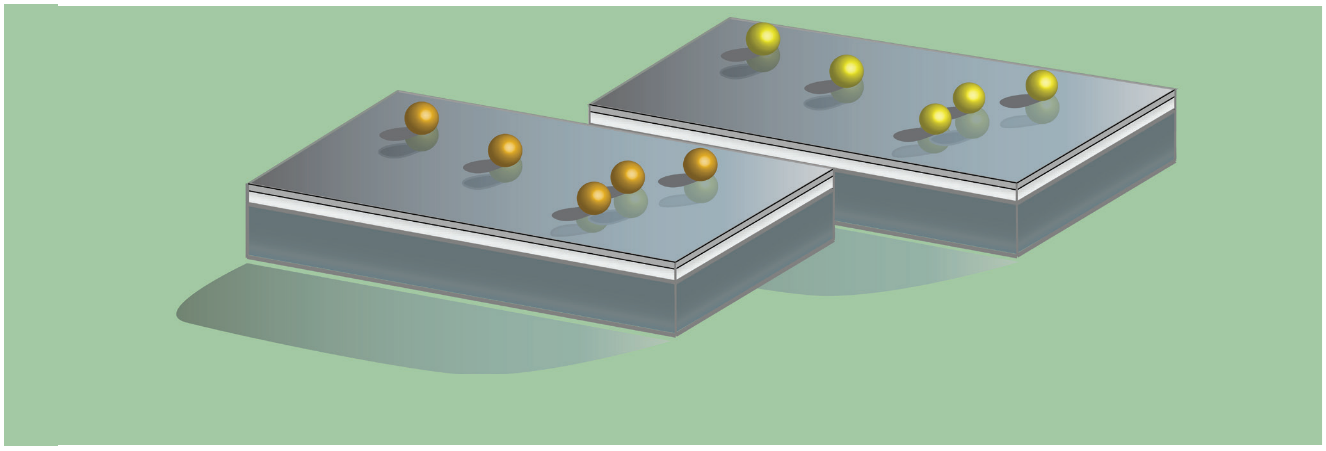
Industrial Affiliates Program

University of Central Florida

CREOL – The College of Optics and Photonics

2014



CREOL

CREOL, The College of Optics and Photonics
University of Central Florida

“Advances in Optics & Photonics” Industrial Affiliates Symposium

7 March 2014

Friday, 7 March, Morning Session –UCF Student Union

8:00 Continental Breakfast and Walk-in Registrations

Time	Topic	Speaker	Affiliation
8:30	Welcoming Remarks	MJ Soileau	UCF Vice President for Research
8:50	Welcome and overview of CREOL, The College of Optics and Photonics	Bahaa Saleh	Dean & Director, CREOL, UCF

Technical Symposium

Session I. Fiber Lasers - Axel Schulzgen, session chair

9:15	“A Brief History of Fiber Lasers”	Bryce Samson	Nufern
9:45	“The Role of Universities in Fiber Lasers”	Lawrence Shah	CREOL, UCF

10:05 BREAK & EXHIBITS

Session II. Nanophotonics for Medical Applications – Pieter Kik, session chair

10:25	“Lanthanide upconverting nanoparticles for bioimaging applications”	John A. Capobianco	Concordia University, Canada
10:55	“Extreme photothermal response enhancement in plasmonic oligomers”	Pieter Kik	CREOL, UCF

Session III. Optical Ceramic Lasers - Romain Gaume, session chair

11:15	“Transparent Polycrystalline Materials: Historical Developments and Next Generation Applications”	Greg Quarles	Optoelectronics Management Network
11:45	"Novel characterization techniques for optical ceramics"	Romain Gaume	CREOL, UCF

12:05 **LUNCH Served** Student Union

Tabletop Exhibits – Student Union

Friday Afternoon Session

Presentations – Student Union

Session IV. Silicon Photonics - Sasan Fathpour, session chair

1:00	"Silicon Photonics for Data Center and High Performance Computing Applications"	Mehdi Asghari	Mellanox.
1:30	"Hybrid Integrated Platforms on Silicon"	Sasan Fathpour	CREOL, UCF

Session V. Panel Discussion

1:50	Panel discussion on "Photonics Education-current and future education expectations in optics & photonics"	Jim Pearson – moderator David Hagan Dan Hull Alex Fong Barry Shoop Tim Fritzley	CREOL, FPC CREOL, FPC OP-TEC Gooch & Housego, FPC USMA-West Point FAZ Technology

2:50 **Break & Walk to CREOL Building**

Session VI. Poster Session, Tours, Exhibits, et al

3:15	Poster Sessions; lab Tours; exhibits; (contiguous).	CREOL Graduate Students	CREOL rooms 102 & 103; Tours start from lobby; exhibits in lobby
4:45	Poster awards presentation; reception	Bahaa Saleh	CREOL, The College of Optics and Photonics

6:00 **End of session and program**

Tabletop Exhibits – Student Union & CREOL Building

Thursday, 6 March, Afternoon Session

Short Courses

90 minute short courses held in CREOL Building, Room 102 & HEC Room 125
All offered at no charge. Attendance limited on a first-come, first serve basis.

1-2:30PM , Room 102
Terahertz Photonics
Instructor: KonstantinVodopyanov, Professor of Optics, UCF
The course covers fundamental principles of THz-wave generation as well as numerous and ever growing THz applications. The course includes sources and systems that provide access to the THz region of the spectrum, such as photonic terahertz generators based on ultrafast lasers, photomixers and nonlinear optical frequency converters, as well as direct terahertz sources, such as molecular and quantum cascade lasers. Applications of terahertz radiation encompass spectroscopy, sensing, and imaging, tomography, terahertz communications, photonic crystals and metamaterials, as wel as high-THz-field effects.

1- 2:30 PM, Room HEC 125
Nanophotonics and Plasmonics
Instructor: Pieter Kik, Professor of Optics, CREOL, UCF
The unique properties of nanostructured optical materials have led to ultrasensitive biochemical sensors, nanoscale light sources, bio-compatible optical markers, nanostructured anti-reflections coatings, and many more thanks in large part to plasmon resonances. This course covers fundamental aspects of plasmonic structures, and how these have enabled new technologies. Topics include biosensing using surface enhanced Raman scattering, refractive index based plasmonic sensors, metamaterial based nonlinear absorbers, and plasmonic nanolasers.

2:45-4:15, PM Room 102
Silicon Photonics
Instructor: Sasan Fathpour, Assistant Professor of Optics, CREOL, UCF
Integrating optical devices on silicon has been a technology in the making for over 25 years. The main motivation has been compatibility with CMOS microelectronics. Silicon photonics had a slow start in late 1980s and early 90s. The availability of silicon-on-insulator (SOI) wafers by mid-90s facilitated tremendous progress in the field to the extent that silicon photonics is nowadays a mature technology with several large and small companies marketing a variety of products, primarily transceivers and active optical cables for short-haul communications (Ethernet, local-area networks and board-to-board optical links). In parallel, nonlinear and mid-wave infrared (mid-IR) devices on silicon are being pursued in academia. The present short course reviews the principles of optical waveguides on silicon, how to make modulators on the platform and how to integrate silicon devices with compound semiconductor lasers and silicon-germanium photodetectors. Basics of nonlinear and mid-IR silicon photonic devices are also reviewed. Final remarks will be made on true compatibility with CMOS, and comparisons will be made with technologies based on gallium arsenide, indium phosphate and lithium niobate. Prospects of the mature field of integrated optoelectronics on these complementary (rather than commonly thought competing) material systems is discussed.

2:45-4:15, PM Room HEC 125
Fiber Lasers
Instructor: Axel Schulzgen, Professor of Optics, CREOL, UCF
Fiber lasers technology has been improving dramatically over the past two decades, making fiber lasers serious contenders for many laser applications. Fiber laser technology capitalizes on the rapid development of fiber optic components and advances in high power semiconductor diode lasers to create highly compact and reliable light sources in an all-fiber format. The flexibility of the fiber optics platform will make fiber lasers a frequent choice to satisfy increasing needs for laser in many fields of application.
In particular, high-power fiber lasers are attracting much interest among researchers and industry professionals. Several kilowatts of optical power have been generated from a single fiber core.
This short course combines an introduction to fiber lasers with technical discussions based on reviews of recent progress and latest developments in fiber laser research.

A Brief History of Fiber Lasers

Bryce Samson
Nufern

Abstract: The advances in performance of fiber lasers have been dramatic in the last 10 years, making fiber lasers a commercial business worth over $500M/year and fastest growing segment of the industrial laser market. All of this is made possible by the unique performance attributes of rare earth doped silica fibers which is at the heart of each of these laser systems. In this review of the technology we will describe the key enabling attributes these fibers, including the use of large mode area (LMA) fibers for high power CW lasers as well as pulsed fiber lasers, along with the key other fiber-based components needed to make a fiber laser. The common rare earth dopants for silica fibers, namely Ytterbium, Erbium, Thulium and Holmium will also be described, along with some of the commercially relevant devices that are enabled by these fibers.

Bryce Samson joined Nufern from Corning where he served as Senior Research Scientist in the areas of doped fibers, fiber amplifiers and fiber lasers.

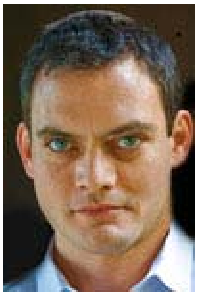
Prior to that, he worked as a Research Fellow at the University of Southampton focusing on novel fibers and fiber device physics. He received his Ph.D. in Physics from Essex University in the UK and his B.S. degree in Applied Physics from Heriot-Watt University in Edinburgh, UK.

He is an inventor on several patents in the amplifier and fiber laser field and has been published in numerous industry journals.

The Role of Universities in Fiber Lasers

Lawrence Shah
CREOL, The College of Optics & Photonics, UCF

Abstract: Research into optical fiber, fiber lasers, and related applications has a well-established history within CREOL. Similar to the recent growth annual revenue and portion of commercial markets, research activities in CREOL have expanded and continue to accelerate. While there is clear overlap in the interests of academic institutions and industry in these research areas, there are also clear differences in "products" and "customers". The primary "product" of universities is highly educated students, along with new concepts and intellectual property. As such, industry is a key "customer" of universities as well as a partner in research; however there are also important differences in funding sources and the determination of excellence. This presentation will review past and present research activities in fibers and fiber lasers in notable academic research institutions highlighting partnerships that have resulted in mutual academic and industrial benefit.



Lawrence Shah became a Research Assistant Professor in 2012 in the Townes Laser Institute within CREOL/The College of Optics and Photonics, after having served as a research scientist since 2008. In 2001, Dr. Shah received his PhD degrees in optical physics from CREOL and the University of Central Florida as part of the Laser Plasma Laboratory (LPL). Prior to rejoining to CREOL, Dr. Shah served as a post-doctoral research at LLNL and as a research scientist at IMRA America Inc. Dr. Shah has been awarded ten patents and been an author of many peer-reviewed publications and presentations at international conferences. His current research activities focus on the development of ultrashort pulse, thin disk, and fiber laser systems along with proof-of-concept investigations of their applications.

Upconverting Nanoparticles: A Platform for PDT, Photoswitching and Bioimaging

John A. Capobianco
Centre for NanoScience Research, Concordia University

Abstract: Lanthanide doped nanoparticles have the ability to undergo upconversion. Upconversion is a non-linear anti-Stokes process that efficiently converts two or more low-energy excitation photons, which are generally near infrared (NIR) light, into a higher energy photon (e.g., NIR, visible, ultraviolet) through the use of long lifetime and real ladder-like energy levels of trivalent lanthanide ions embedded in an appropriate inorganic host lattice. Thus, these materials are quickly emerging as candidates in novel biological applications. This stems from their unique optical and chemical properties, such as non-blinking, non-photobleaching, absence of autofluorescence, low-toxicity, low photodamage to live cells, and their remarkable ability to penetrate light in tissues. Here, we present the synthesis of lanthanide-doped fluoride nanoparticles, their optical properties, and strategies to impart biological functionality. Finally, we show relevant biological applications of these nanoparticles as a platform for PDT, photoswitching and as imaging probes for cancer cells.

John A. Capobianco earned his B.Sc. in Chemistry, from McMaster University and his Ph.D. from the University of Geneva, Switzerland for his work on Mossbauer spectroscopy. He spent 2 years at McGill University as a post-doctoral fellow (laser spectroscopy). He was appointed assistant professor in the Department of Chemistry and Biochemistry in 1986 and started a research program in lanthanide spectroscopy. He was promoted to full professor of chemistry in 1999. In 2008 he was awarded the prestigious Concordia University Senior Research Chair in Nanoscience. He is the founder and director of the Centre for NanoScience Research, at Concordia University.

Professor Capobianco has been invited professor at l'Université d'Angers, France, Università di Trento, Italy, and Universidad Autónoma de Madrid, Spain and University of Verona, Italy. He is the author or co-author of 217 research papers and contributed presentations at confere nces

Extreme Photothermal Response Enhancement in Plasmonic Oligomer

Pieter Kik
CREOL, The College of Optics & Photonics, UCF

Abstract: Surface plasmons on metallic nanoparticles can enhance optical fields at frequencies ranging from the ultraviolet to the near-infrared. This effect can be used in a wide range of applications, ranging from surface enhanced Raman scattering for ultrasensitive biodetection to photovoltaic response enhancement through efficient redirection of incident sunlight. The present talk focuses on a new method for enhancing the photothermal response of plasmonic structures, with possible applications in medicine and nonlinear optical switching. In the plasmon photothermal effect, metal nanoparticles absorb incident radiation efficiently through the excitation of collective oscillations of the free electrons in the particle, which is accompanied by rapid heating of the particle. The combination of a small volume and a large absorption cross-section allows the achievement of large temperature changes at relatively low irradiance. Moreover, these effects can be achieved with chemically stable and non-toxic materials. For these reasons plasmon resonant structures are currently being considered for use in photothermal therapy. Here we discuss how few-particle aggregates of noble metal particles with different sizes can produce a photothermal response that is more than two orders of magnitude larger than that of isolated gold nanoparticles

Pieter G. Kik is an Associate Professor of Optics and Physics at CREOL, The College of Optics & Photonics, at the University of Central Florida. He received his PhD from the University of Utrecht, The Netherlands for work on rare-earth doped optical materials at the FOM Institute for Atomic and Molecular Physics in Amsterdam, The Netherlands. He worked on plasmonics as a postdoctoral scholar at the California Institute of Technology. His research interests include nanophotonics and plasmonics, including applications in biosensing, nonlinear optics, and nanocomposite optical gain media. He is the recipient of an NSF CAREER Award, and is co-editor of the book Surface Plasmon Nanophotonics

Transparent Polycrystalline Materials: Historical Developments and Next Generation Applications

Gregory J. Quarles
Optoelectronics Management Network

Abstract: The thrust of this overview will focus on transparent polycrystalline optical materials, ranging from laser hosts to scintillators to window and dome materials. Comparisons of the spectroscopic, mechanical, thermo-optic, and laser performance properties between single crystal and ceramic oxide gain materials will be presented. The first demonstration of laser-grade optical ceramics took place in 1995 by Ikesue with Nd-doped YAG. Over the past decade a number of studies have shown that there are several techniques for processing the nanopowders that are the precursors to the fabrication of the polycrystalline laser hosts. Unique characteristics include achieving higher doping levels of the laser active impurities than can typically be obtained through standard Czochralski crystal growth techniques. Other unique manufacturing opportunities include uniform distributions of the active ions across the entire cross section of the polycrystalline pieces. In addition, the specimen size can be significantly increased as compared to the largest Nd:YAG boules grown by the Czochralski method, which are nominally 100 mm in diameter. Slabs of the polycrystalline equivalent have been manufactured which are greater then 300 mm in active length. Transparent ceramics can be produced by starting with phase-pureoxide powders, or by the several different reactive approaches in which a mixture of metal oxides are sintered. Utilization of these various nanopowder preparation technologies has led to advanced development and demonstration of large-scale materials utilized in scintillator applications, or as transparent optics on various military platforms. The applications of these polycrystalline materials will be reviewed to provide a context for next-generation evolutions of various systems.

Gregory Quarles is an experienced Chief Executive Officer, Board Member and renowned physicist with 25 years of experience driving cutting-edge laser, optics and photonics technology development and operations within advanced industrial companies. Greg is a globally recognized leader for his strategic partnerships with the Department of Defense, the U.S. Congress, and his innovative work in the progression of global materials research, specifically developing new laser devices for medical, military and industrial applications. Greg has been awarded five patents related to his research in solid-state lasers and has published over 100 peer-reviewed publications.

Greg is currently the President and CEO of Opto-Electronics Management Network, a consulting firm specializing in the lasers and materials industry, with primary focus on the defense, aerospace, and the nanomaterials sectors. Prior to starting this consulting business, Greg recently served as the CEO at B.E. Meyers & Co., Inc., a pioneering company in the development and manufacturing of opto-electronic technology and related products used in defense and law enforcement applications. Greg served on the Board at B.E. Meyers for three years prior to being recruited as President and COO. He has served on eight Boards related to Optic & Photonic education, development, and research, including his current leadership positions as Chair of the OSA Industry Committee, Director-At-Large on the Board of Directors for OSA and as a member of the Board of Directors (and acting-CEO) for Nanocerex. He has recently been named to the Advisory Board for Open-Photonics and has been a leader within the Optical Society and across the partner societies in advancing the National Academy of Sciences National Photonics Initiative.

Dr. Quarles is a graduate of Oklahoma State University and holds a Ph.D. in Physics, a MS in Physics, and a dual BS in Math and Physics. He began his career as a Research Physicist at the U.S. Naval Research Lab, and, among other roles, has served as Assistant Editor for Optical Engineering and IEEE Journal of Quantum Electronics and is a Fellow of both the OSA and SPIE.

Gaumer

Romain Gaume
CREOL, The College of Optics & Photonics, UCF

Abstract: Transparent ceramics are made of a mosaic of micron to sub-micron crystalline grains separated by very thin grain-boundaries. These optical materials, obtained by an elaborate process involving high-temperature densification of nanopowders, allow the fabrication of larger and more efficient laser gain media and high-energy radiation detectors. Yet, after more than four decades of research, challenges remain in producing high optical quality materials with sufficient consistency.

This presentation will review the developments of novel metrology tools that include the ability to correlate composition, stoichiometry and processing variables to ceramic quality.
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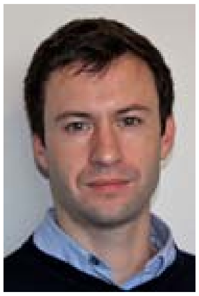

Romain Gaume received his MS degree in Inorganic Chemistry in 1999 and his Ph.D. degree in Materials Science in 2002 from Paris VI University, France. His Ph.D. thesis was on the development of crystal chemistry approaches for the discovery of novel Yb^{3+}-doped solid-state lasers for high-power applications. After obtaining his Ph.D., Dr. Gaume joined Prof. R.L. Byer's and R.S. Feigelson's groups at the Department of Applied Physics at Stanford University where he concentrated his research on the fabrication and characterization of laser and scintillator ceramic materials. Dr. Gaume joined the faculty at the College of Optics & Photonics and NanoScience Technology Center at UCF in 2011 where he continues his research on transparent ceramics for applications in high-power lasers, and nuclear detectors as well as on nanoceramics for thermoelectric devices. Dr. Gaume has published over 30 peer reviewed journal papers and presented 17 invited communications at international conferences.

Silicon Photonics for Data Center and High Performance Computing Applications

Mehdi Asghari
Mellanox

Abstract: In this talk we will review the role that Silicon Photonics can play in data centers and high performance computing. We will review industrial effort in creating the Silicon Photonics platform and provide an outlook for where the field is going and some of the challenges that it faces

Mehdi Asghari has around 20 years of research and product development experience within the silicon photonics industry. Currently, Dr. Asghari is the VP of Silicon Photonics R&D at Mellanox. Prior to that he was the CTO at Kotura Inc. Previously Dr. Asghari served as VP of Research and Development at Bookham Inc. in the UK. Bookham was the first company commercializing Silicon photonics.

Dr. Asghari holds a Ph.D. degree in Optoelectronics from the University of Bath, a M.Sc. degree in Optoelectronics and Laser Devices from the Heriot-Watt and St. Andrews Universities, and a MA degree in Engineering from Cambridge University. He has authored or co-authored over 150 Journal and Conference publications and holds more than 15 active patents within the fields of silicon photonics and optoelectronics.
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Hybrid Integrated Platforms on Silicon

Sasan Fathpour
CREOL, The College of Optics & Photonics, UCF

Abstract: Silicon photonics owes its success to the high quality of silicon-on-insulator (SOI) wafers. In these commercially available wafers, a thin layer of silicon (active layer) sits on top of a buried insulator (silicon dioxide) that serves as the bottom cladding for optical waveguides. However, the SOI technology has its own limitations that prohibits using it for certain applications. For example, the active silicon layer does not possess electrooptic properties for high-performance modulators and other second-order nonlinear optic applications. Also, the so-called buried oxide layer is lossy in the mid-infrared regime. To overcome such shortcomings, we have been developing novel hybrid wafers (namely, lithium-niobate-on-silicon, silicon-on-nitride and suspended membrane) at CREOL's nanofabrication facility and have demonstrated several integrated photonic devices (waveguides, ring-resonator, optical modulators, etc.) on them. Advantages of the novel approaches, the employed fabrication methods and performance of the fabricated devices demonstrated so far on these hybrid platforms will be presented and discussed.

Sasan Fathpour is an Assistant Professor of Optics at CREOL, The College of Optics and Photonics at the University of Central Florida (UCF). He also holds a joint appointment at the Department of Electrical Engineering and Computer Science at UCF. His research interests are silicon photonics, heterogeneous integrated photonic platforms and nonlinear photonics. Since joining CREOL's faculty in 2008, Prof. Fathpour has been involved in several federally-funded grants as the principal investigator. He received the US National Science foundation (NSF) CAREER Award in 2012 and the Office of Naval Research (ONR) Young Investigator Award in 2013. His research at CREOL has been highlighted in Nature Photonics, Optics and Photonics News, Laser Focus World, photonics.com and other trade magazines and professional websites.

Professor Fathpour received the Ph.D. degree in Electrical Engineering from the University of Michigan, Ann Arbor in 2005. His dissertation was on quantum dot lasers and spintronic light sources and materials, in which he demonstrated the world's first temperature invariant semiconductor laser and the fastest quantum dot lasers to date. After receiving his Ph.D., he joined the Electrical Engineering Department of UCLA as a postdoctoral fellow and was promoted to a Visiting Assistant Professor in 2007. His UCLA research on energy harvesting in silicon photonics received worldwide press coverage and won him the 2007 UCLA Chancellor's Award for Postdoctoral Research. Prior to joining CREOL in September 2008, he was a Senior Researcher at Ostendo Technologies Inc., where he was working on novel visible light sources for display applications. He is the co-editor of the book entitled "Silicon Photonics for Telecommunications and Biomedicine," published by CRC Press in 2012. He is a co-author of over 80 journal and conference papers and 6 book chapters.

Panel Discussion

Moderator:

James Pearson, CREOL, The College of Optics and Photonics & Florida Photonics Cluster

James Pearson received his PhD in Electrical Engineering & Physics from the California Institute of Technology. Since joining UCF in 2004, From 2004-2009 at UCF he served as Director, Research & Administration for CREOL, The College of Optics and Photonics and Special Assistant to the UCF VP for Research. He was responsible for establishing research partnerships with individuals and organizations in areas of interest to the UCF faculty and for several special projects including Interim Director, Advanced Materials & Processing Center (AMPAC) and Homeland Security Liaison for UCF. Currently semi-retired, he is Special Consultant for CREOL, contributing to a variety of projects including marketing and partnership development, photonics technician training and certification, and support of the Florida Photonics Cluster. Prior to joining UCF, he was Executive Director of ISA – The Instrumentation, Systems, & Automation Society (1999-2004), Executive Director of SPIE – The International Society for Optical Engineering (1993-1999), and held several positions within United Technologies Corporation (1976-1993), including Chief Scientist at the Research Center, and President of UT Optical Systems. He is a Life Fellow of SPIE, Fellow of OSA, and a Senior Life Member of IEEE, and has served on the Board and several committees of these societies. He served the Council of Engineering and Scientific Society Executives (CESSE) as President, 2001-2002; Secretary, 2000-2001; and member of the Board of Directors, 1995-2003.

Panelists:

David Hagan, CREOL, The College of Optics & Photonics, UCF

David Hagan received his PhD degree in Physics at Heriot-Watt University, Edinburgh, Scotland In 1985. He is a Professor of Optics and Physics at UCF and is also the Associate Dean for Academic Programs of the College of Optics and Photonics. HE is the current and founding editor-in-chief of the open access journal, “Optical Materials Express” and served as the Program chair for the OSA “Frontiers in Optics” meeting in 2013. His current research interests include techniques for nonlinear optical characterization, optical power limiting and switching, strongly nondegenerate optical nonlinear optics, nanostructural enhancement of optical nonlinearities and nonlinear optical spectroscopy.

Daniel Hull, OP-TEC

Daniel Hull is the principal investigator and executive director of the NSF/ATE-funded National Center for Optics and Photonics Education (OP-TEC) at UCF. Prior to his role at OP-TEC, Hull founded the Center for Occupational Research and Development, an organization focusing on technician preparation, which he led from 1979 to 2006. He also founded the National Coalition for Advanced Technology Centers (NCATC) and the National Careers Pathways Network (NCPN).

Hull is the author of seven books on technician preparation and contextual teaching, including *Career Pathways for STEM Technicians* (2012), *Adult Career Pathways* (2007), and *Career Pathways: Education with a Purpose* (2005). Dan is a registered professional engineering with 20 years of practice in the laser field and over 30 years of experience leading education reform efforts in the United States. He is a senior member of SPIE - The International Society for Optics and Photonics, the Optical Society of American, and the Laser Institute of America.

Alexandre Fong, Gooch & Housego

Alexandre Fong is Senior Vice-President, Life Sciences and Instrumentation and Business Development, Gooch and Housego (Orlando). He holds undergraduate and graduate degrees in Experimental Physics from York University in Toronto, Canada, an MBA from the University of Florida and is a Chartered Engineer.

Alex is a published author and lecturer in the fields of precision light measurement, life sciences imaging, remote sensing, applied optics and lasers, an active member of the American Physical Society, Optical Society of America (OSA), SPIE—The International Society for Optical Engineering, International Commission on Illumination CIE), Council for Optical Radiation Measurement and the Institute of Physics. He is also past chair of the OSA Public Policy Committee.

Prior to joining Gooch and Housego, Alex held senior business and technical management positions at ITT Industries, Newport Corporation and Honeywell International.

Alex is the current president of the Florida Photonics Cluster and founder of Cirrus Photonics, LLC.

Panel Discussion

Barry L. Shoop, United States Military Academy

Colonel Barry L. Shoop is a Professor, United States Military Academy and Deputy Head of the Department of Electrical Engineering and Computer Science at the United States Military Academy at West Point. During his twenty years at West Point, he has served in a number of leadership positions including Director of the Electrical Engineering Program and Director of the Photonics Research Center. Currently as Professor and Deputy Head he is responsible for an undergraduate academic department with over 79 faculty and staff supporting ABET accredited programs in electrical engineering, computer science, and information technology and serving over 2300 students annually.
His military assignments include Science Advisor to the Director and Chief Scientist of the Joint IED Defeat Organization in the Office of the Secretary of Defense, Chief of the Afghanistan Military Academy Implementation Support Team, Senior Electronics Engineer at the U.S. Army Foreign Science and Technology Center, and Electronics Engineer for the Defense Satellite Communication System Earth Terminal.

He received the B.S. from the Pennsylvania State University in 1980, and Ph.D. from Stanford University in 1992, both in electrical engineering. Shoop has served on the Board of Directors of IEEE and the OSA and currently serves on the Board of Directors of ABET. He is a Fellow of the IEEE, OSA and SPIE and received the 2013 IEEE Haraden Pratt Medal, the 2013 SPIE Educator Award, and the 2008 OSA Robert E. Hopkins Leadership Award.

Tim Fritzley, FAZ Technology, Inc

Tim Fritzley is an experienced executive with a substantial track record of structuring and aligning organizations and global ecosystems in order to develop and deliver products and services to international markets at scale. Tim has a solid mix of technical and business skills which enable him to work with emerging product development teams; up to senior "Cxx" level executives from around the world representing many countries and cultures. Tim has successfully developed and launched products into many global market segments; as well as has lived and travelled internationally for most of his professional career.

FAZ Technology is developing a portfolio of next generation photonic sensing and measurement products and services; and is majority owned by Fugro N.V., one of the world's largest earth sciences companies. FAZ has delivered the world's highest precision laser interrogation platform based on a swept tunable laser capable of well over 5Khz sweep rates and femto-meter precision. FAZ has also developed a family of next generation sensors for optical mass flow measurements and multi-species gas detection.

Fritzley's other positions throughout his career have spanned a wide variety of functional charters and roles, as well as many diverse areas of technology development, sales, and delivery.

Exhibitors

Edmund Optics
101 East Gloucester Pike
Barrington, NJ 08007
1-800-363-1992
www.edmundoptics.com

Laser Institute of America
13501 Ingenuity Drive, Suite 128
Orlando, FL 32826
407-380-1553
www.LaserInstitute.co

Tektronix
14200 SW Karl Braun Dr.
Beaverton, OR 97077
800-835-9433
www.tek.com

Coherent Inc.
5100 Patrick Henry Dr.
Santa Clara, CA 95054
408-764-4000
www.tech.sales@coheren

ALIO Industries
11919 West 48th Ave. #119
Wheat Ridge, CO 80033
303-339-7500
www.sale@alioindustries.com

Photonics Online
VertMarkets, Inc
5 Walnut Grove Ste 320
Horsham, PA 19044
215-675-1800
www.vertmarkets.com

Ophir-Spiricon
60 West 1000 North
Logan, Utah 84321
435-753-3729
www.ophir-spiricon.com

Gentec Electro Optics Inc.
445 St-Jean-Baptiste, Suite 160
Quebec, QC, Canada G2E 5N7
418-651-8003
www.gentec-eo.com

Laurin Publishing Co., Inc.
Berkshire Common P.O. Box 4949
Pittsfield, MA 01202-4949
413-499-0514
www.Photonics.com

Exhibitors (continued)

DataRay Inc.
14505 Seaman Gulch Rd.
Bella Vista, CA 96008
866-946-2263
www.sales@dataray.com

Tower Optical
3600 S. Congress Ave. Unit J
Boynton Beach, FL 33426
www.sales@toweroptical.com

Analog Modules
126 Baywood Ave.
Longwood, FL 32750
407-339-4355
www.analogmodules.com

Newport Corp.
1791 Deere Ave.
Irvine, CA 92606
877-835-9620
www.newport.com

Lightpath Technologies
2603 Challenger Tech Court
Orlando, FL 32826
407-382-4003
www.lightpath.com

Finisar
1389 Moffett Park Drive
Sunnyvale, CA 94089
408-548-1000
www.finisar.com

OSA
The Optical Society
2010 Massachusetts Ave, NW
Washington, DC 20036
202-223-8130
www.osa.org

SPIE
The International Society for Optics and Photonics
P.O. Box 10
Bellingham, WA 98227
360-676-3290
www.spie.com

SID
Society for Information Display
145 South Bascom Ave. Ste. 114
Campbell, CA 95008
408-879-3901
www.sid.org

IEEE
445 Hoes Lane
Piscataway, NJ 08855
732-981-0060
www.photonicssociety.org

Aerotech
101 Zeta Drive
Pittsburgh, PA 15265
www.aerotech.com

Exhibitors (continued)

Optimax Systems Inc.
6763 Dean Parkway
Ontario, NY 14519
877-396-7846
www.optimaxsi.com

Princeton Instruments
3660 Quakerbridge Rd.
Trenton, NJ 08619
609-587-9797
www.princetoninstruments.com

Open Photonics, Inc.
2682 West Fairbanks Ave.
Winter Park, FL 32789
407-900-5259
www.info@open-photonics.com

Student of the Year Award

Clémence Jollivet
CREOL, The College of Optics and Photonics
University of Central Florida

Thesis: "Specialty Fibers for Novel Fiber Lasers and Devices"

Novel designs of specialty fibers are finely tuned to enable transmission of light carrying specific properties (wavelength, profile, polarization, dispersion, etc.) which are beneficial to applications such as average or peak power scaling of fiber lasers, beam shaping, optical sensing, and telecommunications.
As the complexity of the fiber structure increases, the fabrication process becomes critical and there is a strong demand for advanced experimental diagnostics enabling detailed measurements of fiber transmission properties. In this talk, a powerful mode analysis technique, directly inspired from the spatially and spectrally resolved imaging experiment (S2 imaging), is presented. Several specialty fiber prototypes have been successfully analyzed and a few striking examples are discussed where targeted applications are proposed based on the measured mode contents.
Furthermore, challenges related to the monolithic integration of active specialty fibers with commercially available fiber devices are highlighted and solutions are discussed for two examples of fiber laser systems: one employing an active large-mode-area photonic crystal fiber, and a second using an active seven-core fiber.

Clémence Jollivet was born in Bordeaux, France. She received her B.S. degree in Physics and Chemistry and her M.S. degree in Physics from the University of Bordeaux in 2007 and 2009, respectively. She is currently enrolled in the optics Ph.D. program at CREOL, the College of Optics and Photonics under the supervision of Dr. Axel Schülzgen. Her research is focused on the design, fabrication, characterization, and applications of specialty fibers. Specifically, she is developing advanced mode analysis techniques and monolithic large-mode area and multicore fiber lasers. She is the author or co-author of 6 journal publications and 11 conference proceedings.

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Posters

Poster 1

Liquid Crystal-Based Biosensors for the Detection of Bile Acids

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Abstract
The concentration level of bile acids (BA) is a biomarker for the early diagnosis of liver diseases. We present a biosensor platform based on the anchoring transition of liquid crystal (LC) at surfactant-laden LC/aqueous interfaces for the detection of BA in aqueous solution. In the biosensor platform, the competitive adsorption of BA at the surfactant-laden LC/aqueous interfaces can trigger a homeotropic-to-planar anchoring transition of the LC at the interface, which can be easily observed using a polarizing optical microscope. We find that the detection limit of the LC-based biosensors for BA depends on the pH and ionic strength of the aqueous phase, and the headgroup of the surfactants, and the structure of LCs.

Poster 2

All-Inorganic Substrate-Tuned Nanoparticle Plasmon Resonances for Robust Biochemical Sensors

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Abstract
Film-coupled metal nanoparticle plasmon resonators have been actively studied for use in nanophotonic applications due to their ease of fabrication, cost-effectiveness, and robustness. We have investigated all-inorganic approaches for metal nanoparticle plasmon resonance control. The investigated structures demonstrate superior performance in terms of stability against laser irradiation compared to prior studies using an organic materials. Here we show results of experiments on two film-coupled gold nanoparticle systems; gold nanoparticles on an anodized aluminum, and gold nanoparticles on Al_2O_3 coated gold films. The measured spectra show a combined resonance tuning range of ~140 nm, from 550 nm to 690 nm. The particles exhibit a surface-normal dipole oscillation creating an extremely high electric field enhancement factor which could be useful for sensing methods utilizing surface enhanced Raman scattering signal. The stability of the structures under high power continuous wave (CW) laser irradiation was studied, demonstrating a stable optical response for CW laser powers as high as 100 W/mm^2. The presented all-inorganic structure avoids the introduction of carbon related background signal in Raman measurements, making the structure favorable for low-background signal bio-sensing applications.

Poster 3

Functional APCVD Oxide Films for C-Si Solar Cells

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Abstract

Atmospheric pressure chemical vapor deposition (APCVD) is a versatile process that offers much promise in enabling significant efficiency gains and cost reductions for crystalline silicon (c-Si) solar cells. In this presentation, we will share recent results on the deposition and subsequent processing of functional oxide films (AlO_x, TiO_2, SiO_2 and doped SiO_2) using an in-line, high throughput APCVD system. These oxide films and film stacks can be utilized for doping (e.g. emitter and surface field formation), surface passivation and light management on the front and rear side of c-Si solar cells. Experimental data regarding the microstructure, optical properties and electronic properties of the films will be presented, along with the impact of these films on cell efficiency and other relevant cell parameters. Implications of these results for standard and novel c-Si cell architectures will be covered.

Poster 4

Ninety-Degree Beam Bending Using a Spatially Variant Self-Collimating Photonic Crystal

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Abstract

A spatially-variant photonic crystal that can control the spatial propagation of electromagnetic waves in three dimensions was fabricated and characterized. The geometric attributes of the photonic crystal lattice were spatially varied to make use of the directional phenomena of self-collimation to tightly bend an unguided beam coherently through a 90º angle. A novel algorithm was used to design the spatially variant lattice which is not based on transformation optics. A finite-difference frequency-domain computational method confirms that the device can self-collimate and bend light without significant diffuse scatter caused by the bend. The device was fabricated using multi-photon direct laser writing in SU-8. Experimental characterization at 2.94 μm shows that at least ten times more optical power is guided through the 90-degree turn than exits the opposite side of the lattice, confirming the self-collimating and light-guiding properties of the lattice.

Poster 5

Robust Multimaterial Tellurium-Based Chalcogenide Glass Fibers for Mid-Wave and Long-wave Infrared Transmission

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Abstract

We describe an approach for producing robust multimaterial chalcogenide glass fibers for mid-wave and long-wave mid-infrared transmission. By combining the traditional rod-in-tube process with multimaterial coextrusion, we prepare a hybrid glass-polymer preform that is drawn continuously into a robust step-index fiber with a built-in, thermally compatible polymer jacket. Using tellurium-based chalcogenides, the fibers have a transparency window covering the 3–12 μm spectral range, making them particularly attractive for delivering quantum cascade laser light and in space applications.

Poster 6

Two-Photon Photovoltaic Effect in Gallium Arsenide

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Abstract

The two-photon photovoltaic effect is experimentally demonstrated in gallium arsenide at 976 and 1550 nm wavelengths for the first time. The effect is a nonlinear equivalent of the conventional single-photon photovoltaic effect used in solar cells. Electrical power is harvested from photons lost to two-photon absorption by means of a p-i-n heterojunction diode which is biased in the fourth quadrant of its current-voltage characteristics. A maximum of 123 μW of electrical power can be generated with laser output power of 200 mW at 976 nm. Numerical modeling of the two-photon photovoltaic effect in gallium arsenide heterojunction diodes based on finite-element method is also presented. The effect has potential applications in self-powered electronic-photonic integrated circuit, in which the harvested energy can be used to drive electrical circuits on the same chip, and remote power delivery to physical sensors installed in critical environments.

Poster 7

All-Silicon Waveguiding Platform for Ultra-Broadband Mid-Infrared Photonics

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Abstract

Ridge-shaped optical waveguides are fabricated on suspended silicon membranes. By using direct bonding techniques, a thin layer of silicon is fused to a bulk silicon substrate, which is patterned with narrow trenches. Ridges are etched on the resulting suspended membranes, and their waveguiding performance is characterized at mid- and near-infrared (IR) wavelengths. These waveguides have high mechanical stability and unprecendented design flexibility. Transverse magnetic (TM)-mode propagation losses of 2.8 ± 0.5 and 5.6 ± 0.3 dB/cm at 3.39 and 1.53 μm wavelengths are measured, respectively. This all-silicon optical platform (ASOP) is capable of efficient, low-loss waveguiding from wavelengths of 1.2-8.5 μm, enabling numerous applications in frequency conversion and spectral analysis.

Poster 8

Nonlinear Refraction Dynamics of CS_2

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Abstract

The measured values of the nonlinear refractive index, n_2, of carbon disulfide depends greatly on the pulse-width used, and may vary by order of magnitude [1] because of the non-instantaneous components of its response including molecular collisions, libration, and reorientation [2]. The nonlinear refractive dynamics of CS_2 are measured with the beam deflection technique [3], and fit to a response function model, from which the pulse width dependent $n_{2,eff}$ is calculated and compared to Z-scan measurements. By modeling the third-order response as a summation of four components, we extract the magnitudes, time constants, and tensor symmetries of each mechanism. We are thus able to predict the measured value of $n_{2,eff}$ for any given pulse duration, which is particularly useful given the common use of CS_2 as a Z-scan reference material.

[1] R. A. Ganeev, et al., Appl Phys B, **78**, 433-438, (2004)

[2] D. McMorrow, et al., Quantum Electronics, IEEE Journal of, **24**, 443-454, (1988)

[3] M. R. Ferdinandus, et al., Optics Letters, **38**, 3518-3521, (2013)

Poster 9

Investigation of Dynamic Modal Instabilities in High Power Fiber Amplifiers

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Abstract
Thermal mode instability (TMI) refers to the output beam of a fiber laser system becoming suddenly unstable once that a certain output power threshold is reached. TMI is currently the main factor inhibiting the development of fiber laser to high average powers. Here, an advanced high fidelity time dependent computer model for modal instabilities in fiber amplifiers is presented. The model combines an optical beam propagation method that incorporates laser gain through local solution of the rate equations and refractive index perturbations caused by the thermo-optic effect with a time-dependent thermal solver with a quantum defect heating source term. The model captures the three power dependent regions that are characteristic of the transfer of energy between the fundamental mode and the higher order mode as a function of time and is applied to predicting the threshold of these instabilities. There is excellent agreement between simulation results obtained and experimental results reported. These modeling capabilities will be employed to evaluate and propose new fiber designs and laser configurations to mitigate TMI.

Poster 10

Effect of Aerosols on Laser Filamentation

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Abstract
A femtosecond laser with peak power above 5 GW can produce a nearly non-diffracting beam, called a filament in air, due to a dynamic balance between plasma defocusing and Kerr self-focusing. Filaments can propagate long distances, thus enabling applications such as kilometer range LIDAR, remote THz generation, remote sensing, and lightning control. To further understand the effects of aerosols on the survival of a filament, we experimentally tested how the position of a single droplet affects the survival of a filament by positioning a droplet at different points along the length of the filament and before the collapse position.

Poster 11

Entangled Photon Pairs in Periodic and Disordered Lattices

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Abstract
We present simulations and experimental results showing how extended, spatially entangled photon pairs evolve on periodic and disordered lattices. By using states with different expressions of spatial entanglement, we show how correlations or anti-correlations present in the input state can survive propagation in Anderson localizing lattices, a phenomenon we term Anderson co-localization and anti-localization, respectively. We also demonstrate that in disordered lattices, even though spatial correlations are preserved, entanglement itself is lost as a result of random phase fluctuations.

Poster 12

Filament Interaction with Micro-Water Droplets

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Abstract
A femtosecond laser beam can propagate a long distance as a diffraction free self-channeled structure (i.e. a filament) when a dynamic balance between Kerr focusing and plasma defocusing is achieved. The interaction of a laser filament with micro-sized water droplets is being studied to further understand the energy dissipation of filaments in aerosol media. Using shadowgraph we were able to measure the energy lost by a filament during its interaction with a water droplet. This represents the first step towards quantitative comprehension of the filament interaction with droplet leading towards a better understanding of long distance filament propagation and stability into atmospheric conditions such as through clouds.

Poster 13

Improving Brightness of Multimode Lasers by Use of Volume Bragg Gratings

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Abstract

Design of compact solid state resonators is limited to small mode areas in order to achieve high beam quality, ultimately limiting the maximum achievable output power. We present a method of achieving high beam quality from a compact, multimode resonator by incorporating a volume Bragg grating (VBG) in the laser resonator. This diffractive optical element has a finite angular acceptance, and filters the angular content of diffracted light in the near field. Such a component has several advantages over a traditional aperture to spatially filter the light, because the output beam quality does not depend on the cavity length or the aperture size, only the angular selectivity of the VBG. To measure the effect of the angular selectivity on the beam quality of the generated beam, we designed a 1cm resonator using a 1mm thick slab of Nd:YVO_4 and several VBGs with different angular selectivity's. Such a cavity would normally require an aperture of less than 200μm in diameter to produce an M^2 of 1, however we present research showing that an M^2 of 1 can be obtained with apertures ranging from 800μm in diameter to 2mm in diameter using VBG's with an angular selectivity ranging from 11mrad to 1.8mrad.

Poster 14

Characterization of Induced Changes in Chalcogenide Glass from 2μm, ns Laser Irradiation

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Abstract

Chalcogenide glasses have low bond strengths with lead to their ability to have photo- or thermal- induced material responses such as photo-induced darkening, bleaching, refractive index change, densification or expansion, ablation, and crystallization. The following study aims to be able to induce modifications in the materials properties of the samples used. Various dosages of laser exposure were used in order to probe the threshold for different modifications from a 2μm laser source. The exposed areas were probed in order to see what modifications took place, and what their thresholds were. Threshold dosages needed for change were inconclusive, but various property changes were able to be observed including expansion and ablation. Additionally thermal computational modes were created in order to determine if laser induced heating was likely occurring for this regime. From these simulations it was seen that little heating is to be expected during irradiation.

Poster 15

Deposition of Chalcogenide Glass Films from Solution by Electrospray

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Abstract

The incorporation of luminescent dopants, such as quantum dots (QDs) into chalcogenide glass (ChG) films provides the potential to fabricate chip-based chemical sensing devices with an integrated light source. This can be done by spin-coating a mixture of ChG dissolved in an organic solvent with a suspension of nanoparticles. However, it has been found that aggregation of the QDs in the deposited film is prevalent due to the high surface energy of the QDs, and degrades the efficiency of the luminescence. Potential solutions to this problem include tuning the surface chemistry to reduce the thermodynamic driving force of aggregation, or utilizing film deposition methods that kinetically trap the QDs within the film before aggregation can occur. Using the method of electrospray, a conductive liquid can be formed into droplets with size on the micro or even nano scale. Deposition of a ChG film with electrospray from tiny droplets, specifically the kinetics of solvent evaporation, is therefore very different than spin-coating a continuous liquid. Furthermore, electrospray offers additional flexibility over spin-coating, such as simultaneous deposition of multiple liquids and CNC movement of the substrate relative to the spray to obtain different geometries of the deposited material. This study presents initial results of electrosprayed ChG films, which, to the best of our knowledge, has never been done before. The ultimate goal is to obtain films with homogeneously dispersed QDs for chip-based chemical sensing devices. The ChGs studied were As_2Se_3 and $Ge_{23}Sb_7S_{70}$, and comparisons are made to spin-coated films of the same compositions. Work is also being done in parallel to improve the surface chemistry interface between the QDs and the ChG solution, and initial results are also presented.

Poster 16

PCF Pump Combiner for High Peak Power, All-Fiber Thulium Lasers

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Abstract

Photonic crystal fibers (PCF) have been vital for facilitating large mode area fibers that support diffraction-limited beam quality. However, the microstructured PCF architecture makes them complicated for integrating into "all-fiber" components. Here we investigate an all-fiber, thulium-doped PCF amplifier that includes a pump combiner and step-index fiber mode-field adaptor. The slope efficiency, at 22.1 %, is less than a similar free-space coupled amplifier, but the beam quality is great with an $M^2 < 1.07$. When amplifying a broadband 2 μm source, no multimode interference is observed which indicates negligible higher-order mode content. This PCF pump combiner and amplifier is attractive for scaling peak powers in ultrashort pulse amplification while maintaining single transverse mode propagation and an all-fiber integrated system.

Poster 17

Institute for the Frontier of Attosecond Science and Technology: CEP Stabilization of a 20 TW CPA System at 10 Hz

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Abstract
We stabilized the carrier-envelope phase (CEP) of a 20 TW (300 mJ, 15 fs) Ti:sapphire laser operating at a repetition rate of 10 Hz. This laser was used to generate an extreme ultraviolet (XUV) continuum which exhibited fine structures that shifted periodically as the CEP of the driving laser was scanned. Our stabilization technique unlocks a new class of high-power, CEP-stabilized laser systems capable of generating high-flux isolated attosecond pulses and exploring nonlinear XUV dynamics.

Poster 18

Institute for the Frontier of Attosecond Science and Technology: Towards High-Flux Isolated Attosecond Pulses with a 100 TW CPA

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Abstract
We report on the progress towards a 100 TW CPA system designed to generate high-flux isolated attosecond pulses. We seed a new three-pass amplifier with our lab's pre-existing 10 Hz system, which outputs uncompressed broadband pulses (700 nm – 900 nm) with >500 mJ of energy. The cryogenically-cooled Ti:sapphire crystal (50 mm diameter, 25 mm long) will eventually be pumped with over 10 J by several frequency-doubled Nd:YAG lasers using relay imaging. The ultimate goal is to achieve 3 J, sub-15 fs, CEP-stabilized pulses for generating high-flux isolated attosecond pulses with Generalized Double Optical Gating. In our first test, a 500 mJ seed pulse was amplified to over 2 J when pumping with ~5.5 J. The amplified spectrum supports a transform-limited pulse duration below 15 fs.

Poster 19

Multicore Optical Fiber for High Temperature Sensing

Amy Van Newkirk*, Zeinab Sanjabi Eznaveh, Enrique Antonio-Lopez, Guillermo Salceda-Delgado, Rodrigo Amezcua-Correa, Axel Schülzgen
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Abstract

We have developed a novel high temperature sensor using a multicore fiber (MCF) spliced between two single mode fibers. This fiber chain creates a supermode interference pattern in the MCF that translates into a periodic modulation in the transmission spectrum. The spectrum shifts linearly with changes in temperature and can be easily monitored in real time. Through simulation, we have optimized the multicore fiber design for sharp spectral features in the optical communications window where the interrogation occurs. The number of cores and geometrical parameters of the fiber were selected based on the theory of the supermode interference created by the fiber chain. This device is simple to fabricate and has been experimentally shown to measure temperatures up to 1000°C in a very stable manner. We have also shown that this sensor is able to be multiplexed along a multiple sensor chain, with each sensor monitored simultaneously using a tunable source interrogation system.

Poster 20

Spectral Filtering with Sharp Roll-Off Produced by Multipass Reflections from Volume Bragg Gratings Reduction

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Abstract

The dispersion generated by diffractive elements is commonly used to achieve spectral filtering. Volume Bragg gratings (VBGs) are particularly well suited for spectral filters as they are able to produce high efficiency diffraction into a single order. By using PTR glass as a photosensitive medium for recording VBGs, very narrowband filtering can be achieved due to the excellent optical homogeneity of the material. The spectral bandwidth of a VBG filter is inversely proportional to the thickness of the device such that filters with thicknesses of several centimeters can produce filter bandwidths well below 50 pm for reflecting VBGs. The high efficiency and narrow bandwidth of PTR VBGs make them well suited for applications requiring isolation of a wavelength encoded signal with high precision. The drawback of traditional VBGs for such an application is the spectral sidelobes inherent to this filter. We present several filter geometries based on multipass reflections that allow us to suppress these sidelobes to create a filter with a sharp filter roll-off, giving excellent signal-to-noise ratio. Examples of the spectral response of the various geometries are shown with filter roll-offs as steep at -160 dB/nm, 350 pm bandwidth and insertion loss of only 0.2 dB. We also demonstrate a monolithic implementation of the multipass filter. This device is capable of producing sharp filter roll-offs as a drop-in component without any difficult alignment procedure. The monolithic device also provides simple tunability of the resonant wavelength and will be the topic of further research in laser development projects.

Poster 21

Property Extrema in the GeAsSe Chalcogenide Ternary Glass System

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Abstract

Infrared (IR) imaging systems often utilize expensive crystalline materials, Si or Ge for example, with fixed optical and material properties to transmit and refract IR light. Chalcogenide glasses, such as GeAsSe, offer a broad range of properties for designers to work with while simultaneously decreasing cost. This effort examines the evolution of optical and material properties as Ge is incrementally added to three AsSe glass compositions (starting As:Se ratios of 4:6, 3.5:6.5, and 3:7). Analyzing trends using a glass' average coordination number, <r>, which is a measure of the average number of bonds per atom, is often useful as it is representative of the overall network connectivity. Within the compositional region investigated (2.3 < <r> < 2.8), the optical bandgap, density, and index all demonstrate extrema near <r> = 2.67, while the glass transition temperature (T_g) and coefficient of thermal expansion (CTE) change linearly with increasing <r>. The extrema is often attributed to a change in dimensionality of the glass structure from a 2D to a 3D network. Additional work is also being done to correlate the properties with similar trends, for future work in compositional design of new glasses.

Poster 22

Blueshifted Continuum Peaks from Filamentation in the Anomalous Dispersion Regime

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Abstract

The conical wave generated by ultrafast laser filaments is a key element in the investigation and understanding of ultrafast nonlinear dynamics occurring in laser filaments. In experiments with filaments in the anomalous dispersion regime, an intense spectral peak distinct from the main peak has been observed. By studying the evolution of this blue-shifted peak with varying filamentation wavelength, we uncover the physical mechanism responsible for its generation. In our experiment, the near-IR output from an optical parametric amplifier was focused into a fused silica sample to generate a filament, and the spectrum of the conical emission recorded. A spectral peak in the visible region appeared when the filamenting wavelength was in the anomalous dispersion regime, and significant blue-shift was observed in the visible peak with longer filament wavelengths. This behavior matches very closely the predictions of the effective three-wave mixing model (ETWM), which provides a macroscopic description of the nonlinear interaction of the filamenting pulse with the propagation medium. The blue-shifted spectral peak can therefore be explained as a product of phase-matching in the three wave mixing process.

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Poster 23

Single Mode PT Symmetric Large Area Lasers

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Abstract

In the last few years, compact high-power single-mode semiconductor lasers have been the focus of considerable attention for integrated photonic applications. Despite the intense activity in this area, the realization of such sources in a fully integrated fashion still remains a challenging task. Various strategies to preferentially encourage lasing in the fundamental mode have so far been suggested including spatial filtering by which one aims to increase the losses (or at least lower the gain) experienced by the undesirable modes, without unduly influencing the lasing threshold of the fundamental mode. However, the resulting laser devices tend to be significantly more sensitive to longitudinal and lateral perturbations. Quite recently, a new approach has been proposed to resolve these issues by utilizing parity-time (PT) symmetry. When the refractive index of an optical arrangement is described by an even profile, while its gain/loss obeys an anti-symmetric distribution, the corresponding eigenvalue spectrum may be entirely real-valued. As a consequence, the modes experience zero net gain or loss, unless PT symmetry is spontaneously broken. Within the context of large-mode-area lasers, this phase transition can be judiciously tuned to present substantial gain to the fundamental mode, while appearing neutral to all the higher order modes. Here we demonstrate a novel class of large-area single-mode semiconductor distributed feedback lasers in which notions from parity-time symmetry is employed to reliably suppress higher-order spatial modes while the DFB structure ensure single longitudinal mode operation. Our work provides an important step towards harnessing PT symmetry to enforce single-mode operation in intense large mode-area lasers.

Poster 24

Designs of Advanced Large Mode Area Fibers for High Power Lasers

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Abstract

We present a selection of fiber designs and numerical tools for mode area scaling and realistic modeling of diffraction limited high power fiber amplifiers. The proposed fibers are based in large pitch photonic crystal fiber designs with additional high refractive index inclusions. Here, the high refractive index inclusions resonances are calculated utilizing numerical methods developed for all-solid photonic crystal fibers. Firstly, the bandgap structure of the inclusions is calculated utilizing a multilayered matrix method in the limit of a weak refractive index contrast. Then, the modal properties of the fibers are calculated using finite element methods. The proposed fibers can achieve effective single mode operation at 1064 nm with cores > 50 um. In other the hand, the evolution of the pump and signal powers along multimode fiber amplifiers is solved by a multi-layer method that divides the fiber core into a finite number of layers. This approach is practical for various dopant distributions with circular symmetries.

Poster 25

Monolithic Mode-Locked Lasers Based on High Finesse Silicon Ring Resonators

M. Akhlaghi Bouzan, W. Hayenga, P. J. Delfyett and M. Khajavikhan
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Abstract

Low noise mode-locked lasers and stabilized optical frequency combs are receiving considerable attention due to their broad spectrum of applications that ranges from signal processing and communications to metrology. Progress has been made in the realization of ultralow noise pulse trains that are used as sampling pulses for analog to digital converters from electrically efficient and compact semiconductor gain media. However, these realizations require ultralow expansion (ULE) quartz etalons for filtering the axial mode groups, making miniaturization difficult. Further advances are needed to reduce the size of these sources so that a chip-scale footprint can be achieved to enable new applications. One important step towards miniaturization is the integration of a high finesse optical filter that would serve to replace the ULE etalon. In this talk, we report our experimental results towards the realization of a fully integrated mode-locked semiconductor laser. We present a high finesse and large FSR ring resonator capable of generating pulses at a repetition rate of ~32 GHz when is coupled to a semiconductor amplifier via a larger fiber loop. In addition, an intensity modulator incorporated in the fiber loop and modulated at the free spectral range of the ring resonator produces a stabilized mode-locked optical frequency comb. The performance specifications of this system will be presented and compared with state of the art etalon-based cavities for the realization of on-chip mode-locked lasers. We also present our recipe for fabricating large and low loss silicon ring resonators pertaining to this work.

Poster 26

Fiber Mode Converter Using Holograms of Phase Masks in Photo-Thermo-Refractive Glass

Aniket Patil*, Clémence Jollivet, Ivan B. Divliansky, Marc SeGall, Leonid B. Glebov, and Axel Schulzgen,
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Abstract

In this study we present a novel method of converting transverse modes guided in optical fibers. The mode converter device employed is a hologram of phase masks written in Photo-Thermo-Refractive (PTR) glass. Transverse higher-order modes are generated using a Spatial Light Modulator (SLM). Under proper incidence on theholographic device, $LP_{m,n}$ modes are diffracted and simultaneously converted into higher or lower order LP mode. This process is analyzed by imaging the far field on a CCD camera. We demonstrate that several combinations of LP modes can be converted to each other with efficiencies up to 70%. This approach has several promising applications such as mode multiplexing/de-multiplexing, beam cleaning and power scaling of higher-order mode fiber lasers and amplifiers by combining mode conversion and beam combining.

Poster 27

Compact 10 TW Laser to Generate Multi-Filament Arrays

Benjamin Webb, Joshua Bradford, Khan Lim, Nathan Bodnar, Andreas Vaupel, Erik Mckee, Matthieu Baudelet, Magali Durand, Lawrence Shah and Martin Richardson
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Abstract

The design and construction of a 10 TW Ti:sapphire laser facility suitable for generating arrays of several tens of filaments in air is presented. Arrays of filaments are interesting for microwave guiding and laser machining. The components and compact layout of the Multi-Terawatt Femtosecond Laser (MTFL) will be outlined. Techniques for improving beam profile and laser efficiency are examined. Mitigation of gain narrowing by feedback from a spectrometer to an Acousto-Optic Programmable Dispersive Filter (AOPDF) is demonstrated. This facility includes a monitoring system with cameras and photodiodes installed at multiple locations in the laser in order to record and monitor the system performance, both in the lab and remotely. Compressed pulses of ~40 fs can be obtained from four points in the laser in order to support different experimental conditions: 1.5 mJ at 1 kHz, 15 mJ at 10 Hz, 80 mJ at 10 Hz, and 470 mJ at 10 Hz.

Poster 28

Plasmonic System Interaction with Cavity and High Order Diffraction Modes for Enhanced Sensing Applications

Abraham Vázquez-Guardado*[1,4], Alireza Safaei[2,4], Daniel Franklin[2,4], Sushrut Modak[1,4], Debashis Chanda[1,2,3,4]
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Abstract

Collective oscillation of free electrons coupled to incoming electromagnetic radiation is the fundamental to plasmonic based devices. It is well known that localized surface plasmon resonances (LSPR) emerge on isolated nanoparticles and in their periodic arrangement counterparts leading to stronger LSPR due to their coherent particle to particle interaction, apart from propagating surface plasmon-polaritons (SPP). The resulting enhanced field distribution in small volume have been exploited, for example, in Surface-Enhanced Raman Spectroscopy (SERS), biosensing or even vacuum Rabbi oscillations when fluorescent specimens interact with the system resonance. In recent time a new concept of strong coupling between plasmonic and photonic modes have been demonstrated in hybrid LSPR based systems coupled to a Fabry-Perot (FP) cavity. In such systems, the back reflector works as feedback mechanism whose reflected electromagnetic field phase influences surface plasmon excitation constructively or destructively. Absorption from the plasmonic system is enhanced resulting in strong narrow hybrid resonance which, has been exploited for high sensitive bio-sensing applications.

Poster 29

Scanning 3-D IR Imaging in an Uncooled Wide Band Gap Photodiode Using Nondegenerate Two-Photon Absorption

Himansu S. Pattanaik, Matthew Reichert, Honghua Hu, David J. Hagan*, and Eric W. Van Stryland

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Abstract

In nondegenerate (ND) two-photon absorption (2PA), annihilation of two-photons of very different energies leads to creation of single electron-hole pair in direct-gap semiconductors. This nondegeneracy shows several orders of increase in the magnitude of the 2PA coefficient over the degenerate case. Based on this we have demonstrated sensitive gated detection of mid-IR pulses in uncooled GaAs and GaN p-i-n photodetectors. Here we demonstrate scanning 3-D IR imaging using gated detection of IR pulses (here 1.6 μm) in an uncooled GaN p-i-n photodetector. This is obtained by recording two-photon photocurrent vs. the delay between IR and gating pulses, which gives depth (z) information, for all points on an x-y grid. The signal-to-noise ratio (SNR) of this imaging technique is expected to improve for longer imaging wavelengths due to increased nondegeneracy. This technique also enables 3-D imaging for Mid-IR and long-wave-IR wavelengths.

Poster 30

Curvature Sensor Based on Seven Core Fiber

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Abstract

A compact, low loss, and highly sensitive optical fiber curvature sensor is presented. The device consists of a few-millimeter-long piece of seven-core fiber spliced between two single mode fibers. When the optical fiber device is kept straight, a fixed interference pattern appears in the transmission spectrum. However, when the device is bent, a shift in the transmission spectrum is produced and the visibility of the interference notches changes. This allows for using either visibility or spectral shift for sensor interrogation. The dynamic range of the device can be tailored through the proper selection of the length of the seven core fiber. The effects of temperature and refractive index of the external medium on the response of the curvature sensor are also discussed. Linear sensitivities of about 40pm/mm for bending and 30pm/degree Celsius for temperature were observed through experiment.

Poster 31

Narrowband and Broadband Perfect Metamaterial Absorbers in Infrared

Sushrut Modak*[1, 4], Abraham Vázquez-Guardado[1,4], Alireza Safaei[2,4], Daniel Franklin[2,4], Debashis Chanda[1,2,3,4]
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Abstract

A metamaterial is an artificial media which has engineered electromagnetic response to exhibit optical properties that are not found in nature such as negative index of refraction. They are formed by periodic arrangement of metal and dielectric structures which are small compared to the spectral band of interest. Recently, a new class of metamaterials–metamaterial absorber was introduced. Metamaterial absorbers are designed to absorb large amounts of electromagnetic radiation efficiently over a specific band. These offer a wide range of advantages over conventional absorbers in terms of tunability, adaptability, miniaturization and effectiveness. Here, we present a novel metamaterial absorber that is tunable over a wide wavelength range (3-15 microns) and can be mass produced on large areas with nano-imprint lithography. The absorption is a result of a combined complex interaction among fabry-perot resonance, surface plasmon resonance and radiative and non-radiative coupling between the three metallic layers present in the structure. We also demonstrate realization of a broadband absorber by stacking of the 2D layers of narrowband absorbing structure. In addition, we discuss the prospect of using these absorbers in the design of printable uncooled infrared bolometers in the future.

Poster 32

Fabrication of Highly Photosensitive Fiber from Photo-Thermo-Refractive Glass

Khawlah Al Yahyaei[1,2*], Peter Hofmann[1], Rodrigo Amezcua-Correa[1], Enrique Antonio-Lopez[1], Daniel Ott[1], Marc SeGall[1], Ivan Divliansky[1], Larissa Glebova[1], Leonid Glebov[1], Alan Kost[2], and Axel Schülzgen[1]
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Abstract

We report the fabrication and characterization of a new type of fiber made from photo-thermo-refractive (PTR) glass. Photosensitive single material PTR glass fibers and, for the first time, core/cladding PTR glass step index fibers were fabricated. The entire fiber fabrication is vertically integrated. That is, PTR glass preparation, fiber preform fabrication, PTR glass fiber drawing, and PTR fiber Bragg grating writing and inscription was done at CREOL. Our PTR glass fibers have shown excellent mechanical properties and also low propagation losses of less than 0.1 dB/cm. Fiber Bragg gratings were inscribed into the novel fibers in order to demonstrate the fibers' photosensitivity. A grating strength of up to 20 dB was reached and was maintained during 12 hour exposure to temperatures above 400 °C without noticeable degradation. Our results open exciting new avenues for the development of holographic PTR glass fiber optic components that can be applied to solve challenges in existing fiber optic devices.

Poster 33

Bio-Inspired Hybrid Liquid Crystal-Plasmonic Reflective Display

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Abstract
Inspired by the thin and flexible color changing skin of the octopus, we develop a color changing surface utilizing liquid crystals and plasmonic films. These nanostructured metallic films selectively absorb light at resonant wavelengths while reflecting the rest. In the visible regime, this results in a colored surface. Such resonances are dependent on the index of the surrounding medium and periodicity of the nanostructure. Here, we use liquid crystals to actively shift the plasmonic absorption, which results in a change of color with applied voltage. By also sweeping over structural dimensions, a wide range of colors can be obtained from these dynamic reflective pixels, which have applications in camouflage and display technology.

Poster 34

Optical Measurements of Local Viscoelastic Properties of Complex Fluids

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Abstract
The viscoelastic properties of complex fluids are measured in a number of ways including dynamic light scattering (DLS) and diffusive wave spectroscopy (DWS). These techniques rely on the fact that small, thermally-driven probe particles induce a linear local response of the fluid. Because it is relatively simple to relate the microrheological measurements to bulk material properties, these optical procedures are common characterization tools. Unfortunately, the use of conventional DLS is limited to situations where light scattering is relatively weak (single scattering regimes). DWS on the other hand, is an extension of this dynamic measurement to stronger scattering regimes that can be described by a diffusion approximation of light transport. We developed a novel approach that uses coherence gating to isolate the single-scattering contributions from highly scattering complex systems. This low-coherence dynamic light scattering (LC-DLS) technique allows performing accurate measurements of particle size as well as local measurements of viscoelastic properties. The LC-DLS experimental setup relies on a fiber-based common path interferometer and a super-luminescent diode as a source of low-coherence light. The scattered signal is practically collected from picoliter-sized volumes, thus suppressing multiple-scattering and simplifying the description of viscoelastic properties in terms of single-scattering models. We will present results of particle sizing in mono- and poly-dispersed colloidal systems and we will discuss the inherent viscoelasticity of such complex fluids.

Poster 35

Exciting Localized Surface Plasmon to Enhance Light Harvesting by Graphene

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Abstract

Since the band structure of Graphene doesn't have band gap, the conduction and valence bands touch each other in Dirac point. It means that the conduction from absorption in all regions of wavelength (visible to IR) is approximately constant, leading to 2.3% light absorption in the case of monolayer graphene. In addition, the Graphene has a very high mobility and fast carrier relaxation. By combination of these advantages, we can conclude that the Graphene is a suitable material for ultrafast optoelectronic devices in extremely wide spectral range. The main shortage of the Graphene is its low absorption. Surface plasmon resonance (SPR) is the collective oscillation of electrons on the surface of a material stimulated by incident light. SPR in nanometer-sized structures is called localized surface plasmon resonance. By using the SPR, we can increase the absorption of incident light and transfer its energy to the phonons. Now, by exciting localized surface plasmon (LSP) on the Graphene, the absorption is increased up to 13%. So, we can see an increasing in absorption from 2% to 13% because of these localized plasmons. We can excite more LSP, if put a back mirror in a specific position. It means that by using a gold plate, coating a spacer and after that putting Graphene on it in a special height, there is a constructive interference between incident and reflected beam. In conclusion, more localized plasmons can excite and absorption will be enhanced up to 80%.

Poster 36

Transient Absorption with Ultrabroadband Attosecond Pulses

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Abstract

Isolated attosecond light pulses hold promise for real-time measurement and control of chemical processes on the natural timescale of electron motion. However, attosecond experiments on molecular targets remain challenging due to the lack of both attosecond sources in the vacuum ultraviolet (~6-20 eV) where molecules are most electronically active, and appropriate spectroscopic techniques which allow both high temporal resolution and state selectivity. Here, we combine isolated ultrabroadband attosecond pulses from the double optical gating technique with the recently-developed attosecond transient absorption spectroscopy to uncover the fast electron dynamics in atoms and molecules. Using these powerful tools, we demonstrate attosecond time-resolved measurements of broadband electronic wavepacket dynamics and correlated electron motion in atoms, as well as the rapid electronic response to nuclear vibration in small molecules.

Poster 37

Photonic Thermalization Gap in Anderson-Disordered Photonic Lattices

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Abstract

In a strongly disordered medium, multiple scattering of a quantum-mechanical wave results in exponential localization of states, a phenomenon known as Anderson localization. As spatial localization of the optical field occurs in a disordered medium, one can also expect transition from coherent field to thermal field, and the question arises as to how this process is related to the nature of disorder. Here, we numerically investigate the statistics of the optical intensity due to a single waveguide excitation and the transmitted light is observed for the same waveguide for the asymptotic propagation distances. Specifically, the dependence of the intensity correlation $g^{(2)} = \langle I^2 \rangle / \langle I \rangle^2$ on the disorder level and lattice size is characterized for two types of disorder. For arrays with diagonal disorder, the upper limit of intensity correlation is 2 and introducing disorder to the system reduces this limit down to 1 for very high disorder. For arrays with off-diagonal disorder, the upper limit is 3 and this limit goes down to 2 for the maximum disorder level. As a result, a photonic thermalization gap emerges for $1 < g^{(2)} < 2$ and coherent light traveling through waveguide arrays with off-diagonal disorder exhibits super-thermal statistics ($g^{(2)} > 2$) for sufficiently large lattice size. Diagonal disorder, in contrast, results in sub-thermal statistics ($1 < g^{(2)} < 2$).

Poster 38

Fabrication of Titanium Oxide Magneli Phase Nanoceramics for Thermoelectric Applications

Sudeep J. Pandey[*α], Taylor Shoulders[α], Shidong Wang[ß], Stefano Curtarolo[ß], Romain Gaume[α]

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Abstract

About 90% of world's energy is fulfilled by heat engines, which typically run at 30-40% efficiency resulting in roughly 15 terawatts of energy wastage. Thermoelectric devices are promising candidate for green energy harvesting whose working is based on the principal of Seebeck effect in which a potential difference is created between a hot and cold junction. The efficiency of a thermoelectric device is quantified by the figure of merit ZT=$\frac{\sigma S^2}{\kappa}T$, where κ is the thermal conductivity, σ the electrical conductivity and S the Seebeck coefficient. Most of the recent strategies in improving ZT consist of decreasing κ in order to maintain large temperature gradient across devices. High-throughput ab-initio calculation by Wang *et al*. show that nanocrystalline Ti_5O_9 has the highest power factor and Seebeck coefficient (~4×10^3 μW/cmK^2 nm^{-1} and 4×10^2 μV/K respectively) of all known thermoelectrics. Ti_5O_9 belongs to a class of suboxides of titanium having the generic formula Ti_nO_{2n-1} and called Magnéli phases. The shear planes in every nth octahedral scatters phonons and the effect is much enhanced if the grains are nanosized. Oxygen vacancies in titanium suboxides result in a higher electrical conductivity due to an increased charge carrier concentration, and hence a higher the thermoelectric power factor. Even though nanoceramics of Ti_5O_9 hold great promise for thermoelectric applications, their fabrication is challenging because one needs to (i) achieve ceramic densification at low temperatures in order to maintain a small grain size and (ii) produce a single phase of Ti_5O_9. This poster summarizes our recent efforts to produce and characterize nanoceramics of phase pure Ti_5O_9.

Lab Tours

Labs & Facilities

The main facilities of the College are housed in a state-of-the art 104,000 sq. ft. building dedicated to optics and photonics research and education.

Shared Facilities

Nanophotonics Systems Fabrication Facilities. A 3,000 ft² multi-user facility containing Class 100 and Class 1000 cleanrooms and a Leica 5000+ e-beam lithography instrument capable of 10-nm resolution. These facilities are used for fabrication and study of nanostructured materials and nanophotonic integrated circuits. The Laboratory is designed and operated as a multi-user facility, with availability to companies and other outside users. Rm 180.

Optoelectronic Fabrication Cleanroom. 800 sq. ft. multiuser facility consisting of class 100 and class 10,000 cleanrooms. Used in the development of optoelectronic semiconductor devices. The facility equipment includes a Suss MJB-3 aligner, a Plasma-Therm 790 RIE/PECVD, an Edwards thermal evaporator, along with a bonder, a scriber and microscope. Rm 211

Scanning Electron Microscope (SEM) Facility. Vega SBH system built by Tescan is a tungsten-filament scanning electron microscope. The system is designed with a fully electronic column and is capable of imaging from 1-30 keV with nanometer scale resolution. Additionally, the system is equipped with the state of the art sample positioning stage with 5 nm resolution and a full scale travel of 42 mm. The shared SEM is ideal for checking the fidelty of travel of 42 mm. The shared SEM is ideal for checking the fidelity of the microfabrication routinely performed in the CREOL cleanroom. Rm 176

Cary Spectra-Photometer and Microscope. Cary 500 is Spectrophotometer that is capable of measuring light absorption in both transmitted and reflected light in the UV, visible and near IR spectrum. Rm 159

Varian Cary 500 Scan UV-Vis-NIR Spectrophotometer. Rm 159

Olympus Nomarski Interference Microscope. Rm 159

Zygo Facility. Zygo New View 6300 Interferometer shared facility. Rm 211B. Martin Richardson.

Machine Shop. Has two modern Sharp LMV milling machines and a 16-50G lathe capable of achieving the tolerances required for the instruments used in CREOl. Classes are offered to qualify research scientists and students to safely modify and construct instruments critical to their research. Rm A106. Richard Zotti.

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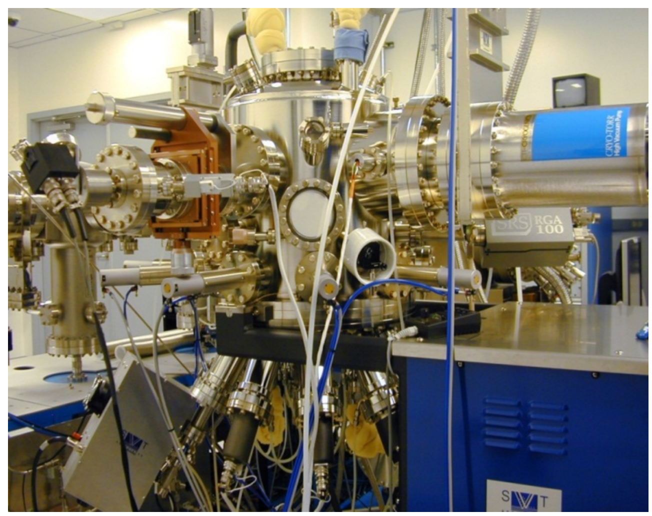
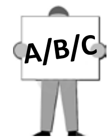
Nanophotonics Fabrication Facility


MBE Facility

Lab Tours

LISTEN FOR  **AND LOCATE** 

IN LOBBY

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Dr. Axel Schulzgen
http://fol.creol.ucf.edu

A109 **Fiber Optic Sensing** ★ Featured in talk
Dr. Axel Schulzgen
http://fol.creol.ucf.edu

153 **Volume Bragg Gratings for Laser Beam Control**
Dr. Leonid Glebov
http://ppl.creol.ucf.edu/

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246 **Plasmonic nanosensors and spectroscopic ellipsometer** ★ Featured in talk
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http://kik.creol.ucf.edu

243 **Nanolaser characterization lab**
Dr. Mercedeh Khajavikhan
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http://lcd.creol.ucf.edu

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202 **Integrated Photonics and Energy Solutions Lab** ★ Featured in talk
Dr. Sasan Fathpour
http://ipes.creol.ucf.edu

227 **Femtosecond Nonlinear Optics Laboratory**
Dr. David Hagan and Dr. Eric Van Stryland
http://nlo.creol.ucf.edu

PSB332 **Fabrication of nanophotonic devices by multi-photon direct laser writing**
Dr. Stephen Kuebler
http://npm.creol.ucf.edu

Building Map

First Floor

Building Map

Second Floor

Industrial Affiliates Program

Membership in the Industrial Affiliates (IA) program provides to industrial corporations, organizations, and individuals many benefits, most of which are also of mutual benefit to the College of Optics and Photonics. One of these mutual benefits is the regular communication and contact the program provides between the research faculty and students at the College and the IA member company's engineers and scientists who are developing new technologies and products for their business. Other benefits include:

- Establishing a close association with this leading institute in optics, lasers, and photonics
- Exposure to the latest research and developments in cutting edge technologies
- Availability of sophisticated measurement, test, and calibration facilities
- Early notice of students approaching graduation (the next generation of experts in the field) and access to their CVs
- Ability to post job openings on the College's website (exclusive benefit for IA members)
- Close interactions with the faculty, each of whom are leaders in their fields
- Opportunity to make presentations about the member's company and products to the faculty and students of the College
- Access to the College's periodic newsletter, Highlights, and monthly e-Highlights
- Notification of seminars at the College
- Opportunity for free presentation space at the annual Industrial Affiliates Day meeting
- Several Web-based benefits, including linkage to the company's web site from the College website
- For companies who donate equipment, getting their hardware/software in the hands of some of the leading researchers—faculty and students—in the field provides visibility to future customer prospects and information on its impact in leading-edge research
- Demonstration by the company of its support of the College, its research programs, and its effective corporate cooperation and partnership activities

In addition, we use many mechanisms to give visibility to our Industrial Affiliates that can be valuable to them in marketing their products. Wherever possible, the level of the membership is indicated. Examples of current practices include:

- Listing in the CREOL Highlights quarterly newsletter
- Special recognition at the annual Industrial Affiliates Day
- Listing in other publications, where appropriate, including on the website (with a link to the company's website)
- Company name plaque prominently displayed in the entrance lobby of the CREOL building.

There are also many intangible benefits that accrue from association with this dynamic research and education institution. Among these are facilitated access to and collaboration with other specialized facilities within the University of Central Florida and the central Florida area. In addition to resources in the Center for Research & Education in Optics & Lasers (CREOL) the Florida Photonics Center of Excellence (FPCE), and the Townes Laser Institute, UCF facilities include the following major research centers:

- Nano-Sciences & Technology Center (NSTC)
- Advanced Materials Characterization Facility (AMPAC)
- Materials Characterization Facility (MCF)
- Biomolecular Science Center
- Institute for Simulation and Training (IST)
- Center for Distributed Learning
- National Center for Forensic Science (NCFS)
- Florida Solar Energy Center (FSEC)
- Florida Space Institute (FSI)

The College's faculty and students play leading roles in both local and international professional associations and can provide effective introductions to the extensive network of industry and expertise to which CREOL, The College of Optics & Photonics, connects. Through the IA program, members can also readily connect with other optics, photonics, and industrial organizations through local Florida organizations in which the College maintains an active participation, including the Florida Photonics

Cluster (FPC), the Laser Institute of America (LIA), Florida High Technology Corridor Council (FHTCC), the UCF Technology Incubator — ranked #1 in the US in 2004 — and a large family of laser and optics companies in the Central Florida region.

Industrial Affiliates Members

Life Members

Cobb Family Foundation
Northrop Grumman Corporation
Nufern
Memoriam Members: *Dr. Arthur H. Guenther and Dr. William C. Schwartz*

Medallion Members

Breault Research	Lasersec Systems Corp.	Optical Research Assoc.
FLIR	Northrop Grumman Laser	Paul G. Suchoski, Jr

Senior Members

AFL Global	LAS-CAD GmbH	Radiant Zemax, LLC
Coherent, Inc.	LightPath Technologies	Tektronix
CST of America	Lockheed Martin	TRUMPF, Inc.
DataRay Inc.	Newport Corporation	V & N
Edmund Optics	Ophir-Spiricon	Zygo Corporation
ER Precision Optical	Optimax Systems	

Affiliate Members

Aerotech, Inc.	Optigrate Corp.
ALIO Industries	Optoelectronics Industry Development Assoc.
Analog Modules	Photonics Online
Applied Image Inc.	Photonics Spectra
Block Engineering, LLC	Plasmonics
eVision, LLC	Princeton Instruments
Fike Corporation	QPC Lasers/Laser Operations, LLC
Finisar	Ray Williamson Consulting
Gentec-EO, Inc.	R-Soft Design Group
Gooch & Housego, LLC.	SCD.USA, LLC
Harris Corporation	Sciperio, Inc.
HORIBA Jobin Yvon	Sterile Environment Technologies-SET3
JENOPTIK Optical Systems Inc.	SPIE- The Int'l Society for Optics & Photonics
Kaufman & Robinson	StellarNet, Inc.
Laser Institute of America	Teledyne ODI
Lee Laser	The Optical Society
NKT Photonics	Tower Optical Corporation
Ocean Optics	Thorlabs
Optigrate Corp.	TwinStar Optics, Coatings & Crystals
Open Photonics Inc.	Vytran, LLC
	Yokogawa Corporation of America

Why Florida?

All high-tech companies benefit from Florida's business environment, which emphasizes innovation, collaboration, and talent formation for today's global markets. From start-ups focused on turning the latest academic research into commercially viable products and technologies, to established industry giants, Florida has what high-tech companies need.

Florida Photonics Industry Cluster

Florida's photonics cluster is the 4th largest in the US, with over 270 companies employing over 5,700 professionals focused on the design, development, manufacturing, testing, and integration of photonics products and related systems. The photonics and optics cluster in Florida spans a very broad range of industry sectors, including lasers, fiber optics, optical and laser materials, thin film coatings, optical components, optoelectronic fabrication and packaging, and photonic systems integrators, addressing almost all applications from energy to medicine to defense. The state's colleges and universities have established interdisciplinary programs and centers focusing on pho-tonics/optics, which graduate over 100 photonics specialists (AS to PhD) each year. The Florida Photonics Cluster, a 501c(6) trade association, (www.floridaphotonicscluster.com) is dedicated to serving the industry and to making Florida the place to go for photonics solutions.

Innovation Economy

Nowhere else is the spirit of innovation more evident than in the State of Florida, which has the reputation as the "Innovation Hub of the Americas". The state's pro-business, pro-technology climate, combined with easy trade access to key growth regions of the Americas, as well as the rest of the world, provide a fertile environment for establishing and growing businesses. Some of the unique resources available to entrepreneurs include the Florida Virtual Entrepreneur Center (www.flvec.com), GrowFL (www.growfl.com), and several business incubators (www.floridahightech.com/region.php) including the rapidly growing and award-winning UCF Business Incubator (www.incubator.ucf.edu).

Top Quality of Life & Great Place for Photonics

Since 2001, Florida has earned top rankings in Harris Poll's "most desirable place to live" survey, so it's no surprise why Florida has become a top destination for high-tech industry, and in particular for the photonics industry. The University of Central Florida houses CREOL, The College of Op-tics and Photonics, and in addition to CREOL, the College houses the Townes Laser Institute and the Florida Photonics Center of Excellence. In addition, the Florida Photonics Cluster, several vigorous university incubators, proactive regional and state-level economic development organizations, and a dynamic grouping of cutting-edge companies form a photonics hub focused on advancing Florida's photonics industry.

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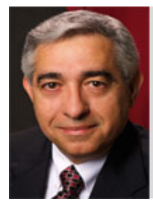

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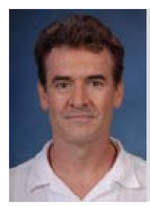

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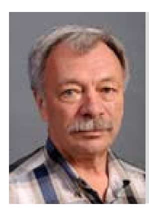

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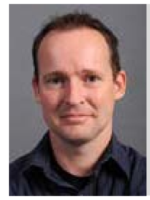

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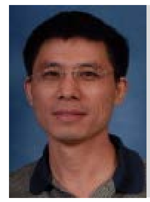

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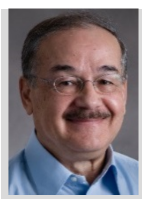

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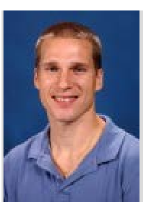

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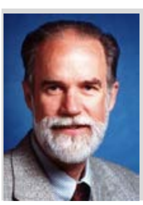

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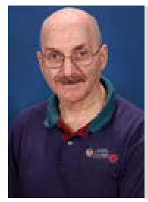

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Notes

Notes

Notes

Thank you for attending!

We look forward to seeing you at our next
CREOL Industrial Affiliates Day
Friday, March 13, 2015

2015 has been designated by the United Nations as the

International Year of Light

and Light-based Technologies

A year-long celebration is being planned, including special events for the 2015 Industrial Affiliates Day