

properties are investigated in the framework of an inverse materials design. An example of application in titanium alloy is used to demonstrate how the optimized properties can be achieved by process design.

**2:45 PM**

**Spout Formation in a Gas-Stirred Ladle – Experimental Results:** *Krishnakumar Krishnapisharody*<sup>1</sup>; Gordon Irons<sup>1</sup>; <sup>1</sup>Steel Research Centre, McMaster University

Model experiments simulating the spout formation in a gas-stirred ladle were performed with and without a slag-simulating phase (oil) above the bulk liquid (water). The height and width of the spout region were obtained by means of a digital video technique over a wide range of operating conditions. A dimensional analysis of the experimental data was employed to correlate the characteristic dimensions of the spout region to the operating variables of the system and the predicted results match with the available data from other works. This analysis reveals that the ladle diameter, size and type of gas injector and physical properties of gas-liquid system do not significantly affect the spout formation. Further, the spout size information have been used to quantitatively characterize gas-liquid plumes in a companion paper.

**3:00 PM**

**Spout Formation in a Gas-Stirred Ladle – The Key to Plume Dynamics:** *Krishnakumar Krishnapisharody*<sup>1</sup>; Gordon Irons<sup>1</sup>; <sup>1</sup>Steel Research Centre, McMaster University

Experimental data on the characteristic spout dimensions and the widths of gas-liquid plumes in vessels simulating Argon-stirred Ladles have been combined to derive a macroscopic model for unconfined two-phase plumes. The model reveals that, beyond the vicinity of the gas injector, various plume parameters in different gas-liquid systems can be expressed in an unified manner using the two variables of the system viz., the gas flow rate and the axial height. Further, expressions have been obtained for the average gas fractions and the area-averaged gas and liquid velocities in the plume. These model expressions are independent of the size of the gas injector as well as the physical properties of the gas-liquid system and thus have wider applicability.

**3:15 PM**

**Laser Surface Modification of AISI 316L Stainless Steel with WC-Si-Ni:** *D. Sastikumar*<sup>1</sup>; A. Viswanathan<sup>1</sup>; Kumar Harish<sup>2</sup>; A.K. Nath<sup>2</sup>; <sup>1</sup>National Institute of Technology; <sup>2</sup>Raja Ramanna Centre for Advanced Technology

The study deals with laser surface modification of AISI 316L stainless steel with WC-Si-Ni (40-40-20 and 80-10-10 wt. %) under different laser processing parameters. The laser irradiated specimens are characterized by Optical and SEM micrograph, Microhardness, X-ray diffraction and chemical composition analyses. The results show the formation of a thick layer (300 μm) over the substrate with strong adhesion when the coating composition is 40-40-20 wt. % (WC-Si-Ni). For the scan speed of 2.0 m/min. and 1.5 kW laser power, a layer with uniform thickness and smooth surface morphology is observed. The hardness is in the range of 800-900 HV. When the composition is 80-10-10 wt. %, coated materials get mixed into the substrate. The microstructure exhibits flower like dendritic growth structure. The bonding strength between the layer and the substrate is examined by the hardness study with various loads.

**3:30 PM Break****3:45 PM**

**Evolution of the Tecnoled Process – From Pilot Plant to Industrial Scale:** *Jose Noldin*<sup>1</sup>; Jose D'Abreu<sup>2</sup>; Ian Cox<sup>3</sup>; <sup>1</sup>Catholic University/Tecnoled; <sup>2</sup>Catholic University; <sup>3</sup>Tecnoled

The Tecnoled process is a new ironmaking technology that has been developed combining empirical and theoretical fundamentals, backed by extensive tests in a dedicated pilot-plant and with close support of universities and research centers. The campaigns in the pilot-plant focused on understand, simulate and operate the furnace using different reactor sizes including a full size modular slice of the industrial furnace, which provided real-life conditions to develop the main features of the process such as internal dimensions, thermal and gaseous profiles and melting zone formation, shape and maintenance. This paper describes the different phases of the technology development with respective goals and achievements including the construction of the first full scale industrial plant.

**4:00 PM**

**Properties of Carbonized Corn Straw as Thermal Insulating Agent of Liquid Metal:** *Nan Wang*<sup>1</sup>; <sup>1</sup>Northeastern University

The properties of carbonized corn straw were investigated for the purpose to substitute carbonized husk as thermal insulating agent of liquid metal due to the price elevation constantly in recent years. By characterizing the properties (including chemical composition, microstructure, flow property) of the obtained corn straw carbonized under different conditions, the optimal carbonation condition was determined. The carbonized corn straw has higher fixed carbon content, larger resting angle and smaller coefficient of thermal conductivity compared to carbonized husk, and thus which is considered suitable to be used as thermal insulating agent of liquid metal. The development and application of carbonized corn straw as thermal insulating agent of liquid metal not only decrease the production cost of metallurgical industries, but also develop a newly valuable way to use corn straw that was usually used as feedstuff and burning materials in village and thus the environment could be protected.

**4:15 PM**

**Preparation of Vanadium Thin Films by Chemical Vapor Deposition:** *Masakazu Mukaida*<sup>1</sup>; Misaki Ishitsuka<sup>1</sup>; Shigeki Hara<sup>1</sup>; Hiroyuki Suda<sup>1</sup>; Kenji Haraya<sup>1</sup>; <sup>1</sup>National Institute of Advanced Industrial Science and Technology

Vanadium-base alloys are expected as hydrogen separation materials because they have higher hydrogen permeability and good workability. In the present work, vanadium thin films were prepared on porous sintered stainless steel substrates by a chemical vapor deposition (CVD) to approach the thermal expansion coefficient of films and substrates. Organometallic compounds were used as source materials. The films were deposited under controlled conditions, which were substrate temperatures, pressures of CVD chamber and flow rates of carrier gas (Ar) for source material. The morphologies of films were observed by scanning electron microscope (SEM), and the elements in the films were investigated by energy dispersive X-ray spectroscopy (EDX).

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## Materials Processing under the Influence of External Fields: Session II

*Sponsored by:* The Minerals, Metals and Materials Society, TMS: Aluminum Committee, TMS: Magnesium Committee, TMS: Solidification Committee  
*Program Organizers:* Qingyou Han, Oak Ridge National Laboratory; Gerard Ludtka, Oak Ridge National Laboratory; Qijie Zhai, Shanghai University

Monday PM Room: America's Seminar  
February 26, 2007 Location: Dolphin Hotel

*Session Chairs:* Qi-Jie Zhai, Shanghai University; Ke Han, National High Magnetic Field Laboratory

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**2:00 PM Introductory Comments****2:05 PM Invited**

**Metals Solidification under the Influence of External Fields: Research Status in Shanghai University:** *Qi-Jie Zhai*<sup>1</sup>; Yu-Lai Gao<sup>1</sup>; <sup>1</sup>Shanghai University

In the present study the research status of metals solidification under the influence of external fields in Shanghai University, which is one of the main academic institutions in China, was introduced. The special self-developed equipments to produce external fields were presented. At present, many kind of external fields have been developed in Shanghai University, including ultrastrong magnetostatic field, ultrasonic, electric current pulse, pulsed magnetic field, and magneto oscillation etc. Also, the research interests in the metals solidification under external fields were systematically illuminated. Besides, the application prospect of these techniques was reviewed, especially in the metallurgy industry.

**2:35 PM**

**Study on the Pulse Magneto Oscillation Solidification Technique and Its Mechanism for Grain Refinement:** *Yong-Yong Gong*<sup>1</sup>; Jin-Xian Jing<sup>1</sup>; Zan-Qi Xia<sup>1</sup>; Yu-Lai Gao<sup>1</sup>; Qi-Jie Zhai<sup>1</sup>; <sup>1</sup>Shanghai University

In this paper, a novel pulse magnetic field that can be effectively used for grain refinement was proposed, which was defined as Pulse Magneto



Oscillation (PMO). The PMO physical field possesses the advantages such as non-contacting, no melt splashing and flexibility for its application. It was found that the pure Al could be distinctly refined after treated by the self-developed PMO. Based on the "crystal rain" experiments, the mechanism for grain refinement of PMO was analyzed. It was deemed that structure refinement rooted in the fall of the heterogeneous nucleus from the mould wall under the effect of PMO.

### 3:00 PM

#### **Effect of Pulsed Magnetic Field on the Solidified Structure of Pure Al Melt:**

*Yu-Lai Gao*<sup>1</sup>; Qiu-Shu Li<sup>1</sup>; Hai-Bin Li<sup>1</sup>; Qi-Jie Zhai<sup>1</sup>; <sup>1</sup>Shanghai University

A comparative study was made of the effect of pulsed magnetic field on the solidification structure of pure aluminum by employing the self-developed high voltage pulsed power source at several solidification stages. It has been shown that the solidified structure was remarkably refined with applied pulsed magnetic field during or in the overall solidification process. In contrast, no significant difference in the solidification structure of aluminum was observed also with pulsed magnetic field prior to the stage of nucleation. As a result, it was convincing that the structure refinement arises from the pulsed magnetic field at the stage of nucleation and growth, yet the incubation effect was negligible.

### 3:25 PM

#### **Controlling Semiconductor Growth Using Magnetic Fields and Rotation:**

*Baskar Ganapathysubramanian*<sup>1</sup>; Nicholas Zabarav<sup>1</sup>; <sup>1</sup>Cornell University

The application of a time varying magnetic field has been shown to affect the properties of the semiconductor single crystal achieved through growth from the melt. The application of a time dependent rotation of the crucible affects the flow pattern in the melt resulting in enhanced distribution of thermal effects. We will discuss a complete three dimensional simulator of the crystal growth process in the presence of a magnetic field and imposed rotation. We will investigate the three dimensional coupled effects of an externally applied magnetic field and a time varying rotation imposed on the solidifying melt. A three dimensional optimization problem will then be posed to design the temporal variation of the magnetic field and/or the rate of rotation to achieve certain goals. These goals include maximizing the pulling rate, minimizing the thermal gradient imposed, as well as controlling the shape of the melt-solid interface.

### 3:50 PM Break

### 4:00 PM Invited

#### **High Magnetic Field Influences on Fabrication of Materials with Magnetic Phases:**

*Ke Han*<sup>1</sup>; Bao Zhi Cui<sup>1</sup>; <sup>1</sup>National High Magnetic Field Laboratory

This paper describes annealing experiment we have undertaken in a large bore high field magnet. The magnet annealing temperatures were carefully selected so that a reaction occurs at the annealing temperature and one or more components are ferro-magnetic phase at the chosen temperatures. Magnetic field has an impact on both nucleation and growth of the phases formed during the reactions. The paper reviews the effects and relevant mechanism of magnetic annealing on microstructures, crystallographic textures, exchange coupling, magnetic anisotropy, and hard magnetic properties for magnet materials. Magnetic annealing was found to promote the phase transformation and increases the nucleation sites for the formation of magnetic phases so that refinement of the microstructure is achieved. Magnetic annealing was also found to manipulate the texture of the materials. The refinement of the microstructure and the optimization of the texture result in the improvements of magnetic properties.

### 4:30 PM

#### **Synthesis of Acicular Magnetite Using Coprecipitation Method under Magnetic Field:**

*Yang XiYun*<sup>1</sup>; Chen Baizhen<sup>1</sup>; Xu Hui<sup>1</sup>; Shi Xichang<sup>1</sup>; <sup>1</sup>Central South University

Acicular magnetite was synthesized by coprecipitation of ferrous and ferric mixed salt solution with urea in the temperature range from 90-95°C in reflux condition for 12h. The magnetite particles were characterized by X-ray powder diffraction, scanning electron microscopy and magnetization measurements. XRD showed that the mole ratio of Fe<sup>3+</sup>/Fe<sup>2+</sup> and concentration of urea have great effects on the composition of the product. SEM showed that the type of anion and surfactant have not been able to obviously affect the shape of magnetite product. In contrary, the magnetic field has remarkable effect on the

shape of magnetite product. The particles grow along its easy-magnetization to form acicular magnetite. The acicular magnetite has a saturation magnetization of 85emu/g and a coercivity of 380 Oe.

### 4:55 PM

#### **Rapid Ceramic Processing by Field-Assisted Sintering Technique:**

*Dat Quach*<sup>1</sup>; Veaceslav Zestrea<sup>2</sup>; Vladimir Kodash<sup>1</sup>; Gregory Toguyeni<sup>3</sup>; Joanna Groza<sup>1</sup>; <sup>1</sup>University of California; <sup>2</sup>Academy of Sciences of Moldova; <sup>3</sup>Ecole Polytechnique de l'Universite de Nantes

The novel field-assisted sintering technique (FAST) has been successfully used to form and consolidate a number of chalcogenide spinels and tialite. For the first time the ternary magnetic sulfide compound FeCr<sub>2</sub>S<sub>4</sub> was prepared from a mixture of commercially available FeS and Cr<sub>2</sub>S<sub>3</sub> powders using FAST. A one-step complete reaction sintering to form FeCr<sub>2</sub>S<sub>4</sub> was done at 1000°C in 10 minutes. ZnCr<sub>2</sub>S<sub>4</sub> and some ternary magnetic oxide compounds (CoAl<sub>2</sub>O<sub>4</sub> and Co<sub>2</sub>AlO<sub>4</sub>) were also prepared using the same technique. The high homogeneity of the composition of the prepared samples was confirmed by XRD analysis. In addition the hard-to-form-and-sinter tialite, Al<sub>2</sub>TiO<sub>5</sub>, can also be FAST-synthesized from regular Al<sub>2</sub>O<sub>3</sub> and TiO<sub>2</sub> powders. Compared to conventional methods where the same reaction sintering step may take hours or days, current FAST-reaction sintering experiments demonstrate the ability of this novel technique to rapidly form and consolidate different ceramic compounds.

### 5:20 PM

#### **Computer-Aided Processing of Advanced Dielectric Composites via Self-Assembly of Arbitrary-Shaped Ferro-Colloidal Particles in External Field:**

*Yu Wang*<sup>1</sup>; <sup>1</sup>Virginia Tech

Ferro-colloidal processing under external field is investigated for fabrication of advanced dielectric composites by using computer modeling and simulation. Our study focuses on the self-assembly of dipolar interacting particles, its effects on composite microstructure and dielectric properties, and the underlying mechanisms. Computational model is developed based on diffuse interface field approach. It explicitly treats particle microstructure and its evolution during self-assembly and accounts for accurate long-range and short-range interaction forces among multiple particles of arbitrary shapes and sizes (the conventional point-dipole approximation is not applicable in particle self-assembly process because of non-spherical particle shapes and small inter-particle distances). External field is used to tune the self-assembling forces and control particle microstructures. The model takes into account the particle size and shape polydispersities and their effects on microstructure control and property optimization. As application example, computer-aided design and processing of ceramic-filler polymer-matrix nanocomposites for high-energy-density capacitors is presented.

### 5:45 PM

#### **Magnetic Alignment of Nanotubes:**

*Ben Wang*<sup>1</sup>; Richard Liang<sup>1</sup>; Chuck Zhang<sup>1</sup>; <sup>1</sup>Florida A&M University-Florida State University, Engineering College

We will present two separate but related projects, both involving the use of magnetic forces to align nanotubes at Florida Advanced Center for Composite Technologies: (1) alignment of nanotubes in aqueous solution before the formation of BuckyPapers, and (2) alignment of nanotubes in epoxy resin. BuckyPapers are thin films (about 15 microns in thickness) of nanotubes held together by their own interdigitation and van der Waals forces. In the case where the application calls for individual nanotubes being "organized" in the same direction, the nanotubes are aligned in a magnetic field before the BuckyPaper is formed. With the advances of carbon fibers as composite reinforcements, the in-plane strength of composite laminates has demonstrated substantial improvement. The shear strength, however, has shown little progress. We developed a process by which nanotubes are aligned in the z direction while in epoxy resin, which is simultaneously reinforced with regular carbon fibers.