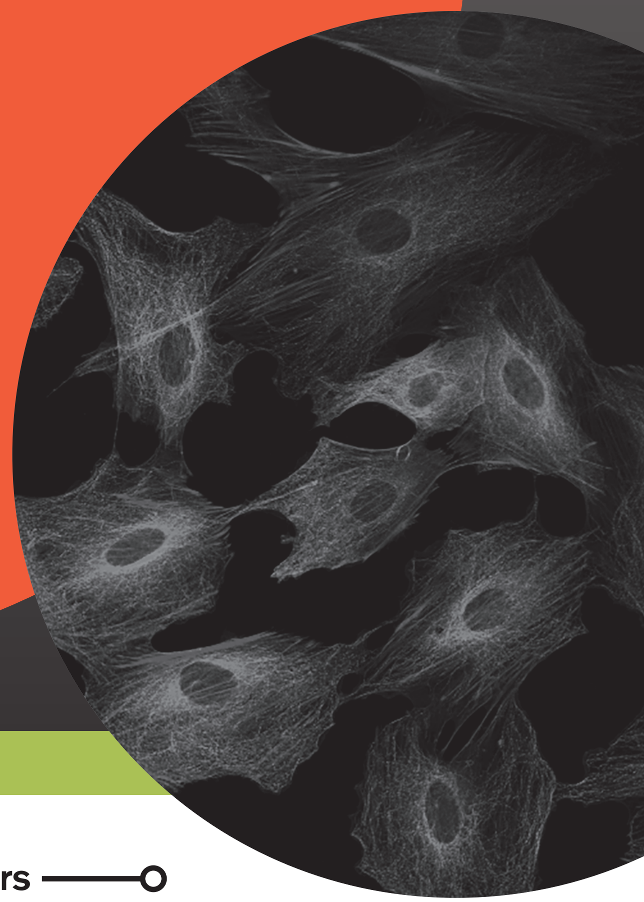
Arizona Imaging and Microanalysis Society presents

Microscopy Conference Program

March 21, 2014



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President's Note

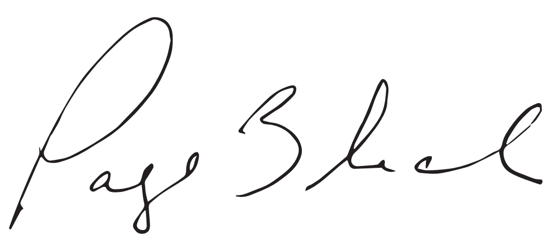
Dear Conference Attendees,

We welcome you to the 2014 Arizona Imaging and Microanalysis Society Conference. We have recruited an excellent group of speakers who are experts in the fields of microscopy and photography for both material and biological sciences. This is the first year that we have offered the highly successful "Digital Images and their Ethical Use in Science Workshop" that was developed at the University of Arizona by our colleagues **Doug Cromey**, **David Elliott** and **Brooke Beam-Massani**, to address the need of training scientists of the acceptable techniques and limits of image manipulation. We are also happy to debut our new website that enabled online registration and payment options for this year's conference. Additionally, we expanded our poster session to include categories and prizes for undergraduate and graduate students as well as postdocs/early scientists and are happy to report that this year we received a record number of poster abstract submissions!

Our conference would not be possible if it were not for the in kind support and sponsorship that we receive each year to host this annual event. AIMS is a Local Affiliate Society [LAS], or chapter, of the national Microscopy Society of America [MSA] and each year we receive funding through the Tour Speaker Program to help offset costs. We also wish to thank our hosting institution, Arizona State University, for providing the excellent venue and to the School of Life Sciences for their sponsorship. Last but not least, we want to thank our vendors for their generous support that allows us to provide poster awards, catering, host the ethics workshop and cover other associated conference expenses. Please take a moment during the conference to stop by their tables to say Hi and check out their microcopy related products.

Thank you for being a part of the AIMS community and I hope you enjoy the meeting!

Best Regards,



Page Baluch, PhD
Arizona Imaging and Microanalysis Society President

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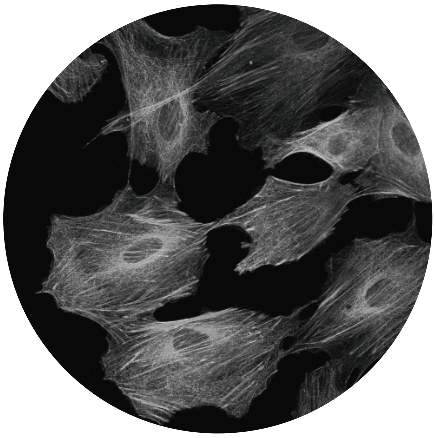

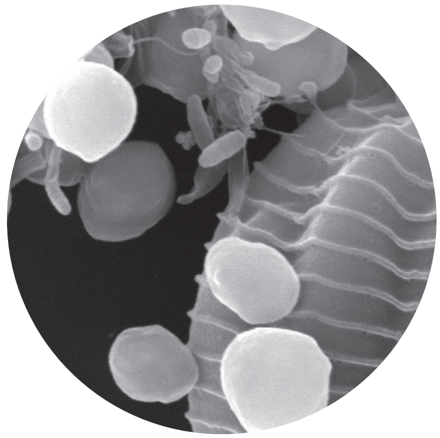

March 21, 2014

All sessions will be held in the Carson Ballroom in ASU's Old Main building.

Check-In . . . . .8 - 8:45 a.m.

Opening remarks. . . . . .8:45 - 9 a.m.

Page Baluch, AIMS President

Aberration Correction: Imaging at Atomic Resolution . . . . .9 - 10 a.m.

Jingyue Liu, Department of Physics, Arizona State University, Tempe, AZ

Morning Break . . . . 10 - 11:20 a.m.

Vendor Demonstrations and Student Poster Session

Imaging and Advancements in Bone and Cartilage Tissue Engineering . . . . 11:30 a.m. - 12:30 p.m.

William J. Landis, G. Stafford Whitby Chair in Polymer Science
University of Akron, OH

Buffet Lunch in Old Main, Carson Ballroom . . . . 12:30 - 1:50 p.m.

Additional time to visit Student Posters

Nano to micro: Connecting Molecular Dynamics to Cell Motility Decisions . . . . 2 - 3 p.m.

Catherine Galbraith, Spatial systems Biology Center at Oregon
State University

What is in a Picture . . . . 3 - 4 p.m.

Michael Traynor, Professional Photographer, Phoenix, AZ

Afternoon Break . . . . .4 - 4:15 p.m.

Vendor Exhibits and Student Awards

Imaging Nervous System Development in Transgenic Mice . . . . 4:15 - 5:15 p.m.

Jason Newbern, School of Life Sciences, Arizona State University
Tempe, AZ

Student Awards and Announcements . . . . 5:15 - 5:30 p.m.

Business Meeting . . . . .5:30 - 6 p.m.

Annual Society general meeting (open to the public)

Speaker Biographies

Jingyue 'Jimmy' Liu

Department of Physics, Arizona State University, Tempe, AZ.

Professor Liu received his B.Sc. (Hons.) degree from Beijing University of Science and Technology, and his Ph.D. degree from Arizona State University. Prior to joining the University of Missouri-St. Louis in September 2006, he was a Senior Science Fellow and Senior Research Manager at Monsanto Company. He is currently a professor in the department of physics at Arizona State University. Innovative and sustainable technologies are emerging from the proper integration of nanoscale building blocks and devices. Nanoscience and nanotechnology are expected to play a major role in providing sustainable energy to power our planet and in improving the quality of human life. Dr. Liu's group focuses on the fundamental understanding of the synthesis-structure-performance relationships of nanostructures and nanostructured systems. They develop and utilize advanced electron microscopy techniques (imaging, diffraction and spectroscopy) to help them understand the synthesis processes of nanoscale materials, their unique properties and their applications in energy harvesting and storage, heterogeneous catalysis, sensing, or delivery. Their key research goals are to understand the formation processes of nanostructures so that they can develop scalable synthesis methodologies to manufacture better controlled nanostructures for desired applications and to understand the charge generation and transfer processes in nanostructures and nano-architectured systems.

William J. Landis

Department of Polymer Science, Univ. of Akron, OH.

Dr. Landis received his bachelor's degree in physics from the University of Massachusetts, Amherst, and a Ph.D. in biophysics from the Massachusetts Institute of Technology, Cambridge, MA. He has been a member of the Department of Polymer Science at the University of Akron Since 2010. Previously he was chairman of the Department of Biochemistry and Molecular Pathology at the Northeast Ohio Medical University, Rootstown, OH, and prior to that position he was a faculty member in the department of Anatomy and Cellular Biology at the Children's Hospital and Harvard Medical School, Boston, MA. He is currently co- director of the Center for Biomaterials and Medicine in the Austen BioInnovation Institute of Akron and G. Stafford Whitby Chair in the Department of Polymer Science. Dr. Landis has research interests in understanding basic mechanisms of mineralization in both vertebrates and invertebrates; tissue engineering bone, cartilage, tendon and other connective tissues; and the effects of mechanical forces on the skeleton and dentition. The Landis Laboratory concerns itself with several aspects of connective tissue molecular biology, biochemistry, structure and function. These include research investigations of (1) Mineral-matrix structure and interaction in normal (bone, calcifying cartilage and tendon, enamel, dentin, and cementum) and abnormal (osteogenesis imperfecta, osteoporosis, osteopetrosis) vertebrate tissues; (2) Bone, cartilage, and tendon biochemistry; (3) Tissue engineering of connective and calcified tissues to fabricate models of human digits, ears, and knees; (4) Effects of mechanical, gravitational, and electromagnetic forces on calcified tissues; and (5) Orthopaedic pathologies such as those involving osteoarthritis, slipped capital femoral epiphysis, hypothyroidism, dysplasia, clubfoot and others.

Catherine Galbraith

Spatial Systems Biology Center, Oregon Health and Science University, Portland, OR.

Dr. Catherine G. Galbraith is trained as both an engineer and a cell biologist. She obtained her Ph.D. in bioengineering at UCSD with Dr. Shu Chien and did her post-doctoral work in cell biology at Duke University with Dr. Michael Sheetz. This fall she moved her research program from the NIH to OHSU where she is an associate professor in the Spatial Systems Biology Center and a Discovery Engine Investigator in the Knight Cancer Institute. Dr. Galbraith's laboratory uses a combination of cutting edge microscopy and biophysics to study problems in cell migration. Her approaches have provided new insights into how cells choose specific directions for migration. Most recently her work involving super-resolution microscopy has led her to making measurements at different length and time scales to create a comprehensive picture of molecular dynamics that define the mechanistic rules that underlie cellular motility and signal transmission. Dr. Galbraith has received several awards in recognition for her work, including the Bioengineering Society Young Investigator Award, a NIH Director's Challenge Award for high-yield, high-risk research, and a NIDCR Special Act Award for her contributions to super-resolution microscopy. She has also served as a judge for the international Olympus Bioscapes Competition and as an editor for The Image Library and the Journal of Optics.

Michael Traynor

Professional Photographer, Image Design Fine Art, Phoenix, AZ.

Michael has been an active photographer for 50+ years and has experienced the transition from film to digital. Long before digital became available to the general public, Michael worked with large commercial clients, learning the benefits and limitations of digital photography. He has continued to expand his knowledge base, staying breast of the latest technology and printing. Part of what drew Michael to photography was that he could create images as fast as he could picture them in his mind. While he started in painting and sculpture, these two art forms required far less technical knowledge than photography. It has taken Michael most of his career to learn the technical and artistic subtleties of photography. Over the years Michael has amassed a fantastic library of books on photography, detailing advances and long lost photographic techniques. Pouring over his collection has enabled him to continuously refine his own photographic skills.

Jason Newbern

School of Life Sciences, Arizona State University, Tempe, AZ.

Dr. Jason Newbern's research is centered on developmental neuroscience. He obtained his Ph.D. in neurobiology from Wake Forest University and completed his post-doctoral training at the University of North Carolina-Chapel Hill Neuroscience Center last year. His laboratory studies the biochemical mechanisms that direct the formation of the brain and spinal cord. He uses genetic, cellular, and molecular techniques to investigate the function of critical intracellular signal transduction proteins in the developing brain. The neurodevelopmental syndromes, Neurofibromatosis Type 1, Noonan, and CFC-Syndrome, are caused by mutations that alter activity in the ERK/MAPK signaling cascade. Abnormal activation of this protein may also be indirectly involved in a wide range of neurodevelopmental syndromes. Dr. Newbern's laboratory is currently studying how ERK/MAP kinase signaling controls neuronal morphological development and neural circuit formation in the brain and spinal cord. His new laboratory is currently funded by a K99/R00-Transition to Independence Award from NINDS.

Student Abstracts

LEDs Provide a Stable and Kind Environment for Live Cell Imaging

Y. Belyaev[1], B. Neumann[1], K. K. Aswani[2]
[1]Advanced Light Microscopy Facility, European Molecular Biology Laboratory, GERMANY, [2]Lumen Dynamics, Mississauga, CANADA

The use of fluorescence light microscopy for live cell imaging has increased dramatically since the discovery of fluorescent proteins (1). Today, we are able to fluorescently tag most proteins in order to study their localization and dynamic behavior. Despite these developments, long-term live-cell imaging often remains challenging as extensive light exposure can lead to cytotoxic stress and unwanted photo-bleaching (2).

Our microscopy facility conducts high-throughput screening projects that typically run over a 48-hour time span (3). For these projects, it is crucial for the light source to be uniform and stable to ensure that the captured images and derived data are consistent, not only over the field of view,but also between the time points. Electronic shuttering of LEDs means that samples are only exposed to light during acquisition.

Previously, we have used Xenon or Mercury arc lamps on our high-throughput screening systems, with automated time-lapse experiments up to 48 hours. Here we evaluate the feasibility of using an X-Cite 120LED system in our high-content time-lapse studies and report the difference in stability as well as cell proliferation when using both an LED and HBO lamp system.

1. Tsien et al., Annu Rev Biochem. 1998; 67:509-44.
2. Schneckenburger et al., J Microsc. 2012 Mar;245(3):311-8.
3. Neumann et al., Nature. 2010 Apr 1;464(7289):721-7.

Characterization of AlGaN-based GRINSCH Using TEM and Electron Holography

A. Boley[1], H. Sun[2], M.R. McCartney[1], D.J. Smith[1], T.D. Moustakas[2]
[1]Arizona State University, Tempe Az, [2]Boston University, Boston MA

AlGaN alloys have much potential as ultraviolet (UV) optoelectronic devices, including UV semiconductor lasers, since varying the alloy composition results in corresponding band gaps that span the UV wavelength range. Current trends in electrically pumped deep-UV semiconductor lasers reveal the necessity of p-type doping for AlGaN. One promising solution to this as yet unmet need is the graded-index-separate-confinement-heterostructure (GRINSCH), in which the active region of the heterostructure is confined on either side by compositionally graded alloys. The graded layers assure a gradual change in refractive index of the heterostructure and therefore confine the optical power of the device in addition to the mobile carriers. In the current work, a AlxGa1-xN/Al0.72Ga0.28N/AlxGa1-xN GRINSCH grown on a (0001)6H-SiC substrate by molecular beam epitaxy (MBE), as shown in Fig. 1, has been investigated. Device cross-sections were examined by diffraction-contrast and high-resolution phase-contrast TEM using a JEM-4000EX operated at 400keV, and off-axis electron holography was used to study the electrostatic profile across the active device region.

Numerous threading dislocations begin at the SiC/AlN cladding and buffer layer interface. In some areas, the dislocations annihilate in the buffer layer, while in other areas, the dislocations continue through the AlN. Out of these that continue to propagate, a large number are annihilated at the lower AlxGa1-xN/AlN interface. These results suggest that an additional advantage of the graded layers is to accommodate the strain caused by gradually transitioning from the lattice constant of AlN to that of Al0.8Ga0.2N. Phase and approximate thickness profiles reconstructed from an electron hologram were plotted from the surface through the second graded layer to the AlN buffer layer. Since the sample is assumed to be uniformly thick, the "thickness" profile is instead indicative of the mean free path for inelastic scattering and is therefore useful in identifying the different layers. The profile is flat for approximately 75nm, in agreement with the uniform composition of the 75-nm active Al0.72Ga0.28N region. On either side, the profile slopes downwards, again in accordance with the graded layers on either side. The rise of the phase profile in conjunction with the top graded layer is noteworthy, as is the continued increase in phase until approximately the end of the active layer. These results indicate that the conduction and valence band energies may change not only in the active region, but also in the top graded layer. Next steps in this investigation will include verification and quantification of this effect, and comparison with previously calculated theoretical values.

Metal Matrix Hydrophobic Nano-Composites for Sustainable Condensation Rate Enhancement

V. Damle, X. Sun, and **K. Rykaczewski**
Arizona State University, Tempe AZ

Using hydrophobic surfaces in applications such as power plants can be advantageous because of their water shedding property as the enhancement in condensation heat transfer coefficient due to sustained dropwise condensation (DWC) promoted by such surfaces is very well understood. DWC is 5-10 times more efficient than baseline filmwise condensation. Better condensation heat transfer coefficient ultimately results in improved heat exchanger effectiveness i.e. more work output for fixed heat exchanger area or less heat exchanger area required for the constant work output.

However, as the hydrophobic materials are usually thermally insulating, only nano scale hydrophobic coatings (<1 um) aid total heat transfer. Usual operational life of a power plant is about 40 years and long term durability of such nano-coatings has been an issue which limits their deployment in harsh applications. For instance, polymeric coatings degrade rapidly in steam (Rose, 2002) and hydrophobic ceramic films delaminate from metals (Azimi et al, 2013). Therefore instead of hydrophobic coatings, we propose to develop "self-healing" metal matrix hydrophobic nano-composites (MMHNCs). Metal micro-graphite composites can be hydrophobic (Nosonovsky et al, 2013) but fail to promote DWC because of flooding by water nanodrops. Hence, we propose the use of hydrophobic nanoparticles to overcome this problem. To develop MMHNC design guidelines for promoting DWC, we explore relation between surface nanoscale wetting heterogeneities, condensation modes, and composite thermal properties.

PVDF:TiO2 Composite Thin Films for Capacitive Energy Storage

C. Ewen, R. Dillingham, and **T. Stufflebeam**
Northern Arizona University, Flagstaff AZ

Thin films composed of the polymer polyvinylidene fluoride (PVDF) and the ceramic nanoparticle titanium dioxide TiO2 are fabricated via thermal vapor deposition. This combination is ideal since it is light weight and improves the energy density. The elemental composition of the films is determined with energy dispersive x-ray spectroscopy using a scanning electron microscope. Elemental mapping of the films shows that the polymer and nanoparticles are homogeneously distributed. The ideal initial concentrations of PVDF and TiO2 were determined to be 83% and 17% respectively. The final films yield a Ti weight percent of 20, which was found using the Scanning Electron Microscope with Energy Dispersive X-ray Spectroscopy.

Parallel plate capacitors were fabricated by combining thermal vapor deposition and sputter coating.

For the electrodes the parallel plates are gold-palladium (AuPd) with PVDF:TiO2 as the dielectric.

The AuPd electrodes were deposited via sputter coating. Each electrode was sputtered for 100s, which yields a thickness of 33nm. Current research is working to improve the amount of Ti deposited by varying the temperature and deposition time, obtain more accurate thickness measurements, and improve on its electrical properties.

Food grade titanium dioxide disrupts intestinal brush border microvilli in vitro independent of sedimentation

J.J. Faust[1], K. Doudrick[2], Y. Yang[2], P. Westerhoff[2], D.G. Capco[1]
[1]School of Life Sciences, [2]Sustainable Engineering and the Built Environment, Arizona State University, Tempe AZ

Bulk- and nano-scale titanium dioxide (TiO2) has found use in human food products for controlling color, texture and moisture. Once ingested, and because of their small size, nano-scale TiO2 can interact with a number of epithelia that line the human gastrointestinal tract. One such epithelium responsible for nutrient absorption is the small intestine, which contains microvilli to increase the total surface area of the gut. Using a combination of scanning and transmission electron microscopy it was found that food grade TiO2 (E171 food additive coded) included ~25% of the TiO2 as nanoparticles (NPs; < 100 nm), and disrupted the normal organization of the microvilli as a consequence of TiO2 sedimentation. It was found that TiO2 isolated from the candy coating of chewing gum and a commercially available TiO2 food grade additive samples were of the anatase crystal structure. Exposure to food grade TiO2 additives, containing nanoparticles, at the lowest concentration tested within this experimental paradigm to date at 350 ng/mL (i.e., 100ng/cm2 cell surface area) resulted in disruption of the brush border. Through the use of two independent techniques to remove the effects of gravity, and subsequent TiO2 sedimentation, it was found that disruption of the microvilli was independent of sedimentation. These data indicate that food grade TiO2 exposure resulted in the loss of microvilli from the Caco-2BBe1 cell system due to a biological response, and not simply a physical artifact of in vitro exposure.

Hyphal tip ultrastructure and cytoplasmic organization in the Zygomycota

K. Fisher, R. Hamel, D. Lowry, R. Reyes, and **R.W. Roberson**
Arizona State University, School of Life Sciences, Tempe AZ

Despite exhibiting rapid, polarized growth, a Spitzenkörper (Spk) has not been documented in a member of the zygomycetous fungi, with the exception of Basidiobolous sp. Past ultrastructural studies, using chemical fixation, have focused on vesicle organization in the hyphal apex of zygomycetes such Gilbertella persicaria and Mucor rouxii. Although an accumulation of vesicles at the hyphal tip was observed, the complex arrangement of vesicles as documented in the Spk of ascomycetous and basidiomycteous fungi was lacking. We have examined the ultrastructural organization of the hyphal tip and subapical cytoplasm of several members of the zygomycetes, including M. indicus, G. persicaria, Rhizopus oryzae, and Coemansia reversa using cryofixation and freeze-substitution preparation methods, which greatly improved preservation of cellular detail. Using phase-contrast light microscopy of growing hyphae, a phase-dark, highly dynamic vesicle crescent in the hyphal apex was observed. These studies have provided further insight into zygomycetous fungal cell growth and cytoplasmic organization, particularly at the hyphal apex.

Barrett's Esophagus Cells have Reduced Resistance to Bile Salts Relative to Normal or Cancer Cells

V.K. Harris, H.L. Glenn, and **D. R. Meldrum**
Arizona State University, Tempe AZ

Barrett's esophagus arises as the result of gastro-esophageal reflux disease (GERD) and is characterized by intestinal metaplasia of the esophageal epithelium. The condition is of particular significance in that it confers an approximate 30-fold increase in the risk of adenocarcinoma. However, less than 5% of Barrett's cases progress to esophageal cancer, and there is no reliable signature to identify which patients are likely to develop malignancy. Though it has long been supposed that the primary damaging aspect of GERD was exposure of the esophagus to low pH, recent evidence suggests that bile, a common component of refluxate, may also contribute to cancer progression. We observed that an esophageal adenocarcinoma-derived cell line, Flo-1, was more resistant to extraction by synthetic detergent than a normal squamous epithelial cell line, EPC2. Our objective was to test the hypothesis that there is a correlation between progression toward carcinoma and resistance to bile salts which are naturally occurring detergents. We expected that Barrett's cells would be more resistant to membrane damage than normal cells and that the cancer cells would be most resistant. We used uptake of DAPI as an indicator of minor or transient membrane disruption in the presence of mixed bile salts. Live cells were imaged by brightfield and fluorescence microscopy. Images were then processed and DAPI positive cells were counted using automated image segmentation algorithms. As expected, we found that adenocarcinoma-derived cells were more resistant to bile damage than normal esophageal epithelial cells. Surprisingly, we also found that both non-dysplastic and dysplastic Barrett's cells were more susceptible to bile than either normal or cancer cells. This result may be explained by the low expression of mucin which has been reported in Barrett's cells. We speculate that increased sensitivity to chemical damage by bile exposure may be a contributing factor in the progression of Barrett's esophagus to adenocarcinoma.

A Histological Analysis of Cell Proliferation Patterns in the Regenerating Tail of the Lizard, Anolis carolinensis

E. Hutchins, M. Tokuyama, J. King, L. Geiger, J.W.Wilson-Rawls, K. Kusumi
School of Life Sciences, Arizona State University, Tempe AZ

While a number of vertebrates, including fishes, salamanders, frogs, and lizards, display regenerative capacity, the process is not necessarily the same. It has been proposed that regeneration, while evolutionarily conserved, has diverged during evolution. However, the extent to which the mechanisms of regeneration have changed between taxa still remains elusive. In the salamander limb, cells dedifferentiate to a more plastic state and aggregate in the distal portion of the appendage to form a blastema, which is responsible for outgrowth and tissue development. In contrast, no such mechanism has been identified in lizards, and it is unclear to what extent evolutionary divergence between amniotes and anamnitotes has altered this mechanism. Anolis carolinensis lizards are capable of regenerating their tails after stress-induced autotomy or self-amputation. In this investigation, the distribution of proliferating cells in early A. carolinensis tail regeneration was visualized by immunohistochemistry to examine the location and quantity of proliferating cells. An aggregate of proliferating cells at the distal region of the regenerate is considered indicative of blastema formation. Proliferating cell nuclear antigen (PCNA) and minichromosome maintenance complex component 2 (MCM2) were utilized as proliferation markers. Positive cells were counted for each tail ($n=9$, $n=8$ respectively). The percent of proliferating cells at the tip and base of the regenerating tail were compared with a one-way ANOVA statistical test. Both markers showed no significant difference ($P=0.585$, $P=0.603$ respectively) indicating absence of a blastema-like structure. These results suggest an alternative mechanism of regeneration in lizards and potentially other amniotes.

Apis mellifera Octopamine Receptor1 (AmOA1) receptor expression in the antennal lobe of 6th day old larva and newly emerge honey bee

C.M. Jernigan, O. Kaftanoglu, I. Sinakevitch, B.H. Smith
School of Life Sciences, Arizona State University, Tempe AZ

During appetitive olfactory learning, the biogenic amine, octopamine (OA) has been shown to be released from the ventral-unpaired median (VUM) neurons in olfactory learning and memory centers of the honey bee. OA acts via different types of G-protein coupled receptors. In the honey bee only the AmOA1 octopamine receptor has been characterized. AmOA1 is primarily expressed in the inhibitory neurons of the antennal lobe network, the primary olfactory center, and its activation has been shown to increase intracellular Ca2+ concentrations. However, these studies were done in adult honey bee foragers of varying ages and show high variability in AmOA1 expression patterns in the antennal lobe. Here we use a immunostaining technique with anti-AmOA1 and anti-synapsin antibodies to characterize the expression of this receptor in the brains of larvae and newly emerged adult honey bees. We show that already at the larval stage, ALs have a microglomerular neuropil, which stains for the AmOA1 receptor. Additionally, compared with the older foraging honey bees, newly emerged honey bees show a lower and more homogeneous expression of AmOA1 in the glomeruli of the antennal lobe.

Development of Stable PtZnZnO Catalyst by Epitaxial Growth

J. X. Liu[1], Y. A. Song[1], B. T. Qiao[1], Y. D. Huang[2], J. Y. Liu[1]
[1]Arizona State University, Tempe AZ, [2]Harbin Institute of Technology

Oxides supported metal catalysts are widely used in industrial processes due to their high activity and/or selectivity. The metal particles usually have sizes ranging 1~20 nm to enhance the atomic efficiency. However, when such small metal particles are subjected to chemical reactions at elevated temperatures they may sinter to larger particles, resulting in drop of activity. Therefore, development of thermodynamically stable supported metal/alloy catalysts is highly desirable for practical applications [1]. The stability of oxide-supported catalysts strongly depends on the interaction between the dispersed metal particles and the supports [2]. Epitaxial growth of metal or alloy nanoparticles on metal oxide supports can significantly enhance their interfacial interactions, resulting in strong anchoring of the metal/alloy nanoparticles [3]. In this research, we selected highly stable ZnO nanowires, primarily enclosed by the low-energy {1 0 -1 0} surfaces. The use of such well-controlled single crystal ZnO nanowires has advantages such as homogenous surface structure (compared to powders) and large surface area (compared to large single crystals). We report here our recent progress in synthesizing, characterizing and testing a catalyst primarily consisting of Pt-Zn alloy nanoparticles epitaxially grown on the {1 0 -1 0} surfaces of the ZnO nanowires.

ZnO nanowires were fabricated by a thermal evaporation-condensation method in a high temperature tube furnace. The Pt-Zn/ZnO nanocatalysts were prepared by a deposition-precipitation method. ZnO nanowires were dispersed into deionized water and the suspension was under constant stirring. Then H2PtCl6•6H2O solution was added stepwise to the suspension, during which the pH value of the mixture was maintained at a fixed value by adding appropriate amounts of Na2CO3 solution. After filtration and being washed with deionized water, the resultant solid was dried at 333 K overnight and calcined at 673 K for 4 h in air. Prior to catalytic reaction, the catalysts were reduced at 923K for 2 h in 10% H2/He. The JEOL JEM-ARM200F aberration-corrected scanning transmission electron microscope (STEM), with a nominal image resolution of 0.08 nm in the high-angle annular dark-field (HAADF) imaging mode, was used to investigate the structure of the Pt-Zn/ZnO catalysts.

1. JA. Enterkin et al, Nano Letters 11(2011) p. 993.
2. J Liu, ChemCatChem 3 (2011) p. 934.
3. Z. Chen et al, Physical Review B 68 (2003) p. 075417.
4. This research was funded by Arizona State University. We gratefully acknowledge the use of facilities within the LeRoy Eyring Center for Solid State Science at Arizona State University.

Organic semiconductors for rapid electrochemical measurement of neurotransmission

A.R. Meier, R.F. Vreeland, and **M. L. Heien**
University of Arizona, Tucson AZ

The ability to make rapid electrochemical measurements of neurotransmission from living cells is desirable for the monitoring the changes in concentrations of neurotransmitters in real time. In this work, chemical vapor deposition (a rapid approach to producing high purity semiconductors) is used to synthesize thin film polymer electrodes composed of poly(3,4-ethylenedioxythiophene):tosylate (PEDOT:tosylate). This reaction proceeds via the acid catalyzed radical polymerization of 3,4-ethylenedioxythiophene using ironIII tosylate as the radical initiator and pyridine as a weak base to control the reaction rate. Similar films have been synthesized previously but high capacitances have results in large time constants which limits rapid electrochemical measurements. By varying the ratios of these precursors as well as the reaction temperature it is possible to control the thickness of the deposited polymer film. A low-pressure microwave-generated plasma was used to dry etch the films forming patterned electrodes with micrometer scale features. Thickness of the polymer layer and the dimensions of the etched features were characterized using atomic force microscopy. The resulting PEDOT:-tosylate electrodes were electrochemically characterized using steady-state cyclic voltammetry and were found to have capacitances lower than 250 μF/cm2. The utility of conductive polymer electrodes with low capacitance is demonstrated by performing fast-scan cyclic voltammetry of redox active neurotransmitters from released from PC-12 cells.

In Situ Nanoscale Observation of Photocatalysts under Visible and UV Irradiation

B.K. Miller and **P. A. Crozier**
School of Engineering of Mater, Transport and Energy, Arizona State University, Tempe AZ

Inorganic photocatalysts are currently being intensely studied for their potential use for the production of fuels from H2O and CO2. Designing new efficient photocatalysts requires an increased understanding of the link between catalyst microstructure and activity. Transmission electron microscopy (TEM) is a well-established and powerful technique for studying the structure of materials at the nanoscale. Environmental TEM (ETEM) is sometimes used to more closely mimic the conditions experienced by a material in use. However, while gaseous environments and variable temperatures are common to ETEM work, illumination of the sample by visible, ultraviolet, and infrared light is much less common. We have installed a variable wavelength light source to irradiate the sample area of an ETEM column. The current design consists of a broadband light source with filters, optical fibers with a vacuum feed through, and a manipulator to precisely position the fiber tip with respect to the TEM sample in the microscope. We are using this new capability to study the structure of titania-based nanostructured catalysts, such as nanowires and high surface area powders.

Investigation of Carbon Deposition on Ni/Gd Doped Ceria Reforming Catalysts for Solid Oxide Fuel Cells

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Intermediate temperature solid oxide fuel cells (IT-SOFC) are promising electrochemical conversion devices that produce electricity by oxidizing chemical fuels. One of the most attractive advantages of IT-SOFCs is that, in principle, various types of fuels (hydrogen, hydrocarbons…) can be utilized. This can be achieved by introducing an internal reforming layer on the anode side of the fuel cell. Our research focusses on Ni/Gd co-doped ceria anode material in which Ni serves as both the electron collector and the reforming catalyst. However, when carbonaceous fuels are employed, under certain conditions carbon can deposit onto Ni surfaces which can significantly degrade or even destroy the anode. While Ni catalyzes carbon growth, ceria is known to be an oxidation catalyst and thus suitably structured combinations of ceria and Ni may result in suppressed carbon formation. To explore this hypothesis it is necessary to conduct a fundamental investigation of the carbon deposition mechanism on Ni/Gd co-doped ceria catalyst. In our study, we synthesized the reforming nanopowders consisting of 20 at% Ni, 15 at% Gd doped ceria using a spray drying technique. The powders were then calcined at 500oC and 700oC for 4 hours to form fresh reforming catalyst. Catalytic reforming characterization was investigated for partial oxidation of methane (POM) by heating the fresh catalyst in flowing methane and oxygen gases in an ISRI RIG-150 microreactor and the exit gases were analyzed using a gas chromatography (Varian GC-450). Then the oxygen flow was reduced to deliberately deposit carbon onto the catalyst as a result of the methane decomposition reaction. A JEOL 2010 F was employed to obtain high resolution images and energy dispersive x-ray spectroscopy (EDS) of both the fresh and carbon deposited catalyst to determine the structure and composition of the material and the form and location of the carbon layer.

Microscopic Examination of Potential Fungal Endoparasitization by Legionella

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Legionella are a relevant example of a bacterial human pathogen with the capability to invade and replicate within eukaryotic host organisms. Though it is typically assumed that amoebae serve as the primary hosts of Legionella in the environment, they have been show to parasitize a number of non-amoeba protozoans, algae, and animals. Despite a well-documented broad host range, limited research has been conducted on the interactions between Legionella and fungi, a knowledge gap this research aims to address. Light and electron microscopy was performed on co-cultures of Legionella and a fungus isolated from compost with cultures of the organisms separated serving as controls. Low magnification phase contrast microscopy revealed significant increases in motility and distinct cell morphotype variation amongst Legionella cultured alongside the fungus, possibly indicative of increased metabolic activity and reproduction. In addition, hyphae growth was less pronounced, accumulation of fungal cell debris was greater, and septae formation occurred more frequently in the typically coenocytic fungus in the presence of Legionella. Bright field examination at 1000X magnification revealed hyphae containing highly motile Legionella-sized particles after 7 days of co-culturing with, but not in the absence of Legionella. Transmission electron microscopy of the mixed culture revealed membrane bound objects similar in size and shape to fungal mitochondria, but with differing density and internal organization, within fungal cells. Examples of fungal filaments lacking cytoplasm, but containing high concentrations of bacteria with morphologies and structure similar to Legionella, were also observed. The results from this study serve as evidence suggesting the possibility for fungus to serve as a novel form of host organism for Legionella.

Identifying the Role of the Dpp pathway within the TGF-β signaling subfamily in Drosophila melongaster

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Genetically controlled cellular pathways dictate events that occur during the development of an embryo and the development of a cancerous cell. The Dpp pathway in the TGF-β signaling subfamily in Drosophila melongaster is a homologue of the Bone Morphogenic Protein pathway in humans. In an assay to detect new proteins associated with the Dpp pathway, the gene longitudinals lacking-like (lolal) was isolated. Our analysis has included the use of 4 four lolal mutations where complementation crosses result in various phenotypes. We have also over expressed both lolal and mutant forms of other known proteins in the dpp pathway to determine the point where lolal interacts with the Dpp pathway. Some of these proteins, such as Mad and Medea have homologues called Smad 2/3 and Smad 4 in humans. Through analysis of embryonic structures and adult genotype frequencies, we can more accurately understand how these genes affect cellular events that play out in development, patterning, and growth.

Rotational live single cell imaging in a hydrodynamic microvortex chip

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Volumetric cell imaging using 3D optical Computed Tomography (cell CT) is advantageous for identification and characterization of cancer cells. Many diseases arise from genomic changes, some of which are manifest at the cellular level in cytostructural and protein expression (functional) features which can be resolved, captured and quantified in 3D far more sensitively and specifically than in traditional 2D microscopy. Single cell analysis (SCA) has been gaining wide recognition and popularity in the last few years and has become a key technology in our efforts to better understand cellular functions.

While both live and fixed cell imaging can elucidate cell biological information, the former is quite attractive since it facilitates the capture of dynamic and transient events like apoptosis in a single cell. Deregulated apoptosis has been implicated in diverse pathologies including cancer and certain neurodegenerative diseases. Some of these apoptotic events include mitochondrial outer membrane permeabilization (MOMP), mitochondrial dysfunction, phosphatidylserine exposure, and membrane permeabilization. The defining morphological characteristics of apoptosis include cell shrinkage, nuclear fragmentation, chromatin condensation and membrane blebbing. A popular approach has therefore been miniaturization of established engineering and cell biological practices and concepts so as to match the dimensions of single cells to enable their interrogation as individuals. Over the years a number of methods have been developed to conduct invasive (chemical) and non-invasive (biological) SCA using innovative microfluidic concepts. A live-cell microtomograph would facilitate dynamic interrogation of protein-protein interactions and a powerful array of other cell biological studies. Imaging live, single cells while rotating them in a compatible media can be a powerful tool for obtaining information about important events in cancer metabolism and protein-protein relationships and protein-nucleic acid interactions.

The method presented here has been used to rotate cells about a stable rotation axis perpendicular to the visualization (optical) axis. The cell is first optically trapped and then rotated in the center of a re-circulant flow stream in a microfluidic chip- dubbed a 'microvortex'. The goal of this research is to study changes in cell morphology and function over a time period of a few minutes to a few hours. Bright-field and fluorescence data from live, single K-562 cells have been analyzed to estimate rotation rate of cells under different conditions of flow rate and laser trapping intensity. In addition, rotation analysis has also been performed. Batches of these cells were also fixed, stained with various dyes, and used as controls. They were imaged on a standard inverted confocal microscope.

Bioinspired Frost-Responsive Antifreeze Secreting Pagophobic Coatings

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Ice and frost pose a major efficiency and safety concern for ships and aircraft. For example, ice accumulation can reduce airplane drag and cause slippery surfaces, loss of communication, firefighting and rescue capabilities. Currently used chemical, thermal, and mechanical techniques of ice removal are time-consuming and costly. Numerous animals secrete functional liquids through their skin. Inspired by this idea we propose bi-layer superhydrophobic-superhydrophilic antifreeze infused coatings: outer SHS layer repels impinging droplets preventing rime, glaze, and sea-spray ice. When frosted over, outer layer becomes hydrophilic triggering antifreeze secretion. Antifreeze release leads to melting of frost and its removal from surface, restoring the superhydrophobic functionality of the outer layer.

Thin Composite Films for Selective in vivo Neurotransmitter Measurements

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Nafion has been dip-coated onto electrodes to enhance selectivity of carbon-fiber microelectrodes to dopamine, while decreasing the sensitivity to interferents and preventing biofouling. Because Nafion is a fluoropolymer like PTFE, it does not adhere well to carbon fiber surfaces. A Nafion and poly(3,4-ethylenedioxythiophene) composite polymer has been synthesized on the cylindrical electrode with the goal of increasing the selectivity and sensitivity of electrochemical dopamine measurement in vivo. Unlike dip-coated Nafion, PEDOT:Nafion coatings are mechanically robust, and can be applied in a controllable and uniform manner. Carbon-fiber microelectrodes have been coated with PEDOT:Nafion via electropolymerization in a fast and facile process, requiring a potentiostat capable of slow-scan voltammetry. Electropolymerization allows any geometry to be coated, and the mechanism of the polymerization is described. PEDOT:Nafion coated electrodes are employed in cyclic voltammetric measurements of dopamine and other transmitter molecules. The sensitivity and selectivity of the coated electrodes are characterized and compared to bare carbon fibers. Electrodes are coated with a minimally thin film of approximately 100 nm to reduce unwanted diffusive impedence of the analyte to the electrode. Furthermore, PEDOT:Nafion electrodes have been extensively characterized by scanning electron microscopy, energy-dispersive x-ray spectroscopy, and electrochemistry. These coatings are shown to contain sulfur and fluorine, and enhance the sensitivity and selectivity of cation measurement, while reducing the signal from anions.

Influence of Bismuth additive on the growth of ZnO nanostructures

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Semiconducting ZnO nanostructures have broad tech nological applications in optoelectronics, photovoltaics, energy harvesting and storage, sensing and catalysis. Among many available techniques to fabricate ZnO nanostructures, the vapor phase transport method has its advantages such as generation of high-purity materials, no use of aqueous chemicals, and the modular addition of various materials to form compound nanostructures. We report here our recent investigation of the effect of Bi additive on the nucleation and growth of ZnO nanostructures. The Bi2O3/ZnO nanostructures were synthesized in a high temperature tube furnace by a standard vapor phase transport process. The products were characterized by a FEI XL -30 scanning electron microscope(SEM) for observation of the general morphology of the different Bi2O3/ZnO structures. The JEOL JEM-ARM200F aberration-corrected scanning transmission electron microscope (STEM), with a nominal image resolution of 0.08 nm in the high-angle annular dark-field (HAADF) imaging mode, was used to investigate the atomic structure of the Bi2O3/ZnO structures.

Label-free three-dimensional tracking of single organelle transportation in cells with nanometer precision using a plasmonic imaging technique

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The dynamics of organelles in cells are responsible for various cellular functions. To image and track the dynamic processes, a technique with both high spatial and temporal resolutions is required. To ensure that the observed dynamics is relevant to the native functions, it is also critical to keep the cells under their native states. Here, we demonstrate a plasmonic-based imaging technique for studying the dynamics of organelles in all three dimensions (3D) with high spatial (5 nm) and temporal (10 ms) resolutions. The technique is label-free and can track subcellular structures in the native state of the cells. Using the technique, we have successfully observed stepwise transport of organelles (e.g., mitochondria) along neurite microtubules in primary neurons, and reconstructed the 3D structure of neurite microtubule bundles from the tracks of the moving organelles.

Adsorption of Sb on the {10 -10} Facets of ZnO Nanowires

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Zinc oxide nanomaterials with a wurtzite structure are used for various applications including catalysis. ZnO nanowires are of interest due to its high surface-to-volume ratio. Uniform antimony coating onto the surfaces of ZnO nanowires may provide new functions for applications in sensing, catalysis, energy conversion or nanoelectronics. We report here our recent study of the adsorption of Sb onto the {10-10} facets of ZnO nanowires.

Microbial Biosignature Preservation in Crystal Geyser, Utah

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The rapid mineralization of carbonates from Crystal Geyser promotes the capture and preservation of cellular and extracellular remains of microbial communities living within the spring environment. Petrographic thin sections cut from teracettes show complex laminar structures reminiscent of larger stromatolite formations found throughout the fossil record. X-ray Powder Diffraction (XRPD) and petrographic studies reveal major mineral phases of aragonite, calcium carbonate, and possible silica polymorphs. Microscopic photography shows some evidence of fossilized cells and extracellular fabric.

Atomic Level In Situ Observation of Surface Amorphization in Anatase Photocatalyst During Light Irradiation in Water Vapor

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Photocatalysts are important for environmental cleanup of undesirable organic compounds and have potential applications for solar fuel generation either through water splitting or CO2 reduction. TiO2 is a promising photocatalytic material for water splitting partly because it is earth abundant and very stable under reaction conditions [1]. It is now recognized that atomic level in situ observations of catalytic nanomaterials are critical for understanding structure-reactivity relations because the active form of the material may exist only under reaction conditions. For photocatalysts, this requires that the nanomaterial be observed not only in the presence of reactant and product species but also during in situ light illumination. Here we report an in situ study of the surface for anatase nanoparticles under reaction conditions for vapor phase water splitting [2]. An in situ atomic level investigation of the surface structure of anatase nanocrystals has been conducted under conditions relevant to gas phase photocatalytic splitting of water with an illumination intensity of approximately 10 suns. In situ observations were carried out using a Tecnai F20

(FEI) environmental electron transmission microscope (ETEM) equipped with a differentially pumped environmental cell operated at 200KV. The ETEM was modified so that samples could be illuminated with UV and visible light from a bright, broadband source, via an optical fiber [3].

Different experiments were conducted in which the electron dose, reactive gas and light flux were varied to ensure changes of materials were not mistakenly attributed to photon irradiation. Pure crystallized and shape controlled anatase particles were transformed from Evonik P25 particles (80% anatase and 20% rutile) using a hydrothermal method [4]. To facilitate the TEM analysis, anatase powders were dispersed onto Stober silica spheres and the spheres then dispersed over Pt grids using a drop casting method. The Pt grid was loaded into a Gatan hot stage and the in-situ TEM characterizations were performed at a temperature of 150°C to simulate the conditions for vapor phase water splitting. A typical set of images before and after exposure to light and water is shown in Figure 1. The initial particle shown in Figure 1a appears crystalline on the surface and the surface is smooth and atomically abrupt. Figure 1b shows a crystal after 40 hrs exposure to water and light without prior exposure to the electron beam. When the titania is exposed to light and water vapor, the initially crystalline surface converts to an amorphous phase one to two monolayers thick. The amorphous layer is stable and does not increase in thickness with time. This disorder layer will be present on the anatase surface under reaction conditions relevant to photocatalytic splitting of water. Control experiments were done to ensure that the amophization is attributed to light and water. Figure 2 shows smooth and ordered surfaces after 40 hrs in H2 gas with 20 hrs light exposure. This proves the amorphization only happens in the presence of water and light. The amorphous surface monolayer should be hydroxylated TiO2 containing titanium in a +3 oxidation state which has been detected by electron energy loss spectrum (EELS) and x-ray photoelectron spectroscopy (XPS) as shown in Figure 3. The energy doses of electron beam and light were calculated to be comparable. Energy transferred by elastic scattering and also inelastic scattering were calculated and possible damage processes will be discussed. Further characterization of modified TiO2 materials like noble metal loaded and semiconductor sensitized TiO2 photocatalyst under light exposure will also be discussed.[5]

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