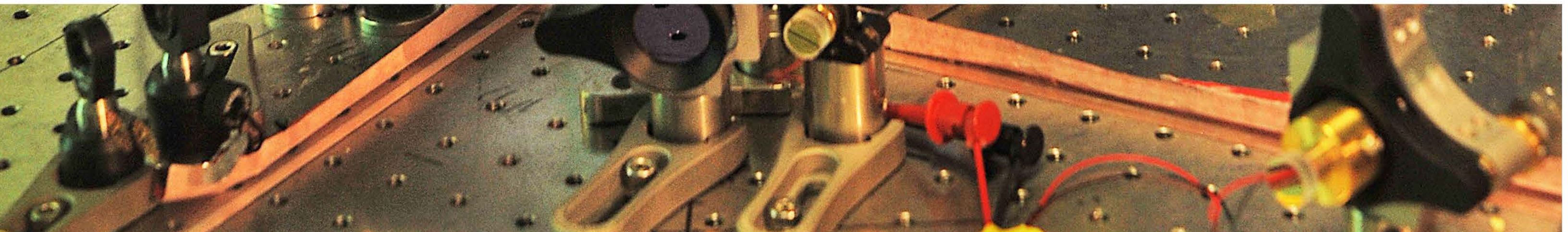
Symposium and Industrial Affiliates Program 2019

UCF

CREOL, The College of Optics and Photonics



Advances in Optics & Photonics
Industrial Affiliates Symposium
14-15 March 2019

CREOL 102 & Harris Engineering 125 ***Thursday, March 14***

Short Courses 9:00AM–12:15PM

9:00-10:30AM, CREOL Building, Room 102
Computational Optical Imaging
Instructor: Shuo "Sean" Pang
Computational imaging is the process of image forming from indirect measurements that does not resemble the image of interest. In optical imaging, in contrast to traditional lens-based imaging, computational imaging systems requires the integration of the sensing system and the computation requires algorithms to reconstruct the image. The ubiquitous availability of fast computing platforms (such as multi-core CPUs and GPUs) and the advances in algorithms open the opportunity for redesigning the imaging systems with enhanced performance in acquisition time, dynamic range, image resolution, etc.. In this Short Course, we will introduce the principles of computational imaging and its application in optical imaging systems.

9:00-10:30AM, Harris Engineering, Room 125
Fundamentals of Ultrafast Photonics -Techniques and Applications in Optical Communication and Signal Processing
Instructor: Peter Delfyett
The development of high-speed communication, interconnects, and signal processing are critical for an information based economy. This short course will cover basic concepts in the generation of ultrafast optical signals, and in developing approaches for modulating, transmitting and detecting these signals. We then show how these technologies can be applied in several optical communication and signal processing applications.

10:45AM-12:15PM CREOL Building, Room 102
Emerging Augmented Reality and Virtual Reality Displays
Instructor: Shin-Tson Wu
Virtual reality (VR), augmented reality (AR) and mixed reality (MR) displays are growing rapidly with numerous applications, such as entertainment, education, tourism, medicine, and simulation training. Display panel and imaging optics play critical roles on the ergonomics and optical performance of these head mounted (or glass-type) display systems. Some technical challenges including resolution density, field of view, motion picture response time, high dynamic range, compactness and lightweight, latency, focus cue mismatch, and occlusion capability remain to be improved. Presently, three technologies are competing for near-eye displays; they are organic light-emitting diode (OLED) display, liquid crystal display (LCD; both transmissive and reflective modes), and micro-LED display. In this short course, I will introduce the optical system including field-of-view and foveated imaging, analyze the pros and cons of each display technology, review the latest progress, and discuss the future development directions.

10:45AM-12:15PM Harris Engineering, Room 125
Mechanical Action of Light and Applications
Instructor: Aristide Dogariu
The idea that light can affect the position of small objects goes back hundreds of years and has its origin in the corpuscular theory of light. Controlling the transfer of momentum from light to matter has led to unique possibilities to cool and trap atoms or to manipulate small objects such as microparticles, cells, molecular motors, etc. For instance, tiny forces in live biological entities are now commonly measured with "laser tweezers". We will review the basic concepts behind the mechanical action of light and we will survey applications where harnessing light at scales comparable with the wavelength offers distinctive capabilities for sensing, guiding, and controlling material systems.

Student Talks 1:30-2:30PM (Harris Engineering, Room 125)

1:30	Optical Monitoring of Blood Coagulability during Cardiovascular Surgery via Coherence-Gated DLS	Student of the Year- Jose Rafael Guzman-Sepulveda
	Large Optical Nonlinearities in Transparent Conductive Oxides at Epsilon-Near-Zero	Sepehr A. Benis
	Performance Comparison of Millimeter Wave Imager Configurations	Nafiseh Mohammadian
	Attosecond Streaking Phase Retrieval with Deep Neural Network	Jonathon White

Poster Session, Reception, Lab Tours & Exhibits 2:30PM-4:30PM (CREOL lobby and balcony)

2:30	Student Poster Session & Lab Tours	CREOL lobby & balcony Tours start from CREOL lobby
4:30	Tribute to Boris Zeldovich	Nelson Tabiryan (HEC 125)

Cape Florida Ballroom, UCF Student Union **_Friday, March 15_**

8:30 Continental Breakfast and Walk-in Registrations

9:00	Welcome and overview of CREOL	Bahaa Saleh	Dean & Director, CREOL, UCF

Technical Symposium

Session I

9:45	Optical Challenges in LIGO: Past and Future	Stan Whitcomb	California Institute of Technology)
10:15	Parity-Time and other Symmetries in Optics	Demetrios Christodoulides	CREOL, UCF

10:35 BREAK & EXHIBITS

Session II

10:55	Optics Research within the Naval Research Enterprise	Craig A. Hoffman	Naval Research Lab
11:25	Ultrafast Nonlinear Optics: New Tricks from Old Materials	David Hagan	CREOL, UCF

Product Review

11:45	OptiGrate Corp.	Alexei Glebov	
11:53	Q-Peak, Inc.	Eric Park	
12:01	Andor Technologies	Jeffrey Oleske	

12:10 **LUNCH Served**

1:25	SPIE	Kent Rochford	CEO

Session III

1:45	Laser Structuring of Fibers and Films	Ursula Gibson	Norwegian University of Science and Technology
2:15	Topological Photonics	Miguel Bandres	CREOL, UCF

2:35 BREAK & EXHIBITS

Session IV

2:55	Engineered Materials for Next Generation EO/IR Sensors	Clara Rivero Baleine	Lockheed Martin
3:25	Controlling Light with Spatially-Variant Photonic Crystals	Stephen Kuebler	CREOL, UCF

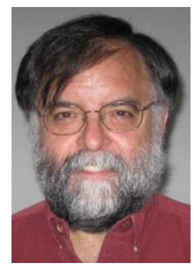
Award Presentations

3:45	Distinguished Alumni Award	Clara Rivero Baleine	Lockheed Martin
4:00-5:00	Reception		

Optical Challenges in LIGO: Past and Future

Stan Whitcomb
California Institute of Technology

Abstract: The Laser Interferometer Gravitational-wave Observatory's (LIGO) detection of gravitational waves, a century old prediction by Einstein, was widely hailed as both a confirmation of his General Theory of Relativity and the opening of a new window into astrophysics. Much less attention has been given to the experimental challenges of making a measurement with a sensitivity better than 10e-18 meters, one one-thousandth of the diameter of a proton. This required the development of optics and optical techniques of unprecedented precision. Next generation detectors, aiming at a factor of 10 better sensitivity, will challenge optical scientists in new ways. This talk will both look back at what has been accomplished, and forward at some of the obstacles ahead.



Stan Whitcomb was most recently the Chief Scientist of the Laser Interferometer Gravitational-wave Observatory (LIGO) Laboratory. The LIGO Lab is operated by Caltech and MIT through funding from the National Science Foundation. It comprises observatories in Livingston, Louisiana and Hanford, Washington, in addition to the groups at Caltech and MIT. The broader LIGO Scientific Collaboration currently includes approximately 1000 scientists, engineers and students from more than 60 institutions in 12 countries. After thirty-five years of development and construction, LIGO detected its first gravitational wave in late 2015, from the inspiral and merger of a pair of black holes. With its partner the Virgo Project, LIGO forms the core of a growing international network of gravitational wave detectors, seeking to learn about the universe through a new type of signal.

Stan received his undergraduate education at Caltech (BS 1973). He had one year of graduate study at Cambridge University before completing his Ph. D at the University of Chicago in far-infrared and submillimeter astronomy in 1980. He returned to Caltech in 1980 as an assistant professor of physics, near the beginning of Caltech's entry into the field of gravitational wave detection. Over the years since then, he has been involved in nearly every phase of the effort to build LIGO—concept development, prototype sensitivity demonstration, detector design and installation, commissioning, data analysis, and management. He is a Fellow of the American Physical Society and of the Optical Society. He was awarded the Henry Draper Medal (National Academy of Sciences) in 2017, the C.E.K. Mees Medal (OSA) in 2018, and the Isaacson Award in Gravitational Wave Science (APS) in 2019.

Demetrios Christodoulides
CREOL, The College of Optics & Photonics

Abstract: The prospect of judiciously utilizing both optical gain and loss has been recently suggested as a means to control the flow of light. This proposition makes use of some newly developed concepts based on non-Hermiticity and parity-time (PT) symmetry-ideas first conceived within quantum field theories. By harnessing such notions, recent works indicate that novel synthetic structures and devices with counter-intuitive properties can be realized, potentially enabling new possibilities in the field of optics and integrated photonics. Non-Hermitian degeneracies, also known as exceptional points (EPs), have also emerged as a new paradigm for engineering the response of optical systems. In this talk, we provide an overview of recent developments in this newly emerging field. The use of other type symmetries in photonics will be also discussed.

Demetrios Christodoulides is the Cobb Family Endowed Chair and Pegasus Professor of Optics at CREOL-the College of Optics and Photonics of the University of Central Florida. He received his Ph.D. degree from Johns Hopkins University in 1986 and he subsequently joined Bellcore as a post-doctoral fellow. Between 1988 and 2002 he was with the faculty of the Department of Electrical Engineering at Lehigh University. His research interests include linear and nonlinear optical beam interactions, synthetic optical materials, optical solitons, and quantum electronics. He has authored and co-authored more than 350 papers. He is a Fellow of the Optical Society of America and the American Physical Society. He is the recipient of the 2011 Wood Prize and 2018 Max Born Award of OSA.

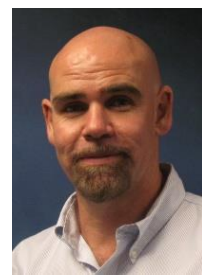
Craig A. Hoffman
Office of Naval Research

Abstract: The Naval Research Enterprise (with key organizations of NRL and ONR) performs significant research in the area of Optics and Optical Sciences. The activities span from basic research to applied research to prototypes and demonstrations. The accomplishments of these activities provide the Navy and other DoD organizations with technologies that are not available in the private sector and allows the Navy and DoD an edge in system development and fielding of significant capabilities. Some of these efforts are presented as well as a discussion of current challenges and new opportunities.

Craig Hoffman has served as Superintendent for the Optical Sciences Division of the U. S. Naval Research Laboratory since October 2014. He manages approximately 200 government and on-site contractor scientists and engineers engaged in a wide variety of optics related research including visible and infrared sensors; semiconductor, solid state, and fiber lasers; fiber optic sensing; radio frequency photonics; free space laser communications; novel infrared materials; image processing; and infrared countermeasures. In October 2018, he also assumed the position of Chief Scientist of the Office of Naval Research (ONR). In this capacity, he exercises oversight and guidance of ONR's entire basic and early applied research portfolio.
Dr. Hoffman came to NRL in 1979 as a National Research Council Post Doctoral Fellow after receiving a B.S. Degree in Physics from Purdue University in 1973, and M.S. and Ph.D. Degrees in Physics from Brown University in 1975 and 1979, respectively. He joined the NRL scientific staff as a research physicist in 1981. His research focused on the opto-electronic and transport properties of narrow gap semiconductors with notable work on HgCdTe alloys and HgTe/CdTe superlattices. He also did pioneering work concerning the susceptibility of infrared detectors and infrared focal plane arrays to laser radiation. He has authored/co-authored close to 150 articles in archival scientific journals and over 50 papers in the classified literature. He co-edited the five-volume 2nd Edition of the Encyclopedia of Optical Engineering. He is a fellow of the Optical Society of America and the Military Sensing Symposia and a member of IEEE, SPIE, Sigma Xi and Phi Beta Kappa and serves on a variety of DoD scientific and technical panels.

David Hagan
CREOL, The College of Optics & Photonics

Abstract: Nonlinear refraction is a phenomenon that occurs when lasers are intense enough to change the refractive index of the materials in which they propagate. Typically these changes are ultrafast, but extremely small. An index change of 10^{-4} is usually considered large. However our recent studies have revealed ultrafast, ultra-large nonlinear index changes. For example, in highly doped semiconductors such as Indium Tin Oxide (ITO) at wavelengths where the real part of the permittivity passes through zero, so-called "epsilon-near-zero" (ENZ) materials, we observe index changes larger than unity. Coincidentally, our studies of direct-gap semiconductors have revealed extremely large nonlinear refraction if we use two lasers of very different wavelength. We will describe our studies and speculate how these large nonlinearities may be used to our advantage.



David Hagan received his PhD degree in Physics at Heriot-Watt University, Edinburgh, Scotland in 1985, where he worked on Mid-Infrared Optical Phase Conjugation and Optical Bistability in Semiconductors. He spent two years as a postdoctoral Research Scientist and the University of North Texas, worklng on applications of semiconductor nonlinear optics, including optical power limiting. In1 987, he became a founding member of the faculty in CREOL (Center for Research and Education in Optics and Lasers) at the Univ. of Central Florida. He is now a Professor of Optics and Photonics and Associate Dean for Academic Programs of the College of Optics and Photonics. He was the founding Editor-in-Chief of the journal, Optical Materials Express, and is currently Executive Editor-in-Chief of Chinese Optics Letters. He has published more than 150 refereed journal papers over 12,000 citations and has an ISI h-index of 48. He is listed as an ISI "Highly-cited researcher". His current research interests include techniques for nonlinear optical materials characterization, cascaded second-order nonlinear optics, methods for enhancement of optical nonlinearities, and applications of two-photon processes in semiconductors.

Optigrate Corp., Alexei Glebov
Optigrate — from CREOL research to world markets

Q-Peak, Inc., Eric Park
Laser innovation since 1985

Andor Technology, Jeffrey Oleske
Focus on Results

Kent Rochford
CEO, SPIE

SPIE, the international society for optics and photonics serves more than 264,000 constituents from approximately 166 countries, the not-for-profit society advances emerging technologies through interdisciplinary information exchange, continuing education, publications, and career and professional growth. SPIE holds over 20 conferences worldwide each year, publishes 10 peer-review journals, and provides a digital library with a half a million papers. In 2018 SPIE provided over $4 million in community support including scholarships and awards, outreach and advocacy programs, travel grants, public policy, and educational resources.

Kent Rochford is the CEO of SPIE, the international society for optics and photonics (Bellingham, WA). Serving more than 264,000 constituents from approximately 166 countries, the not-for-profit society advances emerging technologies through interdisciplinary information exchange, continuing education, publications, and career and professional growth.

Previously, Rochford was the Associate Director for Laboratory Programs at the National Institute of Standards and Technology (NIST), providing direction and operational guidance for NIST's scientific and technical laboratory programs with 2,800 staff and an $800 million budget. He served as Acting NIST Director in 2017. He previously headed up NIST-Boulder Labs and the Communication Technology Laboratory (CTL) in Colorado, and served as chief of both the Quantum Electronics and Photonics and Optoelectronics Divisions at NIST, as well as acting director of the Electronics and Electrical Engineering Laboratory. Outside of NIST held management roles in an optical-communications start-up and a multinational corporations R&D lab.

Rochford holds a PhD in optical sciences from the University of Arizona, a BS in electrical engineering from Arizona State University, and an MBA from the University of Colorado.

Laser structuring of fibers and films

Ursula Gibson
Norwegian University of Science and Technology

Abstract: Recent progress in crystallization of semiconductor-core optical fibers has benefited tremendously from the large thermal gradients that can be established with scanned cw lasers. Not only can the optical losses be reduced by removal/reduction of grain boundaries, but the composition can be locally altered, based on the bulk phase diagram. Studies of simple systems have moved our understanding forward, and suggested ties to other technologies. In this talk, I will present some recent results on fibers, and compare them to scanned laser annealing of silicon films for solar cells, as well as examine possible future cross-fertilization of these presently separate areas.

Ursula Gibson received a Ph.D. in physics from Cornell University in 1982. After Cornell, she was an assistant, then associate professor at the University of Arizona Optical Sciences Center, before moving to the Thayer School of Engineering at Dartmouth College in 1990. She currently holds a professorship in the Physics department at the Norwegian University of Science and Technology (NTNU), where she has been since 2010. She is an adjunct professor in the Department of Applied Physics at the KTH Royal Institute of Technology and the Chemistry Department of Dartmouth College, and presently serves as the President of the Optical Society, OSA.

Her research on optical materials has been wide ranging, including polymers, protein crystals and semiconductors, with an emphasis on limited dimension structures such as thin films and waveguides. She holds three patents and has authored 7 book contributions and over 100 refereed journal articles. Prof. Gibson's recent research is focused on semiconductor-core optical fibers and MBE-grown films for mid-infrared applications.

Miguel A. Bandres
CREOL, The College of Optics & Photonics

Abstract: Inspired by topological insulators in condensed matter, topological photonics is a rapidly-emerging research field in which the topology of the system is exploited to control the behavior of light. This remarkable new phenomenon allows robust unidirectional propagation of light in such a way that defects, strain, or disorder have little effect on optical transport. Topological photonics not only holds great promise for robust photonic devices but also thanks to the flexibility of photonic systems it opens new ways to realize and explore topological physics. So far, most of these activities were carried out in entirely passive, linear, and conservative settings. However, recently, the idea of introducing nonlinearity and non-Hermiticity to topological systems has raised many challenges and fundamental questions.

In this talk, I will present how we propose and experimentally demonstrate a fundamentally new approach in exploiting topological effects in a unique way: the topological insulator laser – a laser whose lasing mode is topologically protected. In contrast to Hermitian topological systems, the design of such a laser is highly non-standard – a laser is an open, non-Hermitian (due to gain/loss) and nonlinear (due to gain saturation) system. I will show how the underlying topological properties lead to an efficient laser, robust to defects and disorder, with single mode lasing even at very high gain. The proposed concept not only opens exciting possibilities in topological physics but also paves the way towards active photonic topological devices with unique properties and functionalities.

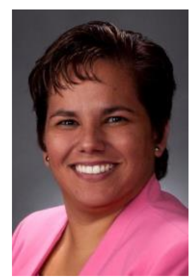
Miguel A. Bandres is an Assistant Professor at CREOL, the College of Optics and Photonics. He received his B.S. degree from the Tecnologico de Monterrey, Mexico, and his Ph.D. degree from the California Institute of Technology (Caltech) both in Physics. He was a Postdoctoral Research Fellow at the Technion – Israel Institute of Technology – in Prof. Moti Segev's group. He is the recipient of the Marie Curie Fellowship, the SPIE John Kiel Scholarship, the SPIE Laser Technology Scholarship, and the Premio Nacional de la Juventud, which is the highest public recognition awarded by the Mexican government to outstanding young professionals.

His research focuses on finding and observing new fundamental phenomena that allow us to control light in nontrivial ways, such as photonic topological insulators, artificial gauge fields in optics, and non-Hermitian photonics; and studying how these phenomena can be applied to improve or realize new photonic systems such lasers, waveguides and imaging systems.

His accomplishments include, among others, the introduction and generation of new nondiffractive and accelerating beams, and the prediction and observation of the third family of modes of stable laser resonator – the Ince Gaussian beams. His most recent accomplishment is the prediction and experimental observation of the first non-magnetic topological insulator laser.

Clara Rivero Baleine
Lockheed Martin

Abstract: The number of broadband infrared (IR) materials that are commercially available is very limited. This in turn limits the design of current Electro-Optical / Infrared (EO/IR) sensors; making them bulky and expensive to manufacture. However, next generation EO/IR sensors, will require more compact, lighter and cost-effective systems for applications where size, weight, power and cost (SWaP-C) becomes a limitation. Due to this fact, the design of next gen EO/IR sensors will require novel multi-functional materials, with tailorable optical properties that can be engineered to serve complex optical functions.
In this talk we highlight the development of broadband IR materials including chalcogenide glass-ceramics and chalcogenide phase change materials with tailorable optical properties. The local refractive index of the material is modified by controlling the local concentration of nanocrystals in the glass matrix using a laser; thus, facilitating the fabrication of complex gradient index (GRIN) components. Consequently, we exploit this additional degree of freedom, not available in traditional IR materials, to develop more compact optical designs to enable next generation EO/IR sensors for SWaP-C limited applications.



Clara Rivero Baleine is a Research Scientist Senior Staff and a member of the Group Technical Staff at Lockheed Martin Missiles and Fire Control (LMMFC) in Orlando, Florida. She has been working in the Applied Research R&D Sensors Systems and Technologies group since joining Lockheed Martin Corporation in 2005. Her research work is focused on advanced material development for optical and photonic applications. Her awards and recognitions include: recipient of the 2007 & 2016 Individual Excellence Award (LMMFC), 2009 National Women of Color Technology Star, 2009 & 2012 Lockheed Martin Innovate the Future Contest team finalist, 2016 Technical Innovation Award (LMMFC), and 2016 NOVA Award for Technical Innovation (LMC).

Controlling Light with Spatially-Variant Photonic Crystals

Stephen Kuebler
CREOL, The College of Optics & Photonics

Abstract: Spatially-variant photonic crystals (SVPCs) are a new class of micro-optical devices that could be useful for integrated photonics, sensors, and new forms of imaging. SVPCs are three-dimensional (3D) lattices comprised of simple repeat units, or unit cells, that are spatially varied throughout the structure in a controlled way. The unit cells used for SVPCs are those which exhibit "self-collimation," an intriguing optical effect observed for some optical lattices in which light propagates without divergence and only in certain directions. By building an SVPC with self-collimating unit cells, and then spatially varying their orientation throughout the lattice, a path can be engineered along which light is forced to flow. SVPCs have been fabricated using an emerging method for nano-scale, laser-based 3D printing called multi-photon lithography (MPL). Optical experiments performed on SVPCs fabricated by MPL show that the devices can steer light through exceptionally sharp bends, with a turn-radius as small as 7◎0, where ◎0 is the wavelength of the light in vacuum. This kind of abrupt control of light, using a non-absorbing material, and in 3D is unprecedented and opens entire new possibilities for exploiting the potential of light. A wide range of SVPC-based devices can be envisioned for optical interconnects, and potentially new forms of imaging, that overcome limitations of waveguides, and more exotic devices based on plasmonics and meta-materials.

Stephen M. Kuebler earned a BS in chemistry and BA in German from Tulane University. He was awarded a Marshall Scholarship and an NSF Graduate Fellowship to pursue graduate research in chemistry at the University of Oxford. There he earned the D. Phil. degree for his studies of the third-order nonlinear optical properties of molecular materials. He then completed postdoctoral research at Caltech and the University of Arizona investigating the photophysics, photochemistry, and applications of two-photon absorbers. Kuebler joined the faculty at the University of Central Florida in August 2003 as an Assistant Professor through a joint appointment with the Department of Chemistry and CREOL, The College of Optics and Photonics. In 2008 he was awarded an NSF CAREER Award and promoted to Associate Professor. His broader interests include the physical and chemical properties of optical and electronic materials and their development for new technologies. His research has been supported by NSF, DARPA, the Petroleum Research Fund, and several companies. Recently he launched a project that is exploring how to teach and cultivate cultures of ethical behavior in science and engineering. Kuebler is a Senior Member of SPIE and OSA, and he serves as Associate Editor for the Journal of Microlithography, MEMS, and MOEMS.

Nelson Tabiryan
Beam Engineering for Advanced Measurements Co.

Abstract: Boris Yakovlevich Zeldovich, a professor of Optics & Photonics, and Physics at CREOL/UCF, an OSA Fellow and winner of the OSA's Max Born Award, a corresponding member of the Russian Academy of Sciences, and co-founder of BEAM Engineering for Advanced Measurements Co., passed away on December 16, 2018 at his home in Cambridge, MA. His legacy will live on through his ground-breaking research, his seminal contributions to modern optics, and his many diverse achievements in fundamental and applied optics. Boris Zeldovich was not only a one-of-a-kind scientist, but also a one-of-a-kind teacher, friend, and parent. This tribute is a humble attempt to reflect upon his incredible work and life.

Nelson Tabiryan is the CEO of Beam Engineering for Advanced Measurements Corporation. He received a Ph.D. degree in Physics and Mathematics from the Institute of Physical Investigations of the Armenian Academy of Sciences, Yerevan (1982), and D. Sc. Degree from the Highest Qualifying Commission of the USSR (1986). OSA Fellow (since 1999), NIAC (NASA) Fellow, Alexander Von Humboldt Research Scholar. Recipient of the Frederiks Medal (2017). American Chemical Society's Cooperative Research Award (2013). Chairman of the International Meetings on Photoalignment and Soft Matter (PhoSM-2020); Chairman of Optics of Liquid Crystals (OLC) advisory board (2007-2011); Chairman and co-chairman of OLC-2005, OLC-2007, SPIE's Display Sciences (1996). Program Committee member, keynote, plenary and invited speaker in numerous conferences. Over 250 refereed publications and 40 issued and pending patents. Principal investigator of many advanced research programs. Pioneered technology development of the Fourth Generation Optics. Demonstrated the first large area active planar optics.

Nelson Tabiryan was a Ph.D. Student of Professor Boris Ya. Zeldovich (Moscow, 1978-1981)

Nelson Tabiryan and Boris Zeldovich

2019 Distinguished Alumni Award

Clara Rivero Baleine

Clara Rivero Baleine is a Research Scientist Senior Staff and a member of the Group Technical Staff at Lockheed Martin Missiles and Fire Control (LMMFC) in Orlando, Florida. She has been working in the Applied Research R&D Sensors Systems and Technologies group since joining Lockheed Martin Corporation in 2005. Her research work is focused on advanced material development for optical and photonic applications. Her awards and recognitions include: recipient of the 2007 & 2016 Individual Excellence Award (LMMFC), 2009 National Women of Color Technology Star, 2009 & 2012 Lockheed Martin Innovate the Future Contest team finalist, 2016 Technical Innovation Award (LMMFC), and 2016 NOVA Award for Technical Innovation (LMC).

Exhibitors

Andor Technology
300 Baker Ave.
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www.andor.com

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www.tek.com

Newport Corp.
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877-835-9620
www.newport.com

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Longwood, FL 32750
407-339-4355
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AFL Global
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Duncan, SC 29334
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Coherent/Nufern
7 Airport Park Road
East Grandby, CT 06026
860-408-5000
www.nufern.com

IMEC Florida
190 NeoCity Way
Kissimmee, FL 34744
407 742 4280
www.imec-int.com

OptiGrate Corp (an IPG Photonics Co.)
562 S Econ Circle
Oviedo, Fl 32765
407-542-7704
www.optigrate.com

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

Elbit Systems of America
12600 Challenger Pkwy
Orlando, FL 32826
www.elbitsystems-us.com

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

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

Thorlabs Inc.
56 Sparta Avenue
Newton, NJ 07860
973-300-3000
www.thorlabs.com

Zemax, LLC
10230 NE Points Drive
Kirkland, Washington 98033
425-305-2800
www.zemax.com

NKT Photonics Inc.
3514 N Vancouver Avenue
Portland, OR 97227
503-444-8404
www.nktphotonics.com

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

IEEE Photonics Society
3 Park Ave, 17th Floor
New York, NY 10016
212-419-7900
www.ieee.org

ASML
77 Danbury Road
Wilton, CT 06897
203-761-4000
www.asml.com

Gentec Electro-Optics
445 St-Jean-Baptiste Quebec,
QC, Canada G2E 5N7
418-580-4456
www.gentec-eo.com

SOCIETY FOR INFORMATION DISPLAY
Society For Information Display
1475 South Bascom Ave. #114
Campbell, CA 95008
408-879-3901
www.sid.org

Finetech
915 Holt Ave
Manchester, NH 03109
603-627-8989
www.finetechusa.com

Student of the Year Presentation

Optical Monitoring of Blood Coagulability during Cardiovascular Surgery via Coherence-Gated DLS

Jose Rafael Guzman-Sepulveda

Light scattering-based approaches have proved robust for monitoring the structural dynamics of complex media thanks to their capability to retrieve collective dynamic information through the intensity fluctuations of the light scattered. In my talk I will address the specific features of fiber-based implementations of optical sensing techniques based on spatio-temporal coherence-gated dynamic light scattering (DLS). This sensing approach has a number of unique capabilities such as an effective isolation of single scattering, a large sensitivity and high collection efficiency, and it can also operate over a wide range of optical regimes while providing means for proper ensemble averaging. I will present the application of this sensing technique in a scenario that falls beyond the capabilities of traditional light scattering-based techniques: the real-time monitoring of blood coagulability during cardiovascular surgeries.

Rafael Guzman is currently a PhD student in Dr. Dogariu's research group. He received his B.Sc. from the University of Guanajuato, Mexico in 2010, and his M.Sc. from the University of Tamaulipas, Mexico in 2013. He also received a M.Sc. from the University of Central Florida in 2016. His research focuses on the development of fiber-based implementations of optical sensing techniques based on spatio-temporal coherence-gated DLS, for the measurement of the structural and micro-rheological properties of dynamic complex media. His work relies on the interdepartmental cooperation at UCF, industry collaborations with Malvern, partnership with Arnold Palmer Hospital for Children, as well as collaborations with Mexican educational institutions in projects funded by CONACyT. Scientific achievements in his multidisciplinary research (optics, materials science, and biomedical) include one book chapter, over 25 peer-reviewed journal publications, some of which have been published in the top journals of the different areas such as Nature Biomedical Engineering, over 30 conference proceedings, and over 150 citations, in different areas including digital processing of medical images, fiber optics devices and sensors, and optical sensing of dynamics in colloids, non-ergodic media, and biological fluids.

Student Presentations

Large Optical Nonlinearities in Transparent Conductive Oxides at Epsilon-Near-Zero

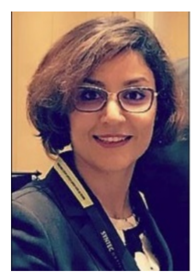
Sepehr A. Benis

In recent years, near-zero refractive index photonics, also known as epsilon-near-zero (ENZ), have emerged as a new paradigm to obtain large optical nonlinearities. Among many possible configurations, transparent conductive oxides are of particular interest since they naturally exhibit ENZ conditions in the near-infrared. In this spectral region, light-matter interactions enhance significantly, which gives rise to unprecedented large nonlinear refraction. This enhancement enables near unity ultrafast changes in the refractive index, which also significantly alters Fresnel coefficients. In this talk, I will present nonlinear optical measurements via two different techniques, Z-scan and Beam Deflection, to characterize the nonlinear refraction and absorption of an Indium Tin Oxide thin film. These nonlinearities are due to redistribution of carriers, and they are enhanced at oblique incidence where there is a stronger coupling to the longitudinal plasmons. I will also discuss the challenges and complications of experiments in the presence of extremely large nonlinearities.

Sepehr Benis is currently a Ph.D. student in Dr. David J. Hagan and Dr. Eric W. Van Stryland's Nonlinear Optics group. He received his B.Sc. degree in Electrical Engineering from the University of Tehran, Iran, in 2014 and his M.Sc. degree in Optics from CREOL, the University of Central Florida in 2016. His research mainly focuses on characterization of optical nonlinearities in solid state and liquid materials. He has authored and co-authored 6 journal publications and proceedings and presented his work in prominent conferences.

Performance Comparison of Millimeter Wave Imager Configurations

Nafiseh Mohammadian



Millimeter wave imaging systems are a promising candidate for many interesting applications, from indoor security to non-destructive industrial and medical applications. Imec is developing radar chips for automotive applications. We explore ways to configure multiple automotive radar emitters and receivers for imaging applications. High resolution real-time imaging requires a large number of measurements. This in turn requires the use of a large number of emitters and receivers where the cost and size become major considerations. We work on the development and performance comparison of antenna array architectures that provide an efficient hardware approach for high resolution imaging. We consider mono-static single-in-single-out (SISO) architectures, multi-static configurations with multiple-in-multiple-out (MIMO) architectures, and a hybrid MIMO – SISO compromise architecture. The reconstructed image quality from each architecture is compared and traded for the system engineering complexity and cost. We present simulations of the aperture radar systems under consideration and representative measurements from a synthetic aperture system based on an automotive Radar sensor.

Nafiseh Mohammadian is currently a PhD student of Optics in Prof. Ronald Driggers' research group. She received her BS degree in Physics from University of Isfahan in 2008 and MS in Optics and Photonics from University of Central Florida in 2018. Her research mainly focuses on mm Wave Imaging Systems which is funded by IMEC-USA Company.

Attosecond Streaking Phase Retrieval with Deep Neural Network

Jonathon White

A new method for retrieving the spectral phase of isolated attosecond X-ray pulses from streaking traces is explored. The deep neural network method shows the potential for nearly instantaneous attosecond streaking phase retrieval, without use of the central momentum approximation. A neural network is trained with computer generated data that contain statistical noise and shown to correctly retrieve the phase of both computer generated and experimental attosecond streaking traces.

Jonathon White is a visiting MSc student from Abbe School of Photonics(Jena), who is currently conducting research supervised By Prof. Zenghu Chang at the Institute for the Frontier of Attosecond Science and Technology (iFAST).

Lab Tours

Guided tours of select CREOL laboratories will start at **2:30 pm** and at **3:30 pm** in the CREOL lobby and last about 45 minutes. A few minutes before the start of the tour please locate one of the tour guides in the lobby. Tour guides are volunteer members of CREOL's student association CAOS.

TOUR A **Start times**: **2.30 pm** and **3.30 pm**

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145 **Mid-IR Frequency Combs Lab**
Konstantin Vodopyanov
mir.creol.ucf.edu

202 **Integrated Photonics**
Sasan Fathpour
ipes.creol.ucf.edu

246 **Ultrafast Laser Processing Laboratory**
Xiaoming Yu
ulp.creol.ucf.edu

TOUR B **Start times**: **2.30 pm** and **3.30 pm**

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201 **Fiber Optics Lab**
Axel Schulzgen
fol.creol.ucf.edu

259 **Virtual reality displays**
Shin - Tson Wu
lcd.creol.ucf.edu

255 **Optical Frequency Combs**
Peter Delfyett
up.creol.ucf.edu

A325 **NanoBioPhotonics**
Ryan Gelfand
nbp.creol.ucf.edu

Posters

Poster 1

Thermal Effects of Ultrafast Laser Interaction with Polypropylene

Arifur Rahaman, Xinpeng Du, Boyang Zhou, He Cheng, Aravinda Kar, Xiaoming Yu*
CREOL, The College of Optics & Photonics, UCF
**arahaman16@knights.ucf.edu*

Ultrafast lasers have been used for high precision processing of a wide range of materials including dielectrics, semiconductors, metals and polymer composites, enabling numerous applications ranging from micromachining to photonics and life sciences. To make ultrafast laser materials processing compatible with the scale and throughput needed for industrial use, it is a common practice to run the laser at a high repetition rate and hence high average power. However, heat accumulation under such processing condition will deteriorate the processing quality, especially for polymers which typically have a low melting temperature. In this paper, an analytical solution to a transient, two-dimensional thermal model is developed using Duhamel's theorem and the Hankel transform. This solution is used to understand the effect of laser parameters on ultrafast laser processing of polypropylene (PP). Laser cutting experiments are carried out on PP sheets to correlate with the theoretical calculation. This study shows that in laser cutting, the total energy absorbed in the material and the intensity are two important figures of merit to predict the cutting performance. Heat accumulation is observed at low scanning speeds and high repetition rates, leading to significant heat-affected zone and even burning of the material, which is supported by experimental data and modelling results. It is found that heat accumulation can be avoided by a proper choice of the processing condition.

Poster 2

Deep Learning Cell Imaging through Anderson Localizing Optical Fiber

Jian Zhao, Yangyang Sun, Zheyuan Zhu, Jose Enrique Antonio-Lopez, Rodrigo Amezcua Correa, Shuo Pang, Axel Schülzgen*
CREOL, The College of Optics & Photonics, UCF
**JianZHAO@knights.ucf.edu*

We demonstrate a deep-learning-based fiber imaging system which can transfer real-time artifact-free cell images through a meter-long Anderson localizing optical fiber. The cell samples are illuminated by an incoherent LED light source. A deep convolutional neural network is applied to the image reconstruction process. The network training uses data generated by a set-up with straight fiber at room temperature (~20 °C) but can be utilized directly for high fidelity reconstruction of cell images that are transported through fiber with a few degrees bend and/or fiber with segments heated up to 50 °C. In addition, cell images located several millimeters away from the bare fiber end can be transported and recovered successfully without the assistance of any distal optics. We further evidence that the trained neural network is able to reconstruct the images of cells which are never used in the training process and feature very different morphology.

Poster 3

Burmese Python Target Reflectivity Compared to Natural Florida Foliage Background Reflectivity

Milad Gholipour Vazimali[1], Orges Furxhi[2], Gonzalo Vaca[2], Ronald Driggers[1,2]*
[1]CREOL, The College of Optics and Photonics, UCF
[2]IMEC Florida, Kissimmee, FL
**vazimali@knights.ucf.edu*

The Florida Everglades is infested with Burmese Pythons caused by the release of exotic pets in the 1980s. The current estimates are between 30,000 to 300,000 pythons, where the result is a severe decline in Everglade mammals. The population of the pythons are increasing exponentially with 20 to 50 eggs per snake with a life span of up to 20 years. Pythons have been captured in the Everglades with lengths nearly 17 feet. Researchers in the State of Florida are concerned that these pythons are 1) permanently damaging the Everglades, 2) migrating further north into populated areas of Florida, and 3) endangering wildlife, pets, and eventually people. There have been a number of sensing efforts attempted in the large area detection of pythons, where limited success has been achieved. For example, infrared sensors have been applied to the problem, but the pythons are cold-blooded, so the infrared bands do not work well. Here at University of Central Florida's college of Optics and Photonics we have had the opportunity to collaborate with Imec, which has leveraged its expertise and infrastructure in semiconductor processing to produce highly compact, higher performance and relatively cheaper hyperspectral image sensors and camera systems. In this work, we teamed with the University of Florida and Extended Reality Systems to obtain hyperspectral reflectivity measurements of Burmese Pythons along with natural Florida background foliage to determine bands or band combinations that may be exploited in the large area detection of pythons. The bands investigated are the Visible-Near Infrared (or VisNIR) and the Shortwave Infrared (SWIR) bands. The results show that there are enough differences in the data collection such that a single band, inexpensive VisNIR band camera may provide reasonable results and a two-band, VisNIR/SWIR combination may provide higher performance results. In this paper, we provide the VisNIR results.

Poster 4

Brightness Enhancement of a Compact, High Energy, Passively Q-switched Nd:YAG Laser using Volume Bragg Gratings

Evan Hale, Ivan Divliansky, Leonid Glebov*
CREOL, The College of Optics & Photonics, UCF
**evan.hale@creol.ucf.edu*

For many Q-switched lasers, it is desired to maximize the pulse energy while minimize the pulse duration. Such high energy, short pulse output can be achieved by pumping with large mode diameters and maintaining a cavity length of a few centimeters. However, increasing the mode area of the resonator while keeping the same cavity length causes the excitation of higher order transverse modes and consequently decreases the brightness of the output radiation. To overcome this drawback, angular mode selection technique with transmitting Bragg grating (TBGs) was implemented inside the cavity in order to suppress the higher order transverse modes, allowing for near diffraction limited and high brightness output. Since a Bragg gratings angular selection works only in one transverse direction, two orthogonal gratings were implemented for mode selection in both transverse directions. A compact high energy passively Q-switched Nd:YAG laser is presented showing output pulses with 1 mJ of energy and 1.5 ns of duration. Due to the compact design requirements and to obtain such high energy, the resulting laser had large mode diameter and was multimode. The laser consists of a 5 mm thick slab of Nd:YAG, a 3 mm thick slab of Cr:YAG with a 65% transmission, and a 40% output coupler. Two TBGs were implemented in the cavity, orthogonal to one another, for mode selection in both transverse directions. Experimental results are presented demonstrating a 5x improvement in the beam quality of the system after implementing the TBG mode selection approach.

Poster 5

Coherent Beam Splitter for Simultaneous Generation of Multiple Vortex Beams based on Holographic Phase Mask in Photo-Thermo-Refractive Glass

Fedor Kompan*, David Guacaneme, Zachary Labossiere, Duc-Quy Nguyen, Ivan Divliansky, Leonid Glebov
CREOL, The College of Optics & Photonics, UCF
* fedor.kompan@knights.ucf.edu

Free space optical (FSO) communications systems require increased transmission capacities due to growing amount of data. Dividing data streams into individual channels by means of orbital angular momentum (OAM) multiplexing is one way to achieve increased optical bandwidth. Vortex beams with different helical modes are mutually orthogonal allowing for efficient multiplexing of channels without crosstalk. Yet successful implementation depends on the systems for generation and multiplexing of vortex beams. We present a high-power stable, simple, and robust device which combines the functions of vortex beam generator and an OAM mode multiplexer. Beams with helical phase profiles can be generated using appropriate phase masks. We demonstrated vortex phase masks produced using a digital micromirror device in photo-thermo-refractive (PTR) glass. PTR glass is a photosensitive silicate glass extensively used for recording of volume Bragg gratings (VBG) and phase masks. Owing to exceptionally low absorption of PTR glass, phase masks recorded in PTR glass are heat stable and can be used for mode conversion of high power laser beams. The phase profile of a mask can be holographically encoded into a transmitting VBG resulting in fabrication of a holographic phase mask (HPM). Multiplexing property of PTR glass allows for several HPMs to be fabricated in a single volume of glass. Multiplexed HPM splits an incident Gaussian beam into several diffraction orders where each diffraction order experiences conversion to an appropriate helical mode. This device provides easy incorporation of SDM technology in existing FSO links, and have a capacity to be used in high-power systems.

Poster 6

Clutter characterization and its effect on Infrared Search and Track (IRST) range performance model

H. Gemar[1], R. Driggers[1], G. Tener[2], C. Halford[3], T. Pace[2], D. Manville[2], D. Shelton[2], M. Theisen[4], D. Gaudiosi[4], C. Olson[4]*
[1]CREOL, The College of Optics & Photonics, UCF
[2]L3 Technologies, Inc., Image Processing Center of Excellence, Orlando, FL
[3]Department of Electrical & Computer Engineering, University of Memphis, Memphis, TN
[4]L3 Technologies, Inc. Sonoma EO, Santa Rosa, CA
**Ron.Driggers@creol.ucf.edu*

Many characteristics of a system can limit performance. However, when dealing with IRST, the background or environment in which your object of observation lies can be limiting or disruptive. This variation is known as clutter. In the following paper, we will identify regions of varying clutter for both LWIR and MWIR. Furthermore, we characterize these regions using the standard deviation of the intensity distribution and the power spectral density. We also show the effect of high-pass filtering the images prior to processing. From these characterizations we show their usefulness in the IRST model and the effect on range performance.

Poster 7

Configurations for Luminescence-based Temperature Sensing Thermal Barrier Coatings

Quentin Fouliard*[1], Sandip Haldar[1], Ranajay Ghosh[1], Seetha Raghavan[1,2]

[1]Department of Mechanical and Aerospace Engineering, College of Engineering and Computer Science, UCF
[2]CREOL, The College of Optics & Photonics, UCF
*quentin@knights.ucf.edu,

Over the past few decades, increases in both power generation and propulsive efficiency have been largely linked to the development of high-temperature Thermal Barrier Coatings (TBCs) that insulate the metallic components in turbine engine systems and that allow higher turbine inlet temperatures. However, state-of-the-art TBCs are not being used to their highest potential because of uncertainties in temperature measurements at high-temperature. Safety margins as high as 200°C are used to accommodate the significant error values, highlighting that a better monitoring of temperature would lead to greater efficiency and more accurate lifetime prediction. Towards this objective, using the temperature sensitivity of luminescence dopants, Phosphor Thermometry offers great potential to non-invasively control the temperature in the depth of the coatings and in operating conditions. This provides a direct safety indicator and limits the thermally driven mechanisms of failure. In this work, a prediction model is presented to account for absorption and scattering of luminescence in TBCs. It is constructed using a modified Kubelka-Munk theory applied to different TBC configurations with embedded phosphors. The effects of the gradient of temperature through TBCs on the luminescence signal have been modeled to provide users of Phosphor Thermometry with a more accurate location of their temperature measurement.

Poster 8

Compact Optical Imaging with Metasurfaces

*Zhao Ma**, Kyle Renshaw
CREOL, The College of Optics and Photonics, UCF
**mazhao2008@knights.ucf.edu*

Imaging systems use curved surfaces on bulky glass optics (i.e. lenses) to collect light and form images. Complex assemblies are designed to reduce aberrations and produce high-quality images. This tends to yield large, heavy and costly optical systems especially when a large field of view is required. Optical metasurfaces use subwavelength features to control phase-delay and enable fabrication of flat lenses. Metasurface lenses promise to remove the bulk of conventional lenses enabling reduction of overall size, weight and, potentially, cost. We investigate the design of high-performance lens assemblies based on combinations of metasurface lenses to correct aberrations over wide FOV in a minimal volume. A two metasurfaces system is optimized by Zemax by adjusting the coefficient of different Zernike patterns while keeping RMS spot size and volume minimum.

Poster 9

A Prototype of In-Band Full-Duplex Free-Space Optical Transceiver on UAVs

A F M Saniul Haq[1*], *Murat Yuksel*[2,1]
[1]*CREOL, The College of Optics and Photonics, UCF*
[2]*Department of Electrical and Computer Engineering, UCF*
[*] *saniul.haq@knights.ucf.edu*

Free-Space-Optical (FSO) communication has become an attractive option over Radio Frequency (RF) communication to meet the increasing demand of wireless data capacity and speed. FSO communication uses the unlicensed optical spectrum with very high data rates (up to 10 Gbps) and much broader bandwidth (up to THz range) than legacy RF networks. Due to the directionality of the transceivers and compactness of the optoelectronic components, FSO communication enables secure, mobile, and fast ad-hoc networks which can be a key component of the futuristic smart wireless communication. In-band full-duplex FSO (IBFD-FSO) transceivers ensure, in some cases enhance, these features enabling future vision of smart communication and Internet-of-Things (IoT) applications. Even though IBFD-FSO transceivers can double the network capacity theoretically, overall performance and capacity is limited by interference and optical feedback. In this work, we present a proof-of-concept prototype for an IBFD-FSO transceiver built using off-the-shelf components, implementing passive isolation technique to prevent the receiver from self-interference. To design an IBFD-FSO transceiver, two major criteria that must be satisfied are, first, simultaneous data transmission (Tx) and reception (Rx), and second, using same frequency in both forward and backward channel directions. Despite having different ports for Tx and Rx, using same frequency to transmit and receive data gives rise to self-interference or optical feedback, which is one of the major challenges of designing an IBFD transceiver. We conducted experiments using the transceiver to show the effectiveness in isolating self-signal in real test-bed, demonstrating IBFD optical wireless communication channel by successfully eliminating self-interference and optical feedback.

Poster 10

Optical Breakdown and Sub-Optical-Cycle Dynamics in Laser-Induced Damage by Ultrashort Pulses

Boyang Zhou[1], *Arifur Rahaman*[1], *Xinpeng Du*[1], *He Cheng*[1], *Yingjie Chai*[1], *Aravinda Kar*[1], *M.J. Soileau*[1,2,3], *Xiaoming Yu*[1]*
[1] *CREOL, The College of Optics and Photonics, UCF*
[2] *Department of Physics, UCF*
[3] *Department of Electrical and Computer Engineering, UCF*
**yux@creol.ucf.edu*

We report on the experimental and theoretical studies of ultrafast laser-induced optical breakdown on the surface of fused silica to elucidate the mechanism of damage formation and suboptical-cycle dynamics in material processing using single and a burst of two femtosecond laser pulses. Ionization pathways, including photo-ionization (PI) and avalanche ionization (AI), are investigated by using single-beam and double-beam laser damage threshold measurements, which are used to analyze electron dynamics and extract the avalanche coefficient. The relationship between damage size and laser fluence is interpreted as a result of a combination of

PI and AI. Electrical field rather than laser intensity is the fundamental influential factor in PI, and AI is found to play a significant role in creating the free electron density needed for optical breakdown. These findings are verified by a double-pulse delay-scan experiment where two cross-polarized pulses are used to induce damage with delay within a few optical cycles. Variation of the damage diameter is observed within one optical cycle, which is explained by the periodic change of polarization in the combined electric field. This finding shows the potential of controlling laser induced damage by tuning the temporal overlap of a burst of ultrashort laser pulses.

Poster 11

Optimization of LWIR Imagers for Target Acquisition

Robert Short*, Ronald Driggers
CREOL, The College of Optics and Photonics, UCF
*rshort@knights.ucf.edu

The best infrared targeting sensors today achieve only a fraction of the available range performance that is theoretically available. Diffraction naturally attenuates high spatial frequencies, diminishing ID range. By using high-frequency boost filtering, we can flatten a sensor's Modulation Transfer Function (MTF), lowering the observer's contrast threshold function (CTF), and improving range performance. For this to be possible, the sensor must be well-sampled, have a high overall SNR (achievable using deep electron wells), and have the capability for digital image processing. We call this overall sensor design concept Pitch-Well-Processing (PWP).

Poster 12

Initial High-Intensity Laser Propagation Experiments at the Mobile Ultrafast High-Energy Laser Facility (MU-HELF)

Daniel Thul[*,1], Robert Bernath[1], Nathan Bodnar[1], Haley Kerrigan[1], Danielle Reyes[2], Jessica Peña[1], Patrick Romayah[1], Shermineh Rostami Fairchild[1,3], Martin C. Richardson[1,2,3]
[1]Laser Plasma Laboratory, CREOL, The College of Optics and Photonics, UCF
[2]Department of Physics, UCF
[3]Department of Physics and Space Sciences, FIT, Melbourne, FL
*thuldj@knights.ucf.edu

The Mobile Ultrafast High-Energy Laser Facility (MU-HELF) has been recently activated on a 1 km test range at the Townes Institute Science and Technology Experimentation Facility (TISTEF). The MU-HELF produces ultrashort pulses at 800 nm with peak powers as high as 5 TW and is well-suited for studies of nonlinear laser propagation effects including filamentation. The pulse width, energy, size, and focusing conditions of the launched beams are all readily adjustable. Field-deployable test stations have been implemented that enable high-resolution, single-shot acquisition of the beam's profile, spectrum, and energy at any point along the range. Continuous monitoring of atmospheric conditions is performed during laser propagation using the array of measurement equipment available at TISTEF. The newly active test facilities and data collection procedures demonstrated here will drive future in-depth high-intensity laser propagation studies and development of field-deployable applications.

Poster 13

Conformal VLC Receivers with Photodetector Arrays: Design, Analysis and Prototype

Pooya Nabavi[1]*, Murat Yuksel[1,2]
[1] Electrical and Computer Engineering, UCF
[2] CREOL, The College of Optics and Photonics, UCF
* pooya.nabavi@knights.ucf.edu

To enable visible light communication (VLC) for mobile receivers, we design and prototype a wide field-of-view (FOV) optical receiver with off-the-shelf components and in forms that are conformal to the receivers' surface. The VLC system uses high-efficiency optical transmitters with high brightness (7645 Lux in 1-m) low power (36-W) white LED panels which also provide proper lighting. To overcome the detrimental effects of the time-varying inter-symbol interference (ISI) due to the VLC receiver's high acceptance angle and potential vibration in its structure during use in real settings, we design and utilize an optimal multiple-symbol detection (MSD) algorithm. The MSD attains remarkable improvements compared to the symbol-by-symbol detection but with exponential time cost. To decrease the MSD's computing demands, we then design an adaptive Decision Feedback Affine Projection Algorithm (DF-APA). DF-APA attains a notable further improvement with polynomial computation complexity which allows faster response to VLC channel dynamics. We, finally, test the system in presence of intense vibration in the receiver's body and show a 20-Mbps VLC link over 7-m distance.

Poster 14

Empirical Modeling and Analysis of Water-to-Air Optical Wireless Communication Channels

Pooya Nabavi[1]*, A. F. M. Saniul Haq[2], Murat Yuksel[1,2]
[1] Electrical and Computer Engineering, UCF
[2] CREOL, The College of Optics and Photonics, UCF
* pooya.nabavi@knights.ucf.edu

Underwater optical wireless communication (UOWC) is attracting significant attention due to global climate monitoring, military applications, and exploration to study marine biology. Optical wireless communication (OWC) can provide the benefits of higher transmission data rate and bandwidth by using unlicensed bandwidth and lightweight transceivers having low power requirements. However, OWC suffers from many limitations such as absorption, scattering, and turbulence, which become harder when the channel includes a water-to-air (W2A) interface. In this work, we focus on the modeling impulse response of a W2A-OWC channel under different turbulent water surface conditions. We empirically evaluate the statistical behavior of the channel and show fits to probabilistic distributions to understand the nature of the W2A-OWC channels.

Poster 15

A Common-Path Polarization-Based Image-Inversion Interferometer

Walker Larson[1*], *Bahaa E. A. Saleh*[1], *Nelson Tabiryan*[2]
[1] *CREOL, The College of Optics, UCF*
[2] *BEAM Co.*
[*] *walkerlarson@gmail.com*

Image inversion interferometry serves many purposes in imaging and has found much use recently in the context of spatial mode analysis. By addition and subtraction of an image with an inverted copy of itself--- the principal action of the image inversion interferometer --- it is possible to probe the spatial symmetries of the input. Nonetheless, issues inherent to interferometry using spatially separated modes have plagued previous implementations, greatly reducing their utility. Here, we present a collinear common-path image-inversion interferometer using the polarization channels of a single optical beam. Each of the polarization channels is an imaging system of unit magnification, one positive and the other negative. The interferometer realizes image formation by means of a set of anisotropic lenses, each offering refractive power in one polarization and none in the other. We experimentally demonstrate the operation of our interferometer as a spatial-parity analyzer separating even- and odd-order orbital angular momentum modes of an optical beam. The common-path configuration, which never separates the paths of either polarization mode, overcomes the stability issues present in conventional two-path interferometers.

Poster 16

Stimulated Brillouin Scattering in All-Silicon Waveguides

Marcin Malinowski[1]*, *Sasan Fathpour*[1,2]
[1]*CREOL, The College of Optics and Photonics, UCF*
[2]*Department of Electrical and Computer Engineering, UCF*
marcinmalinowski@creol.ucf.edu

Recently, there has been renewed interest to harness the stimulated Brillouin scattering (SBS) in integrated devices due to the narrow bandwidth of the SBS response that has potential applications in microwave photonics. One of potential material candidates is silicon. As a cubic material, silicon has nontrivial spectrum of elastic modes. To fully understand the complex nature of SBS we have developed a custom finite-element software that simulates the vibrational modes of integrated waveguides and their interaction with the optical field. Unlike fibers, we demonstrate that the strongest Brillouin scattering in silicon happens in the forward direction. We also show a strong dependence of the resonance frequency on the crystal orientation with respect to the waveguide direction, which in the extreme cases of [100] and [110] crystal orientation can be as large as is 0.8 GHz. On the experimental side, we provide measurements of Brillouin scattering on our previously demonstrated all-silicon optical platform (ASOP).

Poster 17

Scattering in Photo-Thermo-Refractive Glass after UV Exposure and Nucleation

Roberto Alvarez[1]*, *Aleksandr Ryasnyanskiy*[2], *Helene Mingareev*[1], *Leonid Glebov*[1,2]
[1]*CREOL,The College of Optics and Photonics, UCF*
[2]*OptiGrate Corp. Oviedo, FL*
**roberto.alvarez@knights.ucf.edu*

Photo-thermo-refractive (PTR) glass is a multicomponent silicate glass matrix doped with Ce, Ag and F. After exposure to UV radiation and subsequent thermal treatment, it undergoes permanent refractive index change due to crystalline phase precipitation of NaF. This feature enables PTR glass to be a new phase medium for holographic recording of various types of volume diffractive optical elements with high tolerance to elevated temperatures and laser radiation. This study explores phase transformations in PTR glass below temperature of crystalline phase precipitation (about 520°C). As a single-phase multicomponent glass, it has low scattering of optical radiation (usually 1.5-2 times higher than that for fused silica). UV exposure results in the photo-reduction of Ag^+ to neutral state Ag^0, which at temperatures close to the glass transition temperature (T_g=470°C) leads to the formation of nucleation centers that are necessary for the crystal growth at a higher temperature. We study if optical scattering can be produced by nucleation centers using a highly sensitive setup for measuring scattering intensity at 90° with respect to a 1-mm-diameter probe beam at 405 nm. We explored three different nucleation regimes. Induced optical scattering was found for one of them. X-ray diffraction (XRD) of the scattering sample has shown no sharp bands could be detected at the corresponding NaF diffraction peaks. This results allow supposition that optical inhomogeneity is generated in vitreous phase at low temperatures in vicinity of T_g.

Poster 18

Higher Order Mode Suppression in Ytterbium Doped Large Mode Area Fiber with Confined Rare Earth Doping

*Stefan Gausmann**, *J. Enrique Antonio-Lopez, James Anderson, Rodrigo Amezcua Correa, Axel Schülzgen*
CREOL, The College of Optics and Photonics, UCF
**stefan.gausmann@knights.ucf.edu*

Large mode area (LMA) step index fibers are essential for the development of kW class fiber lasers and amplifiers since the

LMA concept mitigates power limiting nonlinear effects. However, mode area scaling while preserving single mode performance is challenging in conventional step index fibers as the number of supported modes increases as the core gets bigger. Therefore, it is common practice to use LMA few mode fibers, for both high power fiber laser oscillators and amplifiers. The majority of strategies, that have been developed over the years to suppress the unwanted higher-order-modes (HOMs) in LMA fiber, exploit differential propagation losses between the fundamental mode and HOMs. An alternative approach relies on tailoring the transvers rare earth doping profile (confined doping) to provide preferential gain to the fundamental mode. While loss induced HOM suppression in LMA fibers has been investigated extensively in the past, experimental results on HOM suppression due to differential gain in LMA step index fibers are rare. In this work, we quantify the HOM content in an amplified signal beam as a function of absorbed pump power using spatially and spectrally resolved (S2) imaging. Our S2 measurements as well as a pointing stability analysis indicate dominant fundamental mode operation of our confined doping fiber amplifier, even under imperfect seed launching condition and environmental perturbation of the fiber.

Poster 19

Aberration Analysis using Zernike Polynomials in a High-NA Multiphoton Lithography System

Chun Xia[1] *and Stephen M. Kuebler*[1,2,*]
[1]*CREOL, The College of Optics and Photonics, UCF*
[2]*Chemistry Department, UCF*
**Stephen.kuebler@ucf.edu*

Multiphoton lithography (MPL) enables unprecedented flexibility and capability for creating complex 3D functional units with sub-micron resolution directly from a computer-generated design. The resolution of MPL is determined by the shape and size of a single polymerized volume element, or "voxel," which depends jointly on the alignment of the beam path, numerical aperture (NA) of the focusing lens, the chemistry of the photopolymer, laser pulse width, laser power, and exposure time. Features of different sizes can be fabricated by changing the average focused laser power and exposure time. The outer boundary of the voxel has a shape that to first order matches the surface of equal irradiance equal to the irradiance threshold for polymerization. However, the voxel quality can be degraded by aberrations accumulated by all the optics in the light path. The point-spread function (PSF) is a useful tool for describing the quality and shape of the voxel. In this work, the PSF was experimentally measured by imaging the focal plane as a retro-reflecting mirror was scanned through the focal spot. The Gerchberg-Saxton (G-S) algorithm was used to analyze the resulting 3D image-data cube and iteratively retrieve the effective amplitude and phase of light at the exit pupil, which includes aberrations from all optics in the focusing system. The total phase was decomposed into a weighted linear sum of the first 19 Zernike polynomials. The aberrations were then used as source-terms for the input field and the PSF was simulated using Richard-Wolf vectorial diffraction theory under high-NA (NA > 0.7) conditions. The simulated and experimentally measured PSFs were then compared to validate the method. In future work, this aberration-extraction method will be used as a closed-loop control for dynamically reshaping the PSF using a spatial light modulator, to improve resolution in MPL

Poster 20

Size Dependent Optical Performance of Light Trapping Metallic Electrodes

Mengdi Sun[1], *Pieter G. Kik*[1,2*]
[1]*CREOL, The College of Optics and Photonics, UCF*
[2]*Physics Department, UCF*
**kik@creol.ucf.edu*

Transparent electrodes are used in many optoelectronic devices, such as solar cells, high speed photodetectors, imaging arrays, and displays. Common materials used for transparent electrodes include conductive oxides, carbon nanotubes, graphene, and metal nanowire networks. In all these materials there is an intrinsic balance between good electrical performance and high optical transmission: thinner films lead to higher transmission, but lower electrical conductivity. Metal nanowire electrodes provide extremely high conductivity but introduce significant shadowing losses due to reflection and absorption. Here we investigate the scale dependent optical and electrical performance of silver nanowire electrodes by reducing reflection losses by the metallic contacts. This is achieved by means of light trapping through total internal reflection at the surface of an added dielectric cover layer. Two electrode types are considered: cylindrical nanowire electrodes, and surface-inclined electrode lines with a cross-sectional shape that produces maximum light trapping. Both designs offer good optical and electrical performance for large wire sizes, while at small sizes diffractive effects reduce the light-trapping ability, causing a reduction in transmittance. In addition, surface plasmon polariton (SPP) excitation is found to affect dissipation under TM polarized illumination. The relative contribution of both radiative and non-radiative loss is evaluated as a function of electrode size. It is found that at a wavelength of 750nm, surface-inclined electrodes with 2μm width can achieve simultaneously more than 95% transmittance and a sheet resistance as low as 0.3Ω/sq.

Poster 21

Clear 3D Single-Molecule Imaging inside Cells with an Extended Imaging Area via Highly Inclined Swept Illumination

*Jialei Tang** , *Kyu Young Han*
CREOL,The College of Optics and Photonics, UCF
**jialei.tang@knights.ucf.edu*

Illumination via a highly inclined and laminated optical sheet (HILO) could effectively decrease the generation of out-of-focus background for three-dimensional (3D) single-molecule fluorescence imaging. However, HILO illumination with favorable signal to background ratio (SBR) can only support a small imaging field-of-view (FOV), which is not suitable for cellular or high throughput imaging. Here, we present a highly inclined swept tile microscopy (HIST) that solves the fundamental limitations of HILO illumination, enabling 3D single-molecule imaging with a full FOV and high SBR. Our new imaging technique showed a much thinner optical sectioning depth and >40-fold larger FOV than conventional HILO microscopy. We demonstrated that it is possible to image mRNA with a few probes using single-molecule RNA fluorescence in situ hybridization in cultured cells and mouse brain tissue.

Poster 22

Optical Ceramics Science for High-Power Lasers

*Matthew Julia**, *Romain Gaume*
CREOL, The College of Optics and Photonics, UCF
**Mjulian6288@knights.ucf.edu*

In the past two decades, a great deal of progress has been accomplished in power-scaling the laser output of solid-state and fiber lasers. In particular, transparent ceramics have demonstrated that they offer optical quality far superior to that of single crystals at large scales, while also delivering thermal conductivity and mechanical strength equal to that of single-crystals. These advances have led to the demand for low optical-loss transparent ceramics for high-power laser components. For these applications this requires that the phase composition and microstructure be controlled through the fabrication process. Departure from nominal stoichiometry leads to development of point-defects and precipitates that influence the sintering kinetics and final densification rate. These defects also introduce color centers, charge-carrier trapping sites and scattering sites that degrade optical properties. To understand the nature and effect of these intrinsic defects on both the sintering behavior and optical properties requires the ability to measure small excess of major elements with accuracies better that 0.1 mol%. Currently there is no simple and direct method in scientific practice with the required resolution for determining the deviation of stoichiometry throughout the fabrication process. We are developing a novel and analytical technique that can provide sensitive and precise real-time assessment of the stoichiometry of a ceramic in both green body and powder forms. The technique is also being implemented to monitor elemental impurities, such as sintering additives, during the fabrication process. Concurrently, the nature of these defects associated to the given departure from stoichiometry and its impact on optical quality is being investigated. Completion of these objectives will lead to more efficiency in the fabrication of high-grade optical transparent ceramics thus allowing larger volume production and broad-based adoption of these materials for integration into high-power laser systems.

Poster 23

Nonlinear Frequency Conversion in Nanophotonic Periodically-Poled Lithium Niobate Waveguides

Tracy Sjaardema, Kamal Abdelsalam, Sasan Fathpour*
CREOL, The College of Optics and Photonics, UCF
*fathpour@creol.ucf.edu

Nonlinear frequency conversion is demonstrated through two nanophotonic approaches. Both approaches utilize ultra-compact, submicron thin-film periodically poled lithium niobate (PPLN) direct-etched waveguides on silicon substrates. The first approach uses a single PPLN segment to produce ultra-efficient second-harmonic generation (SHG). These devices exhibit 4600 %W-1cm-2 normalized conversion efficiency, which is over an order of magnitude larger than previous devices. Broadband sum-frequency generation (SFG) from 1460 to 1620 nm is also demonstrated in these devices. The second approach uses two sequential PPLN segments, each optimized for a specific order of frequency conversion. Characterized with femtosecond, picojoule-level energy pulses at telecom wavelengths, both approaches demonstrate cascaded harmonic generation to the fourth order.

Poster 24

A Comprehensive Methodology to Evaluate Losses and Process Variations in Silicon Solar Cell Manufacturing Using Photoluminescence and Quantum Efficiency Imaging

Mohammad Jobayer Hossain[1]*, *Eric J. Schneller*[2], *Mengjie Li*[2], *Kristopher O. Davis*[1,2]
[1]*CREOL, The College of Optics and Photonics, UCF*
[2]*Material Science and Engineering Department, UCF*
**jobayer@knights.ucf.edu*

Characterization of solar cells is crucial for better understanding their operation and engineering them to be better (e.g., more efficient, less expensive, more durable). The traditional characterization methods provide the global values of the solar cell parameters, for example open circuit voltage (VOC), short circuit current (JSC), series resistance (RS), dark saturation current density (J0), efficiency etc. However, the spatial map of these parameters provides better representation of losses occurring in the cell. In addition, decoupling the losses can point to specific problem in a cell and the production line and process variations. The spatial map of the parameters can be obtained using photoluminescence (PL) imaging and high-speed quantum efficiency measurement. This work introduces a comprehensive methodology to evaluate losses and process variations in silicon solar cell manufacturing using photoluminescence and quantum efficiency imaging.

Poster 25

Beam Deflection Measurements of Transient Nonlinear Refraction in Air in the Mid-IR

*Salimeh Tofighi**, *Natalia Munera, Munan Gao, David J. Hagan, Eric W. Van Stryland*
CREOL, The College of Optics and Photonics, UCF
**s.tofighi@creol.ucf.edu*

The nonlinear response of gases induced by intense laser fields has a critical role in many applications such as high harmonic generation, filamentation, attosecond pulse shaping and pulse compression. For gases where the constituent molecules have an anisotropic polarizability, the nonlinear refraction originates from a nearly instantaneous response of bound electrons along with a non-instantaneous response from molecular reorientation. An intense polarized laser field creates a time-average torque which reorients the molecules towards the direction of polarization, inducing a birefringence. By probing this birefringence at different times after the excitation we can measure the transient change in refraction. Since the bound-electronic and reorientation contributions to the index have different symmetries, these effects can be separated by using several combinations of pump and probe polarization. Further, by measuring these effects at different wavelengths we can determine the dispersion of this nonlinear refraction. We use the polarization resolved beam deflection technique to separate the electronic and rotational components of transient nonlinear refraction of air in the mid-infrared spectral range. We will do this for both ambient and pressurized air.

Poster 26

Imaging Beam Steering for LiFi Communication

Sajad Saghaye Polkoo[1]*, *Pooya Nabavi*[2], *Murat Yuks*[1,2], *Kyle Renshaw*[1]
[1]*CREOL,The College of Optics and Photonics, UCF*
[2]*Electrical and Computer Science Engineering Department, UCF*
**Sajad.Saghaie@knight.ucf.edu*

In addition to room illumination, LEDs have received much attention for Light Fidelity (LiFi) which provides a new modality of wireless communication for indoor application. Here, we utilized imaging based beam steering (IBBS) to provide 49 communication channels using a 7x7 individually addressable white LED array at the focal plane of a wide angle lens. Each LED provides up to 20MHz bandwidth yielding ~1Gbps throughput. The 186cd (560lux) emission from each LED is steered to illuminate different sections (2x2 m^2) of a room enabling space-division multiplexing to multiple devices. A custom designed LiFi receiver conformable to device surfaces is used to demonstrate secure mobile indoor communications. The conformal receiver consist of a multi-photodetector array with large aggregate receiver area (~6cm^2) in a cubical design to enable almost 360° field of view coverage.

Poster 27

Near-Eye Multiplane Display with Polarization Multiplexing

*Guanjun Tan**, *Tao Zhan, Jianghao Xiong, Shin-Tson Wu*
CREOL, The College of Optics and Photonics, UCF
**guanjun_tan@knights.ucf.edu*

We demonstrate a polarization-multiplexed multiplane display system to overcome the vergence-accommodation conflict (VAC) issue for near-eye applications. A polarization-sensitive Pancharatnam-Berry phase lens (PBL) is implemented to generate two focal depths simultaneously. A spatial polarization modulator (SPM) is utilized to direct the two images to designated focal planes. Based on this design, a dual-focal plane display system is constructed with additive light-field image rendering method, to suppress the VAC issue successfully. The proposed system enables the generation of multiple focal planes without the need for temporal-multiplexing nor switchable lenses. Thus, the proposed design can effectively reduce the frame rate by one half.

Poster 28

Wave-Optics Simulation of Correlated Speckle Fields for use in Closed-Loop-Phase-Compensation Studies

Derek J. Burrell[1]*, *Noah R. Van Zandt*[2], *Mark F. Spencer*[2], *Terry J. Brennan*[3]
[1]*CREOL, The College of Optics and Photonics, UCF*
[2]*Directed Energy Directorate, AFRL*
[3]*Prime Plexus, LLC*
**derekburrell@knights.ucf.edu*

In this study we use a series of computational-wave-optics experiments to look at the statistics associated with speckle fields resulting from a tilted flat plate (i.e. one that is optically rough compared to the wavelength of plane-wave illumination). To help quantify the strength of the simulated speckle, we make use of the target Fresnel number. This parameter gives a gauge for the number of speckles across the receiver. The goal throughout is to show that, frame to frame, the analysis can appropriately simulate correlated speckle fields in terms of the magnitude of the complex degree of coherence as a function of tilt. The results show that the simulated speckle fields are properly correlated from frame to frame, and this outcome leads to the ability to perform closed-loop-phase-compensation studies in the presence of extended beacons. Such studies are becoming increasingly important for applications that involve imaging through turbulence.

Laboratories and 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. Other facilities, like the Optical Materials Laboratory (pictured below) are located on the main UCF campus.

College 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, a 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 containing class 100 and class 10,000 cleanrooms. Used in the development of optoelectronic semiconductor devices. The facility includes a Suss MJB-3 aligner, a Plasma-Therm 790 RIE/PECVD, an Edwards thermal evaporator, and a bonder, 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 fidelity 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

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.

Optical Materials Laboratory (OML)

The Optical Materials Laboratory (OML) is a new 4,000 square-foot facility with state-of-the-art laboratory fabrication and characterization capabilities for research in optical ceramics, IR glasses and glass-ceramics as well as optical fibers. It features dedicated ceramic laboratories with extensive powder processing and sintering equipment, IR glass and glass-ceramic advanced manufacturing, and cutting-edge MOCVD fiber-preform fabrication laboratory. These laboratories also include dedicated analytical tools and post-processing capabilities offering student training opportunities in these areas. The OML is located on the UCF main campus (Building 154 on 12765 Ara Drive) in close proximity to the Material Characterization Facility (MCF).

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.

Townes Innovative Science & Technology Facility (TISTEF)

The TISTEF site is a secure facility located at the Kennedy Space Center, Florida. It was a Navy SSC PAC operated facility, but is now an Air Force facility on NASA property, managed and operated by UCF. TISTEF was originally built in 1989 to support the Strategic Defense Initiative Organization's Innovative Sciences and Technology Office (SDIO/ISTEF). Today TISTEF has a much broader mission; it supports research and development of electro-optics sensing technologies for DOD, commercial and academic applications. DOD customers include: the Army, Navy Air Force, DARPA, and DIA. The facilities include a laser and optics laboratory, a 1 km laser test range, a precision tracker (gimbal) with a 0.5 meter telescope and coude mirror path (for laser transmission), and several transportable trackers capable of supporting active (laser) or passive testing at remote sites. Additionally, TISTEF maintains an assortment of telescopes, optics, and sensors to support various data collection requirements. Since TISTEF is a tenant of the 45th Space Wing and NASA, operating agreements are in place that permit tasking AF Eastern Range and NASA assets as needed. It also has standardized range operations and procedures for laser testing against boosting rockets, satellites, and other terrestrial targets. TISTEF has a close partnership with the CREOL which provides access to cutting edge R&D and expertise in atmospheric propagation of lasers, laser communications, laser radar (LADAR), fiber-optic lasers, passive imaging, and optical design.

FACULTY FACILITIES

DIFFRACTIVE AND HOLOGRAPHIC OPTICS LAB

Conducting rigorous analysis, design, and demonstration of diffractive and holographic optical elements, subwavelength grating structures and their applications, E-M theory of grating diffraction, holographic optical information processing and storage, volume holography. Leonid Glebov.

DISPLAY AND PHOTONICS LAB

Developing 1) Advanced displays including LCDs, quantum dots, perovskites, LEDs, OLEDs, augmented reality and virtual reality, and sunlight readable displays, 2) Adaptive lenses for tunable-focus lens, optical imaging and light field displays, and 3) Adaptive optics for wavefront correction and laser beam control. Shin-Tson Wu.

FIBER OPTICS LAB

Research in fiber fabrication technology, nano-structured fibers, nonlinear fiber materials, fiber lasers, and fiber sensing applications. Axel Schülzgen and Rodrigo Amezcua.

FLORIDA ATTOSECOND SCIENCE AND TECHNOLOGY LAB

Generation of attosecond (10-18 s) and zeptosecond (10-21 s) X-ray pulses. Zenghu Chang.

GLASS PROCESSING AND CHARACTERIZATION LABORATORY (GPCL)

Investigating the design, processing methodologies, fabrication and characterization of novel oxide and non-oxide glass and glass ceramic materials for the infrared. Applications include, on-chip sensors, bulk and film materials for GRIN, optical nanocomposites, 3D printing of chalcogenide materials. Kathleen Richardson.

INTEGRATED PHOTONICS & ENERGY SOLUTIONS LAB

Specializing in fundamental and technological aspects of silicon-based optoelectronic devices and chips, including their energy efficiency issues. The lab encompasses near- and mid-infrared setups for characterizing the devices fabricated in CREOL's Nano Fabrication Facility. Sasan Fathpour.

LASER ADVANCED MATERIAL PROCESSING (LAMP)

Engaged in novel manufacturing technology; new materials synthesis including optical, electronic and magnetic materials for a variety of applications such as sensors, detectors and medical devices; and process physics modeling. Aravinda Kar.

LASER AIDED MATERIALS PROCESSING LABS

Investigating the interaction of lasers with absorbing and non-absorbing materials, growth, solidification, and plasma effects; laser CVD; laser ablation, laser drilling, cutting, welding; developing process-monitoring and diagnostic techniques. Stephen Kuebler (NPM) and Martin Richardson (LPL).

LASER PLASMA LAB

Conducting research on X-ray and EUV optics and sources, X-ray microscopy, laser-aided material processing, and laser generated plasmas. Martin Richardson.

LASER SYSTEM DEVELOPMENT LABS

Developing new solid-state lasers, external cavity semiconductor lasers and amplifiers, seeding lasers, laser-induced damage, far infrared semiconductor lasers, high-average-power solid state lasers, semiconductor and solid state volume Bragg lasers, high power laser beam combining, ultra-high-intensity femtosecond lasers, new solid state lasers and materials development (crystals & glasses). Michael Bass, Martin Richardson, Peter Delfyett, Leonid Glebov.

LIQUID CRYSTAL DISPLAY LAB

Investigating 1) advanced liquid crystal display materials, display devices, and device modeling, 2) electronic laser beam steering and adaptive optics using fast-response spatial light modulators, 3) adaptive liquid crystal and liquid lenses for forveated imaging and zoom lens, and 4) bio-inspired tunable optical filters using cholesteric liquid crystals. Shin-Tson Wu.

MID-INFRARED COMBS GROUP (MIR)

Broadband mid-infrared (λ > 2.5 μm) frequency combs generation based on subharmonic optical parametric oscillators. Trace molecular sensing and coherent dual-comb spectroscopy using octave-wide MIR combs. Biomedical applications of frequency combs. Photonic THz wave generation and THz imaging. Nano-IR spectroscopy. Konstantin Vodopyanov.

MULTI-MATERIAL OPTICAL FIBER DEVICES LAB

Research on novel optical fiber structures, nanophotonics, fiber-based optoelectronic devices, optical imaging using large-scale three-dimensional arrays constructed from photosensitive fibers, and mid-infrared fiber nonlinear optics. Ayman Abouraddy.

MULTIPLE QUANTUM WELLS LAB

Research on the design, fabrication and testing of novel all-optical switching devices using III-V multi-quantum well semiconductors, and the integration of high-speed optical and optoelectronic devices to form monolithic integrated optical circuits for high data throughput optical networks. Patrick LikamWa

NANOPHOTONIC DEVICES LAB

Research in epitaxial growth and properties of oxide semiconductors, oxide and nitride-semiconductor light emitting diodes, self-assembled quantum dots, and e-beam nano-lithography. Winston Schoenfeld.

NANOBIOPHOTONICS LAB (NBPL)

Developing nanoaperture optical trapping based single molecule biophysics methods for studying protein dynamics, structure, and behavior; protein-protein and protein-small molecule interactions; drug discovery; and fundamental life sciences. Ryan Gelfand

NANOPHOTONICS CHARACTERIZATION LAB

Optical analysis tools for investigation of nanostructured devices including Near-field Scanning Optical Microscope, fiber-coupled microscope for single particle spectroscopy, leakage radiation setup for surface plasmon imaging, near-infrared waveguide analysis setup, and variable temperature photoluminescence setup. Projects include manipulation of surface plasmon dispersion in nanoscale thin films, enhancement of erbium excitation in semiconductor nanocrystal doped oxides, and enhancement of optical nonlinearities using plasmon resonances. Pieter Kik.

NONLINEAR OPTICS LABS

Conducting research on a variety of nonlinear optical effects, materials, and devices including nonlinear interactions in waveguides, optical power limiting, and characterizing materials response at femtosecond, picosecond and nanosecond scales. Eric Van Stryland, David Hagan, MJ Soileau.

NONLINEAR WAVES LAB

Research in nonlinear optics, spatial and spatio-temporal solitons, discrete solitons in photonic lattices, and curved beams. Demetrios Christodoulides.

OPTICAL CERAMICS LAB

Conducting research on the synthesis of transparent ceramics, powder processing, ceramic casting, vacuum and pressure sintering, diffusion bonding, dopant diffusion, and crystal growth for laser and nuclear detector applications. Romain Gaume.

OPTICAL COMMUNICATION LAB

High-capacity optical communication through linear and nonlinear channels including free space and optical fiber using synergy of advanced optical and electronic techniques. Guifang Li.

OPTICAL GLASS SCIENCES & PHOTO-INDUCED PROCESSING LAB

Conducting studies of new materials for high-efficiency, robust holographic optical elements; high power laser beam combining, glass spectroscopy, refractometry and interferometry; photo-induced processes in glasses; technology of optical quality and high-purity glasses. Leonid Glebov.

OPTICAL IMAGING SYSTEM LABORATORY

Creating novel imaging systems by integrating physical coding and computational methods for biological research, medical diagnosis, and industrial imaging applications in both visible and X-ray regimes. Shuo "Sean" Pang.

OPTICAL NANOSCOPY LAB

Developing and applying novel optical tools such as fluorescence nanoscopy (super-resolution imaging) and single-molecule imaging to study essential problems in biology and neuroscience. Kyu Young Han

OPTICAL IMAGING SYSTEM LAB (OISL)

Research in OISL is focused on developing computational imaging platforms for biomedical research, medical diagnosis, and industrial imaging applications in both visible and X-ray regimes. Research topics include Computational Imaging, Coded Aperture, X-ray Tomography, X-ray Scatter Imaging, Fluorescence Microscopy, Lens-less Optical Imaging, Bio-sensor and Portable Imaging Devices. Shuo "Sean" Pang

PLASMONICS AND APPLIED QUANTUM OPTICS LAB

Developing nanoscale emitters using metallic structures, study the dynamic response of nanoscale lasers. Generation and characterization of non-classical light. (Mercedeh Khajavikhan) (PAQO).

PHOTONICS DIAGNOSTIC OF RANDOM MEDIA

Exploring different principles for optical sensing, manipulation of electromagnetic fields, and phenomena specific to optical wave interactions with complex media. Aristide Dogariu.

QUANTUM OPTICS LAB

Conducting research on the generation and detection of nonclassical light, such as entangled photons, and its quantum information applications, including quantum imaging and quantum communication. Bahaa Saleh, Ayman Abouraddy.

SEMICONDUCTOR LASERS LAB

A III-V epitaxial growth facility used to research new types of semiconductor heterostructures and devices that include quantum dots, quantum dot laser diodes, vertical-cavity surface-emitting laser diodes, spontaneous light sources, and single quantum dots. A characterization laboratory is used to study the optical properties of the samples, including their light emission, microcavity effects, and laser diode characteristics. Dennis Deppe.

THIN-FILM OPTOELECTRONICS LAB

Developing novel optoelectronic materials and devices for sensors, solar cells, lighting and displays that are large area, flexible, cost-effective and efficient. Kyle Renshaw

ULTRAFAST PHOTONICS LABORATORY

Conducting research on ultrafast high power optical pulses from semiconductor diode lasers, for applications in applied photonic networks and laser induced materials modification. Peter Delfyett.

Instructional Laboratories

Laser Engineering Laboratory

Designing and device implementation of diode pumped solid state lasers, nonlinear frequency conversion, Q-switching, mode locking, and pulse second harmonic generation.

Photonics Laboratory

Experimental study of photonic devices and systems including liquid crystal displays, fiber-optic sensors, laser diodes, electro optic modulation, acousto-optic modulation, lightwave detection, optical communications, and photonic signal processing.

Optoelectronic Device Fabrication Laboratory

Design and micro-fabrication of semiconductor optoelectronics devices including passive waveguides, light emitting diodes (LEDs), laser diodes (LDs), photodetectors. Prerequisite Course: Graduate standing or consent of the instructor.

Undergraduate Laboratory

A multipurpose space that accommodates laboratory courses for Optoelectronics, Fiber Optics, Introduction to Photonics, Laser Engineering, and Imaging and Display. The space includes basic instrumentation necessary to conduct experiments.

Senior Design Laboratory

Comprised of six laboratory benches, the Senior Design laboratory space is designed to permit students with flexibility to design, test, and construct their Senior Design projects. Students have access to this space in the semester in which they are enrolled in OSE 4951 and OSE 4952, the Senior Design Courses. They are able to work in this space at any time, day or night.

Building Map

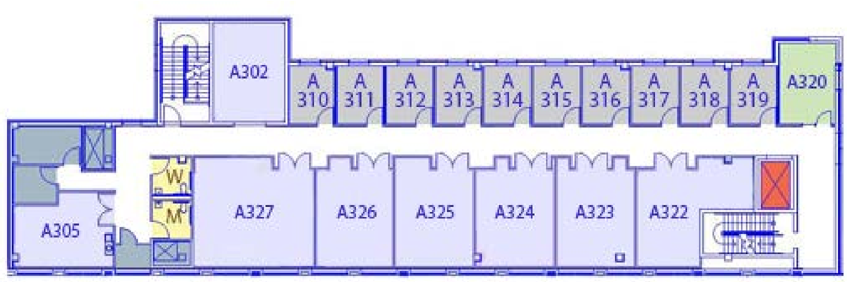
First Floor

Building Map

Second Floor

Building Map

Third 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 CREOL. 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. The following is a list of other benefits.

- Affiliates establish a close association with a leading center in optics and photonics, and exposure to the latest research and development in cutting edge technologies.
- Close interaction with the world-renowned faculty at CREOL can result in research projects for which federal funding may be received.
- Membership in the IA program enables some access to state-of-the-art facilities for specialized optical measurement, testing, and calibration.
- Affiliates have access to students interested in internship opportunities, and receive early notice of students approaching graduation, and ability to post job openings on CREOL's website (an exclusive benefit for IA members).
- IA members receive notifications of seminars presented by leading figures in the optics and photonics community, and copies of CREOL's periodic newsletter, Highlights, which lists new discoveries and inventions in the field, awards and recognitions of the faculty and students, and alumni news.
- Companies that donate equipment get their hardware/software in the hands of faculty and students, providing visibility and product marketing for potential future customer prospects.
- Membership provides affiliates with an opportunity to promote their companies by making presentations about their products to the faculty and students, exhibiting and giving presentations at the CREOL annual Industrial Affiliates meeting, posting a link to their website from the College's website. Affiliates are listed in CREOL publications and website, and receive special recognition at the Industrial Affiliates Meeting, and plaques in their names are prominently displayed in the entrance lobby of the CREOL building.
- Affiliation is a venue for supporting the education of the future workforce. Members receive a certificate or plaque for display in their facility highlighting their partnership and cooperation with educational institutions.

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 at CREOL and the Florida Photonics Center of Excellence (FPCE), UCF facilities include the following major research centers:

- NanoScience & 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 connects. Through the IA program companies 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 and a large family of laser and optics companies in the Central Florida region.

Industrial Affiliate Members

Life Member

Cobb Family Foundation
Northrop Grumman Corporation
Nufern

Memorial Member

Dr. Arthur H. Guenther and Dr. William C. Schwartz

Medallion Member

Breault Research
Coherent, Inc.
IPG Photonics
Newport
Northrop Grumman Laser Systems
Synopsys
Paul G. Suchoski, Jr

Senior Member

AFL
Amplitude Laser, Inc
ASML US
CST of America
FARO Technologies
LAS-CAD GmbH
Lockheed Martin
Oculus Research
Optimax Systems, Inc
Tektronix
Zemax
Zygo Corporation

Affiliate Member

Aerotech Inc.
Analog Modules
Andor Technology
Applicote Associates, LLC
Asphericon, Inc.
Beam Co.
DataRay
Edmund Optics
Elbit Systems of America
eVision, LLC
Finetech
Gentec-EO
Harris Corporation
HORIBA Jobin Yvon
JENOPTIK Optical Systems Inc
Laser Institute of America
LGS Innovations
Lightpath
Luminar
Menlo Systems
NKT Photonics Inc.
Ophir-Spiricon
Optigrate
OIDA
Optronic Laboratories, Inc.
Plasma-Therm
Plasmonics
Q-Peak, Inc
SPIE - The International Society for Optics & Photonics
The Optical Society
Thorlabs
Tower Optical Corporation TwinStar Optics, Coatings & Crystals ULVAC Technologies, Inc
Yokogawa

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 industry cluster is one of the largest in the US with current analysis showing the statewide photonics industry represents over 360 companies employing over 7,400 professionals focused on the design, development, manufacturing, testing, and integration of photonics products and related systems. The photonics industry 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 photonics/optics, which graduate over 100 photonics specialists (AS to PhD) each year. The Florida Photonics Cluster, a 501c(6) trade association (www.floridaphotonicscluster.org) currently with 66 member companies and other organizations, is dedicated to serving the industry and to making Florida the place to go for photonics solutions.

Innovation Economy

Boosting Florida's Economy with High Tech Industry and Innovation

Nowhere else is the spirit of innovation more evident than in the 23-county Florida High Tech Corridor, which has been recognized by numerous scientific and economic development organizations for its achievements. The product of a rare collaborative spirit, The Florida High Tech Corridor Council is led by current presidents of the University of Central Florida, the University of South Florida and the University of Florida – three of the nation's leading research universities, which continually rank among the top 100 universities worldwide granted U.S. utility patents. Visit us at www.floridahightech.com and search "Florida High Tech Corridor" to connect on Twitter, LinkedIn and Facebook.

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

Ayman Abouraddy
Prof. of Optics and Photonics
PhD, Boston University
Multi-material Optical Fiber Devices, Quantum Optics
raddy@creol.ucf.edu

Rodrigo Amezcua Correa
Asst. Prof. of Optics and Photonics
PhD, Southampton University
Fiber optics
r.amezcua @creol.ucf.edu

Luca Argenti
Asst. Prof. of Physics, Optics and Photonics
PhD, Scuola Normale Superiore of Pisa, Italy
Theoretical Attosecond Spectroscopies
luca.argenti@ucf.edu

Miguel A. Bandres
Asst. Prof. of Optics and Photonics
PhD, California Institute of Technology
Optical Sensing and Imaging
Bandres@creol.ucf.edu

Zenghu Chang
University Trustee Chair, Pegasus and Distinguished Prof. of Physics, Optics and Photonics
PhD, Xi'an Institute of Optics and Precision Mechanics
Attosecond Science and Technology
Zenghu.chang@ucf.edu

Demetrios Christodoulides
Pegasus Prof. of Optics and Photonics/Cobb Family Endowed Chair
PhD, Johns Hopkins University
Nonlinear Wave Propagation
demetri@creol.ucf.edu

Peter J. Delfyett
University Trustee Chair and Pegasus Prof. of Optics and Photonics, ECE & Physics
Director, Townes Laser Institute
PhD, City University of New York
Ultrafast Photonics
delfyett@creol.ucf.edu

Dennis Deppe
Prof. of Optics and Photonics
PhD, University of Illinois
Nanophotonics, Semiconductor Lasers
ddeppe@creol.ucf.edu

Aristide Dogariu
University Trustee Chair, Pegasus Prof. of Optics and Photonics
PhD, Hokkaido University
Photonic Diagnostics of Random Media
adogariu@creol.ucf.edu

Ronald Driggers
Prof. of Optics and Photonics & ECE
PhD, University of Memphis
Electro-Optical and InfraRed Systems
Ron.Driggers@creol.ucf.edu

Sasan Fathpour
Prof. of Optics and Photonics & ECE
PhD, University of Michigan
Integrated Photonics and Energy Solutions
fathpour@creol.ucf.edu

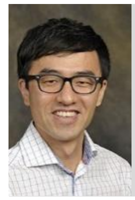
Romain Gaume
Assoc. Prof. of Optics and Photonics & NanoScience Technology
PhD, Paris VI University
Optical Ceramics
gaume@creol.ucf.edu

Ryan Gelfand
Asst. Prof. of Optics and Photonics
PhD, Northwestern University
Nano Bio Photonics
ryan5@creol.ucf.edu

Leonid B. Glebov
Research Prof. of Optics and Photonics
PhD, State Optical Institute, Leningrad
Photoinduced Processing
lbglebov@creol.ucf.edu

David J. Hagan
Assoc. Dean for Academic Programs and Pegasus Professor of Optics & Photonics, Physics
PhD, Heriot-Watt University
Nonlinear Optics

hagan@creol.ucf.edu

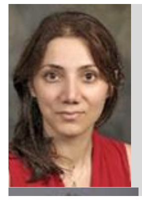


Kyu Young Han
Asst. Prof. of Optics and Photonics
PhD, Seoul National University
Optical Nanoscopy

kyhan@creol.ucf.edu

Aravinda Kar
Prof. of Optics and Photonics, MMAE, EECS & Physics
PhD, University of Illinois
Laser Advanced Materials Processing

akar@creol.ucf.edu



Mercedeh Khajavikhan
Assoc. Prof. of Optics and Photonics
PhD, University of Minnesota
Plasmonics, Quantum Optics, and Silicon Photonics

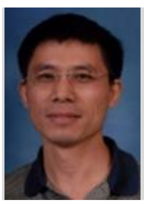
mercedeh@creol.ucf.edu

Pieter G. Kik
Assoc. Prof. of Optics and Photonics & Physics
PhD, Institute for Atomic & Molecular Physics, Amsterdam
Nanophotonics and Near-field Optics

kik@creol.ucf.edu

Stephen Kuebler
Assoc. Prof. of Chemistry & Optics and Photonics
PhD, University of Oxford
Nanophotonic Materials

Stephen.Kuebler@ucf.edu



Guifang Li
Prof. of Optics and Photonics, Physics & ECE
PhD, University of Wisconsin-Madison
Optical Fiber Communications

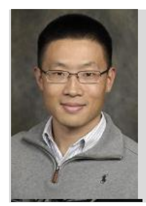
li@creol.ucf.edu

Patrick L. LiKamWa
Prof. of Optics and Photonics & ECE
PhD, University of Sheffield
Multiple Quantum Wells

patrick@creol.ucf.edu

M. G. "Jim" Moharam
Prof. of Optics and Photonics
PhD, University of British Columbia
Photonic Structures and Devices

moharam@creol.ucf.edu



Shuo "Sean" Pang
Asst. Prof. of Optics and Photonics
PhD, California Institute of Technology
Optical Imaging

pang@creol.ucf.edu

Kumar Patel
University Distinguished Professor

PhD, Stanford University

Pranalytica, Inc.

Chandra.Patel@ucf.edu

C. Kyle Renshaw
Asst. Prof. of Optics and Photonics
PhD, University of Michigan
Thin-film Optoelectronics

krenshaw@creol.ucf.edu

Kathleen A. Richardson
Pegasus Prof. of Optics and Photonics
PhD, Alfred University
Infrared glass and glass ceramic optical materials
kcr@creol.ucf.edu

Martin C. Richardson
Pegasus Prof. and University Trustee Chair, Northrop Grumman Prof. of X-ray Photonics; Prof. of Optics & Photonics
PhD, London University
Lasers & Laser Plasma
mcr@creol.ucf.edu

Bahaa E. A. Saleh
Dean & Director, Prof. of Optics and Photonics
PhD, Johns Hopkins University
Nonlinear and Quantum Optics, and Image Science

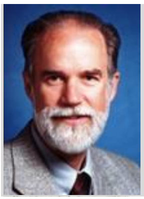
besaleh@creol.ucf.edu

Winston V. Schoenfeld
Prof. of Optics and Photonics & Director, Solar Technologies Research Division (FSEC)
PhD, University of California, Santa Barbara
Nanophotonics Devices
winston@creol.ucf.edu

AXEL SCHÜLZGEN
Prof. of Optics and Photonics
PhD, Humboldt University
Fiber Optics

axel@creol.ucf.edu

M.J. SOILEAU
University Distinguished Prof. of Optics and Photonics, ECE & Physics
PhD, University of Southern California
Nonlinear Optics, Laser Induced Damage
mj@ucf.edu



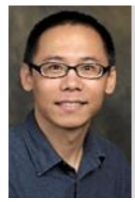
ERIC W. VAN STRYLAND
University Trustee Chair, Pegasus Prof. of Optics and Photonics

PhD, University of Arizona
Nonlinear Optics

ewvs@creol.ucf.edu

KONSTANTIN L. VODOPYANOV
21st Century Scholar Chair & Prof. of Optics and Photonics, & Physics
PhD, Lebedev Physical Institute, Moscow
Mid-infrared Frequency Combs
vodopyanov@creol.ucf.edu

SHIN-TSON WU
Pegasus Prof. of Optics and Photonics
PhD, University of Southern California
Liquid Crystal Displays
swu@creol.ucf.edu



XIAOMING YU
Asst. Prof. of Optics and Photonics
PhD, Kansas State University
Ultrafast Laser Processing

yux@creol.ucf.edu

Faculty Emeritus

LARRY C. ANDREWS
Emertius Prof. of Mathematics

PhD, Michigan State University

Larry.Andrews@ucf.edu

MICHAEL BASS
Emertius Prof. of Optics and Photonics, Physics & EECS
PhD, University of Michigan
Lasers, Spectroscopy & Modeling

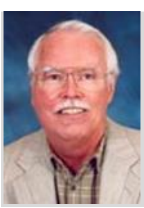
bass@creol.ucf.edu

GLENN D. BOREMAN
Emeritus Prof. of Optics, and Chair, Department of Physics and Optical Science, University of North Carolina at Charlotte
PhD, Univ. of Arizona

gboreman@uncc.edu

RONALD L. PHILLIPS
Emeritus Prof. of ECE and Mathematics
PhD, Arizona State University

Ronald.Phillips@ucf.edu



WILLIAM SILFVAST
Emertius Prof. of Optics and Photonics
PhD, University of Utah
Lasers

silfvast@creol.ucf.edu

GEORGE I. STEGEMAN
In Memorium

BORIS Y. ZELDOVICH
In Memorium

Thank you for attending!

We look forward to seeing you at our next
CREOL Industrial Affiliates Symposium
March 12-13, 2020

CREOL, The College of Optics and Photonics
University of Central Florida
4304 Scorpius Street
Orlando, FL 32816
407-823-6800
www.creol.ucf.edu