Opening Ceremony and Plenary Lecture

Monday AM — Room: Turmalina/Topazio
July 26, 2010 — Location: Intercontinental Rio Hotel

Session Chair: To Be Announced

8:30 AM Opening Ceremony with George Gray(TMS Pres.), Karlheinz Pohlmann (ABM Pres.), Marc Meyers, Ray Peterson, Horacídio Leal, Sergio Neves, Fernando Rizzo

9:30 AM Plenary
Sustainable Development for the 21st Century: The Role of Materials Science and Engineering: *Diran Apelian*[1]; [1]Worcester Polytechnic Institute

By 2050 the world population will reach over 9 billion and "flattening of the world" will be an understatement. We anticipate burgeoning needs regarding energy resources, transportation, housing, food distribution/packaging for the masses, recycling, and health care/ health care delivery, not to mention climate change and environmental issues. The issues we face today will be insignificant to what we may expect if we (Global Society) do not act. World population is increasing at an average rate of 1.4%, and in contrast world energy consumption is increasing at an average rate of 1.7%. Such an imbalance is not sustainable and requires action. From a societal perspective, engineers have played a major role to enhance the quality of life in our world. Sustainable development in the 21st Century is perhaps the most critical issue we face. Resources are finite and it requires innovations as well as governmental policies. Inorganic materials are non-renewable; one would expect that appropriate design, life-cycle analysis, judicious material selection as well as recovery and recycling be the keystones of a new paradigm. The status quo is not sustainable. Solution paths – via Materials Science and Engineering- for a sustainable development in this Century will be presented and discussed.

10:10 AM Break

Materials and Society Symposium: Session I

Monday AM — Room: Turmalina/Topazio
July 26, 2010 — Location: Intercontinental Rio Hotel

Session Chair: Thaddeus Massalski, Carnegie Mellon University

10:40 AM Introductory Comments

10:50 AM Keynote
The Energy Challenge and the Role of Advanced Materials Fernando Rizzo CGEE/PUC-Rio: *Fernando Rizzo*[1]; [1]PUC Rio de Janeiro

The increase in world energy consumption during the next decades is expected to be substantial due to the development of large and populous countries. At the same time, participation of renewable and environmentally friendly sources in the energy matrix is mandatory to mitigate the greenhouse effect and reduce its impact on climatic changes. As a result, considerably funding has been invested in alternatives sources. Among the current options for cleaner energy production, many are dependent on advances in materials related issues, representing an opportunity for researchers and industries in this field. The presentation will highlight examples of potentialtechnologies that have been hindered by materials obstacles

11:30 AM Keynote
The Impact of Corrosion on Society: *Carolyn Hansson*[1]; [1]University of Waterloo

Almost all metals and alloys are unstable in the Earth's atmosphere and will always be susceptible to corrosion, i.e. conversion to a lower energy inorganic compound, such as carbonate, sulphide or oxide, depending on the environment. Thus, the metals and alloys used by engineers today are all in a metastable state and will corrode unless steps are taken to prevent the corrosion. Unfortunately, while this fact is known by the majority of engineers, it is often not taken into account in the design and operation of many systems. There are three aspects to impact of corrosion on society: (i) direct effects resulting in injury or death; (ii) contamination of the environment and (iii) the financial costs. These will be described together with a discussion of what can be done to minimize the corrosion of the civil infrastructure and the obstacles in implementing these measures.

Light Weight Materials for Transportation: Processing and Properties Symposium: Session I

Monday PM — Room: Onix
July 26, 2010 — Location: Intercontinental Rio Hotel

Session Chair: To Be Announced

2:00 PM Invited
Process and Characterization of Dual Phase Steel Foam: *Andrea Gruttadauria*[1]; Davide Mombelli[1]; Enrique Castrodeza[2]; Carlo Mapelli[1]; [1]Politecnico di Milano; [2]COPPE/UFRJ

Porous materials featuring cellular structures are known to have many interesting combinations of physical and mechanical properties. Some of them have been extensively used in the transportation field (i.e. balsa wood). Steel foams presented promising theoretical properties for functional and/or structural applications in transportation, but processing of such a kind of foams is complex due to their high melting point. Cellular metals can be produced by several routes, including molten metal infiltration of a leachable bed of solid particles. Recently a technique for processing Cu-based alloys open-cell foams through the infiltration of amorphous SiO_2 particles was proposed. A variation of the proposed technique that uses SiC particles as space holder is now presented and was more recently successfully applied for dual phase steel foam processing. Results from a processing of dual phase DP500, including some morphological, microstructural and mechanical (compression) characterization, are here presented.

2:30 PM Invited
The Benefits and Challenges of Liquid State Processing for Light Weight Al/SiC MMCs: *Martin Pech-Canul*[1]; [1]CINVESTAV SALTILLO

While SiC-reinforced Al-MMCs are considered amongst the most promising candidates for light weight materials intended for transportation, a major part of the success lies on the fabrication route. Particularly, processing by the liquid state route unveils not only some attractive advantages but also inherent drawbacks. In view of the vast experience of handling molten aluminum in the foundry industry, the idea of using liquid aluminum for the preparation of Al/SiC MMCs is always compelling. Moreover, compared to the solid and semi-solid state processing technologies, it is expected that investment, in terms of equipment and the alterations in plant will be minimum. However, a number of factors related to the processing parameters and composites' microstructure should be taken into consideration before speaking of product performance. These factors include the Al alloys and prior treatments to the SiC reinforcements. In this contribution, the pros and cons of using the liquid state route for Al/SiC composites, particularly when using the infiltration route, are examined.

3:00 PM
Recent Developments in Alloy Design of Magnesium Wrought Alloys: *Timo Ebeling*[1]; Urs Hasslinger[1]; Christian Hartig[1]; Robert Guenther[1]; Rüdiger Bormann[1]; [1]Hamburg University of Technology

The solidification, deformation and recrystallization behavior of semi-finished products of magnesium alloys was investigated by experiments and modeling. The aim was to obtain further insight into the deformation and recrystallization mechanisms of magnesium wrought alloys. The role of ceramic particles as well as alloy elements on magnesium wrought alloys during solidification and processing has been studied by microstructural investigations, texture measurements and mechanical tests. A reduction of the grain size can be ascribed to stimulated heterogeneous nucleation by ceramic particles during solidification. A further distinct reduction of the grain size and a texture randomization are achieved by recrystallization during thermomechanical processing resulting in a decrease of yield anisotropy. The solidification as well as the plastic deformation were modeled using appropriate models (hemispherical cap, VPSC). Influences of the alloying contents on texture evolution and mechanical properties are discussed in terms of deformation and recrystallization mechanisms.

3:30 PM Break

4:00 PM Keynote
Sustainability, Recycling, and Waste Treatment in the Aluminum Industry: *Ray Peterson*[1]; [1]Aleris International Inc

Recycling has long been practiced in the aluminum industry due to the inherently high value of the metal. Both manufacturing scraps and post-consumer scraps find their way back into the metal stream for reuse. As an industry we also try to minimize our by-product materials requiring waste treatment. The aluminum industry can be broken down into four major divisions: • Bauxite to Alumina; • Alumina to Aluminum Metal; • Aluminum Metal to Useful Product; • End-of-Life Product to Aluminum Metal. Each of the four major sub-areas will be examined for sustainability, recycling, and waste minimization. Significant progress has been made in reducing the larger by-product streams, but further effort is still needed in several areas. In addition to new technologies, both economics and local laws will dictate the degree of progress made on eliminating many waste streams. A short discussion of aluminum's sustainability will also be made.

4:40 PM Keynote
Light Weight Materials in the Transportation Industry: Challenges and Opportunities: *Fernand Marquis*[1]; [1]Naval Postgraduate School

In the transportation industry the global use of lightweight materials (LWM) in 2006 was 42.8 million tons. This figure is expected to reach 68.5 million tons by 2011, a compound annual growth of 9.9%. The aircraft industry was the first to introduce aluminum alloys in a widespread basis in 1920s, followed by the introduction of composite materials. This trend was then adopted by the automobile industry in the 1990s and later by the shipbuilding industry. The approach of reducing weight by downsizing in order to meet stringent fuel consumption requirements, yet meeting safety standards and consumer preferences has reached its limits and one needs to focus on other alternatives. One of these is the development of strong, tough, stiff, environmental friendly, cost effective and reliable LWM materials, using a system design approach. Another is the development of hybrid materials, and yet another one is the development of hybrid vehicles.

5:20 PM
Microalloyed Magnesium with Exceptional Mechanical Performance for Degradable Implant Applications: A.C. Hänzi[1]; *Timo Ebeling*[2]; R. Bormann[2]; P.J. Uggowitzer[1]; [1]ETH Zurich; [2]TU Hamburg-Harburg

New Mg–Zn alloys have been developed according to a microalloying concept and in consideration of grain growth restriction during alloy casting and forming. After extrusion they reveal very fine grains, high ductility at considerable strength and homogeneous distribution of intermetallic particles, which suppress grain growth even at comparably high temperatures. The new alloys exhibit also a very low tension-compression asymmetry (Rp,ten / Rp,com ˜ 1). This phenomenon is not only ascribed to the weak as-extruded texture but also to the fine-grained structure, which suppresses twinning activity and enables activation of complementary deformation modes (non-basal slip) at RT. Indeed, plastic deformation simulations indicate low tensile twinning activity and promoted non-basal slip. The overall performance including slow and homogeneous in vitro and in vivo degradation behavior and the choice of only biocompatible alloying elements make the new alloys promising for temporary implant applications.

5:40 PM
Titanium Alloys Production for High Temperature Applications: *Vinicius Henriques*[1]; Mario Lima[1]; Carlos Cairo[1]; [1]IAE/CTA

Titanium alloys parts are ideally suited for advanced aerospace systems because of their unique combination of high specific strength at both room temperature and high elevated temperature, in addition to excellent corrosion resistance. In this work, Ti-6Al-4V and Ti-6Al-2Sn-4Zr-2Mo were produced from induction melting techniques with subsequent heat treatment to reach the adequate microstructure. Samples were characterized for phase composition, microstructure and microhardness by X-ray diffraction, scanning electron microscopy and Vickers indentation, respectively. It was shown that the samples presented homogeneous microstructure from the elements dissolution with low interstitial pick-up.

Materials and Society Symposium: Session II

Monday PM — Room: Turmalina/Topazio
July 26, 2010 — Location: Intercontinental Rio Hotel

Session Chair: To Be Announced

2:00 PM Keynote
Society Changing Needs in Advanced Materials: *Evando Mirra de Paula e Silva*[1]; [1]Universidade Federal de Minas Gerais

Sustainable use of biomass and other natural resources, technical solutions for environment requirements, efficient usage of energy, sensitive technologies, health care, bio-materials, composites, nano-tribology and related features in MEMS, are a few examples of social, economical, political and scientific issues related to the availability and appropriate choice of materials. The decision for launching new material solutions takes various technical, economical, and also political factors – in the sense of assessing the acceptance of the product – into consideration, a process that has led to the so called "hyperchoice". An overview of those changing societal needs and the corresponding materials response will be presented, and some specific applications will be discussed.

2:40 PM Keynote
Biological Materials and Society: *Marc Meyers*[1]; [1]UCSD

Natural (or biological) materials are an intrinsic and inseparable part of the ascendance of Humans to civilization in the Neolithic. The first materials to be utilized were bones, antlers, hides, wood, and stones. The use of synthetic materials, starting with ceramics (pottery and glasses), metals (copper, bronze, iron, and the cornucopia of alloys), and polymers (starting with Dr. Leo Baekeland </wiki/Leo_Baekeland>'s invention, bakelite, in the early 1900s) marks a magnificent development of the field of Materials Science and Engineering. In a full circle, we are in the midst of a revival of interest in biological materials, of which we seek to understand of the structure and properties because of their unique properties and architecture. Some of their unique characteristics have been identified: Hierarchical structure Self assembly Multifunctionality Ambient pressure and temperature synthesis Limited availability of raw materials This work has two components: A fundamental one, in which Materials Scientists and Engineers are using their extensive arsenal of computational, experimental, and characterization methodology to provide novel insight into biological materials. A technological one, by which the lessons learned from nature can be applied in the design of new materials and structures. Both components are proving to be fertile grounds for investigation.

3:20 PM Break

4:00 PM Invited
Technology Transfer in Materials Science: *Diana Farkas*[1]; [1]Virginia Tech

In this talk we will explore particular aspects of the technology transfer process, and the impact of basic research in the development of new technologies and new materials. An important part of this process is the transfer of new discoveries from academia to industry in the innovation, laboratory to market, path. The talk will explore the critical role that major research universities play in the process of innovation, with specific examples in the materials science area. In a second part of the talk we will explore international aspects of scientific and technological cooperation, and how this relates to the innovation process.

4:20 PM
Synthesis and Characterization of Lialxniymn1-X-Yo2 Particle as a Cathode Material of the Lithium Ion Battery: *Chen-Feng Kao*[1]; Kao-Heng Liu[1]; [1]National Cheng Kung University

Lithium-aluminum-nickel-manganese oxides (LiAlxNiyMn1-x-yO2) particles, generally used as cathode of lithium ion battery, were prepared by chemical coprecipitation from an aqueous solution of LiOH, Al(NO3)3, Ni(NO3)2 and Mn(NO3)2 with NH4OH. XRD, SEM and FTIR were used to examine the effect of nickel content on the product. FTIR patterns showed that increase in nickel content decreased the absorption strength of the peak of spinel structure of the product, attributed to the occupation by nickel in the aluminum sites. Particle size and electrical properties of the lithium-aluminum-nickel-manganese oxide (abbreviated as LANMO) particles were also determined.

4:40 PM
Mechanical and Microstructural Investigation of Autoclaved Pozzolanic Ceramic Tile Made with Oyster Shell Waste: *Giovana Collodetti*[1]; Rafael Souza[1]; [1]Federal University of Santa Catarina

Autoclaving process for pozzolans has lower energy consumption than the sintering process, in order to reach the same mechanical performances. Based on this, ceramic tiles were produced using kaolinite, quartz and lime from oyster shell waste from Florianopolis bay, using an autoclaving process with temperature of 200°C. The tensile strength of five different compositions was investigated with a 3 points bending test. The influence of duration of heat treatment on the formation of hydrated phases and porosity of the ceramic material were evaluated to the composition with higher performance, which achieved 15 MPa. Two different times of heat treatment were tested: one and two hours. The samples with one hour of autoclave treatment presented higher flexural strength, but no differences between them were found in thermal and X-ray diffraction analysis. However, microscopy and mercury intrusion porosimetry results showed a difference between porosity of samples.

5:00 PM
Negative Thermal Expansion in YInMo3O12: *Monica Ari*[1]; Bojan Marinkovic[1]; Paula Jardim[1]; Roberto De Avillez[1]; Fernando Rizzo[1]; Fabio Ferreira[2]; [1]PUC-Rio; [2]UFABC

YInMo3O12 was produced by solid state reaction. To verify the phase composition of the synthesized samples was used a microscope (SEM) equipped with EDS. To determine the thermal expansion, a high resolution X-ray powder diffraction data were collected at 423, 573, 723, 873, 1023K at Brazilian Synchrotron Light Laboratory (LNLS, D10B-XPD beamline). Data were obtained from 10 to 70° (2 theta), steps of 0.008° with remaining time of 2s and = 1,23989Å. A calibration curve for the furnace was obtained using a NIST Si sample. The linear thermal expansion coefficient was -3.78 x 10-6 K-1 determined by Rietveld refinement performed using Topas academic. It was determined by termogravimetric analyses that YInMo3O12 is hygroscopic at room temperature. No change in the structure (orthorhombic, Pbcn) was observed by DSC analyses from room temperature to 873K.Acknowledgements: Authors thanks LNLS for D10B-XPD 7756 project and Ari M. thanks FAPERJ for postdoctoral fellowship.

5:20 PM
Characterization and Exploitation of Piston Ring Chips in the Rectification Process a New Recycling Proposal: Amauri Teixeira[1]; José Dias; Manoel Silva[1]; Eduardo Silva[1]; *Marcelo Gontijo*[2]; [1]UNIFEI - Federal University of Itajuba; [2]Aeronautic Technology Institute

The rough grind machine operation in metallic material produce a sub product with the followings components such as: metallic residue, small parts come from the resin grinds, diatomaceous earth material (filter material) and soluble oil in water for tools cooling. According NBR 10.004 of 2004 from ABNT, this sub product is toxic, not inert material, aggress the environment with pollution in the water currency and contaminate the ground when incorrectly go to the municipal solid waste. The final destination of this sub product, is the incineration, in the cements company, being the incorporated the sub product to the cement, during your production. The qualitative result using scanning electron microscopy (SEM), coupled to the energy dispersive spectroscopy (EDS), two experiments were made with objective to separate the magnetic material of the non-magnetic material, using a permanent magnet, conclude that the magnetic material can be used by powder metallurgy process.

5:40 PM
Metal Identification by Means of ICP-OES in Comminuted Printed Circuit Boards for Recycling: *Astrid Damasco*[1]; [1]cefetmg

In today's society, the constant technological development generates a large volume of obsoletes electronic products that are discarded. The recovery of discarded PCI metals allows the reuse of the metals in a new cycle of production and contributes for the reduction of mineral extraction. The objective of this study was to quantify the metals contained in the printed circuit board by means of chemical analysis of comminuted boards using with optical emission spectrometry with induced coupled plasma (ICP-OES). The results will help in metal recycling.

6:00 PM
Ultrafine Grained Structure Development in Steels with Different Initial Structure by Severe Plastic Deformation: *Jozef Zrnik*[1]; Sergey Dobatkin[2]; George Raab[3]; Martin Fujda[4]; Libor Kraus[5]; [1]Comtes FHT, Inc.; [2]Moscow Institute Steels and Alloys; [3]Institute of Physics of Advanced Materials; [4]Technical University of Kosice; [5]COMTES FHT, Inc.

The work presents the results obtained at severe plastic deformation (SPD) of low (LC) and medium carbon (MC) steels. The grain refinement of ferrite respectively ferrite-pearlite structure is described. The steels were deformed by ECAP processing at increased temperature with die channel angle of f = 120°. The efficient development of ultrafine grain (UFG) structure under high straining in both steels was effectively modified by effective strain eef and by temperature of SPD process.

Randomly recovered and polygonized structure and formation of submicrocrystalline grains were found in dependence of strain applied in both steels. In MC steel the straining caused cementite lamellae fragmentation and carbide spheroidization as strain increases. The dynamic polygonization and recrystallization processes contributed to submicron grain structure formation. The tensile behaviour of the both steels was characterized by strength increase, however the absence of strain hardening period was found at both steels.

Characterization and Application of Biomaterials Symposium: Session I

Tuesday AM — Room: Turmalina
July 27, 2010 — Location: Intercontinental Rio Hotel

Session Chair: To Be Announced

9:00 AM

A Comparative Study of Dental Implantations Systems Applied for Edentulous Mandible with Immediate Load: Luiz Pennafort[1]; Silvestre Carvalho de Oliveira Jr[1]; *Enio De Deus*[1]; [1]UFC

The present study aimed at obtaining comparative elements among the guided systems of fixed complete denture with 4 osseointegrated implants with immediate loading, considering the importance of understanding the implant project as a process where biomaterials and biomechanics are assessed. The finite element method was used to analyze the stress concentrations in the whole implant-supported system, associated to the variation of the material of the prosthetic bar among the nickel-chromium, cobalt-chromium and Ti-6Al-4V alloys. Metallographic tests of the Ni-Cr and Co-Cr alloys, were made with the objective of identifying the micro-structure and consequently evaluate its influence in the mechanical behavior of the system. Two systems were analyzed, one with cantilever and another without it, but with tilted implants, submitted to a vertical load of 756N. The study of the alloys appointed the Co-Cr alloy as a material comparable to the other ones, regarding the mechanical behavior.

9:20 AM

Strain Rate Dependent Response of Rabbit Femur Bones: Vasanth Chakravarthy Shunmugasamy[1]; *Nikhil Gupta*[1]; Paulo Coelho[2]; [1]Polytechnic Institute of NYU; [2]New York University

The complex and functionally graded structure of bones results in a challenging scenario for characterizing and modeling its mechanical properties. Recent work showing the strain rate dependence of hard tissues has led to interest in their dynamic properties. The present study attempts to better understand the high strain rate response of rabbit bones. The testing was conducted using the Split-Hopkinson pressure bar (SHPB) set up. A high speed digital camera is used to capture the fracture patterns. The bones were also characterized under quasi-static compression to determine their strain rate sensitivity. The trabecular and the cortical rabbit bones showed a compressive modulus in the range of 2-4 GPa and 8-11 GPa, respectively, under quasi-static compression testing. Under high strain rate loading conditions the modulus is observed to increase with strain rate and attains values as high as 10-12 GPa for trabecular bone and 30-50 GPa for cortical bone.

9:40 AM Keynote

Biodegradable Polymer Composites Based on Brazilian Lignocellulosic Fibers: *Satyanarayana Kestur*[1]; [1]Formerly with Federal University of Parana

Use of eco friendly and energy saving biomaterials and processes have enabled to overcome the effects of growing urbanization and population along with increasing agro-industrial wastes. This has lead to a new approach to the industrial design of products and processes along with the implementation of sustainable manufacturing strategies to “optimize the total material cycle from virgin material to finished material, to component, to product, to waste product and to ultimate disposal”. Developing countries such as Brazil possess abundantly available but underutilized biomaterial resources, which may possibly give excellent opportunities for scientists to discover methods for their better utilization. This talk presents attempts made so far on the developments of biodegradable composites based on biomaterials of Brazil, with details on their processing matrix-reinforcement combinations, morphology, properties and product development, which include a few results of the studies carried out by the author and his colleagues at UFPR-Curitiba.

10:20 AM Break

10:40 AM Keynote

On the Quest for Structural Materials Based on Nature’s Hierarchical Design: *Robert Ritchie*[1]; Antoni Tomsia[2]; [1]University of California Berkeley; [2]Lawrence Berkeley National Laboratory

The structure of materials invariably defines their mechanical behavior. However, in most materials, specific mechanical properties are controlled by structure at widely differing length scales. Nowhere is this more apparent than with biological and natural materials. Bone, tooth dentin and seashells, for example, are sophisticated composites whose unique combination of mechanical properties derives from an architectural design that spans nanoscale to near-macroscopic dimensions; few engineering materials have such hierarchy of structure and properties. Unlike engineering composites where properties are invariably governed by the “rule of mixtures”, the mechanical properties of many natural composite materials are generally far greater than their constituent phases. However, actually making such materials synthetically has proved to be extremely difficult, particularly in bulk form. Here we describe an approach, involving processing by ice-templating, to developing bulk ceramic-polymer and ceramic-metal nacre/bone-like structural materials with unprecedented strength/toughness properties.

11:20 AM Invited

Novel Bioceramic Scaffolds for Regenerative Medicine: *Marcelo Prado da Silva*[1]; [1]Military Institute of Engineering

Calcium phosphate ceramics have been used as synthetic grafts for bone repair. Sintered bovine bone is basically composed of hydroxyapatite (HA), Ca10(PO4)6(OH)2 and is an alternative. This material maintains bone architecture but, the fact of being from animal origin, brings concerns. Chemical and heat treatments are generally required to eliminate biological hazard. However, the more crystalline hydroxyapatite is the less resorbable is the product. An approach to have a highly crystalline and still resorbable material is to use additions of alpha or beta tricalcium phosphate, Ca3(PO4)2, alpha-TCP or beta-TCP. The addition of fractions of some bioactive glasses to hydroxyapatite, has shown to be effective in promoting decomposition into tricalcium phosphate. In addition, glass reinforced hydroxyapatite composite are materials with higher compressive strength due to liquid phase sintering. In this study, novel scaffolds based on hydroxyapatite and tricalcium phosphate are presented.

11:50 AM Invited

The Development of Bone Engineering Materials Based on Calcium Phosphates: *Gloria Soares*[1]; [1]UFRJ

Bone engineering materials are considered a priority in medicine and dentistry. The world market for muscular-skeletal products has been increasing due to the increase in the life expectancy of the population and associated trauma. New alloys for orthopedic prosthesis, nanostructured surface treatments, synthetic or hybrid composites for grafting and tissue engineering are some areas which bring together the fields of materials science, nanotechnology and biotechnology. In our group synthetic grafts based on calcium phosphates, containing substitutions such as magnesium, silicon or strontium are being developed. These materials are in either the granular or tablet form and are physico-chemically characterized, tested “in vitro” (degradation tests and tests with cells) and “in vivo”. Composite scaffolds comprised of hydroxyapatite (HA) or tri-calcium phosphate (TCP) mineral phase and containing bovine collagen, fibroin or chitosan are being developed and characterized. Recently, a bi-layered HA-Chitosan scaffold was proposed for the regeneration of osteochondral defects.

Computational Modeling and Advanced Characterization Symposium: Session I

Tuesday AM — Room: Topazio
July 27, 2010 — Location: Intercontinental Rio Hotel

Session Chair: To Be Announced

9:00 AM
Atomistic Simulation of Carbon Segregation to Dislocations in Alpha-Iron: *Roberto Gomes de Aguiar Veiga*[1]; Michel Perez[1]; Charlotte Becquart[1]; Christophe Domain[1]; [1]Université de Lyon - INSA de Lyon

The aim of this presentation is to present simulations of the formation of Cottrell atmospheres in iron with atomistic modelling. The goal is to capture the complex strain induced interaction between carbon and a dislocation. Molecular statics simulations with embedded atom method (EAM) potentials were carried out to obtain atomic configurations, carbon-dislocation binding energies, and the activation energies required for carbon hops in the neighborhood of the line defect. Simulations of the kinetics of carbon segregation towards the dislocation, in turn, were performed by means of a typical on-lattice Kinetic Monte Carlo (KMC) algorithm using information gathered from molecular statics. Results of this combined KMC-MD approach are in good agreement with thermoelectric power experiments performed on aged low alloyed steel.

9:20 AM
Growth Stresses in Nanostructured Oxide Scales Forming on Iron Aluminides Studied by In-situ Energy-Dispersive Synchrotron XRD: *Haroldo Pinto*[1]; Pedro Brito[2]; Anke Kaysser-Pyzalla[2]; Christoph Genzel[2]; Thomas Wroblewski[3]; [1]Universidade de São Paulo; [2]Helmholtz-Zentrum Berlin fuer Materialien und Energie; [3]HASYLAB at DESY

Iron Alumindes rely upon the formation of an alpha-alumina scale that protects the metal substrate. The oxidation resistance is affected by internal stresses due to growth incompatibilities intrinsic to the oxidation process. At low temperatures, less-protective metastable aluminas may be formed. Transition Al2O3 also modifies the stress state in the oxide layer, since the transformation into alpha-Al2O3 is accompanied by a volume contraction. The aim of this work was to investigate the relation between oxide phase composition during the early oxidation and the growth stresses within the layer. To this end, Fe-15at.%Al polycrystals and single crystals were oxidized at 700oC. The evolution of phase, texture and growth stresses was determined using synchrotron x-ray diffraction. The results show that theta-alumina exists only during the first minutes of oxidation and that the growth stresses are governed by the epitaxy between alumina and hematite and the texture of the oxides.

9:40 AM Keynote
Combined Experimental and Computational Structural Analysis of a Complex Precipitate Phase in High-Temperature $Ti_{50}Ni_{30}Pt_{20}$ Shape Memory Alloys: L. Kovarik[1]; F. Yang[1]; A. Garg[2]; D. Diercks[3]; *Michael Kaufman*[4]; R.D. Noebe[5]; M.J. Mills[1]; [1]The Ohio State University; [2]University of Toledo and NASA Glenn Research Center; [3]University of North Texas; [4]Colorado School of Mines; [5]NASA Glenn Research Center

Aging of the high-temperature shape memory alloy $Ti_{50}Ni_{30}Pt_{20}$ (at.%) results in precipitation of a previously unidentified phase, which plays a key role in achieving desirable shape memory properties. The precipitate phase has been analyzed with electron diffraction, high-resolution STEM HAADF imaging and 3-D atom probe tomography. It is shown that the precipitates have unique crystallography due to their non-periodic character along one of the primary crystallographic directions. It will be shown that the structure can be explained in terms of random stacking of three variants of a monoclinic crystal that is closely related to the high temperature cubic B2 phase; the departure of the structure from the B2 phase can be attributed to ordering of Pt atoms on the Ni sublattice and relaxation of the atoms (shuffle displacements) from the B2 sites. The shuffle displacements and the overall structural refinement were deduced from ab initio calculations.

10:20 AM Break

10:40 AM Keynote
Work Hardening Characteristics of TWIP Steel Cold Rolling and Annealing: *Dagoberto Santos*[1]; Mirelle Oliveira Spindola[1]; [1]Universidade Federal de Minas Gerais

There are a current and growing need for the automotive industry for materials that combine high formability, high strength and low specific weight in order to reduce fuel consumption and increase passenger safety. In this context, appears the TWIP steel (Twinning Induced plasticity), defined as a steel with high content of manganese and, yet, silicon and aluminum (2 to 4%) in its composition. Its main feature is the formation of twining under stress. In this study, it was investigated how the characteristics of work hardening of the steel C-0.06, Mn-25, Al-3, Si-2, Ni-1, with TWIP effect influences their mechanical properties. This research used optical micrographs and scanning electron (SEM) for assessment of grain size and volume fraction of recrystallized grains. To complement this study, tensile tests were performed.

11:20 AM Invited
In Situ Tomographic Characterization of Single Cavity-Growth during High-Temperature Creep of Copper And Brass: *Augusta Isaac*[1]; [1]Laboratório Nacional de Luz Síncrotron

The service lifetime of metallic components for high temperature applications is usually controlled by creep damage consisting of nucleation, growth and coalescence of grain boundary voids. This work presents a conceptually new approach to void growth characterization based on synchrotron microtomographic measurements performed in-situ during creep. We show that the average growth rates of voids in leaded brass and copper are larger by a factor of about 25 and 46 than predicted by the continuum theory, respectively. The distorted shape of voids reconstructed by nanotomography suggests that the enhanced growth rate is related to the crystallographic nature of creep deformation.

11:50 AM
Sensitivity Analysis of the ECAE Process via 2^K Experiments Design: *Neil Medeiros*[1]; Luciano Moreira[1]; José Bressan[2]; Jefferson Lins[1]; Jayme Gouvêa[1]; [1]Universidade Federal Fluminense; [2]Universidade do Estado de Santa Catarina

In this work the theoretical solutions based upon the upper-bound theorem recently proposed by Pérez and Luri [Mech. Mater. 40 (2008) 617] for the equal channel angular extrusion process (ECAE) are analyzed by performing a 2^5 central composite factorial analysis. The uniaxial mechanical properties of commercial pure aluminium are considered by assuming isotropic nonlinear work-hardening combined to von Mises and Drucker isotropic yield criteria to predict the ECAE load and the effective plastic strain. From the proposed 2^5 factorial analysis, the main parameters affecting the ECAE pressure may be ranked as: (1) Friction factor, (2) die channels intersection angle, (3) outer and (4) inner die corners fillet radii and lastly, (5) plunger velocity. Alternatively, the effective plastic strain is mainly controlled by the die channels intersection angle and, in a less extent, by the outer and inner die corners fillet radii.

Light Weight Materials for Transportation: Processing and Properties Symposium: Session II

Tuesday AM Room: Onix
July 27, 2010 Location: Intercontinental Rio Hotel

Session Chair: To Be Announced

9:40 AM
The Effect of Composition on the Texture Evolution of Mg-Zn-Y Alloys: *Amir Farzadfar*[1]; Mehdi Sanjari[1]; Steve Yue[1]; [1]McGill University

Magnesium alloys are excellent candidates for applications where weight saving is of major importance. However, the industrial use of Mg sheets is limited due to the development of a strong basal texture. It has recently been observed that a weaker texture develops in Mg-Zn alloys containing rare earth (RE) elements; however, the responsible mechanism(s) are not clearly understood. This research involves studying the effect(s) of RE intermetallics and solutes on the microstructure and texture evolution during and after hot deformation in Mg-Zn-Y alloys. To achieve this, the alloy selection will be performed by CALPHAD method in order to obtain alloys containing either different types of RE intermetallics or different solutes (Zn or Y) in Mg solid solution to separately study the effect(s) of RE intermetallics and solutes. The evolution of microstructure and texture after hot compression and subsequent annealing will be investigated by means of XRD, SEM and EBSD technique.

9:20 AM
Texture and Microstructural Evolution during High Strain Rate Hot Deformation of AZ31 Mg Alloys: *Mehdi Sanjari*[1]; Amir Farzadfar[2]; Steve Yue[2]; Elhachmi Essadiqi[3]; [1]McGill ; [2]McGill; [3]CANMET-MTL

In this work, the effect of strain rate on the plastic flow behavior, static and dynamic restoration kinetics and features and texture evolution was investigated for a wide range of strain rates. The low strain rate deformation behavior was investigated by MTS hydraulic test machine, in single and double hit compression tests at two strain rates of 1 and 0.01s-1 temperatures of 150, 250, 350 and 450°C. To study the effect of strain rate in range of 10-200 s-1, single and double hit compression tests are performed using the cam plastometer. To measure texture and microstructure evolution, EBSD, optical microscopy is being used. The results show that the most uniform microstructure was obtained at strain rate of 60s-1 and temperature of 370°C. The recrystallization mechanism is twinning induced DRX at high strain rate of 100s-1.

9:00 AM
Deformation and Fracture of an Alpha/Beta Titanium Alloy: *Arnaldo Andrade*[1]; Aparecido Morcelli[1]; Raquel Lobo[1]; [1]Ipen

Titanium alloys are used in the aero-spatial, energy and biomaterial industries among others and exhibit high specific strength and fracture toughness. Their mechanical properties show a strong dependence on the microstructure, especially on the size and morphology of the phases constituents. An experimental evaluation was done to a better understanding of that influence using some techniques like as transmission electron microscopy (TEM) (both low and high resolution (HR)), scanning electron microscopy (SEM) coupled to electron back-scattering diffraction (EBSD), x-ray diffraction (XRD) and optical microscopy (OM). Some in-situ TEM deformation studies were also done. The alloy was submitted to two heat treatment conditions to get different phases distribution. An hcp phase (alpha) in coexistence with a bcc phase (beta) was observed after both treatments as well the occurrence of twins, stacking faults and dislocations arrangements. The work then discusses the influence of these features on the overall alloy strength.

10:00 AM Break

10:40 AM Keynote
The Brazilian Space Program - Connections to Lightweight Materials: *Maurício Pazini Brandão*[1]; [1]Aerospace Technological Institute – ITA

Brazilians have been working on space matters in the last five decades. Since the beginning, activities have been conducted separately by civilian and military organizations. In the 1980´s, the subject has been organized into a single framework: the Brazilian Complete Space Mission (MECB). This organization has been transferred in 1994 to the coordination of the then newly created Brazilian Space Agency (AEB). Since then, the Agency has developed public policies (PNDAE), has created an Integrated System (SINDAE) involving all the area stakeholders, and has acted according to a National Space Activities Program (PNAE). This Program encompasses activities with the objectives of increasing the national sovereignty in space matters, the indigenous industry competitiveness in the market of space products and services, and the rewards of space technologies to the Brazilian society.

11:20 AM Keynote
Advanced Metallic Structure for Aircrafts: *Venâncio Pereira Neto*[1]; [1]EMBRAER

A growing competition on the aeronautical market leads the aircraft manufacturers to invest on new technologies, which results on more efficient products. One of the fields having high potential for a better efficiency of the product is the airframe(aircraft structure). An optimized airframe results in great reduction on weight, manufacturing and maintenance costs. The latest Boeing and Airbus commercial programs show an important tendency: the continuous growing of CFRP(Carbon Fiber Reinforced Polymers) applications in airframes. However metallic materials still have a great potential on contributing to a more efficient airframe, under a new concept called Advanced Metallic Structure. This new concept states that the simple replacement of current for new, advanced and high performance metallic materials does not lead to a better overall performance. New metallic materials can succeed only if their use is established under a view that integrates materials, manufacturing processes and design concepts in a customized and optimized solution.

Characterization and Application of Biomaterials Symposium: Session II

Tuesday PM Room: Turmalina
July 27, 2010 Location: Intercontinental Rio Hotel

Session Chair: To Be Announced

2:00 PM Invited
Titanium Dental Implants Surfaces: *Carlos Elias*[1]; [1]Instituto Militar de Engenharia

Osseointegration has been defined as “a direct structural and functional connection between ordered, living bone and the surface of a load-carrying implant”. But titanium and its alloys cannot directly bond to living bone after being implanted into body. The osseointegration of dental implants is critically dependent on their surface properties. Consequently, various surface modifications have been proposed in attempts to provide to commercially pure titanium with bioactive bone bonding ability. The morphology of dental implant surfaces were modified by chemical and electrochemical treatments. The goal of the developed dental implant surface is to improve tissue response, and decrease the conventional waiting time for implant loading. The results of the present work show that surface morphology, topography, roughness, chemical composition, surface energy, thickness of titanium oxide layer, and titanium oxide structure influence in bone tissue reactions.

2:30 PM Invited

Toughening Mechanisms in Mineralized Biological Materials: *Po-Yu Chen*[1]; Joanna McKittrick[1]; Marc A. Meyers[1]; [1]University of California, San Diego

Mineralized biological composites have exceptional mechanical properties that are far beyond the weak constituents from which they are assembled. The hierarchical structure of these materials is at the crux of this enhancement. Microstructural features such as laminated organic/inorganic interface, twisted plywood structure and the presence of organized porous and fibrous elements are common in these composites. We review our recent studies on a variety of mineralized biological materials, including abalone nacre, crab exoskeletons, fish scales, elk antler, and armadillo armor, using the Materials Science approach. The structure-property relationship, design strategy and toughening mechanisms in mineralized bio-composites will be present and compared. Learning from nature offers insight into the development of novel bio-inspired synthetic materials. Research supported by the National Science Foundation Biomaterials Program (DMR 0510138) and Army Research Office (W911-08-1-0461).

3:00 PM Invited

Vegetable Fibers as Multifunctional Materials: *Sandro Amico*[1]; [1]UFRGS

Environmental concerns related to the ever-growing use of raw-materials from non-renewable sources by modern society is driving the interest of the academic and scientific sectors for a new concept of material, which takes into account not only mechanical performance, cost and availability, but also environmentally-related issues, such as biodegradability, renewability and energy use, along with the promotion of social and economical development of the economically-challenged segment of the population. Vegetable fibers have been used in many home-made objects, such as ropes and artcraft, for perhaps as long as humanity exists. However, these fibers present a combination of interesting properties which enables their recent use in a wider variety of sectors. This invited lecture will focus on the use of vegetable fibers for oil sorption, as infiltration medium and reinforcement for polymer composites, promoting their use in more demanding and rewarding applications.

3:30 PM Break

4:00 PM Invited

Lignocellulosic-Based Carbon Fibers from Biofuel Production Wastes: *Veronica Calado*[1]; [1]UFRJ

A precursor for carbon fibers with a great potential in Brazil is lignin obtained from biofuel production wastes. Lignin is a renewable material, non-toxic, that can be found in different biomasses. In Brazil, the most important biomasses are those from coconut, sugar cane bagasse, and paper industries. Biofuels can be obtained from different sources, such as vegetable oils and biomasses. Because of the concern about using food to produce fuels, there is an increasing interest in producing alcohol, called of second generation, from residual biomasses. Brazilian researcher are studying those processes by using sugar cane bagasse and paper industry waste. Lignin is a residue from this process and the objective of this paper is to use this lignin in order to obtain lignocellulosic-based carbon fibers that can be used in composite for different applications.

4:30 PM

Evaluation of Material Properties and Design Requirements for Biodegradable Magnesium Stents: *Maurizio Vedani*[1]; Stefano Fare'[1]; Gianmarco Vimercati[1]; Francesco Migliavacca[2]; Lorenza Petrini[2]; Stefano Trasatti[3]; [1]Politecnico di Milano, Dipartimento di Meccanica; [2]Politecnico diMilano, Dipartimento di Ingegneria Struturale; [3]Università di Milano, Department of Physical Chemistry and Electrochemistry

Biodegradable stents represent a valid solution to long term in-stent restenosis. Indeed Magnesium (Mg) alloys are extremely promising for this application thanks to their mechanical properties and biocompatibility. In the present work several commercially available alloys were evaluated for this application. The AZ31, AM60, AM80, ZM21 and WE43 alloys in the form of extruded bars were investigated to compare their mechanical behavior and corrosion resistance. Further high temperature characterization was carried out by compression tests at high temperature (temperature range: 320-450°C, strain rate range: 10-4 – 10-2 s-1) in order to assess the optimal processing window for stent precursors manufacturing (small tubes 1 mm in diameter) by hot extrusion. The experimental results made available by this investigation were adopted to support the development of a finite element (FE) framework combining a shape optimization procedure and a detailed model for Mg alloy mechanical and corrosion damage behavior.

4:50 PM

Mechanical Properties and Biocompatibility in-vitro and in-vivo of Plasma Sprayed Carbon Nanotube Reinforced Hydroxyapatite Coatings for Orthopedic Implants: Debrupa Lahiri[1]; Ana Paula Benaduce[1]; Sybille Facca[2]; Lidia Kos[1]; Nadia Jessel[3]; *Arvind Agarwal*[1]; [1]Florida International Univ; [2]INSERM U977, Faculté de médecine, ; [3]INSERM U977, Faculté de médecine,

Carbon nanotube (CNT) is incorporated in hydroxyapatite (HA) using spray drying technique to synthesize a composite HA-CNT powder which was subsequently plasma sprayed to form composite coating. Addition of 4 wt.% CNT increased the elastic modulus of the composite coating by 76% and fracture toughness by 100%. Effect of CNT reinforcement on tribological behavior been recorded in terms of 95% increase in wear resistance and 40% decrease in coefficient of friction. The improvement in wear properties is a cumulative result of strengthening effect and lubrication offered by CNTs. The biocompatibility of HA-CNT coating is established through viability test which suggests that CNT helps in normal growth and proliferation of osteoblast cells. Gene expression study and BRDU assay provide further insight into the effect of CNT on differentiation, and proliferation kinetics of osteoblast. Preliminary results of in –vivo study of the coatings, implanted in mice femur, indicates normal bone-growth.

5:10 PM

Porosity and Surface Topography Characterization of Titanium Samples: Alexandre Ribeiro[1]; Anderson Moreira[2]; Celso Fernandes[2]; Luiz Pereira[3]; *Marize de Oliveira*[1]; [1]Instituto Nacional de Tecnologia; [2]Universidade Federal de Santa Catarina; [3]Universidade Federal do Rio de Janeiro

Porous titanium has been used for surgical implants as it allows the mechanical interlocking of the pores and bone providing a better implant fixation. Some important parameters for porous biomaterials are porosity, pore size, pore shape and pore homogeneity. Many techniques have been used to characterize these parameters and different kinds of information can be achieved depending on the method used. Porous titanium samples were manufactured in this work by powder metallurgy, using pure titanium powders mixed with a pore former additive. The porosity quantification was assessed by geometric method, metallographic quantitative analysis and computed x-ray microtomography. Qualitative evaluation of pore morphology and surface topography were performed by optical microscopy, scanning electron microscopy and confocal laser scanning microscopy. The results allowed the comparison of the different techniques and the determination of the advantages and difficulties of each one, according to the porous titanium samples studied.

Computational Modeling and Advanced Characterization Symposium: Session II

Tuesday PM Room: Topazio
July 27, 2010 Location: Intercontinental Rio Hotel

Session Chair: To Be Announced

2:00 PM Invited

Coupling Advanced Characterization with First-Principles Computations to Investigate Omega Precipitation in Titanium Alloys: Arun Devaraj[1]; Soumya Nag[1]; Robert E. A. Williams[2]; Rajagopalan Srinivasan[2]; *Rajarshi Banerjee*[1]; [1]University of North Texas; [2]The Ohio State University

The omega phase is commonly observed in many commercial beta or near-beta titanium alloys on quenching from above the solutionizing temperature in the single beta phase field. These omega precipitates are highly refined (nanometer scale), homogeneously distributed, and can potentially act as heterogeneous nucleation sites for the precipitation of the equilibrium alpha phase. The present study primarily focuses on omega precipitation within the beta (body-centered cubic or bcc) matrix of simple model binary titanium-molybdenum (Ti-Mo) alloys. Direct atomic scale observation of pre-transition omega-like embryos in quenched alloys, using aberration-corrected high-resolution scanning transmission electron microscopy coupled with 3D atom probe tomography will be presented. First-principles computations have been performed using the Vienna ab initio simulation package (VASP) to determine the minimum energy path for the beta to omega transformation in Ti-Mo alloys with up to 20wt%Mo and the results of these computations will be compared and contrasted with the results from the HAADF-HRSTEM and 3DAP characterization studies.

2:30 PM Invited

Implementation and Practical Use of Neural Networks Models for Hot Rolled Steel Products Adaptation and Development in Usiminas Cubatao: *Willy Ank Morais*[1]; Herbert Christian Borges[2]; Ronald Plaut[3]; [1]USIMINAS / UNISANTA; [2]USIMINAS; [3]Poli - USP

The constant technological development in the steel consuming sectors increased the competition that forces steel makers to narrow dimensional tolerances and mechanical properties range of their products. In this way, the Technical Assistance and Integrated Control Divisions are studying and analyzing microstructural and mechanical characteristics from steel products of USIMINAS Cubatao in order to create phenomenological models to describe their properties. In the present work, basic process data (chemical composition, rolling temperatures, product dimensions) have been used in order to build models based on computational intelligence, Artificial Neural Networks (ANN's) to describe yield strength, tensile strength and elongation of hot rolled materials, in the form of steel coils and sheets, to increase product project and control quality. Products applied to petrochemical and automobilist industry have been improved by the use of these tools as well product control quality internal activities in Usiminas Cubatao.

3:00 PM Invited

Experimental Characterization and Computational Modeling of Microstructure Evolution during Solid State Processes: N. Zhou[1]; R.P. Shi[1]; *Yunzhi Wang*[1]; [1]Ohio State University

The key to predicting, and therefore optimizing, properties of materials is the knowledge of the state of microstructure and its evolution. To develop fundamental understanding of microstructure evolution during solid state phase transformations and dislocation-precipitate interactions in multi-phase alloys, we have adopted an approach that integrates advanced experimental characterization with multi-scale computer simulations. This approach, based on phase field models at different length scales, has allowed for the incorporation of the most relevant mechanisms and ab initio calculations in materials models. Using Ni-base superalloys and a/b Ti-alloys as examples we demonstrate how experimental characterizations have motivated and focused the simulation studies and how computer simulations have helped in resolving long-standing issues concerning phase transformation and deformation mechanisms in these alloys. The work is supported by NSF, ONR and AFOSR.

3:30 PM Break

4:00 PM Invited

Computational Thermodynamics in Steelmaking and Processing – How Useful is Equilibrium Information?: *Andre Costa E Silva*[1]; [1]EEIMVR - Universidade Federal Fluminense - IBQN

The last 40 years have seen the intense development and the maturity of computational thermodynamics and its applications to several materials, in special to steels. In about the same period the steel industry has recovered from a "stagnant" situation to an almost unprecedented vigor in the first decade of the 21st century. This has been due, in part, to the ability of the steel industry to reinvent itself, improving and developing manufacturing processes and developing novel steels at an astonishing pace. It is proposed that, among the decisive factors for this change is the progress in the application of thermodynamics, made possible both by the development of computational thermodynamics and by the creation of consistent and reliable thermodynamic databases.

4:30 PM

Simulation of Nanofoams under Stress and Irradiation Conditions: *Eduardo Bringa*[1]; J. Monk[2]; D. Farkas[2]; J. Rodriguez-Nieva[3]; A. Caro[4]; T. Cassidy[5]; R.E. Johnson[5]; [1]CONICET- Universidad Nacional de Cuyo; [2]Department of Materials Sciences, Virginia Tech; [3]Instituto Balseiro; [4]Lawrence Livermore National Laboratory; [5]Astronomy Department, University of Virginia

High-porosity materials can be found in a number of situations, from space grains to reactor materials. Using molecular dynamics (MD) simulations, we analyze the case of high porosity foams, with pores at the nanoscale, where experimental techniques are difficult to use and interpret. We study the mechanical behavior of nanofoams under tension and compression, together with their evolution under irradiation. We consider to irradiation scenarios: (a) irradiation with ions with energies in the range 1-25 keV, of interest for fusion and fission energy applications; (b) swift heavy ion irradiation, with energies up to 5 GeV, relevant for track formation and interstellar grain evolution. Irradiation effects have larger spatial extent than for compact, full-density solids, and include the production of point-defects and twins which change the foam mechanical properties. In addition, we analyze the swift-heavy ion induced sputtering of these nanofoams.

4:50 PM

Evolution of Different Generations of Gamma Prime Precipitates in a Commercial Nickel Base Superalloy: Antariksh Singh[1]; *Soumya Nag*[1]; Jaimie Tiley[2]; Babu Viswanathan[2]; Yunzhi Wang[3]; Hamish Fraser[3]; Rajarshi Banerjee[1]; [1]Center for Advanced Research and Technology and Department of Materials Science and Engineering, University of North Texas; [2]Materials and Manufacturing Directorate Air Force Research Laboratory; [3]Center for the Accelerated Maturation of Materials and Department of Materials Science and Engineering, The Ohio State University

During continuous cooling of nickel base superalloys from the single gamma phase field, the cooling rate plays a critical role in determining the precipitation of the ordered gamma prime phase. Depending on the cooling rate, either a single or multiple bursts of gamma prime nucleation can occur, changing their size distribution, morphology, and, composition. This study focuses on the compositional and microstructural evolution of different generations of ' precipitates during the continuous cooling, followed by isothermal aging, of a commercial nickel base superalloy, Rene 88DT, characterized by three dimensional atom probe tomography (3DAP) coupled with energy-filtered transmission electron microscopy (EFTEM) and high-resolution scanning electron microscopy (SEM) studies. Composition and morphology of different generations of gamma prime precipitates as a function of cooling rate will be addressed and compared with previously reported phase-field simulation results. The experimental findings would be compared with simulation results obtained via phase-field and solution thermodynamic modeling.

5:10 PM

Thermodynamic Study of Non-Metallic Inclusion Formation in the SAE 1141 Steel: *Wagner Bielefeldt*[1]; Antônio Vilela[1]; [1]UFRGS

The main goal was to study non-metallic inclusion formation in the CC tundish for the SAE 1141 steel. Specific goals: 1) To obtain inclusions as function of steel composition and casting temperature. 2) To establish steel chemical composition for the formation of less harmful inclusions to the SAE 1141 castability. Simulations using the commercial software FactSage and databases were carried out. The results showed the formation of different solid oxides and the formation of liquid phase in the inclusions by the variation of calcium content in the steel. It was possible: 1) to determine the inclusion composition as a function of aluminum and calcium content of SAE 1141 steel. 2) to establish a range of calcium content were the inclusions are formed by predominant liquid phase. 3) to calculate the percent of liquid and solid phases in the inclusions, as well the composition in terms of oxides.

Light Weight Materials for Transportation: Processing and Properties Symposium: Session III

Tuesday PM — Room: Onix
July 27, 2010 — Location: Intercontinental Rio Hotel

Session Chair: To Be Announced

2:00 PM Invited
Gradient Nanomechanics: Applications to Deformation, Fracture and Diffusion in Nanopolycrystals: *Elias Aifantis*[1]; [1]Aristotle University, Thessaloniki, Greece - and - Michigan Tech University

The initial experimental observations and modeling ideas advanced in the mid nineties at Michigan Tech (MTU) for the deformation and fracture of nanocrystalline (nc) and ultrafine grain (ufg) polycrystalline specimens in thin film and bulk configurations are first reviewed. This is done not only because these early results remain still largely unknown, but also because they have motivated recent experimental, theoretical and simulations work for nanophase materials. Next, a continuum nanomechanics framework is outlined for elasticity, plasticity and diffusion in nc's and ufg's and comparisons with experiments are provided. These experimental results concern stress-strain relations under varying grain size, strain rate, and temperature.

2:30 PM Invited
Magnesium Sheets Produced by Extrusion: *Soeren Mueller*[1]; Sven Gall[1]; [1]TU Berlin

Due to the low density and the good mechanical properties magnesium alloys exhibit a very high potential for lightweight constructions, especially for automotive and aircraft applications. These good mechanical properties of magnesium alloys are strongly influenced by the processing route and depend on the developed microstructure. For various applications in different industries thin flat profiles are used. These profiles are mainly manufactured by rolling processes. Thereby, the bars are rolled in several successive rolling steps. Alternatively, the extrusion process permits the production of magnesium sheets with specific dimensions at nearly constant conditions by using only one process step. Moreover the extrusion products exhibit also a different microstructure and texture than the rolled products. Therefore, indirect and direct extrusion trials are performed. For the investigation of the influence of recrystallization mechanisms on the microstructure and texture of the magnesium sheets direct extrusion trials with air and water cooling were carried out.

3:00 PM Break

4:00 PM
The Use of Fly-Ash and Rice-Hull-Ash in Al/SiCp Composites: A Comparative Study of the Corrosion and Mechanical Behavior: *Martin Pech-Canul*[1]; Rodrigo Escalera-Lozano[1]; Miguel Montoya-Dávila[2]; Maximo Pech-Canul[3]; [1]CINVESTAV SALTILLO; [2]Universidad Autónoma de Zacatecas; [3]CINVESTAV MÉRIDA

Fly-ash and rice-hull-ash promise to be low-cost materials for the manufacture of aluminum-based composites. Accordingly, these composites are attractive when planning on the design of light-weight and cost-effective materials. However, it is essential for these composites, to evaluate their corrosion and mechanical behavior. In this work, the corrosion characteristics and mechanical behavior of Al/SiCp/spinel composites prepared by reactive infiltration with fly-ash (FA) and rice-hull ash (RHA) -both with recycled aluminum- were investigated. Results reveal that both FA and RHA help in preventing SiCp dissolution and the subsequent formation of the unwanted Al4C3. However, FA-composites are susceptible to corrosion via formation of Al4C3 by the interaction of native carbon in FA with liquid aluminum. Microstructure and mechanical characterization show that FA- and RHA-composites possess mechanical properties that are significantly different and that this behavior is due to the original ash and MgAl2O4 morphologies.

4:20 PM
Thermal Behavior of the Buriti Biofoam: Sergio Monteiro[1]; *Rubén Jesus Rodriguez*[1]; Lucas da Costa[1]; Tammy Portela[1]; Nubia Suely Santos[2]; [1]State University of the Northern Rio de Janeiro - UENF; [2]University of Campinas, UNICAMP

A natural biofoam extrated from the petiole of the buriti palm tree has shown values of density and mechanical strength with potential for uses in engineering applications such as automobile interior parts and floating components. However, foams can also be used as insulating materials in packing and building panels. In this case same thermal properties are required. Therefore, the objective of this work was to evaluate the thermal behavior of the buriti biofoam by means of TGA and DSC analysis. Measurement of thermal conductivity was also performed. It was found that the buriti biofoam suffers thermal degradation above 200°C but a low thermal conductivity value remains constant up to this level of temperature.

4:40 PM
The Dynamic-Mechanical Behavior of Epoxy Matrix Composites Reinforced with Ramie Fibers: *Frederico Margem*[1]; Jarbas Bravo[1]; Kestur Satyanarayana[2]; Sergio Monteiro[1]; [1]State University of the Northern Rio de Janeiro - UENF; [2]Federal University of Parana

The exceptional tensile strength of ramie fiber has motivated investigations on application as reinforcement in polymeric composites. In this study, the temperature variation of the dynamic mechanical parameters of epoxy matrix composites incorporated with up to 30% in volume of ramie fiber was investigated by DMA tests. The parameters were the storage modulus, loss modulus and delta tangent. The investigation was conducted in the temperature from -100 to 180° in an equipment operating in its flexure modulus at 1 Hz under nitrogen. The results showed that the incorporation of ramie fiber tends to increase the viscoelastic stiffness of the epoxy matrix. Substantial changes were also observed in the glass transition temperature and in the structure damping capacity when the fraction of fiber is increased in the composite. These results indicate that the molecular mobility of the epoxy resin is affected by interaction with ramie fibers in the composite.

5:00 PM
Polyester Composites with Improved Tensile Properties by Thinner Curaua Fiber Reinforcement: *Felipe Perisse Lopes*[1]; Ailton Ferreira[1]; Kestur Satyanarayana[2]; Sergio Monteiro[1]; [1]State University of the Northern Rio de Janeiro - UENF; [2]Federal University of Parana

In recent years curaua fiber reinforced polymer composites have been gaining attention in both research works and industrial applications. It was recently found that curaua fibers with very small diameters may reach tensile strength over 1000 MPa. Therefore the objective of this work was to evaluate the tensile properties of polyester composites reinforced with thinner curaua fibers for improved mechanical performance. Standard specimens were fabricated with up to 40% in volume of very thin, d<0.05 mm, continuous and aligned curaua fibers embedded in an orthophtalic polyester matrix. The specimens were post-cured at 60°C and tensile tested in an Instron machine. The fracture of selected specimens was analyzed by scanning electron microscopy. The results showed a significant improvement in the mechanical properties with the amount of thinner curaua fibers as compared to other works on curaua composites.

Composite Materials Symposium: Session I

Wednesday AM July 28, 2010

Room: Turmalina
Location: Intercontinental Rio Hotel

Session Chair: To Be Announced

9:00 AM
Effect of Fiber Addition on Mechanical Properties of Continuous Miriti Fibers Reinforced Polymer Composites: *Nubia Santos*[1]; Manoel Silva[2]; Elisabete Sanchez[1]; Cecilia Zavaglia[1]; Eder Albuquerque[3]; [1]Universidade Estadual de Campinas; [2]UNIFEI; [3]Universidade de Brasilia

In this study the effect of the addition of miriti fibers on an unsaturated polyester matrix on volume fraction up to 30% was investigated. The miriti fibers are extracted from Mauritia flexuosa L. palm, and were treated with a NaOH aqueous solution (5%), in order to improve the interfacial adhesion between fiber-polymer. The composites were consolidated in a steel mold under pressure for 24 h, and post-cured in an oven at 60 °C for also 24 hours. The TGA analysis were conducted to evaluate the thermal behavior of the composites with fibers addition. Tensile tests were carried out on unidirectional fiber composites and the results indicated an increase in elastic modulus comparing with UP matrix. The SEM micrographs were used to show the fiber/matrix interfacial adhesion for composites after the fracture under tension.

9:20 AM
Cement Composites Reinforced by Short Curaua Fibers: *Ana Lúcia d`Almeida*[1]; Romildo Toledo Filho[1]; João Melo Filho[1]; [1]COPPE/UFRJ

The development of an eco-friendly material that could reduce CO2 emission and that could aggregate value to a natural fiber, setting man at the countryside and raising the income of populations from poor regions is a challenge. Lignocellulosic fibers are cheap and are a readily available reinforcement, requiring only a low degree of industrialization for their processing. The main drawback of using cement composites reinforced with lignocellulosic fibers is that the fibers can be mineralized inside the alkaline environment. In this work, Portland cement was partially replaced by metakaolinite in order to produce a matrix free from calcium hydroxide, avoiding thus the problem of fiber mineralization. Cement composites reinforced with 2 and 4% of short curaua fibers, were manufactured. The composites were submitted to four pointing bending tests in order to determine their mechanical behavior. The results obtained were compared with those found for cement composites reinforced with sisal fibers.

9:40 AM Keynote
Tensile and Fatigue Behavior of High Performance Fibers: *Nik Chawla*[1]; Krishan Chawla[2]; Flavio Silva[3]; Romildo Toledo Filho[3]; [1]Arizona State University, School of Mechanical, Aerospace, Chemical, and Materials Engineering; [2]University of Alabama at Birmingham; [3]COPPE-UFRJ

High performance fibers are ubiquitous in our everyday lives. In a variety of structural applications, fibers and fiber reinforced composites are subjected to static and cyclic mechanical loading. We have conducted extensive work on single fiber tensile and fatigue testing using a microforce testing system. In this talk we review our work on the tensile and fatigue behavior of some common high performance fibers such as ceramic, metal, and natural fibers. Tensile and fatigue mechanisms unique to each type of fiber are identified and a description of damage and fracture is provided.

10:20 AM Break

10:40 AM Invited
Fracture and Fatigue of Metallic Glass Matrix Composites: *Robert Ritchie*[1]; Maximillien Launey[2]; Douglas Hofmann[3]; William Jonhson[3]; [1]University of California Berkeley; [2]Lawrence Berkeley National Laboratory; [3]California Institute of Technology

The mechanical properties of bulk metallic glasses (BMG) are often plagued by low fracture and fatigue resistance. Correspondingly, much effort in recent years has been devoted to improving their damage tolerance properties, either through compositional changes or by introducing some degree of microstructure. By matching the microstructural length scales (of a second phase) to mechanical crack-length scales, metallic glass matrix composites demonstrate strongly improved tensile ductility, fracture toughness, and fatigue resistance. These remarkable improvements are explained by the effect of the mechanically soft and ductile second phase, which acts stabilizing against shear localization and critical crack propagation; it results in extensive plastic shielding, which further stabilizes crack growth. The fracture and fatigue behavior of semi-solidly processed Zr- and Ti-based BMG matrix composites with in-situ dendritic phase was examined. Specifically resistance-curve, fatigue crack-growth, and stress-life behavior are here presented in light of the relevant toughening and fatigue mechanisms involved.

11:10 AM Invited
Morphological Forms of Phosphogypsum Depending on Modification Approaches in Using as Mineral Filler for Polymer Composites: *Yordan Denev*[1]; Georgi Denev[1]; Bogdan Bogdanov[1]; Anton Popov[1]; [1]Prof. Assen Zlatarov University

The waste calcium sulfate (phosphogypsum) is a solid by-product generated from phosphoric acid production processes. The phosphogypsum represents serious ecological problem that isn't solved globally. A potential possibility for its utilization is using as a mineral filler for polymer composite materials with rich morphology, which significantly affect its performance variances. They define the different geometric type, shape and size of particles of phosphogypsum. The use of mineral fillers in polymer technologies requires detailed knowledge of their morphology. The different modification methods give opportunities to increase its effectiveness as mineral filler. From research done it is clear that there are structural levels in the morphology of the observed particles. The aim of present work is research on morphological diversity of phosphogypsum that offers opportunities to obtain mineral filler for polymers with optimum morphological characteristics and the ability to regulate its dispersion composition.

11:40 AM
Effect of Accelerated Carbonation on Kraft Pulp Fiber Reinforced Cement-Based Materials: *Alessandra Almeida*[1]; Gustavo Tonoli[2]; Sergio dos Santos[1]; Holmer Savastano Jr[1]; [1]Universidade de São Paulo/Faculdade de Zootecnia e Engenharia de Alimentos; [2]Universidade de São Paulo/Escola de Engenharia de São Carlos

The present study has been carried out in the attempt to durable fibre-cement composites by means of accelerated carbonation in the early stage of cement hydration. Fibre-cement composites were produced by the slurry dewatering and pressing technique, using the following constituents: 10% of conventional Kraft unbleached eucalyptus pulp, ground carbonate material and Type CPV ARI Portland cement. Two days after moulding, the composites were carbonated under controlled conditions. Physical characteristics, mechanical performance and durability after ageing were evaluated. Microstructure and chemical characteristics were studied by environmental scanning electron microscopy and thermal analysis. Results showed that the accelerated carbonation in the first days of cure improved the mechanical performance and resulted in a denser matrix, which suggests that accelerated carbonation can be an procedure to improve initial strength of composites and to mitigate the degradation of cellulose fibres in a less alkaline medium due to higher content of CaCO3.

12:00 PM
Evaluation of Polypropylene/Saw Dust Composites Prepared with Malealated Polypropylene (MAPP) Produced by Reactive Extrusion: Thais Helena Flores-Sahagun[1]; *Kestur Satyanarayana*[1]; Ernani Trombetta[1]; [1]Universidade Federal do Paraná

Considering the importance of environment and fuel saving, in recent times Brazilian automotive sector has focused on the development of light weight materials based on renewable resources. Substitution of conventionally used PP/talc by PP/saw dust system is one such possibility. Recognizing that maleated polypropylene (MAPP) being a good compatibilizer for PP based composites, while MAPP is not produced commercially in Brazil, present work presents its production through reactive extrusion using different amounts of benzoyl and dicumyl peroxides with maleic anhydride. Melt index, processing characteristics and FTIR analysis were used to evaluate the MAPP samples. Eucalyptus saw dust was coated with different MAPP samples before the preparation of composites containing 20% of these wood fibers. Tensile, impact and flexural properties were evaluated with injection molded specimens along with melt flow index and thermal properties for each composite. Optimized composites were evaluated for their performance and properties with presently used FRP product.

Dynamic Behavior of Materials Symposium: Session I

Wednesday AM　　Room: Topazio
July 28, 2010　　Location: Intercontinental Rio Hotel

Session Chair: To Be Announced

9:20 AM
Dynamic Behavior of Gamma-Irradiated Polycarbonate: *Ricardo Weber*[1]; João Carlos Suarez[1]; [1]IME
Polycarbonate (PC), an engineering thermoplastic, has numerous industrial applications due to its high toughness and excellent light transmission. Bisphenol A polycarbonate is used as window screen and as transparent ballistic armor. The PC, in these applications, is exposed to outdoor agents like sunlight, temperature, moisture, radiation etc. The polymeric materials after environmental exposure, present chemical and physical changes that involve, especially, bond scission of the macromolecule backbone. In the present work, the effects of strain rate and the influence of gamma irradiation on the dynamic behavior of a brazilian polycarbonate plate were investigated. The PC was exposed in air to a 340kGy gamma dose and the molecular weight was determinated by gel permeation chromatography (GPC). A modified split-Hopkinson pressure bar was used to measure stress-strain relations up to a true strain of 0,3 % at strain rates between 690 and 2500 s-1. The results are presented and discussed.

9:40 AM Keynote
Influence of Environmental Degradation on the Ballistic Behavior of Polymeric Armor Materials: *João Carlos Miguez Suarez*[1]; [1]Instituto Militar de Engenharia (IME)
High resistance fibers, thanks to their superior performance, are used, either alone or as a reinforcement element, in several fields, from sport and recreation products to sophisticated structures for civil and military applications. Polymeric materials, such as polyester, epoxy, polyamide, aramid and polyethylene, in the form of fibers or fabrics, have been widely used, since World War II, by the military industry. Materials manufactured with aramid or ultra high molecular weight polyethylene fibers, that show a great capacity for absorbing the impact energy of projectiles, are employed in the production of lightweight polymeric armor, for personnel and vehicular protection. Soft armor is composed of multiple layers of fabric sealed into a covering and hard armor is a composite formed by woven or non-woven fabrics in a resin, thermorrigid or thermoplastic matrix sandwiched, usually, in a plastic film. Exposure of polymeric materials to environmental agents, such us radiations, humidity, heat, chemical products, microorganisms etc., causes macromolecular modifications which lead to aging and, frequently, to a degradation of the material properties. These agents depend strongly on local conditions and thus vary considerably from region to region and from country to country. The performance of polymeric armor made with high-modulus and high-strength fibers has been extensively investigated but very few studies were dedicated to the aging of these materials. In addition, high resistance fibers are often proprietary materials and published data about the influence of the environmental conditions on the behavior of polymeric armor materials are limited and sometimes contradictory. Therefore, investigation of degradation mechanisms is important for developing new polymeric armors and, in special, for predicting useful life of these materials. The results of academic research studies related to degradation of polymeric armor, carried out in the materials science graduate program of IME, will be reported and discussed. The research projects that are being contemplated for the near future will also be presented.

10:20 AM Break

10:40 AM Keynote
Material Deformation Dynamics at Ultrahigh Pressures and Strain Rates: *Bruce Remington*[1]; [1]Lawrence Livermore National Laboratory
Solid state dynamics experiments at extreme pressures, P >1000 GPa,and strain rates(106-107 s-1)are being developed for the NIF laser. The experimental methods are being developed on the Omega, EP, and Jupiter laser facilities. Velocity interferometer(VISAR)measurements establish the ramped, high pressure conditions. Recovery experiments offer a look at the residual microstructure. Dynamic Laue diffraction measurements allow phase and possibly defect density to be dynamically inferred. Dynamic Bragg or Laue diffraction allow an estimate of shear stress(strength)at the lattice level to be inferred. Constitutive models for material strength are currently tested at ~Mbar pressures by comparing 2D simulations with experiments measuring the Rayleigh–Taylor instability evolution in solid state samples of vanadium(V)and tantalum(Ta). New multiscale models for V and Ta, combining MD, DD, and continuum simulations is tested. Our analysis for the vanadium experiments suggests that the material deformation at these conditions falls into the phonon drag regime. We also make an estimate of the(microscopic)phonon drag coefficient, by relating to the(macroscopic)effective lattice viscosity.

11:20 AM Keynote
Influence of Sweeping Detonation-Wave Loading on Shock Hardening and Damage Evolution during Spallation Loading: *George Gray*[1]; [1]Los Alamos National Laboratory
While much has been learned over the past five decades concerning the kinetics of the damage evolution and spallation in shock-loaded materials these studies have focused principally on 1-D shocked samples where the shocks produced possessed “square-topped” profiles as a function of peak stress. However, considerably less is known concerning spallation resulting from direct in-contact HE-driven, where a “Taylor-wave” shockwave profile is applied let alone a sweeping detonation Taylor-wave loading stress path where the applied stress tensor evolves as a function of obliquity. In this talk the influence of HE-driven shock loading, both 1-D and as a function of shock obliquity on the damage evolution and spallation response of Cu, 1018 steel, and Ta is compared and contrasted to that seen in each material subjected to flyer-plate driven “square-topped wave” shock profile prestraining.

12:00 PM Invited
Hydrogen Behavior and Hydrogen Embrittlement of Metals: *Kenichi Takai*[1]; [1]Sophia University
To clarify the function of hydrogen in embrittlement of various metals, identify of hydrogen trapping sites, dynamic behavior of hydrogen during deformation, lattice defect formation enhanced by hydrogen and strain are important. In the present review, determination of hydrogen trapping sites in metals, interaction between dislocation and hydrogen, evaluation of enhanced lattice defects such as vacancies and its clusters, and their relevance to hydrogen embrittlement are discussed.

Mechanical Properties of Materials with Emphasis on Grain-Size Effects Symposium: Session I

Wednesday AM Room: Onix
July 28, 2010 Location: Intercontinental Rio Hotel

Session Chair: To Be Announced

9:00 AM
A General Study of Commercially Pure Ti Subjected To Equal Channel Angular Pressing: Microstructure, Mechanical Properties and Corrosion Resistance: *Anibal Mendes Filho*[1]; Carlos Rovere[1]; Vitor Sordi[1]; Maurizio Ferrante[1]; [1]Federal University of São Carlos

Commercial purity Ti is currently employed in a number of orthopedic devices, such as screws, plates, dental implants and the like. However, the material would benefit from an increase of tensile strength, and this can be accomplished by equal channel pressing (ECAP). In the present work bars of Grade 2 Ti were subjected to that deformation technique both at room and 300°C. Additionally, some specimens were cold rolled up to 70% reduction. From tensile and compression tests data such as yield and maximum strength, elongation and work-hardening exponent were obtained, together with information on work-hardening behavior taken from Kocks - Mecking plots. Results show that the best combination strength - ductility is produced by four ECAP passes followed by cold rolling. Finally, the corrosion behavior was assessed according to ASTM F 2129 and no difference between non - deformed and deformed samples was detected.

9:20 AM
An Evaluation of Superplastic Flow in Ultrafine-Grained Materials Processed Using Severe Plastic Deformation: *Megumi Kawasaki*[1]; Terence Langdon[1]; [1]University of Southern California

The introduction of significant grain refinement is very attractive because small grains will produce excellent creep properties especially superplastic ductilities at elevated temperatures. Since the strain rate in superplastic flow varies inversely with the grain size raised to a power of two, a reduction in grain size to the submicrometer level will lead to the occurrence of superplasticity within the region of high strain rate superplasticity at strain rates $>10^{-2}$ s^{-1}. In the present report, published creep data are analyzed for several different ultrafine-grained materials processed by equal-channel angular pressing. The analysis shows the results from all materials are mutually consistent and there is very good agreement with a flow mechanism developed earlier to explain superplastic flow in conventional materials with coarse grains.

9:40 AM Keynote
Achieving Exceptional Grain Refinement through Severe Plastic Deformation: New Developments in Processing to Attain Homogeneity: Ruslan Valiev[1]; *Terence Langdon*[2]; [1]Ufa State Aviation Technical University; [2]Univ of Southern California

Equal-channel angular pressing (ECAP) is now an accepted processing technique for achieving grain refinement to the submicrometer level in bulk metals. However, ECAP is a repetitive and labor-intensive process that is not easily adapted for use in industrial applications. This paper describes the principles of ECAP, the characteristics of the grain refinement and the alternative techniques that are now becoming available such as ECAP-Conform and processing by ECAP using parallel channels.

10:20 AM Break

10:40 AM Keynote
The Ambient-Temperature Mechanical Properties of UFG Ag with Nanotwins Using Microshear Tests: *Michael Kassner*[1]; P. Geantil[1]; A. M. Hodge[1]; [1]University of Southern California

The ambient-temperature mechanical properties of ultrafine grain (UFG) high-purity silver were studied using microshear specimens. 150µm silver interlayers prepared by planar magnetron sputtering and diffusion bonding were tested in torsion (pure shear). There is a duplex structure with "as deposited" regions of small (0.25 – 1.25µm diameter) columnar grains with microtwins that are parallel to the shear plane and recrystallized regions with a lower density of randomly oriental microtwins. The average grain size, defined by boundaries greater than 15° misorientation, was approximately 1.25µm, not including a high density of oriented nano-twins parallel to the maximum resolved shear stress in the columnar grain regions. The interlayers have very high ductility (equivalent uniaxial strain, , > 3) in pure shear, comparable to conventional grain sizes, and show what appears to be an eventual mechanical steady-state. The Hall-Petch 0.2% offset yield-stress behavior at 1.25µm is consistent with other earlier work at similar grain sizes. The hardening rates (= d /d) are substantially higher in the UFG Ag, possibly due to the high density of nano-twins or possibly the duplex structure. The saturation stresses are essentially identical to that of conventional grain sizes in the UFG material, which contrasts earlier tensile fracture-testing. The strain-rate sensitivity is identical to coarse-grain silver.

11:20 AM
A Comparison between Asymmetric Rolling and Accumulative Roll Bonding as Means to Refine the Grain Structure of an Al-Mg-Si Alloy: *Maurizio Vedani*[1]; Stefano Fare'[1]; Giuliano Angella[2]; Gerardo Garces[3]; [1]Politecnico di Milano, Dipartimento di Meccanica; [2]CNR - National Research Council, IENI; [3]Centro Nacional de Investigaciones Metalurgicas

The possibility of refining the grain structure of an Al-Mg-Si alloy was evaluated using asymmetric rolling (ASR) and accumulative roll bonding (ARB) in the severe plastic deformation (SPD) regime. Samples of the alloy were asymmetrically rolled by a laboratory mill featuring the possibility of independently modifying the rotational speed of the rolls. The effect of the rolling temperature was investigated by tests in the range 150- 250°C. A campaign was also carried out to study the effects of ARB on the same alloy. Analysis on the SPD samples were focused on the distribution of hardness and on the evolution of microstructure and texture as a function of rolling conditions and accumulated strain. The investigations showed that both ASR and ARB can produce an ultrafine grained structure. A discussion on the rate of refining and texture evolution as a function of accumulated strain is given.

Composite Materials Symposium: Session II

Wednesday PM Room: Turmalina
July 28, 2010 Location: Intercontinental Rio Hotel

Session Chair: To Be Announced

2:00 PM Invited
The Elevated-Temperature Creep and Fatigue Behavior of B-Modified Ti-6Al-4V: Wei Chen[1]; *Carl Boehlert*[1]; [1]Michigan State University

This work investigated the creep and fatigue behavior of boron-modified Ti-6Al-4V(wt.%) alloys processed using four processing routes: powder metallurgy (PM) rolling, PM extruding, ingot casting (IC), and IC extruding. The PM alloys exhibited microstructures containing equiaxed grains while the IC alloys contained alpha+beta lath microstructures. This enabled the PM alloys to achieve greater fatigue lives than the IC processed alloys. In both the PM extruded and IC extruded alloys, the TiB whiskers were aligned in the extrusion direction and the alpha-phase was also textured such that the basal plane was predominately oriented perpendicular to the extrusion axis. The fine equiaxed alpha-phase structure and the alpha- and TiB-phase texture were responsible for the significantly higher fatigue strength exhibited by the PM extruded alloy compared with all the other alloys. The reasons why the creep strength of the IC extruded alloys was superior to the other B-modified alloys will also be discussed.

2:30 PM Invited

Recent Advances in the Science and Technology of Carbon Nanotube-Based Composites: *Tsu-Wei Chou*[1]; [1]University of Delaware

This lecture reports a review of the recent advancements in the science and technology of carbon nanotube (CNT)-based fibers and composites. The assessment is made according to the hierarchical structural levels of CNTs used in composites, ranging from 1-D to 2-D to 3-D. At the 1-D level, fibers composed of pure CNTs or CNTs embedded in a polymeric matrix produced by various techniques are reviewed. Developments in pure CNT fibers will be emphasized. At the 2-D level, the focuses are on CNT-modified advanced fibers, CNT-modified interlaminar surfaces and highly oriented CNTs in planar form. At the 3-D level, the mechanical and physical properties of CNT/ polymer composites and textile assemblies of CNTs are examined. CNT-based damage sensing of composites under cyclic and impact loading will be reviewed. The opportunities and challenges in basic research at these hierarchical levels will be discussed.

3:00 PM Invited

A Multi-Scale Investigation of the Mechanical Behavior of Durable Sisal Fiber Cement Composites: *Flavio Silva*[1]; Romildo Toledo Filho[2]; Barzin Mobasher[3]; Nikhilesh Chawla[3]; [1]TU Dresden; [2]COPPE/UFRJ; [3]Arizona State University

Durable sisal fiber cement composites reinforced with long unidirectional aligned fibers were developed and their mechanical behavior was characterized in a multi-scale level. Tensile and fatigue tests were performed in individual sisal fibers. Weibull statistics were used to quantify the degree of variability in fiber strength at different gage lengths. SEM was used to investigate the failure mode of the fibers and their failure mechanisms was described and discussed in terms of the fiber microstructure. The fiber-matrix pull-out behavior was evaluated at several curing ages and embedded lengths. The different sisal fiber morphologies were correlated to their pull-out behavior. The composite's mechanical response was measured under direct tension, bending and fatigue tests while crack formation was investigated using a high resolution image capturing procedure. Crack spacing was measured using image analysis and correlated with the applied strain under both the tensile and bending response.

3:30 PM Break

4:00 PM

Effect of Electron Beam Irradiation on Mechanical Properties of Gelatin/Brazil Nut Shell Fiber Composites: Patricia Takinami[1]; Kleber Shimazaki[1]; Maria Colombo[1]; Ricardo de Rosa[1]; Esperidiana Moura[1]; *Nélida del Mastro*[1]; [1]IPEN

The use of natural fiber as polymeric matrix reinforcement has attracted interest, as fibers are renewable, of low cost, biodegradable and possesses non-toxic properties. In the present paper, Brazil nuts (Bertholletia excelsa) shell fiber in two different percentages of 5 and 10% (w/w) were mixed with gelatin to investigate the resultant mechanical properties and texture analysis upon ionizing radiation. The samples were irradiated at 20 and 40 kGy using a 1.5 MeV electron beam accelerator, at room temperature in presence of air. The results showed that gelatin samples added with 10% of Brazil nuts shell fiber and irradiated at 40 kGy presented better mechanical performance than irradiated at 20 kGy or with 5% of fiber. Compression test showed up collaborated results for texture analysis.

4:20 PM

Investigation of High Strain Rate Properties of A356-Fly Ash Syntactic Foams: Dzung Luong[1]; *Nikhil Gupta*[1]; Atef Daoud[2]; [1]Polytechnic Institute of New York University; [2]Central Metallurgical Research and Development Institute

Hollow particle filled metal matrix composites (syntactic foams) are promising in applications where damage tolerance, compressive and impact energy absorption as well as low density are needed. In the present work, aluminum alloy (A356) and fly ash cenospheres are used as a matrix material and fillers, respectively, in synthesizing syntactic foams. Fly ash is used in 5 and 20 vol.% in these composites. A split-Hopkinson pressure bar (SHPB) setup is used to perform the high strain rate testing and the results are compared with quasi static compressive properties of the same composites. The elastic modulus and energy absorption were found to increase with increasing strain rate in these composites. High speed image acquisition, optical microscopy, and scanning electron microscopy are used to obtain information about the deformation and failure pattern of the specimens.

4:40 PM

Magnetite Formation Observed with TEM on Brake Discs: *Ruth Hinrichs*[1]; Marcos Vasconcellos[1]; Werner Oesterle[2]; Claudia Prietzel[2]; [1]UFRGS; [2]BAM

The most common brakes utilized in automotive braking are polymer matrix composite (PMC) pads that are rubbed against cast iron discs. During the braking process reactions take place and the new phases, mixed with wear debris, adhere to the surfaces forming a third body. Brakes tested with an AK-Master protocol develop a magnetite layer between the interacting surfaces. Disc samples that were obtained interrupting the friction test after a high temperature cycle (650°C) were prepared with FIB. Energy Filtered Transmission Electron Microscopy (EFTEM) results revealed that magnetite is formed on the interface next to graphite flakes in the cast iron disc. TEM captures the detachment of nanometer sized iron particles from the matrix due to wedging in of graphite layers. Gaps between particles allow the access of oxygen and the formation of magnetite. The graphite from the disc is transformed to an amorphous material during the process.

5:00 PM

Layered Materials as Colored Reinforcement for Polymeric Multifunctional Materials: *Fernando Wypych*[1]; Alexandre Mikowski[1]; Rafael Marangoni[1]; [1]Universidade Federal do Paraná

Zn2Al layered double hydroxides (LDHs) were intercalated with anionic dyes, namely, Orange G (OG), Orange II (OII) and Methyl Orange (MO) by zinc chloride and aluminum nitrate simultaneously precipitated with an alkaline aqueous solution, in the presence of anionic dyes excess. Homogeneous composite films were obtained by casting, after dispersing the intercalated dyes (pigments) into commercial Poly(vinyl alcohol) (PVA) and evaporation of water in a vacuum oven. Different anionic blue and orange dyes have also been immobilized on a zinc hydroxide nitrate (Zn5(OH)8(NO3)2•nH2O) by anion exchange with interlayer and/or outer surface nitrate ions of the layered matrix. Orange G (OG) was totally intercalated, orange II (OII) was partially intercalated, while Niagara blue 3B (NB) and Evans blue (EV) were only adsorbed at the outer surface. Several composite films of PVA were also prepared by casting. The obtained composite films were transparent, colored, and capable of absorbing UV radiation. Improved mechanical and thermal properties were also obtained compared to the non-filled PVA films. These results demonstrate the onset of a new range of potential applications for layered hydroxide salts in the preparation of polymer composite multifunctional materials.

5:20 PM

Synthesis and Characterization of Co-ZnO Composite: *Eduardo Brocchi*[1]; Mario Sergio Gonçalves[1]; Francisco Jose Moura[1]; [1]PUC-Rio

This work covers the Co-ZnO composite synthesis by hydrogen preferential reduction of these metals oxides which, in turn, were obtained by dissociation of their nitrates solution. Thermodynamic evaluation and kinetics experiments were carried out in order to study the temperature effect on the reduction. The material involved in the process were characterized by XR-D, SEM/EDS and TEM, being possible to identify a Co-ZnO homogeneous and containing particles in the nano range scale.

5:40 PM

Carbothermal Production of ZrB_2-ZrO_2 Composite Powder from ZrO_2-B_2O_3/B System by High-Energy Ball-Milling and Annealing Assisted Process: *Duygu Agaogullari*[1]; Ozge Balci[1]; Ismail Duman[1]; [1]Istanbul Technical University

The purpose of the present study is to produce zirconium diboride-zirconium dioxide composite powder by comparing two different boron sources as boron oxide and elemental boron. The production method is high-energy ball milling and subsequent annealing of powder mixtures containing stoichiometric amounts of zirconium dioxide, boron oxide/boron powders in the presence of graphite as a reductant. Milling is performed in a vibratory ball-mill using hardened steel balls with 18:1 ball-to-powder weight ratio. The milled products are placed in alumina boats and annealed in a tube furnace held in Argon atmosphere. Milled/annealed products are leached for removing the impurities released by the vial (Fe, Ni, and Cr). ZrB_2-ZrO_2 composite powder is obtained after centrifuging, washing and drying treatments. The effects of milling duration, annealing temperature and annealing duration on the formation and microstructure of composite powder are investigated. The milled and annealed products are characterized by XRD, SEM and DTA analyses.

6:00 PM

Study of Composite Materials Application for Horizontal Axis Wind Turbine Blades: Julio Pires[1]; *Branca Oliveira*[1]; [1]Universidade Federal do Rio Grande do Sul

The most common material used for manufacturing blades for horizontal axis wind turbines is the fiber-reinforced polymer (FRP), or just fiberglass. The production aims to combine high performance with reduced cost in material and manufacturing process. While the low specific weight of a shovel made of fiberglass can help in starting up, in a farm system under weak winds it may leads to a reduced torque situations. Thus a large amount of variation in angular velocity and therefore on the specific velocity of the system could happens. Since the specific velocity is directly related to the coefficient of power Cp of a wind rotor, this article presents a comparative study with different materials and geometries, designed to maximize the rotation of a small rotor (with fixed pitch angle). Also determining the structural limits for the materials used in blades by virtual simulation with finite elements

Dynamic Behavior of Materials Symposium: Session II

Wednesday PM — Room: Topazio
July 28, 2010 — Location: Intercontinental Rio Hotel

Session Chair: To Be Announced

2:00 PM Invited

Collision and Fragmentation of Nanograins: *Eduardo Bringa*[1]; Dalia Bertoldi[2]; Naofumi Ohnishi[3]; Bruce Remington[4]; [1]CONICET- Universidad Nacional de Cuyo; [2]Universidad Nacional de Cuyo; [3]Center for Research Strategy and Support, Tohoku University; [4]Lawrence Livermore National Laboratory

Collision and fragmentation of nanograins can be of interest in various fields, from the dynamics of interstellar dust, to spall in strong shocks. Atomistic molecular dynamics (MD) simulations of grain-grain collisions have been carried out for spherical grains of up to 5 nm, with relative velocities of few km/s and a number of random impact parameters. We have simulated both copper FCC grains using an Embedded Atom Model (EAM) potential, and carbon diamond grains using the Reactive Empirical Bond Order (REBO) potential. For the carbon grains, grain fusion is often observed even at these high velocities. High pressures and temperatures generated by the collision lead to hybridization changes in the carbon grains, and melting in the copper grains. Spall and fragmentation of the grains results in a complex grain size distribution, which does not follow a single power-law distribution.

2:30 PM Invited

On the Behaviour of Body Centered Cubic Metals during One-Dimensional Shock Loading: *Jeremy Millett*[1]; Neil Bourne[1]; George Gray[2]; Nigel Park[1]; Glenn Whiteman[1]; [1]AWE; [2]Los Alamos National Laboratory

The response of metallic materials to shock loading, like all loading regimes, is controlled largely by factors operating at the microscopic or atomic levels. Over the past few years, face centred cubic (FCC) metals have received a level of attention where the role of features such as stacking fault energy and precipitation hardening have been investigated. We now turn our attention to body centred cubic (BCC) metals. In the past, only tantalum, tungsten and their alloys have received significant attention, due to their use by the ordnance community. In particular, this investigation examines the shear strength of these materials under shock loading conditions. Previous results on tantalum and tungsten are reviewed, and more recent experiments on niobium, molybdenum and Ta-2.5wt% W presented. Results will be discussed in terms of known deformation mechanisms and variations of Peierl's stress.

3:00 PM Invited

Experimental and Numerical Investigation of Multiple Shear Bands in Collapsing Cylinders: *Zev Lovinger*[1]; A. Rikanati[1]; D. Rittel[1]; Z. Rosenberg[1]; [1]Rafael

The formation of shear bands in collapsing thick walled cylinders occurs in a spontaneous manner. The advantage of examining spontaneous shear localization, unlike forced shear localization, is that it highlights the inherent susceptibility of the material to adiabatic shear banding. The Thick-Walled Cylinder technique, reported in the literature, uses an explosive cylinder to create the driving force, collapsing the cylindrical sample. This experimental set-up has been established as a controlled and repeatable technique to create and study multiple adiabatic shear bands. We are using an electro-magnetic set-up to provide the collapsing force on the cylindrical specimens. The main diagnostics is post-mortem: the collapsing cylinders, which come to a stop at the end of the experiment, are cut and polished to reveal the spatial distribution of shear bands. 2D numerical simulations are carried out to reproduce the experimental results for both explosively driven and EM driven experiments.

3:30 PM Break

4:00 PM Invited

Microstructural Effects on Evolution of Shear Localization in Pre-Strained Stainless Steels: *George Gray*[1]; Qing Xue[2]; Ellen Cerreta[1]; Marc Meyers[3]; [1]Los Alamos National Laboratory; [2]Intel Corp.; [3]University of California, San Diego

Microstructual and processing effects on evolution of adiabatic shear localization (ASL) was systematically studied in various pre-strained stainless steels. Top hat sample impact on a split Hopkinson pressure bar was used. This well-controlled forced shear technique makes it possible to accurately correlate the microstructural evolution of ASL to the transient mechanical behavior. The initiation and development of adiabatic shear bands were captured and the material sensitivity to trigger a localized deformation was analyzed. The work-hardening rate was found to play a dominant role in ASL formation. The post mortem investigation of microstructure within and near shear bands using transmission electron microscopy (TEM) displays microstructural characteristics of shear band formation. The TEM results indicate that the main substructure inside a shear band consists of elongated lath, fine rectangular, and equiaxed subgrains. Dynamic/static recovery and continuous dynamic recrystallization were the main mechanisms to form the residual microstructure inside shear bands.

4:30 PM

Dynamic Behavior of Hydrogen Desorption from Pure Iron and Inconel 625 during Elastic and Plastic Deformation: *Kenichi Takai*[1]; Hiroki Shoda[1]; [1]Sophia University

Dynamic behavior of hydrogen desorption from pure iron with a body-centered-cubic lattice and Inconel 625 with a face-centered-cubic lattice was examined during tensile deformation using a quadrupole mass spectrometer in a vacuum chamber integrated with a tensile testing machine. Hydrogen desorption from hydrogen-charged specimens was detected under various strain rates and cyclic stresses. Hydrogen desorption rarely increased under elastic deformation. In contrast, it increased rapidly at the proof stress when plastic deformation began, reached its maximum, and then decreased gradually with increasing applied strain for both pure iron and Inconel 625. This desorption behavior is closely related to hydrogen dragging by moving dislocations. The thermal desorption analysis results showed that the amount of desorbed hydrogen differed at each strain rate. This difference in the amount of desorbed hydrogen transported by dislocations depends on the balance between the hydrogen diffusion rate and mobile dislocation velocity.

4:50 PM

Investigation of the Role of Age Hardening on the One-Dimensional Shock Response of Copper-2weight% Beryllium Alloys: *Glenn Whiteman*[1]; Jeremy Millett[1]; Michael Broadbent[1]; Nigel Park[1]; Paul Hazell[2]; [1]AWE; [2]Cranfield University

The Cu-Be alloy system offers an opportunity to investigate the role of age hardening on the mechanical response of a face centred cubic (FCC) system. The alloy system has been investigated in two conditions; solution treated where all beryllium remains in solid solution, and age hardened, where the material is strengthened by the precipitation of intermetallic particles. At 2 wt%, and between 700 and 900°C, Be remains in solid solution. By quenching from these temperatures, a supersaturated solid solution can be maintained, with quasi-static yield strengths of the order 460 MPa. An aging heat treatment of ca. 600°C, leads the material to precipitation harden, resulting in a yield strength in excess of 1000 MPa. In this presentation, we investigate the Hugoniot, dynamic shear strength and Hugoniot Elastic Limit in the stress range 2 - 14 GPa. Results are discussed in terms of the differing heat treatments.

5:10 PM

Mesoscale Effects in Dynamic Strength and Fracture of Granular Composite Aluminum/Tungsten: *Vitali Nesterenko*[1]; Po-Hsun Chiu[2]; Efrem Vitali[3]; Sophia Wang[2]; Karl Olney[3]; David Benson[3]; Kevin Gott[4]; [1]University of California, San Diego; [2]Materials Science and Engineering Program, UCSD; [3]Department of Structural Engineering, UCSD; [4]Department of Mechanical and Aerospace Engineering, University of California, San Diego

Compressive dynamic strength and fracture pattern of high density Al-W granular composites with an identical weight ratio between Al (23.8 wt%) and W (76.2 wt%) and with different porosities, size, shape and orientation of W component were investigated at strain rate 0.001 1/s. Samples were fabricated by Cold Isostatic Pressing with subsequent sintering and Hot Isostatic pressing. Size of particles and morphology of W inclusions had a strong effect on dynamic strength. Samples with W wires arranged in axial direction (diameter 100 microns) had a highest dynamic strength and exhibited bulk distributed fragmentation of Al matrix. Dynamic strength and fracture pattern of composites was numerically simulated using computer code Raven. The support for this project provided by the Office of Naval Research Multidisciplinary University Research Initiative Award N00014-07-1-0740 (Program Officer Dr. Clifford Bedford).

5:30 PM

The Effect of Specimen Dimensions on the Propensity to Adiabatic Shear Failure in Kolsky Bar Experiments: *Zvi Rosenberg*[1]; Yechezkel Ashuach[1]; [1]Rafael Advanced Defense Systems

The compression Kolsky bar is one of the most useful instruments to study dynamic response of solids at high strain rates. In particular, it is very useful in studying the adaibatic shear banding (ASB) of metals, a subject of importance for various fields ranging from terminal ballistics to metalworking. Most of these experiments are conducted with disc-like specimens with aspect ratios of 0.5-1. The occurence of adiabatic shears is manifested by both the reduction in the measured stress-strain curves and their appearance in the recovered specimens. A few workers have noted that the aspect ratio of some of the materials they tested has a magnificent role in determining whether a given specimen will undergo an ASB or not. The aim of our research was to investigate this issue further and understand the physics behind this behavior. We present results on some materials and discuss possible explanations for the observed behavior.

5:50 PM

Collapse Waves Resulting from Catastrophic Rupture of Materials under Dynamic Loading: *Haiying Wang*[1]; Yilong Bai[1]; Mengfen Xia[1]; Fujiu Ke[2]; [1]Institute of Mechanics, Chinese Academy of Science; [2]Beihang University

The propagation of either continuous stress wave or shock wave is driven by stress difference and all stress, strain and particle velocity vary simultaneously. For instance, a shock wave is a supersonically propagating jump driven by the difference of normal stress across the front and accompanied by corresponding jumps of strain and particle velocity. However, for brittle materials fail catastrophically under dynamic loading, some strange waves, namely collapse waves, generate. In this paper, we report two collapse waves, i.e. failure wave with no normal stress jump and sandwich wave with triple fronts. These findings may deepen the current understanding of waves and highlight the crashworthiness design.

6:10 PM

Effects of Temperature and Strain Rate on the Tensile Properties of TWIP Steels: Sven Curtze[1]; *Veli-Tapani Kuokkala*[1]; [1]Tampere University of Technology

Three high manganese TWIP steels were produced with stacking fault energies $_{SFE}$ varying between 20.5 and 42 mJ/m^2. The materials were mechanically tested in tension at temperatures -50°C = T = 80°C, while simultaneously varying the strain rate between 10^{-3} s^{-1} and 1250 s^{-1}. Due to the temperature dependence of $_{SFE}$, also the mechanical behavior of TWIP steels reveals clear temperature dependence, determined by the prevailing deformation mechanism, i.e., dislocation slip, deformation twinning, or -martensite transformation. In addition to the 'ordinary' strain rate sensitivity, an increase in temperature due to adiabatic deformation heating contributes to the stacking fault energy at high strain rates, shifting $_{SFE}$ towards the dislocation slip regime and this way strongly affecting the mechanical behavior. At stacking fault energies close to the transition between twinning and e-martensite transformation, lowering the temperature can ultimately result in entering the e-martensite transformation regime and bring about further ductility.

Mechanical Properties of Materials with Emphasis on Grain-Size Effects Symposium: Session II

Wednesday PM — Room: Onix
July 28, 2010 — Location: Intercontinental Rio Hotel

Session Chair: To Be Announced

2:00 PM Invited

Processing of Ultrafine-Grained Materials through the Application of Severe Plastic Deformation: *Megumi Kawasaki*[1]; [1]University of Southern California

Ultrafine-grained (UFG) materials have attracted much attention in recent years because of their remarkable properties such as high tensile strength at ambient temperatures and excellent ductility at elevated temperatures. In addition, processing through the application of severe plastic deformation (SPD) has become an absorbing tool within the last decade because it provides the potential for refining the grain size of polycrystalline bulk metals to the submicrometer or even the nanometer level. Several SPD methods are now available but the more promising procedures appear to be Equal-Channel Angular Pressing (ECAP) and High-Pressure

Torsion (HPT). This presentation examines these procedures with special emphasis on the evolution of microstructure during processing and the mechanical properties of the UFG materials.

2:30 PM Invited

Grain Size Effects on the Mechanical Properties of Bulk Structural Materials: *Fernand Marquis*[1]; [1]Naval Postgraduate School

The advanced design of structural materials relies on the optimization of key combinations of multi mechanical properties such as yield strength, tensile strength, fracture toughness, fatigue strength, environmental resistance, brittle to ductile transition temperature and formability. Often conventional processing of materials designed to achieve specific microstructures has opposite effects on some of these mechanical properties such as strength and toughness. Grain size refinement has been the main microstructural design that has been observed to drive simultaneously to an improvement on the majority of these properties. The degree of this improvement has been often quantified by appropriate Hall-Petch type of equations. However there has been signification controversy on the operational mechanisms of strengthening and toughening, the meaning of grain size and the range of applicability of mechanical improvement by grain size refinement. This paper discusses some of these challenges drawing across various structural materials.

3:00 PM Invited

From Conventional to Nanocrystalline Metals: Responses over Wide Ranges of Strain-Rates and Temperatures, and Constitutive Modeling: *Akhtar S. Khan*[1]; [1]University of Maryland Baltimore County (UMBC)

Comprehensive experimental results are presented for FCC & HCP metals, over a wide range of strain-rates, during quasi-static (10-5 to 100 s-1) and dynamic loading using tension, compression and ten.-tor. versions of Split-Hopkinson Bar (103 s-1). These results are at low to high temperatures. The materials also include nano-crystalline aluminum and copper. Experiments include uniaxial compression, tension and torsion loading, as well as multi-axial loading. Development of Khan-Huang-Liang (KHL) constitutive model is shown for usual grain sizes of commercially available materials to nano-crystalline metals. Multiaxial experiments on Ti-6Al-4V titanium alloys are also presented. The initial and deformed microstructures are also given. Experiments are performed under proportional loading conditions as well as dynamic torsion followed by dynamic compression at various temperatures. Experiments are also performed to investigate the anisotropic behavior of the alloys. In case of nano-crystalline materials, for the first time, high quality bulk ultra-fine grained and nano-crystalline pure aluminum and copper samples were prepared through room temperature ball milling, cold and warm compaction, sintering and annealing processes. These high quality bulk nano-crystalline FCC metals, with least amount of imperfections, exhibit high strength and ductility at room and high temperatures, and under quasi-static and dynamic types of loading. The samples were subjected to uniaxial compressive loading at quasi-static and dynamic strain rates of 10-2 s-1 and 1840-3105 s-1, respectively, and at temperatures ranging from 223 to 523 K. Further, a new grain size and temperature dependent visco-plastic phenomenological constitutive equation, Khan -Farrokh-Liang (KFL) model, is developed based on the Khan-Huang-Liang (KHL) constitutive model. The model is shown to correlate different observed behaviors of polycrystalline materials in the plastic regime, as the result of grain refinement.

3:30 PM Break

4:00 PM

Young´s Modulus of Al/Sicp/Mgal2o4 Composites with Different Particle Size Distribution of Reinforcements: Miguel Montoya-Dávila[1]; *Martin Pech-Canul*[2]; Rodrigo Escalera-Lozano[2]; Máximo Pech-Canul[3]; [1]Universidad Autónoma de Zacatecas; [2]CINVESTAV SALTILLO; [3]CINVESTAV MÉRIDA

The effect of particle size distribution of SiC particulate reinforcements coated with colloidal SiO2 on Young´s modulus of Al/SiCp/MgAl2O4 composites fabricated by reactive infiltration was investigated. Composites were prepared from porous preforms of silica-coated - SiC powders of 10, 54, 86, and 146 µm, 0.6 volume fraction of reinforcements and particle size distribution from monomodal to cuatrimodal. Infiltration tests with the alloy Al-13.3Mg-1.8Si (wt. %) were carried out in Ar N2 atmosphere at 1100ºC for 60 min. The composites were characterized by X-ray diffraction (XRD) and scanning electron microscopy (SEM). In addition to density and residual porosity measurements, Young´s modulus was evaluated by ultrasonic techniques. Results show that with increase in particles size distribution, residual porosity decreases and density and Young´s modulus of the composites are improved, the latter from 185.39 ±3.6 to 201.93 ±2.3 GPa. This is attributed to the increased metal-ceramic interfaces and to an enhanced matrix-reinforcement load transmission.

4:20 PM

The Microstructure and Mechanical Properties of a Friction Stir Processed Al-Zn-Mg-Cu Alloy: *Margarita Vargas*[1]; Sri Lathabai[1]; [1]Commowealth Scientific and Industrial Research Organisation (CSIRO)

Friction stir processing (FSP) is a novel solid-state technique which combines frictional heating and severe plastic deformation to produce ultra-fine grained metallic materials. FSP was performed on AA 7075-T6, an age hardenable high strength Al-Zn-Mg-Cu alloy commonly used in the aerospace industry. Diverse combinations of the two main processing parameters, i.e., the rotational and the translational speeds of the tool, were studied systematically in order to determine the optimal conditions for microstructural modification. As a result, several ultra-fine grained microstructures were produced, which were characterised using optical and scanning electron microscopy. The mechanical properties such as hardness, strength and ductility of the processed zone were studied and correlated with the microstructure. Significant differences in the mechanical behaviour of the FSP zone as compared to that of the as-received material were observed.

4:40 PM

Grain Refinement in Magnesium Alloys Processed by Severe Plastic Deformation: *Roberto Figueiredo*[1]; Terence Langdon[1]; [1]University of Southampton

Conventional thermo-mechanical processing of magnesium alloys can produce grain sizes in the range between a few microns to tens of microns. However, modern metal processing techniques of severe plastic deformation (SPD) such as equal-channel angular pressing (ECAP) and high pressure torsion (HPT) are able to refine the grain structure of metallic materials, including magnesium alloys, to the sub-micron range. This paper examines the use of SPD techniques to refine the grain structure of magnesium alloys and the effect of grain refinement on the mechanical properties.

5:00 PM

Mechanical and Microstructural Aspects Observed in 6063 Aluminum Alloy after Thermomechanical Treatments: *Waldemar Monteiro*[1]; Sidnei Buso[2]; Ricardo Ferrari[2]; Iara Esposito[2]; Paulo Cetlin[3]; Maria Aguillar[3]; Elaine Corrêa[3]; [1]Presbyterian Mackenzie University; [2]IPEN; [3]Federal University of Minas Gerais

In this work is shown the influence of some deformation processes on the mechanical and microstructure of initially annealed 6063 Al alloy (cold rolling or torsion or extrusion and also tensile deformation, individually or a combination of them). The combination of strength and toughness is intimately related to the work hardening. The analysis and control of work hardening has proven to be one of the problems of materials science due to the complexity of the dislocation processes involved and the non homogeneity of their operation within the deforming microstructure together with presence of a multiphase microstructure on the 6063 aluminum alloy (Al-Mg-Si-Fe). During deformation, particles will affect the deformation microstructure and texture (heterogeneities at larger particles; non homogeneity of slip, e.g. shear bands). The obtained results indicate a significant the effect of second-phase particles on recrystallization and how to control the resulting microstructure and texture by the use of particles.

5:20 PM

Using Accumulative Roll Bonding to Process Ultrafine Grained Titanium-Aluminum-Niobium Alloys: Peng Qu[1]; Rengang Zhang[1]; Gajanan Chaudhari[1]; *Viola Acoff*[1]; [1]The University of Alabama

Accumulative roll bonding (ARB) was used to process Ti-Al and Ti-Al-Nb alloys from elemental titanium, aluminum, and niobium foils. The sheets were severely deformed by repeated cold rolling with interspersed folding of the sheets. Following severe plastic deformation, the specimens were annealed at various temperatures below the melting point of aluminum. The structural evolution of the resulting material was investigated and characterized using transmission electron microscopy (TEM), scanning electron microscopy (SEM), x-ray diffraction (XRD), and differential scanning calorimetry (DSC). Tensile testing and microhardness testing were used to evaluate the mechanical properties of the resulting multilayered specimens. TEM analysis showed the formation of ultrafine, submicron grains as a result of severe plastic deformation. For all of the annealed specimens, the intermetallic compound TiAl3 was observed to form at the Ti/Al interfaces with the specimens that were subjected to the most deformation prior to annealing exhibiting the greatest amount of TiAl3.

5:40 PM

The Effect of Second Phase Precipitates on the Work-Hardening Behaviour of ECAP – Deformed Al Alloys: *Erika Prados*[1]; Vitor Sordi[2]; Maurizio Ferrante[2]; [1]Programa de Pós-Graduação em Ciência e Engenharia de Materiais; [2]Federal University of São Carlos - UFSCar

A strong characteristic of metallic materials subjected to severe plastic deformation is the decrease of work-hardening (W-H) capacity. This reflects negatively on the ductility. Among the available ductility enhancing mechanisms it appears that second phase precipitates increase W-H and the present work compares two aluminium alloys: Al-4%Cu and AA3004, the former representing precipitation hardening alloys while the latter stands for the non-heat treatable systems. ECAP-deformation followed by a combination of precipitation/annealing heat treatment produced a range of microstructures containing or formed by: (i) very large Al2Cu precipitates; (ii) small, peak strength Al2Cu precipitates; (iii) solid solution. Tensile test were performed, the resulting data were organized into Kocks-Mecking plots and the microstructure was studied by TEM. Results show that Al2Cu precipitated contributed to increase the W-H capacity of the binary alloy, either by increasing the dislocation density, or by pinning these defects and keeping them inside the grains, or both.

6:00 PM

Hardness Evaluation, Stoichiometry and Grain Size of Titanium Nitride Films Obtained with Plasma Nitriding on TiAlV Samples: *Marcos Vasconcellos*[1]; Saulo Lima[1]; Ruth Hinrichs[1]; [1]Universidade Federal do Rio Grande do Sul

Titanium nitride films were formed on the surface of Ti-6Al-4V discs by glow discharge in different N2:H2 atmospheres at several substrate temperatures. In this study the influence of the process parameters on dynamic microhardness were investigated. Grain sizes of the nitride films, determined with X-Ray Diffraction, were related to the nitriding parameters. TiNx stoichiometry was determined with Nuclear Reaction Analysis and showed a clear dependence on substrate temperature during the nitriding process. Microhardness measurements were taken on the nitrided surfaces and showed relation to the nitrogen content and grain size of the surface film.

Composite Materials Symposium: Session III

Thursday AM — Room: Turmalina
July 29, 2010 — Location: Intercontinental Rio Hotel

Session Chair: To Be Announced

8:30 AM

Contribution of Brazil Nut Shell Fiber and Electron-Beam Irradiation in Thermo-Mechanical Properties of HDPE: Pamella Polato[1]; Leandro Lorusso[2]; Clécia Souza[2]; Anne Chinellato[3]; Ricardo Rosa[4]; *Esperidiana Moura*[2]; [1]Instituto De Pesquisas Energéticas E Nucleares - Ipen-Cnen/Sp; [2]Instituto De Pesquisas Energéticas E Nucleares - Ipen-Cnen/Sp; [3]Mash: Tecnologia Em Compostos E Masters; [4]Amazon Brazil Nuts

In the present work, the influence of electron-beam irradiation on thermo-mechanical properties of HDPE and HDPE/Brazil nut shell fiber composite were investigated. The materials were irradiated at radiation dose 50 kGy using a 1.5 MeV electron beam accelerator, at room temperature in presence of air. The irradiated and non-irradiated samples were submitted to thermo-mechanical tests and the correlation between their properties was discussed. The results showed that the incorporation of Brazil nut shell fiber represented a significant gain ($p < 0.05$) in tensile strength at break, flexural strength, flexural modules, Vicat softening temperature and heat distortion temperature (HDT) properties of the HDPE. On the other hand, there was a significant decrease ($p < 0.05$) in percent elongation at break tests. In addition, the irradiated HDPE/Brazil nut shell fiber composite presented a significant increase ($p < 0.05$) in this properties compared with irradiated HDPE.

8:50 AM

Morphological and Physics Aspects, and Tensile Mechanical Properties of Miriti Fibers for Reinforced Composites: *Nubia Santos*[1]; Manoel Silva[2]; Cecilia Zavaglia[1]; Eder Albuquerque[3]; [1]Universidade Estadual de Campinas; [2]UNIFEI; [3]UnB

In this work are conducted studies on miriti fibers (Mauritia flexuosa L.) with the purpose of to examine its potential use for reinforced polymeric composites. Attributes such diameter dimensions, cross section, microstructure and surface morphology, and mechanical properties of the fiber are investigated. The diameter average dimensions are studied from cross-section images obtained by SEM. The mechanical properties were determined by tensile tests in according with ASTM 3379 on single fibers specimens. A variability of results were obtained for the diameter dimensions and the morphology of the cross section of fibers indicated various formats, and images from SEM exibt the singular microstructure of miriti fiber. The tensile mechanical properties show also a wide variety of results, characteristic of natural fibers, but the results are similar to other natural fibers used in industry.

9:10 AM

Facile Synthesis of Carbon Encapsulated Iron Nanoparticles from Cellulose by Catalyzed Carbonization: *A.N. Yuliang*[1]; [1]Shenyang Ligong University

A practical and efficient route is presented for preparing carbon encapsulated metal nanomaterials using biomass–cellulose as the starting materials. Fe nanoparticles can be effectively encapsulated inside carbon shells by the carbonizing composite of cellulose and iron oxide in hydrogen flow. The carbohydrate was carbonized in a controllable way that leads to formation of a large amount of carbon cages encapsulated Fe nanoparticles. Transmission electron microscopy (TEM), energy dispersive X-ray (EDX) and X-ray diffraction (XRD) were employed to characterize carbon encapsulated nanomaterials. The growth mechanism of carbon encapsulated metal nanoparticles is briefly discussed in term of composition and structure of precursor.

9:30 AM Keynote

Recent Developments in Cemented Carbides – A Commercially Successful Metal Matrix Composite: *Krishan Chawla*[1]; [1]Univ. Alabama at Birmingham

Cutting tool inserts or drill bits consisting of tungsten carbide (WC) particles distributed in cobalt (Co), called cemented carbides, are nothing but highly successful metal matrix composites. These particulate metal matrix composite combine aspects of a brittle ceramic and a ductile metal to produce a composite with properties that neither one of the individual components has. In this presentation, I shall provide a brief survey of their wide range of applications and describe our work involving extension of the microstructural flexibility and the range of properties of the individual components by means of a hybrid metal matrix composite consisting of discrete granular composite reinforcements in a metal matrix. We call it double cemented carbide (DCC) composite. It promises to be a general extension of the idea of composites. Results on the processing, microstructure, and properties of such composites will be presented.

10:10 AM Break

10:40 AM Invited

Three Dimensional (3D) Microstructure Visualization and Modeling of Deformation in Metal Matrix Composites by In Situ X-Ray Synchrotron Tomography: Jason Williams[1]; Nicholas Chapman[1]; *Nik Chawla*[1]; Francesco De Carlo[2]; [1]Arizona State University, School of Mechanical, Aerospace, Chemical, and Materials Engineering; [2]Argonne National Laboratory

Characterization of damage often involves laborious cross-sectioning, characterization, etc. X-ray tomography provides a wonderful means of characterization damage non-destructively. We report on a novel methodology that addresses the critical link between microstructure and deformation behavior, using x-ray synchrotron tomography. The approach consists of in situ tensile testing in an x-ray synchrotron, followed by x-ray tomography and image analysis, and 3D reconstruction of the microstructure. Incorporation of the microstructure into a finite element modeling code for simulation can also be conducted. We present a case study based on uniaxial tensile deformation of SiC particle reinforced Al alloy matrix composites. In particular, the evolution of damage in the form of particle fracture, interfacial debonding, and void growth will be described. Use of the Advanced Photon Source was supported by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences, under Contract No. DE-AC02-06CH11357.

11:10 AM Invited

Processing and Dynamic Properties of Structural Energetic Composite Materials Coupling Linear Cellular Alloys with Thermite Mixtures: Tammy McCoy McCoy[1]; Anthony Fredenburg[1]; Adam Jakus[1]; Joe Cochran[1]; *Naresh Thadhani*[1]; [1]Georgia Institute of Technology

Structural energetic composite materials based on coupling of Linear Cellular Alloys (LCAs) with thermite powder mixtures are being investigated. The focus is on manipulating the LCA material and channel design, such that transfer of shear stresses from casing to energetic filler provides control of reaction initiation in the filler and patterned fragmentation of the casing. The deformation and fragmentation response of 25% dense LCA casings made from high-strength steels, with waffle- and pie-shaped cell geometries, has been determined and correlated with predictions from AUTODYN simulations. The dynamic densification and thermo-chemical reactivity of Ta+Fe2O3 and Ta+Bi2O3 thermite mixtures under uniaxial strain and uniaxial stress loading has also been determined. The results highlighting the unique attributes of LCA casings with geometries designed to enable controlled transfer of shear stresses to the reactive filler upon impact, will be presented.

11:40 AM

Processing and Characterization of Epoxy Nanocomposites with MWCNTs/CNFs Using Thinky and 3-Roll Mill Techniques: *Mahesh Hosur*[1]; Rajib Barua[1]; Shaik Zainuddin[1]; Shaik Jeelani[1]; Ashok Kumar[2]; Jonathan Trovillion[2]; Yadira Perez[2]; [1]Tuskegee University; [2]U.S. Army ERDC

The purpose of this work is to find the most suitable technique to disperse multi-walled CNTs and CNFs uniformly and to evaluate their effect on the performance of SC-1 epoxy. In this work, ultrasonication and thinky mixing methods were used either in combination/isolation with 3-roll shear mixing. Neat and nanophased epoxy composites were fabricated and the samples were prepared as per ASTM standards. Flexural tests were performed to evaluate mechanical performances. Results of the study showed that both CNTs/ CNFs epoxy composites significantly enhanced flexural strength and modulus in comparison to neat samples. However, these enhancements were observed only up to 0.2 wt. % loading after which the properties were seen to either reduce or not significantly improve. These results indicate that the methods used for dispersion is suitable for low weight percent loading only. Thermal, micrographic and electrical conductivity studies of these samples are currently being carried out.

12:00 PM

Gelatin/Piassava Composites Treated by Electron Beam Radiation: Patricia Takinami[1]; Kleber Shimazaki[1]; Maria Colombo[1]; Esperidiana Moura[1]; *Nélida del Mastro*[1]; [1]IPEN

Piassava (Attalea funifera Mart) fiber have been investigated as reinforcement for polymer composites with potential for practical applications. The purpose of the present work was to assess the behavior of specimens of piassava fiber and gelatin irradiated with electron beam at different doses and percentage of piassava fiber. The specimens were made with 5 and 10 % (w/w) piassava fiber and gelatin. The samples were irradiated up to 40 kGy using a 1.5 MeV electron beam accelerator, at room temperature in presence of air. Results showed mechanical properties enhancement with increasing of the dose and the fiber percentage. Texture analysis also showed collaborated results.

Dynamic Behavior of Materials Symposium: Session III

Thursday AM — Room: Topazio
July 29, 2010 — Location: Intercontinental Rio Hotel

Session Chair: To Be Announced

8:30 AM

Constitutive Modelling and Numerical Simulation of Ship Structure Response to Underwater Explosion: *Anne-Gaëlle Geffroy*[1]; Patrice Longère[2]; Bruno Leblé[3]; [1]DCNS - UBS / LIMATB; [2]UBS / LIMATB; [3]DCNS

Numerical prediction of military ship structure response to underwater explosion needs advanced modelling of the constitutive material behaviour. From an extensive experimental campaign, including notably high strain rate loaded specimens as well as explosion shocked plates, and using an inverse method based parameters identification procedure an elastic-thermo/viscoplastic-damage model has been developed for the structure steel of the study, describing the combined effects of strain, strain rate, temperature and damage until ultimate failure. From physics based considerations, such as post-mortem specimen and plate fractography and real-time observations, a criterion has been defined, allowing for treating consistently, regarding the model, the transition from damage to fracture. The model has been implemented as user material in the engineering FE computation code Abaqus. The first numerical simulations involving a ship hull subject to underwater explosion like loading are encouraging.

8:50 AM

Microstructure Refinement by Metallic Particle Impact: *Vincent Lemiale*[1]; Yuri Estrin[1]; Robert O'Donnell[1]; Hyoung Seop Kim[2]; [1]CSIRO; [2]POSTECH

Surface treatment of metals can be achieved through plastic deformation induced by multiple high velocity impacts of metallic particles. Recent experimental investigations suggest that a significant microstructure refinement takes place at the interface between particles and substrate. Understanding the underlying deformation mechanisms under such extreme conditions is crucial for process optimization. We have considered an extension of a dislocation based model to the high strain rate conditions. The model incorporates information at the dislocation scale thus enabling the evolution of the microstructure to be predicted by finite element simulations. It will be shown that a further grain refinement, beyond that obtained by severe plastic deformation processing, can be achieved by particle impacts. We will also discuss the need for more realistic material models in simulations performed under the dynamic strain rate conditions. Computational techniques such as atomistic simulations may provide new insights in the complex phenomena occurring under these conditions.

9:10 AM
Dynamic Punch Test in the SHPB Apparatus for Calibration of a Shear Failure Model: *Zev Lovinger*[1]; Yechezkel Ashuach[1]; [1]Rafael

We are conducting punch tests in the split Hopkinson pressure bar (SHPB) apparatus to investigate shear failure of several materials: aluminum, tungsten alloys and stainless steel. The tested specimen is a thin disc which is placed between punch and anvil adapters. The strain gauge signal measured on the transmitted bar shows a sudden fall which is related to the failure properties of the material. We are using 2D Numerical simulations of the entire SHPB set-up to calibrate our failure model. The calibration procedure is carried-out in two stages: first, we calibrate a strength model according to stress-strain curves we obtain from standard analysis of tests with cylindrical specimens. Then, using the calibrated strength model, we calibrate our two parameter shear failure model to fit the fall time of the transmitted signal in the punch tests. We achieve good comparison between experimental results and simulations.

9:30 AM Keynote
Impact Initiated Reactions in Intermetallic-Forming Reactive Mixtures: Instrumented Experiments and Meso-Scale Simulations: Paul Specht[1]; Brady Aydelotte[1]; *Naresh Thadhani*[1]; [1]Georgia Institute of Technology

Impact initiation of reactions in intermetallic-forming reactive materials (powder mixtures, compacts, and laminates) under uniaxial-strain and uniaxial-stress loading with the gas gun will be discussed. Instrumented experiments, employing stress gauges, velocity interferometry, and high-speed digital imaging are used to measure the stress profiles, shock velocity, and transient deformation states, to provide evidence of reaction initiation. Meso-scale simulations of wave propagation through discretely represented constituents (with real imported microstructures) are also performed using the multi-material CTH Eulerian code to investigate the effects of reactant morphology on the deformation and mixing in the powder mixtures, compacts, and foils. Observations of particle level processes reveal the heterogeneous nature of the effects of wave propagation through the reactants of dissimilar properties and morphological characteristics. The information generated is useful for understanding the reaction mechanisms and controlling the characteristics of their initiation and resulting energy release.

10:10 AM Break

10:40 AM Keynote
Dynamic Behavior of "Soft" Heterogeneous Materials: *Vitali Nesterenko*[1]; [1]University of California, San Diego

The behavior of "soft" heterogeneous materials (granular, granular composites, laminates composed from granular layers, forest of carbon nanotubes) in a broad range of impact conditions and types of deformation (shock, shear) will be discussed. The current interest on these materials is due to their efficiency as mitigators of blast/impact loading and due to the fact that penetration resistance in some impact scenario is mainly influenced by the behavior of heavily deformed and fractured armor, being actually a dense granular material. These materials also help to address contradictory requirements for some applications, combining high compressive strength with the ability to bulk distribute fracture and even possible reaction on later stages of dynamic deformation. They present challenging fundamental questions related to their multiscale structure and strongly nonlinear behavior.

11:20 AM Keynote
On the Operational Regimes of Deformation in Materials: *Neil Bourne*[1]; Jeremy Millett[1]; [1]AWE

Materials respond to dynamic loading with a variety of mechanisms. Each has its own mechanical threshold for operation including discrete stress levels and times. When a material is exposed to extremes of pressure such mechanisms include martensitic phase transformation, dislocation nucleation and propagation, twinning and potentially melting. The mechanical environment and the thermodynamics of the mechanisms determine the kinetics and the effect upon the microstructure. Examples are drawn from a variety of metallic responses showing the suite of available mechanisms and the range of observables that results. The ordering is shown around particular scales and times and these will be enumerated and effects presented to show that natural mechanical thresholds exist for materials response.

Mechanical Properties of Materials with Emphasis on Grain-Size Effects Symposium: Session III

Thursday AM — Room: Onix
July 29, 2010 — Location: Intercontinental Rio Hotel

Session Chair: To Be Announced

8:30 AM
Consolidation of Nanostructured Al-Powder Alloys by Hot Extrusion: Grain Size Control and Mechanical Properties: Alberto Moreira Jorge Junior[1]; *Mauricio Peres*[1]; Claudemiro Bolfarini[1]; Claudio Kiminami[1]; Walter Botta[1]; [1]Universidade Federal e São Carlos

The effect of the extrusion temperature and ram speed during consolidation by hot extrusion of mechanical-alloyed Al-4.5%Cu alloy and Al6061 matrix reinforced with Si3N4 particle composite is discussed. Pre-existent precipitates in Al-Si3N4 alloy were very effective to control grain growth and to promote good mechanical properties on the consolidated alloys. Precipitation of Al2Cu was observed when extruding the mechanical-alloyed Al-4.5%Cu alloy at 375°C and 400°C, but no precipitation was observed in the material extruded at 425°C. The mechanical properties of the consolidated alloys were found to be strongly dependent on the extrusion conditions and this behavior is discussed in association with the original and modified microstructures, which increased with decreasing temperature and increasing ram speed.

8:50 AM
Grain Refinement during Seamless Tubes Hot Rolling of V-N Steels: *Ricardo Carvalho*[1]; Marcelo Ferreira[1]; Dagoberto Santos[2]; Ronaldo Barbosa[2]; [1]V&M do Brasil; [2]Department of Metallurgical and Materials Engineering - UFMG

The goal of this work is to discuss the main metallurgical aspects involved in seamless tubes hot rolling of V-N steels. Two processing routes were considered here: direct and cold charging. In order to evaluate the microstructural differences caused by these two routes, hot torsion simulation was employed. The industrial termomechanical cycles were characterized and simplified due to machine limitations. Simulations were conducted in a computer controlled servo-hydraulic machine equipped with a radiant furnace. Samples for optical microscopy and transmission electronic microscopy were obtained by interruption of process simulation after selected steps. Industrial scale tests also were conducted in order to evaluate mechanical properties for these two routes. It was observed in these industrial tests that cold charging can promote a ferrite grain refinement and, consequently, an increase in yield strength and impact toughness. The evolution of microstructure and precipitation observed during simulation helped to understand the results found industrially.

9:10 AM
Effect of Twin Lamellar Spacing on the Wear Properties and Surface Hardness Evolution in Nano-Twinned Copper Subjected to Repeated Contact Sliding: *Aparna Singh*[1]; Ming Dao[1]; Lei Lu[2]; Subra Suresh[1]; [1]MIT; [2]Shenyang National Laboratory for Materials Science, Institute of Metal Research, Chinese Academy of Sciences

Nanograined Cu has high strength but poor ductility. Comparable values of hardness of ng-Cu can be achieved by the introduction of controlled concentrations of coherent nano-scale twins within the ultrafine grains when the nanoscale twin lamellar spacing in the twinned material is comparable to the analogous grain size for the ng-Cu. The nanotwinned Cu shows good ductility unlike ng-Cu. Here we outline the results of how nano-scale twins influence the tribological characteristics of Cu under conditions of repeated frictional sliding. The evolution of friction and damage during repeated sliding contact in ultrafinegrained copper with essentially no twins as well as low and high twin densities was studied using a depth-sensing, instrumented indenter so as to develop a perspective on the effects of twin density on sliding contact fatigue. The collective effects of material strength, structural size scale and surface friction coefficient as well as contact fatigue will be presented.

9:30 AM Keynote
Bulk Nanostructured SPD-Processed Materials for Advanced Applications in Engineering and Medicine: *Ruslan Valiev*[1]; Sergey Dobatkin[2]; Walter Botta[3]; Terence Langdon[4]; [1]Ufa State Aviation Technical University; [2]A.A. Baikov Institute of Metallurgy and Materials Science, RAS; [3]Universidade Federal de São Carlos; [4]University of Southern California

Nanostructuring of various metals and alloys by severe plastic deformation (SPD) paves the way to obtaining unusual properties that are very attractive for different applications. Especially significant progress has been made in recent years in this area when generation of new superior properties from nanostructuring has been demonstrated, such as very high strength and ductility, record-breaking fatigue endurance and superplastic forming capabilities. The innovation potential of this research area is outstanding, and the given talk is focused on such new innovative R&D works, for example an important role in this activity has been attributed to development of nanostructured metals and alloys for advanced structural and functional applications. The examples of such developments focusing on the application of nanoTi in medicine as well as superstrong light nanoalloys for advanced structural applications are considered and discussed in the present talk.

10:10 AM Break

10:40 AM Keynote
Mechanical Behavior of Nanoporous Materials: *Eduardo Bringa*[1]; [1]CONICET- Universidad Nacional de Cuyo

Nanoscale porosity appears in solids under a number of conditions: during the initial stages of ductile failure, due to radiation damage in nuclear reactors, due to fabrication or synthesis methods of certain materials, etc. Understanding the mechanical behavior of these materials is crucial to understand failure under a variety of situations, and to assess the applicability of structural materials under extreme conditions of deformation at high stress and strain rate. Experiments that probe the relevant nanoscopic length and time scales are extremely difficult or impossible with current set-ups, and continuum models might not work at the nanoscale. As a result, atomic-scale simulations can provide unique insights, possible links to models at the micro-scale, and help interpretation of experiments that average over the macroscale. We consider atomistic molecular dynamics (MD) simulations covering mainly two scenarios.

11:20 AM
The Influence of Processing Conditions on Hardness Homogeneity Evolution in Commercially Pure Cast Aluminium Processed by ECAP: Sri Lathabai[1]; *Margarita Vargas*[1]; Matthieu Larroque[1]; Claude Urbani[1]; [1]CSIRO Process Science and Engineering

Pure cast aluminium was subjected to equal channel angular pressing (ECAP) at room temperature using routes A, Bc and C. Microhardness distribution maps were produced on sections of extruded billets after one, two, three and four passes for each of the processing routes. It was found that the mean hardness increased significantly already after the first pass. With subsequent passes, the hardness increase was smaller but the hardness distribution became narrower, indicating increasing homogeneity. For route Bc, a slight decrease in average hardness was observed after the fourth pass. The mean hardness after four passes was highest for the route C sample, followed by the route A and route Bc samples. Measurements over a period of time showed that in Bc samples a slight reduction in average hardness occurred, suggesting that the microstructures generated by this route may be less stable than those produced by routes A and C.

11:40 AM
Microstructure and Mechanical Properties of Metal Matrix Composites Processed by Severe Plastic Deformation: *Andrea Bachmaier*[1]; Reinhard Pippan[1]; [1]Erich Schmid Institute of Materials Science

Nanocrystalline and ultrafine-grained materials are commonly known as materials with extraordinary mechanical properties. High Pressure Torsion (HPT) is a simple and effective severe plastic deformation method to produce these ultrafine grained or even nanocrystalline microstructures. However, at a certain applied strain no further refinement of the microstructure occurs. In this work, a strategy to bypass this limitation in the grain refinement and a way to generate stable nanocrystallites using HPT deformation are presented. Initial micrometer-sized powders are oxidized by an annealing treatment and subsequently HPT-consolidated until a fully dense bulk material is obtained. This processing route offers an easy way to produce bulk nanocrystalline metal matrix composites with nanometre-sized oxide dispersions. The incorporated oxides have a huge impact on the final microstructure, as well as on the mechanical properties and the thermal stability of the consolidated material.

Composite Materials Symposium: Session IV

Thursday PM　　Room: Turmalina
July 29, 2010　　Location: Intercontinental Rio Hotel

Session Chair: To Be Announced

2:00 PM Invited
Strain Rate Dependence of Mechanical Properties and Failure Mechanisms of Composite Materials: *Nikhil Gupta*[1]; Rémi Dingreville[1]; [1]Polytechnic Institute of New York University

The deformation and failure mechanisms and the measured mechanical properties of metal and polymer matrix composites are known to have strain rate dependence. The mechanisms for strain rate dependence are different in metal and polymer matrix composites because of differences in the constitutive behavior of these materials. This presentation reviews a variety of techniques to obtain the mechanical properties of composite materials at high strain rates. These include the use of visualization tools such as high speed imaging systems for failure studies, dynamics testing for strain rate dependence of mechanical properties, and microstructural aspects of failure features. Available studies are analyzed and critically compared to obtain insight into the structure-property correlations at high strain rates.

2:30 PM Invited
Complementary Microscopy Techniques Applied to the Characterization of Synthesized Nanocomposites: *Eduardo Brocchi*[1]; [1]PUC-Rio

Nowadays, it has been clear an increasing interest in designing materials that can fulfill the needs for high performance in specific applications. Therefore, many researchres have been attracted to study the synthesis of composite materials due to their unique properties and potential uses. In that field it is well known the particular interest in the nano-composites, specially because they may possess a stable microstructure with good resistance to recrystalization and grain growth. In contrast to hardening by precipitation mechanism, some physical and mechanical properties can be kept, even at high temperature, due to the stability and high melting point of particles such as those of Al2O3, which do not react with the metallic matrix constituted by, for example, copper and/or nickel.

3:00 PM Invited
Digital Microscopy and Image Analysis Applied to Composite Materials Characterization: *Sidnei Paciornik*[1]; José Roberto d´Almeida[1]; [1]PUC-Rio

Composites contain at least two different phases, a continuous matrix and a discontinuous reinforcement phase. This leads to a large number of possible arrangements of the reinforcement that must be characterized to allow the prediction of materials properties. The mathematical models for composites require the determination of several microstructural parameters such as volume fraction, size, orientation and spatial distribution of the reinforcement. However, the traditional methods of characterization cannot provide the completeness, speed and statistical accuracy required. Parameters such as shape, spatial and orientation distribution are not easily obtained. Digital Microscopy (DM) is the convergence of microscope automation, digital image acquisition, processing and analysis. In this work the impact of DM in the characterization of composite materials is presented. New methods are discussed and the microstructure of polymer-matrix, fiber-reinforced and particle-reinforced composites is described. This allows the determination of critical parameters used in the modeling of the materials properties.

3:30 PM Break

4:00 PM

State of the Art in Aluminum Matrix Composites Using Fly Ash: *Martin Pech-Canul*[1]; [1]Centro De Investigacion Y De Estudios Avanzados Del Instituto Politecnico Nacional

Owing to its unique characteristics – like morphology and chemical composition-, fly ash has been identified as a potential reinforcing phase for the manufacture of metal matrix composites (MMCs). Moreover, the recent literature shows that mostly it has been used as a second reinforcement in dually reinforced aluminum matrix composites. In the case of Al/SiCp composites, essentially it offers two major benefits; namely, to protect SiC from being attacked by liquid aluminum during processing, and enhance mechanical properties. Incorporation of fly ash within aluminum matrices with proper Mg content gives place to the formation of secondary phases like magnesium aluminate spinel (MgAl2O4), which could also act as reinforcement. As for mechanical behavior, cenosphere fly ash promises to enhance the energy absorption capabilities and damage tolerance of composites subjected to impact. The aim of the current contribution is to present a critical review on the use of fly-ash in aluminum-based MMCs.

4:20 PM

Stress-Strain Curves for Steel Fiber-Reinforced Concrete in Compression: *Luiz Oliveira Júnior*[1]; Vanessa Borges[2]; Daiane Ramos[3]; Alice Danin[2]; Daniel Araújo[4]; Mounir El Debs[1]; Paulo Fernando Rodrigues[5]; [1]Escola de Engenharia de São Carlos, Universidade de São Paulo; [2]Programa de Pós-graduação em Geotecnia e Construção Civil, UFG; [3]Fundação de Apoio à Pesquisa, UFG; [4]Escola de Engenharia Civil - Universidade Federal de Goiás; [5]Furnas Centrais Elétricas/S.A.

This paper presents a study on the compressive behavior of steel fiber reinforced concrete. In this study, an analytical model for stress-strain curve for steel fiber-reinforced concrete is derived for concretes with strengths of 40 MPa and 60 MPa at the age of 28 days. Those concretes were reinforced with steel fibers with hooked ends 35 mm long and with aspect ratio of 65. The analytical model was compared with some experimental stress-strain curves and with some models reported in technical literature. Also, the accuracy of the proposed stress-strain curve was evaluated by comparison of the area under stress-strain curve. The results showed good agreement between analytical and experimental data and the benefits of the use of fibers in the compressive behavior of concrete.

Dynamic Behavior of Materials Symposium: Session IV

Thursday PM	Room: Topazio
July 29, 2010	Location: Intercontinental Rio Hotel

Session Chair: To Be Announced

2:00 PM Invited

Deborah Numbers: Characterizing Essential Features of Spallation: *Haiying Wang*[1]; Yilong Bai[1]; Mengfen Xia[1]; Fujiu Ke[1]; [1]Institute of Mechanics, Chinese Academy of Science

In order to reveal the underlying mesoscopic mechanism governing spall fracture, the framework of statistical micro-damage mechanics is employed in this paper. Based on the framework and experimental measurement of nucleation and growth of microcracks in an Al alloy subjected to plate impact loading, a trans-scale closed formulation of damage evolution in spallation is obtained. In the formulation, there are several time scales and length scales on meso- and macro-scopic levels. For example, the length scales are microcrack size on meso-scale and the sample size on macro-level, whereas the time scales are nucleation and growth rates of microcracks on meso-level but the imposed loading duration on macro-level. So, analogous to the definition of Deborah number in rheology, these time scales could be reduced to two independent dimensionless Deborah numbers: the imposed Deborah number De* = ac*/LV* and the intrinsic Deborah number D* = nN*c*5/V*, where a, L, c*, V*, and N_N* are acoustic speed, size of sample, size of microdamage, the rate of microdamage growth, and the rate of microdamage nucleation density respectively. Obviously, the imposed Deborah number De* represents the competition and coupling between the microdamage growth and the macroscopically imposed wave loading. In spallation process, De* < 1, which means that microdamage has enough time to grow during the macroscopic wave loading. Thus, the microdamage growth appears to be the predominate mechanism governing the failure. In addition, the intrinsic Deborah number D* implies a certain characteristic damage. In particular, it is derived that D* is a proper indicator of macroscopic critical damage to damage localization, like D* ~(10^{-2} -10^{-3}) in spallation. More importantly, we found that this small intrinsic Deborah number D* indicates the energy partition of microdamage dissipation over bulk plastic work. This explains why spallation can not be formulated by macroscopic energy criterion and must be treated by multi-scale analysis.

2:30 PM Invited

Determination of the Dynamic Mechanical Properties of Materials at Different Strain Rates and Temperatures: *Veli-Tapani Kuokkala*[1]; [1]University of Technology

The dynamic mechanical properties of most materials can be relatively easily determined up to ~10^4 s^{-1} at room temperature with the Hopkinson Split Bar techniques. The strain rate sensitivity of the material is then usually taken as the change in the flow stress corresponding to a certain constant strain measured at different constant strain rates. This apparent strain rate sensitivity, however, does not take into account the strain rate dependent strain hardening of the material, i.e., the possible variations in the microstructure. To obtain the instantaneous strain rate sensitivity of the material for a constant microstructure, a strain rate jump test can be done, where the strain rate is suddenly either increased or decreased during the test. Various techniques to accomplish the strain rate jump can be employed, depending on the jump magnitude and the strain rate range in question. In many cases it is also important to know the dynamic properties of the material at elevated and/or subzero temperatures. In compression the test can be accomplished for example by heating the bars or short sections of them together with the specimen, or by heating only the specimen and manipulating the bars and the specimen mechanically to enable the testing. In tension and torsion the latter technique cannot normally be used because the specimen has to be mechanically fixed to the bars. Also, if heating of the specimen up to the test temperature lasts too long, the microstructure of the specimen may undergo significant changes, and therefore rapid heating of the specimen may be required. At subzero temperatures, testing is usually not as challenging because the temperature difference to RT is not too large and permanent microstructural changes seldom occur. In this paper, different techniques that are used at TUT for high and low temperature dynamic tests as well as for strain rate jump tests in compression and tension are presented and discussed. Also several examples of test results obtained with these techniques, especially for materials that are thermally or mechanically metastable, are presented and discussed.

3:00 PM Invited

Micrometric Solar-Cell Coating Adhesion Characterization by Sub-Picosecond Laser Driven Shock: *Jean-Paul Cuq-Lelandais*[1]; Cédric Brousillou[2]; Laurent Berthe[3]; Michel Boustie[1]; Michel Jeandin[2]; L. Parisii[4]; Emilien Lescoute[1]; Thibaut De Rességuier[1]; Patrick Combis[5]; Laurent Soulard[5]; [1]LCD - PPRIMME - ENSMA; [2]Centre des Matériaux - Ecole des Mines; [3]PIMM - Art et Métiers ParisTech; [4]Nexcis, Photovoltaic technology; [5]CEA/DAM/DIF

Spallation by laser shock wave within materials has been investigated for decades with a few nanosecond characteristic durations. With the latest laser technologies evolution, one can access to shorter regimes in durations, going below the picosecond. This kind of irradiation provides an ultra-short shock wave and also a thin spall ejection, about the micron thick. One possible application to this regime is a adaptation of the Laser Shock Adhesion Test (LASAT) applied for micrometric coatings. Such films are frequently found in the industry. LASAT experiments were performed on the LULI 100TW facility on CuInS2 solar-cell based films to determine the debonding threshold by inducing a dynamic tension state at the interface, an important parameter governing the cell lifetime. Experimental post-test results on recovered samples inform about the interface rupture mechanisms. They are completed by a numerical analysis to understand the debonding processes induced by shock waves propagation.

3:30 PM Break

4:00 PM Invited

On the Perforation of Ductile Plates by Rigid Sharp Nosed Projectiles: *Zvi Rosenberg*[1]; E. Dekel[1]; [1]Rafael

The process of plate perforation by sharp-nosed projectiles has attracted both experimental and theoretical attention during the last decades. However, due to the complexity of the process, there is no comprehensive model which can predict the values of ballistic limit velocities for a given projectile/target combination. In a recent paper we demonstrated that all the data for residual velocities as a function of impact velocity can be represented by a single normalized relation which is due to Recht and Ipson from the 1960's. Thus, the only unknown physical parameter, which one has to determine experimentally, is the ballistic limit velocity (Vbl) for the set up at hand. In order to have a better insight to this issue we performed a large number of numerical simulations in which we varied projectile shapes, target materials and plate thicknesses.

4:30 PM

Destabilization of Sigma 3 Boundaries at High Strain Rates of Electrodeposited Nickel: *Hervé Couque*[1]; Abdelouhab Ouarem[2]; Guy Dirras[2]; [1]Nexter Munitions; [2]LPMTM UPR CNRS 9001 Université Paris 13

Electrodeposited nickel specimens have been tested in compression up to strain rates of 2 x 10+4 s-1. From 2 x 10+3 to 1.5 x 10+4 s-1, a sharp increase of the strength was observed related to the drag dislocation effect known as the viscous regime. Microstructural analyses of the specimen revealed an increase of the grain size up to a strain rate of 10+4 s-1, related to the reduction of the amount of sigma 3 boundaries. This is probably due to the limited motion of the dislocations in the viscous regime implying a highly stressed microstructure favouring twin reductions. At 2 x 10+4 s-1, the grain size is decreasing. At this strain rate, high dislocation density and temperature increase due to plasticity favour dynamic recrystallisation resulting in a decrease of the grain size via the regeneration of sigma 3 boundaries such as coherent twin boundaries.

4:50 PM

Effects of Microstructure on the Fatigue Crack Growth Behavior of Light Metals: *Anastasios Gavras*[1]; Brendan Chenelle[1]; Diana Lados[1]; [1]Worcester Polytechnic Institute

Fatigue crack growth mechanisms of long and small cracks were investigated in cast and wrought aluminum and titanium alloys with various microstructures (as-cast A535, 6061-T61, and mill-and-beta annealed Ti-6Al-4V). In addition, friction stir welded and cold spray processed 6061-T61 were also investigated. The effects of microstructure on the fatigue crack growth response of each material were evaluated. Long crack growth data were generated on compact tension specimens at high and low stress ratio R=0.7 and 0.1 respectively. Small crack growth testing was performed on surface flaw tension specimens at low stress ratio, R=0.1. Fatigue crack growth mechanisms at the microstructure scale of the materials were identified and will be discussed. Closure corrections were applied to long crack growth data, and the results were compared to experimental small crack growth data. Models for small crack growth predictions from long crack growth data will also be presented and discussed.

5:10 PM

Experimental Tests of Vanadium Strength Models at High Pressures and Strain Rates: Hye-Sook Park[1]; N.R. Barton[1]; R. C. Becker[1]; J. V. Bernier[1]; R. M. Cavallo[1]; K.T. Lorenz[1]; S. M. Pollaine[1]; *Bruce Remington*[1]; R. E. Rudd[1]; [1]Lawrence Livermore National Laboratory

Solid state dynamics experiments at extreme pressures, P > 1000 GPa, and strain rates (1.e6-1.e7 1/s) are being developed for the NIF laser. The experimental methods are being developed on the Omega, EP, and Jupiter laser facilities. Velocity interferometer (VISAR) measurements establish the ramped, high pressure conditions. Recovery experiments offer a look at the residual microstructure. Diffraction measurements allow phase and possibly defect density to be dynamically inferred. Constitutive models for material strength are currently tested at ~Mbar pressures by comparing 2D simulations with experiments measuring the Rayleigh–Taylor instability evolution in solid state samples of vanadium (V) and tantalum (Ta). A new multiscale model for V, combining MD, DD, and continuum simulations is tested. Our analysis suggests that the material deformation at these conditions falls into the phonon drag regime. We also make an estimate of the (microscopic) phonon drag coefficient, by relating to the (macroscopic) effective lattice viscosity.

Mechanical Properties of Materials with Emphasis on Grain-Size Effects Symposium: Session IV

Thursday PM	Room: Onix
July 29, 2010	Location: Intercontinental Rio Hotel

Session Chair: To Be Announced

2:00 PM Invited

Fracture Behavior of Ultrafine Grained Metals Processed by Severe Plastic Deformation: *Anton Hohenwarter*[1]; Reinhard Pippan[1]; [1]Erich Schmid Institute of Materials Science, Austrian Academy of Sciences

In the last years the benefits of ultrafine and nanocrystalline materials, such as the enhanced strength in comparison with their coarse-crystalline counterparts, have been investigated extensively. Besides focusing on various material parameters, like strength and ductility, the fracture toughness is also of great importance, especially when the damage tolerance of a material is important for different structural applications. In this contribution an overview of the fracture behaviour of various metals ranging from one phase ultrafine grained bcc and fcc metals to nanocrystalline steels processed via Severe Plastic Deformation (SPD) will be given. It will be shown that the specimen orientation has a tremendous influence on the fracture behaviour and toughness. Due to this toughness anisotropy an unexpectedly good combination of high strength and simultaneously high fracture toughness can be achieved very often in ultrafine grained and nanocrystalline materials.

2:30 PM Invited

Stresses within Dislocation Cell Structures: Size Effects versus Stochastic Processes: *Lyle Levine*[1]; Bennett Larson[2]; Peter Geantil[3]; Jon Tischler[2]; Michael Kassner[3]; Wenjun Liu[4]; [1]National Institute of Standards and Technology; [2]ORNL; [3]University of Southern California; [4]Argonne National Laboratory

We have used depth-resolved, submicrometer X-ray beams to directly measure the axial elastic strains within individual dislocation cell walls and adjacent cell interiors in plastically deformed copper single crystals. These studies have settled long-standing questions about the existence and nature of long-range stresses in heavily deformed metals. However, it is equally important to determine what underlying processes drive the evolution of the measured broad distributions of elastic strain. Two viable mechanisms have been identified that are consistent with the experimental results: size effects arising from the dipolar nature of the stress field and stochastic processes operating during the evolution of individual dislocation walls. Analytic models for both processes will be presented and compared with the measured stresses.

3:00 PM Invited

Mechanical Properties of Submicrocrystalline 0.19%C Low Carbon Steel after Equal Channel Angular Pressing and Heating: *Sergey Dobatkin*[1]; Ruslan Valiev[2]; Vladimir Semenov[2]; Georgy Raab[2]; Svetlana Shagalina[1]; [1]A.A. Baikov Institute of Metallurgy and Materials Science, Russian Academy of Sciences; [2]Ufa State Aviation Technical University

The purpose of the work was to study the structure and properties of the 0.19%C steel after equal-channel angular pressing (ECAP) and subsequent heating. The ECA pressing of the 0.19%C steel at 400°C for 4, 8, and 12 passes at an angle of 120° between the channels led to the formation of the grain-subgrain structure with a ferrite structure element size of about 350 nm. Heating of the steel after ECA pressing to 400 and 450°C increases the fraction of high-angle boundaries, and the ferrite structure element size rises to 360–450 nm. The obtained grain-subgrain submicron-size structure provides a substantial strengthening (YS = 730 –790 MPa) at a sufficient plasticity (EL = 11.0–15.3%). After ECAP and heating, the strength do not virtually change, but the ductility somewhat rises. The impact toughness after ECAP decreases, but remains at a high level.

3:30 PM Break

4:00 PM Invited

Structure-Property Relationship of Ultrafine Grained Titanium-Aluminum-Niobium Alloys Processed by Accumulative Roll Bonding: *Viola Acoff*[1]; [1]The University of Alabama

The severe plastic deformation process of accumulative roll bonding (ARB) was used to process ultrafine grained Ti-Al and Ti-Al-Nb alloys from elemental titanium, aluminum, and niobium foils. The multi-layered foils were subjected to various ARB cycles that consisted of repeated cold rolling with interspersed folding of the foils. The structure-property relationship between the number of ARB cycles and the resulting grain size was investigated and characterized using transmission electron microscopy (TEM), scanning electron microscopy (SEM), x-ray diffraction (XRD), tensile testing and microhardness testing. TEM analysis showed the formation of ultrafine, submicron grains as a result of increasing ARB cycles. The reaction kinetics of solid-state phase transformations that occurred after annealing were also investigated as a function of ARB cycles. A relationship between the grain size and reaction kinetics was developed.

4:30 PM

Processing of a Duplex Stainless Steel by Equal Channel Angular Extrusion: Fernanda Farias[1]; *Marcos Pontes*[1]; Osvaldo Cintho[1]; [1]UEPG

A UNS S32205 duplex stainless steel was processed by ECAE in three different velocities, at room temperature, and heat treated in different temperatures and times to evaluate recrystallization. Attrition forces promoted great deformation heterogeneity in the samples sections, with hardness increase, and morphology changes in the grains and changing orientation through the processed samples. In treated samples surface, two types of distinct structures was formed, with surfaces positioned in 90º and 120º angles, probably because the annihilation of pilled dislocations in ferrite based centered cubic structure and austenite face centered cubic structure, respectively. The induced martensite by cold deformation was also observed. Some samples demonstrate located points of recrystallization in grain boundaries for some treatment conditions, the number of recrystallization nuclei increased with the increase of treatment time.

4:50 PM

Microstructure Evolution of AA7050 Al Alloy by ECAP: *Kátia Cardoso*[1]; Vanessa Guido[1]; Gilbert Silva[1]; Walter José Botta Filho[2]; Alberto Moreira Jorge Junior[2]; [1]Instituto de Pesquisa e Desenvolvimento - IP&D, Universidade do Vale do Paraíba - UNIVAP; [2]DEMa/UFSCar

This work aimed to study the processing by ECAP of commercial aluminum alloy AA7050 in the solubilized condition (W), considering the effects of process parameters as temperature (T_{amb} and 150°C), processing route (A and B_C) and number of passes, in the development of the microstructure of the alloy during pressing. OM, SEM and TEM were used for microstructural characterization, and hardness tests for a preliminary assessment of mechanical properties. The results show that the refining of the microstructure by ECAP occurred by the formation of deformation bands, with the formation of dislocations cells and subgrains within these bands. The increase of the ECAP temperature led to the formation of more defined subgrains contours and intense precipitation of phase in the form of spherical particles. The samples processed by Route B_C present a more refined microstructure.

5:10 PM

Nanostructured Magnesium Hydride Prepared by Cold Rolling and Cold Forging: *Daniel Leiva*[1]; Jacques Huot[2]; Alberto Jorge[1]; Tomaz Ishikawa[1]; Walter Botta[1]; [1]Universidade Federal de São Carlos; [2]Université du Québec à Trois-Rivières

Magnesium is a promising material for solid state hydrogen storage, since it has low cost and its hydride can store reversibly up to 7.6 wt. % of hydrogen. Fast H-sorption kinetics at around 300°C can be achieved after processing Mg-based mixtures by high-energy ball milling (HEBM), which produces nanostructured composite powders. Severe plastic deformation (SPD) techniques are being explored as an alternative to HEBM in order to obtain more air-resistant materials and reduce processing times. In this work, Mg, MgH2 and MgH2-Fe mixtures were severely mechanically processed by extensive cold forging and cold rolling. A very significant grain refinement (to around 10 nm) was achieved using MgH2 instead of Mg as raw material. Enhanced H-sorption kinetics properties were observed for these mechanically processed MgH2-based nanocomposites. These results are promising since it reveals the potential of using low cost mechanical processing routes to produce Mg-based nanomaterials for hydrogen storage.