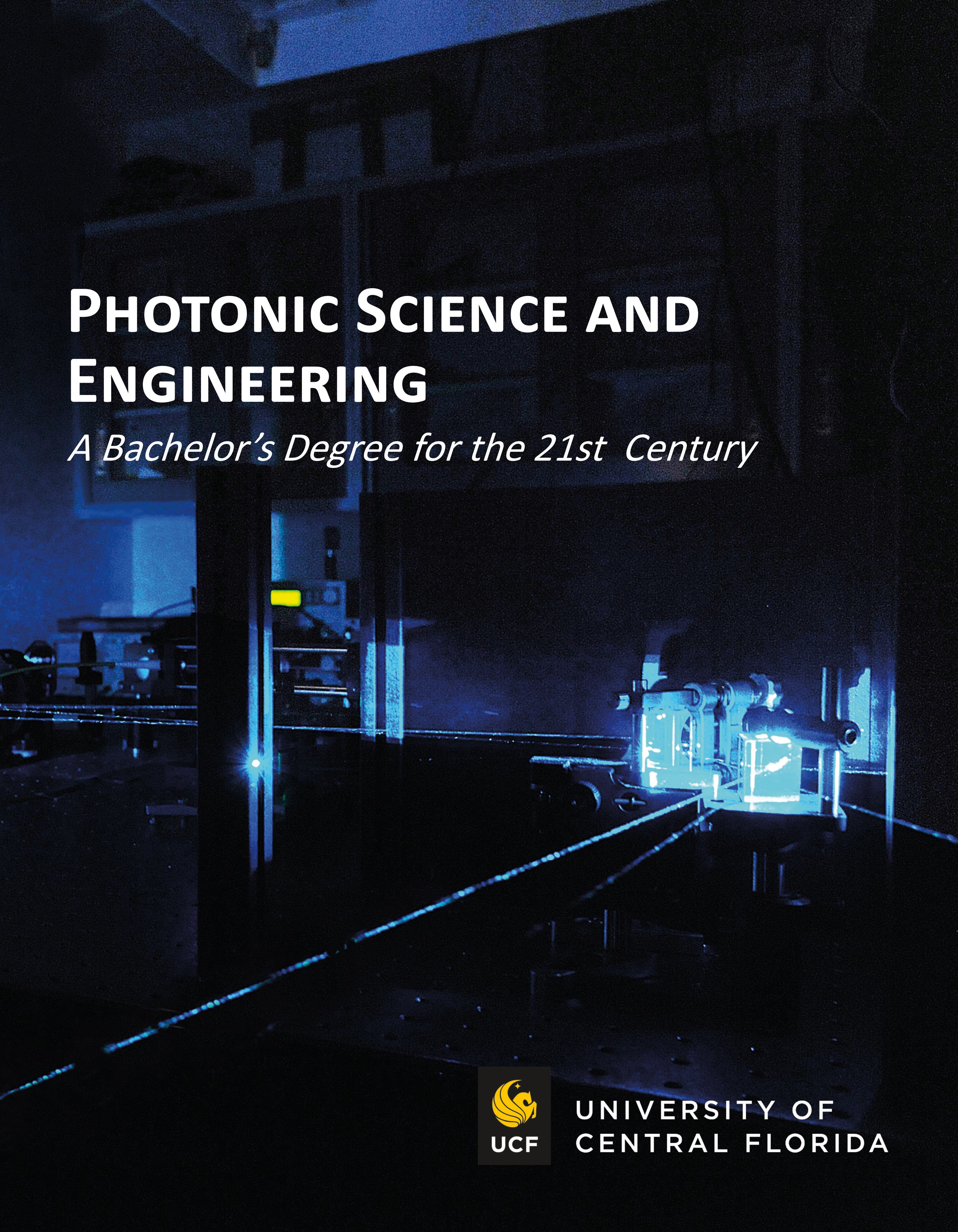
Photonic Science and Engineering

A Bachelor's Degree for the 21st Century



UCF

UNIVERSITY OF CENTRAL FLORIDA

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 and Education in Optics and Lasers, and became a College in 2004, the first US graduate college in this area, offering interdisciplinary graduate programs leading to M.S. and Ph.D. degrees in Optics and Photonics. An undergraduate program offering a B.S. degree in Photonic Science and Engineering began in 2013 in partnership with the College of Engineering and Computer Science and was accredited by ABET in 2017.

The College includes 35 faculty members, 15 faculty with joint appointments, 6 emeritus professors, 59 research scientists, 161 graduate students and over 110 undergraduate students.

The faculty and students are engaged in research covering all aspects of optics and photonics including lasers, optical fibers, integrated photonics, nonlinear and quantum optics, biophotonics, and imaging, sensing and display. These technologies have applications in industry and manufacturing, communication and information technology, biology and medicine, energy and lighting, and defense and homeland security. Nanophotonics, attosecond optics, plasmonics, and manufacturing are also areas of strength and planned future growth. The college is now home to the Center for Research and Education in Optics and Lasers (CREOL), Florida Photonics Center of Excellence (FPCE), Townes Laser Institute (TLI), and the Institute for the Frontier of Attosecond Science and Technology (iFAST).

Over the years, the college has maintained a tradition of promoting growth in optics and photonics and a strong partnership with industry. Its Industrial Affiliates Program has a current membership of 67 companies. The faculty have produced more than 300 patents and spun off 26 companies. Four startup companies are incubated within the CREOL facilities.

A Message from the Associate Dean for Academic Programs

CREOL has excelled at graduate education in optics and photonics for over 30 years. The rapid growth in our field has generated a strong need, both nationwide and in the state of Florida, for Engineers with expertise in Photonics. This led to our decision, in 2012, to create a Bachelor's degree in Photonic Science and Engineering. The program was developed to both meet the diverse needs of industry and for those students who wish to pursue graduate studies. The courses are taught by the same internationally-recognized faculty who teach in our graduate programs.

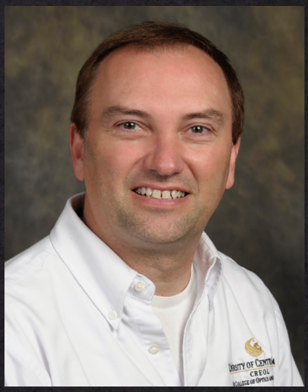
Our program is designed to prepare engineers to have expertise in photonics, while providing a strong foundation in electrical engineering. To ensure our students graduate with practical experience, all of our core photonics courses are accompanied by hands-on laboratory classes. Students must also complete a capstone engineering design course in which they team with engineers from other disciplines to design and build a working prototype device or system.

Our graduates find employment in many sectors of industry – including, defense, telecommunications, consumer electronics, manufacturing. Those who choose to pursue advanced studies have been accepted at leading graduate programs all over the United States. Student may also pursue an option of an accelerated BS-MS program in photonics, which allows students to dual-enroll in the Bachelor's and Master's degrees and earn graduate credits as part of their BS degree. Also, because of the similarity with the Electrical Engineering curriculum, some of our students have chosen to pursue a double-major of electrical and photonics engineering.

We realize that the term "photonics" is new to many people, which is part of the reason we have put this booklet together. Please read it through and you will realize that you are familiar with many of the branches of photonics. If you are excited about the prospect of working in any of these areas, if you like science, are good at math, if you like designing and building things, then you may well be suited to our program. Becoming a photonics engineer is hard work, but most of our students find it highly satisfying and rewarding. Although our program is challenging, we also provide a much higher level of mentorship and support than other engineering programs. If you are interested and feel like you are up to the challenge, please contact me or Mike McKee, and we will be happy to talk to you some more.

David Hagan

A Message from the Associate Director Undergraduate Program, Photonics Advisor



When you are thinking of a university, UCF should be one of the places you look. Yes, UCF is big, with over 66,000 students. As a result, we offer nearly every resource you need to be successful. And yet, our degree program affords you a place where you are not lost in the masses.

With fewer than 300 undergraduate and graduate students in the College of Optics and Photonics, we are small enough that classmates know each other and faculty get to know you by your name.

Our undergraduate student organization, the Society of Optics Students, has regularly scheduled study nights, social events, and professional workshops.

Internships are easy to find as a result of our Industrial Affiliates program. And, advising of classes is easy with my door always open to students.

Many of our students engage in undergraduate research with one of our world-renowned faculty. Some, who plan on attending graduate school, enroll in master's level coursework allowing them to accelerate their attainment of a master's degree.

Our goal is to help you succeed. We want you to graduate with a high GPA and many opportunities. Graduates from our program have commanded salaries of $70,000+ in the Central Florida region.

While our degree is challenging, it opens many opportunities for you to create the future of optics and photonics.

On behalf of our faculty and students, I invite you to join us here at UCF in pursuit of a rewarding degree!

Mike McKee

What is Photonics?

Think about where you see the use of light and its related technologies in daily life - from the displays on your cell phone to the sophisticated technology needed to make the smartphone “smart”, photonics makes use of light to transmit, transfer, and store information.

It’s called an “enabling technology”, finding application in almost every industry and in many consumer products: Energy efficient lighting, cameras, satellite imagery, additive manufacturing, laser surgery, sensing, communication, entertainment, aviation and much more.

U.S. companies active in photonics employ 7.4 million individuals and account for $3 trillion in annual revenues. The photonics engineers employed by these companies are critical to their success.

Our Bachelor of Science in Photonic Science and Engineering provides the knowledge that graduates need to develop new technologies for the 21st Century.

Just as electronics was the dominant technology of the 20th century, photonics will be the dominant technology of the 21st Century.

Communication & Information Processing

Optics has become the way by which most information is sent over nearly all the distance that it travels. The remarkable growth of networks and the Internet has been enabled by previous generations of optical technology.

Optics is, furthermore, the only technology with the physical headroom to keep up with this exponentially growing demand for communicating information.

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, possibly more, over the next 10 years. 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.

The use of optics will not be restricted to the traditional market of long-distance telecommunication. Increasingly optics will be used for ever-shorter distances, possibly providing few-millimeter or shorter links between the silicon chips themselves.

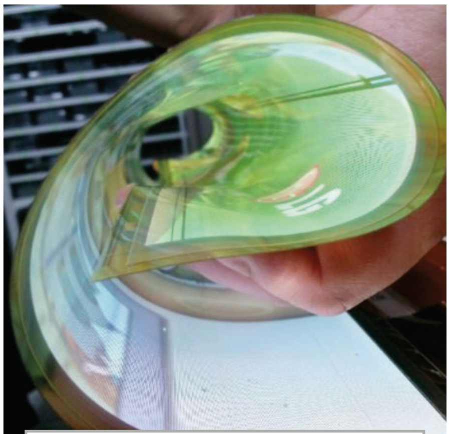
The main, and growing, use of optics in information processing is to connect information within and between information switching and processing machines. There are substantial physical reasons—specifically, reducing power dissipation and increasing the density of information communications—why optics is preferable and ultimately possibly essential for such connections.

In the practical connection of information, optics has increasingly taken over the role of data communications within local networks for information processing systems such as data centers, supercomputers, and storage area networks, for distances from approximately 100 meters to tens of kilometers. As costs decrease, the growth optics to connect devices in much shorter distances will increase.

Related Courses:

- Networks and Systems and Lab
- Signal Analysis and Communication and Lab
- Fiber Optic Communications
- Laser Engineering and Lab
- Optoelectronics and Lab

Entertainment



LG Flexible Display

Samsung VR Headset

Displays are a critical enabling technology for the information age. Over the last two decades, liquid-crystal displays (LCDs) have become the dominant type of display, displacing the cathode-ray tube. During this period, LCD technology improved dramatically in several aspects, including resolution, quality, reliability, size, cost, and capability.

Small displays are used for cell phones and tablets, and large ones for desktop computers, table-based displays, TVs, and wall-mounted displays. However, there is always a drive toward bigger displays.

The use of organic light-emitting diodes (OLEDs) is a growing trend in displays. The fact that the principal pixel component in an OLED display is an LED eliminates the need for external back-lighting technology.

An interesting technology that might have a major impact in the future but will require major investment and innovation is that of flexible displays. Flexible material (such as glass or a polymer) could be used for newspapers, magazines, and "pull down" screens, replacing the typical screen and projector.

Increasingly, at concert venues, LED lighting and panels are replacing incandescent light bulbs and projection displays. Their flexibility, brightness, variability of movement, and durability contribute to their widespread adoption in the entertainment industry.

Related Courses:

- Imaging and Display and Lab
- Laser Engineering and Lab
- Optoelectronics and Lab

Lighting

Perhaps the most obvious application of optics and photonics is in the field of lighting. While the incandescent light bulb has been in use for well over 100 years, their efficiency of converting electrical into light energy is quite low. Lighting consumes well over 20% of the electricity used in the U.S.

In the 1930's fluorescent bulbs became available, which are significantly more efficient but they contain mercury, a hazardous material.

LED lighting is becoming a larger part of the market as their price drops. LED is not only much more efficient than other more common lighting, but they last longer and can be used in locations that are inaccessible or difficult to reach. They are replacing lighting in automobiles, where quite often they last longer than the vehicle itself.

An important factor is the decreasing cost that LED lighting affords compared with incandescent and compact fluorescent bulbs. Over a 20 year period of time, LED lighting for a single light fixture costs consumers approximately $40 while incandescent bulbs are $270, taking into account the cost of bulbs and electricity.

Breakthroughs in lighting will yield longer lasting, more efficient lighting, thereby reducing power costs for consumers.

Related Courses:

- Semiconductor Devices
- Optoelectronics and Lab
- Fiber Optic Communications and Lab
- Optics and Photonics Design

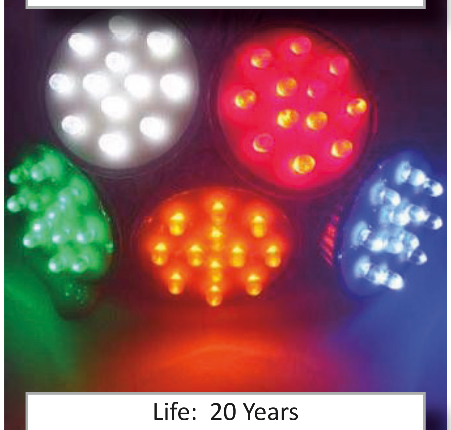
INCANDESCENT

Life: 1 Year
Operating Cost: $12/yr

COMPACT FLUORESCENT

Life: 10 Years
Operating Cost: $2.77/yr

LIGHT EMITTING DIODES



Life: 20 Years
Operating Cost: $2.41/yr

Solar Energy

Solar power has received great interest recently as a renewable energy solution capable of providing energy independence and environmental stability while beginning to deliver power at a competitive price. Because of high costs relative to other energy generation technologies, solar power currently satisfies only a small fraction of the world's energy need. Government support and private investments have led to a boom of technical advances over the past years that have continued to drive solar power toward eventually being a mainstream source of power.

Solar technologies fall primarily into two broad categories: (1) photovoltaics (PV), which convert solar radiation directly into electricity, and (2) concentrating solar power (CSP). CSP uses optical elements to focus the Sun's energy, heating a liquid as part of a heat engine, to generate electricity. Once the Sun's light is focused, it can heat an intermediate material, which can be used to drive a turbine to generate electricity. Concentrated photovoltaics also concentrate the Sun's radiation, but not to the same extent that CSP does. With CPV, the light is concentrated so that high-efficiency solar cells can be used without there being too much concern about cell cost. The cost of the concentrating optics must of course be considered.

With current solar cells, the temperature of the cells must be kept near room temperature in order to maintain high efficiency, and so an efficient heat removal process must be used. CPV solar cells have been measured at 1,000 Suns concentration and 43 percent efficiency, and it is anticipated that at least 2,000 Suns concentration can be used, although it may cost some conversion efficiency.

Despite the rapid growth in installed capacity, photovoltaics are still expected to provide for only a small part of the world's energy demand. As a point of comparison, the total electricity generated in the United States over the last few years has ranged from about 300-400 gigawatts while the total worldwide photovoltaic capacity in 2016 was only 303 gigawatts. (A gigawatt is equivalent to 1,000,000 kilowatts.) This represents 1.8% of electricity demand on the planet.

The primary barrier preventing wider acceptance of utility-scale PV generation is that it is still expected to be more expensive than alternative energy sources. In 2017, most homeowners are paying between $2.87 and $3.85 per watt to install solar, and the average gross cost of solar panels before tax credits is $16,800. This is 9% lower than in 2016, and solar panel system costs are continuing to fall.

The PV industry is still largely reliant on government subsidies and incentives to provide power. It is expected that a competitive solar technology must be below $1.00/W peak installed cost to see widespread adoption of the technology.

Related Courses:

- Semiconductor Devices
- Geometric Optics
- Optoelectronics and Lab
- Optics and Photonics Design

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

Medicine and Healthcare

Photonics technologies are essential for delivery of effective and low-cost diagnosis, treatment, and prevention of disease. Applications in medicine span from elective vision correction and minimally invasive surgeries to characterization of the human genome. In the future, we may see bedside clinical analyses and diagnoses using photonics.

New light-based technologies will help optimize individual responses to medications while minimizing side effects: health care costs will be reduced as costly late intervention procedures are curtailed and hospital stays shortened.

UCF researchers are on the forefront of imaging through tissue and moving cells with light – which offers the potential to harness the healing power of stem cells and guide them to areas of the body that need help.

Medical imaging is key to many health-related needs, both for understanding the status of a patient and for guiding and implementing corrective procedures. Real-time images using fluorescent biomarkers that selectively bind to tumor cells provide a clear demarcation between healthy and diseased tissue during surgery.

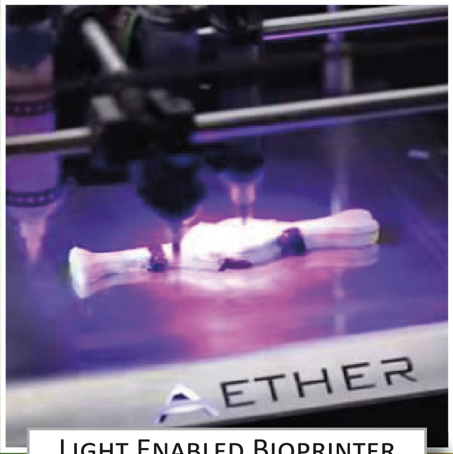
The discipline of biophotonics deals with the interaction of electromagnetic radiation with living organisms and biologically active macromolecules: proteins (hemoglobin), nucleic acids (DNA and RNA), and metabolites (glucose and lactose). At both high (x-ray) and low (radio frequency) energies the body is mostly transparent, thus allowing the non-invasive imaging of the internal structure of organs and bones.

In contrast, certain colors or wavelengths in the infrared and ultraviolet regions are absorbed strongly by biological tissues. The intense, focused light of lasers with these colors can be used for a wide variety of unique therapeutic interventions: making incisions, cauterizing and sealing wounds, and selectively heating or even vaporizing specific regions of organs and tissues.

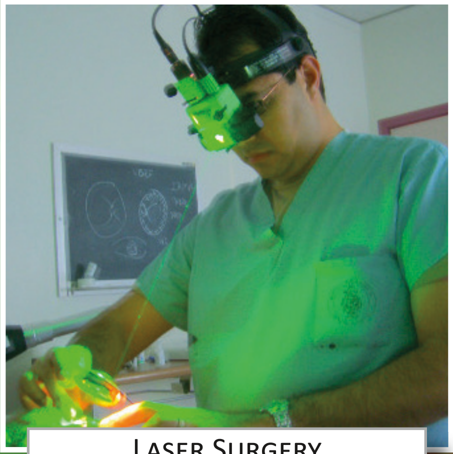
Biophotonics research is driving advances that, together with improved medical instrumentation, will save lives and provide business opportunities. Optics and photonics (sources and materials, imaging devices, and microfluidics) provide unprecedented speed, sensitivity, selectivity and resolution for biomedical instrumentation to aid the physician.

Related Courses:

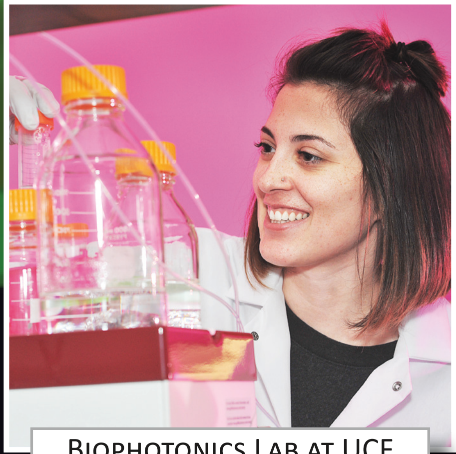
- Biophotonics
- Visual Optics
- Imaging and Display and Lab
- Fiber Optic Communications and Lab



LIGHT ENABLED BIOPRINTER



LASER SURGERY



BIOPHOTONICS LAB AT UCF

Advanced Manufacturing

Technologies that were considered innovative a dozen years ago have undergone significant evolution and are now found in operation in many optics manufacturing firms. Improvements in generation, finishing, assembly, and metrology technologies are being leveraged to generate higher-performing optical systems and push the upper end of the precision scale.

For the last several decades, photolithography has been the dominant printing technology used by integrated circuit manufacturers, and it is a key factor in increasing the transistor density per silicon area and lowering the cost per transistor.

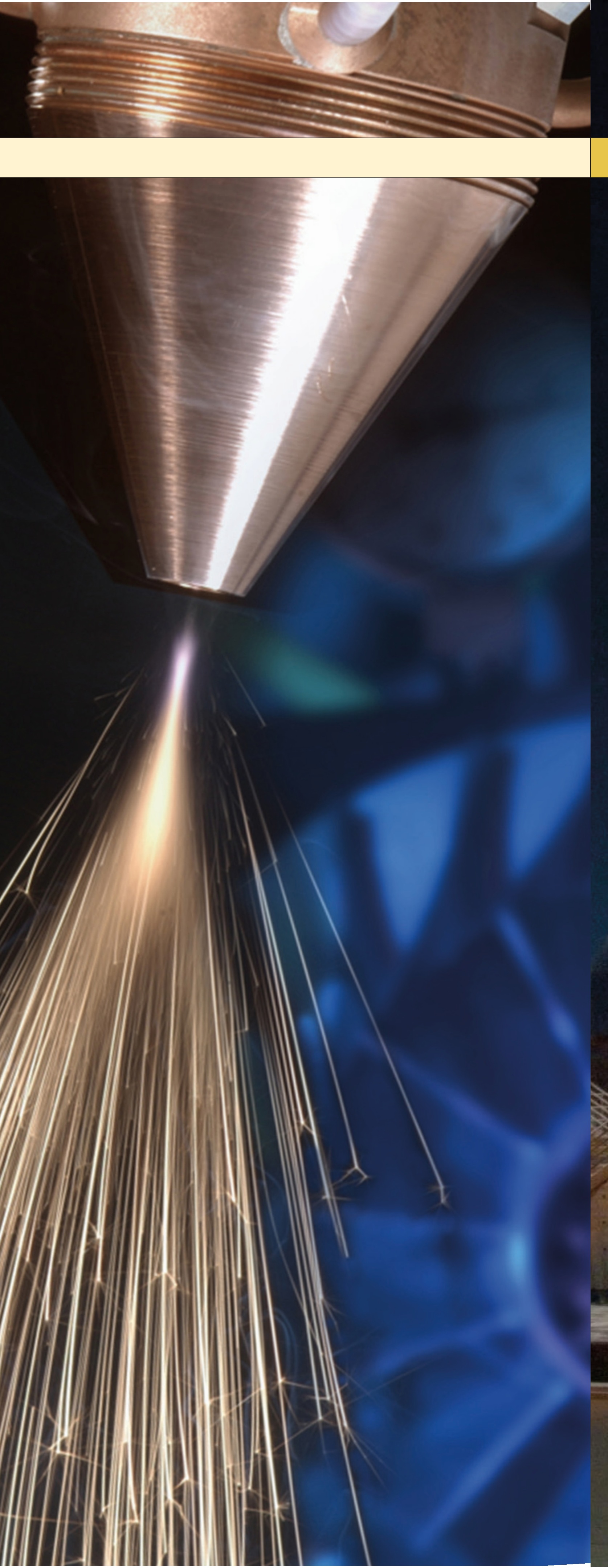
Photolithography is similar to photography since both use imaging optics and a photosensitive film to record an image. In photolithography, the surface of a semiconductor wafer is coated with a light-sensitive polymer known as a photoresist. Light passing through a mask that contains the desired pattern is focused on the photoresist-coated wafer. The material properties of a photoresist change when it is exposed to light, and the changed material can be selectively removed from the wafer surface. The wafer is then chemically treated to etch the exposure pattern in it. The process is repeated many times with different masks to form billions of complicated three-dimensional structures (such as transistors and interconnections) on the wafer.

Laser systems have been transformed from tools applicable only to highly specialized processes to commonplace tools that are used extensively in shop floor operations, such as cutting, drilling, piercing, and welding. Precision lasers that are used to process materials by cutting, welding, drilling, and piercing can provide advantages over conventional processes. These include improvements in the ability to hold tight tolerances, reduction in downtime associated with setups, reduction in part cleaning and deburring, and reduction in distortion of parts during processing. Lasers not only provide the ability to cut materials but provide the ability to produce high-quality components and assemblies precisely and repeatedly.

“Additive manufacturing,” or 3-D printing, describes a group of technologies that are used to create parts by building up layers to, in effect, “grow a part.” Additive processes are fundamentally different from traditional subtractive processes in which material is removed from a block to create a part. One of the big advantages of additive processes is that the amount of waste material is greatly minimized because only as much source material as is needed is used to build the part.

Related Courses:

- Laser Engineering and Lab
- Imaging and Display and Lab
- Optics and Photonics Design



National Defense

There is virtually no part of a modern defense system that is not impacted in some way by optics and photonics, even when the system is not optically based. Modern defense systems are migrating toward optically based imaging, remote sensing, communications, and weapons. This trend makes maintaining leadership in optics and photonics vital to maintaining the U.S. position in defense applications.

Additional areas of impact include the following: precision laser machining, optical lithography for electronics, optical signal interconnects, solar power for remote energy needs, and generation of a stable timebase for the Global Positioning System (GPS). Even when the actual sensor is not optics-based, in many cases optics plays an important role, such as the migrating of radio frequency photonics into microwave radar systems mentioned above.

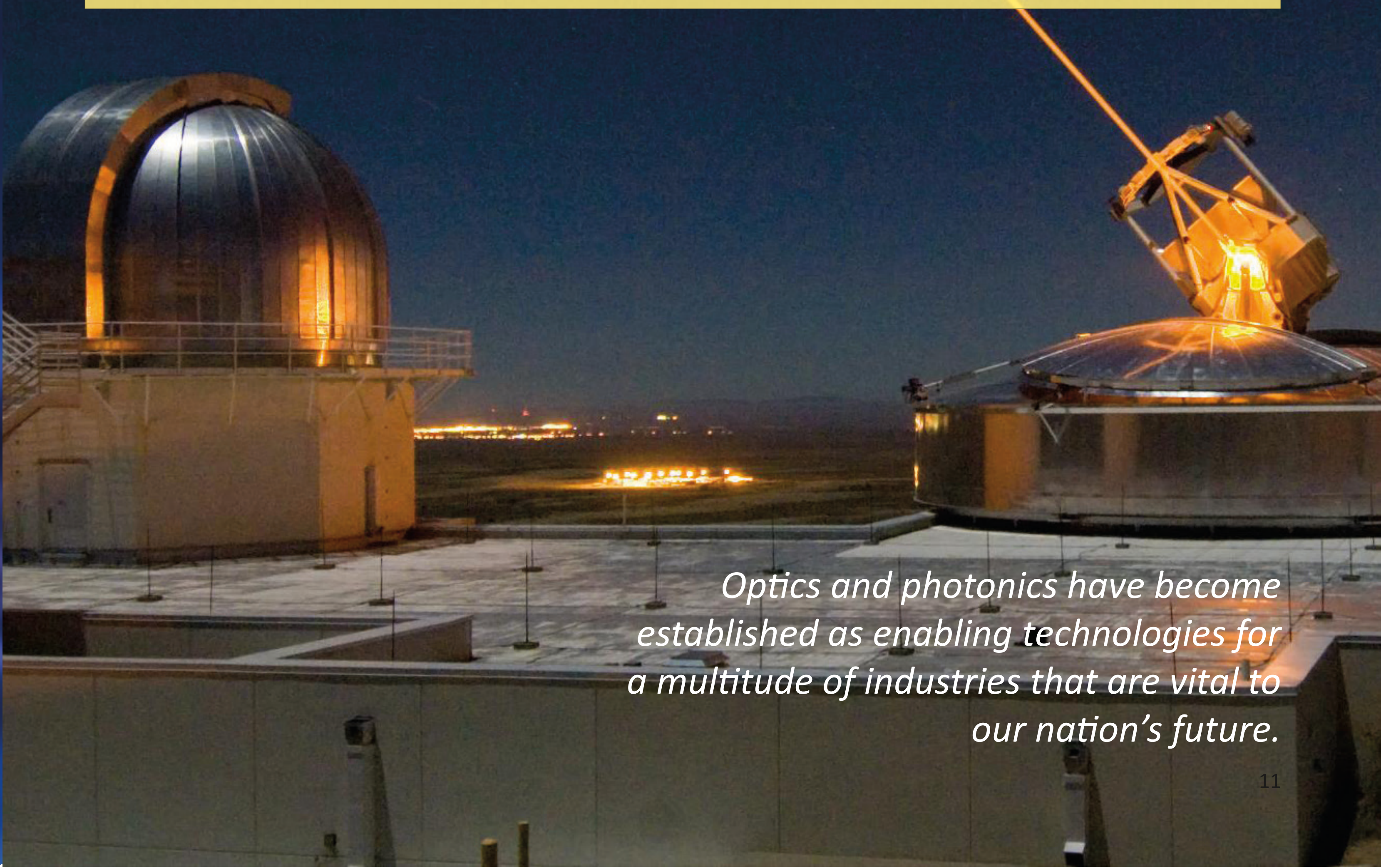
Sensor systems will be the next "battleground" for dominance in intelligence, surveillance, and reconnaissance, with optics based sensors representing a considerable fraction of these systems. Optical sensing technology provides the ability to communicate information at high bandwidths from mobile platforms and can also identify chemical, biological, and nuclear threats, an ability fundamental for homeland security.

Defense against missile attacks is a significant security need with laser weapons systems poised to cause a revolution in military affairs. Laser weapons can provide a substantial advantage for U.S. forces. There are also potential synergies from fully merging optical surveillance technology, laser weapons technology, and free-space laser technology.

Sophisticated platforms have reduced the need for a large set of traditional warfighters, but there is an increased need for a high-tech workforce to support those platforms. This workforce relies on advanced training in technical areas with a basis in science, technology, engineering, and mathematics (STEM), which are precisely the areas in which it is becoming more difficult to find continued optics and photonics education in the United States.

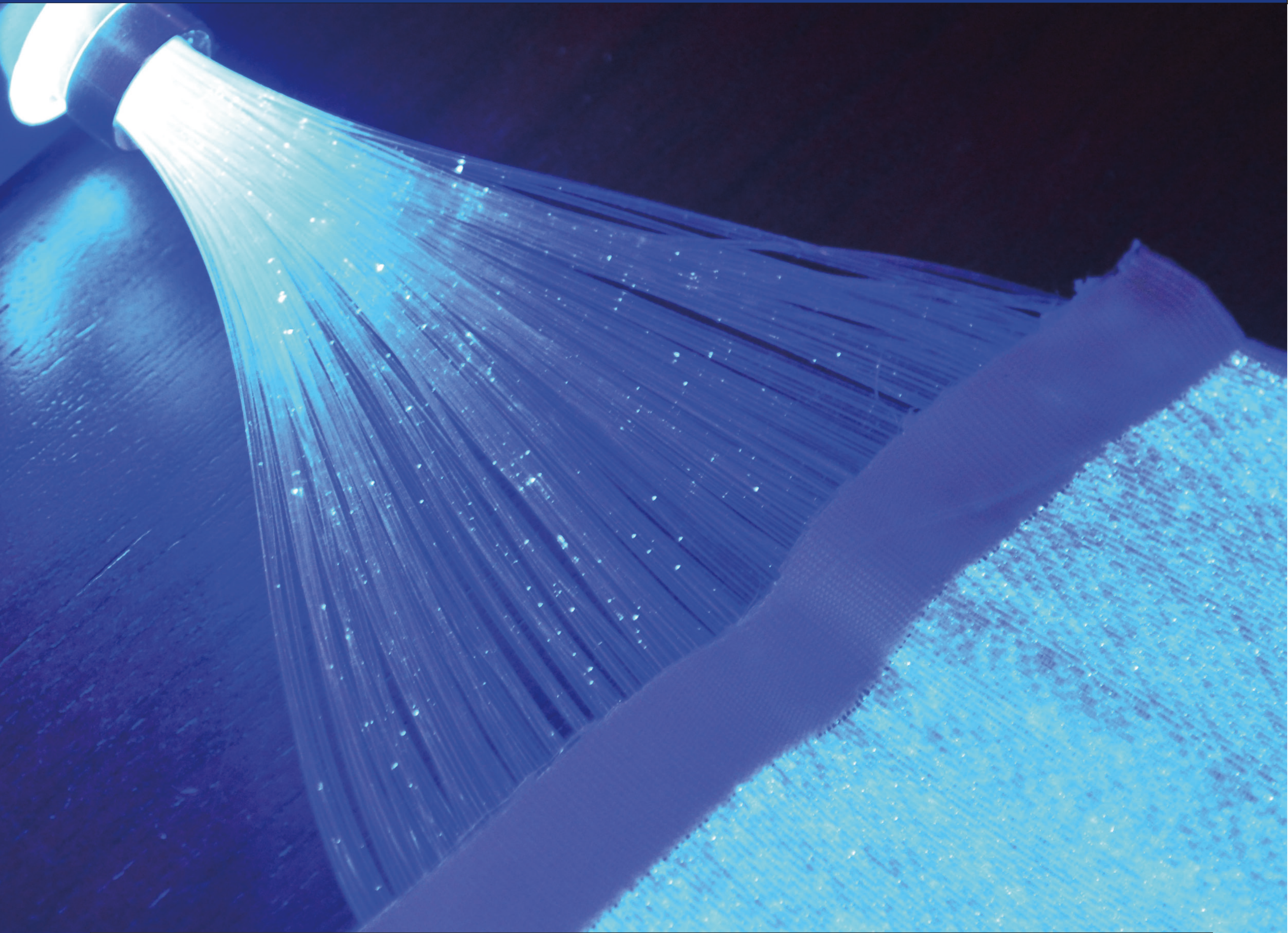
Related Courses:

- Laser Engineering and Lab
- Imaging and Display and Lab
- Fiber Optic Communications and Lab
- Optoelectronics and Lab



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

Smart Textiles



Shirts that can monitor blood pressure, jackets that can store and convert thermal energy, window shades and tents that harvest solar energy, dresses that change color at the push of a button, and self-drying shoes are part of a new photonics initiative with both military and commercial applications. This new technology can be used as threads woven into textiles which could conceivably conduct electricity, sense the temperature and body functions, communicate with the internet, and detect threats and report injuries to soldiers on the battlefield.

A University of Central Florida scientist is playing a critical role in shaping a $317 million U.S. Department of Defense program that could expand the function of clothing to include monitoring our health, sensing the environment, and harvesting energy.

The process of creating a fiber capable of functioning as a fully integrated and networked system will essentially meld together a diversity of materials not usually associated with optical fibers, such as metals and semiconductor materials, along with the more traditional glasses and plastics. These 'multimaterial' fibers can realize the functions provided in electronic devices in a low-cost package slightly thicker than a strand of hair.

The revolutionary threads could disrupt one of the world's oldest industries and keep nearly 50,000 jobs in the U.S. over the next ten years.

Related Courses:

- Fiber Optic Communications and Lab
- Frontiers of Optics and Photonics
- Optoelectronics and Lab
- Imaging and Display and Lab
- Optics and Photonics Design and Lab

Bachelor of Science in Photonic Science and Engineering

The Bachelor of Science in Photonic Science and Engineering (PSE) develops the knowledge needed for the technologies of the 21st Century; our program enables students to analyze and design optical, photonic, and laser systems for a broad set of applications including manufacturing, healthcare, telecommunication, defense, security, and entertainment.

Found only at the University of Central Florida, through a partnership between CREOL, The College of Optics and Photonics and the College of Engineering and Computer Science, the PSE program is unique to Florida and found in few other universities in the United States. The PSE program is designed to fulfill the rapidly growing needs of a industry that is finding applications in nearly every part of everyday life.

Our students have unique advantages at UCF:

- CREOL is home to faculty who are world renowned and leaders in the fields of optics and photonics.
- We have strong industry relationships, with over 60 Industrial Affiliates, forming a network for potential internships.
- Students can participation in the Society of Optics Students (SOS), the undergraduate student organization, which is active throughout the year and holds many events of value.
- The College has a strong academic advising program where students can get help as they register for courses and plan their degree program.
- We are the only Photonic Science and Engineering B.S. offered in Florida and one of only six optical programs in the nation.
- Students have the ability to continue studies in pursuit of a Master's or Doctoral degree and our graduate programs are ranked in the Top 15 nationally.
- The PSE program is accredited by the Engineering Accreditation Commission of ABET, www.abet.org

Students enrolled in the PSE program initially complete electrical engineering coursework that includes calculus, physics, differential equations, and electronics.

Starting in the second year of the program, they begin core photonics coursework ending with a capstone Senior Design in which students collaborate on a project that incorporates photonics technologies into the design.

LEARN MORE ABOUT
PHOTONIC SCIENCE AND ENGINEERING:

HTTP://WWW.CREOL.UCF.EDU

APPLY TO UCF:

HTTP://ADMISSIONS.UCF.EDU/

Photonic Science and Engineering coursework
128 Credits

Foundational Courses (27 CR)

Calculus I, II, III
Differential Equations
Physics I, II
Principles of Chemistry

Basic Core Courses (11 CR)

Introduction to Engineering Profession
Engineering Concepts & Methods
Engineering Analysis & Computation
Physics III
Probability & Statistics

Advanced Core Courses (17 CR)

Electrical Networks
Networks & Systems
Semiconductor Devices I
Electronics I
Signal Analysis and Communications

Photonics Core Courses (36 CR)

Geometric Optics + Lab
Fundamentals of Photonics + Lab
Electromagnetic Waves for Photonics
Laser Engineering + Lab
Optoelectronics + Lab
Imaging & Display + Lab
Fiber Optic Communications + Lab
Frontiers of Optics & Photonics
Senior Design I
Senior Design II

Restricted Elective Options (10 CR)

Analytical Methods of Photonics
Biophotonics
Optics & Photonics Design
Visual Optics
Plus many other approved mathematics, physics or engineering courses.

General Education Program (27 CR)

Students select various courses available from the following areas: Communication, Cultural & Historical, Science, and Social Foundation.

UCF

Faculty Research Areas

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
Baudelet, Matthieu: Nonlinear Optics & Spectroscopy, Laser Spectroscopies (LIBS, Fluorescence, Raman, FTIR)
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
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
Deppe, Dennis: Semiconductor Lasers, Semiconductor & Integrated Photonics, Quantum Dots & Nanostructures, Optoelectronics
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
Driggers, Ronald: Electro-Optical and Infrared Systems
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
Gelfand, Ryan M.: Near-field optics, Aperture-Based Optical Trapping, Plasmonic Trapping, Single Protein Spectroscopy, Protein Biophysics, Dynamics, & Behavior, Fiber Optic Biosensing Device Development, Protein Assay Development, Compact Optical Based Biosensors, Pharmaceutical Treatment Testing for Proteopathy Diseases
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
Khajavikhan, Mercedeh: Fiber Lasers, Semiconductor & Integrated Photonics, LEDs & Laser Diodes, Quantum Dots & Nanostructures, Integrated Optics, Nanophotonics & Plasmonics, Silicon Photonics, Nonlinear & Quantum Optics
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: Optical Ceramics for Lasers, Soft Glasses for Optical Fibers
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
Van Stryland, Eric W.: Nonlinear Optics, Nonlinear Spectroscopy, Nonlinear Optical Materials (Semiconductors and nanostructures, organics), Ultrafast Spectroscopy
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)
Zeldovich, Boris Y.: Physical Optics & Propagation, Electrodynamics of Volume Bragg Gratings, Beam Clean-up and Combining via Nonlinear-Optical Processes, Nonlinear Optics, including Liquid Crystals

"As electronics was the technology of the 20th century,

Photonics is the technology of the 21st"

- Eric Van Stryland

former President, Optical Society of America and former Dean,

UCF College of Optics & Photonics

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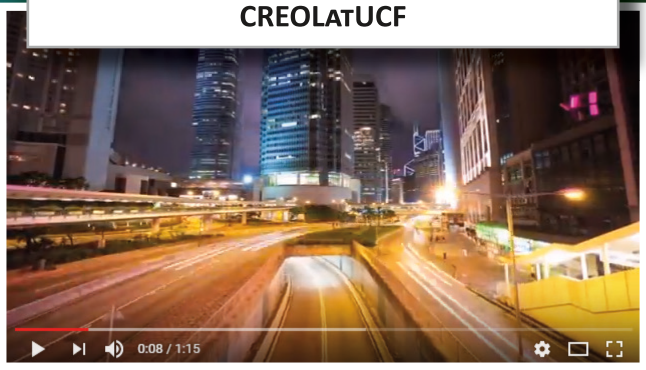

References:

Information used in this document is sourced from the National Academy of Sciences publication Optics and Photonics: Essential Technologies for Our Nation (2012), except where noted below.

Entertainment:

Photo Credits: LG and Samsung

Solar Energy

[1] Greentechmedia.com. (2017). IEA: Global Installed PV Capacity Leaps to 303 Gigawatts. [online] Available at: https://www.greentechmedia.com/articles/read/iea-global-installed-pv-capacity-leaps-to-303-gw#gs.=ix0GaA [Accessed 22 Dec. 2017].

[2] Matasci, S. (2017). 2017 Average Cost of Solar Panels in the U.S. | EnergySage. [online] EnergySage Solar News Feed. Available at: https://news.energysage.com/how-much-does-the-average-solar-panel-installation-cost-in-the-u-s/ [Accessed 22 Dec. 2017].

Medicine and Healthcare

Background: An artistic rendition of an optical setting for observing nonconservative reaction force of light on matter. Artist: Andrii Pshenychnyi.

Bioprinter Credit: Aether Bioprinter http://www.aether1.com/

National Defense:

Photo: U.S. Air Force http://www.afmc.af.mil/News/Photos/igphoto/2001060305/

Textiles:

Exerpted from UCF News and Information: https://today.ucf.edu/ucf-scientist-part-of-317m-initiative-to-revolutionize-textiles/

Photo: Luminous Fabrics, Midnight Sun https://luminousfabrics.files.wordpress.com/2013/09/tissu-lumineux-tissus-lumineux-illuminated-fabric-bright-fabrics-36.jpg

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