IMR Quarterly

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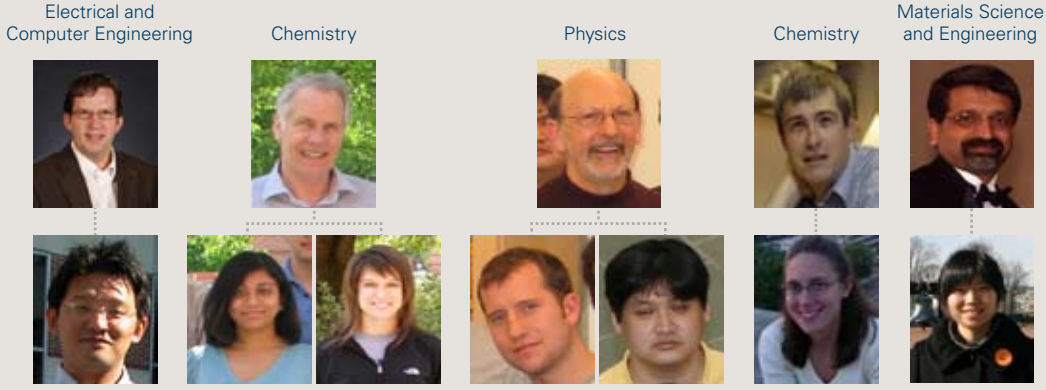
IMR
Institute For Materials Research

Inside this issue:

THE OHIO STATE UNIVERSITY

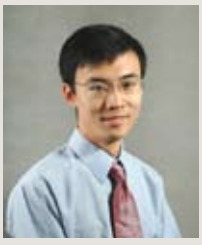
Solar Solutions

Solar energy research is among the strongest research areas within the Ohio State University materials community, and one of its most timely. From creating ultra-light compound semiconductor solar cells tested on the International Space Station to industry interactions via the Wright Center for Innovation and Commercialization (PVIC) to creating novel solar-sensitive molecular structures, IMR researchers are engaged in research, development and commercialization at the cutting edge of the solar energy field. A key part of the overall effort is the team seeded by an IMR Interdisciplinary Materials Research Grant (IMRG) headed by Chemistry Professor Malcolm Chisholm in a collaborative project with faculty and students from the Departments of Chemistry, Physics, Electrical and Computer Engineering, and Materials Science and Engineering to explore "Hybrid Organic-Inorganic Solar Conversion Systems." The recent successes of the IMRG team are highlighted by 3 papers to be presented at the 34th IEEE Photovoltaic Specialists Conference in Philadelphia in June 2009. The IMR photovoltaics community is presenting a total of 7 papers at this prestigious conference, a testament to the great strengths of the materials-for-energy community that IMR continues to grow and support. We invite you to read more about this exciting IMRG research on page 2.



(From top left to bottom right in reading order)
Professors: Paul R. Berger, Malcolm H. Chisholm, Arthur J. Epstein, Terry L. Gustafson, Nitin P. Padture
Graduate Students: Woo-Jun Yoon, Yagnaseni Ghosh, Austin Carter, Lynetta Mier, Tengfei Jiang, Carly Reed, June Hyoung Park

Faculty Spotlight: Yi Zhao



Dr. Zhao is in his third year as an Assistant Professor of Biomedical Engineering, where he founded the Laboratory for Biomedical Micro-systems. Turn to page 6 to learn more about Dr. Zhao's exciting research, including new developments in on-chip muscle tissue fabrication.

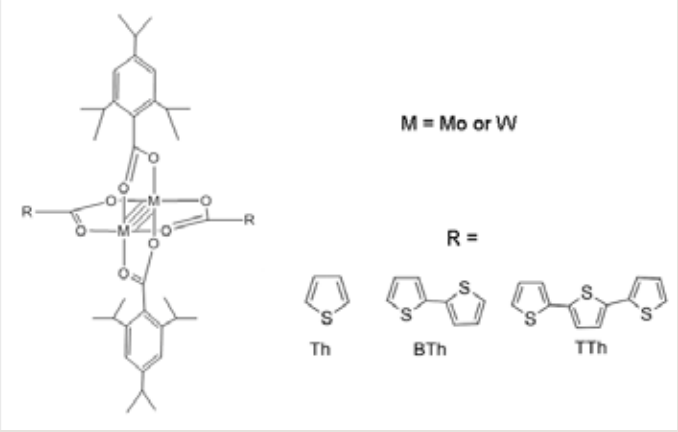
See page 6 for Dr Zhao's research interests and examples of recent research.

Solar Solutions, Continued

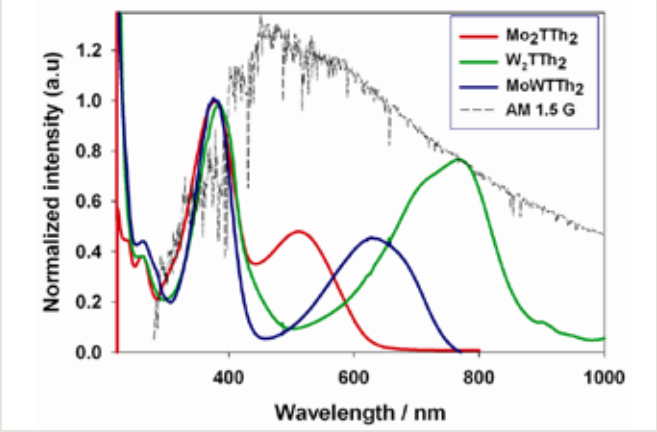
The research conducted by this group addresses a challenge in the area of organic solar cells-harvesting as many photons of light within the solar spectrum as possible. Professor Chisholm and Dr. Yagnaseni Ghosh, a recent PhD graduate in the Chemistry department have synthesized hybrid metallo-organic compounds and studied their photophysical properties. The compounds are composed of quadruply bonded dimetal units with organic carboxylate ligands, shown in *Figure 1*. Increasing the conjugation of the organic ligand and changing the character of the metal unit from molybdenum to tungsten shifts the light absorption of these complexes to longer wavelengths. *Figure 2* shows the absorption spectra of three terthienylcarboxylate complexes with varied metal centers which span the entire solar spectrum.

Due to the highly process-sensitive performance of conventional organic solar cells, great efforts have been made toward the improvement of the fabrication process with the goal of improving power conversion efficiency. Professor Paul Berger and Ph.D. student Woo-Jun Yoon of the Electrical and Computer Engineering department are integrating these hybrid metallo-organic complexes into organic solar cells and determining if the overall efficiency of the cell is enhanced. They have already demonstrated highly efficient conventional organic solar cells by controlling the self-organization properties of organic photoactive films and optimizing electrodes for efficient photo-created electron extraction.

The multidisciplinary component of this research continues and includes Professors Arthur Epstein (Physics), Terry Gustafson (Chemistry), Nitin Padture (Materials Science and Engineering) and their graduate students (see photo). Their work is the springboard for creating efficient hybrid metallo-organic complex solar cells by enhancing solar energy absorption.



▶ Figure 1



▶ Figure 2

The OSU Institute for Materials Research (IMR) Research Enhancement Program includes three unique research grant programs which fund OSU researchers in materials-allied fields. Now at the end of its second year of funding multi-disciplinary research at Ohio State, the IMRG program has funded several successful OSU research collaborations which are leading to publications, invited presentations, and external funding for additional research. We will continue to highlight IMR-funded research projects in future newsletters.

Nanotech West Acquires Ohio State's First MOCVD

IMR's Wright Center for Photovoltaic Innovation and Commercialization (PVIC) has acquired a new Aixtron 3x2" closed coupled showerhead (CCS) metalorganic chemical vapor deposition system, or MOCVD. Utilizing the same CCS design as larger production systems with a capacity for thirty-one 2" wafers, OSU's new 3x2" system can flexibly accommodate sample sizes from 4" down to small pieces making the system ideal for basic materials research, advanced device development or small production. An industry standard technique for the deposition of III-V semiconductors and nanostructures, the new MOCVD capability provides OSU's materials community the flexibility to deposit a full range of device quality arsenide, phosphide, antimonide and dilute nitride III-V compounds. With eight metalorganic sources (including trimethyl aluminum, trimethyl gallium, trimethyl indium, trimethyl antimony, diethyl zinc, diethyl tellurium, carbon tetrachloride, and unsymmetrical dimethyl hydrazine), three gaseous sources (including arsine, phosphine and dilute silane) and the ability to reach processing temperatures up to 900°C, the new MOCVD compliments the vast processing and characterization capabilities available at Nanotech West Laboratory and provides a source of high quality materials for photovoltaics, optoelectronic and high speed electronic devices.

The MOCVD is undergoing installation and testing procedures and will be available June 2009 to OSU and industry researchers. For more information about this new equipment, contact Dr. John Carlin, IMR Member of Technical Staff, at carlin.9@osu.edu.

Facilities Updates

The new Bruker D8 Discover X-Ray Diffractometer has been fully commissioned at the ENCOMM Nanosystems Laboratory (ENSL) and is available for users. The instrument is located in Physics Research Building (PRB) on OSU's central campus. To schedule training and use of the instrument please contact IMR Member of Technical Staff and ENSL Director Dr. Denis Pelekhov (e-mail: dtt@mps.ohio-state.edu).

The new website of the ENCOMM Nanosystems Laboratory (ENSL) can be reached at http://128.146.20.28 (an OSU-related URL is pending approval). The website contains useful information about ENSL including descriptions of available equipment and directions on how to become an ENSL user.

Smart, Clean and *Green*

A team of researchers formed by mechanical engineering professors Stephen Bechtel and Marcelo Dapino and materials science & engineering professor Michael Mills are creating the science to enable the tailoring of composition and processing of active materials. Their goal is to enable novel devices and load-carrying 3D structures which optimally accomplish a specified multi-functionality. Active materials exhibit powerful nonlinear 3D coupling and anisotropy. However, the design and associated models, experimental characterization, and control of adaptive systems are in general targeted at 1D devices. This reduced framework limits applications to devices capable of only 1D motion. A two-year IMR Interdisciplinary Materials Research Grant has supported this research project, "Novel Active Structure Design Exploiting 3D Multi-Functional Materials." In this time, the team has accomplished three related milestones: (1) Calculation of the 3D energy landscape of active materials to deduce their performance space (direct problem); (2) Identification of materials that meet targeted meso-scale properties (inverse problem); and (3) Redefinition of the design and capabilities of major equipment for the synthesis and nonlinear 3D characterization of coupled magneto-thermo-mechanical materials. The team has initiated implementation of the new class of magnetostrictive iron-gallium alloys (Galfenol) into a new class of fuel injectors capable of faster and more precise control of the fuel injection pulses along with higher operating pressure. In combination with the superior strength of Galfenol, these properties will result in fuel injection systems tailored to higher fuel efficiency and cleaner emissions.

Professor Stephen Bechtel, graduate student Sarvani Piratla, and Professor Marcelo Dapino are investigating new ways to create load-carrying adaptive structures with 3D multi-functionality.

IMR's Shuttle Service

transports over 170 passengers each month!

The shuttle service runs 6 times every weekday

IMR shuttle departs every 90 minutes at

9:00am, 10:30am, 12:00pm, 1:30pm, 3:00pm, and 4:30pm

from main campus in front of Dreese Laboratories
at the corner of West 19th and Neil Avenues,
stopping at Nanotech West Labs and the Center for Automotive Research

Go to:
http://imr.osu.edu/funding/rep.cfm

for updated funding information and lists of recent grants awarded, including IMR Interdisciplinary Materials Research Grant (IMRG) and IMR Industry Challenge Grants

Want to join IMR?

All OSU faculty, staff, and students working in materials-allied fields are eligible to become IMR members.

To become a member of IMR, contact IMR Program Manager **Layla Manganaro** at **manganaro.4@osu.edu**

Recently Awarded IMR Facility Grants

Ten new facility grant projects were awarded by the IMR in January 2009, for a total investment of $20,000. The ten projects support 13 faculty researchers from seven departments within the College of Engineering and the College of Biological, Mathematical and Physical Sciences.

Magnetic Force Microscopy of Magnetic Nanoparticles in Biological Systems

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

Strong NDR from Metal-Oxide/Conjugated Polymer Interfaces Enabling Low-Power, Plastic Logic, Memory and Wireless Datalinks

Lead Investigator: Paul Berger, Electrical and Computer Engineering

Characterization of Multivalent Ionic Liquids for Nanolubrication

Lead Investigator: Bharat Bhushan, Mechanical Engineering

Enhance Program on Spintronic Phenomena in Organic-based Materials

Lead Investigator: Arthur Epstein, Physics; Co-Investigators: Deniz Duman and Mark Murphey, Graduate Students

Development of a Mechanically Robust Stem Cell Delivery System for Myocardial Injection

Lead Investigator: Jianjun Guan, Materials Science and Engineering

Nanoscale Modification of Diamond Surface Conductivity

Lead Investigator: Jay Gupta, Physics

Development/Evaluation of Molecular Materials for Spintronics

Lead Investigator: Ezekiel Johnston-Halperin, Physics; Co-Investigator: Malcolm Chisholm, Chemistry

Fabricating Magnetic Traps to Manipulate Nanoparticles and Biological Cells

Lead Investigator: R. Sooryakumar, Physics; Co-Investigator: Jessica Winter, Chemical and Biomolecular Engineering

Development of A Hybrid Microcantilever for Bi-directional Sensing and Actuating at the Small Scale

Lead Investigator: Yi Zhao, Biomedical Engineering

Innovative Micro and Nano Channels for Signal Transmis-sion in Ion Transmission Lines

Lead Investigator: Yuan Zheng, Electrical and Computer Engineering

Faculty Spotlight: Yi Zhao

Professor Yi Zhao joined the Department of Biomedical Engineering at Ohio State University and founded the Laboratory for Bio-medical Microsystems in October 2006. Prior to arriving at OSU he received his graduate training in manufacturing engineering at Boston University and in mechanical engineering at Tsinghua University, China.

Dr. Zhao's research interests span a broad range of multi-disciplinary fields in biomedical micro/nanotechnologies, with a specific emphasis on exploring materials science, engineering mechanics, and manufacturing technologies for Bio-Micro-Electro-Mechanical-Systems (Bio-MEMS), including:

- Micro/nanofabrication strategies for micro total analytical systems
- Sensors and actuators for investigating the mechanical/electrical interfaces between biological organisms and engineering environment at various length scales
- Tissue engineering at the micro scale

Examples of Recent Research

Microfabrication of non-photodefinable polymer materials into microstructures is one of the major challenges for development of functional biomedical microchips.

Figure 1 shows a gallery of microstructures made of non-photodesinable polydimethylsiloxane (PDMS) fabricated in our laboratory. By using a vacuum-assisted microfluidic approach, micro-structures with the characteristic dimensions of less than 10.

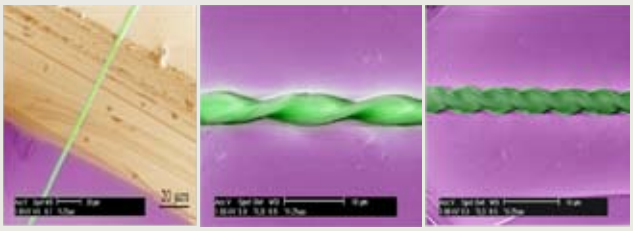


Figure 1: PDMS microstructures were demonstrated: (a) shows the schematics of a suspending microbridge; (b) & (c) show two polymer helical microstructures with different turn densities.

Figure 2 shows on-chip skeletal muscle constructs fabricated using microstructures. By tuning the geometries of the underlying microstructures, the multi-layered constructs can have aligned morphology similar to that in the in vivo skeletal muscles. The ability of the chip to allow detachment of fabricated tissues further validates the utility of this approach for on-chip muscle tissues fabrication. The findings demonstrate that the on-chip device holds promise for providing an efficient means for guided muscle tissue construction. (This work was published in Biotechnology and Bioengineering, 2009, 102(2):624-631 and selected as the cover art of the issue 102(2)).

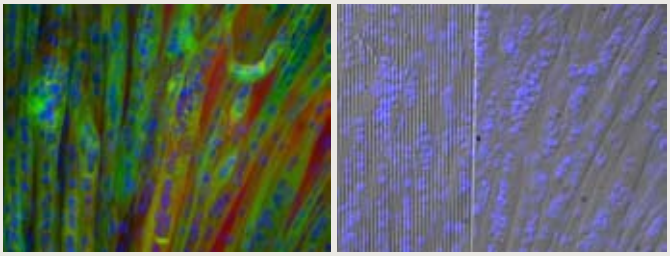


Figure 2: The immunofluorescence images showing the myotube alignment with exposure to different surface topographies. (a) The actin filament staining showed that the myotube in different areas aligned at different angles. (b) The stained cell nuclei overlapped with the underlying micro-structures showing the spatial correlation between the myotubes alignment and the microtopography. (myosin heavy chain is stained red, actin is stained in green, cell nuclear is stained in blue)

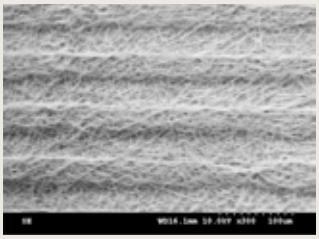


Figure 3: Microstructured nanofibrous materials were formed using a micropatterned collecting substrate.

More information and recent results can be found on the website of Laboratory for Biomedical Microsystems, http://www.bme.ohio-state.edu/yizhao

Director's Note

Dear Colleagues,

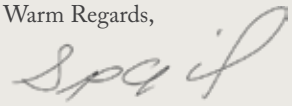
It is with great pleasure that I write this column for the inaugural IMR Newsletter and wish you a hearty welcome! Our dynamic materials community continues to accelerate its growth and international prominence in so many ways. The goal of the IMR Newsletter is to provide a snapshot of various activities, people, opportunities and events to keep you apprised of the efforts and successes occurring within our IMR community.

The past two years have seen momentous events that are already moving the traditionally strong foundation of OSU materials research to the highest plane. Some of these happenings are the award of OSU's first ever NSF Materials Research Science and Engineering Center – Center for Emergent Materials – directed by Prof. Nitin Padture, Department of Materials Science and Engineering, the award of an advanced energy center to IMR – the Wright Center for Photovoltaics Innovation and Commercialization, co-directed by Dr. Bob Davis, IMR Associate Director, and the recent awarding of the Ohio Research Scholars Program – Technology-Enabling and Emergent Materials, through which several endowed chairs have been established in the science of next generation energy and nanoscale characterization thematic areas. It is notable that with the existing NSF Nanoscale Science and Engineering Center, led by Prof. L. James Lee, Dept. of Chemical and Biomolecular Engineering, OSU is one of only 8 U.S. universities with active NSEC and MRSEC programs!

We have also seen the establishment of new shared facilities that are opening the door for new groundbreaking research. The ENCOMM Nanosystems Lab, coordinated by IMR's Dr. Denis Pelekhov, houses a new focused ion beam and high resolution x-ray diffraction facilities for nanoscale research, the Nanotech West Laboratory, operated by IMR, recently installed OSU's first metalorganic chemical vapor deposition and atomic layer deposition facilities, coordinated by IMR's Dr. John Carlin, the campus electron optics facility recently installed a new aberration-corrected optics on the world's highest resolution microscope – the Titan. Several groups that received IMR Interdisciplinary Materials Research Grants have launched new programs in several of IMR's signature areas of emphasis, such as biomaterials (Prof. Stephen Lee, Biomedical Engineering), nanomagnetoelectronics (Prof. Zeke Johnston-Halperin, Physics) and solar energy (Prof. Malcolm Chisholm, Chemistry) and materials in medicine (Prof. Michael Paulaitis, Chemical and Biomolecular Engineering). IMRG projects are designed to seed the next rounds of major centers, sustaining and advancing OSU's presence as a leader in materials research.

In this first IMR Newsletter, we can only capture a small component of the many fantastic research programs going on around us. We are excited to feature IMRGs led by Prof. Malcolm Chisholm on solar energy and Prof. Marcelo Dapino on smart materials, we are proud to introduce you to Prof. Yi Zhao of Biomedical Engineering in the first faculty spotlight, and we are delighted to announce details of our new MOCVD facility at Nanotech West.

Warm Regards,



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Blackwell Conference Center, Columbus, Ohio

August 31– September 3, 2009

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