Volume 4 Issue 1 Fall 2011

IMR Quarterly

MOCVD Synthesis of Semiconductor Nanowire Heterostructures for Investigation of 1D Spin Physics

In this issue we highlight the research of an OSU Physics department team exploring spin physics in novel semiconductor nanowire heterostructures. Originally seeded in 2009 by an IMR Interdisciplinary Materials Research Grant (IMRG), this project led by Fengyuan Yang, Associate Professor of Physics, and co-PI Ezekiel Johnston-Halperin, Assistant Professor of Physics, is now jointly funded on a larger scale by a U.S. Department of Energy grant. Dr. John Carlin, a Nanotech West research scientist, provides essential technical support for this project. The goal of the research project is to investigate spin relaxation, spin transport, and coupling of spins in nanostructures enabled by semiconductor nanowires using a variety of optical techniques.

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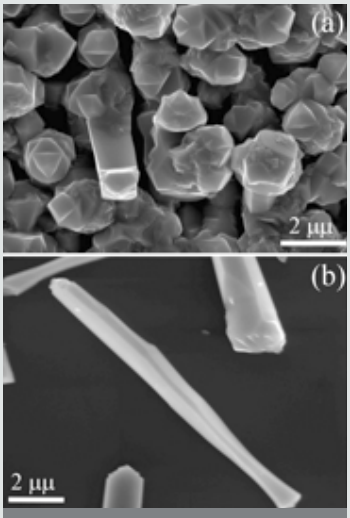


Fig. 1 SEM images of GaAs-$Al_{0.35}Ga_{0.65}As$ core-shell nanowires

Alcoa Funds IMR for Lightweight Vehicle Research

The OSU Institute for Materials Research and the Ohio Manufacturing Initiative jointly developed a proposal to the Alcoa Foundation last spring which resulted in a generous $400,000 gift to support the development of a signature strength in light vehicle design and materials manufacturing by OSU faculty and students.

OSU's partnership with Alcoa in lightweight vehicle structures is the only program in the United States currently supported by Alcoa Foundation's Advancing Sustainability Research initiative. Professors Glenn Daehn, Materials Science and Engineering and Director of the Ohio Manufacturing Initiative, and Anthony Luscher, Mechanical and Aerospace Engineering, will lead this project in design and manufacturing technologies to enable the creation of lighter, more environmentally friendly vehicle structures.

Most of the funding will be used to support graduate students with some support of professional staff and facilities to develop and disseminate the engineering science behind the application of homogeneous and multi-material aluminum-based vehicle structures. Passenger busses will be a primary case study. As part of this process, structural joining solutions that are unique to the application of aluminum will be developed, including aluminum-to-aluminum solutions as well as the joining of aluminum to ferrous, composite, magnesium, and reinforced polymeric materials with an emphasis on vehicle applications.

IMR Institute For Materials Research

THE OHIO STATE UNIVERSITY

Director's Note

Dear Colleagues,

It has certainly been an extraordinarily busy and productive Fall Quarter in 2011, with some key changes of leadership in the community. First, I want to thank Dr. Nitin Padture, College of Engineering Distinguished Professor, for his valuable leadership and close collaboration in developing and directing the Center for Emergent Materials, OSU's NSF MRSEC, from its inception as a proposal to a point now where the CEM is firmly established and ideally positioned to flourish and generate high impact materials science innovations well into the future. As many of you know, Prof. Padture is leaving OSU for Brown University this coming January, and while this is a loss for OSU materials, we nevertheless wish him only the best of luck for great success. Fortunately, we have great scientist/leaders in materials at OSU and I am thrilled to use this space to announce and welcome Prof. P. Chris Hammel as the new CEM Director, a move that became effective October 1, 2011. As many of you know, Prof. Hammel is an Ohio Eminent Scholar in our Physics Department and he has been central to the development of CEM even before it had been proposed formally to NSF. CEM is in great hands under Prof. Hammel's leadership and I am looking forward to working with Chris in his new position. Inside you can read more about CEM's recent accomplishments and changes.

This Fall Quarter kicked off with our largest and most successful OSU Materials Week conference to date. Close to 450 attendees attended Materials Week, which includes participants from 13 other universities and 36 companies. Students presented more than 100 posters in what might be one of the best student poster events in the U.S., and the uniformly high quality and exciting topics presented by our students made it difficult indeed for our committee to select the exceptionally qualified students as the 2011 Materials Week poster award winners. Inside you can read about these students, and the overall breadth and depth of topics that were represented. Materials Week, in its fourth year, has become a galvanizing event in which OSU materials research is celebrated by us all.

In this issue you will also find articles on just a few of the great successes made by IMR members in recent months. Our spotlight focuses on the work of Prof. Fengyuan Yang and Prof. Zeke Johnston-Halperin, who describe their very innovative research on semiconductor nanowires for 1-dimensional magnetic spin physics, a program initiated with a recent IMR Interdisciplinary Materials Research Grant that is now receiving federal support. Also I am proud to announce the start of a program awarded by the Alcoa Foundation to IMR in conjunction with the Ohio Manufacturing Initiative led by Prof. Glenn Daehn of our Materials Science and Engineering department. This large gift, the only one awarded to a U.S. institution through Alcoa's "Advancing Sustainability Initiative," focuses on lightweight materials manufacturing and represents a direction of great importance for OSU materials in the future. This Fall quarter also saw the start of several new initiatives in photovoltaics and energy research, with a research award that successfully graduated from the IMR Wright Center for Photovoltaics Innovation and Commercialization into a federally funded consortium, and the hosting of a very well attended Solar Durability Workshop. Information on all of these advances, including key facility news, welcoming of a new staff member to our Nanotech West Lab, and special recognitions awarded to our faculty members are all inside this issue.

Warm Regards,

Steven A. Ringel, Ph.D.
Neal A. Smith Chair Professor
Director, The Ohio State University Institute for Materials Research

Materials Center Update: Wright Center for Photovoltaics Innovation and Commercialization (PVIC)

At the request of its industrial members earlier in the year, PVIC-OSU hosted a Solar Durability Workshop on September 29, 2011 at the Longaberger Alumni House on the Ohio State campus. The workshop was well attended by approximately 60 solar researchers, predominantly from industry. Featured talks were given by Roger French of Case Western Reserve University, David Miller of the National Renewable Energy Laboratory (NREL), and Stanislaus Wong of SUNY Stony Brook, who also stayed at Ohio State an extra day to give a special IMR seminar. Talks were also given by Thomas Carney (DuPont), Paul Berger (Ohio State), Alex Kawczak (StrateNexus Technologies), Aarohi Vijh (Xunlight), Scott Brown (Replex Plastics), Eduardo del Rio (Tosoh SMD), and Sean Fowler (Q-Labs). Another PVIC meeting on similar topics is scheduled for early January 2012 at Case Western Reserve University.

Attendees at PVIC's Solar Durability Workshop

Two New Ohio Research Scholars Join TEEM

In 2008, IMR was awarded an $18.1 million Ohio Research Scholars award in advanced materials from the Ohio Department of Development, creating a university coalition consisting of The Ohio State University, the University of Akron and the University of Dayton. Five endowed chairs with the title of Ohio Research Scholar were established through this award – three at OSU and one each at the University of Akron and the University of Dayton. The goal of this program, entitled **Technology-Enabling and Emergent Materials (TEEM),** is to pioneer revolutionary approaches to accelerate the development of materials for technological impact, by evaluating emergent materials at an early stage through the application of advanced characterization and predictive modeling.

This fall two new Ohio Research Scholars were hired – David McComb at Ohio State and Nita Sahai at the University of Akron. These new faculty join two other TEEM Ohio Research Scholars previously introduced in *IMR Quarterly* - Katrina Cornish, OSU's Ohio Research Scholar in Bio-based Emergent Materials and Scott Gold, University of Dayton's Ohio Research Scholar in Multiscale Composites Processing. With four of the five Ohio Research Scholars from this award now hired and on board at their respective universities, the TEEM leaders will meet in early 2012 to discuss future research plans and collaborations.

David McComb, Ohio Research Scholar in Nanoscale Materials Characterization

OSU's newest Ohio Research Scholar, David McComb

This Fall, the OSU Materials Science and Engineering department welcomed David McComb as the Ohio Research Scholar in Nanoscale Materials Characterization. He will also direct the nascent Center for Electron Microscopy and AnalysiS (CEMAS), a unique, state-of-the-art structural characterization facility centered around electron microscopy that will support characterization of structural, electronic and biological materials. Dr. McComb is a world leader in electron microscopy and the application of such methods to biological and structural materials, and at Imperial College London he was responsible for the establishment of the first monochromated analytical electron microscopy facility in the UK. Dr. McComb's research concentrates on the development and application of nanoanalytical electron microscopy techniques for the study of chemistry, structure and bonding at the interfaces of atoms. His work also includes the synthesis of novel, multifunctional three-dimensionally ordered solids. OSU faculty and staff may also remember Dr. McComb as one of the speakers at the 2010 OSU Materials Week conference.

At Imperial, Dr. McComb led a research group of seventeen people and served as Co-Director of the London Centre for Nanotechnology. He is a Fellow of the Royal Society of Chemistry and a Member of the IOM3, Council of Royal Microscopial Society and the Institute of Physics, and has over 90 publications and patents. Dr. McComb's specific research concentrates on the development and application of nanoanalytical electron microscopy techniques for the study of chemistry, structure and bonding at the interfaces of atoms. His work also includes the synthesis of novel, multifunctional three-dimensionally ordered solids.

Nita Sahai, Ohio Research Scholar in Polymer Science, University of Akron

Nita Sahai, University of Akron

Dr. Nita Sahai joined the University of Akron as an Ohio Research Scholar and Professor of Polymer Science within the College of Polymer Science and Polymer Engineering. Dr. Sahai is an expert on biomolecule and cell interactions at mineral surfaces, environmental geochemistry, biomineralization, and biomaterials. Dr. Sahai's research falls within the field of interfacial biogeochemistry, which includes medical mineralogy and biomineralization, bioceramics, and environmental geochemistry. Specific research projects she and her group work on include the self-assembly of phospholipids as model cell membranes at mineral surfaces, cell adhesion to mineral surfaces, protein-mediated biomineralization of calcite, silica and apatite, bone growth on silicate bioceramic prosthetic implants, and biomimetic silica synthesis. Sahai was previously at the University of Wisconsin-Madison, where she was a professor of geochemistry in the Materials Science and Environmental Chemistry and Technology programs. As a University of Wisconsin member of the NASA Astrobiology Program, her research was also involved in understanding biomineral morphologies as potential biosignatures on Mars.

MOCVD Synthesis of Semiconductor Nanowire Heterostructures for Investigation of 1D Spin Physics

(continued from page 1)

The discovery of long spin relaxation time of itinerant electrons (up to 100 nanoseconds) and spin diffusion lengths over 100 μm in GaAs has led to extraordinary advances in semiconductor spintronics in the past one and a half decades. Most of the efforts in this field were devoted to two-dimensional (2D) systems such as quantum wells (QW). What has been missing is the investigation of spin dynamics and spin transport in 1D semiconductors. If spin-based electronics is to become one of the next-generation electronic technologies, it is essential to first understand the spin physics in 1D semiconductors since future spintronic devices will most likely function with feature size of tens of nanometers. More importantly, the confinement of the 1D semiconductors provides the benefit of increasing spin relaxation time as the lateral dimension decreases below the momentum mean free path.

"Bottom-up" catalytic synthesis offers a unique route for fabrication of semiconductor nanowires (NW). In particular, metalorganic chemical vapor deposition (MOCVD) has proven an excellent technique in producing a variety of 1D and 0D heterostructures in semiconductor nanowires with well controlled geometry and excellent crystal quality. Specifically, the synthesis of semiconductor nanowires is via the vapor-liquid-solid (VLS) mechanism using gold nanoparticles as catalysts. Monodisperse Au nanoparticles with diameters from 2 to 250 nm are commercially available, providing good control of the nanowire diameters over a broad range (Figures 1 and 2). This capability provides the materials basis for studying spin physics in low dimensional semiconductors. However, the quasi-1D geometry prohibits optical excitation of spins and spin-polarized electroluminescence for study of spin physics in semiconductor nanowires. This is due to the large dielectric mismatch between semiconductor nanowires (e.g. $\varepsilon_{GaAs} \sim 10$) and their environment ($\varepsilon_{air} \cong 1$) which leads to large polarization anisotropy in optical absorption and luminescence. Consequently, only absorption (linearly) polarized along the nanowire axis is allowed, prohibiting optical spin excitation by a circularly polarized light and optical spin detection through electroluminescence of circularly polarized light in semiconductor nanowires.

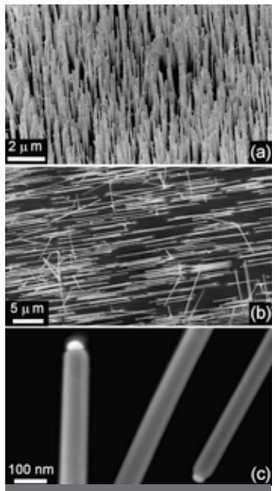


Fig. 2 SEM images of GaAs-$Al_{0.35}Ga_{0.65}As$ core-shell nanowires

Fig. 3 Researchers Ezekiel Johnston-Halperin, Fengyuan Yang, and IMR Member of Technical Staff John Carlin with the Aixtron III-V MOCVD system at Nanotech West Laboratory.

Fortunately, MOCVD is ideally suited for synthesis of III-V core-shell heterostructures, of which a shell (e.g. $Al_xGa_{1-x}As$) of sufficient thickness provides a nearly perfect dielectric match to the core nanowire (e.g. GaAs). This dielectric matching reduces the optical polarization anisotropy from >90% to ~ 5%. As a result, utilizing OSU's MOCVD facility located in IMR's Nanotech West laboratory, Figure 3, this program is able to directly synthesize many unique core-shell nanowire heterostructure designs which can be optimized for optical excitation to investigate spin relaxation, spin transport, and coupling of spins in these nanostructures.

For additional information on this research effort, contact researchers Fengyuan Yang (fyyang@mps.ohio-state.edu) or Ezekiel Johnston-Halperin (ejh@mps.ohio-state.edu).

OSU Dominates in Solar Energy

From the OSU node of the Wright Center for Photovoltaic Innovation and Commercialization (PVIC) to a large group of collaborative faculty members performing research in virtually all areas of photovoltaics technology and basic science, OSU is making a major impact in photovoltaic (PV) innovation. Now two new projects led by IMR Director and Neil A. Smith Chair in Electrical Engineering Steven A. Ringel further strengthen the notoriety of OSU researchers in PV and their impact in the PV field.

DOE SunShot Award

On September 1, 2011, the U.S. Department of Energy announced eighteen new awards totaling $35.8 million for its Solar Foundational Program to Advance Cell Efficiency Projects through DOE's SunShot Initiative. A university-industry-federal lab collaboration team led by IMR Director and Neil A. Smith Chair in Electrical Engineering Steven A. Ringel was awarded one of these highly competitive three-year projects. The proposal, titled "III-V/Active-Si Integration for Low-Cost High-Performance Concentrator Photovoltaics," received $1.5 million in federal support plus an additional $500,000 in cost share. The collaborative project builds upon multiple early stage materials science efforts by Ringel's group and their collaborators, including their recent solar cell development focus that was enabled and funded by the Wright Center for Photovoltaic Innovation and Commercialization (PVIC) on the integration of III-V compound semiconductor photovoltaics with Si substrates for affordable, terrestrial solar energy sources.

The team is jointly supported by DOE and NSF as part of the F-PACE arrangement, and they will emphasize creating a new III-V/Si three and four-junction integrated solar cell technology for concentrator PV (CPV) systems in which sunlight can be focused from 10 times to beyond 1000 times the standard earth intensity, with the potential to reach energy conversion efficiencies in excess of 50% via an affordable manufacturing process. The OSU team includes Dr. John Carlin, IMR Member of Technical Staff, who is also a co-Investigator on the project. Non-OSU collaborators include Emcore Photovoltaics in Albuquerque, the National Renewable Energy Laboratory (NREL), and the Massachusetts Institute of Technology.

The work at OSU will largely occur in three IMR-supported facilities – Nanotech West Laboratory for epitaxial growth and cell fabrication, the Semiconductor Epitaxy and Analysis Laboratory (SEAL) for epitaxial growth and materials and device characterization, and the Campus Electron Optics Facility (CEOF) for electron microscopy. A unique aspect of this program is a rotating internship/mentorship plan in which OSU students will spend time at both NREL and Emcore to gain collaboration experience in both federal research lab and industry research lab/technology advancement settings. This new program will become a key part of an international high performance photovoltaics research thrust centered at OSU that also includes leading teams of PV researchers from Europe, Asia and Australia.

IEEE Journal of Photovoltaics Established

Earlier this year, the IEEE Electron Devices Society announced a new scholarly journal, the IEEE Journal of Photovoltaics, co-founded by Dr. Ringel.

The journal was created in response to the rapid expansion of research in the science, engineering and technology of solar cells materials, devices and systems. The peer-reviewed, archival publication will report original and significant research results that advance the field of photovoltaics and are of primary interest to the photovoltaic specialist. Topics will include fundamentals and new concepts, PV systems, thin-film solar cells, concentrator solar cells, organic PV, and advances in PV characterization. The journal will publish two issues in 2011 and will publish monthly issues thereafter.

The OSU research team working on the Sunshot project: Prof. Steve Ringel, Javier Grandal, Andrew Carlin, Chris Ratcliff, Limei Yang, Prof. Michael Mills, and Tyler Grassman (not pictured, John Carlin, Dan Chmielewski and Beatriz Galiana-Blanco)

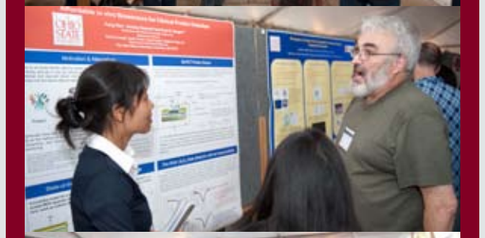
Dr. Ringel chairs the IEEE Electron Devices Society Photovoltaic Technical Committee, and the creation of this journal has been a primary activity since 2009. Ringel now serves on the inaugural editorial board as editor of the journal's "Fundamentals and New Concepts" section. The Editor in Chief is Professor Tim Anderson, of the University of Florida, who gave a plenary presentation on his PV research during the 2010 OSU Materials Week conference.

2011 OSU Materials Week

OSU's Fall quarter began on a high note with the 4th annual OSU Materials Week, once again co-hosted by the Institute for Materials Research and the Center for Emergent Materials, OSU's NSF MRSEC program. The 2011 OSU Materials Week conference took place September 12-14 at the Ohio Union on OSU's Columbus campus. This year's attendance grew considerably to about 450 materials research professionals including OSU faculty, staff, and students and representatives from 13 other universities, 36 industry collaborators, and national labs and state entities.

OSU President Gordon Gee stopped by to see student research posters and preview the Lotus vehicle

A wide variety of materials-allied disciplines were represented at 2011 OSU Materials Week, which included 42 presentations by international authorities in plenary sessions on *Carbon-Based Materials and Biological Materials: From the Nano to Macro Scale,* and technical sessions on *2-D Materials Beyond Graphene, Materials Design and Catalysis, Thermal Spintronics, and Terahertz (THz) Materials.*



A highlight of this year's Materials Week was a day-long symposium organized by the Ohio Manufacturing Initiative focused on *New Approaches to Lighter, Sustainable Vehicle Materials.* This heavily industry-focused day attracted dozens of attendees from automotive manufacturers and suppliers, who joined university engineers and national experts to discuss the role of new materials in vehicle structure and design.

Two evening student poster session receptions provided a venue for OSU students and postdocs to show off their recent contributions to research. Over 100 research posters were exhibited at the student poster sessions, and ten OSU students received Best Student Poster awards at a luncheon reception later that week.

Lotus Engineering displayed one of their lightweight vehicles during Materials Week

2011 OSU Materials Week Best Student Poster Awards

- **Santino Carnevale,** Advisor: Roberto Myers, Materials Science and Engineering; Title: Control of III-nitride Nanowire Growth Kinetics Towards Three-Dimensional Nano-Heterostructure Devices
- **Tricia Meyer,** Advisor: Patrick Woodward, Chemistry; Title: Strategies for Growing High-Quality Double Perovskite Films
- **Rohan Mishra,** Advisor: Wolfgang Windl, Materials Science and Engineering; Title: Engineering Half-metallic Ferrimagnetism in A_2MnRuO_6 (A = Sr, Ca) Double Perovskites
- **Zhenqing Li,** Advisor: Jianjun Guan, Materials Science and Engineering; Title: Basic Fibroblast Growth Factor Enhances Mesenchymal Stem Cell Survival and Cardiac Differentiation under Ischemic Environment in Thermosensitive Hydrogels
- **Julie Drexler,** Advisor: Nitin Padture, Materials Science and Engineering; Title: Mechanisms of Mitigation for CMAS Resistant TBC Materials
- **Thomas Kent,** Advisor: Roberto Myers, Materials Science and Engineering; Title: Embedded Ferromagnetic GdN Nano-Islands In GaN
- **Gang Ruan,** Advisor: Jessica Winter, Chemical and Biomolecular Engineering; Title: Development of A Family of Novel Composite Nanoparticles based on Templated Self Assembly
- **Andrew Gledhill,** Advisor: Nitin Padture, Materials Science and Engineering; Title: Effects of Coal Fly Ash and Volcanic Ash on Thermal Barrier Coatings in Isothermal and Thermal Gradient Testing
- **Harshad Paranjape,** Advisor: Peter Anderson, Materials Science and Engineering; Title: NiTi Shape Memory Alloys: Why Your Polycrystalline Neighborhood Matters
- **Christopher Porter,** Advisor: David Stroud, Physics; Title: Clustering of Iron Adatoms on Graphene

2011 OSU Materials Week Student Poster Award Winners

IMR Hosts 2 Materials Seminars

The IMR hosted two seminars during Fall quarter as part of its commitment to bringing materials experts to Ohio State to share the latest findings in their research with the OSU materials community.

On September 30, IMR hosted a special seminar with Stanislaus Wong, a Professor of Chemistry with the State University of New York (SUNY) at Stony Brook and the Condensed Matter Physics and Materials Sciences Department at Brookhaven National Laboratory. Prof. Wong's talk was titled *Chemical Strategies in Nanoscience* and covered chemical strategies used for the focused functionalization of single walled carbon nanotube (SWNT) surfaces. He also discussed the applications of green chemistry principles to the synthesis of metal-containing nanostructures which have resulted in the creation of a number of different potential architecture systems for gaining valuable insights into fuel cell and photovoltaic performance.

PVIC-OSU Director Bob Davis, Stanislaus Wong, and Alex Kawczak of StrateNexus Technologies

The 2011-2012 IMR Colloquia Series kicked off on November 9th with *Self-Assembly in Materials Chemistry,* a colloquium by Samuel Stupp from the departments of Chemistry, Materials Science and Engineering, and Medicine at Northwestern University. Prof. Stupp discussed the emergence of self-assembly over the past two decades as a chemical strategy to create materials and devices and illustrated self-assembly strategies to create more complex structures of interest in energy and medicine that have hierarchical order across scales. His research is focused on self-assembly and supramolecular materials with an emphasis on regenerative medicine, cancer therapies, and solar energy.

Sam Stupp, Joshua Goldberger, Chemistry, and IMR Director Steve Ringel

The IMR typically hosts between two and six speakers each year through its IMR Colloquia Series. All IMR colloquia are announced through IMR listserve emails and online at imr.osu.edu/events.

Materials Facilities Updates

Nanotech West Laboratory

New Staff Member, Pete Janney

Peter Janney, new Nanotech West Lab Services Coordinator

In early November 2011, Mr. Peter Janney joined the Nanotech West Laboratory staff as a Laboratory Services Coordinator. Pete brings numerous years of process and equipment experience, primarily in industrial CD and DVD fabrication lines. Pete spent over 20 years at Zomax in Dublin, Ohio, mostly as a Replication Engineer for a CD/DVD manufacturing line. During that time he gained extensive experience with robotics, injection molding, sputtering and evaporation systems and other vacuum fabrication tools, computers, networks, and databases, and machine shop operations. He was also employed by Toolex USA and Trace Optical, where he installed major fabrication equipment around the world.

New Research Instrumentation On Order

In early November, orders were placed for four pieces of capital equipment for Nanotech West:

- A silicon drift detector (SDD) for our Zeiss Ultra Plus field-emission scanning electron microscope (SEM02). Silicon drift detectors enable fast, high-count rate X-ray materials analysis and scanning compositional analysis without the need for liquid nitrogen cooling. The detector we have ordered is an Oxford Instruments Aztec X-Max with a 50 mm2 detector;
- A refurbished Plasma-Therm 790 plasma-enhanced chemical vapor deposition (PECVD) system. As a result of discussions with many user groups, we have ordered a tool that will be capable of depositing both silicon oxide and silicon nitride at 13.56 MHz;
- An MBraun nitrogen glovebox, primarily to facilitate the refilling and changing of precursors for the Picosun atomic layer deposition (ALD) tool;
- A Diener Pico 13.56 MHz plasma asher. Our plan is to have this asher pumped with a dry scroll pump, to enable low-damage, completely oil-free oxygen plasma cleaning of semiconductor and other inorganic surfaces.

All three of these purchases will arrive in late 2011, and were enabled by capital funds from the Ohio Wright Center for Photovoltaics Innovation and Commercialization (PVIC).

ENCOMM NanoSystems Laboratory (ENSL)

New Sputtering System and Microscope Now Available

Over the last several months, the ENCOMM NanoSystems Laboratory (ENSL) has further expanded its selection of instrumentation available to researchers, adding a new Kurt J. Lesker Lab-18 sputtering system and an Evico Magnetics GmbH Magneto-Optical Kerr microscope. The purchase of both new research instruments was made possible by funding through OSU's Targeted Investments in Excellence (TIE) Advanced Materials Initiative award.

Kurt J. Lesker Lab-18 sputtering system installed in ENSL's cleanroom

The Kurt J. Lesker Lab-18 sputtering system delivers a combined capability for magnetron sputtering and e-beam evaporation in the same vacuum chamber. The system is outfitted with three 3" sputtering sources and a 6-pocket e-beam evaporation source. In addition, a Kaufman & Robinson, Inc. KDC 40 ion source is installed in the loadlock of the system and can be used for sample surface etching and cleaning. The system was delivered in September 2011 and is now installed in the ENSL cleanroom in rooms 0115/0117 of the Physics Research Building (PRB).

Evico Magnetics Magneto-Optical Kerr microscope installed in ENSL

The Evico Magnetics Magneto-Optical Kerr microscope is a system for rapid magnetic domain visualization in ferromagnetic samples. This instrument will be used for magnetic domain research and offers a unique capability for real-time visualization of domain formation and evolution in applied magnetic field to OSU researchers. It consists of a high-resolution optical microscope combined with a compact electro magnet capable of generating magnetic fields as high as 1 T applied in the plane of the sample surface. The microscope is enhanced by image processing and equipped with electromagnets. Domains and magnetization processes on all kinds of ferro- and ferrimagnetic materials can be studied at variable magnifications down to the resolution limit of optical microscopy which is as low as 300 nm, depending on the sample, with the current optical setup. The microscope is currently installed in room 1159 PRB.

Workshop on Magnetic Domains

As a part of ENSL's mission to assist the OSU materials community in expanding its knowledge about novel material characterization techniques, ENSL organized a three-day workshop on magnetic domains with the Center for Emergent Materials, an NSF MRSEC program at Ohio State. The workshop was presented by Dr. Rudolf Schäfer of the Leibniz Institute for Solid State and Materials Research (IFW), Dresden, September 19-21, 2011. Schäfer is a world renowned expert on magnetism and magnetic domains, and is a co-author, together with Dr. Alex Hubert, of Magnetic Domains: The Analysis of Magnetic Microstructures, a fundamental book on magnetic domain theory, observation techniques and interpretation. The workshop targeted the broad audience of scientists working in the field of magnetism, and was attended by approximately 50 OSU students, faculty and staff.

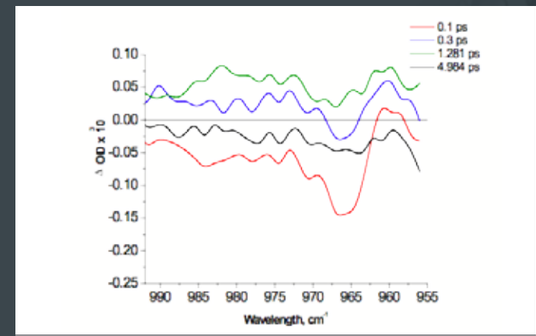
Center for Chemical and Biophysical Dynamics (CCBD)

The Center for Chemical and Biophysical Dynamics (CCBD) lab also saw upgrades to existing equipment this year, as well as the acquisition of new research instruments.

The femtosecond time-resolved infrared spectrometer was upgraded to extend its infrared probe spectral coverage from 3 – 9 μm to 3 – 14 μm with the low frequency limit of ca. 700 cm-1. This upgrade makes it possible for researchers to study low energy vibrations characteristic of such processes as photochemical generation of alkenes as well as photochemically induced isomerization. Transient spectra at time delays from 100 femtoseconds to 5 picoseconds for trans-beta-methylstyrene in CCl4 excited by a 100 fs laser pulse at 270 nm are shown as an example of the photoinduced isomerization (Figure 1). Based on this upgrade, a proposal has been prepared for submission to obtain NSF funding for studying reactive intermediates.

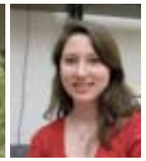
With funding provided by the IMR and Chemistry department, new CCBD equipment acquisitions included a PicoHarp 300 picosecond histogram accumulating real-time processor with USB interface, an Excelitas Technologies single counting module, and an Olympus IX 71 inverted microscope. The upgrade includes a newer version of the hardware and more reliable software running on a computer from a recent generation of Dell machines. The new semiconductor single photon counting module extends the spectral detection range from Visible to near IR (ca. 1100 nm) with sub-nanosecond time resolution. A confocal microscope attached to the instrument allows more efficient collection of fluorescence from small-scale biological or semiconductor films and devices. An alternative optical pump scheme using a focusing mirror instead of the lens/microscope objective allows one to use UV light below 350 nm to excite photoluminescence.

Another CCBD project underway is the upgrade of the femtosecond transient UV/Vis absorption spectrometer. Integrating a 512-pixel InGaAs array detector into the data acquisition system extends its spectral coverage into the near IR range (1100 – 1300 nm). Currently, the long-wavelength probe limit for the pump-probe UV/Vis transient absorption spectrometer is ca. 750 nm. However, several spectral signature bands, especially for transient metal compounds that are of interest as materials for solar photovoltaics, require longer probe wavelengths. The InGaAs array detector is being tested and the related software is being developed for data collection and analysis at those wavelengths. At the next stage glasses, crystals and photonic optical fibers will be tested to find the best near IR continuum generating material. After that, the new addition will be integrated into the existing femtosecond time-resolved spectrometer.



Transient absorption spectra of trans-beta-methyl styrene in CCl_4 excited at 280 nm at later delays, CCl_4 contribution subtracted.

Center for Emergent Materials (CEM) Expanding Collaborations



This Fall, the Center for Emergent Materials, a National Science Foundation (NSF)-supported Materials Research Science and Engineering Center (MRSEC) at OSU, welcomes a new Director, P. Chris Hammel, Professor and Ohio Eminent Scholar, Department of Physics. CEM also welcomes Stephanie Arend as CEM Administrative Associate. This has been an exciting Fall quarter for the Center, with a MRSEC symposium for the National Society for Black/Hispanic Physicists conference, the 2nd Novel Magnetic Materials Workshop held at OSU and a collaboration formed between CEM and the University of Tokyo through a supplemental NSF grant.

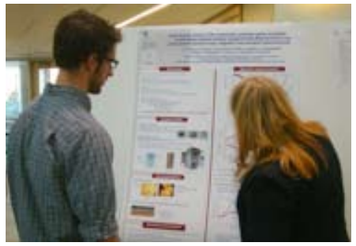
MRSEC Symposium at National Society for Black/ Hispanic Physicists Conference

In September, the CEM organized a MRSEC Symposium called "NSF MRSEC: Innovative Materials Science—Magnetic Materials" at the National Society for Black/Hispanic Physicists Conference in Austin, Texas. The symposium was a collaborative effort between OSU, Cornell and Penn State, represented by presenters Ezekiel Johnston-Halperin from OSU, Greg Fuchs from Cornell, and Andrew Balk from Pennsylvania State University. The purpose of this symposium was to introduce undergraduate and graduate students to interdisciplinary research, as well as to inform them about NSF-funded centers. An emphasis was placed on how the NSF research centers help solve interesting and challenging problems in materials physics and have great promise for advancing technology and our understanding of the physical world.

In addition to the symposium, CEM faculty member Ezekiel Johnston-Halperin, graduate student Santino Carnevale and staff members Michelle McCombs and Jakki Vaughn attended the conference to promote recruitment efforts for the OSU graduate programs and CEM's Research Experience for Undergraduates (REU) program.

2nd Novel Magnetic Materials Workshop

The CEM has established a vibrant collaborative interaction — dubbed the International Materials Research Alliance (IMRA) — with the Leibniz Institute for Solid State Research (IFW) in Dresden, Germany founded on the recognition of the opportunities inherent in bringing together the complementary intellectual strengths, scientific interests, technical expertise, and instrumentation and growth resources of the two international centers.



In November, CEM hosted five collaborators from IFW-Dresden at the 2nd Novel Magnetic Materials Workshop, a sequel to last year's Novel Magnetic Materials Workshop held in Dresden and attended by 24 CEM-affiliated researchers. Over fifty CEM-affiliated researchers participated in this year's workshop, which spanned three days and included nine talks from OSU and IFW-Dresden researchers. Four external speakers also gave talks: Bert Koopmans, Michael Flatté, Martha Greenblatt, and Chenggang Tao. A poster session with 27 contributions, a banquet, and an informal gathering were also part of the program. Four breakout groups, with interests in the areas of Oxides and Heuslers, Magnetic Nanowires, STM/Atom Manipulation and Solotronics, met at the end of the workshop to discuss future possibilities for collaboration. The Novel Magnetic Materials Workshop series is a vital part of CEM's International Materials Research Alliance program and is slated to continue in coming years.

University of Tokyo/CEM Collaboration

CEM faculty members Ezekiel Johnston-Halperin and Roberto Myers received a supplemental grant that develops a collaboration between the University of Tokyo and the Center for Emergent Materials in the area of spin and thermal transport in carbon nanotubes (CNT), including single-wall, multi-wall and CNT mats. Initial measurements will be done on CNT mat samples provided by Yuichiro Kato at the University of Tokyo, with final device fabrication at OSU by Johnston-Halperin and thermal/spin measurements by Myers.

Kato's research laboratory has been directly impacted by Japan's recent tsunami and the rolling brownouts imposed on the city of Tokyo, leading to the periodic shutdown of the university. These work stoppages are likely to extend into the future and significantly complicate research activity. While the synthesis of CNTs is well developed in Kato's lab, and can therefore be accomplished during brief "up" times, the careful and systematic evaluation of these samples is difficult to impossible without long periods of continuous running.

The partnership with Ohio State for device fabrication and measurement makes it possible for Professor Kato to engage in time-intensive research despite the periodic shutdown of his home university. Additionally, this collaboration allows Kato to immediately engage in the rapidly developing field of thermal spintronics.

While OSU has established world leadership in the measurement of thermally assisted spin transport, maintaining this status requires the ability to extend these measurements to new materials systems that are likely to yield significant new insights into the fundamental mechanisms underlying this phenomena. To date, OSU has been able to acquire samples of high-quality magnetic semiconductors (both Mn:GaAs and Gd:GaN), but has no access to high-quality CNTs. Professor Kato is an ideal collaborator in this regard in that he has expertise in both spintronics and the CVD growth of ultra-pure CNTs. As a result he is in a position to provide best-in-world quality samples that are optimized for spintronic measurements.

For more information about the Center for Emergent Materials and its research, visit cem.osu.edu.

IMR Member News

Paul Berger, Professor of Electrical and Computer Engineering, led the winning team of the 2011 Ohio State University Business Plan Competition. He serves as chief technology officer for Genanosys, a semiconductor technology company whose platform technology provides a breakthrough solution to the problem that is known as the "power wall" in the semiconductor industry. Genanosys team members include Andrew Stock, an undergraduate student in Computer Science and Engineering and Anisha Ramesh, an Electrical and Computer Engineering PhD student.

Bharat Bhushan, Ohio Eminent Scholar and Howard D. Winbigler Professor of Mechanical and Aerospace Engineering, was a kenote speaker at the 12th International Conference on Tribology in Serbia. While there, Dr. Bhushan was awarded an honorary doctorate from the University of Kragujevac in recognition of his outstanding contribution to the advancement of engineering sciences and bio/nano technologies as well as his contribution to the development of the faculty of mechanical engineering in Kragujevac.

Henk Colijn, Associate Director of the Campus Electron Optics Facility (CEOF), was awarded the Jacquet-Lucas Award for Best in Show by ASM International at the 2010 International Metallographic Contest for his entry Identification of Secondary Phases in a Ti-Mo Alloy.

Marcelo Dapino, Professor of Mechanical and Aerospace Engineering, received a $1.5 million Ohio Third Frontier Wright Project award to support the establishment of a new manufacturing facility on the Ohio State campus that will develop advanced manufacturing technologies for fabricating novel smart materials and structures. The research team led by Professor Dapino and co-investigator Suresh Babu, Associate Professor of Materials Science and Engineering, will use the project's technology to embed smart materials into metals, targeting a variety of commercial applications such as armor, tooling, sensors, microchannel reactors, aerospace, automotive, and reduced and/or controllable thermal expansion properties industries.

Stephen Myers, Assistant Director of the Ohio Agricultural Research and Development Center and Professor of Horticulture and Crop Science, has been named an American Council on Education Fellow. The ACE Fellows program was designed to strengthen institutional capacity and build leadership in American higher education.

IMR Industry Challenge Grants

Want to work with an industry collaborator and need additional funding to support that research?

The IMR offers a unique internal grant program to strengthen new collaborations between OSU researchers and private industry partners in materials-allied research.

These grants provide one-to-one matching funds up to $20,000 per year to allow OSU researchers to conduct research in collaboration with private industry partners that will lead to major external proposal development. Industry Challenge Grants are eligible for renewal for a second year of funding.

Proposals for Industry Challenge Grants are accepted on a rolling basis, year-round, with no deadline.
Contact Layla Manganaro, IMR Program manager, at manganaro.4@osu.edu, for more details.

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Institute for Materials Research
Peter L. Clara M. Scott Laboratory
201 W. 19th Ave, Suite E337
Columbus, Ohio 43210

IMR Director
Steven A. Ringel
Electrical and Computer Engineering

Program Manager
Layla M. Manganaro, MBA
e-mail: manganaro.4@osu.edu

Contributions are welcome.
Please address correspondence to the Program Manager.

Institute For Materials Research
E337 Scott Laboratory
201 West 19th Ave.
Columbus, Ohio 43210