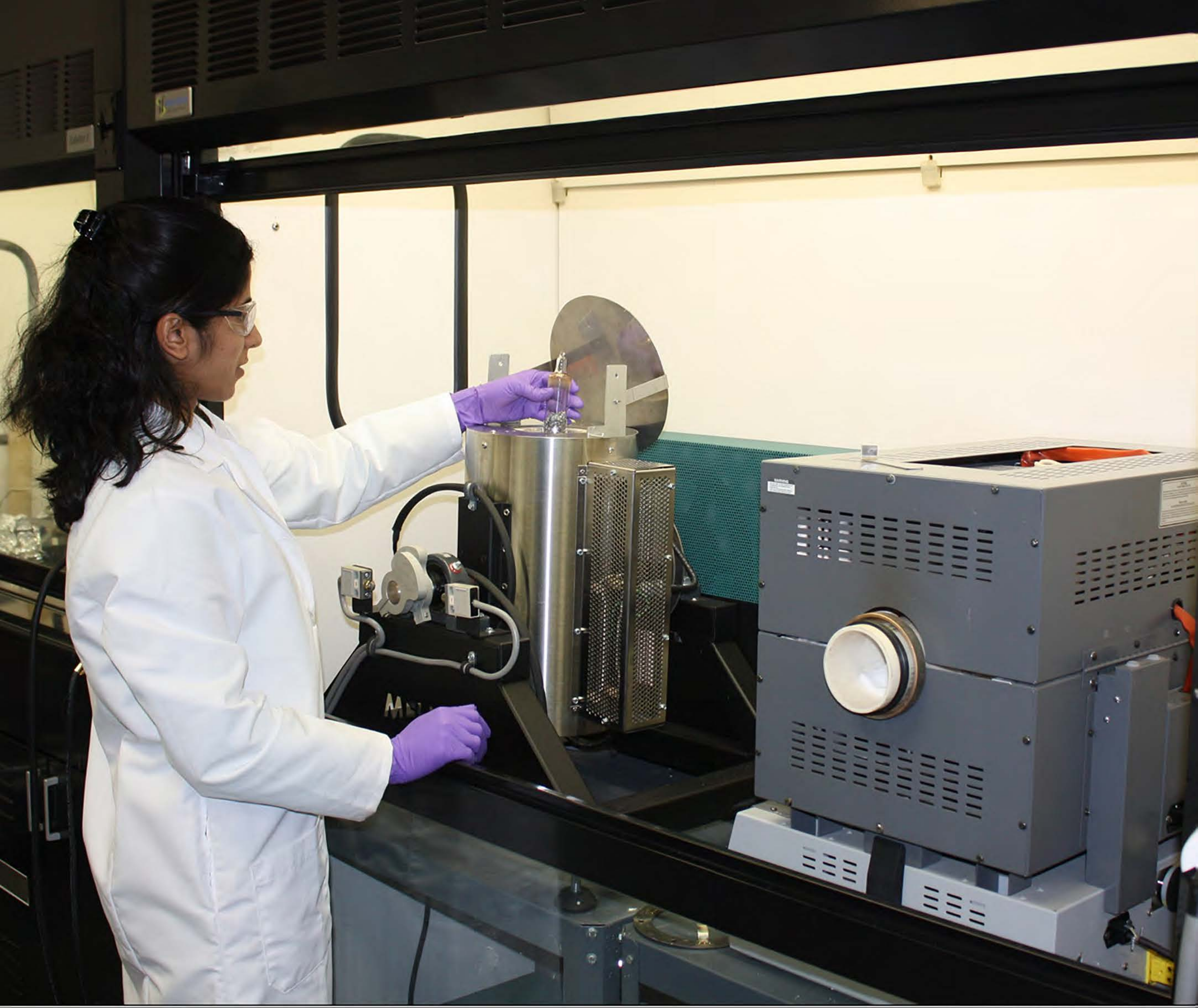

Symposium and Industrial Affiliates Program

2017

College of Optics and Photonics

UCF

CREOL

UNIVERSITY OF CENTRAL FLORIDA

Advances in Optics & Photonics
Industrial Affiliates Symposium
16–17 March 2017

CREOL Building & HEC 125 | ***Thursday, 16 March***

Short Courses 9:00AM–12:15PM

9:00-10:30AM, CREOL Building, Room 102
Title: Photoconducting polymers and its applications
Instructor: Jayan Thomas
Topics covered in this tutorial include electronic delocalization, formation of highest occupied molecular orbitals (HOMO) and lowest unoccupied molecular orbitals (LUMO) and charge conduction in photoconducting polymers. A brief discussion about optical bandgap tuning in polymers will also be presented. In addition, application of photoconduting and hybrid materials in excitonic solar cells, organic light emitting diodes and photorefractive display devices will be discussed.

9:00-10:30AM, HEC Room 125
Title: The fourth generation of optics
Instructor: Nelson V. Tabiryan, BEAM Co.
This short course provides an introduction into the principles of a new generation of optical components and systems enabling: thin gratings with near 100% diffraction efficiency; thin-film performing as a high-power lens, prism, spiral phase plate, or beam shaper, with spectral bandwidths comparable to that of glass; low-voltage optical switches; thin-film optical components providing versatile beam control functions such as all-electronic beam steering, switching between multiple focal points, spectral tuning, and variable transmission; ultralight and ultrathin films used for a very large telescope. The first generation of optics (G1) relied on shaping an optically transparent material such as glass. Modulating refractive index instead of shape – G2 – allows thinner components but compromises bandwidth. Anisotropic materials make available two more parameters for controlling light beams. LCD industry is exploring one of them, modulation of birefringence – G3. A recent breakthrough in optics, G4, relates to patterning optical axis orientation in the plane of anisotropic films, essentially, half-wave retardation films, and related geometrical phase modulation. Obtained as thin-film coatings on any desired substrate, including plastic, flat or curved, all varieties of optical functions can now be obtained using the same materials and processes. The 4G lenses, prisms, vortex waveplates, etc., are thin films of continuous structures combining the broadband efficiency of conventional optics with low-cost, roll-to-roll manufacturing, just by creating desired patterns of orientation of the anisotropy axis, by a touch of polarization modulated light.

10:45-12:15PM CREOL Building, Room 102
Title: Optical trapping
Instructor: Ryan Gelfand
This technique, invented just over 30 years ago, has emerged as a powerful tool with broad-reaching applications in biology and physics. Capabilities for this tool have evolved from the simple manipulation of large micron sized objects to the measurement of nanoscale displacements of optically trapped objects. This short course will review progress in the development of optical trapping apparatus, including instrument design considerations, position detection schemes and calibration techniques, with an emphasis on recent advances. It will cover trapping methods for particles of a variety of sizes: including atoms, proteins, nanoparticles, microparticles and cells. Optical trapping is a pivotal method used in many labs and has led to advances in biophysics, medicine, and quantum computing; this class will provide the fundamentals for understanding this technique.

10:45-12:15PM HEC Room 125
Title: Quantum cascade lasers
Instructor: Arkadiy Lyakh
Due to their unique combination of size, weight, and power, Quantum Cascade Lasers, or QCLs, are revolutionizing infrared laser applications in spectroscopy, imaging, and security areas. Their design is based on bandgap engineering – a very powerful technique for designing complex intersubband semiconductor devices with up to two thousand epi-layers. Specifically, energy levels, electron wavefunctions, and matrix elements can all be controlled in QCL design and can be optimized for a specific application. QCL design principles will be considered in this course along with their electronic, optical and thermal properties. Most important aspects of QCL fabrication will also be discussed. Finally, current research trends in the field will be covered, including high efficiency/power devices, broadly tunable lasers with ultra-fast scanning rate, and QCL-based combs.

Student Talks 1:30PM-2:30PM Harris Engineering 125

1:30	Novel photonic resonant arrangements using non-hermitian exceptional points	Hossein Hodaei, Student of the Year
	Low-loss and fast-response liquid crystals for infrared applications	Fenglin Peng
	New manifestations of mesoscopic interactions in complex media	Roxana Rezvani Naraghi
	Second-harmonic generation in periodically-poled and poling-free lithium niobate on silicon waveguides	Ashutosh Rao

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

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

Distinguished Seminar 4:30PM-5:30PM Harris Engineering 125

Time reversal and holography with time transformations	Mathias Fink, Langevin Institute

UCF Student Union, Pegasus Ballroom ***Friday, 17 March***

8:30 Continental Breakfast and Walk-in Registrations

9:00	Welcoming remarks	Liz Klonoff	UCF VP for Research, Dean of Graduate Studies
9:15	Welcome and overview of CREOL	Bahaa Saleh	Dean & Director, CREOL, UCF

Technical Symposium

Session I

9:45	The final ballet of a pair of colliding black holes: LIGO and the dawn of gravitational wave astronomy	David H. Reitze	Executive Director, LIGO lab, Caltech
10:15	Recent advances in ultrafast laser subtractive and additive manufacturing	Xiaoming Yu	CREOL, UCF

10:35 BREAK & EXHIBITS

Session II

10:55	LEDs, IoT and the future of illumination: Creative destruction in the lighting industry	Robert F. Karlicek, Jr.	Director, LESA, RPI
11:25	Predictive metrology: The next evolution of crystalline silicon PV manufacturing metrology	Winston Schoenfeld	CREOL, UCF & FSEC

Product Review

11:45	Photon-X	Blair Barbour
11:53	Harris Corporation’s Photonics Core Technology Center	Charles Middleton
12:01	Tower Optical	Mel Kantor

12:10 **LUNCH Served** Student Union

1:25	Reflections from SPIE	Eugene Arthurs	Executive Director and CEO, SPIE

Session III

1:45	Through a glass brightly	Donald Keck	Corning (Retired).
2:15	Advanced Functional Fabrics of America (AFFOA): From optical fibers to multifunctional textiles	Ayman Abouraddy	CREOL, UCF

2:35 BREAK & EXHIBITS

Session IV

2:55	Extreme light: Beyond the horizon	Gérard Mourou	Ecole Polytechnique, France
3:25	High energy lasers – impact today, innovation tomorrow	Martin Richardson	CREOL, UCF

Award Presentations

4:00	Distinguished Alumni Award	Gabriel Popescu	University of Illinois
	Special Distinguished Service Award	James Pearson	CREOL, UCF
4:15-5:15	Reception (Pegasus Lobby)		

The final ballet of a pair of colliding black holes: LIGO and the dawn of gravitational wave astronomy

David H. Reitze
LIGO,Caltech

Abstract: The first direct detections of gravitational waves in late 2015 were made possible by a forty year experimental campaign to design, build, and operate LIGO, the Laser Interferometer Gravitational-wave Observatory. In this presentation, I'll cover gravitational waves and what makes them so difficult to detect and at the same time such powerful and unique probes of the universe. Most of the presentation will focus on the interferometers, the LIGO detections and their astrophysical implications.

David Reitze holds joint positions as the Executive Director of the LIGO Laboratory at the Caltech and a Professor of Physics at the University of Florida. He received a Ph. D. in Physics from the University of Texas at Austin in ultrafast laser spectroscopy in 1990 and has worked extensively in the area of ultrafast spectroscopy and experimental gravitational-wave detection over his career. He has authored 250 publications, and is a Fellow of the American Physical Society and the Optical Society. As a member of the LIGO Scientific Collaboration, he was awarded a 2016 Special Breakthrough Prize in Fundamental Physics, the 2016 Gruber Foundation Cosmology Prize, and the 2017 Rossi Prize of the High Energy Astrophysics Division of the American Astronomical Society. In 2017, he was awarded the Award for Scientific Discovery by the National Academy of Sciences.

Xiaoming Yu
CREOL, The College of Optics & Photonics, UCF

Abstract: Current manufacturing landscape is on the verge of dramatic change under the influence of novel manufacturing concepts, such as additive manufacturing and cyber-physical systems. Laser-based material processing, currently playing an indispensable role in manufacturing, needs to reposition itself among other technologies in order to stand out as a driving force toward next-generation manufacturing. This talk will first present an overview of fundamental aspects of laser material processing. Emphasis will be on controlling the interaction between solid material (glass, semiconductor, metal) and laser field on temporal (ultrafast), spatial (nanometer), and spectral (EUV, MIR) domain. The second half of the talk will present a case study about recent advances in laser-based additive manufacturing, demonstrating how to harness the full potential of laser beam to achieve holographic-like, volume-at-a-time 3D printing. This talk highlights the challenges and opportunities in developing next-generation laser-based manufacturing technology.

Xiaoming Yu received his BS in Physics from Nankai University, China, in 2008, MS in Plasma Physics from Shanghai Institute of Optics and Fine Mechanics in 2012, and PhD in Industrial and Manufacturing Systems Engineering from Kansas State University in 2016. His research interest is in laser-matter interaction and laser-based advanced manufacturing.

LEDs, IoT and the future of illumination: Creative destruction in the lighting industry

Bob Karlicek
LESA, Rensselaer Polytechnic Institute

Abstract: Joseph Schumpeter's mid-20th century economic concept of creative destruction is being played out in real time in today's lighting industry. As LEDs and IoT team to bring new "Smart" features and services to lighting systems, a constant stream of invention and innovation across the entire illumination supply chain is drastically changing the lighting industry. This talk reviews the evolving design of efficient LED chips and packages, the development of novel fixtures, and the integration wireless communication, sensing and services. It will look at where some of the technologies called Smart Lighting are today, and makes some guesses at where they will be going in the near future.

Robert F. Karlicek, Jr. directs the Center for Lighting Enabled Systems & Applications (LESA) and is a Professor of Electrical, Computer and Systems Engineering at Rensselaer Polytechnic Institute. Before joining Rensselaer, he performed fundamental opto-electronics research and held technical management positions at AT&T Bell Labs, General Electric, W. L. Gore and Associates, as well as several high-tech startup companies. He obtained his Ph.D. in Physical Chemistry from the University of Pittsburgh and has over 45 published technical papers and 38 issued U.S. patents.

Predictive metrology: The next evolution of crystalline silicon PV manufacturing metrology

Winston Schoenfeld
CREOL, The College of Optics & Photonics, UCF
Florida Solar Energy Center (FSEC), UCF

Abstract: Metrology plays a critical role in manufacturing, widely used to verify conformance of products in the manufacturing line and serving to reduce yield loss through early detection of manufacturing process issues. The rapid drop in crystalline silicon (c-Si) photovoltaic (PV) market price in recent years has led to considerable constraints on insertion costs of PV metrology. This has greatly limited implementation of many metrology systems, driving a need for significant evolution in metrology solutions. In this presentation, I will outline how predictive metrology is emerging to create increased value though earlier detection in both the manufacturing process and in field deployed systems. Two examples will be covered: (1) flash quantum efficiency measurement of cells, and (2) calibrated electroluminescent imaging of modules.

Winston V. Schoenfeld is currently Director of the Solar Technologies Research Division(STRD) at FSEC and Associate Professor at CREOL, The College of Optics & Photonics at the University of Central Florida. He received his Ph.D. degree in materials science from the University of California, Santa Barbara (UCSB) in 2000, and holds an MS and BS in Materials Science and Engineering from the University of Florida. Prior to joining CREOL, Dr. Schoenfeld served as Device Manager at Uniroyal Optoelectronics, working in the area of high brightness light emitting diodes (LEDs), and later in 2003 founded Medical Lighting Solutions, Inc., a supplier of specialty LED lighting solutions for the medical and biomedical industries. He has authored/co-authored more than 120 refereed journal publications in the areas of photovoltaics, the epitaxial growth and properties of oxide semiconductors, oxide and nitride-semiconductor light emitting diodes, self-assembled quantum dots, e-beam nano-lithography, quantum information/networks, comprehensive modeling of nanowire devices, and solid-state nuclear material detection. Dr. Schoenfeld is a Fellow of SPIE, a Principal Editor for the Journal of Materials Research, and OPTO Program Track Chair of the MOEMS-MEMS in Photonics Track at SPIE Photonics West.

Photon X, Blair Barbour
Information through light using innovative 3D Sensor Systems

Harris Corporation's Photonics Core Technology Center, Charles Middleton
An industry leader in high-reliability, high-performance optical and photonic systems supporting today's military, government, and commercial customers

Tower Optical, Mel Kantor
Quality is not expensive, it is Priceless

Eugene Arthurs
CEO, SPIE, The International Society for Optics and Photonics

SPIE is the international society for optics and photonics. It advances emerging light-based technologies through interdisciplinary information exchange, continuing education, publications, patent precedent, career development, and advocacy. SPIE relies on hundreds of individuals who volunteer their time and talents in a variety of roles, influencing and shaping the Society to meet the needs of its members and constituents. In 2016, SPIE provided $4 million in support of education and outreach programs. SPIE recognizes accomplishments and meritorious service in the optics, photonics, optoelectronics, and imaging communities it serves through member recognition programs. Since 1959, SPIE has honored the best in optics and photonics for their significant achievements and contributions in advancing the science of light.

Eugene G. Arthurs joined SPIE staff as CEO in November 1999. Prior to this he was President and CEO of Cleveland Crystals Inc. (CCI) He joined CCI, a closely held company, in 1997 and after reorganizing the company he marketed and sold it at the end of 1998.

He joined Barr and Stroud PLC in Scotland as Head of the Laser Department in 1975. In 1980 he joined Quantronix Corporation in New York, leading laser applications development and then managing its business for the semiconductor equipment market. From 1983 to 1997, Eugene was with Oriel Corporation in Connecticut, initially as Vice President of Technology and Marketing and from 1991, as President. Oriel, originally a privately held corporation, was acquired by a venture capital company in 1987. He changed the business of Oriel to emphasize systems and instruments and in 1996 ThermoElectron Corp. acquired an increasingly profitable Oriel. Eugene became involved in Thermos's growth-by-acquisitions activities. During his time at Oriel, he played an active role on the Boards of Oriel Scientific Ltd., (London, UK), LOT Oriel GmbH, (Darmstadt, Germany) and he was a founder of Andor Technology Ltd. (Belfast, Northern Ireland), a company initially owned mostly by Oriel and later acquired by Oxford Instruments for $400 million.

Eugene received his B.Sc. (1st class honours) in 1972 in Physics, and his Ph.D. in 1975 in Applied Physics from Queens University Belfast, N. Ireland. His Ph.D. research was in generation and measurement of tunable ultrashort pulses. In 1973, he taught the M.Sc. class in optoelectronics at Queens while continuing his research. He then moved to Imperial College in London where he conducted U.S. Air Force sponsored research on lasers.

He is a member of the EU's Photonics21 Board of Stakeholders. He serves on the Steering Committee for the U.S. National Photonics Initiative. He is a member of the boards of Edmund Optics, Open Photonics, and Luminar Technologies Inc. He is an Advisor to the Economic Development Bureau of Taichung City (Taiwan), the Advisory Boards to the Canadian Institute for Photonics Innovation and the Scottish University Physics Alliance.

Donald Keck
Corning

Abstract: Forty-seven years ago, a technological syzygy of four inventions – including Corning's low-loss optical fiber – created the Information Age. Revisiting that remarkable milestone, we'll look at present status and future predictions of the world-changing impact of optical telecommunications.

Dr. Keck is currently a technology consultant and lecturer. He retired in 2002 as Vice President Technology for Corning Incorporated after 34 years. He was a member of the Corning (Keck, Maurer and Schultz) team that invented low-loss optical fiber in 1970. Dr. Keck's research areas include molecular spectroscopy, gradient index and aspheric optics, guided wave optics, optical fiber sensing, and optical fiber waveguides and communication. He has authored more than 150 papers and holds 38 patents.

Dr. Keck received his physics degrees from Michigan State University where he is a Distinguished Alumnus. He received an honorary D.Sc. degree from Rensselaer Polytechnic Institute.

Dr. Keck is an honorary member of the Optical Society of America, an inductee of the National Inventors Hall of Fame, a member of the National Academy of Engineering, and a Fellow of the IEEE. Among his awards are the Distinction in Photonics Award, the Department of Commerce American Innovator Award, and the President's National Medal of Technology and Innovation.

He has served on numerous boards and committees. These include - the committee that recommends the National Medal of Technology and Innovation winners to the US President, the oversight board for the National Institute of Standards and Technology (NIST). the Optoelectronics Industry Development Association (OIDA) Board, and the National Inventor's Hall of Fame Board, the board of PCO, Inc., a joint venture of Corning and IBM, and the Optical Society of America. Locally he has served on the American Red Cross, the Community Foundation, the Salvation Army, and the Science Center Boards. He is a Paul Harris Fellow of Rotary International.

Advanced Functional Fabrics of America (AFFOA): From optical fibers to multifunctional textiles

Ayman Abouraddy
CREOL, The College of Optics & Photonics, UCF

Abstract: New ideas related to the fabrication and functionality of optical fibers have led to a new paradigm: multimaterial fibers. Such fibers incorporate multiple materials with distinct optical, electronic, and thermo-mechanical properties that are incorporated into thin strands in which micro-scale and nanoscale features maintained over extended lengths yield new functionalities delivered in the form-factor of an optical fiber. Progress in fabrication strategies is leading to the potential for mass-producing multimaterial fibers that see, hear, sense, and communicate. This research program, initiated around 2001, is now reaching maturity and has recently been awarded a $300M US Army Manufacturing Innovation Institute (MII) – one of eight in the Nation – focused on the fabrication of multimaterial fibers and textiles, named AFFOA: Advanced Functional Fabrics of America. I will review this emerging field of research and its potential to make impact on society in the immediate future through the partnership between the government, private industry, and universities led by AFFOA.

Ayman F. Abouraddy received the B.S. and M.S. degrees from Alexandria University, Alexandria, Egypt, in 1994 and 1997, respectively, and the Ph.D. degree from Boston University, Boston, MA, in 2003, all in electrical engineering. In 2003 he joined the Massachusetts Institute of Technology (MIT), Cambridge, as a postdoctoral fellow working with Prof. Yoel Fink (Materials Science & Engineering) and Prof. John D. Joannopoulos (Physics), and then became a Research Scientist at the Research Laboratory of Electronics in 2005. At MIT he pursued research on novel multi-material optical fiber structures, photonic bandgap fibers, nanophotonics, fiber-based optoelectronic devices, and mid-infrared nonlinear fiber optics. He has also been engaged in investigating techniques that lead to sub-diffraction-limited resolution in optical microscopy and lithography. He is the coauthor of more than 65 journal publications, 130 conference presentations, and 55 invited talks; he holds seven patents, and has three patents pending. His research also encompasses quantum optics and quantum information processing. He joined CREOL, The College of Optics & Photonics, at the University of Central Florida as an assistant professor in September 2008 where he has since established facilities for fabricating new classes of polymer and soft-glass fibers for applications ranging from mid-infrared optics to solar energy concentration. He also continues to pursue his research testing the foundations of quantum mechanics and implementing optical realizations of quantum computation. He was awarded tenure and promoted to associate professor in August 2014.

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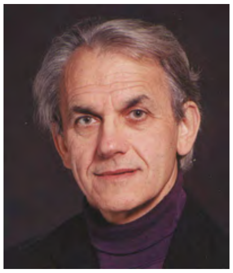
Gérard Mourou
Ecole Polytechnique, Palaiseau, France

Abstract: Hitherto, the laser has been very successful to study atomic physics. The possibility to amplify lasers to extreme peak power offers a new paradigm unifying the atomic and subatomic worlds, to include Nuclear physics, High Energy Physics, Astrophysics and Cosmology. This application needs extreme intensities. At the moment we are experiencing a rush toward the 10 PW led by the 3-pillar ELI infrastructure along with Apollon in France and similar infrastructures in Russia, USA, China and Korea.
The applications include x-ray and TeV /cm with the goal to go beyond the High Energy Standard Model and contribute to apprehending Cosmic Acceleration and revealing Dark Matter. The societal applications are also numerous with proton therapy, short-lived isotope production, nuclear waste transmutation and the like.



Gérard Mourou is Professor Haut-Collège at the Ecole Polytechnique and Director of the International Zettawatt Exawatt Science and Technology center at the Ecole polytechnique. He is also the A.D. Moore Distinguished University Emeritus Professor of the University of Michigan, Professor Mourou made numerous important contributions in the field of ultrafast lasers, high-speed electronics as well as in medicine where he introduced the field femtosecond ophthalmology.
However his most important one is the invention of the laser amplification technique universally known as Chirped Pulse Amplification (CPA) at the university of Rochester(NY). He opened a new branch of optics with Multiphoton Ionization, attosecond generation, relativistic optics, where laser-matter interaction is dominated by the relativistic character of the electrons. He is the initiator of the largest laser infrastructure ELI new infrastructure called ELI (Extreme Light Infrastructure) distributed over three pillars located in Czech Republic, Romania, and Hungary.
Professor Mourou is Member of the US National Academy of Engineering, foreign member of the Russian Science Academy, Austrian Sciences Academy and of the Lombardy Academy for Sciences and Letters.He received many awards including: Recipient of the 2007 Grand Prix Carnot from the French National Academy, Recipient of the 2009 Charles H. Townes Award from the Optical Society of America and F. Ives/J. Quinn Award 2016 from the OSA.

Martin C. Richardson
CREOL, The College of Optics & Photonics, UCF

Abstract: The last decade or more has seen both dramatic improvements in the capabilities of high power lasers, in some circles increasingly being referred to as High Energy Lasers, and their applications in fields as disparate as new manufacturing technologies and multiple defense and security technologies. The improvements in laser performance result from continual developments occurring in high-brightness pump diodes, together with the adoption of new solid-state and fiber laser architectures, to date largely with neodymium, ytterbium and thulium active laser media. The availability of efficient, compact commercial systems with average powers increasing from kilowatts to the 100 kilowatt range in just the past few years, with corresponding reductions in cost and complexity, is enabling rapid growth of new laser applications in many industries. This presentation will review the engineering and development paths of high power lasers particularly in the manufacturing and defense/security sectors, in the frame of identifying future trends, opportunities and growth areas. The impact of new materials and pump sources, accelerated by the demands current applications, and new opportunities for laser applications in space, portends exciting progress in the high power laser field within the next decade.

Martin Richardson's career in building high power lasers began with his thesis project which was not only one the most powerful lasers then in the UK, but also the noisiest! He is an expert in the interaction of high power laser light with matter. His was one of the first experiments to create plasmas with ultrafast lasers. He has lead major government laser fusion programs in Canada and U.S., initially involving his development of the high-power TEA CO2 laser, and subsequently using the OMEGA facility at the University of Rochester. Joining UCF in 1990, he created a laboratory focused on high power and ultra-short pulse lasers and laser plasmas, He founded the Townes Laser Institute in 2007. His laboratory of ~ 30 scientists, engineers and students, addresses laser development (high power fiber, high energy, and ultrafast lasers), light filamentation, femtosecond laser interaction studies, laser-plasma studies, laser materials processing, high power laser propagation and stand-off laser sensing technologies. Richardson has an intense interest in the education of his students. In Canada he enabled students to pursue their Ph.D's at NRC, a government laboratory. He co-founded the first NSF International REU program, and initiated an Atlantis international MS degree program. Some of his students gain co-tutelle Ph.D degrees with the University of Bordeaux. He interests include advancing science in under-developed countries, and enabling equal rights for women through science. He has advised > 75 graduate students from eight universities including UCF, and has held visiting positions at scientific institutions in France, Germany, UK, Japan, Australia, Qatar, Saudi Arabia and the Soviet Union, and is currently a visiting professor at NTU. He has published over 460 scientific articles, holds ~ 25 patents, has chaired many international conferences and has brought over $50M in research grants to UCF, plus the large ($24M) Northrop Grumman donation. He is the recipient of many awards including the Schardin Medal, the Harold E. Edgerton Award, Docteur Honoris Causa' (Bordeaux), and is a Fellow of OSA, APS, JSPS, IEEE, SPIE IoP, and AAAS. He was a Jefferson Science Fellow of the National Academy of Sciences at the State Department in 2014-2015. In 2016 he was awarded the Fulbright-Tocqueville Distinguished Chair at the University of Bordeaux.

Mathias Fink
Langevin Institute

Abstract: Because time and space play a similar role in wave propagation, wave control can be achieved or by manipulating spatial boundaries or by manipulating time boundaries. Here we emphasize the role of time boundaries manipulation. We show that sudden changes of the medium properties generate instant wave sources that emerge instantaneously from the entire wavefield and can be used to control wavefield and to revisit the holographic principles and the way to create time-reversed waves. Experimental demonstrations of this approach with water waves will be presented and the extension of this concept to acoustic and electromagnetic waves will be discussed. More sophisticated time manipulations can also be studied in order to extend the concept of photonic crystals and wave localization in the time domain.

Mathias Fink is a professor of physics at the Ecole Superieure de Physique et de Chimie Industrielles de la Ville de Paris (ESPCI ParisTech), Paris, France. In 1990 he founded the Laboratory Ondes et Acoustique at ESPCI that became in 2009 the Langevin Institute. In 2002, he was elected at the French Academy of Engineering, in 2003 at the French Academy of Science and in 2008 at the College de France on the Chair of Technological Innovation. He has received several scientific awards as the CNRS medal of innovation, the Rayleigh Award of the IEEE Ultrasonics Society (2012), the ERC SYNERGY Grant (European Research Council) for the HELMHOLTZ project (2013) and the Edwin H. Land Medal of the Optical Society of America (OSA), 2014

Mathias Fink's area of research is concerned with the propagation of waves in complex media and the development of numerous instruments based on this basic research. His current research interests include time-reversal in physics, wave control in complex media, super-resolution, metamaterials, multiwave imaging, and telecommunications. He has developed different techniques in medical imaging (ultrafast ultrasonic imaging, transient elastography, supersonic shear imaging). He holds more than 70 patents, and he has published more than 400 peer reviewed papers and book chapters. 6 start-up companies with more than 300 employees have been created from his research (Echosens, Sensitive Object, Supersonic Imagine, Time Reversal Communications, CardiaWave and GreenerWave).

2017 Distinguished Alumni Award

Gabriel Popescu

Gabriel Popescu is an Associate Professor in Electrical and Computer Engineering, University of Illinois at Urbana-Champaign. He received his Ph.D. in Optics in 2002 from the School of Optics/ CREOL (now the College of Optics and Photonics), University of Central Florida. Dr. Popescu continued his training with Michael Feld at M.I.T., working as a postdoctoral associate. He joined Illinois in August 2007 where he directs the Quantitative Light Imaging Laboratory (QLI Lab) at the Beckman Institute for Advanced Science and Technology. Dr. Popescu served as Associate Editor of Optics Express and Biomedical Optics Express, Editorial Board Member for Journal of Biomedical Optics and Scientific Reports. He authored a book, edited another book, authored 130 journal publications, 200 conference presentations, 32 patents, gave 165 lecture/plenary/invited talks. Dr. Popescu founded Phi Optics, Inc., a start-up company that commercializes quantitative phase imaging technology. He is OSA Fellow and SPIE Fellow.

Special Distinguished Service Award

James Pearson

James Pearson is Special Consultant, CREOL, The College of Optics and Photonics at the University of Central Florida. He received his PhD in Electrical Engineering & Physics in 1972 from the California Institute of Technology. In his duties at UCF, he is responsible for marketing and industry outreach of CREOL, and for the development and maintenance of effective relationships with a wide variety of individuals, companies, and organizations for the purpose of establishing research partnerships and funding in areas of interest to the UCF faculty. He leads the evaluation of selected partnership opportunities and related proposal efforts, and supports other UCF programs related to the objectives of the UCF Office of Research and Commercialization. Prior to joining UCF in 2004, Dr. Pearson held the positions of Executive Director of ISA – The Instrumentation, Systems, & Automation Society from 1999 – 2004, and Executive Director of SPIE – The International Society for Optical Engineering from 1993-1999. From 1976 – 1993, he held several positions within United Technologies Corporation, including Chief Scientist at United Technologies Research Center, and President & General Manager of United Technologies Optical Systems. He is a Life Fellow of SPIE, a Fellow of OSA, and a Senior Member of IEEE.

Exhibitors

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Student of the Year Presentation

Novel photonic resonant arrangements using non-Hermitian Exceptional Points

Hossein Hodaei

In recent years, non-Hermitian degeneracies, also known as exceptional points (EPs), have emerged as a new paradigm for engineering the response of optical systems. Among many different non-conservative photonic configurations, parity-time (PT) symmetric arrangements are of particular interest since they provide an excellent platform to explore the physics of exceptional points. In this talk, I will show how the intriguing properties of exceptional points that are arising in judiciously designed parity-time-symmetric systems can be utilized to address two of the long standing challenges in the field of integrated photonics: enforcing single mode lasing in intrinsically multimode cavities, and enhancing sensitivity of micro-resonators.

Hossein Hodaei is a PhD student in Dr. Khajavikhan's Plasmonics and Applied Quantum Optics (PAQO) Group. His research is focused on novel semiconductor lasers and non-Hermitian optics. He has published 6 first-authored journal papers and coauthored 9 additional journal papers. He has also presented his research in prominent conferences in optics like CLEO and SPIE Photonic West.

Student Presentations

Low-loss and fast-response liquid crystals for infrared applications

Fenglin Peng

In addition to displays, liquid crystal (LC) is also a strong contender for infrared (IR) photonic devices, such as adaptive optics, laser beam steering, and dynamic scene projectors. The major challenges for IR LC devices are twofold: large absorption loss and relatively slow response time. In the IR region, several fundamental molecular vibration bands and overtones exist, which contribute to high absorption loss. The absorbed light turns to heat and then alters the birefringence, which in turns causes spatially nonuniform phase modulation. In this talk, I will describe the molecular engineering processes leading to the development of new low loss chlorinated LC mixtures in the mid-wave infrared (MWIR) region. The transmittance is >98% with 2π phase change. Meanwhile, by forming polymer network, I have demonstrated a MWIR phase modulator with response time 100x faster than that using a conventional nematic LC.

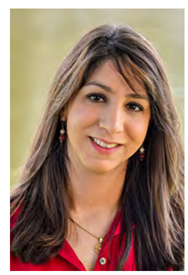
Fenglin Peng is currently a PhD student in Prof. Shin-Tson Wu's research group. She received her B.S degree in Optical Engineering from Zhejiang University in 2012. Her research mainly focus on novel liquid crystal materials and devices for display and photonics applications. Fenglin received SPIE Optics and Photonics Education Scholarship in 2016. She has published one book chapter, 26 journal papers and 18 conference proceedings.

New manifestations of mesoscopic interactions in complex media

Roxana Rezvani Naraghi

Mesoscale optics defines a framework for understanding a wide range of interactions in fields as diverse as biological tissues, optical coatings, colloidal and polymer fluids, fabricated nanostructures, etc. When light interacts with such complex systems, the outcome depends strongly on the length and time scales of the interaction. Mesoscale optics offers a framework for understanding manifestations of wave phenomena such as interference and phase memory in complex media. Approaches specific to mesoscale optics provide the necessary quantitative descriptions that neither microscopic nor macroscopic models of light-matter interaction can offer.

In this talk I will present a brief survey of fundamental concepts, approaches, and techniques specific to light-matter interaction at mesoscopic scales. I will then introduce a novel approach for analyzing particular aspects of light propagation in dense composite media and I will provide evidence that the wave nature of light can be critical for understanding its propagation in unbounded, highly scattering materials. The talk will demonstrate that the perceived diffusion of light is actually subject to competing mechanisms of interaction that lead to qualitatively different phases for the light evolution through complex media. Finally, I will discuss implications for the ever elusive localization of light in three-dimensional random media.



Roxana Rezvani Naraghi is currently a PhD student in Dr. Dogariu's group. She received her B.Sc. in Condensed Matter Physics, and M.Sc. in Atomic, Molecular and Optical Physics from University of Tehran in 2009 and 2012, respectively. She also received a M.Sc. in Optics and Photonics from University of Central Florida in 2015. Her research is focused on using statistical optics to quantify properties of complex media, develop non-invasive sensing techniques, and design photonic structures with unique scattering features. She has authored and coauthored 29 publications in refereed journal papers, conference proceedings and patents.

Second-harmonic generation in periodically-poled and poling-free lithium niobate on silicon waveguides

Ashutosh Rao

Modern large-scale integrated photonics typically relies on centrosymmetric materials, such as silicon, which intrinsically lack second-order optical nonlinearity. Three-wave mixing through the second-order optical nonlinearity in non-centrosymmetric materials, such as lithium niobate, has enabled various regimes of frequency conversion, such as frequency doubling, parametric processes, and spontaneous parametric down conversion. In this talk, I will walk through the process of designing, fabricating, and testing nonlinear lithium niobate waveguides on silicon to demonstrate second-harmonic generation. The waveguides are formed by the transfer of lithium niobate films, less than a micron thick, to silicon substrates by wafer bonding, and are therefore compatible with large-scale silicon photonics. Two classes of waveguide frequency converters will be discussed, which are periodically-poled and poling-free nonlinear waveguides, along with their potential applications.

Ashutosh Rao joined CREOL as a PhD student in Dr. Fathpour's group after receiving a combined Bachelors and Masters in Technology in Engineering Physics from the Indian Institute of Technology, Bombay. His research has primarily focused on high-speed electro-optic modulators and nonlinear optics in thin film lithium niobate on silicon. He is the first author of three peer-reviewed journal articles, and has co-authored a total of 17 journal articles and conference proceedings.

Posters

Poster 1

High-performance electrooptic modulation and second-harmonic generation in thin film lithium niobate on silicon

Ashutosh Rao,[1] Aniket Patil,[2,a)] Marcin Malinowski,[1] Jeff Chiles,[1,b)] Saeed Khan,[1] Amirmahdi Honardoost,[3] Seyfollah Toroghi, [1,c)] Guillermo F. Camacho-González,[1] Payam Rabiei,[2] Richard DeSalvo,[4] Arthur Paolella,[4], Sasan Fathpour [1,3,]*
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Lithium niobate has been the conventional material of choice for high-speed electro-optic modulators and nonlinear optics. In this work, thin films of lithium niobate are integrated onto silicon substrates using room-temperature wafer-scale bonding to form compact submicron low-loss (1 dB/cm) waveguides. The waveguides are used to demonstrate linear Mach-Zehnder modulators in the telecom C band at 1550 nm, operating up to 50 GHz RF modulation, with 33 GHz electrical bandwidth, 18 dB extinction ratio, and third-order intermodulation spurious free dynamic range around 95 dBHz$^{2/3}$ up to 10 GHz at milliwatt levels of continuous wave optical power. The half-wave voltage length product is 3.1 V.cm at DC, and less than 6.5 V up to 50 GHz. The performance demonstrated by the thin-film modulators is on par with commercial lithium niobate modulators but with lower drive voltages and smaller form-factor, a prime candidate for next-generation data center and RF photonic transceivers. Nonlinear optical frequency conversion is demonstrated in the thin film waveguides using two approaches – periodic poling, and a poling-free waveguide grating-assisted quasi-phase matching technique, called mode shape modulation. Second harmonic generation is achieved by both approaches, using pulsed pumping near 1560 nm. The 4-mm-long poled waveguides exhibit 8% power conversion. The novel mode-shape modulation approach can in principle be applied to any second-order nonlinear optical waveguide, notably materials which cannot be periodically poled. In summary, two widely used capabilities, high speed electro-optic modulation and nonlinear optical frequency conversion, of bulk lithium niobate waveguide devices are comprehensively transferred to thin-film lithium niobate on silicon, paving the way for large scale integration with silicon photonics in CMOS foundries.

Poster 2

Image transport through silica-air random core fiber

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A silica-air random core optical fiber with high air-hole-fill-fraction (~26%) in the 270µm diameter core and low attenuation on the order of 1 dB per meter has been fabricated. Transverse Anderson localization is observed by sending a 976nm laser beam into a 4.6-cm-long random core fiber sample. Transport of images, numbers from a USAF resolution test target, through this fiber is demonstrated.

Poster 3

Integrated polarization control via topographically anisotropic photonics

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A novel class of integrated photonic platforms is proposed and demonstrated for polarization control. Polarization control in integrated photonics is important for polarization-diverse telecommunication, polarimetric imaging, and other applications. These applications require large bandwidth and low loss. In this design, isotropic and anisotropic material configurations are used to create waveguides capable of supporting only one polarization. Implemented on silicon nitride, configurations are devised for devices supporting only transverse electric (TE) or transverse magnetic (TM) modes. These structures are combined into a polarization beam-splitting device (PBS) that greatly outperforms current technology. The PBS has a bandwidth of 116 THz corresponding to > 0.5 octaves, which is over three times greater than existing technology. In addition, the PBS has an extinction ratio greater than 15.9 dB, and an insertion loss less than 1.2 dB, which is over 2.8 times better than current technology. This design concept is also applied to beam-taps (BTs) and micro-ring resonators that are each cloaked to one polarization and visible only to the orthogonal polarization. TE-coupling BTs have coupling ratios for TE light that are over 25 times that for TM light. Similarly, TE-resonant micro-ring resonators are entirely cloaked to TM light, and show an unloaded Q-factor of ~30,000. Future work is being done to further improve the bandwidth and overall performance for these devices, as well as to create new devices useful for polarization control using this design.

Poster 4

Femtosecond-nanosecond dual-pulse laser ablation

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Laser ablation of GaAs is investigated under a collinear femtosecond-nanosecond dual-pulse configuration. The amount of material removed by a single femtosecond-nanosecond dual pulse can be enhanced by optimizing the inter-pulse delay. In this experiment, the size and depth of craters generated by a single shot are used to determine the ablation rates for inter-pulse delays ranging from 0 to 50 ns. Furthermore, a shadowgraph technique is used to capture the ejected plasma of ablated material via pump-probe imaging with the femtosecond laser. Shockwave analysis of the expanding plasma plume is used to determine the amount of laser energy that goes into material removal. This investigation provides insight to the fundamental ablation mechanisms involved at different pulse delays and the specific roles of the femtosecond and nanosecond pulses in enhancing material removal.

Poster 5

Hemispherical focal plane arrays

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Larger field of view(FOV) is always being pursued in optical system design since it can extend the observation angle and collect more information. An imager with hemispherical sensor arrays, just like the retina of human eye, can be more compact than conventional wide angle lens like fisheye lens and thus has potential economic benefit. We are trying to demonstrate a way to build up a curved focal plane arrays based on a popular elastomer in recent years-polydimethylsiloxane(PDMS). Applying PDMS on the back side of silicon based photodetectors and dicing silicon wafer into small islands by etching technique. A vacuum mold is designed to deform the circuit into a hemispherical shape. This fabrication flow is suitable for converting CMOS based image sensors into hemispherical sensors. We are trying make a 1-megapixel imager with high-resolution imaging sensor across a 160° FOV with this process.

Poster 6

The effect of sulfur vapor flow on the properties of MoS2 grown by LPCVD

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Highly textured MoS_2 were grown by low-pressure chemical vapor deposition. The effect of turning off sulfur vapor flow during the cooling cycle at 1000, 900, 800 and 700 ºC has been investigated. Turning off sulfur vapor flow at 700 ºC leads to the growth of MoS_2 with the highest mobility (20 cm^2/Vs) and best crystallinity. Turning off sulfur vapor flow at 1000 °C leads to the growth of MoO_x as the main phase due to the presence of small amount oxygen, the absence of sulfur, and high thermodynamic stability of MoO_x at this high temperature. At the lower temperatures 900 and 800 ºC, the growth of MoS_2 dominates. The as-grown MoS_2 has p-type conductivity. The structure quality of the grown films has been studied by x-ray diffraction and Raman spectroscopy. The electrical transport properties of the grown films have been investigated by Hall effect measurements. The mobility increases by 35% when increasing temperature to 220 oC, which is very promising for devices with high operating temperatures, such as transistors and solar cells. The optical constants of the grown films have been determined from the transmittance and reflectance in the 200-2500 nm range.

Poster 7

Diagnostics of refractive index modifications induced by laser filamentation

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For a laser pulse with peak power above a critical value, the refractive index of the nonlinear medium is modified according to the pulse intensity profile, causing the beam to self-focus and thus generate plasma. The Kerr lensing is counterbalanced by the defocusing effect of the plasma, producing a weakly ionized channel called a filament. The refractive index modification induced by filamentation motivates the use of arrays of filaments as waveguides. In addition, the conductivity of the plasma channel can be used to trigger and guide electric discharges. These applications require a thorough characterization of filament dynamics. In this study, an interferometric technique is used to probe the filament induced refractive index modification of the propagation medium. Temporally and radially resolved direct measurements of the Kerr effect and plasma density are discussed, for different initial conditions, and compared with simulation.

Poster 8

Annular core photonic lantern OAM mode multiplexer

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Orbital angular momentum beams are characterized by a helical phase front of exp(ilφ) where, l is an integer, referred to as topological charge number and φ is the azimuthal angle. Due to intrinsic spatial orthogonality of the OAM beams with different topological charge numbers, OAM states have gained considerable interest for a variety of applications in classical and quantum optics. Here, we report the first demonstration of an all-fiber ring core photonic lantern mode multiplexer as a compact, scalable and robust OAM mode generator. Our device is a 5-mode mode selective photonic lantern (MSPL) with an annular refractive index profile which is fully compatible with well-established ring core and vortex delivery fibers. Through simultaneous excitation of the pairs of degenerate linearly polarized (LP) modes of the MSPL, we demonstrate the generation of high quality OAM beams up to the second order. Modes with topological charges of ±1 and ±2 are characterized. By splicing the end-facet of the device to a ring core fiber, we achieve low-loss coupling of OAM modes while maintaining high contrast spiral phase patterns. Furthermore, our results demonstrate the great potential of PLs for generating complex optical beams.

Poster 9

Wavelength tunable dual channel solid state laser for terahertz difference frequency generation

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The generation of tunable narrowband terahertz (THz) radiation has shown much interest in recent years. THz systems are used for rotational-vibrational spectroscopy, nondestructive inspection, security screening and others. Monochromatic THz emission has been generated by means of THz parametric oscillation, nonlinear difference frequency generation, and quantum cascade lasers. Intracavity difference frequency generation (DFG) in the nonlinear crystal gallium arsenide (GaAs) is known as an efficient way to generate a continuous wave THz radiation. A novel high power solid state resonator is presented with the use of volume Bragg grating (VBG) technology to create a dual channel system by spectral beam combination. The system consists of two separate Tm:YLF crystals and two VBGs for narrowband wavelength selection. At the end of the resonator both channels share common spherical mirrors, which provide feedback and focuses the beam for nonlinear purposes. This allows each channel to be independent in power and wavelength, eliminating gain competition and allowing individual wavelength tunability. The VBGs are recorded in photo-thermo-refractive glass, which has a high laser induced damage threshold and can withstand the high intracavity power present in the resonator. Tunability of the system has shown spectral spacing from 5 to 20 nm, 0.4 - 1.7 THz, and intracavity continuous wave power levels from 80 to 100 W. By placing the GaAs crystal near the waist, THz radiation can be extracted from the cavity.

Poster 10

Complex holographic elements in photo-thermo-refractive glass for the visible spectral region

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Planar holographic optical elements (volume Bragg gratings, VBGs) recorded in photo-thermo-refractive (PTR) glass are widely used for fine spectral filtering and laser beam control. PTR glass provides photosensitivity in near UV region. Therefore, while planar holographic elements operate in the whole window of transparency - near UV, visible and near IR spectral regions, application of complex (nonplanar) elements is restricted to near UV. A method has been proposed to create high-efficiency diffractive optical elements in PTR glass using visible light. The method employs excited state absorption in PTR glass doped with Tb^{3+}. UV radiation was used for excitation to a metastable level of Tb^{3+} and pulsed radiation at 532 nm was used for hologram recording. Both planar VBGs and holographic lenses operating at 532 nm were demonstrated. Complex holographic optical elements in PTR glass can provide attractive solutions for lasers and spectroscopy replacing conventional optical components.

Poster 11

Supercontinuum generation on chalcogenide platform and subsequent amplification for CEO offset measurement

Marcin Malinowski,[1], *Guillermo Fernando Camacho Gonzalez*[1] , *Ashutosh Rao*[1], *Michael Plascak*[1] , *Peter Delfyett,*[1,2], *Sasan Fathpour*[1,2]*
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The chalcogenide glasses are promising materials for integrated photonics due to their transparency in mid-infrared and high optical nonlinearity. We demonstrate an octave spanning TM-supercontinuum generation on this platform. A 20-MHz Calmar mode-locked laser is used as the seed. The pulses are amplified to 45kW peak power and compressed to 120fs in a custom made EDFA . The 1.9-um portion of the spectrum is amplified in a custom made Thulium doped fiber amplifier pumped at 1565 nm. The amplification is necessary to achieve efficient second harmonic (SHG) generation on a bulk periodically poled lithium niobate (PPLN) device. In the nearest future the SHG signal will be mixed together with the 950 nm portion of the supercontinum spectrum to produce the carrier envelope offset signal that can be used to stabilize the frequency comb.

Poster 12

Effect of deposition method on morphology of TiO2 thin films

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Self-assembled TiO2 films deposited by different aqueous-spray recipes and by electron-beam evaporation were compared to evaluate morphology, crystalline phase, and optical transparency. All three deposition methods produce highly transparent films. One of the spray recipes and evaporation produce smooth films of Anatase nano-crystalline structure. The second spray recipe produces a highly-textured TiO2 film of Brookite phase. The morphology of this ~1 μm thick film is ropy and tangled with individual strands of ~200 nm diameter and open pores of 0.1 to 3 micron dimensions. Such films are attractive as electron conductor of unprecedented thinness and flexibility for proposed perovskite solar cell comprising CH3NH3PbI3 absorber with additional inorganic films as contact and conduction layers. The spray deposition method would allow conformal solar cell fabrication on flexible substrates for wearable power generation.

Poster 13

Excited-state nonlinearities of Ir(III) complexes

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We have done a comprehensive investigation of the Iridium (III) complexes to comprehend their interesting and complicated linear and nonlinear photo-physical properties. Ir (III) complexes have large spin-orbit effects that results in fast intersystem crossing rates (~picosecond) and large quantum yields (>0.8) from singlet to triplet states. In addition to that, using a transition metal with d6 orbital in the complex exhibits metal to ligand charge transfer.

In order to decouple the triplet cross-section and triplet quantum yield of singlet to triplet transition, a conventional pump-probe is not enough and as a result we use a double pump-probe experiment. We have performed double-pump probe experiments using a Nd:YAG laser from Ekspla with a

10 Hz repetition rate and 30 ps pulsewidth (FWHM) frequency –tripled to generate two pump pulses at 355 nm separated from each other by 6.5 ns. Then we used an electronic model with a double minimum excited state potential energy surface to fit our data.

Poster 14

Phase control of filamenting beams

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Filaments are attractive for many long-range applications such as white-light LIDAR, stand-off spectroscopy and microwave guiding. Energy scaling well beyond the single filament level is often required for such applications. Effective engineering of filament arrays requires control at both preparation and propagation stages. This study focuses on spatial control and stabilization as well as phase manipulation for long range propagation. The analysis presented here highlights the significance of wavefront distortions and demonstrates the use of phase phase plates to form filament arrays over 20 meter propagation.

Poster 15

Mode characterization of fiber lasers under load

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The next generation of high-brightness Yb:silica fiber amplifiers must overcome significant modal distortion in the form of Transverse Modal Instability (TMI) to push power densities beyond kW/m levels. A characterization facility is under development to study power, efficiency, and transverse mode content of novel fiber designs under load. This facility features kW-class power scaling capabilities and diagnostics that include spatio-temporal frequency analysis of mode content, interferometric determination of mode field and phase profiles through fibers under extreme load, as well as more common beam characterization techniques. Results from these measurements have already provided direct feedback to our collaborative fiber design and fabrication efforts.

Poster 16

Time-Resolved nonlinear refraction and absorption of indium tin oxide at epsilon near zero

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Indium tin oxide (ITO) is a common transparent conductive oxide with various applications in photonic devices. The nonlinear refraction of ITO is enhanced in spectral regions where the real part of the permittivity is near zero. This enhancement is attributed to the dependence of the nonlinear response on the linear index as described by $\Delta n=\Delta\varepsilon/2\sqrt{\varepsilon}$ where □n is the material's change in index of refraction and ε is the real part of the electric permittivity. We use our Beam-Deflection (BD) technique to perform time-resolved direct measurements of the nonlinear refraction and absorption of ITO in this Epsilon-Near-Zero (ENZ) regime. We measure a ~ 5000 × larger magnitude of the effective nonlinear refraction than that for a standard glass. The ultrafast dynamics of the nonlinear refraction and absorption is due to the hot carrier scattering mechanisms. This enhancement in ultrafast nonlinear refraction may have applications for all-optical switching.

Poster 17

Using fluctuations in coherent scattering for sensing through obscurants

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The ability to characterize an object obscured by other scattering objects is of paramount importance due to its application in different areas e.g. biomedical and sensing. In recent years, remarkable advances have been achieved in imaging and sensing different objects thorough a turbid medium. However, usually these methods are either in conjunction with a complex computational method or elaborated optical instruments which may be impractical for characterizing dynamics objects.

We exploit the enhanced fluctuations of integrated scattered intensity from random scattering potentials illuminated sequentially by non-stationary probing fields that can be obscured by turbid media. Proposed approach can provide information about both the characteristic length of the target and the motion of the scattering potential's center of mass. We will show that this problem can be approached by exploiting active Stochastic Optical Sensing in which information carrier is statistical properties of the integrated scattered intensity from the targeted potential under stochastic illumination.

Poster 18

High-speed compressive range imaging based on active illumination

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We report a compressive imaging method based on active illumination, which reconstructs a 3D scene at a frame rate beyond the acquisition speed limit of the camera. Our imaging system prototype projects temporally varying illumination patterns and demonstrated a joint reconstruction algorithm that iteratively retrieves both the range and high-temporal-frequency information from the 2D low-frame rate measurement. The reflectance and depth-map videos have been reconstructed at 1000 frames per second (fps) from the measurement captured at 200 fps. The range resolution is in agreement with the resolution calculated from the triangulation methods based on the same system geometry.

Poster 19

Octave-spanning supercontinuum generation in low-loss chalcogenide waveguides on silicon

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Over an octave span of supercontinuum (SC) generation is demonstrated at telecom wavelengths in Ge23Sb7S70 chalcogenide waveguides. Taking advantage of the material's high nonlinearity, we engineer the waveguides' dispersion to be anomalous at the pump central wavelength of ~ 1.55 μm for both transverse-electric (TE) and transverse-magnetic (TM) polarizations pumping. Fabrication process through photolithography and dry etch is described for low-loss waveguides. The anomalous dispersions and the low-loss waveguides allow efficient coherent SC to be achieved. Characterization of the devices is performed using a femtosecond mode-lock laser to generate SC extending from ~ 895 to 2150 nm.

Poster 20

Environmental test of quantum dot light emitting diode

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Quantum dot Light emitting diodes (QD-LED) are a promising technology for lighting and displays due to their low-cost fabrication over large areas and superior color quality compared to organic LEDs (OLED) currently used in displays. One of the key challenges for this technology is improving the lifetime of devices, especially during operation at high brightness. The degradation mechanisms in QD-LEDs is not well understood, but is expected to be due to a combination of physical (i.e. heating, electrostatic breakdown, metal diffusion, etc.) and chemical processes (i.e. reactions of ligands or charge transport layers with atmospheric gases). Packaging QD-LEDs has been shown to significantly extend their lifetime indicating that chemical degradation due to interaction with the environment is likely the primary mode of degradation. Here we investigate the degradation of QD-LEDs by exposing them to controlled atmospheres while monitoring the emission spectrum and intensity of the LEDs under constant drive current. Comparing the evolution of the brightness and spectrum of QD-LEDs exposed to combinations of N2, O2 and H2O provides insight into the photophysical degradation mechanisms in these devices.

Poster 21

X-ray coherent scattering tomography of textured material

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Small-angle X-ray scattering (SAXS) measures the signature of angular-dependent coherently scattered X-rays, which contains richer information in material composition and structure compared to conventional absorption-based computed tomography. SAXS image reconstruction method of a 2 or 3 dimensional object based on computed tomography, termed as coherent scattering computed tomography (CSCT), enables the detection of spatially-resolved, material-specific isotropic scattering signature inside an extended object, and provides improved contrast for applications in medical diagnosis, security screening, and material characterization. However, traditional CSCT methods assume materials are fine powders or amorphous, and possess isotropic scattering profiles, which is not generally true for all materials. Anisotropic scatters cannot be captured using conventional CSCT method and result in reconstruction errors. To obtain correct information from the sample, we designed new imaging strategy which incorporates extra degree of detector motion into X-ray scattering tomography for the detection of anisotropic scattered photons from a series of two-dimensional intensity measurements. Using a table-top, narrow-band X-ray source and a panel detector, we demonstrate the anisotropic scattering profile captured from an extended object and the reconstruction of a three-dimensional object. The presented method demonstrates the potential to achieve low-cost, high-specificity X-ray tissue imaging and material characterization. For materials possessing a well-organized structure with certain symmetry, the scatter texture is more predictable. In this case, we will also discuss compressive schemes that can be implemented in data acquisition for improved collection efficiency and accelerated the imaging process.

Poster 22

Stimulated brillouin scattering thresholds when amplifying a variable pulse duration, narrow-linewidth 2 μm fiber laser

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The nonlinearity that limits power scaling of narrow-linewidth fiber lasers is stimulated Brillouin scattering (SBS). Most nonlinearities scale with wavelength, however SBS is typically assumed not to. In this work, a <1 MHz linewidth 2053 nm source is constructed with variable repetition rate and variable pulse duration (as low as 30 ns) to study SBS thresholds. The threshold for SBS is examined for varying pulse durations, which shows significant enhancement for shorter pulse durations. This can be understood in the frequency domain, in which shorter pulse durations lead to broader bandwidths. Henceforth, the broader bandwidth has reduced overlap with the Brillouin bandwidth. From this, the pulse bandwidths are measured and compared to theoretical SBS thresholds. The analysis shows that the peak Brillouin gain coefficient is ≈3.0 X 10-11 m/W which is typical for silica fibers. The stimulated Brillouin bandwidth is ≈4.4 MHz, which follows the theoretical λ-2 dependence. Therefore, there is no wavelength dependence on a typical SBS threshold for fiber lasers. Fortunately, the Brillouin bandwidth decreases with wavelength. This means that a 2 μm source with the same bandwidth as a 1 μm source allows higher SBS threshold enhancement.

Poster 23

Instantaneous spectral span of 2.9 - 8.5 μm achieved in a Cr:ZnS laser pumped subharmonic GaAs OPO

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Degenerate (subharmonic) optical parametric oscillators (OPO) show great promise for the generation of broadband mid-infrared (MIR) frequency combs. Their main features are low pump threshold, dramatic extension of the spectrum of the pump laser, and phase locking to the pump frequency comb [1]. Here we report on obtaining instantaneous spectrum ranging from 2.9 to 8.5 μm at -40 dB level from a subharmonic OPO pumped by an ultrafast Cr2+:ZnS laser. Our experimental setup includes a free running Kerr lens mode locked 2.35 μm Cr2+:ZnS laser, with 62-fs time-bandwidth limited pulse duration, 630-mW average power, and 79 MHz repetition rate that synchronously pumps a ring-cavity orientation-patterned (OP-GaAs) based OPO. A 0.5-mm-long OP-GaAs crystal has a quasi-phase-matching (QPM) period of 88 μm and is designed to provide a broadband parametric gain at OPO degeneracy. A 0.3-mm-thick ZnSe wedge inside the cavity was used to minimize group velocity dispersion. Spectral span of 1.56 octaves in the MIR that we achieved can be further improved by fabricating an in-coupling dielectric mirror with (i) broader reflectivity range and (ii) with compensation of the residual group velocity dispersion. The broad spectrum achieved, 2.9 - 8.5 μm (2280 cm-1 wide instantaneous span), overlaps with a plethora of fundamental molecular IR resonances and can be used for frequency comb spectroscopic detection applied to such fields as remote sensing, study of fast combustion dynamics and medical diagnostics, to name a few.

Reference:

[1]Wong, S. T., Vodopyanov, K. L., and Byer, R. L., "Self-phase-locked divide-by-2 optical parametric oscillator as a broadband frequency comb source," J. Opt. Soc. Am. B, 27(5), 876-882 (2010).

Poster 24

Octave-wide gallium phosphide OPO centered at 3 μm and pumped by an Er-fiber laser

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The degenerate optical parametric oscillator (OPO) based on periodically poled lithium niobate (PPLN) rigorously both down-converts and augments the spectrum of a pump frequency comb provided by a commercial mode-locked C-band fiber laser [1]. Compared to PPLN, Quasi-phase-matched (QPM) semiconductors, on the other hand, such as all-epitaxially-grown GaAs and GaP, have (i) much deeper mid-IR transparency and (ii) smaller group dispersion – a prerequisite for generating broadband frequency combs. While orientation-patterned GaAs (OP-GaAs) has already shown great promise for wavelength conversion – both in mid-IR and THz ranges, and from CW to fs formats [2], its primary limitation is that it cannot be pumped at wavelengths below 1.7 μm due to the onset of two-photon absorption. Orientation-patterned gallium phosphide (OP-GaP) – a new QPM material with larger (and indirect) band gap of 2.26 eV at 300K overcomes this limitation. Here we report the first octave-wide OP-GaP OPO that is pumped at a telecom wavelength and is suitable for broadband mid-IR comb generation. An octave-wide spectral output of 2.35-4.75 μm was achieved from an Er-fiber laser pumped subharmonic OPO based on OP-GaP that is suitable for ultra-broad bandwidth comb generation. Less than 67-fs pulse duration, 29-mW output power and 14 mW low pump threshold were measured.

References

[1] N. Leindecker et al., Broadband degenerate OPO for mid-infrared frequency comb generation. Opt. Express, 19, 6296 (2011).
[2] K. L. Vodopyanov, Optical THz-wave generation with periodically-inverted GaAs Laser & Photon. Rev. 2, 11 (2008).

Poster 25

Using low-coherence interferometry to monitor cell invasion in an in vitro model system

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In an optically dense random system, light undergoes pronounced multiple scattering. This phenomenon has shown a remarkable potential in characterizing complex materials and can be described in terms of a diffusion equation. We used optical path-length spectroscopy (OPS) to investigate distribution of photon path lengths in random media [1]. In addition, this method is capable of measuring the transport mean free path of light in a highly scattering medium and depth-resolved profiles of the backscattered light. Our OPS experimental configuration is based on a Michelson interferometer geometry using single mode optical fibers and a near IR (λ=1310 nm) low-coherent (lc=30 μm) light source. We performed OPS on three-dimensional organotypic models of esophageal cell invasion, to determine the optical path-length distribution of backscattered light in normal and invasive conditions. The optical path-length distribution of light waves inside the cell samples provides information on how a change in the extracellular matrix affects invasiveness of the esophageal cells and induction of signaling pathways. Also, we studied the structural changes during a two-week period for in vitro cell samples.

Poster 26

Uniform ultra-broad supercontinuum generation in continuously tapered multimode graded-index optical fibers

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Supercontinuum generation is these days finding extensive applications in biomedical imaging, optical metrology, spectroscopy, and sensing, to mention a few. Given that, most of the SC sources have so far relied almost exclusively on single mode or few mode fiber technologies, it will not be long before limits are reached in terms of output power capabilities. To this end, a possible avenue to overcome these hurdles could be to use large-area multimode fibers (MMFs). The main mechanism behind generation of supercontinuum in the visible regime is a geometric parametric instability that occurs in fibers with parabolic index profile through periodic contraction/expansion of light along propagation. This process couples light into a series of sidebands situated symmetrically around the pump. In order to generate a uniform continuum in a broad range of frequency, the idea is to engineer fiber parameters so as to continuously drift the sidebands across spectrum. To do so, either fiber radius or index contrast should change as a function of propagation distance. Here, we achieve this through tapering of the fiber. In this task, the longitudinal fiber transition will be judiciously designed in order to control both spatial and temporal interactions – potentially leading to highly customized MMF light sources. Regarding this idea, one would expect that the generated sidebands will gradually experience stronger blue-shifting towards the visible and red-shifting in the MIR, as the core diameter decreases. This, in turn, will encourage the GPI response to eventually cover a wider spectral region through this acceleration of the spatiotemporal compression of light. We theoretically and experimentally demonstrate that by accelerating the nonlinear processes in multimoded parabolic optical fibers via tapering, a broadband supercontinuum could be generated as a result of continuous drift of sidebands toward higher frequencies.

Poster 27

Super-Sensitive Ancilla-Based adaptive optical phase estimation

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Many metrological applications rely on interferometric measurements of an optical phase. The precision of such measurements at both high and low light levels is set by a fundamental quantum bound. An interferometer using light in a two-photon quantum state is able to saturate this bound, offering greater precision than light in a coherent state with an average of two photons. Unfortunately, such quantum super-sensitivity is highly vulnerable to the slightest decoherence effect, particularly at certain phase values – blind spots – where sensitivity to small drifts in the value of the optical phase lost entirely. This difficulty is often addressed by use of a reference phase within the interferometer. Here we show through numerical simulations that we can instead use an ancilla – another degree of freedom, such as photon polarization – that can be tweaked at the input and output ports of the interferometer to maximize the precision. Through calculation of the Fisher information, we show that globally super-sensitive unbiased estimators are attainable for a range of decoherence probabilities. Furthermore, we also present simulations of an adaptive measurement scheme that can achieve super-sensitivity using this process without prior information or a reference phase.

Lab Tours

Labs & Facilities

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

Facilities

Nanophotonics Systems Fabrication Facilities. A 3,000 ft2 multi-user facility containing Class 100 and Class 1000 cleanrooms and a Leica 5000+ e-beam lithography instrument capable of 10-nm resolution. These facilities are used for fabrication and study of nanostructured materials and nanophotonic integrated circuits. The facility equipment includes a Suss MJB-3 and MJB-4 aligners, 2 Plasma-Therm 790 RIE systems with silicon and III-V etching capabilities, a Temascal and V&N E-beam evaporators, along with an atomic force microscope, a profilometer, aa rapid thermal annealer, a bonder, a scriber and microscope. The Laboratory is designed and operated as a multi-user facility, with availability to companies and other outside users. Rm 180.

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

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

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

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

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

Faculty Laboratories

	Room
Ayman Abouraddy	
• Optical Fiber Characterization and Mid-infrared Nonlinear Fiber Optics	A114
• Optical Fiber Draw Tower	A105
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David Hagan and Eric Van Stryland

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Aravinda Kar

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Stephen M. Kuebler

- Nanophotonic Materials Lab PS332B

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Kathleen Richardson

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- Physical property measurement Lab OML-129
- Optical Fabrication Lab OML-124

Martin Richardson

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Axel Schülzgen

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Winston Schoenfeld

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Eric Van Stryland (See Drs. Hagan and Van Stryland)

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Photonics Incubator

The Photonics Incubator is part of the UCF Business Incubation Program and is located within the facilities of the College. It is one of the ways that the College fulfills one element of its mission, namely to "Aid the development of Florida's and the nation's high technology industries." Companies in the Photonics Incubator have ready access to the CREOL faculty, graduate students, laboratory facilities and other excellent UCF resources including the staff of the Office of Research and Commercialization and the Venture Lab. The following is a list of 2016 clients:

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

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

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

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

Lambda Photonics (Abouraddy) **Lambda Photonics LLC** (Currently, Drs. Scott Webster and Kenneth Schepler) is a research and development business solution for the manufacture and development of various optical systems, visible to mid-infrared, with the possibility of custom manufacturing after a full inspection the project scope is understood.

Tours

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

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

A324 **Thin-Film Optoelectronics Lab**
Dr. Kyle Renshaw / POC Sajad Saghaye-Polkoo
http://tfo.creol.ucf.edu

201 **Fiber Optics Lab**
Dr. Axel Schulzgen / POC James Anderson
http://fol.creol.ucf.edu

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

202 **Integrated Photonics and Energy Solutions (IPES) Lab**
Dr. Sasan Fathpour / POC Tracy Sjaardema
http://up.creol.ucf.edu

255A **Optical Frequency Synthesizer**
Dr. Peter Delfyett / POC Mike Plascak
http://up.creol.ucf.edu

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

Building Map

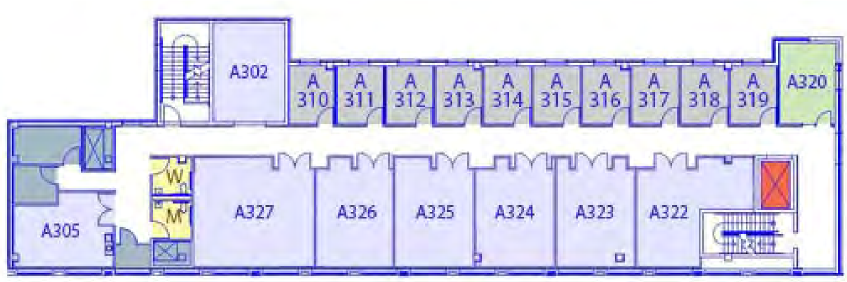
First Floor

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 the College of Optics and Photonics. One of these mutual benefits is the regular communication and contact the program provides between the research faculty and students at the College and the IA member company's engineers and scientists who are developing new technologies and products for their business. Other benefits include:

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

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

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

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

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

The College's faculty and students play leading roles in both local and international professional associations and can provide effective introductions to the extensive network of industry and expertise to which CREOL, The College of Optics & Photonics, connects. Through the IA program, members can also readily connect with other optics, photonics, and industrial organizations through local Florida organizations in which the College maintains an active participation, including the Florida Photonics Cluster (FPC), the Laser Institute of America (LIA), Florida High Technology Corridor Council (FHTCC), the UCF Technology Incubator — ranked #1 in the US in 2004 — and a large family of laser and optics companies in the Central Florida region.

Industrial Affiliates Members

Life Members

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

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Synopsys

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FARO Technologies
Futurewei Technologies
IPG Photonics
LAS-CAD GmbH
Lockheed Martin
Open Photonics
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Optimax Systems
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TRUMPF, Inc.
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Lee Laser
Menlo Systems, Inc.
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Optigrate Corp.
OptoSigma
OSA IDA
Photonics Media
Photonics Online
Plasma-Therm
Plasmonics
Princeton Instruments
QPeak, Inc.
SPIE- The Int'l Society for Optics & Photonics
SYNFuels Americas
The Optical Society
Thorlabs
Tower Optical Corporation
TwinStar Optics, Coatings & Crystals
ULVAC Tech. Inc.

Why Florida?

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

Florida Photonics Industry Cluster

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

Innovation Economy

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

Top Quality of Life & Great Place for Photonics

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

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Director, Townes Laser Institute

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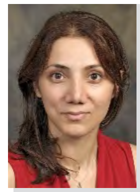

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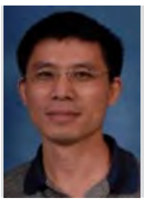

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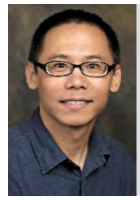

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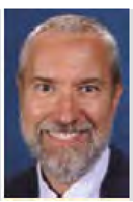

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Thank you for attending!

We look forward to seeing you at our next
CREOL Industrial Affiliates Symposium
April 19-20, 2018

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