

Highlights

Academics • Research • Partnerships



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\$4.5 MILLION FOR LASER TECHNOLOGY INITIATIVE

The Florida Photonics Center of Excellence, FPCE, has been awarded \$4.5M to establish a new program on advanced laser technologies to help maintain and grow the state's laser-enabled economy. The Laser Technology Initiative is one of six research centers recently approved by the Florida State University System Board of Governors, which oversees Florida's public universities. The award was part of a highly competitive \$30M second round of the Florida Center of Excellence program that established the

Florida Photonics Center of Excellence (FPCE) in 2003. The Laser Technology Initiative will bring a new dimension to the College to add to the FPCE, which was originally created as a platform for the growth of next-generation photonics-based industries in Florida, concentrating on nanophotonics, biophotonics, and optical imaging/communications. The new laser initiative will focus intellectual capital in generating and transferring to industry laser technologies for laser surgery and clinical applications of lasers, for advanced

laser manufacturing applications, and for dual-use defense/commercial applications of lasers. These areas are an excellent match to the current base and future economic success of the laser industry in Florida.

To further enhance the goals of the Laser Technology Initiative, the UCF Provost, Dr. Terry Hickey, will provide \$500K of research funds to bring the total Laser Technology Initiative funding to

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Dean's Corner

Eric W. Van Stryland
Dean and Director

Wow! Another \$4.5M along with five new faculty lines for Laser Technology for the Florida Photonics Center of Excellence! Trustee Chair Martin Richardson put together an outstanding proposal to the State's Center of Excellence initiative this year. After some "heart attack" sessions when we were initially told that we would not be funded, an error in scoring was noticed and in the end six proposals were funded including ours. This is a major expansion of the College of Optics and Photonics that includes significant matching money (\$2.6M total) including funds to further build out our new addition and start-up funds for the new faculty. See <http://news.ucf.edu>, (keyword: Center of Excellence). And also the front page story of this issue.

We also were awarded a 21st Century Scholar position that provides an additional \$1M from the State together with \$1M match from UCF for endowing a position in Laser Medicine and for startup funds. This new Florida program is designed to attract nationally-recognized faculty in the areas of the sciences, engineering, and technology and mathematics ("STEM"). For more information see <http://www.creol.ucf.edu/TheCollege/NewsDetail.aspx?NewsID=129>.

And the 21,000 sq ft CREOL building addition is ready for occupancy! We should be in it by the time this Highlights issue gets to you. Besides alleviating our current severe space shortage, the new addition also makes it possible to hire

the five new faculty members in laser technology that we were just awarded, along with the chair of Biophotonics for which we are still searching! And there is still time to donate to the building addition, and to have rooms named – remember, we still haven't built out the 3rd floor! If you would like to be a contributor to our facilities program, please contact us or go to our website at <http://www.optics.ucf.edu/TheCollege/NewBuilding.aspx>. Remember each dollar you donate is eligible for 1 for 1 matching by the State.

We say goodbye to Eric Johnson who helped us build a world-class Nanophotonics Systems Fabrication Facility, NPSFF. He is going to the University North Carolina - Charlotte as Associate Director of the Center for Optoelectronics and Optical Communications, a new position at UNCC-Charlotte. The NPSFF at CREOL has 3,000 sq ft of class 100-1000 clean room space filled with ~\$15M of state-of-the-art fabrication equipment including a Leica 5000+ e-beam lithography system and now two Molecular Beam Epitaxial growth facilities run by professors Dennis Deppe and Winston Schoenfeld. Much of this equipment can now be made available to interested parties as part of a user facility (See <http://ir.creol.ucf.edu/cleanroom.htm> for a partial listing, and contact Jim Pearson or Dennis Deppe for information about how to become a user of this facility).

The CREOL Association of Optics Students, CAOS, held a great 20th Anniversary Fall picnic on the UCF campus at Lake Claire – see photos on the web under events.

I finished my main duties as President of the OSA at the Annual Frontiers in Optics meeting this year in Rochester New York where the OSA was founded 90 years ago! Among my three jobs of being Dean, professor and researcher, and OSA President, I must admit that the OSA job has been a favorite (perhaps because I know it's of finite duration!) and a wonderful learning experience. It has been great working with the highly professional staff and the volunteers.

And as my last message, I announce my retirement as Dean of the College and Director of CREOL & FPCE. We will begin a search for a new Dean in the near future. I have been in this leadership position for going on 8 years now (with various titles! From interim Director on). It has been a remarkable experience and one that I never planned on. It will also be nice to say that I did it, i.e. past tense. Having neglected my graduate students, apologizing to each one as they graduated, I am looking forward to spending more time with them and with research. At the same time, I am looking forward to finding a person of new vision who can take over the Dean's position and help provide new strategies for future excellence at CREOL. We have a truly outstanding faculty and staff as well as a great group of students – and alumni! But we can do more and better in the future!

Save The Date

Friday, April 13, 2007



Industrial Affiliates Day 2007

“ULTRA-SHORT PULSE LASERS & APPLICATIONS”

Please mark your calendars for our great technical program:

- 4 invited external speakers and two notable UCF/CREOL speakers
- Afternoon tour of the new CREOL addition and laboratory tours
- Vendor Exhibits
- Student Research Poster Session, and Faculty Research updates

And plan to stay for the great social event, “The Spring Thing”, the next day, hosted by MJ Soileau at his home on Lake Jessup (home for more alligators per square meter than any other Florida lake!).

For vendor exhibit reservations, please contact Diana Randall at 407-823-6834.

<http://www.creol.ucf.edu/partnerships/Affiliates/AffiliatesDay2007/>

LASER CENTER from Cover

\$5.0M. In addition, the Provost will also provide new continuing funding to enable the hiring of five new faculty members and matching funds of \$1.6M towards infrastructure (the UCF Office of Research & Commercialization will add \$0.8M and the Florida High Tech Corridor Council (FHTCC) will add another \$200K). These funds will be in addition to a \$1M award (together with a \$1M UCF match) from another new state program for a 21st Century Scholar in Laser Medicine, proposed by Martin Richardson and Eric Van Stryland that will enable the College to hire a distinguished faculty member in the area of lasers and medicine.

One of the reasons that the Laser Technology Initiative was chosen in the state-wide competition is the success demonstrated by the FPCE, which leveraged an initial \$10M funding into over \$41M of new investment including three new companies and 40 patent applications. According to Dr. MJ Soileau, UCF Vice-President for Research and Commercialization,

“The success of the Florida Photonics Center of Excellence is exactly the type of return the Florida Center of Excellence program was created for.” The Laser Technology Initiative will build on the success of the FPCE by leveraging existing strengths within CREOL and FPCE and by adding new resources to furnish a comprehensive educational, research, and engineering program, addressing both innovative fundamental laser science and the development of new laser technologies. The efforts will be directed towards three important growth areas of Florida’s knowledge-based economy: (1) Major medical centers in the State (Scripps, Burnham, Mayo, Torrey Pines, Moffitt, Shands, Bascom-Palmer); (2) Development of current laser technology companies within Florida’s High-Tech Corridor and the attraction of new companies; and (3) The \$44B defense and military sector of Florida’s economy. It will seek to make Florida a leader in technology-intensive segments of the medical laser, laser manufacturing tool, and defense laser industries, as well as propel the state to pre-eminence in high-

power laser research.

The Principal Investigator of the Laser Technology Initiative is UCF Trustee Chair and well-known expert in laser technology and applications, Dr. Martin Richardson. The core group of the Initiative will include several experts from the CREOL & FPCE faculty, and will also involve faculty from other institutions across the Florida State University System. It will also draw on well-known laser technology experts across the state, involving people from companies such as the Mayo Clinic, Northrop Grumman Laser Systems, Lockheed Martin Missiles & Space, VLOC Inc., and Crystal Photonics, Inc. The new center will have an industrial advisory board (IAB) with expertise in laser technology involved in the three sectors of medicine, manufacturing, and defense. While some members of this IAB will likely overlap with the current FPCE IAB, additional expertise will be sought including possible participation from industry currently outside of Florida.

Research Focus: Kevin Belfield



Belfield

Three-dimensional (3-D) optical data storage based on two-photon processes provides a mechanism for writing and reading data with less cross talk between multiple memory layers, due to the quadratic dependence of two-photon absorption (2PA) on the incident light intensity. This capacity for highly confined excitation and

Two-Photon 3-D Photochromic Optical Data Storage

intrinsic 3-D resolution afford immense information storage capacity (at least 1012 bits/cm³). We have demonstrated a novel two-photon 3-D optical storage system based on Förster’s resonance energy transfer modulation of the fluorescence emission of a highly efficient two-photon absorbing fluorescent dyes and photochromic diarylethenes in a polymeric medium. One- and two-photon induced data recording and readout was demonstrated, with two-photon readout of multiple layers and data bit size less than 4 μm. This novel photochromic polymeric material is suitable for recording, readout, erasing, and re-recording data in multiple layers in thick storage

media. Our innovation provides a long pursued means of nondestructive data readout in photochromic materials. We demonstrated no apparent fatigue, even after 10,000 readout cycles.

Dr. Kevin D. Belfield,
Professor and Chair
Department of Chemistry;
CREOL, The College of Optics and
Photonics

Research Focus: Dennis Deppe



Deppe

Semiconductor laser diodes are extremely compact and have the uncanny capability for high electrical-to-optical power conversion efficiency. These traits have led to their use as the favored optical pump sources for many new types of high power solid-state and fiber laser systems. The diode laser's high efficiency comes from its ability to use thermal energy to generate electrical currents, this allows for laser operation with a voltage bias nearly equivalent to the value characteristic of the energy of the photons the laser diode radiates. Its unique thermal physics have led to efficiencies that now exceed 70% in high power diodes designed for laser pump applications. Despite these high efficiencies however, there is further incentive for defense and space applications to push laser diode technology to even higher efficiency and accordingly higher power. The motivation is driven by how very large laser systems and the platforms that use them scale with the efficiency of their laser diode pumps, especially for use in air-borne defense and space exploration. Although prompted by defense and space applications, there is an added benefit in industrial and medical applications, where diode pumped solid-state and fiber lasers are finding growing applications for cutting, welding, and surgery, as well as ranging and guidance. In some of the large laser systems the laser diodes used for pumping make up a significant fraction of the cost and set an upper limit to overall performance.

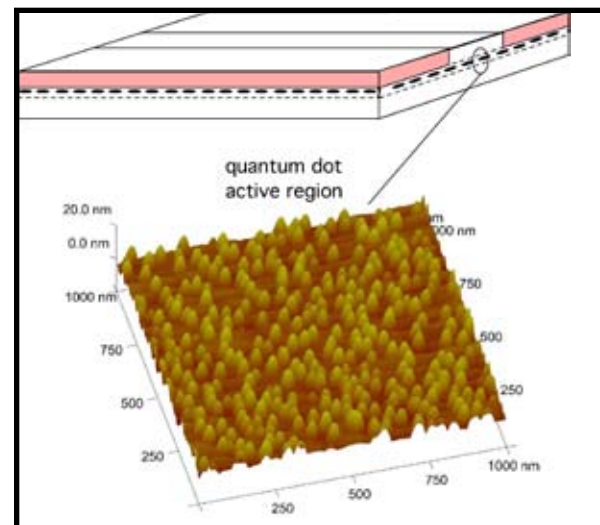
While higher efficiency and

Quantum Dot Laser Diodes for High Efficiency, High Power Applications

power from laser diodes could have dramatic system impact, the current laser diode technologies that use planar quantum well active material appear close to the efficiency limits set by the same electrons and holes that generate its optical gain. These electrons and holes, confined in planar quantum wells, not only give the intense emission of the laser diode output, but also cause internal parasitic optical loss that limits the laser diode size and efficiency. The large optical gain per unit length of a planar quantum well laser diode also requires a significant current density just to reach lasing threshold. These two loss mechanisms, internal optical loss and threshold loss, represent two of the material limitations for increasing efficiency in planar quantum well laser diodes. A third mechanism is closely related, which is the electrical power loss that directly relates to the laser diode's operating current density. However a remarkable historical feature of semiconductors is how material advances have radically altered their internal device physics to create revolutionary advances in new device technologies. In fact, current planar quantum wells used in laser diode active regions represent such an advance from nearly 30 years ago in which electron and hole confinement changed with new epitaxial crystal growth techniques to produce very thin single crystal active layers. The key of these new materials advances is

often the introduction of new quantum effects that change the electron and hole energy structure within the device's active region, and the same is true for laser diodes.

Semiconductor nanostructures in the form of quantum dot active material do just this, and hold the promise of not only pushing laser diode efficiencies to ultimately greater than 90% but doing



so while delivering much higher power levels. The quantum dot advantages come from the change in electronic confinement of the electrons and holes that create the radiative transitions and optical gain of the laser diode over its predecessor, the planar quantum well. In contrast to commercially available planar quantum well diodes that still contain a continuum of radiative transitions for electrons and holes, in quantum dots these transitions come from discrete

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RESEARCH FOCUS from page 5

levels quite analogous to the radiative transitions of the solid-state and fiber lasers the diodes are designed to optically pump.

The key to this change is illustrated in Fig. 1 and comes from a modification in the laser diode crystal growth technology in forming the diode active material from self-organized nanostructures. The nanostructures are formed by introducing just the correct level of stain within a sufficiently thin layer to convert the semiconductor crystal growth front to 3-D islands. When correctly grown these islands form crystallites on the epitaxial surface that while taking their 3-D shapes, do so without forming dislocations that would otherwise damage their optical response. The result is a new type of semiconductor active material based on artificial atoms, the quantum dots, created from the semiconductor itself. These quantum dots contain discrete electronic levels that individually produce optically sharp radiative transitions. Because the laser diode physics is mainly set by the optical response of its active region, modification of the electronic states can also greatly modify the laser diodes operating characteristics. The change

to quantum dots is known in principle to benefit laser diodes in numerous ways and for a range of applications, with these benefits ranging from high speed modulation, high temperature stability, low spectral and intensity noise, and device scaling to small sizes for quantum information and dense photonic integration.

However the major advantages of the quantum dot active material for high power, high efficiency laser diodes is not so much in the new laser diode's optical gain, but in its greatly reduced density of electron-hole pairs required for laser operation. This new quantum dot laser diode has already demonstrated nearly an order of magnitude reduction in its operating current density over planar quantum well devices, a direct result of the smaller density of electrons and holes required for lasing. Because these same electron-hole pairs ultimately set the diode's internal loss that limit present planar quantum laser diodes to cavity lengths of a few millimeters. Therefore, while quantum dots promise an order of magnitude lower operating current density, they also enable an order of magnitude increase in laser diode size and thus much greater power levels.

The result of the self-organized

nanostructures is a new type of laser diode system that can take further advantage of the unique thermal physics of the semiconductor that leads to very high efficiency. And although quantum dot laser diodes are projected to reach efficiencies that could exceed 90%, even these high efficiencies don't reach the ultimate limit offered by a semiconductor diode. While laser diodes are limited to efficiencies less than 100% due to their need to achieve optical gain, spontaneous sources that operate exclusively on diffusion currents suffer no fundamental efficiency limits. Instead, small light emitting diodes, again based on quantum dots but with enhanced light-matter interaction through a small semiconductor cavity, can actually harvest thermal energy from its own environment through self-cooling, providing the remarkable prospect for achieving over 100% electrical-to-optical power conversion efficiency.

Dr. Dennis Deppe
Professor of Optics
FPCE Endowed Chair

Fall 2006 Graduates

Doctorate Degrees

Erwan Baleine, Optics Ph.D.
Advisor: Dogariu

Myoung-Taek Choi, Optics Ph.D.
Advisor: Delfyett

Ion Cohanoschi, Optics Ph.D.
Advisor: Hernandez

Jie Fu, Optics Ph.D.
Advisors: Hagan/Van Stryland

Andrey Krywonos, Optics Ph.D.
Advisor: Harvey

Daniel May-Arrijoja, Optics Ph.D.
Advisor: LiKamWa

Jason O'Daniel, Optics Ph.D.
Advisor: Johnson

Luis Archundia-Berra, Optics Ph.D.
Advisor: Delfyett

Qi Hong, ECE Ph.D
Advisor: S.T. Wu

Master's Degrees

Jeremiah Brown
MS Non-Thesis

Kaia Buhl
MS Non-Thesis

Timothy McComb
MS Non - Thesis

Sidhartha Pandey
MS Non-Thesis

Jonathan Reeves
MS Non-Thesis

Forrest Ruhge, MS Optics
Thesis Advisor: Kik

Awards and Honors:

Faculty News

Congratulations to the winners of the Office of Research and Commercialization awards this year:

The Million Dollar Club (\$1M or more Funding for FY06):

Leon Glebov
Dennis Deppe
Peter Delfyett
ST Wu
Martin Richardson

Also: Martin Richardson & Eric Van Stryland (David Hagan and Pieter Kik are co-PIs) for having 2 of the 3 MURI's, awarded by the US Department of Defense, that went to UCF. Cal Tech was the only other University to have 3.

Dr. Leon Glebov's work has been celebrated as one of the top 100 technological breakthroughs by the Association of University Technology Managers (AUTM) for pioneering a method of writing microscopic pathways - holograms - into glass. Dr. Glebov, and his wife, Larissa,

a research scientist at The College of Optics and Photonics, used their expertise in making and manipulating some of the world's highest quality glass to create the method of etching holograms or pathways into glass that can direct light to perform specific functions. The invention came after years of initial research at the renowned Vavilov State Optical Institute of St. Petersburg, Russia, and was refined at UCF. The hologram provides a pathway and direction for the light beams that pass through it and, in the case of the Glebovs' work, can actually change some of the properties of the light. Such holograms have applications in a variety of commercial uses, including cutting, welding and drilling processes in the automotive, aerospace and ship industries.

Student News

Congratulations to Sachin Bet, graduate student of Dr. Aravinda Kar, who received the 1st place award for this year's Student Paper Award Contest at the Laser Institute of America's ICALEO

conference.

Former graduate student Yung-Hsun Wu won the 2005 IEEE Orlando Section Outstanding Graduate Student Award. He was a graduate student in Professor Shin-Tson Wu's group. Congratulations to Yung-Hsun!

On page 16-17 of the September issue of Optics and Photonics News is an article written by Brian Monacelli (CREOL Alumus) and a coauthor. Letters of recommendation particularly noted his leadership in both the OSA student chapter and CAOS.

Congratulations to Zhibing Ge and Lazaro Padhila, both of whom have won prestigious 2006 LEOS Graduate Student Fellowships. Each will receive a \$5,000 fellowship as well as a \$2,500 travel grant. Thanks to both Zhibing and Lazaro for bringing honor and recognition to CREOL!

CREOL Friends And Family 20th Anniversary Picnic

This year's picnic was held at UCF's Lake Claire. With nearly 150 attendees, the day was filled with the annual CREOLympic Games and a hearty picnic prepared by CAOS.



Highlights is published by The College of Optics and Photonics, at the University of Central Florida. To subscribe: www.creol.ucf.edu/about/highlights

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