Open House Brings Together Industry and Academia

by Veronique Bredas, Seth Marder, and Jason Martin

Participants at the inaugural COPE Open House attend one of several presentations that highlighted the research efforts of faculty members.

On November 17, COPE hosted its inaugural Open House at the Klaus Advanced Computing Building at Georgia Tech. This provided COPE with a forum to showcase the Center and give the Georgia Tech community and industrial representatives greater insight into the research activities of the Center through research presentations, laboratory tours, a poster session, and several networking opportunities.

The day started with an overview presentation of COPE by Dr. Seth Marder, Director of COPE, followed by three 20-minute presentations by Dr. Bernard Kippelen (“An overview of the research on printed electronics at COPE”), Dr. Samuel Graham (“Encapsulation and reliability of organic electronics”), and Dr. Joseph Perry (“Advances in organic photonic materials and nanocomposites for energy storage”).

(continued on page 2)
Faculty Spotlight

Dr. Ken H. Sandhage is the B. Mifflin Hood Professor in the School of Materials Science and Engineering, and an Adjunct Professor in the School of Chemistry and Biochemistry at Georgia Tech. Prior to arriving at Georgia Tech in the fall of 2003, Dr. Sandhage had been a faculty member in the Materials Science and Engineering Department at Ohio State University since 1991. Prior to joining academia, Dr. Sandhage worked as a Senior Scientist at American Superconductor Corporation (where he conducted research on the fabrication of high-\(T_c\) superconducting oxide wires) and at Corning Glass Works (where he conducted research on the processing of optical fibers for applications at high bandwidth and in radiative environments).

Dr. Sandhage’s research interests have been focused at the interfaces between various branches of materials science and engineering (metallurgy, ceramics, polymers) and other disciplines (particularly chemistry and biology). Current interdisciplinary research conducted by the Sandhage group includes:

i) the development of wet chemical layer-by-layer deposition methods to generate thin conformal coatings of inorganic and inorganic/organic composite materials on biological or synthetic templates of complex 3-D shape,

ii) the use of biomolecules (e.g., peptides, proteins) to induce the formation of non-natural inorganic and organic/inorganic composite materials under ambient or near-ambient conditions, and

iii) the chemical conversion of inorganic structures, via displacement reactions with gas or liquid reactants, into new inorganic materials that retain the morphology and fine features of the starting inorganic structures (“materials alchemy”).

Such processes are being examined for the fabrication of chemically- and structurally-tailored materials for photovoltaic cells, minimally-invasive sensors, catalysts, batteries, photonic/phononic devices, implants, and ultra-high-temperature rocket nozzles. Underlying such applied research is the development of fundamental understanding of the mechanisms controlling the kinetics of such reaction processes and the associated micro/nanostructural evolution.

Dr. Sandhage currently directs research within the BEAM (Biologically Enabled Advanced Materials) Center, and co directs (with Prof. Vladimir Tsukruk) research within the BIONIC (Bio-nano-enabled Inorganic/Organic Nanostructures and Improved Cognition) Air Force Center of Excellence. Interdisciplinary research within these Centers has been enabled by effective collaborations with a number of other research groups at Georgia Tech (particularly with COPE members), at other universities (University of California at San Diego, Harvard University, University of Illinois, University of Pennsylvania), and at the Air Force Research Laboratory.

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The morning sessions wrapped up with laboratory tours of some key research facilities. Industrial representatives toured the Molecular Science and Engineering Building where they visited the laser spectroscopy lab, the organic electronics lab, or the chemical synthesis lab. This was followed by a walk-through of the new Marcus Nanotechnology building. Feedback provided by the participants suggested that the lab tours were a very valuable aspect of the day.

In between the morning and afternoon sessions, discussions among faculty, students, and industrial representatives during the Networking Lunch gave participants a forum to help nucleate new partnerships and potentially develop new programs between faculty and industry.

During the afternoon session, presentations by 15 COPE faculty members addressed their specific areas of expertise. This was followed by the Poster Session & Industrial Exhibition. Some 22 graduate students and research scientists presented posters on their research while participants engaged in discussions with faculty members and industrial representatives.

COPE intends to continue building on the industry connections that the Open House generated by launching an Industrial Affiliates Program (IAP) that will increase the Center’s network of industry partners. More information on the IAP can be found on the COPE website www.cope.gatech.edu/IAP.
Partnerships for Research and Education in Materials
by Tatiana Timofeeva

In September 2009, three universities – New Mexico Highlands University (NMHU), the Georgia Institute of Technology (GaTech) and Morehouse College (MC) - were recipients of an award by NSF/DMR to conduct a collaborative project within the framework of the PREM program. PREM - Partnerships for Research and Education in Materials - was established by NSF to increase the participation by underrepresented groups in materials sciences and enhance diversity in materials research and education. This goal is set to be achieved by a long-term, multi-investigator collaboration between minority-serving institutions and large research NSF/DMR centers such as MRSECs or CTSs. The main PI of this project is Tatiana Timofeeva (NMHU) and Co-PIs are Seth Marder (GaTech) and Brian Lawrence (MC).

NMHU and the “Science and Technology Center, Materials and Devices for Information Technology Research” (STC MDITR) collaborated in studies of organic photonic materials for about seven years. Recently, MC joined this collaboration, generating an idea to present a project from the three universities to support their collaborative research and educational activities.

The collaborators are exploring three areas of organic photonic materials: two-photon absorbing materials, applicable for biological imaging and photodynamic therapy; crystalline nonlinear-optical materials, including materials aimed for THz generation and electro optical applications; and the development of new organic polymer materials for solar-cell applications. These subprojects were collected under title “Light Matter Interactions: Theory and Applications” (LMITA). This project is also focused on attracting and increasing the number of students in the area of photonic materials.

Imperial College London has established a new Plastic Electronics Centre to integrate and coordinate the plastic electronics research activity within Imperial, bringing together an interdisciplinary team from across the college. Professor Donal Bradley FRS is the Centre’s director, and the team comprises of researchers from the departments of Physics, Chemistry and Materials, and also from the Institute for Biomedical Engineering and Division of Neuroscience.

The Centre’s mission is to actively stimulate new cutting-edge high impact research and to meet Imperial’s strategic intent to harness the strengths and breadth of our research to address the global challenges of climate change, energy and global health and security. The Centre comprises the following research themes: Materials design; Synthesis and processing; Advanced multi-parameter structural, electrical, and optical characterization; Nanostructure and interface control; Multi-scale materials and device modelling; and Device fabrication and optimization.

In addition to the new Centre, research in plastic electronics at Imperial has been further bolstered by a recent £6 million award from EPSRC for a Doctoral Training Centre (DTC) in plastic electronics. The DTC aims to support postgraduate students and develop the next generation of world-class researchers in this field.

Imperial has had a long standing partnership with COPE through the AtlantIC Alliance programme. More recently, this has been extended through the Solvay Global Alliance programme which is enabling Imperial’s Professor James Durrant and Dr Thomas Anthopoulos to work with COPE on photophysical studies of molecular based photovoltaics and organic transistors.
Tell us more about your research.
Prior to coming to Georgia Tech, I was involved in various types of research including analytical/environmental chemistry at FIU and the study of liquid-crystal systems at Dow Corning in Midland, MI. When I arrived at Georgia Tech in 2006 I wanted to change directions and focus on organic chemistry research. I was fortunate to have the opportunity to join the group of Prof. Marder in 2007. My research is focused on the design and synthesis of novel organic molecules that are utilized as hole-transport layers or as host layers for transition-metal emitters within solution-processed phosphorescent organic light-emitting diodes (PHOLEDs). PHOLEDs are highly sought after as an alternative for efficient lighting and display technologies. I also work on the study of crosslinkers for the insolubilization of solution-processed OLED layers that can simplify and reduce the fabrication costs of such technologies. This work has resulted in two patents and we are currently in the process of writing several papers.

My research is funded by Solvay and is possible with the help of some of our collaborators at COPE, such as Prof. Kippelen and his group who provide their expertise for the design and fabrication of OLED devices. I am especially thankful to my advisor and my group for their invaluable support, help, and friendship.

What are your future career plans?
My immediate plans after graduation are the pursuit of a post doctoral appointment. Beyond that I feel that I will likely pursue a career in academia.

When you are not in the lab, what are some of your interests?
Among other things, I enjoy watching movies and baseball, traveling to new places, and volunteering--I’ve had some wonderful opportunities to be involved in recruitment and outreach activities through COPE and CMDITR.

Recently, I am busy with a new organization that other Hispanic students at Georgia Tech and I founded, called the Latino Organization of Graduate Students (LOGRAS). I currently serve as the first treasurer of the organization and enjoy working with the other members of the executive board and the membership to establish the vision and direction of the group.

Safety in the Laboratory
by William Underwood

Justus von Liebig once gave the following advice to his student, August Kekule, “If you want to become a chemist, you will have to ruin your health.”

Just as chemical knowledge has improved since the 19th century, so has the attitude towards risk. Improved methodology allows potentially dangerous reactions to be performed safely while easy access to MSDS databases makes hazard information readily available. Nevertheless, familiarity breeds complacency and the daily use of chemicals often causes researchers to underestimate the dangers involved with their daily work, resulting in unsafe practices.

In order to improve laboratory safety, safe practices must become habitual and appropriate equipment must be available. To assist in the latter, flame-retardant lab coats are now being rented. These lab coats provide better protection against pyrophoric chemicals and service includes weekly cleaning of the lab coats.

Currently, there are several initiatives underway that promote safe habits:

• Regular lab inspections help make researchers aware of easily overlooked practices.
• Good laboratory habits, such as closing the fume hood, proper labeling, and maintaining a clean lab area, are being enforced.
• Preparation of a detailed risk assessment is required before conducting an experiment for the first time. Such assessments make the researcher stop and consider what dangers could occur during an experiment, and how they may be dealt with, before the reaction is underway. Researchers develop the habit of predicting potential accidents before they happen, and formulating appropriate responses.

These initiatives are, at their core, designed to aid a researcher’s common sense. Such simple changes serve to greatly increase laboratory safety without requiring a large expenditure of time. Chemical researchers no longer need to ruin their health to be productive.

Questions? William Underwood
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Ph.D. in Materials Science and Engineering at Norfolk State University: A Student-Centered Program by Suely Black

Student-centered and broadly interdisciplinary, the Ph.D. in Materials Science and Engineering (MSE) at Norfolk State University (NSU) provides students the opportunity to tailor their education and academic experiences to prepare for their chosen careers. The program, established in the fall of 2007 and coordinated by the Center for Materials Research, is housed in MCAR, the McDermmond Center for Applied Research – a six-story, 135,000 square-foot research building, which was inaugurated just a year before the start of the program. In its two years of existence, the program has doubled its enrollment, and currently supports eighteen students.

Focusing on the design and fabrication of new materials and devices to contribute to the development of technologies of high societal impact, twelve chemistry, physics, engineering and biology faculty advise undergraduate and graduate students in collaborative projects with internal and external partners. The cohesiveness of the faculty and student bodies facilitates constant cross-disciplinary interactions, and leads to varied and numerous opportunities for research and professional experiences. External partnerships through funded projects allow students to take advantage of collaborators’ advice and facilities. Students are encouraged to pursue, and are supported in their efforts to seek, experiences that complement their experiences at NSU. Current partners include Georgia Tech, University of Washington, University of Arizona, Cornell University and Purdue University. Doctoral research projects with focus varying from computational modeling through device fabrication are available. These are some of the major research thrusts currently being pursued:

- **Metamaterials**: engineering multi-phase composite, custom-tailored materials, which have unparalleled responses to electromagnetic waves, acoustic waves and heat flow. Applications include imaging with infinitely high definition and invisibility cloaking.
- **Advanced functional organic and polymeric materials**: organic chromophores and polymers designed to self assemble to exhibit efficient or novel electrical and optoelectronic responses in a controlled manner. Applications include cost effective solar cells, and faster and larger capacity signal processing in fiber-optic communications.
- **Multilayer nanostructures**: semiconductor and inorganic/organic multifunctional materials designed to respond to two or more stimuli, e.g. chemicals and magnetic field.

Applications include biomedical treatment, environmental sensing, and highly sensitive magnetic sensors.

Enhancing experiences beyond the traditional course and research training provide students with opportunities to broaden their knowledge and to exercise those qualities and skills necessary for a successful professional life after graduation. The CMR Colloquium, a weekly series of lectures delivered by invited speakers, NSU faculty and students, provides a forum for learning and discussing new developments in research areas of interest. Mini lecture series and workshops offered by external collaborators enrich the regular course offerings. Students interested in academic careers have the opportunity to co-teach courses, and lead study sessions for undergraduate students. Special fellowships and student clubs support outreach, educational and infrastructure development initiatives, giving students opportunities to exercise leadership skills. Summer internships at partner universities and with industry are encouraged, and students have taken advantage of them, including international experiences. Invariably students travel to one or two national scientific and professional conferences annually, presenting their research and networking. Graduate students meet as a group with the program coordinator weekly, an activity that facilitates interaction among all students, announcement of upcoming events and available opportunities, and sharing of suggestions and concerns by students. This arrangement ensures that students have requests and concerns addressed in a timely fashion, and advance towards graduation without unwarranted delay.

Norfolk State’s partnership with Georgia Tech through the NSF Science and Technology Center on Materials and Devices for Information Technology has played and continues to play an important role in the MSE graduate program, through faculty and student interactions. The Ph.D. in Materials Science and Engineering program will continue to evolve, adapting to the needs of the fast-changing professional landscape of the field; an achievement made possible through the power of partnerships.

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Georgia Tech Awarded U.S. Air Force Center of Excellence in Nanostructures and Improved Cognition
by Vladimir Tsukruk, Ken Sandhage and Abby Vogel

The Georgia Institute of Technology has been awarded a U.S. Air Force Center of Excellence to design nanostructures for energy harvesting and adaptive materials, and to develop tools to optimize critical cognitive processes of the modern warfighter. The $10.5 million/5 year program, known as the Bio-nano-enabled Inorganic/Organic Nanostructures and Improved Cognition (BIONIC) Center, is being co-directed by Vladimir Tsukruk and Kenneth Sandhage, professors in Georgia Tech's School of Materials Science and Engineering.

The BIONIC Center utilizes the expertise and capabilities of integrated teams of Georgia Tech faculty and students (from the Colleges of Engineering and Science), Air Force researchers (from the Materials & Manufacturing Directorate and the Human Effectiveness Directorate of the Air Force Research Laboratory, AFRL), and an Ohio State University (OSU) faculty collaborator.

"Advanced materials is an area of importance for the Air Force, since the landscape of materials science is rapidly changing and biomimetic schemes (e.g., tuning surfaces) and biomolecules (e.g., peptides, proteins, phospholipids) to develop functional inorganic/organic nanocomposites for energetic and adaptive materials and to modify and assess cognitive activity. Such integration of biotechnology with nanotechnology is a major campus-wide theme at Georgia Tech.

Funding for the Center of Excellence is provided by the Materials and Manufacturing Directorate and the Human Effectiveness Directorate of AFRL, the U.S. Air Force Office of Scientific Research, and Georgia Tech.

"Georgia Tech was chosen to lead this Center of Excellence because of its investment in infrastructure development, including new facilities and instrumentation; its recruitment of high-caliber faculty members and students; and its emphasis in bio-nanotechnology and cognitive sciences," said Morley Stone, chief scientist of the Human Performance Wing of AFRL's Human Effectiveness Directorate.

There are three major research thrusts, called interdisciplinary research groups, within the BIONIC Center. Each group contains several collaborators from AFRL's Materials and Manufacturing Directorate and/or Human Effectiveness Directorate.

For the first thrust, led by Sandhage, researchers are designing, fabricating, characterizing, and modeling the performance of inorganic/organic nanocomposites for efficient, remote energy-harvesting devices, such as photovoltaics and batteries.

"The U.S. Air Force utilizes autonomous drones that they would like to operate for longer periods of time," explained co-director Sandhage, who holds the B. Mifflin Hood Professorship in the School of Materials Science and Engineering and an adjunct position in the School of Chemistry and Biochemistry. "To do that, they need a robust, cost-effective energy source that performs efficiently for extended times, while providing high pulses of power when needed."

Tsukruk, co-director of the center, is leading the second interdisciplinary research group, which is focused on designing, fabricating, characterizing and simulating the performance of inorganic/organic nanocomposites for tunable, adaptive materials.

"When these adaptive materials composed of compliant matrices and embedded inorganic nanoparticles are exposed to heat or light or both, they will change their properties in ways that will be useful for sensing or morphing materials," said Tsukruk, who also holds a joint appointment in Georgia Tech's School of Polymer, Textile and Fiber Engineering and is a GT Director of the Microanalysis Center.

The third thrust is being led by Michelle LaPlaca, an associate professor in the Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech and Emory University. LaPlaca and her team plan to develop tools and assessment methods to optimize critical cognitive processes.

"U.S. Air Force analysts must remain attentive to computers and controls for hours at a time, so we aim to find a molecular signature of cognition that is sensitive to changes in stress levels and correlate these molecules with functional brain maps using magnetic resonance imaging techniques," said LaPlaca. "We want to learn about a warfighter's physiological response to different situations and use this information to optimize training and work effectiveness."

In addition to its research objectives, another goal for the Center of Excellence is to conduct stimulating collaborative research that will motivate students to consider working at AFRL. In order to develop required technical expertise and to allow for effective knowledge transfer between Georgia Tech and AFRL, U.S. graduate students ("Air Force Scholars") will spend summer months at AFRL (Dayton, OH) under the supervision of an AFRL researcher. Weeklong stays of post-doctoral fellows and Georgia Tech faculty at AFRL will also be used to enhance research interactions and technology transfer.

Other core members of the Center include Regents' professor Mostafa El-Sayed, professor Seth Marder and assistant professor Nils Kröger from the Georgia Tech School of Chemistry and Biochemistry; professor Bernard Kippelen from the Georgia Tech School of Electrical and Computer Engineering; Sheila Keilholz, an assistant professor in the Coulter Department of Biomedical Engineering; Eric Schumacher, an assistant professor in the Georgia Tech School of Psychology; and Hamish Fraser, a professor in the Department of Materials Science and Engineering at the Ohio State University.

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Improving the Reliability of Organic Electronic Devices Through Advanced Packaging Methods
by Samuel Graham

Over the past decade, rapid advancements in organic semiconducting materials have led to exciting developments in the area of organic light-emitting diodes (OLEDs), organic photovoltaics (OPVs), and organic thin-film transistors (OTFTs) with unprecedented performance. Interest in such organic electronic devices arises due to their wide range of tunable properties, their amenability to low-cost large-area manufacturing, and their potential for use in flexible electronic applications. Thus, organic electronics will enable the development of low-cost devices with new flexible form factors which are not possible with traditional crystalline semiconductor materials.

In recent years, researchers at Georgia Tech have been working to address critical concerns in the development of thin film barrier coatings and transparent electrodes for organic electronic devices. Prof. Samuel Graham in the School of Mechanical Engineering, along with Prof. Bernard Kippelen in the School of Electrical and Computer Engineering, and Prof. Clifford Henderson in the School of Chemical and Biomolecular Engineering have teamed up to develop a new encapsulation architecture and sealing techniques for the use in flexible organic electronics. The thin-film barrier material utilizes a vacuum deposition process in which a thin layer of SiO₂ or SiNₓ is deposited by PECVD at temperatures near 110 °C. Due to the low deposition temperature, the PECVD film is typically filled with many defects and does not present itself as a good barrier film. To create the high barrier material, a second layer consisting of Al₂O₃ is then deposited on top of the SiO₂ or SiNₓ using ALD, conformally coating the surface and filling in small defects. This hybrid barrier layer has been shown to have WVTR rates on the order of 10⁻⁶ g/m²/day which is within the range of required performance for organic electronics. The films were then used to encapsulate Pentacene/C₆₀ solar cells and demonstrated shelf lifetimes over 7000 hours without any significant degradation.

The hybrid film represents an advancement in thin film barrier processing since it only requires a few deposition steps when compared to multilayer laminate films typically used by others. Overall, excellent barrier performance has been achieved while simplifying the manufacturing processing procedure and time. Additional success has also been obtained by developing sealing methods which can be used with lamination to create additional low cost routes to packaging devices. Current work continues to investigate additional hybrid architectures and their use along with the advanced sealing methods to encapsulate OPVs, OLEDs, OFETs, and, most recently, organic electrochromic windows.

Zeno-based OptoElectronics (ZOE)
by Joseph Perry

The DARPA Zeno-based OptoElectronics (ZOE) program is performing research on all-optical switching materials and devices and seeks to enable the development of ultra-low energy (<1 femtoJoule) optical switches. The project is an interdisciplinary, multi-institution effort being led by Joseph Perry who is the Project Director. Seth Marder and Jean-Luc Bredas are the other Georgia Tech team members. Researchers from Cornell University (Michal Lipson and Alex Gaeta), the University of Washington (Michael Hochberg, Alex Jen and Larry Dalton), the University of Arizona (Nasser Peyghambarian and Robert Norwood), the University of California San Diego (Shaya Fainman), the University of Central Florida (Eric Van Stryland), and the University of Oxford (Harry Anderson) are also participating in this program.

(continued on page 8)
Faculty Awards

Jean-Luc Brédas
- Named to Inaugural Class of ACS Fellows

Baratunde Cola
- Awarded a Defense Advanced Research Projects Agency (DARPA) Young Faculty Award

Clifford Henderson
- Fellow, Society for Optics and Photonics (SPIE)

Elsa Reichmanis
- Named to Inaugural Class of ACS Fellows

Laren Tolbert
- Named to Inaugural Class of ACS Fellows

Vladimir Tsukruk
- Fellow, American Physical Society
- Humboldt Research Award
- New member of Editorial Advisory Board, Langmuir
- New member of Editorial Advisory Board, ACS Applied Materials and Interfaces

Student Awards

David Collard Group
Kathy Woody
- Recipient of the ACS graduate fellowship in organic chemistry

Rakesh Nambiar
- First Place Graduate Student Research Award, 2009 Student Research Symposium

Samuel Graham Group
Roderick Jackson
- Recipient of the Young Researcher Award, given for best graduate student oral presentation at the International Symposium on Flexible Organic Electronics (IS-FOE)

Rigoberto Hernandez Group
Gungor Ozer
- Recipient of a Best Poster Award at the Frontiers in Macromolecular Simulations Symposium

Matthew Hagy
- Recipient of a Best Poster Award at the GT Homecoming Research Symposium

Vladimir Tsukruk Group
Maneesh Gupta
- SAIC-GT student paper competition – First Place

Kyle Anderson
- MSE Research Initiation Award

2010 COPE Fellows

Avishek Aiyar
Advisor: Elsa Reichmanis
Chemical Engineering
Structure-property relations in poly(3-hexylthiophene) and its impact on charge transport in organic field effect transistors.

Anthony Appleton
Advisor: Uwe Bunz
Chemistry & Biochemistry
Synthesis of novel pentacene derivatives that possess tetraaza core moieties, as well as peripheral halogen substitution, in order to achieve an air-stable n-type semiconducting organic material.

Lauren Hayden
Advisor: Seth Marder
Chemistry & Biochemistry
Synthesis and characterization of organic semiconductor oligomers for applications in n-type and ambipolar organic field effect transistors.

Min Sang Park
Advisor: Mohan Srinivasarao
Polymer, Textile & Fiber Engineering
To characterize the mechanism of evaporation induced self-assembly of organic electronic polymers, resulting in a new paradigm for creating targeted structured on surfaces in a simple, controllable, and cost-effective manner.

Graduates

Jean-Luc Brédas Group
- Kelly Lancaster, PhD, December 2009
- Shino Ohira, PhD, December 2009

Samuel Graham Group
- Namsu Kim, PhD, December 2009

Seth Marder Group
- Xuan Zhang, PhD, December 2009

Joseph Perry Group
- San-Hui Chi, PhD, December 2009

(“Zeno-based OptoElectronics (ZOE)”, continued from page 7)

The first 18 month phase of the project is underway. The objectives of the DARPA ZOE project are to: 1) develop a new generation of molecular and semiconductor materials with strong nonlinear absorptive properties that can be controlled with a unique pump wavelength, 2) demonstrate all-optical switching using molecular and/or semiconductor materials whereby excitation at one wavelength leads to switching of reflection/transmission characteristics for a beam carrying information at another wavelength, and 3) to integrate the materials into scalable silicon and silicon nitride photonic devices for high-performance switching and/or wavelength conversion processes. If successful in developing ultra-low energy optical switches, the ZOE program will pave the way for a new generation of optical-switching devices that could have applications in telecommunications and optical computing. Many members of our team have previously worked together in collaborative R&D and have successfully employed an approach based on a feedback loop involving design, synthesis, characterization, and application for development of organic photonic materials and devices.
COPE Programs Center for Interface Science: Hybrid Solar–Electric Materials

by Neal R. Armstrong

Faculty at the University of Arizona, Georgia Institute of Technology (including several founding members of COPE), the University of Washington, and Princeton University, teaming up with scientists at the National Renewable Energy Laboratories (NREL) have recently been awarded a $15M grant from the Department of Energy to form one of 46 national Energy Frontier Research Centers (EFRC).

The Center for Interface Science: Hybrid Solar Electric Materials will focus on the basic science of solar-to-electric energy conversion underpinning emerging “Generation III” photovoltaic platforms, which may be composed of small molecule or polymer active layers, or hybrids of these materials with nanomaterials such as oxide or semiconductor nanoparticles. It was selected for this mission, out of a pool of 260 applications, after a rigorous application and reviewing process, and is one of 31 EFRC programs led by universities, the others being led by national laboratories, non-profit organizations and one corporate research laboratory. Many of the EFRC programs led by universities including this one led by the University of Arizona, have been funded by ARRA (stimulus) funds, and will run for five years with an option for competitive renewal for an additional five years.

This group of scientists will specifically focus on the critical interfaces in these technologies which limit their energy conversion efficiencies, including metal/organic, metal oxide/organic and charge collection and encapsulant interfaces which currently limit our ability to efficiently harvest charge from these devices, and keep them stable in robust, inexpensive, “printable” formats.

This EFRC program has its genesis in research funded by the National Science Foundation, especially from the Science and Technology Center for Materials and Devices for Information Technology Research, by the Department of Defense (Navy and Air Force), by industrial affiliates at Georgia Tech associated with COPE, and a host of earlier center-like activities involving members of the University of Arizona and Georgia Tech. It builds extensively on the analytical tools, theoretical methods, and synthetic protocols developed in the last fifteen years of research by these scientists in the area of new materials for telecommunications, display, and energy conversion technologies.

Mission: To become a nationally and internationally recognized center of excellence for science of interfaces in photovoltaic devices based on organic and inorganic nanostructured hybrid materials. Our Center will inspire, recruit, and train future scientists and leaders in the basic interface science of solar electric energy conversion.

University of Arizona
• Neal R. Armstrong, Director
• Jeanne E. Pemberton, Assoc. Director–Surface Science/Theory
• S. Scott Saavedra, Assoc. Director, Operations
• Dominic McGrath
• Jeff Pyun
• Oliver Monti
• Robert Norwood
• Nasser Peyghambarian

Georgia Institute of Technology
• Seth R. Marder, Associate Director–Materials
• Bernard Kippelen, Associate Director–Device Science
• Jean-Luc Brédas
• Samuel Graham

National Renewable Energy Laboratory
• David Ginley, Assoc. Director & DOE Liaison
• Dana Olson
• Joseph Berry

University of Washington
• David Ginger
• Christine Luscombe

Princeton University
• Antoine Kahn

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**New Publications**

Linear ripples and traveling circular ripples produced on polymers by thermal AFM probes. Greco, Enrico; Riedo, Elisa; King, William P.; Marder, Seth R. and Szostakiewicz, Robert. PHYSICAL REVIEW B. 79, 35421 (2009).


Cancellation of environmental effects in resonant mass sensors based on resonance mode and effective mass. Naei, Kianouch and Brand, Oliver. REVIEW OF SCIENTIFIC INSTRUMENTS. 80 (2009).


The kinetics of incongruent reduction of tungsten carbide via reaction with a hafnium-copper melt. Liu, Yajun; Lipke, David W.; Zhang, Yunshu and Sandhage, Kenneth H. ACTA MATERIALIA. 57, 3924–3931 (2009).

Doping Molecular Wires. Heimel, Georg; Zojer, Egbert; Romaner, Lorenz; Bredas, Jean-Luc and Stellacci, Francesco. NANO LETTERS. 9, 2559–2564 (2009).


Electrospinning Physical Gels: The Case of Stereocomplex PMMA. Cre, Matija; Park, Jung Ok and Srinivasarao, Mohan. MACROMOLECULES. 42, 4353–4355 (2009).

Preparation and Characterization of 4 ’-Donor S Stilbene-4-thiolate Monolayers and Their Influence on the Work Function of Gold. Malicki, Michal; Guan, Zelei; Ha, Sieu D.; Heimel, Barlow; Stephen; Rumi, Mariacristina; Kahn, Antoine and Marder, Seth R. LANGMUIR. 25, 7967–7975 (2009).

Pentacene organic field-effect transistors with polymeric dielectric interfaces: Preparation and Characterization of 4 ’-Donor S Stilbene-4-thiolate Monolayers and Their Influence on the Work Function of Gold. Malicki, Michal; Guan, Zelei; Ha, Sieu D.; Heimel, Barlow; Stephen; Rumi, Mariacristina; Kahn, Antoine and Marder, Seth R. LANGMUIR. 25, 7967–7975 (2009).


Charge photogeneration in polythiophene-perylene diimide blend films. Shoaeae, Safa; An, Zesheng; Zhang, Xuan; Barlow, Stephen; Marder, Seth R.; Duffy, Warren; Heeney, Martin; McCulloch, Iain and Durrant, James R. CHEMICAL COMMUNICATIONS. 5445–5447 (2009).


Norbornene-Based Copolymers Containing Platinum Complexes and Bis(carbazolyl)benzene Groups in Their Side-Chains. Feng, Ke; Zuniga, Carlos; Zhang, Ya-Dong; Kim, Dongwook; Barlow, Stephen; Marder, Seth R.; Bredas, Jean-Luc and Weck, Marcus. MACROMOLECULES. 42, 6855–6864 (2009).


Room-temperature discotic liquid-crystalline corone diimides exhibiting high charge-carrier mobility in air. An, Zesheng; Yu, Junsheng; Demarquye, Benoit; Jones, Simon C.; Barlow, Stephen; Kiplenberg, Bernard and Marder, Seth R. JOURNAL OF MATERIALS CHEMISTRY. 19, 6688–6698 (2009).


High Energy Density Nanocomposites Based on Surface-Modified BaTiO3 and a Ferroelectric Polymer. Kim, Phileos; Koss, Natalie M.; Tillottson, John P.; Hotchkiss, Peter J.; Pan, Ming-Jen; Marder, Seth R.; Li, Jiangyu; Calame, Jeffery P. and Perry, Joseph W. ACS NANO. 3, 2581–2592 (2009).


Photophysical Properties of an Alkylne-Bridged Bis(zinc porphyrin)-Perylene Bis(dicarboximide) Derivative. Odom, Susan A.; Kelley, Richard F.; Ohira, Shino; Ensley, Trenton R.; Huang, Chun; Padilha, Lazaro A.; Webster, Scott;

Molecular design for improved photovoltaic efficiency: band gap and absorption coefficient engineering. Mondal, Rajib; Ko, Sangwon; Norton, Joseph E.; Miyaki, Nobuyuki; Becerill, Hector A.; Verploegen, Eric; Toney, Michael F.; Bredas, Jean-Luc; McCgehee, Michael D. and Bao, Zhenan. JOURNAL OF MATERIALS CHEMISTRY. 19, 7195-7197 (2009).


Metalloporphyrin polymer with temporally agile, broadband nonlinear absorption for optical limiting in the near infrared. Hales, Joel M.; Coxz, Matteo; Screen, Thomas E. O.; Anderson, Harry L. and Perry, Joseph W. OPTICS EXPRESS. 17, 18478-18488 (2009).

Hindered rolling and friction anisotropy in supported carbon nanotubes. Lucas, Marcel; Zhang, Xiaohua; Palaci, Ismael; Klinke, Christian; Tosatti, Erio and Riedo, Elisa. NATURE MATERIALS. 8, 876-881 (2009).

Quantum Dynamics of the Excited-State Intramolecular Proton Transfer in 2-(2'-Hydroxyphenyl)benzothiazole. Kim, Justin; Wu, Yinghua; Bredas, Jean-Luc and Batista, V. S. ISRAEL JOURNAL OF CHEMISTRY. 49, 187-197 (2009).


Conjugated polymer-fullerene blend with strong optical limiting in the near-infrared. Chi, San-Hui; Hales, Joel M.; Coxz, Matteo; Ochoa, Charles; Fitzpatrick, Madison and Perry, Joseph W. OPTICS EXPRESS. 17, 22062-22072 (2009).


Modification of the Surface Properties of Indium Tin Oxide with Benzylphosphonic Acids: A Joint Experimental and Theoretical Study. Hotchkiss, Peter J.; Li, Hong; Paramonov, Pavel B.; Paniagua, Sergio A.; Jones, Simon C.; Armstrong, Neal R.; Bredas, Jean-Luc and Marder, Seth R. ADVANCED MATERIALS. 21, 4496+ (2009).


Low-voltage solution-processed n-channel organic field-effect transistors with high-k HfO2 gate dielectrics grown by atomic layer deposition. Tiwari, Shree Prakash; Zhang, Xiao-Hong; Potscavage, Jr., William J. and Kippen, Bernard. APPLIED PHYSICS LETTERS. 95, (2009).


Broadband Transient Absorption Spectroscopy
- Monitoring of transient changes in optical properties to provide broadband spectral information (300 nm – 1.7 μm) and ultrafast temporal resolution (from milliseconds down to femtoseconds)
- Evaluation of the charge-transfer/recombination kinetics in potential photovoltaic materials
- Generation of non-linear absorption spectra of target organic materials that could be used in all-optical signal processing applications

Nonlinear Optical Spectroscopy
- Femtosecond-pulsed Z-scan and degenerate four-wave mixing for absolute determination of third-order optical nonlinearities
- Determination of molecular nonlinearities as a function of chemical structure variation

Microfabrication
- Patterning of materials with true three-dimensional (3D) spatial resolution including photonic crystals, microchannel and microfluidic devices, and biocompatible templates

Material Synthesis and Purification
- Wet chemistry laboratory covering over 2000 sq ft, including 25 fume hoods, and containing state-of-the-art equipment

Physical, Chemical, and Optical Material Characterization
- Gas chromatograph-mass spectrometry
- High-pressure liquid chromatography-mass spectrometry
- UV/VIS/NIR spectrophotometry
- Spectrofluorimetry
- FT-IR spectrometry
- Electrochemistry
- Thermogravimetric analysis
- Thermal analysis of materials using differential scanning calorimeter (Q200, TA Instruments)
- Gas permeation chromatography for the measurement of molecular weights and molecular weight distributions of polymers
- Surface Analysis
  - FT-IR characterization techniques that are surface-sensitive or suitable for thin film analysis. Specular reflectance, diffuse reflectance, attenuated total reflectance, grazing angle specular reflectance
  - Atomic Force Microscopy (AFM) techniques using an Agilent 5600LS for the characterization of surface properties through a wide range of topography including: in contact or tapping mode, scanning tunneling microscopy (STM), lateral force microscopy (LFM), electric force microscopy (EFM), Kelvin force microscopy, piezo-force microscopy; fluid immersed imaging and for electrochemical microscopy of samples; and nanolithography via closed-loop scanner
- X-ray photoelectron spectrometry (XPS) using an Axis Ultra HSA, Kratos, characterized by high-energy resolution and high sensitivity; for the determination of elemental composition of surfaces with surface mapping capabilities and an integrated ultraviolet photoelectron spectroscopy (UPS) unit
Happy New Year to you.

2010 promises to be an exciting new year for the Georgia Tech Center for Organic Photonics and Electronics, COPE. Of primary importance, I would like to announce a leadership transition in which my colleague, Professor Bernard Kippelen, will be assuming the position as the Director of COPE later this year. As the change in leadership involves a shift of certain administrative functions between not only departments, but colleges, I will serve with Bernard as co-Director for the next several months, to ensure that the process moves forward smoothly.

As many of you know, COPE was founded in 2003 and I had the honor to serve as its founding Director. In the past six or so years, COPE has accomplished many things, but I am most proud of it staying true to its core values of supporting excellence in research, embracing and promoting diversity, creating an educational and research environment that encourages interdisciplinary and collaborative interactions, and ensuring that breakthroughs mean more than well cited papers. COPE now has over 20 faculty members from 8 schools, and I have been very privileged and grateful to serve them and Georgia Tech in my capacity as founding Director.

Georgia Tech’s selection of Bernard Kippelen as the next Director of COPE, is a recognition of not only his many scientific contributions to the area of organic electronics and photonics, but also his commitment to the core values I alluded to above. Bernard brings to COPE a tremendous amount of vision, energy and experience and I very much look forward to working closely with him and the greater COPE community in the years to come.

Sincerely,

Seth R. Marder
Director of COPE