Colleagues,

It is with great pleasure that I welcome you to the 20th Canadian Materials Science Conference. I am especially proud that Edmonton, one of the most favourable economies and environments for materials engineers in the world, is hosting the conference for the first time. Whether you are an industrial practitioner, an academic, or a student, I am confident that you will find tremendous "take-away" value at this conference, in both educational development and professional connections.

Our pre-conference workshops provide excellent learning opportunities from an array of world experts and excellent networking opportunities with a diverse group of delegates. We offer a number of provocative workshop topics, both general and specialized, from nanotechnology to welding processes and metallurgy. I know you will be enriched by the broad range of intellectual stimulation provided both prior to and within the symposia.

I wish to thank our Gold sponsors, IPSCO and Sherritt International Corporation; our Silver sponsors, Alta Steel, Enbridge Pipelines, Ludwig Associates, Novelis Global Technology, Sulzer Metco, and TransCanada Pipelines; and our Bronze sponsors, Acuren Group and OSM Tubular. I also wish to thank the University of Alberta, the conference organizing committee, and the many volunteers who gave of their time and talents.

I hope you enjoy your time at the conference and encourage you to experience Edmonton's singular brand of hospitality.

Yours truly,

J. Fraser Forbes
Chair, Chemical and Materials Engineering
University of Alberta

Dear CMSC 2008 attendees:

We trust that you are enjoying this year's event in Edmonton, organized and hosted by the University of Alberta.

As you now know, the Canadian Materials Science Conference offers a unique forum for university researchers, post-doctoral fellows, graduate and undergraduate students, and their industry partners to interact and advance the field of materials science both within Canada and around the world.

Continuing this rich tradition, we invite you to join us in Kingston, Ontario for next year's event, CMSC 2009, which will be held at Queen's University. The conference's technical program will focus on up-to-date materials research in several areas, including biomedicine, transportation, energy, recycling and sustainability, and nano-scale applications to name a few.

The conference venue, Queen's University, was founded in 1841. The campus encompasses a wonderful blend of 19th-century limestone architecture and newer structures, including an energy-efficient "live" building. The city of Kingston, located on the north-eastern shore of Lake Ontario, and its surrounding regions (Thousand Islands, Prince Edward County, Land o' Lakes) offer a wide variety of attractions and activities for visitors during the summer.

All told, it promises to be a great conference – we hope to see you there.

Sincerely,

Keith Pilkey, Ph.D., P.Eng.
Co-Chair CMSC 2009
Associate Professor and Associate Head
Department of Mechanical and Materials Engineering
Queen's University

Mark Daymond, Ph.D., P.Eng.
Co-Chair CMSC 2009
Professor and Tier II CRC
Department of Mechanical and Materials Engineering
Queen's University

General Information

Technical session venue

The conference technical sessions will take place at the Engineering Teaching and Learning Complex, ETLC.

Special lecture venue

DKC MacDonald Memorial Lecture and Mackiw Lecture in Metallurgy will take place at the Engineering Teaching and Leaning Complex, ETLC

Poster venue

Posters will be on display on Wednesday 18th and Thursday 19th at the Solarium - Engineering Teaching and Learning Complex, ETLC.

Registration Desk

The registration desk will be located at the Solarium – ETLC.

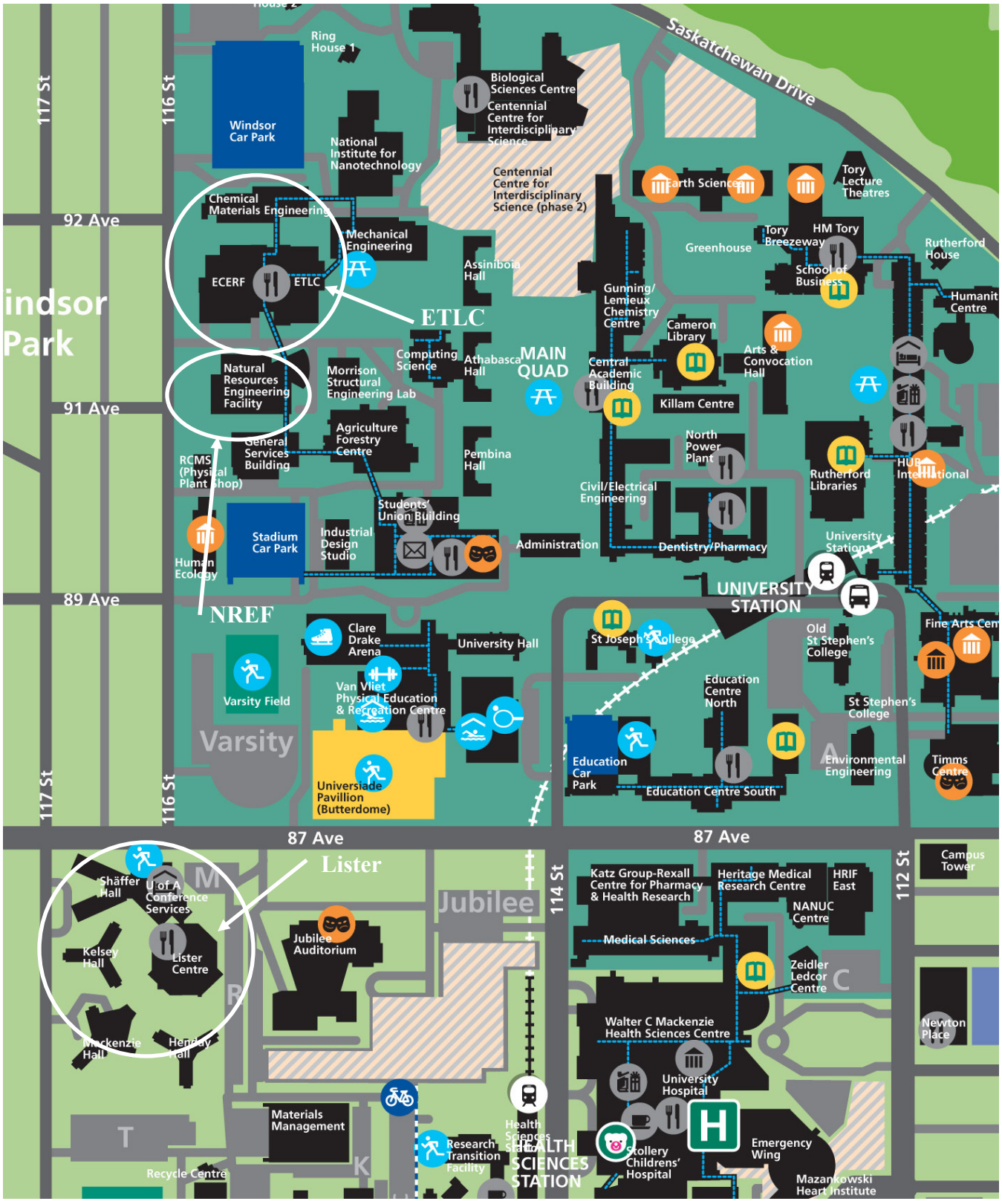
Mixers

A welcome reception will be held on Tuesday at 7:30 PM at the Engineering Teaching and Learning Complex, Solarium. Industry sponsors will be in attendance to meet with students and delegates. Our organizing committee will introduce itself and give a brief welcome address.

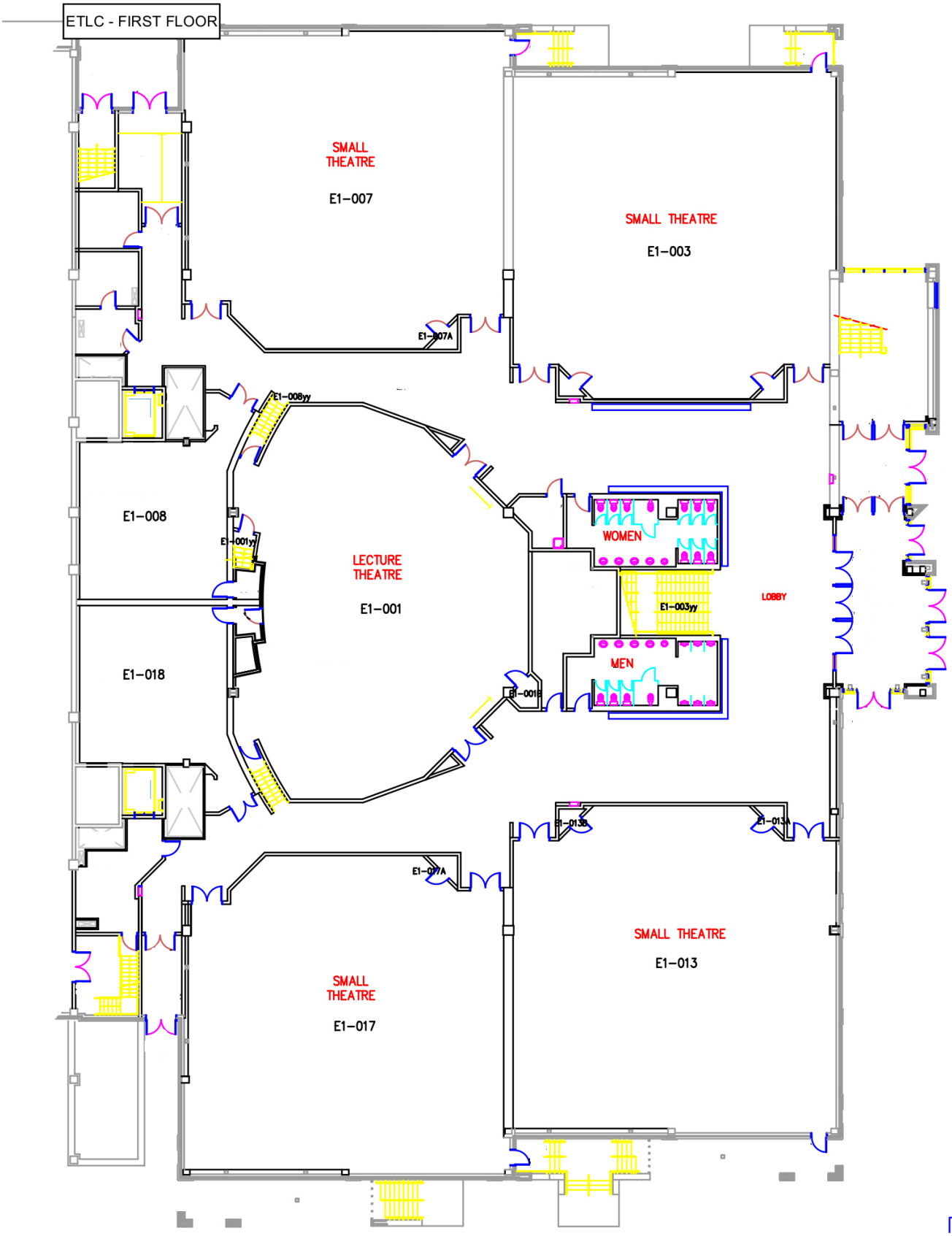
Banquet

The awards banquet will be held the evening of June 18th in the Wild Rose room of the Lister Centre. All conference registrants will receive one banquet ticket (included in the registration fee). Additional banquet tickets may be purchased when registering at the conference.

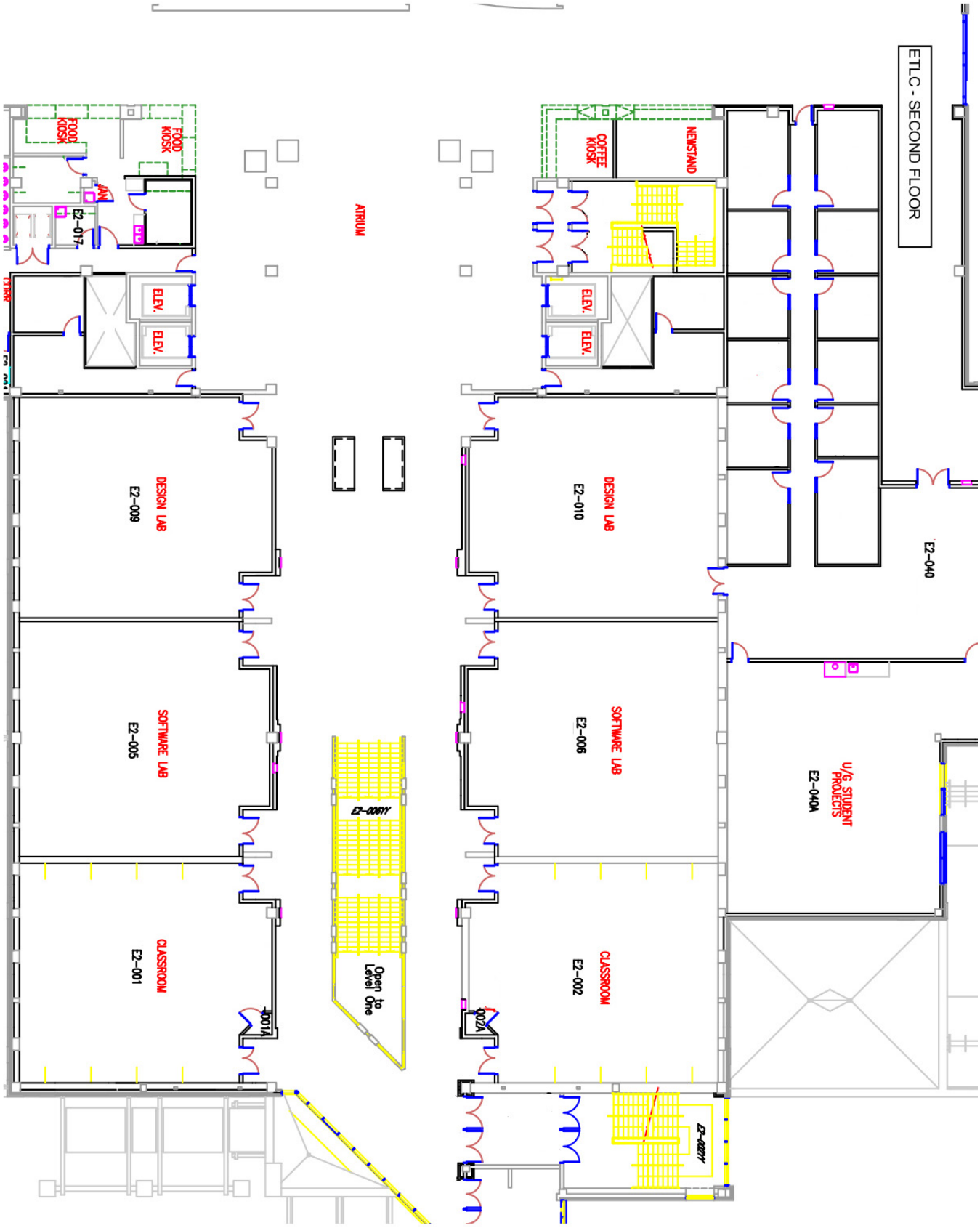
Campus Map, University of Alberta



Engineering Teaching and Learning Complex, Level 1



Engineering Teaching and Learning Complex, Level 2



Calendar of Events

	Tuesday	Wednesday	Thursday
7:30 am		Registration: Solarium-ETLC	
8:00 am			Sessions: Coffee break 10:00 am Characterization I – ETLC E2-001 Modelling – ETLC E1-018 Wear – *NREF 2-090
8:30 am		Plenary – Welcome ETLC E1-003	
9:00 am		Sessions: Coffee break 10:00 am Bionano- ETLC E2-001 Energy I – ETLC E1-003 Welding- ETLC E1-008	
9:30 am			
10:00am			
10:30 am			
11:00 am		Canadian Metal Chemistry Award ETLC E1-003	Canadian Metal Physics Award ETLC E1-001
11:30 am			
12:00 pm		Boxed lunch; Posters-Solarium; CANMET-MTL – ETLC E1-003	Boxed lunch; Posters-Solarium
12:30 pm			
1:00 pm			Sessions: Characterization II – ETLC E2-001 General II – *NREF 2-090 Pipeline – ETLC E1-018
1:30 pm			
2:00 pm		Sessions: Coffee break 3:40 pm Electronic – ETLC E2-001 Energy II – ETLC E1-003 General I – ETLC E1-008	
2:30 pm			
3:00 pm			Refreshments: Solarium-ETLC
3:30 pm			Mackiw Lecture – ETLC E1-001 3:15 – 4:15 pm
4:00 pm			
4:30 pm			Students Award: ETLC E1-001
5:00 pm	Registration: Solarium-ETLC	DKC MacDonald Lecture ETLC E1-007	Conference ends
5:30 pm			
6:00 pm			
6:30 pm		Conference Banquet – Lister Wild Rose Room	
7:00 pm			
7:30 pm	Mixer: Solarium-ETLC		

* NREF: Natural Resources Engineering Facility

DKC MacDonald Memorial Lecture

"Discovering the Dynamic Responses Controlling the Macroscopic Properties of a Material – Seeing is Believing"

Wednesday, June 18th, 5:00 to 6:00 p.m. Engineering Teaching and Learning Complex (ETLC) E1-007

by Prof. Ian Robertson, Department Head, Materials Science and Engineering, UIUC

Transmission electron microscopes have become ubiquitous tools for determining the microstructure and microchemistry of materials. They can be transformed from static to dynamic tools by adding functionality to the specimen holders such that it can impart a stimulus (cooling, heating, straining, environment, magnetic field, current, etc.) to the material and perhaps simultaneously record the macroscopic response. It, therefore, becomes feasible to conduct experiments in which the response mechanisms are visualized in real time and with atomic resolution. The challenge is to add the functionality within the constraints imposed by the available volume. Progress in microlithographic techniques and microelectromechanical machines have made it possible to design and fabricate complex miniaturized laboratories with the means to both stimulate and sense the response of a material. These new capabilities are providing unprecedented opportunities to reveal structure-property relationships.

In this talk, I will demonstrate how the transmission electron microscope has been used as a laboratory for conducting time-resolved experiments; demonstrate how this application has been used to discover the fundamental system processes governing mechanical properties, abnormal grain growth, formation of nanotubes and thin films, and eutectic reaction kinetics; and how this new information has served as the basis for developing physical-based continuum models.

About Speaker:

Dr. Ian Robertson joined the Metallurgy and Mining Engineering Department at the University of Illinois in 1982, after receiving his D. Phil. (Metallurgy) from the University of Oxford. In 2004 he was appointed as Head of the Department of Materials Science and Engineering at the University of Illinois.

Mackiw Lecture in Metallurgy

"The Application of Aqueous Ammonia Chemistry to the Refining of Nickel and Cobalt Sulphides"

Thursday, June 19th, 3:15 to 4:15 p.m. Engineering Teaching and Learning Complex (ETLC) E1-001

by Dr. Derek Kerfoot, Head Hydrometallurgy, INCO Technical Services Limited

The lecture will trace the historical development of the Ammonia Leach Process for the treatment of nickel sulphide concentrates, in terms of its chemistry, from the initial laboratory work at UBC, through the pilot testing in Ottawa, to its successful implementation in the Sherritt Nickel Refinery in Fort Saskatchewan. Over the first thirty five years of operation, the feed to the refinery was expanded to include low-copper and low-cobalt nickel mattes and nickel sulphates, but the process was very limited in its ability to process cobalt-containing feed stocks.

In the early 1990s, the reduced availability of the traditional nickel feed stocks, combined with the expected availability of a nickel-cobalt sulphide precipitate feed from Cuba, prompted a re-examination of the chemistry of the nickel and cobalt ammines in the ammonia pressure leach, in the hope of adapting the process to handle high cobalt content feeds.

As the understanding of the ammine chemistry in the pressure leach improved, new flow sheet options were recognized, leading ultimately to the successful development of a novel and commercially attractive cobalt refining circuit, fully integrated with the existing nickel refinery. This process was adopted by the Refinery and has been in operation for the past fifteen years, producing high quality cobalt powder at one of the industry's lowest production costs. The chemical aspects of the development of this process will be discussed.

About Speaker:

D. Phil in Inorganic Chemistry from the University of Oxford, UK; Worked in hydrometallurgical process research and engineering for Inco Limited, Noranda Research and Seltrust Engineering before joining Sherritt Gordon in 1979.

Metallurgical Society of CIM
Presents the

21st Canadian Metal Chemistry Award

to

Tom Etsell

University of Alberta

Dr. Etsell received his undergraduate and graduate degrees from the Department of Metallurgy and Materials Science at the University of Toronto. Subsequently, he was a NATO postdoctoral fellow for two years at the Max Planck Institute for Chemistry in Mainz, Germany. He has industrial research experience at the Tremco Manufacturing Company, Quality Hermetics and Algoma Steel. After coming to the University of Alberta, he spent a sabbatical year at the Ecole Nationale Superieure de Chimie in Montpellier, France. He was Associate Chair of Materials Engineering from 2002-05. In addition to ceramic materials, he works on secondary recovery and recycling processes for nonferrous metals and minerals. Two of these processes have reached the pilot plant stage while a third was commercialized.

"Ceramic Sensors for Metal Production and Processing"

Wednesday, June 18th, 11:00 to 12:00. Engineering Teaching and Learning Complex, E1-003

Although very limited in number, ceramic materials that conduct ionically, i.e., ceramic electrolytes, or exhibit mixed electronic and ionic conduction have a range of scientific and technological applications including determination of high temperature thermodynamic data, evaluating kinetics of reactions, in situ high temperature sensors, membranes for gas separation, solid oxide fuel cells and steam electrolysis. Ceramic sensors, which generally function as potentiometric sensors whereby a voltage is generated due to the same species at different activities at the electrodes, have met with some success in helping monitor steelmaking, production of several nonferrous metals, heat treating and carburizing operations, and automobile exhaust systems.

In this talk, I shall focus on our efforts to develop these sensors and overcome some of their limitations. Despite numerous incremental improvements, oxygen sensors for liquid metals based on stabilized zirconia retain two serious limitations: short lifetimes and inaccuracy at low oxygen contents. To overcome the former, a nonisothermal probe for continuous oxygen determination in liquid steel has been studied. Instead of a small pellet sealed into Vycor glass or a fragile closed end tube, the stabilized zirconia sensing material can now be a relatively rugged rod. In conjunction with this, a Mo-ZrO_2 cermet with a unique microstructure was produced to maintain long term electrical contact with the steel bath. To address the latter problem, new potential sensor systems have been investigated including La_2O_3-CaO, Y_2O_3-CaO and ThO_2-Y_2O_3 solid solutions.

A brief description of efforts to develop sensors for the in situ determination of manganese and nickel in liquid steel using transition metal aluminates and oxygen in molten cryolite using stabilized zirconia will also be given.

In the case of gas sensors, since there are so few ceramic electrolytes, generally an auxiliary electrode is required to thermodynamically link a species in the electrolyte with the one being sensed, e.g., Na_2CO_3 enables Na β-Al_2O_3 to be used as a CO_2 sensor. However, their response is very sluggish. Rather than introducing this electrode as a pellet or powder, we have studied a technique termed polarized electrochemical vapour deposition whereby the auxiliary electrode can be wrapped around the working electrode as a thin film. This has enabled response and recovery times for CO_2 to be lowered to seconds rather than minutes. Recently, we have worked on a thick/thin film integrated SO_2/SO_3 sensor that can detect SO_3 accurately (SO_2 is calculated) over a wide range of concentrations but becomes insensitive below about 15 ppm.

Metallurgical Society of CIM
Presents the

32nd Canadian Metal Physics Award

to

Doug Perovic

University of Toronto

Dr. Perovic obtained his undergraduate and graduate degrees from the Department of Materials Science and Engineering at the University of Toronto. Subsequently he worked at the Institute for Microstructural Sciences, National Research Council Canada and the Cavendish Laboratory at the University of Cambridge. He joined the Department in 1992 as an Assistant Professor and was promoted to full Professor in 1997 where shortly thereafter he was appointed as Chairman of the Department. In 2003 he was re-appointed for an additional 5-year term as Chairman. In 2000 Dr. Perovic championed the world's first undergraduate degree program in nanotechnology at the University of Toronto. Dr. Perovic continues to Chair the Nanoengineering Science Program at U of T.

"Intrinsic and Extrinsic Defects in Colloidal Photonic Crystal Films"

Thursday, June 19th, 11:00 to 12:00. Engineering Teaching and Learning Complex, E1-001

Since the proposal of photonic crystal theory in 1987, a large experimental effort has been made to design and fabricate dielectric materials that are structurally periodic on the scale of optical wavelengths. One promising category of photonic crystals are self-assembled colloidal crystal films, which can be grown in a facile and inexpensive manner relative to other forms of photonic crystal. This material, which consists of a close-packed lattice of colloidal spheres, can serve as a template for the infiltration of a material of higher refractive index, such as silicon, for the formation of a material possessing a complete photonic bandgap (PBG). However, the self-assembled nature of colloidal crystal films creates the opportunity for the formation of intrinsic defects. Such defects, disruptions in the periodicity of the colloidal lattice, can be expected to have an influence on the optical properties of this photonic material.

In this work, various intrinsically-formed defects are structurally analyzed by various microscopy techniques. Similarities are drawn between defects in both colloidal and atomic lattices. The optical properties of lattice defects are then individually measured through careful spatially resolved micro-optical spectroscopy. Point, line, and volume defects are found to contribute to incoherent scattering, and the measured optical spectra are shown to be in good agreement with finite-difference time-domain simulations. In all cases, the influence of such defects on the fundamental stop-band is negligible, while influences on the "higher-band" region of the band-structure and the PBG are shown to be significant.

Stacking faults, another form of intrinsic defect consisting of variations in the stacking of close packed planes, are shown to occur readily in colloidal crystal films. Through structural and spectroscopic analysis, it is shown that different stacking sequences are associated with a unique optical spectrum. These spectra differ in the higher-band region of the band-structure, while leaving the fundamental stopgap unaffected. Additionally, stacking faults are shown to be caused by the incorporation of differently-sized impurity spheres in the lattice, a hard-sphere type mechanism analogous to atomic systems.Defects can also be deliberately introduced to the colloidal lattice, and through proper design and fabrication can bring desirable photonic functionality to an otherwise bulk, periodic lattice. A fabrication method combining *top-down* photolithographic patterning with *bottom-up* self-assembly for the insertion of embedded linear extrinsic defects into the colloidal lattice is presented.

For the first time, a study of individual lattice defects has been successfully carried out in colloidal crystal photonic crystal films. By better understanding of the structure, optical properties, and formation mechanisms of colloidal crystal defects, the quality of self-assembled photonic crystal films can be improved, resulting in more homogeneous optical properties and allowing the full-potential of colloidal photonic crystals to be realized.

Organizing Committee

Reg Eadie and Tom Etsell, *Conference Chair*

Ken Cadien, John Nychka, and Hao Zhang, *Technical Program*

Katherine Irwin, *Conference Finances*

John Nychka, *Pre-conference Workshops, Conference Website*

Ali Abari, *Conference Website*

Ken Cadien, *Reception*

Adrian Gerlich, *Awards, On-line Registration, Jasper Trip*

Hao Zhang, *Conference Booklet*

Bio-nanomaterials

Date: Wednesday, June18
Location: Engineering Teaching and Learning Complex (ETLC) E2-001
Chair: Robert Burrell

9:00 AM

Elastin-Like Polypeptides: Elucidating Amino Acid Level Effects on Molecular Self-Assembly and Plasma Protein Interactions

Bahniuk, Markian; Unsworth, Larry; Department of Chemical and Materials Engineering, University of Alberta; NRC-NINT

Materials that are non-immunogenic, non-thrombogenic and non-cytotoxic, are being sought for a variety of nanomedicine applications. In addition to these constraints, these materials should allow for the easy incorporation of bioactive moieties, and have non-toxic degradation products. Elastin-like polypeptides (ELPs) have been shown to meet most of these standards, and thus are considered a viable alternative to polymer based materials. Composed of pentapeptide repeats (Val-Pro-Gly-Xaa-Gly, Xaa: guest amino acid), ELP can reversibly self-assemble under environmental stimuli. Preliminary results indicate ELP 'biocompatibility', however, little has been done to understand the effect amino acid composition has on self-assembly, material physicochemical properties (size, charge), and plasma protein interactions. Given the precise control over amino acid content and length, ELP should allow for the elucidation of how individual amino acids influence material properties and the subsequent host response. This information is critical to the development of all peptide based materials for cardiovascular applications.

9:20 AM

Bioresponsive Nanoparticles for Cancer Therapy: MMP2 controlled drug release from Bovine Serum Albumin Nanoparticles

Singh, Harsh; Unsworth, Larry; Uludag, Hasan; Department of Chemical and Materials Engineering, University of Alberta

Bioresponsive materials that can selectively deliver drugs to active tumors, while producing non-toxic degradation products, are highly sought after for clinical use. To this end, coacervation techniques were employed to form nanoparticles (NPs) using bovine serum albumin (BSA). Currently, BSA NPs of 200-250 nm dia are stabilized via the adsorption of the cationic peptide Poly-L-Lysine (PLL) to the surface of the NPs. Given the high concentration of Matrix Metalloproteinase 2 (MMP2) in active cancer sites, it is hypothesized that incorporating the MMP2 cleavage domain (GPQGIASQ) into the stabilizing PLL peptides will allow for localized breakup of the BSA particles at tumor sites. Thus, this study will focus on the development of MMP2 cleavable peptides for the express purpose of controlling the release of therapeutics to metastatic cancers.

9:40 AM

Apparent fracture toughness of interface with inhomogeneous cohesive interactions

Chen, Bin[1]; Shi, X.H.[1]; Gao, H.[1]; Wu, Peidong[2]; [1]Department of Materials Science and Engineering, McMaster University; [2]Department of Mechanical Engineering, McMaster University

The apparent fracture of an interface with inhomogenous cohesive interactions is of general interest to understanding adhesion between micro- or nanostructured surfaces. By theoretical considerations and numerical simulations, we show that the apparent fracture/adhesion energy depends on the ratio between the period of cohesive interaction and the cohesive zone size: it is equal to the average cohesive energy of the interface if the former is much smaller than the latter but becomes the peak value of the local cohesive energy when the opposite is true. Numerical simulations on the peeling of a thin film/strip adhering on a substrate via periodic discrete adhesion patches have confirmed this prediction. Our analysis also provides explanations for one observation made in a recent molecular dynamics simulation of a single-stranded DNA adhering on a graphite sheet.

10:00 AM

Coffee Break

10:20 AM

Strain hardening and strain-rate sensitivity of extra-low interstitial grade Ti-6Al-4V alloy

Devatha Venkatesh, Balaji; Chen, D.L.; Bhole, S.D.; Department of Mechanical and Industrial Engineering, Ryerson University

Ti-6Al-4V of extra-low interstitial (ELI) grade is used in biomedical/aeronautical applications due to its high strength-to-weight ratio, mechanical properties, and biocompatibility. It is commonly used as hip/knee prosthesis, trauma/fixation devices and dental implants. The poor wear resistance of this alloy, however, leads to excessive wear, mechanical and chemical instability, and implant loosening. Various surface treatment methods have been proposed to improve the wear resistance. Thermal oxidation was shown to be a promising approach in producing hard TiO2 surface layer on the alloy. The purpose of this study was to evaluate the effect of heat treatment with or without thermal oxide layer on the hardening behavior, strain rate sensitivity and fracture mechanisms. Results show that the surface layer had minor effect on strength, but reduced the ductility. Strain hardening exponent, hardness and strength were evaluated. Fractal dimensions were observed to be closely related to the mechanical properties of the alloy.

10:40 AM

Peptide based cardiovascular materials: effect of peptide composition on hydrogel properties and plasma protein interaction

Saini, Aditi; Unsworth, Larry; Department of Chemical and Materials Engineering, University of Alberta

Peptide based materials have many inherent properties that make them ideally suited for nanomedicine applications, such as the ability to precisely control the peptide properties: amino acid composition and placement, and peptide length. Critical to their use as biomaterials is understanding how peptide properties affect self-assembly conditions, material properties and how that directs plasma protein adsorption or activation: being the impetus for the immune response, or initiation of coagulation events. Of particular interest is the self-assembling peptide (RADA)4-I, which is known to self-assemble into nanofibers that develop into a viscoelastic hydrogel in aqueous solution. The goal of this study is to incorporate amino acids of various physicochemical properties to this self assembling peptide to determine their effect on nanofiber properties and plasma protein inteactions. The knowledge gained through this project is of fundamental importance to the development of all peptide based materials for cardiovascular applications.

Materials for the Energy Industry I

Date: Wednesday, June18
Location: Engineering Teaching and Learning Complex (ETLC) E1-003
Chair: Tom Etsell

9:00 AM

Mechanical properties of an extruded AZ31 alloy

Begum, Sanjida[1]; Chen, D.L.[1]; Xu, S.[2]; Luo, Alan[3]; [1]Department of Mechanical and Industrial Engineering, Ryerson University; [2]CANMET-Materials Technology Laboratory, Natural Resources Canada; [3]General Motors Research and Development Center, Warren

Magnesium has emerged as a highly enviable material over steel and aluminum because of its low density and excellent strength-to-weight ratio. Wrought magnesium alloys exhibit higher strength and ductility than cast alloys. A lot of work has been done on the tensile behavior of AZ31 sheet/bar and only limited research has been reported on fatigue of this alloy. The present investigation is aimed at studying the mechanical behavior of extruded AZ31 alloy. Tensile tests for samples aligned in the extrusion direction are conducted at different strain rates. Strain hardening rate, strain rate sensitivity, and work hardening rate are evaluated. Strain controlled fatigue tests are performed at different strain amplitudes and strain ratio (Rs=-1). Cyclic strain hardening exponent obtained is about 2.6 times higher than the monotonic hardening exponent. Asymmetric hysteresis loops are observed at higher strain amplitudes. Detailed experimental results will be presented.

9:20 AM

Hydrolytic synthesis of nano titania particles for dye- sensitized solar cells

Charbonneau, Cecile; Demopoulos, George; Mining and Materials Engineering Departement, McGill University

Nano-titania of the anatase variety is currently considered as electrode material for new generation dye-sensitized solar cells. The synthesis of titania nanoparticles is accomplished mainly through expensive and low yield routes like low temperature sol-gel or high temperature plasma methods. Forced hydrolysis is an alternative low temperature synthesis process that is currently investigated in our laboratory. Among the advantages of this technique are its simplicity and high yield output. In this work the effects of temperature (50ºC<T<95ºC), concentration (0.2M<[TiCl4]<1.5M), agitation and additives on the kinetics of formation and stability of different nano titania phase (rutile or anatase) particles are examined. The produced powders are characterized by X-Ray Diffraction (XRD), BET surface analysis and Transmission/Scanning Electron Microscopy (TEM/SEM).

9:40 AM

Hydrogen storage in magnesium silicon and magnesium aluminum

Harrower, Christopher; Haagsma, Julian; Mitlin, David; National Institute for Nanotechnology; Department of Chemical and Materials Engineering, University of Alberta

Metallic hydrides (namely magnesium hydride) have attained much interest as an alternative hydrogen storage media as it may absorb up to 7.6wt%. The main drawback of magnesium-based storage materials is the unacceptably high heat of hydride formation which results in adsorption/desorption times of several hours. One method to increase the kinetics is to introduce destabilizing elements into the magnesium matrix, namely silicon and aluminum. I will demonstrate that these additions increase the kinetics at the expense of lowering the hydrogen storage capacity. A further increase in the kinetics has been achieved by the addition of catalytic active material onto the magnesium matrix (palladium and niobia). The largest challenge in hydrogen storage research is the accurate measurement of the hydrogen that has been absorbed into the material. Finally the limitations of using either gravimetric or volumetric measurement techniques as it relates to hydrogen storage will be discussed.

10:00 AM

Coffee Break

10:20 AM

Processing of the Clear Hills Ironstone Deposit

Kerr, Patrick; Uhlik, Peter; Etsell, Tom; Liu, Q.; Department of Chemical and Materials Engineergin, University of Alberta

For over 50 years, there have been a number of geological, mineralogical, and metallurgical studies carried out on the Clear Hills ironstone deposits. Due to the low grade and complex mineralogy, previous metallurgical studies have achieved limited success. One technique in particular that held the most promise was the iron segregation process. Although the technique worked to beneficiate the iron, the mechanism was not well understood and the process was energy intensive.

Initial investigations into the various physical dressing techniques have revealed rather poor results with respect to iron concentration and recovery. However, with the rapid industrialization of countries like China and India, the demand for iron and steel has increased in recent times driving up the price of the material. Now that market conditions are more favorable, further study on physical separation as well as understanding the mechanism and optimizing the iron segregation process appear to be worthwhile endeavors.

10:40 AM

Chloride Induced Materials Corrosion in Waste-to-Energy Plants

Li, Yuanshi; Hirose, A.; Plasma Physics Lab, University of Saskatchewan

Incineration has been adopted as an effective and hygienic method for disposal of the ever-increasing voluminous industrial and municipal solid waste. The conversion of municipal solid waste (MSW) to energy can conserve more valuable fuel energy and natural

resources and improve the environment by lessening the amount of waste that must be land-filled. However, the corrosion problems during incineration are usually very severe due to the complex reactions of the incinerator tube materials with the aggressive combustion gases and salt deposits. This paper is concerned with the accelerated materials degradation under typical MSW incineration salt deposits. The high-temperature corrosion mechanism is addressed with kinetics, thermodynamic considerations.

Welding and Joining

Date: Wednesday, June18
Location: Engineering Teaching and Learning Complex (ETLC) E1-008
Chair: Adrian Gerlich

9:00 AM
Effect of Process Instability during CO2 Laser Bean Welding of a Heat Resistant Alloy

Ojo, Olanrewaju; Egbewande, A.T.; Department of Mechanical and Manufacturing Engineering, University of Manitoba

Heat resistant nickel based superalloy IN 738 is a precipitation-hardened material that is widely used in aerospace and industrial gas turbine engine because of excellent corrosion resistance and remarkable high temperature strength. Like other precipitation hardened nickel based superalloys that contain a substantial amount of Al and Ti, IN 738 is difficult to weld by fusion welding processes due to the occurrence of heat affected zone (HAZ) cracking during welding. Laser beam welding is an attractive technique for joining heat resistant alloys like IN 738 due to its low heat input that could result in reduced size of HAZ as well as minimal physical distortion and mechanical damage compared to conventional welding methods. In this study, IN 738 given different pre-weld heat treatments were laser beam welded using different welding parameters to investigate the effect of process variables on the microstructure of heat affected zone (HAZ) in the alloy. Considerable liquation microfissuring were observed along intergranular regions in the HAZ, and the extent of the cracking was found to increase with decrease in welding speed, which is in contrast to the generally reported trend in other nickel based superalloys. The variation in the influence of welding speed on HAZ microfissuring will be presented and related to the effect of process instability resulting from obstruction of laser beam from the work piece by surface gaseous plasma generated during welding.

9:20 AM
Experimental Adhesion Analysis of a Polyurethane-Epoxy Interface

Juss, Kulvinder; Mertiny, Pierre; Department of Mechanical Engineering, University of Alberta

A prototype polyurethane-lined fiber-reinforced composite pipe has been developed for use within the oil sands extraction and processing industry. Fabrication of this composite pipe involved filament winding epoxy impregnated fibers onto a partially cured polyurethane (PU) liner. Following the winding procedure, the pipe structure was placed into an oven for final curing. It is during the final curing process that the epoxy resin and PU form a chemical bond across pipe-liner interface through an isocyanate–hydroxyl reaction. The purpose of this study was to assess the bond strength between the PU and epoxy. Using an experimental approach, the fracture toughness of chemically bonded PU/epoxy samples was determined via pressurized blister testing. Furthermore, a relative measure of interfacial strength was established by comparing the fracture toughness of chemically joined samples to the adhesion strength obtained from mechanically bonded PU/epoxy specimens.

9:40 AM
The Effect of Heat Affected Zone Notch Root Placement on X80 Line Pipe Charpy V-Notch Results

Pepin, Joel; Henein, H.; Ivey, D.G.; Wiskel, J.B.; Penniston, C.; Department of Chemical and Materials Engineering, University of Alberta

The welding processes used to produce microalloyed steel pipe can result in mechanical property changes in the heat affected zone (HAZ). While multi-pass welds have successfully achieved CVN values greater than 66.4 ft-lbs (90 J) at the fusion

line, this work will explore the use of double submerged arc welding (DSAW) to achieve similar toughness values. DSAW test coupons were produced to examine the effect of electrode polarity on the Charpy V-notch (CVN) toughness at specified distances from the fusion line.

CVN results indicate that a DC+ lead, AC 50% trail tandem arc setting produces moderately improved CVN test HAZ results at -20°C compared with an AC 75% lead, AC 25% trail tandem arc setting. The difference is believed to be related to differences in effective heat input, though further investigation is required. The CVN coupons notched furthest from the fusion line gave the largest scatter of toughness results. The elevated values (average CVN from 171 to 183 ft-lbs [231 to 249 J]) are believed to be the result of greater lengths of the notch passing through unaffected base metal. Lower values (average CVN from 37 to 59 ft-lbs [51 to 80 J]) were produced by notches located at the fusion line. The weld and base metal CVN results for both sets of welding conditions were comparable. Further optimization of welding parameters is required for DSAW coupons to achieve HAZ fusion line Charpy values exceeding 66.4 ft-lbs (90 J).

10:00 AM
Coffee Break

10:20 AM
Effect of Laser Welding on the Corrosion Performance of Galvanized Steel
Su, Ken; Zhou, Y.; Hansson, Carolyn; University of Waterloo

Laser welding in the automotive industry has gained a prominent role in the manufacturing of tailored blanks whereby a component such as a body side panel joins together galvanized steel sheets having dissimilar thicknesses and possibly different grades. In this study, the effect of welding speed, hence weld width, on the corrosion performance was investigated. Specimens having a weld width ranging from 1mm to 9mm were immersed in 0.1M NaCl solution and monitored by electrochemical and weight loss techniques. Results show that with increasing weld width the corrosion rate generally increases. However, with an increase in the HAZ width, it is possible to prolong the zinc protection on the exposed steel substrate and delay rust formation. Therefore the effect of slow welding speeds, hence wide weld width as well as HAZ width can be favorable to the corrosion protection of galvanized steel.

10:40 AM
Influence of submerged tandem arc welding on HAZ toughnessof X80 micro alloy
Moeinifar, Sadegh; Kokabi, A.H.; Madah Hoseini, S.H.R.; Azad University

X80 HSLA steel is a high grade microalloy steel that is used forthis research.Tandem SAW with two or excess electrode is an economic process for joiningmicroalloy steels components. welding process is done with four wires but lowering in heat affected zone toughness for high grade microalloy steels.Toughness in heat affected zone (fusion line, coarse grain HAZ and fine grain HAZ) studied. Welding done in different amount of heat input. Microstructure and Impact energy with CVN (charpy V notch) studied in -50?C. Heat affected zone in microalloy steels is complex due to many phases (polygonal ferrite, quasi polygonal ferrite, widmanstatten ferrite, acicular ferrite, granular ferrite, bainite, M/A, inclusions). Impact energy changes with heat input up to optimum and increased about fifty percent. Microstructure study with SEM shown that M/A island,austenite grain growth and ferrite side plate is a major factor in CGHAZ toughness.

Electronic Nanomaterials

Date: Wednesday, June18
Location: Engineering Teaching and Learning Complex (ETLC) E2-001
Chair: David Mitlin

2:00 PM
Design of an atomic layer deposition system
Abari, Ali; Cadien, Kenneth; Department of Chemical and Materials Engineering, University of Alberta

Atomic layer deposition (ALD) is a novel thin film depostion technology used for depositing nanometer thick films for electronics and nanotechnology. We

have designed an ALD reactor to minimize the reactor volume while maintaining film uniformity. Small reactor volume reduces precursor consumption and minimizes the purge cycle.

We will discuss ALD technology, the factors that went into the reactor design, vacuum technology principles for ALD, and basic concepts of computational fluid dynamics that allowed modelling of precursor and byproduct flow in the reactor.

2:20 PM

The Electrodeposition of CoFe Alloys with an α-Mn-type Crystal Structure

Crozier, Brendan; Ivey, D.G.; Liu, Q.; Department of Chemical and Materials Engineering, University of Alberta

Cobalt-iron (CoFe) alloys have been intensively studied for use as the core material in hard disk write heads [1]. It has been established that superior soft magnetic properties in thin film CoFe alloys can be achieved by the codeposition of FCC (non-magnetic) and BCC (magnetic) phases. It is theorised that the improved properties are due to the competitive growth between the two phases, which limits the grain size and improves the coercivity of the deposit through the pinning of magnetic domains [2]. Our group has shown that, in addition to these two phases, it is also possible to deposit a cubic metastable phase, with an α-Mn-type crystal structure, when electrodepositing at temperatures above 30°C. The metastable CoFe α-Mn-type phase has a complex structure (58 atoms/unit cell) and has not previously been reported in electrodeposited CoFe films. The presentation will cover the conditions under which this new phase will form and the physical properties it exhibits.

References:

1. P.C. Andricacos, N. Robertson; IBM Journal of Research and Development, 1998, 42(5), 671.

2. G. Herzer; Journal of Magnetism and Magnetic Materials, 1996, 26, 1397.

2:40 PM

Electrodeposition of Sn-Cu and Sn-Cu-Ag solder films from citrate solutions

*Han, Chunfen; Liu, Q.; Ivey, D.G.;*Department of Chemical and Materials Engineering, University of Alberta

Both Sn-0.7wt%Cu (Tm = 231.1°C) and Sn-0.7wt%Cu-3.5wt%Ag (Tm = 216.3°C) are good candidates as Pb-free solders in electronic assemblies. Sn-0.7wt%Cu solder films can be electrodeposited from a simple and "green" solution containing only Sn chloride, Cu chloride and tri-ammonium citrate. Deposit Cu content, for a fixed solution composition, can be controlled by changing the current density and/or the agitation rate. Compositions from 0.5 to 2.5 wt% Cu and plating rates as high as 60 microns/hour are attainable from the same solution. Uniform and dense deposits can be achieved over a wide range of plating conditions.

Silver nano-particles (~100nm in size) were added to Sn-Cu-citrate solutions to electrodeposit Sn-Cu-Ag films. Plating conditions, including current densities, solution Cu concentration and stirring methods were studied. With Ag particles in suspension, the Cu(II)-citrate ions became easier to reduce, resulting in higher deposit Cu contents for Sn-Cu-Ag films than for Sn-Cu films under the same conditions. The differences in deposit Cu contents were less pronounced at higher current densities.

3:00 PM

Effect of deposition variables on the electrical properties of Pt thin films

Jim, Steven; Cadien, Kenneth; Department of Chemical and Materials Engineering, University of Alberta

Platinum thin films are used in Schottky devices (for example, infrared detectors) and in many applications requiring catalysts (including fuel cells). FCC noble metals are also widely used as interconnect materials in semiconductor microelectronics. One of the main obstacles to the future scaling of such devices is the dramatic increase in resistivity (and resultant RC time delay) as metal films (such as copper) enter the sub-100nm thickness regime.

In this presentation, investigations into the electrical properties of magnetron sputter deposited platinum will be presented. The properties of these films were found to exhibit similar scaling trends to copper and to be highly dependent upon deposition conditions (including vacuum chamber base pressure). Finally, suggestions about key deposition data to report along with electrical data will be offered.

3:20 PM

Are we at the bottom yet?

Nychka, John; Cadien, Kenneth; Department of Chemical and Materials Engineering, University of Alberta

In 1959 Richard Feynman gave a talk at the annual American Physical Society entitled "There's Plenty of Room at the Bottom". The theme of the talk was manipulation and control of materials on a small scale and the talk has inspired numerous innovations in micro and nanosystems through Feynman Prizes (and countless other research). Science that is perceived as "nano" is no longer a fashionable new research area, but a reality. Nonetheless, materials behave differently at the nanometer length scale and there are many problems yet to solve in the nanodomain. So we ask the question: "Are we at the bottom yet?" In particular this paper investigates the fundamentals of how sample size affects the analysis of materials and what challenges and opportunities exist.

3:40 PM

Coffee Break

4:00 PM

Nano-particle Doping for Improvement of Superconducting Properties of MgB2 Superconductor

Soltanian, Saeid; Soltanzadeh, M.M.; Wang, X.L.; Dou, S.X.; Department of Physics and research Centre for Nanotechnology, University of Kurdistan; ISEM, University of Wollongong

We report a systematic study on the effect of nanoparticle doping on the phase formation, critical current density, upper critical field and irreversibility field of MgB2 superconductor. Bulk and metal sheathed wires doped with different nanoparticle have been made and heat treated at temperatures ranging from 580 to 1000 °C. Samples are examined by means of transport and magnetic measurement, XRD, SEM, and TEM. Transport and magnetic measurement shows that although Tc slightly decreased in doped samples but doping results in introducing pinning centers effective at high fields and temperatures, and significantly enhancing Jc and Hirr. It is also found that Hc2 increased in doped samples. In order to understand the mechanism, a systematic experiment on the effect of particle size and heat treatment on the samples are also performed. Our finding on the mechanism of enhancement will be presented.

4:20 PM

Electrodeposition of tin-rich, tin-gold eutectic solders for optoelectronic applications

*Watt, Charles; Liu, Q.; Ivey, D.G.;*Department of Chemical and Materials Engineering, University of Alberta

Gold-tin eutectic alloy solders are commonly used for optoelectronic device packaging, because of their excellent combination of mechanical and thermal properties. The industry standard contains 70 at% gold and has a eutectic temperature of 280°C. An alternative to the industry standard could be the other eutectic composition that exists in the gold-tin system. The second eutectic composition is Sn-rich, at a composition of 6.8 at% Au and a eutectic temperature of 217°C. According to Lee and Chuang [1], this composition has suitable properties to be used for packaging applications, and its use would significantly reduce materials costs. Our group has developed a simple and "green" solution consisting of tin chloride and ammonium citrate with suspended gold particles for electrodepositing Sn-rich, eutectic solder films, with uniform thickness and composition. The Sn-rich solder films have then been reflowed to study intermetallic formation and attachment capability of the Sn-rich eutectic solder films.

1.C.C. Lee and R.W. Chuang, IEEE Transactions on Components and Packaging Technologies, 26 (2003) 416-422.

4:40 PM

Ferromagnetic nano-element for information processing devices

Haque, Anis; Department of Electrical and Computer Engineering, University of Calgary

Ferromagnetic nanodots are of great importance because of its enormous applications to logic gate[1], memory, and many others. For information processing devices such as a binary logic gate the output should reliably produce one of the two binary states. The device processes similar binary signals from more than

one input. If a rotating magnetic field is applied on a circular ferromagnetic element, the element, in principle, magnetizes equally in all directions. This type of element is not suitable for the information processing devices. In order to ensure a binary output, the element has to be binary by nature, i.e. it will allow magnetization only in two directions and all other magnetization directions will be forbidden. This work reveals such binary ferromagnetic elements suitable for the information processing devices. A logic gate will be presented and various aspects of these binary elements will be discussed.

Materials for the Energy Industry II

Date: Wednesday, June18
Location: Engineering Teaching and Learning Complex (ETLC) E1-003
Chair: Tom Etsell

2:00 PM

Transition metal-containing carbon nanotubes as catalyst for MgH2 sorption

Shalchi Amirkhiz, Babak; Danaie, Mohsen; Ophus, Colin; Simard, Benoit; Mitlin, David; Department of Chemical and Materials Engineering, University of Alberta

Carbon nanotubes (CNTs) as an additive is shown to have positive effect on hydrogen storage properties of nanocrystalline magnesium hydride. However, the effect of metal particles left from the CNTs production process is often underestimated. To show the catalytic effect of CNTs on MgH2 and to denconvolute the role of transition metal (TM) particles, various mixtures of MgH2/CNT were ball milled for various durations. Using Raman spectroscopy and TEM imaging, we showed that a significant portion of CNT may survive after 1 hour of milling; whereas, after 7 hours, it is completely destroyed. Integral breadth analysis showed progressive reduction in grain size with milling time. DSC/TGA tests revealed that for composites milled for more than 1 hour, where there is no trace of CNT left, the kinetic improvement is less pronounced, although the behavior is still superior to as-milled MgH2 samples. The latter effect is addressed to the catalytic effect of TM particles. The 1 hour milled MgH2/5wt%CNT composite released 4wt% hydrogen within 25 minutes at 300°C and atmospheric pressure. The mechanism through which the kinetics improved is explained via the synergistic effect of CNTs and TM particles.

2:20 PM

Thermal Sprayed Deposition of Yittria Stabilized Zirconia for SOFCs

Starchuk, Nathan; Department of Mechanical Engineering, University of Alberta

As a method of fabricating, dense, zirconia electrolytes for use in high temperature, solid oxide fuel cells, micron-sized (5 - 45 microns) yittria stabilized zirconia (YSZ) particles were deposited onto alumina substrates via air plasma spraying (APS). Plasma spraying is a method of thermal deposition used to heat powdered materials to a semi-molten state, and accelerate them in order to form a surface coating. . Cross-sectional scanning electron microscope (SEM) images of samples were examined to determine the quality of the coatings. SEM micrographs along with IMAGE-PRO software were used to estimate the porosity of the coatings. Four point Van der Pauw tests were also conducted to determine the conductivity of the layers. YSZ coatings deposited onto substrates pre-heated to 300ºC have porosity of 13.8% and specific conductivity of 0.009 S/cm. Macro-cracks were observed through YSZ coatings deposited onto pre-heated substrates, which may have formed during cooling due to different rates of expansion of zirconia and alumina. Thin (~100µm) YSZ coatings were obtained. Results indicate further research is needed to determine parameters to produce fully dense coatings.

2:40 PM

Fabrication and Performance Evaluation of the Composite Cathodes Prepared by the Impregnation Method for Solid Oxide Fuel Cells

Zhang, Qi; Petric, Anthony; Department of Materials Science and Engineering, McMaster University

Wet impregnation has been a widely used technique in the synthesis of heterogeneous catalysts.

The application of the wet impregnation method to fabricate cathodes for solid oxide fuel cells is discussed in the development of Cu1.25Mn1.75O4-YSZ and La0.6Sr0.4Co0.2Fe0.8O3-CGO composite cathodes. A novel structure of nanoparticles in the cathode framework was obtained after the impregnation. XRD results indicated that no second phase was produced during the fabrication process. Electrochemical measurements were carried out to study the dependence of the cathode performance on the microstructure from 600˚C to 800˚C. Enhanced electrochemical performance was observed, compared to the standard La0.8Sr0.2MnO3 cathode.

3:00 PM

Electronic structure of TiO2 nanotube arrays from XANES studies

Zhou, Jigang; Fang, H.T.; Murphy, M.; Ko, Peter; Sham, T.K.; Canadian Light Source, University of Saskatchewan

We report a synchrotron spectroscopy investigation of TiO2 nanotube arrays synthesized with electrochemical method [1] followed by annealing and Li intercalation treatments. Transmission electron microscopy (TEM), high resolution TEM (HRTEM) and XRD of the as-prepared and annealed TiO2 nanotube arrays show that the as-prepared TiO2 formed ordered nanotube arrays, which are amorphous and can be converted to a crystal structure of anatase upon annealing while the nanotube array morphology remains intact [2]. Lithium ions have been electrochemically intercalated into annealed nanotube arrays, which can be discharged electrochemically. X-ray absorption near edge structure (XANES) hasbeen carried out on these samples. XANES at the O K-edge and Ti L3,2-edge show distinctly different spectral characteristics for the as-prepared and the treated nanotube arrays, consistent with the TEM results. This result reflects the change in electronic structure when Li ions are inserted into TiO2 nanotubes. The results and the implications of these techniques to the study nanotube arrays will be discussed.

3:20 PM

The Novel Process Engineering of Thick Thermal Barrier Coating with the combination of Air Plasma Spray (APS) and Chemically Bonded Composite Sol-Gel (CB-CSG)

Yao, Ray; Kim, Hyungkeun; Troczynski, Tom; Materials Engineering, University of British Columbia

For better service life time of Thermal Barrier Coating (TBC), a novel process has been developed with the combination of a traditional Air Plasma Spray (APS) method and an engineered sol-gel method. The engineered sol-gel indicates Chemically-Bonded Composite Sol-Gel (CB-CSG) which is placed with vertically oriented structures between two APS layers. The combination of these two techniques develops a unique Hybrid TBC (HTBC) in terms of its microstructure and compositions, thus introducing a highly porous thick TBC. In addition, it is believed that phosphates (aluminum and/or zirconium phosphates), formed during coating curing and thermal cycling, provide better high temperature oxidation resistance with aluminum phosphates as well as better thermal shock resistance with zirconium phosphates than traditional TBCs. This paper is composed of two parts; Part I currently addressed includes process engineering of HTBC and Part II includes its mechanical and thermal properties.

3:40 PM

Coffee Break

4:00 PM

Crystalline Perfection of Silver Nanoparticles Formed on Chabazite

Liu, Yan; Xu, Zhenghe; Zhu, Zhenping; Feng, Shouai; Kuznicki, S.M.; Yang, Hongqun; Department of Chemical and Materials Enginnering, University of Alberta

Chabazite-supported silver nanoparticles (Ag/MC) were synthesized by ion exchange followed by thermal annealing. Crystalline of silver nanoparticles on Ag/MC during a mercury doping and releasing cycle was investigated by high resolution transmission electron microscopy (HRTEM). Such mercury doping on silver nanoparticles followed by high temperature mercury releasing showed to improve silver crystalline. Based on HRTEM observation, a mechanism of such crystalline perfection was proposed. The Ag/MC demonstrated to be a regenerable mercury sorbent for

high temperature mercury emission control for coal-fired power plant flue gases.

General Topics I

Date: Wednesday, June18
Location: Engineering Teaching and Learning Complex (ETLC) E1-008
Chair: Weixing Chen

2:00 PM
Effect of Surface Conditions on the Corrosion Resistance of Stainless Steel Reinforcing Bars
Anders, Kyle; Hansson, Carolyn; University of Waterloo

Corrosion of plain-carbon steel rebar due to the ingress of chlorides from de-icing salts and marine environments is a major cause of bridge deterioration. Stainless steel rebar is increasingly being used due to its inherently high corrosion resistance and, thus, favourable life-cycle costs. Conventional stainless steel fabrication involves a pickling process where the steel is immersed in a mix of highly toxic hydrofluoric and nitric acids to chemically remove the mill scale after hot rolling. In this study, the corrosion resistance of pickled and non-pickled stainless steel rebar of varying grades in chloride contaminated concrete was compared to investigate if pickling is necessary. In-situ electrochemical microcell and macrocell corrosion monitoring has shown the pickled bars to exhibit less corrosion activity; however despite being in chloride saturated concrete, the corrosion rates of both surface types remain low and typical of passive plain-carbon steel in chloride-free concrete.

2:20 PM
Development of Lead-Free Thermal Fuse Wires Using Ohno Continuous Casting
Bhardwaj, Divya; Department of Materials Science and Engineering, University of Toronto

Due to low melting requirements, thermal fuse wires are made from a combination of bismuth, tin, lead, cadmium or indium. Use of lead or cadmium creates environmental concerns and this provides an incentive to use bismuth, tin or indium alloys. However, alloys with high bismuth concentrations are not easily produced using traditional casting methods since bismuth expands on freezing, is brittle in nature and because of its density, segregates during conventional solidification. Thus the objective of this study is to cast non-toxic bismuth-tin alloy wires using a non-conventional heated-mold continuous casting technique and examine the effect of casting parameters on the microstructure. The mechanical properties of the wires are then evaluated with respect to the microstructure.

2:40 PM
Coke formation and Metal Dusting of Electrodeposited Ni/Cu and Ni/Cu/Al alloy coatings
Cui, Xinwei; Chen, W.; Department of Chemical and Materials Engineering , University of Alberta

Ni/Cu alloy coatings and Ni/Cu alloy matrix-Al particle composite coatings have been successfully developed via Sediment codeposition (SCD) method. Large variation of Cu and Al compositions could be obtained in the alloy coatings. After annealing, Ni/Cu alloy coatings would maintain fcc-Ni/Cu alloy phase; however, Ni/Cu-Al composite coatings would form two phases, Ni/Cu and Ni3Al. Coke formation and metal dusting behaviors of electroplated Ni/Cu and Ni/Cu/Al alloy coatings were studied in 24.4% CO–73.3% H2–2.3% H2O at 650°C for a period of 500h. All alloy coatings shows superior long-term resistance to coke formation and metal dusting to the Fe-Ni-Cr alloy due to alloying of Cu. The effect of Cu has also been discussed.

3:00 PM
Combined Micro-Structural and Compositional Development of Porous Silicon Nitride Ceramics
Gould, Daniel; Quinlan, M.; Plucknett, Kevin; Department of Process and Applied Engineering, Dalhousie University

Investigations into increasing the mechanical behavior of porous ceramics are important to increasing their usefulness. In particular, silicon nitride (Si3N4) ceramics exhibit excellent mechanical properties, even with moderately high porosities. By

controlling the α- to β-Si3N¬4 transformation through sintering additive selection it is possible to develop a ceramic with an improved microstructure and an improved strength and toughness. Several sintering aids have been examined to promote the transformation from α-Si3N4 to β-Si3N4, which can be accomplished while maintaining moderately high porosities at temperatures as low as 1600oC. These sintering aids include lanthanide or Group III element oxides, combined with magnesia (MgO). The incorporation of β-Si3N¬4 seed grains prior to sintering has also been examined in order to promote increased growth of the β-Si3N¬4 grains, as has the use of a bi-modal powder containing differing α-Si3N¬4 particle sizes. The discussion of these microstructural development techniques will involve initial property evaluation using biaxial flexure testing.

3:20 PM

Hydrothermal Decomposition of Concentrated FeCl3 Solutions for the Regeneration of HCl and the Production of Hematite

Hock, Sebastian; Demopoulos, George; Becze, Levente; McGill University

Regeneration of HCl from process solutions is an important unit operation in chloride hydrometallurgy, which is currently accomplished by the highly capital and energy intensive technology of pyrohydrolysis. In the hydrometallurgical laboratory at McGill University, experiments are conducted to transform concentrated aqueous FeCl3 solutions to pure Fe2O3 and high concentration HCl. The process is operated at the boiling point of the solution at ambient pressure. The current research deals with design of an appropriate reactor, optimization of reaction conditions and identification of the hematite products with various advanced characterization techniques. Evaluation of reaction mechanisms during the process and computational analysis by chemical modeling are also considered.

3:40 PM

Coffee Break

4:00 PM

The Influence of Loading on the Corrosion of Steel in Cracked Ordinary Portland Cement and High Performance Concretes

Jaffer, Shahzma; Hansson, Carolyn; Department of Mechanical and Mechatronics Engineering, University of Waterloo

Chloride-induced corrosion of rebars is the major problem encountered in the Canadian infrastructure; however, it is also an issue that has gaps in knowledge. Immediate attention needs to be focused on the effect of cracks on rebar corrosion. A few studies have examined the effect of static cracks; however, many reinforced concrete structures are subjected to variable loads, e.g. those due to traffic. The impact of such loading on cracks and the resulting rebar corrosion was the subject of this investigation.

This study focused on determining the extent of corrosion, corrosion rates, distribution and identification of corrosion products, and crack profiles in cracked reinforced ordinary Portland cement (OPCC) and high performance concretes (HPC) subjected to static and cyclic loading.

The results indicate that corrosion occurred ONLY at the cracks in concrete. Corrosion products diffused into the concrete in OPCC but not in HPC and the crack bifurcated at the rebar level in both concretes.

4:20 PM

Controlling Chemical Reactions in Bioactive Glass with Mechanical Stress

Nychka, John[1]; Li, Ding[2]; Yang, Fuqian[2]; [1]Department of Chemical and Materials Engineering , University of Alberta; [2]University of Kentucky

Bioactive glasses have been used for bone replacement therapies in dentistry and orthopaedic surgery for many decades yet there little understanding how the bioactivity of such glasses is affected by mechanical stresses. Moreover, the effect of mechanical stress on chemical response of bioactive glass (the mechanochemical effect) has not been reported. Our work has focused on inducing residual stresses in bioactive glass and observing changes in the chemical response of the glass in vitro via biomineral formation and electron microscopy. This presentation will cover basic mechanical property evaluation of bioactive glass, residual stress

measurements in glass, in vitro behaviour, and a thermodynamic model for the mechanochemical effect. The major implication of the work is that potential residual stresses from manufacture of bioactive glasses can alter their bioactivity significantly.

4:40 PM

Reliability of Pb-free solder joints under mixed conditions

Kaila, Rishi; Department of Materials Science and Engineering, University of Toronto

The purpose of this study is to study the microstructure formed in solder joints as a result of the mixing of solders having different compositions, in order to evaluate the suitability of the resulting solder joint for use in service. Observations will be made for the purpose of detecting undesirable microstructural features that could lead to joint failure. Microhardness and drop test characteristics of the solder joints will be evaluated. The influence of aging on the microstructure of the mixed solder joints will also be studied. Finally, on the basis of the observations made, a list will be prepared, showing the compatibility or otherwise of the various solder combinations studied.

This study will allow choosing the parameters for successful reflow and rework processes and provide industrial guidance on how to manage through the issues and concerns with incorporating new components in Pb-free and SnPb assemblies.

Characterization I

Date: Thursday, June19
Location: Engineering Teaching and Learning Complex (ETLC) E2-001
Chair: John Nychka

8:20 AM
Characterization of Single Crystal Slip Behaviour in Polycrystalline Mg-Zn Alloys by EBSD and Instrumented Indentation
Diak, Bradley; Decker, Colleen; Department of Mechanical and Materials Engineering, Queen's University

The development of reliable models describing the mechanical behaviour of polycrystalline solids requires measurement and fundamental understanding of single crystal properties. The advent of nano-/micro-indentation techniques has allowed small volumes of materials to be mechanically probed such that single crystal behaviour can be determined from polycrystalline matter. In this study single crystal grains in different dilute Zn containing polycrystalline Mg alloys were probed at room temperature using displacement- controlled micro-indentation. Grain orientation and slip line activity were observed using electron back scattered diffraction (EBSD) and secondary electron imaging in the SEM, respectively. During indentation the strain rate was changed to examine the rate dependence of the hardness in the alloys. Results showed an increase in hardness with increasing Zn content, but also a reduction in the overall strain rate sensitivity. The effects of grain orientation and Zn will be discussed.

8:40 AM
Metallurgical Assesment of a Hypereutectic Aluminum-Silicon P/M Alloy
Heard, David; Bishop, D.P.; Department of Materials Engineering, Dalhousie University

With rising oil prices, there is an increasing pressure on automotive manufacturers to create vehicles with greater fuel economy. This has resulted in broad efforts emphasizing the achievement of reduced vehicle weight, and ultimately improved fuel consumption. Aluminum powder metallurgy (P/M) processes offer the possibility to create high performance, low-density components that are ideal for numerous automotive applications. Alloy development is now viewed as a key step towards the widespread implementation of this technology. One of the newest alloys launched on a commercial scale is Alumix-231 (Al-15Si-2.6Cu-0.6Mg). A detailed metallurgical assessment of this system has been completed. The optimal sintering response of the alloy was identified through the application of thermal analysis techniques (dilatometry and DSC), microstructural analyses, and pilot scale sintering trials. All pertinent processing variables were assessed including the influence of compaction pressure, sintering time, and temperature. The heat treatment response and T6 tensile properties of the sintered product were then determined.

9:00 AM
Comparison of morphological and chemical characteristics of clay minerals in the primary froth and middlings from oil sands processing by high resolution transmission electron microscopy
Hooshiar, Ali; Kaminsky, Heather; Uhlik, Peter; Shinbine, Alyssa; Ivey, D.G.; Etsell, Tom; Liu, Q.; Omotoso, Oladipo; Department of Chemical and Materials Engineering, University of Alberta

Understanding the interaction of clay minerals with bitumen in the oil sands is of great interest in developing water-free or water-reduced bitumen extraction processes. Previous work by Kaminsky et al.[1] has shown, by x-ray diffraction, that there is a difference in clay minerals that partition to the froth stream versus the clays that remain in the middlings. However, x-ray diffraction was insufficient in determining why the different minerals partitioned the way they did. This work examines the clay minerals in each stream by high resolution transmission electron microscopy, combined with energy dispersive x-ray analysis, to examine the characteristic chemical and morphological differences in the clay particles in each stream.

[1] Kaminsky, H.AW, Etsell, T.H., Ivey, D.G., and O. Omotoso, "Characterization of Clay Minerals in Froth, Middlings and Tailings Streams Produced by

Hot Water Extraction of Athabasca Oil Sands", Proceedings of the Processing & Disposal of Mineral Industry Wastes 07, June 14-15, 2007, Falmouth, UK.

9:20 AM

In-situ Neutron Diffraction Study of Annealing of Polycrystalline Magnetic Shape Memory Alloy Ni49.2Mn29.6Ga21.1

Hutanu, Roxana; Swainson, Ian; Gharghouri, Michael; Atomic Energy of Canada Limited

Ni-Mn-Ga magnetic shape memory alloys are smart materials that can exhibit large recoverable strains (up to 10%) when subjected to a magnetic field. Although single crystals have been extensively investigated, there is less work on the behaviour of polycrystalline Ni-Mn-Ga. This paper describes the results of in-situ neutron diffraction step-wise annealing experiments performed on Ni49.2Mn29.6Ga21.1 polycrystalline samples. The composition of the samples was chosen such that the material is martensitic at room temperature; however, the data indicate that at least two phases coexist at room temperature: a monoclinic phase and cubic retained austenite. After the typical martensite/austenite transformation, at much higher temperatures (600-800°C), all the austenite peaks with odd Miller indices gradually disappear and reappear upon cooling. This is indicative of a 2nd order phase transition associated with the reversible austenite/B2' (CsCl) order-disorder transition. This unique behaviour was detected for the first time in this study using an in-situ diffraction technique. Moreover, the B2' phase structure was successfully refined for the first time. The variation of both the austenite and B2' cell size with temperature were also studied.

9:40 AM

Mineralogical composition of streams in oil sands extraction by the hot water extraction process

Kaminsky, Heather; Ivey, D.G.; Etsell, Tom; Omotoso, Oladipo; Department of Chemical and Materials Engineering, University of Alberta

Significant research has been done to examine the composition of different streams produced by the hot water extraction process[1]. However, very little work has been published showing how the minerals are distributed around the extraction process. This work takes a single ore and details how the minerals partition to the froth and tailings streams after batch extraction. Size separation, x-ray fluorescence analysis, and x-ray diffraction combined with quantification by the Rietveld method, are used to provide a detailed breakdown of how elements and minerals are affected by the hot water extraction process. Key results include the observation that while titanium is enriched in the froth the majority of the titanium is found in the <45µm size fraction. Also enriched to both the froth and the <45µm size fraction is iron, found primarily as very fine iron oxides and iron oxide-hydroxides.

[1] Alberta Chamber of Resources (1996) Mineral Developments Agreement Co-Products Study, Final Report.

10:00 AM

Coffee Break

Materials Modeling

Date: Thursday, June19

Location: Engineering Teaching and Learning Complex (ETLC) E1-018

Chair: Hao Zhang

8:20 AM

A Computational Study of Elastic Effects on Phase Transformations

Greenwood, Michael; Hoyt, J.; Provatas, N.; Department of Materials Science and Engineering, McMaster University

Computational processes are used to study pattern formation. Multi-scale modeling can be challenging, the use of computers to simulate real growth processes can require an inordinate amount of time and memory resources if done inefficiently. However there are computational solutions to arise at answers both more quickly and with less memory and computing power. A model for solid-state transformations and elastic effects will be introduced. A competitive growth process between surface tension effects and coherent elasticity allows an examination of the transition from

surface dominated to elastically dominated dendrites by changing the effective strength of each respectively. Side branching of the dendrites, normally suppressed by surface tensions, can be magnified by an A-T-G type instability.

8:40 AM

Slope Selection and Step Edge Topology in Epitaxial Growth on Patterned Surfaces

Jones, Aleksy; Ballestad, Anders; Rottler, Joerg; Tiedje, Tom; Department of Physics and Astronomy, University of British Columbia

In order to understand the effect of atomic scale processes in controlling macroscopic shapes in epitaxial crystal growth, we have performed kinetic Monte Carlo simulations of the epitaxial growth process. Step edge potential barriers (Ehrlich-Schwoebel or ES barriers) are a well-known example of an atomistic property which has an important effect on macroscopic surface morphology. In the case of GaAs, epitaxial growth is found to be stable, suggesting an inverse ES barrier. In this talk, I will discuss our research into crystal surface morphology during growth with inverse ES barriers. Performing kMC simulations of growth on vicinal surfaces, we find a "magic slope" with a step density minimum. The origin of this minimum lies in the fact that arrays of straight step edges are more efficient at capturing incoming adatoms than step edges in the form of closed loops. We show that the step density minimum leads to a preferred macroscopic slope similar to a crystal facet but with a different physical origin.

9:00 AM

A Monte Carlo Simulation of Recrystallization in the Heat Treatable Aluminum Alloy AA6111

Sepehrband, Panthea; Esmaeili, Shahrzad; Department of Mechanical and Mechatronics Engineering, University of Waterloo

Microstructural evolution during recrystallization of an overaged and cold rolled AA6111 aluminum alloy is simulated using a Monte Carlo technique. The simulation is run on a hypothetical overaged and deformed structure which contains large second phase particles, as well. To generate a realistic deformed microstructure, a heterogeneous distribution of stored energy is introduced by allocating high levels of deformation around large particles and assigning a gradient of stored energy within individual grains. Recrystallization behaviour is subsequently simulated based on the competition between recovery and the nucleation of recrystallization, as well as the pinning effect of precipitates on the growth of nuclei. The results of the simulation and the predicted values for the volume fraction and size of the recrystallized grains in the annealed alloy are compared with the existing experimental data in the literature.

9:20 AM

Grain Boundary Migration in Σ5 [001] Twist Boundary: Molecular Dynamics Study

Yan, Xinan; Zhang, Hao; Department of Chemical and Materials Engineering, University of Alberta

Polycrystalline materials can be viewed as a composite of perfect crystal grains separated from one another by a thin grain boundary region. These boundary regions crucially influence both material function and structural integrity. Grain Boundary migration is one of the most important processes that determine the materials properties during thermal mechanical processing. While grain boundary migration has been extensively studies in tilt boundaries, little was known in twist boundaries. In this study, we employed molecular dynamics (MD) simulation to investigate the grain boundary migration in a Σ5 [001] twist boundary in nickel, as described using embedded atom method. A series of MD simulations were performed to determine the temperature dependence of grain boundary mobility and the activation energy for grain boundary migration. Simulations showed that the migration in twist boundary was different from that in tilt boundaries. Possible mechanisms that cause the difference will be discussed.

9:40 AM

Molecular dynamics simulation of tensile deformation of Cu in twin-boundary and grain boundary

Yue, Lei; Li, D.Y.; Department of Chemical and Materials Engineering, University of Alberta

The difference in the effectiveness of blocking dislocation movement between grain boundary and

twin boundary was computationally investigated using a molecular dynamics simulation model. Effects of twin boundary and grain boundaries on the tensile behavior of Cu along [111] direction was simulated with an interatomic potential obtained using the Embedded Atom Method (EAM). It was demonstrated that a single twin boundary resulted in a resistance to dislocation movement that was approximately 10% higher than a single grain boundary. Besides, the resistance of a grain boundary to the dislocation movement decreased with an increase in the vacancy density at the grain boundary, resulting in decreases in overall ultimate strength and ductility.

10:00 AM
Coffee Break

10:20 AM
Particle settling and homogeneity of WC-based MMCs deposited by plasma transferred arc welding
Wolfe, Tonya; Henein, H.; Department of Chemical and Materials Engineering, University of Alberta

Tungsten Carbide (WC)-based Metal Matrix Composite (MMC) coatings are deposited by Plasma Transferred Arc Welding (PTAW) on production critical components in oil sands mining. Homogenous distribution of the WC reinforcement particles is desirable for optimal wear resistance in order to increase equipment lifespan and reduce unplanned maintenance shutdowns. A model of the settling profile of the coatings is developed and compared to coatings produced by PTAW. The optimal conditions for achieving a homogeneous coating are identified.

10:40 AM
Phase Transformation during Hot Strip Rolling of a Nb-Mo Complex-phase Steel
Sarkar, Sujay; Militzer, Matthias; Poole, W.J.; Department of Materials Engineering, University of British Columbia

Complex-phase (CP) steels are an integral part of new generation advanced high strength steels aimed to be used in the automotive sector. The CP microstructure is characterized by a complex mixture of fine ferrite, bainite and martensite, which is further strengthened by fine micro-alloyed precipitates. In order to achieve the desired complex microstructure it is crucial to investigate the microstructural evolution of the steel during hot rolling. In the present study an important metallurgical phenomenon, namely austenite decomposition during run out table cooling has been studied under laboratory simulated hot strip mill condition for a model CP steel (0.05C-1.9Mn-0.5Mo-0.05Nb). The austenite decomposition is studied by performing continuous cooling transformation tests on pre-deformed samples (retained strain of 0.6) under no recrystallization condition. The resulting microstructures are in general a combination of ferrite, bainite and martensite/retained austenite. Based on the experimental investigations, the start of ferrite formation is described by the early growth of corner nucleated ferrite, where a limiting carbon concentration concept is postulated above which ferrite formation ceases. The Johnson-Mehl-Avrami-Kolmogorov (JMAK) approach adopting additivity is employed to describe ferrite as well as bainite growth. Suitable modifications are incorporated into the model to account for transformation stasis.

Wear/Tribology

Date: Thursday, June19
Location: Natural Resources Engineering Facility (NREF) 2-090
Chair: Dongyang Li

8:20 AM
Characterization of the wear of PEEK, a cervical implant material
Austin, Heather; Harper, Megan; Medley, John; Department of Mechanical and Mechatronics Engineering ,University of Waterloo

Polyetheretherkeytone (PEEK) has some advantages as a material for fabricating articulating cervical disc implants. It does not interfere with postoperative imaging of the neural structures of the spine and it is known to be wear resistant thus reducing the risk of an adverse immune response to wear particles that can kill bone around an implant,

leading to loosening and eventual revision surgery. The present study characterized the wear of a PEEK-on-PEEK configuration in the presence of a protein-containing fluid using a pin-on-plate apparatus, thus completing a first step in the design of a viable cervical disc implant made from PEEK.

8:40 AM

Effects of titanium addition on microstructure and wear resistance of hypereutectic high chromium cast iron Fe-25wt.%Cr-4wt.%C

Chung, Reinaldo; Tang, Xinhu; Hinckley, B.; Dolman, K.; Li, D.Y.; Department of Chemical and Materials Engineering, University of Alberta

The microstructural refinement generally helps to increase the wear resistance of materials. Attempt was made to refine the microstructure of a hypereutectic high chromium cast iron (Fe - 25 wt.% Cr - 4 wt.%C) by adding titanium (up to 6 wt.%), which is often used as inoculant for microstructural refinement. Ingot samples were produced in an arc furnace by melting pieces of the cast iron with titanium powder. Microstructures of the samples were examined by optical microscopy, scanning electron microscopy, energy dispersive x-ray spectrometry and x-ray diffraction. It was demonstrated that the added titanium did not act as inoculant for refinement of high chromium primary carbides. However, as titanium amount was increased, the cast iron changed from hypereutectic microstructure to hypoeutectic one due to depletion of carbon in the matrix caused by the formation of titanium carbides. When 2 wt.%Ti was added, a finer microstructure was achieved, which corresponded to the eutectic structure with chromium carbides and titanium carbides. The eutectic structure exhibited the highest wear resistance and hardness.

9:00 AM

The resistances of Fe-Cr-C alloys to corrosion, wear and corrosive wear

Tang, Xinhu; Chung, Reinaldo; Li, D.Y.; Dolman, K.; Hinckley, B.; Department of Chemical and Materials Engineering, University of Alberta

The resistances of a series of Fe-Cr-C alloys respectively to corrosion, wear and corrosive wear were evaluated. Microstructures of the alloys were examined using XRD and SEM/EDX; efforts were made to correlate the microstructures to their resistances to corrosion, wear and corrosive wear. It was demonstrated that the corrosion resistance of the alloys largely depended on the matrix composition, while the wear resistance was dominated by the volume fraction and shape of carbides in the alloys. According to obtained corrosion maps, the centers of the high corrosion region are sensitive to %carbon, %chromium and corrosive environment, which may provide a guide for selecting/designing optimal Fe-Cr-C alloys for specific applications. The corrosive wear tests were performed using a pin-on-disc tribometer. The mechanism responsible for variations in the corrosive wear resistance as a function of carbon and chromium concentrations as well as the corrosive environment will be discussed in this talk.

9:20 AM

Coating of adherent diamond on transitin metal substrate

Li, Yuanshi; Tang, Yongji; Yang, Q.; Hirose, A.; Plasma Physics Lab, University of Saskatchewan

Coating high quality diamond on the transition metal substrates, including elemental Fe, Co, Ni and their alloys and compounds such as steels, superalloys and WC-Co hard metals has been very difficult, primarily due to the technical obstacles of low nucleation density and poor adhesion of diamond. We have explored the feasibility of coating high quality diamond on transition metals by means of modifying the matrix with certain types of alloying elements, by applying surface pretreatment process or developing high performance low-cost intermediate materials. Surface modification/functionalisation of the conventional low-cost transition metals with newly developed diamond materials can offer cost-effective application opportunities. We will demonstrate our recent achievements in their improved corrosion/wear applications.

9:40 AM

Ion Beam Etching Diamond Surface for Anisotropic Friction Coefficient

Tang, Yongji; Yang, Q.; Li, Y.S.; Hirose, A.; University of Saskatchewan

Anisotropic friction coefficient is highly desirable for many applications in surface engineering. However,

this has not been achieved up to now. It is well accepted that the friction coefficient of materials is strongly affected by their surface structure. Control of the surface structure may lead to the control of friction coefficient. In this research, Ar+ ion beam etching is employed to nanostructuring the surface of CVD microcrystalline diamond on Si wafers. The effect of Ar+ ion etching and ion energy on the surface structure was investigated. The results show that well aligned diamond nanotips can be obtained and the orientation of the nanotips can be controlled by adjusting the ion beam direction. Anisotropic friction coefficient was achieved through the control of diamond nanotip orientation.

10:00 AM
Coffee Break

10:20 AM
Chemical characterization of antiwear film on 52100 steel using X-ray absorption near edge structure (XANES) spectroscopy
Zhou, Jigang; Thompson, J.; Cutler, J.; Kasrai, M.; Bancroft, M.; Yamaguch, E.S; Canadian Light Source, University of Saskatchewan

X-ray absorption near edge structure (XANES) spectroscopy at the S, P, O, N, B, Fe, and Zn edges were used to investigate the interactions of zinc dialkyldithiophosphate (ZDDP) and different oil soluble dispersants. Antiwear films were generated from mixtures of ZDDP and dispersants on 52100 steel in a pin-on- disk configuration under boundary lubrications conditions. The wear performance of the oil blends was measured using the wear scar width (WSW) on the pin. XANES measurements using total electron yield (TEY) and fluorescence yield (FY) allowed us to identify the chemical nature of the above elements in the surface and the bulk of the antiwear films. Based on these results, the antiwear properties of these oils have been correlated with the chemistry of the antiwear films on the steel substrate. These results will be presented in detail.

10:40 AM
Synergism of erosion and corrosion of aluminum alloy in ethylene glycol-water solution
Cheng, Frank; Zhang, Guoan; Xu, Luyao; Department of Mechanical Engineering, University of Calgary

Aluminum (Al) alloys are prone to erosion-corrosion (E-C) in automotive coolant, such as ethylene glycol, especially in the contaminated coolant with presence of sand particles. In this work, an impingement jet system was used to study E-C of 3003 Al alloy in ethylene glycol-water solution. The synergism of corrosion and erosion to the total E-C rate of Al alloy was investigated and quantified. Al E-C is dominated by erosion components, i.e., pure erosion and corrosion-enhanced erosion, which account for 92% - 97% of the total E-C rate under the various conditions. Contribution from corrosion components, including pure corrosion and erosion-enhanced corrosion, is slight and even negligible. Passivity of Al that develops in static solution cannot be maintained under fluid flow, where an activation mechanism dominates the corrosion process. The effect of fluid impact angle on Al E-C depends on the competitive combination of normal stress and shear stress.

Characterization II

Date: Thursday, June19
Location: Engineering Teaching and Learning Complex (ETLC) E2-001
Chair: John Nychka

1:00 PM
Precipitate characterization in microalloyed steels
Lu, Junfang; Ivey, D.G.; Henein, H.; Wiskel, J.B.; Omotoso, Oladipo; Department of Chemical and Materials Engineering, University of Alberta

Microalloyed steels have good strength, good toughness and excellent weldability. They are a class of high strength, low carbon steels containing small additions (in amounts less than 0.1 wt%) of Nb, Ti and/or V. The steels may contain other alloying elements, such as Mo, in amounts exceeding 0.1wt%.

Precipitation in these steels can be controlled through thermomechanical controlled processing, leading to precipitates with sizes ranging from several microns to a few nanometers. The larger precipitates are essentially TiN, with partial substitution of Nb for Ti, while the smaller precipitates are based on NbC, with Ti, Mo or V partially substituting for Nb and N partially substituting for C. The nano-sized carbides and carbonitrides are important for precipitation strengthening.

The precipitate size, morphology and chemistry were characterized by scanning/transmission electron microscopy (SEM/TEM) based on carbon extraction replicas. Significant quantities of precipitates of different sizes are collected by means of matrix dissolution from relatively large volumes of material, in order to quantify volume fractions. The crystalline phases of these collected precipitates were identified by X-ray diffraction (XRD). A comparison in terms of size, morphology, chemistry and relative amount of the precipitates was made for a series of microalloyed steels and will be presented.

1:20 PM
Aqueous Colloidal Processing of Bimodal Barium Titanate Powders
Munro, Cameron; Plucknett, Kevin; Department of Materials Engineering, Dalhousie University

Colloidal processing of bimodal mixtures of barium titanate powders is here investigated in terms of both processing characteristics and achievable solids content. Two high purity powders of near monomodal particle size distribution with an average size ratio of 5:1 were studied. Each powder was characterized to determine particle size distribution, crystalline phase and surface area using acoustic attenuation spectroscopy, x-ray diffraction and nitrogen adsorption, respectively. The stability of aqueous suspensions of each powder was determined using sedimentation tests, zeta potential analysis, and rheological measurements. Each test covered a wide range of pH conditions and employed a polyelectrolyte deflocculant, an ammonium salt of poly(methyl methacrylate) (PMAA-NH4). Based on the deflocculant concentrations necessary for stability bimodal slips were prepared, displaying lower viscosity when 20-30% fines were used. Slip cast and sintered samples demonstrated enhanced density when 30% fines were incorporated.

1:40 PM
XAS and XRD Study of Reactivity in Particulate Aluminum Alloy MMCs
Uju, Williams; Oguocha, Ike; Department of Mechanical Engineering, University of Saskatchewan

Particle-reinforced aluminum metal matrix composites (MMCs) are usually reinforced with ceramic particles such as titanium carbide, alumina and silicon carbide to improve their mechanical, wear and thermal properties. However, these particles induce chemical reactions which ultimately affect the mechanical, chemical and electrical properties of the MMCs. In the present work, reactivity in Al-Cu-Mg alloy AA2618 MMCs reinforced with 10 and 15vol.% alumina was investigated using X-ray Diffractometry (XRD) and synchrotron X-ray Absorption Spectroscopy (XAS). High-purity aluminum, α-alumina and spinel were used as reference materials. The results obtained showed evidence of charge redistribution in the aluminum in AA2618 composites. The population of p-orbital electrons in AA2618 increased, thereby indicating that the electrical conductivity of the alloy decreased with the addition

of alumina. It was also shown that spinel is the dominant reaction product in the MMCs, and that its presence could be verified using both XRD and XAS.

2:00 PM

Characterization of microstructural features in microalloyed steels using quantitative X-ray diffraction

Li, Xiujun; Ivey, D.G.; Wiskel, J.B.; Henein, H.; Omotoso, Oladipo; Department of Chemical and Materials Engineering, University of Alberta

The mechanical properties of microalloyed steels are highly affected by the microstructure – especially subgrain size, microstrain, dislocation density and texture. The work presented here examines the use of quantitative X-ray diffraction (XRD) (Rietveld method) to characterize these features in microalloyed steels. This technique was then applied to quantify the microstructures for four X80 pipeline steels and three experimental X100 steels. Measurements were made at the surface and several positions below the surface. The highest dislocation density and finest subgrain size were obtained on the outer pipe surface. X100 steels were observed to have finer subgrains, higher microstrains and higher dislocation densities, which are attributed to different processing parameters during manufacturing. The subgrain size value increased and dislocation density decreased with increasing interrupted cooling temperature.

General Topics II

Date: Thursday, June19
Location: Natural Resources Engineering Facility (NREF) 2-090
Chair: Weixing Chen

1:00 PM

Potential Oscillations of Nickel Containing Stainless Steel in Sulfuric Acid

Jones, Stephen; Coley, K.; Ives, B.; Department of Materials Science and Engineering, McMaster University

Sulfuric Acid is the largest tonnage industrial chemical produced. In order to improve efficiency and product quality, more corrosion-resistant matierals are needed. The study of nickel-containing stainless steel in concentrated sulfuric acid is of particular interest due to the unique oscillatory behavior exhibited by these alloys. The work of J. Kish and Y. Li was instrumental in proposing a mechanism and developing a model which explains this unusual behavior. Recent experimental results suggest that by modifying this model better agreement may be made with the actual behavior. A comparison between the old model and the newly proposed model will be discussed, as well as supporting and conflicting evidence. Finally the model will be used as a basis to explain the dependence of the oscillatory behavior on the compositional alloying of the steel.

1:20 PM

Effect of Laser Deposition Processing on the Phase Transformation and Mechanical Properties of Fe-Ni Alloys

Rasti, Negar; University of Waterloo

This study is a survey on the effects of laser deposition of different materials on the physical and mechanical properties of Fe-Ni alloys. The two transformations forming under the effect of the laser beam are categorized as: solidification and solid-state. Different issues, which are effecting the phase transformation and the microstructure of the material, are investigated. These include; the effect of deposition method on the intensity of the material and dissolution of powders, and the effect of the composition of powders on the property of FGM and the fracture of the material. The effect of solidification rate on the Ferrite to Martensite phase transformation is also investigated. Controlling the number of laser pulses and energy of the laser processing is depicted, which shows that the process has a desired transformation. The Oxidation of the interface surface can be controlled by the method of deposition and the type of the transformation.

1:40 PM

Effect of Alloying Elements on the Passivation of Copper-Nickel Alloys in a Marine Environment

Taher, Abulmaali; Kipouros, G.J.; Department of Processes Engineering and Applied Sciences, Dalhousie University

Copper-nickel alloys have been used in many applications in marine environments, because of the excellent corrosion and biofouling resistance. In this study, the effect of alloying elements on the corrosion behaviour of 90% copper-10% nickel alloys in natural sea water and in artificial saline solutions (containing 2.86% NaCl and 0 ppm or 2260 ppm sulphate) was investigated. Experiments were performed on a commercial copper-nickel alloy C70600 to serve as a reference point for the synthetic alloys. New copper-nickel alloys were prepared in an induction furnace, in an argon/7% vol. hydrogen atmosphere in cylindrical boron nitride crucibles and were homogenized at 950oC for 10 hours in the same protective atmosphere. The electrochemical behaviour was investigated by cyclic polarization (CP), linear polarization (LP), cyclic voltammetry (CV), Tafel extrapolation (TE) and electrochemical impedance spectroscopy (EIS). Corrosion products that formed on the surface were characterized using field emission scanning electron microscopy (FE-SEM), X-ray diffraction (XRD), energy dispersive spectroscopy (EDS), electron probe microanalysis (EPMA), and wavelength dispersive spectroscopy (WDS).

2:00 PM

The role of chloride and fluoride on corrosion behavior of CoCrMo orthodontic materials

Wang, Luning; Luo, Jingli; Department of Chemical and Materials Engineering, University of Alberta

CoCrMo can be applied as orthodontic implant materials for an increasing extent, crowns and bridges. The influences of fluoride and chloride ions on the corrosion behavior of nearly equiatomic CoCrMo orthodontic materials were studied using electrochemical measurement methods, including corrosion potential, potentiodynamic measurements. In addition, scanning electron microscopy was employed to observe the surface morphology before and after the test. All the electrochemical parameters are analyzed based on the sample standard deviations. The results indicated that CoCrMo is primarily susceptible to general corrosion when exposed to a solution containing chloride or fluoride ions. Furthermore, the synergistic effect of equiatomic fluoride and chloride ions on corrosion of CoCrMo alloy is also discussed.

2:20 PM

Evaluation of the Al-Zn binary alloy system for foaming via powder metallurgy

Lafrance, Maxime; Jalilian, F.; Drew, R.A.L.; McGill University

The Al-Zn alloy system was selected in an effort to reduce the foaming temperature of conventional Al foam and its potential for producing foams in the semi-solid region of the phase diagram. The foams are produced by means of powder metallurgy, starting with the hot compaction of an elemental powder mixture along with a blowing agent (TiH2) which releases hydrogen into the melt once it's heated to foaming temperature. The idea of the study is to observe the effect of varying the foaming temperature and alloy composition (low and high) on the drainage, collapse and quality of the foam structure. Results show that at higher Zn concentrations the foaming temperature can be reduced significantly in comparison to pure Al foams created at elevated temperatures. The results at higher Zn concentrations also show a fair pore distribution at these lower temperatures.

Pipeline Materials Issues

Date: Thursday, June19

Location: Engineering Teaching and Learning Complex (ETLC) E1-018

Chair: Reg Eadie

1:00 PM

Microscopic investigation and quantification of interactions of hydrogen, stress and anodic dissolution at crack-tip during pipeline SCC

Cheng, Frank; Li, Moucheng; Tang, Xiao; Department of Mechanical Engineering, University of Calgary

It has been acknowledged that there is a synergistic effect of hydrogen and stress on localized

anodic dissolution at crack-tip in near-neutral pH stress corrosion cracking (SCC) of pipelines. In this research, micro-electrochemical measurement techniques were used to characterize the localized dissolution mechanism and kinetics of pipeline steel under condition that is relevent to near-neutral pH SCC of pipelines. The effect of hydrogen on anodic dissolution reaction was determined and quantified experimentally and mechanistically. Moreover, local dissolution events of steel were characterized in the presence of both hydrogen and stress to determine their synergism in local anodic dissolution. Stress field distribution around the crack-tip was calculated by finite element method and the local electrochemistry of steel ahead the crack-tip was measured. It is anticipated that this research provides a comprehensive understanding of mechanism and quantitative prediction of near-neutral pH SCC of pipelines.

1:20 PM

Digital imaging technique for strain measurement in ERW pipe forming process

Deng, Hua; Wiskel, J.B.; Ben-Zvi, Amos; Rieder, M.D.; Henein, H.; Department of Chemical and Materials Engineering, University of Alberta

To understand the strain history at different stages during ERW pipe forming process, a non-invasive digital imaging procedure has been successfully developed. From digital images obtained during the forming process, discrete spatial data of the object profile was acquired. A fifth-order B-spline curve, with the optimal number of control points, was then applied to obtain a continuous profile. The weight of the B-spline function is calculated by using linear least square regression. The deformation strains were calculated from the curvature of the continuous profile, and a local averaging approach is applied to smooth the fluctuations of the calculated curvature of B-spline curve. The veracity of this procedure was confirmed by validating against strain gauge data. The global forming history was visualized in a 3D transverse strain contour plot.

1:40 PM

Stress Corrosion Cracking Initiation on Oil and Gas Pipelines

Eslami, Abdoulmajid; Fang, B.; Chen, W.; Department of Chemical and Materials Engineering, University of Alberta

A new testing setup was designed to simulate the actual near neutral pH stress corrosion cracking initiation under the disbanded gap formed in polyethylene tape coated pipelines. Different simulations for various environmental and loading conditions were performed. Large changes in pH, potential and corrosion conditions were found to occur within the disbanded gap and under cathodic protection. Pitting corrosion in terms of number and size of pits was found to be most severing at locations where cathodic protection was nearly diminished, and not at locations completely free of cathodic protection as previously believed. Crack like features which were elongated in the direction perpendicular to the loading axis, were formed at locations with the highest susceptibility to pitting corrosion. Increasing either the cyclic peak stress and/or the testing time increased the size and number of these elongated crack like defects.

2:00 PM

Infrared Temperature Characterization of a Steel Strip during TMCP of Line Pipe Steel

Jefferies, Carol; Wiskel, J.B.; Henein, H.; Department of Chemical and Materials Engineering, University of Alberta

This study investigated the surface temperature of a steel strip during TMCP (thermo mechanical controlled processing) following laminar cooling using an infrared camera. The strip temperature was observed to vary along the length and across the width of the steel strip but the average strip temperature compared favourably to the process target temperature. The extent of surface oxidation on the strip was found to strongly affect the infrared temperature readings. Using this information a qualitative assessment of the degree of oxidation on the steel strip was undertaken.

2:20 PM

Crack Growth Behaviors and Mechanisms of Pipeline Steel in Near Neutral pH Environments with Ca^{2+} and HCO^{3-} Ions under Cyclic Loading

Wang, Haishan; Eadie, Reg; Chen, W.; Fang, B.; Department of Chemical and Materials Engineering, University of Alberta

There is increasing evidence that near neutral pH (NNpH) stress corrosion cracking (SCC) may be corrosion fatigue. With this knowledge, crack growth behaviors and mechanisms have been investigated in NNpH environments with Ca2+ and HCO3- ions under cyclic loading conditions. The results show that relatively higher crack growth rates can be found in the solutions with lower pH values, which are related to lower HCO3- concentrations when the composition of purging gas is the same for the solutions and the loading conditions are not very aggressive. The results also show that the effect of Ca2+ ions on crack growth behaviors is related to the concentration of Ca2+ ions. The roles of anodic dissolution and hydrogen in NNpH SCC have been discussed. It is found that the roles of anodic dissolution and hydrogen in crack growth behaviors might change due to the change of the environments and/or loading conditions.

2:40 PM

Analysis of anisotropy behavior in UOE forming for X80 HSLA steel

Moeinifar, Sadegh; Kokabi, A.H.; Madah Hoseini, S.H.R.; Azad University

Anisotropy can potentially affect the integrity of the line pipes, such as their buckling and collapse resistance.Tensile and impact fracture toughness samples selected from 90 and 180 degrees of pipe in longitudinal and transverse directions. The microstructures of the rolled plate have a fine acicular ferrite microstructure with some (M/A) that dispersed in the matrix phase.Tensile properties in 90? (transverse) are highest. Yield strength is about 6% higher that before UOE forming. Minimum amount of charpy impact appears in 90?(transverse) that amount of toughness decrease is about 5.5% in this orientation. Test temperature decrease from 0 ?C to -50?C show toughness impact energy decrease about 0.4-0.9% related to degree and orientation of samples. Therefore impact fracture toughness in all degree and orientation low dependent to decrease in temperature up to -50 ?C in X80 HSLA steel after UOE forming.

Poster Session

Date: June18-19
Location: Engineering Teaching and Learning Complex (ETLC) Solarium (2nd Floor)
Chair: Adrian Gerlich

P.1 Cancelled
PEEK for articulating implants to replace discs in the cervical spine?

Austin, Heather; Harper, Megan; Medley, John; Department of Mechanical and Mechatronics Engineering ,University of Waterloo

Polyetheretherkeytone (PEEK) has some advantages as a material for fabricating articulating cervical disc implants. It does not interfere with postoperative imaging of the neural structures of the spine and it is known to be wear resistant thus reducing the risk of an adverse immune response to wear particles that can kill bone around an implant, leading to loosening and eventual revision surgery. The present study characterized the wear of a PEEK-on-PEEK configuration in the presence of a protein-containing fluid using a pin-on-plate apparatus, thus completing a first step in the design of a viable cervical disc implant made from PEEK.

P.2
Fatigue properties of an extruded AM30 alloy

Begum, Sanjida[1]; Chen, D.L.[1]; Xu, S.[2]; Luo, Alan[3]; [1]Department of Mechanical and Industrial Engineering, Ryerson University; [2]CANMET-Materials Technology Laboratory, Natural Resources Canada; [3]General Motors Research and Development Center, Warren,

Rising concern about global warming that is heavily affected by vehicle emissions can be effectively diminished via the reduction of vehicle weight. The lightweight feature, high strength-to-weight ratio and good damping capacity have exposed magnesium alloys more desirable than conventional structural materials – steel and aluminum. To speed up the application of magnesium alloys and increase productivity, AM30 alloy with better formability has recently been developed. However, there is a lack of fatigue resistance of this alloy. This study is, therefore, to evaluate the fatigue behavior of AM30 magnesium alloy. Tensile tests show that the alloy shows a higher strain hardening exponent at lower strain rates. Strain controlled fatigue tests are conducted at different strain amplitudes. Similar to AZ31 alloy, cyclic strain hardening is stronger than the monotonic strain hardening. Asymmetric hysteresis loops are observed at higher strain amplitudes. Fatigue crack initiation and propagation are examined. Details will be presented.

P.3
Chemical Modifications of a Commercial Aluminum Powder Metallurgy Alloy

Boland, Christopher; Caley, W.F.; Kipouros, G.J.; Bishop, D.P.; Department of Process Engineering and Applied Science, Dalhousie University

As fuel consumption in automobiles becomes a growing concern, industry is looking to reduce vehicular weight. The expanded use of engine components fabricated through aluminum powder metallurgy (P/M) is an effective way to accomplish this. Although, there are aluminum P/M alloys designed with this intention, inadequate mechanical properties can be an area of concern. The additions of hard ceramic or metallic powders to existing commercial P/M alloys have the potential of increasing both tensile and wear properties, without significant alterations to current industrial practice. To investigate this possibility, a number of additions (SiC, AlN, Ni, Si) were blended into an existing industrial alloy premised on the Al-Cu-Mg-Si system. Samples were then uniaxially compacted at various pressures and sintered in a controlled atmosphere. The powder flow rate, apparent, green and sintered densities, green strength, overall sintering response, and tensile behaviour were then assessed for each commercial variant. Preliminary results have indicated that select additions yield considerable gains over the unmodified commercial standard.

P.4

The effect of mask materials and pattern density of through silicon via plasma etching

Luo, Jai; Cadien, Kenneth; Department of Chemical and Materials Engineering, University of Alberta

Through silicon via (TSV) etching is considered an essential part of the current scheme for 3D integration of micro-electronics, micro-fluidics, and micro-optics. 3-D integration enables different electronic device architectures and fabrication processes to be integrated by stacking dies and interconnecting them by copper filled TSV.

In this research, we will be investigating the effect of novel masking materials on TSV cryo plasma etching. As part of this work a mask has been developed which enables the measurement of the effect of the etch and mask material on pattern density as well as via size . In this poster we will show the following: 3D integration, TSV, Cryo plama etching, mask design, and preliminary results.

P.5

Copper chemical mechanical polish (CMP)

Nolan, Lucy; Cadien, Kenneth; Department of Chemical and Materials Engineering, University of Alberta

In copper CMP, a rotating, polymer-based pad is pressed against the metal surface layer on a silicon wafer. The controlled removal of the polished layer and surface planarization is achieved by introducing a chemically active slurry. CMP is a complex chemical and mechanical process that depends heavily on numerous parameters, such as the slurry chemicals, their concentration, and solution pH; the type, charge, size, and concentration of the abrasive particles used in the slurry; the concentration of oxidizers, surfactants, corrosion inhibitors, and buffering agents; the pad material, topography, and design; and the physical, mechanical, and thermal properties of the pad.

In copper CMP, copper and copper diffusion barrier materials are removed and process stops on the interlayer dielectric. High purity copper is a difficult materials to polish due to its softness, susceptability to mechanical defects, and its inability to form a stable protect oxide surface layer. In this poster we will discuss how copper CMP works and research approaches to copper CMP slurry development.

P.6

The Preparation and Characterisation of a Calcium Phosphate-Polycaprolactone Biocomposite

Smith, Reginald; Dunkley, Ian; Department of Mechanical Engineering, Queen's University

The current treatment options for patients suffering from collapsed, damaged or degenerative discs in the vertebral column have a poor short term success rate and can lead to long term problems due to the implants persistence in the body. A significant improvement on the available implant options could be made with the incorporation of advanced biomedical materials engineered specifically to possess the appropriate biological and mechanical properties to meet the clinical requirements for fusion of the cervical vertebra. A composite in which a polymer's processability and controllable degradation complements the ceramics osteoconductivity would provide for an ideal biomaterial for use in this load-bearing orthopaedic application should it possess adequate mechanical performance. The methodology by which a primarily mineral, ceramic-polymer biocomposite may be prepared is detailed as well as the effect of composite composition on density, closed porosity, bending strength and compressive strength.

P.7

Gas Phase Aluminizing of a Nickel-Base Superalloy by a Single-Step HTHA Aluminizing Process

Eslami, Abdoulmajid; Arabi, H.; Rastegari, S.; Department of Chemical and Materials Engineering, University of Alberta

In this research the surface of Ni-base superalloy GTD-111 was coated by a single-step HTHA gas phase aluminizing process using different powder mixture compositions. On the base of observation made on the microstructures of the coating the mechanism of coatings formation was established.

Results obtained indicated that the coatings structures were uniform and consisted of two main layers; an inner layer (interdiffusion layer) and outer layer. Increasing either Al or NH4Cl or both at the same time in the powder mixture resulted in an

increase in coating thickness [However, the effect of increasing the later on increasing coating thickness was more than when either of Al or NH4Cl was increased]. It was found that the amount of AlCl3 supply in the gas phase and the rate of Ni diffusion throughout the initial coating affected the degrees of change in the coating thickness. It was also revealed that the mechanism of coatings formation by the gas phase aluminizing method via the single-step HTHA process was similar to the coatings formed by pack cementation method via the LTHA process. This is a new finding obtained in this research.

P.8

Thermomechanical Characterization of Homogenized AA3xxx

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AA3xxx aluminum alloys require a homogenization heat treatment before being extruded to decrease the amount of Mn in solid solution. The homogenization treatment influences the microstructural response of the material to subsequent thermomechanical processing as well as the final mechanical properties of the material. Heating the as-cast structure precipitates dispersoids which then begin to dissolve at higher temperatures. Dissolution of the dispersoids continues throughout the soaking process; concurrently, constituent particles grow and coarsen. In order to determine the amount of Mn in solution during homogenization, AA3xxx samples were quenched at various points during the heat treatment and resistivity measurements were made. Compression samples, given diverse homogenization treatments, were characterized using a GleebleTM thermomechanical simulator at several strain rates. The results of these tests have been fit to a preliminary flow stress model.

P.9

Preparation of nanostructured Ni/Al2O3 composite coatings in high magnetic field

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Ni/Al2O3 composite coatings were prepared by a novel method from a modified Watt's type electrolyte containing nano-Al2O3 particles, where a high magnetic field was imposed in the direction parallel to an electrolytic current instead of mechanical agitation. Effects of magnetic field on the content of particles, surface morphology, microhardness and wear resistance of plating layer were investigated. It was found that the high magnetic field played an important role in the formation of composite coatings. The amounts of nano-Al2O3 particles in the composite coating increased with increasing of magnetic flux density and reached a maximum value at 8T, then reduced slightly. The microhardness and wear resistance of the nanocomposite coatings also enhanced with increasing of magnetic flux density as compared to that of pure Ni coating fabricated in the absence of magnetic field. That was due to the co-deposited nano-Al2O3 particles were uniformly distributed in the Ni matrix and contributed to greatly increase the microhardness and wear resistance of the composite coatings. Moreover, the mechanism of action of high magnetic field was discussed preliminarily.

P.10

Immobilization of Antimicrobial Peptides onto Titanium Surface

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Implants-associated infection is one of the most serious complications in orthopedic surgeries. Traditional antibiotic drug is facing a dramatic rise of microbial resistance, and one of the alternatives is the naturally-occurred antimicrobial peptides. Because pathogens are less likely to develop resistance to them, these peptides are considered as a promising candidate for future clinical treatment.

The objective of this research is to immobilize the unique peptide onto the surface of titanium implant and to achieve bactericidal activity. In this study, we report our preliminary results on surface modification. Titanium surface was first functionalized by silanization, and a heterobifunctional cross-linker was adopted to connect the antimicrobial peptide to the surface functional groups. A fluorescent method confirmed that the peptide was successfully immobilized on Ti surface.

P.11

Refinement of Al P/M alloy Alumix 431D by modification of sintering parameters

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The ever growing industry of Powder Metallurgy (PM) is developing to include new alloys and improve those currently available. This project relates to the optimization of a commercially available Al-Zn-Mg-Cu based alloy (Alumix 431D). This alloy is the PM equivalent of the wrought 7075 alloy, and yields some of the top performance found in any available aluminum alloy. Optimization of the alloy has been conducted with a focus on sintering conditions; in particular the effect of sintering temperature and post-sinter cooling. Five sintering temperatures were investigated to determine the optimal temperature, which was found to be 605°C. Once the proper temperature was discovered the cooling profile was modified to include an increasingly large post-sinter furnace-cooling section, before air quenching. This is believed to allow the highly alloyed inter-metallics further time at elevated temperature to diffuse into the matrix, improving strength and possibly corrosion resistance.

P.12

Optimized Processing of an Experimental Al-Si-Based Powder Metallurgy Alloy

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From an industrial perspective, the option of producing high strength, light weight aluminum engine components in an efficient and economic manner appears to be a rewarding endeavour. The emerging field of aluminum powder metallurgy (P/M) brings new and promising aspects to this forefront. At Dalhousie University an experimental aluminum alloy premised on the Al-6Si-Cu-Mg system has shown evidence of requiring significantly reduced sintering times over existing commercial alloys that may translate into energy and cost savings during the manufacturing process. Metal powders were blended and then compressed using a uni-axial die compaction method. Powder flow, apparent density, green densities and green strengths for the new alloy have all been studied, as well as the sintering response of the green compacts at several sintering temperatures in a controlled atmosphere. From these data an optimum processing route for this new alloy has been determined.

P.13

Aqueous Colloidal Processing of Lanthanum-doped Lead Zirconate Titanate

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A lanthanum-doped lead zirconate titanate (PLZT) powder was fabricated in-house from high purity precursors using the conventional mixed oxide forming route. The synthesized powder was characterized in terms of particle size distribution, surface area, crystalline phase composition and morphology via acoustic attenuation spectroscopy, nitrogen adsorption, x-ray diffraction and scanning electron microscopy, respectively. Aqueous suspensions of PLZT were prepared at a variety of pH levels with the use of a polyelectrolyte deflocculant, an ammonium salt of poly(methyl methacrylate) (PMAA-NH4). The stability of such suspensions was determined using zeta potential analysis, sedimentation tests and rheology. Stable suspensions were then slip cast and both green and sintered bodies were compared in terms of density and porosity to those produced by simple dry pressing methods.

P.14

Preparation of YSZ Electrolyte Films for SOFC using Sol-Gel Process

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Solid oxide fuel cells (SOFC) are considered the next generation combined heat and power (CHP) generators. They use a solid ceramic oxygen conductor electrolyte known as yttria stabilized zirconia (YSZ). Among varieties of techniques to prepare thin film YSZ electrolytes, sol-gel process has been the preferred method owing to low processing temperatures, film homogeneous, low cost, and its versatility in that it is not limited to the size and shape

of the substrate. The suitability of sol-gel process, however, will not be realized unless the electrolyte films are made to form uniform crack-free layers on the substrates from a stable sol. In this work, a stable yttrium-zirconium alkoxide sol has been synthesized by the controlled hydrolysis of zirconium n-butoxide and yttrium nitrate. Acetic acid and nitric acid were used as chelating agent and catalyst, respectively. The addition of acetic acid and increasing the amount of nitric acid to the system significantly enhanced the sol stability. This rheological behavior is attributed to the polymeric nature of the prepared sol. Thermogravimetric analysis (TGA) and x-ray diffraction (XRD) of calcined xerogels confirmed that fully stabilized cubic zirconia phase was formed at a temperature as low as 600◦ C.

P.15

Optical properties of shape-controlled gold nanoparticles

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Gold nanoparticles with different shapes and sizes have been prepared using the chemical method. These nanoparticles are examined by means of XRD, SEM, and TEM. Optical property of the nanoparticles was also studied by UV visible. Good correlation was observed for optical properties and size of nanoparticles. Absorption peak shifts to the lower wavelength by decreasing the size of nanoparticles. Clear change also observed in the optical properties of particles with almost same particle size, but different shapes. Additional peak appears in the UV spectrum for rectangular shape nanoparticles, in agreement with theoretical application. Results show that shape-controlled gold nanoparticles are promising for medical applications.

P.16

Preparation and Characterization of Magnetic Nanowires

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Ni, Co, and Co alloys nanowires were prepared via electrodeposion using the anodized aluminum oxide template. Templates with different pore diameter and interpore were prepared using high purity aluminum foil. Effect of preparation condition as well as size of nanowires on the magnetic properties of nanowires was studied. It is found that crystal structure, coercive field and squareness of nanowires can be controlled by controlling the preparation condition. We specially focused on the effect of external magnetic field during the deposition on the physical properties of nanowires. It is found that using proper magnetic field during the deposition process improves the saturation field as well as squareness compared to the normal samples.

P.17

Characterization of A36 Steel with Bimodal Grain Size Distribution

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This work sumarizes early results in the characterization and understanding of the effects of bimodal grain size distributions on an A36 Steel. Microscopy and nano-indentation hardness testing have been used to verify and characterize the development of these bimodal structures at each step in the processing route. Scanning electron micrographs of the material have revealed a final grain structure comprised of both small (300-500 nanometer) and large (3-5 micrometer) grains. Subsequent uni-axial tensile testing was conducted, employing digital image correlation techniques in order to identify any macroscopic strain localization during the deformation process.

P.18

Molecular Dynamics Simulation of Ni and Cu Nanoparticle Sintering

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Nanoparticles have been an area of active research in recent years due to their properties, which can be very different to those of the bulk material. We have used molecular dynamics simulations to investigate

the effects of temperature, particle size and particle environment on the consolidation of nanoparticles of nickel and copper. Sintering is found to be extremely rapid for both materials, with neck formation occuring within ~ 10 ps of the particles coming into close contact, and the process is essentially complete within < 100 ps. Increasing the temperature has no effect on sintering rate, whereas the interpenetration of the particles shows a distinct temperature depedence. Sintering kinetics are affected by size, however, with larger particles showing a slower sintering rate. Where particle sizes are mismatched, the kinetics are correlated to the size of the smaller particle. In an gaseous N2 environment, sintering is found to be slightly slower than in vacuo, with a small increase in rate as the pressure increases.

P.19

Hot Deformation of a Commercial Aluminum-Copper Powder Metallurgy Alloy

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Aluminum powder metallurgy (APM) is becoming more important in industry because of the inherent ability to produce a low density product with near-zero waste material. Hot forging of APM products can reduce residual porosity within the sintered structure and thereby maximize mechanical properties. The research pursued has examined the response of a commercially available aluminum-copper APM alloy (Al-4.4 Cu-0.8 Mg-0.6 Si) to hot deformation after sintering, using different strain rates, temperatures, and green densities as experimental parameters. Initially, the sintering process was optimized to strongly correlate the results obtained to those obtained in industry using the same alloy. Hot-compression testing was performed with pressed and sintered APM samples, as well as wrought Al-2024 used for comparison purposes, using a Gleeble™ 1500.

P.20

Deformation and annealing of steel after wire drawing: texture and microstructure evolution

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This study gathers a whole work done on cold wire drawn steel. The deformation causes a lengthening of the grains along the wire-drawing axis. For small deformations, the ferritic grains are more sensitive to lengthening than the perlitic grains. The hardness of the material increases with the deformation amount. Moreover, a new texture appears during the wire drawn process. i.e. the <110> fibre where the <110> direction is parallel to the wire-drawing axis. This fibre presents two reinforcements {110}<111> and {110}<100>. The texture is distributed in a homogeneous way on all the wire section for the various deformation amount. The volume fraction of this fibre quickly increases with the increase of the deformation level.

Annealing causes the recrystallization of the deformed ferritic grains. This recrystallization of the ferritic grains is homogeneous on all the section of wires. The first recrystallized grains belong to the <110> fibre. The thermal treatment does not modify the texture previously established by wire-drawing; the recristallized grains kept the same texture (<110>// ND) established by the deformed grains. So, it seems that the recrystallization texture does not change during the annealing since the partially recrystallized grains also belong to <110>//ND fibre. By calculation de quoi ?, we also found that the deformation amount? Slightly increases the volume fraction of the <110>//ND texture after annealing. The annealing temperature strongly accelerates the recrystallization. Indeed, the annealing samples at 600°C were entirely recrystallized on the other hand those annealed at 500°C were partially recrystallized.

P.21

Effect of Surface Contaminants on the Sintering of Magnesium Powders

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Magnesium and its alloys are attractive materials for use in automotive and aerospace applications because of the low density and good mechanical properties. However, difficulty in forming magnesium and the limited number of available commercial alloys limit their use. The present work reviews the efforts to improve the attractiveness of magnesium through non-traditional processing, and presents results of current work on producing magnesium alloys via powder metallurgy (P/M). P/M can be used to alleviate the formability problem through near-net-shape processing, and also allows unique chemical compositions that can lead to new alloys with novel properties.

The feasibility of producing magnesium powder metallurgy products utilizing the industrially dominant process of mixed powder blending and controlled atmosphere sintering was investigated, using uniaxial die compaction and cold isostatic pressing to form the compacts. Two pure magnesium powders were used, one produced by mechanical grinding and the other by centrifugal atomization. Difficulties arise during sintering due to surface contamination on the powder particles, mainly by oxides. Strategies to effectively sinter magnesium powder and results of preliminary testing are presented.

P.22

Corrosion Behaviour of Powder Metallurgy Light Metal alloys

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Light metal powder metallurgy (P/M) products have been developed and compete with traditional ingot metallurgy products (I/M) for specific applications. To extend the range of applications of these alloys which offer the advantage of net shape and near net shape production, the corrosion behavior need to be evaluated.

In this research a series of electrochemistry experiments on both (I/M) and (P/M) light metal alloys is being performed with the aim to correlate the corrosion behavior to the production technique. Commercially produced alloys as well as synthetic alloys are being examined.

Electrochemical measurements such as Tafel extrapolation (TE), Cyclic Polarization (CP), Linear Polarization (LP), Cyclic Voltammeter (CV) and Electrochemical Impedance Spectroscopy (EIS) will be performed on the alloys immersed in appropriate solutions. The corrosion product will be characterized by Scanning Electron Microscopy (SEM), Energy Dispersive Spectroscopy (EDS), Wavelength Dispersive Spectroscopy (WDS), and X-ray Diffraction (XRD).

P.23

Mechanical Testing of Thin Film Materials at Micro- and Nano-Scale

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An experimental technique has been presented to probe the mechanical behavior of thin film materials. The method is capable of tensile testing thin films on substrate and free-standing thin film specimens. In order to measure the strain field across the gage section, the moiré interferometry technique was implemented and the respective optical setup was designed. A versatile microfabrication process has been developed to fabricate free-standing dog-bone specimens. Aluminum was used as the model material; however, any other metallization material can be integrated in the process. Thin film specimens have been characterized using SEM, AFM, and TEM. A process has been developed to fabrication diffraction gratings on the specimen by FIB milling. Different grating geometries were fabricated and the diffraction efficiency of the gratings was characterized. The structural damage induced by the Ga+ ions during the FIB milling of the specimens was partially characterized using STEM and EDS.

P.24

Au/MoS2 anode catalyst for SOFC using H2S-containing syngas fuel

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Au/MoS2 is an active anode catalyst for conversion of hydrogen sulfide-containing synthesis gas (syngas; 40% H2, 60% CO admixed with 5000 ppmv H2S) as fuel in solid oxide fuel cell systems. Although MoS2 has catalytic activity for conversion of H2 and H2S, it is poisoned by CO, whereas Au/MoS2 catalysts have enhanced and stable fuel cell performance in the syngas environment. Current density over 600 mA/cm2 and maximum power density over 70 mW/cm2 were obtained at 900˚C when using Au/MoS2 as catalyst.

P.25

Effect of impingement angle on the erosion induced corrosion of Stainless Steel

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Stainless steel has very good mechanical properties and owes its outstanding corrosion resistance to the formation of a nano scale passive film on its surface. When the passive film is removed the material repassivates very fast in a fraction of a second. But even during this very short period of time it can damage the material especially if the breakdown of the passive film is continues. Although the corrosion rate is negligible, when happening simultaneously with erosion the damage may be even doubled. Thus understanding the nature of the erosion corrosion and the mechanism with which it happens is of critical importance.

A new device was designed and constructed which is capable of impinging single particles on the surface of materials and is suitable to investigate the synergistic effect of erosion and corrosion. With the use of new facility it is possible to investigate the effect of impingement angle, impingement velocity, different solutions and different particles with sizes up to 2 mm on the erosion corrosion phenomenon in the very basic condition which is a single impact.

A set of experiments have been conducted in order to investigate the effect of impingement angle on the erosion induced corrosion on 304 stainless steel and it is seen that the current peak reaches its maximum when the impingement angle is 60 º showing that the corrosion caused by impact of particles is maximum when the angle of impact is 60 º.

Finally another set of experiments with slurries containing 5 wt% sand particles flowing over the 304 stainless steel samples were conducted in a different setup and the results confirmed the single impingement results showing a maximum corrosion current at 60 º angles of impact.

X

Y

Z