9-11 JULY

**Photonic Next Generation Communication Systems and Novel Devices**

**TOPICS:**

**Space Division Multiplexing for Optical Systems and Networks**
Co-Chairs:
Lynn Nelson, AT&T, USA
John Fini, OFS Laboratories, USA
David Richardson, University of Southampton, UK

**High Power Semiconductor Lasers**
Co-Chairs:
Gary Smith, MIT Lincoln Laboratory, USA
Paul Crump, Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Germany

**Optical Wireless Systems and Applications**
Co-Chairs:
Gee-Kung Chang, Georgia Institute of Technology, USA
Mohsen Kavehrad, Pennsylvania State University, USA

**Renaissance Seattle Hotel**
Seattle, Washington
USA

**GENERAL CHAIR:**
Kent Choquette
University of Illinois at Urbana-Champaign, USA
Photonics Society V.P. of Conferences

www.SUM-IEEE.org
www.PhotonicsConferences.org

Sponsored by IEEE Photonics Society
Welcome to Seattle and the 2012 Photonic Society Summer Topicals

The Topical Meetings of the IEEE Photonics Society are the premier conference series for exciting new areas in photonic science, technology, and applications, creating the opportunity to learn about emerging fields and to interact with the research and technology leaders in an intimate environment. This year the meetings will be held at the Renaissance Seattle Hotel, located in downtown Seattle, WA.

The 2012 Summer Topical Meetings are focused on "Next Generation Photonic Communication Systems and Novel Devices" The following 3 Topicals meetings will be held:

- Optical Wireless Systems and Applications
- Space Division Multiplexing for Optical Systems and Networks
- High Power Semiconductor Lasers

A unique aspect of the Topical Meetings is that Photonic Society member volunteers propose and organize these meetings. Hence I would like to thank each of the Topical Chairs and the Program Committee Members who have volunteered and invested their time organizing these conferences. I also want to thank the plenary and invited speakers for giving us their perspectives on the exciting new developments and the challenges in these three fields. Finally I would like to express my sincere appreciation to the Photonic Society Conference Staff for their professional organization and arrangements.

This topics to be discussed in this year's Summer Topicals span communication theory, semiconductor photonic device technology, military and commercial applications, and advanced optical networks. In addition to the technical presentations, hallway discussions, and coffee break conversations, I hope that you have a chance to experience and sample some of Seattle's best sights and food. Have a great time!

Kent D. Choquette
Photonics Society Topical Meetings General Chair
ACKNOWLEDGEMENT

The Conference Committee would like to thank

TRUMPF Photonics Inc.

For their support of the 2012 Summer Topicals
SUMMER TOPICALS 2012 COMMITTEES

GENERAL CHAIR

Dr. Kent D. Choquette
University of Illinois at Urbana-Champaign - Beckman Institute, Urbana, IL, USA

HIGH POWER SEMICONDUCTOR LASER

Dr. Paul Crump, Co-Chair
Ferdinand-Braun-Institut - Leibniz Institut für Höchstfrequenztechnik, Berlin, Germany

Dr. Gary M. Smith, Co-Chair
MIT Lincoln Laboratory, Lexington, MA, USA

Dr. Eugene A. Avrutin
University of York, Heslington, UK

Dr. Ryan Feeler
Northrop Grumman - , Redondo Beach, CA, USA

Dr. Hans-Dieter Hoffmann
Fraunhofer-Institut - Laser Technology, Aachen, Germany

Dr. Manoj Kanskar
nLight Corporation, Vancouver, WA, USA

Dr. Eric C. Larkins
University of Nottingham, Nottingham, UK

Dr. Norbert Lichtenstein
Oclaro Switzerland GmbH, Zurich, Switzerland

Dr. John H. Marsh
University of Glasgow, Glasgow, UK

Dr. Luke J. Mawst
University of Wisconsin-Madison, Madison, WI, USA

Dr. Uwe Strauss
Osram Opto Semiconductors GmbH, Regensburg, Germany

Dr. Georg Treusch
TRUMPF Photonics Inc., Cranbury, NJ, USA

Dr. Erik Zucker
JDS Uniphase Corporation, Milpitas, CA, USA
OPTICAL WIRELESS SYSTEMS AND APPLICATIONS

Dr. Gee-Kung Chang, **Co-Chair**
*Georgia Institute of Technology, Atlanta, GA, USA*

Dr. Mohsen Kavehrad, **Co-Chair**
*Pennsylvania State University, University Park, PA, USA*

Dr. John R. Barry
*Georgia Institute of Technology, Atlanta, GA, USA*

Dr. Young-Kai Chen
*Alcatel-Lucent - Bell Labs, New Providence, NJ, USA*

Dr. Harald Haas
*University of Edinburgh, Edinburgh, Scotland, UK*

Dr. Ken-ichi Kitayama
*Osaka University - Institute for Laser Technology, Japan*

Dr. Thomas D. C. Little
*Boston University, Boston, MA, USA*

Dr. John E. Mitchell
*University College London - Dept of Electronic & Electrical Engineering, London, UK*

Dr. Greg Mooradian
*QinetiQ North America, San Diego, CA, USA*

Dr. Anthony Ng’Oma
*Corning, Inc. - Sullivan Park R&D Center, Corning, NY, USA*

Dr. Ronald Parenti
*MIT Lincoln Laboratory, Lexington, MA, USA*

Dr. Brian M. Sadler
*US Army Research Laboratory, Adelphi, MD, USA*

Dr. Ting Wang
*NEC Laboratories America, Inc., Princeton, NJ, USA*

Dr. Yong-Kee Yeo
*Agency for Science, Technology and Research - Institute for Infocomm Research, Singapore, Singapore*

Dr. Jianjun Yu
*ZTE USA Inc., Richardson, TX, USA*

Dr. Xiuhua Yuan
*Huazhong University of Science and Technology, Wuhan, Hubei, China*
SPATIAL DIVISION MULTIPLEXING FOR OPTICAL SYSTEMS AND NETWORKS

Dr. John M. Fini, Co-Chair
OFS Laboratories, Norcross, GA, USA

Dr. Lynn E. Nelson, Co-Chair
AT&T - Labs - Research, Florham Park, NJ, USA

Dr. David J. Richardson, Co-Chair
University of Southampton - Optoelectronics Research Centre, Southampton, UK

Dr. Yoshinari Awaji
National Institute of Information and Communications Technology, Koganei, Tokyo, Japan

Dr. Scott R. Bickham
Corning, Inc. - Sullivan Park R&D Center, Corning, NY, USA

Dr. Mark D. Feuer
AT&T - Labs - Research, Florham Park, NJ, USA

Dr. Fatima C. G. Gunning
Tyndall National Institute, Cork, Ireland

Dr. Nobutomo Hanzawa
NTT Corporation - Access Network Service Systems Labs, Tsukuba, Japan

Dr. Joseph M. Kahn
Stanford University - Solid State Photonics Laboratory, Stanford, CA, USA

Dr. Peter Krummrich
University of Dortmund, Dortmund, Germany

Dr. Shoichiro Matsuo
Fujikura Ltd., Koto-ku, Tokyo, Japan

Dr. Francesco Poletti
University of Southampton - Optoelectronics Research Centre, Southampton, UK

Dr. Roland Ryf
Alcatel-Lucent - Bell Labs, New Providence, NJ, USA

Dr. Massimiliano Salsi
Alcatel-Lucent - Bell Labs, New Providence, NJ, USA

Dr. Takashi Sasaki
Sumitomo Electric Industries Ltd., Yokohama, Japan

Dr. William Shieh
University of Melbourne, Parkville, Victoria, Australia

Dr. Pierre Sillard
Prysmian Group, Marcoussis, France

Dr. Dirk van den Borne
Nokia Siemens Networks, Munich, Germany

Benyuan Zhu
OFS Laboratories, Somerset, NJ, USA
<table>
<thead>
<tr>
<th>Room:</th>
<th>East Room (3rd Floor)</th>
<th>South Room (3rd Floor)</th>
<th>North Room (3rd Floor)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Monday, 9 July 2012</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 8:00am – 5:00pm | REGISTRATION: Compass Foyer | | 9:00 am – 9:15 am
Opening Remarks

**MC1: SMD Approaches to Increase Capacity**
Chair: L. Nelson |
| 9:00am - 10:00am | **MA1**: Surface Emitting Lasers
Chair: H. Hoffmann | **MB1**: Frontier of Optical Wireless Technologies I
Chair: E. Chan | |
| 10:00am – 10:30am | COFFEE BREAK | | **MC2**: SDM for High-Capacity Telecom
Chair: D. Richardson |
| 10:00am - 12:00pm | **MA2**: Single-Element Lasers and Bars
Chair: G. Erbert | **MB2**: Frontier of Optical Wireless Technologies II
Chair: E. Chan
(session end at 11:45am) | |
| 12:00pm – 1:30pm | LUNCH BREAK | | **MC3**: SDM Transmission
Chair: F. Gunning |
| 1:30pm - 3:00pm | **MA3**: Plenary
Chair: G. Smith | **MB3**: Emerging Optical Wireless Technologies I
Chair: L. Kazovsky | |
| 3:00pm – 3:30pm | COFFEE BREAK | | **MC4**: DSP Technology
Chair: R. Ryf |
| 3:30pm - 5:00pm | **MA4**: Fiber-Coupled Laser Bars
Chair: P. Crump | **MB4**: Emerging Optical Wireless Technologies II
Chair: L. Kazovsky | |
| 5:15pm – 6:15pm | WELCOME RECEPTION: Madison Ballroom (2nd Floor) | | |
| **Tuesday, 10 July 2012** | | | |
| 8:00am – 5:00pm | REGISTRATION: Compass Foyer | | |
| **Room:** | **Parallel Sessions**
*South Room and West Room (3rd Floor)* | | |
| 9:00am - 10:00am | **TuA1**: Laser Manufacturing
Chair: N. Lichtenstein | **TuB1**: Next-Gen Optical Wireless Systems I
Chair: T. Kane
**TUBB1**: Optical Wireless Technologies & Applications I
Chair: J. Yao | **TuC1**: Few Mode Fibers
Chair: S. Brickham |
| 10:00am – 10:30am | COFFEE BREAK | | |
# 2012 Summer Topicals

## Program – At A Glance

### Tuesday, 10 July 2012 Continued

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Chair</th>
<th>Time</th>
<th>Session</th>
<th>Chair</th>
<th>Time</th>
<th>Session</th>
<th>Chair</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:30am - 12:00pm</td>
<td><strong>TuA2</strong>: Laser Combining</td>
<td>L. Mawst</td>
<td>TuB2: Next-Gen Optical Wireless Systems II</td>
<td>T. Kane</td>
<td>TuC2: SDM in Data Com</td>
<td>J. Fini</td>
<td>(session end at 11:45am)</td>
<td></td>
</tr>
<tr>
<td>12:00pm – 1:30pm</td>
<td>LUNCH BREAK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:30pm - 3:00pm</td>
<td><strong>TuA3</strong>: External Feedback Lasers</td>
<td>E. Larkins</td>
<td>TuB3: Performance of Optical Wireless Systems I</td>
<td>P. Poirier</td>
<td>TuC3: Mode Couplers and Mode Coupling Effects</td>
<td>S. Matsuo</td>
<td>(session begin at 1:15pm)</td>
<td></td>
</tr>
<tr>
<td>3:00pm – 3:30pm</td>
<td>COFFEE BREAK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3:30pm - 5:00pm</td>
<td><strong>TuA4</strong>: Tapered and Long-Wavelength Lasers</td>
<td>H. Koenig</td>
<td>TuB4: Performance of Optical Wireless Systems II</td>
<td>P. Poirier</td>
<td>TuC4: Multicore Fibers</td>
<td>T. Sasaki</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5:00pm - 5:30pm</td>
<td><strong>TuA5</strong>: Special Session on EU-Funded High Power Laser Programs</td>
<td>K. Choquette</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Wednesday, 11 July 2012

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Chair</th>
<th>Time</th>
<th>Session</th>
<th>Chair</th>
<th>Time</th>
<th>Session</th>
<th>Chair</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00am – 5:00pm</td>
<td>REGISTRATION: Compass Foyer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Room:</td>
<td>East Room (3rd Floor)</td>
<td>South Room (3rd Floor)</td>
<td>North Room (3rd Floor)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:00am - 10:00am</td>
<td><strong>WA1</strong>: Monolithic Power Scaling</td>
<td>T. Fan</td>
<td><strong>WB1</strong>: Advanced Optical Wireless Technologies I</td>
<td>K. Ho</td>
<td><strong>WC1</strong>: Components for FMF Systems</td>
<td>Y. Awaji</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:00am – 10:30am</td>
<td>COFFEE BREAK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:30am - 12:00pm</td>
<td><strong>WA2</strong>: Increasing Efficiency</td>
<td>E. Avrutin</td>
<td><strong>WB2</strong>: Advanced Optical Wireless Technologies II</td>
<td>K. Ho</td>
<td><strong>WC2</strong>: MM Fiber Amplifiers</td>
<td>P. Krummrich</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12:00pm – 1:30pm</td>
<td>LUNCH BREAK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:30pm - 3:00pm</td>
<td><strong>WA3</strong>: Increasing Power</td>
<td>E. Zucker</td>
<td><strong>WB3</strong>: Efficient Modulation and Transport System I</td>
<td>J. Cheng</td>
<td><strong>WC3</strong>: Novel Coupling Schemes and SDM Devices</td>
<td>P. Sillard</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3:00pm – 3:30pm</td>
<td>COFFEE BREAK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## 2012 Summer Topicals

**Program — At a Glance**

**Wednesday, 11 July 2012 Continued**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Chair</th>
<th>Notes</th>
</tr>
</thead>
</table>
| 3:30pm - 5:00pm | **WA4**: Improving Laser Performance  
Chair: P. Blood |                |                |
|              | **WB4**: Efficient Modulation and Transport Systems II  
Chair: J. Cheng |                | (session end at 4:45pm)                   |
|              | **WC4**: Silicon Devices  
Chair: M. Feuer |                | (session end at 4:45pm)                   |

Join us 8-10 July in Hawaii for Summer Topicals 2013!

For more information, please visit [www.photonicsconferences.org](http://www.photonicsconferences.org)
OptiGrate Corporation
CONTACT: IGOR CIAPURIN
OptiGrate Corporation
3267 Progress Drive
Orlando, FL 32826 USA
Phone: +1 407 381 4115
Fax: +1 407 384 5995
Email: iciapurin@optigrate.com
Website: http://www.optigrate.com

OptiGrate is a pioneer of commercial volume
Bragg gratings and is a leading supplier of VBGs
for laser line narrowing, ultra-narrow band optical
filters for spectroscopy, ultra-short pulse stretchers
and compressors, and other applications.

Ondax Inc.
CONTACT: DAWN EBERTOWSKI
Ondax Inc.
850 E. Duarte Road
Monrovia, CA 91016 USA
Phone: +1 626 803 5725
Fax: +1 626 513 7494
Email: dawn@ondax.com
Website: http://www.ondax.com

Ondax, Inc. is the world’s largest manufacturer of
commercial Volume Holographic Gratings (VHGs)
and wavelength-stabilized lasers. VHGs improve
laser diode performance by increasing spectral
brightness, locking emission wavelength,
increasing environmental stability and improving
manufacturing yields.

Lighttel Technologies
CONTACT: HUANG SHANGYUAN
Lighttel Technologies
2210 Lind Ave. SW#100
Renton, WA 98057 USA
Phone: +1 425 277 8000
Fax: +1 425 277 5280
Email: sales@lightel.com
Website: http://www.lightel.com

LIGHTEL delivers component, instrument, and
equipment solutions for fiberoptics.
Instruments/equipment include, the CI-1000,
ViewConn™ video microscope probes, and
Coupler Workstations, such as FiberForge and
CW5000. Other products include fiber tapers,
combiners, and passive components.

Lightel Technologies
CONTACT: HUANG SHANGYUAN
Lighttel Technologies
2210 Lind Ave. SW#100
Renton, WA 98057 USA
Phone: +1 425 277 8000
Fax: +1 425 277 5280
Email: sales@lightel.com
Website: http://www.lightel.com

LIGHTEL delivers component, instrument, and
equipment solutions for fiberoptics.
Instruments/equipment include, the CI-1000,
ViewConn™ video microscope probes, and
Coupler Workstations, such as FiberForge and
CW5000. Other products include fiber tapers,
combiners, and passive components.

Lightel Technologies
CONTACT: HUANG SHANGYUAN
Lighttel Technologies
2210 Lind Ave. SW#100
Renton, WA 98057 USA
Phone: +1 425 277 8000
Fax: +1 425 277 5280
Email: sales@lightel.com
Website: http://www.lightel.com

LIGHTEL delivers component, instrument, and
equipment solutions for fiberoptics.
Instruments/equipment include, the CI-1000,
ViewConn™ video microscope probes, and
Coupler Workstations, such as FiberForge and
CW5000. Other products include fiber tapers,
combiners, and passive components.
# Final Program

## High Power Semiconductor Lasers

**Monday, 9 July 2012**

**ALL SESSIONS WILL BE HELD IN EAST ROOM**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session MA1:</th>
<th>Session Chair</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00 AM - 10:00 AM</td>
<td>SURFACE EMITTING LASERS</td>
<td>Hans-Dieter Hoffmann, Fraunhofer-Institut, Aachen, Germany</td>
</tr>
</tbody>
</table>

**MA1.1  9:00 AM - 9:30 AM (Invited)**


High-power SE-DFB lasers have intrinsically narrow, wavelength stabilized spectra and high spatial brightness as a result of monolithic curved gratings. Performance results of high-power SE-DFB lasers in the 9xx - 15xx nm range are discussed.

**MA1.2  9:30 AM - 10:00 AM (Invited)**

**Recent Advances in High-Power VCSEL Arrays**, C. S. Wang, J. C. Geske, G. Berdin, F. Talantov, T. Cardellino, H. Garrett, D. Millenheft, V. Kumsomboone and D. Renner, FLIR Electro-Optical Components, Ventura, CA, USA

High power VCSEL arrays have experienced rapid growth and development. In this paper, we review the unique properties of VCSELs and present the progress that is making them very attractive for high power laser applications.

**10:00 AM – 10:30 AM**

**COFFEE BREAK**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session MA2:</th>
<th>Session Chair</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:30 AM - 12:00 PM</td>
<td>SINGLE-ELEMENT LASERS AND BARS</td>
<td>Götz Erbert, Ferdinand-Braun-Institut, Berlin, Germany</td>
</tr>
</tbody>
</table>

**MA2.1  10:30 AM - 11:00 AM (Invited)**

**Brilliance Improvement of High Power Diode Laser Systems: Status and Prospects**, H.-D. Hoffmann, Fraunhofer-Institut, Aachen, Germany

ABSTRACT NOT AVAILABLE

**MA2.2  11:00 AM - 11:30 AM (Invited)**

**Recent Advances in 8xx-10xx nm Devices**, N. Lichtenstein, Oclaro Switzerland GmbH, Zurich, Switzerland

An overview on the development at Oclaro of high power laser diodes operating in the 8xx - 10xx nm range is given. We present results on laser bars and give a comparison of stabilized and non-stabilized seeders for fiber lasers.

**MA2.3  11:30 AM - 12:00 PM (Invited)**

**High Brightness Laser Sources based upon Low Fill Factor Bars**, R. N. Pathak, H. Winhold, S. Kim, Z. Xu, D. M. Grasso, P. Liang, N. Shou and D. Lee, Coherent Inc., Santa Ciara, CA, USA

We present results from our low fill factor bars used in high brightness optical systems for pumping and material processing applications.

**12:00 PM – 1:30 PM**

**LUNCH BREAK**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session MA3:</th>
<th>Session Chair</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:30 PM - 3:00 PM</td>
<td>PLENARY SESSION</td>
<td>Gary M. Smith, MIT Lincoln Laboratory, Lexington, MA, USA</td>
</tr>
</tbody>
</table>

**MA3.1  1:30 PM - 2:15 PM (Plenary)**

**Progress in High Brilliance Lasers**, G. Erbert, Ferdinand-Braun-Institut, Berlin, Germany

Increasing demands on brightness for laser applications is the driving force of research on high-power diode lasers. Status and current developments of monolithic und hybrid solutions for high brilliance diode laser sources will be discussed.
MA3.2  2:15 PM - 3:00 PM  (Plenary)
25 Years of High-Brightness, Fiber-Coupled Semiconductor Laser Diodes, E. Zucker, JDS Uniphase Corporation, Milpitas, CA, USA
Fiber-coupled laser diodes continue to show dramatic progress in power and brightness. Advances in semiconductor laser power and fiber coupling performance are presented, with focus on recent designs utilizing polarization-, spatial-, and wavelength-combining techniques.

3:00 PM – 3:30 PM  COFFEE BREAK

3:30 PM - 5:00 PM
Session MA4:  FIBER-COUPLED LASER BARS
Session Chair:  Paul Crump, Ferdinand-Braun-Institut, Berlin, Germany

MA4.1  3:30 PM - 4:00 PM  (Invited)
Status on low fill factor 9xx nm laser bars will be presented. Conversion efficiency peaks above 66% and slow axis divergence of less than 7° was reached up to 45W for 10%-fill factor half-bars.

MA4.2  4:00 PM - 4:30 PM  (Invited)
High-Brightness, Fiber-Coupled Sources, K. Price, nLight Corporation, Vancouver, WA, USA
We present methods for improving diode laser brightness, fiber coupling architectures, and beam delivery methods that preserve diode brightness, resulting in improved fiber coupled diode laser modules for pumping KW-class fiber lasers.

MA4.3  4:30 PM - 5:00 PM  (Invited)
High Brightness Fiber Coupled Modular Diode Laser Platform, J. Biesenbach, DILAS Diodenlaser GmbH, Mainz-Hechtsheim, Germany
The price for diode laser erases, reliability and power demand go up. Airborne app. require robustness at low weight and high brightness. Instead of hand made, an automated, flexible featured, power scalable platform is needed.

5:15 PM – 6:15 PM  WELCOME RECEPTION: MADISON BALLROOM (2nd FLOOR)

Tuesday, 10 July 2012

TuA1.1  9:00 AM - 9:30 AM  (Invited)
Aspects of Robust High-Power Semiconductor Laser Design with State-of-the-Art Performance for a Uniform and Reproducible Volume Manufacturing, A. Pietrzak, R. Huelsewede, M. Zorn, O. Hirsekorn and J. Sebastian, Jenoptik Diode Lab GmbH, Berlin, Germany
Diode lasers for volume production should be non-sensitive to manufacturing process variations. JENOPTIK Diode Lab presents a modal loss focused design process of GaAs-based 9xx-laser structures, which is necessary for stable volume.

TuA1.2  9:30 AM - 10:00 AM  (Invited)
Low-Cost Diode Arrays for Production-Scale Fusion Energy Installations, R. Feeler, J. Junghans and J. Levy, Northrop Grumman Cutting Edge Optronics, St. Charles, MO, USA
A detailed investigation of the technical requirements associated with laser diode arrays used in LIFE-based fusion energy power plants. Special consideration given to issues related to scaling for manufacturing.

10:00 AM – 10:30 AM  COFFEE BREAK
TuA2.1 10:30 AM - 11:30 AM (Tutorial)

High-Power, High-Brightness Laser Beam Combining, T. Y. Fan, MIT Lincoln Laboratory, Lexington, MA, USA

Beam combining of arrays of lasers is becoming an increasing attractive approach to generate high-power and high-brightness sources. This tutorial provides an overview on laser beam combining.

TuA2.2 11:30 AM - 11:45 AM


SCOWAs have produced 1.5 W of output power with a 44 mW seed. Arrays of 47 SCOWA elements have demonstrated a raw power of 57 W. Coherent beam combining of these arrays will be discussed.

TuA2.3 11:45 AM - 12:00 PM

Bar Efficiency and Beam Quality for Coarse Wavelength Multiplexing, H. An, J. Jiang, R. Robert, S. Strohmaier and G. Treusch, TRUMPF Photonics Inc., Cranbury, NJ, USA

We will present results from optical power conversion efficiencies as well as near field and far field study of CB packaged bars in the 900-1060nm wavelength region for coarse wavelength multiplexing application.

12:00 PM – 1:30 PM LUNCH BREAK

TuA3.1 1:30 PM - 2:00 PM (Invited)

High Power Diode Lasers with External Feedback: Overview and Prospects, M. Chi and P. M. Petersen, Technical University of Denmark, Roskilde, Denmark

Different external-cavity feedback architectures that enhance the spatial and temporal coherence for both broad-area diode lasers and tapered diode lasers are reviewed and the most promising results in the literature are given as examples.

TuA3.2 2:00 PM - 2:30 PM (Invited)


Wavelength locking of high-power diode laser bars by volume Bragg gratings (VBGs) are investigated in theory and practice. Important diode laser and VBG parameters are discussed, and experimental results are presented.

TuA3.3 2:30 PM - 2:45 PM

High Power High Brightness Volume Bragg Semiconductor Lasers, L. Glebov, G. B. Venus, University of Central Florida, Orlando, FL, USA, K. Shavitmuruk, OptiGrate Corporation, Orlando, FL, USA, I. Divliansky, University of Central Florida, Orlando, FL, USA and V. I. Smirnov, OptiGrate Corporation, Orlando, FL, USA

Development of low-loss volume Bragg gratings recorded in PTR glass and their utilization as components of external resonators of semiconductor lasers enabled dramatic increase of laser brightness without significant penalties in power and efficiency.

TuA3.4 2:45 PM - 3:00 PM


We will present recent results on 9xx-nm single emitters and laser diode bars. A 20 W output from the single emitter and a 200 W from the bar with low smile have been achieved.

3:00 PM – 3:30 PM COFFEE BREAK
TuA4.1  3:30 PM - 4:00 PM  (Invited)
Factors Influencing the Brightness and Beam Quality of Tapered Laser Diodes and Bars, J. J. Lim, S. Bull, S. Kaunga-Nyirenda, S. Sujecki, E. C. Larkins, University of Nottingham, Nottingham, UK, K.-H. H. Hasler and J. Fricke, Ferdinand-Braun-Institut, Berlin, Germany
This paper examines some of the factors affecting the brightness of high-power tapered lasers, including bleaching of the ridge waveguide and mismatch between the taper and the beam diffraction angle, which excite high-order modes.

TuA4.2  4:00 PM - 4:15 PM
Advances in High Power Laser Diodes in the 1400-1910nm Wavelength Regime, R. Lammert, J. Ungar, S. W. Oh, C. Panja and W. Hu, Laser Operations, Sylmar, CA, USA
We report on InGaAsP high power laser diodes recently developed at Laser Operations. Devices including 1532nm MOPAs with >3W of near diffraction limited power and 1470nm bars with 1W/A slopes using monolithically double active regions.

TuA4.3  4:15 PM - 4:30 PM
Lateral Far-Field of Multiple-Stripe High Power 1480nm Broad-Area-Lasers for Pulsed Operation, D. A. Fendler, M. Spiegelberg, W. Rehbein and M. Moehrle, Fraunhofer Heinrich Hertz Institute, Berlin, Germany
A novel 1480nm multiple stripe broad area laser structure is presented featuring a 33% lateral farfield angle reduction compared with conventional single stripe broad area lasers.

TuA4.4  4:30 PM - 4:45 PM
We describe high peak-power, broad area mid-infrared semiconductor lasers. The laser structures incorporated 14 type-II quantum wells and produced near 470 W at 4.1 μm with the output from a Q-switched Ho:YAG laser.

TuA4.5  4:45 PM - 5:00 PM
High Power Bragg Reflection Waveguide Diode Lasers with Twin Near-Circular Emission Spots, C. Z. Tong, Changchun Institute of Optics, Changchun, China
A novel semiconductor laser with two symmetrical near-circular emission spots separated at an angle of 62° was demonstrated using Bragg reflection waveguide. The low beam divergence of 5.4° and power of 2.6 W were achieved.

TuA5.1  5:00 PM - 5:30 PM  (Invited)
EU-Funded High Power Laser Programs: Present and Future Activities, S. Kaierle, Laser Zentrum Hannover e.V., Hannover, Germany
ABSTRACT NOT AVAILABLE

Wednesday, 11 July 2012

WA1.1  9:00 AM - 10:00 AM  (Tutorial)
Mode Control and Monolithic Coherent Power Scaling, L. J. Mawst and D. Botez, University of Wisconsin-Madison, Madison, WI, USA
Monolithic approaches for achieving coherent-power scaling of diode lasers have resulted in watt-range output powers with high beam quality. Thermal lensing effects generally limit the single-mode operational range under CW operating conditions.

10:00 AM – 10:30 AM  COFFEE BREAK
10:30 AM - 12:00 PM
Session WA2: INCREASING EFFICIENCY
Session Chair: Eugene A. Avrutin, University of York, Heslington, Yorkshire, UK

WA2.1 10:30 AM - 11:30 AM (Tutorial)
Radiative Efficiency and High-Power Quantum Well Lasers, P. Blood, Cardiff University, Cardiff, Wales, UK
Optical gain in a laser diode is controlled by the internal voltage. This tutorial gives an account of the processes which contribute to the threshold current but not to stimulated emission for the lasing process.

WA2.2 11:30 AM - 12:00 PM (Invited)
Quantum Dots for High Powers and Efficiencies, D. G. Deppe, University of Central Florida, Orlando, FL, USA
Laser diode power conversion efficiencies tend to saturate at room temperature at ~ 70%. The fundamental limits of the laser diode efficiency are examined based on active material and compared for different active materials.

12:00 PM – 1:30 PM  LUNCH BREAK

1:30 PM - 3:00 PM
Session WA3: INCREASING POWER
Session Chair: Erik Zucker, JDS Uniphase Corporation, Milpitas, CA, USA

WA3.1 1:30 PM - 2:00 PM (Invited)
Mechanisms and Kinetics of the Catastrophic Optical Damage (COD) of High-Power Semiconductor Lasers, J. W. Tomm, M. Hempel, Max Born Institute, Berlin, Germany, M. Krakowski, Alcatel-Thales III-V Lab, Marcoussis, France and T. Elsaesser, Max Born Institute, Berlin, Germany
Mechanisms relevant for the COD in GaAs-based diode lasers are reviewed. Experiments, where COD is artificially provoked, represent a main topic. The sequence of events and the kinetics down to a nanosecond timescale are addressed.

WA3.2 2:00 PM - 2:30 PM (Invited)
Carrier Accumulation in the Optical Confinement Layer, Its Effect on Power Limit in High Power and Brightness Laser Diodes, and Laser Design to Overcome This Limitation, E. A. Avrutin, University of York, Heslington, Yorkshire, UK and B. S. Ryvkin, A.F. Ioffe Physico-Technical Institute, St. Petersburg, Russia
We analyse efficiency degradation due to carrier accumulation in the optical confinement layer of high-power laser diodes. Narrow asymmetric waveguide structures are shown to reduce this limitation while enabling low built-in losses and fundamental-mode operation.

WA3.3 2:30 PM - 2:45 PM
Current dependent absorption in broad area edge emitting lasers has been measured using laser diodes with high reflectivity (HR) output facets.

WA3.4 2:45 PM - 3:00 PM
CW and Pulsed High-Power Semiconductor Separate-Confinement Double Heterostructure Lasers, N. Pikhtin, A.F. Ioffe Physico-Technical Institute, St. Petersburg, Russia
The concept of high power semiconductor lasers based on separate-confinement double heterostructures with quantum wells is presented. Physical and technologic factors limiting optical output power of CW and pulsed semiconductor lasers are discussed.

3:00 PM – 3:30 PM  COFFEE BREAK

3:30 PM - 5:00 PM
Session WA4: IMPROVING LASER PERFORMANCE
Session Chair: Peter Blood, Cardiff University, Cardiff, Wales, UK

WA4.1 3:30 PM - 4:00 PM (Invited)
We report a novel design and fabrication technique for buried overgrown DFB gratings floating in AlGaAs. In-situ etching enables low oxygen contamination and results in > 60% efficient and 10W reliable high power DFB lasers.

Semiconductor laser heterostructure waveguide design considerations are presented. Wide evanescent tails of guided mode penetrating deeply into claddings are essential for reduction of vertical divergence of an emitted beam. Symmetric and asymmetric designs are compared.

Diagnosing and Addressing the Limitations to Lateral Far Field Angle in High Power Broad-Area Diode Lasers, P. Crump, S. Boeldicke, C. M. Schultz, H. Ekhteraei, H. Wenzel and G. Erbert, Ferdinand-Braun-Institut, Berlin, Germany

We show experimentally that thermal lensing largely determines the lateral mode properties of broad-area lasers. However, additional broadening is observed at high powers, which will limit how effectively mode-filtering techniques can improve beam quality.
Final Program
Optical Wireless Systems and Applications

Monday, 9 July 2012

All sessions will be held in South Room

<table>
<thead>
<tr>
<th>Time</th>
<th>Session MB1</th>
<th>Title</th>
<th>Speaker(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00 AM - 10:00 AM</td>
<td></td>
<td>FRONTIER OF OPTICAL WIRELESS TECHNOLOGIES I</td>
<td>Eric Y. Chan, Boeing Research and Technology, Seattle, WA, USA</td>
</tr>
<tr>
<td>MB1.1</td>
<td>9:00 AM - 9:30 AM</td>
<td>Optical Signal Processing for Millimeter-Wave Wireless Systems, T. Kawanishi, National Institute of Information and Communications Technology, Koganei, Tokyo, Japan</td>
<td>Pure optical two-tone signals can be converted into millimeter-wave signals by using high-speed photodetectors.</td>
</tr>
<tr>
<td>MB1.2</td>
<td>9:30 AM - 9:45 AM</td>
<td>Handover in Fixed-Mobile Convergence, N. Ghazisaidi, Ericsson USA, San Jose, CA, USA</td>
<td>The concept of handover to perform inter- and intra-switching for mobile end-users in fixed-mobile convergence broadband access networks is introduced and its impact on the performance of network is evaluated.</td>
</tr>
<tr>
<td>MB1.3</td>
<td>9:45 AM - 10:00 AM</td>
<td>Physical-Layer Authentication for Poisson Channels, R. J. Drost, P. L. Yu, K. S. Chan and B. M. Sadler, US Army Research Laboratory, Adelphi, MD, USA</td>
<td>Physical-layer authentication framework for communications over a Poisson channel. Focusing on on-off keying, we discuss such aspects as the stealth, robustness, and security of the authentication approach.</td>
</tr>
</tbody>
</table>

10:00 AM – 10:30 AM       COFFEE BREAK

<table>
<thead>
<tr>
<th>Time</th>
<th>Session MB2</th>
<th>Title</th>
<th>Speaker(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:30 AM - 11:45 AM</td>
<td></td>
<td>FRONTIER OF OPTICAL WIRELESS TECHNOLOGIES II</td>
<td>Eric Y. Chan, Boeing Research and Technology, Seattle, WA, USA</td>
</tr>
<tr>
<td>MB2.1</td>
<td>10:30 AM - 11:15 AM</td>
<td>Undersea Laser Communications is a “Game-Changer” for the US Navy, So How Do We Make the Promise a Reality?, G. Mooradian, QinetiQ North America, San Diego, CA, USA</td>
<td>This paper addresses the fundamental physics and architecture issues attendant to an underwater blue/green laser communication system: both all-underwater as well as through the air/sea interface. This may represent the most challenging comm propagation channel.</td>
</tr>
<tr>
<td>MB2.2</td>
<td>11:15 AM - 11:45 AM</td>
<td>Ultra-High Capacity 60-GHz Fiber-Wireless Systems, C.-T. Lin, C.-H. Ho, T.-H. Lu, C.-Y. Wang, H.-T. Huang and F.-M. Wu, National Chiao Tung University, Tainan City, Taiwan</td>
<td>Several digital signal processing techniques and methods have been demonstrated to solve many technical challenges of 60-GHz fiber-wireless system. Using these solutions, we have experimentally demonstrated ultra-high capacity RoF systems operating at up to 50Gb/s.</td>
</tr>
</tbody>
</table>

12:00 PM – 1:30 PM       LUNCH BREAK
Onboard Wireless Aerospace Applications - Challenges and Opportunities, W. P. Krug, Boeing Company, Seattle, WA, USA

Onboard wireless shows great promise and offers unique challenges for potential onboard communications and sensing applications.

Wireless Optical Links for Airplane Applications, E. Y. Chan, Boeing Research and Technology, Seattle, WA, USA

This paper describes the development of high quality and error free wireless optical communication links using wide dynamic range and high power small form factor (SFF) transceivers that are suitable for use in airplane platforms.

Indoor Optical Wireless Localization System for High-Speed Personal Area Networks, K. Wang, A. Nirmalathas, C. Lim and E. Skafidas, University of Melbourne, Melbourne, Australia

In this paper we experimentally demonstrate an indoor optical wireless based localization system with single channel imaging receiver for personal area network applications. The results show that an accuracy of ~3.81cm can be achieved.

A 2-D Indoor Localization System Based On Visible Light LED, M. Kavehrad and W. Zhang, Pennsylvania State University, University Park, PA, USA

An LED based 2-D indoor localization system is proposed. For evaluation purpose we also present computer simulations results that show for a normal room size, we can locate a target to within centimeters.

Long-range Indoor Hybrid Localization System Design with Visible Light Communications and Wireless Network, M. Kavehrad, Pennsylvania State University, University Park, PA, USA and Y. U. Lee, Hallym University, Chuncheon, Korea

An indoor hybrid localization system is realized and experimented with, using a five-hop Zigbee wireless network and visible light communications in order to improve positioning accuracy and achieve a long-range localization.

Comparing Wide Field-of-View Optical Receivers for Free Space Optical Communications, M. Kavehrad, P. Deng, Pennsylvania State University, University Park, PA, USA and X. Yuan, Huazhong University of Science and Technology, Wuhan, Hubei, China

We investigate the performance of wide field-of-view diversity optical receiver for free space optical communications in atmospheric strong turbulence. The proposed scheme can help to reduce scintillations and improve BER performance.

Lasercom for High Definition Video to a Moving Platform Using Cat's Eye Modulating Retro-reflectors, P. G. Goetz, M. S. Ferraro, R. Mahon, J. L. Murphy, M. R. Suit, C. I. Moore, M. J. Vilcheck, W. S. Rabinovich and W. W. Schultz, US Naval Research Laboratory, Washington, DC, USA

An Ethernet boat-to-shore lasercom link was established using a cat’s eye modulating retro-reflectors. High-definition video and data were transferred bi-directionally at ranges of 2 – 7.7 km.

Emerging Technologies for Mm-wave RoF Communication, H.-C. Chien, ZTE USA, Morrisstown, NJ, USA, C. Liu, J. Liu, S.-H. Fan, Y.-T. Hsueh, Georgia Institute of Technology, Atlanta, GA, USA, Z. Jia, ZTE USA, Morrisstown, NJ, USA, S. He, Zhejiang University, Hangzhou, China and G.-K. Chang, Georgia Institute of Technology, Atlanta, GA, USA

We review recent experimental demonstrations on optical mm-wave generation and modulation technologies for high-speed radio-over-fiber communication, including the feasibility studies on delivering vector signals over DSB-SC optical mm-wave, duobinary modulation, and Fabry-Perot subharmonic mm-wave generator.

Delivery of Wireless and Wired Services Using a Single-drive Mach-Zehnder Modulator for Bidirectional Radio-over-Fiber Systems, M. Zhu, Georgia Institute of Technology, Atlanta, GA, USA
We designed and experimentally demonstrated a cost-effective RoF system for downstream 1-Gb/s OOK/BPSK and 2-Gb/s 16QAM-OFDM signals using only one single-drive MZM by driving both RF and bias ports, and upstream 1-Gb/s OOK signal.

**Tuesday, 10 July 2012**

<table>
<thead>
<tr>
<th>Time</th>
<th>South Room</th>
<th>West Room</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00 AM - 10:00 AM</td>
<td><strong>Session TuB1</strong>: <strong>NEXT-GEN OPTICAL WIRELESS SYSTEMS I</strong>&lt;br&gt;Session Chair: Timothy J. Kane, Pennsylvania State University, University Park, PA, USA</td>
<td>9:00 AM - 10:00 AM</td>
</tr>
<tr>
<td>TuB1.1</td>
<td>9:00 AM - 9:15 AM</td>
<td><strong>An Archipelago of High-Bandwidth Islands by Optical Wireless Systems – A Solution to the USA Wireless Airwaves Spectrum Crunch</strong>, M. Kavehrad and M. I. Chowdhury, Pennsylvania State University, University Park, PA, USA</td>
</tr>
<tr>
<td>TuB1.2</td>
<td>9:15 AM - 9:45 AM (Invited)</td>
<td><strong>Multi-Carrier versus Single-Carrier Intensity Modulation Techniques for Indoor Optical Wireless Links</strong>, J. M. Kahn, Stanford University, Stanford, CA, USA, D. J. F. Barros, Qualcomm Atheros, San Jose, CA, USA and S. K. Wilson, Santa Clara University, Santa Clara, CA, USA</td>
</tr>
<tr>
<td>TuB1.3</td>
<td>9:45 AM - 10:00 AM</td>
<td><strong>On the EVM Calculation of Clipped Optical OFDM Signals</strong>, Z. Yu, Georgia Institute of Technology, Atlanta, GA, USA, R. J. Baxley, Georgia Tech Research Institute, Atlanta, GA, USA and G. Zhou, Georgia Institute of Technology, Atlanta, GA, USA</td>
</tr>
<tr>
<td>10:00 AM - 10:30 AM</td>
<td><strong>COFFEE BREAK</strong></td>
<td></td>
</tr>
<tr>
<td>10:30 AM - 12:00 PM</td>
<td><strong>Session TuB2</strong>: <strong>NEXT-GEN OPTICAL WIRELESS SYSTEMS II</strong>&lt;br&gt;Session Chair: Timothy J. Kane, Pennsylvania State University, University Park, PA, USA</td>
<td>10:30 AM - 12:00 PM</td>
</tr>
<tr>
<td>TuB2.1</td>
<td>10:30 AM - 11:00 AM (Invited)</td>
<td><strong>Green Optical/Wireless Access/In-Building Networks</strong>, L. G. Kazovsky, K. M. Alibeyoglu, T. Ayhan, T. Ucar, Stanford University, Stanford, CA, USA and D. van Veen, Alcatel-Lucent, Murray Hill, NJ, USA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>This paper analyzes energy and power consumption of integrated</td>
</tr>
<tr>
<td>Time</td>
<td>Session</td>
<td>Title</td>
</tr>
<tr>
<td>-----------------</td>
<td>----------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>11:00 AM - 11:30 AM (Invited)</td>
<td>TuB2.1</td>
<td>Visible Light Communications for Entertainment Networking</td>
</tr>
<tr>
<td></td>
<td>TuB2.2</td>
<td>LED Design for Concurrent Data protocols.</td>
</tr>
<tr>
<td>11:30 AM - 12:00 PM (Invited)</td>
<td>TuB2.3</td>
<td>Visible Light Communications, Z. Ghassemloopy, Northumbria University</td>
</tr>
<tr>
<td></td>
<td>TuB2.4</td>
<td>Undersea Connectivity with Optical Communications, P. Poirier</td>
</tr>
<tr>
<td></td>
<td>TuB2.5</td>
<td>An Adaptive Data Rate Controller (ADRC) for the Through</td>
</tr>
<tr>
<td></td>
<td>TuB2.6</td>
<td>Cloud, Undersea Laser Communications Channel, R. Stokes,</td>
</tr>
<tr>
<td></td>
<td>TuB2.7</td>
<td>An Adaptive Data Rate Controller (ADRC) for the Through</td>
</tr>
<tr>
<td></td>
<td>TuB2.8</td>
<td>Cloud, Undersea Laser Communications Channel, R. Stokes,</td>
</tr>
<tr>
<td>12:00 PM - 1:30 PM</td>
<td>Lunch Break</td>
<td></td>
</tr>
<tr>
<td>1:30 PM - 2:00 PM (Invited)</td>
<td>TuB3.1</td>
<td>Undersea Connectivity with Optical Communications, P. Poirier</td>
</tr>
<tr>
<td>2:00 PM - 2:30 PM (Invited)</td>
<td>TuB3.2</td>
<td>An Adaptive Data Rate Controller (ADRC) for the Through</td>
</tr>
<tr>
<td>2:30 PM - 3:00 PM (Invited)</td>
<td>TuB3.3</td>
<td>Aspects of Oceanic Optical Comms: From Air to Sea</td>
</tr>
<tr>
<td>3:00 PM - 3:30 PM (Invited)</td>
<td>TuB3.4</td>
<td>Enhanced Field of View and Speed Characteristics for Optical</td>
</tr>
<tr>
<td>3:00 PM - 3:30 PM (Invited)</td>
<td>TuB3.5</td>
<td>High Efficiency LED Driver Design for Concurrent Data Transmission</td>
</tr>
<tr>
<td>3:30 PM - 4:00 PM (Invited)</td>
<td>TuB3.6</td>
<td>Semiconductor Ultraviolet Emitters and Detectors with Potential</td>
</tr>
<tr>
<td>4:00 PM - 4:30 PM (Invited)</td>
<td>TuB3.7</td>
<td>High Efficiency LED Driver Design for Concurrent Data Transmission</td>
</tr>
<tr>
<td>4:30 PM - 5:00 PM (Invited)</td>
<td>TuB3.8</td>
<td>Enhanced Field of View and Speed Characteristics for Optical</td>
</tr>
</tbody>
</table>

Optical/wireless in-building networks, with the goal of identifying energy hogs and finding ways to reduce the overall energy consumption of such networks.

In this presentation we discuss visible light communication and discuss challenges and techniques to improve the performance of white organic light emitting diode (OLED) based systems.

Visible light communications is a new approach for many entertainment networking scenarios. We discuss applications in theme park environments with high device densities, and introduce toy networking using LED communications with simple network protocols.

Light propagation through a water/air interface experiences air and seawater, and the communications techniques employed to achieve megabit-per-second laser communications between aircraft above the clouds and submarines at speed and depth.

In this paper we discuss quantum dot approaches to extend the usefulness of IR focal plane arrays into another application, UV wireless communications, in order to achieve a dual-use capability for a conventional imager.

In this talk we introduce visible light communication and discuss challenges and techniques to improve the performance of white organic light emitting diode (OLED) based systems.
<table>
<thead>
<tr>
<th>Session Time</th>
<th>Session Title</th>
<th>Session Chair</th>
</tr>
</thead>
<tbody>
<tr>
<td>3:00 PM - 3:30 PM</td>
<td>COFFEE BREAK</td>
<td></td>
</tr>
<tr>
<td>3:30 PM - 5:00 PM</td>
<td>TuB4.1 PERFORMANCE OF OPTICAL WIRELESS SYSTEMS II</td>
<td>Peter Poirier, SPAWAR Systems Center - San Diego, San Diego, CA, USA</td>
</tr>
<tr>
<td>3:30 PM - 5:00 PM</td>
<td>TuB4.2 Channel Reciprocity in Single-Mode Free-Space Optical Links</td>
<td>R. Parenti, J. M. Roth, J. A. Greco, F. Walther, MIT Lincoln Laboratory, Lexington, MA, USA, and J. H. Shapiro, Massachusetts Institute of Technology, Cambridge, MA, USA</td>
</tr>
<tr>
<td>3:30 PM - 5:00 PM</td>
<td>TuB4.3 A Method for Comparing Remote Optical Clocks over a Free-Space Link</td>
<td>W. C. Swann, F. R. Giorgetta, I. Doddington, E. Baumann, National Institute of Standards and Technology, Boulder, CO, USA, J.-D. Deschenes, Université Laval, Quebec, Canada, L. Sinclair, A. M. Zolet and N. R. Newbury, National Institute of Standards and Technology, Boulder, CO, USA</td>
</tr>
<tr>
<td>3:30 PM - 5:00 PM</td>
<td>TuB4.4 Laser Visible Light Communications</td>
<td>T. Borogovac and T. D. C. Little, Boston University, Boston, MA, USA</td>
</tr>
<tr>
<td>3:30 PM - 5:00 PM</td>
<td>TuB4.5 Distributions of PAPR and Crest Factor of OFDM Signals for VLC</td>
<td>C. Ma, Z. Xu, Tsinghua University, Beijing, China, K. Cui, University of California - Riverside, Riverside, CA, USA, M. Yao and H. Zhang, Tsinghua University, Beijing, China</td>
</tr>
</tbody>
</table>


A 10 Gbps FSO system implements beam tracking, a high dynamic range optical receiver, and a dynamic buffering packet modem. Performance was characterized at the 4.5 km Shuttle Landing Facility at Kennedy Space Center Florida.

- **Session TuB4.2**: Channel Reciprocity in Single-Mode Free-Space Optical Links, R. Parenti, J. M. Roth, J. A. Greco, F. Walther, MIT Lincoln Laboratory, Lexington, MA, USA, and J. H. Shapiro, Massachusetts Institute of Technology, Cambridge, MA, USA

This article describes observations of near-unity signal correlations obtained during a recent series of single-mode lasercom experiments in which links were established between an aircraft and a ground station separated by ranges up to 80km.

- **Session TuB4.3**: A Method for Comparing Remote Optical Clocks over a Free-Space Link, W. C. Swann, F. R. Giorgetta, I. Doddington, E. Baumann, National Institute of Standards and Technology, Boulder, CO, USA, J.-D. Deschenes, Université Laval, Quebec, Canada, L. Sinclair, A. M. Zolet and N. R. Newbury, National Institute of Standards and Technology, Boulder, CO, USA

We demonstrate a method to compare optical clocks approaching 10^-17 uncertainties through the exchange of optical pulses from a ground station separated by ranges up to 80km.

- **Session TuB4.4**: Laser Visible Light Communications, T. Borogovac and T. D. C. Little, Boston University, Boston, MA, USA

Visible Light Communications (VLC) via lighting must overcome the slow white LED. We propose the addition of a fast red laser to improve datarate, coverage, and light quality.

- **Session TuB4.5**: Distributions of PAPR and Crest Factor of OFDM Signals for VLC, C. Ma, Z. Xu, Tsinghua University, Beijing, China, K. Cui, University of California - Riverside, Riverside, CA, USA, M. Yao and H. Zhang, Tsinghua University, Beijing, China

The distributions of peak-to-average power ratio (PAPR) and crest factor (CF) of OFDM symbols in optical wireless communication (OWC) are studied.
Wednesday, 11 July 2012

<table>
<thead>
<tr>
<th>Time</th>
<th>Session WB1: Advanced Optical Wireless Technologies I</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00 AM - 10:00 AM</td>
<td>Session Chair: Keang-Po Ho, Silicon Image, Sunnyvale, CA, USA</td>
</tr>
</tbody>
</table>

**WB1.1 9:00 AM - 9:30 AM (Invited)**

Unlicensed 60-GHz Millimeter Wave for Multi-Gigabit Wireless Communications, K.-P. Ho, S. Emami and J. M. Gilbert, *Silicon Image, Sunnyvale, CA, USA*

A 3.8-Gb/s wireless video area network uses unlicensed 60-GHz millimeter-wave, antenna arrays, and CMOS circuits. Using beam-search techniques, the antenna arrays can steer the beam to avoid line-of-sight blockage.

**WB1.2 9:30 AM - 9:45 AM**

A Cost-effective Multi-gigabit 60-GHz Wireless over Optical Fiber Access System Based on a Novel Frequency Quintupling Technique, L. Zhang, Shanghai Jiao Tong University, Shanghai, China, S.-H. Fan, M. Zhu, C. Liu, Georgia Institute of Technology, Atlanta, GA, USA, X. Hu, Shanghai Jiao Tong University, Shanghai, China, Z. Li, Georgia Institute of Technology, Atlanta, USA, Y. Su, Shanghai Jiao Tong University, Shanghai, China and G.-K. Chang, Georgia Institute of Technology, Atlanta, GA, USA

We propose and demonstrate a cost-effective wireless over optical fiber access system using frequency quintupling technique. A 2.5-Gb/s OOK signal at 60-GHz is successfully transmitted through 30-km SSMF and 10-ft air link without dispersion compensation.

**WB1.3 9:45 AM - 10:00 AM**


20-Gbaud QPSK transmission over 20-km SMF for optical and 7.5-m free space for 90-GHz radio is successfully demonstrated with 50-dBi Cassegrain antennas. This configuration will be feasible for kilometer-order distance transmission.

10:00 AM – 10:30 AM COFFEE BREAK

<table>
<thead>
<tr>
<th>Time</th>
<th>Session WB2: Advanced Optical Wireless Technologies II</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:30 AM - 12:00 PM</td>
<td>Session Chair: Keang-Po Ho, Silicon Image, Sunnyvale, CA, USA</td>
</tr>
</tbody>
</table>

**WB2.1 10:30 AM - 11:15 AM**

Smart Lighting - Beyond Simple Illumination, R. F. Karlicek, Jr., Rensselaer Polytechnic Institute, Troy, NY, USA

Very efficient LED lighting is entering illumination markets, but initial products are aimed largely at replacing inefficient incandescent bulbs. The full potential of electronic lighting systems - Smart Lighting - will revolutionize future illumination systems.

**WB2.2 11:15 AM - 11:45 AM (Invited)**

Broadband Wireless Over Fibre: For Communications and Beyond, C.-P. Liu, University College London, London, UK

This paper discusses latest techniques for sending MIMO signals over fibre, a new application of real-time location monitoring supported by optical fibres and an asymmetric Fabry-Perot modulator as an electrical/optical transducer in radio over fibre.

**WB2.3 11:45 AM - 12:00 PM**

Color Quality Control in dual use Solid State Lighting and Visible Light Communication Systems using Coded Inverse Multiplexing, S. Muralidharan and P. S. Dutta, Rensselaer Polytechnic Institute, Troy, NY, USA

A coded inverse multiplexing scheme is proposed using Red-Green-Blue (RGB) LEDs for general lighting with minimal shift in correlated color temperature (~ 35 K) and visible light communication at modulation rates ~ 50 MHz.

12:00 PM – 1:30 PM LUNCH BREAK
WB3.1  1:30 PM - 2:00 PM  (Invited)
High Dynamic Range Linearized FM Photonic Link, J. M. Wyrwas and M. C. Wu, University of California - Berkeley, Berkeley, CA, USA
We present our work on frequency and phase modulated microwave photonic links which achieve linear demodulation using planar lightwave circuits (PLC) optical filtering and balanced detection, showing improvement in spurious free dynamic-range and signal gain.

WB3.2  2:00 PM - 2:30 PM  (Invited)
Coherent IFDMA-PON: A Novel Green and Elastic Optical Access Networks, Y. Yoshida, A. Maruta and K.-I. Kitayama, Osaka University, Suita, Osaka, Japan
We present a novel bandwidth-elastic and power-efficient coherent PON architecture based on interleaved frequency division multiple access (IFDMA) technique and experimentally demonstrate the coherent IFDMA-PON uplink transmission via 2xONUs with free-running sources.

WB3.3  2:30 PM - 2:45 PM
A novel duobinary RF receiver based on envelope detection is proposed for millimeter-wave radio-over-fiber systems, which simultaneously downconverts and decodes RF duobinary signals. Duobinary signal delivery over optical-wireless link is demonstrated with proposed receiver.

WB3.4  2:45 PM - 3:00 PM
Capacity of MIMO Visible Light Communication Channels, X. Zhang, Tsinghua University, Beijing, China, K. Cui, University of California - Riverside, Riverside, CA, USA, H. Zhang and Z. Xu, Tsinghua University, Beijing, China
Capacity of an indoor multiple-input multiple-output (MIMO) visible light communication (VLC) channel from lighting LED arrays to an imaging receiver is investigated based on Shannon capacity theory.

3:00 PM – 3:30 PM       COFFEE BREAK

3:00 PM – 4:45 PM
Session WB4:  EFFICIENT MODULATION AND TRANSPORT SYSTEMS II
Session Chair: Julian Cheng, University of British Columbia, Kelowna, BC, Canada

WB4.1  3:30 PM - 4:00 PM  (Invited)
Generic Radio over Fiber Access Network federates, on the same optical infrastructure, fixed and mobile access systems. With its innovative control plane, our architecture enables radio frequencies virtualization and promotes new business models for operators.

WB4.2  4:00 PM - 4:15 PM
Subcarrier Intensity Modulated Optical Communications over K-distributed Channels, X. Song, and J. Cheng, University of British Columbia, Kelowna, Canada
Our analysis shows that subcarrier intensity modulation using DPSK suffers an SNR performance loss of 3.92 dB with respect to BPSK under strong atmospheric turbulence conditions.

WB4.3  4:15 PM - 4:30 PM
Closed-form error rate expressions of heterodyne free-space optical transmission are presented for K-distributed turbulent environments. Our simplified solutions are highly accurate for practical multiple-input multiple-output system performance estimation.

WB4.4  4:30 PM - 4:45 PM
Continuous-Amplitude Modulation for Optical Wireless Channels, J. Karout, Chalmers University of Technology, Göteborg, Sweden, G. Kramer, Technical University of Munich, Munich, Germany, F. R. Kschischang, University of Toronto, Toronto, Canada and E. Agrell, Chalmers University of Technology, Göteborg, Sweden
Continuous-amplitude modulation for wireless optical channels is presented. For bandwidth measured as 99% in-band power, its spectral efficiency is 4.57 times that of the same modulation format with discontinuous amplitude for the same power requirement.

END OF PROGRAM
SUM 2012 IEEE Photonics Society Summer Topical Meeting on Space Division Multiplexing for Optical Systems and Networks

Final Program
Space Division Multiplexing for Optical Systems and Networks

Monday, 9 July 2012

ALL SESSIONS WILL BE HELD IN NORTH ROOM

9:00 AM – 9:15 AM  OPENING REMARKS

9:15 AM - 10:00 AM  Session MC1: SDM APPROACHES TO INCREASE CAPACITY
Session Chair: Lynn E. Nelson, AT&T, Middletown, NJ, USA

MC1.1  9:15 AM - 10:00 AM  (Plenary)
Current Capacity Limits and Activities within the EU Project MODE-GAP to Overcome Them, A. D. Ellis, Tyndall National Institute, Cork, Ireland
This presentation will discuss the implications of the Nonlinear Shannon Limit. We will compare technologies including new fibres for long haul transmission and techniques to expand the capacity of existing standard single mode fibers.

10:00 AM – 10:30 AM  COFFEE BREAK

10:30 AM - 12:00 PM  Session MC2: SDM FOR HIGH-CAPACITY TELECOM
Session Chair: David J. Richardson, University of Southampton, Southampton, UK

MC2.1  10:30 AM - 11:15 AM  (Plenary)
Network Capacity Scaling Through Space Division Multiplexing, P. J. Winzer, Alcatel-Lucent, Holmdel, NJ, USA
Space-division multiplexing (SDM) holds the promise to scalably overcome the looming optical networks capacity crunch. We will review SDM techniques using coupled and uncoupled spatial paths and assess their cost and energy scaling properties.

MC2.2  11:15 AM - 12:00 PM  (Plenary)
Preparation for Ultrahigh-Capacity SDM Transmission, M. Nakazawa, Tohoku University, Sendai, Japan
We describe recent advances toward ultrahigh-capacity SDM with high-spectral-density transmission in multi-core fibers (MCF). In particular, our recent activities on optical Nyquist pulse TDM transmission and local mode-coupling measurement along MCF are presented in detail.

12:00 PM – 1:30 PM  LUNCH BREAK

1:30 PM - 3:00 PM  Session MC3: SDM TRANSMISSION
Session Chair: Andrew Ellis, Tyndall National Institute, Cork, Ireland

MC3.1  1:30 PM - 2:00 PM  (Invited)
Transmission in Space-Division-Multiplexed Fibers, G. Li, University of Central Florida, Orlando, FL, USA
Key technologies and approaches for space-division multiplexed optical transmission is reviewed.

We transmitted 5 wavelength channels and 6 spatial- and polarization modes over a 184-km hybrid few-mode fiber span. Low-loss three-spot mode couplers are used in combination with backward pumped distributed Raman amplification.
MC3.3  2:15 PM - 2:30 PM
Reduction of Nonlinear Impairments in Coupled-Core Multicore Optical Fibers, S. Mumtaz, G. P. Agrawal, University of Rochester, Rochester, NY, USA and R.-J. Essiambre, Alcatel-Lucent, Holmdel, NJ, USA
We present a general model for studying the non-linear effects in coupled-core multicore fibers. Our results show that interactions between the intramodal nonlinearities and linear coupling between core can improve system performance.

MC3.4  2:30 PM - 2:45 PM
Nonlinear Interference in Mode Multiplexed Multi-mode Fibers, G. Rademacher, S. Warm and K. Petermann, Technical University Berlin, Berlin, Germany
We present a method to study the nonlinear interference in mode multiplexed multi-mode fibers by employing a four-wave-mixing based Gaussian-Noise Signal model and investigate its effects on the OSNR.

MC3.5  2:45 PM - 3:00 PM
We derive a generalized Manakov equation for multimode fiber to study the rapidly varying birefringence effects in space-division multiplexed fiber systems and show through numerical simulations that birefringence can reduce the impact of nonlinearities.

3:00 PM – 3:30 PM  COFFEE BREAK

3:30 PM - 5:00 PM
Session MC4:  DSP TECHNOLOGY
Session Chair:  Roland Ryf, Alcatel-Lucent, USA

MC4.1  3:30 PM - 4:00 PM  (Invited)
Using MIMO signal processing, we analyze the mode-dependent loss (MDL) of a 4200-km transmission link employing mode multiplexing over a 3-core microstructured fiber. We find that the MDL has a negligible impact on capacity.

MC4.2  4:00 PM - 4:15 PM
We report lab measurements of joint digital signal processing of simultaneous 112Gbps links in a 7-core fiber. Strongly-correlated phase fluctuations between the cores permit reduced processing complexity with no increase in the bit-error ratio.

MC4.3  4:15 PM - 4:30 PM
Adaptive Frequency Domain Equalization for Mode-Division Multiplexed Transmission, N. Bai and G. Li, University of Central Florida, Orlando, FL, USA
We propose and simulate single-carrier adaptive frequency-domain equalization (SC-FDE) for mode-division multiplexed transmission. The FDE approach reduces computational complexity significantly compared to the time-domain equalization (TDE) approach while maintaining the same performance.

MC4.4  4:30 PM - 5:00 PM  (Invited)
DSP Requirements for MIMO Spatial Multiplexed Receivers, B. Inan, Technical University of Munich, Munich, Germany, S. L. Jansen, B. Spinnler, Nokia Siemens Networks GmbH & Co. KG, Munich, Germany, F. Ferreira, Nokia Siemens Networks Portugal S.A., Amadora, Portugal, D. van den Borne, M. Kuschnerov, Nokia Siemens Networks GmbH & Co. KG, Munich, Germany, A. P. Lobato, University of Federal Armed Forces, Neubiberg, Germany, S. Adhikari, Christian-Albrechts University at Kiel, Kiel, Germany, V. Steffler, Eindhoven University of Technology, Eindhoven, The Netherlands and N. Hanik, Technical University of Munich, Munich, Germany
OFDM requires the lowest equalizer complexity for crosstalk compensation in a mode-division-multiplexing receiver. For a 2000-km transmission distance and less than 10% OFDM- specific overhead, the modal dispersion must be below 6 ps/km for 10x10 MIMO.

5:15 PM – 6:15 PM  WELCOME RECEPTION: MADISON BALLROOM (2ND FLOOR)
TuC1.1 9:00 AM - 9:30 AM (Invited)
Design and Fabrication of Weakly-Coupled Few-Mode Fibers, M. Bigot-Astruc, D. Boivin and P. Sillard, Prysmian Group, Marcoussis, France
We study and optimize few-mode fibers for weakly-coupled mode division multiplexed transmissions that allow to multiply the capacity of single-mode systems by more than a tenfold.

TuC1.2 9:30 AM - 9:45 AM
A Large Effective Area Few-Mode Multi-Core Fiber, K. Takenaga, Y. Sasaki, N. Guan, S. Matsuo, Fujikura Ltd., Sakura, Chiba, Japan, M. Kasahara, K. Saitoh and M. Koshiba, Hokkaido University, Sapporo, Hokkaido, Japan
A design concept of few-mode multi-core fiber is presented. A four-core fiber that supports two LP modes with large effective area ($A_{eff}$) larger than 110 µm² realizes the highest relative core multiplicity factor of 11.7.

TuC1.3 9:45 AM - 10:00 AM
Measuring Distributed Mode Scattering in Few Mode Fibers with High and Low Differential Group Delay, L. Grüner-Nielsen, OFS Denmark, Brøndby, Denmark, J. W. Nicholson, OFS Laboratories, Somerset, NJ, USA, K. Jespersen, OFS Denmark, Brøndby, Denmark, Y. Sun, R. L. Lingle, OFS Laboratories, Norcross, GA, USA, D. Jakobsen and B. Palsdottir, OFS Denmark, Brøndby, Denmark
We present measurements of distributed mode scattering in up to 30km long few mode fibers using spatially and spectrally resolved (S2) imaging.

10:00 AM – 10:30 AM          COFFEE BREAK

TuC2.1 10:30 AM - 11:15 AM (Plenary)
Space Division Multiplexing in Data Communications and High Performance Computing, M. Taubenblatt, IBM Research, Yorktown Heights, NY, USA
High performance computing systems are exponentially increasing their dependence on optical interconnects to meet their scaling BW demands. Space division multiplexing continues to play an important role to meet the requirements of these systems.

TuC2.2 11:15 AM - 11:45 AM (Invited)
Recent Progress in Weakly Coupled Multicore Fibers: >100-Tbit/s Transmission and Next Generation Data Centers and Supercomputers, T. F. Taunay, OFS Laboratories, Somerset, NJ, USA
Recent MCF transmission results will be reviewed including record spectral efficiency, low loss and cross-talk and MCF amplifiers. In addition potential benefits of MCF for datacenter and Supercomputer applications will also be presented.

11:45 AM – 1:15 PM          LUNCH BREAK

TuC3.1 1:15 PM - 1:45 PM (Invited)
Mode Converters and Couplers for Few-Mode Transmission, A. Li, X. Chen, A. Al Amin and W. Shieh, University of Melbourne, Melbourne, Victoria, Australia
Space-division multiplexing based on few-mode fiber has been studied as a promising technique to increase capacity. In this paper we review the recent progress on the enabling mode selective components including mode converters and couplers.

TuC3.2 1:45 PM - 2:00 PM
Spot-Based Mode Coupler for Mode-Multiplexed Transmission in Few-Mode Fiber, R. Ryf, N. K. Fontaine and R.-J. Essiambre, Alcatel-Lucent, Holmdel, NJ, USA,
We present designs for a spot based low-loss mode coupler for few-mode fibers. A design optimized for a fiber supporting 12 spatial and polarization modes and < 3dB loss is analyzed in detail.

TuC3.3  2:00 PM - 2:15 PM
Capacity Increase in Spliced Mode-Multiplexed Transmission Systems by Using Mode Mixers, S. Warm and K. Petermann, Technical University Berlin, Berlin, Germany

The capacity of MDM transmission systems may be significantly reduced by fiber splices. Using only a few additional mode scramblers along the link the influence of fiber splices to the capacity is reduced.

TuC3.4  2:15 PM - 3:00 PM (Tutorial)
Mode Coupling Effects in Mode-Division-Multiplexed Systems, J. M. Kahn, Stanford University, Stanford, CA, USA and K.-P. Ho, Silicon Image, Sunnyvale, CA, USA

Strong mode coupling is beneficial in coherent mode-division-multiplexed systems. It reduces modal delay differences, minimizing signal processing complexity, and reduces mode-dependent gain variations, maximizing capacity. With modal dispersion, it creates frequency diversity, reducing outage probability.

3:00 PM – 3:30 PM       COFFEE BREAK

TuC4.1  3:30 PM - 4:00 PM (Invited)
Multi-Core Fibers and Their Crosstalk Characteristics, T. Hayashi, T. Sasaki and E. Sasaoka, Sumitomo Electric Industries Ltd., Yokohama, Kanagawa, Japan

Inter-core crosstalk of multi-core fibers is stochastic and heavily dependent on various perturbations such as bend and twist, and of course on fiber structures. Characteristics of the crosstalk are described from theoretical and experimental results.

TuC4.2  4:00 PM - 4:15 PM

A seven-core few-mode multi-core fiber in which each core supports three spatial modes has been designed and fabricated for the first time. The hole-assisted structure allows low crosstalk transmission of 21 spatial modes per polarization.

TuC4.3  4:15 PM - 4:30 PM
19-Core Multi Core Fiber to Realize High Density Space Division Multiplexing Transmission, K. Imamura, H. Inaba, K. Mukasa and R. Sugizaki, Furukawa Electric Co. Ltd, Ichihara, Chiba, Japan

19-core multi core fiber which has 10 times higher core density than 250µm coated SMF was realized. Each core was located on the three layered hexagonal grid in the 200µm cladding keeping low crosstalk properties.

TuC4.4  4:30 PM - 5:00 PM (Invited)
Homogeneous and Heterogeneous Multi-core Fibers, K. Saitoh, M. Koshiba, Hokkaido University, Sapporo, Hokkaido, Japan, K. Takenaga and S. Matsuo, Fujikura Ltd., Sakurai, Chiba, Japan

Required coupling coefficient and propagation constant difference between neighboring cores as well as allowable outer cladding diameter and assumed bending radii range are investigated for maximizing a relative core density in homogeneous and heterogeneous MCFs.

Wednesday, 11 July 2012

WC1.1  9:00 AM - 9:30 AM (Invited)
All Fiber Components for Multimode SDM Systems, I. Giles, Phoenix Photonics, South Croydon, Surrey, UK, A. Obeysekara, University of Southampton, Southampton, UK, R. Chen, D. Giles, Phoenix Photonics, South Croydon, Surrey, UK, F. Poletti and D. J. Richardson, University of Southampton, Southampton, UK

Fiber based mode converters and mode splitters are important elements in the FMF mux./demux. Long Period Gratings (LPGs) have been investigated and results presented together with a technique for real time mode monitoring during manufacture.
WC1.2  9:30 AM - 9:45 AM
Stable Mode Converter for Conversion between LP01 and LP11 Using a Thermally Induced Long Period Grating, L. Grüner-Nielsen, OFS Denmark, Brandby, Denmark and J. W. Nicholson, OFS Laboratories, Somerset, NJ, USA
A new method for making long period gratings for coupling between symmetric and asymmetric modes is presented. Good stability compared to traditionally mechanical long period gratings, high coupling efficiency and low insertion loss is demonstrated.

WC1.3  9:45 AM - 10:00 AM
The tolerance in a mode-demultiplexer to rotational, longitudinal offset and phase mismatch is demonstrated to be 25 degrees, 15% of the 1/e2 radius of the LP01 mode, and 45 degrees respectively for <1dB SNR penalty.

10:00 AM – 10:30 AM       COFFEE BREAK

10:30 AM - 12:00 PM
Session WC2:  MM FIBER AMPLIFIERS  
Session Chair:  Peter Krummrich, University of Dortmund, Dortmund, Germany

WC2.1  10:30 AM - 11:00 AM  (Invited)
Modal Gain Equalization in a Few Moded Erbium-Doped Fiber Amplifier, S.-U. Alam, Y. Jung, Z. Li, A. Dhar, J. K. Sahu, F. Poletti and D. J. Richardson, University of Southampton, Southampton, UK
We present results on broadband gain equalisation in a MM-EDFA for SDM transmission obtained by optimization of the pump launch and careful tailoring of both the fiber refractive index profile and erbium ion distribution.

WC2.2  11:00 AM - 11:15 AM
Design of Multi-Mode Erbium-Doped Fiber Amplifiers for Low Mode-Dependent Gain, D. Askarov and J. M. Kahn, Stanford University, Stanford, CA, USA
Erbium-doped fiber amplifiers for 12 signal modes (six spatial modes in two polarizations) are studied by numerically solving multi-mode rate equations. Mode-dependent gains are compared for different numerical apertures, index profiles and doping profiles.

WC2.3  11:15 AM - 11:30 AM
Phase-Sensitive Multimode Parametric Amplification in Parabolic-Index Waveguides, M. Vasilyev and M. Annamalai, University of Texas at Arlington, Arlington, TX, USA
We show that multiple spatial modes or images can be amplified by an optical parametric amplifier based on graded-index waveguide, and that the gains of various modes can be equalized by using several pump modes.

WC2.4  11:30 AM - 12:00 PM  (Invited)
Gain Equalization for Few-Mode Fiber Amplifiers with More Than Two Propagating Mode Groups, E. Ip, NEC Laboratories America, Inc., Princeton, NJ, USA
We investigate gain equalization in few-mode fibers with more than two mode groups at the signal wavelengths, and find that a combination of pump control and optimized doping profile is required to equalize mode-dependent gain.

12:00 PM – 1:30 PM       LUNCH BREAK

1:30 PM - 3:00 PM
Session WC3:  NOVEL COUPLING SCHEMES AND SDM DEVICES
Session Chair:  David Boivin, Prysmian Group, Marcoussis, France

WC3.1  1:30 PM - 1:45 PM
Pump Light Source for Distributed Raman Amplification in Multi-Core Fibers with PLC-integrated LD Sharing Circuit, K. Suzuki, H. Ono, T. Mizuno, Y. Hashizume and T. Takahashi, NTT Corporation, Atsugi, Kanagawa, Japan
We report an integrated pump source for distributed Raman amplification in multi-core fiber that utilizes a silica-based planar lightwave circuit for bundling passive components and reducing the number of fiber pigtails and LD modules.

WC3.2  1:45 PM - 2:00 PM
Optical Fiber Amplifier Employing a Bundle of Reduced Cladding Erbium-Doped Fibers for Multi-Core Fiber Transmission, K. Tsujikawa, L. Ma, NTT Corporation, Tsukuba, Ibaraki, Japan, K. Ichii, S. Matsuo, Fujikura Ltd., Sakura, Chiba, Japan, M. Yamada, Osaka Prefecture University, Sakai, Japan, N. Hanzawa, NTT Corporation, Tsukuba, Ibaraki, Japan and H. Ono, NTT Corporation, Atsugi, Japan
We propose a novel optical amplifier that employs a bundle of erbium-doped fibers for multi-core fiber transmission. We demonstrate the amplification of seven independent signals by using a bundle of EDFs with 60 um cladding.
WC3.3  2:00 PM - 2:15 PM

Free-space Coupling Optics for Multi-core Fibers, W. Klaus, National Institute of Information and Communications Technology, Tokyo, Japan

We describe the design of low-loss and low-crosstalk free-space coupling optics for multi-core fibers and discuss in detail its experimental evaluation.

WC3.4  2:15 PM - 2:30 PM

Low Loss Optical Connection Module for 7-Core Multi-Core Fiber and Seven Single Mode Fibers, Y. Tottori, T. Kobayashi and M. Watanabe, OPTOQUEST Co., Ltd., Ageo, Saitama, Japan

A pair of compact optical connection module is developed that connects 7-core multi-core fiber and seven single mode fibers. Insertion loss below 0.6 dB and cross talk better than -50 dB were realized.

WC3.5  2:30 PM - 2:45 PM

Mode Division Multiplexing Over 2km of OM2 Fibre Using Rotationally Optimized Mode Excitation with Fibre Coupler Demultiplexer, J. Carpenter and T. D. Wilkinson, University of Cambridge, Cambridge, UK

A Spatial Light Modulator and a non-specialized multimode coupler are used together to provide sufficient channel isolation and modal bandwidth for 2x12.5Gbps NRZ over 2km of standard graded-index multimode fibre without DSP.

WC3.6  2:45 PM - 3:00 PM

All Optical Degenerate Mode-Group Multiplexing Using a Mode Selective Switch, J. Carpenter, University of Cambridge, Cambridge, UK

A Mode Selective Switch based around an LCoS Spatial Light Modulator is demonstrated to optically demultiplex modes with the same propagation constants to the same output fibres, using a common phase mask for all channels.

3:00 PM – 3:30 PM  COFFEE BREAK

3:30 PM - 4:45 PM  SILICON DEVICES
Session Chair: Mark D. Feuer, AT&T, Middletown, NJ, USA

WC4.1  3:30 PM - 4:00 PM  (Invited)


We examine how the continued increase of single channel data rates combined with spatial multiplexing enabled by multi-core fibers will lead to the aggressive scaling of the aggregate bandwidth of silicon photonics transceivers.

WC4.2  4:00 PM - 4:15 PM


A novel passive integrated optical circuit for mode-multiplexing 6 channels in two-mode fiber has been designed and tested. It can outperform present bulk-optics solutions by its compactness, high coupling efficiency and excellent crosstalk suppression.

WC4.3  4:15 PM - 4:45 PM  (Invited)

Silicon Photonic for Space-Division Multiplexing, C. R. Doerr, Acacia Communications Inc., Maynard, MA, USA

An allure of space-division multiplexing is a very high optical connection density yet it may require significant MIMO processing. Silicon photonics is well suited for handling both.

END OF PROGRAM
Author Index

A
Adhikari, S. MC4.4
Agrawal, G. P. MC3.3, MC3.5
Agrell, E. WB4.4
Ai, Y. TuBB2.3
Al Amin, A. TuC3.1
Alam, S. WC2.1
Albayoglu, K. M. TuA2.3
Andrews, L. C. TuB4.1
Annamalai, M. WC2.3
Arriojo, D. M. TuC4.2
Askarov, D. WC2.2
Avrutin, E. A. WA3.2
Ayhan, T. TuB2.1

B
Bai, J. MA4.2
Bai, N. MC4.3, TuC4.2
Bao, L. MA4.2
Bamowski, T. TuA3.2
Barros, D. J. TuB1.2
Baumann, E. TuB4.3
Bawendi, M. TuBB2.2
Baxley, R. J. TuB1.3
Berkin, G. MA1.2
Bernal, M. TuB3.2
Biesenbach, J. MA4.1, MA4.3
Bigot-Astruc, M. TuC1.1
Blair, R. TuB3.2
Boller, P. WA2.1
Boeldicke, S. WA4.3
Boedov, D. TuC1.1
Borovkov, T. TuB4.4
Botz, D. WA1.1
Brox, O. WA4.1
Buggie, F. TuA4.1
Bull, S. TuA4.1
Burdge, G. TuB4.1

C
Cardellino, T. MA1.2
Carpenter, J. WC3.5, WC3.6
Chan, E. Y. MB3.2
Chan, K. S. MB1.3
Chang, G. MB4.4, WB1.2, WB3.3
Chavez, J. R. TuA4.4
Chen, H. WC4.2
Chen, J. TuB2.3
Chen, R. WC1.1
Chen, X. TuC3.1
Chen, Y. TuBB4.2
Cheng, J. WB4.2, WB4.3
Chi, M. TuA3.1
Chien, H. MB4.4, WB3.3
Chowdhury, M. TuB1.1
Coddington, I. TuB4.3
Collier, C. M. TuB3.4
Connors, M. K. TuA2.2
Correa, R. A. TuC4.2
Credon, K. J. TuA2.2
Crump, P. WA4.1, WA4.3
Cui, K. TuB4.5, WB3.4

D
Dabrowska, E. WA4.2
Dawson, D. MA4.2
De Dobbelaeere, P. M. WC4.1
Delbue, R. MC3.2
Deng, P. MB4.2
Dente, G. C. TuA4.4
Deppe, D. G. WA2.2
Deschenes, J. TuB4.3
DeVito, M. MA4.2
Dhar, A. WC2.1
Diviansky, I. TuA3.3
Doerr, C. R. WC4.3
Dogan, M. WA3.3
Dong, P. TuBB3.1
Dong, R. TuBB2.3
Donnelly, J. P. TuA2.2
Drost, R. J. MB1.3
Dutta, P. S. WB2.3

E
Ekert, H. WA4.3
Ellis, A. D. MC1.1
Elsasser, T. WA3.1
Emami, S. WB1.1
Erbert, G. MA9.1, WA4.1, WA4.3
Essiambre, R. MC3.2, MC3.3, MC3.5, MC4.1, TuC3.2

F
Fan, S. MB4.4, WB1.2, WB3.3
Fan, T. TuA2.1
Feeler, R. TuA1.2
Fendler, D. A. TuA4.3
Ferraro, M. S. MB4.3
Ferreira, F. MC4.4
Feuer, M. D. MC4.2
Fin, J. M. MC4.2
Fishbeyn, M. MC4.2
Foltz, D. WC4.1
Fontaine, N. K. TuC3.2
Fricke, J. TuA4.1
Furlisch, M. MA4.1

G
Gagnaire, M. WB4.1
Garrett, H. MA1.2
Garrod, T. MA1.1
Geske, J. C. MA1.2
Geyer, S. TuBB2.2
Ghassemlooy, Z. TuB2.3
Ghazisaidi, N. MB1.2
Gianardi, D. M. TuA4.4
Gilbert, J. M. WB1.1
Giles, D. WC1.1
Giles, I. WC1.1
Giorgiotta, F. R. TuB4.3
Glebov, L. TuA3.3
Gloeckner, S. WC4.1
Gnauck, A. H. MC3.2
Goetz, P. G. MB4.3
Gomez-Iglesias, A. MA4.1
Gordeyev, S. TuB1.1.1, TuB2.1.2
Grasso, D. M. MA2.3
Greco, J. A. TuB4.2
Griffith, C. TuB3.2
Grönninger, G. MA4.1
Grüner-Nilsen, L. TuC1.3, WC1.2
Guan, N. TuC1.2

H
Haddad, A. WB4.1
Hanik, N. MA4.4
Hanzawa, N. WC3.2
Hashizume, Y. WC3.1
Hasler, K. TuA4.1
Hayashi, T. TuC4.1
He, S. MB4.4
Hein, S. MA4.1
Hempel, M. WA3.1
Hirskorn, O. TuA1.1
Ho, C. MB2.2
Ho, K. TuC3.4, WB1.1
Hoffmann, H. MA2.1
Holzmann, J. F. TuB3.4, WB4.3
Yi, A. WB3.3
Yokoyama, K. WC4.1
Yoshida, H. TuA3.4
Yoshida, Y. WB1.3, WB3.2
Yoshimoto, N. TuBB4.3
Yu, J. MB4.4, WB3.3
Yu, P. L. MB1.3
Yu, S. WC4.1
Yu, Z. TuB1.3
Yuan, X. MB4.2

Z
Zenk, M. TuBB1.2
Zhang, F. TuBB2.3
Zhang, H. TuB4.5, WB3.4
Zhang, L. WB1.2, WB3.3
Zhang, S. TuBB2.3
Zhang, W. MB3.4
Zhang, X. WB3.4
Zhou, G. TuB1.3
Zhou, X. MC4.2, TuC4.2
Zhu, B. MC4.2
Zhu, M. MB4.5, WB1.2, WB3.3
Zolot, A. M. TuB4.3
Zorn, M. TuA1.1
Zucker, E. MA3.2