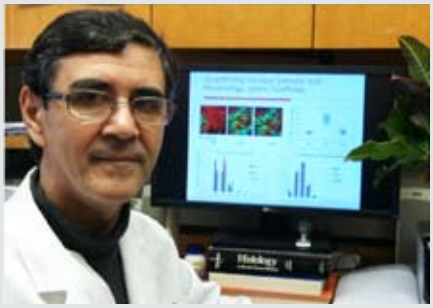
Volume 5 Issue 1 Fall 2012

Innovations in Materials Research

Newsletter of the OSU Institute for Materials Research

IMR Seeds Interdisciplinary Research in Regenerative Medicine

Faculty Spotlight: Nicanor Moldovan, Cardiovascular Medicine



Dr. Nicanor Moldovan was trained in Biophysics at the University of Bucharest, Romania, and in Cell Biology in the renowned Institute for Cellular Biology and Pathology in the same city, co-founded by the late Nobel laureate George E. Palade. He then worked as a postdoctoral researcher in the Department of Cardiovascular Medicine at Johns Hopkins University before he was recruited to be among the first employees of the newly-created Davis Heart and Lung Research Institute (DHLRI) at The Ohio State University in 1997. Dr. Moldovan has since held positions in the departments of Biomedical Engineering and Internal Medicine, where he is currently a Research Associate Professor in the division of Cardiovascular Medicine. He is also on the faculty of the Biophysics, Biomedical Engineering and Integrated Biomedical graduate programs at OSU. He is currently an editor of the *Journal of Cellular and Molecular Medicine*, and is in charge of its Regenerative Medicine reviews section.

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Meet the Superusers!

Over the last two years, a new breed of researchers has joined materials research facilities on OSU's campus. Dubbed "superusers," these advanced graduate students not only conduct their own materials-related research, but train other users to independently and safely work with instrumentation in the lab.

Superusers have the initial responsibility for training new users on specific tools and often assist with general maintenance and/or troubleshooting when needed. This frees up regular staff time for more extensive tool maintenance, contracted research work, enforcement of safety, and other engineering tasks. Superusers are chosen for their expertise and experience in running these tools, and their skill in overall laboratory operations. As a result, being designated a "superuser" is a credit to them and leads to extensive technical experience that may be desirable to future employers. Their research groups also typically receive a small credit towards their monthly users' fees at the lab in exchange for their work, an additional incentive to join the superuser ranks.

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IMR Institute For Materials Research

THE OHIO STATE UNIVERSITY

Director's Note

Dear Colleagues,

You have no doubt noticed that the title of our newsletter has changed, and while our initial and much-loved title of "IMR Quarterly" will be missed, *Innovations in Materials Research* is a much better description of the newsletter's rich content. This move, which was motivated by the change in Ohio State's academic year from a quarter to semester system, appropriately reflects the process of materials innovation as a core guiding principle for IMR and the entire community of Ohio State materials researchers. And, with the move to semesters, change is in the air; I am proud to say that great strides continue to be made in all aspects of materials research and the support for the extraordinary growth in research. For instance, important changes at Nanotech West Laboratory include the addition of two new staff members, Aaron Payne and Stacy Coil, both of whom are already making a big difference in their support of our rapidly growing MOCVD area and of the substantial IT needs of a growing lab. Thanks to suggestions from the monthly meetings of Nanotech West Users Committee, we have created and are now expanding a "superusers" program in the Nanotech West cleanroom, following the success of superusers that similarly support another IMR-supported core facility, the NanoSystems Lab. Superusers are graduate students selected on the basis of their advanced lab skills and demonstrable sense of responsibility to assist permanent staff in user training and technical lab support. These outstanding graduate students are making a big difference for our core facilities to support a very broad range of research.

Inside this issue we have several "not-to-be-missed" items. Our very own Prof. Joseph Heremans and Prof. Roberto Myers, with PhD student Chris Jaworski, landed the cover story in the July 2012 issue of *Nature* based on their groundbreaking research on the giant spin-Seebeck effect that may lead to a revolution in thermal energy converters. At the opposite end of the materials spectrum, this issue's Faculty Spotlight shines on the extraordinary research of Dr. Nicanor Moldovan, who is performing studies in regenerative medicine through an IMR-seeded collaboration on tissue scaffolds with Prof John Lannutti of the Department of Materials Science and Engineering. In October, IMR and the OSU Technology Commercialization Office, in conjunction with the Department of Materials Science and Engineering hosted a special forum at which the first Materials Technology and Innovation Board members were announced with a goal to create pathways for eliminating barriers between research, innovation and commercialization. Inside this newsletter you can also read about more than $500,000 of seed grants that were awarded to a number of IMR research groups and individuals in June, updates on core facilities, an exciting piece of news from our NSF-funded Nanoscale Science and Engineering Center – Center for Affordable Nanoengineering of Polymeric Biomedical Devices – CANPBD – from which Prof. Jessica Winter, working with an undergraduate researcher, is moving some of her research from lab to market, and a number of other exciting news items and events too lengthy to list in this space!

Last but definitely not least, please mark your calendars for the 2013 OSU Materials Week conference and associated events, to be held May 7-10, 2013. I hope to see as many of you as possible at this important event. More information is inside this issue.

Warm Regards,

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

IMR Launches New Website

The **OSU Institute for Materials Research** is excited to announce that our website has had a makeover. The website has a cleaner, more contemporary layout and the content has been streamlined to make the site more user-friendly.

Please visit and bookmark our website soon: http://imr.osu.edu/

Some highlights you will find on our updated website:

- A **calendar** feature listing all upcoming materials-related events on our homepage
- One-page overviews of over a dozen **materials research facilities** on OSU campus: http://imr.osu.edu/research/facilities/
- Peruse all of our past **IMR reports**, including annual reports for Fiscal Years 2011 and 2010: http://imr.osu.edu/about/annual-reports/

If you have information you'd like to share on our website, such as a lab you would like to include in our facilities listings or an upcoming seminar you'd like to include in our calendar, please contact IMR Program Manager Layla Manganaro at manganaro.4@osu.edu.

IMR Members Featured on Cover of *Nature*

The Giant Spin-Seebeck Effect

This article by Nancy Speicher was originally featured in the university publication "*News from The Department of Mechanical & Aerospace Engineering,*" and is republished here with permission.

As 97 percent of the world's energy comes from thermal processes, new designs and materials that can convert waste heat into electrical power can help mitigate global climate change. Because large power plants are already very efficient, mobile applications for waste heat recovery constitute the "low-hanging fruit": indeed, smaller heat engines are generally less efficient than large ones, and the heat they reject comes at a higher temperature. Solid-state energy conversion technologies, such as thermoelectric systems, are particularly suited to mobile waste heat recovery because they have no moving parts, have an essentially infinite lifetime, and require no maintenance. Their most important advantage is their very high specific power, so that they can be built lightweight and compact. Unfortunately, the thermal efficiency of thermoelectric heat cycles is limited by the condition that the same material must have simultaneously a high electrical conductivity, a low thermal conductivity, and a high thermoelectric power (also known as Seebeck coefficient). At The Ohio State University, Professors Joseph Heremans, Ohio Eminent Scholar in Mechanical and Aerospace Engineering and Roberto Myers, Assistant Professor of Materials Science and Engineering, have pioneered a new approach: the spin-Seebeck effect is similar to the conventional thermoelectric power, but it involves two different materials that can be optimized separately.

The spin-Seebeck effect is due to perturbations of magnetic ordering in a ferromagnet subjected to an applied temperature gradient. As these perturbations return to thermal equilibrium, they emit spin waves that are transmitted into an adjacent non-magnetic material (typically platinum, but tungsten could also be used). Here, the spin waves are converted into a voltage by another phenomenon known as the spin-Hall effect. First discovered using thin permalloy films in 2008 by the research group of E. Saitoh at Tohoku University in Sendai, Japan, the effect has since been observed on ferromagnetic insulators, and, at Ohio State, on magnetic semiconductors. The effect is small (on the order of ≤1 μV K^{-1}) in ferromagnets. This year, a giant spin-Seebeck effect has been observed at cryogenic temperatures in a bulk non-magnetic semiconductor, InSb, where it reaches values (~ 8 mV K^{-1}) comparable to the highest classical thermopower.

The conduction electrons in InSb, when subject to a quantizing magnetic field at low temperature, are split by the Zeeman effect into spin-polarized spin-up and spin-down levels. Applying a temperature gradient to those creates a strong out-of-equilibrium

The thesis work of recent Ohio State graduate Christopher Jaworski (PhD ME), who was advised by Professor Heremans, was published in the prestigious journal Nature, and featured on the cover of the July 12, 2012 issue: Jaworski, R. C. Myers, E. Johnston-Halperin & J. P. Heremans, Giant Spin-Seebeck effect in a nonmagnetic material, Nature, volume 487, pp 210-213 (2012)

distribution of electrons between these two levels by a combination of phonon-drag and strong spin-orbit interactions in InSb itself. Although such effect has so far only been observed at cryogenic temperatures, we suggest that the spin-Seebeck effect opens the way to a new class of spin-thermal energy converters, which, with much future research, may prove superior to classical thermoelectric heat cycles. In particular, the 8 mV K^{-1} mentioned above arises across a platinum bar which has high electrical conductivity. The device can therefore generate a much higher specific power than a conventional thermoelectric device, where the voltage is generated in a much less conductive semiconductor.

IMR Seeds Interdisciplinary Research in Regenerative Medicine

Faculty Spotlight: Nicanor Moldovan, Cardiovascular Medicine

(continued from page 1)

In 2002, Dr. Moldovan published a monograph on "Novel Angiogenic Mechanisms," discussing the circulating stem/progenitor cells (SPC) that have a role in neovascularization, and organized an international symposium on this topic. This has remained the research focus in Moldovan's lab, and he relies on a robust network of interdisciplinary collaborations, to advance the basic understanding and translational applications of adult SPC for tissue engineering and personalized medicine.

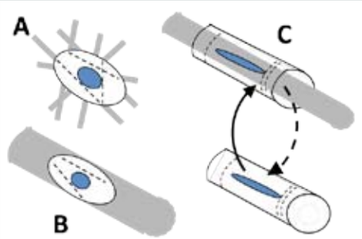

Figure 1. Mode of cell-fiber interaction depends on their relative size. A, B. Cells larger or smaller than the fiber retain their native configuration. **C.** Cells of the endothelial lineage wrap around the fibers, when these are within ~7-15 μm diameter range.

In one research project, the Moldovan lab is investigating in depth the responses of cells to polymeric fibrillar scaffolds as carriers for tissue engineering. These scaffolds are prepared through electrospinning by collaborators in OSU's department of Materials Science and Engineering (MSE), a successful interdisciplinary collaboration between Dr. Moldovan and MSE Associate Professor John Lannutti. In 2008, the researchers jointly received an Interdisciplinary Materials Research grant (IMRG) from the OSU Institute for Materials Research. The goal of the proposal was to optimize the hybrid (cell-biomaterial) scaffolds for SPC survival in vitro and in vivo, in view of their co-implantation for the desired tissue engineering applications. This two-year research project used an original approach to mitigate the consequences of fibrous encapsulation following the ubiquitous foreign body reaction that affects the biosensors and drug delivery devices, namely to 'treat' these implants, even before impanation, with SPC for stimulation of nearby neovascularization. Using the results of this seed project as new preliminary data, the research team expanded to include Drs. Periannan Kuppusamy, Professor of Cardiovascular Medicine and Keith Gooch, Associate Professor of Biomedical Engineering and was awarded a $1.5 million, four-year R01 grant from the National Institutes of Health. The main goal of this NIH study is to develop more robust implantable oxygen sensors that incorporate at the interface the hybrid biomaterials made of SPC- seeded electrospun scaffolds.

One of the major findings so far is the unusual manner in which the cells of the endothelial lineage interact with micro-fibers comparable to their own size (Figure 1). Unlike any other cell types, which attach randomly to the fibers, the endothelial cells wrap around the fibers using a thus far un-described process of polymerization of the cytoskeletal protein actin. This leads to the formation of ring-like, intracellular structures surrounding the fibers, coined "actin grips" (Figure 2). After thorough molecular characterization, the team concluded that these structures represent a novel intracellular formation with key roles in both cell-fiber and cell-cell interactions. Moreover, quantification of the amounts of grips within cells, as well as their biomaterial and physiological determinants (such as differentiation status, Figure 3) requires quantitative image analysis. Therefore, the team further expanded the multidisciplinarity of this research by collaborating with Drs. Raghu Machiraju, Professor of Computer Science and Engineering, and Thierry Pecot, a Postdoctoral Researcher with OSU's Comprehensive Cancer Center.

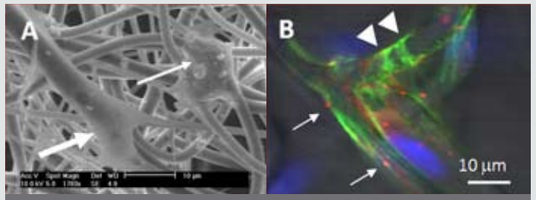

Figure 2. Mechanism of cell-fiber interaction. A. Scanning electron micrograph of endothelial progenitor cells seeded on a poly-ε-caprolactone scaffold obtained by electrospinning. Note the dual manner of cell attachment, dependent on the relative size of the fibers (arrows) (Image courtesy of Dr. John Lannutti). **B.** 'Grips' containing F-actin (green, FITC-phalloidin staining) are present inside of the fiber-wrapping cells (arrowheads). They do not contain focal adhesion protein paxilin (red, immunostaining), unlike the longitudinal cytoskletal 'stress fibers' (arrows). Nuclei are stained in blue with DAPI.

A related sub-project of the NIH grant is the improvement of colonization of electrospun scaffolds with SPC, by using a magnetic beads-based technology. This component of the study also benefited from funding received from NIH in 2009, through an ARRA/RC2 'Grand Opportunities' award obtained in collaboration with Dr. Stuart Cooper, the Chair of Lowrie Chemical and Biomolecular Engineering Department at OSU, and several other investigators. In continuation of this stimulus grant, a detailed mathematical model of magnetic force-driven seeding of scaffolds is being created, with the contribution of an international team led by Dr. Helen Byrne from Center for Collaborative Mathematics at Oxford University, UK.

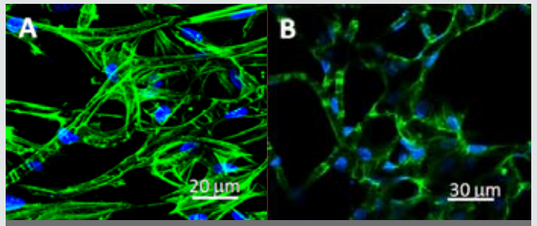

Figure 3. Amount of filamentous (F) actin depends on cell differentiation status and time in culture. A. In fiber-attached endothelial progenitor cells F-actin (green, FITC-phalloidin) is mostly in longitudinal (vs. the fiber) 'stress fiber' organization. **B.** In fiber attached adult endothelial cells most of F-actin is in 'grips' (10 days of *in vitro* cultivation). Nuclei are stained in blue with DAPI.

Another active project in Dr. Moldovan's lab is the study of biomechanical factors controlling the traffic of cells in the bloodstream, and limiting the efficiency of SPC-based cell therapy. The team is studying cellular resilience to biomechanical stress based on new computational models of cytoplasm as a biomaterial, taking into consideration the structural role of water. Furthermore, the lab is pursuing a comprehensive detection of SPC system in human blood (collectively defined as the 'repairome') using novel methods inspired from systems biology and cytomics, and that research was also seeded by the stimulus grant.

For more information about the research in Nicanor Moldovan's lab, you can reach him by email at Nicanor.Moldovan@osumc.edu or visit his group's website at http://medicine.osu.edu/regenerativemedicine/therapies/nicanormoldovan/pages/index.aspx

2013 OSU Materials Week

May 7 – 10, 2013

Ohio Union, OSU's Columbus Campus

Materials Week is moving! Due to The Ohio State University's academic calendar changing from quarters to semesters in 2012, the next OSU Materials Week will take place May 7-10, 2013.

OSU Materials Week is an annual conference that showcases materials-allied research at The Ohio State University and beyond. Hundreds of researchers from OSU, other universities, industry, and government labs come together for technical talks, poster sessions, and evening receptions covering the full spectrum of materials-allied research.

A variety of topics covering the breadth of materials-allied research will be covered again this year, including the following confirmed technical sessions:

- Nano-Engineering of Hybrid Materials
- Integrated Computational Materials Engineering (ICME)
- Materials Design and Catalysis
- Nano-Engineering and Nano-Fluidics for Sequencing Technology
- New Physics and Device Applications in 2D Materials
- Spin-Lattice Interactions

Updates on 2013 OSU Materials Week sessions, confirmed speakers and registration information will be posted on IMR's website: imr.osu.edu.

Spring/Summer 2012 IMR Facility Grants

Six new research projects were awarded by the IMR in June 2012, for a total investment of $12,000 in nascent materials research. The six projects support faculty researchers from five different departments within the College of Engineering and the Division of Natural and Mathematical Sciences.

Each Facility Grant provides $2,000 to offset the cost of user access fees and related minor charges such as materials and supplies. The purpose of IMR Facility Grants is to make shared campus research facilities more accessible to researchers wishing to demonstrate materials-related research results with the goal of strengthening near-term research proposals for external support.

The next proposal deadline for the IMR Facility Grant program is **Monday, May 13, 2013 at 5:00 PM**. Visit IMR's website for the Request for Proposals and full instructions.

Study of Fast Neutron Irradiation Effects on GaN using Depth-resolved Cathodoluminescence Spectroscopy
Lei (Raymond) Cao, Mechanical and Aerospace Engineering

In-situ detection of CO_2 reduction intermediates
Anne Co, Chemistry

Single- and Few-layer transport measurements of Group 14 Graphane Analogues
Joshua Goldberger, Chemistry

Single Cell Culture Wells (SiCCWells) for combinatorial approaches to cell biology
Derek Hansford Biomedical Engineering

Development and characterization of a novel direct patterning technique for graphene using Dip-Pen Nanolithography
Ezekiel Johnston-Halperin, Physics

Using Nanostructured Aerogel Films for Improved Performance of Metal Oxide Gas Sensors
Patricia Morris, Materials Science & Engineering

The Toaster Project
– IMR and MSE Host Toaster Talk

On September 7th, IMR co-hosted a special seminar with the Department of Materials Science and Engineering with designer and author Thomas Thwaites. The presentation, based on Thwaites' recent book The Toaster Project, chronicled his attempt to make an electric toaster from scratch. To construct this toaster, Thwaites sought iron, copper, mica, nickel and crude oil (for the plastic case) from disused mines and other sources around Britain, attempted to process these materials at home, and finally formed them into a version of a product that can be bought for only a few dollars. The finished toaster cost £1187.54, and took nine months to make.

IMR Director Steve Ringel, guest speaker Thomas Thwaites, MSE Chair Rudy Buchheit, and MSE Professor Peter Anderson

During his talk, Thwaites acknowledged the absurdity of this nine-month process to make a simple toaster, and related it to the massive industrial activity we pursue to achieve additional small comforts at ever lower prices. His project, book, and presentation serve to highlight the amazing efficiencies of modern capitalism, but also to question our current trajectory. This popular seminar had approximately 200 OSU faculty, fellows, and students in attendance, representing a wide range of colleges and departments from the Design, Environmental Studies, Materials, and Engineering fields.

Having trouble getting to the lab?
IMR Free Shuttle Service Operating Ten Times Daily

You asked, we listened!

The IMR conducted a survey this summer to gauge the campus' satisfaction with our shuttle service between main campus and west campus materials facilities. Based on feedback received from materials students and professors, we've made the following improvements to the IMR shuttle service:

- Earlier start time- first shuttle leaves Dreese Labs at 8:30 AM
- Later end time – last shuttle leaves Dreese Labs at 5:30 PM
- Four additional shuttles each weekday – ten shuttle runs daily
- More convenient times – easier to remember shuttle schedule with shuttles departing Dreese Labs every hour on the half hour

As a result of the feedback we received, this August we added four shuttle routes to our weekday shuttle service and changed the schedule to every hour on the half hour. This free passenger shuttle service now runs 10 times a day, Monday through Friday, to help OSU faculty, staff and students reach the many state-of-the-art research facilities on OSU's west campus.

The IMR shuttle departs Dreese Labs every hour on the half hour, Monday through Friday:

8:30 AM 9:30 AM 10:30 AM 11:30 AM 12:30 PM 1:30 PM 2:30 PM 3:30 PM 4:30 PM 5:30 PM

The IMR shuttle route remains the same, with stops at Dreese Labs, Nanotech West Lab, Center for Automotive Research, and ending outside Dreese Labs.

Dreese Labs
2015 Neil Avenue (between West 19th and West 18th Ave.

IMR Shuttle Route

Center for Automotive Research (CAR)
930 Kinnear Road

Nanotech West Lab
1381 Kinnear Road

IMR Member News

Gerald Frankel, Professor of Materials Science and Engineering, has been appointed by President Obama to join the U.S. Nuclear Waste Technical Review Board, which advises the Department of Energy, the President, and Congress regarding the selection of a permanent repository for high-level radioactive waste. Frankel is one of eight new appointees and will serve as the board's expert on materials and corrosion.

Dr. W.S. Winston Ho, University Scholar Professor of Chemical and Biomolecular Engineering, was selected as recipient of AIChE'S 2012 Lawrence B. Evans Award for his industrial chemical engineering practice with pioneering and sustained outstanding contributions to novel separations, gas treating invention and commercialization, new membranes and their novel applications.

Heather Powell, Assistant Professor of Biomedical Engineering and Materials Science and Engineering, has been awarded a five-year grant of $1.3 million, for the project entitled "Compression garments: understanding mechanical regulation of scar development" by the Shriners Hospitals for Children Research Foundation. Powell's work, conducted in collaboration with co-investigators at the University of Cincinnati, "will test the central hypothesis that compressive forces control scar development in a magnitude and time dependent manner, and uncovering the molecular pathways through which these forces are translated will guide development of novel strategies to improve scar prevention and promote patient compliance."

Junmin Wang, Assistant Professor of Mechanical and Aerospace Engineering, was recently appointed as an Associate Editor for the SAE International Journal of Engines, a scholarly research journal dedicated to internal combustion engine science and engineering. This is Wang's second journal associate editor appointment; he has served as an associate editor for IEEE Transactions on Vehicular Technology since 2010.

OSU's annual **Innovator of the Year** and **Early Career Innovator of the Year** awards recognize Ohio State researchers who are working actively to promote commercialization of university intellectual property, through invention disclosures filed, patents applied for and/or received, technologies licensed, or spin-off companies formed. These activities support economic development in the Central Ohio region, and serve to attract companies that create a base of operations within the state. The creation of separate categories for more established researchers and for early career researchers allows cultivation of an entrepreneurial spirit among all of our investigators.

The **2012 Innovator of the Year** is **Dr. Liang-Shih (L.S.) Fan**, Distinguished University Professor and C. John Easton Professor of Engineering, Department of Chemical and Biomolecular Engineering. Dr. Fan's creativity, inventiveness, and original contributions to energy conversion, environmental engineering, and particle technology have made and will continue to make significant impacts on energy utilization and global climate change within the U.S. and throughout the world.

The **2012 Early Career Innovator of the Year** is **Dr. Jessica Winter**, Associate Professor, Department of Chemical and Biomolecular Engineering and the Department of Biomedical Engineering. Her research focuses on the applications of nanotechnology in medicine, an area of research that has led to substantial innovations with potential for commercialization. She is working to develop and commercialize next generation illumination and detection nanoparticles to supplant inferior products currently on the market.

The **Student Innovator of the Year** award recognizes innovation and entrepreneurship among our students that has contributed to the development or commercialization of a new technology. The 2012 Student Innovator of the Year is **Qussai Marashdeh**, a senior research associate in the Department of Chemical and Biomolecular Engineering. Qussai received an MS and PhD in Electrical Engineering from Ohio State. In 2012, he received his Master of Business Administration (MBA). Qussai has revolutionized the field of capacitance tomography – an innovative imaging technique that has the potential to revolutionize the energy, aerospace, chemical, and healthcare industries.

Congratulations to the 18 Ohio State faculty who were recently selected to join the exclusive ranks of Fellows of the American Association for the Advancement of Science (AAAS). New AAAS Fellows will be welcomed in a ceremony at the AAAS annual meeting in Boston in February 2013 and recognized for "their scientifically or socially distinguished efforts to advance science or its applications." Among the new AAAS Fellows are 4 IMR Members, as detailed below:

Heather Allen, Professor of Chemistry and of Pathology; for outstanding contributions to the development of vibrational spectroscopic probes of interfaces, and their creative application to problems in environmental chemistry, geochemistry and physiology.

Prabir Dutta, Distinguished University Professor of Chemistry; for notable contributions in understanding zeolite formation and applications of zeolites in photocatalysis and sensing.

Susan Olesik, Professor and Chair of Chemistry and Biochemistry; for distinguished contributions to the field of analytical chemistry as well as excellence in communicating science to the public.

David Williams, Dean of the College of Engineering; for distinguished contributions to metal and material sciences, particularly on electron microscopy, and to higher education, providing academic leadership at three major research universities.

Electronic Materials Featured in IMR Events

IMR Colloquium speaker Asif Khan with IMR Director Steve Ringel

The IMR Colloquia Series kicked off the academic year October 4 with a colloquium with Dr. Asif Khan, Director of Photonics and Microelectronics Laboratory and Carolina Distinguished Professor of Engineering at the University of South Carolina's Department of Electrical Engineering. During his talk, titled "Emerging Trends in AlInGaN Material and Devices Research," Dr. Khan reviewed recent progress and emerging trends in AlInGaN optical and electronic devices. Khan discussed pioneering research at the University of South Carolina which led to the first demonstration and the improvement of power-lifetime performance in deep UV light emitting diodes for air-water purification and bio-medical instrumentation. He also covered recent work in insulating gate-enhancement mode AlINGaN HEMTs on silicon and other substrates and innovative material growth strategies that led to low-defect epi-structures, which are key to yielding improved performance in AlInGaN optical/electronic devices.

On September 14, the IMR and the Solid State Electronics and Photonics (SSEP) seminar series co-hosted a special joint seminar by Dr. Nate Quitoriano, Assistant Professor in the Department of Mining and Materials Engineering at McGill University. Quitoriano spoke about "Lateral high-quality growth of Si and Ge on amorphous and lattice-mismatched substrates using metal-catalyzed growth" Dr. Quitoriano discussed the growth of high-quality Si and Ge on amorphous and lattice-mismatched materials using metal-catalyzed growth at the nano-scale. A high-quality, high-throughput, direct-growth approach to the integration of semiconductors on lattice-mismatched and amorphous substrates would revolutionize large-area and cost-sensitive technologies such as solar cells. He reviewed results at the nanoscale and described a method to scale up this technology towards the wafer-scale and beyond, which could lead to various applications including sensors and photovoltaics.

Meet the Superusers! (continued from page 1)

The Nanotech West superuser program was modeled after similar programs in other US micro- and nanofabrication facilities, in particular, the UC Berkeley Microlab, where the concept has been in use for at least two decades. The NTW superuser program began in late 2010 with coverage of seven major tools/areas (general contact photolithography, consisting of coat, expose, and develop, is covered as a single area). Nanotech West plans to expand the number of tools that are covered by superusers in early 2013, and a current list of capabilities at Nanotech West, including the names of superusers, can be found on their website under "Equipment Status."

One of the superusers at Nanotech West is Christine Jackson, a graduate student in Electrical and Computer Engineering. Jackson has served as a superuser for the Inductively Coupled Plasma Reactive-Ion Etcher (ICP-RIE) since early 2012, helping researchers using plasma to etch gallium nitride, silicon, and other materials. "I get to meet most of the new users in the lab and it's fun to meet new people and hear about their projects," she explains. In exchange for conducting the initial training of new ICP-RIE users, Jackson gains additional hands-on experience with the equipment and some technical training experience. During the busiest times, she may train one new user per week in addition to performing her own research and studies. Jackson notes that new users may be intimidated by the state-of-the-art equipment available in Nanotech West, and she enjoys being a resource to them during a confusing and stressful time, helping them quickly become more comfortable in the lab.

Superuser Christine Jackson demonstrates the ICP-RIE system for another user

This sentiment was shared by Michael Wood, a superuser on Nanotech's Zeiss scanning electron microscope since early 2012 and a doctoral student in ECE where he studies integrated optics. Wood conducts an initial training session to new users which typically lasts up to two hours. Once that training is completed, Aimee Price, Senior Research Associate at Nanotech, ensures that the researcher uses the instrument properly and is able to get good quality SEM images before they are free to use the instrument independently. Wood notes that serving as a superuser affords him several benefits, including the ability to work closely with Nanotech technical staff, some credit for time his research group uses in the lab, and of course, a great deal of additional practice time on the tool. "By working with the SEM more frequently, I've been able to improve the quality of images I take for my own research," explains Wood, adding that he has become more familiar with the tool as a superuser.

Superuser Michael Wood loads a sample into the SEM

Kurtis Wickey is one of two superusers at the Nanosystems Laboratory (NSL) in the Physics Research Building. A doctoral candidate in Physics, Wickey recently became a superuser on the lab's focused ion beam/scanning electron microscope, a dual beam instrument he has been using regularly for four years. After noting his skill with the FIB/SEM tool, NSL Lab Director Dr. Denis Pelekhov invited Wickey to become a superuser and formally assist with training users and performing some routine maintenance in the lab. Wickey said serving in this capacity is "an opportunity to help others with something I enjoy" and he feels it is rewarding to help other researchers save time and money by more efficiently using NSL's instrumentation.

The superuser program is yet another way to provide excellent customer service and user support in these materials facilities. For more information, contact Nanotech West Director Dr. Bob Davis (davis.2316@osu.edu) or Nanosystems Laboratory Director Dr. Denis Pelekhov (pelekhov.1@osu.edu).

Maximizing Materials Commercialization at Ohio State

A push to become a top five technology commercialization institute led to the appointment of Dr. Brian Cummings as Vice President for Technology Commercialization in March 2011 and his creation of OSU's Technology Commercialization and Knowledge Transfer Office (TCO), as detailed in the IMR Quarterly Winter 2012 newsletter. To better connect the TCO with the materials community and its unique needs and challenges in commercialization and other intellectual property activities, leaders from TCO and the IMR have met several times to identify ways to increase successful entrepreneurial activities in materials-allied research.

Materials Technology and Innovation Board Established

One outcome of these discussions is the creation of a Materials Technology and Innovation Board, a joint venture between the Technology Commercialization Office and the Institute for Materials Research to create a unique and efficient linkage between the two offices. Select leaders in materials research innovation at Ohio State were invited to join the board, with the goal of lowering the barriers for technology commercialization and value capture while increasing the magnitude of industry sponsored research contracts to materials-affiliated faculty members and researchers. This will be done by identifying and prioritizing OSU's most valuable inventions of innovative activities, assisting in the linkage and communication between innovators, industry and the Technology Commercialization Office, and developing strategies to define, locate and promote value from materials-related research activities across campus. Likewise, the Board will bring forth targeted industry interest from TCO to our faculty members and leading innovators. Board members are currently identifying industry representatives to join the board from a list of industry participants who best reflect a strong collaborative connection to Ohio State.

Technology Commercialization Forum Connects Researchers with TCO Leaders

On October 18, a Technology Commercialization Forum geared specifically to faculty working in materials-allied research was co-hosted by OSU's Institute for Materials Research, Department of Materials Science and Engineering, and the Technology Commercialization Office. This Technology Commercialization Forum was a materials-focused conversation with faculty and TCO representatives to discuss reducing and removing barriers to intellectual property, cultivating partnerships and inventions, and establishing commercialization pathways. MSE Department Chair Rudy Buchheit moved the department's faculty meeting to take place in the TCO offices immediately before this forum to ensure MSE faculty could participate. Participants heard directly from TCO leaders what the vision was for materials commercialization at Ohio State and how faculty could interact with TCO and best utilize its new resources to drive higher levels of commercialization success.

The very informative overview of TCO and technology commercialization at Ohio State that was shared with the group can be viewed online at IMR's website, imr.osu.edu. As the Materials Technology and Innovation Board continues to meet, grow, and identify strategies for materials commercialization at OSU, we anticipate more events like this in the future to assist and educate the materials community. OSU faculty interested in engaging with TCO regarding their innovations can visit tco.osu.edu or call the TCO office at 614-292-1315

Materials Technology and Innovation Board Members:

- The TCO-IMR Board is co-chaired by Dr. Steven Ringel, IMR Director, and Dr. Brian Cummings, Vice President for Technology Commercialization
- Ray Atilano, Director, Technology Commercialization and Knowledge Transfer
- Rudy Buchheit, Professor and Chair, Materials Science and Engineering
- Katrina Cornish, Ohio Research Scholar, Department of Horticulture & Crop Science and Department of Food, Agriculture and Biological Engineering
- Prabir Dutta, Distinguished University Professor, Chemistry
- Arthur Epstein, Distinguished University Professor,Physics
- Joseph Heremans, Ohio Eminent Scholar, Mechanical and Aerospace Engineering
- Bobbi Noe, Associate Director, Industry Liaison Office
- Siddharth Rajan, Assistant Professor, Electrical and Computer Engineering and Materials Science and Engineering

Materials Facilities Updates

In each issue of our newsletter, IMR provides updates on our three core materials research facilities, the ENCOMM NanoSystems Laboratory (ENSL), Center for Chemical and Biophysica`l Dynamics (CCBD), and Nanotech West Laboratory. More information on these facilities and over a dozen other open user materials research facilities on OSU's Columbus campus, visit our website at: imr.osu.edu/research/facilities.

Nanotech West Laboratory – nanotech.osu.edu

New Plasma-Enhanced Chemical Vapor Deposition (PECVD) Tool

This past summer the Nanotech West Lab completed the installation of, and initial process development for, a refurbished Plasma Therm 790 plasma-enhanced chemical vapor deposition (PECVD) tool. The 13.56 MHz frequency tool has a 200 mm circular platen that can accommodate a wide range of sizes of parts. Initial recipes for the tool include deposition of silicon nitride (from ammonia and 2% silane in He, with N_2 used as a ballast gas) and silicon oxide (from nitrous oxide and also 2% silane in He, also with N_2), both at 250° C. These processes were developed using refractive index, obtained with spectroscopic ellipsometry, as the primary measurement of thin film stoichiometry (targets n ~1.46 for oxide, ~2.05 for nitride). Process development also included pinhole tests (hot KOH etching of PECVD-coated silicon, with subsequent optical inspections), the results of which were excellent. Plans for Fall 2012 include development of a silicon oxynitride process. Numerous projects are already using the tool for antireflective coatings, surface passivations, and simple dielectric isolation levels. The tool also has CF_4 and O_2 gases plumbed to it for in situ chamber and sample cleaning.

Nanotech West staff members Derek Ditmer and Pete Janney with the new Plasma Therm PECVD.

To speed up the initial process development for the PECVD tool, Nanotech West staff was assisted by colleagues at the University of California at Santa Barbara's Nanotech facility. Bob Davis, Nanotech West Lab Director and IMR Associate Director, knows UCSB Nanotech Lab Manager Jack Whaley from the early days of the NSF-sponsored National Nanofabrication Users Network, when Davis was on the graduate faculty at Penn State. The UCSB nanofabrication facility has a nearly identical tool and their staff generously shared their oxide and nitride recipes to NTW.

The PECVD tool was purchased with capital funds from the Wright Center for Photovoltaics Innovation and Commercialization (PVIC), funded by the Ohio Third Frontier Program. The tool is installed in Bay 3 of the cleanroom facility and is open for immediate user training and use. The PECVD tool code in the online scheduling system is CVD02, and interested users can contact Pete Janney, Laboratory Services Coordinator, at janney.9@osu.edu or (614) 688-4213.

New Nanotech Staff

Two new employees have joined Nanotech West Lab this summer, to provide more support for our staff and users. Aaron Payne joined Nanotech West in August as a Laboratory Process Technician. Aaron has years of experience in analytical chemistry including knowledge of a significant alphabet soup of methods (FTIR, GC, ICP-AES, TAN/TBN). At Nanotech West, he has responsibilities in the MOCVD area, including materials growth, reactor maintenance, and epitaxial materials analysis. Aaron holds a B.A. in Biology from Hanover College. Stacy Coil is a part-time IT Systems Specialist, providing desktop and network support to Nanotech West. Stacy earned a B.S. in Computer Science from Ohio State and has numerous years of experience in IT, including his own consulting business and also several years as Director of Information Technology for the Ohio State Alumni Association.

NanoSystems Laboratory (ENSL) – ensl.osu.edu

NSL Staff update

NanoSystems Laboratory (NSL) would like to introduce a new NSL Program Assistant Ms. Laura Heyeck who joined NSL staff in October 2012. We are extremely glad to have her as a part of our team. Ms. Heyeck was hired to take over the administrative and customer service functions for NSL from our previous NSL Program Assistant Ms. Rachel Page, who recently joined the OSU Center for Emergent Materials. Ms. Heyeck is a native of

Laura Heyeck, NSL Program Assistant

Westerville, Ohio and is a graduate of The Ohio State University., where she received a Bachelor of Science degree in International Business Administration and a Bachelor of Arts degree in Japanese. Laura spent a year studying abroad at the University of Tsukuba in Japan, and previously worked for the Ohio Department of Development's Global Markets Division. Her office is located at the NSL kiosk on the second floor south overpass of the Physics Research Building, and she can be reached at heyeck.2@osu.edu or via phone at (614)688-1158. The position of NSL Program Assistant is jointly supported by the OSU Institute for Materials Research (IMR) and the OSU center for Electronic and Magnetic Nanoscale Composite Multifunctional Materials (ENCOMM).

ENCOMM sponsored expansion of NSL equipment base

In a continuing effort to expand the capabilities available to material science researchers at OSU, the OSU center ENCOMM has identified two pieces of equipment with functionality that is not currently offered to the OSU materials research community. These instruments include µPG 501 tabletop direct write lithography system by Heidelberg Instruments Mikrotechnik GmbH (Heidelberg, Germany) and an ECOMET 250 Grinder-Polisher by Buehler (Lake Bluff, IL). The µPG 501 tabletop direct write lithography system will enable optical photo lithography with the feature size as small as 1 µm without a need for fabrication of an expensive photo mask. Such a capability is currently unavailable at OSU. The ECOMET 250 Grinder-Polisher is an important instrument for controlling substrate thickness which is essential for development and characterization of novel electronic devices. The purchase of this equipment was funded by ENCOMM. In order to facilitate equipment maintenance and user access, both instruments will be installed and operated by the NanoSystems Laboratory (NSL). The ECOMET 250 Grinder-Polisher by Buehler has already been delivered and is currently being installed at NSL. It is expected that it will become available to users by December 2012. The order for the µPG 501 tabletop direct write lithography system is currently being processed, and the instrument is expected to become available in April 2013.

Center for Chemical and Biophysical Dynamics (CCBD) – ccbd.chemistry.ohio-state.edu

The CCBD facility has updated its user rates and user categories for Fiscal Year 2013. New usage fees were finalized and approved by the CCBD users' committee and rates are posted on the CCBD website (http://ccbd.chemistry.ohio-state.edu/usagefeespolicies.html). As a part of the Department of Chemistry's Research Support Services (RSS) system, the CCBD adopted a new policy related to research project collaborators with the Department of Chemistry researchers. This policy was recently developed by the RSS following the guidelines from the Accounting Office. To use department-subsidized rates, a collaborator must have an account associated with the Department of Chemistry or the IMR. Individual questions about the use of the subsidized fees can be directed to the CCBD Manager Dr. Evgeny Danilov (danilov.3@osu.edu), the RSS Director Dr. Tanya Young (young.1185@osu.edu), or Chemistry Administration Director Dr. Gerry Raimann (raimann@chemistry.ohio-state.edu).

A Thermo Scientific Velos Pro Linear Ion Trap Mass

Spectrometer is now housed in CCBD's facility in room 0118 Newman and Wolfrom Laboratory. This instrument belongs to Ohio Eminent Scholar Vicki Wysocki's group and it was designed for bioanalytical mass spectrometry, peptide and protein sequencing, ion-surface collisions for surface characterization of organic thin films, biodefense, proteomics and metabolomics. The spectrometer is envisioned to be coupled with the CCBD nano- and picosecond IR sources for laser-induced (and) surface dissociation, and will be available to CCBD users in the future.

A group of advanced CCBD users, primarily made up of senior graduate students, is being trained to encourage enhanced skills and understanding of the experimental techniques and to ensure a smooth transition and transfer of skills to the next generation of users. Educational modules devoted to the facility's instruments and methods are being developed and placed on the CCBD network drive. Finally, a reminder that all CCBD users are required to complete the OSU Environmental Health and Safety Office's online Laser Safety training course and provide the certificate of completion to the CCBD Manager to maintain compliance with university regulations.

NSEC Update: Making Quantum Leap with Spinoff

The following update was provided by the Center for Affordable Nanoengineering of Polymeric Biomedical Devices (CANPBD), a National Science Foundation Nanoscale Science and Engineering Center for Affordable, Nanoengineering of Polymer (NSEC) program at The Ohio State University. The primary goal of the CANPBD is to develop polymer-based, low-cost nanomaterials and nanoengineering technology to produce advanced medical diagnostic devices, cell-based devices, and multifunctional polymer-nanoparticle-biomolecule nanostructures for next-generation medical and pharmaceutical applications. For more information about CANPBD, visit their website: http://nsec.osu.edu/. This article was originally published by *Columbus Business First* business journal.

Ohio State professor Jessica Winter has devised a better way to make fluorescent nanoparticles, which is drawing funding as a spinoff business. Photo: Janet Adams, Business First

Dr. Jessica Winter, NSEC member and Associate Professor of Chemical and Biomolecular Engineering, is successfully navigating the lab-to-market route by actively pursuing commercial potential from her chemical engineering research at Ohio State. After she developed a potentially market-busting way to make fluorescing nanoparticles used in labs, she worked with an undergraduate student to put together a commercialization strategy which won first place in the 2012 Ohio State University Business Plan Competition, sponsored by OSU's Center for Entrepreneurship.

Dr. Winter incorporated Core Quantum Technologies Inc. in June 2012 and completed a six-week National Science Foundation entrepreneurship program, called I-Corps, in which participants conducted in-depth interviews with potential customers. Winter's discovery should enable Core Quantum to break into an established market armed with a better-performing product that's less expensive to make – which means its use can spread to other industries, said Gary Rawlings, TechColumbus' director of technology commercialization. The product, MultiDots, is a new type of quantum dots, which are nanoparticles about the size of a human protein that glow when a light source is shined on them. Attached to antibodies, they can hunt out specific cell structures to light them up under a microscope.

Winter improved on several problems with quantum dots in the market with a novel process to bundle several nanoparticles into a beadlike structure. The size is more consistent, they lose an annoying property of blinking like Christmas lights and they don't degrade as quickly. They can be different colors, or switch colors under different wavelengths of light. "The most important thing is they're five times brighter for the same size," she said. Possible applications range from LED electronics to tattoos that glow under ultraviolet light, according to vice president of new ventures at Dublin-based IT firm Fast Switch Ltd., which is collaborating with Core Quantum. "That's just the fun stuff," Lagemann said. "You could have special inks for tickets and currency. The number of applications (is) astounding." "The challenge," he said, "is to focus in and commercialize in an orderly and planned process." A long-term development would be to add magnetic properties to the fluorescing, which has even greater medical uses, Winter said.

Once new equipment is delivered and installed this Fall, Core Quantum will begin production of the particles for medical and electronic uses, becoming the first company in a TechColumbus incubator space dedicated to Ohio State spinoffs.

2012 OSU Materials Research Seed Grant Program Awards

We are pleased to announce that after a thorough internal and external review process, nine awards have been made to fund innovative and exciting materials research on campus through the OSU Materials Research Seed Grant Program. These awards total $540,000 in internal research funding to 24 OSU researchers in eight departments.

Congratulations to the nine research teams whose projects were selected this year for seed grant funding. Full abstracts for each of these research projects is available online at IMR's website, imr.osu.edu.

2012-2013 Proto-IRG Grants

Proto-IRG Grants are awarded with the goal of developing new Interdisciplinary Research Groups (IRGs) that could be incorporated into the renewal proposal that will be submitted by the CEM to the NSF MRSEC program in 2013. Three Proto-IRG Grants were awarded this year:

- Band Structure Engineering of Si/Ge/Sn Graphane Analogues, Principal Investigator: Joshua Goldberger, Chemistry; Co-Investigators: Wolfgang Windl, Materials Science and Engineering; Jay Gupta, Physics
- Thermal Spintronics: Materials for Enhanced Heat-Spin Interactions, Principal Investigator: Roberto Myers, Materials Science & Engineering; Co-Investigator: Joseph Heremans, Mechanical & Aerospace Engineering; Collaborators: Ezekiel Johnston-Halperin, Physics; David Stroud, Physics
- Functional Dynamics of DNA Scaffolded Materials, Principal Investigator: Michael Poirier, Physics; Co-Investigators: Chris Hammel, Physics; Christopher Jaroniec, Chemistry; Carlos Castro, Mechanical and Aerospace Engineering; Collaborator: Ezekiel Johnston-Halperin, Physics

2012-2013 Multidisciplinary Team Building Grants

Multidisciplinary Team Building Grants form multidisciplinary materials research teams that can compete effectively for federal block-funding opportunities. Two Multidisciplinary Team Building Grants were awarded this year:

- Using Neutron Depth Profiling for the Characterization of Current Collectors in Lithium Ion Batteries, Principal Investigator: Marcello Canova, Mechanical and Aerospace Engineering; Co-Investigator: Raymond Cao, Mechanical and Aerospace Engineering; Collaborator: Anne Co, Chemistry
- Engineered Heart Tissue: A Multidisciplinary Team Centered on Scaffold Structure and Mechanics, Principal Investigator: Jianjun Guan, Materials Science & Engineering; Co-Investigators: Gunjan Agarwal, Biomedical Engineering; Peter Anderson, Materials Science & Engineering

2012-2013 Exploratory Materials Research Grants

Exploratory Materials Research Grants enable nascent materials research to emerge to the point of being competitive for external funding. Four Exploratory Materials Research Grants were awarded this year:

- DNA-based Molecular Actuators for Novel Smart Material Systems, Principal Investigator: Carlos Castro, Mechanical and Aerospace Engineering; Co-Investigators: Marcelo Dapino, Mechanical and Aerospace Engineering; Haijun Su, Mechanical and Aerospace Engineering
- New Approach to Electromagnetic Interference (EMI) Shielding of Plastic Parts: Nanopaper In-Mold Coating, Principal Investigator: Jose Castro, Integrated Systems Engineering; Co-Investigator: L. James Lee, Chemical and Biomolecular Engineering
- Modifying the Kinetics and Selectivity of CO2 Electroreduction through Ionic Liquid-Electrode Interactions, Principal Investigator: Anne Co, Chemistry and Biochemistry; Collaborators: Aravind Asthagiri, Chemical and Biomolecular Engineering; David Cole, Earth Sciences
- Rechargeable Potassium-Air Batteries with High Energy Storage and Efficiency, Principal Investigator: Yiying Wu, Chemistry; Co-Investigator: Sheldon Shore, Chemistry and Biochemistry

About the OSU Materials Research Seed Grant Program

The OSU Materials Research Seed Grant Program provides internal research funding opportunities through three distinct Funding Tiers designed to achieve the greatest impact for seeding and advancing excellence in materials research of varying scopes. The OSU Materials Research Seed Grant Program is jointly funded and managed by the Institute for Materials Research (IMR), the Center for Electronic and Magnetic Nanoscale Composite Multifunctional Materials (ENCOMM), and the Center for Emergent Materials (CEM).

IMR Staff Tailgate Celebration

IMR staff members and affiliates gathered at Nanotech West Laboratory on November 1st to cheer on the Buckeyes and celebrate our own IMR/NTW winning team. Staff, student employees, and facility "superusers" from IMR, Nanotech West, Nanosystems Lab, and the Industry Liaison Office joined together during the tailgate-themed event and enjoyed a delicious lunch from the OH! Burgers food truck. Guests held a cornhole competition as TBDBITL OSU Marching Band music played in the background and OSU Buckeye football classics were screened. This staff appreciation/team building event established a group focused on camaraderie and supported OSU's "One University" vision. Thank you to everyone who participated!

Fall 2012

The IMR Quarterly is a free publication from The Institute for Materials Research at The Ohio Sate University.

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