UNIVERSITY OF CENTRAL FLORIDA

CREOL & FPCE
THE COLLEGE OF OPTICS AND PHOTONICS

Industrial Affiliates Day
April 21, 2006

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CREOL & FPCE , THE COLLEGE OF OPTICS AND PHOTONICS

Industrial Affiliates Day – Friday, April 21, 2006

Theme: Optics & Photonics for Space-Based and Medical Applications

Celebrating the 20th Anniversary of the founding of CREOL

Morning Session – Cape Florida Room, UCF Student Union

Time	Topic	Speaker	Affiliation
8:15a	Continental breakfast & walk-in registrations		
8:45a	Welcoming remarks	Dr. Terry Hickey Dr. MJ Soileau Dr. Eric Van Stryland	Provost, UCF VP for Research, UCF Dean; CREOL & FPCE, COP
9:00a	CREOL 20th Anniversary	Dr. MJ Soileau Dr. Eric Van Stryland	VP for Research, UCF & Founding Director, CREOL Dean, COP
9:25a	"Optical Technology Needs for Future Space Telescopes"	Dr. Philip Stahl	Sr. Optical Physicist, NASA Marshall Space Flight Center
10:00a	"Solar Physics, Space Weather, and Wide-field X-ray Telescopes"	Dr. James Harvey	UCF, The College of Optics and Photonics, Associate Professor of Optics & ECE
10:35	**BREAK**		
10:50a	"Ultrafast Nonlinear Optical Microscopy Illuminates the Biophysics of Life"	Dr. Watt Webb	Cornell University. Samuel B. Eckert Professor in Engineering; Prof of Applied Physics; Dir. of Developmental Resource for Biophysical Imaging Opto-electronics
11:25a	"In Situ 3D Visualization with Deployable and Head-worn Displays"	Dr. Jannick Rolland	UCF, The College of Optics and Photonics, Assoc. Professor of Optics, ECE, & Computer Science
12:00p	Adjourn for lunch - UCF Student Union		

Afternoon Session – CREOL Building

Time	Topic	Speaker	Affiliation
1:00p	Walk to CREOL building		
1:15p	"Multiphoton Biomedical Imaging and Photodynamic Therapy: Agents & Applications"	Dr. Kevin Belfield	UCF, The College of Sciences; Chair, Chemistry Dept and Professor of Chemistry
1:50p	COP: CREOL & FPCE – an overview	Dr. Eric Van Stryland	Dean; CREOL & FPCE, The College of Optics and Photonics
2:30p	Student of the Year – Seminar & Award Presentation	Erwan Baleine	CREOL & FPCE , The College of Optics and Photonics:
3:00p	Poster session & Lab tours	CREOL Students & CAOS Leadership	
5:00p	Reception	Dr. Eric Van Stryland	
6:15p	Program completion		

Industrial Affiliates Day 2006
Invited Presentation

Optical Technology Needs for Future Space Telescopes

Dr. H. Philip Stahl
Senior Optical Physicist
NASA Marshall Space Flight Center, Huntsville AL
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Abstract

Optics is an enabling technology for future NASA space observatories – whether they are searching for Earth-like planets and habitable environments around other stars or exploring the Universe to understand its origin, structure, evolution and destiny. This presentation summarizes several planned missions on the current NASA Space Science roadmap. For each mission, the path from science objectives to performance requirements to derived engineering specifications and finally optical technology challenges will be detailed.

Biographical Note

Dr. H. Philip Stahl is a Senior Optical Physicist at NASA MSFC where he is the James Webb Space Telescope (JWST) Optical Components Technical Lead. Prior to joining NASA, Dr. Stahl was a Senior Optical Engineer at Raytheon Danbury (formerly Hughes Danbury Optical Systems, now Goodrich Aerospace) where he was lead optical engineer on the Space Based Laser Program. As President of Stahl Optical Systems Inc. he supported several NASA microgravity experiments. Also, he was an Assistant Professor of Physics and Applied Optics at Rose-Hulman Institute of Technology, the Optical Products Manager at Breault Research Organization (BRO), and a Senior Optical Systems Engineer at BRO. Prior to that, he worked at Perkin-Elmer, Hughes Aircraft, and Wright-Patterson AFB. Finally, he was a Faculty Fellow at NASA Lewis (now Glenn) Research Center.

Dr. Stahl is a leading authority in optical metrology, optical engineering, and phase-measuring interferometry. Many of the world's largest telescopes have been fabricated with the aid of high-speed and infrared phase-measuring Interferometers developed by him, including the Keck, VLT and Gemini telescopes. He is a Fellow of SPIE, an SPIE Director, Vice-President of ICO and a member of OSA. He earned his PhD in Optical Science at the University of Arizona Optical Sciences Center in 1985.

Industrial Affiliates Day 2006
Invited Presentation

Solar Physics, Space Weather, and Wide-field X-ray Telescopes

Dr. James E. Harvey
CREOL: The College of Optics and Photonics
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Abstract

The sun is essentially a giant thermonuclear fusion reactor (105 x the size of the Earth). The detrimental effects of solar storm induced "space weather" ranges from disruption of our space communication systems to astronaut health hazards to power grid overloads and blackouts. The National Oceanic & Atmospheric Administration (NOAA) and NASA are cooperating on a Solar X-ray Imager (SXI) program intended to allow NOAA to monitor and predict space weather. Four flight models and a spare of the SXI telescope have been designed and fabricated. The first is scheduled to be launched on the next-generation Geosynchronous Operational Environmental Satellite (GOES) in 2006.

After briefly reviewing solar physics and space weather, this talk will discuss a new class of *wide-field* grazing incidence X-ray telescopes developed at CREOL specifically for the SXI program. This new design differs significantly from the classical Wolter Type I designs previously built and used as X-ray *stellar* telescopes.

Biographical Note

James E. Harvey received his Ph.D. in Optical Sciences from the University of Arizona in 1976. Dr. Harvey worked with United Technologies Corp., Rockwell International, and the Perkin-Elmer Corporation before joining academia in 1990. He is currently an Associate Professor in the College of Optics and Photonics and a Senior Staff Member at the Center for Research and Education in Optics and Lasers (CREOL) at the University of Central Florida where he has established the Optical Design and Image Analysis Laboratory. Dr. Harvey is credited with three patents and over one hundred and fifty publications and presentations in the areas of diffraction theory, surface scatter phenomena, adaptive optics, wavefront sensing, beam sampling technology, optical properties of materials, and X-ray/EUV imaging systems. He is a member of the OSA and a Fellow of SPIE.

Industrial Affiliates Day 2006
Invited Presentation

Ultrafast Nonlinear Optical Microscopy Illuminates the Biophysics of Life

Dr. Watt W. Webb
Professor of Applied Physics and Samuel B. Eckert Professor in Engineering
School of Applied & Engineering Physics
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Abstract

We humans are composed of intrinsically fluorescent and optically nonlinear molecules and structures that provide microscopic probes of the dynamics of the molecular biophysics of life. To image them, multiphoton laser scanning fluorescence microscopy utilizes femtosecond pulse trains of infrared light from mode-locked lasers to excite tissue fluorescence and to induce second harmonic generation. Their images by Multiphoton Microscopy (MPM) are now being extended to provide medical endoscopic microscopy for diagnostics and surgery. But necessary optical physics to miniaturize biophysical optics to squeeze them into human microstructures presents a daunting biomedical engineering challenge.

Biographical Note

Professor Webb conducted research in engineering and solid-state and chemical physics as coordinator of fundamental research and assistant director of research at Union Carbide Corporation before and after graduate studies. He joined the Cornell faculty in 1961, served as director of the School of Applied and Engineering Physics from 1983 to 1989 and is presently a member of the graduate faculties of seven fields. He directs the Developmental Resource for Biophysical Imaging Opto-Electronics. He is on the board of directors and executive committee of the Cornell Research Foundation. He is affiliated with the university's Biophysics Program, the Cornell Center for Materials Research, the National Biotechnology Center and serves on the Life Sciences Advisory Council. He has been a visiting scholar at Stanford University, a Guggenheim fellow, a scholar in residence at the NIH Fogarty International Center for Advanced Study, and the 1997 Ernst Abbe lecturer. He is a fellow of the American Physical Society (APS) and the American Association for the Advancement of Science, a founding fellow of the American Institute of Medical and Biological Engineers, and an elected member of the National Academy of Engineering; National Academy of Science, and American Academy of Arts and Sciences. He won the APS Biological Physics Prize in 1990, the Ernst Abby Lecture Award in 1997, the Michelson-Morley Award in 1999, the Rank Prize for Opto-electronics in 2000, the Jablonski Award Lecturer in 2001, and the 2002 National Lecturer of the Biophysical Society, and has served as chairman of the Division of Biological Physics and associate editor of Physical Review Letters. He is active as a consultant and in various national advisory committees and professional societies.

Industrial Affiliates Day 2006
Invited Presentation

In Situ 3D Visualization with Deployable and Head-worn Displays

Dr. Jannick Rolland
Associate Professor of Optics, Computer Science, Electrical Engineering, and Modeling and Simulation
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Abstract

Emergence of several trends such as the increased availability of wireless networks, miniaturization of electronics and sensing technologies, and novel input and output devices is giving rise to user interfaces suitable for use across a wide range of applications. In this talk, we will present emerging visualization methods, particularly as they relate to deployable displays and displays worn on the body to support mobile users. Low field of view designs, suitable for integration into the eyeglasses form factor will also be discussed. Eyeglass based displays are particularly interesting because they are well suited for mobile applications and they are more likely to enjoy higher social acceptance. Finally, we will discuss a vision of how 3D medical datasets, together with modeling, 3D visualization, and coupling to biophotonics imaging technology, may bring us to a new level of medical intervention.

Biographical Note

Jannick Rolland is Associate Professor of Optics, Computer Science, Electrical Engineering, and Modeling and Simulation at the University of Central Florida (UCF). She received a Diploma from the Ecole Supérieure D'Optique in France in 1984, and her Ph.D. in Optical Science from the University of Arizona in 1990. Jannick Rolland joined the Department of Computer Science at the University of North Carolina (UNC) at Chapel Hill as a Postdoctoral Fellow to conduct research in optical design for 3D medical visualization. She was appointed Research Faculty at UNC in 1992 and headed the Vision Research Group from 1992 to 1996. She holds 11 patents, wrote 6 book chapters, and has over 50 peered review publications related to optical design, augmented reality, vision, and image quality assessment for medical imaging. She authored and co-authored over 100 other publications related to the same topics. Dr. Rolland has been on the Editorial board of Presence (MIT Press) since 1996 in various positions, and has been Associated Editor of Optical Engineering 1999-2004. She is a Fellow of the Optical Society of America, and a member of SPIE, IEEE, and SID

Industrial Affiliates Day 2006
Invited Presentation

Multiphoton Biomedical Imaging and Photodynamic Therapy: Agents & Applications

Dr. Kevin Belfield
Professor, Department of Chemistry and CREOL, The College of Optics and Photonics,
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Abstract

Following the pioneering work of Denk and Webb in 1990, two-photon excitation (2PE) fluorescence microscopy (2PM) has had an extraordinary impact on the ability to image living cells and whole organisms. A major impediment to optimizing 2PM imaging is the limited amount of knowledge available about the two-photon absorption (2PA) cross-sections of potential fluorophores. Many conventional fluorophores exhibit low 2PA cross-sections (□), on the order of ~10 GM units with a very few exhibiting ~100 GM units, and only recently has research been reported on the design and development of very efficient 2PA dyes possessing between 100 and several 1000 GM. Recognizing the shortcomings of existing fluorophores, we have focused on developing novel molecules with enhanced 2PA properties and photostability for both bioimaging and photomedicine applications. Our efforts to develop cellular probes and photodynamic therapy agents are based on studies from our laboratory on the design and development of fluorene-based organic dyes with very efficient 2PA and fluorescence emission properties, along with high photostability and low cytotoxicity. This has been a collaborative, interdisciplinary effort between the College of Optics and Photonics, CREOL, the Department of Chemistry, and the Biomolecular Science Center at UCF. A summary relating the development of high fidelity probes and photosensitizers for multiphoton bioimaging and photodynamic therapy will be presented.

Biographical Note

Kevin D. Belfield received the Ph.D. in Chemistry from Syracuse University in 1988, where he studied the kinetics and mechanism of thermal rearrangements of organic molecules. He worked in the area of synthesis and characterization of functionalized polymers at SUNY College of Environmental and Forestry. He then pursued postdoctoral research in mechanistic organic chemistry, utilizing photochemical reactions and determining radical stabilization energies of polyenyl radicals through spectroscopically-aided kinetic studies. He joined the faculty of the Chemistry Department at the University of Detroit Mercy in 1992, where he received funding from Ford Motor Co. for new materials for stereolithography and from the NSF. He moved to the University of Central Florida's Department of Chemistry in 1998 and is currently chairman of the Chemistry Department. He holds joint appointments in the College of Optics and Photonics, the Biomolecular Science Center, and the Department of Mechanical, Materials, and Aerospace Engineering. His research interests are in the area of multifunctional absorbing materials, two-photon photochemistry, magnetic polymeric and sol-gel nanocomposites, site-specific fluorophore labeling, fluorescent-based sensors and fiber optic probes, new photodynamic therapy agents, nanostructured functional organic and polymeric materials, and two-photon based 3-D micro- and nanofabrication methods. Current research is funded by NSF, US Civilian Research & Development Foundation, Research Corporation, Petroleum Research Fund of the ACS, US Army, DARPA, and industry.

Industrial Affiliates Day 2006
Exhibitors

These Exhibits will be displayed in the Student Union Atrium, morning.

Laser Institute of America

13501 Ingenuity Drive, Suite 128
Orlando, FL 32826
407-380-1553
www.LaserInstitute.com

Lockheed Martin

5600 Sand Lake Road
Orlando, FL 32819-8907
407-356-2253
www.lockheedmartin.com

Optical Society of America

2010 Massachusetts Ave NW
Washington DC 20036-1023
202-223-8130
www.osa.org

Alpine Research Optics

3180 Winchester Circle
Boulder, CO 80301
303-444-3420
www.arocorp.com

Photonics Spectra

P.O. Box 4949
Pittsfield, MA 01202-4949
413-499-0514
www.Photonics.com

SPIE-The Int'l Society of Engineering

P.O. Box 10
Bellingham, WA 98227-0010
800-835-9433
www.spie.org

Industrial Affiliates Day 2006
Exhibitors

These Exhibits will be displayed in the CREOL building Lobby, after lunch.

Aerotech, Inc.

101 Zeta Drive
Pittsburgh, PA 15238
412-963-7470
www.aerotech.com

Analog Modules, Inc

126 Baywood Ave.
Longwood, FL 32750-3416
407-339-4355
www.analogmodules.com

Coherent, Inc

5100 Patrick Henry Drive
Santa Clara, CA 95054
770-788-2847
www.coherent.com

Crytur USA

1720 Natchez Trace Blvd.
Orlando, FL 32818
407-578-6469
www.crytur-usa.com

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3880 Park Ave
Edison, NJ 08820
732-494-8660
www.jobinyvon.com

Lambda Research Corporation

80 Taylor Street
Littleton, MA 01460
978-486-0766
www.lambdares.com

Newport & Spectra Physics

1791 Deere Ave.
Irvine, CA 92714
949-253-1461
www.newport.com

Ocean Optics

830 Douglas Ave.
Dunedin,FL 34698
727-458-6875
www.oceanoptics.com

Optimax Systems

6367 Dean Parkway
Ontario, NY 14519-8939
716-265-1020
www.optimaxsi.com

Optronic Laboratories

4632 36th St.
Orlando, FL 32811
407-422-3171
www.olinet.com

Siskiyou Design Instruments

110 SW Booth Street
Grants Pass, OR 97526
541-479-8697
www.sd-instruments.com

Spiricon, Inc.

2600 North Main
Logan, Utah 84341
435-753-3729
www.spiricon.com

Tektronix

14200 SW Karl Braun Drive
Beaverton, OR 97077
800-835-9433
www.tek.com

Trinity Technologies

595 Phalen Road
St. Paul, MN 55101
763-788-8278
www.lasersafety.com

Twin Star Optics, Coatings and Crystals

6741 Commerce Ave.
Port Richey, FL 34668
727-847-2300
www.starstar.com

Industrial Affiliates Day 2006
Laboratory Tour Schedule

NOTE: There will be Guided Group Tours through several CREOL labs today.

Each guided tour will rotate through four labs: about 45 minutes total.

1st Run:	**3:15**	**Groups for the first guided tours will assemble at 3:15 in the CREOL lobby.**
2nd Run:	**4:15**	**Groups for the second run of the tours will assemble at 4:15 in the CREOL lobby.**

TOUR A

3D Head-Worn Displays, Biophotonics Imaging and Curvature Sensing

Lab 147
Director: Dr. Jannick Rolland
http://odalab.ucf.edu

In-vivo optical rheology of blood

Lab 144
Director: Dr. Aristide Dogariu
http://random.creol.ucf.edu

White light continuum z-scan for nonlinear optical characterization of organics

Lab 227
Directors: Dr. David Hagan and Dr. Eric Van Stryland
http://nlo.creol.ucf.edu

3D multi-photon micro- and nano-scale fabrication and imaging

Lab 246
Directora: Dr. S. Kuebler & Dr. K. Belfield
www.cas.ucf.edu/chemistry/faculty_kuebler.php
www.cas.ucf.edu/chemistry/faculty_belfield.php

TOUR B

Photosensitive glasses and holographic optical elements

Lab 151
Director: Dr. Leonid Glebov
http://ppl.creol.ucf.edu

RGB and white light displays based on up-conversion

Lab 157
Director: Dr. Michael Bass
http://bass.optics.ucf.edu

Molecular Beam Epitaxy Lab

Lab 180
Director: Dr. Winston Schoenfeld
http://npdg.creol.ucf.edu

Infrared Systems Lab

Lab 130
Director: Dr. Glenn Boreman
http://ir.optics.ucf.edu

Note: There is a video view of our 3,000 sq ft class 1000/100 cleanroom, just off one side of the Lobby, near the front windows. See, e.g., a Leica 5000+ e-beam writer.

Abstracts

Unless otherwise indicated, authors are affiliated with the College of Optics and Photonics: CREOL & FPCE.
Presenter is underlined.

1

High Responsivity GaAs-based Neutron Detectors

Amy Thompson, JW Mares, HP Seigneur, WV Schoenfeld

GaAs-based PIN detectors of various sizes from 1 to 10 mm were fabricated. A significant reduction in dark current over prior devices was achieved, from 400 pA to 5 pA, and a linear relation between mesa size and dark current was observed. Using a Po-210 alpha source with a decay rate of 353.72 MBq, a strong alpha response of 5 nA/mm^2 was observed with a linear relation between the responsivity and mesa size. From the data, the optimum device size for a given moderator and neutron fluency can be determined. This work indicates that 1 mm detectors are also feasible, and could be used in arrays for neutron imaging and neutron energy spectrometers.

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2

Towards a Silicon Based Microlaser - Deposition and Optical Characterization of Si Based Optical Gain Media Operating At 1.53 μM

Oleksandr Savchyn, Forrest R. Ruhge, Pieter G. Kik, Ravi M. Todi*, and Kevin R. Coffey* *School of Electrical Engineering and Computer Science

The continued size reduction in electronic integrated circuits has lead to the demand for on-chip high-bandwidth and low loss communication channels. To achieve this, all optical interconnects are actively being investigated. The successful development of optical interconnects on silicon requires silicon compatible sources, waveguides, and detectors. Of these, the development of an efficient and cost effective Si based source has proven to be the most challenging, due to the indirect nature of the silicon bandgap.

The present study focuses on the optimization of the optical gain in Si compatible erbium doped materials operating at 1.53 μm. By simultaneous sputtering of SiO_2, Er_2O_3, Si, and Ge in a multi-gun sputtering system, gain media with a wide range of compositions were deposited. The composition of the as-deposited samples was analyzed using Rutherford Backscattering Spectrometry. Annealed samples show clear emission at 1.53 μm from Er^{3+} ions in the SiO_2 based host materials. The photoluminescence intensity and lifetime of the Er emission at 1.53 μm was studied as a function of annealing temperature in the range 500-1200°C. The data reveal Er activation at annealing temperatures up to 700°C, and a strong reduction in PL intensity at temperatures above 950°C which is attributed to Er clustering. Concentration dependent studies clearly reveal the presence of co-operative upconversion for Er concentrations in excess of ~1 at.%, and a co-operative upconversion coefficient of 1.2×10^{-16} cm^3/s is found. The effects of upconversion on gain performance are presented. Future work will focus on the use of Si_xGe_{1-x} nanocrystals in Er doped SiO_2 for achieving a broad-band pumped Si compatible laser operating at 1.53 μm.

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3

Optical Hematorheology Using Multimode Common Path Interferometry

Erwan Baleine, Lorrene Denney, Tracie Wilbur[*], John Biggerstaff[*], Aristide Dogariu
[*]Medical Lab Sciences / Molecular Biology & Microbiology department, University of Central Florida

Conventional methods used in blood viscometry have not found a wide application in medical practice mainly because the blood has to be treated chemically in order to prevent coagulation during the measurement. Using coherence gated dynamic light scattering, we report real time viscosity measurements of human blood in vitro making our technique promising for continuous monitoring of viscosity in vivo. This would be of great benefit in the early diagnosis and therapeutic monitoring of various disease states or post-surgery or trauma related thrombotic events.

Our method uses low coherence illumination and an optical fiber probe inserted into a blood flow. The optical mixing between the field reflected at the end surface of the fiber and the scattered light is directly analyzed in the frequency domain making our technique a good candidate for high throughput measurements. A significant increase of the signal to noise ratio was obtained with graded-index fibers rather than commonly used single mode fibers.

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4

Polarization patterns as a manifestation of the conservation of light angular momentum

Chaim Schwartz and Aristide Dogariu

Spatial patterns can be observed when linearly polarized light is backscattered from turbid media, and viewed through polarizers. The symmetries (which may be fourfold or twofold) and size of these patterns depend upon the scattering centers size and on the optical density.

It can be demonstrated that these patterns can be related directly to the conservation of the angular momentum of light. The circular polarization modes which propagate along planar trajectories may acquire a geometrical phase or not, depending on the helicity preserving characteristics of the scattering media. The geometrical phase is shown to be the result of the coupling between the spin and the orbital angular momentum, while the total angular momentum is conserved. The geometrical phase (which can be shown to be in the form of a phase vortex) manifests itself, upon superposition of the circular modes, as linear polarization vortices. It is also possible to derive spatially resolved Mueller matrices which describe the polarization response of backscattering media.

The model developed relates to the conservation of a basic physical property and also shows good agreement with many experimental observations.

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5

Multi-Mode Interference Waveguide Switches

Daniel A. May-Arrioja and Patrick LiKamWa

When a waveguide structure is purposely designed to support a multitude of guided modes, highly predictable phenomena occur due to the interference between these modes. One very useful device that exploits this property is the multimode interference (MMI) waveguide coupler or beamsplitter. Such a device is much more tolerant to fabrication errors, when compared to a directional coupler, and the required beam-spitting ratio is usually obtained to within a few percent of the designed ratio. However there are some applications that require a much tighter control on the amplitude and phase of the split optical beams. In this paper, we report a tunable 3-dB multimode interference coupler that operates by modifying the phase of the multiple images that are formed around the midpoint of the MMI section. Highly localized phase changes within the MMI section are achieved by injecting current through metal contacts deposited on top of p-doped regions. These p-doped regions are achieved using a selective-area zinc in-diffusion process. The precise locations of the p-doped regions are crucial in minimizing current spreading for optimal operation of the device. The results from our initial device that was fabricated using conventional photolithography and wet chemical etching show that the optical power split ratio can be easily tuned all the way from a 90:10 to a 30:70 splitting ratio of the optical power transmitted through the two output ports. This MMI component can readily be integrated into other devices such as the symmetric Mach-Zehnder switch in which the extinction ratio can be fully optimized by carefully trimming the 3-dB couplers.
Furthermore, minor improvements in the fabrication process will lead to a more symmetric tuning response of the device thereby turning it into an electro-optic switch by itself. The tunable MMI device will most certainly find applications in more complex integrated optic devices.

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6

Multi-Line Guided Mode Resonant Filters with Controlled Spectral Separation

Sakoolkan Boonruang, Andrew Greenwell and M. G. Moharam

A novel multi-line filter using two-dimensional guided mode resonant (GMR) filter is proposed. The filter concept utilizes the multiple planes of diffraction produced by the two-dimensional grating. Multiple resonances are obtained by matching the guided modes in the different planes of diffraction to different wavelengths. It is shown that the location and the separation between the resonances can be specifically controlled by modifying the periodicity of the grating and other physical dimensions of the structure. This is in contrast to one-dimensional GMR filters where the location of the resonances is material dependent. Two-line reflection filter designs with spectral line widths less than 1 nm and a controllable spectral separation of up to 23 % of the short resonance wavelength are presented using rectangular-grid grating GMR structures. Three-line filters are designed in hexagonal-grid grating GMR structures with two independently controllable resonance locations.

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7

High-Density Spectral Beam Combining

Oleksiy Andrusyak, Igor Ciapurin, Vasile Rotar, Armen Sevian, George Venus, Leonid Glebov

High-efficiency volume Bragg gratings (VBGs) in photo-thermo-refractive (PTR) glass are suggested for use as spectral beam combining (SBC) elements within a framework of developing a source of high-power continuous-wave laser radiation. Suggested technique allows laser radiation from multiple sources (laser diodes) to be incoherently combined into a single-aperture near diffraction-limited output beam.

Channel spacing in SBC is dictated by the spectral selectivity of the grating, which is the spectral separation between the maximum and a minimum of the diffraction efficiency. The critical advantage of VBGs over the conventional diffraction gratings is the spectral selectivity that is almost two orders of magnitude narrower. This makes VBGs ideal for high-density SBC, allowing us to combine a much larger number of lasers within the usable bandwidth. Other advantages of VBGs include low losses and high damage threshold, allowing for higher power levels that can be achieved via SBC.

Different arrangements for high-density SBC based on transmitting and reflecting VBGs are presented and compared. Transmitting VBGs have narrow angular selectivity, requiring larger well-collimated input beams with small angular divergence. A shearing interferometer based on a properly selected wedged plate can insure near-perfect beam collimation. Reflecting VBGs can offer an even narrower spectral selectivity with wider angular selectivity, which makes them suitable for beams of virtually any size.

In order to increase the efficiency of SBC, the overall cross-talk from the neighboring channels should be minimized. We consider specific beam-combining schemes and address cross-talk minimization problem based on optimal channel positioning. Coupled wave theory of thick hologram gratings is used in this analysis.

Spectral and angular characteristics of a beam-combining element with 2.2 nm channel separation around 1090 nm, based on a transmitting VBG, are presented. Pathway to laser sources with 100 kW CW near diffraction-limited output beam is discussed.

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8

Two-Photon Cellular Imaging with High Performance Two-Photon Absorbing Fluorescent Probes

Katherine J. Schafer-Hales[1,2], Kevin D. Belfield[1,2,3], Sheng Yao[1], Peter K. Frederiksen[1,3], Kiminobu Sugaya[2], and Emmanuel Vrotsos[2]
(1) Department of Chemistry, (2) Biomolecular Science Center, and (3) CREOL, College of Optics and Photonics

Two-photon fluorescence imaging was demonstrated on both fixed and live NT2 cells incubated with new highly efficient 2PA fluorescent contrast agents. These probes possess high two-photon absorptivity, high fluorescence quantum yields, and high photostability, along with low cytotoxicity. The high performance of these contrast agents allowed two-photon fluorescence imaging using low irradiance over relatively long time periods (~24 h). Two-photon excitation conditions were investigated as a function of excitation wavelength and irradiance power. Two-photon spectroscopic properties and two-photon fluorescent microscopy images will be presented. The stability and sensitivity of these dyes makes them ideally suitable for multiphoton fluorescence imaging.

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9

Nonlinear Photoionization of Optical Glass by Femtosecond Pulses

Leo Siiman, Julien Lumeau, Leonid Glebov

Optical quality silicate glasses are transparent to visible light (λ = 250-2700 nm). In fact, the only practical loss in intensity of transmitted visible light through high-purity silicate glass comes from scattering, not absorption. Even with laser sources in the visible, linear absorption in silicate glass is negligible for low-power lasers. However, high-intensity laser pulses with wavelengths in the visible region have been shown to induce absorption in silicate glasses resulting from different nonlinear mechanisms. This induced absorption is characteristic of color-center generation. Color center absorption in silicate glasses is a well-known phenomena easily observed after ionizing a glass with photon energies greater than the bandgap energy (5.9 eV, λ < 208 nm). For a laser operating in the visible region (1.55 eV – 3.1 eV), a nonlinear mechanism is needed to generate color centers through photoionization. In this presentation we study color-center generation in high purity soda lime glass by pulsed lasers (τ_1 = 5 ns, λ_1 = 1064 nm and its harmonics; τ_2 = 120 fs, λ_2 = 780 nm) and compare the results to color-center generation by conventional radiation sources (X-rays, gamma rays, UV lamp). Of particular interest is the result that a Ti:sapphire femtosecond laser focused to a high intensity (~10^{12} W/cm^2) ionizes soda lime glass. This suggests that other multi-component silicate glasses can be ionized by high-intensity femtosecond pulses. This approach will be used for study of photoionization and hologram recording in photo-thermo-refractive glass.

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10

Nd:YAG Ceramic Crystal Fluorescence Lifetime and Thermal Expansion Measurements

Jed Simmons and Michael Bass

Ceramic crystal laser materials prepared by Konoshima were first made viable in Japan*. This material could be produced with excellent optical quality, in much larger samples and with higher Nd dopant concentrations than possible in single crystals of YAG. As a result ceramic crystal Nd:YAG is a serious candidate for use in high power solid state lasers. In the present research we study the properties of ceramic crystal Nd:YAG and compare them to those of single crystals. The fluorescence lifetimes and thermal expansion coefficients of ceramic crystal Nd:YAG were measured. Fluorescence lifetimes for 0.32, 1, 1.8, and 4 % Nd concentration samples were measured at temperatures ranging from approximately 35 K to room temperature. At room temperature the lifetimes ranged from 85 to 251 μs for the highest to lowest dopant concentrations respectively. An interferometric technique was used to determine the thermal expansion coefficient in three differently doped samples of Nd:YAG ceramic. For the dopant concentrations of 4, 2, and 0.09 % the thermal expansion coefficients of the ceramic crystals in preliminary results ranged from $1.38*10^{-6}$ to $2.24*10^{-5}$ $^oC^{-1}$ while for single crystal Nd:YAG the value for the thermal expansion coefficient is $7.8*10^{-6}$ $^oC^{-1}$. The same interferometric system will be used to measure the temperature dependence of the index of refraction of the ceramic crystalline samples. We also plan measurements of solarization in these materials.

* A. Ikesue, T. Kinoshita, K. Kamata, and K. Yoshida, "Fabrication and Optical Properties of High-Performance polycrystalline Nd:YAG Ceramics for Solid-State Lasers," J. Am. Ceram. Soc., **78** [4] 1033-40 (1995).

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Laser Doping Of Wide Bandgap Semiconductors: Fabrication of Laser Diodes and Wireless Optical Sensors

Sachin Bet, Abhijit Chakravarty, Nathaniel Quick* and Aravinda Kar
*Applicote Associates, LLC, 3259 Progress Dr., Orlando, FL 32826

Ion implantation, which is the current doping technique, causes several problems when applied to wide bandgap semiconductors. It modifiess the stoichiometry, introdues defects and changes the homogeneity of the substrate. Even high temperature annealing does not cure the defects. Defect states are formed within the bandgap region and they provide a channel for the electrons and holes to nonradiatively recombine to produces phonons. So the electron-hole recombination produces heat instead of producing light. This is one of the main failue mechanisms for light-emitting semiconductor devices such as laser diodes. Laser doping provides a new technology to fabricate laser diodes with fewer defect states. An n-type 6H-SiC has been doped with a p-type dopant to form a p-n junction. Al is known to create four impurity states within the bandgap. Electroluminescence of the diode exhibits a sharp blue line at 481.2 nm wavelength, suggesting a laser diode-like operation. This wavelength fits well to an electronic transition between two impurity states. Although SiC is an indirect bandgap semiconductor, the impurity states may allow electronic transitions similar to that of a direct bandgap semiconductor. The laser doping technique can also be used to develop SiC-based wireless optical sensors for temperature, pressure and ambient chemical sensing. An undoped 4H-SiC was tested for its optical response in the presence of pure nitrogen and nitrogen-methane gas mixture at a high pressure for different temperatures. The distinct Fabry-Perot interference patterns for pure nitrogen and nitrogen-methane mixture allow remote optical sensing of such chemicals in combustion systems at high pressure and high temperatures.

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Cholesteric Liquid Crystal Lasers

Ying Zhou, Yuhua Huang and Shin-Tson Wu

In this poster, we demonstrate a dye-doped cholesteric liquid crystal laser whose cavity length is only a few microns. The self-assembled anisotropic chiral structure functions as 1D photonic crystal and hence creates the photonic band gap for circularly polarized light. When doped with an active medium and pumped by a pulsed Nd:YAG laser, laser action takes place at photonic band edge within a few micrometer thickness based on distributed feedback.

The laser emission comes out from both sides of the cholesteric cell and the lasers are circularly polarized. In an experiment, we placed a passive cholesteric liquid crystal reflector to the backside of the laser. Due to the increased length of laser cavity and further stimulated amplification, the polarization-conserved cholesteric reflector not only enhances the laser emission dramatically but also decreases the beam divergence remarkably. This idea is useful in cholesteric liquid crystal lasers, cholesteric filters, micro-lasers and waveguide lasers.

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- Laser Spectroscopy and Optically Written Displays – Rm. 157
- Thermal Management of Diode and Solid State Lasers – Rm. 158
- Microscopy, Electronics, Wave Propagation Studies – Rm. 175

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- Infrared Systems – Measurements & Characterization – Rm. 130
- Infrared Systems – E-Beam Lithography – Rm. 130a
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- Nanophotonics Fabrication Facility – Rm. 180

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- Soliton Theory – Rm. 210

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- Modelocked Erbium Fiber & Glass Waveguide Laboratory 254
- Optical Clocks for Photonic Sampling and Waveform Synthesis - Rm. 256
- High Power Ultrafast Semiconductor Laser Laboratory - Rm. 245A
- OCDMA & Chip Scale WDM Technologies - Rm. 244A
- Quantum Dot Semiconductor Laser Laboratory- Rm. 243A

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Dr. Leon Glebov
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- Volume Holographic Elements – Rm. 128
- Photoinduced processing, semiconductor lasers – Rm. 154
- Holographic Laser Beam Combining (with Boris Zeldovich) – Rm. 249

Drs. David Hagan and Eric Van Stryland
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- Nanosecond Tunable OPO (400-1,500 nm) – Rm. 236
- Picosecond tunable OPA lab (400nm–16microns) – Rm. 230
- Single Mode Nanosecond CO_2 – Rm. 233
- Two-Photon Confocal Microscope with Femtosecond OPO – Rm. 246

Dr. James Harvey
- X-Ray Telescopes – Rm. 122
- Optical Surface Scattering – Rm. 155
- Generalized Scalar Diffraction Theory
- Interferometry (with Jannick Rolland) – Rm. 146

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- Micro-Optics and Nano-Optics metrology facility - Rm. 150
- Test and characterization for photonic devices - Rm. 153
- Nanophotonics Fabrication Facility - Rm. 180

Dr. Aravinda Kar
Laser Advanced Materials Processing (LAMP)
- Laser Advanced Manufacturing – Rm. 263, 264
- Laser Synthesis of Materials – Rm. 263, 264
- Laser Processing of Wide Bandgap Materials – Rm. 263, 264
- Modeling and Simulation for materials processing – Rm. 263, 264

Dr. Pieter Kik
Nanophotonics and Near-field Optics
- Nanophotonics Characterization Lab - Rm. 247

Dr. Stephen M. Kuebler
3D Micro- and Nano-fabrication
- Fabrication of 3D micro- and nano-scale structures – Rm. 246 & Chemistry 318

Dr. Guifang Li
- Optical Fiber Communications – Rm. 246A, 248

Dr. Patrick LiKamWa
- Quantum Well Optoelectronics – Rm. 220, 223
- Nanophotonics Fabrication Facility – Rm. 180

Dr. Jim Moharam
- Diffractive Optics – Rm. 258

Dr. Kathleen Richardson
- Glass Melting – Rm. 255A
- Glass Processing and Characterization – Rm. 255

Dr. Martin Richardson
Laser Plasma Laboratory
- Northrop Grumman Extreme Ultraviolet Photonics Laboratory
- Biological X-Ray Microscopy Facility – Rm. 140 (140 A-F), 143 (143 A-B)
- Multi-TW Femtosecond Laser Interaction Facility
- Laser Development Lab: Femtosecond Laser Waveguide Writing & Micromachining Lab – Rm. 141
- Laser Development Lab: New Solid State Laser Development – Rm. 141B
- Laser induced breakdown spectroscopy (LIBS) laboratory Rm 140
- Zygo New View 6300 Interferometer – 2nd Floor Cleanroom Rm. 211

Dr. Nabeel Riza
- Photonic Information Processing Systems – Rm. 250, 251, 253

Dr. Jannick Rolland
ODALAB -- Optical Diagnostics and Applications Laboratory
- 3D Visualization (Augmented Reality and Virtual Reality) – Rm. 145, 147
- 3D Optical Imaging (Optical Coherence Imaging, Curvature Sensing) – Rm. 146

Dr. Winston Schoenfeld
Nano-Photonics Device Group (NPDG)
- Nanophotonics Devices Lab – Rm. 156
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Dr. Craig Siders
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Dr. Eric Van Stryland (See Drs. Hagan and Van Stryland)

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- Nano Photonics – Rm. 260
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CREOL

A BRIEF HISTORY

1986 – 2006

CELEBRATING THE FIRST 20 YEARS

OF

CREATING THE FUTURE
OF OPTICS AND PHOTONICS

UNIVERSITY OF CENTRAL FLORIDA

CREOL & FPCE
THE COLLEGE OF OPTICS AND PHOTONICS

CREOL
The first 20 years
1986-2006

THE GENESIS

The history of CREOL began several years before it actually became a reality. The story starts with the energy and initiative of Bill Schwartz, who is viewed by many as the founder of Florida's laser industry. Coupled with Bill's leadership was the initiative by then-Governor Bob Graham in the mid-1980's to grow Florida's economy beyond its dependence on tourism and agriculture (mainly citrus) by fostering the development of high-technology, value-added, wealth-generating industry in the state.

Bill Schwartz

To lead the definition of what industries should be emphasized, the state formed the Florida High Technology and Industry Council (FHTIC). The FHTIC was made up of business, industry, and university leaders who were business and technology savvy, and were the type of people that elected leaders respected and would listen to. Bill Schwartz, along with Dr. Bill Oelfke of the UCF Physics Department, proposed a university-based program in 1984, which became one of the recommendations in a FHTIC report to the governor identifying seven technology areas that had high promise and were critical to Florida's economic future, one of which was "Lightwave Technology". Ron Phillips of the UCF Electrical Engineering Department, and chair of the Lightwave Technology Panel of the FHTIC, wrote the portion of the report that recommended the State University System (SUS) take action to "form the Center for Research in Electro-Optics and Lasers (CREOL)* to provide Florida's high-tech industries with access to research, students, and faculty in advanced areas of optical and laser sciences." The SUS Board of Regents approved such an action in 1985, and in 1986, the Florida legislature acted to provide $1.5M of permanent, recurring funds to the University of Central Florida (UCF) budget to support CREOL. It is this second milestone that has been chosen as the founding date of CREOL, even though the search for the first Director was not yet accomplished.

Establishment of CREOL was a bold action on the part of the state since in 1986, Florida typically invested the smallest amount per capita on education, and UCF was a very new university (founded in 1964) known primarily as a commuter school, had only 16,000 students (mostly undergraduates, the first of which graduated in 1970), very little technical research activity, limited graduate programs, including no PhD in physics, and only a handful of faculty who associated themselves with the optics field. Into this promising, but challenging environment came what the founding director, MJ Soileau, calls "The Texans" – MJ, Eric Van Stryland (now the Dean of the College), David Hagan (now the Associate Dean for Academic Studies for the College), and seven graduate students. MJ arrived on January 2, 1987 with the mission to build an internationally competitive academic unit in optics.

Why would a well-established group of academic scientists leave the known environment at North Texas State University to take on such a challenge? Maybe it was the "researcher's disease" that causes an irresistible urge "to go where no one has gone before." MJ has written a modified version of this: "I took the job because of the opportunity to build an academic unit devoted to optics, to staff it with top scholars in the field of optics, and to attract excellent students. The simple idea was to build an academic unit that would be much better than I could ever be hired into, and then to become a member of it by the historical accident of being present at its birth!" Being in a new university like UCF also presented the opportunity to develop something new, without the hindrance of "tradition", the short version of what some call "the 7 last words of an organization" – "We've never done it that way before."

And so the journey began….

The "CREOL Period": 1986 - 1998

The CREOL period (1987-98) includes the formal appointment of the first director (MJ), the securing of facilities and additional base funding, recruitment of faculty, definition of the basic educational and research philosophy that would guide the new center, and solid accomplishments of the faculty that would lead to the next major period of development – status as a full academic unit.

The first challenge of finding suitable facilities was easily recognized by two situations: (1) The Texans were assigned office and lab space on the site where the CREOL building now stands consisting of a double-wide trailer. This would clearly not accommodate even the 10 Texans, never mind the 43,000 pounds of optical tables and equipment they brought with them, nor the 13 additional faculty that were to be hired.

Initial CREOL site with double-wide trailer. The truck in the photo is carrying some of the 43,000 pounds of optics stuff brought by the "Texans."

Research Pavilion, circa 1988

Exploration of options, including temporary use of space in the UCF Engineering Building, led quickly to a second move into the Research Pavilion, a new building in the new Central Florida Research Park adjacent to the UCF campus. By the summer of 1987, the buildup of laboratories in these new facilities was well under way, and the move into them was accomplished over the Christmas holidays.

The recruitment of faculty began in earnest once it was clear where they and their research labs would be housed. Since CREOL was not an academic unit, the tenure lines were held in the established academic departments such as physics, electrical engineering, etc. Table 1 shows the history of who joined CREOL and when. A total of 30 faculty members were hired during this period, 21 of whom are still part of CREOL. This early recruitment included a booth at the CLEO meeting in 1987 to get the word out about the new center and what it was all about.

MJ Soileau explaining the new CREOL at CLEO 1987

As the CREOL era began, there were a few fundamental principles that guided the new center:

- Hire top faculty, seeking the best scientist/engineer available, rather than a specific research topic, and create an environment in which they can be successful.
- Recruit the best students in the world and educate them in both fundamentals and applications of optics and photonics.
- Build solid research partnerships with industry worldwide, and with Florida industry in particular.
- Build a strong sense of community among the faculty and students of CREOL, including having some fun!

People sometimes ask which of the above principles have been most important in CREOL's rapid growth and success. The answer is "All of them!" They are all necessary, and none, or even 2 or 3 of them, are sufficient without the rest. Another important element in the early days was that the CREOL Director had control of the recurring financial resources that supported the faculty, even though CREOL was not yet an academic unit. This fact, coupled with the need for the faculty to have their academic appointment in one of the UCF college/department units, led to some occasional disagreements, but also demanded cooperation between CREOL and the other units. This helped encourage interdisciplinary research and promoted another dimension of partnership that is a fundamental value of CREOL and of UCF.

Although the guiding principle for recruiting faculty was to find the best scientist/engineer available, there were some topics identified to help guide the search. These are illustrated in the figure to the right, taken from the presentation to the Board of Regents before their vote on establishing CREOL in 1986.

CREOL

ORIGINAL UCF AY 86-87 Request to BOR

Funding is requested to "establish new initiatives in both instruction and research in the electro-optics and laser areas."

Proposed areas of emphasis of CREOL included:

1. Spectroscopy and Solid State Devices
2. Diode Pumped Lasers
3. Propagation
4. Optical microelectronics
5. Image understanding
6. Sensors
7. Metrology
8. IR systems
9. Medical uses of lasers
10. Undergraduate and graduate instruction

Center for Research in Electro-Optics and Lasers

The list of the faculty in Table 1 illustrates the rapid expansion of the CREOL faculty, and the success of the effort to attract the best and the brightest. Today, CREOL faculty members are recognized by their peers as leaders in their respective research areas. Some of the quantitative measures of their success include the following:

- 74% hold the rank of Fellow in at least one major technical society
- Collectively produce over 400 scholarly publications and 40 patent applications each year
- Serve in the leadership (boards, committees, officers) of all the major optics and photonics societies: SPIE, OSA, IEEE/LEOS
- Have received numerous honors and awards recognizing their achievements

The goal of attracting and educating the best students has also produced some great results. One of the critical elements of both attracting excellent students into the program, and of educating them to be significant contributors in their post-graduate career, was the CREOL commitment to a broad-based education in both the classroom and research, covering both fundamental and applied topics. A graphical representation of this philosophy is shown below. The lower axis is a typical physics curriculum, and the upper axis is a typical electrical engineering curriculum, each with optics as one of the components. The CREOL curriculum is a combination – ranging from the most fundamental physics aspects of optics and photonics to the more applied, engineering aspects.

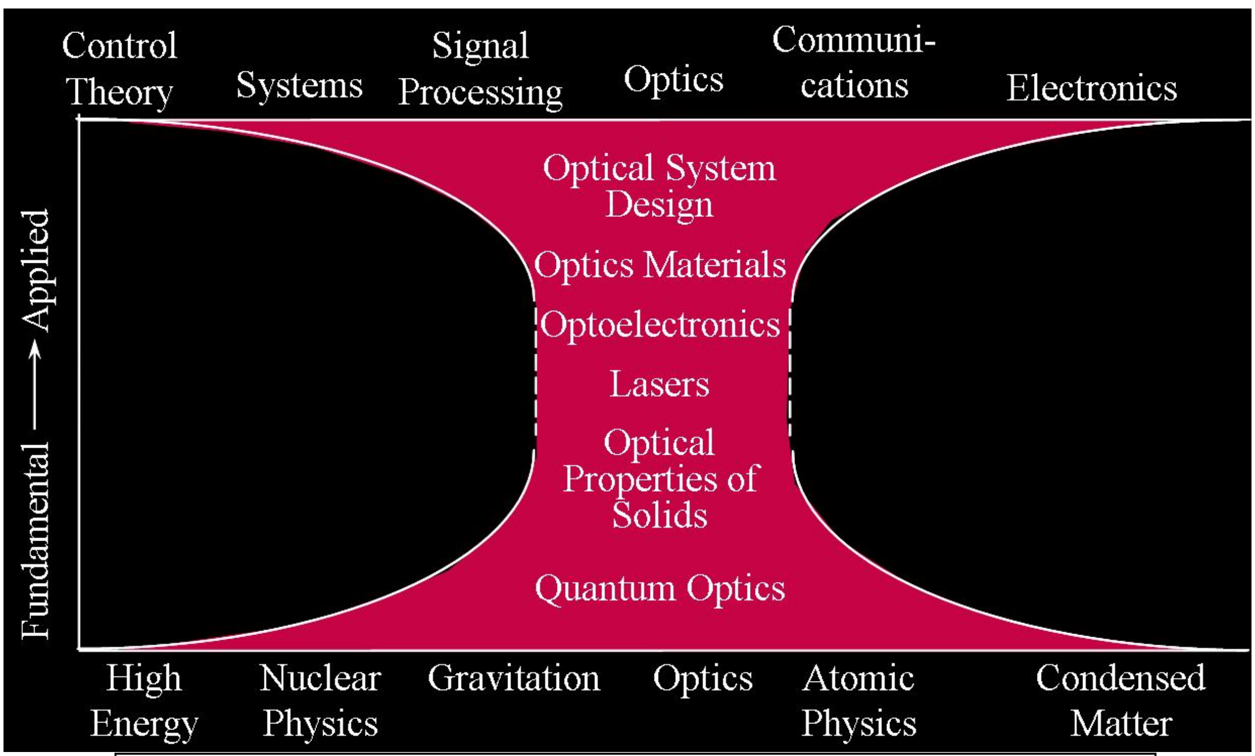


Illustration of the CREOL curriculum philosophy – to cover the full spectrum of topics from fundamental physics to engineering and design.

Table 1. History of hiring of CREOL Faculty

Faculty Member	Current Position	Hire Date
Soileau, MJ	VP for Research and Commercialization; Professor of Optics, ECE & Physics	12/1986
Lin, Jui-Teng	Associate Professor of Physics (departed)	01/1987
Van Stryland, Eric	Dean and Director, Professor of Optics, Physics & ECE	03/1987
Hagan, David	Assoc Dean of Academic Programs & Professor of Optics, Physics & ECE	05/1987
Bass, Michael	Emeritus Professor of Optics, Physics & ECE	11/1987
Guenther, Karl	Associate Professor of ECE & Physics (deceased)	12/1987
Moharam, Mohamed "Jim"	Professor of Optics & ECE	12/1987
Elias, Luis	Professor of Optics & Physics (departed)	06/1988
Kim, Jin	Professor of Physics & ECE (departed)	06/1988
Chai, Bruce	Professor of Optics Physics & MMAE & ECE (on leave)	01/1989
Miller, Alan	Professor of Physics & ECE (departed)	01/1989
Li Kam Wa, Patrick	Associate Professor of Optics & ECE	09/1989
Dixon, George	Assistant Professor of ECE (departed)	12/1989
Silfvast, William	Emeritus Professor of Optics	01/1990
Richardson, Martin	Professor of Optics, Physics & ECE	04/1990
Stickley, Martin	Assoc. Dir of Industrial & Governmental Rel. & Sr. Research Scientist (departed)	07/1990
Stegeman, George	Professor of Optics, Physics & ECE, Cobb Family Chair	07/1990

Faculty Member	Current Position	Hire Date
Boreman, Glenn*	Professor of Optics & ECE	08/1990
Harvey, James	Associate Professor of Optics & ECE	09/1990
Richardson, Kathleen	Associate Professor of Optics Chemistry & MMAE (departed)	08/1993
Delfyett, Peter	Professor of Optics & ECE	12/1993
Kar, Aravinda	Associate Professor of Optics, MMAE & ECE	03/1994
Zeldovich, Boris	Professor of Optics & Physics	08/1994
Jenssen, Hans	Sr. Research Scientist (retired)	09/1994
Riza, Nabeel	Professor of Optics & ECE	02/1995
Glebov, Leon	Sr. Research Professor	09/1995
Rolland, Jannick**	Assoc. Professor of Optics, ECE & Computer Science	03/1996
Dogariu, Aristide	Associate Professor of Optics	08/1997
Li, Guifang	Professor of Optics, Physics & ECE	09/1997
Wolf, Emil	Provost's Distinguished Research Professor	01/1998
Johnson, Eric	Associate Professor of Optics	01/2000
Siders, Craig	Assistant Professor of Optics (departed)	08/2000
Wu, Shin-Tson	PREP Professor of Optics	07/2001
Christodoulides, Demetrios	PREP Professor of Optics	08/2002
Kuebler, Stephen	Assistant Professor of Chemistry & Optics	08/2003
Kik, Pieter	Assistant Professor of Optics	09/2003
Busch, Kurt	Associate Professor of Physics & Optics (departed)	12/2003
Schoenfeld, Winston	Assistant Professor of Optics	05/2004
Deppe, Dennis	Professor of Optics/FPCE Trustee Chair	06/2005

Another vital step to attract great students was the formation of student chapters of SPIE, OSA, and IEEE/LEOS, and the students quickly formed an umbrella organization – the CREOL Association of Optics Students (CAOS) – to coordinate and integrate their activities, and to qualify for funding from the UCF student government programs. They even built a float for an Orlando parade event! The CAOS group has also been instrumental in CREOL's outreach to the community, hosting tours for K-12 groups and other visitors, and developing clever displays to illustrate sophisticated optical concepts such as waveguiding and phase conjugation in tabletop displays that can be used in demonstrations at CREOL, or easily taken to other locations.

The CREOL – LASER Float, circa 1989

A CREOL grad student shows a visitor (Steve Guch – Litton Laser Systems) one of the tabletop demonstrations.

The research partnerships with industry have been built in a number of ways over the years. A Board of Visitors, or External Advisory Board, was developed early, expanding on an existing Industry Advisory Board by adding influential members of the community, including Mr. Charles Cobb (who later endowed the Cobb Family Chair at CREOL) and Joan Ruffier (former Chair of the Board of Regents of the State University System of Florida). And in 1989 the CREOL Industrial Affiliates program was inaugurated. Dr. Art Guenther was one of the first Life Members, and United Technologies Optical Systems (UTOS), led at the time by Dr. Jim Pearson (now CREOL Director, Research & Administration), was an early Affiliates member.

MJ thanking Jim Pearson for UTOS Industrial Affiliates membership

MJ and Eric help Art Guenther place his plaque on the “Wall of Honor” as a Life Member of the CREOL Industrial Affiliates

From the beginning, the partnership between CREOL and industry was not just a “connection”, but a true research partnership. Industry found CREOL to be a great place to get research accomplished that was relevant to their needs, and accomplished on a time scale that met industry needs. As a result, for most of the last 20 years, CREOL has had approximately 25% of its funding coming directly from industry – just over $5M in 2005.

The final foundational element of community and fun is the “soft” element, but an essential one. Since in the early days, there were no decent restaurants within 10km of UCF, so CREOL began the tradition of entertaining faculty candidates and other visitors in the homes of faculty. This practice, plus ad hoc get-togethers at the office, holiday parties, and others helped connect everyone personally through fun events where

L-R: Jim Pearson, MJ, Jim Breckinridge, Henry Arsenault, and Joe Houston help carve the gator tail at the CREOL Spring Thing

CREOL students help Nicholaas Bloembergen celebrate his birthday at the CREOL Spring thing the Director served everyone, literally. One of the parties has been "institutionalized" as the CREOL "Spring Thing," held each year after the SPIE Orlando meeting at MJ’s home on the shore of alligator-infested Lake Jessup.

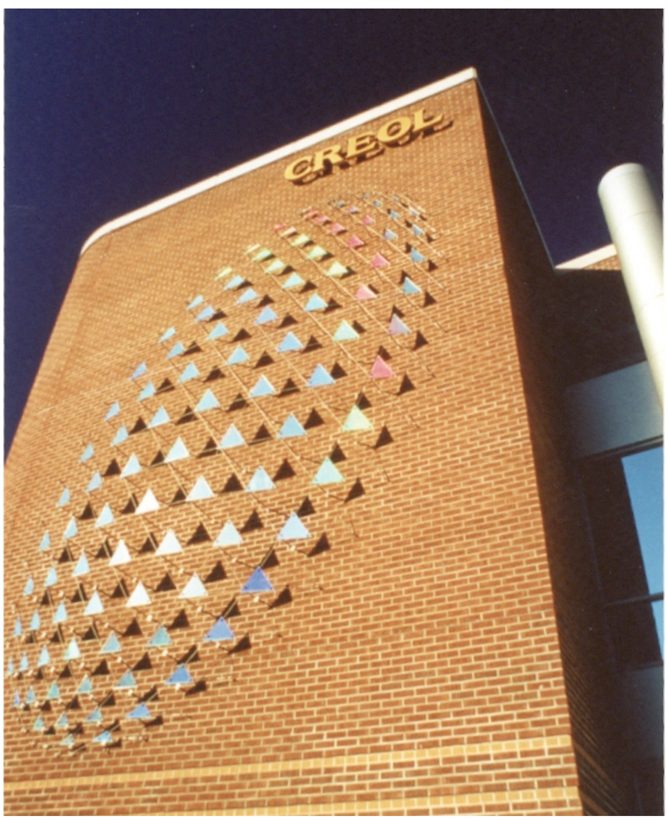
As the research progressed, and the new faculty arrived, CREOL rapidly outgrew the available space in the Research Pavilion and had several labs in another building near the UCF Institute for Simulation and Training (IST). In addition to the operational difficulties this situation presented, everyone really wanted to be on the main UCF campus, both for proximity to colleagues in other units, as well as to be perceived as an integral part of the university. And so a new facility was designed (it was actually promised at the outset, but it took 7 years to get everything in place), and construction began on the site of the original double-wide trailer.

View of the CREOL site cleared for the start of construction. The UCF Engineering building is visible in the far right of the picture. The double-wide trailer is at the far left.

Construction began in 1994, and was completed in time for a move-in over the Christmas holiday in December of 1995. By this time, the center had a total of over 150 students, staff, and faculty. The new 83,000 ft^2 facility was beautiful, functional, and graced by a wonderful sculpture of an artificial (holographic) rainbow on the outside of the building shows different colors depending on the time of day and angle of the sun with respect to the observer (see pictures below).

CREOL building during construction in 1995

The completed CREOL building – early 1996



With the new facilities, great faculty, outstanding students, strong partnerships, and a bit of fun to leaven the hard work, there was still one milestone left to achieve in the "CREOL Period" – although UCF, was granting degrees in optical science and engineering through the Electrical Engineering Department, it was time to consider a new degree program. So in the spring of 1996, an external review panel (Art Guenther, University of New Mexico; Bob Shannon, University of Arizona; and Brian Thompson, University of Rochester) was convened to review CREOL's progress, structure, plans, and programs. One of the recommendations of this panel was that CREOL should be made into an academic unit with its own degree programs, tenure of faculty, etc. The rationale for this recommendation was straightforward: optics had become a discipline unto itself; the CREOL faculty did all the functions of an academic unit: recruited the students, taught the classes, secured the funding for student stipends and research; supervised the student dissertations, and helped place students in jobs upon graduation.

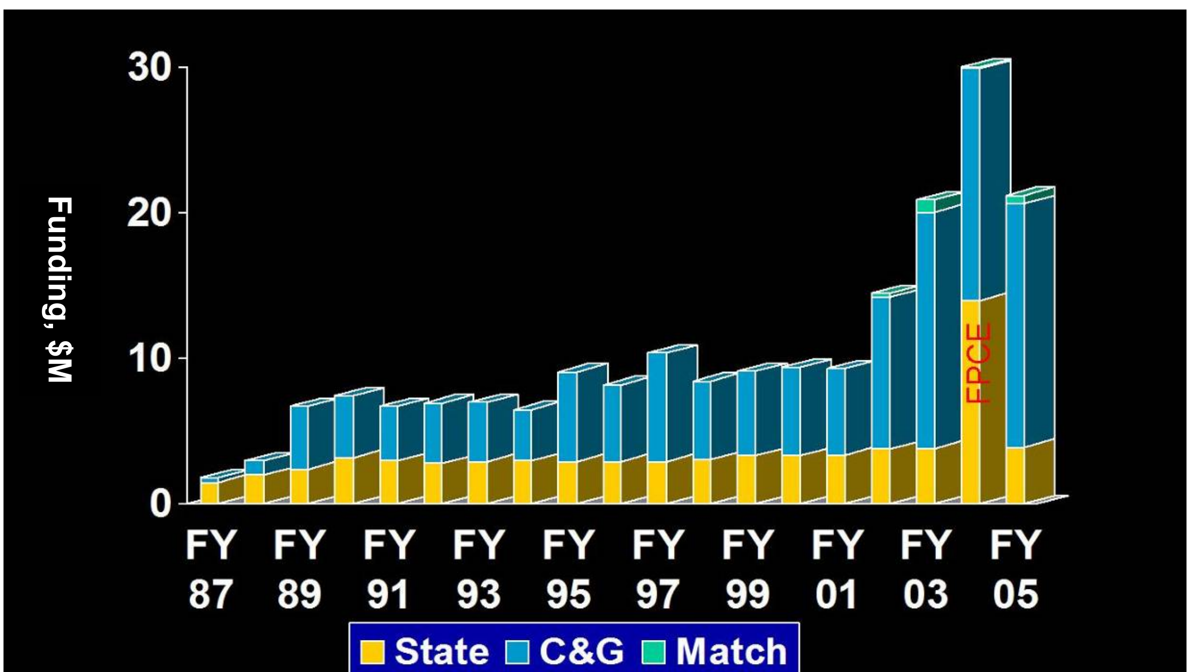
With the panel's recommendation as support, UCF Provost Gary Whitehouse announced approval of the School of Optics in February of 1998, and on September 11, 1998, the Florida Board of Regents gave its formal approval of the school. To celebrate this significant milestone, the School of Optics Inaugural Conference was held 11-12 January 1999, and was attended by many leaders from the optics community, including three Nobel laureates – Nicolaas Bloembergen (who also chaired the conference), Charles Townes, and Steven Chu. Even MJ's 8th grade teacher, Pete Antie, was there to help celebrate!

At the end of the CREOL Period (December 1998), CREOL had 21 faculty, 5 associate faculty with joint appointments in CREOL, 29 research associates, 18 staff, and 104 students.

The end of this Period was marked by a leadership transition. Dr. MJ Soileau stepped down as Director of CREOL to take on the duties of UCF Vice President for Research (to be precise, MJ handed over the directorship in July 1999). Dr. Eric Van Stryland, another of the original "Texans", became Interim Director while a search for a permanent director was conducted, with the caveat that he did not want the permanent job. During subsequent history "periods" below, the search for a better director was fruitless, and Eric became the de facto permanent director, in spite of his protests!

THE "SCHOOL OF OPTICS PERIOD": 1999 – 2004

The establishment of The School of Optics was a defining event in the history of CREOL, even though the momentum continued with great research, outstanding education, growth in faculty, etc. The new governance structure gave CREOL full control of its degree programs and tenure-granting and hiring decisions, and removed a source of conflict between CREOL and other UCF departments. Recruitment of faculty slowed down a bit, but 8 new people were added to the CREOL faculty through 2004, although some faculty also left or retired. Research continued strong, with funding taking a marked upturn beginning in FY2002 (July 1, 2001 to June 30, 2002) – see the figure below. The first optics degrees were awarded in 1999, and recruitment of students expanded.



CREOL funding history. The baseline state funding has slowly increased, with the effect of the one-time FPCE creation grant shown in FY2004. Contract and Grant (C&G) funding includes funding from both industry and government sources, One of the more notable events during this period was the creation of the Florida Photonics Center of Excellence (FPCE). The FPCE was established with a $10 million grant from the State of Florida to create a new center of excellence within the School of Optics. The program began in July, 2003 (FY2004) with three primary goals:

- Advance excellence in research and graduate education chosen to serve existing and emerging industry clusters in the state (photonics, optics, lasers)
- Leverage state resources via partnerships with industry and government
- Work in partnership with local, state and regional economic development organizations to attract, retain and grow knowledge-based, wealth producing industry to Florida.

The focus of the FPCE research and education work is on the technologies of nanophotonics, biophotonics, advanced imaging and 3D displays, and ultra-high bandwidth communications, all of which have forecasts of rapid market growth. The $10M state grant is being used for three purposes:

(1) To develop infrastructure ($6M for new faculty, new facilities, new equipment)
(2) To fund competitive R&D Partnership Projects at Florida universities in partnership with Florida industry ($3.1M)
(3) To pursue commercialization and outreach (0.9M) with the help of the FPCE Industrial Advisory Board, the UCF Technology Incubator, and the Florida Photonics Cluster.

By the end of the School of Optics Period, CREOL/School of Optics had grown to a total of 234 people: 25 faculty, 11 associate faculty, 35 research staff, 18 staff, and 145 students. This growth had fully utilized the CREOL building lab and office space, and even with an office trailer added for graduate student offices, more space was desperately needed. The next period of evolution would address this need.

THE COLLEGE OF OPTICS AND PHOTONICS PERIOD: 2004 – PRESENT

In early 2004, UCF Provost Terry Hickey recognized that with the continuing growth and expansion of CREOL/School of Optics, and of the field of optics and photonics and its increasing importance to the state of Florida, the time had come to elevate the School of Optics to a full college, with a Dean to address not only the needs of the college, but also its place as a full partner with the other colleges at the University of Central Florida. The provost also wanted to try to infuse some of the successful "CREOL Culture" into the rest of the university. Consequently, in May of 2004, Provost Hickey announced the formation of CREOL & FPCE, The College of Optics and Photonics. This event marked the first time an optics program in the United States had achieved the status of a full college in its host institution, a milestone for CREOL, and also an indication that optics and photonics was at last being recognized as a distinct, independent discipline. We had a great time for the next 9 months of being the <u>only</u> college of optics in the US, even while being the youngest of the “Big 3” institutions among our colleagues at the University of Arizona and the University of Rochester. The next spring, the University of Arizona “saw the light” and promoted the Optical Sciences Center to the College of Optical Science. CREOL thus retains the distinction of being the first college in the field, and is glad to see other institutions following its lead.

Although we are only 2 years into the current “period”, a number of new things have been accomplished. Several of the accomplishments are associated with the FPCE. The results of the FPCE to date include the following:

- Support of 5 new start-up companies

- Establishment of 3 endowed chair faculty positions
- Hiring of one senior chaired faculty member (Dennis Deppe) and 4 junior faculty members
- Addition of a unique nanophotonics fabrication facility.
- Significant technical and product development results from ongoing Partnership Projects with industry. Use of $3.1M from FPCE to fund 24 projects at 5 universities and involving 20 company partners who have contributed $5.3M, several of which will enable new commercial products.
- Construction start of a 21,000 ft^2 lab/office building addition, supported in part by a $1.5M grant from the US Department of Commerce, Economic Development Administration, a $750K grant from the Florida High Tech Corridor Council, private donations, and UCF matching support. It includes space for an extension of the UCF Incubator, and will be occupied in December, 2006.

Elevation drawing of 3-story addition to CREOL Building, to be completed in Dec 2006

THE NEXT 20 YEARS

Of course, this chapter has yet to be written. As the next 20 years begins, CREOL & FPCE, The College of Optics and Photonics has a population of 277 people: 28 faculty, 16 research and associate faculty, 54 research associates or post-docs, 19 staff, and 160 students. Some of the things that are in process or on the possibility horizon include the following:

- Addition of a Bachelor's degree in optics. This would complement a relatively new UCF program, started in 2003 by a CREOL graduate, Dr. Al Ducharme, that provides a BSEET-Photonics undergraduate degree. The BSEET (Bachelor of Science in Engineering Technology) degree is designed as a terminal bachelor's degree, with more hands-on course/lab work and less math and physics content than is found in a Bachelor of Optics curriculum.

- Expansion of the biophotonics research activities. A search for a chaired professor in biophotonics is currently underway.
- Expansion of the optics courses offered via distance learning, particularly web-based courses. The technical capability at CREOL to enable such course delivery was enhanced in 2005 and will continue to increase, both at CREOL and at UCF, as resources allow.
- Completion of the current 21,000 ft^2 expansion of the CREOL building facilities, and addition of a final expansion phase, completing the use of the available land on the CREOL site.

The future of CREOL & FPCE, The College of Optics and Photonics is clearly a bright one, full of opportunities and challenges to be met and realized. The philosophy of partnership with industry and of attracting the best and brightest faculty and students will continue to be central to the College's operation, and will continue to serve as a model for the continued development of the University of Central Florida into a 1st-tier research university. The growth and development of UCF research capabilities is providing CREOL with many opportunities to team with colleagues in such diverse disciplines as human-factor psychology, augmented reality for simulation and training, materials science and engineering, biomolecular and medical sciences, information technology, digital media, and many others.

The Central Florida region has recognized the economic importance of optics and photonics, both as an industry and as an enabler to many other industries. With CREOL & FPCE, The College of Optics and Photonics as the academic and research hub, central Florida is poised to be an international center of excellence, technically and economically, in the 21st century – the Century of the Photon!