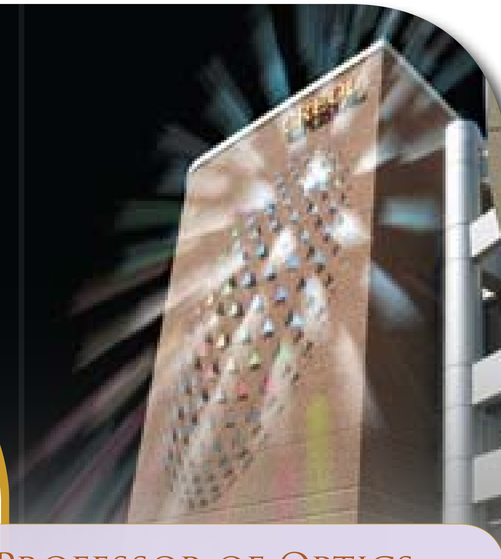
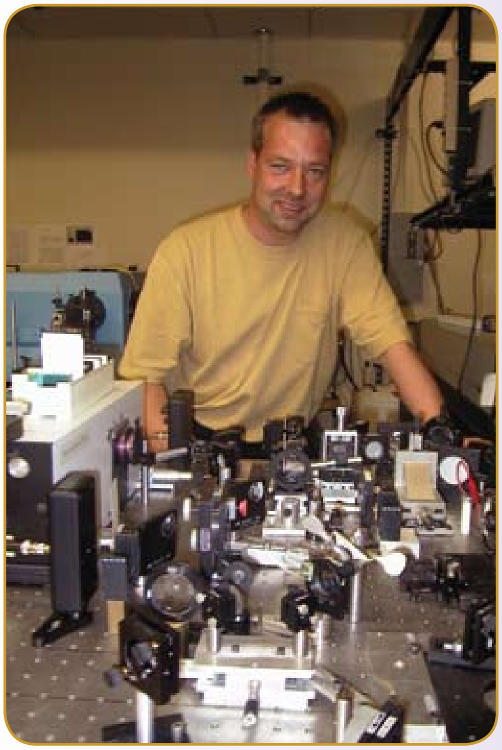
UCF CREOL The College of Optics and Photonics

Highlights

Academics • Research • Partnerships
Creating the Future of Optics and Photonics





CREOL welcomes new Professor of Optics:
Dr. Axel Schülzgen

RESEARCH

- Fiber Laser Devices
- Fiber Optic Sensors
- Linear and Nonlinear Light Propagation in Fiber
- Nanostructured and Functionalized Fiber
- Design and Fabrication of Specialty Optical Fiber
- Advanced Optical Materials

PROFESSIONAL ACTIVITIES

- Associate Editor, Applied Optics - Ultrafast Lasers and Optics
- Member, Optical Society of America
- Member, Materials Research Society
- Member, German Physical Society

HONORS AND AWARDS

- Habilitation Fellowship, German Research Foundation, 1993
- Carl-Ramsauer-Award, AEG Corporation, 1992
- Heinrich-Gustav-Magnus-Award, Humboldt-University Berlin, 1988

CREOL, The College of Optics and Photonics welcomes Professor Axel Schülzgen, Ph.D., who joined the faculty this fall. Dr. Schülzgen, a professor of Optics, has spent the past several months outfitting his laboratory space and selecting a research scientist and students to continue his research in fiber optics.

Dr. Schülzgen was born in Berlin, Germany, where he received a master's and doctoral degree from Humboldt-University Berlin. Following graduation, Schülzgen continued on as a research scientist at Humboldt-University and received a Habilitation fellowship from the German Research Foundation in 1993. After being a visiting researcher in the group of Professor John Hegarty at the Trinity College in Dublin, Ireland, in 1995, he joined the College of Optical Sciences of the University

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Inside
Volume 10, No. 3
Fall 2009

Dean's Corner

Bahaa Saleh, Ph.D.

The new semester brings to CREOL a new crop of graduate students. Their faces often exhibit excitement and hope, mixed with anxiety and confusion. At this time of the year they lineup with advisors, select courses, and learn many new tricks, including myriad passwords. Older students are the experts! They provide voluntary advice about the do's and don'ts, along with stories about the great hurdles to expect, including the dreaded qualifying exam. Sound faculty advising is indispensible, but it is often left to the initiatives of the individual faculty.

During the second week of classes, I met with the new, and the not-so-new, students to tell them about our field —optics and photonics— in an effort to explain the subtle differences between "optics", "photonics", "optoelectronics", "electro-optics", etc. I showed them an intimidating block diagram of approximately three dozen courses that we offer — a long menu from which they will select after they finish the obligatory appetizer, the "core" courses. I made an effort to help them see possible "combos" that define "tracks" or "specialties" for their future careers.

Although our program does not have any formal tracks, five areas of specialization can be identified: 1) Applied optics and image science, the "optics classic," with some significant new advances that keep the field "hot", including computational imaging, near-field imaging, and sub-diffraction-limit imaging. 2) Integrated and Fiber Optics, a specialty for which light is manipulated in a confined environment, mimicking integrated circuits and electrical strip lines and coaxial cables. 3) Nonlinear Optics, which deals with light of intensity sufficiently high to alter the properties of the medium and change the wavelength itself. 4) Optoelectronics, a marriage between optics and electronics (semiconductors or organic materials) for the generation, modulation, and detection of light. 5) Lasers, an area of strong presence at CREOL, which is the home of the Townes Laser Institute.

> It is often said that optics is an enabling technology...industrial communication, medical, biological, defense etc.

It is often said that optics is an enabling technology. Each of the five specialties that I identified can also be projected onto one, or more, application: industrial, communication, medical, biological, homeland security, defense, etc. For example, a student may be specialized in medical imaging, integrated-optic biosensors, fiber optic communication networks, laser material processing, etc. Identifying a specialty is often accomplished by selecting an advisor. Judicious selection of the courses must be based on striking a balance between depth in the specialty and breadth in the overall discipline, in order to enhance the graduate's chances for employment and please the employer.

Along with the demands of the new academic year and the pressures of budget cuts, we continue to pursue new opportunities and establish new links and alliances. I am pleased to report that UCF President John Hitt recently signed a research agreement with the Fraunhofer Institute for Laser Technology (ILT), the leading industrial laser and laser applications laboratory in Europe. Coordinated by Dr. Martin Richardson, Director of the Townes Laser Institute (TLI) at CREOL, the agreement, will explore areas of common interest in advanced high power laser development and laser machining technologies. A visiting scientist from the Fraunhofer ILT has already arrived at CREOL and is beginning collaborative research with the TLI scientists. Since both ILT and TLI/CREOL believe in establishing strong university-industry links, I have high expectations for this collaboration.

Bahaa Saleh, Dean
CREOL, The College of Optics & Photonics

Awards and Honors

FACULTY AWARDS

Leon Glebov (together with Mike Bass, Aristide Dogariu, and Boris Zeldovich) has received a contract from DARPA (ADHELS Phase 2) totaling $1.8M for research on "High brightness multiwavelength laser architectures based on volume diffractive gratings in PTR glass." Phase II of ADHELS aims to generate high power, high spatial brightness laser beams of military interest by spectrally combining the beams of high power, high efficiency, and single-mode fiber lasers.

Dr. Michael Bass was issued a U.S. patent on "High Resolution, Full Color, High Brightness Fully Integrated Light Emitting Devices and Displays"

Winston Schoenfeld, together with Andre Gesquiere of the NanoScience Technology Center and CREOL, have received a five-year $7.5 million contract from Prime Source Initiative, Inc., for research on Advanced Hybrid Organic Photovoltaic Platforms.

Sasan Fathpour has received a 3-year $400k grant from NSF for research entitled "Cladding-Pumped Silicon Raman Amplifiers Integrated with In(Ga)As Quantum Dot Laser Pumps."

Dr. Peter Delfyett was issued a U.S. patent on "Extreme chirped/stretched pulsed amplification and laser"

Dr. Peter Kik and Dr. Winston Schoenfeld were promoted to Associate Professor of Optics & Photonics and Dr. Stephen Kuebler was promoted to Associate Professor of Chemistry & Optics. All three new associate professors were also awarded tenure.

The Ralph E. Powe Junior Faculty Enhancement Award has been awarded to Ayman Abouraddy. This award provides money for research by junior faculty at Oak Ridge Associated Universities (ORAU) member institutions.

Student Awards and Honors

Congratulations to Meizi Jiao, doctoral student under the supervision of Dr. S.T. Wu, has received the IEEE Photonics Society Student Award. The honor carries a $5,000 stipend. Jiao is one of four students in the U.S. to receive this award.

Ying Zhou, graduate student working with Dr. Shin-Tson Wu, has received the prestigious Otto Lehman award given by the Universität Karlsruhe and the Otto Lehmann Foundation to recognize young scientists for an outstanding thesis in the field of liquid crystal technology.

Graduates - Spring 2009:

Doctoral

Jeremiah Brown
Oleksiy Andrusyak
Arnaud Royon
George Curatu

Masters

Robert Grimming
Christopher Brown
Abdullah Demir
Jonathan Rosch
Trenton Ensley
Robert Sims
Timothy McDaniel
Nathan Bickel
Sang Ik Han
Apurva Jain

Graduates - Summer 2009:

Doctoral

Costin Curatu
Supraja Murali

Masters

K Shavitranuruk
Qiong Song
Christina Willis
Daniel Sias

Emerging blue-phase LCDs based on Kerr effect

by Linghui Rao, Zhibing Ge, Sebastian Gauza, and Shin-Tson Wu

Blue phase liquid crystal display (LCD) devices based on the optical Kerr effect are emerging as a leading candidate for LCD displays due to their revolutionary features that include alignment- layer-free fabrication process and fast response time that enables field sequential display without using color filters. Understanding device physics and developing new materials are crucial for optimizing the device performance and realizing their application potentials.

After more than three decades of active research and device development for proving concepts, and then massive investment in manufacturing technology, the thin-film-transistor liquid crystal display (TFT-LCD) industry has finally taken off and is now dominating the flat panel display business. Today, LCDs have become indispensable in our daily life, with applications ranging from cell phones, video games, notebook computers, desktop monitors, large screen TVs, to data projectors.

To many it would appear that the LCD technology is fairly mature. The most critical issue on viewing angle has been solved to an acceptable level using multi-domain structures and optical film compensation. The concern over slow response time has been improved to 2-5 ms through low viscosity LC material development, overdrive and undershoot voltage, and thin cell gap approach. Motion image blur has been significantly reduced by impulse driving, frame insertion, and fast-response LC techniques. The color shift at oblique viewing angle has been dramatically reduced by an eight-domain approach via two transistors. The contrast ratio has exceeded one million-to-1 through local dimming of the LED backlight. The color range would exceed 100% of the NTSC standard if RGB LEDs are used. In addition to these technological advances, the cost has also been reduced dramatically by investing in advanced manufacturing lines. So, what are the possible next advances for LCD displays? Blue phase LCs are one such advance.

Blue phase is a type of liquid crystal phase that appears in a very narrow temperature range (1~2 oC) between chiral nematic and isotropic phase. Its molecular structure is comprised of double-twist cylinders arranged in a cubic lattice with periods of ~100 nm. Blue phase liquid crystals have been explored for several decades. However, their mesogenic temperature range is too narrow to be practical for display applications. But recently work has shown that this situation is changed when a small amount of polymer is imbedded to form a liquid crystal composite. The polymer-stabilized blue phase shows a reasonably wide mesogenic temperature range, including the normal room temperature range. The enthusiasm for developing new blue phase LCDs has thus been revitalized.

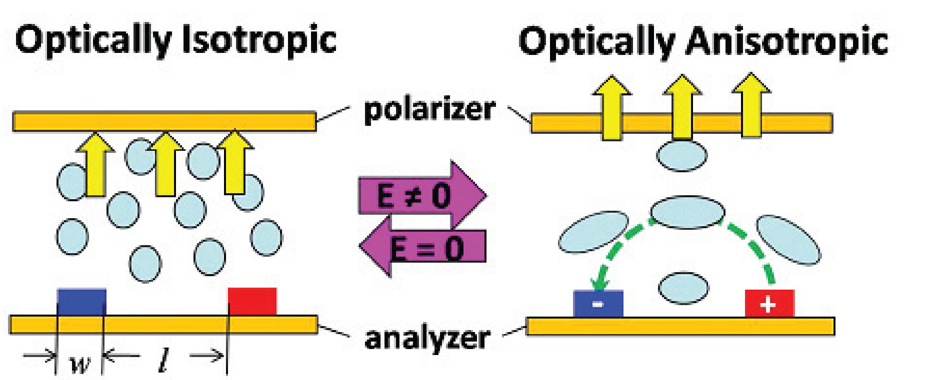

Fig. 1: Blue phase LCs in the in-plane switching electrode cell. Left: voltage-off state, right: voltage-on state. w is the electrode width, and l is the electrode spacing.

Figure 1 shows the blue phase LCs in the in-plane switching electrode cell with and without an electric field applied. Here w represents the electrode width and l the electrode spacing. In the voltage-off state, the blue phase LC appears optically isotropic. As the voltage increases, the induced birefringence increases based on Kerr effect and the LC refractive index distribution becomes anisotropic. When the device is sandwiched between two crossed polarizers, transmittance increases gradually as the voltage increases.

Fig. 2: Samsung 15'' blue phase LCD prototypes.

In comparison to conventional nematic LCDs, polymer-stabilized blue phase exhibits four revolutionary features:

(1) It does not require any alignment layer, say polyimide or inorganic SiO2, which not only simplifies the manufacturing processes, but also reduces the cost.

(2) Its response time is in the sub-millisecond range, which helps to minimize the motion picture image blurs and, more importantly, to enable field sequential color displays without using color filters. Today, RGB LEDs have been used commonly as LCD backlight. Eliminating color filters makes a significant impact: 1) it enhances optical efficiency by ~3X, resulting in lower power consumption if the same brightness is compared; 2) it increases device resolution by 3X (i.e., crisper images); 3) it reduces production cost.

(3) The dark state of a blue phase LCD is optically isotropic. Therefore, its viewing angle is symmetric and wide. The compensation films may or may not be needed, depending on the actual applications.

(4) The transmittance is insensitive to the cell gap, as long as the cell gap exceeds 2-3 μm depending on the birefringence of the LC composite employed. This cell gap insensitivity is particularly desirable for fabricating large screen LCDs in which cell gap uniformity is a big concern, or single substrate LCDs for slimness and lightweight.

Samsung unveiled the world's first blue phase LCD prototype (Fig. 2) at the 2008 Society for Information Display (SID) exhibition, which many in the display field felt was a technological revolution. However, aside from the many promises the polymer-stabilized blue phase LCDs hold, some tough technical issues remain to be overcome before widespread applications can take off. The major challenges are in three areas: 1) The operation voltage is still too high (~50 V_{rms} vs. 5 V_{rms} for conventional nematic LCDs); 2) the transmittance is relatively low (~65% vs. 85% for nematic LCDs); and 3) the mesogenic temperature range is still not wide enough for practical applications (~40 ^{o}C to 80 ^{o}C).

The operating voltage of a blue phase LCD is primarily governed by the induced birefringence which in turn is dependent on the Kerr constant of the LC composite and the electric field strength. Therefore, developing new blue phase LC materials with a large Kerr constant and new device structures for enhancing the horizontal electric field intensity, as shown in Fig. 1, are equally important. Once the existing high voltage problem is properly addressed, a new display era will emerge shortly.

A research team at CREOL, directed by Prof. Shin-Tson Wu, is addressing the limitations of blue-phase LCDs. This research team has developed proprietary blue phase liquid crystal composites and device structures to lower the operating voltage and optimize display performance. The goal is to reduce the operating voltage to ~10 volts so that the display devices can be addressed by standard amorphous thin-film-transistors (TFT), similar to present TFT LCD panels. The current research is funded by Chi-Mei Optoelectronics.

Schülzgen, from Cover

of Arizona in 1996. In Arizona he moved up through the research faculty ranks and became a Research Professor in 2006. This foundation of research and a desire to create hands-on research has lead Dr. Schülzgen to CREOL, The College of Optics and Photonics.

"I'm happy to have the opportunity to join CREOL and be part of this well-known center of excellence in optics and I am looking forward to establishing a fiber optics research group to advance student training in this important and rapidly progressing area of modern optics technology. Developing state-of-the-art fiber fabrication and research facilities will help to attract research contracts, national and international collaborations, and most importantly, deliver education with hands-on experiences for our students," commented Schülzgen.

Dr. Schülzgen's research area is experimental condensed matter physics with a specialization in spectroscopy, optics, and photonics. His areas of expertise include various optical techniques, in particular laser and ultrafast spectroscopy. During his career, he has used optical methods to study a wide range of material systems such as semiconductor quantum wells and quantum dots, conjugated polymers, transition metal oxides, and rare earth doped glasses. Dr. Schülzgen and his collaborators pioneered experimental work on novel wide-gap semiconductor materials, Rabi-oscillations and intervalence band coupling in semiconductor quantum structures, polymer lasers, and third harmonic generation in transition metal oxides. The majority of his recent research focused on the design, fabrication, and application of optical fibers with special emphasis on phosphate glass based fiber lasers. His team's contributions to fiber lasers include the realization of photosensitive phosphate glasses and the development of techniques to fabricate 'micro' and 'nano' structured optical fiber.

When asked about the selection of Schülzgen, Dr. Bahaa Saleh, Dean of the College of Optics and Photonics stated, "We are very pleased to have Dr. Schülzgen join the CREOL faculty. His background and expertise in fiber optics research, particularly the fabrication of novel optical fibers, will help make CREOL one of the leading centers of research and education in this important and rapidly changing area."

Dr. Schülzgen's resume includes more than 70 peer reviewed journal papers and 38 invited presentations at conferences world-wide. Dr. Schülzgen is a member of the German Physical Society, the Optical Society of America, and the Materials Research Society. Dr. Schülzgen is also an Associate Editor of Applied Optics in the area of ultrafast lasers and optics. This foundation of research and a desire to create hands-on research tied to graduate education has brought Dr. Schülzgen to CREOL.

UCF, Fraunhofer Sign Laser Research Agreement

On Monday, August 24, UCF President John C. Hitt signed a research agreement with Fraunhofer ILT, the leading industrial laser and laser applications laboratory in Europe. The agreement, instigated by Dr. Martin Richardson through the UCF Townes Laser Institute at the Center for Research and Education in Optics and Lasers (CREOL), will explore areas of common interest in advanced high power laser development and laser machining technologies. Pictured are, from left, Dr. Richardson, Northrop Grumman Professor of X-Ray Photonics, Dr. John C. Hitt, President of UCF, and Professor Reinhart Poprawe, Director of Fraunhofer ILT.

CAOS Outreach and Education Wins SPIE Grant

Great news came this August when the application CREOL Association of Optics Students (CAOS) made for the SPIE Outreach & Education Grant was approved providing the organization with $5,000 to bolster its efforts for student outreach. Additionally, as a partial match, the Townes Laser Institute has pledged an additional $1,000 to improve and continue optics and laser demonstrations.

The students at CREOL have traditionally participated in many events designed to both educate and excite the public about the field of optical science. Each professional organization student chapter has made outreach a fundamental part of the academic experience. During the past year, CAOS has organized, led, and participated in seven different outreach events reaching over 500 people ranging from middle school students to high school teachers and parents. CAOS worked with teachers, scout leaders, and local community organizers to prepare fun, education oriented events geared toward children and young adults.

Now, with increased funding, CAOS has plans to construct demonstration equipment to offer clear and comprehendible exposure to fundamental aspects of optical imaging to quantum optics.

“We also have hopes to develop portable demonstration suitcases so that we may make visits to local schools as a supplement to their existing curricula,” commented Matt Weed, CAOS Outreach & Education Coordinator.

With thrusts toward disadvantaged students and high achievers, CAOS plans real impact by exciting young students about science and planting seeds that may blossom into a future generation of American science. The work of a student at CREOL goes far beyond the work done in the lab. This is evident when you attend any of their events.

Top: Dimitrios Mandridis explains the optics of a semispherical mirror to a visitor during Optics Day. **Bottom**: Kyle Douglass explains how a telescope works to a group of middle school girls during Expanding Your Horizons day.

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Bahaa Saleh,
Dean and Director

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