OSA Foundation

Siegman International School on Lasers

Co-founded by IPG Photonics

HOSTED BY STANFORD UNIVERSITY, STANFORD PHOTONICS RESEARCH CENTER, & GINZTON LABORATORY

OSA Foundation | Siegman International School on Lasers
Co-founded by IPG Photonics

August 2014

Dear Participants,

It is my pleasure to welcome you to the inaugural Siegman International School on Lasers, co-founded by IPG Photonics. Each year, this school will bring together up to 100 of the world's brightest graduate students to learn from academic and industry leaders. The school will provide a valuable opportunity to present and exchange ideas from the most recent and rigorous researchers in the field.

Our thanks go to many people for helping make this conference happen. In particular I'd like to thank IPG Photonics, Stanford University, Stanford Photonics Research Center, Ginzton Laboratory, our steering and program committees, the OSA Stanford Student Chapter and last but not least our donors.

I would also like to recognize our distinguished line-up of speakers:

- Robert L. Byer, Stanford University, USA
- Hui Cao, Yale University, USA
- Milton Chang, Incubic, LLC, USA
- Connie Chang-Hasnain, University of California, Berkeley, USA
- Steven Chu, Stanford University, USA
- Alexander L. Gaeta, Cornell University, USA
- Valentin P. Gapontsev, IPG Photonics, USA
- Hank Gauthier, IPG Board Member, USA
- Stephen E. Harris, Stanford University, USA
- Jim Kafka, Spectra-Physics a Newport Company, USA
- David Richardson, Southampton University, UK
- Bahaa E. A. Saleh, CREOL, USA
- Mark Sobey, Coherent, USA

Thank you for participating in this OSA Foundation program. I hope you will enjoy your week at Stanford, establish valuable contacts, and continue to expand your knowledge of lasers and their applications.

Best wishes,

Eric Van Stryland
2014 Siegman International School on Lasers Program Committee Chair
Professor and Past Dean CREOL, The University of Central Florida, USA

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The OSA Foundation would like to thank its contributors for their support of the Siegman International School on Lasers. Their generosity and vision built a global resource for the next generation of optics and photonics innovators.

Co-Founder

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The OSA Foundation would like to give special thanks to our ***2014 Siegman School Student Aid Fund Supporters*** *who provided travel grants and tuition assistance to students with financial need.*

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The OSA Foundation would like to thank the following volunteers for their support in the successful implementation of the inaugural Siegman International School on Lasers.

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Olav Solgaard, Ginzton Laboratory
Stanford University Student Chapter

OSA Foundation | Siegman International School on Lasers
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3-8 August 2014 Pigott Hall, Building 260, Room 113 Stanford University, USA	HOSTED BY: Ginzton Laboratory Stanford Photonics Research Center Stanford University

Sunday, 3 August 2014

8:00 – 20:00 **Student Housing Check-In and Registration**
Taper Center at Crothers Hall, 615 Escondido Road
Upon check-in students will receive program materials, room key, meal card, campus map, instructions, a resource guide, and gym card

18:00 – 20:30 **Opening Reception**
The Home of Jeannie Siegman, 550 Junipero Serra Blvd., Stanford, CA USA
Shuttles will depart from the dorms and bring students to/from the reception
Service will be available between 17:50 – 18:30 and 20:00 – 21:00

Monday, 4 August 2014

8:00 – 8:55 **Breakfast**
Arrillaga Dining Service Building, 489 Arguello Way
Students will use their meal card to purchase food

9:00 – 9:25 **Welcome and Opening Remarks**
Pigott Hall, 450 Sierra Mall (Building 260, Room 113)
Eric Van Stryland, *CREOL, USA*
Liz Rogan, *OSA CEO*

9:30 – 10:25 **Exploring a Career in Industry**
Valentin Gapontsev, *IPG Photonics, USA*

10:30 – 11:55 **Electromagnetically Induced Transparency and Slow Light**
Stephen E. Harris, *Stanford University, USA*

12:00 – 12:55 **Lunch Break**
Arrillaga Dining Service Building
Students will use their meal card to purchase food

13:00 – 14:25 **50 Years of Lasers with Tony Siegman; colleague, friend and mentor**
Robert L. Byer, *Stanford University, USA*

14:30 – 14:55 **Coffee Break**
Coffee will be available outside of the classroom

15:00 – 16:25 **Chip-Based Nonlinear Photonics**
Alexander L. Gaeta, *Cornell University, USA*

16:30 – 17:55 **Microcavity Lasers**
Hui Cao, *Yale University, USA*

18:00 – 19:30 **Dinner**
Arrillaga Dining Service Building
Students will use their meal card to purchase food

Tuesday, 5 August 2014

8:00 – 8:55 **Breakfast**
Arrillaga Dining Service Building
Students will use their meal card to purchase food

9:00 – 10:25 **Fiber Lasers: From Basic Principles through to Emerging Applications**
David Richardson, *Southampton University, UK*

10:30 – 11:55 **Coffee Break and Poster Presentations**
The Poster Presentations and Coffee Break will take place outside of the classroom

12:00 – 13:25 **The Energy, Climate Change and Sustainability: A necessity that will be the mother of many inventions**
Steven Chu, *Stanford University, USA*

13:30 – 14:10 **Lunch Break**
A boxed lunch will be provided outside the classroom so that students can participate in the OSA Executive Speaker Series

14:15 – 14:55 **OSA Executive Speaker Series**
Milton Chang, *Incubic LLC, USA*
Hank Gauthier, *IPG Photonics, USA*

15:00 – 16:25 **Coherence and Entanglement: Classical and Quantum**
Bahaa E. A. Saleh, *CREOL, USA*

16:30 – 16:55 **Coffee Break**
Coffee will be available outside of the classroom

17:00 – 18:25 **Parametric Down-Conversion Over Fifty Years: From Microwaves to X-rays**
Stephen E. Harris, *Stanford University, USA*

18:30 – 20:00 **Dinner**
Arrillaga Dining Service Building
Students will use their meal card to purchase food

Wednesday, 6 August 2014

8:00 – 8:55 **Breakfast**
Arrillaga Dining Service Building
Students will use their meal card to purchase food

9:00 – 10:25 **Accelerator on a Chip: Recent Progress (>300MeV/m)**
Robert L. Byer, *Stanford University, USA*

10:30 – 11:55 **Random Lasers**
Hui Cao, *Yale University, USA*

12:00 – 13:55 **Lunch Break**
Arrillaga Dining Service Building
Students will use their meal card to purchase food

14:00 – 17:00 **Stanford Lab Tours**

17:00 – 17:55 **Break**

18:00 – 20:00 **BBQ Dinner, Social & Group Photo**
Spilker Engineering Building Terrace, 348 Via Pueblo Mall
Attendees are asked to wear their Siegman School shirts

Thursday, 7 August 2014

8:00 – 8:55 **Breakfast**
Arrillaga Dining Service Building
Students will use their meal card to purchase food

9:00 – 10:25 **Chip-Based Nonlinear Photonics**
Alexander L. Gaeta, *Cornell University, USA*

10:30 – 11:55 **Coffee Break and Poster Presentations**
The Poster Presentations and Coffee Break will take place outside of the classroom

12:00 – 13:25 **Coherence and Entanglement: Classical and Quantum**
Bahaa E. A. Saleh, *CREOL, USA*

13:30 – 14:25 **Lunch Break**
Arrillaga Dining Service Building
Students will use their meal card to purchase food

14:30 – 15:55 **Fiber Lasers: From Basic Principles through to Emerging Applications**
David Richardson, *Southampton University, UK*

16:00 – 16:25 **Coffee Break**
Coffee will be available outside of the classroom

16:30 – 17:55 **Nano-photonics: Progress and Prospects**
Connie Chang-Hasnain, *UC Berkeley, USA*

18:00 – 18:55 **Cutting Edge Careers and Smartphones**
Mark Sobey, *Coherent, USA*

19:00 – 20:30 **Dinner**
Arrillaga Dining Service Building
Students will use their meal card to purchase food

<u>Friday, 8 August 2014</u>

8:00 – 8:55 **Breakfast**
Arrillaga Dining Service Building
Students will use their meal card to purchase food

9:00 – 10:25 **Nano-photonics: Progress and Prospects (Part II)**
Connie Chang-Hasnain, *UC Berkeley, USA*

10:30 – 10:55 **Coffee Break**
Coffee will be available outside of the classroom

11:00 – 11:55 **Writing Research Papers for International Research Journals & Conferences**
Eric Van Stryland, *CREOL, USA*

12:00 – 13:25 **Lunch Break**
Arrillaga Dining Service Building
Students will use their meal card to purchase food

13:30 – 14:25 **Ultrafast Lasers and Ultrafast Science**
Jim Kafka, *Spectra-Physics, USA*

14:30 – 15:25 **The Benefits of the OSA Student Chapter Program**
Stanford University OSA Student Chapter

15:30 – 15:55 **Coffee Break**
Coffee will be available outside of the classroom

16:00 – 16:55 **Q&A Panel with the Siegman International School on Lasers Lecturers**

17:00 – 18:00 **Break**

18:00 – 19:30 **Closing Reception, Dinner and Student Awards Presentations**
Paul Brest Hall, 555 Salvatierra Walk

<u>Saturday, 9 August 2014</u>

8:00 – 9:00 **Breakfast**
Arrillaga Dining Service Building
Students will use their meal card to purchase food

9:00 – 11:00 **Student Housing Check Out**
Tapper Center at Crothers Hall, 615 Escondido Road

OSA Foundation

Siegman International School on Lasers

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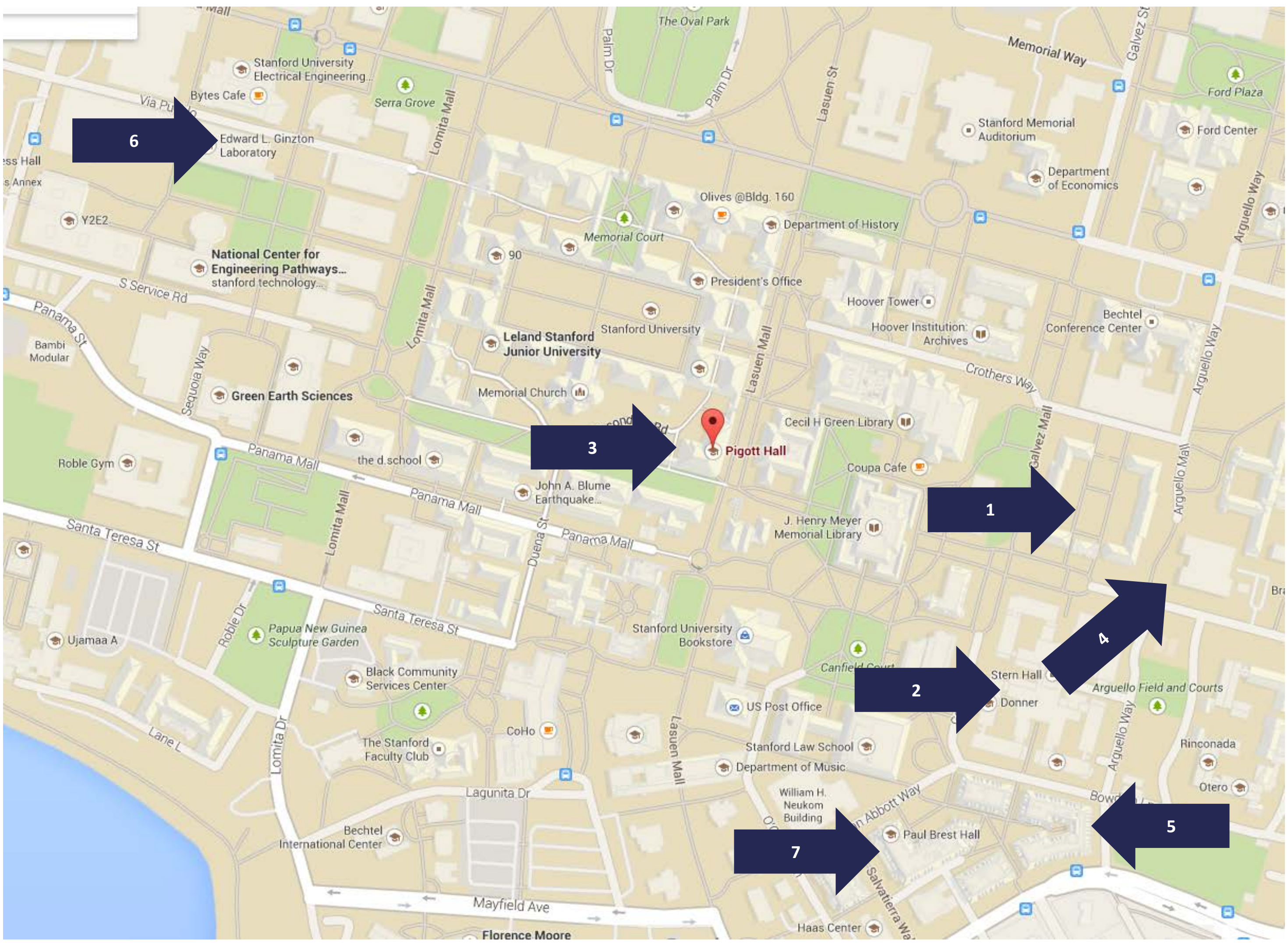
Stanford University Map

1. **Taper Center at Crothers Hall (*615 Escondido Road)*** – Check-in for student housing.
2. **Stern Hall, Serra Building (619 Escondido Road)** – Student Housing.
3. **Pigott Hall, *Building 260, Room 113 (*450 Serra Mall)** – Siegman School Registration and Classroom. All lectures will take place in Pigott Hall. Registration will also take place in Pigott Hall just outside the classroom.
4. **Arrillaga Family Dining (489 Arguello Way)** – School Cafeteria. All meals (unless noted otherwise) will take place in this dining facility.
5. **Munger Hall 4 (554 Salvatierra Walk)** – Faculty Housing. Check-in at front desk in Munger Hall Bld 5.
6. **Spilker Engineering Building (348 Via Pueblo Mall) –** Wednesday evening BBQ Dinner/Social.
7. **Paul Brest Hall (555 Salvatierra Walk) –** Friday evening Closing Dinner.



Robert L. Byer

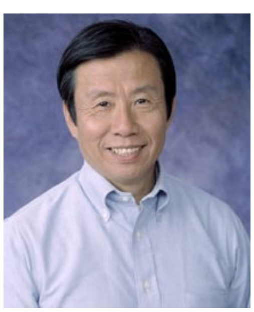
Robert L. Byer has served as President of The American Physical Society, of The Optical Society and of the IEEE LEOS. He has served as Vice Provost and Dean of Research at Stanford. He has been Chair of the Department of Applied Physics, Director of the Edward L. Ginzton Laboratory and Director of the Hansen Experimental Physics Laboratory. He is a founding member of the California Council on Science and Technology and served as Chair from 1995-1999. He was a member of the Air Force Scientific Advisory Board from 2002-2006 and has been a member of the National Ignition Facility since 2000.

Robert L. Byer has conducted research and taught classes in lasers and nonlinear optics at Stanford University since 1969. He has made extraordinary contributions to laser science and technology including the demonstration of the first tunable visible parametric oscillator, the development of the Q-switched unstable resonator Nd:YAG laser, remote sensing using tunable infrared sources and precision spectroscopy using Coherent Anti Stokes Raman Scattering (CARS). Current research includes precision laser measurements in support of the detection of gravitational waves and laser "Accelerator on a chip".

Hui Cao

Hui Cao is a Professor of Applied Physics at Yale University, New Haven, Connecticut. She received her B.S. degree (1990) in Physics from Peking University, and her Ph.D. degree (1997) in Applied Physics from Stanford University. Her doctoral research was in the area of semiconductor microcavity quantum electrodynamics. Prior to joining the Yale faculty in 2008, Professor Cao was on the faculty of the Department of Physics and Astronomy at Northwestern University. Her technical interests and activities are in the areas of complex photonic materials and devices, nanophotonics, and biophotonics. She has co-authored one book and nine book-chapters, and has published more than 180 research papers in the area of random lasers, optical microcavities, photonic crystals, and structural coloration. She is the recipient of the NSF CAREER award, Packard Fellowship, Sloan Fellowship, Guggenheim Fellowship and Maria Goeppert-Mayer Award. She is also a fellow of the American Physical Society and fellow of the Optical Society of America.

Milton Chang



Milton Chang is the author of Toward Entrepreneurship (www.miltonchang.com). He was president of Newport and New Focus, which he took public. And he has incubated more than a dozen company as an angel investor, which resulted in six IPOs and seven acquisitions; none failed.

He is currently a Trustee of the California Institute of Technology, and was a member of the SEC Advisory Committee on Small and Emerging Companies, Visiting Committee on Advanced Technology of the National Institute of Standards and Technology, and the authoring committee of the National Academies' Optics and Photonics: Essential Technologies for Our Nation. He writes a monthly business and management column for the Laser Focus World and spends his time mentoring aspiring entrepreneurs.

Steven Chu

Steven Chu is the William R. Kenan, Jr., Professor of Physics and Molecular & Cellular Physiology at Stanford University. His research spans atomic and polymer physics, biophysics, biology, biomedicine and batteries. He shared the 1997 Nobel Prize in Physics for the laser cooling and trapping of atoms.

From January 2009 until April 2013, Dr. Chu was the 12th U.S. Secretary of Energy and the first scientist to hold a cabinet position since Ben Franklin. During his tenure, he began ARPA-E, the Energy Innovation Hubs, the Clean Energy Ministerial meetings, and was tasked by President Obama to assist BP in stopping the Deepwater Horizon oil leak. Prior to his cabinet post, he was director of the Lawrence Berkeley National Laboratory, Professor of Physics and Molecular and Cell Biology at UC Berkeley, the Theodore and Francis Geballe Professor of Physics and Applied Physics at Stanford University, and head of the Quantum Electronics Research Department at AT&T Bell Laboratories.

Dr. Chu is a member of the National Academy of Sciences, the American Philosophical Society, the American Academy of Arts and Sciences, the Academia Sinica, and is a foreign member of the Royal Society, the Royal Academy of Engineering, the Chinese Academy of Sciences, and the Korean Academy of Sciences and Technology. He has been awarded 24 honorary degrees, published more than 250 scientific papers, and holds 10 patents.

Alexander L. Gaeta

Alex Gaeta received his B.S degree in 1983, M.S. degree in 1984, and his Ph.D. in 1991, all in Optics from the University of Rochester. In 1992 he joined the faculty at the School of Applied and Engineering Physics at Cornell University where he is currently the Samuel B. Eckert Professor of Engineering. He has published more than 190 papers in areas of integrated nonlinear optics, all-optical signal processing, nanophotonics, ultrafast nonlinear optics, and quantum effects in nonlinear optics. He co-founded PicoLuz, Inc. along with Michal Lipson and Alex Cable. He is the founding Editor-in-Chief of Optica. He served as an OSA Director-at-Large from 2008-2010, Chair of the Frontiers in Optics OSA Annual Meeting in 2003, General Chair of the 2007 Quantum Electronics and Laser Science Conference, and Chair of the Nonlinear Optics OSA meeting. He is a Fellow of the Optical Society of America and of the America Physical Society.

Henry E. Gauthier

Henry E. Gauthier has served as a member of IPG's Board since April 2006, it's Presiding Independent Director since 2010 and a member of its Audit Committee since 2006. Mr. Gauthier was President from February 2005 to May 2005, consultant from January 2004 to February 2005 and June 2005 to December 2006, and Chairman of the board of directors from May 2005 to December 2008, of Reliant Technologies, a manufacturer of medical laser systems, which was acquired in December 2008 by Solta Medical.

His service at Coherent, Inc., a manufacturer of photonics products, spanned a total of 34 years. He served as Vice Chairman of the board of directors of Coherent from October 2002 to March 2006; as Chairman of the board of directors from February 1997 to October 2002 and was its President from 1983 to 1996.

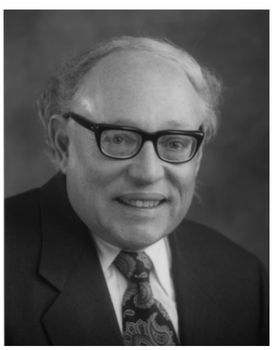
He received the Distinction in Photonics Award in 2002, is a Life Member of the ASLMS and prior member of the LIA and OSA.

Mr. Gauthier attended the United States Coast Guard Academy, San Jose State University, and the Executive Institute of the Stanford University Graduate Business School.

Valentin P. Gapontsev

Valentin P. Gapontsev, Ph.D., founded IPG in 1990 and has been IPG's Chief Executive Officer and Chairman of IPG's Board since its inception. Prior to that time, he served as senior scientist in laser material physics and head of the laboratory at the Soviet Academy of Science's Institute of Radio Engineering and Electronics in Moscow. He has over thirty years of academic research experience in the fields of solid state laser materials, laser spectroscopy and non-radiative energy transfer between rare earth ions and is the author of many scientific publications and several international patents. Dr. Gapontsev holds a Ph.D. in Physics from the Moscow Institute of Physics and Technology. In 2006, he was awarded the Ernst & Young ® Entrepreneur of the Year Award for Industrial Products and Services in New England, and in 2009, he was awarded the Arthur L. Schawlow Award by the Laser Institute of America. Dr. Gapontsev serves as both Chairman and Chief Executive Officer. In 2011, he received the Russian Federation National Award in Science and Technology, and he was also selected as a Fellow of the Optical Society of America. He is the founder of the Company and has successfully led the Company and the Board since the Company was formed.

Stephen E. Harris



Steve Harris received his B.S. degree in electrical engineering from Rensselaer Polytechnic Institute in 1959. After a year at Bell Telephone Laboratories, he attended Stanford University where, with A.E. Siegman as his Ph.D. advisor, he received the M.S. and Ph.D. degrees in electrical engineering in 1961 and 1963. Since 1963 he has been on the faculty of Stanford University where he is now Professor of Electrical Engineering and Applied Physics (Emeritus).

His research work has been in the fields of lasers, quantum electronics, nonlinear optics, and atomic physics. Professor Harris was elected to the National Academy of Engineering in 1977, to the National Academy of Sciences in 1981, and to the American Academy of Arts and Sciences in 1995. In 2013 he was elected as an Honorary Member of the Optical Society of America.

Connie J. Chang-Hasnain

Connie Chang-Hasnain is the Whinnery Distinguished Chair Professor in Electrical Engineering and Computer Sciences, Chair of Nanoscale Science and Engineering Graduate Group, and Associate Dean for Strategic Alliances of College of Engineering, University of California, Berkeley. She received her Ph.D. from the same university in 1987. Prior to joining the Berkeley faculty, Dr. Chang-Hasnain was a member of the technical staff at Bellcore (1987–1992) and Assistant Professor of Electrical Engineering at Stanford University (1992–1995). She is an Honorary Member of A.F. Ioffe Institute, a Chang Jiang Scholar Endowed Chair Professor at Tsinghua University, a Visiting Professor of Peking University and National Chiao Tung University.

Professor Chang-Hasnain has made pioneering contributions to Vertical Cavity Surface Emitting Lasers (VCSELs), tunable micro-electro-mechanical structure (MEMS) VCSELs, III-V nanopillar on silicon and slow light in semiconductors. Recently she invented a new class of ultra-thin optics called high contrast gratings (HCG), with which ultrawide bandwidth reflector, resonator and lens have been demonstrated. She has been honored with the IEEE David Sarnoff Award (2011), the OSA Nick Holonyak Jr. Award (2007), the IEEE LEOS William Streifer Award for Scientific Achievement (2003), and the Microoptics Award from Japan Society of Applied Physics (2009). Additionally, she has been awarded with a National Security Science and Engineering Faculty Fellowship by the US Department of Defense (2008), a Humboldt Research Award (2009), and a Guggenheim Fellowship (2009). She was a member of the USAF Scientific Advisory Board, the IEEE LEOS Board of Governors, OSA Board of Directors, and the Board on Assessment of NIST Programs, National Research Council. She was the Editor-in-Chief of Journal of Lightwave Technology 2007-2012 and Associate Editor of OSA Optica since 2013.

Jim Kafka

Jim Kafka attended the Institute of Optics at the University of Rochester, where he obtained a B.S. in Optics in 1977 and a Ph.D. in Optics in 1983, studying with Conger Gabel and Gerard Mourou. Of his studies, Kafka says, "In retrospect it was a fabulous time to be at the Institute and the Laboratory for Laser Energetics, and the people I met have become lifelong friends and colleagues." In 1983, he started as a Senior Scientist at Spectra-Physics Lasers, where he has held a series of positions with increasing responsibility; he is currently the Senior Director of Advanced Research and Development. He designed several of the company's most significant products, including the Tsunami, the first commercial ultrafast Ti:sapphire laser (1990), and the Millennia X, the first commercial 10 W solid-state green laser (1997). Kafka was recognized as a Spectra-Physics Fellow in 1987 and received the Thermo Electron Corporate Award for Technical Innovation in 2002. He also received the first Newport Corporation Strategic Patent Award in 2007 for his patent of the first diode-pumped double-clad fiber laser. Kafka has over 37 United States patents and multiple foreign equivalents. He has more than 30 publications in refereed journals and has made more than 35 presentations at CLEO, OSA topical meetings, SPIE conferences and at major universities.

Kafka has served the professional community as the Ultrafast Topical Editor for JOSA B (1994-1995), Lasers Technical Group Chair (1995-1997), and on a dozen conference organizing committees. He has served as the CLEO program chair (1999), CLEO general chair (2001) and on the CLEO steering committee (1997–2001) and has served as the Program and General Chair of the highly-regarded Advanced Solid-State Photonics topical meeting (2009-2011). One of his proudest achievements has been serving as a Distinguished Traveling Lecturer for the APS Division of Laser Science from 1999 to the present. Kafka was named an OSA Fellow in 2005.

David Richardson

David J. Richardson joined the Optoelectronics Research Centre (ORC) at Southampton University as a Research Fellow in May 1989 and was awarded a Royal Society University Fellowship in 1991 in recognition of his pioneering work on short pulse fiber lasers. Professor Richardson is now Deputy Director of the ORC with responsibility for fiber and laser related research. His current research interests include amongst others: optical fiber communications, microstructured optical fibers and high-power fiber lasers. He has published more than 1000 conference and journal papers and produced more than 20 patents. Professor Richardson was one of the co-founders of SPI Lasers Ltd., an ORC spin-off venture acquired by the Trumpf Group in 2008. He is a Fellow of the Optical Society of America, the Institute of Engineering and Technology and was made a Fellow of the Royal Academy of Engineering in 2009. He was awarded a Wolfson Research Merit Award by the Royal Society in 2013 for his work on high capacity optical communications.

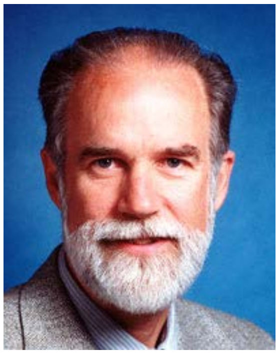
Bahaa Saleh

Bahaa Saleh has been Dean of CREOL, The College of Optics and Photonics at the University of Central Florida, since 2009. He served as Chair of the Department of Electrical and Computer Engineering at Boston University (1994-2008), and as Deputy Director of the NSF Engineering Research Center for Subsurface Sensing and Imaging Systems (2000–2008). He received the Ph.D. degree from the Johns Hopkins University in 1971 and held faculty and research positions at the University of Santa Catarina in Brazil, Kuwait University, Max Planck Institute in Germany, the University of California-Berkeley, the European Molecular Biology Laboratory in Germany, Columbia University, the University of Vienna, and the University of Wisconsin-Madison, where he was Chair of the Department of Electrical and Computer Engineering (1990–1994). Saleh's research spans a broad spectrum of topics in optics and photonics including coherence and statistical optics, nonlinear optics, quantum optics, and image science. He has made significant contributions to each of these areas and his publications include more than 600 journal papers and conference proceedings, as well as 3 books: Photoelectron Statistics, (Springer, 1978); Fundamentals of Photonics (Wiley, 1991, 2nd edition, 2007, with M. C. Teich), and Introduction to Subsurface Imaging (Cambridge, 2011). He served as editor-in-chief of the Journal of the Optical Society of America A (1991–1997) and founding editor of OSA's Advances in Optics and Photonics (2008–2013). Saleh is Fellow of IEEE, OSA, SPIE, and the Guggenheim Foundation. He received OSA's Beller Award for outstanding contributions to optical science and engineering education, SPIE's BACUS award for contribution to photomask technology, the 2006 Kuwait Prize for contributions to optical science, OSA's Distinguished Service Award, and OSA's 2013 C. K. Mees Medal "for lifelong multidisciplinary contributions to statistical optics, quantum optics and image science."

Mark S. Sobey

Dr. Mark Sobey was appointed Executive Vice President and Executive Officer of Coherent in April 2010. He has been Senior Vice President and General Manager for the Specialty Laser Systems (SLS) Business Group, which accounts for approximately 70% of the company revenue, since joining Coherent in July 2007. Prior to joining Coherent Dr. Sobey has spent over 20 years in the Laser and Fiber Optics Telecommunications industry, including roles as Senior Vice President Product Management at Cymer, Senior Vice President World Wide Sales at JDS Uniphase and Vice President General Manager at Spectra-Physics. He received his Ph.D. in Engineering and B.Sc. in Physics both from the University of Strathclyde in Scotland.

Eric W. Van Stryland



Dr. Van Stryland received a Ph.D. in Physics in 1976, from the University of Arizona, Optical Sciences Center, where he worked on optical coherent transients and photon counting statistics. He worked in femtosecond pulse production, multiphoton absorption, and laser induced damage at the Center for Laser Studies, University of Southern California. He joined the physics department at the Univ. of North Texas in l978 helping to form the Center for Applied Quantum Electronics. In 1987 he joined the newly formed CREOL (Center for Research and Education in Optics and Lasers) at the Univ. of Central Florida. NSF and DoD have funded him for the past 30 years. His current research interests are in the characterization of the nonlinear optical properties of materials and their temporal response as well as the applications of these nonlinear materials properties for optical switching, beam control etc.

Dr. Van Stryland developed the Z-scan technique and established the methodology for applying Kramers-Kronig relations to ultrafast nonlinearities and developed the field of cascaded second-order effects. The JQE publication on Z-scan has been noted as the most highly cited paper in the journal's 30 year history by a factor of 2.

He is a fellow of the Optical Society of America (OSA), IEEE, SPIE and APS, a past member of the OSA and LIA Boards of Directors, former co-chair of the OSA Science and Engineering Council. He also served as a topical editor for Optics Letters. He was elected President of the OSA for 2006. He graduated 31 Ph.D.'s and published ~300 papers and is on the ISI 'highly cited' list. In 2003 he was awarded the highest honor UCF bestows, the Pegasus Award (earlier he was co-recipient of UNT's highest award). He was Director of the School of Optics/CREOL from 1999 to 2004. With the elevation of the School to a College, he became its first Dean. In addition, Governor Jeb Bush established the Florida Photonics Center of Excellence (FPCE) in 2003 and he was the Director of that Center along with CREOL, both centers within the College. In a second round of centers of excellence, the College established the Townes Laser Institute named after the inventor of the maser and laser, Charles Hard Townes. In January, 2009 he retired as Dean but continues as a faculty member in the College, and he received UCF's Researcher of the Year Award. He became a Trustee Chair in 2012, and was awarded the R.W. Wood Prize of the OSA in 2012.

3-8 August 2014 Pigott Hall, Building 260, Room 113 Stanford University, USA	HOSTED BY: Ginzton Laboratory Stanford Photonics Research Center Stanford University

Monday, 4 August 2014

10:30 **Electromagnetically Induced Transparency and Slow Light**
Stephen E. Harris, *Stanford University, USA*

Describe the fundamentals and application of EIT and slow light. Topics to be discussed include: Fano Interference and lasing without inversion, basics of EIT, slow and stopped Light, nonlinear optics with EIT, and the use of EIT for the modulation and control of single photons.

13:00 **50 Years of Lasers with Tony Siegman; colleague, friend and mentor**
Robert L. Byer, *Stanford University, USA*

In the fifty years since the demonstration of the laser, coherent light has changed the way we work, communicate and play. The generation and control of light is critical for meeting important challenges of the 21stcentury from fundamental science to the generation of energy.

A look back at the early days of the laser will be contrasted to the recent breakthroughs in solid state lasers and the applications to fundamental science of gravitational wave detection, remote sensing, and laser induced fusion for energy production.

15:00 **Chip-Based Nonlinear Photonics**
Alexander L. Gaeta, *Cornell University, USA*

Since the birth of nonlinear optics, researchers have continually focused on developing efficient nonlinear optical devices that require low optical powers. Silicon nanophotonics has emerged as a highly promising platform for such devices and for enabling massively parallel, integrated optical and electronic devices on a single chip. I will discuss the key features for nonlinear photonics in Silicon including the strong light confinement that enables both a high effective nonlinearity and tuning of the dispersion, which is essential for phase matching of parametric nonlinear optical processes such as four-wave-mixing. I will also describe a wide range of nonlinear optical devices using modest powers < 100 mW for ultrahigh bandwidth all-optical processing, chip-based all-optical clocks, and the generation of very high repetition rate femtosecond pulse sources.

16:30 **Microcavity Lasers**

Hui Cao, *Yale University, USA*

A microlaser is an essential component of integrated photonic circuit. The main challenge for making a microlaser is the strong confinement of light on the micron-scale. Over the past few decades, various types of microcavities have been designed and fabricated to provide efficient confinement of light. I will review the development of microcavity lasers, and introduce the different mechanisms that have been utilized for optical confinement. Finally I will briefly discuss the applications of microlasers.

Tuesday, 5 August 2014

9:00 **Fiber Lasers: From Basic Principles through to Emerging Applications**

David Richardson, *Southampton University, UK*

The rise in output power from rare-earth-doped fiber sources over the past decade, via the use of cladding-pumped fiber architectures, has been dramatic, leading to a range of fiber-based devices with outstanding performance in terms of output power, beam quality, overall efficiency, and flexibility with regard to operating wavelength and radiation format. This success in the high-power arena is largely due to the fiber's geometry, which provides considerable resilience to the effects of heat generation in the core, and facilitates efficient conversion from relatively low-brightness diode pump radiation to high-brightness laser output. As a result fiber lasers are displacing existing laser technology in a increasing range of application spaces, as well as opening new laser applications besides.

In my lectures I will review the basic operating principles and current state of the art in terms of continuous-wave and pulsed fiber laser performance. I will focus primarily of ytterbium-doped fiber lasers, the current fiber gain medium of choice, and by far the most developed in terms of high-power performance. I will then discuss the current status and challenges of extending the fiber technology to other rare-earth dopants and associated wavelengths of operation. Throughout I will identify the key factors currently limiting fiber laser performance in different operating regimes— such as optical nonlinearity, thermal management and damage. Finally, I will speculate as to the likely developments in pump laser technology, fiber design and fabrication, architectural approaches, and functionality that lie ahead in the coming decade and the implications they have on fiber laser performance and industrial/scientific adoption.

12:00 **The Energy, Climate Change and Sustainability: a necessity that will be the mother of many inventions**

Steven Chu, *Stanford University, USA*

Science and technology such as the industrial and agricultural revolutions have profoundly transformed the world. I will discuss the challenges, opportunities and necessity to achieve a sustainable future.

15:00 **Coherence and Entanglement: Classical and Quantum**
Bahaa E. A. Saleh, *CREOL, USA*

The theme of this topic will be the distinction between classical and quantum properties of light, particularly coherence and entanglement. A brief overview of the theory of optical coherence will use, as examples: laser light, thermal light, squeezed-state light, and light in a two-photon state. This will be followed by an introduction to classical and quantum interferometry, using the Hanbury Brown-Twiss interferometer and the Hong-Ou-Mandel interferometer as examples. A definition of quantum entanglement will then be introduced. The mathematical similarity between the propagation of partially coherent light and the propagation of entangled two-photon light through the same optical system will be highlighted. Classical and quantum ghost imaging will then be contrasted. Finally, the classical equivalent of quantum entanglement will be established by comparing two quaternary optical beams: 1) classical light in two spatial modes, each with arbitrary polarization; and 2) light in a quantum state with two photons, each in an arbitrary state of polarization. Polarization and spatial mode coupling in the classical case will be shown to be mathematically analogous to entanglement in the quantum case.

17:00 **Parametric Down-Conversion Over Fifty Years: From Microwaves to X-rays**
Stephen E. Harris, *Stanford University, USA*

First studied as a noise source for microwave parametric amplifiers, parametric down conversion (fluorescence) has become a primary source for generating entangled photons. The lecture will describe the early observation of parametric fluorescence, the opening of the era of Bell's inequalities, some properties of down converted photons such as non-local dispersion and nonlocal modulation, the use of spread spectrum technology to hide single photons and, if time permits, the basics of parametric down conversion with hard x-rays.

<u>Wednesday, 6 August 2014</u>

9:00 **Accelerator on a Chip: Recent Progress (>300MeV/m)**
Robert L. Byer, *Stanford University, USA*

Laser acceleration in dielectric structures offers a new approach to the next generation of accelerators. The recently demonstrated gradient of 300MeV/m is a first step toward an accelerator system with all essential elements designed to be fabricated on a chip using modern lithographic methods. Progress on beam position and future possibilities of X-ray generation with a dielectric undulator will be discussed

10:30 **Random Lasers**
Hui Cao, *Yale University, USA*

One essential component of a laser is the cavity, which provides optical confinement and feedback for lasing oscillation. In a highly disordered medium, light experiences multiple scattering and undergoes a random walk. Surprisingly, lasing can occur in a random system without well-defined cavities. Such lasers are called random lasers, whose development was dated back to the early years of laser development. Over the past two decades there have been extensive experimental and theoretical studies on random lasers. I will review the history of random laser development and introduce the lasing mechanism. I will also discuss the applications that will benefit from the unique characteristic of random lasers.

Thursday, 7 August 2014

9:00 **Chip-Based Nonlinear Photonics**

Alexander L. Gaeta, *Cornell University, USA*

Since the birth of nonlinear optics, researchers have continually focused on developing efficient nonlinear optical devices that require low optical powers. Silicon nanophotonics has emerged as a highly promising platform for such devices and for enabling massively parallel, integrated optical and electronic devices on a single chip. I will discuss the key features for nonlinear photonics in Silicon including the strong light confinement that enables both a high effective nonlinearity and tuning of the dispersion, which is essential for phase matching of parametric nonlinear optical processes such as four-wave-mixing. I will also describe a wide range of nonlinear optical devices using modest powers < 100 mW for ultrahigh bandwidth all-optical processing, chip-based all-optical clocks, and the generation of very high repetition rate femtosecond pulse sources.

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14:30 **Fiber Lasers: From Basic Principles through to Emerging Applications**

David Richardson, *Southampton University, UK*

The rise in output power from rare-earth-doped fiber sources over the past decade, via the use of cladding-pumped fiber architectures, has been dramatic, leading to a range of fiber-based devices with outstanding performance in terms of output power, beam quality, overall efficiency, and flexibility with regard to operating wavelength and radiation format. This success in the high-power arena is largely due to the fiber's geometry, which provides considerable resilience to the effects of heat generation in the core, and facilitates efficient conversion from relatively low-brightness diode pump radiation to high-brightness laser output. As a result fiber lasers are displacing existing laser technology in an increasing range of application spaces, as well as opening new laser applications besides.

In my lectures I will review the basic operating principles and current state of the art in terms of continuous-wave and pulsed fiber laser performance. I will focus primarily of ytterbium-doped fiber lasers, the current fiber gain medium of choice, and by far the most developed in terms of high-power performance. I will then discuss the current status and challenges of extending the fiber technology to other rare-earth dopants and associated wavelengths of operation. Throughout I will identify the key factors currently limiting fiber laser performance in different operating regimes—I such as optical nonlinearity, thermal management and damage. Finally, I will speculate as to the likely developments in pump laser technology, fiber design and fabrication, architectural approaches, and functionality that lie ahead in the coming decade and the implications they have on fiber laser performance and industrial/scientific adoption.

16:30 **Nano-photonics: Progress and Prospects**

Connie Chang-Hasnain, *UC Berkeley, USA*

The invention and development of vertical-cavity surface-emitting laser (VCSEL) marked the beginning of micro-photonics. With a factor of ~100 reduction in active region volume, VCSEL significantly reduced energy consumption which made possible for high port count, high aggregate bandwidth optical interconnects. In this talk, I will review briefly the recent advances of VCSELs. In addition, I will discuss a new class of planar optics using near-wavelength period gratings with a large refractive index contrast. This seemingly simple structure lends itself to extraordinary properties, which can be designed top-down based for integrated optics on a silicon substrate. In particular, the near-wavelength gratings with large index contrast with its surrounding materials are referred as high-contrast gratings (HCG). The extraordinary features include an ultra-broadband ($\Delta\lambda/\lambda$>30%) high reflectivity (>99%) reflector for surface-normal incident light. Another feature is a high quality-factor resonance (Q>1E7) with surface-normal emission. We incorporated HCG as a replacement of conventional distributed Bragg reflectors (DBR) in vertical cavity surface emitting lasers (VCSELs) over a wide wavelength range from 850-nm to 1550-nm. We also demonstrated high-Q cavity with surface-normal input/output beam using a single HCG layer. This resonator is formed without a Fabry-Perot cavity! In this talk, I will review HCG tunable VCSELs and other devices that can be easily designed using simple guidelines for chip-scale optics.

18:00 **Cutting Edge Careers and Smartphones**
Mark Sobey, *Coherent, USA*

There are over twenty laser based manufacturing steps in the production of today's high end smartphones and tablets, not only enabling the latest in mobile devices but also enabling in the order of twenty percent of all laser related employment. The presentation will use examples of specific laser processes used in the manufacture of the flex circuits, semiconductor chips, case engraving and HD displays together with career choices in terms of job function, employer type and personal traits that it takes to invent, productize and support such an industry.

Friday, 8 August 2014

9:00 **Nano-photonics: Progress and Prospects (Part II)**
Connie Chang-Hasnain, *UC Berkeley, USA*

I will discuss recent advances on nanophotonic devices based on III-V compound directly grown on silicon at CMOS-compatible temperatures. With the advances in nano-scale fabrication technologies, there is great interest to "tailor" materials' physical properties when their sizes are made small enough for manipulation of absorption, emission, transmission, refraction, transport, etc. in innovative ways that could have profound implications for many applications. In addition, monolithic integration of devices based upon dissimilar materials is believed to be of grave importance to achieve functionalities greater than the sum of those of the parts. In particular, it is critical to integrate active optical components based on III-V compound, e.g. lasers and semiconductor optical amplifiers, with CMOS electronic circuits and silicon-based photonics. Such integration can alleviate power, speed and bandwidth bottlenecks in data transport as microprocessor performance continues to scale. It is poised to enable new capabilities in many fields including imaging, sensing, medicine and spectroscopy.

11:00 **Writing Research Papers for International Research Journals & Conferences**
Eric Van Stryland, *CREOL, USA*

This workshop will address all you ever wanted to know about publications but were afraid to ask.

13:30 **Ultrafast Lasers and Ultrafast Science**
Jim Kafka, *Spectra-Physics, USA*

Ultrafast lasers have been used extensively in basic research. For example, these sources were instrumental in the work of the Nobel Prize winner in Chemistry for 1999. Ultrafast sources have found increasing use in commercial applications as well. I will review the basic components of an ultrafast laser system and describe how ultrafast pulses are generated. I will then present several commercial applications for ultrafast pulses including micro-machining and confocal microscopy.

Siegman International School on Lasers Poster Sessions
Tuesday, 5 August 2014 and Thursday, 7 August 2014

Tuesday, 5 August 2014
Poster Session

T1
Power Maximization of GaInNAs-GaNAs Quantum Well Laser Diode for Raman Amplifier Pumping, *Mohd Faiez Ali*. Theoretical attempts in devising Ga1-xInxNyAs1-y quantum well broad area laser diodes capable in delivering high optical power output are presented. For each device (A, B and C) the concentration of nitrogen in the Ga1-xInxNyAs1-y quantum well is varied from 0.007 until 0.021 with step of 0.002. Device A and B compromise of conventional waveguide structure while device C utilizes large optical cavity structure and all devices compromises GaNAs barriers to enhance the optical properties of the devices. It was found that by increasing concentration in the Ga1-xInxNyAs1-y quantum well will result in elongation of lasing wavelength however the downside of this effect is the degradation of the optical confinement factor which greatly affect the power output of the laser diodes. When the nitrogen concentration is increased with step of 0.002, the wavelength elongates averagely as much as 55.21 nm, 50.71 nm and 8.63 nm for device A, B, and C respectively. The optical confinement factor then degrade averagely as much as 0.073 %, 0.068%, 0.003 % for device A, B, and C respectively. Resulting from that the power output similarly degrades averagely as much as 181.71 mW, 141 mW and 17.29 mW for device A, B, C respectively. The power of output of these devices are greatly dependent on the optical confinement ratio as it reflects the value of the bowing constant used to determine the bandgap of Ga1-xInxNyAs1-y quantum well. Lower bowing constant has been associated with less optical degradation factor in this study and the use of large optical cavity also have been found to greatly endure higher power output from the device. Proper relationship between nitrogen concentration, optical confinement factor, and bowing parameter has been determined to maximize the power output of these devices. the simulated results also suggest that these devices can be further optimized to be used as Raman Amplifier pump sources.

T2
Optical vortices beyond cylindrical geometries: design and characterization, *Anderson Amaral.* Optical Vortices (OV) are being applied in many areas of optics, ranging from communications to manipulation of particles. Some of the remarkable properties of OV are that they carry Topological Charges (TC), which represent the strength of the intrinsic phase singularity, and the wavefront carries orbital angular momentum (OAM), what allows OV-based optical tweezers to manipulate particles in the plane transverse to the light propagation. Despite the broad range of uses for OV, most of the works consider only beams with cylindrical symmetry. However, it is not hard to envision applications in which the beam profile plays a major role and the cylindrical symmetry probably is not desired. For example, in optical tweezers, one may be interested in manipulating the optical forces to transport a particle along a non-circular trajectory. In this work we describe how non-cylindric OV can be produced and how their most relevant properties can be experimentally measured. To adjust the geometry of OV, we considered that since TC are phase singularities, the light intensity on TC must be zero. By distributing the TC over a given geometry one may obtain OV cores with shapes similar to the original TC distribution, or structured OV (SOV). Using this approach, we obtained OV with cores shaped as a line, a corner and a triangle. Since, to our knowledge, the experimental characterization of OAM and TC in SOV cannot be properly performed with previously reported approaches, we developed a theoretical description based on the definitions of OAM and TC. These concepts were applied to the SOV, and their TC and OAM were experimentally determined. It was observed that the total TC of SOV is precisely given by the designed values. On the other hand the OAM, which depends sensitively on the intensity profile, is always reduced in comparison with the cylindrical OV having the same TC. SOV can be used to extend the applications of OV, and may play an important role in applications as optical tweezers/traps and in the excitation of engineered surface plasmon modes.

T3
Ultrashort pulsed laser direct writing of micro/nano scaffolds for tissue engineering, *Stella Aslanoglou*. S. Aslanoglou1,2, D. Angelaki1,2, Ch. Yiannakou1,2, V. Skoulas1, E. Kavatzikidou1, Ch. Simitzi1,3, A. Ranella1, I. Athanassakis3, E. Stratakis1,4, C. Fotakis1,2 1. Institute of Electronic Structure and Laser, Foundation for Research & Technology Hellas, (IESL-FORTH), P.O. Box 1527, Heraklion 711 10, Greece. 2. Department of Physics, University of Crete, Heraklion 714 09, Greece. 3. Department of Biology, University of Crete, Heraklion 714 09, Greece 4. Department of Materials Science and Technology, University of Crete, Heraklion 714 09, GreeceMaterial micro-nanoprocessing by ultra-short pulsed lasers allow patterning via non-linear

absorption processes, providing excellent control over the regularity and uniformity of micron and submicron features [E. Stratakis, 2012]. We have recently shown [V. Zorba et al., 2006] that femtosecond laser irradiation of crystalline Si in the presence of a reactive gas leads to the formation of arrays of high-aspect ratio microcones (MCs) onto its surface. This method exploits a number of phenomena taking place under the action of intense pulsed laser, in order to induce morphological, structural and compositional modifications. The resulting structures, apart from their unique (conical) morphology, also exhibit improved optical, electronic and wetting properties. Proper tuning of the laser parameters, including laser fluence, pulse number, polarization of the laser field and the irradiation environment (vacuum, reactive gas or liquid), can lead to different morphologies of the fabricated scaffolds. Research over the last decade has shown that biomaterial architecture can drive cellular response via physical and chemical extracellular signals, including topographical and chemical cues at the micro-and nano-scales, mechanical properties of the substrate and adhesion ligands. In this respect, micro-nanoprocessing by ultra-short pulsed lasers constitutes a simple way for fabricating biomimetic cell culture scaffolds for tissue engineering applications [E. Stratakis, 2012]. Accordingly, cell response on laser-fabricated microconical silicon substrates has been initially investigated [A. Ranella et al., 2010]. It was found that controlling surface roughness and wettablity of the micropatterned Si substrates, fibroblast cell adhesion could be readily controlled. Furthermore, the response of cells with nerve cell phenotype, cultured on the substrates was studied. Results on the culture of PC12 cells showed that the morphology of microconical surfaces alone can be used for directional cytoskeletal rearrangement and subsequent differentiation into a neuronal phenotype [Ch. Simitzi et al., 2013]. [1] Stratakis E. 2012, Nanomaterials by ultrafast laser processing of surfaces, Sci Adv Mater, 4:407–31. [2] Ranella A, Barberoglou M, Bakogianni S, Fotakis C, Stratakis E. 2010, Tuning Cell Adhesion by controlling the roughness and wettability of 3D micro/nano silicon structures [3] Zorba V, Persano L, Pisignano D, Athanassiou A, Stratakis E, et al. 2006, Making silicon hydrophobic: wettability control by two-lengthscale simultaneous patterning with femtosecond laser irradiation, Nanotechnology 17:3234. [4] Ch. Simitzi, E. Stratakis, C. Fotakis, I. Athanassakis, A. Ranella. 2013, Microconical silicon structures influence NGF-induced PC12 cell morphology, J. Tissue Engineering and Regen. Medicine (DOI: 10.1002/term.1853).

T4

Evaluation of Burst-mode Operation of a RSOA-based Self-seeded Transmitter for WDM-PON solutions, *Marco Brunero*. We experimentally evaluate burst-mode operation of an RSOA-based self-seeded transmitter at 2.5 Gb/s by recognizing, during the cavity build-up, different evolution of the optical power, which reaches steady-state faster than the spectrum. BER curves explore both initial and full-regime roundtrips.

T5

Theoretical and experimental investigation of a rapidly frequency-swept external cavity laser diode, *Thomas Butler.* The AXSUN laser is a frequency swept source laser combining a semiconductor gain element with a back-reflecting, micro-electromechanical (MEMS), fast tunable Fabry-Pérot filter modulated at high speeds (linear sweep rates of ~2 GHz/ns are possible). This frequency swept laser is designed to be used in Fourier domain Optical Coherence Tomography (OCT) applications and is an alternative to other swept source configurations such as swept filter ring lasers and Fourier Domain Mode Locked lasers (FDMLs). Experimental measurements of the laser's phase via a novel interferometric technique enable a recreation of the instantaneous frequency and thus the total electric field during the various regions of the sweep period. The dynamics of the laser output are examined and compared to theoretical predictions based on a delay differential equation model.

T6

Growth Pattern of Yeast Cells Studied under Line Optical Tweezers, *Sookpichaya Charrunchon*. Cell growth and division has been of scientists' interest for over generations. Several mathematical models have been reported derived from conventional method of cell culture. Here we applied optical tweezers to guide cell division directionally. The patterns of Saccharonmyces Bayanus yeast growth was studied under 1064 nm line optical tweezers generated by time-shared multiple optical traps. Yeast growth was found following the path of the generated laser patterns in linear shape as a result of localized heating effect due to absorption at the focal point. The area of grown yeast cells as a function of time was measure through image processing. Mathematical model for the growth rate under line optical trap has been determined and discussed.

T7

Characterisation of Vibrating Nanostructures with Periodic Impact Excitation, *Theo Chen Sverre*. The Vertical-External-Cavity Surface-Emitting Laser (VECSEL) is a compact semiconductor laser source. When passively mode-locked the repetition rate of the laser can be continuously tuned: sub-500-fs pulses with repetition frequencies between 2.78 and 5 GHz have been demonstrated. These repetition rates are ideal for resonant-excitation of vibrational-modes in nanoscale structures, for example Photonic Crystal Fibre. I present my work and results so far.

T8

Preparation of silicon nanoparticles by laser ablation in NaCl solution, *Pattarin Chewchinda*. Owing to its abundance, cheapness, and unique properties, silicon material usages in electronic, biological, and other diverse potential applications have been widely expanded. Apart from bulk, silicon nanoparticles possess size-dependent properties meaning that their size can be tuned in order to meet the requirement for each application. In addition, multiple exciton generation

(MEG) was proved to occur in silicon nanoparticles, which is possible for an improvement of conversion efficiency of photovoltaic cell. Up until now, the synthesis of silicon nanoparticles can be realized by several techniques including electrochemical etching, microemulsion, or laser pyrolysis. However, these methods either require complicated experimental setup or result in impure product. Laser ablation in liquid is one of the promising technique, which can overcome these limitations. In this work, silicon nanoparticles were prepared by laser ablation in NaCl solution and the results were compared with those obtained from laser ablation in de-ionized water. From TEM images, well-dispersed silicon nanoparticles with spherical shape were synthesized by laser ablation in NaCl solution. The particle size was found to be less than 10 nm in diameter. On the contrary, for the sample prepared by laser ablation in de-ionized water, large amorphous network was observed along with spherical particle in micron range. This large particle was covered with amorphous shell, which was possibly resulted from surface oxidation of silicon. Zeta potential was found to be negative for the sample prepared in NaCl solution, while found to be zero for the sample prepared in de-ionized water. The negative potential indicates that charge stabilization occurred. Thus, nearby particles repelled each other and led to particle dispersion in NaCl solution. From Raman spectra, peak shift from bulk crystalline silicon was detected in the sample prepared in NaCl solution. This result confirms the existence of small crystalline silicon. For the sample prepared in de-ionized water, crystalline silicon peak was detected along with broad amorphous peak. These results suggest that NaCl solution possibly plays a role in particle crytallinity.

T9

Characterization and application of SLM-LC to femtosecond pulse shaping, *Jesus Delgado Aguillon*. Pulse shaping is a recent experimental field, and has much application in many research fields, for example in quantum control, nonlinear microscopy, and micro-structuring field. In the present work, we characterized the curve response of an amplitude-spatial light modulator, and applied to shape the spectral amplitude of femtosecond pulses in a single step, without an iterative algorithm. Additionally, we also present a single step method to shape the intensity profile by two methods, using an influence matrix and generalized retardance function in to a pulse shaper based on a 4-f arrangement with a 0.29 nm of resolution. Experimental results are presented for both methods.

T10

Silver nanoparticles based ultracompact plasmonic devices, *Venus Dillu*. Plasmonics has paved the way for realizing nanoscale optical devices by allowing flow of electromagnetic energy below the diffraction limit of light. The properties of surface plasmons can be tailored by altering the shape,size of metal nanoparticles, leading to miniaturization of photonic circuits with length scales much smaller than those currently achieved. Plasmonic devices offer improved data storage, light generation, microscopy, sensing having applications in high optical transmission, switching, resonant light scattering, bio-chemical sensors etc. Metallic nanoparticles result in localized surface plasmon resonance (LSPR) which in turn causes enhanced field at the interfaces and periodic arrangement of these metal nanostructures offers surface plasmon polariton band gap (SPPBG). These two effects are mingled in the proposed basis geometry. Silver (Ag) nanoparticles are used to devise ultracompact plasmonic devices for integrated circuitry, as it has low interband losses. Ag nanorods are perpendicularly embedded into silicon-on-insulator platform, forming the fortified core offering strong confinement to the propagating plasmon modes. Straight waveguide, bend structure, y-splitter formed in the basis geometry present plasmons routing through these nanoscale devices. Also, SPPBG-enable plasmonic Mach-Zehnder interferometer is proposed for refractive index sensing for classifying different cancer cells. Enhanced Fano resonance in silver ellipsoidal plasmonic crystal cavity reveals the scattering behaviour of the metal nanoparticles with applications in switching, lasing etc. and can be an important component for SPASERS and quantum plasmonics.

T11

WDM-TDM NG-PON Power Budget Extension by Utilizing SOAs, *Ali Emsia*. We describe a new reach extension scheme that at the same time allows increasing the number of subscribers in the network. The amplification technique is based on a bidirectional semiconductor optical amplifier (SOA). Differential phase-shift keying (DPSK) signals are investigated. Hybrid wavelength-division multiplexing/time-division multiplexing (WDM/TDM) downstream transmission up to 120-Gb/s are experimentally demonstrated. The access budget of 33.4 dB is achieved at 10 Gb/s on every WDM channel in case of DPSK enabling a splitting ratio of 1:512 per wavelength.

T12

Injection locking of a hybrid diode-glass waveguide laser, Y*ouwen Fan*. We describe a novel type of laser that combines an active material in the form of a laser diode with an ultra-low-loss passive Si3N4/SiO2 waveguide circuit containing microring resonators as an optical feedback element. With an InP diode as gain medium we achieved a record narrow linewidth of 24 kHz with only about 5 mm in size. To prepare a theoretical modeling we characterized various laser properties, such as internal losses via injection locking, and the wavelength tuning via thermo-optic effect (46 nm tuning range).

T13

Impact of chirp on electron acceleration by ultrashort radially polarized laser pulses, *Pascal Hogan-Lamarre*. Laser-driven electron acceleration has motivated more and more work over the past years and some of the proposed methods showed unique and very promising properties. In this context, some research groups have investigated the use of chirped electromagnetic field in different states of polarization. Interest in the chirp comes from the break of symmetry it introduces in the laser field, thus affecting the interaction with the particles and the potential net energy gain. Even though electron acceleration by chirped radially polarized laser field has already been studied, we revisit it by exploiting new tools and considering the specificities of our acceleration scheme: we explore the use of ultrashort and strongly focused chirped radially polarized pulses to accelerate electrons in vacuum. In order to do so, we adapt exact closed-form solutions to Maxwell's equations developed by our group to take the chirp into account. Using a Poisson-like spectrum, we perform test-particle simulations keeping electromagnetic energy constant and changing the phase of the spectral components for each case. In opposition to what has been observed in most of the other configurations, results show that chirp leads to lower energy gain in the proposed acceleration scheme.

T14

Adaptive Wavefront Correction in Two-photon Microscopy Using Coherence-gated Wavefront Sensing, *Yong Hu*. Two-photon microscopy is a fluorescence imaging technique that excels imaging of living tissue, especially within intact tissues such as brain slices, embryos, and even whole organs. As an alternative to confocal microscopy which produces photobleaching and phototoxicity throughout the specimen, two-photon microscopy has features: 3D imaging; Subcellular resolution; Hundreds micrometer penetration depth; Low phototoxicity; Low photodamage; Low photobleaching; High signal detection efficiency. The problem is that the image quality of a two-photon microscope is degraded by wavefront aberrations induced by the optical components and the specimen. To restore a diffraction-limited focus point, we detect the wavefront using adaptive optics based on coherence-gated wavefront sensing and control the wavefront by a deformable mirror.

T15

Coherence-gated Wave-front Sensing in Two-photon Microscopy with Adaptive Wave-front Correction, *Yong Hu*. Two-photon microscopy is a fluorescence 3D imaging technique that excels imaging of living tissue, especially within intact tissues such as brain slices, embryos, and even whole organs. As an alternative to confocal microscopy which produces photobleaching and phototoxicity throughout the specimen, two-photon microscopy has features: subcellular resolution, hundreds microns penetration depth, low phototoxicity, low photodamage, low photobleaching and high signal detection efficiency. There is no doubt that the imaging quality of the two-photon microscope is degraded by the wave-front aberrations induced by the optical components and the specimen. These aberrations reduce the penetration depth and loss the spatial resolution. As a strategy of adaptive optics used to sense the wave-front aberrations, coherence-gated wave-front sensing method is able to select only the light from the focal plane and reject the reflected light from the region out of the focal plane. Linking into BBSRC (Biotechnology & Biological Sciences Research Council) theme of tissue engineering and cell behaviour, our instrument will provide for the first time a multimodal imaging platform capable of operating not just with subcellular resolution and aberration correction but also with relevant context added to the highest resolution fluorescence images. In combination with algorithms, thus a platform will immediately enable biologists to investigate organelle function and 3D organisation on a dedicated instrument.

T16

Propagation Characteristics Control by Variation of PCF Structural Parameters, *James Jena*. A photonic crystal slab was designed in COMSOL Multiphysics using gallium arsenide (GaAs) pillars placed equidistant from each other in air. A defect was created by removing some GaAs pillars across the crystal slab geometry to form a 90 degree bend through the structure. Structural parameters; the pillar diameter and inter-pillar spacing were separately varied and waves were propagated through the created defect with different permissible wavelengths, within and determined by the photonic crystal's band gap. It was observed for the air filling fraction factor at constant pitch that, when the ratio of the air hole diameter to the pitch is less than 0.63 increasing the air hole requires corresponding increase in the wavelength propagated within the waveguide with minimum loss. Varying both air hole diameter and pitch, increased the air filling fraction resulting in a photonic bandgap of lower frequency range. When the ratio was less than 0.63 the waveguides exhibited slightly increased confinement and bend loss. The diameter and pitch affected the core resonance resulting in selected wavelength bands whose value coincides with the photonic bandgap, being propagated through the created defect in the waveguide.

T17

Linear and Nonlinear Optical Properties of Single GaN/AlN Quantum Dots under Electromechanical Effects, *Ali Khaledi-Nasab*. We have analyzed the linear and nonlinear optical properties of AlN/GaN quantum dots (QD) under the influence of electromechanical effects. The analysis has been based on the two-band strained Hamiltonian in cylindrical coordinates. The influence of piezo-electromechanical effects on linear and nonlinear optical properties of wurtzite AlN/GaN QDs has been studied in detail. The strain dependent two-band Hamiltonian in effective mass approximation has been solved numerically for wurtzite AlN/GaN QDs by using the Finite Element Method (FEM). First, the wave functions for three lowest levels, obtained numerically, have been employed to calculate the dipole moment matrix elements. Then, the density matrix approach has been applied to calculate the linear susceptibility of the system. The real and imaginary parts of susceptibility correspond to optical absorption and relative refractive index change, respectively. Finally, the feasibility of controlling the linear and nonlinear relative refractive index change and absorption has been studied under the effect of externally applied electric field along z-direction.

T18

Femtosecond Yb:KGW oscillators for high-speed high-throughput nonlinear microscopy, *Lukas Kontenis*. Nonlinear microscopy explores structure and order on the micrometer level through various multiphoton, harmonic generation and four-wave mixing processes. It is nonivasive, provides 3D sectioning and deep tissue penetration. To power our nonlinear microscopes we build custom femtosecond Yb:KGW oscillators with advanced features such as extended cavities and multiple output couplers.

T19

Direct observation of enhanced ionization in strong laser fields, *Wei Lai*. Enhanced ionization (EI) of molecules has been extensively studied over the past two decades as a common process in molecular dissociative ionization in strong laser fields. However, direct evidence for EI has only been found in I2 and H2, but not in other small molecules as common as N2 and CO. In this work, we perform the first direct study of EI in CO and N2, and find an enhanced ionization in a newly identified dissociation channel in each of these two molecules following double ionization. Surprisingly, EI does not happen in the commonly-seen dissociation channels that were previously assigned undergoing EI. Instead, EI occurs only in the newly discovered channels with a lower kinetic energy release.

T20

Asymmetric-detection time-stretch optical microscopy (ATOM) for ultra high-speed and high-contrast cellular imaging in flow, *Andy K. S. LAU*. Accelerating imaging speed in optical microscopy is often realized at the expense of image contrast, image resolution, and detection sensitivity – a common predicament for advancing high-speed and high-throughput cellular imaging. We here demonstrate a new imaging approach, namely asymmetric-detection time-stretch optical microscopy (ATOM), which can deliver ultrafast label-free high-contrast flow imaging with well delineated cellular morphological resolution and in-line optical image amplification to overcome the compromised imaging sensitivity at high speed. We show that ATOM can separately reveal the enhanced phase-gradient and absorption contrast in microfluidic live-cell imaging at a flow speed as high as ~10 m/s, corresponding to an imaging throughput of ~100,000 cells/sec. ATOM could thus be the enabling platform to meet the pressing need for intercalating optical microscopy in cellular assay, e.g. imaging flow cytometry – permitting high-throughput access to the morphological information of the individual cells simultaneously with a multitude of parameters obtained in the standard assay.

T21

Infrared Frequeucy Comb setup for High Harmonic Generation, *Xinlong Li*. High harmonic generation (HHG) is a method to produce ultrashort extreme-ultraviolet (XUV) pulses. We use a near-infrared (NIR) frequency comb and a passive enhancement cavity to produce XUV frequency combs with 90 MHz repetition rate. This poster is mainly focus on the setup of producing NIR pulses with enough peak power for HHG by using a rod fiber from NKT Photonics. This source has many applications, including high-harmonic spectroscopy and imaging real-time dynamics of surface photoreactions.

T22

Orbit Angular Momentum of light in a double-ring fiber, *Yangjie Liu*. Recent work by Yang Yue \emph{et al.} simulated the mode properties and propagation effects of orbital angular momentum (OAM) modes in a single-ring fiber[1]. We will extend this idea into the double-ring case and present more freedom to manipulate the OAM modes therein. Analytic derivation from wave equation of a double-ring fiber will be given and discussed. Suppose a simple configuration of three-layer medium in fiber optics. The layers from inner to outer are labelled as 1,2,3, respectively. According to wave function of Cylindrical Circular Waveguide(cf. Kong's book on p441, \cite{Kong1990}), one can write \begin{eqnarray} \Big[\frac{1}{\rho}\frac{\partial}{\partial \rho}\big(\rho\frac{\partial}{\partial \rho}\big)+\frac{1}{\rho^2}\frac{\partial^2}{\partial \phi^2}+k_{\rho}^2\Big]\binom{E_z}{H_z}=0, \end{eqnarray} Here $k_{\rho}^2=\omega^2\mu_i\epsilon_i-k_z^2$ in which μ_i,ϵ_i refer to the relative quantities in each medium i. Then one is allowed to engineer the field herein to follow the equations below: \begin{eqnarray} E_z=\sum_l e^{il\phi}\begin{cases}J_l(k_1 r),& 1\H_l^{(1)}(k_2r)+J_l(k_2r),&2\K_l(k_3r),&3 \end{cases} \end{eqnarray} in which $K_l(\cdot)$ indicates the exponentially vanishing field solution instead of Neumann function $N_l(\cdot)$ or $Y_l(\cdot)$. It is well known that the orbital angular momentum(OAM) for a light beam $\bar E, \bar B$ can be defined as \begin{eqnarray} \bar L=\bar r\times \bar P,\qquad \bar P_{\rm field}=\frac{1}{\mu_0c^2}\int_VdV\bar E\times\bar B. \end{eqnarray} Therefore, OAM modes can be calculated accordingly.

T23

Ultrafast Biphoton Spectral Coding, *Joseph Lukens*. We describe a new biphoton coding scheme based on programmable spectral phase codes. Applying one phase sequence to the signal photon encodes the correlation function, scrambling it in time, and only by applying the matched code to the idler is the biphoton properly decoded; any other code leaves the wavepacket spread. Our results may prove relevant in future quantum key distribution protocols based on optical codes.

T24

Yb-fiber laser with central generation wavelength 1126, *Andrey Machnev*. In our work we present Yb-fiber laser with a central generation wavelength at 1126 nm. This type of laser can find its application primarily as a pump source for holmium lasers and supercontinuum generation. Moreover, this work presents both cw and pulsed mode of operation of the laser.

Thursday, 7 August 2014
Poster Session

TH1
Graphene as saturable absorber for photonics applications, *Farah Diana Muhammad*. Nowadays, graphene, a single layer atom of carbon, has been a great candidate to be applied as the SA with its desirable optical characteristics such as ultrafast recovery time and ultrawideband absorption due to its zero bandgap energy and linear dispersion of Dirac electrons. With its advantage over semiconductor saturable absorber mirror (SESAM) in terms of the cost, tuning range and ease of fabrication, graphene has been widely accepted to replace the usage of SESAM. In this work, several methods of graphene integration onto the fiber ferrule have been demonstrated, such as by optical deposition method, by sandwiching graphene thin film between the fiber ferrules and by adhering graphene flakes onto the fiber ferrule using index matching gel. The saturable absorption properties of the deposited graphene by each different method is also measured and analysed. Taking advantage of the unique properties of graphene, the graphene deposited in this work has been demonstrated for Q-switching operation in various setup configuration, from basic setup of a simple ring cavity of Erbium doped fiber laser (EDFL) to a more advance configuration which enables for the wavelength tunability by employing different wavelength selective elements including the tunable bandpass filter (TBF), arrayed waveguide gratings (AWG) and fiber Bragg gratings (FBG). Comparison on the Q-switching output performance using the different wavelength selective elements is being analysed. In addition, graphene Q-switched EDFL based on distributed Bragg reflector (DBR) cavity configuration and multiwavelength graphene Q-switched based on Brillouin-erbium fiber laser have been demonstrated as well, with each approach having their own advantages. Furthermore, a Q-switched EDFL based on graphene oxide as the saturable absorber with a simple deposition method has also been introduced. Apart from Q-switching, mode-locking generation based on graphene saturable absorber is also being demonstrated and investigated using a simple ring cavity EDFL. To provide the wavelength tunability of the mode locked EDFL, a TBF is inserted into the cavity as the tuning mechanism. Further investigation on the graphene based mode locked fiber laser is carried out by using an exotic and highly doped Zirconia-erbium doped fiber (Zr-EDF) as the gain medium. It is interesting to observe that beyond a certain pump power, harmonic mode locking takes place. In addition, by incorporating a Mach Zehnder filter into the cavity, the spectrum tunability of the mode locked Zr-EDFL is achieved and has been well demonstrated. Further development of this graphene based Zr-EDFL is carried out by demonstrating it as a pulse source for supercontinuum (SC) generation with an advantage of low cost, since only a short length of single mode fiber (SMF) is used as the nonlinear medium. Moreover, in this work, graphene has also been demonstrated as saturable absorber for suppressing the noise and multimode oscillations in the laser cavity, which is the key enabler to produce the single longitudinal mode (SLM) operation in the EDFL. By heterodyning this SLM laser output and an external tunable laser source (TLS) at a photodetector, a tunable radio frequency generation can be realized.

TH2
High-brightness laser by the metamorphosis of a Gaussian beam to flat-top distribution, *Darryl Naidoo*. We explore an intra-cavity beam shaping approach in the selection of a Gaussian distribution by the metamorphosis of a Gaussian beam into a flat-top distribution on opposing mirrors. The concept is tested external to the proposed laser cavity by the use of two spatial light modulators (SLMs), where the first SLM is used to transform a collimated Gaussian into a flat-top distribution and the second SLM is encoded with the conjugate phase of the flat-top for conversion back to a Gaussian. We implement this intra-cavity selection with the use of two optical elements of the refractive variant that are designed from the phase profiles addressed to the SLMs. We consider a solid-state diode side-pumped laser resonator that consists of two planar mirrors where the refractive optics are positioned at the mirrors. We out couple the Gaussian and flat-top beams and we show that we increase the laser brightness as compared to an empty cavity while maintaining a low beam divergence.

TH3
The Talbot Effect, Luneburg Lenses & Metamaterials: Beauty, Elegance, Ingenuity & Practical Application, *Hamdam Nikkhah*. Optical information processing has traditionally been demonstrated using 3D free-space optical systems employing bulk optical components which are unstable due to the stringent alignment tolerances that must be met. These issues may be overcome by confining the light in a planar slab waveguide. The limitation on scaling, consequent on the loss of one dimension is offset by the nanoscale component footprints attainable in a silicon integration platform. Waveguide lenses are the key components in complex crossover interconnections of a switch fabric. The ability to engineer the effective refractive index of structures on a chip has led to several breakthroughs in component technology. A planar metamaterial Lüneburg lens can be implemented in an SOI slab waveguide structure by patterning the silicon core with variable sized holes to enable Fourier optics on-a-chip. Metamaterial offers the major advantage of fabrication by a single etch step. A method is developed to determine the local effective media index of a periodic metamaterial in terms of the parameters of its unit cell. This method is used as a calibration to lay out a metamaterial with graded parameters. The careful approximation of the graded index of the Lüneburg lens by a metamaterial introduces minimal impairments. This structure can be used in optical transpose interconnection systems in optical switching architectures with the advantage of avoiding large number crossover waveguides in optical communication systems.

TH4

Spectroscopic ellipsometry investigation of oxygen impurities influence on cobalt, *Olena Polianska*. This work is devoted to Co – O compounds' investigation by the methods of spectroscopic ellipsometry. The main problem is analyzing information about electronic structure of cobalt-oxygen compounds in different structural states. Oxygen impurity was chosen because it is one of the main atmospheric gases characterized by high chemical activity. Co-O compounds were obtained by the method of magnetron sputtering on leicosapphires' substrate cooled by the liquid helium. Process was provided in vacuum with gradual adding 2% and 4% oxygen into vacuum chamber. Samples were explored in wide spectral range E = 0,07–4,96 eV by the Beatty method. While an experiment was carried out the ellipsometry parameters and were measured near principal angle of incidence. The optical conductivity was calculated using these parameters as the other optical characteristics. The energy dependencies of optical characteristics especially optical conductivity were analyzed. It's proportional to interband density of electronic states. The appearing of new absorption band related to oxygen impurity in optical conductivity spectrum of Co – O compounds in amorphous and crystalline states was shown. Main parameters of position and oxygen impurity band's half-width were defined for Co – O compounds in amorphous state.

TH5

Coupling Mechanisms in an Optomechanical Laser, *Debora Princepe*. Optomechanical systems have been widely demonstrated exploring the mechanism of dynamic back-action in order to get effects of amplification or cooling of the mechanical motion. This mechanism is based mainly in the facts that the cavity photon lifetime is finite and that the scatter of photons pumped into the cavity, detuned in relation to its resonance, causes creation or annihilation of phonons due the coupling between the optical and the mechanical modes. Recent works have been developed in order to explore the interaction of an optomechanical resonator with a gain medium, most of time to look for conditions such that a laser could cool down its own mirrors. In this work we study mechanisms of coupling between population inversion, light emission and mechanical motion in a laser that has a mechanical degree of freedom, looking for effects of amplification of the mechanical oscillator. We propose the coupling between the laser and the harmonic oscillator through the optical force and the photonic lifetime, introducing the change of the frequency due to optomechanical coupling to the optical losses in rate equation approach. The effect is a modulation in the loss of the laser cavity, suggesting mechanisms analogous to Q-switching. We investigate the limits of this coupling through small signal analysis showing an existing resonance with the relaxation oscillation of the laser, which is observed in the dynamic evolution of the system. Numerical simulation also shows that amplification is possible near the frequency of relaxation, although the parameters needed to achieve self-sustained oscillation, and so modulation of the light emitted, are still over the typical values obtained in demonstrated systems.

TH6

Measurement of Nonlinear Refraction Dynamics of CS_2, *Matthew Reichert*. CS_2 is a standard reference material for nonlinear optical spectroscopy due to its large optical nonlinearity. However, its effective nonlinear refractive index depends on the optical pulse width used in the measurement due to various non-instantaneous response mechanisms. We apply the recently developed beam deflection technique to resolve the temporal dynamics, from which each mechanism's response times and polarization dependence can be resolved, and the response function can be determined. From the response function, the effective nonlinear refractive index, including polarization dependence, can be predicted. Comparisons to Z-scan measurements yield excellent agreement.

TH7

Conservative and dissipative dynamics in a Laser with Saturable Absorber, *Cristina Rimoldi*. The description of the dynamics of a laser as a particle in a Toda potential is long known in literature but lacks a full correspondence when we add an absorber in the laser cavity. We found a way to express the dynamics of a Laser with Saturable Absorber (LSA) in terms of a Toda potential both in the regime of damped oscillations and in the regime of sustained pulsations: in this contest it is possible, under certain approximations, to define a conservative limit for a LSA. Under optical injection, the model developed for a LSA is no longer conservative but it remains reversible: therefore it is possible to observe the coexistence of conservative and dissipative behavior in the dynamics of the system. This particular observation is interesting considering its possible application to cavity (dissipative) solitons in VCSEL with saturable absorber. Further research aims at finding a conservative limit for cavity solitons in a LSA without injection and to observe the coexistence of conservative and dissipative behavior in the transverse section of a LSA with optical injection.

TH8

A Comparative Study of Dielectrics as Nanoplasmonic Couplers, *Md. Ghulam Saber*. A theoretical study of nano-plasmonic couplers constructed using gallium lanthanum sulfide (GLS), cuprous oxide (Cu2O), aluminum gallium arsenide (AlGaAs), silicon germanium (Si-Ge), aluminum arsenide (AlAs) and alumina (Al2O3) is presented. The analysis has been done using the finite difference time domain (FDTD) technique. The dependence of coupling efficiency on the width of the air layer of silver-air-silver waveguide has been investigated in order to determine the optimal width of air. Coupling efficiency with the variation of input signal wavelength, reflection coefficient, return loss and insertion loss have been calculated numerically in order to characterize the performance of GLS, Cu2O, AlGaAs, Si-Ge, AlAs and Al2O3 as nano-plasmonic couplers. The couplers provide appreciable performance at 1550nm wavelength and have simple rectangular shape with no tapering which provides advantage in the fabrication process. It also offers broadband operation.

TH9

Supercontinuum Broadening in a Highly Nonlinear Chalcogenide Photonic Crystal Fiber, *Than Singh Saini*. A triangular-core photonic crystal fiber in As2Se3-based chalcogenide glass with all-normal, nearly zero flat-top dispersion has been proposed. Designed PCF structure offers more than 8 µm ultra-broadband supercontinuum generation in only 6 millimetres length of PCF. Proposed structure possesses nonlinear coefficient as high as 5456 W-1km-1 wavelength with effective mode area of 6 µm2. Simulated results indicate that ultra-broadband supercontinuum extending from 1.43 to 10 µm at -35 dB level can be obtained by pumping the PCF with 4.4 µm, 700 watt peak power and 50 fs duration of incident pulses. Proposed highly nonlinear PCF structure has potential applications in optical coherence tomography, pump-probe spectroscopy, metrology or non-linear microscopy.

TH10

Spatial chirp introduced in few-optical-cycle pulses by a plane parallel plate and small-angle wedges, *Benjamin Sánchez*. We study the chirp introduced in few-optical-cycle pulses by a plane parallel plate made with an isotropic dispersive material, when the incident beam makes an angle with the normal to the plate. The pulses have a carrier wavelength of 810nm and a pulse duration of 20fs, 10fs and 5fs. The total phase between the entrance and exit wavefronts is evaluated by using the finite raytracing, so exact expressions for the phase under arbitrary incidence is evaluated. The phase is also expanded up to third-order and a comparison between the electric field of the pulses evaluated with the finite and the third-order dispersion approximation phase is made. We will show that for pulses shorter than 10fs, the temporal spreading of the pulse increases considerable even for a thin plate made with a low dispersive material and a thickness of 1mm. Finally the study of propagation of pulses through a plane parallel plate is extended to a pair of small-angle wedges. The purpose of this study is to analyze the dispersion introduced by the plane parallel plate and wedges in a Z-fold laser cavity.

TH11

Germanium-Tin Technologies for Developing Light Sources on Silicon, *Colleen Shang*. Germanium-tin (GeSn) is an exclusively Group-IV materials system that has the potential to enable families of optoelectronic and photonic devices on silicon. By alloying Sn, it is possible to tune the bandstructure of Ge to achieve a direct band gap as well as develop GeSn/Ge heterostructures for low-threshold lasers on silicon. We demonstrate enhanced light emission of GeSn alloys over bulk Ge and develop suspended microdisk resonator cavities that leverage a novel etch-stop property of GeSn. Furthermore, we also show light emission from an electrically-driven GeSn quantum well light-emitting diode. These technologies present several key building blocks for engineering an efficient GeSn-based laser on silicon.

TH12

Light bullets and its spectral parameters under femtosecond laser pulse filamentation in fused silica, *Evgeniya Smetanina*. We investigated both, experimentally and numerically, the formation of light bullets during femtosecond laser pulse filamentation under anomalous group velocity dispersion in fused silica. The minimum duration of the light bullet reaches 13.5 fs, that is about two periods of the light field oscillation at a wavelength 1800 nm. It was found that the appearance of the light bullet is accompanied with the formation of the isolated high-frequency peak (anti-Stokes wing) in the supercontinuum spectrum. The anti-Stokes wing shifts to the blue side of the spectrum and its width increases with the increasing of the central wavelength of the pulse.

TH13

Gas refractive index and Sodium D–line separation measurement using Michelson's interferometer, *Nyasha Joseph Suliali*. Optical Coherence Tomography (OCT) is a fast growing non-invasive, contactless imaging modality of extensive use in biomedical applications and materials characterization. We are developing a Time-Domain Optical Coherence Tomography (TD-OCT) system for use in investigating surface morphology of selected optically scattering media. Preliminary to Low Coherence Interferometry (LCI) utilized in OCT scanning and signal processing, Michelson Interferometer experiments were carried out using a Helium-Neon laser and a Sodium lamp. The interferometer was calibrated, refractive index of air determined and output beam profiles plotted using a charge-coupled device (CCD) camera connected to a computer. The output beam intensity was measured and plotted as a function of movable mirror translation. The contrast of the interference pattern of a Sodium lamp was measured as a function of movable mirror displacement to determine Sodium D-line separation. This experiment will be used to produce white light fringes for coherence length measurement of a broadband source in this project.

TH14

Threshold Reduction and Soliton Formation in Frequency Combs via Parametric Seeding, *Hossein Taheri*. A theoretical model for microresonator-based frequency comb generation seeded by phase-modulated input is developed. It is shown that the effect of the phase modulation is to counteract the first-order dispersion coefficient of the microresonator. The numerical solutions of the governing equation suggest that such an input, when modulated at a frequency close to the free-spectral-range (FSR) of the microcavity and at modest modulation depths, leads to sub-threshold comb generation. This scheme also provides a deterministic route, without the necessity to pass a chaotic phase, towards soliton formation in microresonators. We also study the stability of the generated solutions against fluctuations in the input power and compare the effect of adiabatic and abrupt removal of the modulation at the input.

TH15

Testing of Cr:ZnSe Laser with Intracavity Methane Cell in 77-300 K Temperature Range, *Mikhail Tarabrin*. The mid-IR cw tunable solid state two-mode Cr2+:ZnSe laser with intracavity methane cryocell was developed. The laser was applied for sub-Doppler spectroscopy of (v1+v4) vibrational-rotational band of methane and observation of narrow resonances of saturated dispersion at λ = 2.36 µm. The new technique of low pressure methane gas cooling was used instead of liquid nitrogen “jacket” design applied in our previous work. Parameters of saturated dispersion resonances were estimated in 77-300 K temperature range. The experiments confirmed that laser with the new “dry cooled” methane cell has prospective for reaching a short-term frequency stability at the level of 10^(-15) – 10^(-16) and can be used as a compact device.

TH16

Investigations of second harmonics in negatively coupled laser arrays, *Chene Tradonsky*. Phase-locked laser arrays, where all the lasers have a common frequency and a constant phase difference relative to each other, have interesting physical properties that can be exploited for research and industry. For example, phase locked laser arrays can serve as excellent tools to investigate the properties of coupled oscillators as analogue to coupled classical-spins in one or two dimensional arrays, the behavior of frustrated array configurations, the conditions for passive phase locking and phase locking dynamics, and the properties of complex networks. Moreover, phase locking of many lasers results in a single powerful laser that can be highly focused. In general, most diffractive coupling techniques cause negative coupling that tend to lock lasers with a negative π phase shift. This leads to a super mode of out-of-phase lasers that cannot be tightly focused, so it cannot be exploited for many applications. Conversion of such a super mode to an in-phase lasers array is thus necessary to obtain tight focusing. Such conversion can be achieved by means of phase doubling with second harmonic generation (SHG). We present an experimental arrangement for forming and detecting the second harmonics of coupled laser arrays and experimental and calculated results for several simple laser arrays, a bistable laser array, and a frustrated laser array.

TH17

Magnetic field-induced optical anisotropy in ferrofluids loaded carbon nanotubes in the presence of uniform magnetic field, *Caridad Vales*. A ferrofluid is a stable colloidal suspension of magnetic nanoparticles suspended in a carrier liquid. These materials are a type of magnetic fluids, which have the feature to modify their properties in the presence of a magnetic field. When a ferrofluid is exposed to an external magnetic field develops optical anisotropy due to the formation of field induced chain microstructures. In recent years, the study of their optical properties has been of great interest from the scientific community, due to the wide application that show magneto-optical phenomena such as birefrigence, dichroism, light scattering, ellipticity and Faraday rotation, which are the basis for the functioning of a large number of optical devices. The presence of carbon nanotubes (CNTs) in ferrofluids enhances the response of the compound to a magnetic field. This suggests that adding CNTs in ferrofluids may be a way to improve the anisotropic effects in the structure of the compound when a magnetic field is applied. These compounds can be used successfully in applications such as optical filters and polarizers. In this work, the experimental investigation of time-dependent anisotropic light-scattering patterns produced by a light beam through of ferrofluids with various carbon nanotube concentrations, in a homogeneous magnetic field is reported. The study of the temporal evolution of diffraction patterns allows analyzing the kinetics of structure formation in magnetic fluids and stabilization. The presence of CNT in ferrofluids favors the formation of chain-like structures even for low intensity fields. The analysis of the experimental data show that the time evolution of the coefficient of optical anisotropy shows dependence on the concentration of CNT, in such a way that at higher concentration the stabilization is reached in shorter time.

TH18

Compact all-fiber laser for ultrafast time-stretch optical imaging, *Xiaoming Wei*. Time-stretch imaging has recently been proposed and demonstrated to support real-time ultrafast imaging without sacrificing the sensitivity. Generally, a broad optical spectrum (~10 nm) is required to conduct the unique space-frequency-time encoding process in the time-stretch imaging, precisely, the time-stretch microscopy. As a potential candidate, supercontinuum generated by pump pulses along a piece of highly-nonlinear fiber has usually been employed. Its stability and coherence, however, would be deteriorated, especially for the picosecond pump pulse. As a result, it is required to enhance the degraded signal-to-noise ratio by averaging, which would compromise the frame rate on the other hand. Thus, we demonstrate a pulse train extracted directly from an all-normal dispersion mode-locked fiber laser with broadband rectangle-shaped optical spectrum for the time-stretch imaging. Based on this, real-time stain-free flow imaging of the HeLa cell, flowing at ~11 m/s, is demonstrated with a frame rate of 26 MHz and a spatial resolution of ~2 micron. Although optical time-stretch is usually performed after the image signal is encoded in the optical spectrum for time-stretch microscopic applications, optical time-stretch can also be used as an all-optical passive swept source, without the need for active wavelength-swept mechanisms and their speed limitation. Thus, we further optimize its bandwidth and compactness for the ultrafast time-stretch optical coherence tomography (OCT), by using a pulse-breathing effect and multifunctional integrated fiber-based component. Ultrafast and stable broadband (58 nm) wavelength-sweep is achieved with a sweep rate as high as 11.5 MHz – ~700000000 nm/s, almost two orders of magnitude faster than the active swept sources. Compared with its FDML counterpart, a 38-times-better roll-off performance is obtained, i.e., ~4.4 mm/dB up to the depth of ~26 mm. Good image quality of time-stretch OCT based on this compact all-fiber swept source is obtained without the need for swept waveform averaging. We stress that the utility of this compact all-fiber laser could also be extended to other emerging applications demanding for ultrafast and high-throughput operations, such as ultrafast spectroscopy, optical single-shot digitizer, time-encoded stimulated Raman microscopy, and hyperspectral imaging.

TH19

Active Mode-Locking of a Semiconductor Laser for a Rubidium D2 Line Distributed Frequency Reference, *Jonathan Woods*. Actively modulated semiconductor lasers can be employed in producing stabilized mini optical frequency combs. These broad-band optical frequency references are useful in many areas of physics, including arbitrary frequency generation, slave laser stabilization through phase-locking, and spectroscopy. We aim to demonstrate a frequency reference onto which CW lasers may be locked for the purpose of light generation for ultra-cold Rubidium Quantum Control experiments. A key further objective is to demonstrate a mini frequency comb Vernier scale. This will provide a novel test bed by which to test arbitrary comb line identification as well as diode-based dual frequency comb spectroscopy.

TH20

High-power nanosecond fiber lasers at 2 µm: exploring gain-switching pulse generation technique, *Jianlong Yang*. We review the development and applications of gain-switched fiber lasers and numerically analyze their temporal characteristics. Special attention is paid on in-band-pumped gain-switched thulium-doped fiber lasers (GSTDFLs) because of their various advantages at 2 µm waveband. We develop a high-power highly-linear-polarized nanosecond all-fiber MOPA at 2040 nm seeded by a GSTDFL, which can directly output tens-of-microjoules pulses with designable pulse duration and Gaussian-like pulse profile. After only two stages of amplification, we achieve an average power of 70 W at a pulse width of 114 ns and a repetition rate of 10 kHz, corresponding to a pulse energy of 7 mJ and a peak power of 61.4 kW. Benefit from the on-site polarization control technique we proposed, a polarization extinction ratio (PER) of 25 dB at the highest output is also obtained. To the best of our knowledge, this is the highest power nanosecond all-fiber laser reported at 2-µm waveband and the PER is also a record among high-power fiber lasers.

TH22

Identification of Biexcitons in Single-layer WSe2, *Xiaoxiao Zhang*. Single-layer transition metal dichalcogenides (TMD) has a direct bandgap at K(K') point and a structure similar to graphene. Because of its strict 2D con-nement, exciton binding energy is huge compared to that in quantum well, and there have been many reports on TMD's tightly-bound charged exciton complex (trion). Here by employing photoluminescence (PL) spectroscopy, we observed a robust biexciton emission feature at low temperature in single-layer WSe2, and its binding energy is deduced to be within 25 meV to 55 meV.

TH23

Beam Deflection Measurements of Transient Nonlinear Refraction from Coherent Rotational Revivals in Air, *Peng Zhao*. We apply the beam deflection technique to measure the transient nonlinear refraction of air well below the filamentation threshold with unprecedented sensitivity at 1 atm. Rotational contributions of N2 and O2 were resolved over 300 ps of delay, which allows high resolution of the rotational Raman spectra and centrifugal distortion in the frequency domain.

Siegman International School on Lasers Poster Sessions Addendum

Tuesday, 5 August 2014 and Thursday, 7 August 2014

Tuesday, 5 August 2014
Poster Session

T25

Engineering design for compressed sensing of optical scanning holography with a spiral trajectory. *Antony C. Chan* Compressed sensing improves the acquisition frame rate of optical scanning holography with a spiral trajectory. To accommodate such an unusual scanning trajectory on the physical hardware, precise machine timing and control must be enforced. We present the rapid prototyping process of a real-time, fully-synchronized scanning holographic setup on a limited budget. In our demonstration, a two-sectional object is reconstructed with high fidelity with at least 5 times speed improvement without manual intervention.

T26

Near-Unity Collection Efficiency of Single Photons from a Quantum Emitter. *Xiao-Liu Chu.* Efficient single photon sources are essential for emerging technologies, such as quantum computation, quantum cryptography or metrology. Recently, we developed a dielectric antenna, which allowed us to collect 96% of the photons emitted by a single molecule [1]. The antenna worked only efficiently for a particular orientation of the dipole moment of the emitter. In this work, we overcome this limitation and collect more than 99% of the photons emitted by an emitter with arbitrary dipole orientation [2,3]. [1] K.G. Lee et al., Nature Photonics 5, 166 (2011) [2][X-W. Chen, S. Götzinger and V. Sandoghdar, Optics Letters 36, 145172 (2011) [3][X-L. Chu, T.J.K. Brenner, X-W. Chen, Y. Ghosh, J. A. Hollingsworth, V. Sandoghdar, and S. Götzinger, arXiv: 1406.0626 (2014)

T27

Assessment of water molecule in liquid state. *Rostyslav Danylo* This investigation is devoted to the vibrational spectroscopy inverse problem. Its solution gives a possibility to make conclusions about the geometry of the investigated molecule. The algorithm based on methods of inverse problem of vibrational spectroscopy solving and method of gradient descend was elaborated in order to design the molecule. Measured vibration spectra frequencies were used as input data in the proposed algorithm. Nonlinear triatomic molecules corresponding to C2v symmetry were investigated. The valence angle of investigated molecule was assessed. The calculation of valence angle is a well-known task but typical methods of vibrational spectroscopy aren't applied to the matter in liquid state. The aim of the research is to assess the valence angle of water molecule in liquid state. The calculation of valence angle permits to design the water molecule in liquid state and its nearest environment.

T28

Raman-free, tunable source of modulation instability correlated twin beams. *Martin Finger.* "Macroscopic (high photon number) quantum states of light have attracted broad interest in the past few years. Such states allow light matter interactions to be enhanced relative to few photon states and have applications in quantum information processing [1, 2]. Here, we present recent work on a new source for the generation of photon number correlated twin-beams, based on modulational instability in noble-gas-filled kagomé-style hollow-core photonic crystal fiber. This system is very interesting because of its low number of modes with high brightness, the wide tunability of the parametric wavelengths and intrinsically low noise due to absence of Raman scattering. 1. L. S. Madsen, V. C. Usenko, M. Lassen, R. Filip and U. L. Andersen. Nat. Commun. 3, 1083 (2012). 2. I. A. Agafonov, M. V. Chekhova and G. Leuchs. Phys. Rev. A 82, 011801-1 (2010)."

T29

Matrix approach for modeling of emission from multilayer spin-polarized light-emitting diodes and lasers. *Tibor Fordos.* Spin-polarized light sources such as the spin-polarized light-emitting diodes (spin-LEDs) and spin-polarized lasers (spin-lasers) are prospective devices in which the radiative recombination of spin-polarized carriers results in emission of circularly polarized photons. A novel approach based on 4 × 4 transfer matrix formalism is derived for modeling of the interaction of light with matter in active media of resonant multilayer anisotropic structure and enables to include magneto-optical effects. Quantum transitions, which result in photon emission are described using general Jones source vectors.

Thursday, 7 August 2014
Poster Session

TH24
Cryogenic optical refrigeration using high power vertical external-cavity surface-emitting lasers (VECSELs). *Mohammad Ghasemkhani.* Laser cooling of solids has a great potential to achieve an all-solid-state crycooler. The advantages of compactness, no vibrations, no moving parts or fluids, and high reliability have motivated intensive research. We have laser cooled a 7% Yb:YLF crystal to 131 K (from R.T.) by placing it inside the external cavity of a high power InGaAs/GaAs VESCEl operating at 1020 nm. This is the lowest temperature achieved in the intracavity geometry to date.

TH25
Design of a Compact, Robust, External Cavity Diode Laser. *Louis Isabella*. Atomic physics experiments require lasers at a specific frequency in order to excite atomic transitions. The lasers need to be stable to within a MHz and have a narrow linewidth on the order of 100 kHz in order to be used for the cooling, state preparation and readout of a trapped ion. To achieve these goals, external cavity diode lasers (ECDLs) with a diffraction grating in Littrow or Littman-Metcalf configuration to provide feedback, are typically used. However, due to their mechanical designs, these lasers require precise alignment of the optics and are sensitive to acoustic noise and temperature fluctuations. To address these issues, we have designed a small, compact laser that will be more robust against acoustic vibrations and temperature fluctuations. Our ECDL design separates the job of the diffraction grating, feedback and frequency selection, into two components. An output coupler and a cateye lens are used to provide feedback. This configuration is orders of magnitude less sensitive to misalignment, which allows most degrees of freedom to be set by machining tolerances and makes it more robust to acoustic noise. An interference filter is used to select the lasing wavelength via its angle. A ring shaped piezoelectric actuator mounted behind the output coupling mirror allows for fine-tuning of the cavity length and thus output wavelength. A thermoelectric cooler mounted underneath allows for temperature stabilization at the desired operating temperature. The overall length of the laser is < 6 cm, with the cavity length < 3 cm. Using only the filter, a tuning range of 4 nm has been observed using a non-AR coated diode, along with linewidths on the order of 100 kHz. This laser therefore meets our requirements to use in ion trapping experiments and, with its compact design, makes it advantageous to use over traditional diffraction grating based ECDLs.

TH26
Noise characterization of a fiber optical parametric oscillator with a tunable pump. *Leily Kiani.* Fiber optical parametric oscillators (FOPOs) are an attractive alternative to supercontinuum light sources for nonlinear microscopy applications. In a recent publication, our group has experimentally compared the intensity noise of these two devices demonstrating an excess noise level that approaches the shot noise limit in the FOPO for optimal cavity tuning parameters. Here we experimentally show the excess noise of a FOPO with an alternative tuning configuration. We also compare this with the single-pass fiber optical parametric amplifier configuration of this device.

TH27
Two Color Hong-Ou-Mandel Interference in Optical Fibers. *Roger Smith.* Hong-Ou-Mandel Interference was demonstrated in 1987 and has become a workhorse within the quantum optics community, especially as a foundational building block for all optical quantum logic gates. However, HOM Interference requires input photons degenerate in frequency. Four wave mixing in optical fibers provides a method for creating interference between photons non-degerate in frequency and extends the practical applications for optical logic gates in quantum computation and quantum information. Two color HOM interference has been shown theoretically via four wave mixing in photonic crystal fibers and we are in the process of experimentally demonstrating this phenomenon.

TH28
Uniquely Defined 2-Dimensional Materials. Preparation and Optical Properties. *Beata Szydlowska.* The creation of 2D nanomaterials with precise control of size, shape, composition and crystal structure opens a new wide field. From the development of photonic device point of view investigation of the nonlinear and ultrafast optical properties of 2D nanomaterials is indisputably important. Molybdenum disulphide dispersions (considered in this study) with high population of single and few layers were prepared by Liquid Phase Exfoliation (LPE) method. High quality of the 2-dimensional MoS2 structures was verified with use of electron microscopy. Ultrafast nonlinear optical (NLO) properties of different size and concentration of MoS2 nanosheets were investigated by Z-scan open aperture technique. All measurements were performed by 6 ns pulses at wavelength of 532 nm from Q-switched Nd:Yag laser with pulse repetition rate 10 Hz and few power setups.

TH29
DBR-Free Optically Pumped Semiconductor Disk Lasers. *Zhou Yang*. VECSELs are good beam quality, high power laser sources at a variety of wavelengths. However, material choices are limited by the need of DBR, usually monolithically integrated with the active region. We demonstrate DBR-free vertically emitting semiconductor active regions, which have been lifted off and bonded to various transparent substrates. For a InGaAs quantum well sample bonded to a sapphire window heat spreader, we achieved CW lasing with an output power of 160 mW at 1037 nm with good beam quality. We also discuss other geometries, using prisms or cubes, and utilizing total internal reflection.

Exploring a Career in Industry

Valentin Gapontsev, IPG Photonics, USA

50 Years of Lasers

Robert L. Byer, Stanford University, USA

The Energy, Climate Change and Sustainability: a necessity that will be the mother of many inventions

Steven Chu, Stanford University, USA