# UAHuntsville 2012 Materials Science Faculty Research Symposium

The University of Alabama in Huntsville

301 Sparkman Drive, Huntsville, AL 35899

Engineering Building, EB 122 DECEMBER 5, 2012

**2012 Materials Science Faculty Research Symposium**

## List of Participants

1. James Kern Baird, CHM
2. R. Michael Banish, CME
3. Ramon L Cerro, CME
4. Krishnan Chittur, CME
5. Jeff Evans, MAE
6. John A. Gilbert, MAE
7. Mark W Lin, MAE
8. George Nelson, MAE
9. Seyed M Sadeghi, PH
10. Carmen Scholz, CHM
11. Houssam Toutanji, CEE
12. Emanuel Waddell, CHM
13. Jeffrey J Weimer, CHM, CHE
14. Ken Zuo, MAE

# Presentation Schedule

| | | |
|---|---|---|
| 10:00 – 10:15 | **WELCOME** | *Shankar Mahalingam* |
| 10:15 – 10:30 | Manufacturing of metamaterials | *Ramon L Cerro* |
| 10:30 – 10:45 | Using Molecular Engineered Surfaces for Biosensing | *Krishnan Chittur* |
| 10:45 – 11:00 | Grain Boundary Character and Creep-Fatigue Crack Tip Kinetics | *Jeff Evans* |
| 11:00 – 11:15 | **BREAK** | |
| 11:15 – 11:30 | Strategically Tuned Absolutely Resilient Structures (STARS) | *John A Gilbert* |
| 11:30 – 11:45 | Smart Materials Research at UAHuntsville | *Mark W Lin* |
| 11:45 – 12:00 | FRP Composites Solutions for Civil Infrastructure | *Houssam Toutanji* |
| Noon - 1:00 | **LUNCH** | |
| 1:00 – 1:15 | Block Copolymers: Materials with a Split Personality | *Carmen Scholz* |
| 1:15 – 1:30 | Modification of Polymer Substrates with Deep UV Radiation | *Emanuel Waddell* |
| 1:30 – 1:45 | Computational Modeling of Brittle Materials under Dynamic Conditions | *Ken Zuo* |
| 1:45 – 2:00 | Heterogeneous Chemical Equilibria Near the Critical Point of Solution | *James K Baird* |
| 2:00 – 2:15 | **BREAK** | |

# Presentation Schedule (Continued)

| | | |
|---|---|---|
| 2:15 – 2:30 | Thermophysical Property Measurements and their Application to Materials Processing | *R. Michael Banish* |
| 2:30 – 2:45 | Materials and Surface Characterization Facilities at UAHuntsville | *Jeffrey J Weimer* |
| 2:45 – 3:00 | Material research activities at nanophotonic group in the physics department | *Seyed M Sadeghi* |
| 3:00 – 3:15 | 3D Imaging of Microstructural Evolution in Solid Oxide Fuel Cell Anodes | *George Nelson* |
| 3:15 | **DISCUSSION AND ADJOURN** | *Shankar Mahalingam* |

# Manufacturing of Metamaterials

**Presentation by:** Professor Ramon L Cerro

**Department:** Chemical & Materials Engineering **E-mail:** cerror@uah.edu

**Abstract**

Metamaterials have been a source of great excitement among researchers, because they display properties that were only theoretically proposed and never demonstrated in nature. These unusual and valuable non-conventional properties arise from the molecular-level structure of the material rather than their composition. Manufacturing of metamaterials demands unique levels of operational and quality control. Langmuir-Blodgett films display an impressive range of functional properties and conform one of the most exciting areas of research in the development of optical and magnetic metamaterials. However, a major obstacles in using the LB technique to create metamaterials for certain applications is the presence of the organic layers of amphiphilic molecules.

The main objective of this research is to develop a technique and theoretical understanding of how the organic layers product of LB deposition, can be removed without disturbing the metal components in order to create very thin metallic crystals with a prescribed structure. This objective will be achieved through the following steps: (1) understanding, through experiments and theory, of the processes needed to develop structural order in Langmuir films at the air/water interface, (2) precise control of the transfer of these structures onto solid substrata using the Langmuir-Blodgett technique, and (3) selective removal of the intermediate organic layers to manufacture metamaterials with prescribed molecular-level structure.

The results of this research, linking molecular-level structure with optical and magnetic macroscopic effects, will impact our understanding of a broad area of physicochemical hydrodynamics and affect two concurrent branches of knowledge: the physical chemistry of Langmuir and Langmuir-Blodgett films and the development of metamaterials.

**Biography**

Professional Preparation:

B.S., Chemical Engineering, Univ. del Litoral, Santa Fe, Argentina M.S., Chemical Engineering, Univ. of California at Davis (J. M. Smith) Ph.D., Chemical Engineering, Univ. of California at Davis (Stephen Whitaker)

Appointments:

Correspondent Member, National Academy of Engineering of Argentina, 1985- Professor, Chemical & Materials Eng. Univ. of Alabama in Hunstville, 1997-2009 Professor, Chemical Engineering, The University of Tulsa, 1987-1997 Principal Research Fellow, National Research Council of Argentina, 1977-1987 Chair Professor, Univ. of Litoral, Santa Fe, Argentina, 1985-1987 Professor, Univ. of Litoral, Santa

Fe, Argentina, 1972-1985 Post Doctoral Fellow and Acting Assistant Professor, Chemical Engineering and Materials Science, University of Minnesota, 1970-1972 Awards and Honors:

**Biography (continued) -** Professor Ramon L Cerro

Correspondent Member, National Academy of Engineering of Argentina, 1985 Correspondent Research Fellow, National Research Council of Argentina, 1988.

Fellow of the American Institute of Chemical Engineers, 1998.

Tallmadge Award, International Society of Coating Science and Technology, 2010

**References**

Patricia Pedraz, Francisco J. Montes, Ramon L. Cerro and M. Elena Diaz, Characterization of Langmuir biofilms built by the biospecific interaction of arachidic acid with bovine serum albumin,Thin Solid Films 10.1016/*j.tsf*2012.10.055 (2012).

Khalid Tantawi, Ramon Cerro, Bakhrom Berdiev, M. Elena Diaz, Francisco Javier Montez, and John D Williams, Investigation of Transmembrane Protein in Lipid Bilayer Membrane Supported on Porous Silicon*, J. of Medical Engineering Technology* (2012)

# Using Molecular Engineered Surfaces for Biosensing

**Presentation by:** Professor Krishnan Chittur

**Department:** Chemical Engineering **E-mail:** chitturk@uah.edu

**Abstract**

Progress in the design of surfaces through chemistry are allowing engineers a very high degree of precision in many areas of design. Many of the medical devices and measurement instrumentation that we take for granted are the result of the convergence of developments in both chemistry and the biological sciences. We have developed a novel method to detect small quantities of nucleic acids from disease causing bacteria, viruses and fungi. I will describe how our efforts in developing a useful medical diagnostic tool is being made possible in part by the availability of engineered surfaces.

**Biography**

Professor Chittur's degrees are all in Chemical Engineering - a PhD from Rice University and a B.Tech from IIT-Bombay. His current research interests are in developing biological/medical sensors that leverage an understanding of methods in molecular biology with materials science. On the teaching front, he remains active in developing and contributing to open source software for students in engineering and science.

**References**

http://dx.doi.org/10.1016/j.ab.2012.07.021 (Dendron-modified surfaces provide an ideal environment for stem–loop DNA probes)

# Grain Boundary Character and Creep-Fatigue Crack Tip Kinetics

**Presentation by:** Dr. Jeff Evans

**Department:** Mechanical & Aerospace Engineering **E-mail:** jeff.evans@uah.edu

**Abstract**

The need for increased thermal efficiency, which provides a reduction in energy consumption, is driving the use of materials with higher temperature capabilities for a variety of applications such as land-based power systems and aircraft engines. These materials are subjected to environmental and thermomechanical extremes for sustained periods during normal operation. The conditions are in a range where several time-dependent damage mechanisms, such as creep deformation, oxygen diffusion, and crack tip oxidation, can operate during cyclic loading and during the dwell period. Therefore, the fundamental mechanisms governing the time-dependent damage and degradation must be well understood. During elevated temperature creep-fatigue loading, polycrystalline Ni-base superalloys have exhibited intergranular failure due to oxygen embrittlement . Grain boundary character distributions have been controlled in an attempt to combat these effects by engineering a more embr! ittlement resistant grain boundary. However, only limited results have been disseminated which characterize this effect on mechanical behavior of nickel or nickel alloys, and no studies have explored the direct influence the grain boundary character has on the kinetics of these time-dependent processes. This presentation will provide an overview of creep-fatigue crack tip kinetics and the influence of grain boundary engineering.

**Biography**

Dr. Jeff Evans is currently an assistant professor at the University of Alabama in Huntsville in the Department of Mechanical and Aerospace Engineering. His previous experience includes positions with the GE Global Research Center, Kennametal, and The Engineering Institute. He earned his B.S. in Metallurgical Engineering from the University of Missouri-Rolla in 1998 and his M.S. and Ph.D both from the University of Arkansas in 2004 and 2008, respectively. Dr. Evans is an active member of the High Temperature Alloys Committee of the The Minerals Metals and Materials Society (TMS) and the ASTM Committee on Fatigue and Fracture. During the summer of 2010 Dr. Evans held a guest scientist position at the Federal Institute for Materials Research and Testing (BAM) in Berlin, Germany. Also in 2010 he received the Keith J. Miller Young Investigator Award from the ASTM Committee on Fatigue and Fracture. Dr. Evans is a licensed professional engineer (P.E.) in the state of Arkansas. His experience and interest is in understanding the failure of materials through investigating the mechanisms of fatigue, fracture, and corrosion, and was recently selected to further these studies through a National Science Foundation Faculty Early Career Development (CAREER) Award.

**References -** Dr. Jeff Evans

Evans, J.L., "Method for Comparing the Crack Tip Kinetics During Creep-Fatigue Loading of Nickel-Base Superalloys," *Materials Science and Engineering A*, Volume **528**, Issue 15, June 2011, pp. 5306–5308.

Findley, K.O., Evans, J.L., and Saxena, A., "A Critical Assessment of Fatigue Crack Nucleation and Growth Models for Ni- and Ni,Fe-Base Superalloys" *International Materials Reviews*, Volume **25**, Number 1, January 2011, pp. 49-71.

# Strategically Tuned Absolutely Resilient Structures (STARS)

**Presentation by:** Professor John A. Gilbert

**Department:** Mechanical Engineering **E-mail:** jag@eng.uag.edu

**Abstract**

Today's common advanced composite materials are made of continuous fibers (graphite, glass, or Kevlar®) suspended in a polymeric matrix, typically an epoxy of some type. The technology underlying these materials has been developed over the past seventy years and the materials have been widely used for applications in civil and aerospace engineering primarily due to their high strength-to-weight and/or stiffness-to-weight ratio. While advances in such composite materials have been steady, there have been relatively few revolutionary changes of late. But the investigation and development of a new breed of high performance composites with matrices based on a unique hybrid blend of inorganic and organic components has the potential to revolutionize structural design through the development of Strategically Tuned Absolutely Resilient Structures (STARS).

The STARS concept makes it possible to build a structure capable of storing potential energy in the form of elastic deformation that can be released in a controlled fashion in the form of work or kinetic energy. The composite section must be designed based on the strength, stiffness, and the position of the component materials. The ability to store and release energy depends upon a complex interaction between the shape, modal response, and the forcing function initiated to the structure. Since the method relies on energy recovery through elastic deformation, steps must be taken to prevent damage so that the structure is absolutely resilient.

Although the designs associated with this relatively new technology are based on the strength and position of the materials in the composite section, the overall design strategy relies mainly on the large difference in stiffness between the constituents in the composite section to drive the internal stress from the matrix to the reinforcement. The greater stiffness ratios associated with polymer-enhanced structures offer design engineers more flexibility than ever.

**Biography**

John A. Gilbert received his doctoral degree from the Illinois Institute of Technology in 1975. He has been a professor at UAH since 1985 where he specializes in experimental stress analysis and applied optics. He also holds adjunct faculty appointments in the Civil and Environmental Engineering Department at UAH and in materials science at the other two University of Alabama campuses located in Birmingham and Tuscaloosa.

While at UAH, John received the Alumni Association's Distinguished Faculty Award, the Foundation's Distinguished Teaching Award, and the College of Engineering's Outstanding Faculty Member Award.

**Biography (continued)** - Professor John A. Gilbert

He received the Engineer of The Year Award from the American Society of Civil Engineers and has been recognized for his long term dedication by both the ASCE Committee on Student Activities and ASCE national president for serving as a co-faculty advisor to the UAH ASCE Student Chapter for the past 27 years.

John is a fellow of the Society for Experimental Mechanics. He is listed in Who's Who in the World, was twice designated as an International Man of the Year by the International Biographical Centre, and declared Man of the Year by the American Biographical Institute.

**References**

Biszick, K.R., Gilbert, J.A., Toutanji, H., Britz, M.T., “Doubly reinforcing cementitious beams with instrumented hollow carbon fiber tendons,” accepted for publication in *Experimental Mechanics*, ISSN 0014-4851, doi: 10.1007/s11340-012-9665-6, 2012.

Alldredge, D., Gilbert, J., Toutanji, H., Lavin, T, Balasubramanyam, M., “Uplift capacity of polyurea-coated light-frame rafter to top plate connections,” *Journal of Materials in Civil Engineering*, doi: 10.1061/(ASCE)MT.1943-5533.0000492, 24(9): 1201-121

# Smart Materials Research at UAHuntsville

**Presentation by:** Dr. Mark W Lin

**Department:** Mechanical & Aerospace Engineering **E-mail:** linm@uah.edu

**Abstract**

Smart materials and structures are an emerging technology aiming to develop engineering structures that can rearrange themselves to achieve their most optimum functional capabilities. Such structures can respond favorably to external stimuli using integrated sensor, actuator, and controller elements. For the past two decades, several engineering applications implementing the smart materials concept have demonstrated many prominent functional capabilities that the integrated elements can achieve. Successful examples include structural vibration and acoustic control, structural health monitoring and damage control, structural shape and motion control, etc. Research activities in the field of smart materials at UAHuntsville, which include developments of a distributed strain sensor, an impedance-based piezoelectric sensor, and a solid state hybrid linear/rotary actuator will be briefly presented.

**Biography**

Dr. Mark W. Lin completed his undergraduate study in 1982 with a B.S. in mechanical engineering from Tamkang University, Taipei, Taiwan. He then received his M.S. in Engineering Mechanics in 1987 and Ph.D. in Mechanical Engineering in 1993 both from Virginia Tech. He joined UAHuntsville in 2000 and currently is an Associate Professor in Mechanical Engineering. Dr. Lin is specialized in solid mechanics, and his current research interests are in the areas of smart structures and mechanics of composite materials.

**References**

Lin, M. W. and Thaduri, J., 2005, "Structural Deflection Monitoring Using an Embedded ETDR Distributed Strain Sensor," *Journal of Intelligent Material Systems and Structures*, Vol. **17**, No. 5, pp. 423-430.

Khoshbakht, M. and Lin, M. W., 2010, "A Finite Element Model for Hygro-Thermo-Mechanical Analysis of Masonry Walls with FRP Reinforcement," *Finite Elements in Analysis and Design*, Vol. **46**, pp. 783-791

# FRP Composites Solutions for Civil Infrastructure

**Presentation by:** Professor Houssam Toutanji

**Department:** Civil & Environmental Engineering **E-mail:** toutanh@uah.edu

**Abstract**

Since the early dawn of civilization, the strong and light material has always fascinated mankind for typical applications. The idea of combining two or more different materials resulting in a new material with improved properties exists from ages. It was discovered long ago that composite materials have the combined advantages with superior performance compared to each individual material.

Today high performance fiber reinforced polymer (FRP) composites are starting to challenge that most ubiquitous material, steel, in everyday applications as diverse as automobile bodies and civil infrastructure. Continuous advances in the manufacturing technologies and performance of FRP have intensified the competition in a growing range of applications leading to significant growth in its market acceptance.

This presentation discusses the advantages of FRP composites over conventional materials, the application of the materials in civil engineering, and basic design criteria that needs to be considered. It presents the different research projects that are going on at UAH, characterizing the mechanical properties and performance of bonded fiber-reinforced polymer (FRP) composites to strengthen, rehabilitate and retrofit different structural elements

**Biography**

Professor of Civil and Environmental Engineering.

**References**

Toutanji, H. and Han, M., "Interfacial Bond Strength Characteristics of FRP and RC Substrate", *ASCE Composites for Construction Journal*, Volume **16**, Issue 1, 2012.

King, L and Toutanji, H., "Load and Resistance Factor Design for Fiber Reinforced Polymer Composite bridge Deck," *Composites B Journal*, Volume **43**, Issue 2, 2012, pp. 673-680.

# Block Copolymers: Materials with a Split Personality

**Presentation by:** Professor Carmen Scholz

**Department:** Chemistry **E-mail:** cscholz@chemistry.uah.edu

**Abstract**

Dr. Scholz' research focuses on biomedical and biodegradable polymers. Research concentrates in two thrust areas: synthesis and characterization of poly(amino acid)s and their copolymers and functionalized poly(hydroxyalkanoate)s, i.e. bacterial polyesters, and their polymer-analogous reactions.

Poly(amino acid)s garner significant attention as biocompatible polymers because they are synthesized from natural L-amino acid building blocks, thus, potential degradation products are naturally biocompatible. Individual building blocks are linked via peptide bonds hence the resulting polymers resemble peptides and proteins in terms of their backbone architecture, thereby further contributing to the overall biocompatibility of poly(amino acid)s. Dr. Scholz' group developed a novel technique to the synthesis of poly(amino acid)s that does not use any metal catalysts and allows for a strict control of the molecular weight. The use of a macroinitiator for these polymerization results in the formation of AB block copolymers. Furthermore, when two different amino acid building blocks are used ABC terblock copolymers will be formed. Research focused on ABC terblock copolymers with a cystein moiety, which rendered block copolymers reactive towards gold and gold nanoparticles. These copolymers were used to coat biomedical implants, with the A block being either poly(ethylene glycol) or poly(oxazoline) the surface of the implant was rendered biocompatible. Current research focuses on investigating the self-assembly properties of PEGylated poly(amono acid) block copolymers that are highly amphphilic.

Research into bacterial polyesters yielded a cationic derivative of this polymer that was water-soluble (first ever described water soluble bacterial polyester) and was shown to be an efficient as a gene delivery vector that was less toxic than common commercial products.

**Biography**

Education:
1987: Diploma (MS) in Polymer Chemistry, University of Technology, Dresden, Germany
1991: Dr. rer.nat. (Ph.D.) in Chemistry, University of Technology, Dresden, Germany

Academic Experience:
2009- Professor, Department of Chemistry, University of Alabama in Huntsville, AL
2004-2009 Associate Professor, Department of Chemistry, University of Alabama in Huntsville, AL
1998-2004 Assistant Professor, Department of Chemistry, University of Alabama in Huntsville, AL
2000- Adjunct Professor, Department of Chemical Engineering, University of Alabama in Huntsville, AL
1996-1998 Research Associate, Department of Chemistry, University of Massachusetts, Lowell, MA

**Biography (continued)** – Professor Carmen Scholz

1994-1996 Research Scientist, International Center for Biomaterials Science at Science University, Tokyo, Noda-Campus, Japan
1992-1994 Postdoctoral Research Associate, Department of Polymer Science and Engineering, University of Massachusetts Amherst, MA

Professional Experience:
Executive Editor: Polymer International
Editorial Board: Bioactive and Compatible Polymers Editorial Board: Journal of Polymers and the Environment
57 publications, edited three books within the ACS Symposium Series,
Patents: 1 issued (USP 5,925,720), 3 pending

# Modification of Polymer Substrates with Deep UV Radiation

**Presentation by:** Professor Emanuel Waddell

**Department:** Chemistry **E-mail:** emanuel.waddell@uah.edu

**Abstract**

The surface modification of polymer substrates is important in biotechnology with specific applications in microfluidics and tissue engineering. The research discussed here focuses on the surface modification and characterization of polymer substrates with excimer radiation. Previous work has included the discussion of polydimethylsiloxane and the effect of surface modification on wettability and electroosmotic flow. In this instance we will discuss the surface modification of polymethylmethacrylate with narrow band excimer radiation generated by KrCl. Several techniques such as attenuated total reflectance infrared spectroscopy, contact angle goniometry, ultraviolet-visible spectroscopy, fluorescence mapping, and electroosmotic flow measurements are used to characterize surface modifications. In particular, we observed that as radiation time increases, wettability increases due to formation of carboxylic acids. The formation of the carboxylic acids is monitored indirectly with methylene blue via absorbance spectroscopy. In addition to using contact angles to determine wettability, contact angle goniometry is used to estimate the number of groups and the acidic strength of the surface. Finally, the carboxylic acids are functionalized with water soluble carbodiimide and utilized to pattern proteins that are characterized with fluorescence scanning.

**Biography**

Emanuel Waddell received his undergraduate degree in Chemistry and Physics from Morehouse College and a Masters Degree in Physical Chemistry from the University of Rochester. Emanuel received his doctorate degree in Analytical Chemistry from Louisiana State University. His research detailed the use of Fiber Optic Based Time Correlated Single Photon Counting Devices for DNA sequencing. Following receipt of his doctoral degree Emanuel was a NRC Post Doctoral Research Associate at the National Institute of Standards and Technology in Gaithersburg, MD. Emanuel investigated the chemical effects of laser ablation on polymer substrates. Professor Waddell has been a member of the faculty at UAHuntsville since 2004. Research tools include contact angle goniometry, Raman spectroscopy, attenuated total reflectance infrared spectroscopy, and electroosmotic flow profiling.

**References**

EA Waddell, S Shreeves, H Carrell, C Perry, BA Reid, J McKee Applied Surface Science 254 (17), 5314-5318

DL Pugmire, EA Waddell, R Haasch, MJ Tarlov, LE Locascio Analytical chemistry 74 (4), 871-878

# Computational Modeling of Brittle Materials under Dynamic Conditions

**Presentation by:** Professor Ken Zuo

**Department:** Mechanical & Aerospace Engineering **E-mail:** zuo@eng.uah.edu

**Abstract**

Brittle materials (ceramics, concrete, grains in energetic materials) are used in a wide range of high-rate applications. Predictive modeling of the response (damage and failure in particular) of brittle materials under high-rate conditions is therefore of practical importance to the design and use of structures and systems containing brittle materials. Predictive modeling of damage and failure of a brittle material is particularly challenging due to the presence of defects (microcracks, microvoids) which are randomly distributed in the material prior to the application of loading. Under shock loading (e.g. impact) the microcracks in a brittle material can open, shear, become unstable and grow in size, coalescence into macroscopic cracks. The behavior of the microcracks can have a significant effect on the macroscopic response of the material. We will discuss on-going research effort in developing crack mechanics-based models for brittle materials under high-rate conditions.

**Biography**

Dr. Zuo received his Ph.D. in Mechanical Engineering from the University of New Mexico in 1995 and is currently an Associate Professor of Mechanical Engineering at the University of Alabama in Huntsville. His research is focused on the computational modeling of the dynamic response (deformation, damage and fracture) of materials. He has over 17 years of research experience in materials modeling, 7 of which were spent with Los Alamos National Laboratory. In collaboration with other researchers, Dr. Zuo has developed several advanced models for deformation, damage and failure of materials under high-rate applications. The models have been reported in leading research journals and have been implemented in the analysis codes. He is currently a Senior Member of American Institute of Aeronautics and Astronautics (AIAA), and a Member of American Society of Mechanical Engineers (ASME), American Society of Civil Engineers (ASCE), American Physical Society (APS), and Sig!

ma Xi: The Scientific Research Society. He has graduated 7 MS students since he joined the faculty of UAH in Fall 2006 and is currently supervising several Ph.D. and MS students.

**References**

Zuo, Q.H., L.E. Deganis and G. Wang (2012), "Elastic Waves and Damage Quantification in Brittle Material with Evolving Damage.", *Journal of Physics D: Applied Physics*, **45** (145302):1-8.

Deganis, L.E. and Q.H. Zuo (2011), “Crack-mechanics Based Brittle Damage Model Including Nonlinear Equation of State and Porosity Growth.” *AIP Journal of Applied Physics*, **109** (073504):1-11

# Heterogeneous Chemical Equilibria Near the Critical Point of Solution

**Presentation by:** Professor James Kern Baird

**Department:** Chemistry **E-mail:** bairdj@uah.edu

**Abstract**

The solubility of metal oxides in isobutyric acid + water near the critical point of solution is greatly suppressed if dissolution is endothermic and greatly enhanced if dissolution is exothermic.

**Biography**

B.S. Chemistry, Yale University, 1963 A.M. Physics, Harvard University, 1965 Ph.D. Chemical Physics, Harvard University, 1969 Captain, US Army, 1969-1970 Research Physicist, Oak Ridge National Laboratory, Oak Ridge, TN, 1970 -1981 Manager, Radiochemistry, General Electric Knolls Atomic Power Laboratory, Schenecteday, NY 1981 -1982 Professor of Chemistry, UAH, 1982 - present

**References**

J. K. Baird, et al., *J. Chem. Phys.* **134**, 154505 (2011)

J. K. Baird, et al., *Phys. Rev. E*. **83**, 061201 (2011).

# Thermophysical Property Measurements and their Application to Materials Processing

**Presentation by:** Professor R. Michael Banish

**Department:** Chemical and Materials Engineering **E-mail:** banishm@uah.edu

**Abstract**

This presentation will focus on thermophysical property measurement and methodologies that we have developed as well as current and pending research activities. Accurate values of transport properties are important as input parameters for numerical modeling efforts as well as to understand fundamental interactions in materials processing. We have previously developed several reduced algorithms for mass and thermal diffusivity determinations in a range of molten metal and semiconductor systems. They were developed under NASA sponsorship to experiments on the International Space Station. These reduced algorithms allow for a "real-time" determination based on simple geometric parameters and do not require post-processing analysis. We have completed measurements on the thermal diffusivity of several lead-free solders and their binary constituents. We found that the thermal diffusivity in these lead-free alloys is very dependent on their thermal hist ory and independent of their composition. We are currently negotiating with an outside company to perform a range of thermophysical property measurements. More recently, I have been involved studies on the properties of JP fuels and we are developing proposals to further investigate the correlation between thermophysical properties and the fuel's atomization and combustion behavior. We are currently funded to evaluate the production of smoke from incendiary sources.

**Biography**

Mike has worked in thermo-physical property measurements, chemical analysis, and semiconductor and protein crystal growth. He has a Ph.D. in Materials Science and Engineering from the University of Utah, 1992. Mike has developed a range of measurement methodologies for mass and thermal diffusivity measurements. He has supervised eight master’s degree students and one Ph.D. student.

He was the PI on three thermophysical property measurement projects funded by NASA. All three project were to be flown on the Mir or International Space Station. One project, to determine the mass diffusivity in molten indium, was completed in 1994.

Mike has been a consultant for several companies covering topics on chemical analysis and property measurements, thermodynamic process analysis and substrate pattern formation.

He is currently working on the thermal and mechanical properties of lead-free alloys.

**References -** Professor R. Michael Banish

T. Pourpoint, R.M. Banish, F. Wessling and R.F. Sekerka, A Real-time method for Thermal Diffusivity Determinations, *Review of Scientific Instruments*, **71** (2000) 4512.

R.M. Banish, L.B. Jalbert, Experimental Confirmation of the Insensitivity of Diffusion Measurements to Deviations from 1-D Transport, *Review of Scientific Instruments*, **71** (2000) 44

# Materials and Surface Characterization Facilities at UAHuntsville

**Presentation by:** Dr. Jeffrey J Weimer

**Department:** Chemistry / Chemical & Materials Engineering **E-mail:** Jeffrey.Weimer@UAH.edu

**Abstract**

This presentation will give a brief overview of our existing and potential facilities for the characterization of materials and surfaces. A concise background to analysis of chemistry and structure will be noted, followed by an overview of what we have and could expand to have on campus. Tools currently available include scanning probe microscopy (SPM) and Fourier transform infrared (FTIR) with diffuse reflectance (DRIFTS), glancing angle (RAIRS), and attenuated total reflectance (ATR) attachments. Potential tools for further consideration include x-ray photoelectron spectroscopy (XPS), Auger electron spectroscopy (AES), energy dispersive spectroscopy (EDS), and x-ray diffraction (XRD).

**Biography**

My research interests are broadly scoped in interdisciplinary materials and surface science / engineering, with the main goal being to define how the nature (chemistry and structure) of materials or surfaces affects their properties or performance. My primary interests include chemical functionalization, nucleation and growth, chemical reaction dynamics / thermodynamics, and materials / surface characterization. My background includes studies of adhesion phenomena, coatings and thin films, heterogeneous catalysis, tribology, and biomaterials using a range of characterization techniques and principles from surface science & technology. Expanding interests currently include bio-sensors and quantum dots.

# Material research activities at nanophotonic group in the Physics Department

**Presentation by:** Professor Seyed M Dadeghi

**Department:** Physics **E-mail:** seyed.dadeghi@uah.edu

**Abstract**

I briefly review the current research activities of the nanophotonics group in the physics department, University of Alabama in Huntsville. This includes some of our recent results regarding: (i) theoretical investigation of hybrid nanoparticles systems consisting of metallic nanoparticles and semiconductors quantum dots, and (ii) photophysics and photochemistry of colloidal quantum dots in the presence and absent of plasmonic effects.

**Biography**

Seyed Sadeghi received his MSc and PhD in Physics from the University of Toronto and British Columbia, respectively. From 1999-2001 he held NSERC postdoctoral fellowship before joining industry. In 2007 he joined University of Alabama in Huntsville. His fields of research include nanomaterials, quantum sensors based on hybrid nanoparticle systems, coherent optics of nanoparticles, and photophysics and photochemistry of colloidal quantum dots. Currently he is serving as an editorial board member of Journal of Nanomedicine and Nanotechnology and Dataset Papers in Optics.

**References**

S.M. Sadeghi, and A. Nejat, " Plasmonically-induced energy flow in monodisperse quantum dot solids" *Plasmonics*, DOI: 10.1007/s11468-012-9407-8 (2012)

S.M. Sadeghi & "Control of energy dissipation in nanoparticle optical devices: nearly loss-free switching and modulation", *J. of Nanoparticle Research*, vol. **14**, 1184(2012)

# 3D Imaging of Microstructural Evolution in Solid Oxide Fuel Cell Anodes

**Presentation by:** Professor George Nelson

**Department:** Mechanical & Aerospace Engineering **E-mail:** george.nelson@uah.edu

**Abstract**

The operation of electrochemical energy storage and conversion devices, including batteries and fuel cells, relies upon composite material systems that provide both sites for chemical reactions and pathways for reactant transport. Forging a stronger understanding of the role microstructure plays in device performance and reliability can further advance the development of next generation storage and conversion technologies. In recent years a host of three-dimensional imaging techniques has arisen to address this challenge. Among these techniques x-ray nanotomography permits observation of mixed material systems at resolutions below 30 nm while preserving sample integrity and providing the capability for imaging in situ under device operational conditions. As a demonstration of this technique, the application of x-ray nanotomography toward imaging microstructure in solid oxide fuel cells (SOFCs) will be addressed. By taking advantage of material responses to x-ray energy, absorption contrast imaging allows observation of microstructure and elemental composition in SOFC anodes. Three-dimensional elemental mapping of the anode Ni, yttria-stabilized zirconia, and pore phases has been applied to gain insight into mechanisms driving SOFC performance degradation during operation. These mechanisms include the coarsening of Ni particles and the related loss of electrochemically active triple phase boundaries and conducting network connectivity. While demonstrated on SOFC anodes, x-ray nanotomography provides the opportunity to investigate many electrochemical energy storage and conversion devices including batteries, fuel cells, supercapictors, and solar cells.

**Biography**

George Nelson received his Bachelor of Science, Master of Science, and Ph.D. degrees in Mechanical Engineering from the Georgia Institute of Technology in 2003, 2006, and 2009. While pursuing his Ph.D., his research involved modeling and analysis of fuel cells and electrolyzers, with an emphasis on mass transport in porous fuel cell electrodes. After completing his Ph.D., he served as an Assistant Research Professor at the University of Connecticut from 2009-2012. His projects at the University of Connecticut focused on the investigation of mass and charge transport in electrochemical energy storage and conversion devices, primarily fuel cells and batteries. During this time he also contributed to the development of three-dimensional imaging methods for energy materials based on x-ray nanotomography. Dr. Nelson started as an Assistant Professor at UAHuntsville in August 2012. His general research interests include transport phenomena, energy storage and conversion devices, sustainable energy systems, and multi-scale modeling and analysis.

**References**

G. J. Nelson, W. K. S. Chiu, et al., *Acta Materialia*, 2012, **60**(8): p. 3491-3500.