CLEO: 2014

Laser Science to Photonic Applications
Technical Conference: 8-13 June 2014
Expo: 8-13 June 2013
Short Courses: 8-10 June 2013
San Jose Convention Center, San Jose, CA, USA

CLEO: 2014 Closes with Increased Attendance, Six Days of Innovative Laser Science & Applications

With a record number of paper submissions and the highest attendance in five years, CLEO: 2014 concluded last week after six days of quality presentations, diverse symposia, important business insights and unique innovations from prominent companies in the laser and electro-optics industry. The event was host to 5,000 attendees and featured sessions and activities in areas such as photonics for brain mapping, high-power lasers, nanophotonics, laser therapeutics, nonlinear optics, quantum optics, technology transfer, laser-based manufacturing and more.

Unique Perspectives from Top Researchers

CLEO: 2014 offered several opportunities to hear from the most prominent experts in the field—including well-known, early pioneers and today's foremost researchers. The late James Gordon, known as one of the founding fathers of quantum electronics, was honored at a special symposium featuring presentations from three Nobel Laureates and a host of well-known laser experts who provided both personal stories of Gordon's life and overviews of the current state of research influenced by Gordon's many contributions.

Plenary speakers this year included Gerhard Rempe of the Max Planck Institute of Quantum Optics, who spoke on quantum coherent networks; Larry Coldren of the University of California, Santa Barbara who discussed the latest in photonic integrated circuits; and Sir David Payne of the University of Southampton who offered a comprehensive view of the future of specialty fibers.

Leading Companies on Display

The exhibit hall showcased products and services from 250 companies, such as Coherent, IDEX, Newport, Thorlabs, Toptica and many others. The CLEO/*Laser Focus World* Innovation Awardsrecognized three companies making novel contributions to the industry, including winner Daylight Solutions for the first laser-based infrared microscopy platform, known as Spero™.

All-inclusive, Quality Programming

More than 2,600 paper submissions resulted in hundreds of technical sessions featuring key research institutions worldwide and covering topics in OCT, space-based laser communications, LIDAR and medical imaging. Meanwhile, special symposia themes ran the gamut from neurophotonics and nanobiophotonics to silicon photonic integration and laser processing for consumer electronics.

Show floor activities included the comprehensive CLEO: Market Focus, which this year featured panels on air quality monitoring, solid-state lighting, photonics business strategies and public-private collaborations. The Technology Transfer Program offered an opportunity for startups to hear from seasoned entrepreneurs about best practices for taking innovations from the lab into the marketplace.

From first-time presenter Benham Behroozpour of the University of California, Berkeley to long-established luminaries Charles Townes and Steven Chu, CLEO: 2014 again proved to be the premier event that serves the entire laser community with best-in-class content, networking and program diversity. Join us next year for CLEO: 2015, 10-15 May in San Jose, California, USA.

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Joint Council on Applications

Wilhelm G. Kaenders, *Toptica Photonics Inc, Germany,* **Chair**
Iain T. McKinnie, *Lockheed Martin Coherent Technologies, USA*
James C. Wyant, *University of Arizona, College of Optical Sciences, USA*
Yu Chen, *University of Maryland at College Park, USA*
Eric Mottay, *Amplitude Systemes, France*
Merrill M. Apter, *Adept Technologies, Inc., USA*
Timothy J. Carrig, *Lockheed Martin, USA*
Amy Eskilson, *Inrad Optics, USA*
Nicusor Iftimia, *Physical Sciences Inc., USA*
Inge Kabert, *Thorlabs Inc, USA*
Rick Plympton, *Optimax Systems Inc, USA*
Gregory J. Quarles, *Optoelectronics Management Network, USA*
Mark Tolbert, *Toptica Photonics Inc, USA*
Christian Wetzel, *Rensselaer Polytechnic Institute, USA*

Joint Council on Quantum Electronics

IEEE/Photonics Society

Andrew Weiner, Purdue Univ., USA, **Chair**

Yujie Ding, *Lehigh Univ., USA*

The Optical Society

Steven Cundiff, *NIST, USA*

Erich Ippen, *MIT, USA*

Antoinette Taylor, *Los Alamos Natl. Lab, USA*

APS/Division of Laser Science

Nicholas Bigelow, *Univ. of Rochester, USA*

Daniel Heinzen, *Univ. of Texas at Austin, USA*

Invited Speakers

Applications & Technology

A&T 1: Biomedical

Methods for Enhancing Visualization of Subsurface Tissue Structures in Real Time, Stavros Demos; *Lawrence Livermore National Lab., USA*

Searching for Biomarkers of Glaucoma using Adaptive Optics Scanning Ophthalmoscopy, Alfredo Dubra; *Medical College of Wisconsin, USA*

Mueller Polarimetric Endoscopy, Daniel Elson; *Hamlyn Centre for Robotic Surgery, Imperial College London, UK*

In Vivo Photothermal Optical Coherence Tomography of Drug Delivery in Tumors, Melissa Skala; *Vanderbilt Univ., USA*

Increasing the Diagnostic Yield and Accuracy of Bronchial Biopsy for the Assessment of Lung Cancer, Melissa Suter; *Harvard Medical School, USA*

Progress on Cellular Resolution Retinal Imaging: Setting the Stage for Translation between Clinical and Basic Science, Robert J. Zawadzki; *Univ. of California Davis, USA*

Photoacoustic Microscopy: Current Situation and New Ultrasonic Detectors, Hao Zhang; *Northwestern Univ., USA*

A&T 2: Environment/Energy

High Efficiency Solar Building Envelopes for Integrated Delivery of Environmental Control Systems, Anna Dyson; *Rensselaer Univ., USA*

Frontiers of Eco-Efficient Ultraviolet Water Treatment Technologies, Gordon Knight; *Trojan UV, Canada*

Artificial Photosynthesis - Helping Nature Regain Control of the Global Carbon Cycle, Thomas Moore; *Arizona State Univ., USA*

A&T 3: Government & National Science, Security & Standards Applications

Quantum Noise Reduction in the LIGO Gravitational Wave Interferometer by using Squeezed States of Light, Lisa Barsotti; *MIT, USA*

Infrared Digital Holography as New 3D Imaging Tool for First Responders Firefighters: Recent Achievements and Prospectives, Pietro Ferraro; *Istituto Nazionale di Ottica, Italy*

Nanowire Superconducting Single Photon Detectors Progress and Promise, Sae Woo Nam; *NIST, USA*

Ultrafast X-ray Absorption Spectroscopy using Superconducting Microcalorimeter Sensors , Joel Ullom; *NIST, USA*

A&T 4: Industrial

Ultra-short Pulse Lasers as Versatile Tools in the Fabrication of Medical Micro Implants, Nils-Agne Feth; *Admedes Schuessler GmbH, Germany*

Ultrafast Beam Modulation and Delivery for Printing and Embossing Applications, Guido Henning; *Daetwyler Graphics AG, Switzerland*

Ultrafast Laser Writing of Advanced Guided Wave Communications Components, Nicholas Psaila; *Optoscribe, UK*

Innovative Applications of Femtosecond Laser Induced Nanostructure, Yasuhiko Shimotsuma; *Kyoto University, Japan*

Science & Innovations

S&I 1: Light-matter Interactions and Materials Processing

Ultrafast Electron Dynamics in Photo-excited Semiconductors Studied by Time and Angle-resolved Two Photon Photoelectron Spectroscopy, Jun'ichi Kanasaki; *Osaka University, Japan*

Ultafast Laser Plasma Spectroscopy, Vassilia Zorba; *Lawrence Berkeley National Lab., USA*

S&I 2: Advanced Science and Technology for Laser Systems and Facilities

Advances in High Intensity Laser Science, Todd Ditmire; *Univ. of Texas at Austin, USA*

Cryogenic Composite Disk Laser for Peak and Average Power Scaling, Luis Zapata; *MIT, USA*

S&I 3: Semiconductor Lasers

Asymmetric Heterogeneously Integrated InP Microdisk Lasers on Si for Optical Interconnect and Optical Logic, Geert Morthier;*Ghent University, INTEC, Belgium*

Quantum Teleportation using Entangled LEDs, R. Mark Stevenson; *Toshiba Research Europe Ltd, UK*

Recent Progress in Near-infrared Vertical External Cavity Surface Emitting Laser (VECSEL) Grown by Metal Organic Vapour Phase Epitaxy (MOVPE), Wolfgang Stolz; *Philipps Univ. of Marburg, Germany*

Polariton Lasers and Quantum Effects in Novel Lasers, Yoshihisa Yamamoto; *Stanford Univ., USA*

S&I 4: Nonlinear Optical Technologies

Sources and Diagnostics for Attosecond Science, Cord Arnold; *Lund Univ., Sweden*

Asynchronous Mid-infrared OPO Frequency Combs and Applications in Spectroscopy, Derryck Reid; *Heriot-Watt Univ., UK*

Room-temperature Bonding and its Applications to Solid-state Lasers and Wavelength-conversion Devices, Ichiro Shoji; *Chuo University, Japan*

New Applications and Devices for Quantum Frequency Conversion, Kartik Srinivasan; *NIST, USA*

S&I 5: Terahertz Technologies and Applications

The Development and Applications of Terahertz Quantum Cascade Lasers, Edmund Linfield; *Univ. of Leeds, UK*

Sparse Imaging with Metamaterials at Terahertz Frequencies, Willie Padilla; *Boston College, USA*

Silicon-based Sources and Detectors for Terahertz Applications, Ulrich Pfeiffer; *Univ. of Wuppertal, Germany*

Colliding Quasiparticles with Intense Terahertz Fields, Mark Sherwin; *Univ. of California Santa Barbara, USA*

S&I 6: Optical Materials, Fabrication and Characterization

Semiconductor Plasmonic Devices for Interconnects, Meir Orenstein; *Technion Israel Inst. of Technology, Israel*

Nano-focused Ultrafast Spectroscopy and Imaging Reaching the Single Molecule Level, Markus B. Raschke; *University of Colorado at Boulder, USA*

Si-based Microcavity Devices with Ge Quantum Dots, Jinsong Xia; *Wuhan National Lab for Optoelectronics, China*

S&I 7: Micro- and Nano-Photonic Devices

Ga(In)N Nanowire Light Emitting Diodes and Single Photon Sources, Pallab Bhattacharya; *Univ. of Michigan, USA*

Cavity Quantum Electrodynamics in Quantum Dot–photonic Crystal Nanocavity Coupled System with Large g/ , Satoshi Iwamoto; *University of Tokyo, Japan*

Quantum Nonlinear Optics with Single Photons, Mikhail Lukin; *Harvard Univ., USA*

Nano-Optical Scan Probes: Opening Doors to Previously-Inaccessible Parameter Spaces , James Schuck; *Lawrence Berkeley National Lab., USA*

Photonic Topological Insulators, Mordechai Segev; *Technion Israel Institute of Technology, Israel*

S&I 8: Ultrafast Optics, Optoelectronics and Applications

Isolated Attosecond Continua in the Water Window via High Harmonic Generation using a Few-cycle Infrared Light Source, Nobuhisa Ishii; *Institute for Solid State Physics, Japan*

Synthesizing Optical Fields of Arbitrary Shape, Andy Kung; *National Tsing Hua University, Taiwan*

Performance Scaling of Ultrafast Laser Systems by Coherent Addition of Femtosecond Pulses, Jens Limpert; *Friedrich-Schiller-Universität Jena, Germany*

S&I 9: Components, Integration, Interconnects and Signal Processing

Breaking the Conventional Limitations of Microring Resonators, Joyce Poon; *University of Toronto, Canada*

InP-Based 100 Gb/s Coherent Receiver Technologies, Hideki Yagi; *Sumitomo Electric Industries Ltd, Japan*

S&I 10: Biophotonics and Optofluidics

Shaping the Future of Biophotonics: Imaging and Manipulation, Kishan Dholakia; *University of St Andrews, UK*

Fluorescence Lifetime Imaging for Biomedicine, Paul French; *Imperial College London, UK*

Computational Imaging and Sensing for Biophotonics Applications, Aydogan Ozcan; *Univ. of California Los Angeles, USA*

S&I 11: Fibers, Propagation and Nonlinear Effects, Lasers, Devices and Materials

The Photonic Lantern, Timothy A. Birks; *Univ. of Bath, UK*

Fiber Laser for Accelerators, Ingmar Hartl; *DESY, Germany*

Phase-locked Multicore Fiber Lasers, Akira Shirakawa; *University of Electro-Communications, Japan*

Tunable Sources from the Visible to Vacuum-UV based on Gas-filled Hollow-core Photonic Crystal Fibers, John Travers; *Max Planck Institute, Germany*

Ultra-long Fibre based Random Lasers, Sergei Turitsyn; *Aston University, UK*

S&I 12: Lightwave Communications and Optical Networks

Novel Fiber and Devices for Space-multiplexed Transmission, Guifang Li; *Univ. of Central Florida, USA*

Signal Regeneration Techniques for Advanced Modulation Formats, Francesca Parmigiani; *Univ. of Southampton, UK*

S&I 13: Active Optical Sensing

Instantaneous Volumetric Combustion Diagnostics , Lin Ma; *Virginia Tech Univ., USA*

Solvent-driven Ionic Processes: Surface Adsorption and Cation-Cation Pairing, Studied by X-ray Absorption and UV-SHG Spectroscopy, Richard James Saykally; *Univ. of California Berkeley, USA*

S&I 14: Optical Metrology

High Sensitivity Gravity Measurement with Cold Atom Interferometry, Zhongkun Hu; *Huazhong Univ of Science and Technology, China*

Optical Atomic Clocks for a Future New Definition of the Second, Fritz Riehle; *Physikalisch Technische Bundesanstalt, Germany*

S&I 15: LEDS, Photovoltaics and Energy-Efficient ("Green") Photonics

Auger Recombination in Light Emitting Materials, Emmanouil Kiopakis; *Univ. of Michigan, USA*

Nanowire-based LEDs and Photovoltaics, Lars Samuelson; *Lund University, Sweden*

QELS-Fundamental Science

FS 1: Quantum Optics of Atoms, Molecules and Solids

Building Quantum Networks with Ions in Optical Cavities, Tracy Northup; *University of Innsbruck, Austria*

Quantum Information and Networks with Spins in Diamond , Tim Hugo Taminiau; *Kavli Institute of Nanoscience Delft, Netherlands*

FS 2: Quantum Science, Engineering and Technology

Atoms, Ions and Photons for Quantum Tasks: Strengths and Weaknesses, Julio Barreiro; *University of California at San Diego, United States*

Quantum Information Processing with Photons, Yuao Chen; *Univ. of Science and Tech. of China (USTC), China*

FS 3: Metamaterials and Complex Media

Densities of States, Dynamics and Intensity Profiles of Transmission Eigenchannels of Opaque Media , Azriel Genack; *CUNY Queens College, United States*

Thermal Emission Control with Surface Waves, Jean-Jacques Greffet; *Institut d'Optique, France*

FS 4: Optical Excitations and Ultrafast Phenomena in Condensed Matter

Observation of Floquet-Bloch States in Topological Insulators, Nuh Gedik; *MIT, USA*

Optoelectronics of 2D-Semicondcutors, Xiadong Xu; *Univ. of Washington, USA*

FS 5: Nonlinear Optics and Novel Phenomena

Inducing Giant Nonreciprocal Effects in Metamolecules, Metasurfaces and Metamaterials, Andrea Alu; *Univ. of Texas at Austin, USA*

Optical Phenomena in Graphene/Boron Nitride Heterostructures, Feng Wang; *Univ. of California Berkeley, USA*

FS 6: Nano-Optics and Plasmonics

Coherent Plasmonics: Optimized for Sensing and Energy Transfer, Naomi Halas; *Rice Univ., USA*

Plasmonic Biosensors and their Analytical Applications, Jiri Homola; *Academy of Sciences of the Czech Republic, Czech Republic*

FS 7: High-Field Physics and Attoscience

Lightwave Control of Plasma Mirrors, Rodrigo B. Lopez-Martens; *Laboratoire d'Optique Appliquée, France*

High Energy Ion Acceleration and Neutron Production using Relativistic Transparency in Solids , Markus Roth ; *Technische Universität Darmstadt, Germany*

Special Symposia

Special Symposium in Memory of James P. Gordon

Sponsored by
Bell Labs, Alcatel-Lucent
Department of Physics, Columbia University
The OSA Foundation

Monday, 9 June, 18:30 - 20:30

Symposium Organizers

René-Jean Essiambre, *Bell Labs - Alcatel-Lucent, USA*
Herwig Kogelnik, *Bell Labs - Alcatel-Lucent, USA*
Susie Gordon

James P. Gordon, one of the founding fathers of quantum electronics, passed away on June 21, 2013. This symposium celebrates his work and life.

Distinguished speakers, including close collaborators of Jim, will recount some of his numerous scientific and technical contributions. These include the discovery of the maser (Microwave Amplification by Stimulated Emission of Radiation), work on the "optical maser" (laser), the birth of quantum information theory, the theory of the confocal resonator, fundamentals of laser cooling and trapping, the first solitons in optical fibers and the theory of optical soliton communication systems. The speakers will share anecdotes with the audience and provide historical reminiscences. We will also learn about the singular philosophy that guided Jim's work, an inspiration to us all.

This symposium is a unique opportunity to hear personal recollections from colleagues about their work with Jim.

Sneak Preview: Read about personal recollections featured in the May issue of Optics & Photonics News.

Invited Speakers

The Early Days of Laser Trapping
Arthur Ashkin, *Bell Labs - Alcatel-Lucent, USA* (retired)

The History of the Confocal Resonator
Gary D. Boyd, *Bell Labs - Alcatel-Lucent, USA* (retired)

Laser Cooling and Trapping
Steven Chu*, Stanford Univ., USA (formerly Bell Labs - Alcatel-Lucent)*
1997 Nobel Prize in Physics Recipient

Solitons in Optical Fibers
Linn Mollenauer, *Bell Labs - Alcatel-Lucent, USA* (retired)

The Impact of the Maser on the Discovery of the Cosmic Background Radiation
Arno Penzias, *Bell Labs - Alcatel-Lucent, USA* (retired)
1978 Nobel Prize in Physics Recipient

The Birth of Quantum Communications
Mark Shtaif, *Tel-Aviv Univ., Israel*

A Historical Perspective on the Maser and Laser
Charles Townes, *Univ. of California*, *Berkeley, USA (formerly Columbia Univ.)*
1964 Nobel Prize in Physics Recipient
Tony Heinz, *Columbia Univ., USA*

Advanced Ultrashort Pulse Laser Technologies in Biophotonics and Nanobiophotonics

Thursday, June 12, 14:00 – 18:30

Willow Glen I, Marriott

Symposium Organizers

Ilko Ilev, *U.S. Food and Drug Administration, USA*

Emma Springate, *Science and Technology Facilities Council, UK*

Category: Applications & Technology

Over the past decade, laser medicine has expanded greatly in a broad range of biomedical areas spanning from various biophotonics applications such as minimally invasive diagnostics, bioimaging, biosensors and targeted therapeutics to nanobiophotonics. A recent advancement in medical laser technology is the development and extensive application of highly effective and compact ultrashort pulse (USP) lasers with pulse durations in the picosecond and femtosecond ranges. The USP lasers have the ability to generate extremely high peak powers while utilizing relatively low nano-joule pulse energies. This is a significant advantage because low pulse energies reduce the collateral damage and unintended effects during USP laser medical procedures while providing submicron tissue manipulation with improved accuracy and repeatability, faster operating and healing characteristics, reduced complication rate, and better patient satisfaction and clinical outcome.

The focus of the CLEO Symposium on "Advanced Ultrashort Pulse Laser Technologies in Biophotonics and Nanobiophotonics" is to provide an interdisciplinary forum for presenting recent state-of-the-art developments of USP laser based technologies employed in the areas of biophotonics and nanobiophotonics. The Symposium objective will cover a broad range of technical fields including but not limited to some advanced USP laser applications in both fundamental and technological areas of biophotonics and nanobiophotonics such as: ophthalmology; dermatology; dentistry; targeted cancer therapy; drug delivery and development; precise single cell and neuron surgery; nonlinear/multiphoton imaging; USP laser-nanoparticle interactions in novel therapeutic technologies and medical devices; nanoparticle manipulation, fragmentation and synthesis; safety and efficacy evaluation at USP laser-tissue interactions.Advanced Ultrashort Pulse Laser Technologies in Biophotonics and Nanobiophotonics

Why such a Symposium?

The development of innovative ultrashort pulse (USP) laser based technologies and medical devices is an emerging field in modern biomedicine with significant public health interest and applications in a variety of biophotonics and nanobiophotonics areas. This Symposium aims to highlight the recently developed state-of-the-art USP laser technologies and applications with emphasis on the advanced features, potential limitations and future trends in these technologies. The Symposium topics will be interested to a broad audience of CLEO participants in both fundamental and technological areas of biophotonics and nanobiophotonics.

Invited Speakers

Plasmonic Nanobubble Theranostics: Detection and Destruction of Drug-Resistant Tumors in a Single Rapid Procedure, Dmitri Lapotko, *Rice Univ., USA*
Ultrafast Laser Induced Ion Beams for Proton Therapy, Paul McKenna, *University of Strathclyde, UK*

Advances in Short-Pulse Fiber Lasers for Nonlinear Microscopy, Frank Wise, *Cornell University, USA*

Advances in Molecular Imaging

Monday, 9 June, 8:00 -12:30
Willow Glen I, Marriott

Symposium Organizers

Ali Azhdarinia, *Univ. of Texas Health Science Center, USA*
Yu Chen, *Univ. of Maryland, USA*
Xavier Intes, *Rensselaer Polytechnic Inst., USA*

Category: Applications & Technology

Molecular imaging has a great potential to impact medicine by early detection of diseases, identification of disease stage and extend, selection of personalized treatment, and application of targeted therapies. Optical molecular imaging technologies, which exploit the interaction of light with tissue, either based on intrinsic molecular properties, or extrinsic molecular-specific contrast agents, may add many important advantages to the imaging options currently available to physicians and researchers. The aim and scope of this special symposium are to provide a novel strong and established source of information to introduce CLEO audience to this technology and its clinical applications; to review and share recent developments in novel optical molecular imaging techniques; and to demonstrate the clinical potential of optical molecular imaging. The speakers are renowned scientists and industry leaders that set the trend in this field.

Invited Speakers

NIR Fluorescent Contrast Agents for Detection of Inflammation of Lungs in vivo, Mikhail Berezin, *Washington Univ. at St. Louis,USA*

In vivo Molecular Imaging using Cerenkov Luminescence, Simon Cherry, *University of California Davis, USA*

Clinical Translation of near-infrared image-guided Surgery: Where do we Stand?, Sylvain Gioux, *Harvard Medical School, USA*

Molecular Imaging for Early Cancer Diagnosis, Surgery and Therapy, Quyen Nguyen, *Univ. of California at San Diego, USA*

Emerging Trends with Molecularly Targeted Optobeacons for Photoacoustic Tomographic Imaging, Dipanjan Pan, *Univ. of Illinois at Urbana-Champaign, USA*

3D Optoacoustic Tomography: From Molecular Targets in Mouse Models to Functional imaging of Breast Cancer, Alexander Oraevsk, *TomoWave Laboratories, USA*

Clinical Translation and Discovery with Near-infrared Fluorescence Lymphatic Imaging, John Rasmussen, *The University of Texas Health Science Center-Houston, USA*

Advances in Neurophotonics

Friday, 13 June, 8:00 – 12:30

Executive Ballroom 210B, Convention Center

Symposium Organizers

Nick Iftimia*, Physical Sciences, USA*

Jin Kang, *John Hopkins Univ., USA*

Category: Applications & Technology

Advanced optical methods are becoming central to neuroscience research. The symposium highlights neurophotonics technologies that enable mapping brain activity and function with a special emphasis on the technologies that enable imaging and sensing of live brains. The importance of this multidisciplinary field and its possible implication to the new national science initiative, Brain Activity Map, will be presented by the distinguished invited speakers from the field.

Invited Speakers

Serial Optical Coherence Scanner for Brain Imaging and Mapping, Taner Akkin, *Univ. of Minnesota, USA*

Optogenetic Approaches for Deciphering the Neural Circuits of the Cortex, Solange Brown, *Johns Hopkins Univ. School of Medicine, USA*

High Resolution Imaging of Live Animals for Early Detection of Diseases, Daniel Cote, *Centre de Recherche de l'Institut en Sante Mentale de Quebec, Canada*

Visible Brain-wide Networks at Single-neuron Resolution with Micro-Optical Sectioning Tomography, Qingming Luo, *Huazhong Univ. of Science and Technology, China*

High-Resolution Optical Microscopy Imaging of Cortical Oxygen Delivery and Consumption, Sava Sakedzic, *MGH, USA*

Optical Coherence Imaging of Hemodynamics, Metabolism, and Cell Viability during Brain Injury, Vivek Srinivasan, *Univ. of California at Davis, USA*

Non-invasive 3D Optical Imaging of Tissue Microstructure and Microcirculations in Vivo, Ruikang Wang, *Univ. of Washington, USA*

Enabling Photonics Technologies for Miniaturization

Monday, 9 June, 13:30 – 18:00

Salon I & II, Marriott

Symposium Organizers

Yves Bellouard, *Eindhoven Univ. of Tech., Netherlands*

Saulius Juodkazis, *Swinburne University of Technology, Australia*

Timo Mappes, *Carl Zeiss, Germany*

Category: Applications & Technology

From consumer products such as smart phones, to portable point-of-care diagnosis like optofluidics biochips, from implantable devices such as artificial retinas, to energy-harvesting devices like dye-sensitized photovoltaics including highly integrated information processing devices exploring the future of quantum computing, photonics plays an essential and leading role in technology miniaturization and integration.

This symposium will explore novel photonics-based design concepts, devices and related manufacturing processes enabling further technology integration as well as fundamental aspects of photonics at the nanoscale.

Invited Speakers

Management of the Photon Orbital Angular Momentum at Small Scale, Etienne, Brasselet, *Université de Bordeaux, France*

Light-guided Nano-Torchs in Mesoscopia, Jesper Glückstad, *DTU, Denmark*

Recent Advances in Ultrafast Laser Nanostructuring: S-waveplates and Eternal Data Storage, Peter Kazansky, *Univ. of Southampton, UK*

Microfabricated Optically-Pumped Magnetometers, Senvja Knappe, *Univ. of Colorado Boulder, USA*

Mapping (slow) Light at the Nanoscale: Don´t Forget the Magnetic Field, L. Kobus Kuipers, *Universiteit Twente, Netherlands*

Optically Driven Microfluidic Devices Produced by Two-photon Microfabrication, Shoji Maruo, *Yokohama Univ., Japan*

Fabrication of Subwavelngth Optics using Glass Imprint Process, Junjii Nishii, *Hokkaido Univ., Japan*

Micro-optics Technology Supply Chain as Key-enabler for Applied Research and Industrial Innovation, Hugo Thienpont, *Vrij Univ Brussels, Belgium*

High Performance Optics

Thursday, 12 June, 14:00 – 18:30

Meeting Room 212 A/C, Convention Center

Symposium Organizers

Jeff Bude, *Lawrence Livermore National Lab, USA*
Constantin Leon Haefner, *Lawrence Livermore National Lab, USA*
Christopher Stolz, *Lawrence Livermore National Lab, USA*

Category: Joint Applications & Technology/Science & Innovations

The need for high quality, high performance optics is becoming increasingly important in applications as diverse as large-scale scientific platforms, laser-based manufacturing, directed energy systems and optics for space or other large aperture systems. These systems require long-lifetime stable optics capable of handling high peak power, high pulse energies, and high average power and often are required to operate in extreme environments. Topics for this symposium may include laser induced damage (physics, scaling, mitigation and repair); advanced high performance materials and coatings for lenses, mirrors, diffraction gratings, conversion crystals, fiber optics and gain-media; large-scale precision optics and low cost manufacturing processes for high performance optics.

Invited Speakers

Metrology and Coatings for the 40 kg LIGO Optics, Rana Adhikari, *California Inst. of Tech., USA*

Defect-driven Laser-induced Damage in Optical Coatings, Xinbin Cheng, *Tongji Univ., China*

James Webb Space Telescope: Optical Performance of a Large Deployable Cryogenic Telescope, Paul Lightsey, *Ball Aerospace and Tech. Corp., USA*

Dispersive Mirrors for Short Pulse Lasers, Vladimir Pervak, *Ludwig Maximilian Univ. of Munich, Germany*

State of the Art Optical Materials for Lithographic Systems for Semiconductor Manufacturing, Ralf Takke, *Heraeus Quarzglas GmbH, Germany*

Large-scale Silicon Photonic Integration

Monday, 9 June, 13:30 – 18:00

Salon V & VI, Marriott

Symposium Organizers

Po Dong, *Alcatel-Lucent Bell Labs, USA*

Christian Malouin, *Juniper, USA*

Jessie Rosenberg, *International Business Machines Corp., USA,*

Category: Science & Innovations

Silicon photonic devices and integrated circuits have undergone rapid and significant progress during the last decade, transitioning from research topics in universities to product development in corporations. Silicon photonics is anticipated to be a disruptive optical technology for data communications, with applications such as intra-chip interconnects, short-reach communications in datacenters and supercomputers, and long-haul optical coherent transmissions. More applications in sensing, metrology, RF photonics, and optical signal processing are also anticipated, as well as many novel on-chip functionalities enabled by integration with MEMS, fluidics, graphene, plasmonic devices, III-V semiconductors, CMOS ICs, etc. Is silicon photonics mature enough for industry, or there are still many remaining challenges? If there are technical challenges to be solved, what are they? This symposium will discuss the current status of silicon photonics and the barriers which are left to overcome.

Invited Speakers

Silicon Photonics Transmitters and Receivers for 4x25 Gb/s Interconnects, *Mehdi Asghari, Kotura, USA*

Silicon PICs for Telecomm, Chris Doerr, *Acacia Communications, USA*

Heterogeneous Integration on Silicon, Alex Fang, *Aurrion, USA*

CMOS integrated Silicon Photonics – Does it make Sense?, Wilfried Haensch, *IBM, USA*

Silicon-Organic Hybrid - A Compact and Energy Efficient CMOS Compatible Active Silicon Photonic Solution, Juerg Leuthold, *ETH Zurich, Switzerland*

Ge-on-Si Integrated Photonics, Jifeng Liu, Dartmouth Univ., USA

Very Large Scale Silicon Photonics Integration, *Michael Watts, MIT, USA*

WDM Silicon Photonics for Chip-scale Interconnects, Xuezhe Zheng, *Oracle, USA*

Laser-Driven Sources of Particle and X-ray Beams

Thursday, 12 June, 8:00 – 10:00; 14:00 – 18:30
Salon I - II, Marriott
Symposium Organizers

Sergei Tochitsky, *Univ. of California at Los Angles, USA*
Donald Umstadter, *Univ. of Nebraska Lincoln, USA*
Simon Hooker, *Univ. of Oxford, UK*
Francois Légaré, *INRS, Canada*

Category: Joint Applications & Technology/Science & Innovations

High-gradient advanced laser-driven electron and ion acceleration schemes are based on energy transfer from the relativistic (1018-1020 W/cm2) laser field to electron oscillations.
Acceleration process is related to excitation of electron plasma waves in the case of electrons and production of strong electrical fields generated by displaced electrons in the case of ions. Very high gradient of acceleration opens possibility to decrease the size and cost of accelerators by orders of magnitude, while also producing particle beams with duration and emittances not achievable with conventional RF devices. During the last decade plasma based particle accelerators have generated 0.1-2 GeV electron beams and 2-30 MeV proton beams with narrow energy spread.

The symposium will cover three main issues:
1) Laser-driven acceleration of electrons and ions and their application to production of positron and neutron beams.
2) Application of laser-accelerated particles to the generation of X- and gamma-rays by Bremsstrahlung, betatron radiation, Compton scattering, and XFEL processes.
3) Development of high-energy, high-average power lasers for driving plasma based accelerators.

The symposium will focus on the continuing transformation of plasma accelerators from being an object of scientific research to driving new applications. The potential applications of laser-driven particle accelerators in physics, biology and medicine will be discussed. The symposium will cover current status and new trends in development of laser-drivers for the plasma based accelerators including OPCPA systems, DPSSLs, Fiber lasers, Ti:Sapphire lasers and gas lasers.

Invited Speakers

Current Status and Future Prospects of Laser-driven Ion Sources, Marco Borghesi, *Queen's Univ. of Belfast, UK*

X-ray Emission from Laser-accelerated Electrons and its use as Diagnostic of Laser-plasma Interaction, Sebastian Corde, *SLAC - Stanford Univ., USA*

Laser Plasma Acceleration using the PW-class BELLA Laser, Wim Leemans, *Lawrence Berkeley National Lab., USA*

Producing Bright X-rays for Imaging Applications using a Laser Wakefield Accelerator, Stuart Mangles, *Imperial College, UK*

Picosecond Thin-Disc Lasers, Thomas Metzger, *TRUMPF Scientific Lasers, USA*

Status of High-Energy OPCPA at LLE and Future Prospects, Jonathan D. Zuegel, *Univ. of Rochester, USA*

Laser Processing for Consumer Electronics

Tuesday, 10 June, 14:00 – 18:30
Salon I & II, Marriott
Symposium Organizers

Jiyeon Choi, *Korea Inst. of Machinery & Materials, South Korea*
Eric Mottay, *Amplitude Systemes, France*

Category: Joint Applications & Technology/Science & Innovations

Photonics, especially lasers, have been recognized both by the National Photonics Initiative in the U.S. and the European Union as a key enabling technology, at the heart of many real life applications. This is especially true for consumer electronics, in which lasers are ubiquitous, from the cell phone to computer to advanced display. This symposium will review advanced and emerging applications in which lasers play significant roles in present and future manufacturing processes.
Invited Speakers

Laser Cutting of Flexible Glass, Xinghua Li, *Corning Glass, USA*

Laser Direct Ablation for Patterning Printed Wiring Boards Using Ultrafast Lasers and High Speed Beam Delivery Architectures,Hisashi Matsumoto, *Electro Scientific Industries, USA*

Opaque Film Metrology using PULSE Technology, Manjusha Mehendale, *Rudolph Technologies, USA*

High Throughput Laser Processing with Ultra-Short Pulses by High Speed Line-Scanning in Synchronized Mode, Beat Neuenschwander, *Bern University of Applied Sciences, Germany*

Ultrafast Laser Processing and Metrology, Keiji Nomaru, *Disco Corporation, Japan*

Laser Processes for Development of Advanced Lithium-Ion Batteries – Increased Capacity and Cycle Life-Time, Wilhelm Pfleging, *Karlsruher Institut für Technologie; Karlsruhe Nano Micro Facility, Germany*

Laser Micronanostructuing for High-performance Organic Optoelectronic Devices, Hong-Bo Sun, *Jilin University, China*

Microcavity Exciton-polaritons, Devices and Applications

Tuesday, 10 June, 14:00 – 18:30
Salon V & VI, Marriott
Symposium Organizers

Marcelo Davanco, *NIST, USA*
Stephane Kena-Cohen, *Imperial College London*, *UK*
Vinod Menon, *Queens College CUNY, USA*

Category: Science & Innovations

This symposium covers fundamental phenomena and applications of microcavity exciton-polaritons towards the realization of a novel class of integrated, micro/nano photonic and optoelectronic devices. The field of microcavity polaritons is extremely rich in new fundamental effects which point towards a new generation of optoelectronic devices. Cavity polaritons are exciton-photon mixed states arising from the strong coupling between an optical cavity mode and excitons confined within the optical cavity. Typically, such strongly-coupled microcavity systems are realized in inorganic semiconductor material such as GaAs by sandwiching an excitonic medium between two distributed-feedback mirrors. More recently, strong coupling has also been demonstrated in cavities embedded with organic materials. The optical properties of such strongly coupled cavities are of great interest because cavity polaritons simultaneously possess properties of light (photons) and matter (excitons). Due to their photonic component, cavity polaritons have extremely small effective masses (~10-4 times that of an electron), and can propagate at speeds ~1% of the speed of light. At the same time, cavity polaritons display strong nonlinear interactions typical of electronic states, due to their excitonic component. Among the exciting new phenomena observed in such systems are: nonlinear processes such as parametric scattering and optical bistability, which, induced by polariton-polariton interactions, have been observed at power thresholds orders of magnitude lower than in dielectric crystals; non-equilibrium Bose-Einstein condensation and phenomena typical of superfluids (for instance, propagation of a coherently driven condensed polariton phase has been demonstrated); polariton lasing at room temperature, with threshold carrier densities orders of magnitude lower than photon lasing. While the great majority of demonstrations in this field have been of fundamental nature, more recently there has been a surge in interest in using cavity polaritons for more practical photonic/optoelectronic devices. Specifically, there have been proposals for realizing ultralow energy polariton switches and integrated polaritonic logic circuits. This symposium will cover topics such as polariton condensation, nonlinear optics and novel device concepts and architectures, with the aim of promoting the development of a novel class of photonic and optoelectronic devices based on polaritonic phenomena.

Invited Speakers

Polariton Lattices for Quantum Simulation, Alberto Amo, *LPN / CNRS, France*

Single-mode Polariton Laser in a Designable Microcavity, Hui Deng, *Univ. of Michigan, USA*

Spectroscopy of Strongly-coupled Organic Semiconductor Microcavities, David Lidzey, *Univ. of Sheffield, UK*

Persistent Current of a Microcavity Polariton Condensate in a Ring Geometry, David Snoke, *Univ. of Pittsburgh, USA*

Novel Light Sources and Photonic Devices in Optical Imaging

Tuesday, 10 June, 14:00 – 18:30

Willow Glen I, Marriott

Symposium Organizers

Charles Lin, *Massachusetts General Hospital, USA*

Nick Iftimia, *Physical Sciences Inc., USA*

Ben Vakoc, *Massachusetts General Hospital, USA*

Category: Applications & Technology

Over the past decade, optical imaging has been increasingly adopted into clinical medicine and biological research. This has motivated the development of numerous novel and enabling source and photonic technologies. These technologies serve to both advance the performance of optical imaging tools, and to make them more robust, inexpensive, and deployable. This symposium will cover some of these recent technologies and their potential to impact optical imaging.

Invited Speakers

Next Generation Swept-sources for OCT and Other Applications, Brian Goldberg, *Axsun Technologies, USA*

Advancements in Nanophotonic-based Optical Coherence Tomography, Nicholas Sherwood, *Tornado Spectral Systems, USA*

Multiphoton Imaging and Manipulation of Biological Systems, Jeff Squier, *Colorado School of Mines, USA*

Laser Sources for Deep Tissue Multiphoton Imaging, Chris Xu, *Applied and Engineering Physics, Cornell University, USA*

Optofluidic Microsystems

Friday, 13 June, 08:00 – 12:00
Salon I-II, Marriott

Symposium Organizers

Andreas Vasdekis, *Pacific Northwest National Lab. and Washington St. Univ., USA*
Ian White, *Univ. of Maryland, USA*

Category: Applications & Technology

This symposium aims to highlight emerging trends in optofluidics and their application in microsystems. Optofluidics, defined as the synergistic combination of photonics technologies and microfluidics, first appeared approximately a decade ago. Initial applications centered on the employment of fluidic waveguides for chemical and biomolecular analysis. In recent years, optofluidics has broadened and has enabled a number of new and unique solutions. This symposium will feature new, important, and practical trends in optofluidics, including optofluidic lasers, optofluidics for energy, optofuidic particle manipulation, optofluidic cellular analysis, and future paths for optofluidics.

Invited Speakers

Optofluidic Bio-Lasers: Bridging Photonics, Nanotechnology, and Biology, Xudong Fan, *Univ. of Michigan, USA*

Optofluidic Manipulation and Sorting for Small Size Particle and Bio-molecule, Ai-Qun Liu, *Nanyang Technological Univ., Singapore*

Optofluidics, 10 Years Later, Demetri Psaltis, *Ecole Polytechnique Federale de Lausanne, Switzerland*

Optofluidic Integration: Past, Present, and Future, Holger Schmidt, *Univ. of California at Santa Cruz, USA*

Quantum Repeaters

Tuesday, 10 June, 11:00 – 13:00; 14:00 – 16:00
Executive Ballroom 210A, Convention Center

Symposium Organizers

Jungsang Kim, *Duke Univ., USA*
Masahide Sasaki, *NICT, Japan*
Wolfgang Tittel, *Univ. of Calgary, Canada*
Category: QELS- Fundamental Science
The current state of quantum communication to distribute quantum resources over long distances is seriously hampered by exponential loss of the quantum information carriers (typically photons) as a function of distance in the communication channel. In classical communications, such loss can be overcome by use of regenerators or optical amplifiers, and communication systems can be successfully constructed with reach beyond the distances limited by fiber loss. Neither signal regeneration nor optical amplification can be directly applied to quantum communication channels. Quantum repeaters, which utilize quantum entanglement, quantum memories and quantum teleportation, are currently heavily researched to successfully extend the reach of quantum communication.

Since the first proposal for quantum repeaters was made some fifteen years ago, there has been tremendous progress in advanced quantum repeater protocols that can dramatically enhance both the reach and bit rate of quantum communication. At the same time, various experimental schemes have been proposed, components developed, and early experimental efforts are under way towards the realization of a quantum repeater. Despite the progress, significant challenges remain, first in the proof-of-principle demonstration and then in the practical system development adequate for deployment in the field.

The goal of this symposium is to bring the active research community together to discuss the progress, challenges and new possible directions for quantum repeater realization. The symposium invites researchers working on advanced protocols, physical realizations, key enabling technologies and system integration efforts towards the demonstration of quantum repeaters and future long-reach quantum communication networks.

Invited Speakers

Ultrafast Quantum Repeaters for Long Distance Quantum Communication, Liang Jiang, *Yale Univ., USA*

Quantum Repeater Approach based on Diamond Spin Qubit, Hideo Kosaka, *Tohoku Univ., Japan*

Toward a Quantum Network based on Semiconductor Quantum Dots, Pascale Senellart, *CNRS-Laboratoire de Photonique et Nanostructures, France*

Science and Applications of Structured Light in Complex Media

Wednesday, June 11, 10:30 – 12:30; 16:30 – 18:30

Executive Ballroom 210C, Convention Center

Symposium Organizers

Shuang Zhang, *Univ. of Birmingham, UK*

Xiang Zhang, *Univ. of California Berkeley, USA*

Category: QELS-Fundamental Science

Complex media consisting of subwavelength scale metallic or dielectric structures enable powerful control of the spin and orbit (optical vortex) of light that depend on the physical design of the structures and their constituent materials. These complex media or surfaces allow for the manipulation of angular momentum of photons on both the local (circular polarizations) and global (vortex beam) levels and lay the essential framework for many exciting topics in photonics research. This symposium is to provide a platform for researchers working on interface of structured light and complex media – metamaterials or metasurfaces, to communicate their recent research results. The symposium will highlight fundamentals and diverse applications of structured light in optical communications, antennas, optical sensing, nanoscale imaging, nonlinear optics and optical forces.

Session topics will include (but not limited to):
1. Metasurface for controlling the phase and polarizations of electromagnetic waves.
2. Excitation of surface plasmon polaritions using structured surface
3. Spin-orbital coupling of light mediate by metasurfaces
4. Symmetry and nonlinear phenomena in plasmonics and metamaterials
5. 3D and planar chiral metamaterials
6. Sensing with chiral surfaces

Invited Speakers

Quantum Electromechanical Processes in Plasmonic Nanostructures, Nicholas Fang, *MIT, USA*

Graphene Metadevices and Metamaterials for Linear and Nonlinear THz Applications, Bumki Min, *Korea Advanced Institute of Science and Tech., South Korea*

Resonating Metasurface Photon and its Spin Manipulation, Xiaobo Yin, *Univ. of Colorado Boulder, USA*

Controlling Light Propagation in Optical Waveguides Using One Dimensional Phased Antenna Arrays, Nanfang Yu, *Columbia Univ., USA*

Howard Schlossberg Retirement Symposium

Sunday, 8 June, 16:00-18:00

Howard “Howie” R. Schlossberg, the Air Force Office of Scientific Research program officer for optical sciences, has made critical contributions to the field of optics and lasers throughout his eminent career. He has guided research in diverse areas, such as ultra-fast optoelectronic techniques, nonlinear optics, laser cooling, and medical laser treatments. Dr. Schlossberg is a Fellow of OSA, IEEE, and ASLMS.

This symposium will highlight some of the scientific advances enabled by Dr. Schlossberg, combined with personal anecdotes, in honor of the occasion of his retirement.

Invited Speakers

Rox Anderson, *Harvard Medical School & Massachusetts General Hospital, USA*

James Fujimoto, *MIT, USA*

Tayyaba Hasan, *Wellman Center at Harvard Medical School, USA*

Erich Ippen, *MIT, USA*

Margaret Murnane, *Univ. of Colorado at Boulder, USA*

Plenary Session

Tuesday, 10 June

Gerhard Rempe, Max-Planck-Institut fur Quantenoptik, Germany

QELS- Fundamental Science

Abstract:

Quantum Coherent Networks

Cavity quantum electrodynamics with singlea toms is an ideal platform for the implementation of a quantum-coherent network featuring long-distance quantum-state transfer, controlled atom-atom entanglement, atomic-state teleportation and non-destructive detection of flying photons.

Biography: In 1992 he accepted an appointment as professor of experimental physics at the University of Konstanz, Germany. In 1999 he became a scientific member of the Max Planck Society, director at the Max Planck Institute of Quantum Optics in Garching, Germany, and professor at the Technical University of Munich.

After studying mathematics and physics at the Universities of Essen and Munich, Germany, Gerhard Rempe obtained his doctorate in 1986 and his postdoctoral teaching qualification (habilitation) in 1990 from the University of Munich. He then worked as a lecturer and Millikan Fellow at the California Institute of Technology, Pasadena

Tuesday, 10 June

Larry A. Coldren, UC-Santa Barbara, USA
Science & Innovations

Abstract:
Photonic Integrated Circuits as Key Enablers for Datacom, Telecom and Sensor Systems
After many years in the research lab, photonic integrated circuits (PICs) are emerging into practical commercial products with advantages not only in size, weight and power (SWaP), but also in cost and performance. They will and must enable much more in the future.

Biography: Larry A. Coldren is the Fred Kavli Professor of Optoelectronics and Sensors at the University of California, Santa Barbara, CA. After receiving his Ph.D. in Electrical Engineering from om Stanford University and spending 13 years in research at Bell Laboratories, he joined UC-Santa Barbara in 1984 where he now holds appointments in Materials and Electrical & Computer Engineering. Since 1990 he has been Director of the Optoelectronics Technology Center, which resulted from a national initiative originated by DARPA. He was Acting Dean of Engineering from 2009-2011. In 1990 he co-founded Optical Concepts, later acquired as Gore Photonics, to develop novel VCSEL technology; and in 1998 he co-founded Agility Communications, later acquired by JDSU, to develop widely-tunable integrated transmitters.

At Bell Labs Coldren researched surface-acoustic-wave filters and later tunable coupled-cavity lasers using novel reactive-ion etching (RIE) technology that he developed for the then new InP-based materials. At UCSB he continued work on multiple-section tunable lasers, in 1988 inventing the widely-tunable multi-element mirror concept, which is now used in numerous commercial products. Near this same time, he also made seminal contributions to efficient vertical-cavity surface-emitting laser (VCSEL) designs that continue to be implemented in practical devices. More recently, Prof. Coldren's group has developed high-performance InP-based photonic integrated circuits (PICs) as well as high-speed, high-efficiency VCSELs, and they continue to advance the underlying materials growth and fabrication technologies.

Professor Coldren has authored or co-authored over a thousand journal and conference papers, a number of book chapters, two textbooks, and has been issued 65 patents. He is a Fellow of the Institute of Electrical and Electronics Engineers, the Optical Society of America, and the Institute of Electronics Engineers (UK), a recipient of the 2004 John Tyndall, 2009 Aron Kressel, and 2014 David Sarnoff Awards, as well as being a member of the National Academy of Engineering.

Wednesday, 11 June

David Payne, Univ. of Southampton, UK
Applications & Technology

Abstract:
Fibres and the future
The great success of optical fibres in telecommunications has generated numerous applications in a number of related fields, such as sensing, biophotonics and high-power lasers. However, the topic remains extraordinarily buoyant and new materials, structure and applications emerge unabated. The talk will review recent developments and explore future possibilities.

Biography: Prof Sir David Payne received his BSc, MSc and PhD from the University of Southampton (1963-1974) where he is currently Professor of Photonics and Director of the Optoelectronics Research Centre (ORC) and the Zepler Institute. He has published over 650 Conference and Journal papers and is co-inventor on over 40 patents.

Over the last forty years, he has made numerous key contributions in optical fibre communications and laser technology. His work in fibre fabrication in the 1970s resulted in most of the special fibres used today, including the revolutionary erbium-doped fibre amplifier (EDFA) and kilowatt-class fibre lasers for manufacturing and defence. He has received the UK Rank Prize for Optics, the 2001 Mountbatten Medal, the 2004 Kelvin Medal for the application of science to engineering, the 2007 IEEE Photonics Award, the 1991 IEEE/LEOS Tyndall Award, the 1998 Benjamin Franklin Medal for Engineering, and is Laureate of the 2008 Millennium Technology Prize. He is also an Eduard Rhein Laureate and a foreign member of the Norwegian and the Russian Academies of Sciences. He is a Fellow of the UK Royal Society, the UK Royal Academy of Engineering, the Optical Society of America, the UK IET and the UK IoP. As an entrepreneur, he founded York Technologies, (now PK Technology Inc.) and SPI Lasers plc (now part of the Trumpf Gruppe). David was knighted in the 2013 New Year's Honours List for services to Photonics Research and Applications. He is this year the IEEE/RSE Wolfson James Clerk Maxwell Awardee.

Market Focus

The CLEO: Market Focus program focuses on the latest trends in the photonics marketplace. CLEO: Market Focus provides a forum to discuss new products and emerging technologies and markets while also providing a networking opportunity within the high-quality atmosphere of the CLEO Conference. All presentations and discussions will be focused on the latest in photonics products and services that have been playing an important role in the industry and those that potentially hold a future business opportunity. A key feature of this forum will be the survey of market trends and market sector outlook in the selected areas.

Market Focus Chair(s)

- Viswa Velur, Business Development, Zygo Corporation, USA, Market Focus 2015 Chair
- Merrill M. Apter, *Vice President North America Sales, Adept Technology, USA*, Market Focus Emeritus Chair

The 2014 Market Focus Program included the folloowing sessions. Please check back for 2015 Programming.

Emerging Mid-Infrared Market Opportunities: Air Quality Monitoring Related to Energy Extraction

Tuesday, 10 June
10:30 -12:30

Moderators:
Joseph X. Montemarano, *Executive Director, MIRTHE, Princeton University, USA*
Joseph X. Montemarano has been involved in state-of-the-art research and commercialization efforts related to environment, health-care, defense and homeland security, advanced materials, computer science and photonic applications throughout his career. Mr. Montemarano has helped large and small companies, and government researchers access emerging technologies, faculty and other university resources resulting in a significant increase in sponsored research, the launch of several spin-off companies, and successful technology commercialization and fielded applications. He joined Princeton University in July 1994, and currently serves as Executive Director for the NSF-Engineering Research Center on Mid-InfraRed Technologies for Health and Environment (MIRTHE) led by Princeton University, and Director for Industrial Enterprise for the Princeton Institute for Science and Technology of Materials (PRISM).

Bernadeta Wysocka, *Industrial Liaison, MIRTHE, Princeton University, USA*
Bernadeta Wysocka is Industrial Liaison for the NSF-Engineering Research Center on Mid-InfraRed Technologies for Health and Environment (MIRTHE) at Princeton University. She is responsible for development of Center's marketing plan and Industrial Partnership Program. She identifies and recruits companies and non-profit organizations as collaborators, sponsors and members of the MIRTHE Center, and develops member retention strategies. She represents MIRTHE Center at national and international meetings, workshops and conferences. Bernadeta also assists students in finding careers in industry and mediates industrial internship programs. She manages industry related grant solicitations. Bernadeta joined the MIRTHE Engineering Research Center in 2008. She holds the M.A. degree in Economics and

Management from University of Economics in Wroclaw, Poland.

Panel Description:
During the process of extracting fuel from the ground it is possible that gases are released into the air. The absence of reliable, comparative data on pre-, concurrent and post- extraction levels of methane and other volatile compounds has led to controversy over the environmental impact of techniques such as hydraulic fracturing of rock for releasing gas and oil. This technique, often known as "fracking", may be used in combination with other extraction techniques such as horizontal drilling to explore considerable expanses. New mid-infrared sensor systems can detect methane as well as other volatile gases down to trace quantities and over wide areas, and hold great promise for detailed benefit-risk assessment of areas designated for energy extraction, as well as long-term monitoring of existing sites. The panel will engage companies, practitioners, policy makers/regulators and other stakeholders to determine optimal requirements for sensor system development and strategies for wide-scale, long-term deployment.

Invited Speakers:
Cost, Concentration and Regulations: Using Optical Techniques in the Oil Field and at Refineries
Alex Cuclis, *Project Manager, Houston Advanced Research Center, USA*

There are environmental costs associated with emissions related to the oil and gas boom include impacts to global warming and air quality ground level ozone and air toxics. The challenge is to develop optical monitoring equipment that can be used to reduce leaks at a reasonable cost to oil and gas operators.

In Colorado, where several towns have banned hydraulic fracturing entirely due to concerns about air, citizen groups and industry have worked with regulators to adopt new rules for monitoring emissions. These rules require periodic checks – and repairs under specified time frames for natural gas leaks. Whether Colorado's model will be adopted by other states is yet to be seen.
Concentrations of emissions are in general lower and less frequent than those found in concentrated refinery and chemical plants. This adds to the challenge – but also to the opportunity for using optical techniques to measure, locate and ultimately reduce emissions.

Alex began working at the Houston Advanced Research Center (HARC) in 2004 as a Research Scientist. Alex has managed numerous projects that involve measurements of air pollutants and improvement of emissions inventories and has been quoted in national radio and newspaper publications on these topics. Alex works closely with the technical support staff at the Texas Commission on Environmental Quality (TCEQ), the Environmental Protection Agency (EPA), and nationally recognized air quality researchers at universities, environmental firms, and government laboratories when working on air quality and climate change issues. Alex consults with business representatives and environmental groups to implement practical solutions. Alex earned his B.S. in Chemical Engineering from UT-Austin, his M.S. in Analytical Chemistry from UI-Urbana, and his M.S. in Behavioral Sciences from the University of Houston-Clear Lake. Alex worked in Cameroon, West Africa as a Peace Corps Volunteer Leader where he supervised 45 Math/Science Peace Corps Volunteer teachers. He worked for 15 years at Shell's Deer Park Refinery and Chemical Plant as a process engineer, and an analyzer engineer. Alex spent three years working on air quality projects for the University of Houston.

Joe Lima, *Global Environmental Solutions Marketing & Technology Manager, Schlumberger Well Services, USA*

Current and Developing Laser Sensors for Wide Area Monitoring of Greenhouse Gases
David Sonnenfroh, *Group Leader, Atmospheric Sciences, Physical Sciences Inc*., USA

The development and promulgation of hydraulic fracturing operations for recovering natural gas and oil has led to the need for effective monitoring of fugitive methane. Methane is a cleaner burning fuel than coal but, as it is a stronger greenhouse gas than carbon dioxide on a per molecule basis, too large a loss from recovery operations can potentially negate this benefit. In addition, leaking methane represents a substantial monetary loss and potential hazard to property and life. New mid-infrared laser-based sensors can detect methane with good precision over wide areas, in order to provide long-term monitoring of sites. This presentation places the fugitive methane source within the overall atmospheric methane budget, reviews basic laser-based sensor technology useful for monitoring fugitive methane, provides examples of current sensor deployments in relevant environments, and looks at challenges for creating laser sensors for widespread deployment that are cost effective and retain high performance.

Dave Sonnenfroh received his Ph.D. in Chemistry from the University of Rochester in 1985. He joined Physical Sciences Inc. in 1990 where he currently is Area Manager for Atmospheric Sciences. One focus of his current research involves the development of semiconductor laser-based sensors for use in tropospheric studies of trace gas transport and chemistry. These sensors are based on both near-IR diode laser and mid-IR quantum cascade laser sources. He has developed sensors for NASA and DOE ground based applications, as well as for research aircraft, including unmanned aerial systems. His group is also developing small footprint solid state laser-based lidars for remote profiling of species in the lower atmosphere, including water vapor and aerosols.

Deploying a DIAL Remote Sensing System in the Canadian Oil Sands: A Regulatory Context His bio is below and a photo attached. The abstract is coming shortly
Michael Wojcik, *Program Manager, Space Dynamic Laboratory, USA*

Often the procedural aspects associated with testing and implementation of new environmental monitoring technologies can dominate the experience of the researcher/technology developer -- often to the point of discouraging innovation. This talk will highlight important scientific, political and policy aspects encountered during the recent of the entire arc of technology rollout of a new-to-Alberta remote sensing technology, Differential Absorption Lidar for wide area sensing of particulate matter, carbon dioxide gas and methane gas.

Dr. Michael D. Wojcik is currently a Senior Scientist and Program Manager for Tactical Sensors at Space Dynamics Laboratory, Utah State University Research Foundation. Dr. Wojcik's research interests range from remote sensing (lidar) of wind and aerosols to trace level detection of atmospheric gas species using molecular laser spectroscopy. Dr. Wojcik's clients include NASA, US Army, US Navy, Alberta Environment, and the USDA-ARS. He received his B.S. in Chemistry from Rensselaer Polytechnic Institute and his Ph.D. in Physical Chemistry from the University of Idaho. After receiving his degrees, Dr. Wojcik held a post-doctoral research fellowship at JILA, University of Colorado - Boulder. Prior to working at Space Dynamics Laboratory Dr. Wojcik was a senior scientist at Pacific Northwest National Laboratory and worked to develop laser based chemical sensors, during which time he also served as an IPA at Dugway Proving Ground to provide expertise on chemical and biological warfare agent detection.

The Solid-State Lighting Revolution: How LEDs are Transforming the $75 Billion Lighting Market

Tuesday, June 10

14:00-16:00

Moderator:

Robert Steele, Independent Consultant in Solid-State Lighting, USA

Dr. Robert Steele is an independent consultant working in the area of solid-state lighting. He retired in March 2010 as the Director of the LED Practice at market research firm Strategies Unlimited, where he had been responsible for all of the company's activities in the area of LED market research and consulting since 1994. From 2000 to 2011, Dr. Steele was the chair of Strategies in Light, North America's largest conference on LEDs and lighting. He is currently the co-chair of Strategies in Light (US) and Strategies in Light Europe, and has also chaired Strategies in Light conferences in Japan and China. He has written regularly for industry publications on LED markets and applications, and has given invited presentations on this subject at major conferences around the world.

Panel Description:

The worldwide lighting market is undergoing a transformation of a magnitude not seen since the invention of the incandescent lamp by Thomas Edison. LED technology has reached a point at which nearly all the lighting applications formerly served by conventional light sources such as incandescent lamps, fluorescent lamps and the like can now be served by LED-based light sources, from flashlights to roadway lights. Although energy efficiency has been the main driver for this transformation, other factors, such as light quality, are now becoming important, and the economics of LED lighting has become attractive in many commercial applications. This panel will focus on the markets, applications and technology of LED lighting, ranging from the top level worldwide market picture to specific applications that highlight the advantages that LEDs bring to the lighting market.

Speakers:

Solid State Lighting Adoption: Benefits and Barriers in LED Streetlight Deployment
Alison Erlenbach, *Program Associate, Bay Area Climate Collaborative, USA*

The San Francisco Bay Area is a national leader in deploying LED street lighting. This presentation seeks to provide an overview of the advantages of LED lighting, outline regional adoption to date, provide insight into the key factors that have accelerated success in the region, and identify common barriers that inhibit agencies seeking to upgrade streetlights. Topics will include:
• Benefits of LED street lighting over incumbent technology in various applications, with a focus on outdoor benefits
• Factors contributing Bay Area and statewide leadership in adopting LED street lighting, including the role of regional incentives, financial issues, and prevailing barriers to SSL adoption
• Main technical considerations and other takeaways from recent municipal procurement efforts
• Market next steps Identifying future opportunities in outdoor solid state lighting in the Bay Area

Bio: Alison Erlenbach has professional experience spanning sustainability implementation, climate change mitigation, energy policy and business development. In her role in the Bay Area Climate Collaborative's Next Generation Streetlight Initiative, she supports Bay Area local governments to drive the deployment of LED streetlight technology throughout the Bay Area. Alison has a BA in Economics from the University of Florida, where she spearheaded multiple campus sustainability initiatives. Her professional experience includes a fellowship at the U.S. Energy Information Administration and climate economics research at Oak Ridge National Laboratory's Carbon Dioxide Information Analysis Center

Market Overview and Forecast of the LED Lighting Market
Shonika Vijay, *Market Research Analyst, Strategies Unlimited, USA*

In the early 2000's white LEDs first became powerful enough to enable their use in general lighting applications. Over the past 10 years the efficiency of the best LEDs has improved by a factor of 10, and prices (per unit of light output) have come down by a factor of fifty. These trends have resulted in a rapid uptake in the adoption of LEDs in general lighting in recent years. This presentation will provide an overview of the market for LEDs in lighting applications, as well as for the lighting products themselves (lamps and fixtures). A five-year market forecast will also be presented.

The Status of Electronic Illumination – A-Lamps and Beyond

Steve Paolini, *Founder and CEO, Telelumen LLC, USA*
Since the dawn of time, humans have endeavored to achieve an on-demand source of illumination. Daylight has been the gold standard for illumination but it's not always around when you need it and even when it is around its difficult to control. Fire was the first alternative source to be tamed and is still valued today. More than 100 years ago an electric lamp was invented that revolutionized artificial illumination and is still in use today. Since then several types of gas discharge lamps have been introduced and more recently electronic illumination in the form of LEDs have become readily available. Arguably these most recent entrants will have the largest impact on our eyes since the sun. This talk will take a brief look at where we have come from and where we are today with respect to illumination on demand. The focus will be on electronic A-lamps (Edison derivatives) because they offer the fastest changing, least expensive way to survey the technology. Finally, a glimpse into what the future of electronic illumination may have in store will be offered.

Bio: Steve Paolini joined Hewlett Packard Optoelectronics Division in 1981 after earning a degree in electrical engineering from the Pennsylvania State University. There he held a variety of engineering and management positions in California, Japan, and Malaysia. In 2000, he joined Philips Lumileds and held management positions in intellectual property, business development, and product development. In 2007 he founded Telelumen LLC to focus on the recording and playback of light. He became the CTO at Lunera Lighting Inc. in 2009 and joined NEXT Lighting Corp. in 2012 as the CTO. He is a frequent speaker at conferences and workshops on a variety of topics relating to solid-state lighting and has been issued nine patents.

Driving Emotion and Building Brands with a New Generation of Light
Thor Scordelis, *Manager Global Product Marketing, Xicato, Inc. USA*
For the vast majority of goods that are purchased, consumers' ability and preference to see, to touch, to feel and to be emotionally engaged means that the bricks and mortar world of retailing has the opportunity to flourish. Notably missing in most retail environments is the use of lighting as more than a functional element. The payoff comes with lighting that drives emotion, behavior and brand memory while also reducing energy costs and minimizing maintenance disruptions.

While effective lighting lets customers "see", purposeful lighting becomes an asset, a gateway to brand value and increased sales. In an emotional purchase environment the difference between blue and BLUE becomes clear and shoppers move from 'like' to 'desire'. Light that makes colors pop brings out the detail of textures in denims, leather and lace or makes tones appear richer and vivid bridges the gap between runway and retail.

New advanced LED and phosphor technologies are being used by color scientists to create new light that can transform the retail lighting experience.

Bio: Thor Scordelis has over 20 years' experience leading luminaire design, engineering, marketing and sales teams. Prior to his current role, Thor was PG&E's Emerging Technologies-Lighting Portfolio Manager where he managed a multi-million dollar research budget focused on assessing the market viability and readiness of emerging lighting technologies. Thor has an undergraduate degree in industrial design, an MBA in marketing, and was a steering committee member and contributor to the development of the lighting chapter of California's Long Term Energy Efficiency Strategic Plan.

Operational Strategies for the Laser and Photonics Industry

Wednesday, June 11
10:30-12:30

Moderator:
Scott Dunbar, *Chief Operating Officer, AdValue Photonics, USA*
Scott Dunbar has over 25 years of general management, operations and engineering leadership experience in the laser, optics and data storage industries. Currently he is the Chief Operating Officer of AdValue Photonics, a leading manufacturer of 2-micron fiber lasers for the materials processing, medical and scientific markets. Previously he was Vice President of Operational Strategy and Transformation at Oclaro where he led the team that developed the strategy to outsource the majority of Oclaro's assembly and test operations to contract manufactures in Asia. As General Manager of Spectra-Physics' and Oclaro's high power diode laser businesses he developed a segmented supply chain model that included both internal and outsourced manufacturing across the globe. Previous positions include: Vice President and General Manager of New Focus and several senior operational leadership positions with increasing responsibility in the disk drive industry with IBM and Read-Rite.

Panel Description:
While the Laser and Photonics industry is becoming more mature, no one manufacturing model has become dominant. Successful companies have deployed very different operational strategies with good results. This panel will explore various supply chain designs along two dimensions: (1) in-house vs external manufacturing and (2) on-shore vs. off-shore manufacturing.

Topics the panel will cover include:

- When does it make sense to use a contract manufacturer?

- Should you build your latest product in a “low cost” country?
- Should you locate manufacturing near your development team?
- Is the quality of on-shore manufacturing really better?
- What about IP protection?
- Return on invested capital Implications

The session will consist of short presentations by supply chain experts and executives from leading laser companies and conclude with a panel discussion open to audience questions.

Speakers:

Mark Holman, *Partner, A.T. Kearney, USA*
Mark is a partner with the leading global management consulting firm A.T. Kearney, where he leads their San Francisco and Silicon Valley offices. He is an experienced strategic advisor to the technology industry with real world operating experience as a member of the leadership team for a F500 company, founding CEO of a publicly traded software company, various operating and P&L roles for hardware and software enterprises combined with over a decade of consulting for leading technology companies. He has spent over 20 years in Silicon Valley deeply involved in the evolution of the global manufacturing strategies of many of the industry leaders – including footprint strategy, make vs. buy alternatives, contract manufacturing management models and sourcing programs.

Nat Mani, *CEO, Bestronics, USA*
Nat is President and CEO of Bestronics, a Silicon Valley-based manufacturing services provider with a 20+ year history of providing an outstanding level of quality and customer service to its customers. He has led business development, finance, operations and strategy teams at all stages of the business cycle ranging from start-up to high growth, sustaining and business restructuring. A pioneer of outsourced manufacturing services of complex assemblies to contract manufacturers, he was co-founder and executive vice president of Fabrinet . At Fabrinet, he built and ran the company’s global sales and marketing function , and he has held management positions with Sanmina, IBM, JTS Corp, and ROLM

Kurt Weingarten*, JDSU, Switzerland*
Dr. Kurt Weingarten received his Ph.D. in electrical engineering at Stanford University, where he

developed an ultrafast measurement tool for integrated circuits using picosecond lasers. After Stanford, Kurt worked at Lightwave Electronics where he pioneered one of the first commercial diode-pumped picosecond lasers. He then founded Time-Bandwidth Products in Zurich, Switzerland in the mid-1990's to develop simple, robust ultrafast mode-locked lasers for scientific and industrial applications. The company was acquired by JDSU in January 2014 to accelerate the adoption of these products into the growing industrial market for ultrafast lasers.

Andrew Willse, *Director of Director of DPSS operations, Coherent, USA*
Andrew Willse is currently the Director of Operations for Coherent's solid state business unit in Santa Clara, CA. He has 16 years of manufacturing experience in the semiconductor and photonics industries. He had led multiple outsourcing projects in the photonics industry, at the advanced packaging, system, and box build level. He previously has worked for Intel, BOC Edwards, and Spectra-Physics

The Future of "Enabling" Photonics Innovation

Wednesday, June 11
14:00-16:00

Moderator:
Jason Eichenholz , CEO, Open Photonics Inc., USA
Jason M. Eichenholz Ph. D. is CEO and a founder of Open Photonics, a crowd sourcing and Open Innovation company designed to accelerate the adoption of optics and photonics technology. Previously he was the Photonics Divisional Technology Director at Halma PLC responsible for supporting open innovation, and technology and strategy development for Halma's Photonics Division as well as other divisions and companies inside Halma.   Prior to that he was CTO and on the board of directors of Ocean Optics Inc. and Director of Strategic Marketing at Newport/Spectra-Physics. Jason has been actively involved in laser, optics and photonics research and product development for more than 20 years, and has written and delivered over 50 papers at conferences and in refereed journals in the areas of fiber optics, photonics, and solid state, ultrafast, and frequency-agile lasers.He holds six US Patents on new types of solid-state lasers, displays and photonic devices. Jason has served as the principal investigator for Air Force and DARPA STTR's and SBIR's.His active interests are in the areas of open innovation, entrepreneurship, optics, photonics, spectral imaging and sensing, MOEMS devices, novel optical coatings, displays and next generation bio-medical devices.Jason is a Senior Member of both OSA and SPIE. He has served on several membership and technical committees for those societies. He also serves

as a Courtesy Faculty Member at CREOL – The School of Optics at the University of Central Florida. Jason has a M.S. and Ph.D in Optical Science and Engineering from CREOL – University of Central Florida and a B.S. in Physics from Rensselaer Polytechnic Institute.

Panel Description:
As we move into the 21st century, many within our optics and photonics industry have described the transition from the era of the electron to the era of the photon. While this might be true, the term "enabling" is becoming a cliché regarding (O&P) technology.

Several different organizations have recently begun the process of attempting to leverage this accurate cliché by targeting end-users in non-photonics based industries to accelerate technology development and implementation in their marketplace.

This panel discussion will explore a brief overview of each organization and the successes as well as challenges these organizations have faced to in bringing a paradigm shift to the way we in the photonics industry bring cutting edge research and "enabling" technology to market.

Invited Speakers

Paul Ballentine, *Director, Rochester Regional Photonics Accelerator University of Rochester, USA*

Philip H. Bucksbaum, *Marguerite Blake Wilbur Professor of Photon Science, Applied Physics, and Physics, Stanford University, USA*

Phil Bucksbaum holds the Marguerite Blake Wilbur Chair in Natural Science at Stanford University. His research is in the areas of ultrafast, short wavelength, and high field laser-matter interactions. He was appointed Professor of Physics at the University of Michigan in 1990, where he became the Otto Laporte Collegiate Professor in 1998 and the Peter Franken University Professor in 2005. At Michigan, Bucksbaum also was the Associate Director for Science at the Center for Ultrafast Optical Science, and the Director of the FOCUS Center, a National Science Foundation Physics Frontier Center. In 2006, Bucksbaum moved to the SLAC National Accelerator Laboratory and Stanford University, and in 2009, he became the Marguerite Blake Wilbur Professor in Natural Science. He has joint appointments in the Physics Department, the Applied Physics Department, and the SLAC Photon Sciences Department, and he served as Department Chair of Photon Science (2007–2010). He is the Director of the Stanford PULSE Institute for Ultrafast Science, and he also directs the Chemical Sciences Research Division at SLAC. Bucksbaum has more than 200 publications. He has contributed to several areas of atomic physics and ultrafast science, including strong-field laser-atom interactions, Rydberg wave packets, ultrafast quantum control, and ultrafast X-ray physics. Most recently, he has helped to pioneer ultrafast research at X-ray free electron lasers.

Tom Hausken, *Senior Engineering & Applicatoins Advisor, OIDA, USA*
With over 30 years in optoelectronics, Dr. Hausken focuses on industry activities at OSA—the Optical Society. This includes OIDA (the Optoelectronics Industry Development Association, the trade association operated by OSA) where he held a position earlier in his career. For 13 years until 2012, Dr. Hausken led market research and strategy consulting for lasers, image sensors, and a range of other photonic products at Strategies Unlimited. He was also a telecom policy analyst at the U.S. Congressional Office of Technology Assessment, and held R&D and production positions at Alcatel and Texas Instruments in photonics and electronics. He has a PhD from the University of California at Santa Barbara, in optoelectronics.

Technology Transfer

Thursday 12 June 2014

Exhibit Hall Session Area

CLEO Technology Transfer Webinar Preview

New this year, the Technology Transfer Program will include a Pitch Panel for entrepreneurs to showcase their technology, explain why it is valuable and discuss the next steps to commercialization. In addition, the program will continue to provide a Tutorial for those that want to learn more about the licensing process – funding, entrepreneurship, technology transfer and intellectual property. In addition, organizations will feature their license ready technologies at tabletop displays in the exhibit hall.

Technology Transfer Abstracts

Becoming an Entrepreneur and Sustaining a Technology Business: What It Takes in Today's World

Keynote Speaker: Dr. Anis Rahman

Abstract

The Steve Blank Lean Launchpad concept of the startup – as a temporary organization in search of a business model – enables many prospective entrepreneurs to pursue the critical early steps toward starting a new venture – "planning to plan" – while keeping their day jobs. The business model canvas is a very useful tool for planning to plan, but just as no battle plan survives the first contact with the enemy, no business model survives the first contact with the customer: the entrepreneur's recognition that prospective customers or suppliers or strategic partners haven't fulfilled his/her expectations needs to be followed by a flexible response, not by doing the same thing and expecting different results. The rapid accumulation of multiple disappointments may indicate that failure is an option, and that's OK – many more ventures fail than succeed: successful entrepreneurs fail early, before exhausting their credit, colleagues and themselves, and they learn from their mistakes. The moment to quit the day job arrives when it begins to interfere significantly with the entrepreneur's ability to acquire and satisfy his/her new customers and scale up the enterprise – and profitability is foreseeable. The best source of funding after founders, family and friends is still the array of federal agency SBIR/STTR programs: Phase 1 and 2 awards can add up to more than a million dollars that doesn't have to be paid back and doesn't require giving up equity, and they can be obtained multiple times; angel investment can also be an important resource to cross over the "valley of death." As ventures grow, tax exemptions can be very helpful. At some point a highly scalable venture will require giving up equity; the process of scaling is likely to require the departure of the founding CEO, which will be implemented by the investors. Few entrepreneurs with the appropriate combination of talents to navigate the startup phase also have the very different combination of talents required to manage an ongoing enterprise – to execute rather than to search. The good news is, there's plenty of demand for ex-CEOs of successful startups – that's why they're called "serial entrepreneurs."

Tutorial: Technology Transfer 101: Technology Licensing and Tech Startups

Abstracts:

Technology Transfer at NRL

Craig Hoffman and Keith Williams, US Naval Research Lab

After a short introduction and description of the Naval Research Lab, both the why and the how of Technology Transfer at NRL will be presented. Tech Transfer at NRL will be discussed as it relates to teaming with industry to create high technology jobs and make lower cost, high-technology items available for US government programs; enabling NRL to leverage DoD R&D funding for maximum efficiency; optimizing workforce incentives and increasing the name recognition of NRL in the industrial community. The various vehicles and their associated processes for Tech Transfer at NRL to be discussed include Targeting Marketing, Non-Disclosure Agreements, Material Transfer Agreements, Co-operative Research and Development Agreements (CRADAs) and Patent Licenses.

Working with NASA

Enidia Santiago-Arce, NASA

The NASA GSFC Innovative Technology Partnerships Office helps leverage NASA developed technologies to form mutually beneficial partnerships with entities such as other NASA centers, other government agencies, private enterprises (big & small), non-profits entities and universities. During the presentation Ms. Santiago-Arce will offer a quick tutorial about the partnership and licensing process, and the different business models that could be used to successfully work with NASA.

From Fiber Lasers to EUV – Successful Transition of Licensed Technology

Christopher Wood, KMLabs, Inc.

KMLabs currently licenses technology from the University of Colorado, Cornell University, Colorado School of Mines, and the University of Michigan. Our portfolio is diverse, and each tech transfer office handles things a bit differently. Successful transition of technology to commercial product requires much more than a signed document – KMLabs leverages research partnerships, co-developments, and the SBIR/STTR program heavily. Two examples will be highlighted: ultrafast fiber lasers and ultrafast cryogenic amplification.

Pitch Panel

Abstracts:

A Low-cost Universal Ultra-broadband SERS Substrate for “All” Excitation Wavelengths

Qiaoqiang Gan, University at Buffalo, SUNY

Surface-enhanced Raman Spectroscopy (SERS) refers to a vibrational spectroscopy technique for characterization of low concentration analytes bound to or near patterned metallic surfaces. Although this technique has been commercialized, substrates with localized enhanced electromagnetic (EM) field that can excite strong Raman scattering are heavily required. In recent years, extensive efforts have been focused on the development of inexpensive, large area SERS substrates with high enhancement factors, reproducible and uniform responses. Current dominant fabrication techniques include electron beam lithography, nanoimprint, self-assembled nanosphere, and hybrid nanoporous lithography methods, which are expensive and complicated to fabricate high quality SERS substrates over large areas, thus resulting in high prices for commercial SERS substrates (e.g. $25-$200/piece with the area of 3X3 or 5X5 mm^2). Furthermore, most SERS substrates can only be used for individual excitation wavelengths. Therefore, different substrates have to be used for multi-wavelength sensing, which consumes more bio/chemical materials, substrates and measurement time. To overcome these limitations, we developed an ultra-broadband super absorbing metasurface substrate that can enhance the SERS signal for excitation wavelengths in a broadband spectral region. Most frequently used excitation wavelengths for SERS (e.g. from 450 nm to 1000 nm) are all covered due to the broad-band light trapping and field concentration within deep subwavelength volumes of this broadband super absorbing metasurface. Therefore, a single substrate can work for almost "all" available excitation wavelengths, which is particularly useful for sensing a broad spectrum of chemicals on the same chip. This is a unique and revolutionary feature that cannot be realized by current commercial SERS products and will simplify the measurement and significantly reduce the time and cost of SERS measurement.

Multi-Resonant Gain Resonators: Closing the Green/Yellow Gap

Ajaykumar ("Ajay") Jain, VerLase Technologies, LLC

A fundamental, patent pending re-think of the resonator in an optically pumped laser is presented, dubbed a Multi-Resonant Gain (MRG) structure. The net effect is lasing at a design output wavelength while simultaneously concentrating pump energy in the gain media for a huge increase in absorption, for so-called In-Well pumping, resulting in significantly higher efficiency, much reduced thermal loss, and lower pump threshold for lasing. Absorption greater than 80% of input light has been demonstrated. While NOT a so-called typical "DBR" design, it does use conventional dielectric coatings and current optical coating processes, and can be designed to use a variety of low cost pump sources. The output spectral shape can similarly be tailored to reduce coherence, a key advantage in circumventing speckle in laser projection.

Such a MRG resonator can be designed for a wide range of gain media, including current (Al, In) GaN based chemistries, and different quantum confining structures including QDs (Quantum Dots) as well as QWs (Quantum Wells). It is readily scalable to higher power and would allow creation of lasers at novel wavelengths. Proof of concept has been demonstrated with Zinc Blende, II-VI materials, pumped with a widely available 450 nm LD to create a 520 nm VCSEL. The technology lends itself well to realizing optically pumped, multi-color (RGB) VCSELs on a single chip.

VerLASE is a start-up focused on projector applications with such optically pumped VCSELs, beginning with true green VCSELs, and seeks to partner for other wavelengths, higher powers and different market applications.

Low-cost, High Resolution Shortwave Infrared Cameras Based on Compressive Sensing

Lenore McMackin, InView Technology Corporation

InView Technology Corporation has developed a low-cost, high resolution shortwave infrared (SWIR) camera for microscopes that will for the first time make available reasonably-priced, high-sensitivity, high resolution imaging instruments for lab and clinical use in a new and potentially transformative spectral band. InView addresses the broad shortwave infrared imaging application needs of the scientific, industrial and biomedical imaging communities by providing an innovative, high-resolution digital SWIR camera for the instrument that these diverse application groups have in common: The Microscope. The low cost of our technology serves to open the multi-billion dollar microscopy community to the benefits of lower cost SWIR imaging.

Continued sales of our platform will be sustained over the long term by the development of specialized image processing and analytical methods developed for specific applications. These processing methods are facilitated by the innovative architecture and the sophisticated software already embedded in the camera and user interface. InView has over 25 patents pending on technology developed in-house and exclusive rights to additional foundational IP. InView continues to perform CS research with a core team of software and algorithm experts under grants from US army and NSF.

D-scan: A New Patent Pending Technology for Measuring and Compressing Ultrashort Laser Pulses

Rosa Romero, Sphere Ultrafast Photonics

The d-scan, a new patent pending technology will be presented. The d-scan allows for high-quality, robust and reliable control and measurement of ultrafast laser pulses down to unprecedentedly short durations (below 4 fs). Such performance is well above that of the best available commercial pulse diagnostics based on other technologies. The unique in-line based configuration allows for the best performance in the market in the ultrafast few-cycle regime. The d-scan has also two functions in one device: compression and measurement. This new technology will facilitate manufacture and optimization of few-cycle laser systems and will open the door to industrial and biomedical applications of such lasers currently hindered by the lack of a robust and accurate control for their demanding pulses. The d-scan is now available in the market and it is manufactured and distributed by Sphere Ultrafast Photonics.

Short Courses

Short Courses by Time

Sunday, 8 June 2014

8:30 - 12:30

SC149: Foundations of Nonlinear Optics

SC221: Nano Photonics: Physics and Techniques

8:30 - 11:30

SC339: Optical Atomic Clocks: New Science and Technology

8:30 - 11:00

SC302: MetaMaterials

13:30 - 17:30

SC318: Coherent and Incoherent Laser Beam Combining: Theory and Methods

SC396: Frontiers of Guided Wave Nonlinear Optics

SC378: Introduction to Ultrafast Optics

14:00 - 17:00

SC403: NanoCavity Quantum Electrodynamics and Applications

Monday, 9 June 2014

12:30 - 16:30

SC270: High Power Fiber Lasers and Amplifiers

SC301: Quantum Cascade Lasers: Science, Technology, Applications and Markets

13:00 - 16:00

SC376: Plasmonics

SC402: Transformational Optics

Tuesday, 10 June 2014

9:00 - 12:00

SC362: Cavity Optomechanics: Fundamentals and Applications of Controlling and Measuring Nano- and Micro-mechanical Oscillators with Laser Light

SC410: Finite Element Modeling Methods for Photonics and Optics NEW

SC379: Silicon Photonic Devices and Applications

13:00 - 16:00

SC352: Introduction to ultrafast pulse shaping--principles and applications

SC271: Quantum Information-Technologies and Applications

Short Courses by Topic

SC149: Foundations of Nonlinear Optics
Robert Fisher, *R. A. Fisher Associates, USA*

SC221: Nano Photonics: Physics and Techniques
Axel Scherer, *Caltech, USA*

SC270: High Power Fiber Lasers and Amplifiers
W. Andrew Clarkson, *Optoelectronics Res. Ctr., Univ. of Southampton, UK*

SC271: Quantum Information-Technologies and Applications
Greg Kanter1, Paul Toliver2; *1NuCrypt, 2Applied Communication Sciences , USA.*

SC301: Quantum Cascade Lasers: Science, Technology, Applications and Markets
Federico Capasso, *Harvard Univ., USA*

SC302: MetaMaterials
Vladimir M. Shalaev, *Purdue Univ., USA*

SC318: Coherent and Incoherent Laser Beam Combining: Theory and Methods
James Leger, *Univ. of Minnesota, USA*

SC339: Optical Atomic Clocks: New Science and Technology
Scott Diddams, Chris Oates, *NIST, USA*

SC352: Introduction to ultrafast pulse shaping--principles and applications
Marcos Dantus, *Michigan State Univ., USA*

SC362: Cavity Optomechanics: Fundamentals and Applications of Controlling and Measuring Nano-

and Micro-mechanical Oscillators with Laser Light
Tobias Kippenberg, *Ecole Polytechnique Federale de Lausanne, Switzerland*

SC376: Plasmonics
Mark Brongersma, *Stanford Univ., USA*

SC378: Introduction to Ultrafast Optics
Rick Trebino, *Georgia Institute of Technology, USA*

SC379: Silicon Photonic Devices and Applications
Michal Lipson, *Cornell Univ., USA*

SC396: Frontiers of Guided Wave Nonlinear Optics
Ben Eggleton, *Univ. of Sydney, Australia*

SC402: Transformational Optics
Ulf Leonhardt, *Weizmann Inst. of Science in Israel, Israel*

SC403: NanoCavity Quantum Electrodynamics and Applications
Jelena Vuckovic, *Stanford Univ., USA*

SC410: Finite Element Modeling Methods for Photonics and Optics NEW
Arti Agrawal, *City Univ., UK*

Short Course Descriptions

SC149 - Foundations of Nonlinear Optics

Sunday, 08 June

08:30 - 12:30

Short Course Level: Beginner

Instructor:

Robert Fisher, *R. A. Fisher Associates, USA*
Short Course Description:

This introductory and intermediate level course provides the basic concepts of nonlinear optics. Although some mathematical formulas are provided, the emphasis is on simple explanations. It is recognized that the beginning practitioner in nonlinear optics is overwhelmed by a constellation of complicated nonlinear optical effects, including second-harmonic generation, optical Kerr effect, self-focusing, self-phase modulation, self-steepening, fiberoptic solitons, chirping, stimulated Raman and Brillouin scattering, and photorefractive phenomena. It is our job in this course to demystify this daunting collection of seemingly unrelated effects by developing simple and clear explanations for how each works, and learning how each effect can be used for the modification,manipulation or conversion of light pulses. Examples will address the nonlinear optical effects that occur inside optical fibers and those that occur in liquids, bulk solids, and gases.

Short Course Benefits:

This course will enable you to:

- Explain and manipulate the Slowly-Varying Envelope Approximation (SVEA)
- Recognize what nonlinear events come into play in different effects
- Appreciate the intimate relationship between nonlinear events which at first appear quite different
- Discuss how a variety of different nonlinear events arise, and how they affect the propagation of light
- Describe how wavematching, phase-matching, and index matching are related
- Summarize how self-phase modulation impresses "chirping" on pulses
- Explain basic two-beam interactions in photorefractive materials
- Develop an appreciation for the extremely broad variety of ways in which materials exhibit nonlinear behavior"

Short Course Audience:

Although we start at the very beginning of each topic, we move quite rapidly in order to grasp a deep understanding of each topic. Therefore, both beginners and intermediates will benefit greatly from this course. The material will be of interest to graduate students, to researchers, to members of the legal profession, to experts who are just transferring to this field, to managers, and to anyone else who just wants to learn how nonlinear optics works.This course, offered on Sunday Morning, will also give an excellent nonlinear optics foundation for those feeling the need so they can also take any of the following more specialized nonlinear optics courses at this CLEO conference: *SC396*: Frontiers of Guided Wave Nonlinear Optics; *SC378*: Introduction to Ultrafast Optics; *SC270:* High Power Fiber Lasers and Amplifiers; *SC410*: Finite Element Modeling Methods for Photonics and Optics; *SC379*: Silicon Photonic Devices and Applications; *SC352*: Introduction to ultrafast pulse shaping--principles and applications; *SC361*: Coherent MidInfrared Sources and Applications.

Instructor Biography:

Robert A. Fisher is a private consultant with interests in nonlinear optics, carbon dioxide lasers, molecular spectroscopy, X-Ray lasers, optical phase conjugation and modern optics. He is a fellow of OSA and SPIE, as well as a senior member of the IEEE. He was a member of the Board of Directors of SPIE (2002-2004). He has authored more than 60 publications. Fisher is the editor of the book Optical Phase Conjugation. He is a past associate editor for the journals Applied Optics, and Optics Letters; and he has chaired six SPIE Conferences on Nonlinear Optics. He served a 3-year term on the Board of Directors of SPIE. He was a topical editor for Optics Letters, the chair of OSA's Excellence in Engineering Award Committee, on SPIE's Scholarship Committee, and on the 2003, 2004, 2005, 2006 and 2007 CLEO Program Nonlinear Optics Subcommittees, which he chaired in 2006 and 2007. He was Program CoChair for CLEO 2010 and was General CoChair for CLEO 2012 (now renamed 2012 CLEO: Science and Innovations). He has served the legal community several times as an Expert Witness.

SC221 - Nano Photonics: Physics and Techniques

Sunday, 08 June

08:30 - 12:30

Short Course Level: Intermediate

Instructor:

Axel Scherer, *Caltech, USA*

Short Course Description:

Students will learn about the applications of printed and integrated optical devices. In particular, optical microcavities and vertical cavity lasers, silicon photonics and plasmonic systems will be introduced and compared. Integrated opto-electronic and opto-fluidic systems for communications and biomedical sensing will be compared.

Short Course Benefits:

This course should enable the participants to:

- Compare dielectric (total internal reflection and Braggreflectors) with metallic (surface plasmon) geometries for confining and guiding light

- Identify opportunities for using printed optical systems in silicon (silicon photonics)

- Describe methods for creating quantum-mechanical systems from optical nanostructures
- Design lithographically defined micro- and nanocavities for resonators and lasers
- Define applications of printed optics in biochemical sensing
- Summarize the evolution of printed optical integrated circuits and devices, such as modulators and switches
- Determine the applications of interdisciplinary integration of optics with electronics and fluidics
- Describe optical performance of semiconductor structures when these are made with nanoscale dimensions

Short Course Audience:

This course is designed for participants with interest in miniaturizing optical devices. Methods of microfabricating dielectric and plasmonic devices will be described, along with examples of their applications and description of future opportunities.

Instructor Biography:

Axel Scherer is the Bernard A. Neches professor of electrical engineering, applied physics and physics at Caltech and the Co-Director of the Kavli Nanoscience Institute. Professor Scherer's research focuses on the development and application of microfabrication and design methods for optical devices. In the past, Professor Scherer pioneered the development of vertical cavity lasers, which have since become a commercial success. His group also developed some of the first silicon photonic circuits, optical nanocavities, and integrated optofluidic devices. Fundamentally new structures, such as photonic bandgap geometries resulted in some of the world's smallest lasers, modulators and waveguides. At the moment, Professor Scherer is also interested in the miniaturization and integration of microfluidic, magnetic and optical devices for applications in nano-biotechnology. His group also explores the limits of lithography at the nanometer scale. Professor Scherer has co-authored over 300 publications and holds over 65 patents in nanofabrication related areas.

SC270 - High Power Fiber Lasers and Amplifiers

Monday, 09 June

12:30 - 16:30

Short Course Level: Beginner

Instructor:

W. Andrew Clarkson, *Optoelectronics Res. Ctr., Univ. of Southampton, UK*

Short Course Description:

Recent advances in cladding-pumped fiber lasers and amplifiers have been dramatic, leading to unprecedented levels of performance in terms of output power, efficiency, beam quality and wavelength coverage. These achievements have attracted growing interest within the community and have fueled thoughts that fiber-based sources may one day replace conventional “bulk” solid-state lasers in many application areas. The main attractions of cladding-pumped fiber sources are derived directly from their geometry, which simultaneously allows very efficient generation of coherent light and almost complete immunity from the effects of heat generation, which are so detrimental to the performance of other types of lasers.

This course aims to provide an introduction to high power fiber lasers and amplifiers, starting from the basic principles of operation and ending with examples of current state-of-the-art devices and some thoughts on future prospects. The course will cover a range of topics, including basic fiber laser and amplifier theory; spectroscopy of the relevant rare earth ions for high power devices; a discussion of the factors influencing laser and amplifier performance; fiber design and fabrication; pump sources and pump launching schemes; fiber resonator design; master-oscillator and power-amplifier configurations, linewidth control and wavelength selection; transverse mode selection; nonlinear loss processes (SBS and SRS) and their impact on performance; and heat generation and its impact on power scalability. The course will also give an overview of techniques (e.g., coherent and spectral beam combining) for further scaling of output power and provide an introduction to hybrid fiber-bulk laser schemes for scaling pulse energy.

Short Course Benefits:

This course should enable the participants to:

- Calculate threshold pump power and slope efficiency, and estimate the maximum output power that can be obtained from a given fiber laser oscillator or amplifier configuration
- Select the optimum pump source for a given rare earth ion transition and fiber design
- Design the pump light collection and coupling scheme and estimate the pump launch efficiency
- Specify the fiber parameters (e.g., cladding design, core size, rare earth ion concentration) required for a particular laser or amplifier configuration
- Design the fiber laser resonator and amplifier and select the operating wavelength
- Estimate thermally induced damage limit
- Estimate the power scaling limit

- Measure fiber laser performance characteristics and relate these to fiber design and resonator parameters

Short Course Audience:

This course is intended for individuals with a basic knowledge of lasers and optics who wish to learn about the basic principles and capabilities of fiber lasers and amplifiers when operating at high power levels. The course will also cover some of the practical issues of operating these devices and provide an update for those wishing to learn about some of the latest developments in this rapidly advancing field.

Instructor Biography:

W. Andrew Clarkson obtained his B.Sc. degree in physics from the University of Manchester (UK) in 1984 and his doctorate from the University of Southampton (UK) in 1991. He currently holds the position of professor at the Optoelectronics Research Centre, University of Southampton, where he leads a research group investigating power-scaling of fiber lasers and solid-state lasers. He has published more than 250 journal and conference papers in this area. He has also served on the program committees of numerous international conferences and as a topical editor for Optics Letters and is a Fellow of the Optical Society of America.

SC271 - Quantum Information-Technologies and Applications

Tuesday, 10 June

13:00 - 16:00

Short Course Level: Advanced Beginner

Instructor:

Greg Kanter1, Paul Toliver2; *1NuCrypt, 2Applied Communication Sciences , USA.*

Short Course Description:

This course will describe the how quantum signals are used in applications such as quantum key distribution and the enabling technologies employed in such systems. The concept of entanglement will be introduced and its essential role in quantum communications will be elucidated. The course will then describe the various technologies that are maturing rapidly for the practical realization of quantum communications. Techniques for generating, distributing, and measuring entanglement in the near infrared part of the optical spectrum for free-space applications and in the 1550 nm wavelength band for applications over the standard optical fiber will be described. Particular emphasis will be placed on the application of quantum communications to quantum cryptography. In the context of quantum cryptography, the objective of key generation/distribution will be differentiated from that of direct data encryption at high speeds. Both single-photon based quantum key distribution approaches and high data-rate quantum data encryption techniques will be described. Recent progress in demonstrations of quantum communications technologies in optical transmission links and quantum network testbeds, both fiber-based and using free-space optical approaches, will be presented. The course will also examine commercial activity in quantum technologies as well as provide considerations for compatibility with conventional optical networking technologies. It will conclude with an outlook on the possible adoption of the quantum technologies in future optical networks and systems.

Short Course Benefits:

This course should enable you to:

- Compare and contrast quantum communication versus classical communication.
- Understand the concept of entanglement and its role in quantum communication.
- Understand the state-of-the-art of single photon detector technology
- Learn techniques for generating entanglement in the various optical bands.
- Get up to date on the practicality of quantum cryptography for free-space, as well as fiber-based, optical networks.
- Explore new applications of conventional technologies with knowledge of the current status of research and commercial activities in quantum technologies.

Short Course Audience:

The audience may include optical networking and optoelectronic technology researchers with an interest in quantum communications, as well as managers of research groups and engineers who want a glimpse into the new and forward-looking technologies in the optical arena. An undergraduate-level understanding of quantum mechanics would be helpful.

Instructor Biography:

Paul Toliver is the Director of Optical Systems Research at Applied Communication Sciences. He received his B.S. from the University of Wisconsin and Ph.D. from Princeton University, both in electrical engineering. He leads forward-looking technology research focused on next-generation optical systems including quantum communications, optical physical layer security, optical signal processing, LIDAR, and optical networking.

Gregory Kanter is the CEO of NuCrypt, LLC which commercializes advanced optical technologies including quantum optical instrumentation and associated equipment. He is also an Associate Research Professor in the Deparment of Electrical Engineering and Computer Science at Northwestern University. He received his B.S. from University of Illinois Urbana-Champaign and Ph.D. from Northwestern University, both in electrical engineering. His work has focused on applications of optics including high rate communications, quantum communications, and metrology.

SC301 - Quantum Cascade Lasers: Science, Technology, Applications and Markets

Monday, 09 June

12:30 - 16:30

Short Course Level: Beginner

Instructor:

Federico Capasso, *Harvard Univ., USA*
Short Course Description:

Quantum Cascade Lasers (QCLs) are fundamentally different from diode lasers due to their physical operating principle, which makes it possible to design and tune their wavelength over a wide range by simple tailoring of active region layer thicknesses, and due to their unipolar nature. Yet they use the same technology platform as conventional semiconductor lasers. These features have revolutionized applications (spectroscopy, sensing, etc.) in the mid-infrared region of the spectrum, where molecules have their absorption fingerprints, and in the far-infrared or so called Terahertz spectrum. In these regions until the advent of QCLs there were no semiconductor lasers capable of room temperature operation in pulsed or cw, as well high output power and stable/wide single mode tunability. The unipolar nature of QCL, combined with the capabilities of quantum engineering, leads to unprecedented design flexibility and functionality compared to other lasers. The physics of QCLs, design principles, supported by modeling, will be discussed along with the electronic, optical and thermal properties. State-of-the-art performance in the mid-ir and Terahertz will be reviewed. In particular high power CW room temperature QCLs, broadly tunable QCL, short wavelength MWIR QCLs and recent breakthroughs in THz room temperature operation will be presented. A broad range of applications (IR countermeasures, stand-off detection, chembio sensing, trace gas analysis, industrial process control, medical and combustion diagnostics, imaging, etc.) and their ongoing commercial development will be discussed.

Short Course Benefits:

This course should enable the participants to:

- Describe underlying QC Laser physics, operating principles and fundamental differences between standard semiconductor lasers and QC lasers
- Explain quantum design of the key types of QC lasers, which have entered real world applications, and how their electrical and optical properties can be tailored to optimize performance in the mid-infrared and THz regions.
- Discuss experimental device performance, including physical limits, design constraints and comparison with theory and determine device characteristics (current-voltage and light-current curves; differential and power efficiency, threshold, gain and losses; spectral behavior, single mode operation; high speed operation)
- Explain the basics of QC laser device technology: fabrication process, materials growth options
- Illustrate the basics of a chemical sensing system; discuss applications of state-of-the-art mid-infrared QC lasers to sensing and present several examples of QC laser commercialization
- Discuss current and future markets of QC lasers

Short Course Audience:

Graduate students; qualified undergraduates (mostly senior level) majoring in EE or physics/applied physics;researchers in industry, academia and government labs; engineers, sales reps and technical managers.

Education: Undergraduate degree or a Ph.D or pursuing a Ph.D in EE, Physics or Applied Physics, with knowledge of introductory level semiconductor devices.

Instructor Biography:

Federico Capasso is the Robert Wallace Professor of Applied Physics at Harvard University, which he joined in 2003 after a 27 years career at Bell Labs where he did research, became Bell Labs Fellow and held several management positions including Vice President for Physical Research. His research has spanned a broad range of topics from applications to basic science in the areas of electronics, photonics, nanoscale science and technology including plasmonics and the Casimir effect. He is a co-inventor of the quantum cascade laser. He has lectured widely including many short courses and tutorials. He is a member of the National Academy of Sciences, the National Academy of Engineering, a fellow of the American Academy of Arts and Sciences; his most recent awards include the King Faisal Prize, the Berthold Leibinger Future Prize, the Julius Springer Prize for Applied Physics, the APS Arthur Schawlow Prize and the IEEE Edison Medal.

SC302 - MetaMaterials

Sunday, 08 June
08:30 - 11:00

Short Course Level: Advanced Beginner

Instructor:

Vladimir M. Shalaev, *Purdue Univ., USA*

Short Course Description:

Metamaterials (MMs) are expected to open a gateway to unprecedented electromagnetic properties and functionality unattainable from naturally occurring materials. We review this new emerging field and recent progress in demonstrating metamaterials from the microwave to the optical range, including the artificial magnetism and negative-index in MMs. Various approaches for optical cloaking will be analyzed. The feasibility of engineering optical space with metamaterials by using the transformation optics will be discussed. A family of novel meta-devices, ranging from superlens and hyperlens to optical black hole and single-photon gun will be also considered.

Short Course Benefits:

This course should enable the participants to:

- Specify the new physics behind metamaterials (MMs) and transformation optics (TO)
- Identify most exciting applications for MMs and TO devices,
- Identify future directions for the development in the field of MMs,
- Identify the biggest challenges in the field fo MMs,
- Suggest new promising material components for the improved MMs,

- Bridge the new physics behind MMs with the recent developments in nanofabication and engineering that can enable the exciting applications of MMs,
- Characterize and specify the major physical properties of MMs,
- Predict the future impact of the field of MMs and TO on the future nanophotonics industry.

Short Course Audience:

R&D representatives from industry, defense and government Lab researchers, and students.

Instructor Biography:

Vladimir (Vlad) M. Shalaev, Scientific Director for Nanophotonics in Birck Nanotechnology Center and Distinguished Professor of Electrical and Computer Engineering at Purdue University, specializes in nanophotonics, plasmonics, and optical metamaterials. Vlad Shalaev received several awards for his research in the field of nanophotonics and metamaterials, including the Max Born Award of the Optical Society of America for his pioneering contributions to the field of optical metamaterials and the Willis E. Lamb Award for Laser Science and Quantum Optics. He is a Fellow of the IEEE, APS, SPIE, and OSA. Prof. Shalaev authored three books, twenty one book chapters and over 300 research publications.

SC318 - Coherent and Incoherent Laser Beam Combining: Theory and Methods

Sunday, 08 June

13:30 - 17:30

Short Course Level: Beginner

Instructor:

James Leger, *Univ. of Minnesota, USA*

Short Course Description:

The performance of conventional high power lasers is often compromised by one or more physical effects, limiting the maximum power that can be obtained from a single lasing element. To increase the power from these individual elements, laser beam combining can be employed to convert the outputs from several lower-power modules into a single, high-power beam. This short course establishes general beam combining principles relevant to all laser systems, and emphasizes the limits that are achievable with differ approaches. The practicing engineer and technical manager will be introduced to a wide variety of beam combining methods. Incoherent beam combining attempts to maximize the radiance of an array of incoherent sources. The theoretical limits of this approach will be derived, and a design methodology developed to achieve maximum radiance. Spectral and polarization beam combining techniques employ wavelength and polarization sensitive elements to sum laser power. Several practical issues of this technique will be discussed, and specific systems described. Coherent beam combining is introduced by exploring methods of establishing mutual coherence across laser arrays. The properties and characteristics of these coherent techniques are quantitatively analyzed using simple modal theories. Methods of converting arrays of coherent beams into a single beam are explored, and the sensitivity of these approaches to path length errors investigated. Real-world examples will be used as case studies to illustrate design principles. This offering of the course will make use of recently developed material on coherent beam combining architectures.

Short Course Benefits:

- Describe the requirements for laser beam combining of all types.
- Estimate the optimum brightness enhancement achievable from incoherent combining.
- Design an ideal incoherent beam combiner.
- Design spectral beam combiners and estimate performance limitations.
- Compare different architectures for establishing mutual coherence across laser arrays.
- Determine the effects of path length errors on beam combining performance.
- Design optical systems to convert coherent arrays of laser beams into a single beam.
- Describe the performance characteristics of several laser systems that utilize beam combining.

Short Course Audience:

The course is designed for students, engineers, scientists and technical managers who are interested in understanding the basics of laser beam combining. No advanced knowledge of laser systems is assumed.

Instructor Biography:

James Leger is the Cymer Professor of Electrical and Computer Engineering at the University of Minnesota. His previous work at MIT Lincoln Laboratory and current research concerns diffractive and microoptics applied to lasers and electro-optic systems. Prof. Leger is a fellow of OSA, IEEE, and SPIE, and winner of the 1998 OSA Fraunhofer award. He is also a member of the academy of distinguished teachers, and has won several awards for his teaching. Current and past service includes Deputy Editor of Optics Express and membership on the OSA board of directors.

SC339 - Optical Atomic Clocks: New Science and Technology

Sunday, 08 June

08:30 - 11:30

Short Course Level: Advanced Beginner

Instructor:

Scott Diddams, Chris Oates, *NIST, USA*

Short Course Description:

In the past decade the field of optical frequency metrology has been advanced by exciting developments in femtosecond laser optical frequency combs and their stabilization to ultra-narrow linewidth CW lasers and laser-cooled atoms and ions. Today, techniques based on optically-stabilized lasers and frequency combs provide a new generation of clocks and frequency and phase noise metrology capabilities that are many orders of magnitude better than those based on microwave technology. Initially, this research was limited to a few advanced metrology labs; however, optical clock technology has matured to the point where it is now becoming accessible to a much wider range of users and commercial and military applications. The goal of this short course is to teach the students how to design and construct their own systems using this revolutionary technology. In the process, we will focus on the unique synthesis properties available with optical frequency combs and describe how they can be stabilized relative to optical and microwave oscillators as well as atomic references. Students will be shown how to match and adapt clock technology to a wide range of applications, while taking into account the trade-offs that exist between stability, accuracy, transportability, complexity and cost.

Short Course Benefits:

This course should enable the participants to:

- Identify the three basic building blocks of an optical clock
- List and assemble the components required to construct each of these building blocks
- Diagram and explain the basic stabilization techniques of femtosecond laser frequency combs
- Design an optical clock that can meet the requirements of a given application
- Evaluate the trade-offs between stability, accuracy, transportability, complexity and cost
- Design a system that generates low noise microwaves from a stable optical frequency

- Characterize the stability and/or phase noise of their optical clock systems
- Identify emerging applications where optical clock technology can have an impact

Short Course Audience:

This course is intended for physicists, chemists and engineers desiring practical knowledge related to the design and construction of optical clocks. Instruction will be at a level appropriate for beginning graduate students, and will assume some basic knowledge of laser and atomic physics.

Instructor Biography:

Scott Diddams received a B.A. in Physics from Bethel College (St. Paul, MN) in 1989 and the Ph.D. degree in Optical Science from the University of New Mexico in 1996. Between 1996 and 2000, he did postdoctoral work at JILA (a joint institute of the National Institute of Standards and Technology and the University of Colorado) where he was supported in part by a National Research Council fellowship. Currently he works as a staff physicist in the Time and Frequency Division of NIST in Boulder, where he enjoys research in nonlinear optics, ultrafast lasers, frequency combs, and optical frequency metrology.

Chris Oates received a B.S. in Physics from Stanford University in 1984 and the Ph.D. degree in Physics from the University of Colorado in 1995. Between 1995 and 1998, he did postdoctoral work at the National Institute of Standards and Technology, where he was supported by a National Research Council fellowship. Since 1998 he has been a staff physicist in the Time and Frequency Division of NIST in Boulder, and currently he leads the Optical Frequency Measurements Group. His research focuses on precision spectroscopy of laser-cooled atoms, with an emphasis on the development of optical clocks based on cold neutral atoms.

SC352 - Introduction to ultrafast pulse shaping--principles and applications

Tuesday, 10 June
13:00 - 16:00

Short Course Level: Beginner to advanced beginner (basic understanding of topic is necessary to follow course material)
Instructor:

Marcos Dantus, *Michigan State Univ., USA*

Short Course Description:

This course begins by describing pulse shaping with a hands-on computer simulation that allows one to get a sense of how femtosecond pulses change in response to different phases and amplitudes. The essential physics and a brief background of the development of shapers are provided. The course goes over the experimental implementation requirements and then covers some of the most salient applications of pulse shapers, among them are pulse compression, pulse characterization, creation of two or more pulse replicas, control of nonlinear optical processes such as selective two-photon excitation and selective vibrational mode excitation, material processing, microscopy and others.

Short Course Benefits:

This course should enable participants to:

- Gain a better understanding of femtosecond laser pulses and their applications
- Learn pulse shaper design principles
- Compare among different pulse shaper designs and to determine which one is best suited for a particular application
- Simulate the output pulse from a pulse shaper given a particular phase and amplitude modulation
- Predict the effect caused by introducing a simple phase such as a linear, quadratic or cubic function on a transform-limited pulse
- Learn two different approaches to creating pulse replica that can be independently controlled with attosecond precision in the time domain using the pulse shaper
- Measure the spectral phase of laser pulses using the pulse shaper itself as the measurement tool, and eliminating phase distortions to compress the output pulses
- Summarize the advantages of having an adaptive pulse shaper for controlling the output of ultrafast lasers

Short Course Audience:

This course, updated yearly, is intended for everyone that uses or intends to use femtosecond laser pulses in academic research or industry. Attendees will learn how pulse shaping can greatly enhance femtosecond laser applications. No prior knowledge about pulse shaping is required.

Instructor Biography:

Professor Dantus has 25 years of experience working with femtosecond lasers. He is presently a Professor of Chemistry and Physics at Michigan State University. Dantus' interests include the development of practical applications for ultrafast lasers, control of nonlinear laser-matter interactions, and biomedical imaging. Dantus has more than 180 publications, 43 invention disclosures and 17 issued patents. Dantus is presently the President and CEO of BioPhotonic Solutions Inc, and serves on the board of advisors for Chemical Physics Letters.

SC362 - Cavity Optomechanics: Fundamentals and Applications of Controlling and Measuring Nano- and Micro-mechanical Oscillators with Laser Light

Tuesday, 10 June

09:00 - 12:00

Short Course Level: Advanced Beginner

Instructor:

Tobias Kippenberg, *Ecole Polytechnique Federale de Lausanne, Switzerland*

Short Course Description:

Radiation pressure denotes the force that optical fields exert and which have wide ranging applications in both fundamental science and applications such as Laser cooling or optical tweezers. Radiation pressure can, however, also have a profound influence on micro- and nanophotonic devices, due to the fact that radiation pressure can couple optical and mechanical modes. This optomechanical coupling gives rise to a host of new phenomena and applications in force, displacement and mass sensing. This course is intended to give an introduction of the Physics and Applications of cavity optomechanics and highlight the rapid developments in this emerging field. Optomechanical coupling can be used to both cool and amplify mechanical motion and thereby allow new light driven photon clocks. Optomechanical refridgeration of mechanical modes gives insights into the quantum limits of mechanical motion. In addition, radiation pressure coupling enables new way of processing light all optically enabling optical mixers, delay lines or storage elements. Moreover, the basic limitations of optomechanical displacement measurements, due to quantum noise and practical laser phase noise limitations, will be reviewed, relevant across a wide range of sensing experiments.

The course will make contact to practical applications of optomechanics in Metrology (force sensors, mass sensors and light driven optical clocks) and review fundamental design principles of optomechanical coupling and the design of high Q mechanical oscillators. The use of finite element simulations will be covered.

Short Course Benefits:

This course should enable participants to:

- Explain gradient and scattering light forces in microcavities and micromechanical systems
- Design high –Q nano-and micro- mechanical oscillators (finite element modeling, FEM)
- Discuss the fundamental limits of mechanical Q in NEMS/MEMS
- Describe of the fundamental and practical limits of displacement sensors
- Summarize Applications of optomechanics in mass and force sensing
- Explain the basic optomechanical phenomena (amplification, cooling)
- Discuss the standard quantum limit (SQL)
- Characterize radiation pressure driven oscillations in terms of fundamental oscillator metrics
- Define Phase and frequency noise of oscillators
- Know the influence of phase and amplitude noise of a wide variety of laser systems (fiber lasers, TiSa, diode lasers) in optomechanical systems

Short Course Audience:

This course is intended for physicists and optical and electrical engineers desiring both focused fundamental knowledge of cavity optomechanical coupling (i.e., radiation pressure coupling of light and NEMS/MEMS) but also a view of emerging applications of this new technology. The instruction will be at a level appropriate for graduate students and will assume some basic knowledge of laser.

Instructor Biography:

Tobias J. Kippenberg is Associate Professor of Physics and Electrical Engineering at EPFL and leads the Laboratory of Photonics and Quantum Measurement. He obtained his BA at the RWTH Aachen, and MA and PhD at the California Institute of Technology (Caltech in Pasadena, USA). From 2005- 2009 he lead an Independent Research Group at the MPI of Quantum Optics and obtained his Habilitation from the LMU with T.W. Haensch. His research area are the Physics and Application of ultra high Q resonators in Metrology and Quantum Measurements of mechanical motion (cavity optomechanics). Tobias Kippenberg is alumni of the “Studienstiftung des Deutschen Volkes” and winner of the 8th EU Contest for Young Scientists (1996) for his invention of an “Infrared-microwave radiation ice condition sensor for cars. For his invention of “chip-scale frequency combs” he is co-recipient of the Helmholtz Price for Metrology (2009). Moreover he is recipient of the EFTF Young Investigator Award (2010) and the EPS Fresnel Prize (2009)

SC376 - Plasmonics

Monday, 09 June

13:00 - 16:00

Short Course Level: Beginner

Instructor:

Mark Brongersma, *Stanford Univ., USA*

Short Course Description:

Plasmonics is an exciting new field of science and technology that aims to exploit the unique optical properties of metallic nanostructures to enable routing and active manipulation of light at the nanoscale. Nanometallic objects derive these properties from their ability to support collective electron excitations, known as surface plasmons (SPs). Presently we are witnessing an explosive growth in both the number and range of plasmonics applications; it is becoming eminently clear that both new fundamental science and device technologies are being enabled by the current plasmonics revolution. The intention of this tutorial is to give the participants a fundamental background and working knowledge of the main physical ideas used in plasmonics, as well as an overview of modern trends in research and applications.

The tutorial will begin with a general overview of the field of plasmonics. This will be followed by an introduction to the basic concepts that enable one to understand and design a range of plasmonic functionalities. This part will be followed by an in-depth discussion of a range of active and passive plasmonic devices that have recently emerged. Particular attention will be given to nanometallic structures in which surface plasmons can be generated, routed, switched, amplified, and detected. It will be shown that the intrinsically small size of plasmonic devices directly results in higher operating speeds and facilitates an improved synergy between optical and electronic components. The field of plasmonics is rapidly growing and has started to provide a whole range of exciting new research and development opportunities that go well beyond chipscale components. A number of such developments will be investigated, including new types of optical sensors, solar cells, quantum plasmonic components, non-linear and ultrafast devices. At the end of the tutorial, a critical assessment of the entire field is given, and some of the truly exciting new opportunities for plasmonics are identified.

Short Course Benefits:

This course should enable the participants to:

- Obtain a working knowledge of the key physical concepts used in Plasmonics that enable light manipulation at ultra small length- and time-scales
- Explain choices of different metal types, shapes, and sizes to accomplish different plasmonic functionalities
- Find out about common electromagnetic computational tools to design plasmonic structures and devices
- Get a feel for the current state of the field in terms of fundamental understanding as well as device applications
- Learn about the most recent trends and developments in research and applications

Short Course Audience:

Optical engineers and scientists who are interested in learning about the rapidly emerging field of plasmonics and its potential impact. A basic knowledge of electromagnetism will be very helpful.

Instructor Biography:

Mark Brongersma is an Associate Professor and Keck Faculty Scholar in the Department of Materials Science and Engineering at Stanford University. He leads a research team of eight students and three postdocs. Their research is directed towards the development and physical analysis of new materials and structures that find use in nanoscale electronic and photonic devices. His most recent work has focused on Si-based light-emitting materials, light sources, modulators, detectors, and metallic nanostructures that can manipulate and actively control the flow of light at the nanoscale. Brongersma has given over 50 invited presentations in the last 5 years on the topic of nanophotonics and plasmonics. He has also presented 3 tutorials at International conferences on these topics. He has authored\co-authored over 85 publications, including papers in Science, Nature Photonics, Nature Materials, and Nature Nanotechnology. He also holds a number of patents in the area of Si microphotonics and plasmonics. He received a National Science Foundation Career Award, the Walter J. Gores Award for Excellence in Teaching, the International Raymond and Beverly Sackler Prize in the Physical Sciences (Physics) for his work on plasmonics, and is a Fellow of the Optical Society of America, the American Physical Society, and the SPIE. Dr. Brongersma received his PhD in Materials Science from the FOM Institute in Amsterdam, The Netherlands, in 1998. From 1998-2001 he was a postdoctoral research fellow at the California Institute of Technology.

SC378 - Introduction to Ultrafast Optics

Sunday, 08 June
13:30 - 17:30

Short Course Level: Beginner

Instructor:

Rick Trebino, *Georgia Institute of Technology, USA*

Short Course Description:

Ultrafast Optics—the science and technology of ultrashort laser pulses—is one of the most exciting and dynamic fields of science. While ultrashort laser pulses seem quite exotic (they're the shortest events ever created!), their applications are many, ranging from the study of ultrafast fundamental events to telecommunications to micro-machining to biomedical imaging - to name a few. Interestingly, these lasers are readily available, and they are easy to understand. But their use requires some sophistication. This course is a basic introduction to the nature of these lasers and the pulses they generate. It will discuss the principles of their generation and amplification and describe their most common distortions in space and time and how to avoid them—or take advantage of them. In addition, it will cover the nonlinear optics of ultrashort pulses for converting pulses to almost any color, as well as the additional interesting and potentially deleterious effects nonlinear optical processes can cause. Finally, it will cover techniques for ultrashort-pulse measurement.

Short Course Benefits:

This course should enable the participants to:

- Explain how ultrashort-pulse lasers and amplifiers work.

- Describe and describe ultrashort pulses and their many distortions.
- Use nonlinear optics to an convert ultrashort laser pulse to virtually any wavelength.
- Take advantage of—or avoid—nonlinear-optical high-intensity effects.
- Meaningfully measure ultrashort pulses.

Short Course Audience:

Any scientist or engineer interested in the science and technology of the shortest events ever created, especially those new to it.

Instructor Biography:

Rick Trebino is the Georgia Research Alliance-Eminent Scholar Chair of Ultrafast Optical Physics at the School of Physics at the Georgia Institute of Technology. His research focuses on the use and measurement of ultrashort laser pulses. He is best known for his invention and development of Frequency-Resolved Optical Gating (FROG), the first general method for measuring the intensity and phase evolution of an ultrashort laser pulse, and which is rapidly becoming the standard technique for measuring such pulses. He has also invented techniques for measuring ultraweak ultrashort pulses, ultracomplex pulses, ultrafast polarization variation, and the complete spatio-temporal measurement of ultrashort pulses. He has also developed pulse compressors and a general theory of spatio-temporal distortions of ultrashort pulses.

SC396 - Frontiers of Guided Wave Nonlinear Optics

Sunday, 08 June
13:30 - 17:30

Short Course Level: Advanced Beginner

Instructor:

Ben Eggleton, *Univ. of Sydney, Australia*

Short Course Description:

This course will review recent research and applications in the field of nonlinear guided wave optics with emphasis on both fundamentals and emerging applications. Starting from a strong foundation in the principles of nonlinear optics, we will review recent progress in emerging nonlinear optical platforms with an emphasis on the different materials, including silicon, chalcogenide, III-V semiconductors, lithium niobate, photonic crystal fibres, nanophotonic circuits and others. We will establish key figures of merit for these different material systems and a general framework for nonlinear guided wave optics with emphasis on the applications in emerging areas of science and technology. We will then review recent progress and breakthroughs in the following areas: All-optical processing, Ultra-fast optical communications, Slow light, highly nonlinear and emerging waveguides, Ultrafast measurement and pulse characterization, Frequency combs and optical clock, Optical parametric amplifiers and oscillators, Generation and applications of optical super-continuum, Nonlinear localization effects and solitons, Nonlinear optics for quantum information.

Short Course Benefits:

This course should enable the participants to:

- Get state of the art knowledge of nonlinear optics in emerging waveguides and materials
- Understand the applications of nonlinear optics in key applications
- Have a foundation of nonlinear waveguide physics for emerging applications and science

Short Course Audience:

This course assumes some basic knowledge/familiarity of nonlinear optics. Individuals lacking such knowledge should consider taking *SC149*: Foundations of Nonlinear Optics first.

Instructor Biography:

Ben Eggleton has made pioneering contributions to nonlinear optics and all-optical signal processing with recent breakthrough achievements in the nonlinear optics of periodic media, slow-light in photonic crystals, ultrafast planar waveguide nonlinear optics and quantum information processing. His research into new classes of nonlinear waveguides has created a new paradigm for photonic chip based ultrafast optical signal processing and his group holds various world records. His breakthroughs in the nonlinear optics of chalcogenide glasses have led to his demonstrations of new ultrafast optical devices for telecommunications applications, record low-threshold supercontinuum generation sources and on-chip parametric sources. His fundamental breakthroughs include the first demonstrations of gap soliton formation in periodic media and of slow-light-enhanced nonlinear optics in photonic crystals. He is the author or coauthor of more than 320 journal publications and over 100 invited presentations with over 9000 citations and an h-number of 49. Professor Benjamin Eggleton is an ARC Laureate Fellow and Professor of Physics at the University of Sydney, Director of the ARC Centre for Ultrahigh-Bandwidth Devices for Optical Systems (CUDOS). He obtained his Ph.D. degree in Physics from the University of Sydney, Sydney, N.S.W., Australia, in 1996. In 1996, he joined Bell Laboratories, Lucent Technologies as a Postdoctoral Member of Staff, and was then promoted to Research Director within the Specialty Fiber Business Division of Bell Laboratories, where he was engaged in forward-looking research supporting Lucent Technologies business in optical fiber devices.

SC402 - Transformational Optics

Monday, 09 June
13:00 - 16:00

Short Course Level: Advanced Beginner
Instructor:
Ulf Leonhardt, *Weizmann Inst. of Science in Israel, Israel*
Short Course Description:

Science Magazine listed transformation optics among the top 10 science insights of the decade 2000-2010. The course gives a self-consistent primer into this subject that may, literally, transform optics. Transformation optics grew out of ideas for invisibility cloaking devices and exploits connections between electromagnetism in media and in geometries. Within a short time it grew into a lively research area with applications ranging from invisibility and perfect imaging to the quantum physics of black holes.

Invisibility has been a subject of fiction for millennia, from myths of the ancient Greeks and Germans to modern novels and films. In 2006 invisibility turned from fiction into science, primarily initiated by the publication of first ideas for cloaking devices and the subsequent demonstration of cloaking for microwaves.

Perfect imaging is the ability to optically transfer images with a resolution not limited by the wave nature of light. Advances in imaging are of significant importance to modern electronics, because the structures of microchips are made by photolithography; in order to make smaller structures, light with increasingly smaller wavelength is used, which is increasingly difficult.

Black holes are surrounded by horizons that create quantum particles from the virtual particles of the quantum vacuum, Hawking radiation. Understanding and testing this mysterious phenomenon will shed light on connections between quantum physics and general relativity.

Short Course Benefits:

This course should enable the participants to:

- Derive the foundations of transformation optics from Maxwell's equations
- Design transformation-optical devices
- Calculate the material properties of transformation-optical devices
- Analyze the performance of transformation-optical devices

Short Course Audience:

The audience can be mixed, coming from academia or industry at various levels, but prior knowledge of electromagnetism at the level of the Maxwell's equations is essential. The audience is not required to know differential geometry, as all required mathematical results will be clearly stated, but should not be afraid of mathematics.

Instructor Biography:

Ulf Leonhardt is one of the founders of transformation optics. For his work on cloaking devices, Scientific American listed him among the world's 50 top policy, business and research leaders in 2006. For the theory of invisibility and quantum forces, and for laboratory demonstrations of artificial black holes he received a Royal Society Wolfson Research Merit Award in 2008, a Theo Murphy Blue Skies Award of the Royal Society in 2009 and a thousand-talent award of China in 2012. Ulf Leonhardt and Thomas Philbin wrote the first textbook on transformation optics: Geometry and Light: the Science of Invisibility (Dover, 2010).

SC403 - NanoCavity Quantum Electrodynamics and Applications

Sunday, 08 June

14:00 - 17:00

Short Course Level: Beginner

Instructor:

Jelena Vuckovic, *Stanford Univ., USA*
Short Course Description:

Strong localization of light in nanophotonic structures leads to enhanced light-matter interaction, which can be employed in a variety of applications, ranging from improved (higher speed, lower threshold) optoelectronic devices, to biophotonics, quantum information and low threshold nonlinear optics.
In particular, quantum dots in optical nanocavities are interesting as a test-bed for fundamental studies of such light-matter interaction (cavity quantum electrodynamics - QED), as well as an integrated platform for information processing. As a result of the strong field localization inside of sub-cubic wavelength volumes, they enable very large emitter-field interaction strengths (vacuum Rabi frequencies in the range of 10's of GHz – a few orders of magnitude larger than in atomic cavity QED). In addition to the study of new regimes of cavity QED, this can also be employed to build devices for quantum information processing, such as ultrafast quantum gates, nonclassical light sources, and spin-photon interfaces. Beside quantum information systems, many classical information processing devices greatly benefit from the enhanced light matter interaction in such structures; examples include all-optical switches operating at the single photon level, electro-optic modulators controlled with sub-fJ energy and operating at GHz speed, and lasers with threshold currents of 100nA.

This course will introduce cavity QED (e.g., strong and weak coupling regimes, Purcell effect, etc.), with particular emphasis on semiconductor nanocavities. We will also describe state of the art in solid state cavity QED experiments and applications.

Short Course Benefits:

This course should enable the participants to:

- Explain light matter interaction in optical nanostructures
- Discuss state of the art in solid state cavity QED
- Identify benefits of employing nano-cavity QED for certain applications

Short Course Audience:

Scientists and engineers interested in cavity QED and nanophotonic devices in general. Some background in electromagnetics, quantum mechanics, and optoelectronics is helpful, but not required

Instructor Biography:

Jelena Vuckovic is a Professor of Electrical Engineering at Stanford University, where she leads the Nanoscale and Quantum Photonics Lab. She received her PhD degree in Electrical Engineering from the California Institute of Technology (Caltech) in 2002, and joined Stanford faculty in 2003. She has received many awards including the Hans Fischer Senior Fellowship (2013), the Humboldt Prize (2010), the DARPA Young Faculty Award (2008), the Presidential Early Career Award for Scientists and Engineers (PECASE in 2007).

SC410 - Finite Element Modeling Methods for Photonics and Optics NEW

Tuesday, 10 June

09:00 - 12:00

Short Course Level:

Instructor:

Arti Agrawal, *City Univ., UK*
Short Course Description:

Numerical modelling and simulation of optical devices and components is a key tool in improving performance by reducing time and monetary costs, design optimization and characterization as well as innovating new ideas. Both passive and active devices are modelled and optimized numerically. In some cases simulation is the only way to explore phenomena where technology is not advanced enough for fabrication. The interaction of the optical beam with physical effects such as non-linearity, stress, strain, change in refractive index due to temperature, application of electric fields etc. are now extremely important. Modelling complements experimental work perfectly and almost no research is conducted without it.

The Finite Element (FE) method is one of the most popular and powerful methods for modelling in Photonics. This short course starts with Maxwell's equations and explains the basic principles of numerical modelling and the key assumptions involved. This foundation is used to develop the FE method, including a brief tour of the mathematics. How the method can be applied to various optical devices is discussed in detail. How can physical effects be included with the FE method for modelling is considered. The course ends with an explanation of FE based beam propagation methods and how these can be used to find the evolution of the optical fields.

Some salient features of the short course include:

- Emphasis on practical application of FEM for modelling of devices
- Discussion on developing code
- Perfectly Matched Layer and Periodic boundary condition

- Generating mesh for structures, post-processing of results
- Discussion on popular commercial software such as COMSOL and how to best utilize them

Methods covered include:

- Full vector Finite Element method for modal solutions
- FEM with physical effects
- Finite Element Beam Propagation Methods (FE BPM)

Practical illustrations include:

- Optical fibers including photonic crystal fibers
- Si slot waveguides, nanowires and high index contrast structures
- Bent waveguides and loss
- Plasmonic waveguides
- Second Harmonic generation in waveguides: FE BPM

Short Course Benefits:

- Identify and explain basic principles of numerical modelling in Photonics
- Discuss and explain Full vector Finite Element Method (FEM) for modal solutions
- Discuss FEM with physical effects (non-linearity, stress/strain, acousto-optic, electro-optic effect etc.)
- Discuss Finite Element Beam Propagation Methods (FE BPM)
- Discuss and explain how to incorporate Perfectly Matched Layer and Periodic boundary condition

- Summarize how to generate mesh for structures and post-processing of results
- Discuss popular commercial software such as COMSOL and how to best utilize these
- Discuss the application of the method to practical devices: nano wires, optical fibers, sensors etc.
- Identify the appropriate modeling method for their problem
- Use commercial Finite Element based solvers for simulation incorporating PML boundary conditions as well as write their own code.

Short Course Audience:

This course is intended for researchers, engineers and students who use simulation in their work in both fundamental and applied aspects of Optics and Photonics, especially for components and devices. The course is useful for members of both academic and industrial institutions. Basic background and familiarity in Optics will be sufficient.

Instructor Biography:

Arti Agrawal is an expert in numerical modelling methods for Photonics and has co-authored a text book “Finite element modelling methods for Photonics” published by Artech House. She is currently a Lecturer of Photonics in the Department of Electrical, Electronic and Information Engineering at City University London. Her research interests are modelling of photonics devices: spiral fibres, solar cells, photonic crystals etc. and development of numerical methods. She writes a blog http://artiagrawal.wordpress.com.

Special Events

Special Symposium in Honor of Howard Schlossberg

Sunday, 8 June, 04:00–06:00

Howard “Howie” R. Schlossberg, the Air Force Office of Scientific Research program officer for optical sciences, has made critical contributions to the field of optics and lasers throughout his eminent career. He has guided research in diverse areas, such as ultra-fast optoelectronic techniques, nonlinear optics, laser cooling, and medical laser treatments. Dr. Schlossberg is a Fellow of OSA, IEEE, and ASLMS.

This symposium will highlight some of the scientific advances enabled by Dr. Schlossberg, combined with personal anecdotes, in honor of the occasion of his retirement.

A Half-Day Trip to Historic New Almaden

An OSA Members, Family and Friends Event

Monday, 9 June, 09:00–12:30
OSA members and their families are invited to a half-day tour of the village of New Almaden, once a world-famous quicksilver mining community that was the site of California's first mining operation. Learn about the history of the mine and its importance to California history during a private tour of the Almaden Quicksilver Mining Museum. You will also enjoy a guided walking tour of the historic town and outdoor museum.

International Year of Light 2015 Informational Meeting

Monday, 9 June 17:00 -18:00
Room 231B, Convention Center

Be a Part of a Global Movement – The International Year of Light (IYL 2015) is a global initiative to raise awareness of how optical technologies promote sustainable development and provide solutions to worldwide challenges. The science and technology of light have revolutionized medicine, have opened up international communication, and are central to linking the cultural, economic and political aspects of the world. This meeting is open to all attendees to come learn about the many exciting activities planned for IYL 2015 and how you can celebrate at your local level.

Special Symposium in Memory of James P. Gordon

Monday, 9 June, 18:30 - 20:30

James P. Gordon, one of the founding fathers of quantum electronics, passed away on June 21, 2013. This symposium celebrates his work and life. Distinguished speakers, including close collaborators of Jim, will recount some of his numerous scientific and technical contributions.

Several Nobel Laureates and laser pioneers are featured speakers.

CLEO: 2014 Conference Reception and Poster Session

Tuesday, 10 June, 18:30–20:00

Exhibit Hall 3

Sponsored by THORLABS

The reception is open to all Technical attendees. Badges must be worn to enter the reception. Exhibit Pass Plus registrants will need to purchase a Conference Reception ticket from Registration (Concourse Level) to join the Joint Conference Reception and Poster Session. Network and enjoy the evening with your colleagues.

Student Lounge

Tuesday, 10 June - Thursday 12 June during the Expo

Exhibit Floor

Sponsored by Newport

Students attending CLEO: 2014 can take a break during the conference and visit the Newport Student Lounge, open **10-12 June** in the exhibit hall of the San Jose McEnry Convention Center.

OSA Student Member Reception

Tuesday, 10 June, 20:30

South First Billiards

OSA Student Members are also invited to attend the OSA Student Member Happy Hour taking place on Tuesday, **10 June** at 8:30 PM (after the conference reception) at South First Billiards. Stop by to network with your fellow student attendees and enjoy free food and drinks!

Poster Sessions

Tuesday, 10 June, 18:30–20:00

Wednesday, 11 June, 13:30–15:00

Thursday, 12 June, 11:30–13:00

Exhibit Hall 3

These poster sessions are an integral part of the Technical program. Take advantage of the opportunity to have a one on one conversation with author and ask questions about his or her significant research. Select sessions are complimentary with Exhibits Pass Plus Registration.

Optics for Energy Panel Discussion & Networking Session

Tuesday, 10 June, 18:45 – 19:45
Executive Ballroom 210F, San Jose Convention Center

The event will feature mini-talks on hot topics & fundamentals of photon energy conversion, followed by ample Q&A and informal discussion time. The event is open to everyone, food and refreshments will be served.

Featured discussion topics include but are not limited to:

(1) Thermodynamics of energy conversion:

- efficiency limits of photon energy conversion processes
- photovoltaics vs solar-thermal vs thermionic emission vs thermophotovoltaics
- photon up-conversion & angular selectivity
- radiative cooling

(2) Plasmonics for energy:

- plasmonic light trapping/extraction
- catalytic reactions enhancement
- novel IR plasmonic materials & near-field effects for PV & TPV

Tomorrow of Metamaterials - OSA Technical Group Event at CLEO

Tuesday, 10 June, 19:30 – 21:30
Executive Ballroom 210E, San Jose Convention Center

The field of metamaterials has flourished for 14 years or so. Fundamental science has been explored. We have witnessed breathtaking theoretical predictions and experimental demonstrations. Now it may be a time to catch a breath and ask ourselves the question "now what?" The Optical Society's Technical Group Photonic Metamaterials (OP) will run an "extracurricular" session at CLEO 2014 to address this question. The session will feature several panelists, who will seed the discussion with 3-to-5 minute presentations. After that the floor will be opened to discussions aimed to answer the question "what is next?".

OSA Laser Therapeutics Workshop

Wednesday, 11 June, 10:00 - 17:00
Location TBD, San Jose Convention Center

Explore Therapeutic Technologies. Develop Valuable Connections.
Hosted by two renowned scientists in the field of laser therapeutics, Dr. Rox Anderson, Harvard Medical School & Massachusetts General Hospital and Dr. Adela Ben-Yakar, University of Texas at Austin, have created a must-attend workshop featuring a panel of distinguished speakers. This full day workshop will bring together leading scientists and clinicians in the optical diagnostics and laser therapeutics areas.

This workshop is collocated with CLEO. **Separate registration is required**.
Visit www.osa.org/lasertherapeutics

Nanophotonics Poster Session & Dine & Discover

Wednesday, 11 June, 18:30 – 19:30
Meeting Room 231B, San Jose Convention Center

This event will bring together colleagues around nanophotonics and opens the floor to share your latest research findings, exchange ideas, and facilitate collaborations in relevant areas. The poster session is on a first-come, first served basis, while everyone is welcome to join the dinner afterwards. The poster can be, but does not have to be limited to your CLEO presentation and it is encouraged to prepare the poster with a more general picture of your work.

The "Dine & Discover" portion of this event will take place at II Fornaio at 20:00. The restaurant is located at 302 South Market Street (at the Sainte Claire Hotel). All are welcome to come dine, at your own expense, and connect with colleagues.

VIP Industry Leaders Networking Event: Connecting Corporate Executives, Young Professionals and Students

Wednesday, 11 June, 12:00–13:30
Exhibit Hall 3, San Jose Convention Center

Sponsored by GoFoton

This session brings together Industry Executives to share their business experience – from how they started their careers and lessons learned along the way, to using their degree in an executive position – with Young Professionals, Recent Graduates and Students. The program starts with informal networking during lunch and then transitions into "speed meetings" – small, brief visits with each executive to discuss careers, industry trends or other career topics.

Pizza Lunch Party!

Thursday, 12 June, 12:30 - 14:00
Exhibit Hall

Don't miss this year's free Pizza Lunch at the CLEO: Expo!
Freshly baked pizza will be available Thursday, 12 June, 12:30–14:00 in the Exhibit Hall. Join your colleagues on the show floor to enjoy a slice, and while you're there make sure to take advantage of the final networking opportunity with the exhibitors.

Postdeadline Papers

Thursday, 12 June, 20:00 - 22:00
Location TBD, San Jose Convention Center

Come and participate in these sessions! Find out about the significant late-breaking research and new, significant material in rapidly advancing areas.

OIDA 100GbE per Lambda for Data Center Workshop

Thursday, 12 June, 20:00 - 22:00
Location TBD, San Jose Convention Center

Learn How to Commercialize Single-channel 100GbE Optical Communications
OIDA and the Ethernet Alliance are partnering to host a workshop on 100GbE single-channel interconnects for data center networks. The event will be collocated with the CLEO in San Jose, in June 2014. The workshop aims to address the challenge of commercializing single-channel 100GbE optical

communications. The workshop will not address whether 100GbE will or will not happen, especially with regard to other technical approaches, such as parallel channels. The workshop will not address standards-making issues. This workshop is collocated with CLEO. **Separate registration is required**.

American Physical Society Booth

Founded in 1899, the American Physical Society (APS) is a non-profit membership organization working to advance and diffuse the knowledge of physics. APS publishes the world's most widely read physics research and review journals: Physical Review Letters, Reviews of Modern Physics, Physical Review X, Physical Review A-E, Physical Review Special Topics, Physics, and the newest addition to the APS family, Physical Review Applied.

IEEE Photonics Society Booth & Member Lounge

Come visit the IEEE Photonics Society booth located in the registration area and see all we have to offer. Members are also welcome to visit our members-only lounge where you can sit down, relax and connect to the Internet. Not a member? Let us sign you up at the booth, and you may start enjoying the benefits of IPS membership today!

OSA Booth & Member Lounge

The OSA Member Lounge is an inviting space where you can relax, unwind, access the Internet and meet with OSA colleagues. Located on the Concourse Level, the lounge will offer comfortable seating, meeting tables, wireless Internet, computer/printer access and light refreshments. If you are not a member, sign up at the OSA Booth, which is located next to the lounge.

Show Your Badge Program

Show your badge and receive discounts up to 25% off at some of San Jose's finest restaurants and attractions.