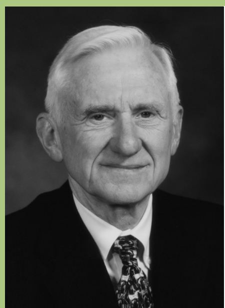
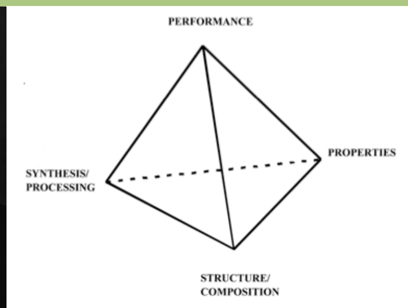
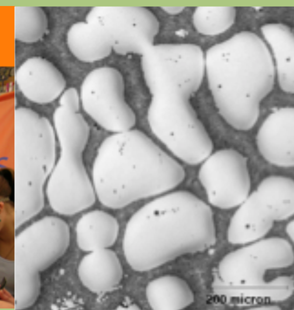
Merton C. Flemings Honorary Symposium and Banquet







Pittsburgh, PA October 27-28, 2009

Merton C. Flemings Honorary Symposium

Materials out of the Box: On Crossing the Threshold from Science to Innovation

Materials Science & Technology 2009

To Register: http://matscitech.org/?page_id=30

This symposium will honor Professor Merton C. Flemings of the Massachusetts Institute of Technology who has been, over his long career, one of the leading pioneers of solidification science and engineering. Among his many contributions, one of the most original, which has in retrospect deeply marked his many alumni, is an exceptional capacity to "think beyond the box", i.e., to glean from queries in the science of materials towards the invention of new materials and processes, and to bring innovations to the way we produce or shape existing materials.

The M. C. Flemings Honorary Symposium will be devoted to an exploration of the passage from research to innovation and invention in materials, synthesis and processing. It will comprise three sessions of invited presentations on innovative processing and synthesis at the cutting edge of materials science and engineering, with focus on the many contributions of Professor Merton Flemings.

Global Impact: ***Tuesday, October 27 8:00 AM - 12:00 PM***

Industry Perspective: ***Tuesday, October 27, 2:00 PM - 4:20 PM***

Solidification Science & Engineering: ***Wednesday, October 28, 8:00 AM - 12:00 PM***

Merton C. Flemings Honorary Banquet

The Duquesne Club

Wednesday, October 28, 6:30 PM - 9:30 PM

To reserve a place at the banquet email mrp@wpi.edu by Oct. 21st.

Organizing Committee

Diran Apelian, WPI
Harold Brody, University of Connecticut
Mehmet Gungor, GE Energy
Toshihiko Koseki, The University of Tokyo
Andreas Mortensen, Ecole Polytechnique Fédérale de Lausanne

Global Impact

Tuesday AM, October 27, 2009

Room: 405, David L. Lawrence Convention Center

Session Chair: Prof. Andreas Mortensen,
Ecole Polytechnique Fédérale de Lausanne

8:00 AM Materials Research across Disciplinary Boundaries

Prof. Subra Suresh, Dean of Engineering, MIT

This presentation will present select topics in materials research that span multiple disciplinary boundaries, including physical sciences, life sciences, informatics, genetics, medicine, and public health. Particular emphasis will be placed on the potential for significant impact on society on a global scale. The presentation will also highlight examples of Prof. Flemings' educational, research and leadership contributions that have had broad impact.

8:40 AM Materials Research from Fundamentals to Application: A Portrait of INM

Prof. Eduard Arzt, Scientific Director, INM - Leibniz Institute for New Materials, Saarbrucken

The INM - Leibniz Institute for New Materials is currently expanding from chemical nanotechnology to additional new fields of materials research. Its scope extends from nanomers, optical materials, CVD/ biosurfaces, and surface protection, to nanotribology, functional surfaces, structure formation at small scales, biomineralization and nanotoxicity. In all of these areas, we strive for a balance between fundamental and applied research. Patenting, industrial cooperations and product development are key elements of our work. This keynote lecture describes the current concept of our research and highlights several specific examples.

9:20 AM Lessons Learned on Promoting University Industry Collaboration

Prof. Diran Apelian, Director, Materials Processing Institute, WPI

Knowledge creation is a mission of research universities, in so doing we embark on a journey of learning that transforms those participating in the "journey". Traditionally, the impact has been on students and faculty but Flemings' work has expanded these boundaries to bring into the forum the industrial sector. As a graduate student in Mert's group in the late 60's-early 70's, we learned from the master the value of understanding market needs, responding to those needs, and addressing the root cause of the problem rather than the symptoms. The Metal Processing Institute at WPI was established in the early 90's in many ways following the philosophical tenets that we learned from Mert during our formative years. In this presentation, the framework for a successful industry-university collaborative research center will be discussed; as well as effective practices that can be shared.

9:40 AM Break

10:00 AM From Materials Education to Growth of Jewelry Diamonds

Prof. Reza Abbaschian, University of California, Riverside

This symposium honors the contributions of M.C. Flemings in advancing the science and technology of solidification processing. His influence in this arena, however, has much larger implications as his work has impacted industrial practice by transforming mostly empirical based foundry and casting practices to science based and predictive materials processing technologies. M.C. Flemings has also been a voice and leader for modern materials science and engineering (MSE) education. He has defined and delineated MSE around four basic elements of synthesis and processing, structure, properties and performance. In this presentation, an overview of the trends in modern MSE education will be given, followed by an example of the application of the four MSE elements in high pressure-high temperature growth of diamonds for jewelry applications.

10:40 AM Battery Materials Science and Engineering to Enable Electric Transportation and Improved Grid-Level Storage

Prof. Yet-Ming Chiang, MIT

Electrical energy storage represents one of the most punishing testbeds for advanced materials due to the unique combination of electrical, chemical and mechanical stresses that are imposed during even ordinary use, and the long service lifetimes any practical device must meet. For the materials scientist and engineer, this therefore also presents a playground in which opportunities for innovation abound. This talk will use contemporary examples, some already fielded and others not quite, to illustrate the role of materials structure, properties, processing and performance in developing energy storage solutions that can help to alleviate the dual global crises of energy supply and climate change.

11:20 AM Engineered Drug Therapies: Nanoparticles of Controlled Size, Shape, Deformability and Chemistry

Prof. Joseph DeSimone, University of North Carolina at Chapel Hill

To translate promising molecular discoveries into benefits for patients, we are taking a pharmaco-engineering systems approach to develop the next generation of delivery systems with programmable multi-functional capability. Our laboratory has pioneered the development of a technique called PRINT (Particle Replication in Non-wetting Templates). PRINT is a remarkable top-down particle fabrication technique that has its roots in the fabrication techniques used in the microelectronics industry to make transistors. PRINT is a high resolution molding technique that allows the fabrication of precisely defined nano-particles with control over size, shape, deformability and surface chemistry. PRINT allows for the precise control over particle size (20 nm to >100 micron), particle shape (spheres, cylinders, discs, toroidal), particle composition (organic/inorganic, solid/porous), particle cargo (hydrophilic or hydrophobic therapeutics, biologicals, proteins, oligonucleotides, siRNA, imaging agents such as MR contrast agents, positron emitters), particle modulus (stiff, deformable) and particle surface properties.

Industry Perspective

Tuesday PM, October 27, 2009

Room: 405, David L. Lawrence Convention Center

Session Chair: Toshihiko Koseki, The University of Tokyo

2:00 PM Application of Computational Science and Engineering to Continuous Casting of Steel

Dr. Tooru Matsumiya, Nippon Steel Corp.

Solid mechanics is applied to deformation analyses of cast slabs in order to prevent the formations of various kinds of crack. Computational fluid dynamics is applied to fluid flow control to encourage the separation of inclusions and discourage their entrapment by initial solid shell. Combined computational fluid dynamics and solid mechanics can analyze the macrosegregation. Computational thermodynamics is applied to designing mold flux, sulphide shape control in unti-HIC steel and deformability improvement of oxide inclusions in an austenitic stainless steel for wire drawing. In order to conduct the phenomenological simulations various property values are required such as activities of solutes, interfacial energy between nonmetallic inclusions and liquid steel, viscosity, diffusion coefficient, etc. For the estimation of these property values, ab-initio calculation, that is, electronic level simulation, and atomistic level simulations should be utilized.

2:40 PM Materials Processing Innovation – Why's the Path so Tortuous?

Rod Riek, Harley-Davidson Motor Company

I had the good fortune of working in a number of companies engaged either directly in materials processing development, or attempting to utilize the process innovations of other companies in its products. My career has been profoundly influenced by being a participant in the early work at MIT in semi-solid metal processing under the guidance of Mert Flemings, and in subsequent industrial work resulting in the first commercial applications of this technology. It's been noted that the time required for manufacturing process innovations to have an impact in the commercial world is often longer than anticipated or than it should be. Personal examples will be given that are consistent with this observation. Additionally, some reflections will be shared on repeating patterns often observed in materials processing development that delay or hinder commercial application, along with some thoughts on potential countermeasures to these patterns and other enablers to development efficiency.

3:00 PM Paradigm Shifts in Scrap Sortation and Melt Analysis

Dr. David Spencer, wTe Corporation

Professor Flemings made substantial contributions to the fields of casting and solidification in his early career, to the field of materials science as Head of the Department at MIT, and later to invention and innovation as Executive Director of the MIT Lemelson Foundation. Those contributions are substantial. Perhaps more important, and why he is so revered by those he has mentored and guided, is what he gave to them. He inspired them to go forward and conduct their own independent contributions thereby “spawning” a cadre of lifetime contributors and innovative thinkers. Many of his students have advanced technologies, made contributions inside and outside metallurgy, and who thereby improved our lot in society as a whole. As examples, the author will discuss some of his own career experiences in ‘garbage processing” and more recently in advanced optoelectronic sortation technologies funded by the NSF and NIST such as Spectramet® and Melt Cognition.

3:20 PM Synthesis and Processing of Industrial Ceramics: M. C. Flemings‘ Role in Championing Industry-University Interfaces

Dr. Peter Bell, Saint-Gobain Industries

In his role as member of the Norton Company Technical Advisory Board, during the time period 1980-1995, Merton Flemings shared his extensive ideas and knowledge of the chemistry and structure of materials. He regularly drew upon his materials ideas and his famous tetrahedron. Mert’s references to metalworking and molds translated in many ways to ceramics applications, a direction toward which Materials Processing was moving. Mert advised on the revolutionary sol-gel abrasives that Norton pioneered. It is notable that these new materials were the first successful applications of synthetics to a materials product group that had gone essentially unchanged for centuries. The presentation will discuss the critical role synthesis and processing science and engineering have played in the development of industrial ceramics. Examples will be provided to illustrate Mert Flemings’ pivotal role.

3:40 PM Materials in Medicine

Prof. Michael Cima, MIT

The impact of materials in medicine goes well beyond prostheses for hips and knees. Three areas will be covered: materials in pharmaceutical science, medical devices, and diagnostics. I'll try to convince the audience by using several examples that this area could be an important part of the future of our discipline. Indeed, health care and economic trends ensure that materials will be important part of a revolution happening in medical technologies.

4:00 PM Materials Processing at MIT and on the National Research Agenda

Profs. Carl Thompson and George Kenney, MIT

Merton Flemings provided visionary and passionate leadership in returning materials synthesis and processing to its rightful position as a central research theme in Materials Science and Engineering, first within MIT and then in the Nation. Through his seminal research on solidification processing Mert developed a personal appreciation of the importance of research on processing and its complementary role to research on the engineering science of materials. This led him to found the Materials Processing Center at MIT in 1979, which now involves faculty and students from across both the School of Engineering and the School of Science. In 1989, Flemings and Chaudhari led a highly influential National Research Council study titled “Materials Science and Engineering for the 1990’s: Maintaining Competitiveness in the Age of Materials.” This study played a key role in putting research on materials processing and synthesis at the forefront of the global materials research agenda.

Solidification Science and Engineering

Wednesday AM, October 28, 2009

Room: 405, David L. Lawrence Convention Center

Session Chair: Mehmet Gungor, GE Energy; Harold Brody, University of Connecticut

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8:00 AM Deterministic and Stochastic Permeability in the Mushy Zone

Profs. David Poirier and Robert Erdmann, University of Arizona

The mushy-zone of a solidifying alloy can be described with continuum equations based on porous-media theory. The central property of a porous medium is its permeability. Quantification of permeability is needed to model flow of interdendritic liquid during solidification. In current models, the permeability is given as a deterministic function of the volume fraction of liquid and a characteristic length scale of the developing dendrites. We first provide an overview of experimental data and resulting correlations for deterministic permeabilities. The stochastic nature of the local permeability in the mushy zone is then discussed with examples from numerical simulations of creeping flow through random microstructures. These simulations reveal that even slight variations in the local permeability cause dramatic effects on the interdendritic flow patterns. We conclude with a comparison of deterministic and stochastic permeabilities, which suggests that future solidification models should include stochastic permeabilities.

8:40 AM From Engineering to Science and Back: A Tribute to Mert Flemings

Prof. Jon Dantzig, EPFL and University of Illinois

The modern era of solidification science began in the 1950's, with Bruce Chalmers and his coworkers, who used analytical modeling combined with experimental observations to describe the basic phenomena. Through the 1960's and 1970's, Mert Flemings and his coworkers took this approach and extended it, both in scientific directions and to practical engineering applications. For example, their work on microstructure formation, microsegregation and macrosegregation, still provides the fundamental underlying principles encoded in the complex computational codes used to design castings today. This presentation will trace some of these developments, in order to demonstrate the impact that this work continues to have to this day.

9:20 AM Eliminating Weld-Edge Cracking from Aluminum Welds

Prof. Sindo Kou, University of Wisconsin-Madison

Along the edge of the weld metal (i.e., the fusion zone) is the partially melted zone that is heated to between the liquidus and eutectic temperatures during welding, where melting and hence cracking along grain boundaries can occur. Most aluminum alloys are susceptible to such weld-edge cracking during welding. Recently, based on temperature T and fraction solid fS during solidification, Kou and coworkers have proposed a criterion for the susceptibility to weld-edge cracking: susceptible if weld-metal fS > base-metal fS after about fS > 0.3 during solidification. The T-fS curves of the base metal and the weld metal can be easily calculated from their compositions and compared to determine the susceptibility. Since the weld-metal composition and hence T-fS curve can be effectively controlled by the filler-metal composition, the criterion can guide the selection or development of filler metals to eliminate weld edge cracking. This will be demonstrated in the presentation.

9:40 AM Break

10:00 AM Solidification Advances

Prof. Lars Arnberg, NTNU, Norway

Advances in solidification science over the last decade have led to a significant improvement in understanding of the formation of solidification microstructures and casting defects. These advances have been made both in mathematical modelling and experimental techniques. One technique that has seen significant development is in-situ X-ray imaging of solidification processes and microstructure evolution. The advancement of these techniques has been made possible by the brilliance and X-ray selectivity of modern synchrotron radiation sources. The techniques include X-ray topography, X-ray radiography and X-ray tomography. Results from such investigations include topography studies of strain development during solidification and high resolution X-radiography of dendrite growth and fragmentation, giving full 3-dimensional reconstructions of solidification microstructure- and porosity development. The presentation will review some recent results from in-situ synchrotron X-ray imaging solidification studies and demonstrate how such studies can be used towards the development of innovative processes and materials.

10:20 AM Fundamentals of Crystal Cohesion during Late-Stage Solidification

Prof. Alain Karma, Northeastern University

This talk will discuss recent progress made using a combination of atomistic and phase-field simulations to characterize the interaction between solid-liquid interfaces that come into close contact during the late stages of solidification. When interfaces belong to different crystal grains, this interaction can be either attractive or repulsive depending on the relative orientation of the two grains. For strong repulsion, crystal cohesion is retarded and interface bridging only occurs substantially below the liquidus temperature, thereby promoting hot cracking. Results will be presented that shed light on complex factors that control interface bridging and the mechanical response of partially wetted polycrystals in between the liquidus and bridging temperatures.

11:00 AM Melt Processing of Metallic Foams

Prof. David Dunand, Northwestern University

A brief review is first given of established melt processes for aluminum foams, in which bubble are entrapped in the melt before solidification. Then, the author presents recent research in his group where new melt/solidification processes are used to create foams from other, usually higher melting, metals: infiltration of beds of hollow spheres to create syntactic foams; infiltration of salt or oxide particle preforms to form composites, followed by removal of the particles by leaching. Finally, the freeze casting method is described, where an aqueous slurry of Ti powders is directionally solidified, forming long, parallel ice dendrites that reject the powders to interdendritic space. The ice is then sublimated and the Ti powders are sintered, resulting in a Ti foam with aligned, elongated pores replicating the ice dendrites.

11:20 AM   The Solidification of Methane Hydrate

Prof. Peter Flemings, University of Texas at Austin

Methane hydrate is an ice-like solid that contains methane in the lattice of water molecules. It is stable at high pressures and low temperatures and is found in the deep ocean and in permafrost regions. I will present a multicomponent, multiphase, flow and solidification model to describe hydrate formation. The model assumes local equilibrium and gaseous transport of methane. In this model, gas flows upward by buoyancy through pores in water-saturated rock. As the gas rises and enters cooler regions of the earth's crust, methane reaches its saturation point in the water and hydrate begins to solidify. The hydrate deposit at the sea floor lies at three-phase equilibrium and small increases in temperature or decreases in pressure will cause melting and gas release. Consequently, these forms of hydrate deposits can both impact climate and be a potential energy source.