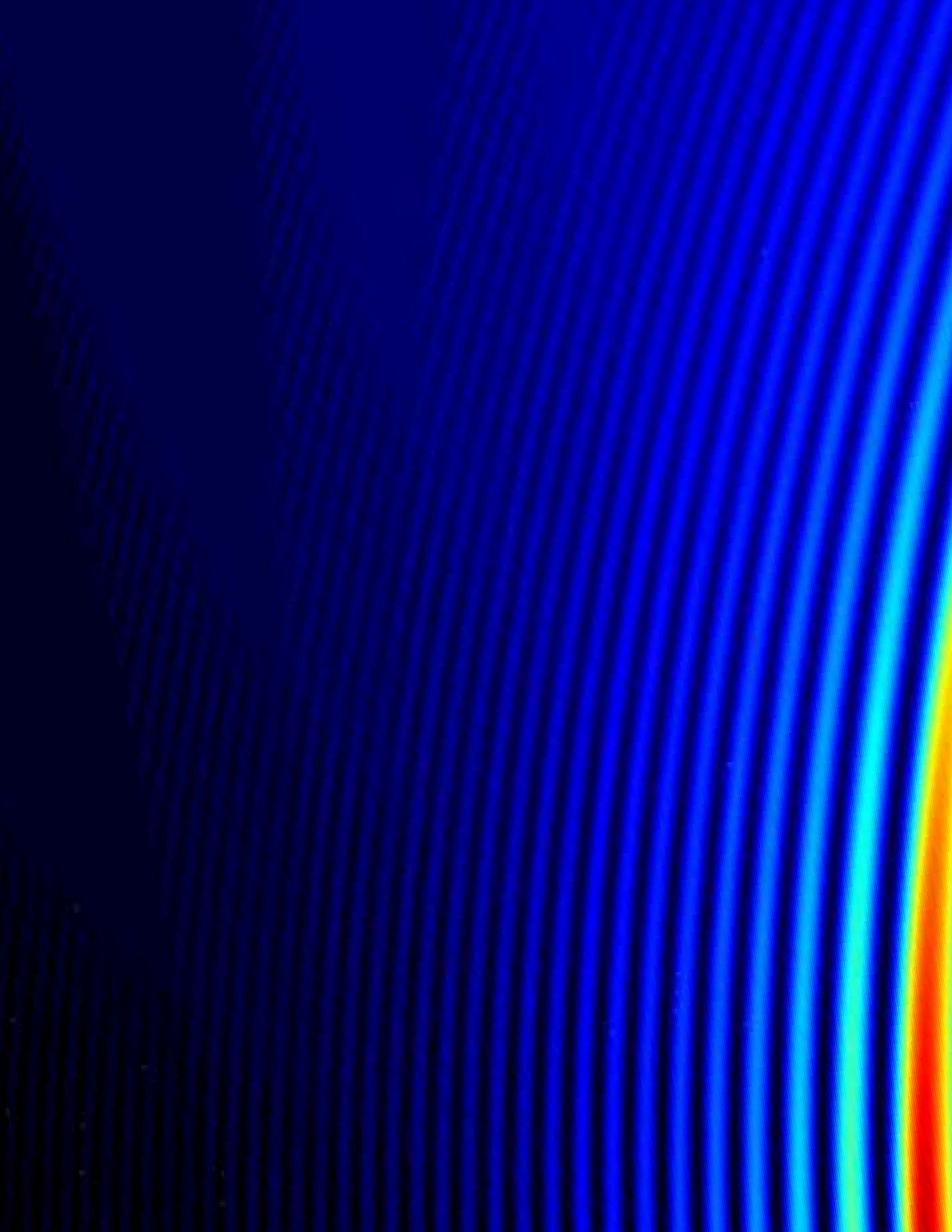
UCF Strength in Optics and Photonics

Essential Technologies for our Nation

UCF | CREOL, The College of Optics and Photonics

UNIVERSITY OF CENTRAL FLORIDA



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UCF Strength in Optics and Photonics is an overview of the research at the **University of Central Florida**. The structure of this document is based on "Optics and Photonics: Essential Technologies for Our Nation," published by the National Research Council of the National Academies.

UCF's Role in Optics and Photonics

Essential Technologies for Our Nation

In 1998, the National Research Council released a report, "Harnessing Light: Optical Science and Engineering for the 21st Century," that presented a comprehensive view of the potential impact of optics and photonics on important industries. In response, several economies – including Germany, China, and the European Union – advanced their already strong optics and photonics sectors. The United States, however, did not develop a cohesive strategy, leaving us at risk of falling sharply behind.

In 2012, the National Research Council released a follow-up report to Harnessing Light - titled "Optics and Photonics: Essential Technologies for our Nation" - that called for an umbrella organization to identify and advance areas of photonics critical to maintaining competitiveness and national security. Heeding the call, five organizations – Optica (Formerly OSA); SPIE, the International Society for Optics and Photonics; the IEEE Photonics Society; the Laser Institute of America; and the American Physical Society Division of Laser Science – worked together to form a National Photonics Initiative (NPI).

The University of Central Florida is playing an important role in strengthening the potential for U.S. and regional dominance in this important field.

The 2012 Essential Technologies report emphasized the imperative role optics and photonics will play in future technology development and opportunities the U.S. needs to pursue to be a global leader in the field. The report focuses specifically on opportunities in:

- ▲ Energy
- ▲ Health and Medicine
- ▲ Advanced Manufacturing
- ▲ Communications, Information Processing, and Data Storage
- ▲ Defense and National Security
- ▲ Advanced Photonics Measurements and Applications
- ▲ Strategic Materials for Optics
- ▲ Displays

We are producing disruptive technologies and educating tomorrows workforce in each of these areas. In many cases these involve joint initiatives with the College of Engineering and Computer Science, the College of Sciences, and the College of Medicine. This booklet describes UCF's strengths in each of the essential photonics technologies for our nation.

David J. Hagan
Dean of the College of Optics and Photonics

Optics and photonics have become established as enabling technologies for a multitude of industries that are vital to our Nation's future.

Impact of Photonics on the Economy

Optics and photonics drives a significant part of our economy because light-based technologies are central to modern life. These technologies are needed to make and inspect the integrated circuits in nearly every electronic device we use. They are used in displays for TVs and smart phones, in the optical fibers that carry the information on the internet, in advanced defense systems, and in advanced precision manufacturing and metrology. A plethora of medical diagnostic and therapeutic tools rely on lasers and other photonic technologies.

Core photonic components and materials include LEDs, lasers, detectors, fibers, image sensors, lenses, prisms, optical filters, and gratings. Photonic products include LEDs, cameras, displays, optical scanners, markers, advanced manufacturing systems, and inspection systems. Photonic-enabled products include lighting, internet and datacenters, smart phones, machine vision systems, TVs, and medical imaging systems.

Public companies that are focused on optics and photonics create more than 10% of all U.S. public revenue, or more than $3 trillion. They also create 6% (7.4 million), of all public company jobs. (Source: The National Academies report "Optics and Photonics, Essential Technologies for Our Nation.")

For example, the emerging field of "biophotonics" represents a $34 billion global market that is expected to reach $91 billion by 2024. Information technology and the telecom industry, enabled by the key technology of photonics, accounts for more than $4.7 trillion or more than 6% of the total world GDP. *(Source: National Photonics Initiative recommendations "Photonics: Enabling American Innovation, Competition and Security.")*

The U.S. Congress stated that partnerships between U.S. industries, academia, and the government are needed to invest in vital optics and photonics research and development, enhance innovation in private and public sector laboratories, and promote continued US competitiveness. To this end, Florida plays an important role in the optics and photonics field. As a national leader, CREOL has strong industry partnerships and burgeoning research. Within the state there are a multitude of companies working in this space, employing thousands of engineers, researchers, and technicians across a wide range of industries.

Salaries for those employed in the U.S. photonics industry are quite high, with average salaries across all photonics jobs (research, engineering, technician) approximately $130,000. (Source: SPIE 2021 Optics & Photonics Global Salary Report)

New opportunities arising from optics and photonics offer the potential for even greater societal impact in the next few decades, including new optical capabilities that will be vital for supporting the continued exponential growth of the internet, autonomous vehicles, high efficiency lighting, genome mapping, medical devices, and solar power. It is critical for the United States to take advantage of emerging optical technologies for creating new industries and generating high-value job growth.

CREOL, The College of Optics and Photonics

CREOL, The College of Optics and Photonics at the University of Central Florida, is one of the world's foremost institutions for research and education in optical and photonic science and engineering. CREOL started in 1987 as the Center for Research in Electro-Optics and Lasers, later renamed the Center for Research and Education in Optics and Lasers. Strong academic activity of its faculty resulted in the formation of the School of Optics in 1998, and then a College in 2004, the first US graduate college in this area, offering interdisciplinary M.S. and Ph.D. degrees in Optics and Photonics. A B.S. degree in Photonic Science and Engineering began in 2013 in partnership with the College of Engineering and Computer Science and in 2021 was accredited by the Engineering Accreditation Commission of ABET, https://www.abet.org.

As of Fall 2021, the college had 35 faculty members, 18 faculty with joint appointments, 6 emeritus professors, 71 research scientists, 120 graduate students and 170 undergraduate students.

We are engaged in research covering most aspects of optics and photonics, including lasers, optical fibers, integrated photonics, nonlinear and quantum optics, and imaging, sensing and display. These technologies have applications in industry and manufacturing, communication and information technology, biology and medicine, energy and lighting, and homeland security. Nanophotonics, attosecond optics, integrated photonics, biophotonics, and manufacturing are also areas of strength and planned future growth. In addition to CREOL, the college is home to the Florida Photonics Center of Excellence (FPCE), the Townes Laser Institute (TLI), and the Institute for the Frontier of Attosecond Science and Technology (iFAST). The college also has a strong affiliation with the recently-formed UCF Center for Directed Energy, which is led by CREOL faculty member, Martin Richardson.

Over the years, the college has maintained a tradition of promoting growth in optics and photonics and a strong partnership with industry. The college Industrial Affiliates Program has a current membership of over 50 companies. CREOL faculty have produced more than 300 patents and spun off 26 companies.

Communication & Information Processing

Optics and photonics have increased the capacity of the Internet by nearly 10,000-fold over the past two decades, and bandwidth demand is expected to grow another 100-fold or more over the next 10 years. The optical networking and communication market size was valued at $18.7 Billion in 2020 and is projected to reach S37.6 Billion by 2028, growing at a compound annual growth rate of 5.58% from 2021 to 2028. Without optics, the Internet as we know it would not exist, and it may not be able to keep up with growing demands without a breakthrough.

Data centers, such as those used by Amazon and Google, are overwhelmingly owned by U.S. Companies. These data centers will continue to grow and will be major consumers of new communications technologies; it is critical that for the U.S. to maintain its technical leadership in optical communication.

Strong partnerships between industry, universities, and government are necessary to ensure the U.S. leverages its innovation abilities to regain market leadership. Developing such partnerships has been a key strength of CREOL since its founding and one of the primary strategic elements of UCF.

Related Technologies:

- Fiber optics
- Fiber fabrication
- Multimaterial fibers
- Atmospheric propagation
- Silicon and compound semiconductor integrated photonics
- Gratings & HOE
- LCD technology
- Nonlinear guided waves
- Integrated-optic signal processing
- Quantum information processing

Related Applications:

- High data rate transmission
- Optical networks
- Free-space communication
- Information processing
- Sensors and sensor networks

Faculty involved in related research:

Ayman Abouraddy
Rodrigo Amezcua-Correa
Demetrios Christodoulides
Peter Delfyett
Sasan Fathpour
Leon Glebov
Guifang Li
Patrick LiKamWa
Kyle Renshaw
Bahaa Saleh
Axel Schulzgen
Shin-Tson Wu

Related companies created as Spin-Offs or through the UCF Business Incubator Program:

AC Materials, Crystal Photonics, Raydiance, NexGen Global Technologies, sdPhotonics, Applied Photonics, Optium, LC Matter Corp. OptiGrate, Archangel Lightworks, FiconTEC

Photo Credit: Google

Defense and National Security

Optics and photonics greatly enhance the ability to gather intelligence, defend citizens and protect troops in the field. Optical sensing technology makes surveillance and reconnaissance possible and enables identification of chemical, biological and nuclear threats. Optical sensing technology makes surveillance and reconnaissance possible, and can also identify chemical, biological, and nuclear threats, an ability fundamental for homeland security. Optical communications provide the ability to share information at high bandwidths from mobile platforms.

Photonics makes laser-guided weapons more accurate, provides lasers for critical defense capabilities and permits personalized use of flexible display technology, which allows men and women in uniform to remain informed and safe during operations with night vision, GPS and physiological feedback. Coordinated investment and associated technology development in remote sensing, photonic integrated circuit manufacturing, advanced lasers and cybersecurity will ensure future military and economic security.
Directed energy in the form of laser weapons can provide substantial advantages. There are also potential synergies from fully merging optical surveillance technology, laser weapons technology, and free-space laser communications technology.

Related technologies addressed by UCF & CREOL:

- ▲ High-power lasers
- ▲ Laser beam combining
- ▲ IR and THz imaging
- ▲ IR and THz spectroscopy
- ▲ LIBS
- ▲ Laser atmospheric propagation
- ▲ Novel IR Optics
- ▲ RF Photonics
- ▲ Nonlinear optical limiters
- ▲ Computer vision

Related applications addressed by UCF & CREOL:

- ▲ Directed energy
- ▲ Laser protection
- ▲ Surveillance
- ▲ Non-GPS location finding
- ▲ Object identification
- ▲ Free-space laser communication
- ▲ Secure communication

Faculty involved in related research:
Yehuda Braiman
Peter Delfyett
Aristide Dogariu
Leon Glebov
David Hagan
Guifang Li
Arkadiy Lyakh
Kyle Renshaw
Martin Richardson

Related companies created as Spin-Offs or through the UCF Business Incubator Program:
IRradiance Glass, Raydiance, Optigrate, Plasmonics, OSI LaserScan, Archangel Lightworks, FiconTEC, Pico Technologies, sdPhotonics, Oelkin Optics.

Optical sensing technology provides the ability to communicate information at high bandwidths from mobile platforms and can also identify chemical, biological, and nuclear threats, an ability fundamental for homeland security.

Photo Credit: Department of Defense

Energy

Solar energy can potentially produce the current and projected future U.S. energy consumption many times over. Recent advancements in solar technologies have resulted in both efficiency and cost benefits that have sparked solar energy adoption. More widespread adoption will require advances in materials, technology, transmission, storage, and manufacturing. Not only is solar energy a critical part of renewable energy, but it also has a role to play in creating sustainable jobs in the United States and in Florida – the Sunshine State.

Likewise, solid-state lighting (SSL), a research strength of UCF's and CREOL, has begun to realize significant efficiency benefits in lighting applications. SSL has enabled new levels of spectral control and reduced electricity use in general lighting applications that exceed those of traditional lighting sources. Recent advancements in light emitting diode (LED) technology have fueled widespread adoption of SSL and have now realized significant beneficial impacts in related application spaces such as displays and backlighting.

At UCF's Florida Solar Energy Center, researchers are working with utilities, municipalities and developers to examine the resiliency of key buildings under different climate or utility interruption scenarios. Work includes solar-generated hydrogen storage, batteries, vehicle to grid-technology and natural gas combined heat and power.

Related technologies addressed by UCF & CREOL:

- Photovoltaics
- LEDs
- Oxide Semiconductors
- Fiber collectors
- Integrated Optics
- Metamaterials

Related applications addressed by UCF & CREOL:

- Solar energy collection
- PV power generation
- Solid state lighting

Faculty involved in related research:

Yehuda Braiman
Debashis Chanda
Kristopher Davis
Sasan Fathpour
Aravinda Kar
Pieter Kik
Patrick LiKamWa
Kyle Renshaw
Winston Schoenfeld
Xiaoming Yu

Related companies created as Spin-Offs or through the UCF Business Incubator Program:

Green Solar Solutions, AppliCote Associates, sdPhotonics

Solar energy could potentially produce many times the current and projected future U.S. electricity consumption.

Health and Medicine

Light-based technologies are essential for diagnosis, treatment and prevention of disease as well as for understanding fundamental mechanisms of biology and medicine. Applications in biomedicine span from elective vision correction and minimally invasive surgeries to characterization of the human genome and cellular structure and functions. Photonics technologies will also help reduce healthcare cost and improve precision of examination. UCF researchers are on the forefront of the field of healthcare by developing new imaging systems and studying interaction of cells with light – which offers the potential to provide invaluable insights in biological systems and harness the healing power of cells and guide them to areas of the body that need help.

Biophotonics research is driving advances that, together with improved medical instrumentation, machine-learning and bio-reagents, will offer numerous business opportunities. Optics and photonics (light sources, materials, imaging devices and systems) will provide unprecedented speed, throughput, sensitivity, selectivity, and resolution for biomedical instrumentation to aid the scientist and physician.

Related technologies addressed by UCF & CREOL:

- Fiber sensors
- Plasmonic sensors
- Laser spectroscopy
- IR & THz spectroscopy
- Multiphoton imaging
- Imaging through tissue
- Lasers for med apps
- Super-resolution fluorescence imaging
- Ultrasensitive immunoassay
- Deep-learning based image analysis
- Optical cellular control
- Optical tweezers
- X-ray Imaging

Related applications addressed by UCF & CREOL:

- Biosensing
- Deep tissue imaging
- Imaging-based genomics, transcriptomics and proteomics
- Cellular & sub-celluar Imaging
- Diagnostics
- Surgery
- Therapeutics
- Blood analysis

Faculty involved at UCF & CREOL:

Ayman Abouraddy
Matthieu Baudelet
Aristide Dogariu
Kyu Young Han
Kyle Renshaw
Shuo Pang
Martin Richardson
Mubarak Shah
Bahaa Saleh
Konstantin Vodopyanov

Related companies created as Spin-Offs or through the UCF Business Incubator Program:

Plasmonics, Speckodyne, Medical Optics & Photonics, Applicote Associates, Raydiance

Photonics technology plays a key role in providing the most effective, lowest-cost approaches for diagnosing, treating, and preventing disease and maintaining a healthy U.S. citizenry.

Advanced Manufacturing

Additive manufacturing, including laser sintering and 3D printing, describes technologies that create parts by building them layer by layer. These processes are particularly suited to automation and are inherently low waste, compared to traditional subtractive processes where material is removed from a block to create a part. Sustained growth in additive manufacturing will require higher resolution to build increasingly complex parts and to repair high-cost parts like turbine blades. UCF research is addressing these areas as well as the development of optical sources such as soft x-ray lasers and imaging tools that will be needed for manufacturing next-generation chips.

Precise detection includes detecting light at the single-photon resolution with a high degree of confidence and precision.

Topics in this area include nanolithography, 3D direct writing, additive manufacturing, etc., which are based on cutting-edge optical and photonic research that enables the discovery of new processing science and the development of disruptive manufacturing technologies. Research is vertically integrated, ranging from theoretical studies on laser-matter interaction, the development of high-power laser sources, innovative beam delivery techniques, and novel materials. New manufacturing technologies improve quality of life, address issues related to climate change, and benefit national security.

Related technologies addressed by UCF & CREOL:

- ▲ High power lasers
- ▲ IR, EUV, X-ray lasers
- ▲ Solid State & ceramic lasers
- ▲ Fiber lasers
- ▲ Semiconductor lasers
- ▲ Nano lasers
- ▲ Ultrafast lasers
- ▲ Laser beam shaping & steering
- ▲ High resolution 3D lithography
- ▲ Photochemistry
- ▲ Single-photon technology
- ▲ Optical Phase Change materials

Related applications addressed by UCF & CREOL:

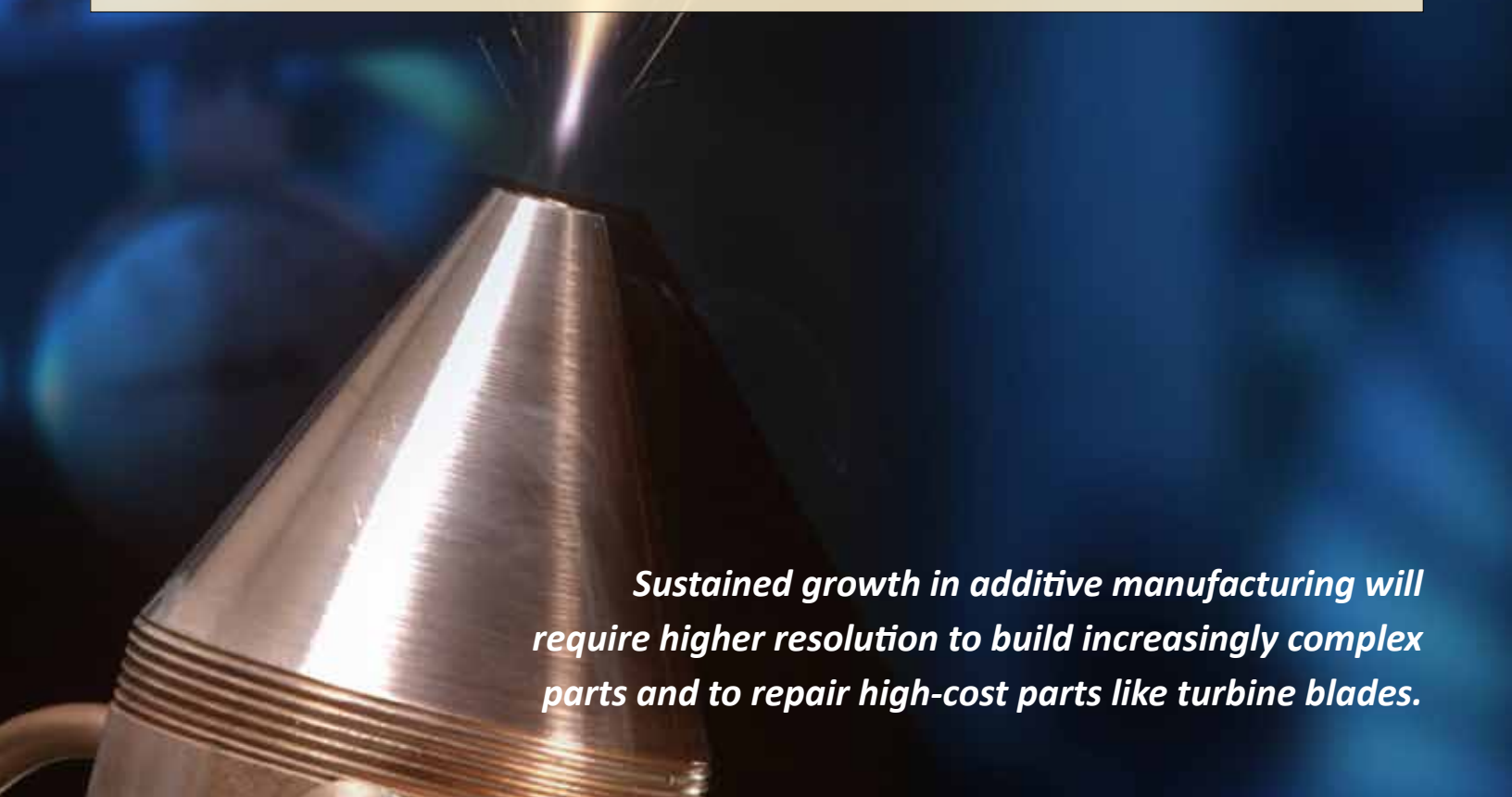
- ▲ Material processing
- ▲ Additive manufacturing
- ▲ Lithography
- ▲ Nano-fabrication
- ▲ Ultrasensitive detection

Faculty involved in related research:

Peter Delfyett
Sasan Fathpour
Suhada Jayasuriya
Jayanta Kapat
Aravinda Kar
Stephen Kuebler
Kathleen Richardson
Martin Richardson
Bahaa Saleh
MJ Soileau
Xiaoming Yu

Related companies created as Spin-Offs or through the UCF Business Incubator Program:

Rini Technologies, Applicote Associates, LP Photonics, Pico Technologies, Applied Photonics, Optium, Orlando Photonics Laboratory Corp.



Sustained growth in additive manufacturing will require higher resolution to build increasingly complex parts and to repair high-cost parts like turbine blades.

Advanced Photonics Measurements and Applications

The role of optics in advanced measurements and sensing has undergone a revolution. The Nobel Prize-winning scientific development of frequency combs enables precisely spaced lines of optical frequency (down to 1 Hz) that span mid-infrared to deep blue. That enables a direct link between RF and optical standards in a small table-top apparatus. This allows extremely precise metrological applications, or for spectroscopic analysis of trace gases, enabling medical diagnoses based on breath analysis. Along another vein, the technological development of mass-market optical imagers, such as high-resolution cell phone cameras, has made possible personalized sensing and imaging applications.

Extremely precise photonic devices developed for fiber optic communication systems are now finding applications in new areas, like astronomy, giving birth to the field of Astrophotonics, reducing size, weight and cost of precise observational instruments. Similar paradigms are being applied to lidar systems for ranging and atmospheric sensing.

Significant new technological opportunities for sensing emerge as nanotechnology increasingly enables new kinds of optical and optoelectronic structures, some without precedent in the classical optical world. Nanophotonic structures that are fabricated on sub-wavelength scales open new or enhanced functions for many precision applications in sensing and measurement.

Related technologies addressed by UCF & CREOL:

- ▲ Microresonator frequency combs
- ▲ Attosecond pulse trains by means of high-harmonic generation
- ▲ Table-top availability of extreme intensities by means of chirped pulse amplification
- ▲ Dual frequency combs for Mid Infrared
- ▲ Quantum cascade lasers
- ▲ Nano optics and plasmonics
- ▲ Topological Lasers
- ▲ Photonic Lanterns

Related applications addressed by UCF & CREOL:

- ▲ Multi-aperture telescopes
- ▲ Chip Scale Low Noise Microwave Signal Generation
- ▲ Atmospheric sensing
- ▲ Biomedical Sensing
- ▲ Exoplanet detection
- ▲ Lidar
- ▲ Low Noise Semicondutor Optical Clocks

Faculty involved in related research:

Rodrigo Amezcua Correa
Miguel Bandres
Zenghu Chang
Demetri Christodoulides
Peter Delfyett
Aristide Dogariu
Stephen Eikenberry
Pieter Kik
Arkadiy Lyakh
Martin Richardson
Konstantin Vodopyanov

Related companies created as Spin-Offs or through the UCF Business Incubator Program:

Oelkin Optics, Optigrate, Plasmonics, Inc., Beam Co., IR Glare

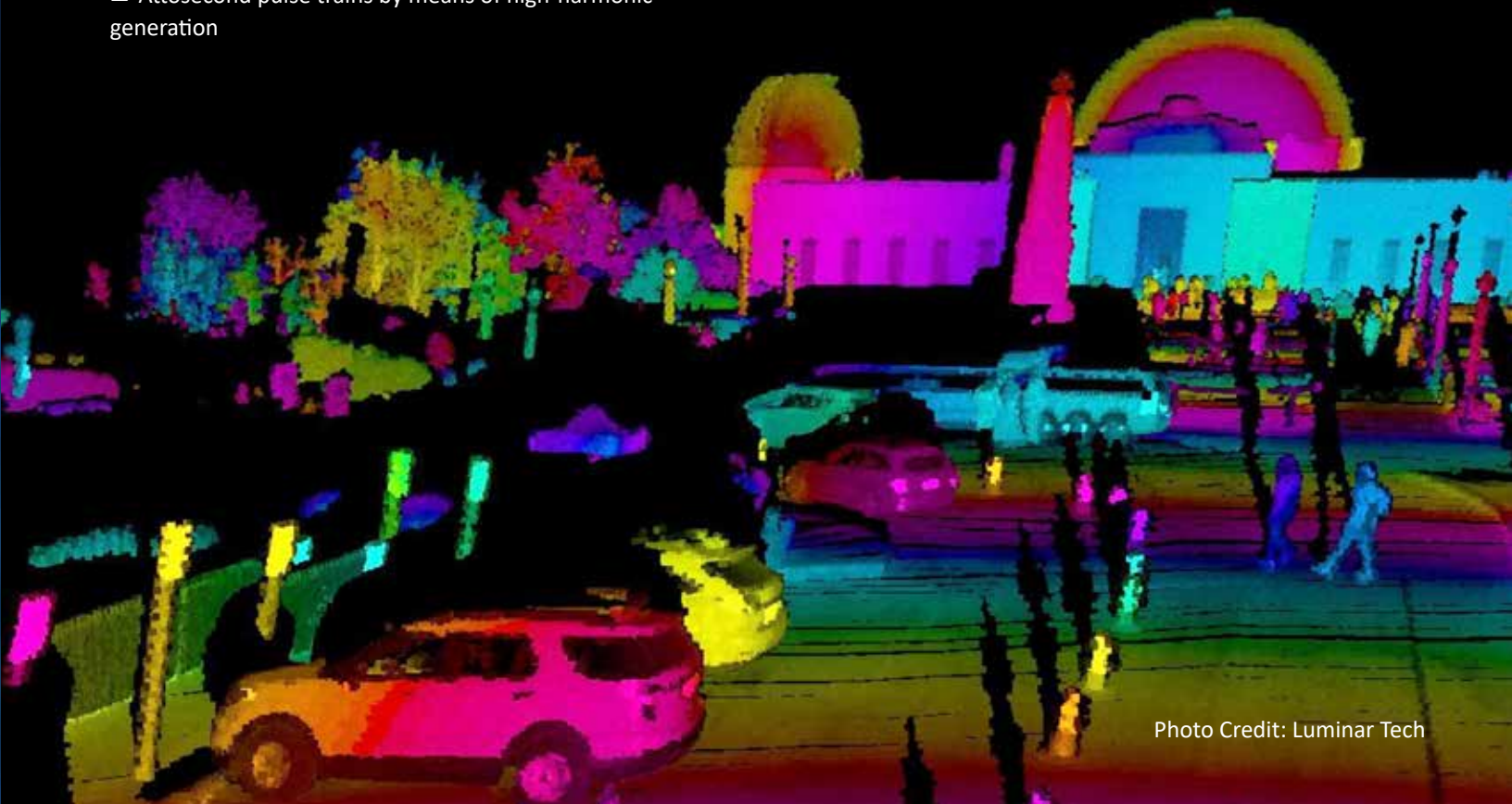


Photo Credit: Luminar Tech

Strategic Materials for Optics

The ability to design and fabricate materials with unique optical function allows the creation of state of the art optical systems with uses that span a wide range of civilian and defense applications. New optical materials have found their way into novel 'flat' bulk optics, as on-chip waveguides, filters and splitters for chem-bio sensors, as new laser sources and in a range of homeland security applications. Optical fibers with unique sizes, shapes and cross-sections can be created permitting chemical identification or system monitoring of changes in temperature and stress. These components can be made from glass, crystals, transparent ceramics, and other low loss crystalline alloys that can be shaped into bulk media, deposited as thin films or drawn into optical fibers.

While many users rely on existing materials in their design of new optical systems, CREOL researchers work to understand the limitations and shortcomings of such media. Using this knowledge, compositional design, processing optimization and fabricate to unique form factors, results in new materials with specialized function. This is realized through modification of material chemistry, optimization of structure and performance for use in diverse environments ranging from space-based satellites, to soldier-mounted imaging systems. The ability to develop optical components and systems through material, component and optical system design and fabrication, is a capability unique to UCF.

Related technologies addressed by UCF & CREOL:

- Fiber optics
- Fiber fabrication
- Multimaterial fibers
- Silicon and compound semiconductor integrated photonics
- Photothermal glass technology
- Gratings & HOE
- Transparent ceramics
- LCD technology
- Nonlinear optical materials
- Optical phase change materials
- Integrated-optic signal processing
- Quantum information processing

Related applications addressed by UCF & CREOL:

- Optical sensors
- Microphotonic sensors
- GRIN materials
- Fiber laser materials
- Optical Imaging
- Optical composites
- Data storage
- Sensors and sensor networks

Faculty involved in related research:

Rodrigo Amezcua
Debashis Chanda
Sasan Fathpour
Romain Gaume
Leon Glebov
Joshua Kaufman
Patrick LiKamWa
Kyle Renshaw
Kathleen Richardson
Martin Richardson
Axel Schulzgen
Shin-Tson Wu

Related companies created as Spin-Offs or through the UCF Business Incubator Program:

AC Materials, Crystal Photonics, Raydiance, NexGen Global Technologies, sdPhotonics, Applied Photonics, Optium, LC Matter Corp. OptiGrate, IRradiance Glass

Displays

Display is ubiquitous in our daily lives. Its widespread applications range from smart watches, smartphones, pads, notebook and desktop computers, TVs, vehicles, public information display boards, to data projectors, just to name a few. Presently, liquid crystal displays (LCDs) and organic light-emitting diode (OLED) displays are dominating this $120 billion industry, while micro-LED is emerging as a strong contender.

More recently, the metaverse technologies under active development are no longer limited to flat panels that just placed in front of the users but aimed at revolutionizing the way of interactions between the users and their surrounding environment. At one end of the spectrum is virtual reality (VR) display, which effectively extends the field of view, blocks the entire ambient, and offers an immersive virtual environment independent of the user's real surroundings. At the other end, augmented reality (AR) display not only pursues high-quality see-through performance but also enriches the real world by overlaying digital contents. With advanced level of optical technology and refreshing user experience, AR and VR displays exhibit potential to enable new applications, including but not limited to healthcare, education, engineering design, manufacturing, retail, simulation and training, and entertainment.

Although these display devices require huge investment in advanced manufacturing technologies, a strong partnership between industry, universities, and government will be necessary to continue to advance the performance of these display devices. Developing such partnerships has been a key strength of CREOL since its founding and one of the primary strategic elements of UCF.

Related technologies addressed by UCF & CREOL:

- Liquid crystal materials and devices
- Organic light-emitting devices
- Mini and micro-light-emitting diodes
- Quantum dots and perovskites
- High dynamic range displays
- Wide color gamut
- Fast response time
- Electro-optics
- Gratings & HOE
- Light engines

Related applications addressed by UCF & CREOL:

- Flat panel displays
- Compact and lightweight AR/VR headsets
- Sunlight readable displays
- Spatial light modulators

Faculty involved in related research:

Ayman Abouraddy
Yajie Dong
Leon Glebov
Jim Moharam
Patrick LiKamWa
Kyle Renshaw
Bahaa Saleh
Sean Pang
Shin-Tson Wu

Related companies created as Spin-Offs or through the UCF Business Incubator Program:

LC Matter Corp., and OptiGrate

Credit: Los Alamos National Laboratory

Educating the Workforce in Photonics

UCF offers a broad range of programs in optics and photonics, where students are taught by its world-leading faculty.

Degrees offered:

- PhD, Optics and Photonics
- MS, Optics and Photonics
- MS, Optics and Photonics (Photonics track)
- MS, Optics and Photonics (Optics Track)
- BS, Photonic Science and Engineering

Certificate Programs offered:

- Graduate Certificate in Optical Imaging Systems
- Graduate Certificate in Applied Photonics

Programs available online:

- MS, Optics and Photonics
- Graduate Certificate in Optical Imaging Systems
- Graduate Certificate in Applied Photonics

Faculty Research Areas

For More Information: https://creol.ucf.edu/research/

Abouraddy, Ayman: Fiber Optics, Semiconductor & Integrated Photonics, Photovoltaics, Nonlinear & Quantum Optics, Imaging, Sensing & Display

Amezcua Correa, Rodrigo: Lasers, Fiber Optics, Nonlinear & Quantum Optics

Argenti, Luca: Theoretical Photoelectron Spectroscopy of Atoms and Molecules, Attosecond Physics & Quantum Control, Time-Resolved Non-Linear Optical Response

Bandres, Miguel: Topological Photonics

Baudelet, Matthieu: Nonlinear Optics & Spectroscopy, Laser Spectroscopies (LIBS, Fluorescence, Raman, FTIR)

Braiman, Yehuda: Nonlinear dynamics and chaos control, friction and fracture at the atomistic scale, and detection of weak signals in noisy environment, beam combining and phase-locking of high-power, broad-area semiconductor diode arrays

Chanda, Debashis: Nanophotonics, Printed Optoelectronics, Infrared Detectors, Displays, Bio-Sensing, Semiconductor & Integrated Photonics, Photovoltaics

Chang, Zenghu: Attosecond Science, Terawatt Femtosecond Laser, Ultrafast Atomic; Physics, Coherent XUV & X-Ray Sources, High Order Harmonic Generation, X-Ray Streak Camera & Other Detectors, Near & Mid-infrared Femtosecond Sources

Christodoulides, Demetrios: Fiber Optics, Fiber Fabrication Technology, Semiconductor & Integrated Photonics, Nonlinear & Quantum Optics

Davis, Kristopher: Photovoltaics, Oxide Semiconductors, Optoelectronics, Nanophotonics, Nanofabrication

Delfyett, Peter J.: Lasers, Optical Frequency Combs, Fiber Optics, Fiber Lasers, Semiconductor & Integrated Photonics, LEDs & Laser Diodes, Quantum Dots & Nanostructures, Optoelectronics, Integrated Optics, Nonlinear & Quantum Optics

Divliansky, Ivan: High-power laser beam combining, diffractive phase elements, diode and fiber lasers systems design

Dogariu, Aristide: Optical Sensing, Manipulation of Electromagnetic Fields, Near Field Imaging, Propagation in Random Media

Dong, Yajie: LEDs & Laser Diodes, Quantum Dots & Nanostructures, Nanophotonics, Nanofabrication, Hybrid Materials & Devices, Lasers in Medicine, Integrated-Optic Sensing, Optical Sensing, Displays

Eikenberry, Stephen: Astrophotonics, astronomical instrumentation, applications to astrophysics, biomedical imaging, remote sensing, LIDAR, communications, and Dark Energy

Fathpour, Sasan: Semiconductor Lasers, Semiconductor & Integrated Photonics, LEDs & Laser Diodes, Quantum Dots & Nanostructures, Optoelectronics, Photovoltaics, Integrated Optics, Nanophotonics & Plasmonics, Silicon Photonics, Nonlinear & Quantum Optics

Gaume, Romain: Solid State Lasers, Transparent Ceramics, High-Power Lasers, Scintillation Detectors, Crystal Growth, Rare-Earth Spectroscopy

Glebov, Leonid B.: Photosensitive and Optical Glasses, Holography, Lasers, Interaction of Optical Radiation with Glasses

Hagan, David J.: Nonlinear Optics, Two photon processes, Techniques for nonlinear optical materials characterization, Nonlinear Optical properties of nanomaterials, semiconductors and nanostructures

Han, Kyu Young: Fluorescence Nanoscopy/Super-Resolution Imaging, Fluorescence Correlation Spectroscopy, Photophysics of Fluorophores, Fluorescent Tags, Single Molecule FRET

Kar, Aravinda: Lasers (Solid State, Ceramic, EUV, X-ray, Ultrafast lasers), Semiconductor & Integrated Photonics, LEDs & Laser Diodes, Photovoltaics, Infrared Sensors & Systems, Imaging, Sensing & Display

Kaufman, Joshua: Fiber Optics and Cables, Multimaterial Fibers & Devices, E-Textiles & Functional Fabrics, Multi-Functional Micro- and Nano-Particles, Mechanical and Fluid Instabilities

Kik, Pieter G.: Semiconductor & Integrated Photonics, Quantum Dots & Nanostructures, Integrated Optics, Periodic Structures & Photonic Crystals, Nanophotonics & Plasmonics, Silicon Photonics, Nonlinear & Quantum Optics, Nonlinear Optical Materials

Kuebler, Stephen: Integrated Photonics, Nanophotonics & Plasmonics, Nonlinear & Quantum Optics, Nonlinear Optical Materials, Nonlinear Optics & Spectroscopy

Li, Guifang: Fiber Optics, Fiber Fabrication Technology, Nonlinear & Quantum Optics, Imaging, Sensing & Display, Millimeter & THz Technology

LiKamWa, Patrick L.: Semiconductor & Integrated Photonics, Optoelectronics, Integrated Optics, Nonlinear & Quantum Optics

Lyakh, Arkadiy: Semiconductor Lasers, High Power Lasers, Optical Frequency Combs

Moharam, M. G. "Jim": Semiconductor & Integrated Photonics, Integrated Optics, Periodic Structures & Photonic Crystals, Nanophotonics & Plasmonics

Pang, Shuo "Sean": Computational imaging, Optical imaging, X-ray imaging, Biophotonics: Microscopy, Optical Design, Microfluidics & Micro Total Analysis System

Peale, Robert E.: Semiconductor Lasers, Far-infrared lasers. Oxide Semiconductors, Photovoltaics, Photodetectors, Periodic Structures & Photonic Crystals, Nanophotonics & Plasmonics, Silicon Photonics, Infrared Materials, Infrared Sensors & Systems, Millimeter & THz Technology, Laser Fabrication & Lithography

Renshaw, C. Kyle: Thin-film optoelectronics, Organic LEDs, Solar Cells & Sensors, Perovskite LEDs, Lasers and Photovoltaics, Hybrid Organic/Inorganic Materials and Devices, Thin-Film Transistors, Flexible Electronics, Nanofabrication, Large Area Optoelectronics

Richardson, Kathleen: Glass and glass-ceramic media for the infrared, optical composite materials, IR GRIN materials

Richardson, Martin C.: Lasers (Solid State, Ceramic, EUV, X-ray, Ultrafast lasers), Fiber Optics, Fiber Fabrication Technology, Multimaterial Fibers, Mid Infrared Fibers, Fiber Lasers, Semiconductor & Integrated Photonics, Periodic Structures & Photonic Crystals, Nonlinear & Quantum Optics, Nonlinear Guided Waves & Fibers, Nonlinear Optical Materials, Nonlinear Optics & Spectroscopy, Photosensitive Glasses, Imaging, Sensing & Display, X-ray & EUV Technology, Infrared Sensors & Systems, Millimeter & THz Technology

Saleh, Bahaa E. A.: Nonlinear & Quantum Optics

Sigman, Michael: Photochemistry, Spectroscopy

Schoenfeld, Winston V.: Semiconductor & Integrated Photonics, Epitaxial Growth, LEDs & Laser Diodes, Quantum Dots & Nanostructures, Optoelectronics, Oxide Semiconductors, Photovoltaics, Periodic Structures & Photonic Crystals, Nanophotonics & Plasmonics, Nonlinear & Quantum Optics

Schülzgen, Axel: Lasers (Solid State, Ultrafast), Fiber Optics, Fiber Fabrication Technology, Nano-structured Fibers, Fiber Lasers, Semiconductor & Integrated Photonics, Quantum Dots & Nanostructures, Nonlinear & Quantum Optics, Nonlinear Guided Waves & Fibers, Nonlinear Optical Materials

Soileau, MJ: Laser-Induced Breakdown, Laser Damage, Self-Focusing, Nonlinear Optics

Thomas, Jayan: Quantum Dots & Nanostructures, Photovoltaics, Periodic Structures & Photonic Crystals, Nanophotonics & Plasmonics, Gratings & Holographic Optical Elements, Nanofabrication, Hybrid Materials & Devices, Solar Energy Applications, Nonlinear Optical Materials

Vasu, Subith: Infrared Sensors & Systems, Optical Sensing

Vodopyanov, Konstantin: Laser Spectroscopy, Biomedical Applications of Lasers, THZ Sensing

Wu, Shin-Tson: Fiber Optics, Nano-structured Fibers, Imaging, Sensing & Display, Optics of Liquid Crystals

Yu, Xiaoming: Ultrafast Lasers, Optoelectronics & Integrated Photonics (Nanofabrication & Electro-Optic Modulators), Nonlinear Optics & Spectroscopy, Imaging, Sensing & Display (Optical Design & Image Analysis & Optics of Liquid Crystals)

Addtional Resources:

National Photonics Initiative: www.lightourfuture.org

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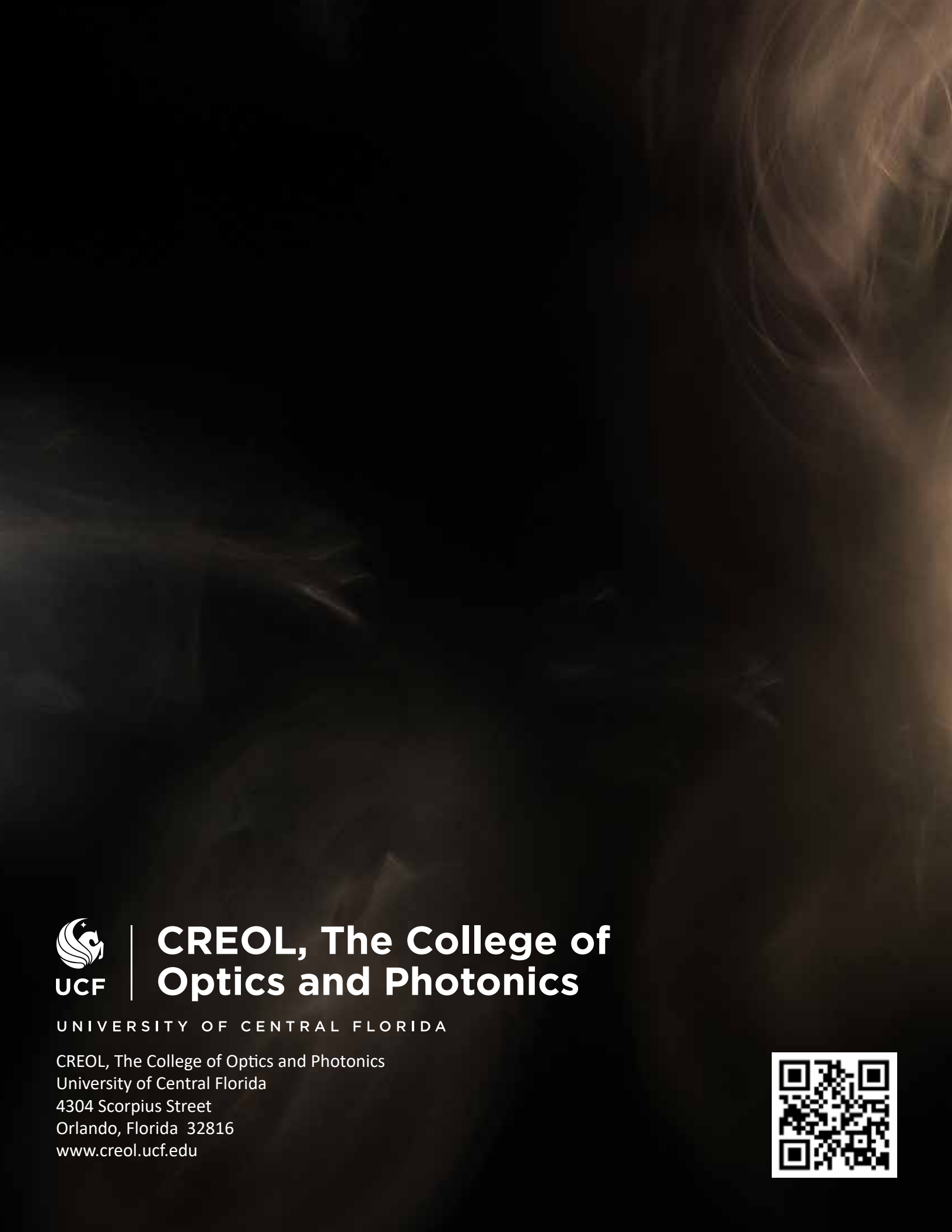

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