SCIENCE CHARACTERIZATION ENVIRONMENTAL
STRUCTURE COMPUTATION ENGINEERING
TECHNOLOGY DEVICES
SYNTHESIS ENERGY ORGANICS OXIDES
NANO PROCESSING

INSTITUTE FOR MATERIALS RESEARCH

THE GATEWAY TO MATERIALS RESEARCH AT THE OHIO STATE UNIVERSITY

FISCAL YEAR 2010 - 2011
ANNUAL REPORT

ENGINEERING PHOTONICS
BIOLOGICAL POLYMERS MAGNETIC TECHNOLOGY
MANUFACTURING SYNTHESIS
INTERDISCIPLINARY
SCIENCE ELECTRONICS SENSORS

IMR
INSTITUTE FOR MATERIALS RESEARCH

THE OHIO STATE UNIVERSITY

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Introduction

The past year of activities within the Institute for Materials Research (IMR) community continues to demonstrate the substantial levels of excellence and broadening reach of materials research at The Ohio State University. Not only has the IMR continued to attract top new faculty members with expertise in topics ranging from electron microscopy to bio-based materials synthesis through programs such as the Ohio Research Scholars, led the development of new, major laboratories for interdisciplinary and industry-relevant research in our west campus research park, and been responsible for a wide array of new research awards ranging from the most competitive federal programs to vitally strategic State-funded efforts, but IMR has also evolved several of its internal support programs to meet the expanding needs of our community.

For instance, IMR has launched an exciting, new core seed funding program based on its highly successful IMRG (Interdisciplinary Materials Research Grant) program, expanding it into multiple tiers of funding opportunities to cover topics that range from exploratory single investigator efforts to topics that are ready for major team efforts. This year, IMR also cultivated a new program funded by the Alcoa Foundation via its Advancing Sustainability Research Initiative – the only award from Alcoa made in the U.S. for this world-wide program, which is a testament to OSU's prowess in industry-relevant materials research and education. This will lead to seed efforts in lightweight materials manufacturing and a special relationship between Alcoa and Ohio State.

Our major laboratories continue to advance in terms of both acquisition of new state of the art equipment and in expansion of our user base, both externally and internally. Our many centers of excellence, including the NSF supported Center for Emergent Materials MRSEC, and the Center for Affordable Nanoengineering of Polymeric Biomedical Devices NSEC, are thriving and making world leading discoveries. Our faculty members have continued to exceed their already high level of publication and citation activities, which are part and parcel of training of top students.

More specifically, the wide range of achievements, which span external and internal activities for this past year include:

- 31 member companies and not-for-profits now part of IMR's Wright Center for Photovoltaic Innovation and Commercialization
- The start of our recently awarded NSF I/UCRC (Industry/University Cooperative Research Center) in materials joining
- The start of three new Department of Defense MURI programs
- Successful recruitment of 4/5 total Ohio Research Scholar endowed chairs in Technology Enabling and Emergent Materials (TEEM) program
- Award of Alcoa Foundation Grant and seed program in Sustainable, Lightweight Materials Manufacturing
- Winning 3 out of 5 total awards made in industry-relevant photovoltaics research statewide through the Ohio Department of Development (and supporting a fourth)
- Initial planning of the new, 20,000 square foot Center for Electron Microscopy and Analysis (CEMAS) to be located in our west campus research park
- 3rd annual Materials Week Conference, with more than 300 attendees

- Funding of 7 interdisciplinary teams via the IMRG program and of 20 IMR Facility Grants to encourage use of major facilities in core research
- Led development of new, integrated materials seed grant program to align internal opportunities into a single, cohesive program
- New externally funded research projects starting in FY2011 exceeded $168.6 million in awarded total funds, almost double the figure from FY2010

This annual report that follows provides more detail into many of these accomplishments, and in general summarizes progress and current status of the IMR within its broad mission to advance and support the University's materials-allied enterprise.

Overview of the Institute for Materials Research

The Ohio State University Institute for Materials Research (IMR) is an interdisciplinary organization established in 2006 with the purpose of facilitating, promoting and coordinating research activities and infrastructure related to the science and engineering of materials throughout the University. IMR serves as the gateway to the materials research enterprise at The Ohio State University.

IMR VISION: A multidisciplinary research institute that propels OSU to the recognized international forefront of materials-allied research and scholarship

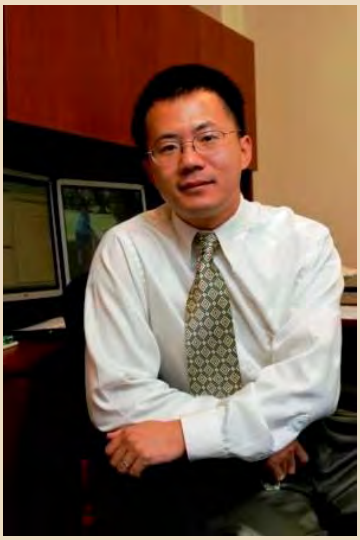
IMR MISSION: To nurture, grow and support research groups leading to small, large and center-level awards; to provide strategic planning, resources, infrastructure, and educational/outreach activities; to coordinate, support and assist with management of campus-wide materials-allied research and related resources

In 2005, a Materials Vision Committee of 13 OSU faculty from a broad range of departments involved in materials research from the Colleges of Engineering, Math & Physical Sciences and Medicine was formed by the OSU Senior Vice President for Research to develop a compelling and strategic vision for materials-allied research at OSU. This Committee's mission was to assess OSU's materials community and its activities and make recommendations designed to propel OSU to worldwide leadership in materials research. In September 2005, the Materials Vision Committee submitted its report, and based on critical assessments of the status, assets, needs and unique strengths of materials research across the University with respect to international trends and future opportunities, the Committee recommended formation of a strong and vibrant Institute for Materials Research (IMR).

IMR Members and the OSU Materials Community

The OSU materials community is made up of a diverse and distinguished group of faculty researchers. Members of the materials community at Ohio State include 6 National Academy members, 7 Ohio Eminent Scholars, 5 Distinguished University Professors, and dozens of Fellows at various professional associations such as AAAS and IEEE. During this past year, IMR's membership grew to 145 faculty members and professional research staff representing 20 departments and 6 colleges. IMR members are faculty from the Colleges of Engineering; Arts and Sciences (Division of Natural and Mathematical Sciences); Food, Agricultural and Environmental Sciences; Medicine; Pharmacy; and Veterinary Medicine.

A Google Scholar literature search of IMR members' publications found that these 145 faculty members authored 1,249 publications, or 8.61 papers per faculty member during the reporting period (July 1, 2010 – June 30, 2011). Additionally, an ISI literature search indicated that those 145 faculty members' publications also received 27,490 citations during that same 12-month period, for an average of 189.59 total citations per faculty member this year. The Ohio State Office of Sponsored Programs tabulated the current research activities of all faculty members within the IMR materials community, and found that during the same 12-month period of July 1, 2010 – June 30, 2011, IMR members received $168,646,764 in new externally sponsored research projects this fiscal year, nearly double the figure from Fiscal Year 2009-2010.



Yiying Wu, Assistant Professor of Chemistry and IMR Faculty Science Advisory Committee member, was recently ranked sixth worldwide on the Times Higher Education "Top Materials Scientists of the Past Decade." This list, published in February 2011, ranks the top 100 materials scientists based on Thompson Reuters' Essential Science Indicators measurement of the impact of each scientist's published works from 2000-2010.

IMR Organizational Structure

The Institute for Materials Research reports to a single Executive Committee and is advised by two other committees, the Faculty Science Advisory Committee (FSAC) and the External Advisory Board. This organizational structure was created by the original vision committee, and has proved to be an effective way to obtain a wide range of guidance from university, industry, and national laboratory leadership. **Figure 1** shows the organization chart depicting the placement and role of these committees, their memberships, and also formal reporting lines.

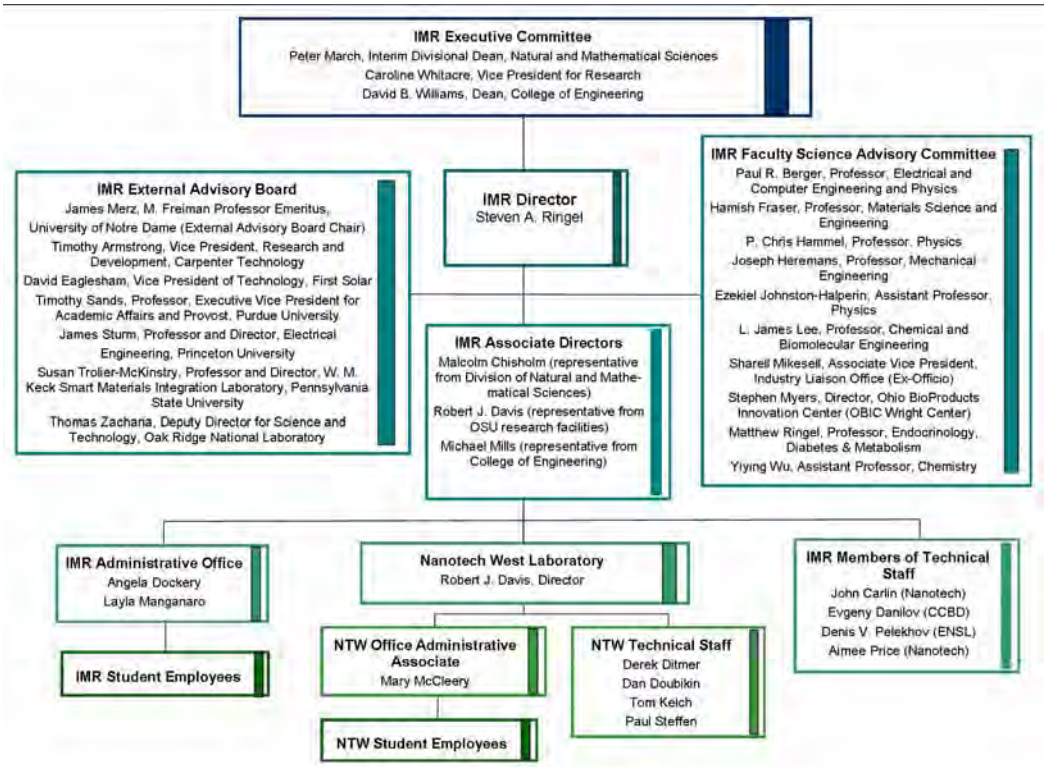


Figure 1. IMR organizational chart and formal reporting lines.

IMR Executive Committee

The IMR Executive Committee is made up of Ohio State leaders from the three units of the university that provide direct operational funding for IMR: OSU's Office of Research, College of Engineering, and the Division of Natural and Mathematical Sciences of the College of Arts and Sciences. This committee meets two to three times each year with the IMR Director to review IMR activities, finances, and future plans, and in turn provides oversight and guidance regarding IMR's strategic planning and ensures that IMR activities are aligned with college priorities in materials and are in the best interests of the colleges supporting IMR. The balance in this committee between equivalent financial stakeholders is critical and has allowed IMR to assist in creating unique college-to-college interactions that leverages the strengths of each.

IMR Faculty Science Advisory Committee

The IMR Faculty Science Advisory Committee (FSAC) is made up of Ohio State faculty representatives of the entire university materials community. The Faculty Science Advisory Committee meets quarterly to advise the IMR Director and Associate Directors regarding near and long-term strategies, important external opportunities for funding and collaboration, decisions on priority areas for IMR Research Enhancement Support, and issues related to facility clusters. The Advisory Committee provides representation of faculty associated with their own departments and colleges to the IMR. The composition is balanced as follows: 4 members from the College of Engineering, 4 members from the Division of Natural and Mathematical Sciences of the College of Arts and Sciences and 2 at large members from other colleges (currently

Agriculture and Medicine). The Associate Vice President and Director of the OSU Industry Liaison Office is an ex-officio member. Currently there are 10 FSAC members, representing three OSU colleges and two Ohio Wright Centers of Innovation.

IMR External Advisory Board

The IMR External Advisory Board (EAB) was formed in 2009 with the purpose to provide IMR leadership with non-OSU perspectives and experience-driven advice from other universities, industry and federal laboratories, to help ensure the success and relevance of IMR activities moving forward. An important goal for the EAB is to assist IMR in maximizing its impact and to enhance its collaborations with partners from the industrial and non-profit sectors, including federal laboratories, by providing advice on both technical directions and mechanisms for interactions with external organizations. The EAB meets annually with IMR leadership to review and discuss IMR research activities, directions, facilities and programs and provide a written assessment and recommendations for future success.

New EAB Chair. At this past year's EAB meeting held November 2, 2010, the board unanimously elected Dr. Jim Merz as the new EAB chair to replace the Dr. Jeffrey Wadsworth, CEO and President of Battelle, who is now serving as a member of OSU's Board of Trustees. Dr. Wadsworth was the founding EAB Chair and served in that capacity for two years. Dr. Merz, an initial EAB member, is the Frank M. Freimann Professor Emeritus of Electrical Engineering at the University of Notre Dame and an internationally recognized scholar in the field of optoelectronic materials and devices. Dr. Merz was formerly Professor of Electrical Engineering, Professor of Materials, and Director of the Center for Quantized Electronic Structures (QUEST) at the University of California at Santa Barbara.

On April 13, 2011, new IMR External Advisory Board Chair Dr. Jim Merz (second from right) visited OSU's Columbus campus and met with various representatives of our materials community to get a better feel for the OSU research enterprise and the needs of researchers. Dr. Merz is the Frank M. Freimann Professor Emeritus of Electrical Engineering at The University of Notre Dame and an internationally recognized scholar in the field of optoelectric materials and devices. Pictured with Dr. Merz touring the Nanotech West Laboratory is IMR Associate Director Dr. Bob Davis, IMR Director Prof. Steve Ringel, and IMR Member of Technical Staff Dr. John Carlin.

IMR Administration and Management

IMR employs a staff comprised of technically-oriented and administrative employees to sustain IMR in is mission to advance materials research and community at OSU. Below is a brief overview of IMR's employees and their roles within the Institute.

IMR Director: Steven A. Ringel, Ph.D.

Dr. Steven A. Ringel has served as the Director of IMR since its inception. Dr. Ringel is a Professor in the Department of Electrical and Computer Engineering, where he also holds the Neal A. Smith Endowed Chair in Electrical Engineering. He also holds courtesy appointments as a Professor of Physics and a Professor of Materials Science and Engineering. Dr. Ringel's research program is internationally recognized and is focused on electronic materials, devices, photovoltaics and defect science with a particular interest in integrating basic science and engineering issues to create new device technologies.

The IMR Director is appointed by the Vice President for Research, with the advice and recommendation of the Executive Committee, and serves 50% of his time as the chief administrative officer of the IMR. He is responsible for the external and internal leadership, vision, overall direction, general welfare and progress of the IMR. The Director is also responsible for the accomplishment of IMR's programs, financing and staffing, and serves as the linkage for the IMR community to OSU central administration, and to state and federal government and external agencies as may be appropriate.

IMR Associate Directors: Malcolm Chisholm, Ph.D., Robert J. Davis, Ph.D., Michael Mills, Ph.D.

IMR's three Associate Directors represent much of the core OSU materials community, with one Associate Director with a home department in the College of Engineering, one Associate Director with a home department in the Division of Natural and Mathematical Sciences of the College of Arts and Sciences, and a third Associate Director who represents leadership from OSU's materials-allied research facilities on our west campus research park, emphasizing large facilities and industry interactions. Each Associate Director assists with the leadership and planning of IMR, and serves as a formal liaison between his/her college or unit constituency and the IMR. The Associate Directors more generally help to plan and participate in major IMR events and coordinate and review IMR Members of Technical Staff. They meet with the IMR Director at least monthly to consult with and provide advice regarding strategic decisions that include research priorities, facility planning, modifying and proposing new plans, and related issues. They create and recommend review processes regarding allocation decisions to the Director for funding of programs and support of technical staff through its Research Enhancement Program.

IMR Administrative Staff

The IMR has a small but agile and effective administrative staff, comprised of a Program Manager, an Administrative Associate, and an Information Associate. IMR administrative staff is responsible not only for the entire financial administration of IMR and major externally funded research programs, but also has key leadership within the Institute for activities such as proposal development, management of our large internal research funding program, the annual Materials Week conference, marketing and communications, and seminar series. In addition, each quarter the IMR hires several undergraduate students to provide a wide range of support services for our organization, including driving the IMR shuttle van, assisting our Members of Technical Staff with laboratory maintenance, and supporting our administrative staff with

general clerical duties. The incorporation of Nanotech West Laboratory as an organizational unit of IMR in this past year has added substantial and new financial and human resource management duties to the IMR staff.

The diagram in **Figure 2** shows how IMR interfaces with the materials community as an umbrella institute providing overall support in a variety of ways.

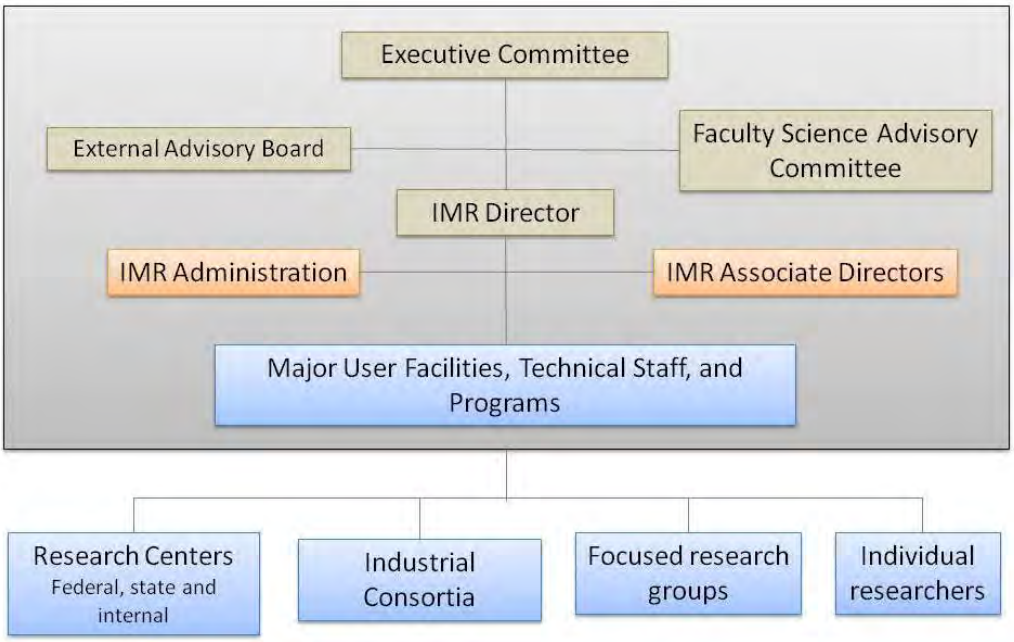
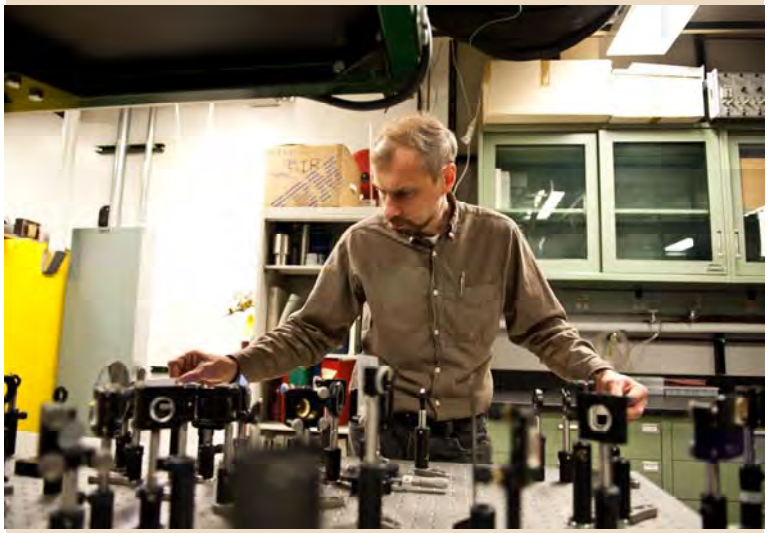


Figure 2. The interface between IMR and the OSU materials community, showing some of the organizational structure of IMR and how it serves as an umbrella organization with resources available to research centers, groups, and individuals.

IMR Members of Technical Staff

IMR employs and also supports, in a variety of cost-share arrangements, highly skilled technical experts, research engineers and scientists whose primary function is to enable world-class research within our core, multi-user facilities. Their responsibilities include maintaining facilities at peak operating conditions, coordinating between materials user facilities across campus, enabling facility access, providing training and generally being available to assist with research programs from various sources. Importantly, the members of technical staff, each of whom are assigned to one primary facility, but are by no means limited to only that facility, themselves create a human interface that networks between the many materials facilities and laboratories across colleges. IMR Members of Technical Staff are a major part of the fabric that enables cross-disciplinary research, assisting in the avoidance of redundant lab development and at the same time providing engineering and scientific support on any number of projects. Generally speaking, MTS employees serve as laboratory coordinators to enable access by researchers not only from OSU but also from outside the university. In addition to dealing with all aspects of maintaining complex instrumentation, including scheduling, data management and financial responsibilities, MTS employees are encouraged to develop research programs and contracts depending upon their own level of expertise and education.

Departments or centers receiving an IMR MTS to support their activities execute a Memorandum of Understanding with IMR that details specifics of the agreement regarding MTS supervision, salary support,



IMR Member of Technical Staff Dr. Evgeny Danilov is the lab manager of the for Chemical and Biophysical Dynamics (CCBD). The CCBD is an ultrafast laser spectroscopy research laboratory that converted to an open user facility this year.

and expectations for the arrangement. Success metrics are jointly agreed upon between the faculty member or senior staff member in charge of the particular facility and the MTS, with approval by the IMR Director. MTS may be reassigned by the IMR Director in consultation with the Associate Directors to another research area based on university demands, needs and history of performance. It is understood that any facility that is supported by an MTS must become itself an "earnings" center so that the facility can be accessible to users throughout the IMR community, irrespective of home department, via a fee-for-use model. We currently have four Members of Technical Staff with primary facility responsibilities at the Nanotech West Laboratory (Ms. Aimee Bross – nanolithography and Dr. John Carlin – MOCVD and processing), the ENCOMM NanoSystems Laboratory (Dr. Denis Pelekhov – magnetoelectronics), and the Center for Chemical and Biophysical Dynamics (Dr. Evgeny Danilov – fast optical spectroscopies).

IMR-Supported Externally Funded Research Centers and Programs

A primary goal and function of the IMR is to develop and secure major block research grants, centers and multi-investigator efforts, since the creation of teamed efforts leads to scholarly activity and impact that is greater than the sum of their parts. IMR continues to enjoy extraordinary success, with many examples of block efforts having been awarded, some by virtue of internal IMR seed grants, and others due to extensive team building processes and proposal development activities. The Center for Emergent Materials (CEM), OSU's first NSF MRSEC award (Nitin Padture, P.I.), granted in 2008 after two years of internal team development and limited submission reduction, is arguably the award from NSF that truly signifies an elite materials research program. Taken together with the NSF Nanoscale Science and Engineering Center (NSEC), another similarly prestigious and competitive program that is directed by Prof. L. James Lee that is currently in its second phase of funding, *OSU is one of a handful of universities that have active NSEC and MRSEC programs simultaneously*. IMR, in its role as the university-wide entity for nurturing and advancing large scale materials research, supports both centers with a variety of seed grants, facility support programs, technical staff, laboratory space and outreach and engagement activities. Additionally, IMR is the lead organization for a state-wide materials program funded by the State – the Ohio Research Scholars Cluster Program – entitled Technology-Enabling and Emergent Materials (TEEM), with a total of 5 endowed chairs being created in 3 universities (3 at OSU), with IMR Director Steven A. Ringel as the P.I. In FY11, we have completed the hiring of 4 out of 5 available positions - excellent progress toward fulfilling the initial

goal of creating a coordinated, trans-institutional, in-state materials alliance. Adding to these three major center efforts is the IMR's current Wright Center in solar energy (Wright Center for Photovoltaics Innovation and Commercialization - PVIC), which is co-directed by IMR (IMR Associate Director Bob Davis is the PI) with the University of Toledo. PVIC's goal is to help fuel the advancement of Ohio as the nation's leading producer of solar power and connecting university research to that strategic asset. PVIC was once again responsible for several millions of dollars in secondary funding targeting key collaborations between OSU faculty and industry partners in advanced energy materials, and seeded recently submitted large proposals to the U.S. Department of Energy Sunshot Initiative. Moreover, several new collaborative efforts began during this past year, including several Multidisciplinary University Research Initiative (MURI) awards via the U.S. Department of Defense, and an NSF I/UCRC award. As these emanated from IMR's IMRG seed program and the IMR faculty cluster hiring efforts, those are described later in this report.

In FY11 important advances were made in the above primary research centers and an imperative role for IMR is to support the continued growth and success of these centers so that they thrive for many years to come. The remainder of this section of the report consists of progress reports and FY11 status for these externally-funded research centers that are a direct result of the Institute for Materials Research through ongoing proposal development, operational support, technical support, administrative support and infrastructure support. Please note that while IMR now supports the NSF Nanoscale Science and Engineering Center (NSEC) program at OSU through providing of industry match grant funds, the NSEC program in fact predates IMR. However, NSEC is almost entirely housed in, and serviced by, the IMR Nanotech West Laboratory and staff, so this relationship has grown to be very important.

Below are the prime centers to be summarized (due to the very different nature and goals of these programs, the format for each summary, below, varies as appropriate to their specific missions):

- NSEC – Nanoscale Science and Engineering Center for Affordable, Nanoengineering of Polymer Biomedical Devices, National Science Foundation, PI: L. James Lee, Co-PIs: Jeffrey Chalmers, Terrence Conlisk, John Lannutti, Robert J. Lee, Susan Olesik and Barbara Wyslouzil, 9/1/2004 – 9/30/2014, $25,716,460
- MRSEC: Center for Emergent Materials, National Science Foundation, PI: Nitin Padture, Co-PIs: Leonard Brillson, P. Chris Hammel, Ezekiel Johnston-Halperin, Patrick Woodward, 9/1/2008 – 8/1/2014, $10.8 million
- Wright Center for Photovoltaic Innovation and Commercialization (PVIC), Ohio Department of Development (Subcontract through University of Toledo), PI: Robert J. Davis, Co-PIs: Paul Berger, Malcolm Chisholm, Arthur Epstein, Joseph Heremans, Nitin Padture, Steven Ringel, 2/16/2007 – 11/15/2011, $18.6 million total ($6.9 million to Ohio State)
- Ohio Research Scholars Program: Technology-Enabling and Emergent Materials, Ohio Department of Development, PI: Steven Ringel, Co-PIs: Jeffery McNeal, Steven Slack, Greg Washington, Stephen Cheng (U. Akron), Charles Browning (U. Dayton) 8/18/2009 – 8/17/2013, $18,153,846 ($8,953,846 to Ohio State)
- MRI: Acquisition of a Hybrid Diamond/III-N Synthesis Cluster Tool, National Science Foundation Major Research Instrumentation Program, PI: Ezekiel Johnston-Halperin, Co-PIs: Harris Kagan, Steven Ringel, Siddharth Rajan, Fengyuan Yang, Roberto Myers, 8/1/2009 – 7/31/2011, $601,890 ($421,323 from NSF plus $180,576 cost share from The Ohio State University and Ohio Board of Regents Action Funds)

Center for Emergent Materials

Funding Agency: National Science Foundation - Materials Research Science and Engineering Center (MRSEC) Program

Principal Investigators: PI: Nitin Padture, Co-PIs: Leonard Brillson, P. Chris Hammel, Ezekiel Johnston-Halperin, Patrick Woodward, with 14 senior investigators

Duration: 9/1/2008 – 8/1/2014

Amount: $10.8 million + $6.8 million cost share, including more than $1M from IMR

Description: The CEM (Center for Emergent Materials), a NSF Materials Research Science and Engineering Center (MRSEC), was established at OSU on September 1, 2008. CEM is the first MRSEC at Ohio State and the only MRSEC in the state of Ohio. Its development was achieved over the course of several years of prior internal planning in internal processes led by IMR and the ENCOMM initiative as part of the Targeted Investment in Excellence program that was funded to IMR from the OSU Provost's office in 2007. Details of how IMR helped to create the successful CEM program were provided in the 2009 IMR Annual Report. The CEM includes 22 core faculty members and 8 other faculty investigators drawn from 6 different disciplines and 3 universities, with its primary research focus on magnetoelectronics. Interdisciplinary teams of faculty, graduate students and postdoctoral scholars are addressing complex scientific issues in this area by integrating materials synthesis/growth, characterization and theory/modeling. The scientific mission of the CEM is to lay the foundation for creating new opportunities and directions in spintronics. The foundation is in the form of innovation in synthesis/growth of emergent materials, in probes used to understand emergent phenomena, and in predictive theory/modeling. The CEM includes two Interdisciplinary Research Groups (IRGs) as the primary research thrusts, a Seed program that is integrated with the core IMR seed program, and a substantial education and outreach program that is required for all MRSECs, which is also supported by IMR. This report summarizes research progress of CEM, which has now completed its third year in its first six year cycle.

Highlights and Accomplishments of CEM for FY 2011

The information below is excerpted from the CEM's annual report to NSF for the period of May 16, 2010 to May 15, 2011.

IRG-1 Major Accomplishments

Building on the foundation of previous work demonstrating world leadership in spin transport in graphene and all-organic spintronics, over the past year IRG-1 has made the following key advances in areas directly relevant to the scientific mission of the IRG.

Organic-Based Spintronics

The Ohio State University has a long history of leadership in the development and characterization of organic-based magnetic materials. Leveraging that expertise, the following breakthroughs have further established the world-leading position of the CEM in this area:

- *Spin injection in hybrid organic/inorganic heterostructures:* CEM researchers have demonstrated the first injection of spin-polarized current from the organic-based magnet vanadium tetracyanoethylene (V[TCNE]~2) into a III-As semiconductor heterostructure. This result builds on the recent demonstration of an organic-based spin valve and recently appeared in *Physical Review Letters*. This breakthrough promises both significant technical advances in spin-based electronics as well as a novel platform for the exploration of spin physics in organic and molecular materials.
- *Magnetism in single molecules:* Individual TCNE molecules as well as Co[TCNE] and Fe[TCNE] complexes have been measured using STM. By depositing these organic building blocks on single-atom-thick insulating Cu2N islands details of the magnetic anisotropy are revealed with atomic resolution. These results agree with ab initio calculations of the molecular orbitals.

Microscopy

The CEM has assembled a world-class precision microscopy group including multiple flavors of STM and scanned force microscopy including force detection of magnetic resonance. Since the advent of IRG-1 there has been a concerted push to apply this expertise to problems directly impacting spin injection, transport and modulation. The following two achievements highlight recent program successes:

- *Tuning the properties of single dopants in semiconductors using a scanning tunneling microscope:* The ability of STM to both manipulate and probe materials at the atomic scale has been exploited to explore the impact of individual impurities (and associated electric fields) on the magnetic properties of isolated magnetic impurities. This investigation resulted in breakthroughs in understanding of the general properties of charged defects at semiconductor surfaces and the origins of ferromagnetism in (Ga,Mn)As, which appeared in *Science*.
- *Modeling the impact of a spatially varying magnetic field on spin dynamics:* Numerically solving the drift-diffusion equations for spin in the presence of a spatially inhomogeneous magnetic field has led to a quantitative understanding of the interaction of magnetic probe tips with spin ensembles in non-magnetic channels. This result lays the theoretical foundation for the development of novel materials-generic and spatially resolved probes of spin scattering and lifetime, one of the central goals of IRG-1.

IRG-2 Major Accomplishments

IRG-2 researchers are positioning themselves to be world leaders in the field of double perovskite (DP) oxides through key accomplishments in theory/modeling in conjunction with studies of bulk materials and growth and characterization of high-quality epitaxial films.

- Using magnetron sputtering high-quality, stoichiometric, nearly 100% ordered, epitaxial films of Sr2CrReO6, have been deposited and characterized by IRG-2 researchers. These films have a *T*C = 530 K and a saturation magnetization *M*S = 1.3 μB/f.u., values that are 50 K and 0.3 μB/f.u. higher than the best films previously reported in the literature. The quality of these films sheds light on the intrinsic properties of this compound showing the importance of spin-orbit coupling on the magnetic and transport properties.
- Theoretical modeling of Sr2CrOsO6 (*T*C = 720 K) using a multi-band Hubbard model including spinorbit coupling shows that this compound is a Mott-Hubbard insulator whose high TC originates from superexchange interactions. The ferrimagnetism and unusual temperature dependence of the

magnetization are due to geometric frustration arising from competition between Cr–Os and Os–Os superexchange interactions, rather than spin-orbit coupling effects as previously thought.

- Using a variety of experimental techniques we have shown a close coupling between spin and orbital degrees of freedom in A2–xA'MnRuO6 perovskites, where the Mn and Ru ions are randomly arranged. The combination of strong antiferromagnetic Mn–Ru coupling and ferromagnetic Mn–Mn coupling leads to the surprising observation of ferrimagnetism in a chemically disordered system. Furthermore the strong coupling between orbital and spin degrees of freedom provides an opportunity to control magnetism through chemical pressure, external pressure and epitaxial strain.
- Working in collaborations with researchers at IFW in Dresden, Germany we have grown small single crystals of the highly ordered double perovskite Sr2NiWO6, which is proposed to be an ideal substrate for growth of highly ordered half-metallic Sr2FeMoO6 films. We have also prepared Sr2NiWO6 buffer layers using PLD. These results are a launching pad for further exploration of DPs interfaces and heterostructures and provide the basis for future devices based on DPs.

Broader Impact

The CEM is having a broad impact on materials research and researchers at OSU and beyond. The researchers responsible for the above scientific accomplishments are participating in wide-ranging educational and outreach activities. In this reporting period the CEM as a whole was engaged in education, training, and outreach programs that have impacted over 6,800 K-12 students, 72 K-12 teachers, 583 undergraduates in classes, 17 undergraduate researchers, 26 graduate students, and 8 postdoctoral scholars.

The Center for Emergent Materials and the Leibniz Institute for Solid State and Materials Research (IFW Dresden) co-hosted a 3-day “Novel Magnetic Materials” workshop to advance promising research collaborations. The CEM delegation included 12 faculty, 10 graduate students, and 1 post doctoral researcher, and the group traveled to Dresden for three days of talks, facility tours, social activities, and a joint poster session. An estimated 75 individuals attended the sessions that included 17 individual presentations and 40 posters. A follow-up visit bringing IFW participants to Ohio is being planned for Fall 2011.

- The Research Experience for Undergraduates (REU) program had 9 students (6 female, and 1 underrepresented minority) during the academic year 2010-2011, and 8 students (5 female, 2 from underrepresented minority groups) during summer 2010. One academic year REU student presented her research at The Minerals, Metals and Materials Society (TMS) Annual Conference in San Diego, CA in March 2011. For summer 2011 REU, 8 students (4 women, 1 underrepresented minority and 1 student with a declared disability) have registered. Successful recruitment of high-quality REU students from diverse backgrounds is a key accomplishment.
- Significant progress was made in the Materials Science Education Research program. This program entailed identifying student difficulties (*e.g.,* misconceptions) in learning introductory materials science (583 undergraduates participating). Instruction was modified to target specific misconceptions, resulting in measurable improvement in student exam scores. This work was presented at the American Society for Engineering Education conference (2010).
- A high school materials science course has been developed and is being taught at Columbus Metro Early College High School (Ohio's flagship STEM high school), partially supported by the CEM. Class enrollment is 19 (5 female and 9 from underrepresented minority groups). CEM was involved in ASM Materials Camps for Teachers held at OSU, which provides high school teachers with training on materials science-related laboratory activities and projects. The Basic Camp was attended by 17 teachers. A new Advanced Camp was offered a third time and was attended by 31 teachers. Three Camp alumni have already offered the materials science course, and 6 more are offering it during 2010-2011.
- CEM outreach activities have focused primarily on a collaboration with Arlington Park Elementary (greater than 90% underrepresented minority and free/reduced lunch) in the Columbus City School District. Graduate and undergraduate student volunteers work with teachers and program coordinators to develop inquiry-based lessons and teach them to the students.
- The CEM formed a unique partnership with NSF-funded Ohio STEM Ability Alliance, with the goal of increasing the number of students with disabilities who enter STEM careers. Additionally the CEM has connected with the AAAS EntryPoint program, a program that offers internship opportunities for students with apparent and non-apparent disabilities and successfully recruited a summer 2011 REU student.

Collaborations and International Alliances

CEM members have established collaborations with 65 individuals from universities, national laboratories, and industry. This includes 22 international collaborators from Australia, Canada, China, Czech Republic, Finland, Germany, India, Israel, the Netherlands, Spain, Sweden, and the United Kingdom. Most notably, a significant alliance between Leibniz Institute (IFW, Dresden, Germany) and the CEM has been established. The collaborations are primarily driven by common intellectual pursuits and complementary expertise/ facilities. The CEM has established industrial collaborations with three companies: Lakeshore Cryotronics, Traycer Diagnostics, and IBM Yorktown Heights.

International Materials Research Alliance (IMRA)

The CEM has established a vibrant collaborative interaction with the Leibniz Institute for Solid State Research (IFW), Dresden, Germany that is 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 institutions. These interactions have been strengthened at the institutional level by a workshop held in August 23-25, 2010 in Dresden, Germany. This workshop involved 25 CEM faculty and, critically, graduate students who traveled to Dresden and a similar number of IFW counterparts. A complementary workshop is scheduled to take place at OSU in Columbus on November 6-9, 2011. This will allow IFW researchers to visit OSU and better understand the science and capabilities of OSU researchers and provide opportunities to germinate new collaborations. Given the success of the initial workshop, both centers are eager to make this a regular, continuing event. This international materials research alliance provides a new and powerful avenue for making optimum use of complementary, high-performance science communities, and is generating a high level of involvement within the two international institutions.

Wright Center for Photovoltaic Innovation and Commercialization (PVIC)

Funding Agency: Ohio Department of Development

Principal Investigators: PI: Robert J. Davis, Co-PIs: Paul Berger, Malcolm Chisholm, Arthur Epstein, Joseph Heremans, Nitin Padture, Steven Ringel

Duration: 2/16/2007 – 11/30/2011

Amount: $18.3 million total ($6.8 million to Ohio State) and $30M in cost sharing from Ohio industries and participating universities

Description: IMR's first major sponsored project award created the current Wright Center in solar energy – the Wright Center for Photovoltaics Innovation and Commercialization - which is co-directed with the University of Toledo. PVIC was established in early 2007 through an $18.6 million award from the Ohio Department of Development, along with matching contributions of $30 million from universities, federal agencies, and industrial collaborators. PVIC is a scientific partnership of the University of Toledo, Bowling Green State University, and The Ohio State University, and more than 25 Ohio-based companies engaged in various aspects of photovoltaics technology. PVIC has a primary goal of enabling Ohio to become the nation's leader in photovoltaics research, development and commercialization. The overall PVIC mission is to accelerate the photovoltaic (PV) industry in Ohio by reducing solar costs, improving technologies, and transferring these new techniques from the laboratory to the production line. The OSU/IMR node of PVIC has a specific focus on so-called 3rd generation photovoltaics, which inherently involves advanced materials and nanotechnology using both inorganic and organic materials. Primary thrust areas are multijunction solar cells, heterogeneous integration of high efficiency PV with low cost platforms, nanostructured solar cells, polymer photovoltaics and basic optical-thermal processes. IMR administers the Ohio State University PVIC site and IMR Associate Director Dr. Robert J. Davis serves as the Principal Investigator of the OSU PVIC site.

Highlights and Accomplishments of PVIC for FY2011

The Ohio State University node of the Ohio Wright Center for Photovoltaics Innovation and Commercialization (PVIC) completed its fourth year in late February 2011. PVIC continues to support nine OSU co-PIs in photovoltaics-research areas, invests in capital equipment (predominantly at the OSU Nanotech West Lab), and fosters academic-industrial collaborations in the photovoltaics arena. PVIC is funded in total by $18.6M in Ohio Third Frontier Program direct support, plus over $29M in matching funds and activities from its numerous members. The two primary nodes of activity are at the University of Toledo (with Bowling Green State University considered part of that node), at Ohio State. A strong feature of the PVIC-OSU effort is the technological range of 3rd generation PV activities it includes, ranging from

Replex Plastics' employees Kara Shell and Scott Brown install a prototype 7x low-concentration photovoltaics system in Athens, Ohio in November 2010. The system, based on silicon PV cells and acrylic/aluminum compound parabolic concentrators, also includes advanced DuPont® ionomers as encapsulant materials. The project is led by Replex Plastics of Mt. Vernon, Ohio and includes collaborations with OSU PVIC Director and IMR Associate Director Robert Davis, Dovetail Solar and Wind of Athens, Ohio, and most recently Prof. Roger French of Case Western Reserve University. For performance comparison, two commercial unconcentrated silicon solar panels (right) were included on the tracker.

compound semiconductors (Steven A. Ringel, Bob Davis, John Carlin, Siddharth Rajan, Roberto Myers) to polymeric photovoltaics (Malcolm Chisholm, Arthur Epstein, Paul Berger, Terry Gustafson), through novel and nanostructured materials (Nitin Padture, Joseph Heremans), and PV systems (Bob Davis), a span that ranges from Electrical Engineering, Materials Science and Engineering, and Mechanical Engineering, to Chemistry and Physics.

PVIC-OSU once again enjoyed the results of the Ohio Third Frontier Program Advanced Photovoltaics Program competition in late January 2011, when four of the five new program awards involved PVIC/IMR members. Energy Focus (Solon, OH) was awarded a $1M program to develop a solar-powered off-grid lighting system in conjunction with the III-V/Si solar technology being developed by the Ringel group. GreenField Solar (Oberlin, OH) was awarded a $1M program for cost-reduction efforts targeting their concentrated PV (CPV) system designs, including OSU and the Edison Welding Institute (Columbus, OH). Process Technology (Mentor, OH) was awarded a $357k program to develop a pure process water heater for PV and semiconductor process applications; the alpha version of the system is planned to be tested at the OSU Nanotech West Lab as part of the program. Finally, PVIC-OSU supported a $900k winning proposal for mirror -augmented photovoltaics by Case Western Reserve University and Replex Plastics (Mt. Vernon, OH) as an extension of its collaboration with Replex in other programs, in an unfunded partnership.

In FY11 other new Third Frontier programs with PVIC-OSU as a collaborator continued. A collaboration of Ferro, Inc. (Cleveland, OH), StrateNexus Inc. (Columbus, OH), the Edison Welding Institute (Columbus, OH) and Ohio State (Prof. Paul Berger) continued their efforts to develop new encapsulants and sealing strategies for a wide variety of photovoltaic devices and modules. A collaboration of Replex, Dovetail Solar and Wind (Athens, OH), and Ohio State (through Dr. Robert Davis, PVIC Co-Director, Nanotech West Director, and IMR Associate Director) constructed and tested their first (Gen 1) low-concentration photovoltaic system based on compound parabolic concentrators (see below). In FY11 this collaboration expanded to include a growing

effort at Case Western Reserve University. **Table 1** summarizes the considerable number of industry-relevant secondary funding emanating from the PVIC activities and members. A key goal of the IMR is to dominate the State's PV investment portfolio, particularly by assisting commercial development via connecting faculty innovations to interested industry partners, leveraging the facilities at Nanotech West Laboratory and PVIC.

Title	Collaborators	Agency	Duration and Amount	Relation to IMR
Low Cost Concentrated Photovoltaic (CPV) Design	GreenField Solar Corporation, Edison Welding Institute, OSU (R. Davis)	Ohio Department of Development Third Frontier Photovoltaics Program	$1,000,000/2 years ($50,000/2 years to OSU)	Based partly on IMR-PVIC project; requires IMR/NTWest/PVIC facilities; PI is IMR staff member
High Efficiency Photovoltaic Enabled Off-Grid System	Energy Focus, Inc. and OSU (S. Ringel)	Ohio Department of Development Third Frontier Photovoltaics Program	$1,000,000/2 years ($345,000/2 years to OSU)	Based partly on IMR-PVIC project; requires IMR/NTWest/PVIC facilities; PI is IMR staff member
Commercialization of Inline Heater for Use in Photovoltaic Solar Cell Manufacturing	Process Technology and OSU (R. Davis)	Ohio Department of Development Third Frontier Photovoltaics Program	$357,000/2 years (OSU Nanotech West Lab will receive user fee income from project)	Based partly on IMR-PVIC project; requires IMR/NTWest/PVIC facilities; PI is IMR staff member
Sealing Systems for Solar Cells	Ferro, Inc., StrateNexus Inc., Edison Welding Institute and Ohio State (P. Berger)	Ohio Department of Development Third Frontier Photovoltaics Program	$1,000,000/2 years ($270,000/2 years to OSU)	Based partly on IMR-PVIC project; requires IMR/NTWest/PVIC facilities; Davis serves on project Advisory Board
Low-Cost Concentrated Photovoltaics	Replex Plastics, Dovetail Solar and Wind, and Ohio State (R. Davis)	Ohio Department of Development Third Frontier Photovoltaics Program	$1,257,500/2 years ($357,500/2 years to OSU)	Based partly on IMR-PVIC project; requires IMR/NTWest/PVIC facilities; PI is IMR staff member
Mirror-Augmented photovoltaics	Case Western Reserve University and Replex Plastics	Ohio Department of Development Third Frontier Photovoltaics Program	$900,000/2 years	R. Davis of OSU is an unfunded collaborator; project is closely related to Replex/Dovetail/OSU project above

Table 1: External Funding Resulting from PVIC Activities and Members

OSU-PVIC Technical Highlights To Date

Selected OSU research technical highlights from the PVIC program include:

- Demonstration of advanced polymeric photovoltaic devices based on P3HT:PCBM materials and with silver nanodot-enhanced absorption
- First low defect density 1.7 eV/1.1 eV metamorphic GaAsP/Si structure developed; possesses ideal

bandgap distribution for maximum 2J PV conversion, on inexpensive substrate

- 2 eV bandgap III-V PV material achieved without needing problematic Al- or N-containing alloys to achieve an internally lattice-matched high bandgap top cell for integration with GaAsP/Si for ideal 3J PV cells on low-cost Si
- Metamorphic GaInP shown to have superior resistance to radiation in space PV environment that lattice matched counterparts– may lead to improved space PV survivability and performance
- New growth regime for GaP established by both MBE and MOCVD – enables transition from research to industry-compatible epitaxy platform
- Development of metalorganic polymer materials based on Mo, W, and Ti that have absorption across the entire visible solar spectrum
- Development of new thallium-doped PbTe thermoelectric materials that double thermoelectric response compared to their undoped counterparts
- Observation of anomalous magnetoresistance in polymeric materials that may be beneficial to future photovoltaic devices
- Demonstration and initial results from a prototype low-concentration PV system

Membership, Funding, and Meetings

At the end of FY11, twenty-four companies and seven not-for-profits were PVIC members. In January 2011 the Ohio Department of Development granted the PVIC program a no-cost extension (NCE) to the program, through the end of November 2011, for the three University members to complete spending of their funds.

Table 2 below contains a list of PVIC members as of the end of FY11, and the primary node (Ohio State or U. Toledo) to which they are affiliated. Note that a few PVIC members choose not to have their membership status publicly listed.

With the help of IMR staff PVIC-OSU hosted the semi-annual meeting of PVIC in May 2011, attracting approximately 60 participants, predominantly from industry. As a result of a significant discussion at that meeting, PVIC-OSU is planning to host an industry-focused meeting on Solar Durability of Materials in late September of 2011, with the help of Alex Kawczak of StrateNexus Technologies (Dublin, OH) in forming the agenda and inviting national-level speakers.

In early FY12 considerable discussion will be devoted to the role of PVIC after its initial funding has expired. Industrial members generally agree that PVIC has filled two important roles; first, the acquisition and subsequent availability of PV-related process and metrology equipment at user facilities; and second, the emergence of PVIC meetings as important networking and informational opportunities for industrial PV activities in Ohio. Continuation and possible expansion of the number of PVIC meetings and workshops will likely occur in FY12, and PVIC academic collaborations will expand to include new solar-related materials research activities at Case Western Reserve.

PVIC Member	Ohio Location	Primary Affiliation	Main Activity
The Ohio State University	Columbus	--	University research and industrial outreach
University of Toledo	Toledo	--	University research and industrial outreach
Bowling Green State University	Bowling Green	UT	University research
Battelle Memorial Institute	Columbus	OSU	Alternative energy systems
Edison Materials Technology Center (EMTEC)	Dayton	UT/OSU	Alternative energy systems design
Green Energy Ohio	Columbus	UT/OSU	Alternative energy policy
Honda Research Partnership	Columbus	OSU	Alternative energy for transportation
Advanced Distributed Generation	Toledo	UT	PV installer
Calyxo Inc.	Perrysburg	UT	PV module manufacture
Cornerstone Research Group	Dayton	UT/OSU	Advanced PV device designs
Decker Homes	Lambertville (MI)	UT/OSU	Energy-efficient home construction
DuPont Inc.	Circleville	UT/OSU	Backsheet and other materials for PV modules
Ferro Electronic Material Systems	Independence	UT/OSU	Advanced materials for PV
Lake Shore Cryotronics	Westerville	OSU	Sensor power and sensor materials development
Marshall and Melhorn LLC	Toledo	UT	Public policy and legal issues in alternative energy
MetaMateria Technologies	Columbus	OSU	Materials in PV and advanced energy
Owens-Corning Inc.	Granville	UT/OSU	PV for roof systems
Natcore Solar (formerly NewCyte),	Oberlin	OSU	Advanced AR coatings and nanostructured materials for PV
Nippon Sheet Glass (formerly Pilkington)	Toledo	UT/OSU	Glass for PV
PPG Industries	Numerous locations	UT/OSU	Glass for PV
Plasma Si Inc.	Toledo	UT	Materials for PV
Replex Plastics	Mt. Vernon	OSU	Low-cost PV systems development
Solar Spectrum LLC, Toledo OH	Toledo	UT	Materials for PV
SSOE Group, numerous OH locations	Numerous locations	UT/OSU	Energy-efficient architecture and building design
Tosoh SMD Inc.	Columbus	OSU	PV materials
Willard and Kelsey Solar Group	Perrysburg	UT	CdTe panel manufacture
Xunlight Corporation	Toledo	UT	a-SiGe:H panel manufacture
Xunlight 26	Toledo	UT	CdTe on polymer technology development

Table 2: PVIC Membership List at End of FY11. (Note that a few PVIC members choose not to have their membership status publicly listed)

Major Capital Investments

As of early July 2011, PVIC-OSU has invested more than $3M in capital equipment at Ohio State, predominantly at the OSU Nanotech West Lab. While these investments have been made with PV foremost in mind, however, they have also always been made in consideration of the support of a wide spectrum of materials-related technologies and programs, and that strategy has been extremely successful. **Table 3** below lists the main PVIC-funded capital investments made at Nanotech West during the program, their direct utility to photovoltaic device fabrication, and also examples of uses of the tools by other technologies.

Capability	PV Uses	Other Uses (examples)
Picosun® SunALE R-150 atomic layer deposition tool	Deposition of electrical passivation and anti-reflective coatings	Passivation of high-speed transistors, depositions of gate dielectrics and spin-tunneling devices
Zeiss® Ultra 55 Plus field emission scanning electron microscope	Imaging of nanostructured materials for PV and DSSC devices	Imaging of nanostructures for electronics, optics, biology, and materials science
Aixtron® 3x2" metalorganic chemical vapor deposition system	Growth of single, tandem, and triple-junction solar cells based on III-V materials	Growth of epitaxial III-V structures for visible and IR photodetectors, high-speed transistors, and nanowires for basic sciences
AJA International® 5-gun RF/DC sputter deposition system	Deposition of high-quality metallizations for ohmic contacts	Sputter deposition of metallizations for magnetic and non-magnetic devices, dielectric depositions for optical waveguides and MEMs
CHA® Solution Systems 6-pocket electron gun evaporator	High-quality ohmic contacts to crystalline PV cells	High-quality contacts to transistors, semiconductor photodetectors, sensors, and lasers
Plasma-Therm SLR770 inductively-coupled plasma reactive ion etcher	Mesa etching for silicon and III-V compound semiconductor photovoltaics	Low-damage dry etching for III-V and III-N electronics and electrooptics, dielectric optical waveguides, and materials test structures

Table 3. Major PVIC Tool Investments at Nanotech West

In FY11, PVIC-OSU also purchased a J.A. Woollam alpha-SE spectroscopic ellipsometer, currently located in Bay 3 of the Nanotech West Lab. Capital plans for PVIC-OSU with the remainder of its funding include a plasma-enhanced chemical vapor deposition (PE-CVD) tool for oxides and nitrides, an advanced silicon drift detector (SDD) for the Zeiss FESEM for materials analysis, a dicing saw, and a plasma asher.

Nanoscale Science and Engineering Center for Affordable Nanoengineering of Polymer Biomedical Devices - CANPBD

Funding Agency: National Science Foundation – NSEC (Nanoscale Science and Engineering Center) Program

Principal Investigators: PI: L. James Lee, Co-PIs: Jeffrey Chalmers, Terrence Conlisk, John Lannutti, Robert J. Lee, Susan Olesik and Barbara Wyslouzil

Duration: 09/01/2004 – 09/30/2014

Amount: $25,716,460

Description: The primary goal of the Center for Affordable Nanoengineering of Polymeric Biomedical Devices (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. Although challenging, this goal provides opportunities for scientific breakthroughs, cutting edge technologies and novel interdisciplinary system integration. Fundamental science and engineering is one of the major foci of

our center. In Phase I, which ended in 2009, many useful nanotechnologies, devices and nanoconstructs have been developed. Each has specific merits and value-added capabilities providing for near-term applications. Following this success, a nanotechnology pipeline for Phase II has been initiated to address the need for (1) 'up-stream' fundamental science, (2) high risk technologies meeting long-term research objectives, and (3) 'down-stream' devices and nanoconstructs requiring integrated system-level effort. In addition to NSF NSEC funding, we will also pursue leverage grants from NSF SBIR/STTR, other funding agencies (e.g. NIH, Ohio Third Frontier Program), and industry through joint proposals and CANPBD spin-off companies. Joint industry/academia/government opportunities provide not only commercialization pathways but also a 'blueprint' for a business plan providing center sustainability after Phase II funding ends.

Highlights and Accomplishments of CANPBD for FY2011

In the past year, Center for Affordable Nanoengineering of Polymeric Biomedical Devices (CANPBD) faculty and students made significant progress in research. Our faculty and students published 135 technical papers (100 in technical journals and 35 in conference proceedings), 5 patents were filed, 1 patent was awarded, and 4 inventions were disclosed. The research program and industrial collaborations are strongly enhanced by approximately $0.72M in support from the Ohio Department of Development, being used to obtain state-of-the-art new equipment items in nanomachining, nanoscale polymer processing, nanobio characterization and manipulation, and micro/nanofluidic analysis in a centralized location, IMR's Nanotech West Laboratory. A "supply chain" is growing, linking CANPBD with nearby national laboratories, major centers at OSU such as the Comprehensive Cancer Center, and the biotech industry. Results from several past testbeds have gained strong interest from industry and are in the process of early phase commercialization. To further bridge the development of new nanomaterials and nanoscale devices in the Center to biomedical and other applications, CANPBD works closely with medical doctors and industry through joint research projects and student and post-doctoral fellow internships.

The interconnections among fundamental sciences, technology innovations and medical applications of our research plan in Phase II are organized into two nanofactory systems, ACBA with four inter-connected subgroups- (1) Optical tweezers based ACBA, (2) Magnetic tweezers based ACBA, (3) Nanofibers based cell sorting, (4) Label-free bio detection, and MNDS with two inter-connected subgroups- (1) Nanoparticle chemistry and Nanoparticle engineering. All subgroups share similar nanotechnologies and nanomaterials, while the optical tweezers and magnetic tweezers provide complementary ACBA platforms to address a broad range of biomedical needs. To realize this goal, system level challenges and technical barriers are addressed through team efforts using the SIMILAR system integration process and the Risk Management approach. A brief summary of major research accomplishments in the two nanofactory systems and our center-level system integration efforts during the last reporting period of Phase II are introduced here.

Optical Tweezers-Based ACBA

For the Optical tweezers based ACBA, we have successfully demonstrated a prototype ACBA system consisting of an antibody array for capturing targeted cells in a cell mixture and an innovative nanochannel electroporation (NEP) device for injecting molecular beacons (MBs) to detect the targeted mRNA biomarkers inside the captured living cells. The two are integrated on a low-cost optical tweezers platform for cell manipulation. NEP is realized by a low-cost DNA Combing and Imprinting (DCI) process recently invented in our center to produce polymer microchannel-nanochannel-microchannel arrays on large surface areas. Using an automated dip coating process and a layer-by-layer approach, we are now able to produce DCI

chips with a successful rate of >90% nanochannels from <5 to >200 nm diameter covering an area larger than 1 cm2. This is 3-4 times better than the yield produced from the original manual process. The current ACBA system has satisfied our Level 1 technical metrics requirements for system integration. We are now working towards Level 2 and Level 3 technical metrics, i.e. to sort out ~10 targeted cancer cells from a mixture of greater than 30,000 cells and to achieve the detection of one or two targeted microRNA at the single cell level with a user friendly and low-cost ACBA system. To achieve these goals, a high-resolution cell sorting technology based on a novel immunoliposome nanoparticle array design is being tested. We are also designing a new molecular probe, locked nucleic acid based molecular beacon (LNA-MB) to carry out the in situ microRNA detection in individual living cells using NEP. For higher detection sensitivity and multiple detections inside a single cell, a quantum dot mediated fluorescence resonance energy transfer (Qdot-FRET) technology is also under development. In addition, a micro-lens array will be developed to facilitate cell manipulation and a comprehensive and automated DCI process is being developed.

Magnetic Tweezers-Based ACBA

For the Magnetic tweezers based ACBA, we have demonstrated that cells can be rapidly (within seconds) conjugated to labeled magnetic beads on a microarray platform of Permalloy (NiFe) disks. The labeled cells are then introduced into a microfluidic channel with an embedded array of zigzag FeCo wires or circular NiFe disks whose highly localized, permanent magnetic field gradients have been used to separate labeled cells from unlabeled ones. This separation is achieved through directed magnetic forces by combining externally controlled programmable weak (~60 Oe) fields with the magnetic fields originating from the surface patterned wires or disks. In order to interrogate the sorted cells, we have shown that individual magnetically labeled cells can be introduced into an ionic droplet and transported for further interrogation. We are now advancing to the next level of achieving our ultimate metric of sorting out ~10 targeted cancer cells from a mixture of about 30,000 cells and to subsequently detect one to five targeted microRNAs at the single cell level with a biocompatible and low-cost magnetic tweezers based system.

In order to achieve more efficient cell labeling within the “on-chip” ACBA platform, we are developing a microfluidic “cell-labeler” that directly links to the magnetic separation stage. In this labeling stage, magnetic polymeric beads labeled with specific antibodies are introduced, along with a parallel input of the mixture of cells, to a designed central channel that promotes nanointerfacial folding for enhanced labeling. An attractive feature of this approach is its direct integration to the magnetic traps/ tweezers stage where both, positive or negative, selection can be promoted during separation. In the third distinct stage of this ACBA platform, label-free microRNA detection will enable evaluating the biochemical character within the captured cells to enable diagnosis and treatment of tumors that are linked to the source of the cancer cells. The detection is being advanced through two parallel approaches - electrical impedance spectroscopy and nanowire charge sensor based arrays. The experimental work on the different platform stages is supported by modeling and simulations related to microfluidic flow and droplet formation.

Nanofibers Based Cell Sorting

For Nanofibers based cell sorting, we have established a comprehensive electrospun fiber process producing highly aligned nanofiber capable of guiding the motion of migrating metastatic tumor cells. Based on this success, we have utilized this biological phenomenon to create “migrational chromatography,” or a sorting technique based purely on a cellular behavior rather than biomarker analysis. While the latter is very valuable both in our Center and in biomedicine as a whole, the combination of biomarkers predicting metastasis remains a distant goal. As a natural complement to this thrust, we have relevant fiber technologies involving core-shell-based fiber modulus variations, highly aligned fiber, oxygen-sensing fibers

and nanoporous fibers all of which can be used to enhance the overall function and value of migrational chromatography. Close collaboration with femtosecond laser machining continues to allow us to locally structure the fiber and this is critical to the construction of defined arrays presenting parallel "stopping points" at which the cells can be removed from the array. Both the upstream (cell seeding) and downstream (cell removal) have been considered utilizing a combination of microfluidics and optical or magnetic tweezer technologies from the ACBA systems. Efficient local control of oxygen tension requires the investigation of different types of hemoglobin (human, bovine and earthworm) to determine which regulates tension with the greatest efficiency.

This novel "cell race track" technology requires that we learn to guide the cells to achieve separation as quickly and efficiently as possible. This will require localized dispersions of chemoattractants to 'lure' the cells to the end of the array rather than wait for the otherwise random walk nature of their motion to transport them there. Key to this will be the use of supercritical/subcritical fluids, as a means of infusing bioactive molecules into the polymeric nanofiber at defined locations such that these infused depositions guide the cells at the appropriate locations. An additional technology is localized electroosmotic delivery that could induce a well-characterized gradient of chemoattractants. Once at the end of the array, we will utilize a combination of polymeric surfaces and surface treatments to decrease cell adhesion allowing easy removal of cells from these surfaces. In addition, we plan to utilize localized electroosmotic delivery of trypsin or collagenase to decrease cell adhesion for these surfaces.

Label-Free Biomolecule Detection

For Label-free Biomolecule Detection, we have made progress in developing and evaluating promising alternative technologies for enhanced detection of target miRs that can be incorporated into the third stage of either ACBA system. These alternative technologies are: electrochemiluminescence (ECL), ion transport through functionalized DNA nanostrand arrays, electrochemical impedance spectroscopy (EIS) through bio-hybrid nanopores, and the capture and profiling of miR-containing cell-secreted microvesicles. During this reporting period, key components of the ECL detector were assembled, and cyclic voltammetric data on the detection of guanine acquired to provide benchmark data on current sensitivity and the detection limit of the device. Optimization of operating conditions, supporting ionic polymer, and surface catalysts are currently under study. In label-free biomolecule detection using functionalized DNA nanostrand arrays, we have fabricated inexpensive sensors using our in-house DNA Combing and Imprinting (DCI) process, and have demonstrated the feasibility of this device for detecting DNA/RNA sequences comparable in chain length to miRs. Further modification and calibration of the device for low DNA/RNA concentrations are ongoing. In collaboration with our modeling group, we have used molecular simulations to predict the characteristics of ion and solvent transport in polymer nanopores containing aligned DNA detection methods, and defined experimentally accessible targets for measured ion currents. Further molecular simulation studies will treat explicitly the biotin-streptavidin complexes for conjugating probe oligonucleotides to the DNA strands. Research accomplishments in EIS using bio-hybrid nanopores include successful fabrication and the testing of devices consisting of tethered bilayer lipid membranes (tBLMs) anchored to pre-designed silicon-based nanopore arrays. Different nanopore diameters and spacings were tested to find optimal configurations that yield stable, reproducible EI spectra, and to demonstrate the feasibility of this bio-hybrid detection system design. Further testing of the reusability and improving performance by incorporating alpha-hemolysin nanopores are planned in the upcoming year. In collaboration with our modeling group, we have built molecular structures of the different components of the tBLM system in order to study the dielectric properties/conductivity as a function of the system structure. Modeling goals in the upcoming year are to complete construction of the composite system and carry out molecular simulation to study the effects of transitions in tBLM structure from densely packed to loosely packed structures. In our work to selectively

capture miR-containing cell-secreted microvesicles (MVs) and detect the miR content of specific sub-populations of these MVs, we have selectively captured the cancer-specific MV sub-populations of interest on antibody microarrays, and have also characterized this sub-population based on MV size, size distribution, and morphology. In addition, we have shown that miRs contained in MVs secreted from the cancer cells can be distinguished from those in MVs secreted from the non-malignant cells, suggesting that measuring the miR content of cell-secreted MVs may enhance the sensitivity of miR detection compared to detecting miRs expression levels within the parent cells. High-throughput microarray screening assays are now underway to identify a large library of capture molecules selective for miR-containing cancer-specific MVs. Further characterization and the isolation/purification of miR-containing Mvs as a function of cell source and cell state, and by inducing secretion from specific cell types using external stimuli are planned in the upcoming year.

MNDS System

For MNDS system, significant progress was made in both the chemistry and engineering aspects. New cationic lipids and co-lipids were developed which has shown superb siRNA transfection activity both in vitro and in vivo. Novel methods have been developed, based on molecular beacon and QDot-FRET, to study the intracellular trafficking of nanoparticles. On engineering, microfluidics has been integrated with electrospray for nanoparticle synthesis. In addition, a microwell-nanochannel array has been explored to synthesize multifunctional nanoparticles in a highly controlled manner. We plan to further integrate innovations in chemistry with engineering, together with intracellular mechanistic findings, to determine the structure-function relationships related to multifunctional nanoparticles and enable rationale design of the nanoparticles.

Commercialization Efforts

A key to eventually realizing the commercialization of nanoengineered biomedical devices is engaging in industry-recognized systems engineering processes for the three platforms that are being integrated (ACBA I, ACBA II and MNDS) early enough in the development process so that key technical risks are retired and interface issues resolved by the end of NSEC Phase II. This approach should facilitate the next phase of investment (e.g. NIH Center) to allow further development of these platforms.

There are three systems engineering processes in which we have been engaged in 2011 that will allow system integration to proceed in a structured way that reduces programmatic risk: Requirements Management, Risk Management and System Integration Planning. For ACBA II, we have made significant progress towards three documents that are work outputs of these processes: System and Subsystem Requirements Specifications, a Risk Management Plan and a System Integration Plan. By the end of 2011, we plan to have all 3 of these processes operational across all 3 integration platforms.

Education and Outreach

We have also made good progress in teaching, training, outreach and diversity in the past year. In addition to the ongoing three graduate core courses, CANPBD has continued to offer and update 26 courses and on-line modules. Through these course developments, the core of an undergraduate minor and graduate certificate in nanobiotechnology continues to be processed as a new option when OSU converts to semester in 2012. The graduate fellows of CANPBD continue to participate through a student organization (CONGS) to

better integrate the student researchers and provide a social fabric for the center. Outreach to K-12 reached over 385 students and 29 teachers in the past year through visits to center laboratories and the teacher workshop. In diversity, we report continuing growth in the number of underrepresented faculty and student participants in the past year, such that the Center now compares favorably with national averages in nearly every measure. As part of our diversity plan, we continue to work to: establish a cultural change that promotes, encourages, and integrates a positive image with respect to diversity; recruit and retain members of underrepresented groups to improve their representation among undergraduates, graduate students, and faculty; and in cooperation with academic departments increase the number of underrepresented faculty members by hiring at least 50% of the new faculty each year from these groups and continue to develop programs to retain them.

Research Scholars Cluster on Technology-Enabling and Emergent Materials (TEEM)

Funding Agency: Ohio Department of Development

Principal Investigators: PI: Steven Ringel, Co-PIs: Jeffery McNeal, Steven Slack, Gregory Washington

Duration: 8/18/2009 – 8/17/2013

Amount: $18,153,846 ($8,953,846 to Ohio State) and cost share of $17.2 million

Description: IMR is the lead organization for a state-wide materials program funded by the State, the $18.1M Ohio Research Scholars Program (ORSP) award entitled Technology-Enabling and Emergent Materials - TEEM. This award creates a university coalition consisting of The Ohio State University, the University of Akron and the University of Dayton and funds are for creation and support of five endowed chairs with the title of Ohio Research Scholar – three at OSU and one each at the University of Akron and the University of Dayton. IMR Director Steven Ringel serves as that award's Principal Investigator and IMR performs all program management and research administration for the award.

The technical goal of this program through targeted faculty hiring 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. By targeting the Scholars positions toward advanced microscopy, including applications toward biomaterials, chemical synthesis from bio-based sources, and scalable processing based on nanostructure-enhanced composite and also bio-based materials, this unique cluster aims to build upon and coordinate strategic strengths existing at the partnered universities in areas of international impact. A prime area of focus is the exploration and development of innovative materials that possess tailored functionalities and are derived from nontraditional (including bio-based) sources, with the state's universities and industries being the prime beneficiaries. IMR has established a *Materials Innovation Council* that includes leaders from the three state universities and a wide range of industry leaders and other state-supported industrial consortia, in order to maintain alignment and communications up and down the value-chain from basic science to commercialization, which is chaired by the P.I., Steven A. Ringel, IMR Director.

Highlights and Accomplishments of the TEEM ORSP for FY2011

Major progress has been made this fiscal year in the successful recruitment of four of the five Ohio Research Scholars positions funded by this award. As shown in **Figure 3**, the first two Ohio Research Scholars joined

the faculty of their universities this past academic year, with two more committed to starting in Fall 2011. An active search is underway for the fifth and final ORS position, based in OSU's departments of Chemistry and Biochemistry, and the search has progressed this year with several candidates visiting OSU's Columbus campus to meet with department faculty and key ORSP contacts.

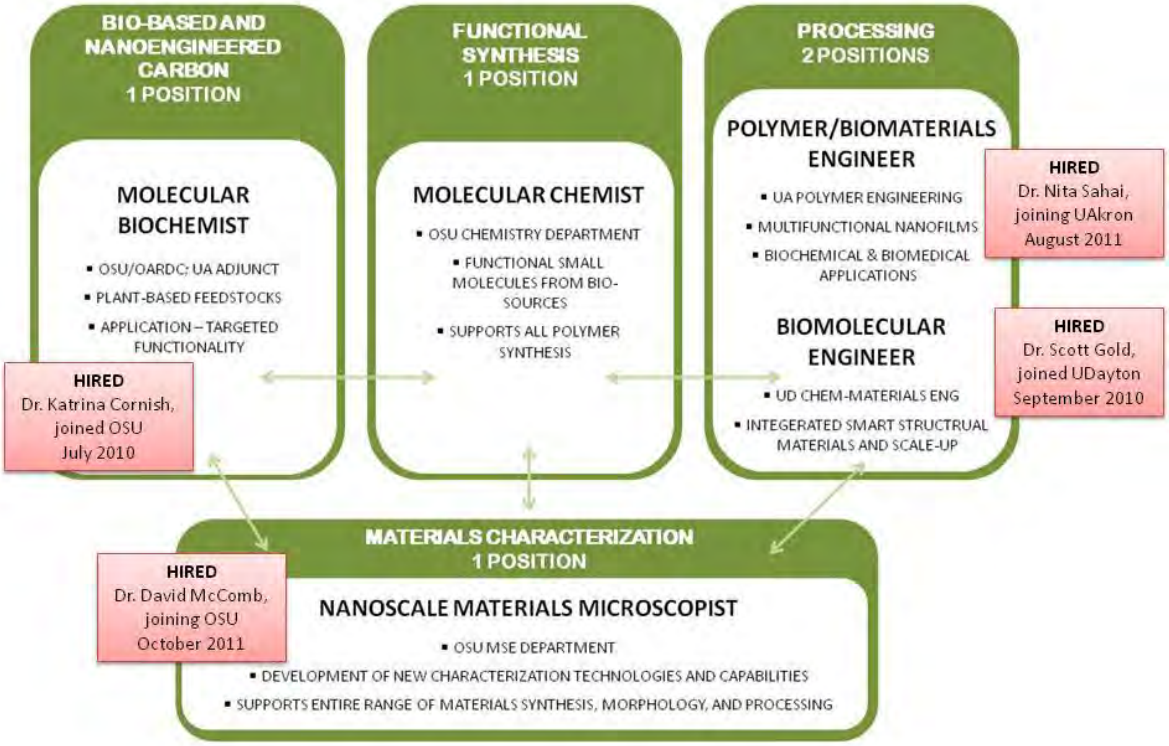


Figure 3. Update on the hiring of Technology-Enabling and Emergent Materials Award's Ohio Research Scholars and their interactions across three Ohio universities.

Of particular note is the planned creation of a new state-of-the-art research facility, the Center for Electron Microscopy and AnalysiS (CEMAS), directly tied to the successful recruitment of Dr. David McComb, who will join OSU as an Ohio Research Scholar in Nanoscale Materials Characterization in October 2011. Details about Dr. McComb's background and research expertise, the new CEMAS, and the two Ohio Research Scholars who joined this research cluster this fiscal year are below.

Katrina Cornish, Ohio Research Scholar in Bio-based Emergent Materials

In Summer Quarter 2010, Dr. Katrina Cornish joined the faculty at OSU's Horticulture and Crop Science department as an Ohio Research Scholar in Bio-based Emergent Materials. Dr. Cornish is widely considered to be the leading U.S. scientific expert, and is internationally recognized as a principal authority, on alternative natural rubber production, properties and products, and on natural rubber biosynthesis in

general. Her research focuses on bioemergent materials including exploitation of opportunity feedstocks from agriculture and food processing wastes for value-added products and biofuels.

Dr. Cornish holds a joint appointment with the Department of Horticulture and Crop Science and the Department of Food, Agricultural and Biological Engineering. She leads a multidisciplinary team in the creation of innovative industrial materials from plant-based sources and associated biological, chemical and physical processes. She also trains new scientists and engineers for the emerging global bio-based economy. Dr. Cornish is based on the Wooster campus of the Ohio Agricultural Research and Development Center (OARDC) - which is the research arm of OSU's College of Food, Agriculture and Environmental Sciences and the largest university agricultural bioscience research facility in the United States.

The author of 145 scientific articles and patents, Cornish has also provided leadership for the development of new crop varieties, processing innovations, industrial and regulatory regulations and standards, clinical trials, and the creation of novel materials from hypoallergenic medical devices to termite-resistant building materials to biofuels. She has overseen several extramural research agreements with academia and the federal government in the United States, the European Union, Australia and southeast Asia.

Dr. Cornish worked with the US Department of Agriculture at its Western Regional Research Center in California, where she led the USDA's development of domestic natural rubber and rubber latex sources for over 15 years. Prior to joining OSU, she served as the Senior Vice President of Research and Development of Yulex Corporation. Her inventions at USDA were licensed by Yulex and form the foundation of the US domestic rubber industry by commercializing rubber and other industrial products made from guayule, a plant native to the southwestern United States. At Yulex, Dr. Cornish oversaw the company's ongoing research, development, production, validation and regulatory programs for the commercialization of guayule latex for safe medical devices and specialty consumer products, including extramural programs.

Scott Gold, Ohio Research Scholar in Multiscale Composites Processing, University of Dayton

During the Fall 2010 semester, the University of Dayton School of Engineering hired Dr. Scott Gold as an Associate Professor in chemical and materials engineering and Ohio Research Scholar in Multiscale Composites Processing. His research interests include surface chemistry and the development of novel nanostructured materials, with a focus on energy related applications. Gold's area of expertise is the processing of nanoscale materials and composites using surface tension, or how a liquid interacts with solid surfaces. Applications include the fabrication of nano-structured materials that can be used in electronic devices, batteries, fuel cells or composite materials. Dr. Gold is the owner of five inventions and the journal *Synthetic Metals* has profiled his work. For the past six years, Gold served in the chemical and nanosystems engineering programs at Louisiana Tech University. In 2008, he earned the College of Engineering and Science Outstanding Teacher award. Gold also led the development of online engineering courses and is a certified peer reviewer for online courses.

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

Dr. Nita Sahai will be joining the University of Akron during Fall 2011 semester 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. The unifying theme of this work is organic and inorganic interactions at mineral surfaces on the molecular- and nano-scale. 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. In order to determine thermodynamically feasible reactions and to identify kinetic reaction pathways, the group used theoretical modeling (quantum chemical-molecular orbital calculations and classical thermodynamics), aqueous analytical methods (ICP-OES, AA, etc.), spectroscopic and microscopic techniques to characterize solid, sorbed and aqueous phases (NMR, HRTEM, AFM, XAS) and thermochemistry (microcalorimetry). Dr. Sahai is a Fellow of the Mineralogical Society of America and was the recipient of a National Science Foundation CAREER Award.

David McComb, Ohio Research Scholar in Nanoscale Materials Characterization

In February, 2011, IMR and The Materials Science and Engineering department at The Ohio State University recently announced the successful recruitment of Professor David McComb, Professor of Nanomaterials, Imperial College London as the fourth of five total TEEM Ohio Research Scholars. Dr. McComb will join the OSU faculty on October 1, 2011 as an MSE Professor and Ohio Research Scholar in Nanoscale Materials Characterization. He will also direct the nascent Center for Electron Microscopy and AnalysiS (CEMAS) in conjunction with both IMR and the MSE department, described below. 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. 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.

As part of the plan to recruit Dr. McComb, IMR, along with the MSE Department, the College of Engineering, and OSU's central administration including the Office of Research, the Center for Electron Microscopy and AnalysiS (CEMAS) has been established, and will be directed by Dr. McComb. CEMAS which is currently in the planning stages, will move and combine the existing advanced microscopy assets within OSU's Center for the Accelerated Maturation of Materials (CAMM) and new facilities associated with the IMR's TEEM award, to create a unique, state-of-the-art structural characterization facility that centers around electron microscopy that will support characterization of structural, electronic and biological materials. CEMAS will be located in recently allocated space approximately 100 yards from Nanotech West Laboratory in the Kinnear Road west campus research complex, and will be jointly managed by IMR and MSE. The location of CEMAS within the West Campus research park is strategic since the location will encourage substantial industry interaction, and will leverage the large base of existing materials processing, fabrication and biomaterials capabilities at Nanotech West, next door. **Figure 4** shows an early draft of the CEMAS floor plan, which is being customized to accommodate the move of existing facilities now residing in Watts hall of the MSE department and the addition of new facilities to be procured via the IMR's ORSP award.

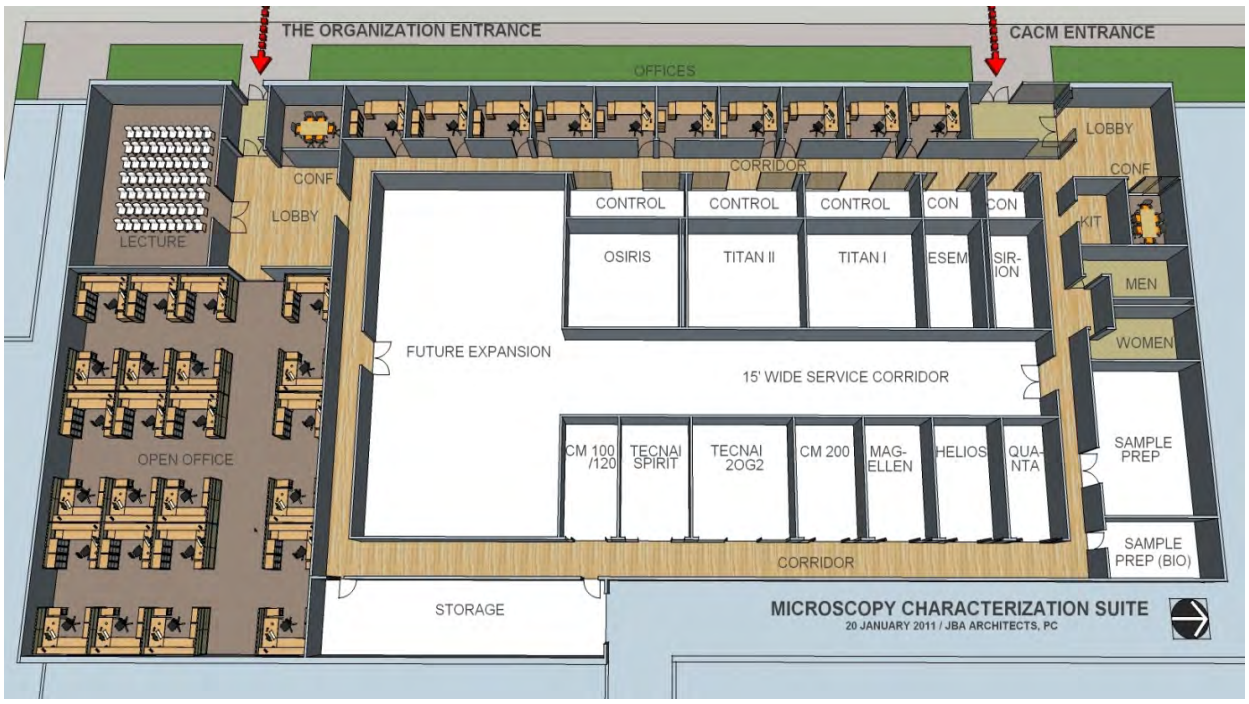


Figure 4. Draft floor plan of prime OSU West Campus space that will house the new Center for Electron Microscopy and AnalysiS (CEMAS) facility, serving as a center of excellence in microscopy characterization of advanced materials.

It is anticipated that CEMAS will become one of the world's finest and most unique advanced microscopy facilities and one that will facilitate the application of electron microscopy to incredible breadth of materials science, from biomaterials and bio-based materials, to nanoelectronics, energy materials and advanced structural materials. CEMAS will enable the entire research scholar cluster will advance beyond its already strong plan, since the facility will create an easy-access, user-based infrastructure for collaborative research and development where industries can be brought closely to the ORSP activities that are focused on explorative materials.

MRI: Acquisition of a Hybrid Diamond/III-N Synthesis Cluster Tool

Funding Agency: National Science Foundation

Principal Investigators: PI: Ezekiel Johnston-Halperin, Co-PIs: Siddharth Rajan, Roberto Myers, Harris Kagan, Steven A. Ringel, Fengyuan Yang

Duration: 08/01/2009 – 07/31/2011

Amount: $601,890 ($421,323 from NSF plus $180,576 cost share from The Ohio State University and Ohio Board of Regents Action Funds)

Description: Though not a block grant, we include this $601,890 NSF Major Research Instrumentation (MRI) award due to the strategic nature of this multi-user instrumentation and its joint location within 2 IMR-supported facilities housed in two colleges, and because it is a collaboration of 3 of the young, outstanding

faculty members who were recruited as part of the IMR's strategic faculty cluster hires in Materials Science and Engineering, Electrical and Computer Engineering and Physics.

Figure 5 shows a conceptual diagram of how the diamond synthesis tool and the customized ammonia molecular beam epitaxy (MBE) system acquired through this MRI interface with multiple research centers and groups. The locations of the systems within two IMR major user facilities, will allow for their long-term prosperity as core infrastructure resources. Because the acquisition enables a strong path forward for future collaborative and externally funded projects through a unique coupling of materials systems that many in the field are only now realizing may be possible, IMR provided significant funding for lab renovation so that the necessary equipment integration could be achieved. IMR also provided cash towards cost share for some of the equipment, and IMR is providing the necessary administration of all aspects of the grant itself. IMR looks to this effort to be one of several key paths forward for OSU leadership in the next generation of materials research.

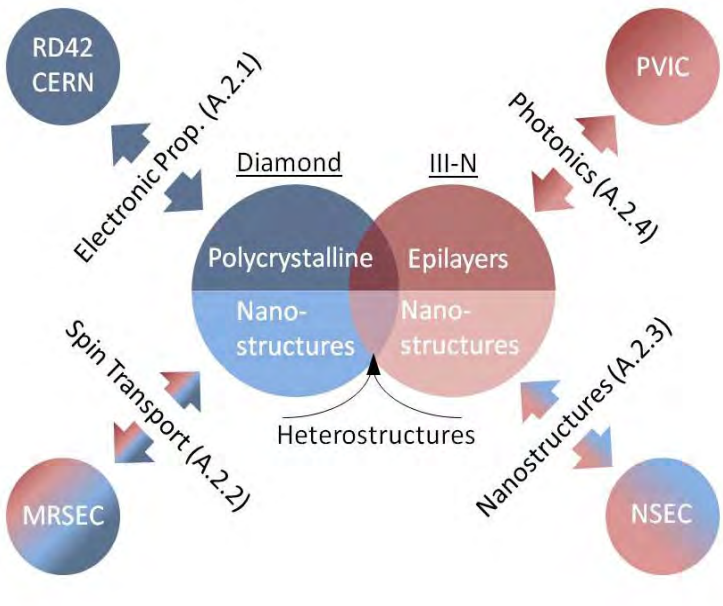


Figure 5. Diagram of how the new equipment acquisitions through the MRI integrate across various traditional disciplines and other interdisciplinary centers within the IMR purview, in addition to international collaborations.

Highlights and Accomplishments of the MRI for FY2011

Fiscal Year 2011 was a critical year for this MRI project, as it saw the delivery and installation of the diamond synthesis tool and the final development of the customized ammonia molecular beam epitaxy (MBE) system and the placement of the final order for its delivery. These two tools will add significant new functionality to Ohio State's materials synthesis program. For example **Figure 6** shows electron microscopy and Raman spectroscopy of a poly-diamond film deposited on a silicon substrate. Since June 2011, Dr. Camelia Margineau, a Research Associate in the ENSL facility, has led the effort to commission this tool by "dialing in" the growth parameters for this benchmark growth. This diamond-on-insulator (DOI) growth has applications ranging from high-frequency micromechanical systems (MEMS), to thermal dissipation layers for high power electronics, to radiation-hard detectors for the large hadron collider (LHC) at CERN. Of course,

this work only scratches the surface of the materials that this new tool will ultimately be able to produce, with OSU researchers already working on projects ranging from the growth of perfect single crystals of diamond for experiments that push the frontiers of quantum measurement to the synthesis of diamond nanowires only tens of nanometers in diameter but many microns long.

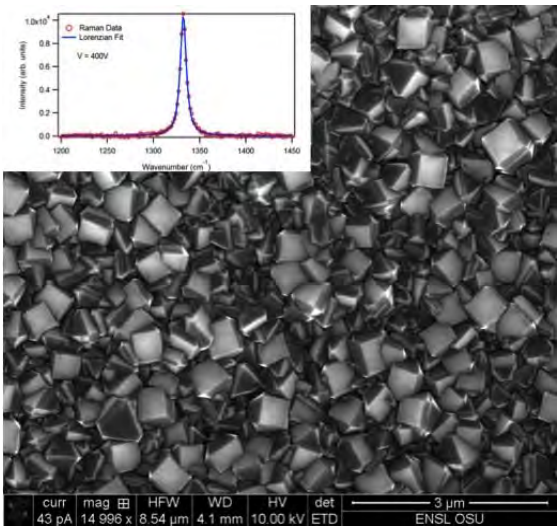


Figure 6. SEM image of polycrystalline diamond film (scale bare is 3 micron). Inset is Raman spectroscopy revealing a peak width of 7 cm^{-1}.

While the diamond synthesis tool was ordered as a "turn key" system, the second major piece of equipment purchased through this proposal, an ammonia-based molecular beam epitaxy (MBE) system for the synthesis of nitride semiconductors, was designed according to custom specification provided by Profs. Roberto Myers and Siddharth Rajan and will be located in the Semiconductor Epitaxy and Analysis Laboratory - SEAL. This system will complement their existing GaN MBE synthesis tool, a nitrogen-plasma based system, by allowing the synthesis of high-luminosity electro-optical devices in addition to the high-mobility, high-power devices already being produced. The customization of the new tool will provide the ability to not only grow new material, but enables joint-growths between the two systems (i.e. a sample is started in one chamber and then transferred to the other).

The Advanced Materials Initiative – A Targeted Investment in Excellence Award

Funding Institution: The Ohio State University Office of the Provost

Principal Investigators: PI: Steven A. Ringel (Director, IMR), Co-PIs: P. Chris Hammel (Physics), W. "Bud" Baeslack (former Dean of Engineering), Richard Freeman (former Dean of MAPS)

Duration: 7/1/2006 – 6/30/2011

Amount: $9.7 million (split between IMR, Colleges of MAPS and Engineering; $2.1M to IMR core) plus 1:1 matching from IMR, MAPS and COE

Description: In 2006 the OSU Office of the Provost conducted a unique internal competition designed to provide targeted funds to areas of existing excellence at the University, with the goal of making those areas to be the pre-eminent programs of research in their fields. The program is called the Targeted Investment in Excellence, or TIE, and the response to the call for proposals yielded approximately 100 proposals from across the entire University, of which 9 were awarded. The IMR, collaborating with the College of Engineering and the College of MAPS teamed to develop the "Advanced Materials Initiative," which received the largest total sum of funds from the competition. The funds were split into three, complementary sub-areas, one for each of the two colleges, and one for IMR to enhance its core programs, but all integrated via IMR's overarching, multi-college mission. The entire program has been coordinated and with funds being used strategically for support of new faculty hiring and their start up packages, outfitting core laboratories with major shared instrumentation, team building exercises that contributed to the creation of both

successful IRGs of the MRSEC award via the interdisciplinary ENCOMM group that is centered in the Department of Physics. For the IMR core, funds assisted in procuring some limited ($418k) strategic equipment, but most of the award went toward creating and supporting teams of researchers through our Research Enhancement Program, increasing the breadth of technical staff being distributed to various major facilities, and supporting the two joint faculty hires in Electronic Materials and in Photovoltaics that were awarded to the Department of Electrical Engineering and the Department of Materials Science and Engineering. Details of progress in the use of the TIE funds are distributed throughout this annual report and will not be separately discussed here.

**Note: this is not an external grant; however the scope and magnitude of the program demanded its inclusion here.*

Major Multi-Investigator and Multi-Disciplinary Proposal Development in FY11

While much of IMR's activity in the area of major externally funded programs focused on the previously mentioned major centers during FY11 – CEM, CANPBD, PVIC and the TEEM ORSP programs, IMR did also focus on several other avenues of multi-investigator funding opportunities that are of a strategic nature. These included multiple proposals in the area of alternative energy materials to both state and federal opportunities, various forms of proposals centered on industrial collaborations and transitioning of research into commercial opportunities, proposals that target sustainable manufacturing, and highly competitive DoD MURI proposals. Overall in FYII, IMR actively worked with different teams of faculty researchers on proposals to NSF (crosscutting programs - I/UCRC [successful], STC [unsuccessful] and SOLAR [unsuccessful]), DoE (Sunshot [successful] and PV Manufacturing [unsuccessful]), DoD (MURIs [3 awarded]), Ohio Department of Development (3/7 submissions awarded from Ohio Third Frontier Advanced Energy Program, Photovoltaics Program and Wright Projects). This is in addition to the many public-private projects that are listed elsewhere as the relate to the IMR Industry Challenge Grant program, contract work with the IMR Nanotech West Facility, and through the various Wright Centers that are supported by IMR. Our goal is to create the most competitive teams and proposals possible for these opportunities, and thus we always note that there are many factors that go into final selection of awards, that are not generally in the control of the PIs. By simply having these teams form around opportunities greatly increases their likelihood of competing for other programs, whether funded or not. We have chosen to not list the exceedingly large number of proposals and awards by IMR members, IMR-recruited faculty, and IMR seed-initiated projects support that were submitted through the participating colleges, since we desire to explicitly focus on those activities that are particularly significant in a multi-college sense, having a large number of investigators, consistent with the mission of IMR.

Below we list a selection of primary awards made during the period July 1, 2010 – June 30, 2011.

Title: I/UCRC Center for Integrative Materials Joining Science for Energy Applications

Agency: National Science Foundation, Industry/University Cooperative Research Center (I/UCRC) Program

PI: Sudarsarnam Suresh Babu (Materials Science and Engineering)

Co-PIs: Avraham Benatar (Materials Science and Engineering), Glenn Daehn (Materials Science and Engineering), Dave Farson (Materials Science and Engineering), John Lippold (Materials Science and Engineering)

Amount: $2,130,000/5 years

IMR Role: Recruited PI in cluster hiring program; based partly on IMR seed funding; assisted with proposal development

Title: III-N Devices and Architectures for THz Electronics - DATE

Agency: Office of Naval Research MURI program (submitted through University of Notre Dame)

PI: Siddharth Rajan (Electrical and Computer Engineering, Materials Science and Engineering)

Co-PIs: Paul Berger (Electrical and Computer Engineering), Kubilay Sertel (Electrical and Computer Engineering), John Volakis (Electrical and Computer Engineering)

Amount: $3,000,000/ 3 years

IMR Role: Recruited PI in cluster hiring program, supported initial work via IMRG seed support

Title: Dielectric Enhancements For Innovative Nitride Electronics - DEFINE

Agency: Office of Naval Research MURI program (submitted through Univ. California at Santa Barbara as prime)

PI: Steven A. Ringel (Electrical and Computer Engineering, Institute for Materials Research)

Co-PIs: Siddharth Rajan (Electrical and Computer Engineering; Materials Science and Engineering)

Amount: $1,250,000 (7,500,000 total for 11 investigators from 7 universities)/ 5 years

IMR Role: Recruited Co-PI in cluster hiring program, supported initial work via IMRG support

Title: Cryogenic Peltier Cooling

Agency: Air Force Office of Scientific Research, Multidisciplinary University Research Initiative (MURI) Program

PI: Joseph Heremans (Mechanical and Aerospace Engineering)

Amount: $7,500,000/ 5 years

IMR Role: Based partly on IMRG seed project to PI; assisted with proposal development

Title: III-V/Active-Si Integration for Low-Cost High-Efficiency Concentrator Photovoltaics

Agency: Department of Energy – Foundational Program to Advance Cell Efficiency (F-PACE) Sunshot program

PI: Steven A. Ringel (Electrical and Computer Engineering, Institute for Materials Research)

Co-PIs: John Carlin (Institute for Materials Research), Michael Mills (Materials Science and Engineering)

Amount: $1,500,000/3 years (awarded and in negotiation)

IMR Role: Based partly on IMR-PVIC project; requires IMR/NTWest/PVIC facilities; Co-PI is IMR staff member

Title: Low Cost Concentrated Photovoltaic (CPV) Design

Agency: Ohio Department of Development Third Frontier Commission Photovoltaics Program (through GreenField Solar Corporation)

PI: Robert Davis (Institute for Materials Research)

Amount: $1,000,000/2 years to lead

IMR Role: Based partly on IMR-PVIC project; requires IMR/NTWest/PVIC facilities; PI is IMR staff member

Title: High Efficiency Photovoltaic Enabled Off-Grid System

Agency: Ohio Department of Development Third Frontier Commission Photovoltaics Program (through Energy Focus, Inc.)

PI: Steven A. Ringel (Electrical and Computer Engineering, Institute for Materials Research)

Co-PIs: John Carlin (Institute for Materials Research)

Amount: $1,000,000/2 years ($345,000/2 years to OSU)

IMR Role: Based partly on IMR-PVIC project; requires IMR/NTWest/PVIC facilities; PI is IMR staff member

Title: Commercialization of Inline Heater for Use in Photovoltaic Solar Cell Manufacturing

Agency: Ohio Department of Development Third Frontier Commission Photovoltaics Program (through Process Technology)

PI: Robert Davis (Institute for Materials Research)

Amount: $357,000/2 years to lead

IMR Role: Based partly on IMR-PVIC project; requires IMR/NTWest/PVIC facilities; PI is IMR staff member

Interdisciplinary Faculty Cluster Hiring: Status FY11

The IMR continues to take an active role in working with colleges and departments to support strategic faculty hiring. This is a very unique role for a research center that does not appoint faculty within its organization and it has proven to be of great value to attract some of the top faculty talent to OSU. Typically this means a focus on interdisciplinary aspects of materials research such that IMR can aid departments in collaborating across traditional boundaries. IMR is achieving this in two ways, first through the Advanced Materials Initiative Targeted Investment in Excellence Award, and second through the Ohio Research Scholars Program in Technology Enabling and Emergent Materials. Both of these funded programs were described earlier in the report but the faculty recruitment impact as a whole is provided in this section.

As part of the Advanced Materials Initiative TIE award led by IMR and its Director as PI, IMR coordinates the recruitment and selection of faculty in targeted hiring areas to further strengthen the OSU materials community. IMR initiated and coordinated a unique approach to hire faculty members via a "cluster hiring' process, in which topical areas defined the positions, and not academic departments, to ensure that a focus on interdisciplinary hiring could be achieved. As candidates applied, appropriate departments were identified in order to position each candidate in the correct tenure-initiating unit and in some cases appointments were shared between two departments. The primary focus of the process was applied to two areas, Computational Multiscale Materials Modeling and Electronic Materials, the latter of which was augmented via a designed overlap with the Energy TIE in the area of Photovoltaics. Significant amounts of the startup funds for each position were provided to each of these positions via the Advanced Materials TIE award. During FY09, the modeling cluster was broadened somewhat to augment and complement the successful hires made in FY08, and now includes biomaterials and validation/verification computation methods to reflect the ever evolving nature of advanced materials. To date 6 faculty members have joined the materials community through the cluster recruiting process, and each have contributed substantially to furthering the scholarly quality and quantity of our community in various ways.

Through the Research Scholars award, IMR received ~ $18,000,000 in funds to hire 5 endowed chair faculty members, 3 at OSU and 1 each at the University of Dayton and the University of Akron as described earlier. Each faculty line includes generous capital and operating funds. At OSU, two of the Ohio Research Scholars have now joined, and the single remaining position is currently in the final interviewing stages at the time of this writing. This research cluster has a primary focus on acceleration and innovation of material from basic science to application, via coordinated characterization, predictive modeling and synthesis. A particular emphasis is on nanomaterials, soft materials and materials from renewable and sustainable resources.

The eight faculty members recruited by IMR to date at OSU, in conjunction with the appropriate departments, according to the programs just summarized, are listed below along with their external funding and publication records since joining OSU's faculty. We pride ourselves on being able to attract some of the best and brightest and the role of IMR to assist the colleges and departments in this process has proven to be extremely important.

Ezekiel Johnston-Halperin, Assistant Professor, Physics, October 2006. *Magnetic and electronic materials, spintronics and nanostructures*

> Total external funding: $6,696,323 ($496,324 as Lead PI); Publications since joining OSU: 28, including 2 in *Nature*

Sudarsanam Suresh Babu, Associate Professor, Industrial, Welding and Systems Engineering Department, October 2007. *Materials joining, non-equilibrium processing, modeling and manufacturing*

Total external funding: $6,203,943 ($2,399,536 as Lead PI, including PI of an NSF I/UCRC); Publications since joining OSU: 41

Ji-Cheng (J.C.) Zhao, Associate Professor, Materials Science and Engineering Department, January 2008. *Computational thermodynamics, phase diagrams, diffusion, materials property microscopy tools*

Total external funding: $4,751,262 ($2,825,102 as Lead PI); Publications since joining OSU: 21

Siddharth Rajan, Assistant Professor, Electrical &Computer Engineering (80%) and Materials Science and Engineering (20%) departments, October 2008. *High-performance semiconductor devices and materials for electronics, energy devices, optoelectronics*

Total external funding: $7,593,194 ($670,680 as Lead PI, including two MURI projects); Publications since joining OSU: 28

Roberto Myers, Assistant Professor, Materials Science and Engineering (80%) and Electrical and Computer Engineering (20%) departments, October 2008. *Electronic materials, nanostructures, optoelectronic properties and magnetoelectrics*

Total external funding: $2,003,516 ($1,078,064 as Lead PI, including an NSF CAREER award); Publications since joining OSU: 13

David Wood, Professor, Chemical and Biomolecular Engineering, October 2009. *Biomaterials and the application of molecular biology to develop new materials for bioseparations*

Total external funding: $497,474 ($497,474 as Lead PI,); Publications since joining OSU: 8

Katrina Cornish, Professor and Ohio Research Scholar Endowed Chair in Bio-based Emergent Materials, Horticulture and Crop Science and Food, Agricultural and Biological Engineering departments, July 2010. *Bioemergent materials, alternative natural rubber production, natural rubber biosynthesis, materials and products from plant-based sources*

Total external funding: $256,992 ($256,992 as Lead PI,); Publications since joining OSU: 5

David McComb, Professor and Ohio Research Scholar Endowed Chair in Materials Characterization, October 2011. *Electron microscopy and the application of such methods to biological and structural materials*

Industry and International Collaborations and Partnerships

The Institute for Materials Research initiated several strategic partnerships in this past year, targeting directions involving industry collaborations in advanced manufacturing and energy. In addition, following the initial memorandum of understanding between the Universidad Politecnica de Madrid (UPM) in the prior year, IMR initiated a major thrust in advanced electronic materials with UPM, leading to the beginning of an international exchange program in multifunctional oxide materials and nitride semiconductors. This section briefly summarizes these various partnerships.

Ohio Manufacturing Institute

During the past year, IMR sought out a collaboration with the newly formed Ohio Manufacturing Institute (OMI), which was founded at The Ohio State University in 2010, with the goal of improving local manufacturing capabilities by making university resources more user-friendly for industry, providing deep technical development offerings to industry through industry partnerships, and offering unique technical outreach and engagement opportunities. Funded by the Ohio Department of Development, the OMI services the needs of Ohio manufacturers by connecting these needs with the technical resources available at OSU including labs, equipment, faculty and students in order to provide technical solutions. OMI serves as a single point of entry for Ohio manufacturers to easily access the deep technical university resources and promote collaborative relationships through teamed research and development projects. OMI has been working to develop mechanisms to allow operation at the speed of business due to its lean staff, simple contract mechanisms with low overhead, and its one-stop-shopping experience for customers to access a wealth of resources through one entity. The intent has been that mechanisms and procedures would be piloted at Ohio State and could be adapted or ported to other universities in the University System of Ohio (USO). OMI has made great progress in its first year of operations, such as streamlining industry contracts with OSU, establishing student internships and actively engaging in state policy and recruitment efforts. Below are some highlights of OMI's first year activities and accomplishments:

OMI Engineering Service Contracts

The Ohio Manufacturing Institute formalized and launched a new mechanism that has been used many times in the OSU College of Engineering, the Engineering Service Contract (ESC), in order to expedite technical contract work between industry and universities. The ESC provides a quick and effective way to engage with university resources through a no-nonsense easy contract process. Contracts can be executed in <24 hours enabling collaborations to move at the speed of business. The contract is simple and the project scope is described in a simple one-page attachment to the contract. 13 total ESCs have been initiated with a total of $100K+ revenue generated from industry dollars and an additional anticipated $100K worth of projects in final stages of negotiation.

OMI Co-Located Internships

OMI has recently designed and launched a program that we believe to be unique, the Co-Located Internship program. This internship program is structured such that OSU students are employees of an Ohio manufacturing company and subject to its supervision and human resource rules. The student works on a pre-determined project under the guidance of an OSU faculty mentor while maintaining full access to all OSU resources including labs, equipment, and computer programs in order to further enhance the project impact. This structure gives an unprecedented and efficient mechanism for technology transfer from the university to manufacturers. Companies that have signed up to participate in year one include: Sutphen (Hilliard, OH), Guardian Automotive (Upper Sandusky, OH) and Honda R&D (Raymond, OH). OMI expects three jobs to be created as a result of year one projects. This program has resonated with Honda management and has gained the financial support of a $45K two-year pilot fund through the Honda-OSU Partnership. Plans are in place to develop this into a self-sustaining long-term program.

OMI Policy and Manufacturing Environment

The Ohio Manufacturing Institute is serious about affecting policy decisions at the state and federal level in order to ease the burden on US manufacturers and grow the local manufacturing economy. Due to this commitment, this year OMI has hosted, presented, and played a key role in a variety of meetings, including the Automotive Industry Council Meeting, Auto Support Council, OMI Lecture Series, and Ohio Manufacturing Roundtable. OMI leaders also help the state recruit manufacturing companies to Ohio.

Alcoa Foundation Advancing Sustainability Research Collaboration

An immediate result from the early conversations between IMR and the OMI was the identification and then joint development of a strong proposal to the Alcoa Foundation led by IMR Director, Professor Steve Ringel and OMI Interim Director, Professor Glenn Daehn, 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. This OSU partnership 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 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.

To further leverage the advancements already made by OMI and IMR in this area of industry-OSU collaborations, an entire day of the 2011 OSU Materials Week conference will also be devoted to the topic, "New Approaches for Lighter, More Sustainable Multi-Materials Vehicle Structures." A variety of talks and panel discussions planned for that day will showcase the novel research in lightweight vehicles by OSU researchers and industry collaborators from many different fields and perspectives including welding, corrosion, computational alloy design, and polymers and adhesives. At the time of this writing, representatives from seven industry partners (including Alcoa) will conduct talks and participate in a roundtable discussion.

Ohio Third Frontier Photovoltaics Program Awards: Partnering with Ohio's Photovoltaics (PV) Industries

The Institute for Materials Research became a central collaborator on three of the five Ohio Third Frontier Photovoltaics Program Awards made by the Ohio Department of Development for fiscal year 2011, and was an unfunded partner on a fourth, dominating the ODOD PV award portfolio this past year. These three projects totaling $3.35 million in new funding of advanced energy sector awards were largely enabled by OSU's founding role in the Ohio Wright Center for Photovoltaics Innovation and Commercialization (note that these programs are included in the earlier list of overall FY11 new programs, but are called out here to provide some technical depth regarding the intent of each project). The OTF Photovoltaics Program awards will add to OSU's advanced position within Ohio's economy through strategic collaborations with key industry

partners, building on the industry-OSU research partnerships created through PVIC, whose state funding ends this year. All three research projects are built upon innovations and facilities initiated by the PVIC Wright Center, and centrally involve IMR-supported faculty, staff and facilities to conduct innovative research that targets university-industry transitions, as described below.

GreenField Solar Corporation in Oberlin, Ohio will use its $1 million award to support its program titled *Low Cost Concentrated Photovoltaic (CPV) Design*, with the goal of lowering the cost of its high-concentration PV system and obtaining UL certification. As part of the collaboration, metals deposition capabilities at OSU Nanotech West will be used to examine cost-reduction and manufacturing improvements in the metallizations used in the GreenField Photovolt® vertical multi-junction silicon PV device that resulted from technology developed at the NASA Glenn Research Center. The team also includes the Edison Materials Technology Center (EMTEC) of Dayton. The Principal Investigator of the Ohio State portion of the work is IMR Associate Director Bob Davis.

Energy Focus, Inc. in Solon, Ohio will receive $1 million to support its project, *High Efficiency Photovoltaic Enabled Off-Grid System*. The goal of this program is to develop and manufacture a standalone outdoor lighting product powered by an integrated low concentration photovoltaic system. Low-cost concentrator fabrication and supporting design structures will be created by team member Replex Plastics (Mt. Vernon OH). The solar technology is based on an integrated compound semiconductor-on-silicon PV approach to enable low-cost, silicon-based high performance multijunction solar cells developed by Professor Steven A. Ringel's group in the department of Electrical and Computer Engineering, with partial support by the PVIC Wright Center. The primary OSU effort will transition this PV technology to an industry-compatible materials platform based on the new MOCVD (metalorganic chemical vapor deposition) facility at Nanotech West in collaboration with the Semiconductor Epitaxy and Analysis Lab (SEAL). The Principal Investigators of the Ohio State effort are IMR Research Scientist John Carlin, and ECE Professor and IMR Director Steve Ringel.

Process Technology of Mentor, Ohio was awarded over $350,000 for its project *Commercialization of Inline Heater for Use in Photovoltaic Solar Cell Manufacturing*, a collaboration with Cleveland State University and the OSU Nanotech West Lab. The project will design and market an ultrapure, low cost, intrinsically safe, inline chemical/water heater utilizing positive temperature coefficient (PTC) heating elements. As part of the development, Process Technology will install one of the new heater units at Nanotech West and demonstrate its reliability and utility in PV processing. Dr. Bob Davis will be leading the Ohio State demonstration effort.

Universidad Politécnica de Madrid

In our Fiscal Year 2009-2010 annual report, a newly formed international partnership between the OSU Institute for Materials Research and the Universidad Politécnica de Madrid (UPM), a top technological/engineering university in Spain, was reported. This formal collaboration was created to enhance educational, academic and research in areas central to advanced materials and related technologies at both institutions. Leaders at UPM and IMR agreed upon a set of research topics of initial common interest, based on assessing similar interests and assets at both institutions. Collaborative activities initially envisioned are in the following areas: development of optoelectronic devices; advancement on semiconducting oxides; multispectral photodetectors in the VIS-IR based on III-V heterostructures; and High Electron Mobility

Transistors (HEMTs) based on AlGaN/GaN.

During the current reporting period, IMR hosted Professor Adrian Hierro from UPM's Department of Electrical Engineering, who spent a week at OSU in February 2011, in the first steps of implementing the IMR/UPM partnership. In addition to meetings with colleagues and facility tours to see OSU's newest research capabilities, Dr. Hierro spent part of his time on campus working to initiate two collaborative research projects, one studying defect analysis in ZnO and ZnMgO, and one exploring photo detectors in the infrared spectrum. During his visit, Dr. Hierro also shared the latest findings of this research at a seminar jointly hosted by IMR and the Solid State Electronics and Photonics (SSEP) Seminar Series, titled "Oxide-based UV Photodetection."

The IMR/UPM collaboration was created with the expectation of leading to vibrant collaborations through the exchange of faculty members and researchers, the exchange of students, the exchange of information and academic resources that are of mutual interest, and activities such as collaborative research, joint symposia and exchange lectures such as Dr. Hierro's. The collaborative work on semiconducting oxides has in less than one year resulted in 2 jointly-authored journal publications, one accepted for publication and one pending publication, and 3 jointly authored conference talks. With this extremely rapid and successful start, UPM and OSU are currently exploring joint funding with initial results now in hand.

IMR Research Enhancement Program

IMR's Research Enhancement Program provides different funding mechanisms to support innovative research at The Ohio State University. During Fiscal Year 2011, IMR continued its Facility Grant program, awarding two rounds of internal research funding to assist OSU faculty with facility user access fees and related minor charges. The IMR Industry Challenge Grants increased in number and activity, with two new awards and one continuation this year. Finally, Fiscal year 2011 saw the final year of the Interdisciplinary Materials Research Grants (IMRG), which was integrated into the OSU Materials Research Seed Grant program, an exciting new program that allows IMR and other materials-related centers within the IMR umbrella on campus to better leverage resources and effectively seed innovative research projects, as detailed below.

Interdisciplinary Materials Research Grants (IMRGs)

Seven Interdisciplinary Materials Research Grants (IMRG) research projects were awarded a second year of funding from IMR for an additional $287,500 in direct research support from IMR. All seven of these projects were originally reported in the 2010 IMR Annual Report, were renewed for FY11, and continued to progress this year with additional resources. To date, three of the research teams funded by the IMRG program this year have already reported 5 external research awards totaling $3,554,000 directly resulting from their IMRG seed support, during their second seed year of funding, a remarkable response and rapid return on IMRG funding investment. One of these awards was a National Science Foundation Major Research Instrumentation (MRI) award, and the other a new Wright Project through the Ohio Department of Development.

The seven IMRG projects awarded a second year of funding during FY 2011 are listed below.

Multi-Scale Characterization of Battery Materials for Improved Performance, Lead: Sudarsanam Suresh Babu, Industrial, Welding and Systems Engineering and Materials Science and Engineering; Co-Applicants: Bharat Bhushan, Mechanical Engineering; Yann Guezennec, Mechanical Engineering; Giorgio Rizzoni, Mechanical Engineering; Shrikant C. Nagpure (PhD Student), Mechanical Engineering

Metamaterials with Smart Reconfiguration for Broadband RF Antennas, Lead: Marcelo Dapino, Mechanical Engineering; Co-Applicants: Suresh Babu, Industrial Systems Engineering; John Volakis, Electrical and Computer Engineering.

Structure-Property Relationships in Novel Structural Materials, Lead: Katherine Flores, Materials Science and Engineering

Economical Platforms for FET-based Protein Detection to Support Sensor Clinical Translation, Lead: Stephen C. Lee, Biomedical Engineering; Co-Applicant: Paul Berger, Electrical and Computer Engineering.

Use of Electrospun Biomaterials as Carriers of Bone Marrow Derived Stem/Progenitor Cells to Stimulate Tissue Neovascularization, Lead: Nicanor I. Moldovan, Internal Medicine; Co-Applicant: John J. Lannuti, Materials Science and Engineering.

Exploring Electrically Tunable Magnetism in Gd-doped Nitride Quantum Structures, Lead: Roberto C. Myers; Materials Science and Engineering & Electrical Computer Engineering; Co-Applicants: Ezekiel Johnston-Halperin, Physics; Michael Mills, Materials Science and Engineering

Synthesis of III-V Semiconductor Nanowire Heterostructures Using Metalorganic Chemical Vapor, Lead: Fengyuan Yang, Physics; Co-Applicants: Ezekiel Johnston-Halperin, Physics; Roberto C. Myers, Materials Science and Engineering & Electrical and Computer Engineering

Between 2007 and 2011, the IMR Interdisciplinary Materials Research Grants (IMRG) program funded over $1.5 million in direct costs to 36 multidisciplinary research projects. **Figure 7** shows the distribution of these IMRG awards over the lifetime of the program.

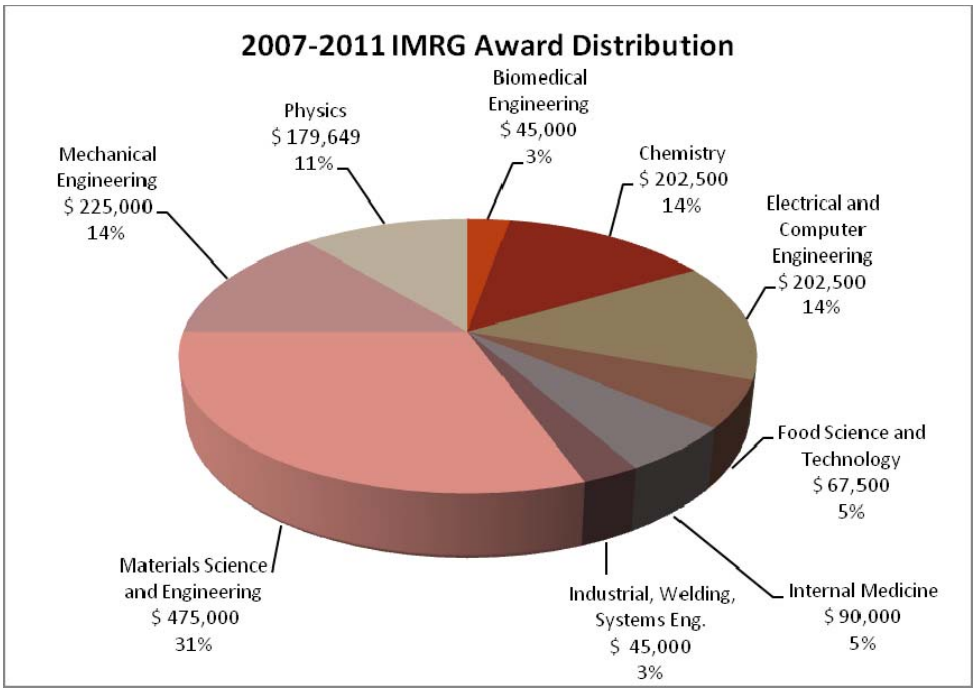


Figure 7. Distribution of IMR Interdisciplinary Materials Research Grants (IMRG) program awards from 2007 – 2011, by Lead Principal Investigator department. Note however that funds are used to support either co-advised graduate students or postdoctoral researchers by two or more co-investigators and so this distribution only reflects the departments in which the fund account as provided and does not necessary show the true multidiscipinarity of the supported research.

OSU Materials Research Seed Grant Program

IMR's Interdisciplinary Materials Research Grants (IMRG) program, established many best practices which led to a large number of interdisciplinary, multi-investigator externally funded projects of high technical impact and novelty. After 4 very successful years of running our vibrant IMRG program, IMR recognized a growing need to integrate this program with two other existing materials seed grant programs that have evolved and share a similar goal for multidisciplinary, teamed research from two centers within the IMR's over-arching umbrella -the Center for Emergent Materials MRSEC and the internally supported Center for Electronic and Magnetic Nanoscale Composite Multifunctional Materials (ENCOMM). As the seed programs within these two entities had evolved in their respective organizations, the message of a unified materials seed effort to the larger OSU materials research community became somewhat blurred and so in December 2010, IMR leadership decided to adapt and set up a series of discussions and meetings in which the ENCOMM and CEM seed program leaders met with IMR to accelerate the creation of an integrated, single seed grant program. The goal was to ensure that the most effective seed program was broadly available, to achieve better leveraging of valuable financial resources, and to combine the best practices developed by the three seed programs. The result was the creation of a united OSU Materials Research Seed Grant Program, which is comprised of three Funding Tiers designed to achieve the greatest impact for seeding excellence in materials research of varying scopes: Proto-IRG grants for large teams, Multidisciplinary Team Building grants for smaller teams, and Exploratory Materials Research grants that target high-risk, individual investigator grants with a bias toward junior faculty members. The former IMRG program has been integrated specifically through the Multidisciplinary Team Building grants and the Exploratory Materials Research grants. This new program remains supplemented by the IMR Facility Grants and IMR Industry Challenge Grants programs, which IMR will continue to manage and offer to the materials community, along with the new, 3-tiered OSU Materials Research Seed Grant Program.

The integrated OSU seed grant program plans to award up to $480,000 across all tiers for projects to start within FY12. However, the process was implemented at the time of this writing and funding decisions are currently being made. **Appendix D** provides copies of the OSU Materials Research Seed Grant Program Request for Proposals and the proposal evaluation forms that were provided to both external and internal reviewers for all three tiers. Also included in Appendix D is the formal announcement of this program, as it described the highly evolved process by which grant proposals were cultivated, which includes open team building meetings prior to the grant proposal deadline so that optimized teams and ideas can be formulated to create the strongest proposals, prior to receiving both external and internal review. Full details of the new seed program, and the winning teams and individuals, will be highlighted in next year's annual report.

IMR Industry Challenge Grants

This year saw increased interest and activity in the IMR Industry Challenge Grants program, which is intended to strengthen collaboration 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. IMR Industry Challenge Grants are eligible for renewal for a second year of funding. Three research programs are currently receiving support through IMR Industry Challenge Grants, and we expect activity will grow over time due to the increasing number of private-public collaborations through several centers and facilities. Due to intellectual property agreements, we are limited in the amount of information we can share regarding Industry Challenge Grants. This year, IMR renewed the first Industry Challenge Grant to Dr. Dennis Bong, Assistant Professor of the Department of Chemistry, providing

an additional $20,000 in cost share to supplement his externally sponsored research project funded by a key industrial partner. A new Industry Challenge Grant was awarded to Dr. R. Sooryakumar, Professor of Physics, in support of his externally sponsored research project, also providing $20,000 in direct cost share. The third research project funded this year through the IMR Industry Challenge Grant program has fewer restrictions on what details can be shared. This IMR Industry Challenge Grant to Professor Wolfgang Windl, Materials Science and Engineering, in support of a new research project he is undertaking with L-3 Communications Cincinnati Electronics. In this project, Dr. Windl's group will work in collaboration with L-3 on the calculation of fundamental parameters in III-V compounds relevant for infrared-active optical devices, using electronic-structure methods commonly known as “ab-initio” methods in conjunction with device modeling within the framework of Technology Computer Aided Design (TCAD). State-of-the-art methods will be used that can be applied to any combination of elements (including straight III-V as well as alloyed semiconductors, heterojunctions, and systems under bias) and are able to predict the small band gaps of IR-sensitive materials correctly. The calculated parameters will be implemented into a TCAD device model for verification in comparison to existing experimental data, as well as to predict optimized materials compositions, doping levels, and device structures.

Synthesis of amphiphilic core-shell latex emulsions from soy proteins and delivery of corrosion inhibitors and biocides for coatings application, Lead Investigator: Dennis Bong, Chemistry

Thermo-Mechanical Billouin Light Scattering Characterization of Nanometer Scale Interconnect Materials and Structures, Lead Investigator: R. Sooryakumar, Physics

HOF Midwavelength Infrared Focal Plane Array Modeling, Lead Investigator: Wolfgang Windl, Materials Science and Engineering (supporting a collaboration with L-3 Communications Cincinnati Electronics)

IMR Facility Grants

IMR has continued to offer the successful and popular IMR Facility Grants program, which provides $2,000 per award to assist OSU faculty with facility user access fees and related minor charges associated with conducting innovative materials-allied research. To date, IMR has awarded 93 Facility Grants totaling $202,916 to support the research of 68 IMR members from 3 colleges and 10 academic departments. In fiscal year 2011, IMR award 20 Facility Grants for a total of $40,000, with distribution by Principal Investigator department shown in **Figure 8**.

A full listing of these twenty new Facility Grants is provided in **Appendix E**, including abstracts for each research project.

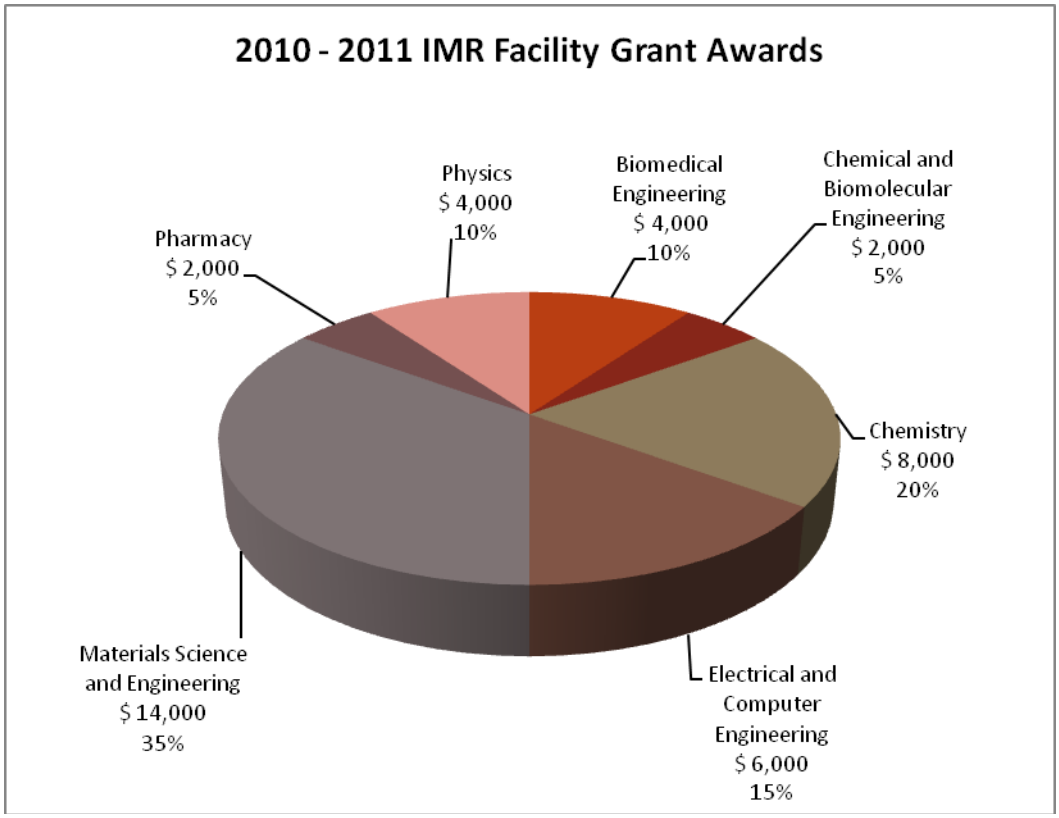


Figure 8. Distribution of Fiscal Year 2010 – 2011 IMR Facility Grant awards, by Principal Investigator department.

Facility Updates

Nanotech West Laboratory

Nanotech West Overview

Open to both academic and industrial users, Nanotech West Laboratory's state-of-the-art facilities include a 6,000 square foot biohybrid laboratory and a 6,000 square foot class 100 cleanroom specializing in micro and nanoscale fabrication and material synthesis with a full-flow 100mm process capability. Nanotech West includes a wide array of major facilities, all staffed, coordinated and serviced by research scientists, engineers and technicians. As a result, Nanotech has now become a central facility for wide areas of materials research.

A partial list of primary capabilities at Nanotech West as of the end of FY11 is provided here:

- Electron beam lithography [Vistec® EBPG-5000]
- Metalorganic chemical vapor deposition [Aixtron / Swan® 3x2]

- Atomic layer deposition [Picosun SunALE® R-150B]
- Field-emission scanning electron microscopy [Carl Zeiss Ultra 55 Plus]
- ICP-RIE, inductively coupled plasma reactive ion etching [Plasma-Therm SLR 770] and several other plasma etch tools
- Five-gun RF/DF sputter deposition system (AJA International)
- Semiconductor PCD lifetime measurement system (Sinton)
- Six-pocket electron gun evaporator (CHA) Wafer bonding and micro– and nanoimprint lithography [EVG 520HE]
- I-V, C-V, L-I-V, microfluidic, and solar device testing
- Atomic force microscopy [Veeco 3100, NanoInk, Asylum BioAFM]
- Full-flow 100 mm process capability including photolithography, wet/dry etching, deposition, oxidation, metrology
- 6,000 square foot class 100 cleanroom
- 10 full-time equivalent engineering and administrative staff

An impressive way to summarize the current state of Nanotech West is that this facility is the physical home to 3 very large (>$15M each) interdisciplinary materials centers – The NSF Nanoscale Science and Engineering Center, the Wright Center for Photovoltaics Innovation and Commercialization, and the Wright Center for Multifunctional Polymer Nanomaterials and Devices, and is a primary user facility that serves the NSF Materials Research Science and Engineering Center - CEM. Additionally, Nanotech West is now the primary location for university-industry interactions in advanced materials, and has users from over 30 companies. In summary, Nanotech West has been completely upgraded to a level that is approaching that of comparable facilities at the very elite universities in this field. As the primary IMR location on OSU's west campus, it has become a centerpiece for collaborative research in OSU's materials community.

Nanotech West Laboratory Highlights and Accomplishments During FY2011

Nanotech West Lab continued to grow in activity level in FY11. As measured by user fee income, usage grew 11% over its FY10 level, rising to a total of $416k for the year (**Figure 9**). This was essentially completely due to a sharp increase in internal Ohio State research program usage, which rose a remarkable 40% over the previous year. This usage represented the efforts of 44 Ohio State research principal investigators (PIs) with 102 funded research projects. Approximately 30 companies, nearly all in the state of Ohio and nearly all startup, small, or medium-sized, also used Nanotech West in FY11.

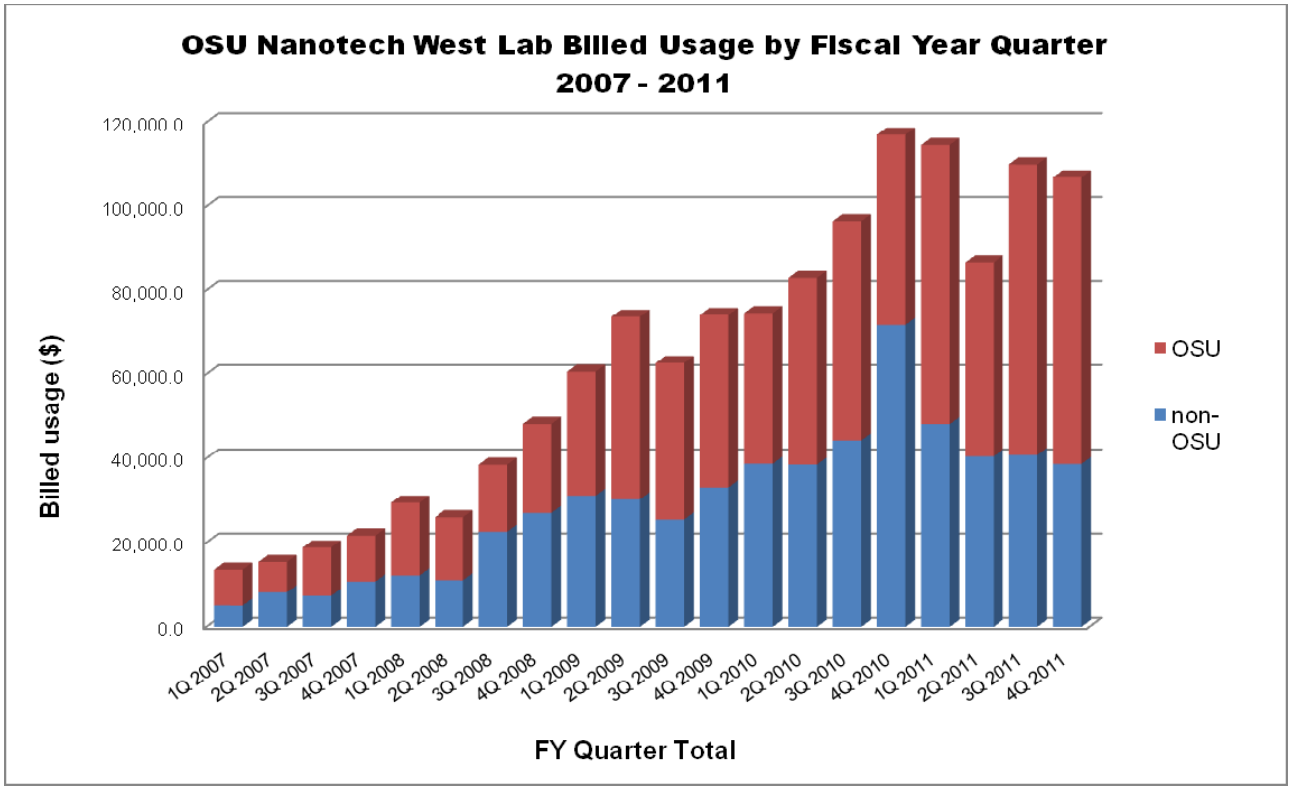


Figure 9. Chart showing growth in user fee income for Nanotech West Laboratory facilities. Final FY 2011 user fee income, not including direct grant support to the lab, was $416K.

These usage figures are even more notable given the fact that the new Aixtron metalorganic chemical vapor deposition (MOCVD) tool, which was anticipated to have a major impact on Nanotech West activity in FY11, was only available for a few months of that fiscal year due to tool acceptance and other issues, and even in those two months was not a significant contributor to activity. As a result of its acceptance this year, and a result of new programs including a Third Frontier award that depend on it, FY12 will be a heavy year of activity in MOCVD growth at the Lab. The tool has sources for materials and doping of In, Ga, As, and P epitaxial growth; during FY11 we added an Sb source and made our first antimonide growth runs.

Compared to FY10, which was very busy with major new tool installations, there were no major tool installations at Nanotech West in this fiscal year. However, newly installed tools such as the AJA Orion DC/RF sputter deposition tool and the new CHA Solution System electron gun evaporator ramped up in usage and capabilities during this time. The list of targets for the sputter tool increased to 16, and a pure nitrogen process gas line was added to the tool to enable the deposition of nitrides such as TiN. The CHA e-gun evaporator transitioned quickly from a new installation to being the primary workhorse metallization tool at Nanotech West.

New, however, to Nanotech West in FY11 was a Woollam alpha-SE spectroscopic ellipsometer, which was installed in Bay 3 of the cleanroom. The ellipsometer has a wavelength range of 380-900 nm and has proven very useful in, for example, the characterization of dielectrics grown using atomic layer deposition (ALD) or sputter deposition. Capital plans for FY12 include the purchases and installations of a plasma-enhanced chemical vapor deposition (PECVD) tool, a dicing saw, a plasma asher, and a silicon drift detector (SDD) for X-ray analysis on the Zeiss scanning electron microscope (SEM02). The majority of these purchases will be enabled by the Ohio Wright Center for Photovoltaics Innovation and Commercialization (PVIC).

Nanotech West staff member Derek Ditmer operates the new Woollam alpha-SE spectroscopic ellipsometer located in Bay 3 of the cleanroom.

In FY11, a Nanotech Users Committee was established. This committee is comprised of heavy Nanotech users and was established to improve the efficiency of communication between users and Nanotech West staff in the face of significantly increased lab usage, and to make recommendations regarding the optimization of best practices. The first priority recommendation that was made and implemented in FY11 was the creation of a "superuser" system to assist in training of new users on tools. In this system, advanced graduate students or postdocs are used to do initial training of new users, which are then given a final "check-out" by the staff member in charge. The superusers are selected by faculty and Nanotech staff members for their proven skills in the operation of the tools in question, and are modestly compensated for their time via credit toward their monthly user fee bill; their efforts free up regular staff time with the primary goal of increasing equipment uptime. The initial set of 6 superusers has worked out quite successful and the concept will be expanded in FY12 to additional tools.

In autumn of 2011 the Nanotech West Lab will complete a major (and much needed) overhaul in the design and content of its website. The new web site will closely resemble the IMR web site in design, but with design features that match the new brochure that was printed last year. An experienced marketing consultant is leading the overhaul, which will also have features that will attract and inform search engines about Nanotech West news and capabilities. Updating the site on a continuous basis will be enabled by a content management system.

Finally, Nanotech West will undergo a personnel change in FY12 since Tom Kelch, Laboratory Services Coordinator, is taking part in OSU's voluntary separation incentive plan at the end of August 2011. This vacant Laboratory Services Coordinator position will be advertised during Summer Quarter 2011 and the recruitment and training process will take place in Autumn 2011.

ENCOMM NanoSystems Laboratory (ENSL)

ENCOMM NanoSystems Laboratory Overview

ENCOMM NanoSystems Laboratory (ENSL) is an established OSU user facility located on the Columbus Campus of The Ohio State University in the Physics Research Building. The facility is open to all academic and industrial customers on a user fee basis. A primary ENSL goal is to provide users with access to advanced material characterization and fabrication tools for research and development applications. We have simplified user access to the equipment and enabled transparent, after-hours access for experienced users.

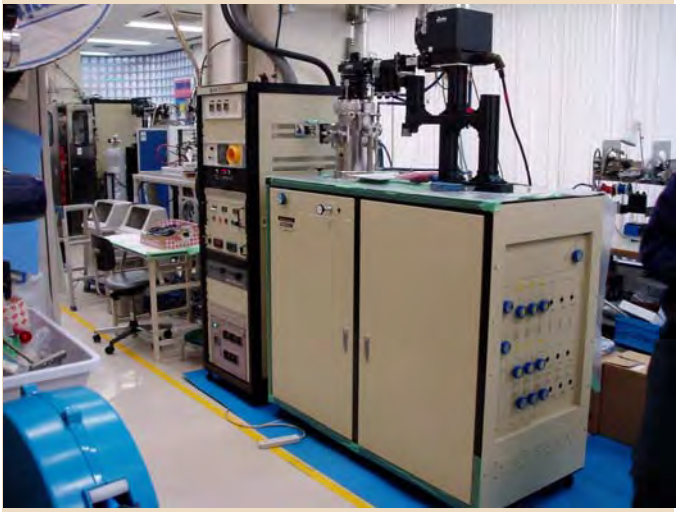
ENSL is fully up and running with a diverse suite of research instrumentation including items acquired using TIE funding such as FEI Helios Nanolab Dual Beam Focused Ion Beam/Scanning Electron Microscope (FIB/SEM), Bruker-AXS D8 Discover X-ray diffractometer and NIMA Technology Model 612D Langmuir-Blodgett Trough (LBT). ENSL is one of the research infrastructure facilities falling under the IMR umbrella and the ENSL Director is an IMR technical staff member.

Research capabilities available at ENSL include focused ion beam/scanning electron microscopy, e-beam lithography, nanomanipulation, EDS X-ray microanalysis, X-ray diffractometry, SQUID magnetometry, atomic force/magnetic force microscopy, Langmuir-Blodgett trough monolayer deposition and a capability for Low-Temperature Magnetotransport measurements.

ENCOMM NanoSystems Laboratory Highlights and Accomplishments During FY2011

During Fiscal Year 2010-2011, ENCOMM NanoSystems Laboratory (ENSL) has continued growth in the number of staff members, the number of available instruments, the volume of provided services and the number of customers served. This year ENSL supported 117 users from 39 research groups and three industry partners. ENSL provided research services to users valued at $150,200, all representing a 25% increase in the volume of services provided to facility users compared to the previous year of operation.

Several new equipment acquisitions were made by ENSL this fiscal year to further enhance its broad capabilities in material characterization and fabrication. In June 2011, a new Bruker Dimension Icon Atomic Force/Magnetic Force microscope (AFM/MFM) was delivered and commissioned, and is currently fully available to ENSL users. The instrument represents the next step in AFM/MFM technology development. In particular, it has a new Peak Force QNM mode of operation unavailable in scanning probe microscope of other models/manufacturers. This mode of operation allows simultaneous acquisition of data on sample topography and sample mechanical properties. A SEKI microwave CVD system for diamond growth, purchased with funds from the NSF MRI award detailed earlier in this report, has been installed and commissioned in January 2011. The system is currently used for diamond growth recipe development, and will be used for the growth of diamond and carbon nanotubes. ENSL has ordered a Kurt J. Lesker Lab-18 magnetron sputtering system combined with e-beam evaporator and an ion mill, which is to be delivered in August 2011 and expected to become operational in September 2011. Also arriving this fall is a new Evico Magnetics magneto-optical Kerr microscope for real time magnetic domain visualization, to be delivered and commissioned in September 2011.



The ENCOMM NanoSystems Laboratory (ENSL) dramatically expanded its research capabilities through the acquisition of three new pieces of equipment this year, including the Seki Technotron Corp. AX5200M 1.5kW Microwave-Plasma Enhanced-Chemical Vapor Deposition System (CVD) pictured above. This state-of-the-art deposition tool is used for synthesizing high quality poly crystalline and single crystal diamond films for research and production.

ENSL staff continued to grow this year to keep up with user demand. A new full time staff member, Mr. Robert Wells, joined ENSL in July 2011 as a Laboratory Services Coordinator, a position is funded by the Center for Emergent Materials, Ohio State's NSF MRSEC program. Mr. Wells has been supporting research at the Department of

Physics for 18 years as a member of the Electromechanical Support Staff, and brings a wealth of knowledge and experience to ENSL that will help the facility, as it keeps expanding, to continue to provide support to the OSU material science community.

Center for Chemical and Biophysical Dynamics (CCBD)

Center for Chemical and Biophysical Dynamics (CCBD) Overview

Through a partnership between the IMR and the departments of Chemistry and Biochemistry, the Center for Chemical and Biophysical Dynamics (CCBD) has in this reporting period become an open user lab available to OSU faculty and their research groups, as well as external users. The mission of the CCBD is to provide users with access to laser spectrometry instrumentation, including all the equipment necessary to measure transient UV/Vis, fluorescence, infrared, and stimulated Raman spectra on femto-, pico-, and nanosecond time scale. Researchers use CCBD instrumentation to perform several forms of ultrafast laser spectrometry to reveal the complex evolution of light quanta absorbed by matter. By measuring with high temporal precision the changes in characteristic spectral signatures of photogenerated intermediates, the sequence of individual events can be discerned, the information which otherwise is smeared and integrated over time. The evolution steps provide a rich harvest of knowledge about the energy flow and mechanisms of transformations in biological, chemical, physical, and materials systems. This knowledge is invaluable for learning how photoreactive systems work in nature as well as for optimizing the energy transfer and eliminating energy losses in artificial systems and materials.

Center for Chemical and Biophysical Dynamics (CCBD) Highlights and Accomplishments During FY2011

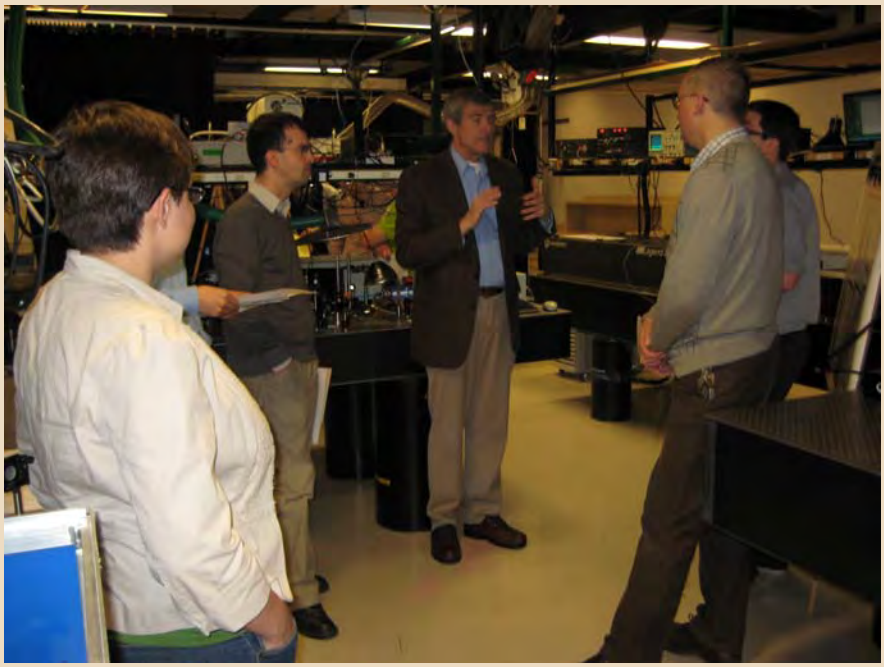
As indicated in last year's annual report, Dr. Evgeny Danilov was hired in January 2010 as the CCBD facility manager, and was tasked with taking this multi-user research facility and turning it into a facility open to the entire materials community. The majority of Dr. Danilov's time this fiscal year was spent refurbishing the laboratory space for users; establishing facility policies and procedures, an operating budget and user fee schedule; repairing, upgrading, calibrating, and testing existing equipment; and evaluating the needs of the facility and its users for new equipment.

The Center for Chemical and Biophysical Dynamics (CCBD) celebrated its conversion to an open user facility with an open house on May 6, 2011. Visitors were able to tour the CCBD's two labs in Newman-Wolfrom Laboratory and see the available instrumentation, talk with CCBD Lab Director, Prof. Terry Gustafson and Lab Manager Dr. Evgeny Danilov about the lab's capabilities, and see posters of recent work done in CCBD by OSU students. The CCBD Open House was attended by OSU faculty, staff, students, and potential industry collaborators, who learned more about this exciting addition to OSU's materials facilities. A student assistant was hired by the IMR to assist Dr. Danilov with day-to-day tasks, laboratory maintenance, and instrument upgrades in the CCBD laboratories.

CCBD maintained collaboration with the core PIs and research groups within the Department of Chemistry. Three new user groups with PIs, staff, and students from Physics, Materials Science and Engineering, and Electrical and Computer Engineering were trained to use CCBD equipment, and these research collaborations continue. The CCBD budget and fee schedule was finalized in January 2011, and in the final

six months of this fiscal year, the income generated in six months by CCBD has amounted to $4,500. This is expected to grow considerably as CCBD moves beyond its first few inaugural months of operation as an IMR user facility.

With funding provided by the IMR and Chemistry, 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 equipment will be used to modernize the CCBD time correlated single photon counting apparatus. The upgrade will include a newer version of the hardware and more reliable software running on a computer from a recent generation of Dell machines.



Center for Chemical and Biophysical Dynamics (CCBD) Director Prof. Terry Gustafson talks to guests about the lab's instrumentation during the CCBD Open House on May 6, 2011.

The new semiconductor single photon counting module will extend the spectral detection range from Visible to near IR (ca. 1060 nm) with sub-nanosecond time resolution. A confocal microscope attached to the instrument will allow more efficient collection of fluorescence from small-scale semiconductor films and devices. An alternative optical pump scheme using a focusing mirror instead of the lens / microscope objective will allow one to use UV light to excite photoluminescence. The upgrade will be completed by July 2011. After the upgrade the users of the instrument will enjoy a more reliable, user-friendly setup with an expanded spectral range.

Future plans for the next year involve building a near IR transient absorption spectrometer and a fluorescence up-conversion setup. The current broadband data collection system covers a probe wavelength region from 320 to 750 nm. On the other hand, many transient absorption signals are positioned in the near IR region above 1000 nm. A near IR sensitive CCD camera has to be incorporated into the measurement system to allow for the near IR signal detection. The corresponding communication hardware has to be designed and the communication and data acquisition software has to be engineered and integrated into the existing femtosecond pump-probe optical layout. This upgrade will be completed during Winter Quarter 2012. The current time correlated single photon counting setup's subnanosecond time resolution, even though standard for this kind of instrument, is often insufficient in experiments with thin films and some

solutions. Accordingly, a time resolved photoluminescence setup is sought to be built utilizing existing CCBD femtosecond lasers and nonlinear frequency conversion technique. The optical layout has to be designed and built and data acquisition software has to be engineered. It is anticipated that this upgrade will be completed by Summer Quarter 2012.

Integrated Laboratory Management Software Implementation

In Fiscal Year 2009, IMR Member of Technical Staff member Dr. Denis Pelekhov in the IMR-supported ENCOMM Nanosystems Laboratory (ENSL) developed a comprehensive tracking database data-entry software suite that tracks all forms of major facility use, and allows for timely and accurate billing and invoicing. Once the software was beta-tested in ENSL and fully operational in that lab, it was determined that the implementation of this software in other OSU research facilities was essential for addressing proper cost recovery issues and to unburden the IMR Members of Technical Staff from using separately developed billing and tracking systems. Furthermore, a standard approach for tracking enables much simpler reports on usage, impact, multidisciplinary involvement, industry involvement and so on. In FY 10, Dr. Pelekhov worked with IMR administrative and technical staff to adapt the software for other IMR-enhanced and operated labs, including the Semiconductor Epitaxy and Analysis Lab (SEAL). Since then, the IMR initiated a contract with the Ohio Supercomputer Center to house a platform that could work with and between the various department level computer firewalls and security systems to enable sharing of data between IMR and the various labs housed in different departments and colleges. During FY 2011, the software was also implemented in the Microelectronics Laboratory, a cleanroom facility within the department of Electrical and Computer Engineering which houses major equipment including the ammonia MBE system acquired through the NSF MRI award described earlier. Now that this Integrated Laboratory Management software has been successfully implemented in three research facilities, IMR plans to expand the software integration to others, with the goal of further standardizing billing, invoicing and reporting for all major materials facilities at OSU.

Communications, Outreach and Engagement

2010 OSU Materials Week Conference

Each September, IMR hosts Materials Week, an annual conference that showcases materials-allied research at The Ohio State University and beyond. In 2010, IMR was joined by the Center for Emergent Materials, OSU's NSF Materials Research Science and Engineering Center, in planning and organizing the conference, renamed OSU Materials Week. This annual event brings together hundreds of researchers and covers the full spectrum of materials-allied research. 2010 OSU Materials Week was a great success and our largest conference yet, with over 330 participants representing OSU and 15 other universities, over a dozen industry collaborators, and several government labs. Materials Week is a collaborative effort and each year a call is sent out to the OSU materials community who respond with ideas for session topics and suggested speakers. This year a program planning committee was created with faculty representatives from five academic departments and two Ohio Wright Projects.

This committee put together a comprehensive lineup of exciting topics and speakers in Plenary, Cross-Cutting, and focused technical sessions, in addition to two full evenings of student posters, covering the following areas:

- Materials Science of Energy Storage
- Spintronics and Graphene
- Next Generation Photovoltaics, Advanced Characterization and Ultra-Fast Phenomena
- Materials, Entrepreneurship, and the Innovation Cycle
- Computational Materials Design
- Epitaxial Control of Novel Materials
- Biomaterials and Bio-Based Products
- Frontiers in Biomaterials

OSU President Gordon Gee applauds the work of over 80 undergraduate and graduate students for their participation in the 2010 OSU Materials Week student poster sessions. A sample of our conference marketing materials is shown at right.

This year, 80 research posters were presented by students and postdoctoral researchers who are doing cutting edge materials research at OSU. Ten award winners were announced at the Materials Week luncheon and were presented plaques by OSU President Gordon Gee. The 2010 OSU Materials Week student poster sessions/receptions were generously sponsored by several industry partners: Entrotech, Energy Focus, Polymer Ohio, Replex Plastics, and LakeShore Cryotronics.

IMR Quarterly Newsletter

Since Spring 2009, the Institute for Materials Research has published IMR Quarterly, a quarterly newsletter with technical articles highlighting materials-allied research, and newsworthy information relevant to materials at The Ohio State University. IMR administrative staff members collect information from various subject matter experts throughout campus for each newsletter, including activities within the many federal, state and industry supported materials research and innovation centers, updates on research funded by IMR grants, facility updates, recently awarded grants, and other materials research news. The publication highlights one or two IMR members per issue as well. Each quarterly newsletter is available online at IMR's website and is distributed by mail to approximately 1,500 readers on campus and at 600 individuals from national labs, other universities, and industry partners.

The IMR has published eight issues of the *IMR Quarterly* newsletter, a well-received publication highlighting individual and team research, industrial collaborations, updates from materials centers, IMR members' major awards and honors, facility profiles and major acquisitions, and other news pertinent to the OSU materials community. All 8 issues of *IMR Quarterly* are also available online on IMR's website.

2010-2011 IMR Colloquia Series

The Institute for Materials Research hosts a colloquia series each academic year, bringing internationally - renowned materials researchers to Ohio State to share the latest findings in their research and have fruitful discussions with OSU faculty and students. The 2010-2011 IMR Colloquia Series brought two outstanding, acclaimed materials scientists in areas of strategic interest to the IMR community:

Tuesday, May 3, 2011: Personalized Energy (for 1 x 6 Billion)

Daniel G. Nocera, Henry Dreyfus Professor of Energy; Director, Solar Revolutions Project; Director, Eni Solar Frontiers Center, Massachusetts Institute of Technology

Abstract: The capture and storage of solar energy at the individual level – personalized solar energy – drives inextricably towards the heart of this energy challenge by addressing the triumvirate of secure, carbon neutral and plentiful energy. The doubling of global energy need by mid-century and tripling by 2100 is driven by 3 billion low-energy users in the non-legacy world and by 3 billion people yet to inhabit the planet over the next half century. The possibility of generating terawatts of carbon-free energy, and thus providing society with its most direct path to realizing a low GHG future, may be realized by making solar PE available

to the 6 billion new energy users by high throughput manufacturing. This talk will present the creation of new catalysts for the oxygen evolving reaction (OER) and hydrogen evolving reaction (HER) that capture many of the functional elements of photosynthesis; these catalysts are then integrated to make the first artificial leaf. A movie will be shown of a OER/Si/HER wafer (no wires!) that sits in a glass of water and performs water splitting under one sun irradiation. It is indeed a leaf. The discovery sets a new paradigm for the direct production of solar fuels. In doing so, we provide a highly manufacturable and inexpensive method to effect a carbon-neutral and sustainable method for solar storage – solar fuels from water-splitting. By developing an inexpensive 24/7 solar energy system for the individual, a carbon-neutral energy supply for 1 × 6 billion becomes available.

On May 3, 2011, Dr. Daniel Nocera closed out the 2010-2011 IMR Colloquia Series with an engaging talk titled "Personalized Energy (for 1x6 Billion)." His multimedia presentation was attended by approximately 100 guests—primarily OSU faculty and graduate students—who heard about Nocera's research on the capture and storage of solar energy at the individual level. Pictured above are Chemistry Chair and IMR Associate Director Malcolm Chisholm, Dan Nocera, and IMR Director Steve Ringel.

Wednesday, November 10, 2010: The Convergence of Science and Engineering: Energy Conversion at Nano Scale

Fritz B. Prinz, Finmeccanica Professor of Engineering and Robert Bosch Chair, Department of Mechanical Engineering, Stanford University

Abstract: Selective mass and charge transfer drive energy conversion in any living system. Not unlike nature, man-made energy conversion systems such as fuel cells depend on membranes with selective ionic conduction. Our experiments have shown that we can fabricate freestanding oxide membranes with a thickness of tens of nanometers. In particular, we used Yttria stabilized Zirconia and Gadolinia doped Ceria as electrolyte membranes for the creation of a new class Solid Oxide Fuel Cells (SOFCs) that are capable of operating at several hundred degrees centigrade below the temperature of traditional SOFCs. First principles calculations help in understanding oxide ion incorporation and ion conductivity as a function of dopant concentration. Our ability to effectively draw power from ultra thin membrane structures inspired us to explore interrupting the natural electron transport chain in thylakoid membranes, the key ingredient of every chloroplast organelle in light sensitive plant cells. Exposing thylakoid membrane stacks to nano-scale electrodes and stimulating them with light pulses resulted in measurable polarization currents.

In addition to IMR's formal Colloquia Series, the Institute also co-sponsored a seminar with the Electrical and Computer Engineering Department's Solid State Electronics and Photonics (SSEP) Seminar Series during Spring 2011 quarter. On February 3, 2011, Professor Adrian Hierro of the Universidad Politecnica de Madrid (UPM) presented a seminar titled Oxide-based UV Photodetection as part of an international partnership between the OSU Institute for Materials Research and UPM. The IMR-UPM collaboration, detailed in our FY2009-2010 Annual Report, was created to enhance educational, academic and research in areas central to advanced materials and related technologies at both institutions.

Support for Student Conference Participation

Once again this year, the OSU Institute for Materials Research provided direct funding for student sponsorship to support OSU student participation in the **Ohio Innovation Summit**. The 2011 Ohio Innovation Summit's theme was Returning to Ohio's Material Roots, and the conference was held April 19 -20, 2011 in Toledo, Ohio. IMR's financial sponsorship included the Summit registration fee and a hotel room, which allowed ten OSU students to participate in this important statewide materials conference. Attendance at this conference offers students the opportunity to showcase their work and expand their knowledge of nanomaterials, biomaterials, and new polymer systems for application in advanced energy, biomedical devices, electronics, aerospace and transportation. The sponsored OSU students were also provided an excellent opportunity to network with representatives from a range of companies who are experts in these fields.

The Institute for Materials Research also contributed $2,000 towards the **2011 Committee on Constitutional (CIC) 25th Annual Summer Research Opportunities Conference (SROP)**, an annual conference which brings together REU students from underrepresented racial/ethnic minorities from the Big 10 schools and the University of Chicago. The goal of the program is to increase the number of underrepresented students who pursue graduate study and research, and ultimately academic careers. SROP helps prepare undergraduates for graduate study through intensive research experiences with faculty mentors and enrichment activities at participating universities.

Financial Report

The Institute for Materials Research is supported by the OSU Office of Research, the College of Engineering, and the Division of Natural and Mathematic Sciences of the College of Arts and Sciences, through a three-year renewable memorandum of understanding. Each entity provides equal 1/3 shares of the base IMR support, which totaled $819,300 in FY11. As a result of this direct support at the college and Office of Research level, IMR does not receive cash from the return on indirect expenses via faculty-led funded projects, since faculty maintain full appointments in their home departments, and are not appointed into IMR directly. In addition to the IMR core support, IMR receives direct internal support from the Office of the Provost through the Targeted Investment in Excellence (TIE) program, which was a competitively awarded program led by IMR. FY11 is the final phase of the TIE, which amounted to an additional $418k of funding into the IMR core. The sum of these internal sources for FY11 was $1,237,300.

In the early part of FY11, the formal operation and unit reporting responsibility of the OSU Nanotech West Laboratory was transferred from the College of Engineering to the IMR. This formal move aligned the unit authority with the actual technical facility management that is already in place, since the Nanotech Director already reports to the IMR Director. A one-year memorandum of understanding was executed for FY11 to initiate this process, with the anticipation that the Nanotech West formal operations be incorporated in conjunction with the expected renewal of the three year IMR MOU to begin in FY12. The Nanotech West operating budget, including rent of the entire building, power, water and all other essentials, personnel, etc., is supported by an agreement between the Office of Research, the College of Engineering and the IMR, with the IMR contribution being solely derived from user fee income from the facility.

Table 4 details the IMR expenses tagged for FY11. The associated pie chart in **Figure 10** reveals the general distribution into primary categories.

Category	Total Expenses FY 2011	Notes
Personnel		
Administrative Personnel: Salary and Fringe	$ 527,990	
Total Administrative Personnel	**$ 527,990**	
Technical Personnel: Salary and Fringe	$ 632,041	
Total Tehnical Personnel and Staff	**$ 632,041**	
Equipment/Capital Investment		
ENSL NSF MRI Facility	$ 6,000	
Total Equipment/Capital Investment	**$ 6,000**	
Seed Grants		
Research Enhancement Programs (Seed Grants)	$ 529,200	*This includes 7 IMRG Renewals transferred prior to FY11*
Total Seed Grants	$ 529,200	
Laboratory Operating Support		
IMR Support for the MOCVD Facility	$ 97,199	
Total Laboratory Operating Support	**$ 97,199**	
Faculty Recruiting/Start-up		
IMR ORSP Faculty Recruitment	$ 150,000	Cost sharing of new member of technical staff for CEMAS
Total Faculty Recruiting/Start-up	**$ 150,000**	
Proposal Development Support		
Proposal Development Support	$ 23,250	
Total Proposal Development Support	**$ 23,250**	
Additional Support of Prime Materials Research Centers		
OSU Center for Emergent Materials - MRSEC	$ 49,710	Administrative support
OSU Center for Affordable Nanoengineering of Polymeric Biomedical Devices - NSEC	$ 64,000	Industry match seed grants
Total Additional Support of Prime Research Centers	**$ 113,710**	
Operating Expenses		
IMR Core Operating Expenses		
General Marketing Materials	$ 16,335	
Outreach, Education & Sponsorships	$ 15,436	
IMR Colloquia	$ 1,303	
IMR 2010 Materials Week	$ 40,562	
Business Meals and Entertainment	$ 594	
Office Supplies and Computer Equipment	$ 26,330	
IMR External Advisory Board	$ 3,518	
Total IMR Core Operating Expenses	**$ 104,077**	
NTW Operating Expenses		
Building Expenses	$ 51,752	
Lab Supplies & Services	$ 229,298	
Lab Equipment & Repair	$ 268,631	
Office Supplies and Computer Equipment	$ 11,652	
Communications Expenses	$ 12,865	
Overhead	$ 23,995	
Total NTW Operating Expenses	**$ 598,192**	
Total IMR and NTW Operating Expenses	**$ 702,270**	
Total Expenses	**$ 2,781,660**	

** Above listed expenses do not include personnel, operating, and capital expenses paid by external research funding such a the Wright Center for Photovoltaics Innovation and Commercialization*

Table 4. Institute for Materials Research Fiscal Year 2010-2011 Expenses

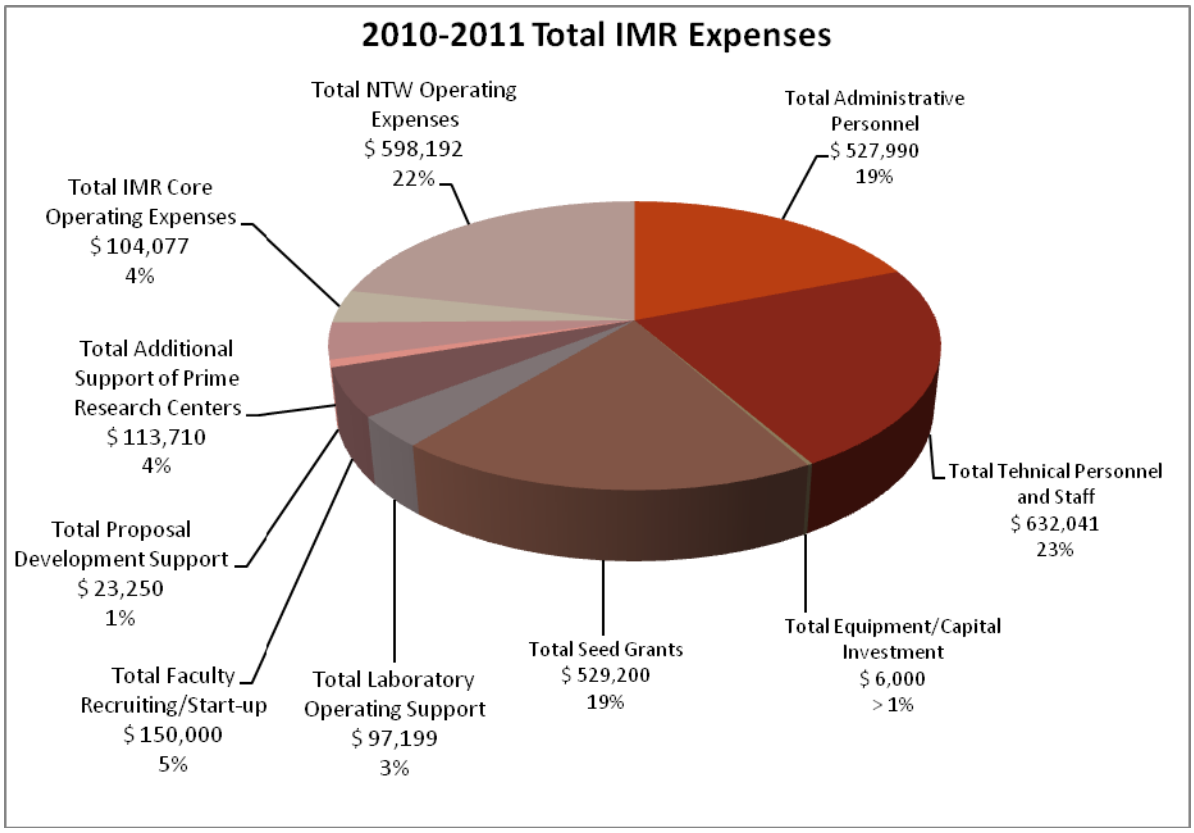


Figure 10. Institute for Materials Research total expenses for Fiscal Year 2010-2011 by major category.

Appendices

Appendix A: Members of the Institute for Materials Research (IMR) as of July 2011

Appendix B: Research Outputs from OSU Materials Community Directly Resulting from IMR Resources and Activities for Fiscal Year 2010 - 2011

- Peer-Reviewed Publications
- Professional Presentations
- External Research Funding

Appendix C: Activities of IMR Members of Technical Staff (MTS) for Fiscal Year 2010 - 2011

- Dr. John Carlin, Research Scientist, Nanotech West Laboratory
- Dr. Evgeny Danilov, Senior Research Associate, Center for Chemical and Biophysical Dynamics
- Dr. Robert J. Davis, Director, Nanotech West Laboratory and Associate Director, Institute for Materials Research
- Dr. Denis V. Pelekhov, Research Scientist, ENCOMM NanoSystems Laboratory
- Aimee Bross Price, Senior Research Associate, Nanotech West Laboratory

Appendix D: 2011 OSU Materials Seed Grant Program

- Request for Proposals
- Sample Evaluation Forms
- Announcement

Appendix E: 2010-2011 IMR Facility Grants Awards

Appendix A

Members of the Institute for Materials Research (IMR) as of July 2011

Appendix A: Members of the Institute for Materials Research (IMR) as of July 2011

Sudha Agarwal, Oral Biology

Gunjan Agarwal, Biomedical Engineering

Kristy Ainslie, Pharmacy

Sheikh Akbar, Materials Science and Engineering

Boian Alexandrov, Materials Science and Engineering

Heather Allen, Chemistry

Betty Lise Anderson, Electrical and Computer Engineering

Peter Anderson, Materials Science and Engineering

Mirela Anghelina, Davis Heart and Lung Institute

Sudarsanam Suresh Babu, Materials Science and Engineering

Jovica Badjic, Chemistry

Yakup Bayram, Electroscience Laboratory

Thomas Bean, Food, Agricultural and Biological Engineering

Jim Beatty, Physics

Stephen Bechtel, Mechanical and Aerospace Engineering

Paul Berger, Electrical and Computer Engineering

Bharat Bhushan, Mechanical and Aerospace Engineering

Thomas Blue, Mechanical and Aerospace Engineering

Dennis Bong, Chemistry

Leonard Brillson, Electrical and Computer Engineering

Rudy Buchheit, Materials Science and Engineering

Ralf Bundschuh, Physics

Lei (Raymond) Cao, Mechanical and Aerospace Engineering

John Carlin, Institute for Materials Research

Carlos Castro, Mechanical and Aerospace Engineering

Malcolm Chisholm, Chemistry

William Clark, Materials Science and Engineering

James Coe, Chemistry

Edward Collings, Materials Science and Engineering

Terry Conlisk, Mechanical and Aerospace Engineering

Stuart Cooper, Chemical and Biomolecular Engineering

Katrina Cornish, Horticulture and Crop Science

Glenn Daehn, Materials Science and Engineering

Evgeny Danilov, Institute for Materials Research

Marcelo Dapino, Mechanical and Aerospace Engineering

Robert Davis, Institute for Materials Research

Frank De Lucia, Physics

Appendix A: Members of the Institute for Materials Research (IMR) as of July 2011

Suliman Dregia, Materials Science and Engineering

Charles Drummond, Materials Science and Engineering

Prabir Dutta, Chemistry

Arthur Epstein, Physics

Edward Eteshola, Biomedical Engineering

Liang-Shih Fan, Chemical and Biomolecular Engineering

Katharine Flores, Materials Science and Engineering

Gerald Frankel, Materials Science and Engineering

Hamish Fraser, Materials Science and Engineering

Richard Freeman, Physics

Somnath Ghosh, Mechanical and Aerospace Engineering

Josh Goldberger, Chemistry

Keith Gooch, Biomedical Engineering

Jianjun Guan, Materials Science and Engineering

Yann Guezennec, Mechanical and Aerospace Engineering

Prabhat Gupta, Materials Science and Engineering

Jay Gupta, Physics

Terry Gustafson, Chemistry

Nathan Hall, Radiology

P. Chris Hammel, Physics

Derek Hansford, Biomedical Engineering

Richard Hart, Biomedical Engineering

Joseph Heremans, Mechanical and Aerospace Engineering

Anton Heyns, Chemistry

Julia Higle, Integrated Systems Engineering

George Hinkle, Pharmacy

W.S. Winston Ho, Chemical and Biomolecular Engineering

Ezekiel Johnston-Halperin, Physics

Matt Kleinhenz, Horticulture and Crop Science

Kurt Koelling, Chemical and Biomolecular Engineering

Ashok Krishnamurthy, Electrical and Computer Engineering

Gregory Lafyatis, Physics

John Lannutti, Materials Science and Engineering

Robert Lee, Electrical and Computer Engineering

Stephen Lee, Biomedical Engineering

L. James Lee, Chemical and Biomolecular Engineering

Robert J. Lee, Pharmacy

Thomas Lemberger, Physics

Yebo Li, Food, Agricultural and Biological Engineering

Appendix A: Members of the Institute for Materials Research (IMR) as of July 2011

John Lippold, Materials Science and Engineering

Wu Lu, Electrical and Computer Engineering

Anthony Luscher, Mechanical and Aerospace Engineering

Peter March, Natural and Mathematical Sciences

Edward Martin Jr., Surgery Oncology

Chia-Hsiang Menq, Mechanical and Aerospace Engineering

Carolyn Merry, Civil, Environmental Engineering and Geodetic Sciences

Julia Meyer, Physics

Fred Michel Jr., Food, Agricultural and Biological Engineering

Sharell Mikesell, Nanoscale Science and Engineering Center and Industry Liason Office

Terry Miller, Chemistry

Michael Mills, Materials Science and Engineering

Nicanor Moldovan, Davis Heart and Lung Institute

John Morral, Materials Science and Engineering

Patricia Morris, Materials Science and Engineering

Randy Moses, Electrical and Computer Engineering

Roberto Myers, Materials Science and Engineering

Stephen Myers, Ohio Bioproducts Innovation Center

Susan Olesik, Chemistry

Michael Ostrowski, Molecular and Cellular Biochemistry

Umit Ozkan, Chemical and Biomolecular Engineering

Nitin Padture, Materials Science and Engineering

Wendy Panero, School of Earth Sciences

Jon Parquette, Chemistry

Srinivasan Parthasarathy, Computer Science and Engineering

Michael Paulaitis, Chemical and Biomolecular Engineering

Denis Pelekhov, Institute for Materials Research

Jonathan Pelz, Physics

Matthew Platz, Chemistry

Michael Poirier, Physics

Stephen Povoski, Surgery Oncology

Heather Powell, Materials Science and Engineering

Shaurya Prakash, Mechanical and Aerospace Engineering

Aimee Price, Institute for Materials Research

Siddarth Rajan, Electrical and Computer Engineering

Mohit Randeria, Physics

Appendix A: Members of the Institute for Materials Research (IMR) as of July 2011

Bill Ravlin, Ohio Agricultural Research and Development Center

Ronald Reano, Electrical and Computer Engineering

David Rigney, Materials Science and Engineering

Matthew Ringel, Molecular Virology, Immunology and Medical Genetics

Steven Ringel, Electrical and Computer Engineering

Giorgio Rizzoni, Mechanical and Aerospace Engineering

Patrick Roblin, Electrical and Computer Engineering

Thomas Rosol, Surgery Oncology

Gang Ruan, Chemical and Biomolecular Engineering

Yogeshwar Sahai, Materials Science and Engineering

Kubilay Sertel, Electroscience Laboratory

Sadhana Sharma, Pharmacy

Scott Shearer, Food, Agricultural and Biological Engineering

Sherwin Singer, Chemistry

Ratnasingham Sooryakumar, Physics

Krishnaswamy Srinivasan, Mechanical and Aerospace Engineering

Doru Stefanescu, Materials Science and Engineering

David Stroud, Physics

Vishwanath Subramaniam, Mechanical and Aerospace Engineering

Michael Sumption, Materials Science and Engineering

Nandini Trivedi, Physics

Claudia Turro, Chemistry

George Valco, Electrical and Computer Engineering

Murugesan Velayutham, Davis Heart and Lung Institute

Hendrik Verweij, Materials Science and Engineering

Yael Vodovotz, Food Science Technology

John Volakis, Electrical and Computer Engineering

Robert Wagoner, Materials Science and Engineering

Eric Walton, Electroscience Laboratory

Yunzhi Wang, Materials Science and Engineering

Gregory Washington, Mechanical and Aerospace Engineering

John Wilkins, Physics

James Williams, Materials Science and Engineering

Wolfgang Windl, Materials Science and Engineering

Appendix A: Members of the Institute for Materials Research (IMR) as of July 2011

Jessica Winter, Chemical and Biomolecular Engineering

David Wood, Chemical and Biomolecular Engineering

Patrick Woodward, Chemistry

Yiying Wu, Chemistry

Ronald Xu, Biomedical Engineering

Fengyuan Yang, Physics

Sheng-Tao John Yu, Mechanical and Aerospace Engineering

Yi Zhao, Biomedical Engineering

Ji-Cheng Zhao, Materials Science and Engineering

Yuan Zheng, Electrical and Computer Engineering

Appendix B

Research Outputs from OSU Materials Community Directly Resulting from IMR Resources and Activities for Fiscal Year 2010 - 2011

- Peer-Reviewed Publications
- Professional Presentations
- External Research Funding

Appendix B: Publications Directly Resulting from IMR Resources and Activities for Fiscal Year 2010-2011

Note: This list relies on self reporting and is likely to be underestimated; an asterisk (*) indicates those items obtained through leveraging more than one IMR-supported activity

Suresh Babu

S. S. Babu, "In pursuit of optimum welding system design for steels," Science and Technology of Welding and Joining, 2011, Vol. 16, pp. 306 - 312

D. Schick, S. S. Babu, D. Foster, M. Short, M. Dapino, and J. C. Lippold, "Transient Thermal Response in Ultrasonic Additive Manufacturing of Aluminum 3003," Rapid Prototyping Journal, Vol. 17 Iss: 5, pp.369 – 379, 2011

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Yael Vodovotz

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S. Modi, K. Koelling, Y. Vodovotz, “Miscibility of Poly-(3-hydroxybutyrate-co-3-hydroxyvalerate) and Poly (Lactic Acid) blends Determined by Thermal Analysis.” Journal of Applied Polymer Science [In Progress]

S. Modi, K. Koelling, Y. Vodovotz, "Mechanical and Rheological Properties Poly-(3-hydroxybutyrate-co-3-hydroxyvalerate) and Poly (Lactic Acid) blends.” Journal of Applied Polymer Science [In Progress]

David Wood

Wu, W.-Y., Miller, K. D., Coolbaugh, M. J. & Wood, D. W., "Intein-mediated One-step Purification of E. coli Secreted Human Antibody Fragments," *Protein Expression and Purification*, Vol. 76, pp. 221-228, (2011).

Fong, B. A. & Wood, D. W., "Expression and purification of ELP-intein-tagged target proteins in high cell density E. coli fermentation," *Microbial Cell Factories*, Vol. 9, p. 77, (2010).

Wood, D. W., "Non-chromatographic Recombinant Protein Purification by Self-Cleaving Purification Tags," *Separations Science and Technology*, Vol. 45 (15), pp. 2345-2357, (2010).

Fong, B. A., Gillies, A. R., Ghazi, I., LeRoy, G., Lee, K. C., Westblade, L. F. & Wood, D. W., "Purification of Escherichia coli RNA polymerase using a self-cleaving elastin-like polypeptide tag," Protein Science, 19(6): 1243–1252, 2010.

Wu, W. Y., Gilles, A. R., Hsii, J., Contreras, L., Oak, S., Perl, M. B., & Wood, D. W., "Self-cleaving purification tags re-engineered for rapid Topo® cloning," *Biotechnology Progress*, 26:5, 2010.

Shapero, K., Eyster, T. W. & Wood, D. W. "Bacterial Biosensors for Evaluating Potential Impacts of Estrogenic Endocrine Disrupting Compounds in Multiple Species," *Environmental Toxicology* (In press).

Fengyuan Yang

Dongkyun Ko, Xianwei Zhao, Kongara Reddy, Oscar Restrepo, Nandini Trivedi, Wolfgang Windl, Nitin Padture, Fengyuan Yang, and Ezekiel Johnston-Halperin, "Role of defect states in charge transport in semiconductor nanowires," submitted to Phys. Rev. Lett.

Lei Fang, Xianwei Zhao, Yi-Hsin Chiu, Dongkyun Ko, DongSheng Li, Nitin Padture, Fengyuan Yang, and Ezekiel Johnston-Halperin, "Controlling the polarization anisotropy through oxide coating in InP and ZnO nanowires," submitted to Appl. Phys. Lett.

A. J. Hauser, R. A. Ricciardo, A. Genc, R. E. Williams, P. M. Woodward, H. L. Fraser, F. Y. Yang, " Magnetic and Structural Properties of Half-Metallic Sr2FeMoO6 epitaxial Films Fabricated by ultra-High Vaccuum Sputtering," Journal of Applied Physics [In Progress]

Ji-Cheng (JC) Zhao

Z. Huang, X. Chen, T. Yisgedu, E.A. Meyers, S.G. Shore, J.C. Zhao, "Ammonium Octahydrotriborate ($NH_4B_3H_8$): New Synthesis, Structure, and Hydrolytic Hydrogen Release," Inorganic Chemistry, vol. 50, Issue 8, (2011).

D.T. Shane, L.H. Rayhel, Z. Huang, J.C. Zhao, X. Tang, V. Stavila, M.S. Conradi, "Comprehensive NMR Study of Magnesium Borohydride," J. Phys. Chem., 115 (7), pp. 3172-3177, (2011).

Z. Huang, X. Chen, T. Yisgedu, J.C. Zhao, S.G. Shore, "High-capacity hydrogen release through hydrolysis of NaB_3H_8," International Journal of Hydrogen Energy, vol. 36, Issue 12, (2011).

J.C. Zhao, X. Zheng, D.G. Cahill, "High-throughput measurements of materials properties," Journal of the Minerals, Metals, and Materials Society, vol. 63, Issue 3, (2011).

T.B. Yisgedu, X. Chen, H.K. Lingam, Z. Huang, A. Highley, S. Maharrey, R. Behrens, S.G. Shore, J.C. Zhao, "Synthesis, Structural Characterization, and Thermal Decomposition Study of $Mg(H_2O)_6B_{10}H_{10}\cdot 4H_2O$," J. Phys. Chem. C, 115 (23), pp. 11793-11802, (2011).

Z. Huang, G. King, X. Chen, J. Hoy, T. Yisgedu, H.K. Lingam, S.G. Shore, P.M. Woodward, J.C. Zhao, "A Simple and Efficient Way to Synthesize Unsolvated Sodium Octahydotriborate," Inorganic Chemistry, vol. 49, Issue 18, (2010).

X. Chen, J.C. Zhao, S.G. Shore, "Facile Synthesis of Aminodiborane and Inorganic Butane Analogue $NH_3BH_2NH_2BH_3$," J. Am. Chem. Soc., 132, (31), pp. 10658-10659, (2010).

Yi Zhao

H. Borteh, B. Kim Y. Zhao. 2011. "Porous Microfluics: A Unique Platform for Transvascular Study". Technical Digest of the 23rd IEEE International Conference on Micro Electro Mechanical Systems (MEMS '11), Cancun, Mexico, January 23-27, 2011.

B. Kim, Y. Zhao. 2010. "Programmable Micropatterning of Polymer Nanofibers". ASME International Mechanical Engineering Congress and RD&D Expo (ASME '10). Vancouver, BC, Canada

Appendix B: Presentations Directly Resulting from IMR Resources and Activities for Fiscal Year 2011-2012

Note: This list relies on self reporting and is likely to be underestimated; an asterisk (*) indicates those items obtained through leveraging more than one IMR-supported activity

Sheikh Akbar

"Nanofibers of TiO2 grown on Ti and Ti alloys as gas sensing platforms," 13th International Meeting on Chemical Sensors (IMCS13), Perth, Australia; 7/2010

"Dendritic Barium Titanate Formed by Hydrothermal Conversion of TiO2 Nanowire Template," Ceramographic competition, MS&T 2010, Huston, TX; 10/2010

Paul Berger

Paul R. Berger, "Negative Differential Resistance Devices for Quantum Functional Circuitry," The A. Usikov Institute of Radio Physics and Electronics of the National Academy of Sciences of Ukraine (IRE NASU) at Kharkiv, Ukraine (August 26, 2011)

Paul R. Berger, "Negative Differential Resistance Devices for Quantum Functional Circuitry," Hong Kong University of Science and Technology (March 2011)

Paul R. Berger, "Negative Differential Resistance Devices for Quantum Functional Circuitry," Fudan University (March 2011)

Paul R. Berger, "Negative Differential Resistance Devices for Quantum Functional Circuitry," Southeast University (March 2011)

Paul R. Berger, "Negative Differential Resistance Devices for Quantum Functional Circuitry," Nanjing University (March 2011)

Paul R. Berger, "Extending CMOS: Quantum Functional Circuits with Si-Based Resonant Interband Tunnel Diodes," St. Petersburg State Polytechnical University (October 26, 2010)

Paul R. Berger, "Quantum Tunneling Devices for Sub-Terahertz Detection and Low-Power CMOS," St. Petersburg State University of Informational Technologies, Mechanics and Optics (October 25, 2010)

Bharat Bhushan

Bharat Bhushan. 9/2010. Institute Colloquium, "Biomimetics – Lessons from Nature," State Key Laboratory of Nonlinear Mechanics, Beijing, China

Bharat Bhushan. 9/2010. Institute Colloquium, "Biomimetics – Lessons from Nature," College of Engineering Peking University, Beijing, China.

Bharat Bhushan. 9/2010. Institute Colloquium, "Biomimetics – Lessons from Nature," Lanzhou Institute of Chemical Physics, Lanzhou, China.

Bharat Bhushan. 9/2010. Plenary Lecture, “Biomimetics – Lessons from Nature,” The Third International Conference of Bionic Engineering, Zhuhai, China.

Bharat Bhushan. 10/2010. Invited Lead Lecture, “Biomimetics – Lessons from Nature,” Ringberg Symposium Molecular Bionics – From Biomineralization to Functional Materials, Rottach-Egem, Germany.

Bharat Bhushan. 10/2010. Institute Colloquium, “Biomimetics – Lessons from Nature,” Institute for Applied Physics and Institute for Nanotechnology, Karlsruhe Institute of Technology, Karlsruhe, Germany.

Marcelo Dapino

“Smart materials research,” presented to Parker Hannifin Hydraulics Group, Columbus, Ohio, 22 July 2011.

“National Science Foundation I/UCRC on Smart Vehicle Concepts – Center Overview,” presented to Parker Hannifin, Columbus, Ohio, 21 July 2011.

“National Science Foundation I/UCRC on Smart Vehicle Concepts – Center Overview,” presented to Boeing, Columbus, Ohio, 14 July 2011.

“Smart materials: from constitutive modeling to system integration,” presented at The Boeing Co., Huntington Beach, California, 10 March 2011.

“Ultrasonic additive manufacturing of smart material systems,” presented at University of California, Los Angeles, 24 February 2011.

“Ultrasonic additive manufacturing of smart material systems.” presented at Texas A&M University, College Station, Texas, 15 February 2011.

“Very high power UAM concepts,” presented at Edison Welding Institute, Columbus, Ohio, 5 November 2010.

“Smart Vehicle Concepts Center,” presented to Goodyear Tire & Rubber Co., Columbus, Ohio, 13 August 2010.

“Design, manufacture, modeling and control of smart systems,” presented at Shanghai Jiao Tong University, China, 21 July 2010.

Arthur Epstein

Yoo et al. America Physical Society March Meeting, Portland, OR (2010)

Bozdag et al. American Physical Society March Meeting, Portland, OR (2010)

JianJun Guan

J. Guan, “Injectable, highly flexible and thermoresponsive hydrogels for mesenchymal stem cell proliferation and differentiation”. 2010. ACS Fall Meeting, Boston

Nicanor Moldovan

“Inducing Stem Cells to the Cardio-Vascular Lineage with Biomaterials” at the 15th Annual Scientific Meeting of the Heart Failure Society of America, September 18-21, 2011 at the Hynes Convention Center in Boston, MA

Roberto Myers

March 2011, March Meeting of the American Physical Society, Dallas, Texas, “Room Temperature Ferromagnetism in GaN-AlN Quantum Confined Heterostructures”, Thomas Kent, J. Yang, L. Yang, S. D. Carnevale, B. Niles, D. R. Hoy, Y.-H. Chiu, E. Johnston-Halperin, M. J. Mills, R. C. Myers (student talk).

May 2011, Walter Schottky Institute Department Seminar, Technical University Munich, Munich, Germany, “Exploring semiconductor functionality at extreme length scales: macroscopic thermal spintronics and 3D nanowire heterostructures” (invited talk)

June 2011, American Nuclear Society Annual Meeting, Hollywood, Florida, “A Gadolinium Doped Superlattice GaN Schottky Diode for Neutron Detection”, J. Wang, P. Kandlakunta, T. F. Kent, J. Carlin, D. R. Hoy, R. C. Myers, L. Cao (submitted, student talk).

June 2011, Department of physics Seminar, University of Basel, Basel, Switzerland, “3D nanowire heterostructure from III-Nitrides and Ferromagnetic Gd:GaN” (invited talk)

June 2011, Embedded Nanoparticle Workshop, University of California, Santa Barbara, “Growth study of GdN in GaN by Plasma-Assisted Molecular Beam Epitaxy”, J. Yang, T. F. Kent, L.-M. Yang, S. D. Carnevale, M. J. Mills, R. C. Myers (student talk).

Heather Powell

H.M. Powell. 2010. “Composite Scaffolds for Skin Engineering”, Heal Ohio Annual Meeting. Northeast Ohio University College of Medicine, Rootstown, OH

H.M. Powell. 2010. "Engineered Skin Biomechanics: Balancing Biology and Materials Science", University of Illinois at Urbana-Champaign, Department of Mechanical Science Colloquium Series

R. Sooryakumar

Department of Physics, University of West Virginia, September 2010.

Department of Physics, Kenyon College, Ohio, November 2010.

Seventh International Conference on Low Dimensional Structures & Device, Telchac, Mexico, May 2011.

International Conference on Electromagnetics in Advanced Applications, Torino, Italy, September 2011.

David Wood

International Conference on Biomolecular Engineering (SBE) San Francisco, CA, January 15-19, 2011, "Engineered Allosteric Proteins for Drug Discovery and Environmental Monitoring."

PepTalk: Protein Purification and Recovery: Tag Technologies, Cambridge Healthtech Institute, San Diego, CA, January 10-13, 2011, "Self-Cleaving Tags: New Options and New Applications."

AIChE National Meeting (2010) Salt Lake City, UT, November 8-12, 2010, "Modulating the Sensitivity of a Bacterial Biosensor for Peroxisome Proliferator-Activated Receptors Gamma to the Ligands by Engineering Spacer Linker," oral presentation by Jingjing Li, Izabela Hartman, Alison Gillies, Charles Warden and David W. Wood.

"Probing Into the Mechanism for Bacterial Biosensor for Nuclear Receptor Ligand," oral presentation by Jingjing Li, Izabela Hartman and David W. Wood.

Preclinical Scale Bioprocessing IBC Life Sciences, Boston, MA, November 1-3, 2010, "Emerging Alternatives to Conventional Downstream Technologies: Considerations and Implementation at Preclinical Scale"

SUNY Buffalo Dept of Chemical and Biological Engineering, Buffalo, NY, October 27, 2010, "New Technologies from Engineered Self-Modifying Proteins."

Fengyuan Yang

"GaAs nanowires and GaAs/AlGaAs core/shell nanowires synthesized by MOCVD," B. Peters, N. G. Minutillo, J. A. Carlin, and F. Y. Yang, American Physical Society March Meeting, Dallas, March 2011.

"Role of defect states in charge transport in semiconductor nanowires," D. K. Ko, X. W. Zhao, K. Reddy, W. Windl, N. Padture, N. Trivedi, F. Y. Yang, E. Johnston-Halperin, American Physical Society March Meeting, Dallas, March 2011.

Ji-Cheng (JC) Zhao

"Borohydrides, Aluminoboranes and Boron-Cage Compounds for Hydrogen Storage", J.-C. Zhao*, X. Chen, Z. Huang, H. K. Lingam, T. Yisgedu, B. Billet, and S.G. Shore, (**Keynote lecture** and session chair), First International Conference on Materials for Energy, Karlsruhe, Germany, July 4-8, 2010.

"Compositional Point Defect Evaluation Using Diffusion Multiples", J.-C. Zhao*, X. Zheng, and D.G. Cahill, (**Invited talk**) 2010 Chinese Materials Research Society (CMRS) Annual Meeting, Changsha, China, June 19-22, 2010.

"Some Early Thoughts on a Materials Genome Project", J.-C. Zhao*, (**Invited lecture**) Central South University, Changsha, China, June 17th, 2010.

"Lightweight Metal Hydrides for Hydrogen Storage", J.-C. Zhao*, X. Chen, Z. Huang, H. K. Lingam, T. Yisgedu, B. Billet, and S.G. Shore, (Oral presentation) U.S. Department of Energy Annual Merit Review, Washington, DC, June 7-11, 2010.

Yi Zhao

B. Kim, D. Grzybowski, C. Roberts, P. Weber, and Y. Zhao. 2010. "Nanoengineered Polymer Scaffold with Controllable Porosity towards 3D In Vitro Trabecular Meshwork Model". ARVO 2010 Annual Meeting, Reducing Disparities in Eye Disease and Treatment. Fort Lauderdale, FL

Appendix B: Awards Directly Resulting from IMR Resources and Activities for Fiscal Year 2010-2011

Note: This list relies on self reporting and is likely to be underestimated; an asterisk (*) indicates those items obtained through leveraging more than one IMR-supported activity

Suresh Babu

"Development of Thermal Management Solutions for Lithium Ion Batteries," Ohio Third Frontier Advanced Energy Program, (Lead: GrafTech International, Ltd.), PI: Yann Guezennec, Co-PI(s): Suresh Babu, Marcello Canova, 3/4/2010-1/25/2012, $200,058

Paul Berger

"Conjugated Polymer Tunneling Devices for Plastic Electronic Memory", National Science Foundation, Program: Unsolicited, Electronics, Photonics and Device Technologies (EPDT), PI: P.R. Berger, 6/15/2010-5/13/2012, $223,547

"GOALI: Passive Millimeter-Wave Camera Using Monolithic Si-based Square-Law Detectors for Security and Transportation Safety," Sponsor: NSF, Program: Unsolicited, Electronics, Photonics and Device Technologies (EPDT), Lead: The Ohio State University, P.I. Paul R. Berger, Project Dates: 9/15/10-9/14/13, Total Funding: $412,000

Bharat Bhushan

"Mechanically reliable surfaces for superhydrophobicity, self-cleaning and drag reduction", National Science Foundation Division of Civil, Mechanical, and Manufacturing Innovation, PI: Bharat Bhushan, 8/15/2010-7/31/2013, $300,000

Dennis Bong

"Selective aqueous phase adhesion by molecularly engineered materials", National Science Foundation Division of Civil, Mechanical, and Manufacturing Innovation,, PI: D. Bong, 9/1/2009-8/31/2012, $380,000

"Synthesis of amphiphilic core-shell latex emulsions from soy proteins and delivery of corrosion inhibitors and biocides for coatings application," Anonymous Industry Sponsor, PI: D. Bong, 8/1/2008-7/31/2011, $150,000

Leonard Brillson

"Development of AlGaN biosensor sensitive in physiological saline," National Science Foundation, PI: Stephen Lee, Co-PI(s): Leonard Brillson, Wu Lu, 9/1/2008-5/31/2012, $350,000

Marcelo Dapino

"Multifunctional composities with embedded sensing," Edison Welding Institute, Program: Industrial membership in NSF I/UCRC Vehicle Concepts Center, PI: M. Dapino, 7/1/2011-6/30/2014, $160,000

"Thermally invariant smart composites," MIT Lincoln Laboratories, Program: Industrial membership in NSF I/UCRC Smart Vehicle Concepts Center, PI: M. Dapino, $40,000

JianJun Guan

“Multifunctional hydrogels as stem cell carriers for cardiac therapy”, National Science Foundation Division of Materials Research, PI: JianJun Guan, Co-PI(s): Sudha Agarwal, 9/15/2010 – 8/31/2013, $310,000

Chris Hammel

"High Performance Nuclear Magnetic Resonance Imaging Using Magnetic Resonance Force Microscopy," US Army Research Office, PI: P.C. Hammel, 7/15/2009-2/14/2012, $465,000

Ezekiel Johnston-Halperin

“MRI: Acquisition of a Hybrid Diamond/III-N Synthesis Cluster Tool,” National Science Foundation, PI: Asst. Prof. Ezekiel Johnston-Halperin, Co-PIs: Harris Kagan, Roberto Myers, Siddharth Rajan, Steven Ringel, Fengyuan Yang; Amount: $600,000 (including mandatory cost share); Duration: 10/1/2009 – 9/31/2011.*

Wu Lu

“III-Nitride Heterojunction Field Effect Transistors for Biological Sensing”, National Science Foundation, PI: Wu Lu, 4/15/2007-3/31/2012, $290,000

“Collaborative Research: Scaling Laws for NanoFET Biosensors”, National Science Foundation Division of Electrical, Communications, and CyberSystems, PI(): Wu Lu, 10/1/2008-9/30/2012, $228,772*

"III nitride NEMS devices for chemical and biological sensing,” National Science Foundation, PI: Wu Lu, Co-PI(s): S. Rajan, 10/01/2009 - 09/30/2012, $360,000*

Nicanor Moldovan

“In vivo monitoring of oxygenation in implants: Applications to tissue engineering,” National Heart, Lung, and Blood Institute R01 HL096524; PI: Nicanor Moldovan; Co-Is: K. Gooch, P. Kuppusamy, J. Lannutti, 5/1/2010 – 4/30/2014; $1.58M in total costs*

Patricia Morris

“Gas Sensor Array Devices Based on Nano-structured Metal Oxides,” Edward J. Orton Jr. Ceramic Foundation, PI: Patricia A. Morris, 10/1/2010-09/30/2011, $289,671.

Roberto Myers

“Epitaxial growth of highly confined nitride nanostructures toward short wavelength quantum cascaded and ultrafast optical devices”, Office of Naval Research, PI: Roberto Myers, 8/12/09-8/31/12, $315,216*

“MRI: Acquisition of a Variable Temperature 14 Tesla Physical Properties Measurement System Including a High Resolution Scanning Probe Force Microscope,” National Science Foundation, PI: P. Chris Hammel Co-I(s): R. Myers, J. Winter, P. Woodward, N. Padture, 10/1/2010-9/30/2012, $504,129*

“SPINCATS, an investigation of Spin Caloric Transport in Magnetic Semiconductors”, National Science Foundation Division of Chemistry, Bioengineering, Environmental, & Transportation Systems, PI: Roberto Myers, Co-PI: J. Heremans, 9/1/2011-8/31/2014, $350,000

Nitin Padture

“High-Performance Graphene-Based Devices,” National Science Foundation, PI: N. Padture, Co-I(s): S. Rajan and W. Windl, 8/1/2009-7/31/2012, $350,000*

Siddarth Rajan

"AlGaN/GaN 1 - Dimensional Channel HEMT,” Office of Naval Research, PI: Siddharth Rajan, 02/25/09-04/30/12, $339,348*

"Investigation of Electron Transport in N-polar AlGaN/GaN HEMTs,” Office of Naval Research, PI: Siddharth Rajan, 7/1/2009-4/30/2011, $140,000*

"(ARRA) I-SMART: Integrated curriculum for smart power engineering”, US Department of Energy, PI: Jin Wang, Co-PI(s): S. Rajan and 14 others, 5/13/2010-5/12/2013, $2,499,939

"Center for High-Performance Power Electronics,” Ohio Department of Development, PI: Longya Xu, Co-PI(s): S. Rajan, W. Lu, J. Wang, 7/10/2010-7/18/2013, $3,000,000*

"MURI: Dielectric Enhancements for Innovative Electronics." Office of Naval Research, Co-PI (subcontracted from UC Santa Barbara), 8/1/2010-7/31/2013, $625,000*

III-N Devices and Architectures for THz electronics – DATE; Office of Naval Research MURI Program (Lead: University of Notre Dame); PI: Siddharth Rajan; Co-PIs: Paul Berger, Kubilay Sertel, John Volakis; 6/1/2011 – 5/31/2014; $3,000,000

R. Sooryakumar

“Fluorescent-Magnetic Nanomanipulators for Cytoskeletal Mechanical Investigations,” National Science Foundation CMMI-0900377, PI: J. Winter, 06/01/2009-05/31/2012, $313,433

Claudia Turro

“Design, Synthesis, and Photochemistry of New Ru (II) Complexes as Potential Photo-Cisplatin Analogs,” National Science Foundation (Renewal of CHE-0503666), 9/1/2009-7/31/2012, $690,000

Eric Walton

"Autonomous Non-Battery Wireless Strain Gage for Structural Health Testing and Monitoring in Extreme Environments", Small Business Innovation Research program with Syntonics, LLC, PI: Yakup Bayram, Co-I(s): E. Walton, J. Young, 5/1/2010-4/30/2012, $250,000

"High Temperature Sensing Parameters", Small Business Innovation Research program with Syntonics, LLC, PI: Yakup Bayram, Co-I(s): E. Walton, J. Young, 5/8/2007-12/31/2011, $250,000

David Wood

“Production of Self-Purifying Proteins in a Variety of Expression Hosts with Focus on Organophosphorous Hydrolase;” US Army Research Office; PI: David Wood; 4/1/2011 – 3/31/2011; $50,000

“Bacterial Screens for Autism Spectrum Disorder-Associated Compounds,” Nancy Lurie Marks Family Foundation; PI: David Wood; 7/1/2009 – 6/30/2011; $125,000 (direct costs)

“Bacterial Screens for Autism Spectrum Disorder-Associated Compounds,” Christina and Jeffrey Lurie Family Foundation; PI: David Wood; 04/01/08 - 03/31/12; $125,000 (direct costs)

“Bacterial Biosensors for Endocrine Disrupting Compounds;” National Institute of Environmental Health Sciences (NIEHS), NIH Exploratory Research Grant (R21); PI: David Wood; 6/25/2010 – 2/28/2012; $275,000 (direct costs)

Yiying Wu

“Fabrication of Highly Efficient Photocathodes for P-Type Dye-Sensitized Solar Cells,” US Department of Energy, PI: Y. Wu, 9/1/2007-8/31/2013, $1,428,000

Fengyuan Yang

“Optical Study of Spin Dynamics in Semiconductor Nanowires,” U.S. Department of Energy, PI: F. Yang, Co-I: E. Johnston-Halperin, 8/15/2009 - 5/14/2012, $1,561,323

Yi Zhao

"Integrated Micro-Electro-Mechanical-System for Cellular Mechanotransduction Studies," National Science Foundation-CAREER, PI: Y. Zhao, 3/1/2010-8/14/2011, $151,211*

Appendix C

Activities of Members of Technical Staff (MTS) for Fiscal Year 2010 - 2011

- Dr. John Carlin, Research Scientist, Nanotech West Laboratory
- Dr. Evgeny Danilov, Senior Research Associate, Center for Chemical and Biophysical Dynamics
- Dr. Robert J. Davis, Director, Nanotech West Laboratory and Associate Director, Institute for Materials Research
- Dr. Denis V. Pelekhov, Research Scientist, ENCOMM NanoSystems Laboratory
- Aimee Bross Price, Senior Research Associate, Nanotech West Laboratory

IMR Member of Technical Staff Update:
Dr. John A. Carlin, Ph.D., Research Scientist, Nanotech West Laboratory

Dr. John Carlin is a lead scientist at Nanotech West Laboratory where he leads the atomic layer deposition (ALD) and III-V metal organic chemical vapor deposition (MOCVD) efforts for IMR and the Wright Center for Photovoltaic Innovation and Commercialization (PVIC). In addition to other research activities, Dr. Carlin contributes much time to the day-to-day operation of the NTW cleanroom and expanding the process knowledge and capabilities to meet the growing needs of the user. These activities have included tool training for new users, tool acquisition and installations, process development and documentation and assisting internal and external users with project and process planning.

Dr. Carlin has been responsible for directing the activities of the various undergraduate and graduate students (8 students throughout FY11) hired to provide laboratory and process support to the NTW user base. While currently the primary contact for seven pieces of synthesis, fabrication and metrology equipment, during FY11 Dr. Carlin also oversaw completion of the process qualification, development of the cost structure and cultivating the user base for the metal organic chemical vapor deposition (MOCVD) system. Eighty-four total deposition runs were executed following the completion of the system qualification in October 2010 (of which 61 were billable runs). MOCVD efforts were primarily directed at supporting three research grants, providing basic system calibrations and initiating use of a new antimony source of particular interest for prospective MOCVD users and joint proposal development. One new research proposal centered around the MOCVD system was awarded in FY11 and two other MOCVD centric proposals are currently under review.

Publications and Presentations

Jinghui Wang, Praneeth Kandlakunta, Thomas F. Kent, John A. Carlin, Daniel R. Hoy, Roberto C. Myers, Lei Cao, "*A Gadolinium Doped Superlattice GaN Schottky Diode for Neutron Detection*", The Transaction of America Nuclear Society no. 104. Hollywood, FL, USA. (June 2011): 207-209.

Brian Peters, Nicholas Minutillo, Yi-Hsin Chiu, John A. Carlin, Ezekiel Johnston-Halperin, Fengyuan Yang, "*GaAs nanowires and GaAs/AlGaAs core/shell nanowires synthesized by MOCVD"*, American Physical Society March Meeting, Dallas, TX, USA, 2011.

Chris Ratcliff, Tyler J. Grassman, John A. Carlin, Steven A. Ringel, "*High Temperature Step-Flow Growth of Gallium Phosphide by Molecular Beam Epitaxy and Metalorganic Chemical Vapor Deposition*", Applied Physics Letters, submitted 2011.

Tyler J. Grassman, Andrew M. Carlin, Krishna Swaminathan, Javier Grandal, John A. Carlin, Limei Yang, Michael J. Mills, Steven A. Ringel, "*Expanding the Palette: Metamorphic Strategies over Multiple Lattice Constant Ranges for Extending the Spectrum of Accessible Photovoltaic Materials*", 37th IEEE Photovoltaic Specialists Conference, Seattle, WA, USA, 2011.

Proposals Developed

During FY11 Dr. Carlin collaborated on various proposals involving multi-year efforts with PI's from academia (OSU and external), US National Laboratories and industry. To date, funding has been awarded on one proposal ($175,000/year in OSU effort) while the remaining submissions remain under review.

Title: "High Efficiency Photovoltaic Enabled Off-Grid Solar/Led Lights"
Agency: Ohio Third Frontier
Lead PI: Energy Focus Inc
Co-PI's: Steve Ringel (OSU), John Carlin (OSU), Mark Schuetz (Replex Plastics), Kurt Allerman (Lighting Services, Inc)
Amount Requested: $1,000,000
Period of Performance: 24 months
Status: FUNDED (Performance start date 8/1/11)

Title: "III-V/Active-Si Integration for Low-Cost High-Performance Concentrator Photovoltaics"
Agency: DOE – Energy Efficiency and Renewable Energy
Lead PI: Steve Ringel (OSU)
Co-PI's: John Carlin (OSU), Robert Davis (OSU), Paul Sharps (Emcore Corporation), Pete Sheldon (NREL), Eugene Fitzgerald (MIT)
Amount Requested: $1,500,000
Period of Performance: 36 months
Status: In Review (July 2011)

Title: "Investigation of III-V Quantum Dot Systems for Concentrator Photovoltaics and Intermediate Band Solar Cells"
Agency: DOE – Energy Efficiency and Renewable Energy
Lead PI: Seth Hubbard, Rochester Institute of Technology
Co-PI's: Steve Ringel (OSU), John Carlin (OSU), Manuel Romero (NREL)
Amount Requested: $1,500,000
Period of Performance: 48 months
Status: In Review (July 2011)

Title: "Cleave-Engineered Layer Transfer: Cost Reduction Pathway for High Efficiency III-V Solar Cells"
Agency: DOE – Energy Efficiency and Renewable Energy
Lead PI: Mark Goorsky, UCLA
Co-PI's: Steve Ringel (OSU), John Carlin (OSU), Eugene Fitzgerald (MIT), Richard King and E. Rehder (Spectrolab, Inc)
Amount Requested: $1,500,000
Period of Performance: 36 months
Status: In Review (July 2011)

OSU User Impact Summary

In addition to general cleanroom activities and providing primary support for various synthesis, fabrication and metrology equipment at NTW, Dr. Carlin provides process and project expertise to the NTW user base on a daily basis impacting almost all NTW users in some way. In addition to the internal OSU groups which receive support, Dr. Carlin has collaborated with or provided process support for 10 external companies (including Lakeshore Cryotronics, 4Power LLC, Natcore/Newcyte, Veeco Turbodisc and Replex Plastics) during FY11. Dr. Carlin and IMR continue to foster these relationships to both generate future proposal opportunities as well as expand the regular user base of OSU's NTW lab.

Graduate student and undergraduate student impact

- Presentations and publications resulting from direct collaborations with graduate student research are listed in the previous section.
- In addition to collaborative efforts resulting co-authored research, more general support of student research through expertise and analysis of material synthesis, fabrication and metrology was provided regularly for various OSU research groups across multiple departments.
- Hired and directed the activities of 8 undergraduate students throughout FY11 to provide research support to NTW users. UG students received training in various fabrication, material synthesis and metrology techniques and assisted in supporting research efforts of both internal and external researchers.
- Assisted ECE graduate student in completion of ECE997 research credit performing synthesis, processing and electrical analysis of single junction GaAs photovoltaic devices.
- Provided processed photovoltaic devices for ECE737 student laboratory course to support lab analyzing the electrical performance of solar devices.

Outreach and Engagement Activities (

- Staffed IMR information booth at the Ohio State Research Expo to develop new interactions.
- Provide regular tours of Nanotech West to both OSU and external parties including: faculty candidates, IMR review board members, postdoc and graduate student candidates, undergraduate students, OSU ECE undergraduate class, IMR and ECE seminar visitors and external industry visitors and interested lab users.

General NTW Impact Summary

- Provided day-to-day management and support of cleanroom operation and activities

- Process and user base development for MOCVD resulting in 61 billable depositions (~$15.5k) during 7 months of uptime during FY11 after final process qualification in October 2010
- Development of cost/billing structure for MOCVD
- Member of cleanroom committee formed to provide advice and oversight to improve the cleanroom operation and user effectiveness
- Primary training and support contact for seven pieces of synthesis, fabrication and metrology equipment
- Provided direct process and project planning to new and old, internal and external NTW users
- Process support for the atomic layer deposition (ALD) system including new precursors (NH3 and Hf) and depositions for external customers
- Managed student engineering interns (8 throughout FY11) including hiring and planning short and long term activities
- Coordinated donation of and facilitization and planning for new equipment: GCA stepper and X-10 solar simulator
- Collaborated with or provided process and project support to more than 10 external companies. (PV process and metrology support for Veeco and 4Power alone included > $28,000 of NTW fees billed)

IMR Member of Technical Staff Update: Dr. Evgeny Danilov, Ph.D., Senior Research Associate, Center for Chemical and Biophysical Dynamics

Dr. Evgeny Danilov manages the operations of the Center for Chemical and Biophysical Dynamics (CCBD), a laser facility in Newman-Wolfrom Laboratory within the Departments of Chemistry and Biochemistry. Through a partnership between IMR and Chemistry, he has been tasked with taking this multi-user research facility and turning it into a facility open to the entire materials community. Researchers use CCBD instrumentation to perform several forms of ultrafast laser spectroscopy to observe photogenerated intermediates in biological, chemical, physical, and materials systems on femtosecond (10^{-15} s) time scale. A highlight of the lab is a million-dollar ultrafast laser system which makes it possible to perform dynamic studies of photochemical intermediates over a wide time and spectral range.

Maintained collaboration with core PIs and research groups within the Department of Chemistry as well as users from the Physics and Materials Science and Engineering departments. In general, the work with users involved tuning up the existing experimental setups (optical layout, excitation and detection sources and wavelengths, data collection) to accommodate specific needs for users' samples. In parallel, continued work upgrading the laboratory and building new experimental apparatus for time-resolved spectral measurements.

Accomplishments During FY 2011

- Updated two laboratory spaces in preparation for expanding research facility to be an open user facility
- Completed design and construction of a femtosecond time-resolved stimulated Raman instrument
- Completed software engineering for the Raman data collection and analysis
- Tuned up the instrument to enhance performance and collected test data
- Created and published online a laboratory website with descriptions of the instruments, fees and policies
- Maintained 100 % operability on all femtosecond instruments
- Extended the IR probe wavelength range on the femtosecond time-resolved IR instrument to 750 cm^{-1}
- Fixed and tuned up a dye laser – the excitation source for time resolved photoluminescence instrument

- Developed a facility budget and user instrument fee schedule, finalized in January 2011
- Generated $4,500 in billable income between January and June 2011

Publications and Presentations

Julia M. Keller, Ksenija D. Glusac, Evgeny O. Danilov, Sean McIlroy, Paiboon Sreearuothai, Andrew R. Cook, Hui Jiang, John R. Miller, and Kirk S. Schanze "Negative Polaron and Triplet Exciton Diffusion in Organometallic "Molecular Wires". *J. Am. Chem. Soc.*, 2011, *133* (29), pp 11289–11298.

Lynetta Mier; Yong Min; Evgeny O. Danilov; Arthur J. Epstein; Terry L. Gustafson. "Ultrafast Vibrational Spectroscopy of Perylene Diimide Complexes". Book of Abstracts of XXII International Conference on Raman Spectroscopy, August 8-13, 2010, Boston, MA, USA.

Lynetta M. Mier; Evgeny O. Danilov; Arthur J. Epstein; Terry L. Gustafson. "Excited State Vibrational Analysis of N,N'-Dioctyl Perylene Diimide and its Anion". Book of abstracts of the Fifthteenth International Conference on Time-Resolved Vibrational Spectroscopy June 19-24, 2011, Centro Stefano Franscini, Monte Verità, Ascona, Switzerland, p.96.

IMR Member of Technical Staff Update: Dr. Robert J. Davis, Ph.D., Director, OSU Nanotech West Laboratory; Associate Director, Institute for Materials Research; Co-Director, Ohio Wright Center for Photovoltaics Innovation and Commercialization (PVIC)

Dr. Robert J. Davis is the Director of Nanotech West Laboratory, the largest micro- and nanotechnology user facility at OSU. Davis is also the Co-Director for the Wright Center for Photovoltaics Innovation and Commercialization (PVIC), an Ohio Third Frontier Program with the goal of advancing the research, development, and commercialization of photovoltaics (solar cells) in Ohio. Davis also serves as one of three Associate Directors of the Institute for Materials Research at OSU, is a participating faculty member/lecturer in the OSU Art and Technology Program, and is an Adjunct Associate Professor of Electrical and Computer Engineering at OSU.

Publications and Conference Presentations

"Design and Construction of a ~7x Low-Concentration Photovoltaic System Based on Compound Parabolic Concentrators", Mark A. Schuetz, Scott A. Brown, Kara A. Shell, Roger H. French, and Robert J. Davis, Proceedings of the 37th IEEE Photovoltaics Specialists Conference, Seattle WA, June 2011, also submitted by invitation to the new IEEE Journal of Photovoltaics.

"Solar Radiation Durability of Materials Components and Systems for Low Concentration Photovoltaics", Roger H. French, Myles P. Murray, Wei-Chun Lin, Kara A. Shell, Scott A. Brown, Mark. A. Schuetz, and Robert J. Davis, Proceedings of the 37th IEEE Photovoltaics Specialists Conference, Seattle WA, June 2011.

"Solar Radiation Durability of Materials Components and Systems for Low Concentration Photovoltaics", Roger H. French, Myles P. Murray, Wei-Chun Lin, Kara A. Shell, Scott A. Brown, Mark A. Schuetz, and Robert J. Davis", Proceedings of the 2011 IEEE Energy Tech Conference, Case Western Reserve University, Cleveland OH, May 2011.

"Performance of a Low-Cost Low-Concentration Photovoltaic Module", Kara A. Shell, Scott A. Brown, Mark A. Schuetz, Robert J. Davis, and Roger H. French, Proceedings of the 7th International Conference on Concentrating Photovoltaics, Las Vegas NV, April 2011.

Conferences Organized

- Co-Chaired Oral Session on HCPV Modules, Optics, and Receivers (Area 3) at the 37th IEEE Photovoltaic Specialists Conference, Seattle WA, June 2011, and served as an Area 3 reviewer.
- With Mary McCleery, organized the Semi-Annual Meeting of the Wright Center for Photovoltaics Innovation and Commercialization, Columbus OH, 19 May 2011.

- With Steve Ringel, organized and then Chaired the Advanced Photovoltaics session of the 2011 Ohio Innovation Summit, Toledo OH, April 2011; assisted Sharell Mikesell in obtaining Industry Sponsorships for the Summit in the four months prior to that.
- Assisted Steve Ringel in organizing the Photovoltaics session of 2010 OSU Materials Week, September 2010.

Current Research Funding

"Ohio Wright Center for Photovoltaics Innovation and Commercialization", $6.9M plus OSU matching funds, 27 February 2007 to 27 November 2011, Ohio Third Frontier Program. Obtained final No-Cost Extension for this program to this new end date during January 2011.

"Low-Cost Low-Concentration Photovoltaics Systems for Mid-Northern Latitudes", with Replex Plastics, Mt. Vernon OH, OSU share $357,500, 01 February 2010 – 01 February 2012.

"Low Cost Concentrated PV Design", with GreenField Solar, Oberlin OH, OSU share $50,000, 01 April 2011- 31 March 2012.

Proposal Activities

- Collaborator on four Dept. of Energy SunShot Program proposals with John Carlin and Steve Ringel, June 2011.
- Supported three proposals (Replex Plastics/Case Western, GreenField Solar, Process Technology) through to Ohio Third Frontier Program wins in January 2011.

Other Ohio State University Representation

- Represented Ohio State at the Ohio Board of Regents Centers of Excellence Meeting and at the Centers of Excellence Showcase at the Annual Meeting of the University Clean Energy Alliance of Ohio, both Columbus OH, 08 and 28 April 2011 respectively.
- Represented Ohio State and PVIC at a Governor's Reception for a Chinese Trade Delegation, State House, Columbus OH, 07 December 2010.

IMR Activities

- Served as Associate Director in FY11, attending Director's Meetings to discuss issues including programs, budgets, Materials Week symposium, and guest speakers.

- Served as a reviewer for two rounds of Facilities Grants, two Industry Challenge Grants, one Interdisciplinary Materials Research Grants, and one integrated OSU Materials Research Grant Seed Program (with CEM and ENCOMM).

Nanotech West Activities

In summary, Nanotech West Lab activity continues to grow; user fee income grew 11% over its FY10 total to $416k, fueled completely by internal OSU usage, which grew 30% over the prior year as measured by user fee income. Refer to the separate Nanotech West report for extensive details on FY11 activity at that lab.

PVIC Activities

Dr. Davis continues to Co-Direct the Ohio Wright Center for Photovoltaics Innovation and Commercialization (PVIC), an $18.6M research and development program funded by the Ohio Third Frontier Program with the goal of creating jobs in Ohio via the commercialization of advanced technology. A major challenge in FY12 will be the transition of PVIC from its Third Frontier initial funding, which ends in late November 2011. PVIC will continue to organize meetings, which its industry members have communicated is its most important function.

Other Activities

- Serves on the Proposal Review Board of the Center for Nanophase Materials Sciences of the Oak Ridge National Laboratory.
- Section Editor for the future Springer Encyclopedia of Nanotechnology, which will be published in 2012.

IMR Member of Technical Staff Update: Dr. Denis V. Pelekhov, Ph.D., Research Scientist, ENCOMM NanoSystems Laboratory

Dr. Denis V. Pelekhov is the Director of the ENCOMM NanoSystems Laboratory (ENSL) of the Center for Electronic & Magnetic Nanoscale Composite Multifunctional Materials (ENCOMM) which is located in the Physics Research Building on OSU's Columbus campus. ENSL is a user facility with the goal of providing academic and industrial users with access to various material characterization and fabrication techniques, including Focused Ion Beam/Scanning Electron Microscopy, X-ray diffractometry, SQUID magnetometry, Atomic Force/Magnetic Force microscopy, EDS X-ray microanalysis, Langmuir-Blodgett trough monolayer deposition and e-beam lithography. Dr. Pelekhov oversees day to day operations of the facility; directs ENSL staff consisting of two permanent staff members and one undergraduate research assistant; interacts with equipment vendors and suppliers for existing equipment repairs, upgrade and maintenance; oversees purchase of new equipment including negotiations of equipment specifications, design and price; oversees development and implementation of laboratory safety measures and protocols including chemical safety and chemical waste disposal; conducts training of ENSL users in use of laboratory equipment; maintains online facility data acquisition software for ENSL, SEAL and Dreese clean room; and works with potential and current ENSL industrial customers in order to guarantee their satisfaction with provided services and to enlarge industrial customer base.

Publications

F. Wolny, Y. Obukhov, T. Mühl, U. Weißker, S. Philippi, A. Leonhardt, P. Banerjee, A. Reed, G. Xiang, R. Adur, I. Lee, A.J. Hauser, F.Y. Yang, D.V. Pelekhov, B. Büchner and P.C. Hammel, "Quantitative magnetic force microscopy on permalloy dots using an iron filled carbon nanotube probe", Ultramicroscopy, in press, available online June 1 2011

I. Lee, Y. Obukhov, A.J. Hauser, F.Y. Yang, D.V. Pelekhov and P.C. Hammel, "Nanoscale confined mode ferromagnetic resonance imaging of an individual Ni(81)Fe(19) disk using magnetic resonance force microscopy (invited)", Journal of Applied Physics vol. 109, p. 07D313 (2011)

I. Lee, Yu. Obukhov, G. Xiang, A. Hauser, F. Yang, P. Banerjee, D.V. Pelekhov and P.C. Hammel, "Nanoscale scanning probe ferromagnetic resonance imaging using localized modes", Nature vol. 466, p. 845 (2010)

P. Banerjee, F. Wolny, D. V. Pelekhov, M. R. Herman, K. C. Fong, U. Weissker, T. Muhl, Yu. Obukhov, A. Leonhardt, B. Buchner and P.C. Hammel, "Magnetization Reversal in an Individual 25 nm Iron-Filled Carbon Nanotube", Applied Physics Letters vol. 96, p. 252505 (2010)

General ENSL Impact Summary

- Negotiated purchase of a new Bruker Dimension Icon Atomic Force/Magnetic Force microscope at approximately $30k below list price. The instrument has been delivered and commissioned in June 2011. It is currently fully available to ENSL users.
- Negotiated purchase and design characteristics of a new Kurt J. Lesker Lab-18 magnetron sputtering system combined with e-beam evaporator and an ion mill. The system has met budget expectations and is to be delivered in August 2011
- Organized purchase, installation and commissioning of SEKI microwave CVD system for diamond growth. The system has become fully operational in January 2011 and is currently used for diamond growth recipe development.
- Negotiated purchase of a new Evico Magnetics magneto-optical Kerr microscope. The instrument is to be delivered and commissioned in September 2011.
- Conducted facilities tour for research and development personnel from Diamond Innovations (Worthington, OH).
- Implemented online facility data acquisition software for SEAL and Dreese clean room

Overall ENSL Performance During 07/01/2010 – 06/30/2011

- Revenues from user fees: $150,200.00
- Number of supported research groups (PIs): 39 (three industrial customers)
- Number of supported users: 117
- Number of accounts/research projects that benefited from ENSL use : 69
- This represents a 25% increase in the volume of services provided to facility users compared to the previous year of operation.

IMR Member of Technical Staff Update:
Aimee Bross Price, Senior Research Associate, Nanotech West Laboratory

Aimee Price is a Senior Research Associate at the Nanotech West Laboratory, where she is the lead engineer for the lab's nanolithography process, specifically direct write ebeam lithography with the Vistec EBPG5000 electron beam lithography tool. She works with users on the unique aspects of process design for ebeam and nanolithography at Nanotech West, including running the lithography exposure for most users. Additionally, she assists many users of ENCOMM's electron beam writer in their initial process development.

Ms. Price has trained several high level users (6 current users) to become independent on the Nanotech West ebeam lithography tool, three of whom have become very successful ebeam lithographers and have recently completed their M.S. or Ph.D. degrees within the last year. Further, Ms. Price uses the ebeam to fabricate photomasks for the Nanotech West community for use in lower resolution lithography. Much of Ms. Price's time is devoted to interacting and training users on layout and pattern design because often, a student or researcher's first experience with pattern design and layout is in creating a photomask. Over the past year, Ms. Price has worked with 25 individual users performing either direct write EBL or mask fabrication. These users come from 12 OSU research groups and 3 external companies.

OSU User Impact Summary

Data is self-reported from users who deemed their work significantly impacted by the ebeam at Nanotech West

Papers Published	Papers submitted/in prep	Presentations	M.S. Graduates	Ph.D. Graduates
11	5	15	2	2

General NTW Impact Summary

1. **High Resolution SEM:** Ms. Price, with the assistance of our new SEM super-user Dr. Xuejin Wen, has trained over 79 users and staff for the Zeiss Ultra Plus SEM. **30** of those users have been trained within the last year (July 2011-June 2010), as compared with **19** new users in FY10. With the addition of the Zeiss Ultra Plus, researchers at OSU Nanotech West can now image nanometer range structures immediately after patterning on conductive AND non-conductive substrates, indeed even polymers/resists without coating the surface. This gives researchers a true image of their nanostructures from both a quality and size standpoint, early in the fabrication flow, resulting in real time feedback and more efficient process development. Ms. Price assists users with imaging and higher level training on difficult samples such as piezoelectric materials, cross sections of thin layers, nanostructured surfaces, etc.

2. **Nanotech West Lab Process and General Support:** Ms. Price has taken an active role in supporting IMR and Nanotech West in areas outside of ebeam lithography and SEM, as appropriate. This is in order to help spread the general lab safety and training burden, which has become significant as the Nanotech West Lab user base has grown. Specific examples of activities include:
   - **ALD -** Chose an HfOx precursor appropriate for our PicoSun booster source and initial process development, used by at least 3 OSU groups currently.
   - **X-ray safety -** developed safety document and system to track certification, coordinated initial surveys of all x-ray producing equipment, initial training of all required users (>75)
   - **Specific Chemical Safety -** Leading effort to train and document on specific chemical hazards in cleanroom lab

Outreach and Engagement Activities

- Represented IMR at OSU Research Expo to promote opportunities for researchers in IMR labs and expand collaboration efforts.
- Participated in OSU "unfreezing retreat" with other members of IMR, Nanotech West, and Office of Research as part of OSU's Excellence to Eminence program.
- Attended PVIC Wright Center Semi-Annual Meeting and lead tours of Nanotech West
- Lead numerous tours of Nanotech West Lab for various groups (OSU courses, faculty candidates, potential collaborators)

M.S. Degree Progress

Ms. Price is progressing toward her Masters degree in Electrical and Computer Engineering at OSU. All coursework is completed and she is currently pursuing research in defect reduction for III-V epitaxy on Si by incorporating silicon oxide nanostructures into buffer layers. Initial XPS and SEM results are promising. Ms. Price has created ~20nm pseudo-isolated features for study and is working on optimizing the size/spacing design for a model epitaxial system.

Appendix D

2011 OSU Materials Seed Grant Program

- Request for Proposals
- Sample Evaluation Forms
- Announcement

2011-12 Request for Proposals
Materials Research Seed Programs

ANNOUNCING IMRG AND PROTO-IRG SEED GRANTS

To simplify and streamline the major seed funding opportunities available to OSU materials researchers, the Institute for Materials Research and the NSF-supported Center for Emergent Materials are pleased to announce this joint Request for Proposals for 2011-12 funding via two vehicles, the IMR Interdisciplinary Materials Research Grant (**IMRG**) program and the CEM Prototype Interdisciplinary Research Group (**proto-IRG**) program.

The goal of both is to establish research teams who will achieve acknowledged research excellence at the forefront of materials science, with the proto-IRG program specifically targeting the formation of newly proposed IRGs (approximately 6-10 faculty members) within 2-3 years for possible inclusion within the CEM in its renewal phase. As such, the size and scope of both programs are somewhat different, and the purpose of this joint announcement is to maximize the impact and efficiency of these select programs. *In order to ensure optimum leverage of seed resources, research teams may respond to and be funded by only one of these seed programs at any one time*. Below is a brief summary of both programs. Subsequent pages provide necessary details for the Request for Proposals pertaining to both opportunities.

IMRG: IMR Interdisciplinary Materials Research Grants (IMRGs) are supported by the OSU Institute for Materials Research to stimulate and advance collaborative and multidisciplinary research in materials-allied fields with the specific goal of generating highly competitive external grant proposals that target multi-investigator and center-level opportunities. An important goal of IMRG funding is the development of new research efforts that are differentiated from ongoing activities, so that the breadth of high quality and impactful materials research at Ohio State is expanded over time.

These grants provide funds of up to $50,000 in total direct costs per year to support collaborative proposals between two or more faculty members across two or more OSU departments and/or colleges. IMRGs may be considered for a second year of funding on a competitive basis, contingent upon availability of funds.

Proto-IRG: Proto-IRG Seed Grants are provided by the Center for Emergent Materials, an NSF MRSEC, to stimulate interdisciplinary research that broadens the scope of the CEM and eventually evolves into full-scale Interdisciplinary Research Groups (IRGs) at the time of renewal of the CEM (June 2013). Technical overlap of the proposed research with the existing IRGs is not required; however, some form of synergy with the mission of the CEM is preferred (for example through shared facilities, techniques, theory/modeling, materials, etc.).

Awards will be up to $100,000 in direct costs per proto-IRG per year, with smaller awards possible for proposals with technical merit but insufficiently developed IRG-potential. Successful Proto-IRGs can be renewed on a yearly basis until the OSU MRSEC renewal, and will be expected to participate actively in further team building and CEM activities.

IMR INTERDISCIPLINARY MATERIALS RESEARCH GRANTS

IMR Interdisciplinary Materials Research Grants (IMRGs) are intended to stimulate and advance collaborative and multidisciplinary research in materials-allied fields with the specific goal of generating highly competitive external grant proposals that target strategic areas of interest, including multi-investigator and center-level opportunities. An important goal of IMRG funding is the development of new research efforts that are differentiated from ongoing activities, so that the breadth of high quality and impactful materials research at Ohio State is expanded over time.

These grants provide funds up to $50,000 in direct costs to be expended over a one year period to support collaborative proposals between two or more faculty members across two or more OSU departments and/or colleges. IMRGs may be considered for a second year of funding on a competitive basis, contingent upon availability of funds.

Please note below that we have introduced a modified process to this year's competition, which will include presentations to discuss your ideas in advance of the actual proposal submission and external review, with the goal being to provide helpful feedback to make your proposals as strong as possible.

ELIGIBILITY

Eligible applicant teams must consist of regular faculty members of The Ohio State University *and* who are also members of the OSU Institute for Materials Research. Typical team sizes are 2-4 faculty members, but this information is meant as a guide only. Eligibility is limited to teams who are not currently supported by an IMRG or a proto-IRG and who do not currently receive funding for reasonably related research topics. This restriction exists to support the IMRG goal to advance new research endeavors. Researchers with an active IMRG who wish to request a second year of funding should follow a separate reporting/request process and not the instructions in this RFP.

LETTER OF INTENT DEADLINE

Teams planning to submit an application for an IMR Interdisciplinary Materials Research Grant must first submit a **brief letter of intent by 5:00 PM on Friday, March 4, 2011** via email to Peggy Kraft, IMR Program Manager, at kraft.106@osu.edu.

Letters of intent should include the name and departments of the lead Applicant and Co-Applicants (if known), a tentative project title, a short description of the proposed research (not to exceed 100 words), and the names and contact information (including email address) for at least three suggested external reviewers. **Any proposal that does not provide this information or does not meet this deadline will not be considered for review.**

APPLICATION INSTRUCTIONS AND PROCESS

Once Letters of Intent have been received, lead applicants will be contacted to reserve a date for the **preliminary presentation**. All presentations will occur during 4:00 – 5:00 pm on the first 5 Fridays of Spring Quarter, from April 1 through April 29, 2011. There will be up two 2 presentations per session and if additional times to accommodate more proposal presentations are needed, this information will be communicated separately. Presentations should be developed for a 30 minute period, including time for discussion, and should

include information that is both contextual and technical in nature, with expected outcomes and their significance clearly stated. Feedback will be provided after each presentation. The presentations are strongly recommended, but not mandatory. The goal is to provide each project team with additional feedback prior to review consideration by both external and internal reviewers.

The **required** proposal format with length restrictions are as follows:

1. Cover Page (1 page): the names, titles, and departments of the Applicant and any Co-Applicants and contact information for the Lead Applicant only (mailing address, email, phone and fax numbers)
2. Project Description (4 pages maximum): Summary of the proposed research including:
    - Objectives of the proposed research project
    - Description and scope of research
    - Work plan and methodology
    - Expected outcomes
    - Research facilities that may be used to conduct the research
    - Synergy among team members
    - Relation to Planned External Proposal(s): a short statement listing the external agency(ies) and program(s) targeted by the Applicant with deadlines, if known, and how meeting the objectives of the proposed research would translate into external proposal development for the research team
3. References Cited (1 page maximum)
4. Budget Information: A detailed budget for the proposed project and a brief explanation of the proposed budget items. Refer to the "Budget Restrictions" section below when developing your budget proposal. (1 page maximum)
5. Curriculum Vitae of each Applicant (2-page maximum)
6. Current and Pending support of each Applicant

All applications should use a minimum 11-point font size and 1 inch margins. **Applications longer than the stated page limits or omitting information requested above will not be reviewed.**

Please submit your application as an email attachment in one file in PDF format by 2:00 PM, May 13, 2011 to Peggy Kraft, IMR Program Manager, at kraft.106@osu.edu. **There will be NO exceptions to this deadline.**

BUDGET RESTRICTIONS

The intent of the IMR Interdisciplinary Materials Research Grants is to enhance research through the financial support of student and postdoctoral researchers and related fee authorizations and user fees, materials and supplies consumed in association with conducting the proposed research. The following expenses are not allowed: faculty salary or benefits (including release time and summer quarter salary), travel, computers and equipment purchases.

REVIEW CRITERIA

The IMR will allocate resources based on the the quality of the proposed research, relevance to external funding opportunities, and to college- and department-level strategic plans. The review process includes input from both external and internal referees.

Review criteria for the IMR Interdisciplinary Materials Research Grant program are:

- Intellectual merit of proposed research activity: originality, potential contribution to science, technology and education
- Extent to which proposed research fosters interdisciplinary collaborations
- Plan for external proposal development and relation to strategic opportunities
- Relation to department- and college-level strategic plans
- Past performance on IMR-funded programs, if applicable
- Availability of resources

TERMS AND CONDITIONS

1. Grant funds will be awarded by July 1, 2011 and must be fully expended by August 31, 2012 for this cycle of awards. Any unused funds at the end of this period must be returned to IMR, unless otherwise agreed upon in writing. If an extension is necessary, the PI should submit a written request to IMR by June 15, 2012. A brief technical and financial report will be due at the end of each award cycle.
2. IMRG recipients will be expected to share their research findings at future IMR events, including seminars and workshops.
3. IMR requests that all researchers inform IMR of all external proposals and/or awards, presentations, publications, etc. that result fully or in part from the IMRG project.
4. Recipients of IMR funds shall acknowledge IMR support in publications resulting from IMR-funded research projects. The acknowledgement shall read as follows: *This work was supported in part by The Ohio State University Institute for Materials Research.*
5. Submission of a proposal to this IMR Interdisciplinary Materials Research Grant competition constitutes an agreement to follow the above terms and conditions.

CONTACT INFORMATION

Potential applicants may contact Peggy Kraft, IMR Program Manager at kraft.106@osu.edu, or (614) 292-1185) with any administrative or procedural questions. IMR Director Steven Ringel (ringel.5@osu.edu or (614) 688-3924) is the primary contact for technical questions related to potential research activities.

PROTO-INTERDISCIPLINARY RESEARCH GROUPS (IRG)

Development of Prototype Interdisciplinary Research Groups (IRGs)

The Center for Emergent Materials (CEM), a National Science Foundation (NSF) Materials Science and Engineering Center (MRSEC) at the Ohio State University (OSU) announces acceptance of proposals for its Seed Program.

The aim of the 2011 Seed Program is to provide funds to stimulate interdisciplinary research that broadens the scope of the CEM and eventually evolves into full-scale Interdisciplinary Research Groups (IRGs) at the time of renewal of the CEM (June 2013). Technical overlap of the proposed research with the existing IRGs is not required. However, some form of synergy with the mission of the CEM is preferred (for example through shared facilities, techniques, theory/modeling, materials, etc.).

These proto-IRG Seed Grants will support research by small interdisciplinary groups of 3 to 4 principal investigators (PIs). These PIs are expected to form the core of new proposed full IRGs (constituting 6-10 PIs) within 2 years. The proposed research projects should be broad and interdisciplinary while maintaining a focus on a central theme to meet the requirements of a MRSEC IRG. Although not required for proto-IRGs, a strong synergy between experimental and theoretical components is essential for full IRGs. Applicants are encouraged to review the most recent MRSEC call from the NSF for further details as to what is expected of a fully developed IRG. This question will be further addressed in an open workshop on what makes a successful IRG hosted by the CEM in early spring 2011, and various venues to assist in team-building will be announced in coming months.

Ultimately, the CEM will hold an internal competition to downselect a total of 4 to 5 IRGs that will form the renewal proposal of the CEM. This competition is projected for Winter, 2013 and will be open to all OSU faculty independent of participation in this Seed Program.

Awards will be up to $100,000 in direct costs per proto-IRG per year, with smaller awards possible for proposals with technical merit but insufficiently developed IRG-potential. The initial funding period is 12 months. Successful Proto-IRGs can be renewed on a yearly basis until the OSU MRSEC renewal, and will be expected to participate actively in further team building and CEM activities.

ABOUT THE MRSEC SEED PROGRAM

The Materials Research Science and Engineering Center (MRSEC) funded by the National Science Foundation (NSF) at the Ohio State University (OSU), titled Center for Emergent Materials (CEM), performs integrated research on emergent materials and phenomena in magnetoelectronics. The aim of the CEM is to lay down the scientific foundation for building future spin- and oxide-based electronic devices that can perform multiple functions, and energy-efficient, fast computers that have integrated memory and logic. The scientific foundation is in the form of deep and comprehensive understanding of the emergent materials and phenomena, and the development of highly sophisticated experimental and theoretical tools required to study them. The CEM has two Interdisciplinary Research Groups (IRGs). IRG-1: “Towards Spin-Preserving, Heterogeneous Spin Networks” develops a new understanding of electron-spin injection and transport in low-dimensional, spin-preserving materials such as silicon and carbon. This understanding provides a new materials-basis for creating novel high-density spin networks for next-generation computing. IRG-2: “Double Perovskite Interfaces and Heterostructures” designs and controls multifunctional properties of innovative double perovskite heterostructures through the understanding of structure, defects, and magnetotransport properties at interfaces. This new understanding of magnetism in metallic oxides enables important advances in the emerging field of oxide-based electronics.

Through the Seed Program, NSF intends to provide flexibility for the CEM to respond quickly and effectively to new opportunities beyond the current scope of the CEM, and pursue high risk / high impact and transformative research. From this year, the main task of the CEM Seed Program is to stimulate interdisciplinary group research in promising areas with the potential to evolve into full IRGs which are expected to participate in an internal competition for the renewal proposal of the CEM in 2013. Seed funding through the Center is not intended to provide a substitute for NSF individual investigator funding. More information about the CEM and the Seed Program can be found at http://cem.osu.edu

ELIGIBILITY

All regular faculty members of OSU are eligible to apply to the CEM Seed Program. Current core members of the CEM are not eligible to be the lead Applicant, but can be co-Applicants.

DEADLINE

Written proposals for the 2011 **Seed Program are due 2:00 PM, Friday, May 13, 2011**. Selected teams shall be asked to make 30-minute presentations to the Executive Committee of the CEM in mid-August, 2011. The anticipated start date is September 1, 2011.

APPLICATION INSTRUCTIONS AND PROCESS

All OSU faculty interested in applying to the Seed Program are invited to submit a written proposal as specified below. Selected applicants will be invited to provide an additional oral presentation to a CEM panel for further evaluation. Details of the oral presentation will be provided as necessary, and the information content and length restrictions for the written proposal are given below:

1. Cover Page (1 page maximum): the names, titles, and departments of all the Applicants, contact information for the Lead Applicant only (mailing address, email, phone and fax numbers).
2. Project Description (4 pages maximum) including:
   a. Objectives of the proposed research project
   b. Description and scope of research
   c. Work plan and methodology
   d. Expected outcomes
   e. Research facilities that may be used to conduct the research
   f. Quality of the team and synergy among team members
   g. Plan for expansion to a full IRG with integrated experimental and theoretical components
3. References Cited
4. Budget Information: A detailed budget for the proposed project and a brief explanation of the proposed budget items. Refer to the "Budget Restrictions" section below when developing your budget proposal. (1 page maximum)
5. Curriculum Vitae of each Applicant (2-page maximum)
6. Current and Pending Support of each Applicant

All applications should use a minimum 11-point font size and 1" margin. Applications longer than the stated page limits or omitting information requested above will not be reviewed.

Please submit your application as an email attachment in a single file in PDF format by **2:00 PM, Friday, May 13, 2011** to Tracee Mohler, CEM Administrative Associate, at mohler@mps.ohio-state.edu.

BUDGET RESTRICTIONS

The following expenses are not allowed: faculty salary or benefits (including release time and summer quarter salary).

REVIEW CRITERIA

The Seed Program will allocate resources based on the quality of the proposed research and the synergy with the CEM activities.

Review criteria for the 2011 Seed Program are:

- Intellectual merit of proposed research activity: originality, potential contribution to science, technology and education
- Potential to evolve into a full IRG which will be able to justify that "the whole is greater than the sum of the parts" as specified in the MRSEC RFP
- Potential to leverage the existing capability of the CEM
- Extent to which proposed research fosters interdisciplinary collaborations
- Availability of resources
- Broader impacts

Written proposals will be evaluated by internal and external reviewers. Based on these reviews, the Seed Board will forward recommendations to the CEM Executive Committee for oral presentations. A panel selected by the CEM will evaluate these oral presentations and will recommend final dispensation to the Executive Committee.

TERMS AND CONDITIONS

Seed Grants must be fully expended within twelve months of award. The grants are eligible for competitive renewal. A brief technical report, financial report, and an oral presentation to the CEM are due at the end of the award cycle. An additional progress report in the form of oral presentation is required at the end of first six months. Seed Grant recipients are expected to acknowledge support of the CEM Seed Program on publications resulting from the funded research, and to share their research findings at CEM events, including seminars, workshops, and poster sessions.

CONTACT INFORMATION

Potential applicants may contact the Seed Board Co-Chairs Ezekiel Johnston-Halperin (ejh@mps.ohio-state.edu, 614-247-4074) or Fengyuan Yang (fyyang@mps.ohio-state.edu, 614-688-4390) for questions related to potential research activities.

The Ohio State University
Materials Research Seed Grant Program (2011-12)

Evaluation Form

Applicant Information		Reviewer Information	
Applicant Name		Reviewer Name	
Applicant Department		Reviewer's University or Institution	
Project Title		Reviewer Email Address	
Co-Applicants and Departments/Affiliations			

Evaluation Criteria and Comments

Use the space provided to comment on the reviewed proposal as it relates to each of the criteria detailed below.

1. Intellectual Merit Comment on the overall intellectual merit of the proposed research activity, including the originality and potential contribution it would make to science, technology and education in the materials-allied fields.
2. Collaboration Comment on the extent to which the proposed research fosters interdisciplinary collaborations and partnerships.
3. Availability of Resources Comment on the reasonableness of the proposed budget and use of infrastructure, facilities, and personnel to complete the research.
4. Applicant Qualifications Comment on the Applicants' ability to conduct the proposed research.

Revised March 2011

5. Potential for Generating Successful External Proposals Comment on the plan for using the proposed project in future external proposal development in the materials area and its relation to strategic opportunities outlined by major sponsors (NSF, DOD, DOE, NIH, etc.).
6. Potential Timeframe for Publication and External Proposal Development In your opinion, what timeframe could be expected with respect to generating a viable, external group proposal that would be supported by publications resulting from the proposed research - short term (<12 months), mid-term (12-24 months) or long-term (>24 months)?
7. Broader Impacts Comment on the potential for broader societal impacts proposed by the research.
Overall Summary Use the space below to provide your comments and feedback regarding the overall proposal and how it relates to advancing materials research.

Overall Rating

Check the appropriate box to indicate your overall rating for this proposal

☐ Excellent – highest priority for funding

☐ Very Good –recommend for funding if funds are available

☐ Fair – recommend to modify for consideration in future competitions

☐ Poor – do not recommend for funding

Return form to Peggy Kraft, IMR Program Manager, via email to kraft.106@osu.edu or via fax to 614.247.2581.

OSU Materials Research Seed Grant Program (2011-12)

We are pleased to announce a Request for Proposals (RFP) for the **OSU Materials Research Seed Grant Program** (**2011-12),** open to the Ohio State University (OSU) Materials community. This enhanced seed program leverages resources and best practices from the seed programs of the Center for Emergent Materials (CEM), ENCOMM, and Institute for Materials Research (IMR). The result is a unified RFP with three Funding Tiers designed to achieve the greatest impact for seeding excellence in materials research of varying scopes.

The three Funding Tiers are:

1. **Proto-IRG Grants**, which provide funds up to $100,000/year per award in direct costs, and require one Principal Investigator (PI) and two Co-Principal Investigators (Co-PIs), and may have unfunded collaborators, with the goal of forming new Interdisciplinary Research Groups (IRGs) that could be incorporated into the CEM renewal proposal in 2013.

2. **Multidisciplinary Team Building Grants**, which provide funds up to $60,000/year per award in direct costs, and require one PI and one Co-PI, and may have unfunded collaborators, with the goal of forming multidisciplinary materials research teams that can compete effectively for federal block-funding opportunities.

3. **Exploratory Materials Research Grants**, which provide funds up to $40,000/year per award in direct costs, and require one PI, and may have Co-PIs and/or unfunded collaborators, with the goal of enabling nascent materials research to emerge to the point of being competitive for external funding.

This new OSU Materials Research Seed Grant Program replaces the previously separate CEM Proto-IRG, ENCOMM Seed Grant, and IMR Interdisciplinary Materials Research Grant (IMRG) programs. As a result, the proposal submission and review processes for the three Funding Tiers have been integrated and aligned.

The following pages describe the three tiers of seed funding opportunities and provide details on how to apply.

Please visit imr.osu.edu or cem.osu.edu or physics.ohio-state.edu/ENCOMM/index for additional information and updates.

Description of the Three Funding Tiers

1. Proto-IRG Grants

The aim of these grants is to stimulate interdisciplinary research that broadens the scope of the CEM — a National Science Foundation (NSF) Materials Science and Engineering Center (MRSEC) at OSU. The ultimate goal of these grants is to help develop full-scale IRGs at the time of CEM renewal in 2013. Technical overlap of the proposed research with the current CEM IRGs is not required. However, some form of synergy with the mission of the CEM is preferred (for example through shared facilities, techniques, theory/modeling, materials, *etc.*). Information about the CEM and current IRGs can be found at: http://cem.osu.edu.

These grants will support materials research by small interdisciplinary groups of 1 PI and 2 Co-PIs per team. Each Proto-IRG team is expected to form the core membership of a future full IRG (typically 6-10 faculty level investigators in each full-scale IRG). Additional unfunded collaborators may be included. Proposed research projects should be broad and interdisciplinary while maintaining a focus on a central theme to meet the requirements of a full IRG.

Although not required for Proto-IRGs, a strong synergy between experimental and theoretical components is essential for full IRGs. Proposers are encouraged to review the most recent RFP from the NSF for further information on what is expected of a full IRG, in particular the specification of "the whole is greater than the sum of the parts" at: http://www.nsf.gov/pubs/2010/nsf10568/nsf10568.htm. This question will be addressed further in a panel discussion on what makes a successful IRG hosted by the CEM in early April 2011. (Note that the NSF has morphed MRSECs into Centers of Excellence for Materials Research and Innovation (CEMRIs) in the latest RFP.)

Ultimately, the CEM will hold an internal competition to select several full IRGs that will form the renewal proposal of the CEM. This competition is projected for early 2013 and will be open to all OSU regular faculty independent of participation in the Proto-IRGs.

Awards will be up to $100,000 in direct costs per grant per year. The initial funding period is one year, but successful Proto-IRGs may apply for renewal in the next year's open competition of the OSU Materials Research Seed Grant Program (2012-13). Funded Proto-IRGs are expected to participate actively in further team building and CEM activities. Tentative start date is September 1, 2011.

Contact Information

Contact Prof. Nitin Padture (padture.1@osu.edu, 614-247-8114) with any questions.

2. Multidisciplinary Team Building Grants

The aim of these grants is to enable and to invigorate interdisciplinary collaborations with high potential to have broad impact and win substantial federal block funding. These grants require one PI and one Co-PI. Additional unfunded collaborators may be included. The goal is to form multidisciplinary materials research teams of 2 to 4 faculty members each.

Awards will be up to $60,000 in direct costs per grant per year. The initial funding period is one year, but successful Multidisciplinary Teams may apply for a maximum of

one additional year renewal in the next year's open competition of the OSU Materials Research Seed Grant Program (2012-13). Tentative start date is July 1, 2011.

Contact Information

Contact Profs. P. Chris Hammel (hammel@physics.osu.edu, 614 247-6928) or Steven A. Ringel (ringel@ece.osu.edu, 614 688-3924) with any questions.

3. Exploratory Materials Research Grants

The aim of these grants is to stimulate nascent materials-allied research to the point where a highly competitive external proposal can be developed. These grants require one PI. Additional Co-PI(s) and/or unfunded collaborators may be included. These grants complement the Multidisciplinary Team Building and the Proto-IRG grants.

Awards will be up to $40,000 in direct costs per grant per year. The initial funding period is one year, but successful PIs may apply for a maximum of one additional year renewal in the next year's open competition of the OSU Materials Research Seed Grant Program (2012-13). Tentative start date is July 1, 2011.

Contact Information

Contact Profs. P. Chris Hammel (hammel@physics.osu.edu, 614-247-6928) or Steven A. Ringel (ringel@ece.osu.edu, 614-688-3924) with any questions.

How to Apply?

Eligibility

An applicant may serve as PI or Co-PI on only **ONE** proposal in response to this RFP (all Funding Tiers). The PI must hold a faculty-level appointment at OSU. Faculty members currently funded by ENCOMM Seed Grants and/or IMRGs as PIs or Co-PIs beyond September 1, 2011 are not eligible to apply under this RFP (all Funding Tiers). On the Proto-IRG proposals, current CEM core faculty members may not serve as PIs but may serve as funded Co-PIs or as unfunded collaborators.

All proposed research must be clearly distinct from ongoing externally or internally funded research.

Letters of Intent

Applicants planning to submit a proposal in response to this RFP (all Funding Tiers) must first submit a brief Letter of Intent as an email attachment in **one file in PDF format** by **2:00 PM on Monday, March 21, 2011** via email to Peggy Kraft, IMR Program Manager, at kraft.106@osu.edu. The Letter of Intent should include: names, titles, and departmental affiliations of PI, Co-PIs (if applicable) and collaborators (if known); contact information for the PI only (mailing address, email, phone and fax numbers); identification of the Funding Tier; tentative project title; short description of the proposed research (100 words maximum); and the names and contact information (including email address) for at least 3 suggested external reviewers. **Any Letter of Intent that does not provide this information or does not meet the deadline will not be considered.**

Presentations and Discussion

Once Letters of Intent have been received, the PIs will be contacted to reserve a date for making informal presentations. The presentations (up to 30 minutes) will take place on consecutive Fridays April 1 through May 6, 2011 in Room 4138 Physics Research Building (PRB), as part of the first six regularly scheduled ENCOMM meetings (4 to 5 PM) of Spring 2011 quarter.

The purpose of the presentations is to provide a forum for forming and enhancing interdisciplinary collaborative connections amongst OSU materials researchers in an informal setting, and to provide an opportunity to strengthen the proposals.

The presentations will not be evaluated. Presentations are strongly recommended, but are not mandatory.

Proposal Submission

Submit your proposal as an email attachment in **one file in PDF format** by **2:00 PM on Monday May 16, 2011** to Peggy Kraft, IMR Program Manager, at kraft.106@osu.edu. **Any proposal that does not meet the deadline will not be considered.**

Proposal Preparation Instructions (all Funding Tiers)

1. Cover Page (1 page maximum) including: identification of the Funding Tier; proposal title; names, titles, and departmental affiliations of PI, Co-PIs (if applicable) and collaborators (if any); contact information for the PI only (mailing address, email, phone and fax numbers); proposal abstract (200 words maximum)
2. Project Description (4 pages maximum) including:
   a. Objectives of the proposed research project
   b. Description and scope of research
   c. Work plan and methodology
   d. Expected outcomes
   e. Research facilities that may be used to conduct the research
   f. Expertise of the team and synergy among team members to enable research of a scope and complexity requiring the advantages of scale and inter-/multi-disciplinarity provided by a team (required only of Proto-IRG and Multidisciplinary Team Building proposals)
   g. A coherent management plan detailing how the project will be executed as a team effort (required only of Proto-IRG and Multidisciplinary Team Building proposals)
   h. A list of targeted federal block-funding opportunity(ies) with deadline(s) (if known), and a description of how the team will be able to compete effectively for those opportunity(ies) if the proposed research objectives are met (required only of Multidisciplinary Team Building proposals)
   i. A list of targeted external funding agency(ies), with deadline(s) (if known), and a description and how meeting the objectives of the proposed research would translate into external proposal development (required only of Exploratory Materials Research proposals)

j. Plan for expansion to a full IRG with integrated experimental and theoretical components (required only of Proto-IRG proposals)

3. References Cited (no page limit)
4. Budget Information (1 page maximum): Provide detailed budget for the proposed project and a brief explanation of the proposed budget items.
5. Curriculum Vitae (2 pages maximum each) for PI and all co-PIs (if applicable)
6. Current & Pending Support (no page limit) for PI and all co-PIs (if applicable)

Use a minimum 11-point font size, single line-spacing, and 1" margins. **Proposals longer than the stated page limits and/or omitting information requested above will not be reviewed.**

Budget Restrictions

These seed grants are intended to support primarily: student and postdoctoral researcher salaries and benefits; tuition; materials and supplies; and equipment user fees. The following expenses are **NOT** allowed (all Funding Tiers): faculty salaries and benefits; computers and equipment purchases; and food and entertainment.

Terms and Conditions

All selected proposals are subject to terms and conditions, including reporting requirements, that will be specified when the awards are made.

Review Process

Each proposal (all Funding Tiers) will be reviewed by external and OSU reviewers. In the case of Proto-IRG proposals only, a few proposals will be selected for further consideration. Each selected Proto-IRG team will be invited to give an oral presentation to a CEM review panel for further evaluation. Details of the oral presentation will be provided later.

Review Criteria (all Funding Tiers)

- Intellectual merit of proposed research activity, including originality, novelty, and potential for contribution to science, technology and education
- Potential to seed transformative advances involving materials-allied research

Additional Review Criteria (Proto-IRG)

- Potential to evolve into a full IRG
- Potential to leverage existing CEM capabilities and synergy with CEM activities

Additional Review Criteria (Multidisciplinary Team Building)

- Evidence of team synergy
- Potential for winning federal block funding

Additional Review Criterion (Exploratory Materials Research)

- Plan for external proposal development

Appendix E

2010-2011 IMR Facility Grants Awards

Fall 2010 Facility Grants
Awarded by the OSU Institute for Materials Research (IMR)

Thirteen new research projects were awarded by the IMR in December 2010, for a total investment of $26,000. The thirteen projects support faculty researchers from seven departments within the College of Engineering and the Division of Natural and Mathematical Sciences.

Characterization of Single Domain Superparamagnetic Nanoparticles

Lead Investigator: Gunjan Agarwal, Biomedical Engineering; Co-Investigator: P. Chris Hammel, Physics

This project aims to characterize the magnetic properties of single-domain superparamagnetic nanoparticles with respect to their crystalline orientation. A combination of analytical transmission electron microscopy (TEM) and atomic-force microscopy (AFM) based techniques will be employed for qualitative and quantitative analysis of data.

Characterization of Dendritic Barium Titanate Formed by Hydrothermal Conversion from Nanostructured TiO_2 Precursors

Lead Investigator: Sheikh Akbar, Materials Science and Engineering; Co-Investigator: Prabir Dutta, Chemistry

Titania (TiO_2) nanowires grown by a simple one-step thermal oxidation process are used as precursors for hydrothermal conversion to dendritic barium titanate. Preliminary tests have shown the dendrites to exhibit ferroelectric response to an applied electric field. The proposed study focuses on the characterization and optimization of the growth and conversion process to enhance the ferroelectric behavior and understand the basics governing the production of the dendritic morphology.

Freestanding Infrared Plasmonic Mesh

Lead Investigator: James Coe, Chemistry

The Coe group will create a mask and procedure for producing freestanding metal films with arrays of subwavength holes, i.e. plasmonic metal mesh, at the OSU facilities. The holes will be used to capture airborne dust particles that are sucked out of the air. The plasmonic properties of the mesh will enable infrared absorption spectra to be recorded of single, individual dust particles which enables their chemical composition to be determined. Since the concentration of respirable dust is directly correlated with human health, these results will provide some preliminary results for an NIH proposal.

Self Patterning of Zirconia Substrate Surfaces for YBCO Superconductors

Lead Investigator: Suliman Dregia, Materials Science and Engineering; Co-Investigator: Michael Sumption, Materials Science and Engineering

Surfaces of yttria-stabilized zirconia (YSZ) are patterned by a simple process, to produce arrays of self-assembled epitaxial nano-islands with strong order in size, spacing and alignment. The patterned surfaces are used as substrates for the pulsed-laser deposition of YBCO superconducting coatings, in an investigation of the potential enhancement of flux pinning and critical current density. The immediate focus of the study is on characterizing the microstructure of the films and correlating the defect types and content with measured flux pinning and critical current. In the long term, and owing to the ease and scalability of the patterning process, the benefits of substrate surface patterning can be transferred smoothly to the leading large-area technologies for producing coated conductor tapes.

Spintronic Phenomena in Organic-based Materials and Organic-based Biosensors

Lead Investigator: Arthur Epstein, Physics; Co-Investigators: Bin Li and Jesse Martin, Physics Graduate Students

IMR support will go to two sub-projects of the team's program for spintronics phenomena based on the organic and organic-based biosensors are: (1) Use of the fully spin polarized semiconductor V[TCNE]x (TCNE = tetracyanoethylene) with TC as high as 400 K in spin light emitting diodes and spin valve devices, and (2) Use of polyaniline nanoparticles and nanostructured thin-films in biosensors.

Hybrid Lamellar Lattices as a Platform for Molecular Electronics

Lead Investigator: Joshua Goldberger, Chemistry

Hybrid materials that consist of inorganic – small molecule junctions have shown great promise as inexpensive, solution-processible active matrices in a variety of energy conversion technologies, such as thermoelectrics, or photovoltaics, although the heterogeneity in bonding arrangements and variability of the nanostructure limits our ability to predictably and reproducibly achieve desired properties. Here, we seek to create crystalline solid-state materials comprised from conducting organic mono- or bilayers that are bound to two-dimensional metallic or semiconducting inorganic frameworks with molecular scale thicknesses. These hybrid lamellar materials feature an extremely high-density of inorganic-small molecule interfaces in parallel, oriented orthogonal to the lamellar axes. With this IMR facilities grant, we will develop the capabilities of measuring the electronic properties across specific crystalline axes, in order to provide a fundamental understanding of how to chemically control the flow of charge across the organic/inorganic interface as well as within each component.

A Novel Immunoisolation System for Islet Transplantation

Lead Investigator: Jianjun Guan, Materials Science and Engineering

The research objective is to explore a novel immunoisolation system with efficient immunoisolation and enhanced islet survival properties. The successful development of the proposed immunoisolation system will significantly augment islet survival after transplantation, and will eventually lead to a remarkable improvement in the efficacy of islet transplantation. To achieve this goal, we will create a capsule-type immunoisolation system possessing two critical functions: 1) efficient immunoisolation to decrease immune response-induced islet apoptosis. This includes immunoisolating both immune proteins and pro-inflammatory cytokines; and 2) favorable microenvironments to actively enhance islet survival and function.

High-Quality Gate Dielectrics by Atomic Layer Deposition for III-Nitride-based Power Electronics

Lead Investigator: Wu Lu, Electrical and Computer Engineering

This project aims to develop high-quality gate dielectric for higher breakdown voltage, faster power-switching speed, and higher current capability required for wide-bandgap semiconductor power switching devices. Such devices can contribute to energy saving and can be used as smart power grid interfaces for solar, wind and other renewable energy generations, and traction drives in electric or hybrid electric vehicles. This IMR Facility Grant will cover partial cost of facility user fees at NanotechWest (NTW) and Nanoscale Material Processing Center (NanoMPC) for device development.

Analysis and Characterization of Metal-Oxide Thick Films for Use in Gas Sensor Applications

Lead Investigator: Patricia Morris, Materials Science and Engineering

Metal oxide semiconductor materials are useful for analyzing trace amounts of off-gases through changes in their electrical properties (resistance). Our work will involve the development, analysis, and characterization of metal-oxide thick films for use in detection of off-gases in the steel making industry. A special emphasis will be placed on characterization of microstructure in order to maximize

sensitivity and reproducibility. The goal is to produce a metal oxide thick film sensor array that can accurately and repeatably analyze off-gas concentrations in harsh industrial conditions.

Self-Assembly of Nanostructured Hybrid Materials

Lead Investigator: Jon Parquette, Chemistry

The self-assembly of small molecules into one-dimensional nanostructures offers many potential opportunities for electronic and biomedical applications. Most applications require the assembly or co-integration of molecules with specific properties within the nanostructures. Thus, the self-assembly process must not only be controllable with regard to nanostructure, it must be capable of integrating these functional components. The long-term objective of this work is to understand how the nature, dimensions and composition of the nanostructures can be controlled on the nanoscale, and to correlate these structural factors with the corresponding physical, chemical and functional properties.

Tissue Scaffolds: Connecting Synthesis, Structure, and Mechanical Environment

Lead Investigator: Heather Powell, Materials Science and Engineering; Co-Investigator: Peter Anderson, Materials Science and Engineering

A clear understanding of the interconnection between synthesis, structural properties and mechanical response in scaffolding materials is needed in order to advance the field of tissue engineering. A validated finite element model which can predict these behaviors based on single fiber properties and fiber architecture would provide a platform to make substantial advances at a far more rapid pace. This proposal seeks to utilize recent advances fibrous scaffold synthesis to develop a model scaffold system where mechanical properties of the macroscopic scaffold can be altered without a change in scaffold architecture or surface chemistry. State of art imaging and image analysis techniques will then be utilized to quantitatively describe the geometry of the scaffolds as a function of applied mechanical strain. Finally, micromechanical analyses using force AFM will be used to connect subfiber structure with single fiber mechanics and multifiber mechanical response. This new information will be utilized to generate a finite element model which can predict the mechanical response of a scaffold to an applied load or strain.

Micro-Electro-Mechanical Switches for Integrated Optical Applications

Lead Investigator: Siddharth Rajan, Electrical and Computer Engineering; Co-Investigator: Gregory Washington, Mechanical Engineering

By modeling, designing, developing and fabricating a GaN-based micro-electro-mechanical optical switching device, the research team will add valuable momentum to the nascent, promising field of GaN micro-devices that can go beyond the limitations of conventional optical-MEMS. In order to meet the aforementioned broader goal, the proposed research involves the following specific objective: The development of a novel microfabrication process based on PhotoElectroChemical (PEC) etching necessary towards realizing the device and characterizing the GaN material.

Micelle-Mediated Self-Assembly of Multifunctional Hybrid Nanoparticles

Lead Investigator: Jessica Winter, Chemical and Biomolecular Engineering; Co-Investigators: Barbara Wyslouzil, Chemical and Biomolecular Engineering; Gang Ruan, Chemical and Biomolecular Engineering

The great potential of nanoparticles with a single function (e.g. fluorescence OR magnetism) has been widely demonstrated. Recently, we successfully developed a platform technology based on micelle-mediated self assembly to create nanoparticles with multiple functions. This proposed work seeks to develop a large-scale production strategy for these hybrid nanoparticles. Fundamental studies on the production process and the structure of the hybrid nanoparticles will also be pursued.

Spring 2011 Facility Grants Awarded by the OSU Institute for Materials Research (IMR)

Seven new research projects were awarded by the IMR in April 2011, for a total investment of $14,000. The seven projects support the research work of faculty from eight departments within the College of Engineering, College of Pharmacy, and the Division of Natural and Mathematical Sciences.

High Throughput Production of Multi-Component Multi-Layered Acetalated Dextran-based Microparticle for Vaccination Applications

Lead Investigator: Kristy Ainslie, Division of Pharmaceutics, College of Pharmacy; Co-Investigators: Barbara Wyslouzil, Chemical and Biomolecular Engineering, Sadhana Sharma, Research Scientist, Division of Pharmaceutics

To facilitate production scale-up and improve vaccine efficacy we propose the use of electrospray drying for fabrication of multi-layered microparticles encapsulating protein and small molecules. These microparticles will be fabricated from the novel polymer Acetalated Dextran (Ac-DEX) which has shown enhanced immune activity compared to traditional biopolymers. Processing parameters (e.g. flow rate, concentration) will be varied to optimize protein and drug loading of the electrosprayed microparticles.

Nanostructured Metal Surfaces for Electrocatalytic Chemical Conversion

Lead Investigator: Anne Co, Chemistry

Nanostructured metals are ideal electrode materials for advanced electrical energy storage and conversion devices. The ability to control surface and bulk structures of electrode materials is key to manipulating catalysts reactivity. In this work, our goal is to control surface structures by depositing highly ordered metal adlayers, and to develop a systematic method for studying surface structure effects on reactivity and reaction mechanism.

Direct Writing and Infusion of Bioactive Molecules for Guided Microvessel Formation

Lead Investigator: John Lannutti, Materials Science and Engineering; Co-Investigators: Dave Farson, Materials Science and Engineering; Heather Powell, Materials Science and Engineering

This project seeks to combine polymer scaffold fabrication technology, femtosecond laser patterning and sub-critical CO2 infusion to develop a functional microvascular network within a 3D scaffold to provide a structural and nutritional support to the islets during and after implantation. Diabetes affects 23.6 million Americans at an annual medical cost of over $174 billion. Islet transplantation has emerged as an important surgical component of diabetes treatment. However, a majority of islet recipients do not remain insulin independent over a 5-year time frame. Islet transplantation often fails due to disruption of the microvascular network and destruction of the islet microenvironment during isolation. Tissue scaffolds that both provide an appropriate physical environment for adhesion/growth and direct *in vitro* microvessel network formation would be a critical advance for biomedicine.

Polymer-based Flexible and Stretchable RF Electronics

Lead Investigator: John Volakis, Electrical and Computer Engineering; Co-Investigator: Lanlin Zhang, Postdoctoral Researcher, Electroscience Lab

This project focuses on the development of a new class of flexible and stretchable RF electronics. These electronics rely on the successful deposition of RF circuits on polymer-based dielectrics. Although polymers have the highly desirable properties of being stretchable and flexible, their metallization to form RF circuits is very challenging. This is due to the poor adhesion properties of

polymer substrates. However, our recent research showed that thin Cu conductors can be directly deposited reliably onto polymer substrates using a modified state-of-art microfabrication process. Our process is expected to greatly improve the electrical and mechanical performance of the printed RF circuits by optimizing fabrication protocols.

Silicon Carbide Cryogenic Neutron Damage Testing

Lead Investigator: Wolfgang Windl, Materials Science and Engineering; Co-Investigator: Thomas Blue, Mechanical and Aerospace Engineering

This project proposes to fabricate Hall bars to investigate the effect of neutron irradiation on the carrier mobility in SiC at cryogenic temperatures. Besides the relevance of the results for the performance of electronics in the radiation field of an outer-space environment, we want to test the hypothesis that the irradiation of materials at low temperatures and low radiation fluence may simulate the results of a high radiation fluence experiment, due to the low target material temperature locking in the radiation-induced damage. If low-fluence-low-temperature results can be correlated to high-fluence-high-temperature environments, this will open up a wide range of opportunities to study irradiation effect problems that are currently outside of the capabilities of the OSU Research Reactor Lab and most other reactor labs; decrease the cost of further neutron testing of SiC and other devices; and advance understanding of the neutron damage and crystal defect annealing processes.

Device Physics and Characterization of $LaAlO_3/SrTiO_3$ 2DEG Fabricated by Ultra-High Vacuum Sputtering

Lead Investigator: Fengyuan Yang, Physics; Co-Investigator: Siddharth Rajan, Electrical and Computer Engineering

This project proposes the deposition of $LaAlO_3$ epitaxial films on $SrTiO_3$ using ultra-high vacuum (UHV) sputtering for the study of device physics and characterization of complex oxide two-dimensional electron gas (2DEG)-based novel electronic devices. The team comprises complementary expertise in the epitaxial film growth of complex oxides using UHV sputtering (Yang) and semiconductor device fabrication and characterization (Rajan). Using state-of-the-art UHV sputter technique, we have demonstrated the growth of complex oxide epitaxial films such as $BiFeO_3$ and the $A_2BB'O_6$ double perovskites that rival the quality of semiconductor epitaxial films. Our technique should produce similar or higher quality films of $LaAlO_3$, which is a less complex than double perovskites.

Polymeric Artificial Compound Eye for Advanced Endoscopic Imaging

Lead Investigator: Yi Zhao, Biomedical Engineering

This project proposes to develop a polymeric optical component, the key structure in the proposed artificial compound eye imaging system. The component with an adaptive focus length will implement three-dimensional image acquisition with a wide field of view. The long term goal of the research is to develop an advanced artificial compound eye system that can present three-dimensional, wide field-of-view and high definition images to improve the medical outcome of endoscopy procedures by fabricating a smart microfluidic system which combines the advantages of both the compound eye of insects and the camera eye of mammalians.