technology (AIST) in 2001. In 2007, she became group leader of the Length Standards Section at the National Metrology Institute of Japan (NMIJ), AIST. From 2011 to 2013, she served as Bureau Manager at the Innovation School, AIST. In April 2013, she moved to the University of Electro-Communications. Prof. Minoshima also served as a Visiting Professor at the University of Bordeaux I, France (1996), a Visiting Scientist at the Massachusetts Institute of Technology, USA (2000-2001), and a guest professor at the Tokyo University of Science (2007-2013).

Her areas of research are ultrafast optical science and technology and their application to optical metrology, particularly time-resolved imaging, generation of frequency combs, and precision metrology using frequency combs. She received the Prize for Science and Technology given by the Minister of Education, Culture, Sports, Science and Technology (MEXT), Japan, in 2008, and the first Women Scientists Award from the Japan Society of Applied Physics (JSAP) in 2010, Distinguished Paper Award of Laser Society of Japan, and Nice-Step Award from NISTEP, MEXT, in 2013.

Prof. Minoshima served as the Conference on Lasers and Electro-Optics (CLEO) Technical Subcommittee Chair (2004-2005), where she built a new subcommittee for Optical Metrology, and as Subcommittee member (2006-2008), Program Co-Chair (2009), and General Co-Chair (2011). She has also served on technical and organizing committees for several other international conferences, including CLEO-Pacific Rim, CLEO-Europe, IQEC, Ultrafast Phenomena, and ASSP. She served as a member of the Townes Award selection committee of The Optical Society (OSA) (2012-2013).

Prof. Minoshima is a member of the Science Council of Japan (2011-present). She has served as editor of the Japanese Journal of Applied Physics (JJAP) (2006-2009), Program Chair of Optics Photonics Japan (2011), and she is involved with several other academic and society activities in Japan. She is a Fellow of the JSAP and OSA, and a member of the Physical Society of Japan and Laser Society of Japan.

**Abstract**

Optical frequency combs have opened up several new application fields not only in frequency metrology as “ultraprecise frequency ruler” but also in broad area such as fundamental science, broadband spectroscopy, communications, signal processing, environmental sensing, biomedical diagnosis, length and distance measurements, industrial measurements, space technology, and astronomy. Since optical frequency comb can be used as a tool for fully controlling the phase, timing, and frequency information of light waves, i.e., “optical synthesizer”, light can be used to its full extent with an extreme precision and wide dynamic range. In this short course, I will give an overview of technologies of optical frequency combs, including its historical background, fundamental technologies for generation and control of combs, types of light sources, key technologies for various applications, and finally some of the examples of applications.
3. Tutorial Speakers

<table>
<thead>
<tr>
<th>Session</th>
<th>Title</th>
<th>Speaker</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>25G1-1</td>
<td>Quantum Optomechanics</td>
<td>Warwick Bowen</td>
<td>University of Queensland, Australia</td>
</tr>
<tr>
<td>25G3-1</td>
<td>Photonic Structures for Information and Energy Applications</td>
<td>Shanhui Fan</td>
<td>Stanford University, USA</td>
</tr>
</tbody>
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4. Invited Speakers

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<td>Shunsuke Yoshida</td>
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<td>Katsumi Midorikawa</td>
<td>RIKEN Center for Advanced Photonics, Japan</td>
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<td>Arno Klenke</td>
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Julien Broux (CNRS-CRHEA, France)

25H2-1 Two-dimensional Mapping of Strain and Piezoelectric Polarization in InGaN/GaN MQWs by Electron Dark-field Holography
Sang Ho Oh (POSTECH, Korea)

25H2-2 Study of Percussion Transport in the InGaN/AlGaN LEDs with Random Alloy Fluctuation
Yuh-Renn Wu (National Taiwan University, Taiwan)

25H3-1 Visible-wavelength Two-photon Excitation Microscopy
Katsunasa Fujioka (Osaka University, Japan)

25I2-1 Localized Toroidal Dipole Moment of Spoof Surface Plasmon Polaritons
Sang Soon Oh (Imperial College London, UK)

25J1-1 Silicon-Photonics Devices for Chip to Chip Communications
Ken Morito (Photonics Electronics Technology Research Association, Japan)

25J2-1 Silicon Photonic Integration Platform for Optical Communications and Other Applications
Hiroshi Fukuda (NTT, Japan)

25J3-1 GeSn Optical Gain Media Towards Monolithic 3D Photonic Integration
Jingjing Liu (Dartmouth College, USA)

25J3-2 Heterogeneous Integration of Silicon Photonic Devices and Integrated Circuits
Hyundai Park (Aurrion Inc., USA)

26A1-1 Development of an Ultrafast Thin-Disk Ring Oscillator with an Intra-Cavity Average Power Higher than 1 kW
A. Amani Eilanlou (RIKEN Center for Advanced Photonics, Japan)

26A2-1 Gate-Controlled All-Fiber Graphene Device and Its Application to Ultrafast Fiber Laser System
Dong-Il Yeom (Ajou University, Korea)

26A3-1 Sub-Fs Hybrid Synchronization between Mode-Locked Fiber Lasers
Yincheh Lai (National Chiao Tung University, Taiwan)

26B1-1 Low Temperature Laser Processing for the Application in Flexible & Stretchable Electronics
Seung Hwan Ko (Seoul National University, Korea)

26B1-2 Novel Process for Nano-structuring of Conducting Polymer Thin Film
Hye-Jung Kim (Pusan National University, Korea)

26B2-1 Femtosecond Laser Patterning of Plasmonic and Nonlinear Optical Properties in Silver-doped
Lianel Canioni (Universite Bordeaux, France)

26B3-1 Highly Immersive Head-mounted Displays Based on Aspherical and Freeform Optics
Yangtian Wang (Beijing Institute of Technology, China)

26B3-2 Switchable Liquid Crystal Lens for 3D Applications
Hak-Rin Kim (Kyungpook National University, Korea)

26C1-1 Strong-field-ionization Induced Air Lasers
Ya Cheng (Shanghai Institute of Optics and Fine Mechanics, China)

26D1-1 Precision Performance for Full-scale Operation of LFEX PW Laser
Noriaki Miyamura (Osaka University, Japan)

26D1-2 Recent Progress and Research Status of Petawatt Femtosecond Lasers in SIOM
Xiaoyan Liang (Shanghai Institute of Optics and Fine Mechanics, China)

26D1-3 Dynamics of Cluster Ionization and Neutral Atom Acceleration
Krishnamurthy Marchkanti (Tata Institute of Fundamental Research, India)

26D2-1 0.1 Hz 4.0 PW Ti:Sapphire Laser at CoReLS
Jae Hee Sung (GST, Korea)

26D2-2 Recent Progress on an Upgrade of the J-KAREN Laser at JAEA
Hiromitsu Kiriya (Japan Atomic Energy Agency, Japan)

26D2-3 Ultra-high Intensity Laser-Matter Interaction Studies at RRCAT, India
Jazer Ali Chakera (Raja Ramanna Centre for Advanced Technology, India)

26D3-1 High Performance Materials Processing Using Tailored Femtosecond Laser Pulses
Fei He (Shanghai Institute of Optics and Fine Mechanics, China)

26D3-2 Optical Fabrication and Operation of Micronano-Robots
Hong-Bo Sun (Jilin University, China)

26E1-1 Parity-time Optical Metamaterials
Zi Jing Wong (University of California, Berkeley, USA)

26E2-1 Light Emission Enhancement by using Patterned Multilayer Hyperbolic Metamaterials
Zhaoxue Liu (University of California, San Diego, USA)

26E2-5 Stimuli Responsive Plasmonic Resonator and Its Sensing Application
Sunghwan Kim (Ajou University, Korea)
26E3-1  Plasmon Lasers: Development, Features and Applications  
Ren-Min Ma (Peking University, China)

26F1-1  Extremely Large Freeform Optics Manufacturing and Testing  
Dae Wook Kim (University of Arizona, USA)

26F2-1  Quantum Entangled Photon Sources and Their Application to Quantum Metrology  
Shigeki Takeuchi (Kyoto University, Japan)

26F2-2  High Efficiency Single Photon Detection with Optimized SNSPD and Compressed Beam  
Labao Zhang (Harbin Engineering University, China)

26F3-1  Ultrahigh-Precision Measurement and Optimization of Timing Jitter in Mode-Locked Lasers  
Jungwon Kim (KAIST, Korea)

26G1-1  Vortex Pair Creation and Annihilation in a Bose-Einstein Condensate  
Yang-S Shin (Seoul National University, Korea)

26G2-1  Round-robin Differential-phase-shift QKD Protocol  
Masato Kasai (The University of Tokyo, Japan)

26G3-1  Storing Single Photons in a Quantum Register  
Joerg Wrachtrup (Stuttgart University, Germany)

26H1-1  Nitride-based Light-emitting Diodes Using Conducting Filament Embedded TCO  
Tae Gyun Kim (Korea University, Korea)

26H1-2  Drastic Enhancement of Eu Emission from Red Light-emitting Eu-doped GaN in a Microcavity  
Yasufumi Fujwara (Osaka University, Japan)

26H2-1  Expanding Imaging Ranges for Spectral Domain Optical Coherence Tomography  
Beop-Min Kim (Korea University, Korea)

26H3-1  Extraordinary Light Transmission for Super-resolved Axial Imaging  
Donghyun Kim (Korea University, Korea)

26I2-1  Hyperbolic Metamaterials  
Shi Satoshi (National Institute for Materials Science, Japan)

26J1-1  Ultrahigh-Q Asymmetric Microcavity Photonics on a Silicon Chip  
Yun-Feng Xiao (Peking University, China)

26J2-1  Development of a Versatile InP-Based Photonic Platform Based on Butt-Joint Integration  
Francisco M. Soares (Fraunhofer Heinrich-Hertz Institute, Germany)

26J3-1  Nanophotonics for Future Data Communication and Ethernet Networks  
James A. Lott (Technische Universität Berlin, Germany)

Thursday, August 27

27A2-1  Solid-State Lasers Directly Pumped by InGaN Blue/Green Diode Lasers  
Fumihiko Kanari (Kobe University, Japan)

27B1-1  Continuous Wave Terahertz Signal Generator Based on Difference Frequency Generation in Gallium Phosphide Developed for Industrial Applications  
Tetsuo Sasaki (Shizuoka University, Japan)

27B2-1  Biomedical Science and Technology Using Terahertz Waves  
Joo-Huk Son (University of Seoul, Korea)

27B2-2  A Terahertz Technology for Label-free Immune Assay  
Toshitake Kawa (Okayama University, Japan)

27B2-3  Ultrafast Spin Spectroscopy for Rare-earth Orthoferrites and Orthochromites by THz Pulses  
Makoto Nakajima (Osaka University, Japan)

27C1-1  High Harmonics and Attosecond Pulses – Seeing Inside Molecules  
David Whittenu (National Research Council and University of Ottawa, Canada)

27C1-2  Laser-assisted Electron Scattering and Diffraction in Femtosecond Intense Laser Fields  
Reika Kanya (the University of Tokyo, Japan)

27C2-1  Measurement and Control of Optical Waveforms  
Kyung Tae Kim (GIST, Korea)

27C2-4  Measurement and Synthesis of Ultrafast Scalar and Vectorial Optical Arbitrary Waveforms  
Shang-Da Yang (National Taiwan University, Taiwan)

27D1-1  Progress on Mid-infrared Intense Laser Aiming at 100 TW Peak Power  
Guo Qiang Xie (Shanghai Jiaotong University, China)

27E1-1  Scattering Superlens: Near-field Focusing and Imaging Exploiting Multiple Scattering in Turbid Media  
Yong Keun Park (KAIST, Korea)

27E2-1  High Precision Prediction of Thin Film Composition by LIBS  
Sungho Jeong (GIST, Korea)

27F1-1  Optical Observation of DNA Translocation Dynamics through Solid-State Nanopores  
Toshifumi Sato (Keio University, Japan)

27G1-1  Monolithic Optical Integration for Scalable Trapped-Ion Quantum Information Processing  
David Keating (Griffith University, Australia)
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<td>Shigeki Takeuchi (Kyoto University, Japan)</td>
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<td>Wonshik Choi (Korea University, Korea)</td>
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<td>Mototsuki Iwaya (Mejo University, Japan)</td>
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<td>Mercedes Khajavikhan (University of Central Florida, USA)</td>
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<td>Da Xing (South China Normal University, China)</td>
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5. Oral and Poster Sessions

Instructions for Oral and Poster Presentations

**Oral Presentation**

1) **Presenting Time**
   The length of an oral presentation should be as follows: Tutorial Papers 45min. / Invited papers 30 min. / Contributed Paper 15 min. We strongly request that you keep to the time limit, with sufficient time left for questions and discussions.

2) **Presentation File**
   Please prepare your presentation files in English using Microsoft PowerPoint. If you use fonts other than the standard Windows Office 2010 fonts, please bring the associated font files. However, it is recommended that you use the standard fonts such as Arial or Times New Roman.

   Please bring your presentation file in a USB drive and give it to the session assistant in the meeting room at least 10 minutes before the start of your session so that the session assistant will be able to upload the files to the laptop PC.

   All presenters are also asked to submit a short autobiography to the session chair at least 10 minutes before the start of the session.

3) **Audio Visual (A/V) Equipment**
   Each session room will have the following equipment:
   - Laptop computer with a USB port running MS-Office PowerPoint 2010 on Windows 7
   - Smart pointer and mouse
   - Beam projector (RGB Port)
   - Screen

   We strongly recommend that you use the A/V equipment provided by the conference. Should you need to use your own laptop computer (especially an Apple laptop), it is your responsibility to ensure that it is compatible with the A/V equipment in the meeting rooms.

**Poster Presentation**

All poster presenters are asked to prepare posters following guidelines described below. Posters should be displayed on a designated panel for the assigned time and place.

**Session Date / Time:**
August 26 (WED), 2015. / 9:00am-6:00pm
(Presentation Time: 1:45pm-3:15pm)

August 27 (THU), 2015. / 9:00am-6:00pm
(Presentation Time: 1:45pm-3:15pm)

**Session Room:**
Exhibition Hall (#103), 1F, Convention Hall, BEXCO

- Poster Size: 0.9m x 1.2m (or 35.4in x 47.2in)
- Poster Panel Size: 1.0m (width) x 2.4m (height)
- Each paper’s code will be shown on the panel.
- Scotch tape will be provided for your use.

Please do not use double-sided tapes.
- All presenters are required to preside at their poster panel during the session for answers and discussion with participants.
- Each poster should include the paper title, authors, affiliation, abstract number and must fit within the 0.9m x 1.2m poster space.
Room A (101)

Session Title 25A1 / [T01] Raman Lasers
Date & Time Tuesday, 25 August, 11:00 – 12:30
Session Chair Valentin Petrov (Max Born Institute, Germany)

[25A1-1] 11:00–11:30 Invited Talk
Diamond Raman Lasers: Nonlinear Optical Beam Conversion at High Average Powers
Richard Milhen
Macquarie University, Australia
Recent advances in high power beam conversion in diamond are reviewed. It is shown that there are excellent prospects for developing high power (kilowatt) devices with diffraction-limited beam quality in bulk and at room temperature.

High Power Single Frequency Raman Fiber Amplifiers
Yan Feng
Chinese Academy of Sciences, China
Single frequency Raman fiber amplifiers have been developed for applications of laser guide star and atom physics. Suppression of stimulated Brillouin scattering is the main technical challenge for power scaling.

[25A1-3] 12:00–12:15
Generation of Dissipative Solitons in Normal-Dispersion Raman Fiber Laser
Ugur Tegin, Parviz Elahi, Cagri Senel, and G. Ömer İlay
"Bilkent University, Turkey; TUBITAK National Metrology Institute, Turkey; "METU, Turkey
Dissipative soliton pulses in a synchronously pumped all-normal-dispersion Raman fiber laser are presented theoretically and experimentally. The laser generates 7.1 μJ intra-cavity pulses at 1.12 μm and is compressed to 136 fs.

Dual-Band Eye-Safe Nd:YAP/KTP Raman Laser
Y. J. Huang, Y. F. Chen, W. D. Chen, and G. Zhang
"National Chiao Tung University, Taiwan, "Chinese Academy of Science, China
A compact efficient dual-wavelength eye-safe Nd:YAP Raman laser at 1478 and 1503 nm is originally demonstrated based on simultaneous excitations of the cascaded 267 cm⁻¹ mode and the 694 cm⁻¹ shift in the KTP crystal.

Room B (102)

Session Title 25B1 / [T13] Novel Devices and Systems for Display
Date & Time Tuesday, 25 August, 11:00 – 12:30
Session Chairs Yongtian Wang (Beijing Institute of Technology, China) Hak-Rin Kim (Kyungpook National University, Korea)

[25B1-1] 11:00–11:30 Invited Talk
Fission: Interactive Glasses-free 3D Images Floating on a Flat Tabletop Surface
Shunsuke Yoshida
National Institute of Information and Communications Technology, Japan
Our proposed glasses-free tabletop 3D display, fission, employs a hollow conical screen and tiny, circularly arranged projectors installed underneath the table. It floats interactive virtual 3D objects on a flat tabletop surface.

Evaluation Methods of Retro-Reflector for Polarized Aerial Imaging by Retro-Reflection
Masao Nakajima, Yuka Tomiyama, Ichiro Amimori, and Hirotsugu Yamamoto
"Utsunomiya University, Japan, "The Tokushima University, Japan, "SN Partners, Japan
To improve the brightness of polarized aerial imaging by retro-reflection, we have established evaluation methods of retro-reflector. We found prism type retro-reflectors have higher reflectance and lower polarization maintenance rate than beads type retro-reflectors.

[25B1-3] 11:45–12:00
Blurring Correction for Aerial Image Formed by Dihedral Corner Reflector Array
Daisuke Miyazaki, Shinji Onoda, Yuki Mano, and Takashi Mukai
Osaka City University, Japan
A method to improve blurring in an aerial image formed by a novel optical imaging element consisting of micro mirror array is proposed. This method is based on prior inverse filtering with a point-spread function.

[25B1-4] 12:00–12:15
Side-wall Surface Relief Gratings for Micro-structured Liquid Crystal Alignment
Zhichao Ji, Xizheng Zhang, Wei Li, Haina Chevensuk-Olenk, and Jingjun Xu
"Nankai University, China, "J. Stefan Institute, Slovenia
The nematic liquid crystal can be uniformly aligned via its contact to a side-wall of a polymer ribbon fabricated by the TPP-CLW process. The origin of the alignment is analyzed. The surface anchoring energy on the side-wall structures is measured.

To Enhancement Luminous Efficiency of OLED by Roughness Thin Film Included Microparticles
Chung-Hung Chiu, Chao-Heng Chien, Jen-Chi Lee, and Wei-Cheng Chien
"Chunghsia Picture Tubes, Taiwan, "Taiung University Taipei, Taiwan
Including micro-particles and rough surface, an optical thin film was provided to address light extraction efficiency of OLED up to 80%. Two kinds of oxidized metal micro-particles were chosen to dope inside the optical thin film to increase scattering and refraction effect, and to rough surface on the optical thin film can enhance more light extraction efficiency due to the exit angle change on the top of the optical thin film.
Room C (103)

**Session Title**
25C1 / [T02] Femtosecond Laser

**Date & Time**
Tuesday, 25 August, 11:00 – 12:00

**Session Chair**
Fabien Quere (CEA, France)

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**25C1-1 11:00–11:30**

**Invited Talk**

**Frequency Domain Optical Parametric Amplification**


1Institut National de la Recherche Scientifique, Canada, 2Few-Cycle Inc., Canada, 3University of New Mexico, USA

General restrictions arising from gain-narrowing and phase-matching are circumvented by employing parametric amplification in the frequency rather than the time domain. Frequency-domain OPA has been used for amplifying few cycle pulses and for high gain amplification.

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**25C1-2 11:30–11:45**

**Broadband 800nm Pulse Generation with an Optical Parametric Amplifier based on BiB3O6**

Yanyan Li, Yuxin Leng, Wenkai Li, Xiao Zou, Y.Xu, and Yun Chen

Chinese Academy of Sciences, China

We demonstrated the generation of broadband 800nm laser pulse with a BiB3O6 based OPA followed by a SHG process. The achieved pulses are with spectrum of 53.3nm (FWHM) and pulse width of 18.6 fs.

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**25C1-3 11:45–12:00**

**Ultra-Broadband Femtosecond Optical Gating System Using Transient Kerr Lens Effect**

Wenhua Li, Zhenhua Wang, Xincheng Zhang, Yu-E Wu, Jiang Wu, and Jingjun Xu

1Nankai University, China, 2Collaborative Innovation Center of Chemical Science and Engineering, China

A convenient ultra-broadband femtosecond optical gating system utilizing transient Kerr lens effect is demonstrated with its application on measuring the time-frequency property of some broadband light sources.

Room D (106)

**Session Title**

**Date & Time**
Tuesday, 25 August, 11:00 – 12:30

**Session Chair**
Changhwan Lim (KAERI, Korea)

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**25D1-1 11:00–11:30**

**Invited Talk**

**Nonlinearity Management: From Fiber Oscillators to Amplifiers**


1Bilkent University, Turkey, 2TBİTAK National Metrology Institute, Turkey

While the standard approach to performance scaling in fiber lasers seeks to reduce nonlinear effects through chirping or mode scaling, I will review recent progress in a complementary approach, whereby the governing dynamics are meticulously exploited towards achieving superior performance.

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**25D1-2 11:30–12:00**

**Invited Talk**

**Coherent Combination of Ultrafast Laser: A Path towards High Repetition Rate Joule-class fs Pulses**

Jens Limpert

Friedrich-Schiller-Universität Jena, Germany

In recent years intense laser pulses have found applications in various industrial and scientific areas. Significant progress has been made in scaling the energy of the pulses as well as the average power. However, different amplification schemes have been pushed to their specific limits, caused by detrimental nonlinear effects, by damage or by the occurrence of thermo-optical effects. New concepts have to be considered to address these issues and to enable new application fields. In that context, I will review the basics and achievements of coherent combination of amplified femtosecond pulses, a concept which has already out-performed single aperture femtosecond laser systems and which allows for a scaling to unprecedented performance levels, i.e. the combination of highest peak power (Petawatt) and highest average power (Megawatt).

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**25D1-3 12:00–12:15**

**High Energy Hybrid Fibre Regenerative Amplifier for Nanosecond Laser Pulse**

Diao Zhi, Wang Xiaochao, Fan Wei, and Lin Zung

Chinese Academy of Sciences, China

A hybrid fibre-bulk regenerative amplifier with maximum output energy of 600uJ at 1Hz for narrow linewidth nanosecond laser is demonstrated. Nearly diffraction limited beam is obtained. The total gain is more than 63dB.

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**25D1-4 12:15–12:30**

**Kerr Lens Mode-locked Yb:Lu2O3 Ceramic Oscillator Pumped by a Multimode Laser Diode**

Tomohiro Imahoko, A. Amani Eilanlou, Yasu Nabeckawa, Yoshitaka Fujihara, Tomohiro Imahoko, Tetsuru Sumiyoshi, Fumioke Kanno, Makoto Kuwata-Gonokami, and Kazumi Mihonkawa

1RIKEN Center for Advanced Photonics, Japan, 2Keio University, Japan, 3Cyber Laser Inc., Japan, 4The University of Tokyo, Japan

We report a Kerr lens mode-locked Yb:Lu2O3 ceramic oscillator with a pulse energy of 23.5 nJ, which is the highest value in bulk Yb:Lu2O3 ceramic oscillators, to the best of our knowledge.
Recent Advances on Metasurfaces
Lei Zhou, Shulin Sun, Dongs He, Ziqi Miao, Weijie Luo, and Wuyong Sun
Fudan University, China

We briefly summarize our recent efforts in employing meta-surfaces to control electromagnetic waves, including realizing high-efficiency photonic spin-Hall effect and surface-plasmon couplers, and controlling phases with graphene-based meta-surfaces.

Point-source Optical Coupling to Electromagnetic Guided Modes of Metasurfaces
Per Lunnemann and A. Femius Koenderink
1Technical University of Denmark, Denmark, 2FOM Institute AMOLF, Netherlands

We present a semi-analytical method for calculating the dispersion-relation and local density of states of a two-dimensional lattice with arbitrary electro-magnetic dipole scatterers. The method is demonstrated on lattices with electric and magnetic plasmonic spheres.

Vividly-colored Silicon Metasurface Based on Collective Electric and Magnetic Resonances
Wuzhou Song, Shiqiang Li, and Kenneth B. Crozier
University of Melbourne, Australia

We fabricate a silicon nanorod-based metasurface that shows vivid colors. Each nanorod supports electric and magnetic dipole modes whose coupling leads to collective resonances. The reflected field is described by a classical coupled dipole model.

Metasurface Polarized Beam Splitter and Hologram Based on One-dimensional Metallic Grating
Jun Zheng, Zhi-Cheng Ye, Zheng-Ming Sheng, and Jie Zhang
Shanghai Jiao Tong University, China

Based on the one-dimensional bi-layered metallic nanowire grating with engineered nanoslits, a novel form of metasurface polarized beam splitter and holography are proposed and demonstrated. The photon manipulation mechanism is fundamentally different from those in 2-D or 3-D metasurfaces.

Superradiant Mode Competition in Silver Slit Array on InGaAsP Structure
Kwang Jun Ahn, Seung-Hyun Kim, and Ki-Ju Yee
Ajou University, Korea, 1Chungnam National University, Korea

We studied superradiance at surface plasmon and waveguide mode in a silver slit array / InGaAsP, and showed that although the former has a larger loss, it overwhelmed the latter as the pump energy increases.

A Flat Spectral Photon Flux Source for Single Photon Detector Quantum Efficiency Calibration
Haiyong Gan, Ruoduan Sun, Nan Xu, Jianwei Li, Yantei Wang, Guoqin Feng, Chunli Zheng, Chong Ma, and Yiandong Lin
National Institute of Metrology, China

A flat spectral photon flux source is proposed to facilitate the single photon detector quantum efficiency calibration in an extended wavelength range (500-900 nm). The absolute quantum efficiency at certain wavelengths (e.g. 633 nm and 807 nm) of the photon counter under test can be measured via correlated photon measurement and used to evaluate the photon statistics of the flat spectral photon flux source. A correction factor derived from the photon statistics can then be applied throughout the wavelength range for improved detector quantum efficiency measurement.

Test System of 100 GHz Photodetector Time Response at NIM
Jianwei Li, Haiyong Gan, and Nan Xu
National Institute of Metrology, China

Electrooptic sampling has been shown to be a very powerful technique for making time-domain measurements of fast electronic devices and circuits. In this paper, we review the principles of electrooptic sampling technique for electronic waveform probing with applications to characterizing 100 GHz photodetector pulse response.

Measurement of Relative Spectral Responsivity of Photovoltaic Detectors by Using Single Tunable Pulsed Laser
Kee Suk Hong, Seongchong Park, Dong-Hoon Lee, and Jisoo Hwang
Tohoku Institute of Technology, Japan

Internal conversion efficiencies of solar cells are measured based on electrical substitution method. The external energy conversion efficiencies and the internal & the external quantum efficiencies are also derived. Agreements validate this technique.

Detection of Thermal Protrusion at Laser Heating Spot
Chengwei An, Hongchi Yang, Dang-Hoon Lee, and Kuoqing Ye
Agency for Science, Technology and Research, Singapore

A method based on the detection of the variation of the reflected laser beam’s optical divergence was used to detect the temporary thermal protrusion at the laser heating spot.
Session Title: Quantum Optomechanics

Date & Time: Tuesday, 25 August, 11:00 – 12:30

Session Chair: Yoon Ho Kim (POSTECH, Korea)

[25G1-1] 11:00–11:45 Tutorial

Quantum Optomechanics

Warneck Rosen

University of Queensland, Australia

Quantum optomechanics is a rapidly growing field studying the quantum interaction of light with mechanical devices. This tutorial will review the field, as well as applications in precision sensing, quantum information science, and fundamental physics.

[25G1-2] 11:45–12:00

An Ion Trap of Monolithic 3D Structure for Quantum Information

Dahyun Yum, Ye Wang, Kuan Zhang, Shuming An, and Kihwan Kim

Tsinghua University, China

We develop a three-dimensional (3D) monolithic ion trap that has advantages of both 3D geometry trap and surface trap. The characteristic properties are measured, i.e. the axial and radial trap frequency and heating rate. We successfully load Yb and Ba ions together in this trap. The hybrid ion trap will be used for quantum information experiment.

[25G1-3] 12:00–12:15

Phonon-Phonon Interaction in a Linear Ion Trap

Shigian Ding, Glete Masedenkevicius, Roland Hablützel, Huangpan Loh,1,2, and Dmitry Matsukevich

1Centre for Quantum Technologies, Singapore, 2Massachusetts Institute of Technology, USA, 3National University of Singapore, Singapore

We observe nonlinear coupling of phonons between radial and axial directions in a system of two ions in a linear Paul trap. Anticrossing of phonon modes and adiabatic energy transfer are demonstrated.


Scalable Trapped-Ion Single-Photon Sources with Monolithically Integrated Optics

Mjota Gudmundsdottir, Valdis Bloks, Ben Norton, Zulfar Hasan Khairullah, Harley Hayden, Jason Arnold, Curtis Volet, Erin Street, and David Keinath

1Griffith University, Australia, 2Georgia Tech Research Institute, USA

We demonstrate the first fully integrated and scalable diffactive mirrors for efficient ion light collection. We also generated single photons using an Yb+ ion and collected them using these mirrors to do a quantum communication protocol.

Session Title: III-Nitride Quantum Dot Based Light Emitting Diodes for UV Emission

Date & Time: Tuesday, 25 August, 11:00 – 12:30

Session Chair: Yuh-Renn Wu (National Taiwan University, Taiwan) Sang Ho Oh (POSTECH, Korea)

[25H1-1] 11:00–11:30 Invited Talk

Growth of Light-Emitting Devices Based on InGaN Quantum Dots by MOVPE

Lai Wang, Zh Yang, Jadong Yu, Zhibiao Hao, Yi Luo, Changhong Sun, Yanjun Han, Bing Xiong, Jian Wang, and Hongtao Li

Tsinghua University, China

In this paper, we report our recent progresses on growth of InGaN quantum dots and related lightemitting devices by metal organic vapor phase epitaxy.

[25H1-2] 11:30–12:00 Invited Talk

III-Nitride Quantum Dot Based Light Emitting Diodes for UV Emission

Julien Braut,1 Benjmin Dimlavo,1 Almeiric Courville,2 Mohamed Al Khalfioui,2,3 Mathieu Lenos,4 Sébastien Chereau,4 Philippe Brenigui,1 Philippe De Mery,4 Jean Massies,2,3 Daniel Risal0,d,4 Thierry Bretagnon,1,4, and Bernard Gf

1CNRS-CRHEA, France, 2Université de Nice Sophia-Antipolis, France, 3CNRS-Université Montpellier, France

Al/Ga, N-based nanostructures have been fabricated by Molecular Beam Epitaxy and their properties as UV emitters investigated. The structure designs leading to shortest wavelength emission are presented. Quantum dot based LED properties are shown and discussed.

[25H1-3] 12:00–12:15

Selective Area Growth of InN Nanocolumns: Effect of Lattice Polarity

Ping Wang, Xin Rong, Xiantong Zheng, and Xinqiang Wang

Peking University, China

A weird effect of lattice polarity on the morphology of InN nanocolumns (NCs) via position-related lightemitting devices by metal organic vapor phase epitaxy.


Green Luminescence of Quasi-Molecular Level in Graphene Quantum Dots Fabricated by Microwave Bottom-up Strategy

Min-Ho Jung, Sin Muma,1,2 Jung-Hwan Jung, Anchal Shrivastava, A-Keeon Oh,1 and Yong-Hoon Choi

1KOST, Korea, 2Banaras Hindu University, India

Green photoluminescent graphene quantum dots were synthesized by one step microwave assisted method using organic solvent acetylacetone, which have two different light emissions at 460 and 505 nm irradiated by 370 and 470 nm of monochromatic light from xenon lamp, respectively.
**Room I (203)**

**Session Title:** 25I / [T10] Plasmonic Devices

**Date & Time:** Tuesday, 25 August, 11:00 – 12:00

**Session Chair:** Bumki Min (KAIST, Korea)

<table>
<thead>
<tr>
<th>Session [25I1-1] 11:00–11:15</th>
<th>Connecting Deep Sub-Wavelength Plasmonic Waveguide to Si Photonics Waveguides</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Masaaki Ono(^1,2), Hap Xu(^1,2), Masato Tsunekawa(^3), Elchi Kuramochi(^4), Kengo Nozaki(^2), Hideaki Taniyama(^5), and Masaya Notomi(^5,6,7)</td>
</tr>
<tr>
<td></td>
<td>Nanophotonics Center, Japan, (^2)NTT Corporation, Japan, (^3)Tokyo Institute of Technology, Japan</td>
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<td></td>
<td>We achieved three-dimensional mode conversion between a Si-wire waveguide and a deep sub-(\lambda) plasmonic slot waveguide (60 (\times) 50 nm(^2)) for the first time. The coupling loss was only about 2 dB.</td>
</tr>
</tbody>
</table>

**Session [25I1-2] 11:15–11:30 | Tunable Plasmonic Multi-channel Demultiplexer with Graphene Sheets and Ring Resonators |
|                               | Xiaye Liang, Shinhan Gu, Ci-Song, Xu Shan Xia, Baigje Tang, and Jicheng Wang |
|                               | Jangnan University, China |
|                               | The actively tunable plasmonic multi-channel wavelength demultiplexer (WDM) based on graphene sheets and ring resonators is proposed and numerically investigated by utilizing finite element method (FEM) simulations. |

**Session [25I1-3] 11:30–11:45 | Phase Characteristics of Broadband Mach-Zehnder Directional Coupler with Quasi-Decoupled Hybrid Plasmon |
|                               | Shih-Hsiang Hsu, Kuo-Wei Chuang, and CI-Syo Chen |
|                               | National Taiwan University of Science and Technology, Taiwan |
|                               | The phase from quasi-decoupled hybrid plasmon and coupled bending regions of Mach-Zehnder directional couplers was characterized for broadband optical power dividers. The splitting ratios demonstrated within 8% variation across 200 nm bandwidth using 400 nm quasi-decoupler spacing. |

**Session [25I1-4] 11:45–12:00 | Nondiffracting Bloch Surface Wave: 2D Quasi-Bessel-Gauss Beam |
|                               | Myun-Sik Kim, Elie Banakat, Richu Dube, Toralf Scharf, and Hans Peter Herzig |
|                               | Ecole Polytechnique Fédérale de Lausanne, Switzerland |
|                               | 2D Bessel-Gauss beam, which is known as nondiffracting beams in 3D space, is demonstrated in the domain of Bloch surface wave. Its self-healing capacity is verified by using cylindrical obstacles in the diffraction-free beam path. |

**Session [25I1-5] 12:15–12:30 | Silicon-Photonics Devices for Chip to Chip Communications |
|                               | Ken Morita, Seok-Hwan Jeong, Shin-Soke Tanaka, Takasi Simoyama, Shigekazu Okumura, Yehe Sobu, and Yu Tanaka |
|                               | Photonics Electronics Technology Research Association, Japan |
|                               | Recent progress of silicon-photonics devices developed for chip-to-chip communications is presented. WDM MUX/DEMUX filters, multi wavelength light sources, 1D and 2D grating couplers and 25 Gbps interchip transmission experiment with low driving power are detailed. |

**Room J (204)**

**Session Title:** 25J / [T12] Silicon Photonics Interconnection

**Date & Time:** Tuesday, 25 August, 11:00 – 12:30

**Session Chairs:** Hiroshi Fukuda (NTT, Japan), Dong Jae Shin (Samsung Electronics Co., Ltd., Korea)

<table>
<thead>
<tr>
<th>Session [25J1-1] 11:00–11:30 Invited Talk</th>
<th>Design of Low Loss Crossing of Si Waveguides</th>
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<tbody>
<tr>
<td></td>
<td>Yugao Deng, Kazumi Wada, Naoyuki Kawai, Zyi Zhang, and Motoki Yako</td>
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<td>University of Tokyo, Japan</td>
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<td>A novel waveguide crossing structure is proposed, where Si waveguides are tapered off at the crossing. Two-dimensional finite difference time domain simulation indicates that the presented crossing has low insertion loss of 0.015dB/crossing around 1550nm.</td>
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<tr>
<th>Session [25J1-2] 11:30–11:45</th>
<th>Apodized Amorphous Silicon Grating Coupler with Metal Mirrors for 3D Optical Interconnection</th>
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<tbody>
<tr>
<td></td>
<td>Yuki Kuno, Jonghyun Kang, Kazuto Itoh, Yusuke Hayashi, Junichi Suzuki, Tomohiro Amemiya, Nobuhiro Mohiyama, and Shigeru Arai</td>
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<td>Tokyo Institute of Technology, Japan</td>
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<td>Inter-layer coupling between multilayer waveguides was demonstrated using hydrogenated amorphous silicon (aSi:H) grating couplers with metal mirrors. The fabricated device which has the inter-layer distance of 2 μm successfully showed wider bandwidth compared with uniform grating structure.</td>
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<tr>
<th>Session [25J1-3] 11:45–12:00</th>
<th>Tunable Grating Coupler Based on Thermo-Optic Effect in Silicon</th>
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<tbody>
<tr>
<td></td>
<td>Jong-Hun Kim(^1), Sun-Kyu Han(^1), Min-Jung Bae(^2), Ji-Hwan Park(^1), Dong-Eun Yoo(^1), Dong-Wook Lee(^1), and Ho-Hoon Park(^1)</td>
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<td>(^1)KAIST, Korea, (^2)National Nanofab Center, Korea</td>
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<td>We demonstrate an efficient tunable grating coupler using thermo-optic heater in silicon. Tuning of the central wavelength from 1537nm to 1573nm is achieved with an increased 1 dB-bandwidth up to 59nm.</td>
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<th>Session [25J1-4] 12:00–12:15</th>
<th>Non-blocking 8×8 Silicon Electro-optic Switch</th>
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<tr>
<td></td>
<td>Lei Qiao, Weijie Tang, and Tao Chu</td>
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<td></td>
<td>Chinese Academy of Sciences, China</td>
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<td></td>
<td>A re-arrangeable non-blocking 8×8 silicon electro-optic switch was demonstrated. It had extinction ratios of 18.3–25.5dB on all “Cross” status and 13.3–19dB on all “Bar” status at 1550nm.</td>
</tr>
</tbody>
</table>
Room A (101)

Session Title: 25A2 / [T01] Optical Frequency Combs
Date & Time: Tuesday, 25 August, 13:45 – 15:15
Session Chair: Jungwon Kim (KAIST, Korea)

GHz Level Fiber Laser and Frequency Comb
Zhigang Zhang, Alimin Wang, Chen Li, and Yuxuan Ma
Peking University, China

The advanced laser technology has led to gigahertz level repetition rate femtosecond fiber laser possible. This laser offers advantages of high average power, chirp-free output pulses and helps the frequency comb made compact and simplified.

Er Comb Fiber Laser with Fceo Noise below 0.2 rad
N. Kuse1, J. Jiang1, C.-C. Lee1,2, Y. Yun1, T. R. Schibli1,2, and M. E. Ferr cannon1
IMRA America Inc., USA, 2University of Colorado, USA

We demonstrate an all polarization-maintaining Er fiber frequency comb with a record low phase noise for the locked carrier envelope offset frequency of 0.18 rad.

[25A2-3] 14:30–14:45
All-Fiber Soliton Er-Laser Mode-Locked by a Planar Lightwave Circuit (PLC)-Based CNT Saturable Absorber
Yeun Jeon Cheong1, Dohyun Kim1, Chir Kim1, Sun Young Cho1, Hwanseong Jeong2, Sang Jun Choi1, Jeong-Woo Lee3, Dong-Ho Yeon3, Fabian Rotermark1, and Jungwan Kim1
KAIST, Korea, 2Ap University, Korea, 3Fiber Pro Inc., Korea, 4Care Cross Inc., Korea

We show an all-planar, fiber-connected CNT saturable absorber manufactured by the planar lightwave circuit (PLC) process. The fabricated saturable absorber was successfully employed in an all-fiber soliton mode-locked Er-laser.

[25A2-4] 14:45–15:00
All-Optical Control of Repetition Rate in Mode-Locked Fiber Lasers
Kangwen Yang, Diang Hao, and Heping Zeng
University of Shanghai for Science and Technology, China

We obtained high precision repetition rate stabilization of an all-fiber laser by modulating the pump power of an additional doping fiber. The standard deviation of the locked repetition rate was 2 mHz.

[25A2-5] 15:00–15:15
Yb-Doped Fiber Comb Based on a Tapered Single-Mode Fiber
Yang Xie1, Haibin Han1, Long Zhang2, Lei Hou3, Zhiqiao Yu3, Zheng Zhu3, Liqiu Peng3, Wenjun Liu1, and Zhiyi Wei2
1Wuhan University, China, 2Chinese Academy of Sciences, China

We present an Yb-doped fiber frequency comb based on a tapered single mode fiber by locking the repetition frequency and the carrier-envelope-offset frequency simultaneously to the microwave frequency reference outside.

Room B (102)

Session Title: 25B2 / [T01] Material Processing & Applications
Date & Time: Tuesday, 25 August, 13:45 – 15:00
Session Chair: Richard Mildren (Macquarie University, Australia)

Ultrafast Laser Materials Processing for Manufacturing Innovation
Jiyeon Choi, Min Lee, Yong Hyeon Kim, and Sangmin Chae
KIMM, Korea

Ultrafast laser based materials processing has shown remarkable success in various area of industrial applications. A few examples of innovative applications in displays, OSCs, and other consumer electronics fabrication are demonstrated.

Yb-Doped LMA Fiber Fabrication Using Chelate Precursor Doping Technique
Zhen Wang, Cong Gao, Li N, Xiaoliang Wang, Kun Peng, Yuying Wang, Huan Zhan, Jianjun Wang, Feng Jing, and Aoxiang Lin
Chinese Academy of Sciences, China

We report on the fabrication of a kW-level Yb-doped fiber by using chelate precursor doping technique. Lasing performance was tested up to 1 kW laser output with slope efficiency of 81.8%.

Characteristics of the Coherent EUV Light Source for EUV Metrology
Yong Soo Kim1,2, Younghee Kim1, Junie Park1, Hamin Sung1, Jongsool Kim1, Ju Han Lee1, and Young Min Jho1
1KIST, Korea, 2University of Seoul, Korea, 3Laser Spectronix, Korea

Coherent EUV light at 13.5 nm was generated by high-harmonic generation using a 35-fs pulsed laser at 796 nm in Ne gas, which showed stable operation within 5% deviation over an hour.

Observation of Rogue Waves in a 980 nm-Laser Diode Subject to Filtered Optical Feedback
Min Won Lee1,2, Fadia Bialal3, Jean-René Burie3, Jean-Paul Burel2, and Alexis P. A. Fischer3
1Université Paris 13, France, 2JS Photonics Technologies, France

Rogue waves are observed in a 980 nm laser diode subject to filtered optical feedback via an FBG. A rogue wave map is established experimentally as a function of the optical feedback ratio and the laser current.
Room C (103)

Session Title: 25C2 / [T02] Attosecond Physics
Date & Time: Tuesday, 25 August, 13:45 – 15:15
Session Chair: Francesco Legare (Institut National de la Recherche Scientifique, Canada)

Observation of Attosecond Quantum Wavepackets in Molecules
Katsumi Midorikawa, Tomoya Okino, Yasuaki Nabekawa, and Yasuika Furukawa
Riken Center for Advanced Photonics, Japan
Attosecond Fourier transform spectroscopy with attosecond pulse trains is implemented for observing ultrashort quantum wavepacket dynamics in diatomic molecules. Coupled nuclear-electron motions in the molecules are investigated with an attosecond-pump and attosecond probe method.

[25C2-2] 14:15–14:30 Non-collinear High-order Harmonic Generation in Ionized Media
Kentaro Sato, Takamiki Kondo, Haruka Ono, Kyohei Suzuki, and Akira Suda
Tokyo University of Science, Japan
High-harmonic generation by non-collinear wave mixing in ionized media is demonstrated, in which the phase matching is realized in the direction of difference frequency mixing. The emission angle temporarily varies depending on the ionization degree.

[25C2-3] 14:30–15:00 Invited Talk
Ultra-high-intensity Laser-plasma Interactions Using Structured Light Fields
Subhendu Kahaly, Sylvain Monchicé, Gustave Pariente, Adrien Leblanc, and Fabien Quéré
Commissariat à l’Energie Atomique, France
We explain how structuring femtosecond laser pulses in space and time leads to new effects in ultra-high intensity laser plasma interactions, with three examples: ultrafast wavefront rotation, transient plasma gratings, and light springs.

Room D (106)

Session Title: 25D2 / [T04] High Power, High Energy Lasers
Date & Time: Tuesday, 25 August, 13:45 – 15:00
Session Chair: Arno Kleinke (Friedrich Schiller Universität Jena, Germany)

Ultrafast Thin Disk Lasers: towards Intralaser Extreme Nonlinear Optics
1Université de Neuchâtel, Switzerland, 2ETH Zürich, Switzerland
Ultrafast thin disk lasers generate higher power levels than any other femtosecond oscillator technology. We review the current state of the art and give an outlook towards new applications such as intralaser extreme nonlinear optics.

[25D2-2] 14:15–14:30 Scalable Cryogenic Gas Cooled Multi-Slab 10 J and 100 J, 10 Hz DPSSL System
Sascha Rüedi, Klaus Ertel, Paul Mason, Jonathan Phillips, Maria Del Rio, Jade Smith, Thomas Butcher, M. Dicky, J. Pillay, Cristina Hernandez-Gomez, Justin Greenhalgh, and John Collier
STFC Rutherford Appleton Laboratory, UK; *Institute of Physics, Czech Republic
We report the demonstration of a cryogenic gas cooled multi-slab 10 J 10 Hz laser, producing 10.8 J pulses at 10 Hz, and initial results from a scaled-up DPSSL designed to produce 100 J pulses.

[25D2-3] 14:30–14:45 The Output Ability Promotion of the SG II - Up Laser Facility
Yanqi Gao1, Zhaodong Cao1, Xunchun Li3, Jianqiang Zhu3, and Zunqi Lin1
1Shanghai Institute of Laser Plasma, China, 2Shanghai Institute of Optics and Fine Mechanics, China
The SG- II -up laser facility is one of the most important high power laser facilities in China. The maximum output of this facility is studied, and it is improved to 8000J from the design point 5000J.

Haidong Zhu1, Ailin Guo1, Xinglong Xie1, T. Südmeyer2, J. Pilar1, F. Emaury1, M. Golling1, and John Collier2
1Shanghai Institute of Optics and Fine Mechanics, China, 2ETH Zürich, Switzerland
The Shenguang II laser facility (SGII-LF) is a total output 40 kilojoules laser facility containing a 8-beam Nd glass laser. To meet stringent demands on the delivered energy for the physics experiments research, the SGII-LF utilizes an integrated wavefront control system to significantly improve the ability to tightly focus each laser beam onto a target. Multiple sources of both static and dynamic aberration are corrected. On the other hand, we have designed two adaptive optics systems for the ShenguangII multi-petawatt laser facility (SGII-MPFL) to correct the spatial and temporal aberrations introduced by the uncorrected wavefront.

Conference Program & Abstracts
The 11th Conference on Lasers and Electro-Optics Pacific Rim
In this talk, I will discuss our recent efforts to develop purely dielectric metamaterials possessing low absorption loss at optical frequencies. I will discuss implementations ranging from wavefront control to high Q-factor resonances.

In this talk, I will discuss our recent efforts to develop purely dielectric metamaterials possessing low absorption loss at optical frequencies. I will discuss implementations ranging from wavefront control to high Q-factor resonances.

We have proposed the dimensional metrological methods for smart devices using the optical comb of a femtosecond pulse laser. For precision and high speed measurements, these methods were realized based on spectral-domain interferometry.

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We have proposed the dimensional metrological methods for smart devices using the optical comb of a femtosecond pulse laser. For precision and high speed measurements, these methods were realized based on spectral-domain interferometry.

Recently it has been demonstrated that a rapid phase change at a phase-discontinuity metasurface (PDM) leads to an additional momentum gradient enabling a direct observation of optical spin Hall (OSH) shift. We show that the helicity-dependent OSH shift depends on incidence and refraction angles at PDM, and construct a weak value measurement to control OSH shift by a variable phase retardance in the post-selection.

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New Directions in Optical Quantum Computing
Tim C. Ralph
University of Queensland, Australia

We will discuss new sampling algorithms that are hard for classical computers but can be solved with linear optical quantum processors and techniques for implementing universal quantum gates using strong optical non-linearities and Gaussian optics.

Experimental Implementation of Delayed-Choice Decoherence Suppression
Jong-Chan Lee, Hyang-Tap Lim1, Kang-Hee Hong1, Yoon-Chang Jeong1, M. S. Kim2, and Yoon-Ho Kim3
1POSTECH, Korea, 2Imperial College London, UK

We propose and experimentally implement the delayed-choice decoherence suppression protocol. Using photonic entanglement, we successfully demonstrated that the choice to suppress decoherence can be delayed after decoherence and even after the detection of a qubit.

Correlation between Initial and Final Result in a Sequential Quantum Measurement
Masataka Inoue1, Yutaro Suzuki1, Taki Nii1, Ryui Aonoshi1, and Holger Hoffmann1,2
1Hiroshima University, Japan, 2JST, Japan

Measurement error can be evaluated using the concepts introduced by Ozawa in 2003. Importantly, this evaluation takes into account the non-classical effects of quantum correlations. We investigate this effect by using a sequence of non-commuting measurements of photon polarization with a variable measurement resolution for the intermediate measurement. It is shown that quantum correlations between the initial and the final measurement outcomes result in a significant reduction of the measurement errors for the target observable, even though the final measurement is not sensitive to the polarization component of interest.

Generation and Characterization of a Frequency Anti-correlated Entangled Biphoton Source at 1560nm
Feylan Hou, Ruitang Dong, Xiao Xiang, Runai Quan, Yiwei Zhai, Shaofeng Wang, Tao Liu, and Shougang Zhang

We report the generation and characterization of a frequency anti-correlated entangled biphoton source at the wavelength of 1560nm via a continuous-wave laser pumped spontaneous parametric down-conversion process. The spectra of the signal and idler photons are measured to have their center wavelength being 1559.7nm and 1559.8nm while their 3-dB bandwidths being 3.2nm and 3.15nm respectively. The joint spectrum of the photon pair is observed to be frequency anti-correlated and have a spectral bandwidth of 0.5nm. According to the ratio of the single-photon spectral bandwidth to the joint spectral bandwidth, the degree of frequency entanglement is quantified to be 64.4. By investigating the relative overlap between the achieved two-photon spectral intensity function and its transpose, the spectral indistinguishability of the photon pairs is expected to be 90%. Based on a HOM interferometric coincidence measurement setup, a visibility of 89.8% is demonstrated, which shows a good agreement with the expectation.

Near-Deterministic Bell Measurement for Multiphoton Quantum Information Processing
Seung-Woo Lee1,2, Timothy C. Ralph1, and Hyunseok Jeong3
1Seoul National University, Korea, 2Palacky University, Czech, 3The University of Queensland, Australia

We propose a Bell measurement scheme for discriminating logical Bell states with many photons. The logical qubit is in Greenberger-Horne-Zeilinger entanglement with an arbitrary number of photons. Remarkably, its success probability can be made arbitrarily high using only linear optics and photon on-off measurements as the number of photons increases. It is shown that our scheme outperforms all the previously known schemes using single-photon qubits with respect to both the efficiency and feasibility. Our proposal provides an alternative candidate for all-optical quantum information processing.
We investigated the optical properties of a single dielectric nano-antenna fabricated by electron beam induced deposition. Based on an analytical model and numerical simulations, we show that the defect mode has toroidal dipole moment and high Q factor.

Luminescent carbon based nanomaterials such as carbon dots and graphene quantum dots (GQDs) have attracted much attention owing to some unique properties, including wavelength-dependent emission, better photo-stability and chemical inertness, thus can be used as efficient nano-scale light sources for promising applications in optoelectronics and bio-photonics. Despite aforementioned advantages, the main challenge is their moderate improvements to biaxially strained Ge lasers for silicon-compatible optical interconnects.

CMOS-compatible Athermal 400GHz spaced MZI Interleaver
Jong-Moo Lee, Min-Su Kim, Claudio J. Dotor, Maryse Fournier, Pierre Labeley, and Francesco Testa

We show with experiments that localized surface plasmon resonances in conductive nitride nanoparticles result in broadband light absorption covering solar spectrum. The rhodamine nanoparticle dispersed water was warmed and generated vapor efficiently by sunlight illumination.

Optical Characterization of a Single Dielectric Nano-antenna Fabricated by Electron Beam-induced Deposition
Eun-Khwang Lee, Jung-Han Song, Kwang-Yong Jeong, Ju-Hyung Kang, Hong-Gyu Park, and Min-Keong Seo

We evaluated wideband 25 Gbps error-free operation of Si slow light modulators. The fluctuation in extinction ratio was 1 dB over the bandwidth. Larger group indices produce larger extinction ratios and lower bit error rates.

3D Plasmonic Focusing with a Spiral Taper Anchored on a Fiber Tip
Jiadong Li, Zhiguang Liu, Jiaqi Mu, Xiaomei Gao, Wulei Li, Changshi Gu and Zhi-Yuan Li

We observed the avalanche photodiode operation through detect levels at telecom band in Si photonic crystal slow light modulator. Maximum responsivity was 0.71 A/W with 350 avalanche gain. The eye opened at 20 Gbps.

A nanomembrane-based bandgap-tunable Ge microdisk for Si-compatible optoelectronics
Donguk Nam, David Sukhdeo, Ju-Hyung Kang, Mark Brongersma, and Krishna Saraswat

A Nanomembrane-Based Bandgap-Tunable Ge Microdisk for Si-Compatible Optoelectronics

Room I (203)

Session Title: 25I2 / [T10] Plasmonics and Subwavelength Structures
Date & Time: Tuesday, 25 August, 13:45 – 15:15
Session Chair: Hyunyoung Choi (Yonsei University, Korea)

Localized Toroidal Dipole Moment of Spooft Surface Plasmon Polaritons
Sang Soon Oh, John J. Wood, Seong-Han Kim, Chul-Sik Kee, and Oh-Heui Hesl
1Imperial College London, UK, 2QST, Korea
At infrared wavelengths, we demonstrate subwavelength scale localization of spoof surface plasmon polaritons. Based on an analytical model and numerical simulations, we show that the defect mode has toroidal dipole moment and high Q factor.

25I2-2] 14:15–14:30
Lossy Plasmonic Resonances in Nanoparticles for Broadband Light Absorption
Satoshi Inui, Ramu Sugavaneswarao, Kai Chen, Thang Dao, and Tadakazu Nagao
1National Institute for Materials Science, Japan, 2JST, Japan
We show with experiments that localized surface plasmon resonances in conductive nitride nanoparticles result in broadband light absorption covering solar spectrum. The rhodamine nanoparticle dispersed water was warmed and generated vapor efficiently by sunlight illumination.

[25I2-3] 14:30–14:45
Optical Characterization of a Single Dielectric Nano-antenna Fabricated by Electron Beam-induced Deposition
Eun-Khwang Lee, Jung-Hwan Song, Kwang-Yong Jeong, Ju-Hyung Kang, Hong-Gyu Park, and Min-Keong Seo
1KIST, Korea, Korea University, Korea
We investigated the optical properties of a single dielectric nano-antenna fabricated by electron beam induced deposition. Polarization-resolved dark-field spectra showed that both transverse-magnetic and transverse electric resonances are supported and tuned over the visible wavelength range.

[25I2-4] 14:45–15:00
3D Plasmonic Focusing with a Spiral Taper Anchored on a Fiber Tip
Jiadong Li, Zhiguang Liu, Jiaqi Mu, Xiaomei Gao, Wulei Li, Changshi Gu and Zhi-Yuan Li
1KIST, Korea, Korea University, Korea
Based on a spiral taper that possesses polarization-insensitive three-dimensional (3D) plasmonic focusing properties, here we show that subwavelength 3D plasmonic focusing is readily achieved by integrating this spiral taper on a fiber tip. This portable fiber-integrated taper may find great potentials in near-field optics, high resolution fiber endo-devices, as well as bio-nanophotonic applications.

[25I2-5] 15:00–15:15
Photoluminescence Properties of Carbon-Nanomaterial Doped Solid Films Coupled to Plasmonic Optical Nano-Antennas
Chi-Tsu Yuan
Chung Yuan Christian University, Taiwan
Luminescent carbon based nanomaterials such as carbon dots and graphene quantum dots (GQDs) have attracted much attention owing to some unique properties, including wavelength-dependent emission, better photo-stability and chemical inertness, thus can be used as efficient nano-scale light sources for promising applications in optoelectronics and bio-photonics. Despite aforementioned advantages, the main challenge is their moderate improvements to biaxially strained Ge lasers for silicon-compatible optical interconnects.

Room J (204)

Session Title: 25J2 / [T12] Silicon Photonics Integration
Date & Time: Tuesday, 25 August, 13:45 – 15:15
Session Chairs: Ken Morito (PETRA, Japan), Hyo-Hoon Park (KAIST, Korea)

Silicon Photonic Integration Platform for Optical Communications and Other Applications
Hiroshi Fukuda
NIT, Japan
This paper describes recent progress in silicon photonics integration technology and related developments in optical communications and other applications. A new design concept for integrated photonic circuits and an application for tera-hertz generation are discussed.

CMOS-compatible Athermal 400GHz spaced MZI Interleaver
Jong-Moo Lee, Min-Su Kim, Claudio J. Dotor, Maryse Fournier, Pierre Labeley, and Francesco Testa
1ETR, Korea, 2Scuola Superiore Sant’Anna, Italy, 3Consorzio Nazionale Interuniversitario per le Telecomunicazioni, Italy, 4CEA Leti, France, 5Ericsson, Italy

Wideband Slow Light Effects in 25 Gbps Si Photonic Crystal Mach-Zehnder Modulators
Yosuke Hinakura, Yosuke Terada, Takuya Tamura, and Toshikazu Bata
Yokohama National University, Japan
We evaluated wideband 25 Gbps error-free operation of Si slow light modulators. The fluctuation in extinction ratio was 1 dB over the bandwidth. Larger group indices produce larger extinction ratios and lower bit error rates.

Avalanche Photodiode Operation of Si Photonic Crystal Modulator
Yosuke Terada, Kenji Myasaka, Hironori Ikari, and Toshikazu Bata
Yokohama National University, Japan
We observed the avalanche photodiode operation through detect levels at telecom band in Si photonic crystal slow light modulator. Maximum responsivity was 0.71 A/W with 350 avalanche gain. The eye opened at 20 Gbps.

A nanomembrane-based bandgap-tunable Ge microdisk for Si-compatible optoelectronics
Donguk Nam, David Sukhdeo, Ju-Hyung Kang, Mark Brongersma, and Krishna Saraswat
1Inha University, Korea, 2Stanford University, USA
We present a new, CMOS-compatible platform for inducing a large, spatially homogeneous biaxial strain in Ge microdisks. This platform can deliver substantial performance improvements to biaxially strained Ge lasers for silicon-compatible optical interconnects.
Different Interaction Schemes with Carbon Nanotubes in a Pulsed Planar Waveguide Laser
Joun-Wan Kim\textsuperscript{1}, Sun Young Choi\textsuperscript{2}, Mi Hye Kim\textsuperscript{2}, Dong-Yeol Yoon\textsuperscript{1}, Kwang-Jun Ahn\textsuperscript{2}, Xavier Malie\textsuperscript{3}, Madalina Agui\textsuperscript{1}, François Diaz\textsuperscript{4}, Uwe Greiner\textsuperscript{5}, Valentin Petrov\textsuperscript{1}, and Fabian Rotermund\textsuperscript{1}
\textsuperscript{1}Apu University, Korea, \textsuperscript{2}Universitat Rovira i Virgili, Spain, \textsuperscript{3}Max Born Institute for Nonlinear Optics & Short-Pulse Spectroscopy, Germany.
We studied operation characteristics of a Ga\textsuperscript{0.8}In\textsuperscript{0.2}As\textsuperscript{2+} and Lu\textsuperscript{3+} co-doped Yb:KYW planar waveguide laser, Q-switched by carbon nanotube-based saturable absorbers in two direct interaction and one enhanced-field interaction regimes.

Ultrafast Nonlinear Absorption in SWNTs: an Ultra-Broadband Investigation
Frank Wang\textsuperscript{1}, Shuo Xu\textsuperscript{2}, Hao Hong\textsuperscript{1}, Richard Howel\textsuperscript{1}, Kailhu Liu\textsuperscript{1}, Tawfique Hasan\textsuperscript{1}, and Yonghui Wu\textsuperscript{1}
\textsuperscript{1}Nanjing University, China, \textsuperscript{2}Peiking University, China, \textsuperscript{3}University of Cambridge, UK.
Z-scan spectroscopy is used to reveal ultra-broadband nonlinear absorption across different orders of resonance transitions in single-wall carbon nanotube ensembles, demonstrating the potential of nanotubes for nonlinear optics beyond the conventional NIR range.

Room A (101)

<table>
<thead>
<tr>
<th>Session Title</th>
<th>Date &amp; Time</th>
<th>Session Chair</th>
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<td>[25A3-1] 15:45–16:00</td>
<td>Tuesday, 25 August, 15:45 – 17:30</td>
<td>Takashige Omatsu (Chiba University, Japan)</td>
</tr>
</tbody>
</table>

**Session Title:** Diffrent Interaction Schemes with Carbon Nanotubes in a Pulsed Planar Waveguide Laser

**Date & Time:** 15:45–16:00

**Session Chair:** Takashige Omatsu (Chiba University, Japan)

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Diode-Pumped Alexandrite Laser - a New Prospect for Remote Sensing
Michael Damzen\textsuperscript{1}, Gabrielle Thomas\textsuperscript{1}, Achaya Nepalkisk\textsuperscript{1}, Emma Arbaba\textsuperscript{1}, William Kerridge-Johns\textsuperscript{1}, and Ana Mnas\textsuperscript{1}
\textsuperscript{1}Imperial College London, UK, \textsuperscript{2}Unilase Ltd., UK.
Tunable-wavelength diode-pumped Alexandrite laser operation includes highest power > 26 W (end-pumped rod); > 12 W (side-pumped slab); and first Q-switched operation with pulse energy ~ 1 mJ at kHz repetition rate, as development for space lidar application.

**Session Title:** Diode-Pumped Alexandrite Laser - a New Prospect for Remote Sensing

**Date & Time:** 15:45–16:15

**Session Chair:** Christian Kränkel (Universität Hamburg, Germany)

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High-Energy Nonlinear Optics in Fiber
Siddharth Ramachandran
Baston University, USA
Intermodal nonlinear interactions with higher-order modes circumvent the dispersion-vs-nonlinearity tradeoff of single-mode waveguides. We review advances in title platform to enable nonlinear optics in fibers at energy levels potentially approaching that achievable in bulk crystals.

**Session Title:** High-Energy Nonlinear Optics in Fiber

**Date & Time:** 15:45–16:15

**Session Chair:** Christian Kränkel (Universität Hamburg, Germany)
Optical Constants Measurement of Nonlinear Crystals for Terahertz Generation
Nan Yi1, Yu-Sup Lee2, Do-Kyung Koi, Shonji Takekawa3, and Kenji Kitamura1
1GST, Korea, 2National Institute for Materials Science, Japan
Optical constants of nonlinear crystals for terahertz generation were measured by terahertz time-domain spectroscopy. Coating and step-index crystals of lithium niobate (LiNbO3) and lithium tantalate (LiTaO3) were compared in the 0.1–2 THz range. The chiroptical lithium tantalate (SLT) was estimated as a most promising single crystal to generate efficient THz source in an ordinary polarization direction. In addition, temperature dependent material dispersion for SLT was derived in the THz range.

Four Wave Mixing in 5th Order Cascaded CMOS Compatible Ring Resonators
Li Ji1, Alessia Pasquazi2, Luigi Di Lauri3, Marco Peccianti4, Brent E Little1, David J Moss1, Roberto Morandotti5, and Sai Tai Chu1
1City University of Hong Kong, Hong Kong, China, 2University of Sussex, UK, 3AN Institute of Optics and Photonics, Uppsala, Sweden, 4McGill University, Canada
We report wavelength conversion via four wave mixing in a CMOS compatible 5th order cascaded microring resonator.

Second Harmonic Generation from Suspended Graphene Sheets
Kung-Hsuan Lin1, Shao-Wei Weng1, Po-Wen Lu2, Tsung-Fu Tu1, and Wei-Bin Su1
1Academia Sinica, Taiwan, 2National Taiwan Ocean University, Taiwan
An ideal freestanding graphene in air is centrosymmetric in three dimensions, and its optical second harmonic generation is inhibited. However, we found strong second harmonic generation from suspended graphene sheets, and attributed this observation to curved sheet in the long range.

Third-order Seeded Parametric Down-conversion in Silica Submicro-wire
Kee Hwan Nam1, Dae Seok Han2, and Myeong Soo Kang2
1KAIST, Korea, 2Department of Electronic Engineering, Pusan National University, Korea
We experimentally demonstrate the 3rd-order seeded parametric down-conversion in a silica submicro-wire. Amplification of a 1597.38 nm seed beam is observed upon co-launching a 532.46 nm pump beam in the HE12 mode of the wire.

Quality Assessment of Quasi-Phase-Matched Gratings by Gaussian Beam Diffraction
Prashant Povel Dwivedi1, Pavan Kumar2, Heejoo Choi3, and Myoungsik Cha3
1Pusan National University, Korea, 2Pusan National University, Korea, 3Department of Physics, Korea University, Korea
Random duty-cycle error is genetic in quasi-phase matched gratings. An estimate of this error is significant to avoid parasitic harmonic generation. This study highlights an advanced, high-resolution method to quantitatively assess the gratings centered on Gaussian beam diffraction.

Improvement of Frequency-tripling Efficiency through a Walk-off Compensation
Changsoo Jung1, Konkuk Kim2, Dong-Ahn Yu1, Yeung Lak Lee1, Wookjin Shio1, and Young-Chul Nah1
1GST, Korea, 2KIMM, Korea
We experimentally investigated a walk-off-compensation method to improve the ultraviolet output power. We confirmed that the higher output-power improvement can be obtained in the narrower-beam case. The maximum output-power improvement was 3.0 times.

Control of Optical Rogue Waves in the Femtosecond Supercontinuum Generation Using a Weak Continuous Wave Trigger
Xiaoqi Duan and Qian Li
Peking University, China
We numerically study the characteristics of optical rogue waves in the femtosecond supercontinuum generation. The continuous wave trigger is proved to be an effective way to control optical rogue waves in the femtosecond supercontinuum generation.
Top-down and bottom-up fabrication techniques for isotropic metamaterials
Takao Tanaka 1,2

Top-down and bottom-up fabrication techniques are developed and applied for an isotropic infrared metamaterial that consists of fourfold-symmetric 3D SRRs. Mass-productive formation of the 3D SRRs was achieved by metal-stress driven self-folding process.

Inside-out, 120 nm Diameter Metal Slot Disk Resonator Arrays for Full Access to Air Slot Modes
Jiuru Lin, Chia-Yang Tsai, Pin-Tso Lin, Tae-En Hsu, and Po-Tsung Lee

Large-area array of 120 nm diameter air gap plasmonic disk resonators with 30-nm thick air-gap is fabricated using nanoprinting. An inside-out structure allows full access to the slot mode, and easy excitation of the plasmon mode.

Strong Plasmonic Coupling in Rod-dimer/Ring Nanostructure
Jia-Yu Lin, Chia-Yang Tsai, Pin-Tso Lin, Tae-En Hsu, and Po-Tsung Lee

A rod-dimering (RDR) plasmonic nanostructure with different gap distances is investigated in both experiment and simulation. Compared to rod-dimer and ring, the localized near-field intensity of RDR can be significantly enhanced and further increased in smaller gap distance owing to stronger coupling effect.

Use DNA Origami as a Scaffold for Self-Assembly of Optical Metamolecules
Yoon Jo Hwang, Shelly F. J. Wolkam, Steven D. Perrault, Sanghyun Yoo, Sung Ha Park, William M. Sheff, and Seungwoo Lee

We propose to use DNA origami to achieve custom arrangements of metallic nanoparticles for deterministic assembly of optical metamolecules.

Alloy Plasmonic Materials
Yoshiki Nishijima1, Yoshikazu Hashimoto1, Shintaro Gedemina2, Armandas Balcius2, and Saulius Juodkazis

We focused on the Au, Ag and Cu alloy systems and the experimental determination of their optical permittivity using optical transmission and reflection measurements with thin film metals. The optical constants define the plasmon resonance frequency and the electromagnetic field intensity localized around the nanoparticles. However it is less known how the alloy metals perform in the fields enhancement. Due to the unknown morphology and composition of the alloy, optical properties have to be determined experimentally. We demonstrate experimentally determination of the permittivity and Drude parameters of alloys and discuss the obtained results in comparison with X-ray crystallography measurements.

Mechanisms of High Refractive Index Properties in Fish-bone Shape Structures
In-Sung Lee, Jin Kyo Yang, Chul-Sik Kee, and Jong Wooh Lee

We demonstrated the subwavelength metamaterial structures with multiple three-dimensional subwavelength confinement and high effective-refractive index of terahertz electromagnetic waves. The properties can be explained by the coupling between electric-dipole and magnetic-dipole resonances.

Aluminum Infrared Plasmonic Perfect Absorbers Fabricated by Collodial Lithography
Thang Duy Dao1,2, Kai Chen1,2, Sabotcho Luh1,2, Akiko On1,2, Yoshinori Nabatame1,2, Masahiro Kitajima1,2, and Tadakazu Nagao1,2

We report on the fabrication of large-area aluminum plasmonic perfect absorber (Al-PA) using colloidal lithography combined with reactive ion etching process. Using the Al-PA, we demonstrate selective thermal emitters and tailor-made molecular vibrational sensing.

Temperature Dependence of Lasing Characteristics of a Q-switched Tm:YLF Laser at Temperatures Lower than 250 K
Atsushi Sato1,2, Yoshiki Miyake1, Kazuhiro Asai2, Shoken Ishii2, Kohei Mutozani2, and Satoshi Ochiai1

We report on the development of a mid-infrared source based on difference frequency generation in a fan-out MgO-doped PPLN crystal, which can be tuned from 2.5 μm to 3.6 μm by pumping at 1064 nm.

Generalized Aberration Reduction of a Concave Grating for Hyperspectral Sensing
Cheng-Hao Ko1,2, Chia-Hui Tang1, Jin-Hsun Tsai1, and Bang-Ji Wang2

We generalized optimization process to reduce the aberration of a concave grating is developed. The approach has a dramatic improvement in aberration reduction and spectral resolution. Calculated result is in good agreement with measurement.

Precise Measurement of Optical Fiber Length Using a Gain-Switched Distributed Feedback Laser with Delayed Optical Feedback
Saburo Matsukura, Atsuko Tanaka, Kenji Wada, Tetsuya Matsuyama, and Hiromichi Hirokawa

By utilizing the optical feedback induced noise in a gain switched distributed feedback laser, the optical length of a 1 km optical fiber was measured with an accuracy of 3.7×10^{-8} m without using fast equipment.

Tracking of Three-dimensional Speckle Distributions Produced by Fish Otoliths for Fish Stock Identification
Edward Mosso, Guido Plaza, and Darío Pérez
Pontificia Universidad Católica de Valparaíso, Chile

Analyses have been conducted on the three-dimensional speckle distribution produced by fish otoliths. By tracking optical properties of these speckle patterns (autocorrelation areas and contrasts), a fish stock identification can be achieved.

Copper Bromide Laser Monitors for Microstructures Visualization
Fedir A. Gunaver1,2, Andrei V. Mostovshchikov1,2, and Miron S. Klenovskii1,2

A method of observing processes accompanied by intense background light using laser microscopes is demonstrated. The visualization results of process of aluminum nitride synthesis occurring by combustion of aluminum nano powder in the air are presented.
Coherence Time Limit of Entangled Pared Photons Generated in a Cold Atom Cloud
Jietai Jing, East China Normal University, China
Through electromagnetically-induced transparency (EIT) assisted spontaneous four-wave mixing, we produce the entangled paired photons with a coherence time of 2.34 µs from a cold atom cloud. The EIT dephasing rate is the ultimate limit.

Ablation of Targeted Cardiomyocyte in Zebrafish Larvae Utilizing Femtosecond Laser
Kazuo Okano, Chung-Han Wang, and Ian Liau, National Chiao Tung University, Taiwan
An intended death of target cardiomyocyte was induced in zebrafish by femtosecond-laser illumination. Time-lapse imaging revealed that cellular morphology changes accompanied by increase of membrane permeability and generation of cytosolic bubbles enclosed with plasma membranes.

Dark State Dynamics of Fluorescent Proteins Investigated by Fluorescence Transients
Naoto Kamiyama, Yoshiya Sunairi, Keisuke Toda, Hiroshi Takahashi, and Akira Suda, Tokyo University of Science, Japan
Transient fluorescence variations of enhanced green fluorescent protein and enhanced yellow fluorescent protein indicate the existence of two transient dark states including the lowest triplet state and the other dark state with a longer life time.

Characterization of Electromagnetically Induced Transparency in Rydberg State of 87Rb
Hyo Min Kwon1, Taek-Joong1, Yoon-Seok Lee1, No-Weon Kang2, Seung Kwan Kim2, and Han Seb Moon1
1Pusan National University, Korea, 2KRISS, Korea
We present the direct measurement of highly excited Rydberg state using a ladder-type electromagnetically induced transparency in the $^3S_{1/2}-^3P_{1/2}$ - $^3P_{3/2}$ transition of 87Rb atoms in a room-temperature vapor cell.

Manipulation of Frequency-Time Quantum Correlation of Narrow-Band Photon Pairs
Young-Wook Cho, Kwang-Kyoong Park, Jong-Chan Lee, and Yoon-Ho Kim, POSTECH, Korea
A specific form of frequency-time quantum correlations is naturally inherent in the nonclassical photon pairs generated via a parametric process. Here, complete manipulation of frequency-time quantum correlations of narrowband biphotons is reported.

Subtraction Threshold for Fluorescence Difference Microscopy
Nan Wang1 and Takayoshi Kobayashi2,3,4,5
1University of Electro-Communications, Japan, 2JST, Japan, 3National Chiao-Tung University, Taiwan, 4Osaka University, Japan, 5KAIST, Korea
We report on our recent experimental results of generating quadruple quantum correlated beams by using cascaded four-wave mixing processes in hot rubidium vapor. The intensity-difference squeezing of the four beams is about 8.0 dB.

Experimental Generation of Multiple Quantum Correlated Beams from Four-wave Mixing
Jietai Jing, East China Normal University, China
We report on our recent experimental results of generating quadruple quantum correlated beams via cascaded four-wave mixing processes in hot rubidium vapor. The intensity-difference squeezing of the four beams is about 8.0 dB.

Visible-wavelength Two-photon Excitation Microscopy
Kotousama Fujita, Osaka University, Japan
We demonstrated two-photon excitation of fluorescent proteins by using visible light. The excitation scheme has been applied to simultaneous multicolor imaging of biological cells with improved spatial resolution.

Side-view Confocal Endomicroscopy for in Vivo Longitudinal Cellular Imaging of Small Intestine
Jinho Yu1,2, Kobak Choi1, Taeyun Wang2, Yoonhwa Hwang2, Yi Hyeon Kim2, and Pilhan Kim1
1KAIST, Korea, 2POSTECH, Korea
In vivo longitudinal repetitive cellular level observation of microvasculature and fluorescent cells in a small intestinal tract of single mouse in minimally invasive manner was demonstrated by using GRIN lens based sideview confocal endomicroscopy.

High-speed, Thermal Damage-free Ablation of Brain Tissue with Femtosecond Pulse Bursts
Can Kereş1, Seyd Yerra1,2,3, Hakan Küküçüoğlu1, Mehmet D. Aşık1, Önder Arıçalan1, and E. Ömer Kızılay,1,2,3,4
1Bilkent University, Turkey, 2FiberLAST, Inc., Turkey, 3Hacettepe University, Turkey
We report a novel ultrastiff burst mode fiber laser system and results on ablation of rat brain tissue at rates approaching an order of magnitude improvement over previous reports, with no discernible thermal damage.

Subtraction Threshold for Fluorescence Difference Microscopy
Nan Wang1 and Takayoshi Kobayashi2,3,4,5
1University of Electro-Communications, Japan, 2JST, Japan, 3National Chiao-Tung University, Taiwan, 4Osaka University, Japan, 5KAIST, Korea
The selection criterion of subtraction factors used in subtraction microscopy is numerically investigated. The fluorescence peak intensity after subtraction and resolution derivative are proposed as essential parameters for evaluating the subtraction threshold.

Cellular Imaging of Small Intestines
Beop-min Kim1,2,3,4, Kibaek Choe1,2,3,4, and Han Jeong1,2,3,4
1FiberLAST, Inc., Turkey, 2Korea University, Korea, 3POSTECH, Korea
We present the direct measurement of highly excited Rydberg state using a ladder-type electromagnetically induced transparency in the $^3S_{1/2}-^3P_{1/2}$ - $^3P_{3/2}$ transition of 87Rb atoms in a room-temperature vapor cell.

Ablation of Targeted Cardiomyocyte in Zebrafish Larvae Utilizing Femtosecond Laser
Kazuo Okano, Chung-Han Wang, and Ian Liau, National Chiao Tung University, Taiwan
An intended death of target cardiomyocyte was induced in zebrafish by femtosecond-laser illumination. Time-lapse imaging revealed that cellular morphology changes accompanied by increase of membrane permeability and generation of cytosolic bubbles enclosed with plasma membranes.

High-speed, Thermal Damage-free Ablation of Brain Tissue with Femtosecond Pulse Bursts
Can Kereş1, Seyd Yerra1,2,3, Hakan Küküçüoğlu1, Mehmet D. Aşık1, Önder Arıçalan1, and E. Ömer Kızılay,1,2,3,4
1Bilkent University, Turkey, 2FiberLAST, Inc., Turkey, 3Hacettepe University, Turkey
We report a novel ultrastiff burst mode fiber laser system and results on ablation of rat brain tissue at rates approaching an order of magnitude improvement over previous reports, with no discernible thermal damage.
**Session Title**: Photonic structures for information and energy applications  
**Date & Time**: Tuesday, 25 August, 15:45 – 17:30  
**Session Chair**: Sang Soon Oh (Imperial College London, U.K.)

### [25I3-1] 15:45–16:30 Tutorial

**Photonic structures for information and energy applications**

Shanhu Fan  
Stanford University, USA

We discuss some of our recent works in seeking to develop photonic structures for information processing and for energy applications. In particular, we will discuss our efforts in creating non-reciprocal photonic structures, without using magneto-optical effects, for the control of on-chip propagation of light. We will also discuss the design of photonic structures for energy applications, leading to the demonstration of daytime radiative cooling and radiative cooling of solar absorbers.

### [25I3-2] 16:30–16:45

**On-chip Operation of Optical Correlator**

Shun Kinugasa, Norifumi Ishikura, and Toshihiko Baba  
Yokohama National University, Japan

We fabricated a compact on-chip optical correlator using two photonic crystal slow light waveguides, and succeeded in complete on-chip operation. Observed pulse waveform agreed well with the one observed by commercial optical correlator.

### [25I3-3] 16:45–17:00

**Detection of Endotoxin Using a Photonic Crystal Nanolaser**

Daichi Takehashi, Shigeho Hachida, Takumi Watanabe, Yoshiki Nishiyama, and Toshihiko Baba  
Yokohama National University, Japan

We demonstrate the sensing of endotoxin using photonic crystal nanolaser and Limulus amebocyte lysate reaction. We detected low concentrations of 0.001 and 0.0001 EU/ml with a twice faster speed of the conventional methods.

### [25I3-4] 17:00–17:15

**High Group Index Silica-Clad Silicon Photonic Crystal Slow Light Waveguides**

Takuya Tamura, Keisuke Kondo, and Toshihiko Baba  
Yokohama National University, Japan

We comprehensively investigated practical silica-clad photonic crystal waveguides, and found two lattice shifts optimum for low-dispersion slow light. Fabricated device shows a high group index of >50, which ensures twice higher performance than conventional ones.

### [25I3-5] 17:15–17:30

**Optically-Induced Doppler Shift in Photonic Crystal Slow Light Waveguides**

Keisuke Kondo and Toshihiko Baba  
Yokohama National University, Japan

Doppler shift of signal light is obtainable by moving photonic bandgap mirror, which is dynamically formed by slow light pulse. Large wavelength shift from several 10 nm to a few 100 nm are numerically demonstrated.
**Room A (101)**

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<td>26A1 / [T01] High-Power Solid-State Lasers</td>
<td>Wednesday, 26 August, 09:00 – 10:30</td>
<td>Thomas Südmeyer (University of Neuchatel, Switzerland)</td>
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</tbody>
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**[26A1-1] 09:00–09:30 Invited Talk**

Development of an Ultrafast Thin-Disk Ring Oscillator with an Intra-Cavity Average Power Higher than 1 kW

A. Amari Elinabz , Yasuo Nabe kawa , Makoto Kuwata-Gonokami , and Katsumi Midokaw a 1,2

1 RIKEN Center for Advanced Photonics, Japan, 2 The University of Tokyo, Japan

We report intra-cavity average power upscaling of a Kerr lens mode-locked ring oscillator to 1060 W. Obtained pulse energy of 68 μJ is the highest inside a ring-type oscillator, to the best of our knowledge.

**[26A1-2] 09:30–09:45**

Duality-Wave Laser Operation of a Diode-Pumped Yb:KGW Laser

R. Akbari, H. Zhou, and A. Major

University of Manitoba, Canada

A high power continuous-wave dual-wavelength Yb:KGW laser using a birefringent plate was demonstrated. Stable operation at 1014.6 nm and 1046.3 nm with 34 W of average output power was obtained with diffraction-limited beam profile.

**[26A1-3] 09:45–10:00**

Yb:YAG Thin-Disk CPA Laser System for Intense THz Pulse Generation at 1 kHz Repetition Rate

Y. Ochi, K. Nagashima, M. Maruyama, M. Tsubouchi, F. Yoshida, N. Kano, and A. Sagiyama

Japan Atomic Energy Agency, Japan

We have developed a high average power picosecond laser system dedicated to intense terahertz (THz) pulse generation. The system is a chirped pulse amplification laser employing a Yb:YAG thin-disk amplifier. The Yb:YAG thin-disk regenerative amplifier at room temperature provides pulses with energy over 10 μJ and spectral bandwidth of 1.2 nm at a repetition rate of 1 kHz. In a pulse compressor, the laser pulse is compressed to be 1.3 ps.

**[26A1-4] 10:00–10:15**

Monoclinic 20% Tb3+-Doped β-BaLuF6 Single Crystals: Growth and Efficient Green Laser Operation

Philip Werner Metz, Daniel-Timo Marzahl, Ahmad Majid, and Christian Kränkel

University of Hamburg, Germany

We report on the Czochralski growth of monoclinic β-BaLuF6 single crystals. The solid-state phase transition was quenched by substituting 20% of the Lu+-ions with Tb3+. An efficient green emitting β-BaLuF6:3+ laser could be demonstrated as well.


High Average Power Picosecond Sapphire Face-Cooled Nd:YVO4 Bounce Laser System

Masaaki Kawa, Masashi Abe, Katsumi Miyamoto, and Takanobu Ono

University of Chiba, Japan

We developed a high average power, diffraction-limited (M2~1.1) picosecond laser system formed of a sapphire face-cooled Nd:YVO4 slab amplifier with a multi-pass geometry. Average output power of 46.4 W was obtained at an optical-optical efficiency of 56%.

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**Room B (102)**

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<td>26B1 / [T06] Laser Processing for Flexible Electronics</td>
<td>Wednesday, 26 August, 09:00 – 10:30</td>
<td>Sang Hoon Ahn (KIMM, Korea), Jiyeon Choi (KIMM, Korea)</td>
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**[26B1-1] 09:00–09:30 Invited Talk**

Low Temperature Laser Processing for the Application in Flexible & Stretchable Electronics

Habeom Lee, Sukjong Hong, Young Duk Suh, and Shun Hwan Ko

Seoul National University, Korea

Nanomaterials show various interesting unique thermal characteristics such as size dependent melting temperature drop, which can be used to develop plastic compatible low temperature metal patterning process. Focused laser as a local heat source can further reduce the processing temperature or induced localized thermochemical reaction. In this talk, recent research development and trend in nanomaterial based low temperature laser thermal engineering as well as applications will be discussed.

**[26B1-2] 09:30–10:00 Invited Talk**

Novel Process for Nano-structuring of Conducting Polymer Thin Film

Sang Min Chae, See Wook Lee, Yong Hyo Jei, Ji Yeon Cho, Hyun Heel Lee, and Hyo Jung Kim

1 Pusan National University, Korea, 2KIMM, Korea, 3POSTECH, Korea

We present new technique for nano-structuring of conducting polymers using femto-second (fs) laser in P3HT:PCBM films with special chain alignment. In an optimized condition of fs laser (1030 nm) irradiation on P3HT:PCBM films, the surface changed into a photoexpanded structure. The crystalline order of edge-on P3HT decreased, while the crystalline order of face-on P3HT increased in the photoexpanded area. The chain alignment of face-on P3HT was affected by the polarization direction of irradiated laser. The PCBM amount also increased in the photoexpanded area in comparison with the pristine area. The results of micro Raman measurement confirmed the stability of P3HT chains under the laser irradiation, i.e. the main P3HT chains were kept chain configuration and bonds after laser in photoexpanded areas. These results imply that orientation of P3HT crystals can be selectively controlled into face-on configuration by the fs-laser irradiation.

**[26B1-3] 10:00–10:15**

Numerical Analysis of Plasmonic Heating of Silver Nanowires under Femtosecond Laser Irradiation

Jeonghoon Ha and Donguk Kim

POSTECH, Korea

This work analyzes the electromagnetic and thermal phenomena occurring in welding of silver nanowires by femtosecond laser irradiation. We suggest that the nanowires can be joined by a non-thermal mechanism, substantially below the melting point.

**[26B1-4] 10:15–10:30**

Direct Ultrafast Laser Patterning of Transparent Conducting Layers for Flexible Electronics Fabrication

Minse Lim, Yongyeon Kim, Hyongwon Kim, Hanki Kim, and Jiyeon Choi

KIMM, Korea, Kyung Hee University, Korea

An ultrafast laser was used to ablate transparent conducting layers deposited either by multilayered silver and ITO or silver web. Performance of the devices using them as electrodes was examined to confirm the process’ efficiency.
Session Title: 26C1 / [T02] Fiber Laser
Date & Time: Wednesday, 26 August, 09:00 ~ 10:30
Session Chair: Myeong Soo Kang (KAIST, Korea)

[26C1-1] 09:00~09:15
Passively Mode-Locked Erbium-Doped Fiber Laser Using Gold-Nanosphere Based on Double Cladding Fiber as Saturable Absorber
Jin Yuan, Xinkun Bai, Dengfeng Fan, Jie Gu, Shaofei Wang, and Xianglong Zeng
Shanghai University, China
We have obtained a serial of mode-locked pulses at 1530 nm with a repetition rate of 8.47 MHz by using a double cladding fiber coated with gold-nanosphere as saturable absorber.

[26C1-2] 09:15~09:30
Femtosecond Erbium-doped Fiber Oscillator with Pulse Energy up to 58 nJ
Hao-Yuan Jiang, Chia-Lun Tsai, and Shang-Da Yang
National Taiwan University, Taiwan
Mode-locked erbium fiber oscillator with pulse energy up to 58 nJ is experimentally demonstrated. The highest value is obtained. The broadband spectrum corresponds to a transform-limited pulse of 93 fs duration.

[26C1-3] 09:30~09:45
A 359 fs Er-doped Fiber Laser Based on Topological Insulator: Bi2Se3
Kixuan Li, Yansong Song, Zhenhua Yu, and Jinong Tian
Beijing University of Technology, China
A 359 fs erbium-doped fiber laser using topological insulator Bi2Se3/Polyvinyl alcohol (PVA) composite film as a saturable absorber was demonstrated. When changing the length of the erbium-doped fiber, a mode-locking pulse ranging from 1557 nm to 1600 nm could be generated.

[26C1-4] 09:45~10:00
Passively Q-switching of Erbium-doped Fiber Laser Using Ferrite as Saturable Absorber
Xuekun Bai, Jin Yuan1, Shaofei Wang, Dengfeng Fan1, Jie Gu1, Yi Huang1, Yunhe Zhao1, Mengxi Ji, and Yi Wang
Shanghai University, China, 1University of Shanghai for Science and Technology, China
We report on passive Q-switching of an erbium-doped fiber laser with ferrite saturable absorber achieving for the first time short (~3.2 μs) pulse durations with a low threshold pump power (~15 mW).

[26C1-5] 10:00~10:15
Dissipative-soliton-resonance in All-normal-dispersion Fiber Lasers
Daqing Li1, Luming Zhao2, Dingyuan Tang2, and Deyuan Shen2
1Fudan University, China, 2Nanyang Technological University, Singapore
Multiple dissipative soliton operation is numerically found to be caused by the spectral filtering effect. Strong peak-power-clamping effect is required for the dissipative-soliton-resonance generation. The peak power is controlled by the cavity peak-power-clamping effect.

[26C1-6] 10:15~10:30
Ultra Low Threshold Optical Power Limiter Based on a Silicon Photonic Crystal Cavity
Zheng Wu, Mengqi J, and Yi Wang
Huazhong University of Science and Technology, China
Limiting high intensity light transmission and passing through the low in a L3-type nanocavity was proposed. This thermo-optic-effect-based power limiter realized a threshold power 19 μW. The threshold as a function of detuned wavelength is given.

Session Title: 26D1 / [T04] Ultrahigh Intensity Lasers I
Date & Time: Wednesday, 26 August, 09:00 ~ 10:30
Session Chair: Guoqiang Xie (Shanghai Jiao Tong University, China)

[26D1-1] 09:00~09:30
Invited Talk
Precision Performance for Full-scale Operation of LFEX PW Laser
Noriaki Miyanaga, Junti Kawakami, Shigeki Takita, Takahisa Jitsuno, Yoshiaki Nakata, Motoki Shiraga, and Shinsoke Fujoka
Osaka University, Japan
LFEX is a four-beam, picosecond Nd: glass laser system based on the chirped pulse amplification. The current operation level of amplifier is ~400 J/beam with a chirping of ~2 ns/3 nm. The compressor output is ~1.4 kJ at a pulse width of ~1.5 ps with a contrast better than 10^9.

[26D1-2] 09:30~10:00
Invited Talk
Recent Progress and Research Status of Petawatt Femtosecond Lasers in SIOM
Xiaoyan Liang, Yue Chu, Zhibiao Gan, Jianghong Yu, Lu Xu, Cheng Wang, Xiaoming Lu, Yuxin Leng, Ruxin Li, and Zhizhan Xu
Shanghai Institute of Optics and Fine Mechanics, China
The latest progress towards a 10 PW ultra-intense femtosecond laser at SIOM was reported. The energy of 192.3 J was achieved with Ti:sapphire amplifiers, which could support a peak power of 3.13 PW.
Room E (107)

Session Title 26E1 / [T05] Plasmonics and Metamaterials IV
Date & Time Wednesday, 26 August, 09:00 ~ 10:30
Session Chair Zhaoxue Liu (University of California, San Diego, USA)

[26E1-1] 09:00~09:30 Invited Talk
Parity-time Optical Metamaterials
Zi-Jing Wang, Liang Feng, Ren-Min Ma, Xuan Wang, and Xiang Zhang
University of California, Berkeley, USA
Exploration of the interplay between gain and loss in optical materials can lead to novel device functionalities. Here we demonstrated a single-mode laser based on parity-time symmetry breaking.

[26E1-2] 09:30~09:45
Chiral light-matter Interactions in Resonant Metamaterials
Seok Jae Yoo and Q-Han Park
Korea University, Korea
We present a theory of the chiral Purcell effect to describe the cavity-modified differential decay rate of chiral molecules to left and right circular-polarized modes. We also show negative-index metamaterials support the chiral Purcell effect.

[26E1-3] 09:45~10:00
Dual-band Optical Response Based on Plasmonic Metamaterial
Wudeng Wang, Yudong Li, Mingsi Zhang, Jingjun Xu, and Qian Sun
Nankai University, China
We investigated transmission of metamaterial composed of stacked double semicircular-arc structures with an angular offset. Optical response is observed simultaneously at visible and near-infrared band. Circular dichroism of ~0.47 within the near-infrared band is achieved.

[26E1-4] 10:00~10:15
Quantum Dot Nano Gap Metamaterial Terahertz Resonators
Launmi Narayan Tripathi, Taehee Kang, Yong-Mi Bahn, Sanghoon Han, Geunchang Choi, Jiyeon Rhee, Jeeyoon Jeong, and Dai-Sik Kim
Seoul National University, Korea
We present 2DSe quantum dot nanogap metamaterial fabrication over large scale, resonant tunneling of terahertz waves across 10 nm gap with giant terahertz intensity enhancements and quenching of photoluminescence of 2DSe inside the gap.

[26E1-5] 10:15~10:30
Microscopic Origin of Metal-to-Insulator Transition in Tightly-Coupled Metamaterials
Ji-Hun Kang1,2, Seo-Joo Lee1, and Q-Han Park1
1University of California, Berkeley, USA, 2Korea University, Korea
We present a microscopic origin of metal-to-insulator transition (MIT) in tightly-coupled metamaterials. Like Mott transition in crystal solid, MIT in metamaterial is shown to arise when the distance between unit resonators passes the critical gap-size.

Room F (108)

Session Title 26F1 / [T07] Optometry and Sensing IV
Date & Time Wednesday, 26 August, 09:00 ~ 10:15
Session Chair Hyug-Gyo Rhee (KRISS, Korea)

[26F1-1] 09:00~09:30 Invited Talk
Extremely Large Freeform Optics Manufacturing and Testing
Dae Hwak Kim, Pong Soo Chung, Jin Oh, and James H. Burge
University of Arizona, USA
The 4.2 m Daniel K. Inouye Solar Telescope (DKIST) primary mirror has about 9 mm freeform aspheric departure. Actively controlled stressed Lap and infrared deflectometry system have been developed to manufacture the extremely large freeform optics.

[26F1-2] 09:30~09:45
The Study of High Precision MIR Lens Back Focal Length Measurement System
Feng-Ming Yeh1, Der-Chin Chen2, Siak-Lim Lee2, Shih-Chieh Lee3, and Wen-Te Hsieh4
1Da Yeh University, Taiwan, 2Feng Chia University, Taiwan,
3Academia Sinica, Taiwan, 4National Tsing Hua University, Taiwan
This paper presents a new method of measuring the back focal length of middle infrared (MIR) lens that uses MIR pulse collimated beam and thermopile sensor. The experiment results state that the measurement accuracy of the back focal length of MIR lens is up to 2% at 5~25 mm range EL. The advantages of this testing system are low costs, fast measurement speed, high precision, less complicated system and replacements of light source and detector of different IR spectrum for measuring BFL of lens.

[26F1-3] 09:45~10:00
The Study for Gigapixel Image Utilizing Robot Panoramic Head and Image Stitching Technique
Seung-Jo Noh, Yeon-Chan Choi, Hee-Joon Moon, Ho-Kwan Kang, and Cheon-Seog Rim
Hannam University, Korea
Currently, while the technology related to gigapixel image might not be well known to the general masses of people, leading edge enterprises like Google and BAE Systems are successively reporting for achieving the progress of gigapixel application and camera system. Even though conventional camera technology is limited to the class of megapixel image, we can obtain gigapixel image reality by means of robot panoramic head and image stitching technique. In this paper, we investigate the total process of creating gigapixel image which will be expected to make the chance of a multibillion dollar business in the industrial area related to vision technology and surveillance. From the experience of this research, we can also utilize the knowledge to devise and develop new types of gigapixel camera system such as Awareness camera of Duke University and Argus IC camera of BAE Systems. Meanwhile, we try to report very important issue realized from the process of creating gigapixel images, that is, visibility problem and how to correct.

[26F1-4] 10:00~10:15
Snapshot Spectroscopic Polarimeter Based on Polarized Dual Spectra
Daesuk Kim1, Yonghee Yoon1, Yongho Seo2, Hyunsuk Kim3, and Robert Magnusson4
1Chonbuk National University, Korea, 2University of Texas at Arlington, USA
This paper describes a snapshot spectroscopic polarimeter which can measure an accurate spectral Stokes vector of a transmissive object in a wide spectral domain within tens of msec.
**Session Title**: [26G1-1] 09:00~09:30 Invited Talk

**Vortex Pair Creation and Annihilation in a Bose-Einstein Condensate**

Woo Jin Kwon, Geol Moon, and Yong-II Shin  
Seoul National University, Korea

We describe our recent experiments where we studied creation and annihilation of vortex pairs in a highly-oblate Bose-Einstein condensate. We measured the critical velocity for vortex shedding and investigated the thermal relaxation of two-dimensional superfluid turbulence.

**Session Title**: [26G1-2] 09:30~10:00

**Atomic Fountain for Atom Interferometry**

Nan Li, Zhouriang Xu, Hao Ying, Kaikai Huang, and Xuahui Lu  
Zhejiang University, China

We demonstrated a highly controlled atomic fountain which is realized by simultaneous detuning of the upward beams versus the downward beams. A fountain height of 90cm is achieved after fine adjustment.

**Session Title**: [26G1-3] 09:45~10:00

**Progress Towards a Strontium Optical Lattice Clock at NTSC**

Wang Yebing, Liu Hai, Lu Binqu, Ren Jie, Xu Qinfang, Yin Mojuan, Kong Defuang, Ma Jie, and Chiang Hong

National Time Service Center, China, University of Chinese Academy of Sciences, China

Stable narrow line lasers are built up and some precision measurements are performed. Based on the cold 88Sr atoms loaded in to one dimension optical lattice, a sideway resolved clock transition spectrum is obtained.

**Session Title**: [26G1-4] 10:00~10:15

**Stark and Zeeman Effects as Tools for Magnetic Diagnostics in Toroidal Plasmas**

Jinseok Ko, Jinil Chung, and Maximilian Messmer  
Eindhoven University of Technology, Netherlands

Doppler-shifted Stark and Zeeman effects are applied to the measurement of the magnetic structure that confines toroidal plasmas for nuclear fusion. Progress on these applications to the Korean tokamak is presented.

**Session Title**: [26G1-5] 10:15~10:30

**Ultrafast Laser-Driven Rabi Oscillation of Morris-Shore Transformed Multi-Level Atoms**

Hyusub Kim, Yoonseung Song, Han-Gyeol Lee, and Jaewook Ahn  
KAIST, Korea

We show that the 24 energy levels involved in the D1 transition of atomic Rb are reduced to independent 12 two-level systems of a single Rabi frequency by Morris-Shore transformation. Experiment performed with ultrafast laser interacting with cold atoms in a MOT confirms the prediction.

**Session Title**: [26G1-6] 10:30~10:45

**Doppler-Shifted Stark and Zeeman Effects of Light Emitted from the Multi-Level Atoms**

Jinseok Ko, Jinil Chung, and Maximilian Messmer  
Eindhoven University of Technology, Netherlands

Doppler-shifted Stark and Zeeman effects are applied to the measurement of the magnetic structure that confines toroidal plasmas for nuclear fusion. Progress on these applications to the Korean tokamak is presented.

**Session Title**: [26H1-1] 09:00~09:30 Invited Talk

**Nitride-based Light-emitting Diodes Using Conducting Filament Embedded TCO**

B. R. Lee, K. H. Kim, T. H. Lee, and Tae Geun Kim  
Korea University, Korea

We present an electroforming transparent conductive electrode that enables current injection from metal to semiconductor, by forming conducting filaments (CFs) in wide-bandgap materials such as silicon nitride, and employ it as an n-type electrode for GaN-based vertical light emitting diodes to investigate the effect of the CF densities on the electrical and optical characteristics in VLEDs.

**Session Title**: [26H1-2] 09:30~10:00 Invited Talk

**Drastic Enhancement of Eu Emission from Red Light-emitting Eu-doped GaN in a Microcavity**

Yasufumi Fujiwara, Tomohiro Inaba, Takanori Kojima, and Atsushi Kozumi  
Osaka University, Japan

Eu-doped GaN (GaN:Eu) has been identified as a promising red emitter. A GaN:Eu layer was confined in a microcavity consisting of a Ag mirror and an AlGaN/GaN distributed Bragg reflector (DBR), resulting in drastic enhancement of Eu emission intensity.

**Session Title**: [26H1-3] 10:00~10:15

**Reflection Properties of Nano Textured Distributed Bragg Mirrors**

Yoon-Jong Moon, Han-Kyeol Lee, Jin-Young Na, Sang-Woon Lee, and Sun-Kyung Kim  
Kyung Hee University, Korea

We designed nano-textured distributed Bragg reflectors and investigated their reflectance properties by conducting finite-difference-time-domain, mostly focusing on the effect of surface roughness.

**Session Title**: [26H1-4] 10:15~10:30

**Direct Growth of Thick AlN Template on Micro-circle Patterned-Si Substrate**

Tinh Binh Tran, Hideki Hirayama, Kototsuru Maeda, Masafumi Jo, and Shiro Toyoda  
RIKEN, Japan

A 8-µm-thick AlN template has been successfully directly grown on micro-circle patterned-Si substrate. Low surface roughness of 3.5 nm and both screw and edge dislocation densities are in the order of 10⁸/cm² have been obtained.
### Session Title: 26I1 / [T10] Waveguides

**Date & Time:** Wednesday, 26 August, 09:00 – 10:15

**Session Chair:** Seungwoo Lee (Sungkyunkwan University, Korea)

#### [26I1-1] 09:00–09:15

**Waveguide Side-wall Angle Dependant Resonance of a Si Micro Ring-resonator**

Mohammad Rakib Uddin¹, Nur’Azmina Lingas¹, Bikash Nakarmi², and Yong Hyub Won¹

¹Institut Teknologi Brunei, Brunei; ²KAIST, Korea

Si waveguide side-wall angle dependent resonance characteristic of a micro ring-resonator is presented. The peak resonant wavelength and the modulation depth have changed significantly due to the changes of side-wall angle.

#### [26I1-2] 09:15–09:30

**Broadband Guidance and Control of Polarization Vector Beams in Small-core Ultrahigh-NA Optical Waveguides**

Eunmi Kim, Ki Sang Lee, and Myeong Soo Kang

KAIST, Korea

We demonstrate direct excitation and broadband guidance of polarization vector beams (PVBs) in commercially stock-available small-core ultrahigh-NA optical fibers. A simple numerical analysis supports the experimental results and provides criteria for stable guidance of PVBs.

#### [26I1-3] 09:30–09:45

**Grating Based MEMS Tunable Filter for WDM Optical Network**

U. Poornalakshmi, Somya Aparna, M. Balasubramanian and Prasant Kumar Pathak

BITS-Pilani, India

A simulation model of in-plane MEMS tunable optical filter based on grating located on a silicon micro-machined cantilever beam is presented. Upon actuation a shift in filtered frequency varies linearly in C-band has been observed.

#### [26I1-4] 09:45–10:00

**Theoretical Investigation of Graphene-Based Inverted Rib-type Silicon Waveguides**

Yonghan Kim and Min-Suk Kwon

UNIST, Korea

We demonstrate that graphene-based inverted rib-type silicon waveguides can be used as absorption modulators. Simulation shows that the modulation depth of such a modulator is larger than those of previous graphene-based silicon waveguide modulators.

#### [26I1-5] 10:00–10:15

**Fabrication of 0.7µm² Ridge Waveguide in Ion-Sliced LiNbO3 by Proton-Exchange Accelerated Etching**

Keisuke Tanaka and Toshiaki Suhara

Osaka University, Japan

We fabricated ridge waveguides in ion-sliced LiNbO3 by accelerated chemical etching in the proton-exchanged region. We obtained the low-loss waveguides of 0.7 µm² cross-sectional area. Strongly confined guided modes were obtained at 1.55 µm wavelength.

### Session Title: 26J1 / [T12] Micro Cavity Devices

**Date & Time:** Wednesday, 26 August, 09:00 – 10:15

**Session Chairs:** Jifeng Liu (Dartmouth College, USA) and Kyong Hon Kim (Inha University, Korea)

#### [26J1-1] 09:00–09:30

**Invited Talk**

**Ultra-high Q Asymmetric Microcavity Photonics on a Silicon Chip**

Yun-Feng Xiao, Xun-Feng Jiang, Luido Shao, Li Wang, and Oiuang Gong

Peking University, China

We experimentally realized on-chip deformed microcavities supporting both highly unidirectional emission and ultra-high Q factors exceeding 168. This type of microcavity holds potential in ultralow-threshold laser and sensitive nanoparticle detection.

#### [26J1-2] 09:30–09:45

**High-Frequency Self-Modulation in Short-External-Cavity VCSEL with Semi-Spherical Mirror**

Tao Liu, Takeo Katayama, and Hitoshi Kawaguchi

Nara Institute of Science and Technology, Japan

Optical output modulation of over 15 GHz frequency was achieved in a short-external-cavity VCSEL by using a semispherical mirror for the cavity. The modulation was caused by the beat note between two external cavity modes.

#### [26J1-3] 09:45–10:00

**Electro-Optic Polymer/TiO2 Vertical Slot Waveguide Modulators**

Yasufumi Enami¹, Youssif Jouane², Jongdong Luc³, and Alex Jen⁴

¹Kochi University of Technology, Japan; ²University of Washington, USA

We report the efficient poling of electro-optic (EO) polymer in a hybrid EO polymer/ TiO2 vertical slot waveguide modulators based on enhanced conductivity of sol-gel silica under-cladding. The electrical volume conductivity of sol-gel silica cladding increases approximately 30 times when the cationizing time of the cladding layer is critically reduced to 45 minutes, which increases the in-device EO coefficient of the 600-nm-thick EO polymer film in modulators and reduces the lower halfwave voltage (Vπ) of the modulators. The lowest driving voltage (Vπ) of the TiO2 slot waveguide modulator is 2.0 V for an electrode length (Le) of 10 mm and wavelength of 1330 nm (λλ = 2.0 V·cm) for the low-index guest-host EO polymer SEO125. The optical propagation loss is reduced to 7 dB/cm.

#### [26J1-4] 10:00–10:15

**High Sensitivity, Ultra-Broadband SWNT-Graphene Hybrid Photodetector**

Frank Wang¹, Haimda Lu², Xiaomou Wang³, Yao Li³, Xizhang Wang⁴, Xinxuan Wang⁵, Yongbing Xu³, Yi Shi³, and Rong Zhang

¹Nanjing University, China; ²Yale University, USA

A photodetector based on SWNT-graphene hybrid films and facile fabrication steps is demonstrated, which exhibits a remarkably high photoresponsivity of ~ 100 A/W across visible (400 nm) to the telecommunication wavelengths (1550 nm).
We demonstrate an all-polarization maintaining Er-doped soliton fiber laser using evanescent field interaction with carbon nanotube saturable absorber. Fabricated fiber laser stably generates linearly polarized 510-fs soliton pulses with polarization extinction ratio of 18 dB.

Jiangfeng Zhu

[26A2-5] 12:15~12:30
Laser Diode Pumped Kerr-Lens Mode-Locking Nd, Y-Codoped CaF2 Laser
Jiangfeng Zhu1, Lijuan Zhang2, Juting Zhang3, Zye Gai2, Junti Wang3, Zhiyi Wei4, Liangbi Su5, and Jun Xu1
Volcan University, China, 1Chinese Academy of Sciences, China

We realized a diode-pumped Kerr-lens modellocking operation in a Nd, Y-codoped CaF2 laser. Pulses with 357 fs duration at 1063 nm were obtained. The average power was 210 mW under 5 W pump.

Room A (101)

Session Title 26A2 / [T01] Mode-Locked Lasers I
Date & Time Wednesday, 26 August, 11:00 ~ 12:30
Session Chair Zhigang Zhang (Peking University, China)

[26A2-1] 11:00~11:30 Invited Talk
Gate-Controlled All-Fiber Graphene Device and Its Application to Ultrafast Fiber Laser System
Dong-Y Yeom
Apou University, Korea

Actively controlled all-fiber graphene device exhibiting strong graphene-light interaction is demonstrated through electrical gating of graphene layers, and its application as a tunable nonlinear saturable absorber in ultrafast fiber laser system is discussed.

High Frequency 60 fs Mode-Locked Fiber Laser
Yanyong Song, Zhiyuan Dou, and Jinrong Tian
Beijing University of Technology, China

An Er-doped all fiber laser with high-repetition-rate of 224 MHz is demonstrated. The mode locking mechanism is nonlinear polarization rotation mode-locking. The fiber laser is compact and simple with pulse-width of 60-fs and spectral-width of 60-nm.

[26A2-3] 11:45~12:00 Invited Talk
All-Polarization Maintaining FemtoSecond Fiber Laser Based on Evanescent Field Interaction with SWCNT Saturable Absorber
1Apou University, Korea, 2KIST, Korea

We demonstrate an all-polarization maintaining Er-doped soliton fiber laser using evanescent field interaction with carbon nanotube saturable absorber. Fabricated fiber laser stably generates linearly polarized 510-fs soliton pulses with polarization extinction ratio of 18 dB.

[26A2-4] 12:00~12:15 Invited Talk
Demonstration of Femtosecond Ti:Sapphire Laser Oscillation Pumped by InGaN Diode Lasers
Ryota Sawada, Hiroki Tanaka, Ryosuke Kariyama, Kenichi Hirosawa, and Fumihiko Kannari
Keio University, Japan

We demonstrate a mode-locked Ti:sapphire laser pumped by green InGaN diode lasers from both sides of the crystal. An output power of 45 mW is achieved in modelocking with a SESAM (semiconductor saturable absorber mirror).

Room B (102)

Session Title 26B2 / [T06] Ultrashort Pulsed Laser 3D Processing
Date & Time Wednesday, 26 August, 11:00 ~ 12:30
Session Chair Sung Hik Cho (KIMM, Korea)

[26B2-1] 11:00~11:45 Tutorial
Volume Processing of Transparent Materials by Ultrashort Laser Pulses: Potential and Applications
Stefan Nolte1, Klaus Bergner1, F. Krämer2, Daniel Richter3, Sören Richter3, Christian Vogtlander1, and Felix Zimmermann1
1Friedrich Schiller University Jena, Germany, 2Fraunhofer Institute for Applied Optics and Precision Engineering, Germany
Internal structuring of transparent materials using ultrashort laser pulses enables a plethora of applications. This includes precise cutting, welding but also the realization of various photonic components like waveguides, artificial birefringent devices or Bragg gratings.

Femtosecond Laser Patterning of Plasmonic and Nonlinear Optical Properties in Silver-doped LiNbO3 Crystal
Y. Petit1,2, M. Vangheluwe1, N. Marquestaut2, T. Cardinal1, and Lionel Canioni2
1Université Bordeaux, France, 2Institut de Chimie de la Matière Condensée de Bordeaux, France
Nowadays the optical properties and structural arrangements of several inorganic materials can be modified using ultrashort and intense laser sources. Among several lithographic techniques, Direct Laser Writing (DLW) considered as a maskless patterning process, presents numerous advantages over usual techniques. DLW offers rapid patterning at sub-micrometer resolutions, with flexibility and scalability. At last, true three-dimensional structuration is allowed thanks to non-linear interaction in optical transparent materials. In this context, DLW of materials containing photosensitive agents can initiate photochemical processes, opening routes toward the design of nanocomposites. DLW techniques can modify the size, the shape, and the arrangement of the metal clusters. It is a powerful and flexible tool to control and optimize the linear and nonlinear properties of metal-dielectric composites. Many groups have shown interest in patterning metals in three dimensions in transparent media such as glasses or polymers. This becomes particularly challenging when structures much smaller than the diffraction limit need to be patterned for infrared or optical applications.

Extraordinary Characteristics of Spatiotemporally Focused Laser Pulses and Their Roles in Precision Materials Processing
Fei He1, Zaohui Wang2, Bin Zeng1, Jielei Ni3, Ya Cheng2,3, and Koji Sugioka1
1Université Bordeaux, France, 2Institut de Chimie de la Matière Condensée de Bordeaux, France, 3Mitsubishi Electric Research Laboratories, USA
We report on the observation of novel spatiotemporal effects of a spatiotemporally focused beam, which play important roles in many applications of femtosecond laser processing of materials.

Conference Program & Abstracts
The 11th Conference on Lasers and Electro-Optics Pacific Rim
### Room C (103)

**Session Title**: 26C2 / [T02] Novel Materials  
**Date & Time**: Wednesday, 26 August, 11:00 – 12:30  
**Session Chair**: Nan Ei Yu (APRI/GIST, Korea)

### [26C2-1] 11:00–11:15
**Heat-Spreading Role of Graphene Studied by Coherent Phonon Propagations**  
Hoon-Jeong Jeong, A. J. Minnich, Soon-Young Park, Hyung-Yong Hwang, Sung-Yong Yoon, and Yeong-Dahl Jho  
GST, Korea, California Institute of Technology, USA  
We have experimentally explored the role of graphene transferred on top of a GaN-based light-emitting diode (LED) as a heat spreading layer by monitoring the propagations of coherent phonon modes (CPMs).

### [26C2-2] 11:15–11:30
**Ultrafast Mid-infrared Investigations on the Surface Dirac Fermions with Topological Phase Transition**  
Jun Park, Sangwan Sim, Nkeki Korulu, Matthew Brehlik, Seongpik Oh, and Hyunjong Choi  
Yonsei University, Korea, Rutgers The State University of New Jersey, USA  
We present ultrafast optical studies of the Dirac surface dynamics in a topological insulator Bi2Se3 via optical pump mid-infrared probe spectroscopy. We observed largely enhanced coherence and carrier relaxation when the topological-phase transition takes place.

### [26C2-3] 11:30–11:45
**Electrically Controllable Detection of Transverse Acoustic Phonons**  
Young-Dahl Jho, Hoon-Jeong Jeong, S. Y. Yoo, and C. J. Stanton  
GST, Korea, University of Florida, USA  
In this work, we report on the electrical manipulation of photothermal properties in wurtzite semiconductors for allowing transverse acoustic (TA) phonon detection.

### [26C2-4] 11:45–12:00
**Coherent Phonon Dynamics in Single-Layer and Multilayer Graphene**  
Taejung Jeong, Soyang Jung, and Kjo Yee  
Chungnam National University, Korea, POSTECH, Korea  
Coherent phonon dynamics of single-layer graphene (SLG) and multi-layer graphene (MLG) on sapphire substrate were investigated using femtosecond pump-probe techniques. The center peak of G-mode phonon redshift with the number of graphene layer and the dephasing time upshift from 0.82 ps to 1.14 ps as the number of graphene layer increases. The results reflect thermal expansion and damping constant of SLG and MLG.

### [26C2-5] 12:00–12:15
**Observation of the Mid-infrared 1s Intraexcitonic Dynamics in Monolayer MoS2**  
Soonyoung Cha, Ji Ho Song, Sangwan Sim, Jun Park, Moon-Ho Je, and Hyunjong Choi  
Yonsei University, Korea, POSTECH, Korea  
We report the first measurement of ultrafast mid-infrared (IR) spectroscopy in monolayer MoS2. The observed mid-IR dynamics shows large photo-excited absorption, indicating the predominant intraexcitonic transition from the ground to the higher-lying excitonic states.

### [26C2-6] 12:15–12:30
**Ultrafast Mid-IR Carrier Dynamics in Three-Dimensional Dirac Semimetal Cd3As2**  
Chunhui Zhu, Xiang Yuan, Yongbing Xu, Faxian Xiu, and Fengqi Wang  
Nanjing University, China, Fudan University, China  
We investigated ultrafast carrier dynamics in Cd3As2 at 2.6 μm. Single-exponential decay and saturable absorption features are observed. The ultrafast optical nonlinearity suggests that Cd3As2 is useful for mode-locking lasers in the mid-IR range.

### Room D (106)

**Session Title**: 26D2 / [T04] Ultra-high Intensity Lasers II  
**Date & Time**: Wednesday, 26 August, 11:00 – 12:30  
**Session Chair**: Noriaki Miyangana (Osaka University, Japan)

### [26D2-1] 11:00–11:30  
**Invited Talk**  
**0.1 Hz 4.0 PW Ti:Sapphire Laser at CoReLS**  
Jae Hae Sung1,2, Soong Ku Lee1,2, Hwang Mooon Lee1,2, Je Yoon Yoo1,2, Tae Moon Jeong2,3, and Chang Hye Nam1  
1IBS, Korea, 2GIST, Korea  
0.1-Hz 4.5-PW laser is being developed for research on relativistic laser-matter interactions. The upgrade will be achieved by increasing the laser energy of the current 1.5-PW laser to 80 J and decreasing the pulse duration to 20 fs.

### [26D2-2] 11:30–12:00  
**Invited Talk**  
**Recent Progress on an Upgrade of the J-KAREN Laser at JAEA**  
H. Kinya1, M. Morii1, A. S. Pirzadeh2, K. Ogura1, M. Nishuchi1, M. Kandn1, H. Sakaki1, A. Koiz1, M. Kanasaki1, H. Tanaka1, Y. Fukuda1, Y. Koga1, A. Sagi1, S. T. Ishii1, T. Zh. Esirkepov, Y. Hayashi1, H. Koyama1, S. V. Balatsky1, K. Kondo1, Y. Masuda1, M. R. Asai1, D. Stesak1, D. Ujita1, M. Sawicka-Chyl1, V. Jambunathan1, A. Lucarelli1, and T. Moriz1  
1Japan Atomic Energy Agency, Japan, 2Kyushu University, Japan, 3Kansai University, Japan, 4Institute of Physics, Czech Republic  
We describe recent advances on the J-KAREN laser upgrade to provide an intensity capacity surpassing 10²² W/cm² at 0.1 Hz. The present high-spatiotemporal quality pulses of 20 J will be amplified in an additional amplifier.

### [26D2-3] 12:00–12:30  
**Invited Talk**  
**Ultra-high Intensity Laser-Matter Interaction Studies at RRCAT, India**  
Juver Ali Chakera, Anand Moorti, Himanshu Singhal, Babhul Sanjaysa Rao, Vipul Arora, Suman Basu, Muhammad Tayyab, Mukund Kumar, Ranjana Rathore, Tirtha Mandal, Prasad Anant Naik, and Parshotam Dass Gupta  
Raja Ramanna Centre for Advanced Technology, India  
This article presents some of the recent experimental studies in ultra-high intensity laser-matter interaction, carried out at Raja Ramanna Centre for Advanced Technology, India, at laser intensities of ~3x10²¹ and ~5x10²² W/cm², using 0.5W and 150 TW Ti:sapphire laser systems.
**Session Title**: 26E2 / [T05] Plasmonics and Metamaterials V

**Date & Time**: Wednesday, 26 August, 11:00 – 12:45

**Session Chair**: Junsuk Rho (POSTECH, Korea)

**Invited Talk** 11:00–11:15

**Light Emission Enhancement by Using Patterned Multilayer Hyperbolic Metamaterials**

Dylan Lu, Hadilang Glen, Kangwei Wang, Jimmy Kan, Eric Fullerton, Paul Yu, and Zhaowei Liu
University of California, San Diego, USA

We study nanopatterned multilayer hyperbolic metamaterials with tunable plasmonic properties for enhancing fluorescent molecules and LEDs at different working wavelengths. About two order of magnitude of spontaneous emission rate enhancement was demonstrated.

**Low-Scattering Hyperbolic Nanotube**

Kyoung-Ho Kim, Yoo-Shin No, Sehwan Chang, Jae-Hyuck Choi, and Hong-Gyu Park
Korea University, Korea

We present a low-scattering radial anisotropic hyperbolic metamaterial nanotube of which angular permittivity is near zero. As a realization of the hyperbolic nanotube, we propose a metal/dielectric layered nanotube in the visible wavelength regime.

**Angle-dependent Phase Reversal through Deep-subwavelength Dislocation in Hyperbolic Metamaterials**

Jinho Hong, Sunyeu Yu, and Namkyo Park
Seoul National University, Korea

In this communication, we show that phase-shifted transmission can be achieved through the deep subwavelength dislocation in hyperbolic metamaterials. Based on the analysis using Fourier modal method, we show that the regime of "phase reversal" exists for the oblique incidence which has the tangential wavevector anti-parallel to the direction of dislocation.

**Reconfigurable Designs for EIT in Solid State Plasma Metamaterials with Multiple Transmission Windows**

Xiangkun Kong, Shaobin Liu, Guowen Dong, and Bingxiang Li
1Nanjing University, China, 2Kent State University, USA

A reconfigurable metamaterial analog electromagnetically induced transparency (EIT-like) effect is theoretically and numerically demonstrated in this paper. The unit cell is composed of a stimulated circular loop element and an unstimulated arc slot element, which are both constructed by semiconductor. The proposed designs can realize a continuously tunable EIT-like effect in a broad frequency range, while the number of EIT-like transmission windows can be increased by the number of arc slots.

**Stimuli Responsive Plasmonic Resonator and Its Sensing Application**

Myung Jae Lee, Heonsu Jeon, and Sungwan Kim
1Seoul National University, Korea, 2Ajou University, Korea

A fully biocompatible and tunable plasmonic resonator consisting of silk protein and gold nanostructure is demonstrated. The silk plasmonic absorber sensor is based on the metal-insulator-metal resonator exhibiting stimuli responsive optical properties.

**Room F (108)**

**Session Title**: 26F2 / [T07] Optical Metrology and Sensing V

**Date & Time**: Wednesday, 26 August, 11:00 – 12:30

**Session Chair**: Dong-Hoon Lee (KRISS, Korea)

**Invited Talk** 11:00–11:15

**Quantum Entangled Photon Sources and Their Application to Quantum Metrology**

Shigeki Takeuchi
Kyoto University, Japan

Quantum information science has been attracting significant attention recently. It harnesses the intrinsic nature of quantum mechanics such as quantum superposition, the uncertainty principle, and quantum entanglement to realize novel functions. Recently, quantum metrology is emerging as another appealing application of quantum information science. In this talk, we will report our recent progresses on the development of novel quantum entangled-photon sources and application to quantum measurements.

**High Efficiency Single Photon Detection with Optimized SNSPD and Compressed Beam**

Laba Zhao, Zhen Li, Jin Chen, and Peiheng Wu
Nanjing University, China

The efficiency is one of the most important parameter of single photon detector (SNSPD). The ideal SPD is expected to have 100% efficiency without false counts (always called dark counts). Improving the efficiency and reducing dark counts are interesting work for both scientific research and practical applications. Superconducting nanowire single photon detector (SNSPD) was intensively developed for its merit of low dark count, less than 1 count per second. However, its efficiency was limited by the optical absorption of superconductor nanowire. In this work, we analyzed the optical absorption of superconductor nanowire of SNSPD in theory. Then, we designed a SNSPD considering film growth and microfabrication process by optimizing the device structure, including the filling factor, films thickness, substrate index and cavity. With the SNSPD, a high absorption of 97% was calculated by FDTD method and a detector efficiency of 90% was achieved in experiments assisted by beam compressing settings.

**Intensity-based Pointwise Processing in Dynamic Laser Speckle Analysis**

Elena Stoykova, Natalia Berenová, Dimana Nazarová, and Atanas Gotchev
1KETI, Korea, 2Bulgarian Academy of Sciences, Bulgaria, 3Tampere University of Technology, Finland

Intensity-based pointwise algorithms for 2D evaluation of optical metrology with dynamic speckle analysis are studied. They are applied to a temporal sequence of correlated speckle patterns formed at laser illumination of the object surface. A new algorithm is proposed that provides the same quality of the 2D activity map but at less computational effort.

**Actinic EUV Mask Inspection Using Coherent EUV Source Based on High-order Harmonic Generation**

Yong Soo Kim, June Park, Han Yong Park, Hamin Sung, Jomsoap Kim, Seung Beam Lee, Hyun Woo Oh, Ju Han Lee, Min Chul Park, and Young Min Jeon
1KIST, Korea, 2University of Seoul, Korea, 3Laser Spectronix, Korea, 4Ukraine, Korea

We developed a coherent scattering microscope (CSM) for actinic EUV mask inspection. The CSM system was designed to measure critical dimensions down to 86 nm, and 200 nm U/S patterns were experimentally inspected.
We propose and demonstrate an experimental technique that generates and measures still share non-zero entanglement. Exchange symmetry is broken once decoherence is introduced, even though the photons subsystems are exchangeable without affecting the quantum state. Here, we report that the speedup of quantum algorithm and strong universality in quantum computation.

By employing photon polarization and spatial modes. This work displays the remarkable demonstration of quantum permutation algorithm with a single photon ququart.

Measurement of arbitrary superpositions of core modes in a multi-core fiber

Adaptive polarization-state monitoring and stabilization scheme for one-way polarization-encoded quantum key distribution systems

Invited Talk

Round-robin differential-phase-shift QKD protocol

Deep-tissue imaging with collective accumulation of single scattering microscopy

Room H (202)

Session Title 26H2 / [T11] Optical Coherence Tomography
Date & Time Wednesday, 26 August, 11:00 – 12:30
Session Chair Donghyun Kim (Yonsei University, Korea)

Invited Talk

Expanding imaging ranges for spectral domain optical coherence tomography

Fiber-based dual modal system for noncontact photoacoustic and optical coherence tomography

Visualization of prostatic nerves using polarization-sensitive optical coherence tomography

All-fiber burst mode laser system integrated with OCT for cataract surgery
[26I2-1] 11:00~11:30 | Invited Talk

**Hyperbolic Metamaterials**

Evgenii Narimanov1 and Ishii Satoshi2

1Purdue University, USA, 2National Institute for Materials Science, Japan

Photonic hyper-crystals represent a new class of artificial optical media. These composites, which are hyperbolic metamaterials with periodic spatial variation of dielectric permittivity on a subwavelength scale, combine the features of optical metamaterials and photonic crystals.

[26I2-2] 11:30~11:45

**Tunable and Broadband Perfect Absorption in Epsilon-Near-Zero Indium Tin Oxide Thin Films at Near Infrared Wavelengths**

Junho Yoon1, Md. Alamgir Badsha1, Tae Young Kim1, Young Chul Jun2, and Chang Kwon Hwangbo1

1Inha University, Korea, 2UNIST, Korea

In this study we demonstrate tunable and broadband perfect absorption in epsilon-near-zero ITO thin films and multilayers at near infrared wavelengths and investigate their optical, electrical, and structural properties.

[26I2-3] 11:45~12:00

**Hollow Core Negative Curvature Fiber with Layers of Photoaligned SD1 Azo Dye**

Dmitri Bogdanovitch1, Abhishek Shristava2, Vladimir Chigrinov2, Alexander Brhukov3, and Andrey Pryamikov2

1Irkutsk State Technical University, Russia, 2Hong Kong University of Science and Technology, Hong Kong, China, 3Russian Academy of Sciences, Russia

Microstructured hollow core negative curvature fiber containing layers of SD1 azo dye exhibits spectral shift of photonic bandgaps and change of guided light amplitude under the influence of external linearly polarized UV radiation.

[26I2-4] 12:00~12:15

**Full-field Sub-wavelength Imaging with a Multiple Scattering**

Chunghyou Park, Jung-Hoon Park, Christophe Rodriguez, Hyelim Seung Yu, Minkwon Kim, Kyounguk Jeon, Seongyung Hahn, Jonghwa Shin, Seung Hwan Ko, Ki Taek Nam, Yong Hee Lee, Y. Cho, and Yong Keun Park

KAIST, Korea, Seoul National University, Korea

We demonstrate the scattering superlens using elastic scattering to obtain sub-diffraction resolution. Scattering from disordered nanoparticles enables to reconstruct the sub-wavelength image of the target through time-reversal and transmission matrix.
**Room A (101)**

**Session Title:** 26A3 / [T01] Mode-Locked Lasers II

**Date & Time:** Wednesday, August 26, 15:45 – 17:45

**Session Chair:** Fengguu Wang (Nanjing University, China)

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**26A3-1** 15:45–16:15 Invited Talk

Sub-fs Hybrid Synchronization between Mode-Locked Fiber Lasers

Y. Yu, W.-W. Hsiang, and S.-Y. Wu

National Chiao Tung University, Taiwan, and Fu Jen Catholic University, Taiwan

Sub-fs timing synchronization between a 1030 nm Yb doped and a 1560 nm Er-doped mode-locked fiber laser is successfully demonstrated by utilizing a hybrid passive/active approach. The physical mechanisms for determining the relative timing jitter are clarified.

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**26A3-2** 16:15–16:30 Dispersion Management in Nanotube Mode-Locked, Compact Linear-Cavity Fiber Laser

Tomoyasu Honda, Yu Wang, and Shinya Yamashita

The University of Tokyo, Japan

By managing the intracavity dispersion in nanotube mode-locked linear-cavity fiber laser, we achieved dissipative soliton operation at repetition rate of 62.5 MHz, which is the highest repetition rate for dissipative soliton.

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**26A3-3** 16:30–16:45 Efficient Diode-Pumped High Power Femtosecond Yb:LYSO Laser

Wentong Tian, Zhazha Wang, Zhiwei Wei, Jiangfeng Zhu, Lie Zhang, Xiaodong Xu, and Jun Xu

Xidian University, China, Chinese Academy of Sciences, China

We report on a diode-pumped high power femtosecond Yb:LYSO laser. More than 3 W average power with pulse duration of 215 fs at 1042 nm and 297 fs at 1035 nm, respectively, were obtained.

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**26A3-4** 16:45–17:00 Diode-Pumped Kerr-Lens Mode-Locked Yb:GSO Laser Generating 72 fs Pulses

Wentong Tian, Zhazha Wang, Zhiwei Wei, Jiangfeng Zhu, Lie Zhang, Xiaodong Xu, and Jun Xu

Xidian University, China, Chinese Academy of Sciences, China

We demonstrated a diode-pumped Kerr-lens mode-locked Yb:GSO laser starting with SESAM. Stable mode-locking operation with average power of 85 mW and pulse duration of 72 fs was achieved at repetition rate of 113 MHz.

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**26A3-5** 17:00–17:15 Dissipative Soliton Generation in All Fiber Mode Locked Thulium Laser

Fangzhou Tan, Jiang Liu, Huifu Li, and Pu Wang

Beijing University of Technology, China

We demonstrate all fiber dispersion managed mode locked thulium laser generating sub-200 fs pulses with 168 mw output power at repetition rate of 30 MHz.

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**26A3-6** 17:15–17:30 Dissipative Soliton Yb-Doped Fiber Laser Using a Bulk-Structured Bi4Te3 Topological Insulator

Jinan Guo, Chenhui Chen, Joonho Koe, and Ju Han Lee

University of Seoul, Korea

We experimentally demonstrate mode-locking of an ytterbium-doped fiber laser using a bulk-structured Bi4Te3 topological insulator. The stable mode-locked pulses with temporal width of ~230 ps and repetition rate of 1.44 MHz were obtained.

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**26A3-7** 17:30–17:45 Multimwavelength, Subpicosecond Pulse Generation from a SWNT-SA Mode-Locked Ring Birefringent Fiber Laser

Guoping Hu, Xin Zhao, Ye Liu, Zijun Yao, Meng Zhang, and Zheng Zheng

Beihang University, China, Collaborative Innovation Center of Geospatial Technology, China

By leveraging the polarization interference filtering and the gain profile tailing based on polarization dependent loss tuning, ultrashort pulses at up to four wavelengths are generated covering both 1530 and 1560 nm windows of the C-band.

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**Room B (102)**

**Session Title:** 26B3 / [T13] 3D Display

**Date & Time:** Wednesday, August 26, 15:45 – 17:45

**Session Chairs:** Kun Liu (Tianjin University, China) and Hee-Jin Choi (Sejong University, Korea)

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**26B3-1** 15:45–16:15 Invited Talk

Highly Immersive Head-mounted Displays Based on Aspherical and Freeform Optics

Dewen Cheng and Yongqiang Wang

Beijing Institute of Technology, China

Field of view (FOV) and resolution are two key parameters for head-mounted displays (HMDs), which determine the user's experience including immersion and comfort. We present four different designs for large FOV and high resolution HMDs developed at Beijing Institute of Technology. Each of them provides a FOV greater than 80 degrees and an angular resolution better than 4 arcminutes. Two of the designs are immersive for virtual reality applications, and the other two are optical see-through for augmented reality applications. The designs can be divided into another two categories according to the size of the display devices employed. Design methods and experimental results are discussed in detail.

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**26B3-2** 16:15–16:45 Invited Talk

Switchable Liquid Crystal Lens for 3D Applications

Xi-Been Son, Min-Kyu Park, Mugeon Kim, Heewon Park, and Hak-Rin Kim

Kyungpook National University, Korea

We developed a polarization dependent reactive mesogen lens array by using both bottom-up and top-down alignment method for 3D switchable 3D device systems like autostereoscopic display and light field camera.

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**26B3-3** 16:45–17:00 Full-color Table-top Display with Rotating Transmissive Screen

Kwang-Soo Kim, Housung Jeon, Hee Kim, and Joonguk Hahn

Kyungpook National University, Korea

We already suggested a 360-degree table top display system using transmissive screen. We improve our system as a full-color table-top display using RGB LEDs and cross dichroic prisms.

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**26B3-4** 17:00–17:15 Time-Multiplexed Two-Directional Sequential Projections for Integral Imaging 3D Display

Md. Ashraful Alam, Seok-Hee Jeon, and Nam Kim

Chungbuk National University, Korea, Incheon National University, Korea

A time-multiplexed two-directional sequential projection scheme (TTSP) is proposed and demonstrated to implement a viewing-angle-enhanced integral imaging display system. The main idea behind the method is sharing of the same image screen to display two sets of directional elemental images (DEIs) in a time-multiplexed sequential projection manner.

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**26B3-5** 17:15–17:30 Comparison of Perceived Depth Resolution between Different Image Generation Methods for Lenticular 3D Display

Mingyung Park and Hee-Jin Choi

Sejong University, Korea

The shape of the displayed image of the lenticular lens array method is changed with the sampling methods. In this paper, we try to compare the perceived depth resolution between different sampling methods.

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**26B3-6** 17:30–17:45 Luminance Profile Control Method Using Gradation Iris for Autostereoscopic 3D Displays

Munekazu Date, Tohru Kawakami, Motsumi Sasai, and Hideaki Takada

Nippon Telegraph and Telephone Corporation, Japan, and Tokoku University, Japan

A precise control method of angular luminance distribution of viewing zone using a filter with gradation in transmittance in an iris of a projector is proposed for autostereoscopic 3D display with smooth motion parallax.
**Room C (103)**

**Session Title**
26C3 / [T02] Supercontinuum Generation

**Date & Time**
Wednesday, 26 August, 15:45 – 17:45

**Session Chair**
Kyung Taec Kim (IBS/GIST, Korea)

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**26C3-1** 15:45~16:15 **Invited Talk**

**Strong-field-ionization Induced Air Lasers**

Bin Zeng1, Jingpeng Yao1, Wei Chu1, Honggang Xie1, Ziling Li2, Jie Na2, Guihua Li2, Chenrui Jing1, Haoliang Xu1, and Ya Cheng1

1 Shanghai Institute of Optics and Fine Mechanics, China; 2 Xin University, China

We report on generation of strong-field-ionization induced free-space air lasers and explore their applications in remote sensing and molecular physics.

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**26C3-2** 16:15~16:30

**Interaction between a Single Water Droplet and a Laser Filament**

Cheonha Jeon, Danielle Harper, Khan Lim, Magali Durand, Michael Chin1, Matthieu Baudelot1, and Martin Richardson

University of Central Florida, USA

The analysis of the destruction and reformation of a single laser filament interacting with a single micro-sized water droplet allows a better understanding of filament propagation through atmospheric aerosols.

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**26C3-3** 16:30~16:45

**Optical Guiding Using Femtosecond Laser Filamentation**

Xiao-Long Liu1, Xin Li3, Zhi Gui Du1, and Jie Zhang2

1 Chinese Academy of Sciences, China; 2 Shanghai Jiao Tong University, China

Optical guiding of the laser pulse using filamentation is investigated experimentally. Guiding effect as a function of temporal delay shows that it is the most effective when pump beam goes 8 ps before signal beam.

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**26C3-4** 16:45~17:00

**Highly Coherent Supercontinuum Pumped by Picosecond Pulse with a PCF Taper**

Feng Li1, Qian Li1, Jinhui Yuan1, and P. K. A. Wai1

1 Hong Kong Polytechnic University, Hong Kong, China; 2 Peking University, China

We propose to directly generate highly coherent supercontinuum with single noisy picosecond pump pulses by self-similarly pre-compress them down to ~50 fs with negligible pedestal in a nonlinearly engineered large mode area photonic crystal fiber taper.

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**26C3-5** 17:00~17:15

**High-order Modes Supercontinuum Generation in a Large-core Photonic Crystal Fiber**

Stanislav Leonov1, Vladimir Lazarev2, Mikhail Tarabrin1, Dmitry Dvoretsky1, Valeriy Karasik1, and Andrey Pyramov1

1 Bauman Moscow State Technical University, Russia; 2 Russian Academy of Sciences, Russia

We report on experimental investigation spectral properties of high-order modes SC generation in a large-core photonic crystal fiber with high air-filling fraction. Optical properties of large-core photonic crystal fiber were analysed. The SC generation in high-order modes LP01, LP11, LP21 and LP02 were observed under different input conditions.

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**26C3-6** 17:15~17:30

**Supercontinuum Generation in Suspended Core Photonic Crystal Fibers Doped with Silver Nanoparticle**

Surajit Bose1, Rik Chattopadhyay1, Samudra Roy1, and Shyamal K. Bhadra1

1 CSIR-Central Glass and Ceramic Research Institute, India; 2 Indian Institute of Technology, India

We study optical properties of silver nanoparticles doped highly nonlinear silica suspended core photonic crystal fiber. We numerically obtained a nearly octave-spanning supercontinuum in few centimeters of such doped fiber with very low input power.

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**26C3-7** 17:30~17:45

**Supercontinuum Notch Shaping via Fiber Bragg Grating for the Excitation Source in Coherent Anti-Stokes Raman Spectroscopy**

Seung Ryed Oh1, Daeseon Kang1, Jindoo Choi1, Jin Hwan Kim1, Hyub Lee1, Kyung-Soo Kim1, and Soboonyun Kim1

1 KAST, Korea

We show the feasibility of an all-fiber based single-pulse coherent anti-Stokes Raman spectroscopy. The system consists of a supercontinuum source from erbium-doped fiber amplifier and fiber Bragg grating for notch filtering.

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**Room D (106)**

**Session Title**
26D3 / [T06] Novel Laser and Optical Technologies in Manufacturing

**Date & Time**
Wednesday, 26 August, 15:45 – 17:30

**Session Chair**
Sung Ho Jeong (GIST, Korea)

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**26D3-1** 15:45~16:15 **Invited Talk**

**High Performance Materials Processing Using Tailored Femtosecond Laser Pulses**

Koji Sugisaka1, Katsumi Mokodawaki1, Rei H2, and Ya Cheng1

1 RIKEN Center for Advanced Photonics, Japan; 2 Shanghai Institute of Optics and Fine Mechanics, China

Tailored femtosecond laser pulses can enhance the performance for materials processing, temporarily tailored femtosecond laser pulses are employed for high efficiency glass welding, while the spatially one, for formation of taper-free through Si vias.

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**26D3-2** 16:15~16:45 **Invited Talk**

**Optical Fabrication and Operation of Micronano-Robots**

Hong-Bo Sun

Jilin University, China

Femtosecond laser direct writing (FLDWR) was utilized to create micronano-robots, which were then demonstrated to be optically, electronically, magnetically or chemically manipulated. An appropriate operation mechanism is considered as essential for functionalizing the robots.

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**26D3-3** 16:45~17:00

**Physical Model for Subsurface Silicon Writing**

Onur Toker1, Ahmet Tuna2, Ilker Pavlyov, and F. Omer Olay3

1 Bilkent University, Turkey

We have recently reported a direct laser writing method enabling buried structures deep inside silicon. Here we study the formation of these subsurface structures. We take advantage of Nonlinearly Engineering to understand this new phenomenon.

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**26D3-4** 17:00~17:15

**Material Response of Semiconductors Irradiated with IR Ultrashort Laser Pulses**

Ilya Mingareev, Mark Ramme, and Martin Richardson

University of Central Florida, USA

We utilize near- and mid-IR ultrashort laser radiation to investigate the processing of crystalline silicon with different dopants. A numerical model is adopted to simulate the material response depending on the wavelength and the dopant concentration.

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**26D3-5** 17:15~17:30

**Experimental and Numerical Investigation of Laser-based Short Wavelength Plasma Sources**

Homaia Parchamy, John Szilagyi, Majid Masnavi, and Martin Richardson

University of Central Florida, USA

Laser-based plasma lamps are of particular interest in the semiconductor industry. This study examines the optimum regions of laser-plasma operational space for a number of intense laser-irradiated mass-limited droplet source scenarios.
## Plasmon Lasers: Development, Features and Applications
**Ren-Min Ma**  
Peking University, China

Plasmon lasers are a new class of lasers that surpassed the diffraction limit of light which stimulates the exploration of nanometer-scale laser science and the development of high performance devices.

### Effective Engineering of Sub-wavelength-scale Plasmonic Cavities

**Myung-Wi Kim**, Hongchul Sim, and Hong Hee Lee  
KAIST, Korea

We suggest cladding and geometric engineering methods for effective field engineering of sub-wavelength-scale plasmonic cavities, which enable 90% coupling to the integrated waveguide and extreme 3D field confinement in a volume of ~10^{-7} μm^3 (~5×10−10mm^3).

### The Measurement of Surface Plasmonic Transport on Silver Nanowires Arrays

**Sean Sung-Yen Juang**, Ming-Hui Lin, and Hsiang-Chen Chui  
National Cheng Kung University, Taiwan

We measured the scattering intensity of the anodic aluminum oxide embedded the silver nanowires arrays and calculate out the propagation surface plasmonic length is about 2 μm.

### Surface Plasmon Absorption Characteristics of Gold Deposited on Optical Fibers

**Shuji Taue**, Yuya Utsunomiya, and Hideki Fukano  
Okyama University, Japan

We deposited gold films on optical fiber surfaces and annealed them to analyze the absorbance in the visible and near infrared wavelength range. The corresponding relations between the absorption spectra and the structural images of the deposited gold were identified.

### Giant Modulation Depth in the Photoexcited Topological Surface Plasmons Exceeding 2,400% (Invited Talk)

**Sangwan Sim**, Houk Jang, Nkesh Konrad, Matthew Brattek, Ji-Ho Sung, Jun Park, Soo Young Che, Seongshik Oh, Jong-Hyun Ahn, Moon-Ho Jo, and Hyunyong Choi  
Yonsei University, Korea, Rutgers the State University of New Jersey, USA, POSTECH, Korea

We present ultrastable optical modulation of plasmons in a topological insulator Bi2Se3 microribbon array. Unprecedented giant modulation depth up to 2,400% is obtained with very low fluence of optical control pulse.

### Propagation of Quantum Signal in Plasmonic Waveguides

**Xiteng Ren**, Yongling Cai, Ming Li, Changping Zou, Xiao Xiong, Huailin Lei, Biheng Liu, Geping Guo, and Guangan Suo  
University of Science and Technology of China, China

Here we introduce two works on quantum plasmonics: high-visibility on-chip quantum interference of single surface plasmons and transmission of quantum polarization entanglement in a nanowire hybrid plasmonic waveguide. Our works can bridge nonlinearities and quantum optics.

### Non-polarizing Subtractive Structural Color Filters Based on Aluminum Plasmonics

**Vivek Raj Sheethal**, Sang-Shin Lee, Eun-Soo Kim, and Dak-Yong Cho  
"Kwangweon University, Korea, "The Australian National University, Australia

We report non-polarizing subtractive structural color filters based on surface plasmon-induced suppressed transmission via two-dimensional array of aluminum nanopatches over a glass substrate. Three subtractive primary colors i.e. cyan, magenta and yellow are demonstrated with high transmission efficiencies reaching 75 %.
### Session Title: 26G3 / [T08] Atom-Photon Interaction II

**Date & Time:** Wednesday, August 26, 15:45 – 17:15

**Session Chair:** Yong-II Shin (Seoul National University, Korea)

<table>
<thead>
<tr>
<th>Time</th>
<th>Title</th>
<th>Abstract</th>
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<tbody>
<tr>
<td>15:45-16:15</td>
<td>[26G3-1] Storing Single Photons in a Quantum Register</td>
<td>Joong Whacchup, Stuttgart University, Germany. The efficient transfer of photons from a light field to a solid state quantum register is key to distributed quantum computing and quantum repeater architectures.</td>
</tr>
<tr>
<td>16:15-16:30</td>
<td>[26G3-2] Experimental Investigation of Transverse Spatial Coherence of an Optical Pulse in Atomic Vapor Quantum Memory</td>
<td>Jong-Chan Lee, Kwang-Ryoung Park, Young-Wook Cho, and Yoon-Ho Kim (POSTECH, Korea). We experimentally investigated the transverse spatial coherence of an optical pulse stored in atomic vapor quantum memory. Using Young-type spatial interference, it is demonstrated that the atomic vapor quantum memory preserves transverse spatial coherence.</td>
</tr>
<tr>
<td>16:30-16:45</td>
<td>[26G3-3] Saturated Absorption Spectroscopy of Helium-4 2S1/2-3P Transitions</td>
<td>Chia-Wei Chen, Jieh-You Chen, Pei-Ling Luo, Jow-Tsong Shy, Li Bang Wang, and Huang-Chen Chiu (National Cheng Kung University, Taiwan, National Tsing Hua University, Taiwan). We have observed the saturated absorption spectra of the He-4 2S1/2 - 3P transitions in a Rb-discharged helium cell using a 6-mW 389-nm laser. The linewidth broadening due to power was investigated.</td>
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<tr>
<td>16:45-17:00</td>
<td>[26G3-4] The Effects of Two Photon Coherence on the Four-wave Mixing Spectrum in a Ladder-type Atomic System</td>
<td>Yoon-Seok Lee and Han Seb Moon (Pusan National University, Korea). We report the analysis of four-wave mixing spectrum in terms of two-photon coherence in a ladder-type atomic system of the 5S1/2 - 5P3/2 - 5D5/2 transition of 87Rb atom. This spectroscopy is potentially useful for the effective way to generate a correlated photon pair from an atomic ensemble.</td>
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<tr>
<td>17:00-17:15</td>
<td>[26G3-5] Resonant Four-wave Mixing with Co-propagating Scheme in Rubidium Vapor Cell</td>
<td>Taek Jeong and Han Seb Moon (Pusan National University, Korea). We have observed four-wave mixing (FWM) of weak pumping in a resonance double-Λ configuration composed of the common excited state Sr (F=2) and the two ground state Ss (F=1 and 2). We demonstrated the generated FWM signal filtering the three beams using polarization and etalon filters. The spectral width of FWM signal was measured to be ~10 kHz under the condition of coherent population trapping (CPT). Dependence of FWM signals on the intensities of the two beams related CPT and pump beam was investigated in detail.</td>
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### Session Title: 26H3 / [T11] Tissue Imaging

**Date & Time:** Wednesday, August 26, 15:45 – 17:45

**Session Chair:** Hyuk-Sang Kwon (GIST, Korea)

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<th>Time</th>
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<th>Abstract</th>
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<tr>
<td>15:45-16:15</td>
<td>[26H3-1] Extraordinary Light Transmission for Super-resolved Axial Imaging</td>
<td>Wonja Lee, Jong-Ryal Choi, Kyung-Kim Kim, Youngshin Chi, and Donghyun Kim (Yonsei University, Korea, Daegu-Gyeongbuk Medical Innovation Foundation, Korea, Pusan National University, Korea). In this paper, the feasibility of super-resolved axial imaging is explored by extraordinary light transmission using graded nanohole arrays. Intracellular axial sectioning was performed with an effective resolution as small as 20 nm.</td>
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<td>16:15-16:30</td>
<td>[26H3-2] Monte Carlo Model of Laser Doppler Perfusion Imaging in Skin Cancer Detection</td>
<td>Alireza Movela, Thomas Taimre, Yeh-Leng Lim, and Aleksander D. Rakic (The University of Queensland, Australia). We present a laser Doppler perfusion imaging model to map the perfusion in melanoma and non-melanoma skin cancers. We numerically investigate the use of neovascularization as an early detection method using Monte Carlo method to simulate the interactions of photons and skin tissue.</td>
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<tr>
<td>16:30-16:45</td>
<td>[26H3-3] Optical Coherence Gating with Stimulated Emission</td>
<td>Fu-Jen Kao, Chun-Hui Yu, Shen-Shou Chung, and Wen-Chuan Kao (National Yang-Ming University, Taiwan). Stimulated emission-based optical coherence gating is established for feasibility study in tomography, which shows a depth resolution of approximately 66 μm.</td>
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<tr>
<td>16:45-17:00</td>
<td>[26H3-4] Endoscopic Probe for Optical Coherence Tomography with Magnet Driving Device</td>
<td>Zwei Pang1 and Jiqing Wu2,3 (1Shanghai Jiao Tong University, China, 2Tsinghua University, China). We proposed and implemented a magnetic-driven side imaging endoscopic probe for optical coherence tomography. The probe can achieve 380-degree unobstructed circumferential imaging with a 1.4-mm outer diameter, and thus suitable for many endoscopic applications.</td>
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<td>17:00-17:15</td>
<td>[26H3-5] In Situ Visualization of Collagen Fiber Produced by Cultured Osteoblasts Using Sensitive Second-harmonic-generation Microscopy Equipped with a 10-fs Ti:Sapphire Laser</td>
<td>Eiji Hase1, Katsumu Sato1, and Takeshi Yasui1 (1The Tokushima University, Japan, 2Osaka University, Japan). In this paper, we constructed sensitive second-harmonic generation (SHG) microscopy equipped with a 10-fs Ti:sapphire laser and succeeded in visualizing collagen fibers produced by the cultured osteoblasts in situ.</td>
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<td>17:15-17:30</td>
<td>[26H3-6] Photonic Crystal Enhanced Fluorescence through Extraction of Dual Polarization Modes</td>
<td>Cheng-Sheng Huang, Yo-Ari Wu, and Po-Yun Wu (National Chiao Tung University, Taiwan). In this paper, we demonstrate that the fluorescence collection efficiency of surface-bound fluorophores can be enhanced through coupling of fluorescence emission into both TE and TM resonant modes of a photonic crystal substrate.</td>
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<td>17:30-17:45</td>
<td>[26H3-7] Optically-tunable Multiple Switching Effects of Biopolymer Memory Devices</td>
<td>Yu-Chueh Hung, Yi-Tzu Lin, Chau-You Hung, and Wan-Ping Tu (National Tsing Hua University, Taiwan). We present optically-tunable switching effects based on biopolymer nanocomposite. Without the need of external doping, the nanocomposites can be manipulated by light to exhibit multiple switching behaviors, showing promising for memory device applications.</td>
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</table>
A nanobeam laser made of InGaAsP material is printed on a SiO$_2$/Si substrate via transfer-printing process. From this structure, single mode lasing near 1550 nm with continuous-wave (CW) operation at room-temperature is achieved.

Optimized Aperiodic Nanobeam Lasers
Sueh-Ki Moon$^1$, Kwang-Yong Jeong$^1$, and Jin-Ay Yang$^1$

$^1$Kyonggi National University, Korea, $^2$KAIST, Korea.

We demonstrated lasing action at aperiodic nanobeam cavities composed of two different air holes at room temperature. As the size ratio of two holes is changed, different type of optical modes is selected for lasing.

Room Temperature Continuous Operation of Sub-$\mu$W Threshold Nano-Island Lasers
Hoon Jang, Indra Kannadi, Putu Eka Pramudita, and Yong Hee Lee

KAIST, Korea.

Nanobeam laser with nano-island quantum well (QW) is demonstrated. Continuous operation with 210 mW threshold is achieved. We remove the absorptive QW surrounding the central cavity, leaving the gain only inside $0.7 \times 0.25 \times 0.02 \, \mu$m.

Self-Aligned InGaAsP Nano-Emitters Near Telecom-Wavelength
Putu Eka Pramudita, Hoon Jang, Chang-Min Lee, Indra Kannadi, Jongmin Lee, Myung-Ki Kim, and Yong Hee Lee

KAIST, Korea.

We study selective wet-etching systems for realizing self-aligned nano-emitters. Controllability of the nano-emitters’ shapes, sizes and positions are the major advantages of this method. Emission of nano-emitters at telecom-wavelength is characterized from photoluminescence measurement.
### Room A (101)

**Session Title**: 27A1 / [T01] Tm Fiber Lasers  
**Date & Time**: Thursday, August 27, 11:00 – 12:30  
**Session Chair**: Ju Han Lee (University of Seoul, Korea)

#### [27A1-1] 11:00–11:15

**Resonantly Pumped Amplification in a Thulium-Doped Photonic Crystal Fiber**  
Alex Sincro, Lawrence Shail, Mateusz Wysokinski, Robert Ryan, Ali Abdultafati, and Martin Richardson  
1University of Central Florida, USA, 2Laser Zentrum Hannover, Germany  
Efficiencies <50% are typical in large mode area, thulium-doped photonic crystal fibers when pumped at 790 nm. These large thermal loads limit power scaling. In this work, we investigate resonant pumping and demonstrate slope efficiencies >64%.


**Dissipative Soliton Generation at 2µm from a Mode-Locked Fiber Laser Using CNT**  
Yu Wang, Alain Shail-uf, Elena D. Obraztsova, Ariadiki S. Posthava, and Shoji Yamashita  
1The University of Tokyo, Japan, 2University of Southampton, UK, 3A.M. Prokhorov General Physics Institute, Russia  
We report for the first time, generation of dissipative soliton from a ring-cavity thulium fiber laser mode-locked with the use of a carbon nanotubes saturable absorber and a length of DCF producing 416 pJ pulse energy.

#### [27A1-3] 11:30–11:45

**High-Power Narrow-Linewidth Thulium-Doped All-Fiber MOPA**  
Jiang Liu, Hongxing Shi, Chen Liu, and Pu Wang  
Beijing University of Technology, China  
We demonstrated a high-power narrow-linewidth thulium-doped all-fiber laser based on master-oscillator power amplifier. The amplifier yielded 342 W of narrow-linewidth laser output at central wavelength of 2000.3 nm with 3 dB spectral bandwidth of 90pm.

#### [27A1-4] 11:45–12:00

**Linearly Polarized Thulium Doped All-Fiber Laser**  
Jiachen Wang, Sang Bar Lee, and Kwain Lee  
1KIST, Korea, 2University of Science and Technology, Korea  
We report an all-fiber, linearly polarized Thulium doped fiber laser operating at 1950 nm. In the experiment, as high as 14.2 Watts power is generated from the laser with slope efficiency of 48.4%.

#### [27A1-5] 12:00–12:15

**Long-Cavity Nanosecond Thulium Fiber Laser: A Compact Source of Energetic Mid-IR Pulses**  
Yao Li, Jing Bi, Yafei Meng, Xing Bi, Yafei Meng, Yafei Meng, and Fengqiu Wang  
1Nanjing University, China, 2Imperial College London, UK  
We demonstrate nanosecond operation in an elongated cavity thulium fiber laser: a simple scheme for pulse energy scaling and repetition rate reduction. 7.5 nJ pulses with a repetition rate of 530 kHz are achieved.


**Optical Properties of Er⁺⁺-doped K-Ca-Al Fluorophosphate Glasses**  
K. Linganna, K. Suresh, S. Ju, W. T. Han, C. K. Jayasankar, and A. M. Prokhorov General Physics Institute, Russia  
Optical absorption and emission properties of the Er⁺⁺-doped K-Ca-Al fluorophosphate glasses were investigated and compared with other reported glasses for optical amplification application at 1.534 μm.

### Room B (102)

**Session Title**: 27B1 / [T03] Terahertz Technologies and Applications I  
**Date & Time**: Thursday, August 27, 11:00 – 12:30  
**Session Chair**: Il-Min Lee (ETRI, Korea)

#### [27B1-1] 11:00–11:15

**Continuous Wave Terahertz Signal Generator Based on Difference Frequency Generation in Gallium Phosphide Developed for Industrial Applications**  
Tetsuo Sasaki, Tadao Tanabe, Tomokazu Sakamoto, and Jun-ichi Hashizawa  
Shizuoka University, Japan, 2Tokyo University, Japan, 3National Institute of Health Sciences, Japan  
We have developed a CW THz signal generator on the principle of DFG in a GaP crystal and constructed THz spectrometers. Simple and easy operation/maintenance of the device would be suitable for industrial applications.

#### [27B1-2] 11:15–11:30

**Enhanced Terahertz Emission from SL-GaAs with a Sub-wavelength 1D Metal Array**  
Maria Angela Faustino, Lorenzo Jr. Lopez, Jessica Afalla, Joelimul Madora, Mark Jayson Felix, Amel Salvador, Armando Somintac, and Elmer Estacio  
University of the Philippines, Philippines  
Terahertz emission enhancement in SL-GaAs, having a deposited periodic 1D metal array, is reported. The one order enhancement is currently attributed to the localization of the terahertz electromagnetic field at the GaAs apertures.

#### [27B1-3] 11:30–11:45

**Stoichiometry Controlled Liquid Phase Growth of GaSe Crystals for the Efficient THz Generation**  
Yozohro Ota, Kohei Suzuki, Kenkoo Moeeda, and Yutaka Gymi  
Tokyo University, Japan  
THz generation efficiency from GaSe crystals were deteriorated by thermal equilibrium point defects and deviation from stoichiometry. Low temperature solution grown GaSe crystals were evaluated in comparison with commercially available Bridgman-grown crystals.

#### [27B1-4] 11:45–12:00

**Progress on Terahertz in-line Digital Holography Based on 3THz QCL**  
Dinghua Deng, Weihua Li, Xueqin Wang, Changle Shen, and Tao Jiang  
China Academy of Engineering Physics, China  
By shaping the output from 3THz QCL, Gaussian-distributed THz source with very small divergence was obtained. With this good-quality QCL source, a Terahertz in-line digital holography set was built up. Resolution of this Terahertz in-line digital holography set is as small as 200μm, which is the smallest resolution reported up to now.

#### [27B1-5] 12:00–12:15

**Real-Time Absolute Frequency Measurement of CW THz Radiation Based on a Free-Running THz Comb**  
Takahiro Ogura, Kenta Hayashi, Takeo Nakajima, Hajime Inaba, Kenta Hayashi, Hajime Inaba, Kenta Hayashi, Hajime Inaba, and Takeshi Yasui  
Nagoya Institute of Technology, Japan, 2The University of Electro-Communications, Japan, 3The University of Science and Technology, Korea  
Absolute frequency of continuous-wave terahertz radiation was determined at an accuracy of 10⁻¹¹ in real time by modulating a frequency spacing of photocarrier terahertz comb induced by a free-running femtosecond laser.
### Session C (103)

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<th>Date &amp; Time</th>
<th>Session Title</th>
<th>Room C (103)</th>
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<tr>
<td>Thursday, 27 August, 11:00 – 12:15</td>
<td>27C1-1 / [T02] Strong Field Physics</td>
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<td>Session Chair: Ryuji Itakura (Japan Atomic Energy Agency, Japan)</td>
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<tr>
<td>[27C1-1] 11:00–11:30</td>
<td>Invited Talk</td>
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<td>High Harmonics and Attosecond Pulses – Seeing Inside Molecules</td>
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<td>Alexandre Thai</td>
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<td>Low laser intensity (1-5 GW/cm²)</td>
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<td>Tunneling photoemission and electron acceleration was demonstrated at an unprecedently</td>
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<td>generated on gold metal layer in Kretschmann configuration at 3.1 microns wavelength.</td>
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<td>Strong-field ultrafast photoemission was studied by propagating surface plasmons</td>
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<td>with high temporal resolution (&lt;10 fs), and applied it to CO₂.</td>
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<td>[27C1-2] 11:30–12:00</td>
<td>Invited Talk</td>
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<td></td>
<td>Laser-assisted Electron Scattering and Diffraction in Femtosecond Intense Laser Fields</td>
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<td></td>
<td>Reika Kanya, Yuya Morimoto, and Kaoru Yamanouchi</td>
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<td>the University of Tokyo, Japan</td>
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<td>We have developed a method called laser-assisted electron diffraction through which</td>
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<td>geometrical structures of molecules can be determined with high precision (~0.01 Å) and</td>
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<td>with high temporal resolution (&lt;10 fs), and applied it to CO₂.</td>
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<td>[27C1-3] 12:00–12:15</td>
<td>Invited Talk</td>
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<td>Strong Field Nanoplasmic Photoemission in the Mid-IR at &lt;1 GW/cm² intensity</td>
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<td>Peter Récz, Stegan Heinemann, Marcelo Ciappina, José Antonio Pérez Hernández, Alejandro Thal, Julia Fedele, Abdulkareem Ekozlak, Laszlo Vecs, Jens Belgen, and Péter Domitl</td>
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<td>Wigner Research Centre for Physics, Hungary, ICFO-Institut de C/enies Fotóniques, Spain, Max-Planck-Institut für Quantenoptik, Germany, Centro de Láseres Pulsados, Spain, University of Alberta, Canada</td>
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### Session D (106)

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<tr>
<th>Date &amp; Time</th>
<th>Session Title</th>
<th>Room D (106)</th>
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<tbody>
<tr>
<td>Thursday, 27 August, 11:00 – 12:30</td>
<td>27D1 / [T04] High Power, High Energy Lasers</td>
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<tr>
<td></td>
<td>Session Chair: Jae Hee Sung (IBS/GIST, Korea)</td>
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<tr>
<td>[27D1-1] 11:00–11:30</td>
<td>Invited Talk</td>
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<td></td>
<td>Progress on Mid-infrared Intense Laser Aiming at 100 TW Peak Power</td>
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<td>Guo Giang Xie, Fu Yong Wang, Peng Yuen, and Lie Ja Qian</td>
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<td>Shanghai Jiaotong University, China</td>
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<td>We have accomplished designing of a 100-TW level midinfrared laser based on two-</td>
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<td>stage optical parametric chirped pulse amplification (OPCPA) scheme. At present, we</td>
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<td>have experimentally demonstrated 120-GW midinfrared pulse generation with single-stage</td>
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<td>OPCPA.</td>
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<td>Design and Progress of SG-II Multi Petawatt Laser Facility</td>
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<td>Jiangang Zhu, Xining Xie, Dongwei Yang, Jun Kang, Haibang Zhu, Ailin Guo, Peng Zhu, Qi Gao, Zhengli Liu, Guangdong Fan, Daichong Liu, Xiaoying Ouyang, Hui Wei, and Xiaochao Wang</td>
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<td>Shanghai Institute of Optics and Fine Mechanics, China</td>
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<td>We studied the concept of EDP amplification for the 10-100 PW level of the three ELI-pillars</td>
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<td>laser systems. The design of EDP – duty amplifiers required to achieve these parameters</td>
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<tr>
<td>[27D1-3] 11:45–12:00</td>
<td>Invited Talk</td>
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<tr>
<td></td>
<td>Final EDP Ti: Sapphire Amplifiers for ELI –Project</td>
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<td>Vladimir Chvykov, Mikhail Kalashnikov, and Kordy Ososy</td>
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<td>1ELI-ALPS, Hungary, 2Max Born Institute, Germany</td>
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<td>[27D1-4] 12:00–12:15</td>
<td>Invited Talk</td>
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<td>1.02 Petawatt Hybrid-scheme Laser System Based on LBO-OPCPA Near 800 nm</td>
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<td>Langlong Y0, Xiaoyan Liang, Zhanggui Hu, Youn Leng, Ruixi Li, and Zhizhan Xu</td>
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<td>Shanghai Institute of Optics and Fine Mechanics, China, 2Technical Institute of Physics and Chemistry, China</td>
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<td>We report a hybrid laser system with peak power of 1.02 PW based on LBO-OPCPA</td>
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<td>near 800 nm. The amplified energy of 45.3 J centered at 800 nm was generated with a</td>
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<td>conversion efficiency of 26.3%. After compression, the pulse duration was 52 fs.</td>
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<td>[27D1-5] 12:15–12:30</td>
<td>Invited Talk</td>
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<td>Optical Parametric Chirped Pulse Amplifier for a 4 PW Laser Front-end</td>
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<td>Hwang Woon Lee, Je Yoon Yoo, and Hee Sung</td>
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<td>Lee</td>
<td>1IBS, Korea, 2GIST, Korea</td>
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<td>conversion efficiency of 26.3%. After compression, the pulse duration was 52 fs.</td>
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The 11th Conference on Lasers and Electro-Optics Pacific Rim

Room E (107)

Session Title: 27E1 / [T05] Plasmonics and Metamaterials VII

Date & Time: Thursday, 27 August, 11:00 ~ 12:30

Session Chair: Remnin Ma (Peking University, China)

[27E1-1] 11:00~11:30 Invited Talk

Focusing Surface Plasmon Polaritons through a Disordered Nanohole Structure
Yong Keun Park
KAIST, Korea

We demonstrate that multiple scattering can be controlled via wavefront shaping in order to obtain a sub-diffraction limited focus at an arbitrary position and the full-field dynamic sub-wavelength imaging. Due to the random structure of the highly scattering media there are no restrictions on the physical position of the focus giving the system a high degree of freedom. We also present that the full-field dynamic sub-wavelength imaging can be obtained by transferring the optical near-field into propagating far-field components by multiple light scattering from disordered nanoparticles, which was previously demonstrated in microwave regime.

Session Title: 27E2 / [T06] Nanophotonics and Nanosystems

Date & Time: Thursday, 27 August, 11:30 ~ 12:45

Session Chair: Hakjoon Lee (Korea University, Korea), Young Min Jhon (KIST, Korea), Sanghoon Lee (KAIST, Korea), and Wonshik Choi (Korea University, Korea)

[27E2-1] 11:30~11:45 Invited Talk

A Self-Mixing Effect Based Fiber-Optic Acoustic Sensor Using Oil as an Optical Reflector
Lutang Wang, Nian Fang, and Zhaoming Huang
Shanghai University, China

We present an optical fiber sensor based on the self-mixing interferometers. General principles are described and experimental results are presented.

[27E2-2] 11:45~12:00 Invited Talk

Surface as an Optical Reflector
Seungong Kim and Kihong Kim
Apuo University, Korea

The mode conversion and the resonant absorption and amplification phenomena occurring in homogeneous chiral media are theoretically studied. Mode conversion is found to occur when the medium contains regions where at least one of the effective refractive indices corresponding to two circular polarizations vanishes. Resonant absorption and enhancement phenomena are useful for designing efficient absorbers and nonlinear photonic devices.

[27E2-3] 12:00~12:15 Invited Talk

Multi-frequency-swept OCT adopting the wide field heterodyne detection technique is demonstrated for high-speed 3D vibration measurements. The axial resolution and the accuracy of vibration amplitude measurement were estimated to be 2.5 μm and 1.3 nm, respectively.

Session Title: 27E3 / [T07] Optoelectronics, Photonics, and Photonic Devices

Date & Time: Thursday, 27 August, 12:45 ~ 14:00

Session Chair: Kwang Jo Lee (Kyunghee University, Korea)

[27E3-1] 12:45~13:00 Invited Talk

State Nanopores
Hirohito Yamazaki, Shintaro Itoh, Keiko Esashita, and Toshiharu Sakai
Keio University, Japan

We report an optical nanopore detection system for investigating DNA translocation dynamics through a nanopore at sub-millisecond and sub-100-nm resolutions. The proposed optical nanopore detection scheme enables the observation of both the translocation process and the escape process. We found different correlation between the translocation time and the escape time, depending on whether the translocation occurs in a folded or unfolded configuration.

[27E3-2] 13:00~13:15 Invited Talk

Wide-field Heterodyne En-face OCT System for Vibration Measurement of Internal Surfaces
Samuel Choi, Fumiaki Nin, Takamasa Suzuki, and Hiroshi Hitono
Nagoya University, Japan

We propose a wide-field heterodyne OCT adopting the wide field heterodyne detection technique which is demonstrated for high-speed 3D vibration measurements. The axial resolution and the accuracy of vibration amplitude measurement were estimated to be 2.5 μm and 1.3 nm, respectively.


Design and Simulation of Light Source Integrated Photonic Crystal Nanobeam Biosensor
Geoyoung Kim and Jong H. Shin
KAIST, Korea

We report on design and simulation results of a SiN photonic crystal waveguide integrated with silicon quantum dot light sources for low-cost, high-performance biosensor on a chip.

Session Title: 27E4 / [T08] Phase Measurement and Imaging

Date & Time: Thursday, 27 August, 13:30 ~ 14:45

Session Chair: Jalal Al Roumy, Julien Perchoux, and Thierry Bosch
The Centre National de la Recherche Scientifique-Laboratoire for Analysis and Architecture of Systems, France


Phase Relationship of Photodetected Signals of an Optical Feedback Interferometry Sensor
Jalal Al Roumy, Julien Perchoux, and Thierry Bosch
The Centre National de la Recherche Scientifique-Laboratoire for Analysis and Architecture of Systems, France

Optical Feedback Interferometry signals can be acquired by photodetection either from rear or front facet of the laser. We present a model that links both signals to the injection current. The comparison with experimental results validates the model.

[27E4-2] 13:45~14:00 Invited Talk

A Self-Mixing Effect Based Fiber-Optic Acoustic Sensor Using Oil Surface as an Optical Reflector
Ludang Wang, Nan Fang, and Zhaoqing Huang
Shanghai University, China

A novel fiber-optic acoustic sensor based on the laser self-mixing effect is presented, which consists of an ultra-sharp resonance with high frequency and high trans-
Session Title | 27G1 / [T08] Atom-Photon Interaction III  
Date & Time | Thursday, 27 August, 11:00 – 12:15  
Session Chair | Gleb Maslennikov (National Univ. of Singapore, Singapore)  
[27G1-1] 11:00–11:30 Invited Talk  
Monolithic Optical Integration for Scalable Trapped-ion Quantum Information Processing  
Benjamin G. Norton, Maji Ghadimi, Valdis Blum, and David Kippenerski  
Griffith University, Australia
Quantum information processing (QIP) promises to radically change the outlook for secure communications, both by breaking existing cryptographic protocols and offering new quantum protocols in their place. A promising technology for QIP uses arrays of atomic ions that are trapped in ultrahigh vacuum and manipulated by lasers. Over the last several years, work in my research group has led to the demonstration of a monolithically integrated, scalable optical interconnect for trapped-ion QIP. Our interconnect collects single photons from trapped ions using a diffractive mirror array, which is fabricated directly on a chip-type ion trap using a CMOS-compatible process. Based on this interconnect, we have proposed an architecture that couples trapped ion arrays with photonic integrated circuits to achieve compatibility with current telecom networks. Such tightly integrated, highly parallel systems open the prospect of long-distance quantum cryptography.

[27G1-2] 11:30–11:45  
Efficient Single Photon Collection Using a μ-Fiber-Coupled Microcavity  
Chang-Min Lee, Hee-Jin Lim, Christian Schneider, Sebastian Maier, Sven Hilbring, Martin Kamp, and Yong-Hee Lee  
KAIST, Korea, University of Wuerzburg, Germany, University of St. Andrews, UK
Efficient single photon collection is demonstrated based on a μ-fiber-coupled photonic crystal cavity. 249 kHz of single photons are detected, and estimated single photon count rate (overall collection efficiency) is 20 MHz (25%).

[27G1-3] 11:45–12:00  
Phase Dependent Light Switching in a Triple-Λ System  
Bongjune Kim, Byoung-Uk Sohn, and Hoosoo Kang  
GIST, Korea
We experimentally demonstrate switching can be occurred between D1 |F’=1>, |F’=2> and D2 |F’=2> pulses. Each of pulses is probe field of triple-system composed of 87Rb D1 and 87Rb D2 transition line.

[27G1-4] 12:00–12:15  
Spectro-Spatial Coherent Control of Ultrafast Laser Interaction with Atomic Vapor  
Woyun Lee, Hyoouk Kim, Kyungtae Kim, and Jaewook Ahn  
KAIST, Korea
Spectro-spatial coherent control methods are reported demonstrating optimized resonant two-photon transitions of rubidium atomic vapor by counter-propagating ultrashort pulse pairs. By properly programming the spectral sign changes across resonance frequencies, two-photon transitions of rubidium atomic vapor by counter-propagating ultrashort pulse.

Session Title | 27H1 / [T09] Novel Materials and Devices  
Date & Time | Thursday, 27 August, 11:00 – 12:30  
Session Chairs | Yasufumi Fujimura (Osaka University, Japan), Dong-Soo Shin (Hanyang University, Korea)  
[27H1-1] 11:00–11:30 Invited Talk  
ZnO Microcavity Polariton Lasers  
Tien-Chung Lu  
National Chiao Tung University, Taiwan
ZnO with a large exciton binding energy and oscillator strength shows its advantages in serving active medium in microcavity polariton lasers. Large temperature operation range promises ZnO polaritonics as future highly efficient emitters.

[27H1-2] 11:30–12:00 Invited Talk  
True Green and Yellow Low-Threshold II-VI Laser Heterostructures for II-VIII-N Laser Diode Converters  
Sergey Ivanov, Sergei Sorokin, Sergei Gromov, Irina Sedov, Aliaksei Vainikov, and Eugeni Lutsenko  
Ioffe Institute, Russia, Stepanov Institute of Physics of NAS Belarus, Belarus
We report on recent progress in developing green-yellow (530-590 nm) II-VI-N microchip laser converters comprising low-threshold (0.8-2.5 kW/cm2 ) II-VI laser heterostructures with CdTe/ZnCdTe quantum dot active region, optically pumped by InGaN laser diodes.

[27H1-3] 12:00–12:15  
Temperature Dependence Photoluminescence of Co-axial ZnO/PVK Nanocables  
Sheng-Hung Hsu, Chien-Hung Lin, and Shih-Shou Lo  
Feng-Chia University, Taiwan
In this study, we demonstrated an inorganic-organic coaxial nanocable fabricated through facile-coating of organic molecules on an inorganic nanorod. The coaxial nanocable consists of a unique core (ZnO nanorod) and a shell (poly(N-vinylcarbazole)PVK). The temperature dependence of nanocables were carried out.

[27H1-4] 12:15–12:30  
E-beam Pumped Mid-ultraviolet Sources Based on AlGaN Multiple Quantum Wells Grown by MBE  
Xin Rong, S.V. Ivanov, V.N. Jmerik, V.I. Kozlovsky, and Aliaksei Vainikov  
1Institute of Solid State Physics, Russian Academy of Sciences, Russia, 2Ioffe Physical-Technical Institute, Russia
We report on the development of e-beam pumped mid-UV (~ 280nm) sources fabricated from AlGaN MQWs grown by plasma-assisted (PA) MBE on AlN/AInN templates. The high output power above 100 mW has been demonstrated in a pulse-scanning regime. This achievement is attributed to the enhanced carrier confinement within the high-quality sub-mono-layer digital alloying quantum wells and improved quality of the AlN buffer layer due to the high temperature PA MBE growth employed. The time-resolved photoluminescence shows the radiative recombination dominate the recombination process, indicating high crystal qualities.
[27I1-1] 11:00~11:30 Invited Talk

Photonics beyond Multiple Light Scattering
Wonshik Choi
Korea University, Korea
I will introduce an experimental method that makes use of multiple-scattered waves for performing optical imaging and enhancing light energy delivery through scattering media.

[27I1-2] 11:30~11:45
A Portable Grating-Based Spectrometer for Plasmonic Biosensing Applications
Shu-Cheng Lo¹, En-Hung Lin², Pei-Kuen Wei², and Wan-Shao Tsai¹
¹National Chi Nan University, Taiwan, ²Academia Sinica, Taiwan
A portable grating-based spectrometer for plasmonic biosensing is presented. Spectral resolution on the order of nm is achieved within wavelength range 628-640 nm. The spectrometer shows good sensitivity response by testing the biosensor with glycerin solutions.

[27I1-3] 11:45~12:00
Molecular Range Light Confinement of Metal-Air-Metal Structure for Biosensor Applications
Jaehak Lee¹, Sangkeun Song¹, and Jung H. Shin¹
¹KAIST, Korea, ²Korea Institute of Machinery and Materials, Korea
We report on an MIM-type plasmonic resonator with a 4-nm slot. The gap was defined using selfaligned deposition using conventional photolithography. The structure shows great promise for a biosensor, with 12 nm/nm surface sensitivity at least.

[27I1-4] 12:00~12:15
Disorder Effect on Broad-angle Reflection from Morpho-inspired Structures
Bokwang Song, Seok Chan Eom, and Jung H. Shin
KAIST, Korea
We investigate the effect of disorder on broad-angle reflection from Morpho-inspired structures. And we also propose Morpho-inspired structures applying gratting diffraction to fully reproduce the reflection of Morpho butterflies.

[27I1-5] 12:15~12:30
Three Dimensional Optical Manipulation on a Lap-on-a chip Device through Standing Wave
Jisu Kim and Jung H. Shin
KAIST, Korea
We propose and demonstrate optical manipulation in three dimensional space through standing wave. FEM simulations suggest a capability of trapping 1 µm particle at room temperature, and stationary trapping by counter propagating beams is achieved.

[27J1-1] 11:00~11:30 Invited Talk

Narrow Linewidth Tunable Lasers for Digital Coherent System
Toshikazu Mukaihara, Toshio Kimura, and Hiroyuki Koshi
Furukawa Electric, Japan
We describe µ-ITLA characteristics with DFB/CSR laser array based narrow linewidth tunable laser. We also introduce ITXA of a co-packaged DFB array based laser and InP-based modulator for metro digital coherent application.

[27J1-2] 11:30~11:45
Microring-based Tunable Optical Delay Lines for Optical Time-division Multiplexers
Zhihua Yu¹, Xin Jin², Jun Chen³, Qiaotong Wang⁴, and David R. Selviah⁵
¹China University of Geosciences, China, ²University College London, UK
Microring-based tunable optical delay lines are proposed to construct an optical time division multiplexer (OTDM) system, with which, we can get ultrahigh bit rates with several low-speed channels.

[27J1-3] 11:45~12:00
Dielectric-Loaded Magnetic and Nonmagnetic Plasmonic Waveguides on SOI Wafer
Terunori Kaihara and Hiromasa Shimizu
Tokyo University of Agriculture and Technology, Japan
Propagation characteristics of magnetic and nonmagnetic plasmon waveguides using Au and Fe have been studied. The devices are theoretically optimized and fabricated on a SOI substrate. The transmission characteristics are investigated on those waveguides.

[27J1-4] 12:00~12:15
Design of Optical Isolators Utilizing Directional Coupling within Asymmetric Waveguides
Masashi Hosoda, Jo Sato, Daniel Wahl, Takaya Sato, and Hiromasa Shimizu
Tokyo University of Agriculture and Technology, Japan
We designed magneto-optic waveguide isolators based on the nonreciprocal coupling by the coupled mode theory. Optical isolation over 40 dB was estimated with the waveguide length of 700 µm.
[27A2-2] 16:15~16:30
Mid-IR Supercontinuum Generation in ZBLAN Fiber Pumped by Diode-Seeded Tm-Doped MOPA
Hongxing Shi, Kun Liu, Fangzhou Tan, Jiang Liu, and Pu Wang
Beijing University of Technology, China
We demonstrate 22 W average power mid-IR supercontinuum (1900nm-3600nm) generations in a single mode ZBLAN fiber pumped by nanosecond pulses from diode-seeded Tm-Doped MOPA.

[27A2-3] 16:30~16:45
Handedness Control of Sub-MilliJoule Mid-Infrared (6-12μm) Vortex Laser
Jie Ma, Guoqiang Xie, Shi Rong Ping, and Liejia Qian
Nanyang Technological University, China
We demonstrate a hand-matched control of a 6-12 μm optical vortex output from an optical vortex parametric oscillator formed by a 1-μm vortex pumped KTP, optical parametric oscillator with a ZnTeP, frequency difference generator.

[27A2-4] 16:45~17:00
Room Temperature High Energy High Efficient Fe+:ZnSe Laser
Changjun Xu, Ran Wang, Zhiling Li, and Yinh Yang
Chinese Academy of Sciences, China
The characteristics of a room-temperature Fe+:ZnSe laser based on a polycrystalline sample pumped by a non-chain HF laser were studied. The Fe+:ZnSe laser energy is E = 15 μJ at the efficiency with respect to the absorbed HF laser energy, η > 15%.

[27A2-5] 17:00~17:15
Intracavity-Pumped Ho:KLu(WO₄)₂, Microchip Laser at 2.1 μm
J. M. Serres1, X. Mateos2, P. Lloret2, K. Yumashev3, M. Kuleshov2, V. Petrov2, U. Grietener2, M. Aguell1, and F. Diaz2
1Universitat Rovira i Virgili, Spain, 2Belarusian National Technical University, Belarus, 3Max-Born Institute for Nonlinear Optics and Ultrashort Spectroscopy, Germany
Maximum output power of 285 mW is achieved at 2080 nm (Ho⁺ emission) with a slope efficiency of 8.3% in a compact intracavity-pumped microchip Ho: laser using stacked Ho:KLu(WO₄)₂:Zn, Nd:YAG crystals.

[27A2-6] 17:15~17:30
Passively Mode-Locked Mid-Infared Solid-State Laser
Lingchen Kong1, 2, Jie Ma1, 3, Xingyu Shi1, 2, Ying Wu1, 2, Shuangyi Chen1, 2, Junhua Liu1, 2, and Chao Li1, 2
1Shanghai Jiao Tong University, China, 2Nanyang Technological University, China, 3Beijing University of Technology, China
Passively mode-locked lasers provide a convenient way to generate ultrafast laser pulses with high peak power. In this report, we introduce the progress of passively mode-locked mid-infrared solid-state lasers at 2 μm region in our laboratory.

[27A2-7] 17:30~17:45
Experimental Investigation of 2.8 μm Er³⁺-Doped ZBLAN Fiber Lasers
Hongwei Chen, Yanfeng Shen, Ke Huang, Kuizeng Luan, Li Yu, Aiping Yi, and Godin Feng
Northwest Institute of Nuclear Technology, China
In this presentation, we reported the recent progress on 2.8 μm Er³⁺-doped ZBLAN fiber laser in our research group. Terawatt-level CW, watt-level passively Q-switched and 122-mm tunable mid-infrared fiber lasers have been demonstrated.

[27B2-1] 15:45~16:15 Invited Talk
Biomedical Science and Technology Using Terahertz Waves
Joo-Huk Son
University of Seoul, Korea
Various biomedical applications utilizing terahertz technology are presented. Technical challenges in such applications are discussed in terms of limited penetration depth, blurred spectral features, and deficient contrast and the feasible solutions to the problems are also suggested.

A Terahertz Technology for Label-free Immune Assay
Toshikiko Kawa, Masahiro Ogawa, Kosuke Akimune, Hiroyuki Akimune, Kenji Sakai, and Keiji Tsukada
Okayama University, Japan
This paper reviews recent works of label-free immune assay using terahertz technology, which includes a terahertz chemical microscopy. Experimental results of label-free detection of lectin-sugar chain reactions were also presented.

Ultrafast Spin Spectroscopy for Rare-earth Orthoferrites and Orthochromites by THz Pulses
Makoto Nekajima
Osaka University, Japan
Impulsive excitation of terahertz magnetic field induces spin precession motions and the spin dynamics are probed. The results of temperature dependence in SrFe₂O₄, and enhancement of spin precession amplitudes using metamaterial in ErFe₂O₄ is reported.

[27B2-4] 17:15~17:30
In Vivo Analysis of Immune Cell Motility After THz Wave Irradiation
Yoonha Hwang1, Jungho Mor1, Je Hyo An1, Sangyoun Ba1, Young Uk Jeong1, Nikolay A. Vinkovskii1, and Pilhan Kim1
1KAIST, Korea, 2KETRI, Korea
Cellular-level effects by THz wave irradiation on live animal were visualized by intravital laser-scanning confocal microscopy. Time-lapse imaging analysis revealed an acute inflammatory response induced by THz wave irradiation in vivo.

[27B2-5] 17:30~17:45
Simultaneously Detection Two Types of Ions Using THz Chemical Microscopy
Kosuke Akimune, Yuki Okawa, Kenji Sakai, Toshikiko Kawa, and Keiji Tsukada
Okayama University, Japan
THz chemical microscopy has been proposed and developed to detect ions in water solutions. In this work, the change in the amplitude of THz radiation was measured when ion solutions was dropped on detection plate.
### Conference Program & Abstracts
The 11th Conference on Lasers and Electro-Optics Pacific Rim

#### Room C (103)

<table>
<thead>
<tr>
<th>Session Title</th>
<th>Date &amp; Time</th>
<th>Session Chair</th>
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<tbody>
<tr>
<td><strong>[27C2-1]</strong> 15:45–16:15 <strong>Invited Talk</strong></td>
<td>Thursday, 27 August, 15:45 – 17:30</td>
<td>Ya Cheng (Shanghai Institute of Optics and Fine Mechanics, China)</td>
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<tr>
<td><strong>Measurement and Control of Optical Waves</strong></td>
<td></td>
<td>Kyung Taec Kim1,2, Kyungseung Kim1,2, and Chang Hee Nam1,3,4 1Institute for Basic Science, Korea, 2GIST, Korea, 3KAIST, Korea</td>
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<td>An arbitrary optical wavefront can be measured by adding a weak additional signal field in high harmonic experiments. The wavelength dependence of the signal field is investigated using the quantum path analysis.</td>
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<td><strong>[27C2-2]</strong> 16:15–16:30</td>
<td></td>
<td>Jing Jing, Xue Ke, Wei Peng, Hongming Tao, Zhijun Li, and Jielei Ni1,2 1Jilin University, China, 2Zhejiang University, China</td>
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<tr>
<td><strong>Gain Dynamics and Temporal Characteristics of Nitrogen Lasers Pumped by Circularly-polarized Femtosecond Laser Pulses</strong></td>
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<td>We experimentally investigate gain dynamics and temporal characteristics of a free-space nitrogen laser pumped by circularly-polarized femtosecond laser pulses based on the pump-probe scheme.</td>
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<tr>
<td><strong>[27C2-3]</strong> 16:30–16:45</td>
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<td>Takakazu Suzuki, Fumihiro Isi, Leo Fujii, Kenichi Hiroasa, and Fumihiko Kannari 1Keio University, Japan</td>
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<tr>
<td><strong>All-optical Single-shot Ultrafast 2D-burst Imaging Using a Linearly Frequency Chirped Pulse</strong></td>
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<td>We demonstrate a new scheme of spatially and temporally resolved all-optical wavelength-multiplexed imaging (STRAW) in the 4f configuration with a DOE and a band-pass filter. Using a frequency chirped pulse, we realize single-shot ultrafast imaging.</td>
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<td><strong>[27C2-4]</strong> 16:45–17:15 <strong>Invited Talk</strong></td>
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<td>Shang-Da Yang 1National Tsing Hua University, Taiwan</td>
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<tr>
<td><strong>Measurement and Synthesis of Ultrafast Scalar and Vectorial Optical Arbitrary Waveforms</strong></td>
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<td>The latest methods to simultaneously characterize and synthesize ultrafast optical arbitrary waveform in the scalar and vectorial regimes are reviewed.</td>
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<tr>
<td><strong>[27C2-5]</strong> 17:15–17:30</td>
<td></td>
<td>Juan Du, Zhan Xiong, Bing Kurl, Takayoshi Kobayashi, Yuanan Zhao, and Yuxin Leng 1Chinese Academy of Sciences, China, 2University of Electro-Communications, Japan</td>
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<tr>
<td><strong>Ultrafast Pre-damage Dynamics in Al2O3/SiO2 Reflector</strong></td>
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<td>Ultrashort reflectivity decrease due to free electron absorption and spectral shift due to generation of defect state in Al2O3/SiO2 UV reflector have been observed for the first time to the best of our knowledge.</td>
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#### Room D (106)

<table>
<thead>
<tr>
<th>Session Title</th>
<th>Date &amp; Time</th>
<th>Session Chair</th>
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<tbody>
<tr>
<td><strong>[27D2-1]</strong> 15:45–16:00</td>
<td>Thursday, 27 August, 15:45 – 17:00</td>
<td>Zee Hwan Kim (Seoul National University, Korea)</td>
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<tr>
<td><strong>Radiation Coupling Between Two Deformed Microcavities</strong></td>
<td></td>
<td>Fang-Jie Shu1, Chang-Ling Zou2, F-W. Sun3, and Wen-Cong Chen2</td>
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<td>1Shanghai Normal University, China, 2University of Science and Technology of China, China</td>
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<td>Strong and steady coupling between optical elements is important in integrated optical circuit. Through deforming the boundary of microcavities we construct a coupling system composed with two cavities. Then the characteristics of the system are studied.</td>
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<td><strong>[27D2-2]</strong> 16:00–16:15</td>
<td></td>
<td>Yasuhiko Arakawa 1The University of Tokyo, Japan</td>
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<tr>
<td><strong>Influence of the Relative Positions of Quantum Dots and Nanocavities on the Optical Coupling Strength</strong></td>
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<td>We use scanning electron microscopy to precisely measure the locations of quantum dots buried in photonic crystal nanocavities. We show that well-positioned dots (at the field maximum) can exhibit vacuum Rabi splittings larger than 160μeV.</td>
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<td><strong>[27D2-3]</strong> 16:15–16:30</td>
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<td>Sungkyunkwan University, Korea</td>
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<tr>
<td><strong>Enhanced Second-harmonic Generation Efficiency in a Waveguide-coupled Photonic Nanocavity</strong></td>
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<td>We investigate second-harmonic generation (SHG) efficiency in a waveguide-coupled photonic nanocavity. The factors for highly-efficient SHG are analyzed. It is found that 100% efficiency is achievable by introducing a mirror at the waveguide.</td>
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<td><strong>[27D2-4]</strong> 16:30–16:45</td>
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<td>Osaka University, Japan, 1Osaka University, Japan</td>
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<tr>
<td><strong>Ultra-Widely Tunable Nanofiber Bragg Cavities for Quantum Optics</strong></td>
<td></td>
<td>Andreas W. Schell1, 2, 3, Hideaki Takahama1, 2, Shinya Kamioka1, 2, Yasuo Oe1, 2, Shinjiro Fujita1, Masazumi Fujikawa1, 2, Oliver Benson1, and Shihoji Takeuchi1, 2, 2</td>
</tr>
<tr>
<td>1Kyoto University, Japan, 2Humboldt-Universitat Zu Berlin, Germany, 3Hokkaido University, Japan</td>
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<td>For efficient interfacing of quantum emitters nano- and microcavities are important tools. Here, we introduce Bragg cavities fabricated on nanofibers. We show strain-tuning of the cavity resonance and first coupling experiments with quantum emitters.</td>
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<tr>
<td><strong>[27D2-5]</strong> 16:45–17:00</td>
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<td>Hokkaido University, Japan, 1Hokkaido University, Japan</td>
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<tr>
<td><strong>Frequency Comb Generation in Green, Red and Infrared Region from AIN Microring Resonator</strong></td>
<td></td>
<td>We demonstrate optical frequency comb generation in visible and IR spectrum within a high Q aluminum nitride microcavity resonator. High resolution spectroscopic study of the comb indicates matched free spectral range over all the bands.</td>
</tr>
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**Session Title**: 27C2 / [T02] Characterization of Ultrashort Laser Pulses  
**Date & Time**: Thursday, 27 August, 15:45 – 17:00  
**Session Chair**: Ya Cheng (Shanghai Institute of Optics and Fine Mechanics, China)
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<thead>
<tr>
<th>Session Title</th>
<th>Date &amp; Time</th>
<th>Session Chair</th>
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<tr>
<td>Invited Talk</td>
<td>15:45~16:15</td>
<td>Dongseok Kim (POSTECH, Korea)</td>
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<td>Nondestructive Inspection of Fiber-glass-Reinforced Plastic Mortar Pipes Using Electro-Optic Sensors and Microwave Propagation</td>
<td>15:45~16:00</td>
<td>Hyoseong Sin (POSTECH, Korea)</td>
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<tr>
<td>Highly Stable Periodic Structures Using Nonlinear Laser Lithography</td>
<td>16:15~16:30</td>
<td>Hyunmin Yoon (POSTECH, Korea)</td>
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<tr>
<td>The Formation of Periodic Surface Structures on Ni-Fe Film Induced by Single Femtosecond Laser Pulse with Diffraction Rings</td>
<td>16:30~16:45</td>
<td>Can Zhou (POSTECH, Korea)</td>
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<td>Ultrafast Micromachining of Cu and Si at Ultra-high Repetition Rates with Pulse Bursts</td>
<td>16:45~17:00</td>
<td>Dongsik Kim (POSTECH, Korea)</td>
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<tr>
<td>Hybrid Manufacturing of Stainless Steel and Zirconia Micro Components Using Laser Micromachining and Powder Injection Molding</td>
<td>17:00~17:15</td>
<td>Dongsik Kim (POSTECH, Korea)</td>
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<td>Femtosecond Laser Machining of Transparent Materials at High Speed and Quality</td>
<td>17:15~17:30</td>
<td>Dongsik Kim (POSTECH, Korea)</td>
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<td>Optical Metrology and Sensing VIII</td>
<td>16:00~16:15</td>
<td>Haiyong Gan (National Institute of Metrology, China)</td>
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<tr>
<td>Optical Metrology and Sensing VIII</td>
<td>16:45~17:00</td>
<td>Haiyong Gan (National Institute of Metrology, China)</td>
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<tr>
<td>Optical Metrology and Sensing VIII</td>
<td>17:00~17:15</td>
<td>Haiyong Gan (National Institute of Metrology, China)</td>
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<tr>
<td>Optical Metrology and Sensing VIII</td>
<td>17:15~17:30</td>
<td>Haiyong Gan (National Institute of Metrology, China)</td>
</tr>
</tbody>
</table>
Quantum State Estimation and Discrimination
Shigeki Takeuchi
Kyoto University, Japan
Quantum state estimation and discrimination are important tasks not only for many quantum information protocols but also precise measurements. In this paper, we report our recent efforts on this issue. In the first part, we report adaptive quantum state estimation, which provides the most accurate estimation using an optimal measurement basis for each measurement. In the second part, we introduce quantum state data mining where the erroneous states (density matrices) are discriminated from the normal ones efficiently using machine learning method.

Advances in Photonic Remote Entanglement Sharing
Geoff J. Pryde
Griffith University, Australia
Remote entanglement sharing is a primitive for a range of quantum information science tasks and for fundamental studies of nonlocality. We experimentally demonstrate advances in performing secure, loss-tolerant entanglement sharing with photonic systems.

Quantum Teleportation of Two Different Types of Optical Hybrid Quibits Over a Lossy Environment
Hoyong Kim, Seung-Woo Lee, and Hyunseok Jeong
Seoul National University, Korea
Hybrid of photon-polarized states with coherent states and hybrid of vacuum and single-photon states with coherent states are compared for teleportation. We have shown that the latter is better than the former under photon losses.

Waveguide Logic Gates for Polarization Encoded Magneto-Optical Quibits
Shukhhat Egamber and Isibom Abdunazarov
Samarkand State University, Uzbekistan
Results of magneto-optical waveguide logic gates properties investigation are presented. Simple logic operations can be realized using photon properties in modulated magnetic field. Changing the magnetic field amplitude and its orientation relating to light propagation direction, choosing polarizer and analyzer orientation and proper waveguide geometry, we can design logic gates avoiding small coherence time of regular optic qubits.

Quantum Refractometer
Anna Pateresa,1 Dmitry Kalatsynok,1 Sergei KoAl,1 and Leonid Krivitsky1
1Agency for Science Technology and Research, Singapore, 2Lomonosov Moscow State University, Russia
We exploit interference of two Parametric Down Conversion (PDC) sources to observe infrared resonances of CO2. Frequency correlations of PDC enable determination of the refractive index at IR wavelengths with visible range optics and photodetectors.

Non-Maximal Polarization-Entangled Photons with Spectrally-Varying Non-Maximality
Mao Tong Liu1 and Han Chuen Lim1,2
1Nanyang Technological University, Singapore, 2DSO National Laboratories, Singapore
We pump two periodically-poled lithium niobate waveguides of different lengths in a Sagnac loop to produce photons with spectrally-varying non-maximal polarization entanglement for the first time. The desired non-maximality is selectable by optical wavelength filtering.

Polarimetric Characterization of Healthy and RF Ablated Myocardial Tissue
Rahbar Ahmad1,2, Adam GrifB, Alex Vélez2, and Masoru Nekan1
1Pakistan Institute of Engineering and Applied Sciences, Pakistan, 2University of Toronto, Canada
Polarization signatures of ex vivo healthy and RF ablated porcine hearts in backscattered geometry were explored through Mueller matrix polarimetry. Significant differences in depolarization and linear retardance values were observed between the healthy, ablated and rim regions.

Experimental Investigation of Timing Jitter of a 1.06-µm Gain-Switched Laser Diode for Stimulated Raman Scattering Microscopy
Kiyasu Takunaga1, Yi-Cheng Fang1, Yuta Kusama1, Hiroki Yokoyama1, and Yasuyuki Ochi1
1The University of Tokyo, Japan, 2Tohoku University, Japan
The timing jitter of 13-ps gain-switched laser diode pulses at 1.06 µm is measured to be 3.9 ps, which is further reduced by external injection. We successfully demonstrate stimulated Raman imaging using the pulses.

Identification of Amyloid Plaques in Mouse Brain Tissue Slides Using Quantitative Phase Imaging
Moosung Lee, Jae Hoong Jung, Eunjung Lee, Yong Jeong, and Yong Keun Park
KAIST, Korea
We demonstrate that quantitative phase imaging (QPI) can detect amyloid plaques in the brain of Alzheimer’s disease (AD). Comparing QPIs and fluorescence images from wildtype and AD mouse brains, we suggest that digital microscopic holography can be utilized for diagnosing AD.

Quantitative Characterisation of MPP+ Effects on Neurons Using 3-D Retractive Index Tomography
Su-A Yang, Jonghee Yoon, and Yong Keun Park
KAIST, Korea
Quantitative characterization of neurodegeneration in Parkinson’s disease-like model via 3-D refractive index (RI) tomogram measurements is presented. 3-D RI information enables quantification of neurodegenerative sequences, which provides insight on pathogenesis of neurodegeneration in Parkinson’s disease.

Dark-field Imaging Tracking of BSA Stabilized Gold Nanorods in Macrophage
Hui Yu1, Ken-Tye Yong2, and Junle Qu1
1Shenzhen University, China, 2Nanyang Technological University, Singapore
Bovine serum albumin (BSA) stabilized gold nanorods were fed to macrophages and tracked through dark-field imaging. Intracellular aggregation of the nanorods was observed before they were excreted from cells.
Manufacturing of Smartphone Based Real-time Cell Observation Microscope
Taemin Yoon and Kiyung Kim
Pusan National University, Korea
In this study, we designed microscope for real-time observation of the cells. This microscope uses a smartphone as detector. Therefore, we can observe in real time cells through the remote control of smartphone.
**Room A (101)**

**Session Title**: 28A1 / (T01) Fiber-based Sources  
**Date & Time**: Friday, 28 August, 09:00 – 10:15  
**Session Chair**: Kwanil Lee (KIST, Korea)

**[28A1-1] 09:00–09:15**  
**Formation Sequences of Noise-Like Pulse in Fiber Ring Cavity Configuration and Their Effect on the Partial Coherence**  
Seunghyoon Lee, Luis Alonso Vazquez-Zuniga, Youngchul Kwon, Hared Xun, Dongyul Lee, and Yeonchan Jeong  
Seoul National University, Korea  
We experimentally investigate the partially coherent nature of noise-like pulses (NLPs) generated from passively mode-locked fiber ring cavity, and emphasize that the coherence of NLPs can be completely different, depending on the NLP formation sequence.

**Widely-Tunable Single-Frequency Yb-Doped Fiber Ring Laser**  
Hou Yunbin, Wang Jing, Zhang Qian, Li Jiajun, and Wang Pu  
Beijing University of Technology, China  
We report a widely-tunable single-frequency fiber ring laser based on a loop mirror filter and a tunable filter with a wavelength tunable range of 17.5 nm and a linewidth of less than 2 kHz.

**[28A1-3] 09:30–09:45**  
**On the Efficiency of Self-Similar Pulse Evolution in Fiber Amplifiers with Gain Shaping**  
Sijia Wang¹, Lei Wang², Bowen Li³, Youjian Song¹, and Mingfei Hu¹  
¹China Academy of Space Technology, China, ²Tianjin University, China, ³Shanghai Jiao Tong University, China  
Influences of initial pulse parameters on self-similar evolution efficiency in fiber amplifiers with gain shaping are discussed. Optimal center wavelength, duration, negative chirp and triangular profile can minimize the gain-shaping disturbance and accelerate self-similar amplification.

**[28A1-4] 09:45–10:00**  
**CW High Power Dual Wavelength Switching in an Ytterbium Doped Coupled Cavity Fiber Laser**  
W. J. Li and L. Wang  
Nanyang Technological University, Singapore  
We demonstrate CW dual wavelength switching in an Ytterbium doped coupled cavity fiber laser by changing the direction and power of the pump. Slope efficiencies of > 70% and output power of > 100W have been achieved.

**[28A1-5] 10:00–10:15**  
**Experimental Investigation on Laser Performance of Distributed Side-Pumping Fiber Amplifier**  
Cong Gao, Li N, Xiaodong Wang, Xueming Wang, Zhen Wang, Kun Peng, Zhunhua Huang, Jianjun Wang, Peng Jing, and Aoxiang Lin  
Chinese Academy of Sciences, China  
1+1 type distributed-side pumping active fibers were fabricated. Pumped with 976 nm LD, over 1 kW output power was achieved at 1064 nm and 591 W power was launched into the coupling unit via one port.

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**Room B (102)**

**Session Title**: 28B1 / (T03) Terahertz Technologies and Applications III  
**Date & Time**: Friday, 28 August, 09:00 – 10:30  
**Session Chair**: Toshihiko Kiwa (Okayama University, Japan)

**[28B1-1] 09:00–09:30**  
**Efficient Broadband THz Wave Generation Based on Organic Phenolic Electro-Optic Crystals**  
D-Pi Kwon, Seung-Heon Lee, Dong-Joo Kang, and Fabian Rotermund  
Apu University, Korea  
Highly efficient broadband THz wave generation based on electro-optic phenolic molecular crystals are reviewed. As-grown phenolic quinolinium crystals exhibited large macroscopic nonlinearity and suitable crystal characteristics for THz wave generation.

**[28B1-2] 09:30–10:00**  
**Novel THz-wave Detection Technique via Interaction between Optical Pumping Waves and THz-wave Generated by Cherenkov Phase Matching**  
Koji Suzu¹, Naoya Kaneko², Takuya Akiba², Seungho Kim², and Takashige Omatsu²  
¹Chiba Institute of Technology, Japan, ²Chiba University, Japan  
THz-wave and optical waves in nonlinear optical process are strongly correlated. Thus, THz-wave information can be transferred to pump and signal wave. THz-wave generated by Cherenkov phase matching can be used as evanescent/probe at interface facet of the crystal. Phase shift and attenuation of reflected THz-wave has information of a sample set at the interface, so the information can be detected by optical analysis for pump and signal wave.

**[28B1-3] 10:00–10:15**  
**Polarization Independent and Optical-controlled Metamaterial Modulator in Terahertz Regime**  
Yang Bai and Kejian Chen  
University of Shanghai for Science and Technology, China  
We demonstrated a polarization independent and optical-controlled terahertz wave modulator based on hybrid metamaterials. Experimental validations confirm an intensity modulation depth more than 90% by changing the pump power between 0 and 2.5 W, spanning 0.45–0.85 THz.

**Broadband THz Vortex Pulse Generation by a Tsurupica Spiral Phase Plate**  
Katsuhiko Miyamoto¹, Bong-Joo Kang², Won-Tae Kwon², Fabian Rotermund², and Takashige Omatsu²  
¹Chiba University, Japan, ²Apu University, Korea  
We demonstrated a broadband, highly intense 0.6-terahertz vortex pulse by utilizing a polymeric Tsurupica spiral phase plate.
The 11th Conference on Lasers and Electro-Optics Pacific Rim
Busan, Korea / August 24 - 28, 2015

**Room C (103)**

**Session Title** 28C1 / [T02] Nonlinear Optics

**Date & Time** Friday, 28 August, 09:00 – 10:30

**Session Chair** Dong-il Yeom (Ajou University, Korea)

### [28C1-1] 09:00–09:15

**Second Harmonic Generation and Shaping of Contra-propagating Light Pulses in Negatively Dispersive Metamaterials**

Alexander Pape1,2, Sergey Mysyrov1, Alexander Kildishev1, and Alexander Kosturkevich1

1Purdue University, USA, 2Siberian Federal University, Russia, 3University of New Mexico, USA

The possibility of great enhancement of short pulse second harmonic generation by employing phase matching of ordinary and backward electromagnetic waves in the metamaterials with mixed negative/positive spatial dispersion is demonstrated with numerical simulations.

### [28C1-2] 09:15–09:30

**Second-harmonic Generation of Near Ultraviolet Wavelength by Surface Nonlinearity Polarization**

Jinhui Yuan1,2,3, Xinhui Tang1, Xiaoting Zhang1, Zhe Kang1,2, Feng Li1,3, Chonglei Yu1, and P. K. Alexander Wai1

1Beijing University of Posts and Telecommunications, China, 2The Hong Kong Polytechnic University, Hong Kong

Second-harmonic generation of near ultraviolet wavelength by the surface nonlinearity is experimentally demonstrated in a silica photonic crystal fiber. The maximum conversion efficiency of second-harmonic centered at 410 nm can be up to 1.6×10⁻⁶.

### [28C1-3] 09:30–09:45

**Analysis on Morphological Domain Changes at the Hexagonal Corner of MgO:SLN Crystals**

Ju Won Choi1,2,3, Gyu Hyo Kim4,5,6, and Jung Hoon Ro7

1,2KIST, Korea, 3Pusan National University, Korea

We report improved thermal performance in the heat removal module for stable wavelength conversion efficiency of second-harmonic centered at 410 nm can be up to 1.6×10⁻⁶.

### [28C1-4] 09:45–10:00

**Heat-Removal Wavelength-Conversion Module by Air-bubble Reduction**

Masanobu Nonaka1,2,3, Wataru Nogashima1,2, Hwan Hong Lim1,2, Sunao Kurimura1,2, and Ichiro Shoji1

1,2National Institute for Materials Science, Japan, 3Chuo University, Japan

We report improved thermal performance in the heat removal module for stable wavelength conversion, fabricated by a new method, air-bubble reduction. The quantitative relation between focusing position, normalized conversion efficiency and effective heat capacity is investigated.

### [28C1-5] 10:00–10:15

**Multi-component Chalcogenide Glasses for Mid-infrared Nonlinear Optics**

T. Wang1, K. Khamma2, C. Smith1, W. Chen1, G. F. R. Chen1, A. M. Agarwal2, K. A. Richardson1, and D. T. H. Tan1

1Singapore University of Technology and Design, Singapore, 2University of Central Florida, USA, 3National University of Singapore, Singapore, 4Massachusetts Institute of Technology, USA, 5Chinese Academy of Sciences, China

We report here a series of 2-scan experiments of the third-order nonlinearity of three typical chalcogenide glasses (As₂S₃, As₂Se₃, and Ge₂Sb₂S₆) from the near-infrared to mid-IR wavelengths for the first time. This work measured the n2 values of As₂S₃ at 1.3×10⁻¹⁰ cm²/W and of Ge₂Sb₂S₆ to be 6.75×10⁻¹⁰ cm²/W at the wavelengths of 2600 nm.

### [28C1-6] 10:15–10:30

**Improved Sellmeier Equations of Undoped and Mg-doped Stoichiometric LiNbO₃ and LiTaO₃ from Visible to Mid-IR Region**

Dai Kato1,2, Syota Nak1, Daisuke Gunji1, Tatsuo Fukuda1, Yasunori Funakawa1, and Ichiro Shoji1

1Chuo University, Japan, 2IXDE Corporation, Japan

We have succeeded in deriving accurate and simple Sellmeier equations for stoichiometric LiNbO₃ and LiTaO₃, available from visible to mid-IR region, based on the direct measurements of refractive indices and previously reported OPO experiments.

**Room D (106)**

**Session Title** 28D1 / [T04] High Power, High Energy Lasers II

**Date & Time** Friday, 28 August, 09:00 – 10:00

**Session Chair** Yong-Ho Cha (KAERI, Korea)

### [28D1-1] 09:00–09:15

**Particle Acceleration with Laser and Applications**

Kazu-Fatema Kakke1, Domenico Dona2, and Marco Borghesi1

1GIST, Korea, 2Queen’s University, UK

The biological effectiveness of laser driven protons on cells at high dose rate in a single exposure has been studied. V79 cell lines were irradiated with laser driven protons.

### [28D1-2] 09:15–09:30

**Capture and Loss of Electron by MeV Ions Penetrating through Liquid Spray: Formation of Negative Ion and Neutral Atom Beams**

Sangil Ter-Avetisyan1, M. Borghesi2, M. Schnürer3, J. Brägel1, S. Jeglaev3, and V. Tikhonchuk3

1ISS, Korea, 2GIST, Korea, 3The Queen’s University of Belfast, UK, 4Max Born Institute, Germany, 5University Bordeaux, France

Charge changing processes of MeV ions penetrating through liquid spray is confirmed to be an abundant source of various energetic negative ion and neutral atom beams. Its generic nature is demonstrated.
MoS2, Monolayers for Propagating Plasmon Emitter and Detector in Long Range
Hyun Seok Lee, Min Su Kim, Youngjo Jin, Gang Hee Han, Young Hee Lee, and Jeongyong Kim
Sungkyunkwan University, Korea
We used a hybrid configuration of monolayer MoS2 and silver nanowires to demonstrate the excitation of localized plasmons in doped, nanostructured graphene can enhance absorption in surrounding materials by tens of times.

Graphene Plasmonics for Light Trapping and Tunable Absorption Enhancement
Jianxi Zhang, Zhonghong Zhu, Wei Li, Xiaodong Yuan, and Shiqiao Qin
National University of Defense Technology, China
We propose the usage of graphene plasmonics for light trapping and show that the excitation of localized plasmons in doped, nanostructured graphene can enhance absorption in surrounding materials by tens of times.

Photoinduced Nonlinear Mixing of Terahertz Dipole Resonances in Graphene Metadevice
Chihun In1, Hyeon-Don Kim2, Bumki Min1, and Hyunyoung Choi1
1Yonsei University, Korea, 2KAIST, Korea
The plethora of nonlinear optical phenomena can offer an innovative route for developing subwavelength-scale optical components. Here, using graphene-integrated metadevices, nonlinear interaction between two electric dipole resonances is demonstrated by ultrastable terahertz spectroscopy.

Multimode Plasmonically Induced Transparency in Dual Coupled Graphene Ring Resonators
Kuixian Xia, Baigle Tang, Xiaosui Wang, and Jicheng Wang
Jiangnan University, China
The graphene-based multi-mode PIT device has been numerically investigated. The spectral response shows active control of the device through varying the Fermi energy of the graphene, which provides guideline for a compact high-performance PIT device.

Surface Plasmon Supermodes in Graphene Multilayers
Chenghui Qin, Bing Wang, and Peiwen Lu
Huazhong University of Science and Technology, China
We investigate the effective indices and mode profiles theoretically and reveal the forming mechanisms of the supermodes in graphene multilayers. Out-of-phase coupling supermode possess both the lowest propagation loss and shortest mode wavelength.
Using Travelling Wave Equations Simulation of 1550nm Mode Locked DBR Semiconductor Lasers

A. Çağlar Duman

10:00~10:15

very small index contrast. The linear polarization property of laser has been demonstrated. The directional
quasicrystal fabricated by all organic materials of holographic polymer dispersed liquid
Lasing emissions are obtained in a dye-doped two-dimensional Penrose photonic quasicrystal.

Dispersed Liquid Crystals

Lasing from Penrose Quasicrystal Made by Holographic polymer-Dispersed Liquid Crystals

D. Luo

South University of Science and Technology of China, China

Lasing emissions are obtained in a dye-doped two-dimensional Penrose photonic quasicrystal fabricated by all organic materials of holographic polymer dispersed liquid crystals. The linear polarization property of laser has been demonstrated. The directional dependence property of laser, whereas different directions of photonic quasicrystal correspond to different lasing spectra, was also studied. Our experiment showed that the lasing actions can be generated in two-dimensional Penrose photonic quasicrystal with even very small index contrast.

Simulations of 1550nm Mode Locked DBR Semiconductor Lasers Using Travelling Wave Equations

A. Çağlar Duman1 and B. Bülent Çakmak1,2

1Erzurum Technical University, Turkey, 2Atatürk University, Turkey

A distributed Bragg reflector (DBR) InGaAsP semiconductor laser with an absorber region was modelled using travelling wave equations. Thus, it was shown that optical pulses with ultrashort durations were obtained from a passively mode-locked laser.

Invited Talk

Novel Lasers in the Visible Spectral Range

Christian Kränkel1,2, Daniel-Timo Marzahl1, and Philip Werner Metz2

1Universität Hamburg, Germany, 2The Hamburg Centre for Ultrafast Imaging, Germany

We report on blue semiconductor laser pumped solid-state lasers doped with different rare earth ions with emission wavelengths in the visible spectral range. Highly efficient, tunable and pulsed lasers are presented.

Invited Talk

RIN of Hybrid Soliton Pulse Source with Sinusoidally Chirped Grating

Nuran Dogru and Erhan Ersoy

University of Gaziantep, Turkey

Hybrid soliton pulse source utilizing a sinusoidally chirped fiber Bragg grating (FBG) produces shorter pulses with and without noise than linearly chirped FBG as well as giving a RIN reduction at the fundamental frequency.

Invited Talk

Optofluidic Guiding Based on Plasmonic Absorption

Jiajia Chen and Zhiwen Kang

Sub-diffraction Limited Imaging Based on Plasmonic Silver Nanodot Arrays

Taehwang Son, Yongjin Oh, Wonju Lee, Heejin Yang, and Donghyun Kim

Yonsei University, Korea

Blocks of metallic nanodot arrays enable image deconvolution using localized near-fields. Under total internal reflection, J774 cells were imaged on silver nanodot arrays. Sub-diffraction limited resolution was achieved in the range of 100-150 nm.

Invited Talk

Real-time Single-molecule Co-immunoprecipitation Analyses Reveal Cancer-specific Ras Signaling Dynamics

Hyeon-Soo Chin1,2, Changhoon Lim1,2, Jin Young Ryu3, Hanki Lee4, Ji Young Yoo3, Taeyoon Kyung5, Changyong Hyeon3, Jin Young Ryu3, and Dae-Sik Lim1,2

1KIST, Korea, 2BioNanotechnology Research Center, Korea, 3Korea Institute for Advanced Study, Korea, 4Institute for Basic Science, Korea

The conventional co-immunoprecipitation provides static and qualitative information about protein-protein interactions. We report real-time imaging of coimmunoprecipitation process with single-molecule resolution, allowing for characterization of the native Ras proteins derived from individual cancers.
Video-rate Color Holographic Displays Using Doped Liquid Crystals
Yikai Su, Xiao Li, Pengcheng Zhou, Yan Li, and Chaoping Chen
Shanghai Jiao Tong University, China
Real-time holographic displays are achieved with dyedoped and quantum-dot doped liquid crystals. Reconstructed holographic videos at a refresh rate of 60 Hz are demonstrated by experiments with color multiplying capability.

3D Color Holographic Imaging by Wavefront Printing
Hoonjong Kang1, Elena Stoykova2, Youngmin Kim1, Sunhee Hong1, Jooop Park1, and Jisoo Hong1
1Korea Electronics Technology Institute, Korea, 2Bulgarian Academy of Sciences, Bulgaria
Design and implementation of a holographic wavefront printer with demagnification of the object beam is presented. The printer prints a white light viewable color analog hologram from a set of computer generated holograms displayed on an amplitude spatial-light modulator. We achieved bright 3D reconstruction with a motion parallax at saturated colors from holograms of test objects that were printed on a silver-halide emulsion.

Full-color 13-inch Electronic Holographic Display with 16.5 Megapixels
Wooshin Moon1, Hee Kim1, and Jookyu Hahn1
1Kyungpook National University, Korea, 2Korea Electronics Technology Institute, Korea
We propose a high-resolution electronic holographic system with eight high resolution liquid crystals. We use two large parabolic mirrors where one is for the collimation and the other is for focusing on the viewing window.

RGB Emitters by Optical Parametric Generation Using Nonlinear Waveguide
Hwan Hong Lim, Sunao Kurimura, and Kazufumi Fujii
National Institute for Materials Science, Japan
We demonstrated RGB laser sources by optical parametric-generation using first-order quasi-phase-matched adhered slab waveguides with a periodically-poled Mg-doped stoichiometric lithium tantalate core. We also examined the extensible spectral bandwidth by chirped periods against speckle with simulation.
Room A (101)

**Session Title** 28A2 / [T01] Mid-IR OPOs & High-Power Fiber Lasers

**Date & Time** Friday, 28 August, 11:00 – 12:30

**Session Chair** Yoonchan Jeong (Seoul National University, Korea)

**28A2-1** 11:00–11:30 **Invited Talk**

Progress in 1-µm Pumped Mid-IR Optical Parametric Oscillators Based on Non-Oxide Nonlinear Crystals

Valentin Petrov
Max Born Institute, Germany

This talk reviews recent developments in singly-resonant optical parametric oscillators based on wide band-gap nonoxide nonlinear crystals pumped near 1 µm for generation of high energy and average power mid-IR (3-10 µm) pulses.

**28A2-2** 11:30–11:45

Single-End Pumped 2 kW All-Fiber Integrated Laser Oscillator with Near Diffraction Beam Quality

Xiaolin Wang, Jingong Leng, Pu Zhou, Hanwei Zhang, Haolong Yu, Rumao Tao, Rongtao Su, and Xiaojun Xu
National University of Defense Technology, China

We report a monolithic laser oscillator with record power of 2 kW employing all-fiber format and single-end-pump configuration. The optical to optical efficiency is 68.9% and beam quality $M^2$ factor is about 1.3.

**28A2-3** 11:45–12:00

Generation of 1.2-nJ, 62-fs, Chirp-Free Pulses Directly from a Yb-Doped Fiber Oscillator

Tesfay G. Teamir and F. Ömer Iday
Bilkent University, Turkey

1.2-nJ, 62-fs, linear-chirp-free pulses are generated directly from a mode-locked fiber oscillator through optimized interaction of second- and third-order dispersion with self-phase modulation.

**28A2-4** 12:00–12:15

Quasi-CW Yb Fiber Laser with 3 kW Peak Power

Minjoo Jeon1, Yeji Jeong2, Hoou Jeong3, and J. W. Kim1
1Hanyang University, Korea; 2KITECH, Korea

We report on a 3 kW quasi-cw 16 fiber laser with a 10 ns pulse width and a 10 Hz repetition rate by combining two Yb fiber lasers with a 1.5 kW peak power.

**28A2-5** 12:15–12:30

174 W, Linearly-Polarized, Flat-Top, All-Fiber Pulsed MOPA Seeded by a DSR Fiber Oscillator

Haolong Yu, Habilix Lu, Pengfei Ma, Rumao Tao, Xiaolin Wang, and Pu Zhou
National University of Defense Technology, China

We demonstrate a single-polarization all-fiber pulsed MOPA producing flat-top pulses with average power of 174 W, pulse energy of 51 µJ and peak power of 38.5 kW, which is seeded by one dissipative soliton resonance (DSR) fiber oscillator.

Room B (102)

**Session Title** 28B2 / [T03] Terahertz Technologies and Applications IV

**Date & Time** Friday, 28 August, 11:00 – 12:15

**Session Chair** O-Pil Kwon (Ajou University, Korea)

**28B2-1** 11:00–11:30 **Invited Talk**

THz Spectroscopic Analysis of Transparent Conductive Silver Nanowire Films

Hyeyeong Ahn
National Chiao-Tung University, Taiwan

The influence of thermal heating and oxidation on the percolational characteristics of silver nanowire films is investigated through the comprehensive measurements of terahertz spectroscopy.

**28B2-2** 11:30–12:00 **Invited Talk**

Terahertz Response of Electron Charge and Spin Studied by Time-domain Spectroscopy

Takeshi Nagashima
Setsunan University, Japan

THz time-domain spectroscopy is a powerful tool for investigating dynamics of electron charges and spins. Estimation of electrical properties of semiconductors and studies of coherent magnons in antiferromagnets are carried out by using THz-TDS.

**28B2-3** 12:00–12:15

Millimeter-Wave Antenna Using Metamaterial ELC Resonators on Electro-Optics Substrate

Ashif Aminulloh Fathnan1, Yusuf Nur Wijayanto1,2, Pamungkas Daud1, Dadin Mahmudin1, Atsushi Kanno2, and Tetsuya Kawanishi2
1Indonesian Institute of Science, Indonesia; 2National Institute of Information and Communications Technology, Japan

We propose and present millimeter-wave antennas using metamaterial ELC resonators on electro-optic substrates for wireless millimeter-wave receivers and optical modulators. Analysis for the antenna characteristics of the device are discussed at millimeter-wave frequency of 100GHz.
Session Title: 28C2 / [T09] Light Emitting Devices
Date & Time: Friday, 28 August, 11:00 – 12:30
Session Chair: Sergey Ivanov (Ioffe Physics and Technique Institute, Russia)
Tien-chang Lu (National Chiao Tung University, Taiwan)

[28C2-1] 11:00~11:30 Invited Talk
Growth of Semipolar GaN Substrates by Hydride Vapor Phase Epitaxy on Patterned Sapphire Substrate
Kazuyuki Takatomo, Takashi Inagaki, Naohito Okada, Kenji Ikeda, Hiroshi Furuya,
and Yasunori Hashimoto

[28C2-2] 11:30~12:00 Invited Talk
Extremely Low-resistivity and High-carrier-concentration Si-doped AlGaN with Low AlN Molar Fraction for Improvement of Wall Plug Efficiency of Nitride-based LED
Motoki Iwaya, Daikichi Naka, Kunhiro Takeda, Toru Sugiyama, Tetsuya Takeuchi,
Satoshi Kamiyama, and Isamu Akasaki

Jong Won Lee, Jun Hyuk Park, Dong Yeong Kim, Jungsub Kim, and E. Fred Schubert
POSTECH, Korea, Samsung Electronics, Korea, Rensselaer Polytechnic Institute, USA

Guo-Dong Hao, Manabu Taniguchi, Kouen Nakaya, and Shin-ichi Houe
National Institute of Information and Communications Technology, Japan

Session Title: 28D2 / [T10] Micro/Nanophotonics
Date & Time: Friday, 28 August, 11:00 – 12:00
Session Chair: Ki-Hun Jeong (KAIST, Korea)

[28D2-1] 11:00~11:30 Invited Talk
Single-mode Parity-time-symmetric Micro-ring Lasers
Mercedeh Khajavikhan, H. Hoodak, M. A. Miri, and D. Christodoulides
University of Central Florida, USA
Parity-time (PT) symmetry has been recently emerged as a new paradigm for mode management in micro-cavity lasers. Single-mode lasing is demonstrated in longitudinally and transversely multi-moded PT-symmetric micro-ring arrangements.

[28D2-2] 11:30~11:45 Particle Propulsion Using Higher Order Microfiber Modes
Maimaiti Aili, Viet Giang Tran, Marios Sergides, Ivan Gusachenko, and Sile Nic Chormaic
Okinawa Institute of Science and Technology Graduate University, Japan, University College Cork, Ireland
Propulsion of polystyrene particles in the evanescent field of the first group of higher order modes in an optical microfiber were studied. Higher speeds were observed for higher order mode propulsion than for fundamental mode.

[28D2-3] 11:45~12:00 FRET-mediated Wavelength Conversion for Enhanced Solar Cell Efficiency
Xi Ding and Yu-Chueh Hung
National Tsing Hua University, Taiwan
We report an efficient Förster resonance energy transfer (FRET) realized in biopolymer thin films. Via FRET, shorter wavelengths of solar light are down-shifted which may result in enhanced light absorption by Si solar cells.
Fiberized Plasmonic Fresnel Zone Plate for Wavelength Dependence Position Tunable Optical Trapping

Hyuntai Kim, Luis Alonso-Vazquez-Zungila, Jinseok Kim, Kyungyoon Park, Dangyeol Lee, Seungho Hong, and Yoonchan Jeong
Seoul National University, Korea
We propose a Fresnel metal plate on top of a fiber facet for wavelength-dependent position tunable optical trapping. We achieved a tunable trapping range of 10.79 μm among a wavelength shift of 505 nm.

Analysis of Plasmonic Mach-Zehnder Modulator with Metal Taper Structure Embedded in FTO-EO Polymer

Naoya Higo, Tomohiro Amemiya, Zichen Gu, Nobutaka Nishimiya, and Shigejiro Araki
Tokyo Institute of Technology, Japan
We analyzed a Mach-Zehnder plasmonic modulator with metal-insulator-metal structure embedded by the FunaniTiophene Chromophore. n-phase shift between two Mach-Zehnder arms can be obtained with a device length of 6.5 μm and the figure of merit of 3.1.

Gain-assisted Propagation of Surface Plasmons in Nanodisk Resonator

Genquai Han, Yan Li, and Jing Yan
Chongqing University, China
Gain medium is introduced into the nanodisk resonator to enable loss-negligible surface plasmon polariton propagation in near-infrared wavelengths, which benefits the applications of switches and lasers based on SPPs in the planar optoelectronic deeply integration.

Optical Properties of Metallic Nanocuboid Dimer Connected by Conductive Bridge

Mingsi Zhang, Yadong Li, Jiong Xun, and Qian Sun
Nankai University, China
When a conductive bridge is inserted into metallic dimer, the charge transfer and the bonding dimer plasmon mode can redshift and blueshift hundreds nanometers by shifting the bridge less than 50 nm, respectively.

Layered Semiconductor GeS: a Metamaterial With Extremely Low Refractive Index

Abdulrahman Oztrak and Rauf Suleymanli
1Marmara University, Turkey, 2Georgia Technical University, Turkey
Reflection and transmission optical spectra of layered semiconductor GeS are investigated. It is shown, that this semiconductor can be considered as natural metamaterial with extremely low n, n<0.14, refractive index in wide spectral region, μ=0.8-1.0 μm.

The Meaning of Enhancement in Hybrid Horizontal Slot Microdisk Whispering Gallery Mode Resonator with Gold Particles

Nabita Khirnova Dewi and Jung H. Shin
KAIST, Korea
Horizontal slot microdisk resonator attached with gold particles is simulated using FDTD resulting hotspot existence in the vicinity of gold. The field enhancement is detected, especially for diameter less than 8 μm.

Estimation of Refractive Index of Crystal Plate from Haidinger Fringes

Ryu Jun Yeol, Choi Hee Joil, Lee Chang Hwan, Jin Jongha, and Cha Myoungsik
1Pusan National University, Korea, 2Kirss, Korea, 3Kyung Hee University, Korea, 3POSCO, Korea, 3KRISS, Korea
We proposed and realized an accurate method for measuring the refractive index and physical thickness of a transparent wafer by analyzing the Haidinger fringes. Simply, we took transmitted Haidinger fringes caused by multiple reflections at the back and front surfaces of the wafer, which worked as a Fabry-Perot etalon. The refractive index was determined by analyzing the interferogram obtained in terms of an incidence angle at a single-shot. Based on the proposed method, the absolute value of the refractive index of a LiNbO3 wafer was estimated with an overall uncertainty of 10-3.

Cosine Apodization of In-Fiber Acousto-Optic Gratings for Sensing Application

Keaeng Jo Lee and Hyun Chul Park
1Kyung Hee University, Korea, 2POCG, Korea
We present a novel cosine-apodization scheme for optical fiber-based acousto-optic gratings. The technique is based on the modulation of coupling strength by the combination of fiber twist and input acoustic polarization.

Strain Characteristics of a Photonic Crystal Fiber with Two Birefringent Cores in the Sagnac Loop

Younggoo Chung and Khurrum Naeem
GIST, Korea
We experimentally investigated the strain sensing characteristics of two types of the high-birefringent two-core photonic crystal fibers (HB-TOPCF) in the Sagnac loop configuration using phase-monitoring method, where each elliptic core in a typical birefringent fiber independently forms a distinct Sagnac loop interferometer.

Radiation in 45-Degree tilted Fiber Bragg Gratings

Nai-Hoang Sun, Shih-Ching Lee, Yu-Wei Liu, Jung-Sheng Chiang, and Wen-Fung Liu
1Shou University, Taiwan, 2Feng Chia University, Taiwan
Surface-normal radiation of 45° tilted fiber gratings are fabricated and measured. A 3-minute exposure time of tilted FBGs can cause ~15 dB radiation efficiency, while a 1.5-minute exposure time can create the radiated efficiency of ~16.2 dB.
### Room G (201)

**Session Title**
28G2 / [T01] Optical Mode Control

**Date & Time**
Friday, 28 August, 11:00 – 12:15

**Session Chair**
Jiwon Kim (Hanyang University, Korea)

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<tr>
<td><strong>28G2-1</strong> 11:00–11:15</td>
<td>High Efficient Frequency Doubling of Optical Vortex</td>
<td>Room G (201)</td>
<td>Yuta Sasaki, Taximaiti Yusufu, Katsuhiko Miyamoto, and Takashige Omatsu. 1(^{1}), 2Chiba University, Japan; 2CREST Japan Science and Technology Agency, Japan.</td>
<td>We present the first demonstration of the ultrahighly efficient second harmonic generation of an optical vortex pulse. An optical-optical efficiency of &gt;70% frequency-doubled vortex output was obtained.</td>
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<td><strong>28G2-2</strong> 11:15–11:30</td>
<td>Transverse Mode Control of a Nd:YAG Laser Using an Acousto-Optic Modulator</td>
<td>Room G (201)</td>
<td>E. J. Park, D. J. Kim, and J. W. Kim. Hanyang University, Korea.</td>
<td>A simple technique to control the transverse beam profile employing an acousto-optic modulator in the secondary cavity of a solid state laser systems is reported.</td>
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<tr>
<td><strong>28G2-3</strong> 11:30–11:45</td>
<td>Conversion of Orbital Angular Momentum in Helical Long-Period Fiber Gratings</td>
<td>Room G (201)</td>
<td>Xiaoqiang Zhang and Anting Wang. University of Science and Technology of China, China.</td>
<td>In this paper, we use an UV-side exposure method to obtain a helical long-period fiber grating (H-LPG) which can generate and convert the optical vortices (OVs). The H-LPG is obtained by rotating fiber which is three layer during single-side UV exposure. The H-LPG is directly inscribed on the central layer of the ring-core-fiber (RCF). Using this fiber the order of the OVs can be adjusted efficiently and we can get higher order vortices easily.</td>
</tr>
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<td><strong>28G2-4</strong> 11:45–12:00</td>
<td>Coupled Multicore Fibers in the High Power Regime: Impact of Core Size Mismatch</td>
<td>Room G (201)</td>
<td>Henrik Tünnermann and Akira Shirakawa. University of Electro-Communications, Japan.</td>
<td>The impact of core diameter mismatch in multicore fibers in the context of the Kerr nonlinearity is analyzed. A mismatch decreases the stability of the even mode. The odd mode is unaffected.</td>
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<tr>
<td><strong>28G2-5</strong> 12:00–12:15</td>
<td>Passively Q-switched and Cylindrical Vector Fiber Laser</td>
<td>Room G (201)</td>
<td>Lin Zou, Yao Yao, and Jianlang Li. Chinese Academy of Sciences, China.</td>
<td>We demonstrated a passively Q-switched Yb-doped fiber laser that emitted azimuthally polarized pulse with high efficiency and high output power. The polarization discrimination mechanism by utilizing a single lens and a birefringent crystal was developed.</td>
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### Room H (202)

**Session Title**
28H2 / [T11] In vivo and In vitro Methods

**Date & Time**
Friday, 28 August, 11:00 – 12:30

**Session Chair**
Shi-Wei Chu (National Taiwan University, Taiwan)

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<tr>
<td><strong>28H2-1</strong> 11:00–11:30</td>
<td>In Vivo Multiphoton Imaging of Mouse Brain</td>
<td>Room H (202)</td>
<td>Chris Xu. Cornell University, USA.</td>
<td>3-photon microscopy at the long wavelength spectral windows is well suited for deep imaging within scattering biological tissues. In vivo 3-photon imaging of neuronal structure and function deep within an intact mouse brain is presented.</td>
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<td><strong>28H2-2</strong> 11:30–12:00</td>
<td>Intravascular Photoacoustic Tomography for Characterization of Atherosclerotic Lipid and Inflammation</td>
<td>Room H (202)</td>
<td>Sihua Yang, Jian Zhang, Yue Zhao and Da Xing. South China Normal University, China.</td>
<td>This study sought to examine whether intravascular photoacoustic tomography (IVPAT) allows localization and quantification of lipid content in atherosclerotic plaques.</td>
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<td><strong>28H2-3</strong> 12:00–12:15</td>
<td>Seeing an Explosive Way of NSF/SNAP-mediated SNARE-complex Disassembly Using Single-molecule Measurements</td>
<td>Room H (202)</td>
<td>Je-Kyung Ryu, Duoyung Min, Sang-Hyun Rah, Haesoo Kim, Reinhard Jahn, and Tae-Young Yoo. KAIST, Korea; Max-Planck-Institute for Biophysical Chemistry, Germany.</td>
<td>N-ethylmaleimide-sensitive factor (NSF) and alpha soluble NSF attachment protein (α-SNAP) disassemble the SNAP receptor (SNARE) complex for recycling of the SNARE proteins. Using single-molecule fluorescence and force spectroscopy, we found that NSF appears to use a “spring-loaded” mechanism.</td>
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<td><strong>28H2-4</strong> 12:15–12:30</td>
<td>In-fiber Photo-immobilized Bioactive Surfaces for Liposome Tethering</td>
<td>Room H (202)</td>
<td>Derrick Yong, Elizabeth Lee, Kwang Yong Lee, Yi Yang Tan, Xia Yu, Chi Chiu Chan, Quan Liu, and Chenjie Xu. Singapore Institute of Manufacturing Technology, Singapore; Nanyang Technological University, Singapore.</td>
<td>The in-fiber surface-attachment of dye-loaded liposomes is demonstrated. This was achieved via in-fiber light-induced biotin-functionalization, enabling the subsequent sandwiching of streptavidin with biotinylated-liposomes. Liposomes were then probed through in-fiber fluorescence spectroscopy.</td>
</tr>
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Room I (203)

**Session Title**
28I2 / [T13] Optical Storage and Information Processing

**Date & Time**
Friday, 28 August, 11:00 – 12:15

**Session Chairs**
Hoonjong Kang (KETI, Korea)
Jae-Hyeung Park (Inha University, Korea)

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**[28I2-1] 11:00~11:30 Invited Talk**

Encryption and Data Embedding of Error Diffusion Hologram

Peter Tsang
City University of Hong Kong, Hong Kong, China

A fast method for converting a complex hologram into an encrypted data embedded phase-only hologram (POH) is described. Both the hologram and the embedded data can only be retrieved with the correct encryption key.

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**[28I2-2] 11:30~11:45**

Optical Beam and Operator in Low Dimensional Space

Shifeng Li, Gang Zhao, Yiqiang Qin, Xinjie Lv, and Shining Zhu
Nanjing University, China

The concept of low dimensional optical beam and operator are proposed. Beam and operator can be decomposed to orthogonal low dimensional beams and operators through the singular value decomposition method. Storage space can be saved.

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**[28I2-3] 11:45~12:00**

Simultaneous 10 Gbit/s 4-PAM Wired Signal and 1 Gbit/s MB-UWB Wireless Signal Downstream Transport in WDM-PON

Huan Ma, Wei Wang, Weibin Wang, Xin Zhang, and Qiong Yu
Chongqing University of Technology, China

Simultaneously transport multi-band ultra-wideband (MB-UWB) wireless signal and multi-level wired signal over single wavelength in wavelength-division multiplexing passive optical network (WDM-PON) is proposed, which can greatly improve spectrum efficiency and transmission ability of optical infrastructure.

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**[28I2-4] 12:00~12:15**

Wavelets for Multiview Imaging

Vladimir Saveljev,1,2
1Hanyang University, Korea, 2KIST, Korea

Considering the previously proposed reference functions for multiview and integral images as scaling functions of a wavelet transform, the multiview wavelets are proposed.

Room J (204)

**Session Title**

**Date & Time**
Friday, 28 August, 11:00 – 12:30

**Session Chairs**
David Marpaung (University Sydney, Australia)
Min-cheol Oh (Pusan National University, Korea)

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**[28J2-1] 11:00~11:30 Invited Talk**

A Fully Analog Electronic Dispersion Compensator for 10-Gb/s Directly Modulated Distributed-Feedback Lasers

Kyeongha Kwon, Jonghyeok Yoon, Hyosup Won, and Hyeon-Min Bae
KAIST, Korea

This paper presents the design of an electronic dispersion compensator (EDC) for 10-Gb/s directly modulated distributed-feedback (DM-DFB) lasers. The proposed EDC overcomes the chirp-induced dispersion and achieves 2x reach extension in SMF-28 optical fiber.

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**[28J2-2] 11:30~11:45**

Room-temperature Continuous-wave Operation of $\lambda/4$-shifted Membrane Distributed Feedback Lasers

Takahiro Tomiyasu, Daisuke Inoue, Takuo Hiratani, Yuki Atsuji, Tomohiro Amano, Masanobu Nakamura, and Shigehisa Arai
Tokyo Institute of Technology, Japan

We realized $\lambda/4$-shifted membrane DFB lasers for an ultralow threshold current operation. A threshold current of 280 µA was obtained for the cavity length of 30 µm under room-temperature continuous-wave condition.

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**[28J2-3] 11:45~12:00**

A Sub-microwatt Threshold Raman Silicon Laser Using a High-Q Nanocavity

Daiki Yamashita,1, Yasushi Takahashi,1, Takashi Asano,2 and Susumu Noda2
1Osaka Prefecture University, Japan, 2Kyoto University, Japan

We develop a nanocavity Raman Si laser with a submicrowatt threshold of 0.52 µW by accurately matching a frequency spacing of the two nanocavity modes to the Raman shift of Si nanocavity.

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**[28J2-4] 12:00~12:15**


Yi-Chia Hwang, Jen-Hung Huang, Bai-Wei Chen, Yao-Zhong Dong, Shun-Chieh Hsu, and Chien-Chung Lin
National Chiao Tung University, Taiwan

The peak frequency stability in the time domain is examined in the monolithic and discrete component conditions. The PFI peak drift is two times less in the monolithic case than that of the discrete component.

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**[28J2-5] 12:15~12:30**

Cut-off Frequency Enhancement of Light-Emitting Transistor under Illumination

Shan Fong Leong, Yuan-Fu Hsu, and Chao-Hsin Wu
National Taiwan University, Taiwan

A monolithic-integrated device with light-emitter and photodetector in light-emitting transistor (LET) format is fabricated. The electrical speed, i.e. cut-off frequency, of the LET is found to be modulated and enhanced by the selfaligned optical input.
[26P-1] Q-Switching of Yb:KLu(WO₄)₂ Lasers with Graphene Saturable Absorbers
University of Würzburg, Spain, 2Belarusian National Technical University, Belarus, 3Max-Born Institute for Nonlinear Optics and Ultrafast Spectroscopy, Germany
A diode-pumped Q-switched Yb:KLu(WO₄)₂ mini-laser generated a maximum average output power of 170 mW at 1030 nm. The shortest pulse duration was 165 ns at a pulse repetition rate of 350 kHz.

[26P-2] Halide Gas-Phase-Doping Technique to Fabricate Large-Mode-Area Fiber Laser
Kun Peng, Huanyi Wang, Li N., Zhen Wang, Cong Gao, Huan Zhai, Jianjun Wang, Feng Jing, and Aoxian Lin
China University of Engineering Physics, China, 2Chinese Academy of Sciences, China
We by using rare-earth-halide gas-phase-doping technique, we fabricated Yb-doped large-mode-area fiber. Yb concentration is of ~9500ppmw in core area and 951W@1064nm laser output was obtained with a slope efficiency of 83.3%.

Ziye Gao, Jianfeng Zhu, Junli Wang, and Zhiyi Wei
Villan University, China, 2Chinese Academy of Sciences, China
We experimentally demonstrated a diode-pumped pure Kerr-lens mode-locked femtosecond laser based on a Yb:YAG ceramic. Pulses with 97 fs pulse width, 2.8 nJ pulse energy and 320 MHz average power were obtained.

Václav Kubětka, Mislav Jelenek, Miroslav Čech, David Vyhlídal, Jiří Slíž, Dapeng Jiang, Fengkai Mu, Qian Zhang, Yong Soo Lee, and Jun Xu
1Czech Technical University in Prague, Czech Republic, 2Chinese Academy of Sciences, China
Passively-mode-locked operation of Nd:YSF₅ laser pumped by low-power-laser diode at 796 nm is reported. The continuous pulse train with total output power of 100 mW and pulse duration of 1.5 ps at 136 MHz was generated.

[26P-5] Numerical Study on Spectral Coherence of Noise-Like Pulses in a Fiber Ring Cavity Configuration
Youngchul Yoo, Seungjing Lee, Kyungsyo Park, Dangyu Lee, Luis Alano Vázquez-Zuniga, and Jongchan Jeong
Seoul National University, Korea
We numerically investigate the noise-like pulse (NLP) operation in a simply modelled fibre ring cavity. Under the different cavity conditions, we verify how the spectral coherence of the NLP is altered.

[26P-6] Wavelength-Selectable Visible Output in a Miniature Crystalline Ramanaser
Zaolu Li
Beijing University of Technology, China
We demonstrate a miniature crystalline Ramanaser operating at three discretely-tunable wavelengths in the green-yellow. Over 200 mW output powers were obtained for each wavelength with 3.8 W threshold. The threshold is below 0.4 W.

[26P-7] Investigation of Thermonoptic Effects in a High-Brightness Yb:KGW Laser
J. Yang, G. H. Kim, B. Lee, E. G. Siat, S. A. Chikov, V. E. Yashin, and L. Kang
1KRFIP, Korea, 2S. I. Vavilov State Optical Institute, Russia
The thermo-optical effects in the diode-end-pumped lasers with Yb:KGW anisotropic crystals is experimentally investigated. Strong dependence of optical power and aberrations of the lenses on orientation of laser crystals concerns a direction of laser radiation propagation and a polarization direction is confirmed by optimizing the crystal configuration we obtained a high-power output laser beam with the high spatial quality M2 close to unit in Q-switched mode and at regenerative amplification of chirped pulses.

[26P-8] Tb,Ho:KLu(WO₄)₂, Microchip Laser Q-Switched by a Cr³⁺:ZnS Saturable Absorber
Belarusian National Technical University, Belarus, 2Universitat Rovira i Virgili, Spain, 3Max-Born Institute for Nonlinear Optics and Ultrafast Spectroscopy, Germany
A diode-pumped Tb,Ho:KLu(WO₄)₂ microchip laser Q-switched by a Cr³⁺:ZnS saturable absorber generated average output power of 131 mW at 2061 nm. The shortest pulses had duration of 9 ns and energy of 10 μJ.

Xu Ou and Han Yoshi
Guangdong University of Technology, China
An improved approach is presented for a two symmetrically phase shifted structure based on FBGs. A step-apodized profile is designed to raise the transmission of peaks, which can help laser building in dual-wavelength fiber lasers.

Yixuan Duan, Xi Chen, and Ru Zhang
Beijing University of Posts and Telecommunications, China
We discuss the feasibility of multi-wavelength lasers fabricated using femtosecond laser pulses. A stable and narrow linewidth (<10 pm) dual-wavelength waveguide laser with the spacing between two lasing wavelengths of ~140 pm is reported.

[26P-11] Revisiting Low Frequency Fluctuations in High Power Multi-Mode Laser Diodes Subject to Filtered Optical Feedback
Fawad Balaš, Min Won Lee, Jean-René Burié, Mauro A. Bettiol, Azeddine Boudioua, and Alexis P. A. Fischer
1Université Paris 13, France, 23S Photonics Technologies, France
A highly detailed and extended map of low frequency fluctuations is established for a high power multi-mode 980nm laser diode subject to filtered optical feedback from a fibre Bragg grating. The low frequency fluctuations limits and substructures exhibit substantial differences with previous works.

[26P-12] Double Cladding Dispersion Compensating Photonic Crystal Fiber with High and Birefringence
Yong Soo Lee, Chang Guo Lee, and Seseun Kim
1GST, Korea, 2Chosun University, Korea
We proposed double cladding photonic crystal fibers based on dual lattice structure which has high and flattened birefringence. Using double cladding structure of square lattice, high flat birefringence and negative flat dispersion can be achieved at the same time over wide wavelength region including C, L and S bands.

[26P-13] Mode Analysis of Tunable Single Longitudinal Mode Tm-Doped Fiber Ring Laser
Jae-Keun Ioo, Sun Do Lim, and Seung Kwan Kim
1KRIS, Korea, 2Korea University of Science and Technology, Korea
Longitudinal modes of a tunable Tm-doped fiber ring laser with/without an unpumped Tm-doped fiber as a saturable absorption grating are analyzed using an all-fiber scanning ring resonator. Temporal characteristics of the laser are also discussed.

[26P-14] Efficient Sum-Frequency Generation of a Yb Fiber Laser and an Er,Yb Fiber Laser Using an External Resonant Cavity
J. H. Lee and J. W. Kim
Hanyang University, Korea
We report efficient sum-frequency generation of a Yb fiber laser at 1064 nm and an Er,Yb fiber laser at 1550 nm by employing a bow-tie resonant cavity system.
[26P-15] Sub-10 ps, 700 kW Peak-Power Pulses from a Nonlinearly Compressed All-Fiber MOPA System
Ryuta Yamashita, Kazuo Inada, Gori Watanabe, Kazuyuki Ito, Shigeo Yamaguchi, Jun Enokidani, and Shin Sumida
Tokai University, Japan, OPT Co., Ltd., Japan
We demonstrate sub-10 ps pulse generation by nonlinear compression of pulses from an all-fiber-MOPA. The architecture supports wide range in pulse width, 8 ps to 2 ns. The shortest pulse has 700 kW peak power and <0.15 nm line width.

Wei Shi1,2, Jiang Fang1,2, Jing Fan1,2, Ting Gu1,2, and Yingjie Meng1,2
1Tianjin University, China, 2Shandong HFB Photonics Co., Ltd., China, 3Tianjin Optera Laser Technology Co., Ltd., China, 4Tianjin Institute of Modern Laser & Optics Technology, China
We report a high power, narrow linewidth, linearly polarized, MOPA based fiber laser at 1064.48 nm with 520W average power, 30 GHz linewidth, 16 dB polarization extinction ratio, 88.7% slope efficiency, and diffraction-limited beam quality.

Kyung-Hyun Lee1, Yonghee Kim1, Yong-Ho Choi2, Guow Lin1, Hyunmin Park1, Hyuk Cho1, and Do-Young Jung1
1Chonbuk National University, Korea, 2Chungnam National University, Korea, 3KAERI, Korea
We report on the development of 2015-nm single-frequency Thulium-doped fiber amplifiers. The average output power is 85 W, and the slope efficiency is 54%. The laser linewidth is 20 MHz.

[26P-18] Stable and Amplitude-Equalized Rational Harmonic Mode-Locked Short-Cavity Fiber Laser Using a Bismuth-Oxide-Based Highly Nonlinear Erbium-Doped Fiber
Yutaka Fukuchi and Akishi Enda
Tokyo University of Science, Japan
We demonstrate a rational harmonic mode-locked fiber laser employing a 151-cm-long bismuth-oxide-based highly nonlinear erbium-doped fiber. The cavity length is as short as 6 m. Stable and amplitude-equalized short pulses up to 40GHz are obtained.

[26P-19] Flat Optical Frequency Comb Generation from an Actively Mode-Locked Short-Cavity Fiber Laser Using a Bismuth-Based Highly Nonlinear Erbium-Doped Fiber
Yutaka Fukuchi, Kouta Hirata, and Jaji Maeda
Tokyo University of Science, Japan
We generate frequency comb from a 10-GHz actively mode-locked laser using a bismuth-based highly nonlinear erbium-doped fiber and an optical filter with a rectangular profile. Flat 20 comb lines within 3-dB variation are obtained.

[26P-20] Fluorescence Resonance Energy Transfer (FRET) in Random Dye Lasers
Wan Zailah Wan Ismail1,2, Ewa M. Goldys1, and Judith M. Dawson1,2
1Macquarie University, Australia, 2ARC Centre of Excellence for Ultrahigh Bandwidth Devices for Optical Systems, Islamic Science University of Malaysia, Malaysia
We demonstrate the effect of fluorescence resonance energy transfer on the emission spectra and threshold of Rhodamine 6G / methylene blue / titania random lasers. Rhodamine 6G enhances the laser emission of methylene blue at ~700 nm.

[26P-21] Impact of Cascading on the Efficiency of External Cavity Cr:Wann Laser
Soumya Sarang, Robert J. Williams, Ondrej Kitzler, Aaron McKay, Hadiya Jasbeer, and Richard P. Millen
Macquarie University Australia
Factors affecting the output efficiency of an external cavity quasi-cw Cr:Wann laser were investigated. We show that a major limit to efficiency, in addition to thermal effects, results from a cascading effect involving a secondary Raman mode of Cr:Wann at 87 cm−1.

Won-Kyo Jung1, Changhwan Lim1, and Hee-Jong Moon2
1Sejong University, Korea, 2KAERI, Korea
A temperature measurement scheme using spectral shift was applied to a diode end-pumped Yb:YAG laser with ~ 4 W pumping level. The temperature rise was ~ 90 °C at the input power of 3.3 W.

[26P-23] Study of Femtosecond Laser Pulse Induced Thermal Lensing Effect in Cs2
Yi-Ci Li, Yu-Ting Kuo, Po-Yuan Huang, and Tai-Hwei Wei
National Chung Cheng University, Taiwan
We experimentally verified that laser pulse induced thermal lensing effect in Cs2 with the Z-scan technique and explain this effect as a result of stimulation of Raman scattering excited libration.

Zian Cheak Yu1,2, Harith Ahmad1, and Sulaman Wadi Harun1
1KDU University College, Malaysia, 2University of Malaya, Malaysia
CDNLSE dark pulse is demonstrated in EDFL with NPR technique. Pulse repetition rate, pulse width, and highest pulse energy of the CDNLSE dark pulse are obtained at 1.52 MHz, 219 ns, and 0.59 nJ, respectively.

[26P-25] Transient Kerr Effect and Its Influence in a Nonlinear Photonic Crystal Nanocavity
Chao Li, Min Wang, Yong-Lu Hu, Dao-Lu Liu, and Jun-Fang Wu
South China University of Technology, China
We present an analytical model to investigate the dynamic features of the transient Kerr effect in a nonlinear photonic crystal microcavity, and the theoretical predictions agree perfectly with the proposed experimental results.

[26P-26] Numerical Analyses of All-Optical Retiming Switches Using Quasi-Phase Matched Lithium Niobate Waveguide Devices: Output Deterioration by Domain Length Error
Yutaka Fukuchi and Masaru Yamamoto
Tokyo University of Science, Japan
We analyze characteristics of all-optical retiming switches employing the cascaded second-order nonlinear effect in quasi-phase matched lithium niobate waveguides. The domain length error decreases the switching efficiency and causes significant deterioration of the output signal.

[26P-27] Various Soliton Molecules in Large Anomalous Dispersion Fiber Laser
Xiaoliang Han and Xuejing Liu
Chinese Academy of Sciences, China
Soliton molecules (SMs) induced by the spectral filtering with the phase difference of D, π, π/2 and multiple separations are observed. It is found that the equilibrium distances of SMs are multiple and discrete.

[26P-28] Strong Modulation Instability and Ultra-short Pulse Train Generation in Silicon-organic Hybrid Slot Waveguide
Xianting Zhang1, Xinhui Yuan2, Zhe Kang2, Jinhui Yuan1, Zian Cheak Yu1,2, Gwon Lim1, Hyuck Cho1, and P. K. Alexander Wall1
1Beijing University of Posts and Telecommunications, China, 2The Hong Kong Polytechnic University, Hong Kong
We investigate the strong modulation instability at telecommunication band in a silicon-organic hybrid slot waveguide. The pulse train is obtained via pump pulses with pulse width of 10 ps and peak power of 250 mW.
[26P-29] Bidirectional Soliton Tunneling Effects in the Regime of Optical Event Horizon
Jie Gu, Haijun Gao, Shaoke Wang, Xuekun Bai, Jun Yuan, and Xiangfeng Zeng
Shanghai University, China, *Technical University of Denmark, Denmark
We study the cross-phase-modulation-induced soliton spectral shifting in the regime of the optical event horizon. The perturbed soliton to either red-shifting or blue-shifting is controllable, which could evoke bidirectional soliton spectral tunneling effects.

[26P-30] Defect Solitons in Two-dimensional Gaussian Potential
Yang Zheng, Huijie Zhang, and Youwen Liu
Nanjing University of Aeronautics and Astronautics, China
We report on the existence and stability of defect solitons in 2D optical Gaussian potentials. The power of the defect solitons is a monotonically decreasing function of the propagation constant, and the existence domain expands when the defect gets deep. Fundamental solitons are stable in the entire existence domain regardless of the depth of the defect. Dipole solitons exhibit instability in most of the power region and the instability window expands with the depth of the defect.

[26P-31] Active Control of Nano Plasmonic Field Using a Few Cycle Laser Pulse
Sungho Choi, Ziaul Haque, Seungchul Kim, and Dong Eon Kim
POSTECH, Korea
In this study, we show that localized ultrafast plasmonic field of nano structure can be spectrally or spatially manipulated under excitation of few cycle pulse. By controlling geometrical parameters of nanostructure, plasmonic response can be actively tailored.

[26P-32] Refinement of Dispersion Relations in the VUV from Spectral Fringes in Non-Phase-Matched Second Harmonic Generation
Peter Tjelta, Frank Noack, Aleksandr Aleksandrovsky, Alexandre Zaitsev, Nikita Radionov, and Valentin Petrov
Max-Born-Institute for Nonlinear Optics and Ultrafast Spectroscopy, Germany,*Russia and Siberian Federal University, Russia
Spectral fringes in the second harmonic of fs pulses under strong phase- and group-velocity mismatch are used to evaluate the refractive index of SrB₄O₇ down to 160 nm, essential for random quasi-phase-matching in the VUV.

[26P-33] CEP-stabilized Infrared Optical Parametric Amplifier with High Efficiency
Xiaotao Geng, Wenjun Ling, Shuyan Guo, Zhiyi Wei, Ferencc Krausz, and Dong Eon Kim
POSTECH, Korea, *Tianzhu Normal University, China, *Chinese Academy of Sciences, China, *Max-Planck-Institut für Quantenoptik, Germany, *Ludwig-Maximilians-Universität, Germany
A high efficiency, tunable, carrier-envelope-phase (CEP) stabilized optical parametric amplifier (OPA) is demonstrated with single-crystal. We achieved a pump-biased conversion efficiency of 34% which is the highest conversion efficiency reported in broadband OPA using two stages.

[26P-34] CEP-stable, Sub-6 fs, 300-kHz OCPA System with an Average Power of more than 15 W
Yeon Lee, Stephan Pizzi, Matthias Haehner, Catherine Yuriko Teisset, Robert Bessing, Knut Michels, Xiao Tao Geng, Seungchul Kim, Dong Eon Kim, Thomas Metzger, and Marcel Schultze
POSTECH, Korea, *TRUMPF Scientific Lasers GmbH + Co. KG, Germany, *Technische Universität München, Germany, *Max-Planck-Institut für Quantenoptik, Germany
We report on a CEP-stable OCPA system reaching multi-GW peak power at 300 kHz repetition rate. It delivers over 50 µJ of pulse energy and pulse duration below 6 fs. Power fluctuations < 1.5% was achieved including a pump-seed-synchronization.

[26P-35] Laser-driven Fast Electron Beam from the Solid Target for Ultrafast Electron Diffraction
Ye Tian and Jianzhong Liu
Shanghai Institute of Optics and Fine Mechanics, China
We have obtained stable collimated quasi-monenergetic electrons near the target specular direction. The fast electron pulse is prominent for the laser-driven fast electron diffraction source.

[26P-36] Ultrafast Interaction between Water-soluble Corrole and DNA
Hui Wang, Li-Li Wang, Lei Zhang, Hai-Yang Liu, and Liang-Nian JF
*Sun Yat-Sen University, China, *South China University of Technology, China
The interaction of the water-soluble Ga(II) corrole with calf thymus DNA via an outside binding mode has been studied by femtosecond transient absorption spectroscopy. The forward (k ≥ 6.41012 s⁻¹) and back (k ≤ 2.351012 s⁻¹) electron transfer processes have been observed.

[26P-37] Ultrafast Broadband Third-order Nonlinearity of Silk Biopolymer
Byung-Jc Lee, Hyunsoo Kwon, Fabian Rotermund, and Sungwhan Kim
Apu University Korea
We report on ultrafast broadband third-order nonlinearity of silk, a newly and high-technologically reinvented biopolymer in optics and electronics. Z-scan and optical Kerr-gate measurements at various wavelengths were used to investigate third order susceptibilities of silk films.

[26P-38] Ultrafast Optical Modulation of Magnetization Orientation in TbFeCo/GdFeCo Coupled Bilayer
Zhiteng Chen, Xiaohui Fang, Bingzi Zhang, Wenlan Li, and Jun Peng
Guangzhou University, China
We study the optical modulation effect of magnetization orientation in TbFeCo/GdFeCo bilayer using pump-probe polar Kerr spectrosopy. The magnetization rotation is triggered by fs pulse, driven by exchange interaction, and occurs within ~300 ps.

Seong-Jin Son, Ju Won Choi, Do-Kyeong Ko, and Nan Ei Yo
GIST, Korea
We design the apodized aperiodic poled lithium niobate crystals that generated broadband red, green, blue light based on second harmonic generation for laser projection display. The spectral and temporal bandwidth are about 10 nm. The broadband light sources exhibited speckle noise free.

[26P-40] Insulator-to-semimetal Transition of Calcium Fluoride Induced by Optical Field
Opion Kwon and Dong Eon Kim
POSTECH, Korea
We studied response of calcium fluoride single crystal against intense optical field. It undergoes transition into semimetal, ensured by detecting optical-field-induced current. The transient conductivity jumps by 16 orders of magnitude within sub-femtosecond time scale.

[26P-41] Large Diameter Ceramic TGG Faraday Rotator for High-average-power Laser Systems
Hidenori Yoshida, Koji Tsuikakimoto, Hisanori Fujita, and Noriaki Miyakawa
Osaka university, Japan
A large diameter Faraday isolator for few kW laser systems was demonstrated using a TGG Faraday rotator compensated for thermal induced depolarization.

[26P-42] 300-W Spectral Beam Combination of Narrow-linewidth Pulsed Rod-type Fiber Lasers
Yong-Ho Cha, Gwon Lim, Yong-Hee Kim, and Do-Young Jeong
KAERI, Korea
We have demonstrated spectral beam combination of three narrow-linewidth pulsed rod-type fiber lasers with different wavelengths by using a multi-layer dielectric grating. The combined laser power is 300 W with a good beam quality.
The 11th Conference on Lasers and Electro-Optics Pacific Rim
Busan, Korea / August 24 - 28, 2015

Poster Session I (Exhibition Hall / Wednesday, 26 August, 13:45~15:15)

[26P-43] Computational Simulation Methodology for the Beam Quality of a High Power Zigzag Slab Laser
Jae Sung Shin1, Yong Ho Cha2, Byung Heon Choe1, Hyeon Cheol Lee1, and Hyun Tae Kim2
1KAERI, Korea; 2Daejeon CAT, Korea
A computational simulation methodology for the beam quality of a high power zigzag slab laser has been developed. This methodology can predict the beam quality for various optical arrangements and optimize the design effectively.

[26P-44] Generation of 30 mJ CW Ultraviolet by a Two-path Geometry for Cascaded γ(3) Processes with Periodically Poled Lithium Niobate Crystals
Yin-Kuang Yang1, Chia-Lun Tsai2, Jui-Yu Lai3,4, Chen-Shao Hsu2,5, Yen-Yin Lei6, Chiang-Chung Fu1, and Shiang-Da Yang1
1National Tsing Hua University, Taiwan; 2National Tsing Hua University, Taiwan; 330 mJ continuous wave ultraviolet radiation is generated via a two-path geometry for cascaded frequency doubling and sum-frequency generation (SFG) at 18.9 W pump, where SFG is enabled by a third-order periodically poled MgO:LNNBO3.

[26P-45] Investigation of Contamination Induced by Various Processes on Fused Silica Optics
Liu Hongjie, Huang Jin, Jiang Xiaodong and Zheng Wang
China Academy of Engineering Physics, China
We investigated contamination on fused silica optics with various processes by TOF-SIMS. The kinds and quantities of metal-impurities and their distribution as a function of depth from the surface are obtained.

A. Kon, M. Nishihuchi, H. Kinyamu, K. Ogura, H. Sakaki, Y. Fukuda, M. Kando and K. Konno
Japan Atomic Energy Agency, Japan
We have developed a multi-channel cross-correlator (MCCC) for single-shot measurement of temporal contrast of Peta-watt class laser pulse. We report experimental results with the MCCC system.

Victor Shudyayev and Anatoly Orishch
Khristianovich Institute of Theoretical and Applied Mechanics, Russia
The results of development of the optical system for the repetition rate laser plasmatron are presented. A self filtering resonator is applied to form the high-quality laser beam at the high power level pulses Q-switching Co2 laser. The system permits forming the quasi-stable plasma beam in the supersonic air flow.

[26P-48] Development of 1 J, 100 Hz Yb:YAG Laser Amplifier System for OPCPA Pumping
Shigeo Toki1,2, Martin Dick8, Sungil Hwang2,3, Kachi Ayun2, Toshiyuki Kawashima2, Hajeime Mohokura2, and Junji Kawarada1
1Osaka University, Japan; 2Institute of Physics, Czech Republic; 3Hamamatsu Photonics K.K., Japan; 4The University of Electro-Communications, Japan.
We report on our progress in the development of a 1 J class Yb:YAG laser amplifier system for OPCPA pumping. We have demonstrated amplification of 10 ns pulses to 1 J at 100 Hz by using a multi-TRAM.

[26P-49] Pulse Stretching in a Narrow-band Yb:YAG Regenerative Amplifier using Transmission Gratings
Shigeo Toki1,2, Sungil Hwang2,3, Toshiyuki Kawashima2, Hajeime Mohokura2, and Junji Kawarada1
1Osaka University, Japan; 2Hamamatsu Photonics K.K., Japan; 3The University of Electro-Communications Tokyo, Japan.
We report on our progress in the development of a high-power-energy-Yb:YAG laser system for OPCPA pumping. We have demonstrated generation of 160-ps chirped-pulses with a spectral bandwidth of 0.12 nm and a pulse energy of a few mJ by using a Yb:YAG regenerative amplifier inserting a transmission grating pair.

[26P-50] Fano Resonant Chiral Electromagnetic Fields by Metasurfaces
Seo Joo Lee, Seok Jae Yoo, Sueyoon Lee, and O-Han Park
Korea University, Korea
We demonstrate for the first time that chiral electromagnetic fields display Fano resonance using nanohole metasurfaces. We show the nano-hole structure can be utilized as biosensors to detect chiral molecules.

[26P-51] Double Fano Resonances in a Composite Metamaterial Possessing Tripod Plasmonic Resonances
Yeong Il Lee and Jeong Weon Wu
Ewha Womans University, Korea
Double Fano resonances are observed in a planar composite metamaterial possessing tripod plasmonic resonances, where a common subradiant driven oscillator is coupled with two superradiant oscillators. As a classical analogue of four-level tripod atomic system, the extinction spectrum of the composite metamaterial exhibits a coherent effect based on double Fano resonances. It is shown that a transfer of the absorbed power between two orthogonal superradiant oscillators is mediated by a common subradiant oscillator.

[26P-52] Active Control of On-chip Plasmonic Nanocavities by Two-plasmonic Absorption
Zhen Chai, Xiyang Gu, Hong Yang, and Qiuhuang Gong
Peking University, China
The tunable on-chip plasmonic coupled nanocavities are realized by two-plasmonic absorption of (SU-8)-co-(gold nanoparticles) composite film. Strong near resonance nonlinear absorption and localized field plasmonic can realize microwatts order pump tunability.

[26P-53] Low Propagation Loss in an Asymmetric Plasmonic Crystal Waveguide
Motoki Ibus1, Masashi Fujikura2,3, Masashi Ota1, Asahi Suminura1, Yuji Ishi2, and Mitsuo Fukuda3
1Tohoku University of Technology, Japan; 2Japan Society for the Promotion of Science, Japan
We present a promising design for low-loss asymmetric plasmonic crystal waveguides. The plasmonic crystal consists of Au cylinders, and the waveguide is introduced by eliminating a single line of Cylinders on Au metal.

[26P-54] Designing Whispersing Gallery Modes via Transformation Optics
Yushin Kim1, Seo-Young Lee2, Jung-Wan Ryu2, Inbo Kim2, Jae-Hyung Har1, Heung-Sok Tai2, Mohan Choe1, and Runki Min1
1KAIST, Korea; 2Kyungpook National University, Korea
Transformation optics suggest a novel way to control the propagation of light. By applying it to resonant optical cavity, we restore the whispering gallery mode in an optical cavity of deformed boundary.

[26P-55] Giant Electric Field Enhancement in a Multilayered Dipole Nano-antenna
Evgeny Milonov1,2, Abdul Kheleque3,4, Lijin Liu1,5, and Haroldo Hattorf1
1UNSW Australia, Australia; 2Australian National University, Australia
We investigate the electric field enhancement in multilayered dipole nano-antenna and show that the combination of Au/SU8 layers taken at a 50% filling factor can produce extremely high field enhancements in the order of 17.8.

[26P-56] All-semiconductor Optical Microcircuit Board
Li Min and Lirong Huang
Huazhong University of Science and Technology, China
A low-loss all-semiconductor metamaterial-based optical circuit board with optical inductors, capacitors, insulators and conductors at the microcircuit is proposed, which can always hold band-stop filtering function for various polarized waves.
[26P-57] Graphene Plasmonic Metamaterials to Manipulate Infrared Light
Chao Zeng, Xiaoming Liu, and Jing Guo
Xi’an Institute of Optics and Precision Mechanics, Chinese Academy of Sciences, China
Two and three dimensional graphene plasmonic metamaterials are proposed and investigated to manipulate infrared light. The gradient-index lenses are implemented to focus, collimate, and guide the surface plasmon waves. High-contrast electro-optic modulator is also conceived.

[26P-58] Solving the Optical Modulation Mechanism of Graphene-hybridized Plasmonic Metamaterials
Lei Zhu, Zhongfui Nie, Yongbing Xu, and Frank Wang
Nanjing University, China
Optical modulation characteristics of graphene hybridized plasmonic metamaterials is investigated. It is revealed that resonance peak transmission can be effectively tuned by the applied gate voltage, suggesting an electro-absorption modulation (EAM) mechanism.

[26P-59] Optimization of Lorentz Model Parameters for Crystalline As$_2$S$_3$, SiC and Modified Lorentz Model Parameters for Nanocrystalline SiO
Mehedi Islam, Md. Nazmul Islam, Mustafa Alam, Md. Ghiyam Saber, and Rakibul Hasan Sagar
Islamic University of Technology, Bangladesh
We have presented the optimized Lorentz model parameters for crystalline arsenic sulfide (As$_2$S$_3$), silicon carbide (SiC) and modified Lorentz model parameters for nanocrystalline silicon oxide (SiO) obtained using a large scale non-linear algorithm. The complex relative permittivity calculated using the optimized parameters agree well with the experimental values over broad frequency bands. The associated RMS deviations are 0.254, 0.393, 0.010 and 0.009 respectively.

[26P-60] Metamaterial-based Light Diffuser with Deep-subwavelength Thickness
Jong Uk Kim and Jonghwa Shin
KAIST, Korea
Metamaterial based angular light difuser with deep subwavelength thickness is proposed. It consists of metallic strips with randomized width and separations. We numerically demonstrate that metamaterial diffuser exhibits light diffraction angles comparable to conventional, thick diffusers.

[26P-61] Magnetic Response Based on Deep Subwavelength Nonmetallic Structures
Minsung Heo and Jonghwa Shin
KAIST, Korea
We proposed the nonmagnetic metallic col-plate array to manipulate the magnetic resonance caused by an inductive capacitor circuit resonance in microwave range. The effect of geometrical parameters on the magnetic response is studied.

[26P-62] Bowtie-shaped Hole Array for Fiber-optic Refractive Index Sensing in Telecom-wavelengths
Hang-Eun Jee, Farid Ahmed, Martin B.G. Juul, and Byung-Kwan Min
1Yonsei University, Korea, 2University of Victoria, Canada
Array of bowtie-shaped holes is proposed to develop a fiber-optic refractive index sensor. Reflection spectra in telecom-wavelength range around 1.3 μm and 1.55 μm obtained by FDTD simulations are designed to detect single molecule.

[26P-63] Surface-Plasmon Sensor in Photonic Crystal Fiber
Jung-Sheng Chang, Yong-Hang Wu, Syuan-Yu Jhang, and Nai-Felang Sun
I-Shou University, Taiwan
We analyze the surface-plasmon sensor of photonic crystal fiber by the finite element method. The photonic crystal fiber sensor with the thin-film of copper corresponds to the resonance wavelength 750 nm.

[26P-64] Three-Dimensional Plasmonic Ruler Based on Silver Metal Blocks
Tae-Woo Lee, Da Eun Lee, Yong-Jin Lee, and Soon-Hong Kwon
Chung-Ang University, Korea
We introduce a three-dimensional plasmonic ruler based on silver metal double nano-blocks. Two resonant modes show different wavelength dependences on x- or y-directional shift of blocks, which enables the measurement of spatial position with nanometer resolutions.

[26P-65] Energy Harvesting with Black Si/plasmonics Composite Material
Ryusuke Kamatsu, Armandas Balcius, Gediminas Seniutis, Yoshiaki Nishijima, and Savvas J. Andreadis
1Yokohama National University, Japan, 2Swinburne University of Technology Australia, 3The Australian National Fabrication Facility ANFF, Australia
The photo-thermo electrical conversion system using black silicon and gold nanoparticles have been suggested for energy harvesting. Efficient light absorption with black silicon and plasmonic photo-thermal energy conversion was successfully improving the energy conversion efficiency of light. Totally ~50% of improvements has been achieved with optimization of Au nanoparticles diameter and density.

[26P-66] Heterogeneous Three-Dimensional Assembly of Metamaterials and Metadevices by Modular Transfer Printing
Seungwoo Lee, Byungsoo Kang, Hohny Koom, Ala Alhamed, Myun-Sung Park, Numair Ahmed, John A. Rogers, Pascl M. Ferreira, Seok Kim, and Bunki Min
1KAIST, Korea, 2University of Illinois, Urbana Champaign, USA
A metamaterial transfer printing method done by adhesion switching of viscoelastic stamp is presented. 3-D stack of heterogeneous material can be built at a desired position regardless of target substrate even on cheese.

[26P-67] Three-dimensional Sub-5-nm-gap Plasmon Antenna Printed on the Apex of Optical Fiber
Seung Ju Yoon, Hyeongchul Shim, Myung-Ki Kim, and Yong Hee Lee
KAIST, Korea
We demonstrate fiber-integrated three-dimensional sub-5-nm-gap plasmon antennas by employing proximal milling and micro-transfer printing techniques. The photons are extremely confined in a volume of 10$^{-10}$ λ$^3$ and efficiently couple to a single-mode optical fiber.

[26P-68] Whispering Gallery Mode Biosensor Detection Using Nanopost Structures
Seung Hun Lee and Kyung Jin Kim
Pusan National University, Korea
High-quality (Q) factor whispering gallery mode biosensor which detects wavelength shift induced by biomolecules can be amplified by introduction of nanostructures. We demonstrate molecule detection by localized WGQ field on nanopost structures.

[26P-69] Simulation of Improved Sensitivity of Whispering Gallery Modes Sensor by Nanostucture Chip
Taeyoung Kang and Kyung Jin Kim
Pusan National University, Korea
We simulated Whispering Gallery Mode (WGM) sensor that is highly sensitive enough to detect unlabeled single molecule and method of improving sensitivity using nano structure chip.

[26P-70] Effect of DC Power on Alternative Plasmonic Materials Fabrication with Room Temperature High-power Impulse Magnetron Sputtering
Zhi-Ying Yang, Yi-Hsun Chen, Bo-Hua Liu, and Kuo-Ping Chen
1National Chiao Tung University, Taiwan, 2National Applied Research Laboratories, Taiwan
TiN thin films were prepared using magnetron sputtering. When the power increases from 80W to 300W, the conductivity rises to 16.8 times, and the plasma frequency is blue-shifted from 515 nm to 460 nm.
[26P-71] Polarization Independent Terahertz Metamaterial Filters Based on Combinatory Array of Crosses and Mesh Network
Dongju Kim, Mutammad Tayyab Nauman, Soyeon Kim, Kyeojeong Lee, and Jae-hyung Jong
GIST, Korea
Design of a polarization independent bandpass filter based on two-dimensional wire lattice metamaterial is presented. Introducing wires among the dipoles transforms its bandstop characteristics to bandpass characteristics. By applying abovementioned principle to cross shaped metamaterials a polarization independent bandpass characteristic is demonstrated.

[26P-72] Plasmonic Vortex Lens with Distributed Nanoslots for Arbitrary Tuning of Vortex Size
Gun-Yeal Lee, Seung-Yeol Lee, and Byungho Lee
Seoul National University, Korea
A tunable plasmonic vortex lens (PVL) that can adjust the size of vortex by changing optical polarization is proposed. The tunable PVL provides a novel degree of freedom in managing surface plasmon polariton fields.

[26P-73] Tunable Polarizer Based on Graphene Nanoantennas at Terahertz Wave Band
Yi Cheng Tang, Zhu Hong Zhu, Jian Fa Zhang, Chu Cai Guo, Ken Liu, Xiao Dong Yuan, and Shi Qiao Qin
National University of Defense Technology, China
We theoretically and numerically demonstrate that a transmission-type electrically tunable polarizer can be realized using graphene nanoantennas supported on a dielectric film with a graphene sheet behind the polarizer. The polarization mechanism originates from the antenna plasmon resonance of graphene stripes. The results of fullwave numerical simulations reveal that transmittance of 0.70 for one polarization and 0.0073 for another polarization can be obtained at normal incidence. The transmission-type electrically tunable polarizer provides and facilitates kinds of applications, including filtering, detecting, and imaging.

[26P-74] Enhanced Optical Torque on Planar Metal-insulator-metal Cavity Structured Gammadion
Sun-Je Kim, Kyookun Lee, Yohan Lee, Hyoonsoo Park, and Byungho Lee
Seoul National University, Korea
Novel planar metal-insulator-metal cavity structured gammadion is suggested. It is shown that the proposed gammadion can exhibit 8 times higher optical torque under spin-less fabrication size.

[26P-75] Complex Modulation by One-Port Absorbing Structure in Plasmonic MIM Waveguide
Hyoonsoo Park, Seung-Yeol Lee, and Byungho Lee
Seoul National University, Korea
We present a sub-micron sized complex modulator. It consists of a magnetic dipole resonant absorbing structure and Fabry-Perot resonator. Additional wave retardation in the resonator gives full modulation of reflected light.

[26P-76] Electrically Tunable Polarizer Based on Pattern-free Graphene
C. Ye, Z. Zhu, W. Xu, X. Yuan, and S. Qin
National University of Defense Technology, China
We theoretically demonstrate that an electrically tunable polarizer can be obtained using a pattern-free graphene monolayer supported on a periodical dielectric array.

[26P-77] Dielectric Environment Affects Photoinduced Voltage in Nanoporous Gold Thin Film
Masut Akabori and Tenya Ushihara
Tohoku University, Japan
We report an experimental study of photoinduced voltage in nanoporous gold film with/without dielectric infiltration under the irradiation of obliquely incident nanosecond laser light in visible frequencies.

[26P-78] Waveguiding of Spoof Surface Plasmon Polartions
Seong-Han Kim*, Sang Soon Oh*, Kap-Joong Kim*, and Chul-Sik Kee*
1GIST, Korea, 2Imperial College London, UK, 3ETRI, Korea
We numerically and experimentally demonstrate subwavelength scale waveguiding of spoof surface plasmon polaritons at a line defect in a two-dimensional groove metal array that exhibits a band gap region.

[26P-79] Single Line Waveguide inside Ho3+-doped Chalcogenide Glass Inscribed by Femtosecond Laser
Juni Wang*, Bongon He*, Jiangfeng Zhu*, Dinh Viet Tan*, and Shoun Diao*
1Xidian University, China, 2Chinese Academy of Sciences, China, 3Ningbo University, China
We inscribed a single mode waveguide with the minimum propagation loss of 1.58 dB/cm at 1030 nm inside the Ho3+-doped chalcogenide glass by femtosecond laser. The inscribing parameters are 0.4 μJ pulse energy and 90 μm/s translation speed.

[26P-80] Ablation Depth Control on ITO Using Beam Shaped Femtosecond Laser
Hoon-Young Kim1,2 and Sung-Hak Cho1,2
1KIMM, Korea, 2Korea University of Science and Technology, Korea
We report on the ablation depth control with a resolution of 40 nm on indium tin oxide (ITO) thin film using a square beam shaped femtosecond (190 fs) laser (λ = 1030 nm). A slit is used to make the square, flat top beam shaped from the Gaussian spatial profile of the femtosecond laser. An ablation depth of 40 nm is obtained using the single pulse irradiation at a peak intensity of 2.8 TW/cm2. The morphologies of the ablated area are characterized using an optical microscope, atomic force microscope (AFM), and energy dispersive X-ray spectroscopy (EDS). Ablations with square and rectangular types with various sizes are demonstrated on ITO thin film using slits with varying x-y axes. The stereo structure of the ablation with the depth resolution of approximately 40 nm is also fabricated successfully using the irradiation of single pulses with different shaped sizes of femtosecond laser.

[26P-81] Analysis of Laser Induced Oxidation Processes with Different Laser Powers
Feng Xia*, Xinzheng Zhang1, Meng Wang1,2, Samming Yi1, Qian Liu1,2, and Jiegian Xu1
1Hunan University, China, 2National Center for Nanoscience and Technology, China
Metal-transparent-metallic-oxide (MTMO) grayscale photomasks fabricated by laser-induced oxidation are studied based on three stages oxidation theories and absorbed laser power density distribution. The calculated fabrication diameter is consistent with the experimental fabrication size.

[26P-82] Ultrashort Laser Ablation for Hydrophilic Surface
Munjoo Baek1, Jyeon Park2, BinX. Cao1, Hyonkeek Sohn2, Chang-Soo Rim1, and Jiwhan Noh1
1KIMM, Korea, 2Hanam University, Korea
The hydrophilic property of the surface with the microsize spiky was tested. Water drops placed on the microspikes to measure the contact angle, which was 10° while that of the surface without micro spikes was 90°. This shows that a surface can be processed to be hydrophilic with laser ablation.

[26P-83] Maximization of the Ablation Rate of Metal, Semiconductor and Dielectric with a MHz Repetition Rate Ultrafast Laser
Mirae Lim, Yonghyeon Kim, Hyonkeek Sohn, Donggai Shin, and Jyeon Choi
KIMM, Korea
Maximization of the ablation rate of various materials was investigated by optimization of ultrafast laser parameters. The optimized parameters were used to engrave metal roles on indium tin oxide with high efficiency and low damage to the substrate.

Takuya Sato, Yusuke Yamanaka, Kenichiro Hosaowa, and Fumihiko Kannari
Koel University, Japan
Channel waveguides are fabricated in a Nd:YLF crystal with 400-nm femtosecond laser pulses, and the laser oscillation at 1047 nm pumped by an 800-nm laser is demonstrated.
[26P-85] Fabrication of Micro Lens Shape Array Using Picosecond Laser
Jyeon Park, Moonju Bae, BinhK. Cao, Hyunkyung Sohn, and Jehwan Nah
KIMM, Korea
In this paper, we fabricated a convex-lens-shaped microstructure with a diameter of 50 μm on a metallic mold substrate using a laser ablation process. The fabricated convex-lens-shaped microstructure on the metallic substrate can be used as the mold for the micro lens or superhydrophobic/hydrophobic surface.

[26P-86] 1-μm Periodical Grating Structure on Stainless Steel Designed by High-power Nanosecond Pulsed Fiber Lasers
Shawlowang Chen, Seongwo Yeo, Penny Pong Shun, Xiaohui Li, Meng Liu, Yunan Ma, and Qi Jie Wang
Nanyang Technological University, Singapore
Nanosecond-pulsed, 1μb-doped fibre laser has been used to create laser induced periodic surface structure on the surface of stainless steel. Grating periodic structure for visible light with distance of 1 μm is demonstrated and explained.

[26P-87] Holographic Optical Element for Solar Concentrators Using Photopolymer
Jeong Hyeon Lee, Jong-Chan Kim, Jae Wook Jeong, and Nam Kim
Chungbuk National University, Korea
In this study, the holographic optical element for solar concentrators using photopolymer was proposed. For this, we fabricated the holographic solar condensing lens which has maximum efficiency. To add sun tracking function, we performed the angular multiplexing.

[26P-88] Pulsed Laser Sintering for Fabricating Indium Tin Oxide Thin Films
Jeonghong Ha and Dongsik Kim
POSTECH, Korea
A direct excimer laser sintering process and a novel laser-induced plasma sintering process were developed for fabricating Indium Tin Oxide (ITO) thin films from wetcoated ITO nanoparticles.

[26P-89] Laser-induced Spray Jet Cleaning for Nanoscale Contaminant Removal Using Water-Isopropyl Alcohol Mixtures
Changho Seo and Dongsik Kim
POSTECH, Korea
In this work, we demonstrate a novel laser-induced spray jet cleaning process using non-water cleaning agents including isopropyl alcohol. The process could remove <30 nm PSL particles from silicon surfaces without watermark generation.

[26P-90] Laser Fabrication of Micro-lens Array on Fused Silica
Ik-Bu Suh1,2,3, Hui-Kook Choi2,3, Young-Jun Jeong4, Young-Chul Nah2,5, Jae-Hee Sung4, Seong-Ku Lee4, Tae-Moon Jeong1, and Jin-Tae Kim1
1KIST, 2Chonnam National University, Korea, 3Seoul Branch of Korean Academy of Science and Technology, Korea, 4GIST, Korea, 5Chosun University, Korea
We fabricated micro-lens array on fused silica glass using femtosecond and CO2 laser. We micro-machined periodic micro-grooves on the glass surface with femtosecond laser, and polished the patterned surface with CO2 laser. We confirmed that curvature was formed on the surface by heat from the CO2 laser beam as the surface roughness was removed. Depending on the fabricated pattern size, we could fabricate micro-lens array with controlling sizes. Using such laser fabrication technique, we have demonstrated micro-lens array with various dimension.

[26P-91] Bessel Beam Scanning without Mechanical Scanner
Maria Elesba Ventura, Paul Leonard Alcione Niloano, Giovanni Tapang, and Caesar Saloma
University of the Philippines, Philippines
We demonstrate nonmotionless Bessel beam scanning with a spatial light modulator (SLM). The scanning control was emulated in the SLM by adding a grating phase or chirp phase to translate the beam transversely or axially.

Guofeng Yang1, Zhenlong Wu2, and Peng Chen1
1Jiangnan University, China, 2Nanjing University, China
A monolithic color synthesis method based on InGaN/GaN multiple quantum wells (QWs) grown on GaN microstructures formed by selective area epitaxy on sapphire2 mask patterns is demonstrated. The stripe microfacet structure is composed of (0001) and (11-22) planes, attributed to surface polarity and surface energy. InGaN/GaN QWs on different microstructures contain spatially inhomo geneous composition due to the diffusion of adatoms among the facets. The unique property allows microfacet QWs emits blue light from the (11-22) plane and yellow light from the top (0001) plane, of which the luminescence reveals white due to the dual color mixing.

Engin Tirar1, Gokhan Atmaca1, Sedef Bora Ilesivdin2, Suken Ardal2, T. Miki3, V. Mansurov3, and K. Zhuravlev3
1Anadolu University, Turkey, 2Gazi University, Turkey, 3Siberian Branch of Russian Academy of Sciences, Russia
The surface passivation effect on the power-loss mechanisms in AlGaN/AlN/GaN heterojunctions was investigated. The electron temperatures of hot electrons was obtained from the temperature and the applied electric field dependencies of the Hall mobility.

[26P-94] Effect of Nanometer Sized Ni-dot/Ag/Pt Metal on White Light Emitting Diodes
Mjoung Hyun Safl and Kyu Sang Kim1
1California Institute of Technology, USA, 2Songi University, Korea
Ni-dot/Ag/Pt metal coating films were incorporated in InGaN blue light emitting diodes as p-type reflection metal to enhance the extraction efficiency of blue light. For the reflectivity change from 84% to 93.7%, the optical output power of blue light before phosphor coating and the luminous flux white light after phosphor deposition have improved by 49.3% and 58.2% at the current of 350 mA, respectively.

[26P-95] Consideration of Number of via Holes for High Efficiency GaN Based VI-LED Design
Gil Jun Lee1, Ju-Jung Cha1, Young-Kyu Oh2, Hyoung-Jo Park2, Tak Jeong, and Jeon Seop Kwek1
1Sunchon National University, Korea, 2Sunchon Photonics Technology Institute, Korea
This study examined the electrical and optical characteristics of GaN-based vertical- injection lightemitting diodes (VI-LEDs) with various numbers of via holes.

[26P-96] Modification of Spontaneous Emission Rate in GaN-based Nanorod LED Structures Investigated by FDTD Simulations
Guem-Hwan Ryu and Han-You Ryu
Inha University, Korea
The characteristics of modifications in spontaneous emission (SE) from GaN-based nanorod light-emitting diode structures are numerically investigated using finite-difference time-domain methods. It is found that the SE rate can be enhanced by >6 times in optimized design.

[26P-97] Analysis of the Characteristics with Increasing the Number of QWs for Near-Ultraviolet LEDs
Hyo-Shik Choi and Jong-In Shin
Hanyang University, Korea
This paper reports the analysis of the near-ultraviolet light-emitting diodes (NUV LEDs) characteristics with increasing the number of QWs from 5 to 7 by same growth process. By means of optical, electrical characterization and carrier rate equation analysis, we show that the NUV LEDs performances were improved with increasing the number of QWs by decreasing the non-radiative recombination rate.

[26P-98] Localized Surface Plasmon Resonance from Pt-based Split Ring Structures
Kyung-Rock Son, Byeong Ryong Lee, Tae Hoong Kim, and Tae Geun Kim
Korea University, Korea
We fabricated split ring (SR) nanostuctures to enhance the interaction with resonant photons caused by an excitation of localized surface plasmon resonance (LSPR) in the deep-ultraviolet region. Also, the effect of SR diameter size and split gap angle on the coherent plasmon coupling was investigated in 2D arrays of Pt based SR. The absorption resonance of the fabricated Pt-based SR depends on its diameter, and shifts toward shorter wavelength for the SR with larger diameter.
[26P-99] Various Metal-doped ITO as Transparent Conductive Electrode for Near-ultraviolet Light Emitting Diodes

Min Ju Kim, Ju Hyun Park, Dong Soo Shin, and Jong-In Shim
Hanyang University, Korea

We fabricated various metal doped indium tin oxide (ITO) transparent conductive electrodes (TCE) for use in near-ultraviolet (NUV) light emitting diodes (LEDs). The role of metal is to improve the transmittance especially in NUV region and current spreading of ITO. The ITO/ITO (Ti, Ga, Ge, Al) TCEs (annealed at 550°C, 1 min) exhibit 90.5 ~ 94.7% transmittance at 385 nm on the quartz substrate and the sheet resistance is ranged from 23.2 to 73.5Ω/sq. on the NUV LED wafer.

[26P-100] Low-Frequency Noise Characteristics of InGaN-Based Light-Emitting Diodes

Chan-Hyoung Oh, Dong-Pyo Han, Dong-Soo Shin, and Jong-In Shim
Hanyang University, Korea

We investigate the low-frequency noise characteristics of InGaN-based light-emitting diodes with different forward leakage currents. It is found that the low-frequency noise characteristics are closely correlated with the forward leakage current.


Juhyuck Park, Guan-Bo Liu, Dong Yeong Kim, Jong Won Lee, Jaehee Cho, E. Fred Schubert, and Jong Kyu Kim
POSTECH, Korea; *RenesasEltier Polytechnic Institute, USA; †Chonbuk National University, Korea

The efficiency of an AlGaN deep-ultraviolet light-emitting diode with peak emission wavelength of 285 nm is investigated as a function of current over a wide range of temperatures (10K to 300K). We find that the efficiency-versus-current curve exhibits unique and distinct features over the entire temperature range including three points of inflection, a u-shape phenomenon which the efficiency increases again after the minimum; and higher low temperature efficiency than room-temperature efficiency at high-current density regime.

[26P-102] Influence of Aging on the Characteristics of Near-Ultraviolet LEDs

Hyo-Stik Choi, Jong-In Shim, and Won-Jin Choi
Hanyang University, Korea

We analyzed the influence of a current aging on 380 nm band near-ultraviolet-light emitting diodes with different current densities. Aging have been carried out on LEDs with current densities of 5, 35 and 50 A/cm² at room temperature for 1000 h. After stress, both optical and electrical characteristics of LEDs are getting worse as increasing aging current density. We suggest that the possible degradation mechanism of characteristics is increase of the non-radiative (NR) recombination of LEDs due to generation of NR recombination centers in active regions after a current aging.

[26P-103] Investigations on Correlation between Photoluminescence Images of an LED Epi-wafer and Characteristics of LED Chips

Jongaeok Kim, Hyung Tae Kim, Seungjae Kim, Hoon Jeong, In-Sung Cho, Min Soo Noh, and Hyundai Jung
KITECH, Korea; Soft-Epi, Korea; *Elatmax Co., Korea

Photoluminescence (PL) imaging is employed in order to inspect InGaN/GaN LED epi-wafer. The image shows a map of integrated PL intensity over the wafer and dark spots with degraded luminescence properties. Dark spots with various sizes indicate areas with nonradiative defects showing that the nonradiative recombination coefficient increases with the size. The PL images are compared with data obtained from LED chips on the wafer after fabrication process. The characterization results for LED chips show that most of the chips fabricated on the dark spots have degraded properties. The result indicates that PL imaging of epi-wafer could be an inspection tool to predict properties of LED chips.

[26P-104] Shadow Excitation of Nanoneedles: Roguing Localization and Strain Effects from Photoluminescence

Hyung-Sung Heo1, Hoonil Jeong1, Hyun-Jun Bae1, Gyo Chol Y1, Hyung-Chan Kim2, and Young-Seh Ah2
1GIST, Korea; 2Seoul National University, Korea; *National Fusion Research Institute, Korea

In order to pinpoint the spatially resolved role of strain, localization, and quantum confinement (QC) in tapered nanoneedles (NNs), angle-resolved photoluminescence (PL) was adapted as a function of temperature.

[26P-105] Dopant-dependent Chemical Wet Etching Phenomena of Semipolar (11-22) GaN Film

Jiyeon Park and Sung-Nam Lee
Korea Polytechnic University, Korea

Wet etching properties of semipolar (11-22) GaN films are investigated by using the O2 and NH3 etchants. The etching rate and the etching rate ratio increased by the addition of NH3 to the O2 etchant. Furthermore, the etch rate ratio was varied with the etchant gas flows. The formation of chemical etching pits on the film surface was not observed. These results are explained by the chemical reaction of the etching gases with the GaN film. The O2 etchant is etched with the galvanic reaction at the anodic area, while the NH3 etchant is etched with the galvanic reaction at the cathodic area. The results also suggest that the semiconductor layers on the GaN film surface are etched by the chemical reaction of the etching gases with the semiconductor layers.

[26P-106] Study of the Ideality Factor of Blue Light-Emitting Diodes Using the Photovoltaic Characteristics

Jae-Hoon Ham1, Chan-Hyung Oh2, Dong-Pyo Han1, Hyunsoo Kim1, Jong-In Shim1, Dong-Soo Shin2, and Kyu-Sang Kim1
1Hanyang University, Korea; 2Sangji University, Korea

We investigate the diode ideality factors obtained from the photovoltaic characteristics and compare them with the ones from the conventional current-voltage characteristics. By eliminating the series resistance in the bulk region, the ideality factors from the photovoltaic measurements can give more accurate information on the recombination processes and the defects in the active quantum wells.

[26P-107] Experimental Separation of Injection and Radiative Efficiencies in InGaN/GaN Light Emitting Diodes

Nan-Choo Oh1, Taegoo Shin1, Youngbo Moon1, and Jung-Hoon Song1
1Kongju National University, Korea; 2UL Inc, Korea

The carrier injection efficiency (CIE) and the radiative efficiency (RE) are experimentally determined in order to clarify the origin of the efficiency drop in blue-emitting GaN light emitting diodes. The difference in the shape of RE curves and the external quantum efficiency (EQE) curves shows the CIE is a function of the injection current, while the RE curves show the drop behavior to a certain degree. The experimentally determined CIE is significantly lower than unity and decreases with the current density, indicating that imperfect carrier injection has strong effects on the efficiency drop. Through our analysis, we conclude that both an intrinsic component, such as Auger recombination, and current leakage component exist and make notable contributions to the total EQE drop. These two components can be quantitatively separated through our proposed method. In addition, the result above is also comparatively investigated with the result of time-resolved electroluminescence (TREL) spectroscopies. The obtained CIE and RE consistently explain the behavior of TREL at various current density levels.

[26P-108] Carrier Overflow in InGaGaN Light-Emitting Diodes Investigated by Temperature-Dependent Short-Circuit Current Characteristics

Dong-Kuk Yoo, Gyeong Won Lee, Dong-Soo Shin, and Jong-In Shim
Hanyang University, Korea

The temperature dependence of the short-circuit current in the InGaGaN multiple-quantum-well light-emitting diode is investigated. From the experiments, we demonstrate that the carrier overflow to the p-GaN clad occurs more severely with decreasing temperature, resembling the behavior of the efficiency drop and the open-circuit voltage.

[26P-109] Quantitative Analysis of Carrier Escape Efficiency in GaN-Based Light-Emitting Diodes

Seong-Yuk Lim, Young-Ho Ko, and Yong-Hoon Cho
KAIST, Korea

Internal quantum efficiency, non-radiative efficiency in the active region, and efficiency of carrier escape out of the active region in InGaN-based light-emitting diode are deduced by comparison between open- and short-circuit photocurrent experiments.

[26P-110] Effect of the p-type GaN Thickness on the Near-Ultraviolet Light-emitting Diodes

Hyo-Stik Choi, Jong-In Shim, and Dong-Soo Shin
Hanyang University, Korea

We analyzed the influence of the p-type GaN layer thickness on the 380nm band near-ultraviolet-light-emitting diodes. Both electrical and optical characteristics of the LEDs were getting worse p-type GaN layer thickness increases with growth time. We suggest that the possible degradation mechanisms of characteristics are due to the increase of the non-radiative (NR) recombination rate in the active region as a result of thermal damage during p-type GaN layer growth process.
[26P-111] Strong Correlation Between Efficiency and Carrier Recombination Processes in Efficiency Droop of GaN Based Light-Emitting Diodes
Yang Seok Yoo, Jong Ho Na, Sung Jin Son, and Yong Hoon Cho
KAIST, Korea, LG Innotek, Korea
We present strong correlation between efficiency droop and carrier recombination rate variation in GaN based light-emitting diodes. And we analyze effect of radiative and nonradiative recombination processes under current injection without assuming any theoretical model.

[26P-112] Efficiency analysis of AlGaN deep UV-LEDs based on rate equation
Joosun Yun, Hideki Hirayama, and Jong-In Shin
RIKEN, Japan, Hanyang University, Korea
Efficiencies of 280nm AlGaN Deep UV-LEDs are extracted based on carrier rate equation. The results point out that hole density in p-type cladding layer is one of the important factors for efficiency droop phenomena.

[26P-113] Design Principles of Ultra High Transmittance Dielectric/Metal/Dielectric Electrodes
Jin-Young Na, Han-Kyeol Lee, Yeon-Jong Moon, and Sun-Kyung Kim
Kyung Hee University, Korea
We designed a high-transmittance dielectric/Ag/ITO electrode for high-efficiency GaN-based deep-ultraviolet light-emitting diodes. The optimized multilayer dielectric/Ag/ITO electrode yielded a transmittance of > 0.90 with an approximately 10-nm-thick Ag layer.

Manabu Taniguchi, Guo-Dong Hao, Kousei Nakaya, and Shin-Ichiro Inoue
National Institute of Information and Communications Technology, Japan, Kobe University, Japan
Light extraction efficiency (LEE) in deep-ultraviolet light emitting diodes with AlN substrate was investigated using Ray Tracing method. The results showed that LEE was dramatically improved by optimizing the sidewalls angle and AlN thickness.

[26P-115] Direct Mapping of Strain State in Nonpolar InGaN/GaN Multilayers Using Dark-field Inline Electron Holography
Ja Kyung Lee, Kyung Song, Christoph T. Kloc, Woo Young Jong, Dmitry Tyutyunnikov, Jong Kyu Kim, Chan Gyung Park, Peter A. Van Aken, and Sang Ho Oh
POSTECH, Korea, Ulm University, Germany
Two-dimensional strain in a nonpolar InGaN/GaN quantum well was measured quantitatively using inline electron holography. A periodic undulation of the strain was observed to arise to compensate otherwise diverging potential associated with a plane-polarization.

[26P-116] Injection-Locked Dual Fabry-Perot Laser Diodes for Interferometric Noise Suppression
Sang-Hwa Yoo, Myonggyoon Kye, Guoc-Huai Tran, and Chang-Hee Lee
KAIST, Korea
We propose and demonstrate a reduction of mode partition noise of an F-P LD using a fiber-based Mach-Zehnder interferometer (MZI). Injection-locked dual F-P LDs suppress polarization dependence to reduce a noise power by 3-dB.

[26P-117] Global Performance Investigation of Composite Pulses in Atom Interferometry
Yukun Luo, Shuhua Yan, Jun Yang, Qingqing Hu, Alai Jia, Chunhua Wei, and Guochao Wang
National University of Defense Technology, China
We theoretically analyzed the global performance of composite pulses on compensating off-resonance effects in atom interferometry. Results suggest emphasis be drawn on the necessity of a uniform phase response.

[26P-118] Optical and Optomechanical Design of Multiscale Gigapixel Camera System
Hyun-Tae Bae, Hee-Joon Moon, Yeon-Chan Choi, Ho-Kwan Kang, and Cheon-Seog Rim
Hannam University, Korea
As reported in Nature journal, the super resolution gigapixel camera of Duke University was highlighted on June, 2012 from Wall Street Journal and mass media. According to the reports, Duke gigapixel camera system was developed with big grant for the purpose of military operation and surveillance under the supports of DARPA because of the needs of US military. And this gigapixel camera is expected to promote new big market in the area of national defense and vision technology in the near future. In this paper, optical structural study was first proceeded to make a sense of whole optical ray mechanism so that the lens system could be optimized effectively by utilizing the data from structural study. And we also studied optomechanical desighn and building whole camera system.

[26P-119] A Bragg Diffraction-based Atomic Gravimeter
Qingqing Hu, Jun Yang, Shuhua Yan, Yukun Luo, Alai Jia, Chunhua Wei, and Guochao Wang
National University of Defense Technology, China
We presented a Bragg diffraction-based atomic gravimeter, which is able to increase the gravity measurement sensitivity significantly compared with the common Raman atomic gravimeter. We also discussed its advantages and difficulties.
[27P-2] Terahertz Multi-mode Resonances in T- and /\-shaped Resonators
Myeong-Seong Song, In-Seong Lee, Jin-Kyu Yang, and Joong Wook Lee
Chonnam National University, Korea
We demonstrate the characteristics of multi-mode resonance in coupled resonators with multi-slots. Our results show that the multi-mode resonance is caused by the structural complicity of the multi-slot coupled resonators. Each resonance mode corresponds to each distribution of electric charges determined by the structural dimensions.

[27P-3] Nondestructive and Remote Diagnosis on Coated Metal Surface by THz Imaging
Takashi Kimura, Seiya Takahashi, Kinsaku Maeda, and Yutaka Oyama
Tohoku University, Japan
THz wave technique is available for nondestructive diagnosis on invisible metal surface covered with opaque coating and/or painting. The demonstrations are successfully conducted in which samples are insulated copper cable and hot-dip galvanized steel sheet.

[27P-4] Non-destructive Measurement of Water Contents in Polyethylene Films by THz Time Domain Spectroscopy
Yasuyuki Matsuzaka, Kenji Sakai, Toshifumi Kawa, and Anji Tsuchida
Okayama University, Japan
Transmittance change of low-density polyethylene films during drying process were measured by THz-TDS. The results suggest that the quantity of water molecules in films were estimated by evaluating the magnitude of absorption peaks.

[27P-5] New Organic Electro-Optic Crystals for Highly Efficient Optical-to-THz Conversion
Seung-Heon Lee, Byung-Joo Kang, Ji-Soo Kim, Fabian Rotermund, and D-PY Kwon
Ajou University, Korea
New organic electro-optic crystals based on acentric core (OH) exhibit excellent nonlinear optical properties and crystal characteristics, which show one order of magnitude higher THz generation efficiency than inorganic ZnTe.

[27P-6] THz Near-field Spectral Encoding Imaging Using a Rainbow Metasurface
Kanghee Lee, Hyeon Joo Choi, Jaehyeon Son, Hyun-Sung Park, Jaewook Ahn, and Bumki Min
KAST, Korea
We develop a spectral encoding image technique in the terahertz range using a space-frequency converting metasurface. From the developed technique, 2-dimensional images are successfully reconstructed using only 1-dimensional data acquisition processes.

[27P-7] Adaptive Sampling, Terahertz Dual Comb Spectroscopy Using Unstabilized Dual Lasers
Tatsuya Mitoguchi, Ryutichi Ichikawa, Takuma Motoyama, Yi-Da Hsieh, Kazu Minoshima, Hajime Inaba, and Takeshi Yasui
Tokushima University, Japan; JSJ, Japan; The University of Electro-Communications, Japan; National Institute of Advanced Industrial Science and Technology, Japan
Terahertz (THz) dual comb spectroscopy (DCS) is a promising method for high-accuracy, high-resolution, broadband THz spectroscopy. In this paper, we have demonstrated adaptive-sampling THz-DCS, allowing the use of unstabilized dual femtosecond lasers.

[27P-8] Phase Modulation of Terahertz Waves in Arrayed Nanowire Heterojunction Diode
Jong-Hyuk Yim, Sang Hyuk Park, Jeong-Woo Hong, Sang-Bae Cho, Jung-Hong Min, Dong-Seon Lee, Jae Cheol Shin, and Young-Dal Jho
GIST, Korea; KOPPI, Korea; Yeungnam University, Korea
We demonstrate how the phase of terahertz (THz) waves could be electrically manipulated in one-dimensional nanostuctures such as $\text{InAs}_x\cdot\text{P}_{1-x}$-$\text{InP}$ core-shell nanowires (NNS).

[27P-9] Enhanced Terahertz Transmission through Graphene on Si/it Antenna
Hyun-Dek Yoo, Jong-Nyuk Yim, Yi-Bu Sohn, Hun-Kook Choi, and Young-Dal Jho
GIST, Korea
We observed enhanced terahertz (THz) transmission by implementing visible excitation in bilayer graphene transferred on a metal slit which was designed for tunneling THz field.

[27P-10] Various Photoconductive Antennas for Efficient Terahertz Detection
Won Tae Kim, Bong-Joo Kang, Tae-Kyoung Kho, Hyeon Sang Park, Kang Ho Kim, Jae-In Lee, Ki-Mo Park, Tae In Jeon, and Fabian Rotermund
1Ajou University, Korea; 2Korea Maritime University, Korea
We propose three different photoconductive antenna designs applicable as efficient THz receiver and investigate their detection properties. The experimental results showing different characteristics of spectral sensitivity and gain agree very well with the theoretical prediction.

[27P-11] Terahertz Wavefront Characterization Using a Hartmann Sensor Combined with 2D Electro-Optic Imaging
Harsano Cabyadi, Jérémie Deger, Eric Freysz, Takeshi Yasa, and Emmanuel Abraham
1The University of Tokushima, Japan; 2Bordeaux University, France
Two-dimensional electro-optic imaging combined with a Hartmann sensor enables THz wavefront characterization in time- and frequency-domain without cross-section scanning. Reconstruction with Zernike polynomials method allows qualitative and quantitative analysis as additional advantages.

[27P-12] Gas-Phase Spectroscopy Using THz Frequency Synthesizer Based on Dual Optical Combs
Yi-Da Hsieh, Kento Hayashi, Hajime Inaba, Kazu Minoshima, Takeshi Yasui
1Tokushima University, Japan; 2JST, Japan; 3The University of Electro-Communications, Japan; National Institute of Advanced Industrial Science and Technology, Japan
We constructed a THz frequency synthesizer based on photomixing of two continuous-wave lasers phase-locked to dual optical combs, and applied it for precision spectroscopy of molecular gas at low pressure.

[27P-13] Analysis of Fano Coupling in Terahertz Sub-wavelength Hole Arrays with Coupled Oscillator Model
Shan Yin, Xinchao Lu, Qingfeng Xu, Jiwen E, Weli Zhang, and Li Wang
Chinese Academy of Sciences, China; Institute of Microelectronics of Chinese Academy of Sciences, China; Oklahoma State University, USA
Firstly employing coupled oscillator model to quantitatively analyze the Terahertz enhanced transmission through sub-wavelength hole arrays, we clarify the surface plasmons resonance is excited by the localized resonance via coupling instead of the external E-field.

Singhoon Shin and Younghun Yu
1KEPCO KPS, Korea; 2Jeju National University, Korea
We propose a method for simultaneously measuring the front and back surface profiles of transparent optical components. The proposed method combines dual wavelength transmission deflectometry with liquids to record distorted phases at different wavelengths, and then numerically reconstructs the three-dimensional phase information to image the front and back surfaces of the bifocal lens.
[27P-15] Enhanced Optical Absorption in VO₂ Film Using Photonic Crystal
Zhe Wang, Wei Hong, Qian Chen, Guohua Gu, and Jun Lu
Nanjing University of Science and Technology, China
A VO₂ film with photonic crystal (PC) pattern is investigated and the optical absorption enhancement is significantly enhanced in near IR band. The structural parameters for PCs are optimized to get a better performance.

[27P-16] Spectral Dependence of Photovoltaic Cell Conversion Efficiency for Monochromatic Radiation
Minato Takesawa and Terao Baito
Tohoku Institute of Technology, Japan
Photovoltaic cell conversion efficiencies for quasi-monochromatic radiation have been measured as a function of the wavelength. It has been proven that the conversion efficiency is nearly proportional to the wavelength of the input radiation as the theory predicts. Also, it has been shown that the efficiency increases as a logarithmic function of the input irradiance. In conclusion, highest conversion efficiency is realized by illuminating a photovoltaic cell by intense radiation of low energy photons close to the bandgap energy while satisfying sufficient absorption.

[27P-17] Stress-induced Optical Rotation in CVD-grown Diamond
Hadiya Jaber, Robert Williams, Ondrej Kitzler, Qijing Lin, Aaron McKay, and Richard Miliken
Macquarie University, Australia
Defect induced stress birefringence in CVD grown diamond has been investigated using Metripol and Mueller polarimetry. Optical rotation was observed, up to a maximum of 28° through an 8 nm long diamond sample, in addition to linear birefringence.

[27P-18] Broadband Soft Glass Photonic Crystal Fiber Polarization Splitter
Zhenkai Fan and Shuguang Li
Yaroslav National University, China
We report on a novel soft glass dual-core photonic crystal fiber (DC-PCF) with a chalcogenide glass core, whose polarization dependent coupling can be enhanced by the high refractive index As₂S₃ core. Numerical results demonstrate the designed soft glass DC-PCF application as a broadband polarization splitter.

Yi-Chuan Tseng, Chen-Chien Yu, Pao-Yun Su, Kuei-Ying Chang, Yu-Ting Yen, and Hsuen-Li Chen
Yu-Ting Yen, and Hsuen-Li Chen
National Taiwan University, Taiwan
We developed a low-cost and direct imprint-in-metal method to prepare incident angle-tuned, broadband, ultra-high-sensitivity plasmonic antennae from nanoparticles (NPs) and imprinted-metal mirrors that can detect analytes at concentrations as low as 10⁻¹⁵ M.

[27P-20] Spatial Mode Projection Technique in Extracting Nanofeatures
Nenad J. Barcza and Nathaniel Hermosa
University of the Philippines, Philippines
We propose a technique based on spatial mode projection that can access dimensional information of nanofeatures. We demonstrate this by calculating the power of a mode-projected Gaussian beam that has been reflected by a nanocylinder.

Cheng-Hao Ko¹, Kuei-Ying Chang¹, Yau-Min Huang¹, Sh-Hung Tsai¹, and Bang-Ji Wang¹
¹National Taiwan University of Science and Technology, Taiwan, Taiwan National Space Organization, Taiwan
An analytical thin film thickness model calculates the profiles of linear variable filters, which perform spectral filtering. Coupled with an image sensor and using a computational algorithm, this device becomes a LVF-hyperspectral imager.
[27P-29] Stress Induced Bend Compensation in a Large Mode Area Fiber
Xuan Wu, Huoji Li, and Seongwoo Yoo
Nanyang Technological University, Singapore
Large mode area fiber with pre-compensated index profile by asymmetric stress applying part is proposed to effectively cancel out the bending effects. Mode area scalability up to ~2500 μm² is presented.

[27P-30] Fibre Fabrications for High Power Laser Fibres and High Nonlinearity Fibres
Seongwoo Yoo, Seetharaman Rajaguru, Daryu Ho, Min Seog Yoo, Xuan Wu, and Lilting Zhang
Nanyang Technological University, Singapore
This paper presents fabrication methods to achieve asymmetric core fibre for high power laser applications and high-nonlinearity fibres for Raman scattering. Fabrication results and challenges are discussed.

Oleg Prudnikov, Denis Bratnikov, Anatoly Boren, Andrei Goncharov, Roman Ilenkov, Alexey Tichenachev, and Valery Yudin
1Novosibirsk State University, Russia; 2Institute of Laser Physics SB RAS, Russia; 3Novosibirsk State Technical University, Russia
The two-stage laser cooling strategy for Mg atoms is proposed. The calculations based on quantum treatment with full account for the recoil effect. The results can assist overcoming current difficulties in deep laser cooling of magnesium.

[27P-32] Discrete Rogue Waves in an Array of Waveguides
Cem Yuce and S. Efe
Anadolu University, Turkey
We study discrete rogue waves in an array of nonlinear waveguides. We show that very small degree of disorder due to experimental imperfection has a deep effect on the formation of discrete rogue waves. We predict long-living discrete rogue wave solution of the discrete nonlinear Schrödinger equation.

[27P-33] Sub-Doppler DAVLL for D Lines of Rib Atoms
Gyeong-Won Choi and Heung-Ryoul Noh
Chonnam National University, Korea
A theoretical and experimental study of lineshapes in sub-Doppler DAVLL dichromic atomic vapor laser beck spectroscopy for the D lines of rib atoms was presented. From the calculation of sub-Doppler DAVLL spectra using both density matrix equations and rate equations we found that the coherence effect depended significantly on the branching ratios of the transition lines. We also investigated the dependence of the amplitude and the slope of the spectra on the magnetic field and the pump beam intensity, and found good agreement with the results calculated from the rate equation.

[27P-34] Propagation of the Light Phase Pulses in Atomic A-type Medium Under EIT Conditions
Maksim Basalev, Oleg Prudnikov, Alexey Tichenachev, and Valery Yudin
1Novosibirsk State University, Russia; 2Institute of Laser Physics SB RAS, Russia; 3Novosibirsk State Technical University, Russia
We study the dynamics of the phase pulses of laser radiation with two resonant frequency components propagating in an atomic three-level medium. We show that the effect of slow-down occurs also for phase pulses.

[27P-35] Protecting Quantum Discord Using Weak Measurement and Quantum Measurement Reversal
Jiyeon Yune, Kang-Hee Hong, Hyung-Tag Lim, Jong-Chan Lee, Osung Kwon, Sang-Hook Han, Sung Moon, Yong-So Kim, and Yoon-Ho Kim
1KIST, Korea; 2POSTECH, Korea
We report that quantum discord can be protected from decoherence by making use of weak and revering quantum measurements, making it possible to distribute quantum correlation between two remote parties in noisy environment.

Osung Kwon, Kwang-Ryoon Park, Young-Sa Yu, Yong-Su Kim, and Yoon-Ho Kim
1KIST, Korea; 2POSTECH, Korea
We report another regime for generation of time-bin entangled photon pairs and demonstrate the scheme experimentally. In our scheme, the photon pairs are pumped by a cw multi-mode laser having coherence revival property.

Roman Ilenkov, Oleg Prudnikov, Alexey Tichenachev, and Valery Yudin
1Novosibirsk State University, Russia; 2Institute of Laser Physics SB RAS, Russia; 3Novosibirsk State Technical University, Russia
Developed a statistical approach, which provides information about the cooling time of an atomic ensemble without directly solving a dynamic problem. The effect of velocity saturation of laser cooling with increasing Rabi frequency was found.

[27P-38] Avoiding Entanglement Sudden Death on Two-qubit Systems Using Single-qubit Quantum Measurement Reversal
Hyang-Tal Lim, Jong-Chan Lee, Kang-Hee Hong, and Yoon-Ho Kim
POSTECH, Korea
Decoherence on two-qubit systems degrades entanglement, and sometimes even causes entanglement sudden death (ESD). We show that quantum measurement reversal on only one subsystem can avoid ESD, providing methods for practical entanglement distribution under decoherence.

Min-Seok Kim, Moo Young Lee, Jeong Ho Han, and Yong-Yul Shin
Seoul National University, Korea
We present an experimental apparatus where we can generate a Bose-Einstein condensate of 6.2×10⁴ 174Yb atoms or a degenerate Fermi gas of 7.8×10⁴ 173Yb atoms at T/T_F=0.31.

[27P-40] Cotrollable Asymmetric Matter-wave Beam Splitter and Ring Potential on an Atom Chip
Seung Jin Kim, Seok Tae Gang, Hoon Yul, and Jong Bang Kim
1Korea National University of Education, Korea; 2University of Colorado, USA
We have constructed an asymmetric matter-wave beam splitter and a ring potential on an atom chip by applying rf-field parallel to the quantization axis added to perpendicular rf-fields. Versatile controllability on the potentials can be obtained.

[27P-41] Quantum Key Distribution with Mode-locked Two-Photon States
Tomoyuki Horikiri
Yokohama National University, Japan
Quantum key distribution (QKD) with mode-locked two-photon states is discussed. The photon source with a comblike second-order correlation function is shown to be useful for implementing long distance time-energy entanglement QKD.

[27P-42] Two-photon Interference between Distinguishable Pathways Utilizing SPDC Pumped by a Multimode Diode Laser
Osung Kwon, Tujun Choi, Young-Soo Kim, Sang Hoo-Kun, and Sung Moon
1KIST, Korea; 2POSTECH, Korea
We report the two-photon interference between distinguishable pathways before arriving at photo detectors utilizing SPDC pumped by a multimode diode laser with the distinctive coherence property.

[27P-43] Polymer Planar Optical Waveguides for Optical Interconnections
Vaclav Pajer, Pavel Nekvindov, Petr Hysa, Jan Brychtla, and Vlastislav Jerabek
1Czech Technical University, Czech; 2Institute of Chemical Technology, Czech
The paper reports on technology for realization of an optical planar waveguides for optical interconnections. The waveguiding properties were measured by dark mode spectroscopy and optical loss were measured by the fiber probe technique.
**[27P-44] Circular Polarization Filters Using Perturbed Chiral Sculptured Thin Films**

Zahir Muhammad  
Quaid-i-Azam University, Pakistan

A structurally chiral layer defect or central 90°-twist defect in chiral sculptured thin film (STF) transmits light of one circular polarization state and reflect other in a spectral Bragg regime. The perturbed chiral STF reflects light of both circular polarization states in the Bragg regime if the amplitude of modulation of vapor incident angle is increased. A structurally chiral layer defect in a perturbed chiral STF results as a narrow bandpass or ultranarrow bandstop filter depending upon different thickness of the STF. However, both the bandpass or narrow bandpass and ultranarrow bandstop filters are made polarization-insensitive by the appropriate modulation of the tilt nanowhiskers of perturbed chiral STF. Moreover, it is also observed that the polarization-insensitive Bragg mirrors, laser mirror and Bragg reflector fabricated using chiral STFs, which are very tolerant of structurally chiral layer defect if the amplitude of modulation vapor incident angle of the structural nanomaterials is sufficiently large.


Wei-Guo Jin, Soo Kawamura, Yuja Ro, Tatsuya Minowa, and Takahiro Ikeda  
Tohoku University, Japan; RIKEN, Japan

Propagation and transmission of laser beam through tapered glass capillaries were investigated for light microbeams. Transmittances of laser light at 886 nm and 653 nm through capillaries were measured to be up to 15%, depending on outlet diameters. By modeling the real capillary, transmittances were calculated using taper angles obtained from shape analysis and agree well with experimental ones.

**[27P-46] Tunable Chirality Induced-double-layer Metamaterials**

Yu Zhou  
Peking University, China

An all-optical tunable chirality is realized in a double-layer photonic metamaterial. The maximum circular dichroism reached 30%. Under excitation of a 40 kV/cm weak pump light, the peak in the circular dichroism shifts 45 nm in the short-wavelength direction and an ultrafast response time of 35 ps is maintained.

**[27P-47] Nanolithography Using Micro-scale Mask Enabled by Hyperbolic Metamaterial**

Donghwan Kim, Yong Rae Cho, and Bumki Min  
KAIST, Korea

We newly developed a nano-scale patterning method overcoming the diffraction limit of conventional photolithography technique by utilizing micro-scale aluminum mask-hyperbolic metamaterials hybrid structures, which is supported by our numerical simulation and experimental results.

**[27P-48] PL Emission of InP/GaInAs/InP Core-multishell NWs Grown by Self-catalytic VLS Mode**

Takeru Ogiue, Keita Asakura, Takao Waho, and Kazunori Shimomura  
Sophia University, Japan

Photoluminescence emission of InP/GaInAs/InP core-multishell nanowires was obtained at room temperature. InP nanowires were grown on InP(111)B substrate by self-catalytic VLS mode of MOVPE using an indium catalyst. InP-core and GaInAs-shell structure was grown at 650°C and 520°C, respectively, and the InP nanowires were measured to be up to 15%, depending on outlet diameters. By modeling the real capillary, transmittances were calculated using taper angles obtained from shape analysis and agree well with experimental ones.

**[27P-49] Terahertz Wire-grid Polarizer with AI Grating**

Ren Yoshida, Ritsuru Yamada, Jonichki Yanagihara, Ketsuke Takano, Masanori Hanyou, Mitsunori Saito, and Wataru Watanabe  
University of Shiga Prefecture, Japan; Osaka University, Japan; Kyoto University, Japan; Tokyo University of Science, Japan

A terahertz (THz) wire-grid polarizer consisting of a micrometer-pitch Al grating on a Si substrate was fabricated by photolithography and wet etching. Extinction ratio of the ratio of TM and TE transmittances was over 35 dB at 0.3 THz, and over 23 dB at the 0.5–3 THz range. At the Brewster’s angle of Si (74°), TM transmission exceeded 90% in the 0.5–3 THz range. The fabricated polarizer had a lower extinction ratio than conventional free-standing terahertz wiregrid polarizers.

**[27P-50] Lasing Characteristics of Cardioid-Shaped 2-D Microcavity Laser**

Sogang University, Korea; DGIST, Korea; ETRI, Korea

Directional emission in a cardioidal-shaped microcavity is investigated. When a microcavity laser deformed from a circular shape in polar coordinate is excited by current injection, it emits unidirectionally at a certain deformation parameter. We confirm the emission characteristics in an InGaAsP semiconductor laser.

**[27P-51] Dynamical Properties in Asymmetric Reuleaux Triangle 2-D Microcavity**

Jin-Goo Jin, Ji-Won Lee, Changwan YW, Ji-Hwan Kim, Jin-Goo Lee, Sung Min Go, and Chul-Min Kim  
Sogang University, Korea; DGIST, Korea

A Reuleaux triangle microcavity is one of the curves having a constant width. We deform it asymmetry and compute its ray and wave properties. As a result, we find a unidirectionally emitting mode at a single window. Here, we investigate the emission mechanism and characteristics depending on the deformation.

**[27P-52] Mid-Infrared Optical Waveguide Modulator Based on the Epsilon-near-Zero Effect ofITO**

Jeonghun Lee and Min-Suk Kwon  
UNIST, Korea

Electroabsorption modulators based on the epsilon-near-zero (ENZ) effect of ITO are theoretically investigated. They are designed to work in the mid-infrared. We demonstrate that the modulator length is made smaller than 1.16 μm.

**[27P-53] Optical Mode Converter Using Ring Resonator Structure**

Intekhab Alam, M. Raquib Ehsan, Sakia Mumtaha Bar, Manin Haque, and Nur-E-Mohammad Rubat  
United International University, Bangladesh

We present a novel ring resonator structure for optical mode conversion for mode division multiplexing. The proposed microstructure (<15x15 μm) converts 0th mode to 1st mode with just 0.18 dB conversion loss (Δ=−1.55 μm, TEMode).

**[27P-54] Ultra-flat and Broad Optical Frequency Comb Generation Based on Novel Dispersion-flattened Double-slab Microring Resonator**

Yuanwu Wang, Mingmin Zhang, Luolai Mu, Mingli Li, Zhiru Wang, and Deming Liu  
Huston University of Science and Technology, China

An ultra-flat and broad optical frequency comb with 7 dB bandwidth of 1155 nm wavelength bandwidth is obtained, based on a novel double-slab microring resonator in simulation, which produces flattened dispersion of 0 ~ 3.5 ps/(nm·km) over a 1155 nm wavelength range.

**[27P-55] InGaAsP Nanobeam Light Emitter Integrated with Si Waveguide via Transfer Printing**

Jaehyun Son, Indra Kamarad, Ji-Young Kim, Hoon Jang, Seungwooa Lee, Ki Soo Kim, Yong Hee Lee, and Bumki Min  
KAIST, Korea; Stanford University, USA; Sungkyunkwan University, Korea; ETRI, Korea

A nanobeam photonic crystal cavity made with InGaAsP quantum well and Si waveguide is integrated on SiO2/Si substrate via transfer printing. The light emitted from the nanobeam showed coupling to waveguide. We demonstrated novel way to integrate III-V devices on Si based photonic integrated circuits.

**[27P-56] Ultralow-energy InGaAsP Modulators Based on a Photonic Crystal Waveguide/Nanocavity Involving the Franz-Keldysh Effect**

Kengo Nakazi, Shinji Matsuo, Abdul Shakoor, Shuvi Dinulescu, Koji Takeda, Takuo Fujii, Eiichi Kuranochi, and Masaya Natsumi  
NTT Corporation, Japan

Ultrasmall InGaAsP optical modulators were realized using a photonic crystal waveguide/ nanocavity with a small capacitance p-n-junction and the Franz-Keldysh effect. Eye patterns reaching 56 Gb/s and a record-low charging energy of <100 aJ/bit were evaluated.
[27P-57] Microwave Signal Generation Using Sideband Injection Locking in an Fabry-Perot Laser Diode
Liqing Gan1, Feng Li1, Je Lu1, and F. K. A. Wu1
1 The Hong Kong Polytechnic University, Hong Kong, China, 2Sun Yat-sen University, China
Microwave signal generation using sideband injection locking in a Fabry-Perot laser diode is studied numerically. The frequency tuning range in frequency doubling, tripling, and quadrupling is compared.

[27P-58] Spectral Tuning of an Add-drop Filter by Using Double Dielectric Microdisks
Da Eun Lee, Tae-Woo Lee, and Soon-Hong Kwon
Chung-Ang University, Korea
A spectrally tunable add-drop filter based on a whispering gallery mode in a double dielectric microdisk pair with an air gap is proposed, and its operation process and performance are demonstrated by finite-difference time-domain simulation.

[27P-59] Optical Bistable Temperature Switch Properties Using 1DPC with a Kerr Defect
Jian Zhang and Rongjun Zhang
Shanghai University, China
Optical bistable temperature switching is investigated for one-dimensional Kerr defective photonic crystal. Steep transition and high optical contrast can be achieved and switching temperature and the hysteresis width can be precisely tuned.

[27P-60] Emission Characteristics of a Microcavity Laser Comprised of Half Circle and Half Ellipse
Ji-Won Lee, Changwan Yoo, Ji-Hwan Kim, Kwang Ryong Oh1, Sung-Bock Kim2, and Chi-Lim Min1
1DGIST, Korea, 2Sogang University, Korea, 3ETRI, Korea
We experimentally investigate emission characteristics of a microcavity laser, which is comprised of a half ellipse and a half circle. The emission direction of the fabricated InGaAsP semiconductor laser is unidirectional. At high injection current, the laser emits a single mode.

[27P-61] Interaction between Slots as Oscillator Model
Syeon Lee and O-Han Park
Korea University, Korea
We present oscillator model for coupled plasmonic resonators. Narrow slot on metal film can be modeled as a bound charge oscillator. The oscillator model offers quantitative description about fundamental modes and electromagnetic induced transparency spectrum.

Tae Young Kim1, Md. Alamgir Badshah1, Junho Yoon1, Young Chul Jeo1, and Chang Kwon Hwang2
1Inha University, Korea, 2UNIST, Korea
In this study, we report ITO thin film designs for epsilon-near-zero coherent perfect absorption in near infrared wavelength regime using an admittance matching method and investigate their optical properties.

[27P-63] Numerical Simulation of an Ultra-Wide Tunability and Enhanced Spontaneous Emission of a Nanofiber Bragg Cavity
Hitoshi Takakusima1,2, Andreas W. Schaef1,2, Shin’Ro Fujita1, Yusaku Okada2, Syunya Kamioka2, Masayumi Fujitani1, and Shigeki Takeuchi1,2
1Kyoto University, Japan, 2Hokkaido University, Japan, 3Osaka University, Japan
A detailed numerical study using 3D FDTD simulation on the fiber Bragg grating cavity is reported in order to further improve the ultra-wide tunability over 20 nm and the enhanced spontaneous emission we recently reported.

[27P-64] Design of High-Efficiency Nanorod Emitters Using Optical Cavity Effects
Du-Sam Kim, Jin-Yang Niu, Yoon-Jong Moon, and Sun-Kyung Kim
Kyung Hee University, Korea
We studied the extraction efficiency of nanorod emitters by performing full-vectorial electromagnetic simulations. The result indicated that the extraction efficiency was dramatically changed by the radial position of a light generation layer.

[27P-65] Polarization-dependent Properties of Human Scleral Tissues at Terahertz Frequencies
Da-Ched Shin1, Jung-Min Park2, Gyeong Bok Jung2, Jae-Ho Shin2, Chul-Sik Kee2, Chul Kang3, and Young Wook Lee1
1Chonnam National University, Korea, 2Kyung Hee University, Korea, 3GST, Korea
We used terahertz time-domain spectroscopy to distinguish between normal and cross-linked human scleral tissues. Normal tissue is sensitive to the polarization of terahertz waves, whereas cross-linked tissue is polarization insensitive. Our results demonstrate terahertz spectroscopy can be a powerful tool for investigating human scleral tissues.

Zhigang Yang, Danyong Lin, Xiao Peng, and Junye Ou
Shenzhen University, China
A fluorescent rotor was developed for mitochondrial microviscosity imaging by which the mitochondrial average viscosity was determined to be ca. 62 cp in normal HeLa cells and was increased to ca. 110 cp after treated by ryanstain.

[27P-67] Fluorescence Lifetime Determination of Photo-bleaching Correlation
Won Sang Hwang, Yongjool Song, and Duyoung Kim
Yonsei University, Korea
FLM is reliably stable about photo-bleaching effect. In case of dye has multi-exponential decay property, fluorescence lifetime can be affected by photo-bleaching. Such lifetime variation can cause critical error in many FLM applications. If lifetime is changed by photo-bleaching, we cannot measure accurately donor lifetime with acceptor. It is difficult to separate lifetime variation by photo-bleaching and FRET. For this reason, we carry out the experiment to know influence of such fluorescence intensity loss on fluorescence lifetime.

[27P-68] Imaging through Turbidity by Using Speckle Illumination
Joo Eun Oh1, Giuliano Scarcelli2, and Yoon-Ho Kim3
1POSTECH, Korea, 2University of Maryland, USA
We demonstrate that a clear image of an object hidden behind a turbid medium may be obtained by using speckle illumination and correlation measurement whereas conventional measurement only results distorted and blurred images.

[27P-69] Digital Holographic Microscopy for Phase Images of Cervical Cells 3D Structure
Mona Mihalcescu1, Inna Alexandra Pavel1, Eugen Scarlat1, Inna Grigorescu1, Oana Tatiana Nedelcu2, and Roxana Nada2
1Politehnica University from Bucharest, Romania, 2National Institute for Microtechnology, Romania, 3Conac Hospital, Romania
The phase images of cervical cells were obtained in digital holographic microscopy to establish the 3D characteristics as criteria for information quantification and cells classification. We introduced a simple approach for the cells overlapping regions based on the focalization criteria.

[27P-70] Supercontinuum as a Light Source for Miniature CMOS Sensors in Endoscopic Imaging
Ming-Auan Lu1,2, Hsin-Yu Lin1,2, Dih-Cheng Hsieh3, and Fu-Jen Kao3
1National Yang-Ming University, Taiwan, 2Chung-Hua Telecom Research Institute, Taiwan, 3Taipei Veterans General Hospital, Taiwan
We have successfully implemented supercontinuum through fiber coupling as a light source for miniature CMOS sensors (ranging 0.8 mm) in endoscopic imaging. Comparison with LED and other light sources are also made to show the advantages and characteristics of supercontinuum.
[27P-71] Multiple Labeling Fluorescence Lifetime Analysis in a Single Shot Imaging
Young Sik Song1, Young Jae Won1, Chang Jun Lee1, and Dug Young Kim1
1 Yonsei University, Korea, 2Osong Medical Innovation Foundation, Korea
We propose new approaches analysis for fluorescence lifetime imaging measurement of multiple labeling at single shot process. This paper suggests analysis concept of which can extract small scale signal ratio simply in the complex environment.

Youngmo Jeong, Jiwoon Yom, and Byoungho Lee
Seoul National University, Korea
A detection system for blood flow using laser speckle contrast with dual wavelengths is proposed. A 780 nm near-infrared laser and a 450 nm blue laser are simultaneously utilized to eliminate the effect of scattering at skin.

[27P-73] Mapping the Progression of Malaria Infected Erythrocytes with Holographic Microscopy
Xunlei He, Alexander Blak, and Steve Lee
The Australian National University, Australia
We demonstrate an off-axis digital holographic microscopy system for imaging infected red blood cell and propose to combine that with flow channels to study adhesion bonds of infected blood cells at the cellular and molecular level.

[27P-74] Compact Probe Head of Second-Harmonic-Generation Microscopy for Dermatological Applications
Kosuke Atuda, Eji Hase, and Takeshi Yasu
The Tokushima University, Japan
We construct a compact probe head of the fiber-based SHG microscopy for the dermatological applications, and successfully demonstrated SHG imaging of the tendon sample using it.

[27P-75] Lithium-Niobate-Silica Hybrid Whispering-Gallery-Mode Resonators
Fang Bo1, Jeong Han2, Jiaxu Cui1, Sahin Odemir2, Yongta Kang3, Guoqian Zhang1, Jingjun Xu1, and Lan Yang1
1Nankai University, China, 2Washington University, USA
Hybrid whispering-gallery-mode resonators were made by depositing a plasmonic lithium niobate film onto silica resonators. Efficient coupling with tapered fiber and all-optical modulation were realized in these resonators.

[27P-76] Optical Feedback Effects on the Dynamics of Semiconductor Nano-lasers
Alan Shore and Zubaida Sattar
Bangor University, UK
Enhanced spontaneous emission effects are shown to increase the sensitivity of semiconductor nano-lasers to optical feedback. These results have significance for the use of nano-lasers in photonic integrated circuits.

[27P-77] Lasing on Surface States at the Edge of a Defect-free Photonic Crystal
Yuan Su1, Chun-Yan Lin2, Ray-Ching Hong1, Wen-Xing Yang2, Chien-Chung Jeng3, Tian-Chang Liu1, and Ray-Kuang Lee1
1National Tsing-Hua University, Taiwan, 2Southeast University, China, 3National Chung-Hsing University, Taiwan
We report experimental observation of lasing on surface states, in the form of standing waves at the termination of a defect-free photonic crystal on top of vertical cavity surface emission lasers. Direct images of lasing modes at the truncated periodic potential, along one side of a square lattice, are demonstrated by collecting near-field radiation patterns, as well as in numerical simulations.

[27P-78] Realization of Bragg Grating Based Integrated Fractional Photonic Hilbert Transformer
Bolan Liu1, Chaotan Sima1, Wei Yang1, Deming Liu2, Yu Hu3, James Gates4, Michaelis Zervas5, and Peter Smith6
1Kuwait University of Science and Technology, China, 2University of Southampton, UK
Wideband integrated fractional order photonic Hilbert transformer (FrPHT) is proposed and demonstrated, by using single apodized Bragg gratings with phase shifts in a silica-on-silicon planar platform. Effects of apodization profiles and operation bandwidths are analyzed.

[27P-79] Lasing Characteristics of Resonance Modes in a Racetrack Cavity with Hexagonal Corners
Jae-Dong Kim, Kyung-Sook Hyun, and Hee-Jong Moon
Sejong University, Korea
We propose resonance mode in a racetrack cavity with hexagonal corners, in which the modes are guided by both boundaries of the corner. The modes were demonstrated by investigating the laser oscillations in semiconductor cavities.

[27P-80] Optical Heterodyne Detection of a Surface Plasmon Signal in an Electronic Circuit
Shinya Okahisa1, Hiroki Sakai1, Takuma Aihara1, Masashi Fukuhara2, Yuya Ishii1, and Mitsuo Fukuda1
1Tohoku University of Technology, Japan, 2Japan Society for the Promotion of Science, Japan
We demonstrate the dynamic operation of monolithically integrated plasmonic detector and MOSFETs on silicon. The integrated device operates at the beat signal of surface plasmons converted from two light beams in 1.31-µm wavelength band.

[27P-81] In-Situ Monolithic Integration of Nanobeam Laser with Passive Waveguide on SOI
Jungmin Lee, Hoon Jang, Inha Kamardi, Prudhvi Pramudita, Hwi-Min Kim, and Yong Hee Lee
KAST, Korea
We demonstrate in-situ monolithic integration of an InP-based nanobeam laser and a passive waveguide on SOI using selective quantum well etching technique. The device on SOI platform is realized by employing transfer printing process.

[27P-82] Cavity Length Dependence on Lasing Characteristics of Double-capped QDs Laser
Toshihiko Sugiyama, Yuta Yamamoto, Tetsuo Moriya, and Kazuhiko Shimomura
Sophia University, Japan
Cavity length dependence on lasing characteristics was obtained in the p-modulation doped double-capped InAs QDs laser on the InP substrate at 1.65 µm wavelength. Stranski-Krastanov InAs QDs was grown low-pressure MOCVD, and employed the p-modulation doping in the capping layer during the double-capped process. Lasing characteristics was obtained under pulsed injection current at room temperature. We have shown the lasing wavelength and threshold current dependent on the cavity length of the laser.

[27P-83] Monolithic Integration of Microlaser with Passive Waveguide via Selective Quantum well Etching
Hwi-Min Kim, Hoon Jang, Sejong Kim, and Yong Hee Lee
KAST, Korea
Monolithic integration of a photonic crystal laser and a passive waveguides via selective quantum well etching are demonstrated. Coupling efficiency between photonic crystal cavity and waveguide is investigated numerically.

[27P-84] Integrated Polarization Rotator on Silicon Waveguides with an Asymmetric Trench
Yuduk Kim1, Dong Wook Kim2, Moon Hyuck Lee3, Min Hee Lee4, Dong Eun Yoo5, Ki Nam Kim2, Sang Chul Jeon6, and Kyong Hon Kim6
1Inha University, Korea, 2National Nanofab Center, Korea, 3Korea Polytechnics, Korea
We demonstrate an integrated polarization rotator with a single trench on a silicon waveguide fabricated using a single etch-step complementary metal-oxide–semiconductor (CMOS)-compatible process. The measured polarization rotation efficiency is 95 %with 0.76 dB insertion loss for a total 67-µm long and 100-µm wide asymmetric trench.
[27P-85] Measuring Equi-frequency Contours of Spoofer Surface Plasmon Polaritons
Kap-Joong Kim1, Seong-Han Kim1, Chul-Sik Kwee1, and Yong Hee Lee2
1ETRI, Korea, 2GIST, Korea, 3AIST, Korea
By directly measuring electric fields, we obtain equi-frequency contours of surface waves. In
the metallic square lattice, the presence of the anisotropy from the equi-frequency contours
is experimentally confirmed.

[27P-86] Thermo-optic Tunable Silicon Grating Coupler
Linghai Liu, Bingqing Zhu, and Hong Nl Tsang
The Chinese University of Hong Kong, Hong Kong, China
We demonstrate a thermally tunable silicon grating coupler. The experimental result of
~10nm shift in center wavelength at about 410nm electrical power was in reasonable
agreement with the expected ~16nm tuning range.

[27P-87] Selection of the Lasing Direction using S-bend in the Semiconductor Cavities
Kiyoung Sook Hyun, Sang-Hyuk Jeong, Young Hoon Kim, Daen-Jin Kim, and Jinwoong Lee
Sejong University, Korea
The selection of lasing direction in micro cavity is demonstrated by using s-bend in the
rectangular cavity. The parameter of S-bend section is calculated to minimize the
propagation loss and optimized to serve good selectivity.

[27P-88] Proposal of a PLC-based 3-mode (2 LP modes) Demultiplexer
Koito Kataoka, Hironkai Kubota, Yui Miyoshi, and Masanori Ohashi
Osaka Prefecture University, Japan
We propose a PLC-based 3-mode demultiplexer and numerically investigate three mode
separation of the demultiplexer. Insertion loss is calculated by the numerical simulation.

[27P-89] Plasma Assisted Tunable Exciton States in Monolayer MoS2
Younghee Kim, Young In Jhon, June Park, Jae Hun Kim, and Young Min Jhon
KIST, Korea
We performed photoluminescence (PL) and Raman spectroscopy for Cl2 and H2 plasma
modified monolayer MoS2. (1L-MoS2) crystals. We demonstrated that PL intensities in
1L-MoS2 can be tuned by heating Cl2 and H2 plasma.

[27P-90] Electrically Driven Quasicrystal Microcavity Laser Based on Organic Semiconductor
Xiao Chen, Yuanquan Cai, Ning Li, Changwei Li, and Yiyan Wang
Mizcu University of China, China
We design and fabricate an electrical pumping laser with a quasicrystal microcavity based on
MEH-PPV layer sandwiched between two electrodes. The lasing performance is observed
at 606 nm. The threshold current is around 0.8 mA.

[27P-91] Polarization Dependence and Optical Aharonov-Bohm Oscillations in a Single Local QR in a Large Droplet QD
Seongho Park1, Takayuki Kida1, Akhiro Murayama1, JinGang Song1, and Kwangsook Kyhm1
1Pusan National University, Korea, 2Nihon University, Japan, 3AIST, Korea
We analyzed time-resolved and magneto-micron-PL of a single droplet quantum dot in terms
of polarization anisotropy, decay time, and diamagnetic coefficient in order to support the
presence of localized state in a large droplet quantum dot.

[27P-92] Scale-Adaptive Compressive Tracking
Zhengping Wu, Yang-Jie, and Haibo Liu
Wuhan University of Technology, China
Real-time Compressive Tracking (CT) tracker may drift away or fail especially when the object
is under the complex environment, including cluttered background, similar color distribution,
disturbing illumination change and occlusion, etc. Based on the framework of the CT
tracker, this paper proposes a new scale-adaptive tracker. Two main components improve
the robustness of our approach: 1) a novel object information measure method based on
CT algorithm, and 2) a simple and feasible algorithm for adjusting the scale of the tracked
bounding window according to the amount of the object information. Numerous experiments
with three state-of-the-art compressive trackers on challenging sequences demonstrate that
the proposed algorithm performs well in terms of accuracy, robustness and speed under the
complex environment.

[27P-93] Chaos Synchronization of a Star Network Based on Delayed Electro-Optical Systems
Hu Han Ping and Chen Xiaofeng
Huazhong University of Science and Technology, China
Chaos synchronization of a star network based on delayed electro-optical systems is discussed in
this paper. The outer nodes of the star network are connected to a center node through a unidirectional
optical injection signal from the center node to each outer node. We design a special network coupling
function through the Lyapunov stability theory, and set up the mathematical model of the proposed star network. We prove stable zero-lag chaos synchronization can be realized among all the nodes of our proposed star network mathematically. At last, chaos synchronization of the star network is numerical investigated. The simulation results are consistent with the results of theoretical analysis.

[27P-94] Optical Compensation for Elimination of Off-Axis Light Leakage in a Liquid Crystal Display
Seung-Won Oh and Taio-Noon Yoon
Pusan National University, Korea
Optical compensation for wide viewing angle characteristics in a liquid crystal display (LCD)
is essential for high-quality dark images, especially from the bisector direction of the
crossed polarizers. We introduce achromatic compensation configurations for a perfect dark
state in LCDs. To cancel out the effect of wavelength dispersion, we replaced each A plate in
the conventional uniaxial configurations by a pair of orthorhombic A plates.

[27P-95] A Study of Lens Array Compensation for Exciimer Laser Beam Homogenizing
A. Hyenjun Song1, Hakjun Lee2, Kwangwool Cho2, Daegub Gweon2, and Hongil Park2
1Laser Total Solution, Korea, 2AIST, Korea
In recent display industry, an interest of laser manufacturing process is increasing. It is
important homogeneity of the beam because of manufacture. In this study, we propose a
new lens array compensation system for beam homogenizing. To verify the performance of
system, experiment are carried out.

[27P-96] Formation of Holographic Memory by Angle-multiplexing Recording in Liquid Crystal Composites
Akifumi Ogiwara1 and Minoru Watanabe2
1Kobe City College of Technology, Japan, 2Shizuoka University, Japan
Formation of holographic polymer-dispersed liquid crystal (HPDLC) memory for an optically
reconfigurable gate array based on the angle-multiplexing recording is discussed by
controlling the laser interference exposure in liquid crystal (LC) composites. The successive
laser illumination system to record the various configuration contexts at the different
region and angle in HPDLC memory is constructed by using the half mirror and photomask
placed on the motorized stages under the control of a personal computer (PC). The
effect of laser exposure energy on the formation of holographic memory is investigated by
the measurement of diffraction intensity during the grating formation process. The
reconstruction of configuration contexts for the various logical circuits is demonstrated by
the laser illumination at different incident angle in the HPDLC memory.

[27P-97] Reference Functions in Grayscale and Noised Multiview Images
Vladimir Savelev1 and Sung-Kyu Kim1
1HanYang University, Korea, 2KIST, Korea
The previously proposed reference functions for synthesis and analysis of multiview images
in autostereoscopic 3D displays are applied to the analysis of grayscale and raised images of
a wireframe object.

[27P-98] Effect of the Coherence Length of Sunlight on the Absorption of V-shaped Organic Solar Cells
Kyungnam Kang1, Changjo Lee2, Sungchul Kim2, and Jungho Kim2
1Kyung Hee University, Korea, 2Myongji University, Korea
We numerically investigate the effect of the coherence length of sunlight on the absorption
of V-shaped organic solar cells. The absorbance and the spatial distribution of power dissipation are calculated with respect to partially coherent light.
Conference Program & Abstracts
The 11th Conference on Lasers and Electro-Optics Pacific Rim

Poster Session II (Exhibition Hall / Thursday, 27 August, 13:45~15:15)

[27P-99] Off-Axis Terahertz Digital Holography Using Continuous-Wave Terahertz Radiation
Takayuki Ogawa1, Dari Ibrahim2, Takashi Masuoka2, Takeo Yasu2, and Hirobugu Yamamoto3
1The Tokushima University, Japan, 2JST, Japan, 3Osaka University, Japan
We constructed an off-axis THz digital holography system equipped with a 0.1-THz CW-THz source and a mechanically-scanning THz pyroelectric detector, and then acquired THz digital hologram by it.

[27P-100] The Authenticity of Art: Analysis of the Optical Characteristics of Paintings
Seohee Hwang, Kiujung Kim, and Eunhee Kim
Pusan National University, Korea
In this study, we designed a setup using two different light sources to prove the authenticity of paintings through analysis of optical characteristics.

[27P-101] Computer-generated Holograms Using Stereo Disparity with a Multi-matching Algorithm
Yan-Ling Piao1, KI-Chul Kwon1, Jeong-Hyeon Lee2, Sang-Kiun O3, and Nam Kim1
1Chungbuk National University, Korea, 2Sewn University, Korea
Extracting depth information from stereoscope image is an important field in 3D imaging. In this paper, we proposed a method to record the computer-generated holograms based on high quality point cloud models which are generated by the disparity map from the stereoscopic image by use of a multi-matching algorithm.

[27P-102] Temperature-dependent Transport Properties in Vanadium Dioxide Thin Films
Jeongyong Cho1, Bong-Jun Kim2, Giwan Seo1, and Yong Wook Lee3
1Pukyong National University, Korea, 2Matric Co. Ltd., Korea, 3KAIST, Korea
In VO2, which is a promising strongly correlated material of electro-optics, temperature-dependent electrical transport properties were investigated by using ordinary Hall effect measurement. The interesting variation on the near boundary of insulator-to-metal transition was observed.

[27P-103] Organic Thin Film Photomemory with Isolated Photo-active Charge Storage
Mincheol Kim, Hyejeong Seoang, Seungwon Lee, Hyukyun Kwon, Sung Gap Im, and Seunghyup Yoo
KAIST, Korea
Organic photomemory devices are demonstrated in a geometry similar to that of floating gate memory. Simultaneous application of gate bias and light triggers a threshold-voltage shift. The proposed devices show fast light programming with gate pulse as short as 50 msec.

[27P-104] Trans-scale Optical Simulation for OLEDs Involving Scattering Substrates
Eunhye Kim, Hyunsu Cho, Jin Chung, Jinouk Song, and Seunghyup Yoo
KAIST, Korea
Scatter-embedded substrate is a powerful platform for improving light extraction efficiency in OLED lighting. In this work, we propose trans-scale optical simulation for OLEDs involving scattering substrates. This simulation combines rigorous diode model analyzing thin-film stacks with Monte-Carlo simulation based on Henyey-Greenstein phase function for tracing rays encountered with specific size of scatter. The simulation provides a useful tool to analyze and design OLEDs with bulk scatter.

[27P-105] Design of Holographic Head Mounted Display Using Holographic Optical Element
Han-Ju Yoon, Hae-Jae Kim, Seung-Rok Kim, and Jae-Hyeong Park
Inha University, Korea
Recently, head mounted displays based on holographic optical elements have been reported. These head mounted displays can be implemented in a compact form factor but the image presented to each eye is still two-dimensional, which causes fatigue in stereoscopic three-dimensional image viewing condition. In this paper, we propose a holographic three-dimensional head mounted display which displays holographic three-dimensional images. We experimentally confirmed that holographic three-dimensional images are presented to each eye through a holographic optical element. In order to reduce the volume and weight of the system, we use one more holographic optical element and perform a simulation based on ray tracing through the two holographic optical elements.

[27P-106] Light-Field Camera Using Fast Switchable Micro-lens Array for Simultaneous 2D/3D Image Acquisition
HeeWon Park1, Min-Kyu Park1, Mugeon Kim1, Ki-Beom Son1, Hyun Lee1, and Hak-Rin Kim2
1Kyungpook National University, Korea, 2ETRI, Korea
To make switchable light field camera, we developed fast switchable micro lens array which allows to capture both 3D image and 2D image by high frame rate.

Jinok Song, Seunghyup Yoo, and Eunhee Kim
KAIST, Korea
We explore the feasibility of ‘radiative transfer theory’ for simulation of scattering media by comparing accuracy and simulation time with Monte-Carlo simulation. Simulation based on ‘radiative transfer theory’ agrees very well with Monte-Carlo simulation with about 1/20 simulation time. Hence, radiative transfer theory is effective basis for trans-scale simulation and fast optimization of OLEDs with scattering media.

[27P-108] Study of Reflection-beam Shape Using Beam Splitter and CCD Camera
Binh X. Cao1, Munju Bae1, Jiyeon Park1, Hyokee Sohn1, and Jiwhan Noh2
1Korea Institute of Machinery and Materials, Korea, 2Korea University of Science and Technology, Korea
We report a new method for measuring a beam’s shape at the focus point on a surface using an optical system and a CCD camera. An analytical model based on 2-axis movement testing has been proposed, and experimental setups have been developed. Analysis of the obtained results allowed us precisely position the specimen for the focus point identification.

[27P-109] Probabilistically Coupled Multi-Population Rate Equations Model of 1.55 μm InAs/InP Quantum Dot Lasers
Zhaoyun Lin, Zhuanzhuang Wang, Gaochu Yuan, and Meng Yang
University of Electronic Science and Technology of China, China
A multi-mode model of 1.55 μm coupled quantum dot lasers (CQD-Ls) is developed and simulated by fourth order Runge-Kutta method. Calculated results show that the coupled CQD-Ls have significant advantages over the uncoupled ones.

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<td>25A3-4</td>
</tr>
<tr>
<td>Zhu, Yu</td>
<td>27P-46</td>
</tr>
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<td>Zhu, Z.</td>
<td>26P-76</td>
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<td>Zhu, Zheng</td>
<td>25A2-5</td>
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<tr>
<td>Zhu, Zhi Hong</td>
<td>26P-73</td>
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<tr>
<td>Zhu, Zhihong</td>
<td>28E1-2</td>
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<tr>
<td>Zhuravlev, K.</td>
<td>26P-93</td>
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<tr>
<td>Zimmermann, Felix</td>
<td>2682-1</td>
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<tr>
<td>Zou, Changling</td>
<td>26E3-6</td>
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<td>Zou, Chang-Ling</td>
<td>27D2-1</td>
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<tr>
<td>Zou, Lin</td>
<td>28G2-5</td>
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<td>Zou, Ling-Xiu</td>
<td>27J2-1</td>
</tr>
<tr>
<td>Zou, Xiao</td>
<td>25G1-2</td>
</tr>
<tr>
<td>Zunqi, Lin</td>
<td>25D1-3</td>
</tr>
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</table>
V. Exhibition Information

1. Layout of Exhibitions

<table>
<thead>
<tr>
<th>NO</th>
<th>Company</th>
<th>NO</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Jinsung Instruments, Inc.</td>
<td>8</td>
<td>MJL Crystek, Inc</td>
</tr>
<tr>
<td>2</td>
<td>HBL Corporation</td>
<td>9</td>
<td>Opti rate Corporation</td>
</tr>
<tr>
<td>3</td>
<td>L2K Co., Ltd</td>
<td>10</td>
<td>RayVis</td>
</tr>
<tr>
<td>4</td>
<td>Quantum Design Korea</td>
<td>11</td>
<td>Laser Spectronix</td>
</tr>
<tr>
<td>5</td>
<td>NPI LASERS Co., Ltd</td>
<td>12</td>
<td>Qbic Laser System Inc.</td>
</tr>
<tr>
<td>6</td>
<td>KOS, Inc.</td>
<td>13</td>
<td>Korea Tourism Organization</td>
</tr>
<tr>
<td>7</td>
<td>OMA Company</td>
<td>14</td>
<td>EO TECHNICS Co., Ltd</td>
</tr>
</tbody>
</table>
## 2. Exhibitor Directory

<table>
<thead>
<tr>
<th>Name of Company</th>
<th>Jinsung Instruments, Inc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>5F,A, LeardersTown, Man-Nyung dong, Seo-Gu, Dae-Jeon City, South Korea</td>
</tr>
<tr>
<td>President</td>
<td>Ha-Won Lee</td>
</tr>
<tr>
<td>Web site</td>
<td><a href="http://www.jinsunginst.com">www.jinsunginst.com</a></td>
</tr>
<tr>
<td>Tel</td>
<td>+82-42-823-5300</td>
</tr>
<tr>
<td>Fax</td>
<td>+82-42-823-7447</td>
</tr>
<tr>
<td>Contents of Exhibit</td>
<td>Laser</td>
</tr>
</tbody>
</table>

Jinsung Instruments is a leader of laser application and has been offering total solution including lasers, laser equipments and components, etc. since 1997. We have a lot of global partners who are providing laser solution like Thorlabs, Toptica Photonics AG, Picoquant GmBH, Ophir spiricon Inc, etc.

<table>
<thead>
<tr>
<th>Name of Company</th>
<th>HBL Corporation / 한빛레이저</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>32-48, yuseong-daero 1596 beon-gil, Yuseong-gu, Daejeon, Korea 대한민국 대전광역시 유성구 유성대로 1596번길 32-48</td>
</tr>
<tr>
<td>President</td>
<td>KIM Jeong Moog / 김정묵</td>
</tr>
<tr>
<td>Web site</td>
<td><a href="http://www.hblaser.co.kr">www.hblaser.co.kr</a></td>
</tr>
<tr>
<td>Tel</td>
<td>+82-42-879-3300</td>
</tr>
<tr>
<td>Fax</td>
<td>+82-42-862-6289</td>
</tr>
<tr>
<td>Contents of Exhibit</td>
<td>High Power Ultrafast Laser</td>
</tr>
</tbody>
</table>

Est. Laser Laboratory in 2002, 20 researchers registered in Korea Industrial Technology Association. Technologies convergence based company that integrated with Human, Materials and Technology Resources. 10W high power femtosecond laser could be applied in the field of Display and Semiconductor industries on glass cutting and wafer dicing, etc.

### 2002년 기업부설연구소(한국산업기술진흥협회 등록)설립
기업부설연구소 연구인원: 20명, 전체직원의 14
인적, 물적, 기술자원이 집약된 기술기업
출품된 레이저는 고출력 10W 펌토초 레이저로 디스플레이, 반도체분야의 유리절단 및 웨이퍼다이싱에 적용예정

<table>
<thead>
<tr>
<th>Name of Company</th>
<th>L2K Co., Ltd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>530-ho, 187, Techno2-ro, Yuseong-gu, Daejon 305~500, Korea</td>
</tr>
<tr>
<td>President</td>
<td>JAE PIL, JEON</td>
</tr>
<tr>
<td>Tel</td>
<td>+82-42-934-7744</td>
</tr>
<tr>
<td>Fax</td>
<td>+82-42-934-7740</td>
</tr>
<tr>
<td>Contents of Exhibit</td>
<td>Ultra Short Pulsed (fs, ps) Laser, High Energy Laser, Beam Delivery &amp; Control</td>
</tr>
</tbody>
</table>

L2K Co., Ltd is leading company for Laser, Laser related components and Fiber Optic Components in the Scientific, Industrial and Security, Defense market. We have the huge experience of Laser application in these markets and can make a chance to meet the most suitable solution for each application.
<table>
<thead>
<tr>
<th>Name of Company</th>
<th>Quantum Design Korea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>#303 Dongshin Bldg., 204 Dogok-ro, Gangnam-gu, Seoul 135-857, Korea</td>
</tr>
<tr>
<td>President</td>
<td>Ji Won Park</td>
</tr>
<tr>
<td>Web site</td>
<td><a href="http://www.qdkorea.com">www.qdkorea.com</a></td>
</tr>
<tr>
<td>Tel</td>
<td>+82-2-2057-2710</td>
</tr>
<tr>
<td>Fax</td>
<td>+82-2-2057-2712</td>
</tr>
<tr>
<td>Contents of Exhibit</td>
<td>NeaSNOM (s-SNOM, nano FT-IR), Lynceetec (Digital Holographic Microscopy), Montana Instruments Cryostation (Optical Cryostat)</td>
</tr>
</tbody>
</table>

The NeaSNOM is the only microscope on the market capable of imaging & spectroscopy in the visible, infrared and even terahertz spectral region at only 10 nm spatial resolution. This makes NeaSNOM the ideal tool for cutting-edge nanoanalytic applications such as chemical nano-composition (nano-FTIR-mode), nano-plasmonic fields, nanoscale stress/strain fields and free charge carrier distributions.

<table>
<thead>
<tr>
<th>Name of Company</th>
<th>NPI Lasers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>Floor 4, Cui-Ping Science Park, 37 Jiangjun Avenue, Jiangning District, Nanjing, China, 211100</td>
</tr>
<tr>
<td>President</td>
<td></td>
</tr>
<tr>
<td>Web site</td>
<td><a href="http://www.npilasers.com">www.npilasers.com</a></td>
</tr>
<tr>
<td>Tel</td>
<td>+86-25-84989433</td>
</tr>
<tr>
<td>Fax</td>
<td>+86-25-84989433</td>
</tr>
<tr>
<td>Contents of Exhibit</td>
<td>We offer a full range of 2μm fiber laser products for both research and industrial customers. Our product line includes ultrafast lasers, amplifiers, broadband sources, narrow-linewidth and wavelength-tunable 2μm lasers. During CLEO-PR2015, we showcase highly-stable 1 picosecond mode-locked oscillator (ML-2000-Osci) together with a 3W high power amplifier (TDFA-2000-HP).</td>
</tr>
</tbody>
</table>

NPI LASERS is a fiber laser company focused on delivering innovative mid-IR laser modules and systems. The goal of our company is to change the paradigm of fiber laser market by providing versatile, reliable and cost-effective products to serve the emerging applications in the mid-IR wavelength range.

Our product portfolio includes mode-locked oscillator, thulium-doped fiber amplifier, narrow-linewidth fiber laser, multi-channel CW laser as well as broadband light sources. Most of our products feature compactness and highly customizable parameters such as output power level and operating wavelength.

The NPI team consists of leading international experts in photonics research as well as executives with strong commercial track record. We share a combined industrial experiences of more than 60 years and this ensures that we understand your specific application needs, regardless of whether it is in the field of niche photonics research, industrial sensing and detection, advanced bio-medical procedures, or next-generation laser material processing.
<table>
<thead>
<tr>
<th>Name of Company</th>
<th>KOS, Inc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>O213, Green-zone, ITECO, #150, Jojeong-daero, Hanam-city, Gyeonggi-do, Korea</td>
</tr>
<tr>
<td>President</td>
<td>Daehee-Choi</td>
</tr>
<tr>
<td>Tel</td>
<td>+82-2-486-7930</td>
</tr>
<tr>
<td>Fax</td>
<td>+82-2-486-7931</td>
</tr>
<tr>
<td>Contents of Exhibit</td>
<td>Monochromator, CCD Camera, Laser, Mini spectrometer, Filters</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>* Application</td>
<td>Long Term Cell Observation System</td>
</tr>
<tr>
<td></td>
<td>Real Time Confocal Microscope System</td>
</tr>
<tr>
<td></td>
<td>In Vivo Whole-body Animal Imaging System</td>
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<tr>
<td></td>
<td>FRET Imaging System</td>
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<tr>
<td></td>
<td>FRAP Imaging System</td>
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<tr>
<td></td>
<td>Fluorescence Life Time Measurement</td>
</tr>
<tr>
<td></td>
<td>Ca++ Ratio Imaging System</td>
</tr>
<tr>
<td>* Instruments</td>
<td>Cooled Digital CCD Camera</td>
</tr>
<tr>
<td></td>
<td>EM CCD and ICCD Camera</td>
</tr>
<tr>
<td></td>
<td>Digital Holographic Microscope</td>
</tr>
<tr>
<td></td>
<td>Image Analysis Software</td>
</tr>
<tr>
<td></td>
<td>Fluorescence Light Source</td>
</tr>
<tr>
<td></td>
<td>Polychromator / Monochromator</td>
</tr>
<tr>
<td></td>
<td>Automatic Filter Wheel &amp; Fluorescence Filters</td>
</tr>
<tr>
<td></td>
<td>Auto X, Y, Stage &amp; Z motors</td>
</tr>
<tr>
<td></td>
<td>* June 3, 2014 Acquire Certificate of Research Institute By Korea Industrial Technology Association</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Name of Company</th>
<th>OMA Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>1596-64 YUSUNGDAE-RO YUSUNG-GU DAEJEON KOREA 305-811</td>
</tr>
<tr>
<td>President</td>
<td>Jinho Lee</td>
</tr>
<tr>
<td>Tel</td>
<td>+82-42-822-9501</td>
</tr>
<tr>
<td>Fax</td>
<td>+82-42-822-9504</td>
</tr>
<tr>
<td>Contents of Exhibit</td>
<td>Opto-Mechanics, Optical Power Meter, Auto-Collimator</td>
</tr>
<tr>
<td>Hand-Held Optical Power/Energy Meter</td>
<td></td>
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<tr>
<td>BenchTop Optical Power/Energy Meter</td>
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<tr>
<td>OpticsCage+</td>
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<tr>
<td>Double Density Breadboard</td>
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</tr>
<tr>
<td>Mirror/Lens Mounts</td>
<td></td>
</tr>
<tr>
<td>Beam Tube</td>
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<tr>
<td>Auto-Collimator</td>
<td></td>
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</tbody>
</table>
### MJL Crystek, Inc

<table>
<thead>
<tr>
<th>Name of Company</th>
<th>MJL Crystek, Inc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>1117 Expotel 381, 44, 117beon-gil, Dunsan-daero, Seo-Gu, Daejeon, 302-834, Korea</td>
</tr>
<tr>
<td>President</td>
<td>Jae Hyuk Choi</td>
</tr>
<tr>
<td>Web site</td>
<td><a href="http://www.mjlinc.com">www.mjlinc.com</a></td>
</tr>
<tr>
<td>Tel</td>
<td>+82-42-471-8070</td>
</tr>
<tr>
<td>Fax</td>
<td>+82-42-471-8073</td>
</tr>
</tbody>
</table>

**Contents of Exhibit**

- Laser (fiber Laser, HeNe/HeCd Laser, Tunable Laser, Femtosecond Laser, DPSS Laser, CO2 Laser, Excimer Laser...), Laser Machining Head (Scanner Head, Welding Head), Optical Scanner (Scanner Mirror, Galvo Motor, Driver, Controller), F-theta Lens/Beam Expander, Modulator, Test & Measurement, Optics & Crystal, Optomechanics & Motion control, Pulse Generator, Laser Dye, Telecom products (Tunable Laser Source, Modulator, Isolator, Lensed Fiber, Circulator, Microscope, Interferometer, Measurement, etc.)

MJL Crystek, Inc. is supplying a variety of lasers, optics and optical communication components throughout industries, research institutes, universities and medical field from 1990 to the present. We have constructed an effective system to offer the skills and information customers need at any time and have not handled roughly even a small part.

### RayVis

<table>
<thead>
<tr>
<th>Name of Company</th>
<th>RayVis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>#512. World Officetel, 1355-3, Seocho-dong, Seocho-gu, Seoul, 137-862, Korea</td>
</tr>
<tr>
<td>President</td>
<td>Chaemyong Ryu</td>
</tr>
<tr>
<td>Web site</td>
<td><a href="http://www.rayvis.co.kr">www.rayvis.co.kr</a></td>
</tr>
<tr>
<td>Tel</td>
<td>+82-2-3461-1103</td>
</tr>
<tr>
<td>Fax</td>
<td>+82-2-3461-1104</td>
</tr>
</tbody>
</table>

**Contents of Exhibit**

- **M square:** World Best Sealed Ti:Sap Wavelength tunable CW LASER
- **APE:** 피코, 펌토초 펄스폭 및 특성 측정기기
- **Lighthouse:** 최고성능 및 가격, CW 그린펌프용 고체레이저
- **EKSPLA:** 탑클래스 나노, 피코초레이저 및 OPO, 플래시램프파워

The name of our company, RayVis is composed of 2 Latin words, RAY(Light) & VIS(Power) so it means ‘Power of Light’ and based on these words, the major business of our company is distribution & technical service of worldwide LASER systems & optical products to our industrial customers that manufactures various LASER processing equipments including the customers at Laboratories & Universities for scientific researches as well as medical customers.

There are three divisions in our company, which are Scientific, Medical and Industrial divisions. We have many regular customers at Samsung, LG & medical companies for industrial and GIST, KAIST, POSTECH, IBS, SNU, ETRI, etc. for scientific. Therefore we believe that we can do great work with you based on our experience with deep understanding on customer applications so far if we have a chance to introduce our good products to you. Also on the other side, we want to have a chance to learn about your product as well to learn more about you and we want to be a real partner to make a success with you.
<table>
<thead>
<tr>
<th>Name of Company</th>
<th>OptiGrate Corporation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>562 South Econ Circle, Oviedo, FL 32765, USA</td>
</tr>
<tr>
<td>President</td>
<td>Dr. Alexei Glebov</td>
</tr>
<tr>
<td>Web site</td>
<td><a href="http://www.OptiGrate.com">www.OptiGrate.com</a></td>
</tr>
<tr>
<td>Tel</td>
<td>+1-407-542-7704</td>
</tr>
<tr>
<td>Fax</td>
<td>+1-407-542-7804</td>
</tr>
<tr>
<td>Contents of Exhibit</td>
<td>Holographic Volume Bragg Gratings (VBG)</td>
</tr>
</tbody>
</table>

OptiGrate is a pioneer of commercial Volume Bragg Gratings and supplies VBGs to more than 500 customers on 6 continents for laser line narrowing, spectroscopy, laser pulse stretching and compression, etc. We are located in Oviedo (Florida, USA) where we design, develop and make all of our products.

<table>
<thead>
<tr>
<th>Name of Company</th>
<th>Qbic Laser System Inc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>303-901, Seokcheon-ro 345, Ojeong-gu, Bucheon-si, Gyeonggi-do, 421-741, Korea</td>
</tr>
<tr>
<td>President</td>
<td>Changkon Kim</td>
</tr>
<tr>
<td>Web site</td>
<td><a href="http://www.qbiclaser.com">www.qbiclaser.com</a></td>
</tr>
<tr>
<td>Tel</td>
<td>+82-32-325-4544</td>
</tr>
<tr>
<td>Fax</td>
<td>+82-32-323-4736</td>
</tr>
<tr>
<td>Contents of Exhibit</td>
<td>Optical Systems manufactured by Qbic Laser System Inc.</td>
</tr>
</tbody>
</table>

- Laser Beam Homogenized Module
- Multiple Spot Generating Module
- Laser Beam Attenuator
- Fiber Coupled Diode Laser System
- Two Color Optical Pyrometer System
- MOPA (Master Oscillator Power Amplifier) Laser System

<table>
<thead>
<tr>
<th>Name of Company</th>
<th>EO TECHNICS Co., Ltd.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>91 Dongpyeono Anyang Korea</td>
</tr>
<tr>
<td>President</td>
<td>Kyu-Dong Sung</td>
</tr>
<tr>
<td>Web site</td>
<td><a href="http://www.eotechnics.com">www.eotechnics.com</a></td>
</tr>
<tr>
<td>Tel</td>
<td>+82-31-422-2501</td>
</tr>
<tr>
<td>Fax</td>
<td>+82-31-422-2502</td>
</tr>
<tr>
<td>Contents of Exhibit</td>
<td>Laser Sources like fiber laser, diode lasers etc. Laser power meter &amp; beam profilers</td>
</tr>
</tbody>
</table>

EO Technics manufactures fiber lasers, diode lasers, ps and fs lasers.
Those lasers can be used in future applications.
EO Technics’ laser applications are very numerous.
EO Technics also produces laser systems for marking, scribing, cutting, drilling, trimming and material processing.
VI. Sponsors and Supporting Organizations

Organized by

OSK
OPTICAL SOCIETY OF KOREA

Technically Co-sponsored by

OSA
Electronics Society
IEEE
Communications Society

Supported by

BUSAN
KOFST
KOREA TOURISM ORGANIZATION

Sponsored by

OPTiCIS
LaserSpectronix
OE SOLUTIONS
apri
ADVANCED PHOTONICS RESEARCH INSTITUTE
PUKYONG NATIONAL UNIVERSITY
LIGHTRON
Laser QUANTUM
CoReLS

HEXA SOLUTION
FIBERPRO
광통신 분야의 세계 선도기업을 꿈꾸다

Company Introduction

<table>
<thead>
<tr>
<th>대표 이사</th>
<th>업종</th>
<th>유무선통신 제조업</th>
</tr>
</thead>
<tbody>
<tr>
<td>박용관, 추안구</td>
<td>주요 사업</td>
<td>광통신용 모듈의 개발, 제조 및 판매</td>
</tr>
<tr>
<td>설립일</td>
<td>사업장</td>
<td>(주)광주 북구첨단연신로 30번길 53 경기 안양시 동안구 희도로 282</td>
</tr>
<tr>
<td>2003. 08. 07</td>
<td></td>
<td>(美) Englewood Cliffs, NJ 07632</td>
</tr>
<tr>
<td>상장일</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014. 02. 27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>임직원</td>
<td></td>
<td></td>
</tr>
<tr>
<td>325명 (한국:308명/미국:17명)</td>
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<td></td>
</tr>
<tr>
<td>매출 규모</td>
<td></td>
<td></td>
</tr>
<tr>
<td>720억원 (2014년말 기준)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>홈페이지</td>
<td><a href="http://www.oesolutions.com">http://www.oesolutions.com</a></td>
</tr>
</tbody>
</table>

Patent Applications

특허: 46건 (30건 출원 중)

- 반사 노이즈를 감소시키는 구조를 갖는 양방향 광 서브어셈블리
- 단일 파장을 이용한 광송수신 트랜시버
- SIOB을 이용한 TOCAN 평행광 패키지
- 광통신용 냉각형 투-캔과 이를 이용한 냉각형 보자
- 초고속 광송수신 모듈
- 스마트SFP 또는 SFP+,XFP 트랜시버의 가변파장송신을 원격제어하는 방법
- 반사노이즈를 감소시키는 구조를 갖는 양방향 광 서브어셈블리
- Scheme for Remote Control of the Slicing Level of a Receiver in a Smart SFP Transceiver

Customer

주요 거래처

[브랜드 이미지]

[브랜드 이미지]
Further information:
E-mail: khj24@gist.ac.kr
Tel: 062-715-3417
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- Ultra-intense Laser Laboratory & IBS
- Quantum Beam Applications Laboratory
- Laser Application System Laboratory
- Spectroscopy Sensor Laboratory
- Biophotonics Laboratory
- Integrated Optics Laboratory
해양환경에서 사용되는 첨단 LED 기술은 우리 센터가 세계 일류를 창조합니다.

국제공인 시험인증 및 국가공인 검사 서비스

LED조명 분야 영남권 최초의 KOLAS
- KOLAS 국제공인 시험기관 인정
- KOLAS 국가공인 검사기관 인정
- 고 효율 에너지 기가제정시험기관

LED융합 특화장비 활용 지원
- 미러타입 배광기, 첨단, 해상도 분해 800만 화소
- 장비관리자 내부 '시염안'과 함께 "http://www.led-marine.org/
  에서 검색 해설 용지 또는 QUICK MENU-시험연구장비
  이용안내시' Click

LED방폭장비 활용 지원
- LED 내압방폭, 본질안전 방폭 등 개발 중
- LED 방폭조명 R&D 및 인증지원 실시 중
- 국제인증(IECEx, ATEX)시험장비 Full line-up 완료

공동연구개발 성과

LED 항해등
- 항해등용 Fresnel Lens 개발
- 광밀도기 4형량, 소비전력 6Wx2단
- 로이드 인증 획득(공동개발: 대양전기공업)
- 산업통상자원부 장관상 수상(2014년)

해양생물생장 LEVD융합조명
- 전급격적 해양열 회원 LED시스템 개발 및 현장 실증
- 해양생물 생장용 다파장 LED조명장치
- 인큐베이터용 LED형광등 개발

‘부산, 빛의 도시’ 구현
- 부산시 야간경관 기본 계획(조명) 구현
- 부산시 빛공해환경영향평가 연구
- 경인대학교-도난조명 후원
- 영화의 전당 ‘미디어 파사드’ 고장 분석

보유기술 기업지원

LED조명 광학계 설계 지원
- 용도별 최적 배광, 광학부품 설계 및 제작 지원
- 실내외 조명 설계 및 시뮬레이션 지원
- 광학 분석 및 스틱트럼 제어 최적화 지원

해양 LED융합 조명/전원 회로 설계 지원
- 기구설계(방수, 방진, 방역) 설계/제작 지원
- 발열 부품 설계/제작 지원
- 조명시스템, 전원 회로 설계/제작 지원

인력양성 지원

LED 융합 인력 양성
- 과학기술융합전문대학원 "LED융합공학 전공" 개설
- 전임교수 3명, 석사 16명, 박사 7명 지원
- 의료 및 기계설계 석사의 LED 융합 전문교육

Center for Relativistic Laser Science
- Exploration of superintense laser-matter interactions -

- Exploration of the interactions between ultra-intense laser field and matter in the relativistic regime by using femtosecond petawatt lasers
- Investigation of ultrafast (attosecond) atomic/molecular processes

Research topics

- High-power femtosecond lasers
- Relativistic laser-plasma interactions
- Laboratory astrophysics
- High-energy density physics
- Attosecond science

Super-intense Laser Pulse

Relativistic laser-matter interaction

High Energy Protons

Relativistic Electrons

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**Layer 1 Wavelength Stack-up**

- 2 Wavelengths within 15nm Spectrum
  - 2X Fiber Link Capacity: λ 1 to λ 36
  - λ Stability: +/-0.2nm

**Layer 2 Wavelength Stack-up**

- 6 Wavelengths within 15nm Spectrum
  - 6X Fiber Link Capacity: λ 1 to λ 108
  - λ Stability: +/-0.2nm

36 Wavelengths Roll-out Architecture

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- Cooled BOSA
- HSFP Transceiver

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* CES: Cavity Engineered Substrate

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주요 응용분야
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eXtra-Coherent EUV Light Source System between 10-30nm

COHERENT EUV IMAGING, ACTINIC INSPECTION IN THE EUV LITHOGRAPHY

The eXtra is the extreme UV (EUV) spectra light source system* which is based on the high harmonic generation (HHG) in the laser-produced plasma to provide the coherent (laser-like) spectra between 10nm and 30nm. The system is configured with a kHz rep rate, femtosecond Ti:sapphire laser at wavelength around 800nm, and a gas cell with gas handling assembly under vacuum. The laser pulses are focused with intensity of $10^{14}$-$10^{15}$ W/cm² into the patent-pending gas cell to produce the gas plasma inside the cell. The generated EUV spectra are separated from the laser wavelength with an appropriate combination of the EUV beamsplitters and filters.

The EUV spectra generated depends on various parameters including the laser intensity, gases, gas pressure and cell manifold. The eXtra-13.5 is highly focused to a spectra 13.5nm which is the 59th harmonics of the laser wavelength 800nm, and exactly matched with the wavelength of the semiconductor EUV lithography. The system provides a compact, table-top solution for the actinic inspection and metrology applications in the EUV lithography. The Fig.1 shows its typical EUV spectra generated on the Ne gas pumped with 35fs Ti:sapphire laser pulses of 5mJ at 1kHz. The peak at 13.5nm is dominated with the Zr filter. The calibration was done with the spectra of Al filter. (*developed under research collaboration with KIST, Korea Institute of Science and Technology)

Fig.1

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For more information, please contact:

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