Symposium and Industrial Affiliates Program

2016

UCF CREOL, The College of Optics and Photonics

Advances in Optics & Photonics

Industrial Affiliates Symposium

10–11 March 2016

CREOL Building & HEC 125 ***Thursday, 10 March***

Short Courses 9:00 AM–12:15 PM

9:00-10:30AM, CREOL Building, Room 102
Laser Safety
Instructor: Tony Imm, Founder & CEO, Laser Guardian LLC

This short course is a comprehensive overview of laser safety as it applies to academic and industrial sites. Improper use of hazard class 3B and 4 lasers can result in permanent injury to the eyes and health of individuals who are subjected to laser radiation over the maximum permissible exposure limits. Potential harmful physiological effects of beam and no beam hazards are minimized through use of engineering and administrative control measures. Use of such measures is required by the State of Florida under administrative code 64E-4. The course will focus on the practical application of ANSI standard Z136.1 to ensure a laser safe environment.

9:00-10:30AM, HEC Room 125
Volume Holographic Elements for Spectroscopy and Laser Applications
Instructor: Leon Glebov, Research Professor of Optics & Photonics, UCF CREOL

This short course summarizes the results of volume holographic elements development for spectroscopy and fine laser control. The basics of holographic recording in photo-thermo-refractive (PTR) glass are discussed. Comparison of conventional diffraction gratings with volume Bragg gratings (VBGs) is shown. The main types of holographic optical elements recorded in PTR glass are described: reflecting and transmitting VBGs, longitudinal and transverse chirped Bragg gratings (CBGs), along with tunable and achromatic holographic phase masks (HPMs). Applications of those elements for conventional and Raman spectroscopy, spectral and angular mode selection in lasers, mode conversion, spectral and coherent beam combining, ultrashort pulse stretching, compression and shaping, and monolithic solid state lasers with distributed Bragg reflector (DBR) are discussed. Interaction of such holograms with high power laser radiation is discussed. The methods of heat management enabling operations at multikilowatt CW regimes are described.

10:45-12:15PM CREOL Building, Room 102
Fiber Lasers
Instructor: Larry Shah, Research Assistant Professor of Optics & Photonics, UCF CREOL

Fiber lasers, and more generally fiber optic elements, have become modular building blocks that are configured into systems ranging from high bitrate long-haul telecommunications networks to directed energy weapons systems. As fiber lasers continue to become more and more common in our every day lives, the definition of what is a fiber laser continues to evolve. This course will review the fundamental waveguide and material properties that are critical to the performance of fiber lasers. The ability to precisely and controllably engineer both the waveguide and material properties makes fiber lasers extremely attractive for generation/amplification of light that can be relatively easily integrated into systems providing temporal modulation, phase modulation, broadband wavelength tunability, dispersion management, polarization control, etc.

10:45-12:15PM HEC Room 125
Optical Modulators
Instructor: Patrick LiKamWa, Associate Professor of Optics & Photonics, UCF CREOL

This tutorial sets out to explain the different types of optical modulators that have evolved over the years. Devices that are presently in use and others that have been developed for future use will be examined.

Student Talks 1:30 PM-2:30 PM HEC 125

1:30	Fundamental studies of ultrashort laser pulse interaction with aerosols	Cheonha Jeon, Student of the Year
	Sensing with special optical fibers	Amy Van Newkirk
	Mid-IR OPCPA laser for generating isolated attosecond pulse in the water window	Jie Li
	Ultrafast nonlinear response of organic solvents and molecular gases	Peng Zhao

Poster Session, Lab Tours & Exhibits 2:30PM-4:30PM CREOL 102 & 103

Student poster session	CREOL rooms 102 & 103
Exhibits	CREOL lobby
Lab Tours	Tours start from CREOL lobby

4:30 Event ends

Morning Session –UCF Student Union, Pegasus Ballroom Friday, 11 March

8:30 Continental Breakfast and Walk-in Registrations

9:00	Welcoming Remarks	MJ Soileau	UCF Vice President for Research
9:15	Welcome and overview of CREOL	Bahaa Saleh	Dean & Director, CREOL, UCF

Technical Symposium

Session I

9:45	Solid state lighting - the remaining challenges	Fred Schubert	Rensselaer Polytechnic Institute
10:15	Playing with proteins: optical trapping and spectroscopy of a single molecule	Ryan Gelfand	CREOL, UCF

10:35 BREAK & EXHIBITS

Session II

10:55	Optoelectronics: Is there anything it cannot do; can opto-electronics provide the motive power for future vehicles?	Eli Yablonovitch	UC-Berkeley
11:25	Hemispherical focal plane arrays using organic semiconductors	Kyle Renshaw	CREOL, UCF

Product Review

11:45	Ocean Optics	Gary Manche
11:51	Jenoptik	Marc D. Himel
11:57	EVision Inc.	Tony Van Heugten
12:03	Gooch & Housego, LLC	Alex Fong

12:10 **LUNCH Served** Student Union

Friday Afternoon Session

Presentations – Pegasus Ballroom, Student Union

Photonic Milestones

1:25	OSA's 100th Anniversary	Liz Rogan	Executive Director and CEO, OSA – The Optical Society

Session III

1:45	Device applications of metafilms and metasurfaces	Mark Brongersma	Stanford University
2:15	Single-mode microring lasers	Mercedeh Khajavikhan	CREOL, UCF

2:35 BREAK & EXHIBITS

Session IV

2:55	The fourth generation of optics	Nelson Tabiryan	President-Beam Engineering for Advanced Measurements Co.
3:25	Engineering novel materials for infrared photonics	Kathleen Richardson	CREOL, UCF

4:00 Event ends

Solid State Lighting - The Remaining Challenges

Fred Schubert
Rensselaer Polytechnic Institute

Abstract: III-V nitride light-emitting diodes (LEDs) have become the backbone of light-generation technologies used for general lighting, controllable lighting, displays, signage, status-indicator lights, and emerging UV applications such as sanitation. Furthermore III-V arsenide and phosphide LEDs are used for long-wavelength visible and IR applications including communications and sensing. Although remarkable progress has been made, such as overcoming the challenge of reducing cost, there are remaining challenges: they include the efficiency of LEDs, which is typically is less than 30% at high current levels for GaN-based visible LEDs, and less than 10% for GaN-based deep UV LEDs. While the reduced efficiency at high current densities is a novel effect, and while the effect is generally recognized as a major technical challenge in solid-state lighting, the underlying physical causes of the effect are subject to vigorous discussions within the technical community. We will discuss the asymmetry in carrier-transport characteristics, i.e. the disparity in the properties of electrons and holes (as well as donors and acceptors) as an inherent characteristic of III-V nitride semiconductor materials. The implications of the asymmetry in carrier-transport characteristics on the injection efficiency and power efficiency of GaN-based devices will be discussed.

E. Fred Schubert is a Professor at Rensselaer Polytechnic Institute (RPI) in Troy NY. He made pioneering contributions to the field of compound semiconductor materials and devices, particularly to the doping of compound semiconductors, to the development and understanding of light-emitting diodes and solid-state lighting, and to nano-porous optical coatings. He headed the Future Chips Constellation at RPI for a 13-year period. He is the Founding Director of the Smart Lighting Engineering Research Center that was established by the National Science Foundation and has been funded with over $40 million. He authored the books Doping in III–V Semiconductors (1992), Delta Doping of Semiconductors (1996), and Light-Emitting Diodes (1st edition 2003 and 2nd edition 2006). He is co-inventor of more than 35 US patents and co-authored more than 300 publications. He is a Fellow of the APS, IEEE, OSA, and SPIE and has received several awards.

Playing with Proteins: Optical Trapping and Spectroscopy of a Single Molecule

Ryan Gelfand
CREOL, The College of Optics & Photonics, UCF

Abstract: Proteins, macromolecular assemblies of amino acid chains, are vital for life and found in every cell of our bodies. Their functions include catalyzing metabolic reactions, replicating DNA, responding to stimuli, transporting molecules, and forming our mechanical and structure tissue. Since their discovery, proteins have been studied using x-ray crystallography, NMR, mass spectrometry, ultra-fast spectroscopy, and florescent spectroscopy, but it has yet been possible to study the structure of single protein molecules in free solution without any steric hindrance. By exploring protein behavior in an environment that more closely resembles the cell we would be able to make advances in biophysics, drug discovery, and our understanding of human physiology. The key technology developed that will enable us to perform these experiments is self-induced back-action (SIBA), single nanoparticle trapping in an optical aperture. According to Bethe's aperture theory, a small change in the electromagnetic environment surrounding a subwavelength aperture in a metal film, such as by the presence of a dielectric object with a refractive index higher than that of the surrounding medium, causes an increase in the transmission through it. SIBA trapping approach offers superior trapping ability at lower powers for Rayleigh particles and provides an automatic feedback control without the need for any external monitoring mechanisms. While the protein is trapped in our aperture, we will be able to study their vibrational resonances, perform florescent studies without any homogenous broadening affects, and develop single protein optical biosensors.

Ryan M. Gelfand has been assistant professor at CREOL, the College of Optics and Photonics at UCF since September 2015 and has just started his research into NanoBioPhotonics. Before this position he was awarded an NSF postdoctoral fellowship in Biology under the directorate to bridge the life and physical sciences. His two-year postdoctoral research position was in the Nanoplasmonics Laboratory with Professor Reuven Gordon at the University of Victoria, BC. There he worked on SIBA trapping and in collaboration with Vertex Pharmaceuticals. His PhD is from Northwestern University in the Bio-Inspired Sensors and Optoelectronics Laboratory with Professor Hooman Mohseni where he worked on plasmonic platforms for optical biosensing. Before his PhD work he was a pharmaceutical chemist with Abbott Laboratories and his BS in Physics is from Carnegie Mellon University.

Optoelectronics: Is there anything it cannot do;
Can Opto-Electronics Provide the Motive Power for Future Vehicles?

Eli Yablonovitch
UC-Berkeley

Abstract: A new scientific principle has produced record-breaking solar cells. The 28.8% single-junction solar efficiency record, by Alta Devices , was achieved by recognizing the importance of extracting luminescent emission. This is exemplified by the mantra: "A great solar cell also needs to be a great LED". It was essential to remove the original semiconductor substrate, which absorbed luminescence, and to replace it with a high reflectivity mirror. The solar efficiency record crept up as the rear reflectivity behind the photovoltaic film was increased, 96% reflectivity -- 97% -- 98% luminescent reflectivity;-- each produced a new world efficiency record.

In thermo-photovoltaics, high energy photons from a thermal source are converted to electricity. The question is what to do about the majority of low energy infrared photons? It was recognized that the semiconductor band-edge itself can provide excellent spectral filtering for thermophotovoltaics, efficiently reflecting the unused infrared radiation back to the heat source. Exactly those low energy photons that fail to produce an electron-hole pair, are the photons that need to be recycled.

Thus the effort to reflect band-edge luminescence in solar cells has serendipitously created the technology to reflect all infrared wavelengths, which can revolutionize thermo-photovoltaics. We have never before had such high rear reflectivity for sub-bandgap radiation, permitting step-function spectral control of the unused infrared photons for the first time. This enables conversion from heat to electricity with >50% efficiency. Such a lightweight "engine" can provide power to electric cars, aerial vehicles, spacecraft, homes, and stationary power plants.

O. D. Miller, Eli Yablonovitch, and S. R. Kurtz, "Strong Internal and External Luminescence as Solar Cells Approach the Shockley–Queisser Limit", IEEE J. Photovoltaics, vol. 2, pp. 303-311 (2012). DOI: 10.1109/JPHOTOV.2012.2198434

Kayes, B.M.; Hui Nie; Twist, R.; Spruytte, S.G.; Reinhardt, F.; Kizilyalli, I.C.; Higashi, G.S. "27.6% Conversion Efficiency, A New Record For Single-Junction Solar Cells Under 1 Sun Illumination" Proceedings of 37th IEEE Photovoltaic Specialists Conference (PVSC 2011)Pages: 4-8, DOI: 10.1109/PVSC.2011.6185831

The heat source can be combustion, radio-activity, or solar thermal.

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

Yablonovitch introduced the idea that strained semiconductor lasers could have superior performance due to reduced valence band (hole) effective mass. With almost every human interaction with the internet, optical telecommunication occurs by strained semiconductor lasers.

In his photovoltaic research, Yablonovitch introduced the 4(n squared) ("Yablonovitch Limit") light-trapping factor that is in worldwide use, for almost all commercial solar panels.

Based on his mantra that "a great solar cell also needs to be a great LED", his startup company Alta Devices Inc. has, since 2011, held the world record for solar cell efficiency, now 28.8% at 1 sun.

He is regarded as a Father of the Photonic BandGap concept, and he coined the term "Photonic Crystal". The geometrical structure of the first experimentally realized Photonic bandgap, is sometimes called "Yablonovite".

His startup company Ethertronics Inc., has shipped over one billion cellphone antennas.

He has been elected to the NAE, the NAS, and as Foreign Member, UK Royal Society. Among his honors is the Buckley Prize of the American Physical Society, and the Isaac Newton Medal of the UK Institute of Physics.

Hemispherical Focal Plane Arrays Using Organic Semiconductors

Kyle Renshaw
CREOL, The College of Optics & Photonics, UCF

Abstract: A simple lens focuses to a curved surface, the Petzval surface, producing the aberration known as image field curvature. However, conventional imaging systems use a flat imaging sensor to sample this fundamentally curved image surface. This solution imposes strict design rules for imaging systems and these rules enforce trade-offs between lens complexity, image quality, resolution, and field of view (FOV). Balancing these properties becomes particularly difficult for imaging systems with a wide FOV; this balance usually results in a complex, bulky and expensive lens design or severely distorted, non-uniform images. In contrast, a curved focal plane array would eliminate these constraints and allow development of compact, wide FOV imaging systems without sacrificing image quality. Recent advances in the fabrication of flexible and non-planar optoelectronics have made the realization of curved FPAs possible. This talk will review these technologies and introduce our current research efforts to develop hemispherical focal plane arrays using organic semiconductors.

Kyle Renshaw received his PhD in Applied Physics and his MS in Electrical Engineering, both from the University of Michigan. His thesis work was focused on the development of hybrid organic/inorganic optoelectronics. After completing his PhD, Dr. Renshaw spent two years in the Advanced Technology Center at Northrop Grumman supporting the development of advanced electro-optical and infrared (EOIR) systems including imaging, tracking, missile warning and countermeasure systems. In the fall of 2015, he joined the College of Optics and Photonics (CREOL) as an Assistant Professor. At CREOL, he directs the Thin-Film Optoelectronics (TFO) group which conducts research on novel optoelectronic devices enabled by thin-film materials. His group uses organic and hybrid organic/inorganic semiconductors to develop sensors, photovoltaics and LEDs that can be fabricated on large, flexible and/or non-planar substrates.

Ocean Optics-Gary Manche

Helping people solve problems with spectroscopy

JENOPTIK Optical Systems, Inc. - Marc D. Himel

Enabling tomorrow's technologies through precision optics, micro-optics, and systems

EVision Inc.-Tony Van Heugten

Electronic lenses for vision correction in long duration space missions

Gooch & Housego, LLC-Alex Fong

From VOC to Product Release - The Development of the G&H OL 455-KSA Ultra Uniform Luminance Calibration Standard

Liz Rogan
Executive Director and CEO, OSA – The Optical Society

OSA: Reflecting a Century of Innovation

One hundred years ago Perley Nutting and nine scientists from industry and academia in Rochester, New York, joined together to create The Optical Society. Throughout a century of breakthroughs by Nobel prize-winning scientists and our innovative members, OSA has brought together the best minds in optics and photonics to light the future. Optics and photonics may not be household words, but they improve our lives on a daily basis. They help make it possible for doctors to operate using state-of-the-art technology, for your smartphone to work and for your car to drive itself – one day soon! With so much of our daily lives influenced by optics, it begs the question: where would the world be without The Optical Society and its innovators?! In the dark – perhaps. We look forward to celebrating with you throughout 2016 and exploring what the future may hold. Please join us—visit OSA.org/100 to learn more.

Liz Rogan has spent 30 years working in the corporate, federal and non-profit industries. She worked on Capitol Hill for the Architect of the Capitol, spent time on a successful re-election senate campaign and with a political action committee. In Washington, she gained first-hand experience in the unique way things get accomplished in the world of government. She also learned the importance of grassroots advocacy and the value of listening and responding to constituent needs and interests, a skill that has served her well over the years. Liz held corporate positions in the real estate, public accounting and banking industries before she transitioned to the non-profit world as the Asst. Controller of the John F. Kennedy Center for the Performing Arts. She has a BA in Accounting from the University of Connecticut, is a CPA, and an alumnus of an executive business program from the Wharton School at the University of Pennsylvania.

Liz has been at OSA for more than 20 years in positions initially focused on operations, the last position being Chief Operating Officer. Beginning in 2002, she was honored with the role of Chief Executive Officer of OSA and the OSA Foundation. As OSA CEO, she reports to the Board of Directors and is responsible for the oversight, strategic direction and fiscal soundness of programs and activities of this $35-$40M, 150+ staff Society. The Foundation has a $7M+ reserve and activities include both fundraising and program development. In addition, Liz is the Society's spokesperson and advocate to a wide range of OSA constituencies, including its members, volunteers, co-sponsors and customers, throughout the global optics community.

Device Applications of Metafilms and Metasurfaces

Mark Brongersma
Stanford University

Abstract: Many conventional optoelectronic devices consist of thin, stacked films of metals and semiconductors. In this presentation, I will demonstrate how one can improve the performance of such devices by nano-structuring the constituent layers at length scales below the wavelength of light. The resulting metafilms and metasurfaces offer opportunities to dramatically modify the optical transmission, absorption, reflection, and refraction properties of device layers. This is accomplished by encoding the optical response of nanoscale resonant building blocks into the effective properties of the films and surfaces. To illustrate these points, I will show how nanopatterned metal and semiconductor layers may be used to enhance the performance of solar cells, photodetectors, and enable new imaging technologies. I will also demonstrate how the use of active nanoscale building blocks can facilitate the creation of active metafilm devices.

Mark Brongersma is a Professor in the Departments of Materials Science and Engineering and Applied Physics at Stanford University. He received his PhD from the FOM Institute in Amsterdam, The Netherlands, in 1998. From 1998-2001 he was a postdoctoral research fellow at the California Institute of Technology. Brongersma received a National Science Foundation Career Award, the Walter J. Gores Award for Excellence in Teaching, the International Raymond and Beverly Sackler Prize in the Physical Sciences (Physics) for his work on plasmonics, and is a Fellow of the Optical Society of America, the SPIE, and the American Physical Society.

Single Mode Microring Lasers

Mercedeh Khajavikhan
CREOL, The College of Optics & Photonics, UCF

Abstract: Microring resonators represent one of the archetypical building blocks of photonic integrated circuits. Their small foot-print, high quality factor, and modularity make them ideal candidates for on-chip laser applications. Progress towards utilizing such ring structures in laser configurations, however, has been hindered by the lack of a systematic strategy in suppressing unwanted longitudinal frequency oscillations. Here we present a new versatile approach for mode management based on the physics of open (non-conservative) systems. This versatile technique is inherently self-adapting and facilitates mode selectivity over a broad bandwidth without the need for other additional intricate components.

Mercedeh Khajavikhan received Ph.D. in Electrical Engineering from University of Minnesota in 2009. Her Ph.D. dissertation was on coherent beam combining for high power laser applications. In 2009, she joined University of California in San Diego as a postdoctoral researcher where she worked on the design and development of nanolasers, plasmonic devices, and silicon photonics components. In August 2012, she joined the College of Optics and Photonics (CREOL) at University of Central Florida as an assistant professor. In 2015, she received NSF Early CAREER Award.

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Nelson Tabiryan
Beam Engineering for Advanced Measurements Co.

Abstract: Light is an elusive state of matter with only a few opportunities for controlling its propagation. Shaping an optical material such as glass – evidently the first generation of optics - is still the most applied technique for making a lens, a prism, etc. Modulating refractive index instead of shape allows thinner components at the expense of compromised efficiency and bandwidth. Anisotropic materials in the form of liquid crystals made a major breakthrough in optical technologies by introducing two new control parameters. Modern display industry is essentially exploring one of them, variations of the effective modulation of birefringence - the third generation of optics. A recent breakthrough in optics relates to patterning optical axis orientation in the plane of an anisotropic film in conditions of half-wave retardation. Obtained as thin film coatings on any desired substrate, glass and plastic, flat or curved, different optical functionalities are obtained with same materials, same coatings, same processes - just by creating different patterns of the orientation of optical anisotropy axis by a touch of polarization modulated light. The new generation lenses, prisms, vortex waveplates, etc. combine the broadband efficiency of conventional optics with low-cost manufacturing and continuous thin structures no other diffractive optics can match. New optical concepts extend to transparent and flexible displays with no polarizers or color filters, provide viable solutions to key photonics problems including all-electornic beam steering and switchable lenses, and make feasible ultralight and ultrathin primary optics for very large telescopes.
Different aspects of the development were supported by the US Army, US Air Force Research Laboratories, and NASA Innovative Advanced Concepts (NIAC) program.

Nelson Tabiryan received a Ph.D. degree in Physics and Mathematics from the Institute of Physical Investigations of the Armenian Academy of Sciences, Yerevan, in 1982, and D. Sc. Degree from the Highest Qualifying Commission of the USSR in 1986. He is the President of Beam Engineering for Advanced Measurements Corporation co-founded by him in 1996 with Professor Boris Ya. Zeldovich, advisor of his Ph.D. studies. Dr. Tabiryan is an OSA Fellow and NIAC Fellow; Chairman of Optics of Liquid Crystals (OLC) Association (2007-2011), Chairman, co-chairman, program committee member of many international meetings on optics of liquid crystals, materials and displays. Keynote speaker at several conferences, including Eurodisplay 2015. He has successfully managed numerous advanced projects, particularly, with the US Government.

Kathleen Richardson
CREOL, The College of Optics & Photonics, UCF

Abstract: Next generation Electro-Optical / Infrared (EO/IR) optical components and sensors require novel optical materials that serve defined optical functions and possess attributes which can be tailored to accommodate specific optical design, manufacturing or component/device integration constraints. Efforts by the UCF team and our collaborators over the past decade have focused on developing a toolbox of materials, process methodologies and metrology tools that employ multi-component mid-infrared (MIR) transparent glasses (chalcogenide glass (ChG) and heavy metal oxide (HMO) glasses) with tailorable physical properties for diverse applications.

This presentation reviews application-specific needs that can be realized in MIR material systems with suitable optical quality and loss levels which are transferable to commercially relevant platforms. Most recently, we have developed ChG planar films for diverse photonic applications as well as bulk/film GRIN materials based on ChG nanocomposite materials. We review aspects of compositional design and property tuning to accommodate thermo-optic and other environmental demands required for bulk or planar component/device needs.

Kathleen Richardson is currently Professor of Optics and Materials Science and Engineering at CREOL/College of Optics and Photonics at the University of Central FL, where she runs the Glass Processing and Characterization Laboratory (GPCL). Most recently at Clemson University, she and her research team carry out synthesis and characterization of novel glass and glass ceramic materials for optical applications, examining the role of structure/property relationships on resulting optical function and performance in bulk, planar and fiber optical materials. Prof. Richardson's group has extensive industrial and government supported research programs evaluating materials for precision molded optics, the use of non-oxide glasses in chem-bio planar sensors, evaluation of complex material interactions in next-generation integrated opto-electronic chip design, and in nano-composites for advanced detection and optical applications. Prof. Richardson's group is a leading source of expertise in the evaluation of photo-induced structure/property modification mechanisms in non-oxide glasses for optical applications, and has authored more than 190 peer-reviewed publications, numerous proceedings and book chapters, and has organized and chaired multiple domestic and international meetings within her discipline.

Dr. Richardson is Past-President of the American Ceramic Society (ACerS), is a past-Chair of ACerS' Glass and Optical Materials Division (GOMD) and a past-President of the National Institute of Ceramic Engineers (NICE). She presently serves on the Coordinating Technical Committee (CTC) of the International Commission on Glass (ICG) and the Board of Directors of the American Ceramic Society (ACerS). Dr. Richardson has just completed her term as a member of the Board of Directors of the Society of Photo-Optical Instrumentation Engineers (SPIE) and most recently has served on advisory boards for Virginia Tech's Materials Science and Engineering Department, the NSF-ERC on Mid-Infrared Technologies for Health and the Environment (MIRTHE) at Princeton University and as part of the Australian Research Council's Centre of Excellence for Ultrahigh-bandwidth Devices for Optical Systems (CUDOS), in Sydney Australia. Professor Richardson is a recognized world leader in infrared glass research and education, and as a result of these efforts, currently holds the rank of Fellow, in the American Ceramic Society, the Society of Glass Technology (UK), SPIE and the Optical Society of America (OSA). Since 2006, she has served as a member of the Board of Trustees at Alfred University.

Exhibitors

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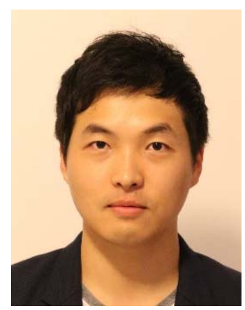
Student of the Year Presentation

Fundamental Studies of Ultrashort Laser Pulse Interaction with Aerosols

Cheonha Jeon

Delivering high intensity ultrashort laser pulses over long distances to irradiate targets has gained interest for various applications since the discovery of a laser filament. Laser filamentation in air produces a cylindrically symmetric self-channeled high intensity beam (~ 5 x 1013 W/cm2) generated by the dynamic balance between the Kerr self-focusing, self-generated plasma defocusing and diffraction. To efficiently deliver this high intensity diffraction-free beam over long distances in the atmosphere, there is a need to understand the changes in the characteristics of the laser beam as it interacts with obstacles present in air such as microscopic dust particles and aerosols. In this talk, I will present a quantitative approach to measure the energy dissipated by an ultrashort filamenting laser pulse during its interaction with a single aerosol and the subsequent effects on both the laser pulse and the aerosol. In addition to this, the impact of the droplet's position along the radial and longitudinal axes of the beam on its characteristics will also be discussed, leading to the study of filament propagation through multiple aerosols such as fogs and clouds.

Cheonha Jeon received his B.S degree (2009) in optical engineering from University of Rochester, M.S degree (2010) in electrical engineering from Yale University, and is in pursuit of his Ph.D. degree in CREOL. He has worked in the general areas of laser induced plasmas, ultrashort laser systems and associated applications under the supervision of Prof. Martin Richardson. In particular, he has made contribution to the development of a new facility that studies the interaction of ultrashort lasers with aerosols. .



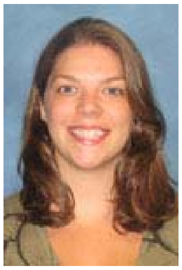
Student Presentations

Broadband, Widely-Spaced Optical Frequency Combs from Semiconductor Mode-Locked Lasers

In an increasingly connected world, the demand for high speed data is rapidly growing. Optical frequency combs offer an attractive solution to increase our information carrying capacity using the existing infrastructure by serving as a massive number of parallel, coherent data channels. Comb sources based on semiconductor lasers have a number of advantages including low noise operation at multi-gigahertz repetition rates and their ability to operate in different wavelength bands through bandgap engineering. However, semiconductor based combs have to date typically offered narrower bandwidth spectra compared to fiber or solid state based alternatives. We have worked to advance the state of semiconductor combs by measuring the dispersion of our lasers using a novel dual-comb measurement technique we developed. By adding a pulse shaper inside the laser cavity, we can compensate for this dispersion and broaden the output comb spectrum to span an unprecedented 5 THz with 10 GHz line spacing.

Tony Klee received his B.S. degree in optical engineering from Rose-Hulman Institute of Technology in 2010. He then joined CREOL at the University of Central Florida as a Ph.D. student in Dr. Peter Delfyett's Ultrafast Photonics group. His research focuses on the development and characterization of semiconductor-based optical frequency comb sources for novel detection and signal processing applications. He is the first author of two journal publications and nine conference proceedings.

Sensing with Specialty Optical Fibers



Specialty fiber optic sensors offer solutions to many of the obstacles faced by industries operating in harsh environments, such as high temperature operation, remote interrogation, and immunity to electromagnetic interference. Sensors based on multimode interference in fiber allow for high sensitivity to many environmental changes, while minimizing fabrication cost and complexity.

I will show the design and optimization of a fiber sensor based on multicore fiber, which has high sensitivity, simple fabrication, and the ability to withstand temperatures up to 1000°C. I will also show the sensor's performance when measuring temperature, strain, acoustic waves, and bending, as well as its integration with a novel fiber optic device for 3D shape sensing. Additionally, several designs of hollow core fiber will be introduced, and their characterization, as well as potential use in fiber optic sensing, will be explored.

Amy Van Newkirk is currently a PhD student in Dr. Axel Schülzgen's research group. She received her BS in Applied Physics from Grove City College in 2011. Her research is focused on the design and application of specialty optical fibers, primarily for use in sensors. She is the first author of three peer-reviewed journal articles, and has authored or co-authored a total of 22 journal articles and conference proceedings. Amy has received numerous awards from CREOL, UCF, SPIE, as well as a fiber optics company.

Advanced High Power Fiber Lasers and Devices

Fiber lasers and amplifiers have experienced an impressive growth in recent years due to their remarkable power scalability. However, due to the high optical intensity in the core, the performance of the high power fiber lasers is limited by detrimental nonlinear processes. To mitigate nonlinear effects large mode area (LMA) fibers that exhibit a mode field diameter (MFD) larger than 50 microns have been developed. Unfortunately, LMA fibers are not strictly single mode (SM) which ultimately at high average powers results in appearance of modal instabilities (MI) which leads to sudden degradation of the output beam of a fiber laser or amplifier. In this talk, I will present a novel design of a micro-structured SM large pitch, very large-mode-area fiber, featuring simultaneously, an enhanced HOM delocalization and efficient preferential gain in active fibers by breaking the cladding symmetry to improve the MI threshold in high power fiber lasers and amplifiers.

Zahoora Sanjabi is a PhD student in Dr. Amezcua's Microstructured fibers and devices group since 2012. Her research interests include fiber design, fabrication and characterization for variety of different applications including lasers, sensors, communications, high power delivery and medical and biotechnology. She has published 14 journal and conference papers and received the "Frances Townes Fellowship Award" in 2012.

Posters

Poster 1

Microdevice prototyping facility

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The UCF MicroDevice Prototyping Facility (MPF) is a user facility that provides low-cost wafer-scale fabrication of experimental devices in MEMS, microelectronics, microfluidics, and optoelectronics. We have over fifty current active users from Physics, Engineering, CREOL, and local industry. We offer individualized and course-level training. Recent projects have included MEMS cantilevers, air-bridge micro bolometers, photonic waveguides, single electron transistors, and microfluidic sensors. Processing tools include resist spinners, contact mask aligner, e-beam writer, thermal and electron-beam evaporators, sputtering of both metals and dielectrics, plasma enhanced vapor deposition of SiO_2, reactive-ion etchers with inductively-coupled plasma, barrel asher, deep reactive ion-etcher with Bosch process, and annealing/diffusion furnaces. Characterization includes scanning electron microscope, atomic force microscopes, profilometer, temperature dependent Hall effect, 4 point probe, and UV-vis spectrometer. Additional facilities under the same administrative umbrella include a machine shop and helium liquefier. Our website mpf.physics.ucf.edu provides a detailed description, instructions for gaining access, and illustrated operating procedures for each instrument. We particularly welcome industry users.

Poster 2

Fabrication and characterization of micro-structures created in arsenic trisulfide chalcogenide glasses by multi-photon lithography

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Arsenic trisulfide (As_2S_3) is a chalcogenide (ChG) material with excellent infrared (IR) transparency (620 nm to 11 μm), an optical bandgap at 2.35 eV (λ ~ 517 nm), and large nonlinear refractive indices. In this study, multi-photon lithography (MPL) is used to photo-pattern nano-structured arrays in single-layer and multi-layer As_2S_3 films. We investigated the properties and processing of single-layered films of thermally deposited As_2S_3 and multi-layered films of As_2S_3 deposited onto an underlying thin film of arsenic triselenide (As_2Se_3). The As_2Se_3 serves as an anti-reflection (AR) layer which reduces reflection of the incident laser beam back into the focal volume during laser patterning. By eliminating the back-reflection we are able to fabricate smaller nano-structures in the As_2S_3 layer with sub-wavelength features, cylindrical shapes, and increased substrate adhesion. The multi-layered films were used to fabricate large arrays (250 μm × 250 μm) of homogeneous nano-structures with a 500 nm pitch and dimensions as small as 120 nm. Processing procedures were developed to fabricate large area nano-structured arrays with optical function.

Poster 3

Photo-thermo-refractive glass with long wavelength photosensitivity

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Photo-thermo-refractive (PTR) glass is a holographic material, which is extensively used for recording of volume Bragg gratings (VBGs). Exceptional optical properties of the glass provide remarkable performance of VBGs recorded in it. However, only planar holographic structures, such as VBGs, but not complex holograms could be recorded in PTR glass for applications in visible / IR spectral region. We proposed a method to extend photosensitivity of PTR glass into the visible / IR spectral region. A new type of PTR glass doped with Tb^{3+} ions was fabricated for the purpose. Photoionization of the glass was carried out by exciting Tb^{3+} ions using excited state absorption upconversion process.

Concurrent exposure to UV and visible / IR radiation followed by thermal development yielded a refractive index change of over 200 ppm in the glass. The magnitude of refractive index modulation in the glass is sufficient for high efficiency hologram recording. Complex volume holograms recorded using visible light were demonstrated in Tb3+ doped PTR glass.

Poster 4

A High ambient contrast augmented reality system

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We have proposed a compact, yet high ambient contrast ratio augmented reality (AR) system by incorporating a tunable transmittance liquid crystal (LC)cell and a thin functional reflective polarizer. The voltage driven LC cell has a high tunable transmittance range from ~73% to ~26% with a low turn-on voltage of 8V. At the same time the LC cell is at least 10X faster than photochromic materials used in commercial transition glasses. Combing the LC cell with a light sensor, the tunable transmittance LC cell can efficiently control the ambient contrast ratio of the AR system under different lighting conditions. At the same time the functional reflective polarizer works similarly to a polarizing beam splitter (PBS), but is much more compact. In addition, with transmittance optimization, the functional reflective polarizer can help people with color vision deficiency.

Poster 5

Switching of the image plane utilizing twisted nematic liquid crystals for virtual and augmented realities

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We report a switchable optical device in which a twisted nematic (TN) liquid crystal cell is utilized to control polarization. Different polarization state leads to different path length in the device, resulting in different image plane. This device has the merit of fast response time, low operation voltage, and inherently lower chromatic aberration. Multiple devices can be cascaded to increase the number of switchable image planes and pixelated switching is also achievable.

Poster 6

BaTiO3 film grown by water-based process

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Self-assembled nano-crystalline $BaTiO_3$ films on stainless steel foil substrates, were grown by the water based **S**treaming **P**rocess for **E**lectrodeless **E**lectrochemical **D**eposition (SPEED). SPEED is an aqueous process that deposits self-assembled nanomaterial inorganic thin films over large areas, without a vacuum, providing a scalable and manufacturing friendly process to fabricate durable films. Water-soluble compounds with complexing agents grow films by heterogeneous reaction on the substrate, with little wasteful homogeneous reaction. Hydrophilic substrates bind hydroxyl ions (OH^-), which are attachment sites for nucleation with density exceeding 10^{12} per square centimeter. The water based precursor, nebulized into 10 to 20 μm droplets (vapor phase SPEED, or VPSPEED), impinges on the substrate, which is at temperatures of ~300 ℃, giving growth rate exceeding 200 nm per minute. The substrate heating provides the reaction activation energy, and decomposes/volatilizes reaction byproducts, but the required temperatures are well below those required for spray pyrolysis. All films were subsequently annealed at 500 C for 1 hour. The morphology of the ~1 ◎m thick films comprises single crystals of micron dimensions imbedded in a matrix of nanocrystals. XRD confirms presence of $BaTiO_3$ crystals of hexagonal phase. Further annealing at 500 C increases the hexagonal peak intensity. Subsequent annealing at 600 C for 1 hour causes a substantial transformation to the cubic phase. Potential applications include dielectric layers, capacitors, waveguides, ferroelectric RAM, and pyroelectric infrared detectors and phosphors. Characterization of pyroelectric properties and application to infrared detection will be presented. The photoresponse to $BaTiO_3$ @ 500 C 1 hour annealed by using applied 300kV/m for 2 minutes TEA CO_2 laser is 20mV output signal from the circuit that made it for measured it photoresponse. But photoresponse of $BaTiO_3$ @ 500 C 2 hour annealed is 350 mV.

Poster 7

Spatially-variant self-collimating photonic crystal for beam bending at telecommunication wavelength

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Spatially-variant self-collimating photonic crystals (SVPCs) have been shown to be capable of controlling the spatial propagation of electromagnetic waves, by bending light beams through a 90 degree turn without significant loss to diffuse scattering or absorption. SVPCs make use of the directional phenomena of self-collimation by gradually changing the orientation of unit cells in the lattice as a function of position. Here we report the fabrication of a three-dimensional (3D) SVPC and experimentally demonstrate beam-bending at a telecommunications wavelength of $\lambda 0$ = 1.55 μm. The fabrication was done by multiphoton direct laser writing (mpDLW) using the photopolymer IP-Dip. Optical characterization of the fabricated SVPCs shows that a bending efficiency of 48% is possible for an SVPC having a volumetric fill factor of ca. 46%. It is found that the bending efficiency depends not only on the volumetric fill factor but also on the lattice spacing and the aspect ratio of the unit cell. Moreover, the SVPC has a bending bandwidth of ca. 130 nm , which is almost four times wider than the telecom C-band. The experimental results demonstrate the potential of SVPCs as interconnects for optoelectronic circuits.

Poster 8

Improving energy harvesting using plasmonic optical horns

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Energy harvesting is an attractive means for decreasing the costs of materials and devices used for photovoltaics and related applications. One potential way to harvest infrared energy is to use plasmonic horns. These devices would harvest energy over a wide aperture and funnel it to a smaller-area photovoltaic device. Horn arrays designed to function at 2.94 μm were fabricated and characterized. Error in fabrication was less than 10%, showing reliable structures could be reliably fabricated. Preliminary optical characterization was also performed.

Poster 9

Controlled red and blue bandgap energy shifted LEDs and modulators integrated on a single InP substrate

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We demonstrate bandgap tuning of InGaAsP multiple quantum well structures by utilizing an impurity free vacancy disordering technique. We have fabricated LED sources that operate with a wide spectral bandwidth together with optical modulator devices that have large contrast switching ratios, utilizing this controllable technique for red and blue shifting of quantum well's bandgap energy. In this work, we have realized substantial modification of the bandgap energy toward the red and blue part of the spectrum by rapid thermal annealing of the MQW sample with regions covered by SiO_2, SiO_yN_x, SiN_x capping layers. The resulting degree of tuning, up to 120nm red-shift and 140nm blue-shift of the band to band wavelength emission has been studied using room temperature photoluminescence, in agreement with the emission spectra obtained from semiconductor LED devices fabricated on this platform. The intensity modulator devices that have been integrated with the LED sources are designed to experience minimal optical losses and residual absorption modulation over the whole emission spectrum.

Poster 10

Wavefront characterization of a multi-terawatt femtosecond laser for filamentation

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In this study, two phase-front measurement methods are investigated to characterize the wavefront profile of ultrashort pulse lasers generating multi-terawatt peak power used for filamentation studies. This effort is made in order to diagnose laser performance, inform propagation models, and determine initial beam conditions relative to filament engineering. The first method of wavefront characterization

utilizes a commercial Shack-Hartmann wavefront sensor. This device allows measurements to be made directly with little need for data post-processing. However, setbacks of this technique include poor spatial resolution and the inability to accurately capture phase discontinuities. To overcome these shortcomings, a split-step Fourier transform phase retrieval algorithm will be implemented, which uses intensity measurements at multiple planes to recover the corresponding phase information. While this method comes at the cost of a large amount of post-processing, the trade-off is an increase in spatial resolution and the ability to recover phase discontinuities. In addition, increasing the number of measurement planes in the iterative retrieval algorithm increases the accuracy of the recovered phase whereas the accuracy of the Shack-Hartmann sensor is fixed

Poster 11

Extremely nondegenerate nonlinear refraction in direct-gap semiconductors

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Nondegenerate nonlinear refraction (NLR), namely the refractive index change at frequency ω_1 caused by the presence of a beam at frequency ω_2, is measured for several direct-gap semiconductors including ZnO, ZnSe and CdS using our ultrafast beam deflection technique. The magnitudes and nonlinear dispersion of the NLR coefficient $n_2(\omega_1;\omega_2)$ are resolved over a broad spectral range with high nondegeneracy. We found agreement between our experimental results and theoretical predictions. The theory is based on Kramers-Kronig transformation of the nondegenerate nonlinear absorption spectrum, where two-photon absorption (2PA), electronic Raman and optical Stark effect are taken into account. In the extremely nondegenerate case, $n_2(\omega_1;\omega_2)$ near the 2PA edge is positively enhanced and significantly larger than its degenerate counterpart. At higher photon energies, $n_2(\omega_1;\omega_2)$ rapidly switches sign to negative. This rapid anomalous nonlinear dispersion provides large modulation of a femtosecond pulse with 10nm bandwidth centered near the zero crossing frequency. This enhanced nondegenerate NLR may impact numerous applications such as all-optical switching, and may enable other new applications such as nonlinear pulse shaping.

Poster 12

Hybrid divided-pulse amplification

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A novel picosecond laser utilizing both active and passive divided-pulse amplification (DPA) is presented, demonstrating spatial and temporal DPA of up to four pulses in flashlamp-pumped Nd:YAG amplifiers. Gain saturation is achieved while avoiding optical damage or large accumulation of B-integral. The final pulse energy after recombination of 216 mJ is the current DPA record. This design is capable of combining pulses at the Joule-level with high efficiency using novel large-aperture interferometers.

Poster 13

High brightness, sub-nanosecond Q-switched laser using volume Bragg gratings

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The design of Q-switched lasers capable of producing pulse widths of 100's of picoseconds necessitates the cavity length be shorter than a few centimeters. Increasing the amount of energy extracted per pulse requires increasing the mode area of the resonator that for the same cavity length causes exciting higher order modes and decreasing the brightness of output radiation. To suppress the higher order modes of these multimode resonators while maintaining the compact cavity requires the use of intra-cavity angular filters. A novel Q-switched laser design is presented using volume transmitting Bragg gratings (TBGs) as angular filters to suppress the higher order transverse modes. The laser consists of a 5 mm thick slab of Nd:YAG, a 3 mm thick slab of Cr:YAG with a 20% transmission, two orthogonally aligned TBGs to suppress the higher order modes, and a 40% output coupler. The gratings are recorded in photo-thermo-refractive (PTR) glass, which has a high damage threshold that can withstand both the high peak powers and high average powers present within the resonator. The TBGs recorded in PTR glass have narrow angular selectivity ranging from 0.1 to 10 mrad, and can spatially filter beams with a diameter ranging from 0.1 to 10 mm. Experimental results are presented demonstrating the Q-switched laser with a cavity length of 1 cm, millijoule level output, sub-nanosecond pulse width, and diffraction limited beam quality.

Poster 14

Optical frequency comb generation by pulsed pumping

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Frequency combs are composed of a series of short and high power pulses in the time domain that translate into a broad comb in the frequency domain. This duality translates into a host of applications in sensing and metrology. Recent demonstration of frequency comb generation on silicon nitride has brought the vision of a fully integrated frequency comb source within reach. Frequency comb generation is an inherently inefficient process, with conversion efficiency on the level of 1% to 2%. To tackle this issue, we propose a novel architecture incorporating a breathing mode locked laser and a highly nonlinear microring cavity. We justify this approach using both an analytical approach with input pulses of the form 1/ cosh(t) and numerical simulations. We devise a path towards pulse compression (soliton formation). We show that, independent of the pulse shape, if the peak of pulse is locally flat the solitons formed from the pulse are of the same shape as the ones formed from CW background with power on the level of the peak power of the pulse. This implies that for a pulsed pump the average power requirement will be reduced to a fraction of the CW power, that is the duty cycle of the pulse. We map out the stability of the soliton solutions and argue that the stability and the coherence of combs generated in a microring cavity is superior to supercontinuum generation in straight waveguides with the same pulsed input.

Poster 15

A reliable approach to membrane photonics: The T-Guide

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A novel class of membrane-type optical waveguides, the T-Guide, is proposed and demonstrated. In addition to numerous practical features, such as enhanced mechanical stability and self-aligned fabrication, these structures possess unusual and promising optical features such as ultra-broad single-mode operation, effective single-polarization operation, and intuitive control over mode shape and dispersion characteristics. Exploring their application to mid-infrared integrated photonics, T-Guides up to 5 cm in length are fabricated on a silicon integrated platform, showing transverse-electric (TE) mode propagation losses of 1.75 dB/cm at a measurement wavelength of 3.6 μm. T-Guides have promising potential applications in hybrid photonic integration and broadband frequency conversion.

Poster 16

Performance comparison of grating-assisted optical delay lines

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On-chip optical buffers or delay lines are important components in a variety of applications, including optical communication systems and networks and optical beam-forming control of phased-array antennas (PAAs). Optical delay lines not only should possess large true delay times, but they should also be tunable, have large spectral bandwidth for high information trafficking and have small footprint to be suitable for photonic integrated circuits. Here, incorporation of apodized gratings in performance of integrated-photonic delay line structures is proposed and studied. Particularly, apodized gratings are incorporated in straight waveguides and two common microring configurations known as coupled-resonator optical waveguides (CROW) and side-coupled integrated spaced sequence of resonators (SCISSOR). The performance of the six optical delay line configurations (with and without grating) are then compared. Specifically, performance in terms of the attainable time delay and its tunability, the delay- and tunability-times-bit-rate products, as well as the delay per footprint, are studied.

Poster 17

High ambient contrast ratio OLED and QLED without a circular polarizer

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A high ambient contrast ratio display device using a transparent OLED or transparent Quantum-dot LED (QLED) with embedded multilayered structure and absorber is proposed. With the help of the multilayered structure, the device structure allows almost all ambient light to get through the display and be absorbed by the absorber. Because the reflected ambient light is greatly reduced, the ambient contrast ratio of the display system is improved significantly. Meanwhile, the multilayered structure helps lower the effective refractive index, which in turn improves the outcoupling efficiency of the display system. The new design does not need a circular polarizer, and therefore it opens a new door for flexible and rollable display applications.

Poster 18

Comparison of beam bending efficiency of waveguides and spatially variant photonic crystals (SVPCs)

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Conventional devices like photonic crystals and metamaterials can be used to control and steer light through tight turns with bend radius Rbend comparable to the wavelength of the light, λ. But fabricating these devices involves complex processes and exotic material properties, some of which introduce inherent loss. Spatially variant photonic crystals (SVPCs) on the other hand are 3D dielectric lattices which can control light and bend it through sharp turns, without necessarily incurring loss. In this work, an SVPC was designed for bending a light beam having $\lambda = 2.94$ μm. The structure was then fabricated in SU-8 using multi-photon lithography (MPL). Optical characterization showed that the device can bend a light beam through a tight turn having a bend radius as small as Rbend = 6.4λ. Waveguides having a comparable bend radius were also fabricated and characterized to compare their performance with that of the SVPC. The experiments show that the waveguides are highly lossy, as expected, because light incident within the guide exceeds the angle for total internal reflection with the turn radius is small, and that the SVPCs cannot be bending beams through total internal reflection.

Poster 19

Applications of laser-induced breakdown spectroscopy (LIBS) in forensic anthropology

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Forensic anthropology requires the classification of questionable fragmentary materials. Laser-Induced Breakdown Spectroscopy (LIBS) for elemental analysis in the field of anthropology is explored for rapid identification of osseous/dental fragments, as well as their identification as human or non-human. Current techniques used to identify human osseous material are time-consuming, potentially destructive, and for some, require easily identifiable large segments of bone. LIBS can aid in the identification of human remains using rapid laser ablation to analyze elements in a sample. With this analysis occurring at the micro-scale, the technique is virtually non-destructive to the sample and cannot typically be seen by the naked eye. Using ratios of certain elements (calcium, potassium, magnesium, etc.), osseous/dental fragments can be separated from non-skeletal samples. Furthermore, human bones can be differentiated from non-human remains. This study focused on samples of human bone, alligator bone, and bird bone. The laser spectra for each species were analyzed for outstanding elemental signatures, and then compared. Laser-Induced Breakdown Spectroscopy has the potential to advance the field of anthropology, especially in forensic and archaeological contexts, through its efficient and non-destructive elemental analysis of unknown materials.

Poster 20

Few mode multicore photonic lantern mode multiplexer

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We demonstrate the first few-mode, multi-core mode-selective photonic lantern. The device is a 7-core, 3-mode MUX capable of exciting the LP_{01} and $LP_{11a,b}$ modes of the individual cores with low core to core crosstalk. Selective excitation of the LP_{01} and $LP_{11a,b}$ modes is achieved for individual PL cores. By inserting 21 graded-index fibers at two different sizes of 13µm (to excite LP_{01} mode) and 11µm (to excite LP_{11} modes) in a fluorine doped preform and tapered down to 125µm OD, we obtain a multi-core facet with individual core diameters of 16µm and 33.5µm core to core distance. The seven cores are positioned in a hexagonal arrangement. However, different core arrangements are feasible. Device characterization is performed by coupling a super-luminescent diode centered at 1550nm. The experimental observations confirmed low insertion losses of less than 0.4 dB for all modes. The proposed multi-core, few-mode PL is a compact component that can play an important role for emerging few-mode, multi-core transmission systems. In addition, the device is scalable to larger number of cores and/or modes per core.

Poster 21

Emission of carbon black

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Here we present an experimental study of thickness based emissivity measurements of carbon black grown by a streaming process for electrodelsss electrochemical deposition (SPEED). SPEED is a high-rate uniform deposition technique that uses water-soluble precursors to rapidly coat most substrates with nanoparticle-based films having no fundamental limitation to these achievable film thicknesses. Carbon black itself exhibits exceptional spectral and angular emissivity of nearly unity across the infrared spectra. These properties allow for a variety of multi-scale uses ranging from thermal detectors to satellite radiative temperature control to infrared obscurances. We focus this particular study on thickness-dependence of spectral emissivity. An objective is to optimize the thickness. Films that are too thin have low absorptivity and low emissivity following Kirchoff's law. Films that are too thick have a temperature gradient from the substrate to the surface, resulting in reabsorption features in the emission spectrum.

Poster 22

Near-field effects in mesoscopic light transport

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In scattering media, optical waves comprise both homogeneous and evanescent components. At very high concentrations of scatterers, particles are located in close proximity and interact through evanescent near fields. Thus, in this regime the energy is not only carried by propagating waves but it also evolves through evanescent coupling between individual scatterers. We have shown that in dense composite media additional transmission channels open because of these near-field interactions between close proximity scatters and, consequently, a new regime of transport emerges. This is clearly beyond simple descriptions of scatterers acting independently of their environment and framed in terms of far-field characteristics such as Mie cross-sections. We will show that, because in the dense media the energy can transfer through both diffusion and evanescent channels, the total transmittance is $T = T_{CS} + T_{NF} = 1/L(l_{CS}^* + l_{NF}^*)$ Correcting the total transmission in this manner is appealing because it is done in terms of physically meaningful and measurable quantities such a near-field (NF) scattering cross-section σ_{NF}.

Poster 23

Spatial mode-selective amplification in large mode area double-clad Yb:fiber using a photonic lantern

S. Wittek, R. Bustos Ramirez, J. Alvarado Zacarias, Z. Sanjabi Eznaveh, G. Lopez Galmiche, J. Bradford, D. Zhang, W. Zhu, J. Antonio-Lopez, L. Shah, R. Amezcua Correa*
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We demonstrate a few mode, double-clad Yb-doped large mode area (LMA) fiber amplifier utilizing an all-fiber photonic lantern. High power amplification to >4 W is achieved while preserving spatial mode quality. We achieve gain of > 15.5 dB for each mode independently (LP01, LP11). Additionally, we investigate simultaneous amplification of LP01+LP11b and LP11a+LP11b.
This amplifier configuration enables active spatial mode control for potential mitigation of modal instabilities.

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Poster 24

Filamentation by combining sub-critical peak power ultrashort pulses

Daniel Kepler[1*], Shermineh Rostami[1], Matthieu Baudelet[1, 2], Lawrence Shah[1], and Martin Richardson[1]
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Filament generation from ultrashort, high-power (>3-10 GW) laser pulses occurs through a dynamic balance of Kerr self-focusing and plasma defocusing. The formation of plasma channels combined with their organization into arrays of filaments can support guided modes for microwave, RF, IR, and visible radiation. The generation of these filament arrays requires phase manipulation of the laser pulses. Studying the combination of pulses with sub-critical peak power to form filaments provides insight into the physics of this process and may lead to novel methods to generate massive filament arrays. In this study, we experimentally show the impact of spatial overlap between two 50 fs pulses from a Ti:Sapphire laser (800 nm at 10 Hz), each with a peak power just below the critical value for filamentation (P_pulse~0.7P_cr). The intensity profile and spectrum of the combined beam are measured as a function of transverse separation between the peaks of the two sub-critical beams.

Poster 25

Six mode erbium-doped fiber amplifier using mode selective photonic lantern

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[4]*Prysmian Group, Parc des Industries Artois Flandres, 644 boulevard Est, Billy Berclau, 62092 Haisnes Cedex, France*
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We demonstrate the first implementation of a six mode erbium doped fiber amplifier incorporating a photonic lantern for modal gain control. Signal gains >20 dB and differential modal gain <3 dB were obtained through mode selective pumping using LP21 mode. It is expected that lower values of DMG can be obtained by modifying the modal content of the pump, by using a superposition of modes. This interesting scheme replaces the free space coupling method used previously. In addition, the proposed photonic lantern EDFA is a scalable and simple all-fiber system with the possibility of providing reconfigurable modal gain control.

Poster 26

Visible supercontinuum generation in a low DGD graded index multimode fiber

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We report visible SC generation using a low differential modal group delay (DGD) telecommunication multimode graded index fiber with a core diameter of 50 μm, pumped in the normal dispersion regime. A compact picosecond amplified microchip laser at 1064nm with pulse energies ~95 μJ and maximum peak power of ~240 kW was used to generate a high brightness broad SC extending from 414 nm to 1750 nm. The enhanced visible supercontinuum was

obtained in a tunable fashion based on initial launching conditions. Of interest would be to further study the effect of launching conditions (modal content) and refractive index profiles on the evolution of SC generation in such heavily multimoded fibers.

Poster 27

Observation of raman solitons in filamentation

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Filamentation manifests as the self-focused, confined propagation of an ultrashort laser pulse with peak power above the critical value, (P_{cr}~ 3-10 GW in air). There has been increasing interest in characterizing the effects of long range propagation of filaments under different atmospheric conditions for applications such as LIDAR. This requires an understanding of the spectral generation mechanisms along propagation for different conditions. In this study, spectra induced during the filamentation of 800 nm, 50 fs pulses are measured for pressures below 1 atm and input pulse powers between 0.4 P_{cr} and 3.3 P_{cr}. For these conditions, a spectral redshift is observed. The relationship of this spectral shift between the pulse power and pressure is examined as a function of the nonlinear Kerr parameter, $n_2 I$. Furthermore, the evolution of this spectral redshift along the propagation axis is observed to be confined within the filament core.

Poster 28

High-power Laser Beamline

Jian Zhao, Yang Wang, Yi Wu, Eric Cunningham, Tianyi Guo, Wenxu Zhang, *Zenghu Chang
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We are constructing a 10 Hz, 200 TW (3 J in 15 fs) Ti:Sapphire-based chirped pulse amplification (CPA) system to generate microjoule-level isolated attosecond pulses. Due to the CPA's high peak power, we designed a 23-meter long vacuum system after the final amplifier for avoiding nonlinear interactions with air. The stretched, multi-joule pulses are first directed into a large vacuum chamber which houses the grating-based pulse compressor. After being compressed to 15 fs, the beam is directed into an 8-inch five-way-crossing chamber where the beam can be directed out to characterize the pulse duration using FROG. Next, a 6-inch diameter vacuum line is used to direct the beam into a 10-inch six-way-cross where a 45 degree corner mirror directs the beam through the Generalized Double Optical Gating (GDOG) optics (two wave plates, Brewster window and lithium triborate (LBO) crystal) chamber. After being gated with GDOG, the beam goes through additional vacuum lines (from 4.5 inch diameter tube to 2.75 diameter tube) before reaching the high harmonic generation (HHG) chamber, where a 10 Hz pulsed gas jet is located inside a 1 cm diameter gas cell. The position of the gas cell can be adjusted over a distance of one meter in order to tune phase-matching conditions and the intensity of the laser. After the HHG chamber, the resultant XUV beam is directed into an end station for characterizing the XUV beam and performing atto-pump-atto-probe experiments..

Poster 29

Development of microscopic tools for forensic analysis of trace evidence

Bryan McCullough[1,2], *Matthieu Baudelet[1,2,3]
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Forensic Microscopy is a crucial component of the non-destructive forensic analysis of trace evidence. Either it is for physical imaging (SEM, stereoscope, compound microscope), structural information (PLM) or chemical analysis (EDX, micro-spectrophotometry, IR, Raman), it is inherent to trace analysis. There are few advances that lately introduced novel concepts or new analytical power to the field. The main question is then: Are there needs as well as room for improvements in forensic microscopy?

This poster will walk you through the use of optical and spectral microscopy for the analysis of trace evidence. From the stereoscope to the SEM-EDX, from the polarized light to Raman to ATR-FTIR microscopes, the advances in the technology as well as the novel concepts developed by the Forensic Spectroscopy group at the National Center for Forensic Science will be presented.

Poster 30

Dynamics of the plasma electronic density induced by a laser filament

Danielle Reyes, Cheonha Jeon, Khan Lim, Shermineh Rostami, Michael Chini, Matthieu Baudelet, *Martin Richardson
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An ultrashort pulse with peak power above the critical power will collapse due to the nonlinearities of the propagation medium leading to the creation of a plasma. The ensuing competition between Kerr self-focusing and plasma defocusing results in a dynamic self-guided structure with an intense core surrounded by an energy reservoir. This process, called filamentation, produces a weakly ionized plasma channel. Some of the proposed applications of filamentation seek to employ this plasma as a means to guide electromagnetic radiation, or discharges. The characterization of the conductivity via the electronic density of the filament is crucial to these applications. In this study, temporally and radially resolved direct measurements of filament plasma electronic density are acquired using an interferometric technique. The dynamics of the plasma channel (rise and decay times, diffusion) are discussed.

Poster 31

Quantification of non-stoichiometry in transparent ceramics using laser-induced breakdown spectroscopy (LIBS)

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[2]*Chemistry Department, UCF*
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In the last decades, transparent ceramic materials have emerged in various optical applications including transparent armors, high-power lasers and radiation sensors. In most cases however, the fabrication of these polycrystalline materials requires a strict control of the composition to avoid the formation of deleterious scattering and color centers. An analytical technique, with the capability of testing departure from stoichiometry with accuracy on the order of 0.1 mole %, is needed to guarantee an accurate and reproducible fabrication process as no current method presently exists for that purpose. In this work, we show that the aluminum-to-yttrium ratio in YAG ceramics can be assessed with a resolution better than 0.2 mole % with an optimized Laser-Induced Breakdown Spectroscopy (LIBS) system. This result opens up new perspectives in the manufacturing and quality control of other advanced materials.

Poster 32

Mode-locking in a monolithic seven-core fiber laser

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We have assembled a monolithic, multicore fiber (MCF) laser based on a gain section of Yb-doped, seven-core fiber. At the operation wavelength near 1030 nm, each core is single-mode and strong coupling between the cores gives rise to the propagation of supermodes, resulting in supermode interference (SMI). By temperature control of a fiber Bragg grating (FBG), the ability to tune across multiple SMI periods was demonstrated.

Utilizing the FBG's reflectivity tuning, characterization of laser properties has been performed for wavelengths at various points in the SMI period. Investigation of temporal measurements showed an unstable, Q-switched regime of pulses, suggesting that varying the cavity length to increase nonlinearities could lead to more stabilized pulse trains. Additional amounts of single mode fiber at a variety of lengths was added to the system, leading to the observation of passive mode-locking. The effect of different cavity lengths on pulse width and stability is presented.

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.

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 facility equipment includes a Suss MJB-3 and MJB-4 aligners, 2 Plasma-Therm 790 RIE systems with silicon and III-V etching capabilities, a Temascal and V&N E-beam evaporators, along with an atomic force microscope, a profilometer, aa rapid thermal annealer, a bonder, a scriber and microscope. 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 fidelty 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

Zygo Facility. Rm 211B. Shared facility administered by 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.

Faculty Laboratories

	Room
Ayman Abouraddy	
• Optical Fiber Characterization and Mid-infrared Nonlinear Fiber Optics	A114
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David Hagan and Eric Van Stryland

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- Nanosecond Tunable OPO (400-1,500 nm) – Z-scan, optical limiting 236
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Aravinda Kar

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Martin Richardson
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Photonics Incubator
The Photonics Incubator is part of the UCF Business Incubation Program and is located within the facilities of the College. It is one of the ways that the College fulfills one element of its mission, namely to “Aid the development of Florida’s and the nation’s high technology industries.” Companies in the Photonics Incubator have ready access to the CREOL faculty, graduate students, laboratory facilities and other excellent UCF resources including the staff of the Office of Research and Commercialization and the Venture Lab. The following is a list of 2014 clients:

LC Matter Corp. (Sebastian Gauza, www.lcmatter.com) offers custom design and manufacturing of liquid crystal materials and its polymeric composites. Applications include military electronically driven laser devices, optical telecommunication and entertainment systems.

Plasmonics, Inc. (David Shelton, www.plasmonics-inc.com) is developing tunable infrared metamaterials which are engineered composites with unique refractive-index characteristics. Metamaterials with tunable resonances have wide ranging potential for optical devices, modulators, and sensors.

sdPhotonics LLC (Dennis Deppe) is an emerging leader in the development of high power laser diode technologies that provide improved power, efficiency, brightness and reliability.

Partow Technologies, LLC, (Payam Rabiei) is developing compact high-speed lithium niobate modulators for data-center and telecommunication applications. The company technology is based on nano-waveguides made in thin film lithium nionbate on silicon substrates. The devices can fit into small form factor transceivers used in data-centers and in telecommunication coherent systems.and reliability.

Tours

TOUR A **Start times**: **2.30 pm** and **3.15 pm**

259 **Liquid crystal devices for virtual reality and augmented reality**
Shin Tson Wu
http://lcd.creol.ucf.edu

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

145/147 **Mid-IR Frequency Combs Lab**
Konstantin Vodopyanov
http://mir.creol.ucf.edu

TOUR B **Start times**: **2.30 pm** and **3.15 pm**

154 **Applications of volume Bragg gratings for advancing high-power laser systems**
Leonid Glebov
http://ppl.creol.ucf.edu/

A119 **Microstructured Fibers and Devices**
Rodrigo Amezcua Correa
http://mof.creol.ucf.edu

258 **Glass Processing and Characterization Lab - IR Metrology**
Kathleen Richardson
http://gpcl.creol.ucf.edu

201 **Fiber Optics Lab**
Axel Schulzgen
http://fol.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

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Lasersec Systems Corp.
Newport Corporation
Northrop Grumman Laser
Optical Research Associates
Paul G. Suchoski, Jr

Senior Members

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Amplitude
Coherent, Inc.
CST of America
DataRay Inc.
Edmund Optics
LAS-CAD GmbH
Lockheed Martin
Open Photonics
Ophir-Spiricon
Optimax Systems
Radiant Zemax, LLC
Tektronix
TRUMPF, Inc.
V & N
Zygo Corporation

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ALIO Industries
Analog Modules
Asphericon
eVision, LLC
Fiberguide Industries Inc.
FLIR Systems, Inc.
Gentec-EO, Inc.
Gooch & Housego, LLC.
Harris Corporation
HORIBA Jobin Yvon
IRadiance Glass, Inc.
JENOPTIK Optical Systems Inc.
Laser Institute of America
Lee Laser
Ocean Optics
Optigrate Corp.
OSA IDA
Photonics Media
Photonics Spectra
Plasma-Therm
Plasmonics
Princeton Instruments
Sciperio, Inc.
SPIE- The Int'l Society for Optics & Photonics
StellarNet, Inc.
SYNFuels Americas
The Optical Society
Thorlabs
Tower Optical Corporation
TwinStar Optics, Coatings & Crystals
ULVAC Tech. Inc.
Yokogawa Corporation of America
Zomega Terahertz Corp.

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.

Faculty

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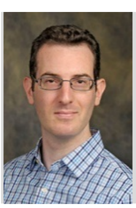

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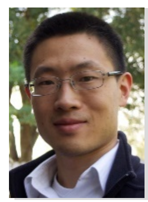

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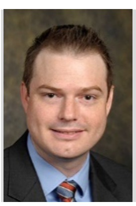

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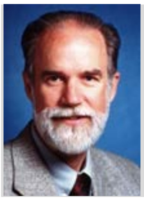

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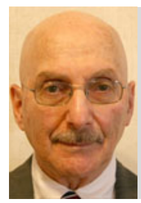

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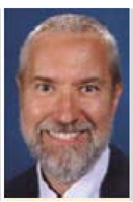

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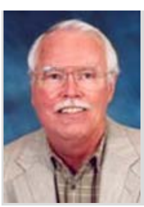

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In Memoriam: George I. Stegeman, 1942-2015

George Stegeman, Emeritus Professor of Optics and Photonics, passed away suddenly on May 2, 2015, at the age of 72. He joined the UCF faculty in 1990 and was the first recipient of the Cobb Family Chair in Optical Sciences and Engineering at UCF. The principal interest of Dr. Stegeman's research was the experimental study of nonlinear optics in waveguide structures, especially the properties of spatial solitons in various regions of the electromagnetic spectrum.

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