2014 ASM SPRING SYMPOSIUM

Materials
For
Extreme Applications

PROGRAM AND ABSTRACTS

May 13th & 14th, 2014
GE GLOBAL RESEARCH (GEGR)
NISKAYUNA, NEW YORK

Materials
For
Extreme Applications

May 13th & 14th, 2014

GE Global Research
Niskayuna, New York

OBJECTIVES

Sponsored by the Eastern New York Chapter of ASM, a Technical Symposium on a topic of materials science and engineering is held annually in the spring. The purposes of the technical symposium are to provide opportunities for technical information exchange between professionals, to provide continuing education for professionals, and to educate students in science and engineering fields in Eastern New York.

2014 Spring Symposium Organizing Committee

Steve Buresh (GEGR), Symposium Committee Chair

Tom Angeliu (GEGR)  Jenna Krotke (KAPL)
Andy Detor (GEGR)    Jennifer Kruk (KAPL)
Voramon Dheeradhada (GEGR)  Jud Marte (GEGR)
Laura Dial (GEGR)  Jo Newkirk (GEGR)
Evan Dolley (GEGR)  Terry Nolan (KAPL)
Nell Gamble (GEGR)  Scott Oppenheimer (GEGR)
Mike Hanson (KAPL)  Joe Pyle (KAPL)
Brittany Hamilton (KAPL)  Raul Rebak (GEGR)
Mohammed Haouaoui (GEGR)  Jim Sears (GEGR)
Chris Klapper (GEGR)  Faramarz Zarandi (GEGR)
# 2014 ASM Annual Spring Symposium
Materials for Extreme Applications
Steinmetz Hall, GE Global Research Center, Niskayuna, NY

Tuesday, May 13th, 2014

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<td>8:30</td>
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<td>Steve Buresh</td>
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<td>Hamish Fraser</td>
<td>The Ohio State University</td>
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<td>8:40</td>
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<td>Hamish Fraser</td>
<td>Center for the Accelerated Maturation of Mtls.</td>
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<td>9:10</td>
<td>Session I: Materials Design</td>
<td>Young-Won Kim</td>
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<td>Advances, Dilemmas, Breakthroughs, and Future of Gamma Alloy Technology</td>
<td>Ben Poquette</td>
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<td>9:50</td>
<td>Field Assisted Sintering Technology (FAST) - Current and Future Thrusts</td>
<td>Ben Poquette</td>
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<tr>
<td>10:30</td>
<td>Break</td>
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<tr>
<td>10:50</td>
<td>Process and Fabrication</td>
<td>Peter Hong</td>
<td>NewTech Ceramics</td>
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<td>11:30</td>
<td>Ultrahard Materials (BAM)</td>
<td>Holly Shulman</td>
<td>Grid Logic</td>
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<td>12:10</td>
<td>Superconducting Nanocomposite Materials</td>
<td>Matt Holcomb</td>
<td>Grid Logic</td>
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<td>Lunch</td>
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<tr>
<td>12:50</td>
<td>Session II: Processing and Fabrication</td>
<td>Drew Spradling</td>
<td>MillenniTEK</td>
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<tr>
<td>12:50</td>
<td>Fabrication &amp; Processing of Nuclear Ceramic Materials</td>
<td>Mike Hanson</td>
<td>Knolls Atomic Power Laboratory</td>
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<td>12:50</td>
<td>Fabrication &amp; Processing of Nuclear Ceramic Materials</td>
<td>Terry Nolan</td>
<td>Knolls Atomic Power Laboratory</td>
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<td>1:30</td>
<td>Microwave Assist Technology for Enhanced Processing at Ultra High Temperatures</td>
<td>Holly Shulman</td>
<td>Ceralink</td>
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<tr>
<td>2:10</td>
<td>Break</td>
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<td>2:25</td>
<td>Materials Processing to Enable Extreme Performance: Refractory metals and C-C composites</td>
<td>Martin Butterhof</td>
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<td>3:05</td>
<td>Materials Processing to Enable Extreme Performance: Refractory metals and C-C composites</td>
<td>Kirk Rogers</td>
<td>Carlisle Brake &amp; Friction</td>
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<td>3:45</td>
<td>Taking the Low Road to Composite Commercialization</td>
<td>Curt Colopy</td>
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<td>4:45</td>
<td>GE Global Research Tours – Combustion and Metals Processing</td>
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Tuesday evening, May 13\textsuperscript{th}, 2014

Waters Edge Lighthouse Banquet Facility
Glenville, NY

6:00 - 7:00  Student Poster Session /Hors d’oeuvres and Cash Bar Reception (Waters Edge Banquet Facility)
7:00 - 8:00  Symposium Dinner
8:00 - 8:40  Dinner Talk: Prof. Suveen Mathaudhu

Program Mgr, Mtls Sci. Division, U.S. Army Research Office
Adjunct Professor - Materials Science and Engineering  NCSU

\textit{Captain America's Shield, Wolverine's Claws}

\textit{& the Future of Materials in Extreme Applications}

\textbf{Directions to Waters Edge Lighthouse Banquet Facility}

2 Freemans Bridge Road
Glenville, NY 12302
(518) 370-5300

Take the first right off the traffic circle after exiting GE Global Research onto River Road (heading west)
Continue on River Road (turns into Providence Ave, after crossing Balltown Rd/Rt. 146) for 1 mile
Turn right at the light onto Hillside Ave.
Continue on Hillside Ave down the hill ~ 1.1 miles
Turn left onto Van Vranken Ave and then quickly veer right onto Maxon Rd.
Continue on Maxon for ~1 mile and turn right at the light onto Freeman’s Bridge Rd
The Waters Edge is just over the bridge on the right side.
The Banquet Facility is at the rear of the parking lot
Wednesday, May 14th, 2014

7:30 - 8:15  
*Check-in and coffee*

**Session III**  
**Testing and Characterization**

**Chairs:**  
Tom Angeliu – GE Global Research  
Joe Pyle – Knolls Atomic Power Laboratory

8:20 - 9:00  
Ryan Latta  
*TerraPower*

*Traveling Wave Reactor Fuel System Development*

8:00 - 9:40  
Alex Hamza  
*Lawrence Livermore National Lab - NIF*

*Materials for Inertial Confinement Fusion Targets for the National Ignition Facility*

9:40 - 10:10  
Stephen Bartolucci  
*U.S. Army Benet Laboratories*

*From Gun Tubes to Nanotubes: Materials in Ballistic Heating Environments*

10:10 - 10:35  
*Break*

10:35 - 11:15  
Eric Lifshin  
*SUNY College of Nanoscale and Engineering*

*Image Analysis*

11:15 - 11:55  
Jay Thomas  
*Rensselaer Polytechnic Institute*

*Exploring the Earth Through Experimental Geochemistry: A Quick Tour*

11:55 - 12:55  
*Lunch*

**Session IV**  
**Environmental Degradation**

**Chairs:**  
Evan Dolley – GE Global Research  
Voramon Dheeradhada – GE Global Research

1:00 - 1:40  
Brian Gleeson  
*University of Pittsburg*

*Recent Advances in the Testing and Mitigation of Sulfate-Deposit Induced Hot Corrosion*

1:20 - 2:20  
Bruce Pint  
*Oak Ridge National Laboratory*

*The Effect of Water Vapor on High Temperature Oxidation*

2:20 - 2:50  
*Break*

2:50 - 3:30  
Raul Rebak  
*GE Global Research*

*Ferritic Steels for Accident Tolerant Fuel Cladding in Commercial Light Water Reactors*

3:30 - 4:10  
Tom McKrell  
*Massachusetts Institute of Technology*

*Alloys Response in Supercritical CO₂ Environment*

4:10 - 4:20  
*Concluding Remarks*
2014 ASM SPRING SYMPOSIUM

Materials
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Extreme Applications

PROGRAM AND ABSTRACTS

May 13th & 14th, 2014

GE GLOBAL RESEARCH (GEGR)
NISKAYUNA, NEW YORK
Keynote Speaker

Hamish Fraser

The Ohio State University
Director for the Accelerated Maturation of Materials
Columbus, Ohio

Abstract

There has been considerable effort in our center (Center for the Accelerated Maturation of Materials (CAMM)) focused on developing and applying integrated computational materials engineering (ICME) to optimization and development of materials. In our case (and more generally), the integration is between computational methods and materials characterization. Materials characterization has two important roles to play, the first being in the provision of mechanistic details to the modeling efforts (to increase accuracy and place the models on sound physical bases), and the second to validate predictions of models, at the appropriate scale. Because the results of characterization are to be used in the development of computational models, it is important that they are also of the highest possible accuracy and precision. For this reason, we have developed rigorous stereological procedures for the interpretation of 2D data, and developed methods for direct 3D characterization. These various methods will be described. The efforts involved in the development of models for the prediction of microstructural evolution in titanium alloys integrating phase field modeling and characterization will be outlined, and ways in which microstructure/property interrelationships are predicted will be discussed.

Biographical Sketch

Dr. Fraser graduated from the University of Birmingham (UK) with the degrees of B.Sc. (1970) and Ph.D. (1972). He was appointed to the faculty of the University of Illinois in 1973 (Assistant, Associate and Full Professor), before moving in 1989 to the Ohio State University (OSU) as Ohio Regents Eminent Scholar and Professor. He was appointed as a Senior Research Scientist at the United Technologies Research Center from 1979-1980. He has also been a Senior von Humboldt Researcher at the University of Göttingen, a Senior Visitor at the University of Cambridge, a visiting professor at the University of Liverpool, and spent a sabbatical leave at the Max-Planck Institut für Werkstoffwissenschaften in Stuttgart. He has been an Honorary Professor of Materials and Technology at the University of Birmingham since 1988. In 2014, he was recognized as an Honorary Professor at the Nelson Mandela Metropolitan University in Port Elizabeth, South Africa. At present, he serves as Director of the Center for the Accelerated Maturation of Materials (CAMM) at OSU. He has been a member of the National Materials Advisory Board and the US Air Force Scientific Advisory Board. He has consulted for a number of national laboratories and several industrial companies. He is a Fellow of TMS, ASM, IOM3 (UK), and MSA. He has published over 380 papers in scholarly journals, and given over 280 invited presentations. He has graduated 48 doctoral students and 36 students graduating with the degree of M.S.
Materials Design

Session I

Chairs: Jud Marte (GEGR) and Jim Sears (GEGR)

Authors and Titles

Young-Won Kim (Gamteck)
Advances, Dilemmas, Breakthroughs, and Future of Gamma Alloy Technology

Ben Poquette (GE Healthcare)
Field Assisted Sintering Technology (FAST)
- Current and Future Thrusts

Peter Hong (NewTech Ceramics)
Ultrahard Materials (BAM)

Matthew Holcomb (Grid Logic)
Superconducting Nanocomposite Materials
Advances, Dilemmas, Breakthroughs, and Future of Gamma Alloy Technology

Young-Won Kim
Gamteck, LLC
BeaverCreek, Ohio

Abstract

Gamma alloy materials-processes technology is finally transforming its first generation cast alloys (Ti4822 and XD) to viable engineering materials as their relatively low temperature (<750°C) low-pressure turbine blades. However, their wider-spread and higher performance/temperature applications require overcoming major barriers by answering two questions: 1) why cast alloys are not advancing further and 2) why wrought-processed materials have not made into services. The most crucial, common answer to these is their inability of producing fine-grained, anisotropic fully lamellar (FFL) microstructures. Manufacturing difficulties in processing and machining are also major barriers. “Beta gamma” alloys are introduced as a distinct low-Al-gamma-rich alloy system that not only generate FFL (<90µm) microstructures in cast as well as wrought forms but also significantly improve their compositional and microstructural homogeneities, processibility and machinability. The distinct design concept for beta gamma alloys is discussed, along with the exciting pathway to elevate their high temperature (750~850°C) strength and creep capabilities. Strategic distribution of controlled incoherent particles (H-carbides and γ-silicides) along gamma lath interfaces can further enhance the creep resistance. Integration of the practical dispersion hardening into FFL beta gamma alloy materials is discussed as another exciting pathway to achieve even higher service temperatures.

Biographical Sketch

Dr. Kim, FASM, was educated at Seoul National University, Korea, and the University of Connecticut. Over the last 30 years, he has conducted, or involved in, extensive R&D in high temperature Al/Mg alloys and all aspects of titanium aluminides, and targeted research in NbTiSi-X, MoSiB-X, high entropy alloys and dual superalloys. His major activities in gamma technology include recent exploration of “beta gamma” alloys, a new class of TiAl alloys that remove the limitations of current gamma alloys. Dr. Kim has over 90 publications in TiAl alone and six patents. He has delivered over 80 invited and 12 keynote lectures, organized ten major symposia, edited seven proceedings, and served as panel member or referee for several international gamma TiAl alloy programs. Since 2012, Dr. Kim has been running Gamteck, a research and consulting company, which possesses perhaps the most comprehensive, dynamic data and knowledge base for the gamma alloy technology. Gamteck helps the technology advance through 1) contractual R&D work at any level; 2) forming partnerships for component and business development, 3) consulting on all aspects in gamma technology and their integration, project development, and cultural changes in IH gamma work, and 4) group or on-site education and training.
Field Assisted Sintering Technology (FAST)  
- Current and Future Thrusts

Ben Poquette  
GE Healthcare  
Milwaukee, Wisconsin

Abstract

Field Assisted Sintering Technology (FAST), also known as SPS (Spark Plasma Sintering) is an innovative sintering technology that is becoming increasingly important in the processing of numerous materials. The process is based on a modified hot pressing approach in which the electric current is run directly through the tool and component. With the application of pulsed electric current and the resulting “spark plasma effect”, very fast heating rates and resultant short process cycles are realized. Recent advancement is component size and ultimate sintering temperature make FAST a strong candidate for industrial production of high temperature components.

Biographical Sketch

Ben Poquette, Ph.D., is an Architect Advanced Manufacturing and Materials Engineer at GE Healthcare in Milwaukee, WI and Adjunct Faculty at Virginia Tech (2009-2013). Dr. Poquette is a recent Chair of both the ASM Emerging Professionals Committee and the TMS Young Professionals Program.
Ultrahard Materials (BAM)

Peter Hong
New Tech Ceramics Inc.
Boone, Iowa

Abstract

Invented at the Ames National Lab, AlMgB14+ is a family of boron-based ceramics materials with extreme properties of hardness that is 2/3 that of industrial diamonds and a low coefficient of friction approaching that of PTFE. Nicknamed, BAM, this material with its extreme mechanical properties this material is being commercialized by a startup company, New Tech Ceramics (NTC), located in Boone, Iowa. The company has classified its broad range of industry and market segment uses into four platforms distinct platforms: thin film, thick film, sintered solid, and powder as an additive. NTC has entertained hundreds of inquiries for potential applications that can leverage BAM’s properties which are the focus of the discussion looking at several extreme applications and the potential labor and cost savings and as an enabling technology that promotes the use of other 21st century materials and designs.

Biographical Sketch

Peter is a versatile leader with over 35 years experience in manufacturing and business development consulting. As a young engineer, Peter worked in both manufacturing and product design for John Deere. After leaving to serve as president of Positech Corporation, a custom engineered material handling equipment company, Peter used his experience as a former customer to transform the small design and manufacturing company located in a rural northwest Iowa community into an ISO-certified customer centric division of parent company, Columbus McKinnon Corporation. After orchestrating a leveraged buyout of Positech and successfully running it for four years, Peter turned his attention to business development consulting and serving as a CEO Coach to small and mid-sized companies. Peter also devotes time to influencing and improving the social, economic, and political environment around him, having served 8 years as mayor of Laurens, IA and participating in variety of regional and state committees throughout Iowa including the Iowa Innovation Council.

Peter is serving as the COO of New Tech Ceramics leading the commercialization effort for a super hard boron-based ceramic material that was invented at the Ames Laboratory. He also serves as a Principal Advisor mentoring USDA SBIR Phase II grant recipients in their commercialization efforts and a mentor to university sponsored entrepreneurs coming out of the University of Iowa and Iowa State University.
Superconducting Nanocomposite Materials

Matthew Holcomb
Grid Logic Inc.
Lapeer, Michigan

Abstract

Grid Logic has developed a new class of superconductor/metal composite materials that consist of micron-sized ceramic superconductor particles embedded in a ductile metal matrix. In this composite architecture, the superconductor particles are separated on a 10 to 100 nanometer length scale by the metal matrix. At temperatures below the critical temperature of the superconductor, the metal is induced to be superconducting by the proximity effect. The thermal, mechanical, and superconducting properties of these composites are largely determined by the intrinsic properties of the metal matrix, which can be engineered for a specific application. Grid Logic has developed these Superconducting Nanocomposite (ScNc) materials using superconducting magnesium diboride (MgB2) and a variety of metal matrix materials. We find improved superconducting properties in MgB2/metal composites that contain metals with both high electron-phonon coupling constants and long electron mean free paths; clear evidence of the existence of a strong superconducting proximity effect. In addition, the use of a ductile metal matrix dramatically simplifies the fabrication of technical components (e.g., wire or bulk parts) from brittle MgB2, and results in materials with superior electrical and mechanical properties as well.

More recently, Grid Logic has applied ScNc technology to the copper oxide-based high temperature superconductor (HTS) materials with critical temperatures in excess of 77K. Unlike MgB2, the chemical reactivity and short coherence lengths of the HTS materials require that the superconductor particles be first coated with an ~10nm thick coating of noble metal before fabricating the ScNc. We present the latest results on this development effort and discuss Grid Logic’s ongoing effort to manufacture low cost, high current HTS conductors for self-field applications operating at 77K.
Biographical Sketch

Dr. Matthew Holcomb has synthesized new advanced materials and developed advanced manufacturing methods for over 25 years. He developed a new class of superconducting materials and is an authority on superconducting composite materials and manufacturing methods for metallic composites. Dr. Holcomb is the inventor of Grid Logic’s superconducting materials production technology and has developed numerous methods for composite part fabrication. He leads the scientific and engineering staff for the company’s materials, manufacturing, and product development initiatives. Dr. Holcomb also invented the Micro-Induction Sintering (MIS) process, which is a new 3D additive manufacturing (AM) technique that uses a spatially compact, ultra-high frequency magnetic field to heat and sinter metallic powders. Dr. Holcomb’s academic work covers sub-disciplines within the both theoretical and applied superconductivity including: synthesis and structural characterization of new superconducting materials, superconducting proximity effect theory, high-temperature superconductivity theory, magnesium diboride composite wire and bulk component development, superconducting fault current limiter design, superconducting flux pumps, and superconducting magnet design. He is an inventor on over 30 patents relating to advanced manufacturing, superconductivity, additive manufacturing using micro-induction sintering, non-destructive testing and qualification of AM parts, nanostructured materials synthesis, superconducting devices, and cryogenics.
Processing and Fabrication

Session II

Chairs: Mike Hanson (KAPL) and Terry Nolan (KAPL)

Authors and Titles

Drew Spradling (MillenniTEK)
Fabrication & Processing of Nuclear Ceramic Materials

Holly Shulman (Ceralink)
Processing High Temperature Ceramics with Microwave Assist Technology

Martin Butterhof (VacuumSchmelze)
Vacuum-Induction-Melting (VIM) and Rapid Solidification Processes at VACUUMSCHMELZE

Kirk Rogers (Carlisle Brake & Friction)
Materials Processing to Enable Extreme Performance: Refractory metals and C-C composites

Curt Copoly (INEX)
Taking the Low Road to Composite Commercialization
Boron carbide has been used for decades as an effective material to absorb and control thermal neutrons in commercial nuclear power plant reactors. MillenniTEK manufactures various configurations of boron carbide neutron absorbers, each particular to the design of the intended reactor. An overview of the ceramic manufacturing process will be presented, including powder preparation, pressing, sintering, machining, and quality inspection. There are several unique considerations in manufacturing boron carbide ceramics for neutron absorber applications that will be discussed, versus other applications where high hardness and low density of the material are the primary properties of interest.

Mr. Drew Spradling joined MillenniTEK a year and half ago and is currently the Director of Product and Business Development. He is responsible for nuclear ceramic product development, ranging from formulation to manufacturing integration. Additional areas of responsibility are in the development of non-nuclear ceramic products. Mr. Spradling has held previous positions in R&D, business development, and manufacturing with Ceralink, Touchstone Research Laboratory, and SGL Carbon over the last 18 years. He received his B.S. degree in Ceramic Engineering from Clemson University and an M.B.A. from West Virginia University.
Microwave Assist Technology for Enhanced Processing at Ultra High Temperatures

Holly Shulman  
Ceralink Inc.  
Troy, New York

Abstract

Microwave energy has been used in chemical processing and drying operations for many years with a significant impact on time and energy savings, and property improvements. There is an even greater incentive to use microwaves for ceramic processing which undergoes higher temperatures and long cycles. Through support from the National Science Foundation, Ceralink has built the world's first 2300 °C Microwave Assist Technology furnace. This talk will discuss the technical challenges and opportunities when adding microwaves to conventional furnaces, with a focus on ultra high temperature processing and materials.

Biographical Sketch

Dr. Holly S. Shulman is the founder and President of Ceralink Inc. Ceralink is a small woman owned business, founded by Dr. Holly Shulman in 2000. Ceralink applies their strength in materials engineering to develop energy efficient processes and products. They offer consulting and exclusive hands on R&D to serve their customers. Dr. Shulman also leads the development of several Ceralink technologies for licensing or spin off. Dr. Shulman has 30 years of experience developing advanced materials technology and processes, with a focus on ceramics. She is an inventor on several patents and pending patents. Prior to founding Ceralink, Dr. Shulman worked at a Crown Research Institute in New Zealand, and with Kennametal in Pittsburgh. She received her PhD from the Swiss Federal Institute of Technology (EPFL) in Lausanne, Switzerland, an MS from University of Pittsburgh, and a BS in Ceramic Engineering from Alfred University.
Vacuum-Induction-Melting (VIM) and Rapid Solidification Processes at VACUUMSCHMELZE

Martin Butterhof
Vacuumschmelze
Elizabethtown, Kentucky

Abstract

Introduction of the VIM process with regards to the benefit of the material with the affiliated hot-rolling and cold-rolling process. Process requirements for manufacturing of extreme temperature magnetic material like cryogenic shielding material, high magnetic saturation materials for elevated temperatures. Intermediate annealing processes to adjust mechanical properties on spring materials applicable in high corrosion atmospheres. Production of thin foil materials via Rapid solidification process to prevent re-melting and parting of joints.

Biographical Sketch

The speaker is application engineer at VACUUMSCHMELZE (VAC). He consults customers in terms of technical topics relating to soft-magnetic alloys, expansion alloys, high-end spring materials, brazing foils, etc. He studied material sciences in Nuremberg, Germany and has long experience in project work and project monitoring. He is located in the Sales Office for VAC in Elizabethtown, KY since 2013 and coordinates from there projects with Product Marketing, R&D, logistics and manufacturing and engineering departments.
Materials Processing to Enable Extreme Performance: Refractory metals and C-C composites

Kirk Rogers
Carlisle Brake & Friction
Solon, Ohio

Abstract

Starting materials, processing routes, microstructure and materials performance for 2 classes of materials will be reviewed. For the refractory metals (Tungsten, Molybdenum, Rhenium, Tantalum and Niobium), we will detail powder processing routes are commonly used to achieve final shapes for applications such as X-Ray sources; electron collector; and bearing components for medical imaging equipment. For the Carbon-Carbon composites, several high performance friction applications such as aircraft braking systems, racing clutches and brakes, and the processing routes required to manufacture these objects as well as the materials performance in the applications will be discussed.

Biographical Sketch

Kirk is an R&D Materials Scientist at the Carbon Group at Carlisle Brake and Friction, a position he has held since early 2014. His responsibilities there include C-C composite materials development for a variety of friction and non-friction applications. The prior 15 years he held positions of increasing responsibility at Refractory Process Innovations (a.k.a. the Cleveland Target Plant) at GE Healthcare. His responsibilities there included designing manufacturing processes for and launching new products; analyzing new business opportunities; Identifying, investigating and applying new process methodologies and inspection techniques; developing and executing patent and technology strategy; and manufacturing process improvement.

Dr. Rogers has 20 years experience in materials processing, primarily powder metallurgy, more than 10 of which have been focused on P/M of refractory metals. His primary focus has been process improvement for co-pressing molybdenum alloys with tungsten-rhenium alloys, but has also done research on novel joining methods, novel molybdenum alloys, carbide or oxide-containing Tungsten-Rhenium alloys. He has also done significant work in recycling materials and is a champion of sustainable manufacturing. He is a certified Six Sigma Blackbelt.

Kirk obtained his B.S. Materials Engineering from Case Western Reserve University, his PhD in Material Science and Engineering from Purdue and performed postdoctoral work at Ohio State on metal ceramic composites.
Taking the Low Road to Composite Commercialization

Curt Copoly
INEX Inc.
Holland, New York

Abstract

CMC and MMC composites are on the forefront of many high technology industries. However, there is also a “backward” path for the commercialization of these materials in mature product markets where expensive metal alloys and conventional monolithic ceramics are replaced solving tough, long-standing industrial problems. Economic solutions are essential in these competitive applications and the development of appropriate, cost-effective composite technology is crucial to successful market penetration.

Biographical Sketch

Curt Colopy is VP for Product and Business Development at INEX Incorporated, the innovator in ceramic composites for radiant tubes and other heat-treating components. Curt has managed several businesses in electronic and structural ceramics, and started his career at The Carborundum Company where Silicon Carbide was first commercialized. He has several patents relating to ceramic precursor composites and related product applications.
Keynote Talk
Monday Evening, May 12th, 2014
Waters Edge Lighthouse Banquet Facility
Posters/Cocktails 6:00 pm             Dinner 7:00 pm              Keynote Talk 8:00 pm

Captain America's Shield, Wolverine's Claws & the Future of Materials in Extreme Applications

Prof. Suveen Mathaudhu
Program Mgr, Mtls Sci. Division, U.S. Army Research Office
Adjunct Professor - Materials Science and Engineering  NCSU
Raleigh, North Carolina

Abstract
Materials have been the backbone of technological and military advancement for thousands of years, with whole time periods being named after them (Stone Age, Bronze Age, Iron Age). Perhaps then, it's no surprise that advanced materials such as Captain America's shield and Wolverine's claws have been key components in comic book mythos and are widely recognized. These stories often surreptitiously highlight the processing, control and performance of materials under extreme environments such as high-rates, high pressures, high temperatures and high magnetic/electrical fields. For this talk, we will learn of the rich history of "materials in extremes" from comic books, and discuss the newest scientific breakthroughs in research that make real-world materials suitable for such environments.

Biographical Sketch
Suveen N. Mathaudhu is currently the Program Manager for Synthesis and Processing of Materials in the Materials Division of the U.S. Army Research Office. In July 2014, Dr. Mathaudhu will begin a faculty position within the Mechanical Engineering Department and Materials Science and Engineering Program at the University of California- Riverside. Dr. Mathaudhu joined ARO in 2010 after serving first as an ORISE postdoctoral fellow, and subsequently as a Materials Engineer at the Weapons and Materials Research Directorate in the U.S. Army Research Laboratory. In his current role, he manages programs that focus on the use of innovative scientific approaches for the synthesis and processing of high performance structural materials. He also has held an Adjunct Assistant Professor position with the Materials Science and Engineering Department of North Carolina State University since 2009, where his research interests have focused on advanced structural metallurgy in the areas of ultrafine-grained and nanocrystalline materials by severe plastic deformation, processing of metastable particulate materials, processing-microstructure-property-performance relationships of lightweight and refractory alloys, and thermally stable nanocrystalline metals. Dr. Mathaudhu received his B.S.E. in Mechanical Engineering from Walla Walla University in 1998, and Ph.D. in Mechanical Engineering from Texas A&M University in 2006. He also loves reading comic books.
Testing and Characterization

Session III

Chairs: Tom Angeliu (GEGR) and Joe Pyle (KAPL)

Authors and Titles

Ryan Latta (*Terra Power*)
Traveling Wave Reactor Fuel System Development

Alex Hamza (*Lawrence Livermore National Lab  NIF*)
Materials for Inertial Confinement Fusion Targets for the National Ignition Facility

Stephen Bartolucci (*U.S. Army Benet Laboratories*)
From Gun Tubes to Nanotubes: Materials in Ballistic Heating Environments

Eric Lifshin (*SUNY College of Nanoscale and Engineering*)
Image Analysis

Jay Thomas (*Rensselaer Polytechnic Institute*)
Exploring the Earth Through Experimental Geochemistry: A Quick Tour
Abstract

The TerraPower Traveling Wave Reactor (TWR) is a sodium-cooled breed and burn fast reactor with a metallic fuel system. TWR fuel pins are required to withstand long operational times at high temperature, reaching a very high fluence and burnup beyond the current test experience. An extensive analysis of existing information combined with state-of-the-art modeling indicates that a substantial improvement in material performance should be achievable, and the demanding requirements of a true TWR are attainable. TerraPower’s approach to material performance challenges began with an extensive (and ongoing) review of U.S. D.O.E. metallic fuel performance data together with new PIE on previously irradiated fuel pins. Insights derived from this work are driving new irradiation testing of advanced fuels and cladding materials. In parallel, collected empirical data are being used to support the development and validation of thermo-mechanical fuel performance models, which are based on our steadily improving physical understanding of fuel pin behavior. The combination of empirical data and fuel performance models will ultimately support the licensing case for prototype and commercial fuel systems in TWRs.

Biographical Sketch

Ryan Latta is a Fuel Performance Analyst for TerraPower. He is responsible for fuel element design and performance, fuel performance codes, irradiation test design and data analysis. He previously worked for Knolls Atomic Power Laboratory (KAPL) developing advanced fuel systems for application in Naval Reactors. Latta attended Purdue University, where he received a Bachelor’s and Master’s degree in Nuclear Engineering.
Materials for Inertial Confinement Fusion Targets for the National Ignition Facility

Alex Hamza
Lawrence Livermore National Laboratory
National Ignition Facility
Livermore, California

Abstract
The National Ignition Facility at Lawrence Livermore National Laboratory is fielding indirect drive, “hot-spot” inertial confinement fusion experiments. To achieve the conditions necessary for a burning hydrogen plasma in the laboratory, precision targets with novel materials are required. Capsules which ablate to compress the hydrogen fuel to high pressures and temperatures require uniformity to one part in 10,000 and surface finishes below 10 nanometers. Hohlraums, which are the ovens that heat the capsules, are made of gold and gold plated uranium, have shape requirements with the sub 10 micron tolerances. Thin polymer membranes which precisely position the capsule in the hohlraum are required to be thinner than 50 nanometers. The solid hydrogen fuel itself is also a novel material with its own requirements and characterization. This presentation will describe the materials’ requirements, performance, and characterization.

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

Biographical Sketch
Alex Hamza received his S. B. and S. M. degrees from the Massachusetts Institute of Technology in Chemical Engineering in 1981. He received his Ph. D. in Chemical Engineering from Stanford University in 1986. Since 1989 Dr. Hamza has been at Lawrence Livermore National Laboratory. He has focused on target fabrication research since 2002. Dr. Hamza has led the high energy density target development and fabrication efforts since 2006. In 2009 Alex added the role of target fabrication manager for the inertial confinement fusion program. In addition he is director of the Nanoscale Synthesis and Characterization Laboratory at LLNL, where he is focused on research and development of novel nanoscale materials and their characterization for application to inertial confinement fusion and high energy density physics. He is the co-author of over 200 refereed papers and 6 patents.
From Gun Tubes to Nanotubes: Materials in Ballistic Heating Environments

Stephen Bartolucci
U.S. Army Benet Laboratories - ARDEC
Watervliet, New York

Abstract

The large caliber cannon firing environment represents an extremely harsh thermal and mechanical environment where temperatures can reach 1500 K in approximately two milliseconds and pressures are on the order of 100 ksi. Exposure to thermal shock conditions and high mechanical loads, in addition to chemical attack by propellant gases, produces effects in cannon materials and coatings that have been studied extensively for many years. While live-fire testing of cannon materials represents the actual conditions a material will experience, high costs associated with such testing has lead to the development of more rapid and economical evaluation methods. Laser pulse heating (LPH) with a variable pulse duration Nd-YAG 1064 nm wavelength laser has been shown to be an effective tool for simulating the thermo-mechanical loading experienced by cannon bores during firing. LPH has been used to study the behavior of traditional cannon materials, as well as developmental coatings. Recent work using laser pulse heating as a tool to study the degradation of polymer nanocomposites under highly transient heating has provided a new approach to studying these materials. Polymer nanocomposite thermal degradation has traditionally been investigated at slow heating rates using thermogravimetric analysis. The results of studies on nanoclay and carbon nanotube/polymer nanocomposites using laser pulse heating will be presented.

Biographical Sketch

Dr. Bartolucci earned his Bachelor’s and Doctorate degrees in Materials Science and Engineering from Rensselaer Polytechnic Institute, where he studied phase transformations in aluminum alloys for his doctoral thesis work. He then joined GE Power Systems in 2001 as part of the Materials and Processes Engineering group where he worked on materials and coatings for gas and steam turbine applications. After some time at GE, he then returned to Rensselaer to perform post-doctoral research on carbon nanotube composites at the Rensselaer Nanotechnology Center. In 2005, he joined the US Army Benét Laboratories, a division of the US Army Armaments Research Development and Engineering Center. Since joining Benét Laboratories, Dr. Bartolucci has worked on various basic and applied materials research programs for the Army ranging from metals to composites. He actively collaborates with numerous universities and DOD partners, including the US Navy, Cornell University, and the Institute for Soldier Nanotechnologies at MIT. Most of his current research and publications focus on polymer nanocomposites and the behavior of such materials under highly transient heating. Dr. Bartolucci also currently holds a Visiting Scholar position in the Department of Mechanical, Aerospace, and Nuclear Engineering at RPI.
Image Analysis

Eric Lifshin
SUNY College of Nanoscale and Engineering
Albany, New York

Abstract

Not Available at the Time of Print.

Biographical Sketch

Not Available at the Time of Print.
Exploring the Earth Through Experimental Geochemistry: A Quick Tour

Jay Thomas
Rensselaer Polytechnic Institute
Troy, New York

Abstract

Our experimental geochemistry group conducts experiments to reproduce conditions that exist in or on the Earth. Simple experimental methods can be used to generate pressure-temperature conditions that span the Earth’s crust and upper mantle (i.e. pressures up to 50 kbar, and temperatures up to ~2500° C). Rocks and minerals are synthesized to explore equilibrium and kinetic processes that are important to understand geologic processes. Experimental run products (rocks and minerals) are analyzed using a variety of analytical tools including scanning electron and scanning probe microscopy, wavelength dispersive X-ray spectroscopy, mass spectrometry, and infrared and Raman spectroscopy. In this presentation I will discuss (1) the equilibrium solubility of titanium in silica mineral polymorphs, and (2) the kinetics of magnesium transport through polycrystalline rock analogs. The equilibrium solubility of titanium in silica polymorphs has been ‘calibrated’ as a function of pressure and temperature to develop a thermobarometer that can be used to estimate the pressure and temperature of silica mineral crystallization. Grain boundary diffusivity of magnesium can be used to estimate mass fluxes that control mineral growth in rocks.

Biographical Sketch

Jay B. Thomas is a senior research scientist in the Department of Earth and Environmental Sciences at Rensselaer Polytechnic Institute. The central focus of his research is to use experiments to reproduce conditions in or on terrestrial bodies to determine how igneous and metamorphic processes generate observed mineralogical and geochemical variations. He has been at RPI in his current capacity since 2009. Prior to that he was a Postdoctoral researcher at RPI under E. Bruce Watson, 2003-2009. He has had experiences at the Fluid Research Laboratory at Virginia Tech with Robert J. Bodnar and performed research at Los Alamos National Laboratory. He has a PhD and MS from the Department of Geological Sciences at VirginiaTech and a BA from the Geology Department at Guilford College, NC.
Environmental Degradation

Session IV

Chairs: Voramon Dheeradhada (GEGR) and Evan Dolley (GEGR)

Authors and Titles

Brian Gleeson (University of Pittsburgh)
Recent Advances in the Testing and Mitigation of Sulfate-Deposit Induced Hot Corrosion

Bruce Pint (Oak Ridge National Laboratory)
The Effect of Water Vapor on High Temperature Oxidation

Raul Rebak (GE Global Research)
Ferritic Steels for Accident Tolerant Fuel Cladding in Commercial Light Water Reactors

Tom McKrell (Massachusetts Institute of Technology)
Corrosion of Various Alloys in Supercritical Carbon Dioxide
Recent Advances in the Testing and Mitigation of Sulfate-Deposit Induced Hot Corrosion

Brian Gleeson
University of Pittsburgh
Pittsburgh, Pennsylvania

Abstract

Hot corrosion is a highly accelerated form of surface degradation caused by the presence of a molten-salt deposit, prototypically Na₂SO₄, or a molten reaction product from this deposit. Despite its longstanding prevalence in commercial applications, many unresolved aspects remain of the manner by which compositional, microstructural, and environmental factors influence the hot-corrosion behavior of alloys and coatings. For instance, the mechanism by which Cr and Pt enhances the hot-corrosion resistance of Ni-based coatings is not clear. Moreover, an element such Co is nearly always found in coatings as a result of intentional addition and/or interdiffusion with the superalloy substrate, but the effects of such an element on the hot-corrosion behavior has not been systematically investigated. This presentation will review research being conducted at the University of Pittsburgh to better understand the interplay between coating or alloy composition and hot-corrosion resistance in order to guide relevant testing, performance prediction and coatings development.

Biographical Sketch

Brian Gleeson received his degrees in materials science & engineering (MSE) from the University of Western Ontario, Canada (BE in 1984; ME in 1986) and the University of California at Los Angeles (Ph.D., 1989). He was a postdoctoral fellow and then a faculty member in the MSE department at the University of New South Wales, Australia, from 1990-1997. He moved to Iowa State University (ISU) in 1998, where, in 2006, he was appointed the Renken Professor of MSE. From 2001-2006 he also served as Director of the Materials & Engineering Physics Program at the USDOE Ames Laboratory, which is managed by ISU. In the fall of 2007 he moved to the University of Pittsburgh (Pitt) to be the Harry S. Tack Chair Professor in the School of Engineering. He is also the Director of Pitt's Center for Energy. His research interests include the high-temperature degradation behavior of metallic alloys and coatings; phase equilibria and transformations; deposition and characterization of metallic coatings; and diffusion and thermodynamic treatments of both gas/solid and solid/solid interactions. He is Editor-in-Chief of the international journal Oxidation of Metals.
The Effect of Water Vapor on High Temperature Oxidation

Bruce Pint
Oak Ridge National Laboratory
Oak Ridge, Tennessee

Abstract

Water vapor is a constituent in many environments of technical significance, including those associated with combustion, fuel cells, power conversion, and other applications. While its influence on high-temperature corrosion and environmental effects has long been recognized, various effects of water vapor on the degradation of metallic and ceramic materials have been the focus of increasing scientific and technological interest over the past decade. However, there is still debate as to the role of water vapor on oxidation behavior especially accelerated oxidation rates for Fe-base alloys and increased scale spallation and decreased lifetime for alumina-forming alloys and coatings. The presentation will highlight ~20 years of studies for various applications including thin-walled recuperators for gas turbines, exhaust valves in reciprocating engines, stainless steel boiler steam tubing and alumina-forming alloys and coatings used in applications ranging from thermal barrier coatings to accident tolerant fuel cladding.

Research sponsored by the Office of Fossil Energy, Cross Cutting Technology Program, U. S. Department of Energy

Biographical Sketch

Bruce Pint is the group leader of the Corrosion Science and Technology group at ORNL where he has worked since 1994. He received his Ph.D. in Ceramic Science and Engineering from M.I.T. in 1992 and has been conducting high temperature oxidation research since 1986.
Ferritic Steels for Accident Tolerant Fuel Cladding in Commercial Light Water Reactors

Raul Rebak
GE Global Research
Niskayuna, New York

Abstract
After the unfortunate events in Fukushima on 11-March-2011, the U.S. congress directed the Department of Energy (DOE) to focus efforts on the development of fuels with enhanced accident tolerance. Fuels with enhanced accident tolerance are those that, in comparison with the standard UO2–Zircaloy system, can tolerate loss of active cooling in the core for a considerably longer time period (depending on the LWR system and accident scenario) while maintaining or improving the fuel performance during normal operations. A GE Global Research led program is investigating the behavior of advanced alloys (mostly ferritic steels) under normal operation conditions in high temperature water (e.g. 288°C) and under accident conditions for reaction with steam up to 1400°C. Ferritic steels are highly more resistant to stress corrosion cracking in high temperature water than austenitic materials of similar composition. Ferritic steels such as T91 and HT9 are less susceptible to irradiation damage such as void swelling. Ferritic steels also offer desirable higher thermal conductivity and lower thermal expansion coefficients. Ferritic steels such as APMT containing ~20% Cr and 5%Al are both highly resistant to reactions with superheated steam and resistant to crack propagation under normal operation conditions.

Biographical Sketch
Raul B. Rebak is a Corrosion Engineer working at the GE Global Research Center in Schenectady, NY since October 2007. Previously, he was employed at the University of California Lawrence Livermore National Laboratory where he was the lead for materials corrosion testing for the Yucca Mountain Project. Raul has more than 30 years’ experience in Corrosion Science and Corrosion Engineering both from the academic and the industrial fields. Raul is very active in seven national and international professional societies chairing committee activities, organizing symposia and publishing. Raul has a Master of Science equivalent degree in Chemical Engineering from the University of Misiones (Argentina) and a Ph. D. degree in Materials Science and Corrosion from The Ohio State University (USA). Raul is a Fellow of NACE International, The Corrosion Society.
Corrosion of Various Alloys in Supercritical Carbon Dioxide

Tom McKrell
Massachusetts Institute of Technology
Cambridge, Massachusetts

Abstract

The corrosion resistance of ten engineering alloys were tested in a supercritical carbon dioxide (S-CO2) environment for up to 3,000 hours at 610°C and 20 MPa. The purpose of this work was to evaluate each alloy as a potential candidate for use in S-CO2 cooled nuclear reactors and power conversion cycles. The ten alloys tested were classified into four categories: 1) ferritic-martensitic steels, 2) austenitic stainless steels, 3) nickel alloys, and 4) special alloys. The majority of the alloys were focused on the five alloys within the austenitic stainless steel series, followed by three nickel alloys. These alloys were F91, HCM12A, 316SS, 310SS, AL-6XN, Alloy 800H, Haynes 230, Alloy 625, PE-16, and PM2000.

The experimental procedure consisted of placing multiple samples of each alloy in an autoclave and exposing them to S-CO2 in 500 hour increments for a total time of up to 3,000 hours. At every 500 hour increment each alloy was removed from the autoclave, photo documented, and weighed. One sample from each 500 hour interval was held in reserve for future analysis while the other samples were returned to the autoclave for further testing. The 3,000 hour samples were sectioned, mounted in epoxy, and polished normal to its oxide growth to document the thickness and structure of each oxide layer formed. The results of this work will be presented.

Biographical Sketch

Dr. Thomas J. McKrell is a Research Scientist for the Nuclear Science and Engineering Department at the Center of Advanced Nuclear Energy Systems (CANES), Massachusetts Institute of Technology (MIT). Prior to employment at MIT he was a mechanical systems design and research engineer at Heidelberg Web Systems, and an engineering consultant and program manager at Altran Solutions. Accordingly, he has extensive mechanical design and instrumentation experience, resulting in several patents. Research interests include materials in extreme environments, thermal-hydraulics, and nanomaterials. He has reviewed for journals, sat on review panels, provided invited lectures, serves on a journal editorial board, acted as conference chairs and organizers, and taught seminars. Honors and recognitions include MIT Infinite Mile Award of Excellence, Outstanding Staff Award, MIT Section of the American Nuclear Society, Best Paper Award at the 1st ASME Micro/Nanoscale Heat Transfer International Conference, January 6-9, 2008, Tainan, Taiwan, January 2008, and Best Paper Award at the 9th International Topical Meeting on Nuclear Thermal-Hydraulics, Operation and Safety (NUTHOS-9), Kaohsiung, Taiwan, September 9-13, 2012. Mat Sci PhD/MS UConn, ME BS University of New Hampshire.
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