

**EIGHTEENTH ANNUAL SYMPOSIUM ON  
METALLURGICAL AND MATERIALS  
RESEARCH**

**12<sup>th</sup> and 13<sup>th</sup> January, 2005**

*Programme and Abstracts*



**Department of Metallurgy  
Indian Institute of Science  
Bangalore-560012**

# **Eighteenth Annual Symposium on Metallurgical and Materials Research**

*Department of Metallurgy  
Indian Institute of Science, Bangalore-560012*

**January 12-13, 2005**

## **January 12, 2005**

09:30-10:00 a.m.                      **Inauguration**

10:00-10:30 a.m.                      **High Tea**

10:30-11:05 a.m.                      **Invited talk I**

Metal nanocrystals and their self-assembly into electronic nanostructures  
**S. Venugopal**

11:15-12:00 p.m.                      **Session I**

**Chairman:**                              M. Phaniraj

Growth and morphological evolution in elastically inhomogeneous systems: A phase field study

**M.P. Gururajan and T.A. Abinandanan**

Damping characteristics of aluminium metal matrix composites

**Ranjit Bauri**

Solidification of undercooled peritectic Fe- 25 at% Ge alloy

**Krishanu Biswas**

12:00-12:15 p.m.                      **Tea/Coffee**

12:15-01:00 p.m.                      **Session II**

**Chairman:**                              N. R. Sathya Swaroop

Synthesis, microstructure and superconductivity in nanoscaled indium-tin alloys

**Victoria Bhattacharya, P. Ayyub and K.Chattopadhyay**

Atomistic simulations of plastic deformation in amorphous materials  
**P.Murali, U.Ramamurty and V.B.Shenoy**

Asymmetrical spreading of a bubble in contact with a solid surface  
**Manas Mukherjee**

01:00-02:00 p.m                      **Lunch break**

02:00-2:45 p.m.                      **Session III**

**Chairman:**                              Subhradeep Chatterjee

Particulate suspension properties in the presence of polyelectrolytes  
**L. Saravanan and S. Subramanian**

Raceway size correlations based on cold model experiments  
**Sabita Sarkar**

Aging response and its effect on mechanical and functional properties of Cu-Al-Ni shape memory alloys  
**N. Suresh and U. Ramamurty**

02:45-3:00 p.m.                      **Tea/Coffee**

3:00-3:35 p.m.                      **Invited talk II**

Microwave synthesis and sintering of silicon carbide and silicon carbide-alumina composites  
**L. N. Satapathy**

3:45-4:30 p.m.                      **Session IV**

**Chairman:**                              S.J. Suresh

Infiltration kinetics of Al-Mg alloy into Al<sub>2</sub>O<sub>3</sub> preforms  
**Debdutt Patro and Vikram Jayaram**

Precipitate Growth Kinetics: A Phase Field Study  
**R.Mukherjee and T.A.Abinandan**

Glass Forming Ability of Al-La-Ni System: Miedema Approach  
**Tripti Biswas**

4:30-4:45 p.m.                      **Tea/Coffee**

4:45-6:00 p.m.

**Session V**

**Chairman:**

Saswata Bhattacharyya

Selective separation of pyrite from chalcopyrite in presence of  
*Acidithiobacillus ferrooxidans*

**Chandraprabha M.N. and Natarajan K.A.**

Indentation strength of piezoelectric ceramics: simulations and experiments

**S. N. Kamble, D. Kubair and U. Ramamurty**

Dry sliding wear behaviour of saffil short fibre reinforced Mg-MMC

**Ashok Kumar Mondal and Subodh Kumar**

Structure-thermodynamic property correlation in 2-3 oxide spinels and their solid  
solutions: System Ni-Al-Cr-O

**Kay Thi Lwin**

On the development of an ultra-fine grain structure in commercial pure aluminium by a  
cyclic extrusion and upsetting route

**Srinivasan. K**

6:15-7:00 p.m.

**Cultural Programme**

7:00 p.m. onwards

**Alumni meet and Dinner**

**January 13, 2005**

9:30-10:30 a.m.

**Session VI**

**Chairman:**

Rejin Raghavan

Stir casting of hybrid Al-SiC-fly ash composite

**Sudarshan and M.K. Surappa**

Micromechanisms of deformation and fracture in Ti-B alloys

**L. Maheshwari and U. Ramamurty**

Characterisation of boron carbide manufacturing process

**Manjunath P.**

Thermodynamic measurements and modeling in the Al-Bi-Sb system

**S. Acharya and J.P.Hajra**

10:30-10:45 a.m.

**Tea/Coffee**

10:45-11:45 a.m.

**Session VII**

**Chairman:**

Ranjit Bauri

Processing and mechanical properties of multi-layer coatings of TiN/AlTiN on steel

**S. J. Suresh, S. K. Biswas and V. Jayram**

Assessment of acid production potential of the Ajjanahalli gold tailings

**Vidhya Lakshmi R, Evvie Chokalingam S. Subramanian, K. A. Natarajan and J. J. Braun**

Processing of bulk nanocrystalline materials by conventional deformation processes

**Kanhaiya Kumar**

Strain Hardening and Fatigue in Metal Foams: The effect of Constraint

**Shweta Gaonkar and U. Ramamurty**

11:45 a.m-12:00 p.m.

**Tea/Coffee**

12:00-1:00 p.m.

**Session VIII**

**Chairman:**

M. P. Gururajan

Solidification of a Ti/Ni dissimilar weld

**S. Chatterjee, T.A. Abinandanan and K. Chattopadhyay**

Punch tests: Is it equivalent to extrusion?

**R. C. Shivamurthy and S.V. Kailas**

Microstructure and mechanical properties of a extruded AZ21 Mg alloy

**M.A. Azeem, A. Tewari and U. Ramamurty**

Tensile and Compressive Deformation, and Wear Behavior of as cast Mg<sub>97</sub>Zn<sub>2</sub>Y<sub>1</sub> Alloy

**Manish Patel**

01:00-02:00 p.m

**Lunch break**

02:00-3:00 p.m.

**Session IX**

**Chairman:**

Victoria Bhattacharya

Crystal Structures of a Mg-Zn-Y Alloy: A First-principles Study

**A. Datta, U. Ramamurty, S. Ranganathan, U. V. Waghmare**

Role of Surface Topography in Tribology

**Pradeep L. Menezes, Kishore, and Satish V. Kailas**

Bubble Formation and Detachment at Liquid-Liquid Reaction Interface

**Vikash Kumar Sinha**

Structural relaxation in metallic glasses: Effect of cooling rate

**R. Raghavan, S. Ranganathan, U. Ramamurty**

03:00-03:15 p.m.

**Tea/Coffee**

3:15-3:45 p.m.

**Invited talk III**

Arsenic in drinking water: conflicting standards and beyond

**Amitav Mukherjee**

03:45-4:45 p.m.

**Session X**

**Chairman:**

Debdutt Patro

Monte Carlo study of interfacial properties of phase separating alloys

**Saswata Bhattacharyya, Ferdinand Haider and T.A. Abinandanan**

Effect of grain aspect ratio on diffusion creep rate in bamboo structures

**Vivek Srivastav**

Dry sliding wear behaviour of  $Mg_{97}Zn_1Y_2$  alloy: A comparative study in two different environments

**P. Prakash, S. Ranganathan and Satish. V. Kailas**

Structural and Optical Studies on RF Plasma Polymerised Furfural Thin Films

**S. Saravanan, M. R. Anantharaman, S. Venkatachalam, D. K. Avasthi**

4:45-5:15 p.m.

**Closing ceremony**

5:15 p.m.-

**High tea**

**Day –I (12<sup>th</sup> Januray,2005)****Invited Talk I****Metal nanocrystals and their self-assembly into electronic nanostructures***Santhanam Venugopal*

Department of Chemical Engineering, Indian Institute of Science, Bangalore-560012

Nowadays, Nanotechnology is a catchword that evokes excitement in researchers and captures the imagination of laymen. There are two alternative approaches for fabricating nanoscale devices namely; Top-down and Bottom-up approaches. The top-down approach consists of 'chiseling' nanometer scale features from bulk materials, while bottom-up approach consists of 'building' nanoscale devices from smaller individual units akin to bricks. There are several challenges that need to be overcome for bottom-up techniques to be successful with the chief among them being to develop reliable and robust processes for forming uniform self-assembled assemblies from the building blocks. Currently, there are several candidates for use as building blocks in fabricating nanoscale electronic devices, viz. metal nanocrystals, carbon nanotubes and molecular rectifiers. Compared to the other two choices metal nanocrystals have been studied and characterized for a longer period of time and manufacturing-scale synthesis of size-selected metal nanocrystals is currently feasible. Metal nanocrystals and nanoparticles in the size range of 1 – 10 nm have been synthesized and characterized mainly as ligand stabilized colloidal solutions for more than two decades and are denoted as MPC's (Monolayer Protected Clusters). MPC's have been proposed as building blocks for sensor and nanoelectronic applications due to their unique properties that fall between those of atomic species and bulk matter. The capability to manipulate MPC's as individual molecular species, the capability to manipulate particle size, and the capability to manipulate interparticle spacing in a MPC array by changing the nature of the ligand makes them ideal building blocks for nanoscale applications. An important technological challenge to the advent of practical nanoelectronic devices is the formation of large ordered arrays of MPC's. These superlattice arrays can be considered as 'crystals of MPC's' and their long-range order is critical for proposed applications in electronics, optoelectronics and sensors. In this talk, I will discuss some of the enabling technologies developed at Purdue to address this issue [1,2].

(1) Santhanam, V.; Liu, J.; Agarwal, R.; Andres, R. P. *Langmuir* **2003**, *19* (19), 7881.

(2) Santhanam, V.; Andres, R. P. *Nano Lett.* **2004**, *4* (4), 45.

**Growth and morphological evolution in elastically inhomogeneous systems: A phase field study**

*M.P. Gururajan and T.A. Abinandanan*

Elastic stresses that arise due to compositional heterogeneities in a two phase binary alloy strongly affect the microstructural evolution. In addition, when the elastic constants of the two constituent phases are different, the microstructural evolution is further affected by externally applied stresses. In this presentation, we present some preliminary results on the growth rates and morphological evolution of a single precipitate growing into a supersaturated matrix. Further, we compare our results (obtained using a phase field model) with the analytical sharp-interface solutions available in the literature.

**Damping characteristics of aluminium metal matrix composites**

*Ranjit Bauri*

Damping capacity is the measure of a material's ability to dissipate elastic strain energy during mechanical vibration or wave propagation. Materials that possess high damping capacity are useful in passive attenuation of noise and vibration in structures. This has led the way for development of materials possessing high damping capacity in combination with low density and high stiffness. Al based low density metal matrix composites (MMCs) are particularly suitable for this purpose since these can be mass produced and possess high specific stiffness. In MMCs damping capacity can be improved through the addition of reinforcing phases that possess high intrinsic damping or that dramatically modify the matrix microstructure in such a way as to increase the damping capacity. In this study, damping characteristics and mechanisms of damping of 8090 Al alloy and its composites reinforced with 8, 12 and 18 vol.% SiC particles were investigated using a Dynamic Mechanical Analyzer (DMA). Tests were done at four different frequencies (0.1, 1, 10 and 20 Hz) over a temperature range of 27 to 300 °C. Composites show higher damping capacity than the unreinforced alloy. Damping capacity is found to increase with decreasing frequency. The damping data is analyzed in the light of matrix microstructure and different operative mechanisms. Thermoelastic damping is the dominant damping mechanism in the unreinforced alloy at lower temperatures beyond 20 Hz. Dislocation, grain boundary and interface damping are found to be the operative damping mechanisms in the composites.

**Solidification of undercooled peritectic Fe-25 at % Ge alloy**

*Krishanu Biswas, Gandham Phanikumar<sup>1</sup> and Kamanio Chattopadhyay*

The present investigation deals with phase selection in deeply undercooled Fe-25 at% Ge alloy. Bulk samples of Fe<sub>3</sub>Ge peritectic alloy are undercooled upto 260 K using electromagnetic levitation technique. The growth rate of the primary phase is measured using a capacity proximity sensor technique. Solidification microstructure is studied as a

function of level of undercooling. The microstructure of samples undercooled below 110K consists of residual primary phase  $\alpha_2$ , peritectic phase  $\epsilon$ , and inter-dendritic  $\epsilon$ - $\beta$  eutectic. Microstructure at higher cooling is phase-pure  $\epsilon$ . Time resolved diffraction analysis of the levitated droplets using synchrotron radiation indicates the nucleation of primary  $\alpha_2$  in all levels of undercooling. The results are analyzed using current theories on dendritic growth. Interfacial undercooling is found to play an important role in growth kinetics. Our results also suggest suppression of peritectic reaction.

<sup>1</sup>German Aerospace Centre (DLR), Cologne, Germany

### **Synthesis, microstructure and superconductivity in nanoscaled indium-tin alloys**

*Victoria Bhattacharya, P. Ayyub<sup>1</sup> and K. Chattopadhyay*

We have synthesized nanoscaled indium-tin alloys embedded in a continuous aluminum matrix to study the effect of size on superconductivity. The morphology and size distribution of these nanoscaled alloy particles were studied in detail using transmission electron microscope. Our results indicate that majority of the alloy particles are biphasic and show presence of beta and gamma phases. Superconducting properties of these samples were investigated using a vibratory sample magnetometer, measured in both field cooled and zero field cooled conditions. Both transition temperature and critical fields for these nanoscaled particles were found to be significantly lower than those of the bulk alloys measured under identical conditions. We will highlight some of our major findings in this presentation.

<sup>1</sup>Department of Condensed Matter Physics and Materials Science, Tata Institute of Fundamental Research Homi Bhabha Road, Mumbai 400005, India

### **Atomistic simulations of plastic deformation in amorphous materials**

*P. Murali, U. Ramamurty and V.B. Shenoy<sup>1</sup>*

The plastic deformation in crystalline materials is in general explained in terms of motion of line defects (known as dislocations). Amorphous materials lack long range order and hence the concept of a line defect is not so straight forward as in crystalline materials. Hence these materials fail to yield and tend to be brittle. On contrary metallic glasses (formed by rapid quenching  $\sim 10^6$  K/s) and recently developed bulk metallic glasses ( $\sim 1$  K/s) exhibit good amount of plasticity. These materials deform through a change in structure in much localized regions (known as shear bands). There are several experimental observations indicating stress induced crystallization and void formation in these regions. Molecular dynamic simulations were performed to understand the plastic deformation in model amorphous systems. The results are in agreement with the available experimental observations of stress induced crystallization. The physical parameters (in terms of atomic potentials) that control the onset of crystallization are identified and will be presented.

<sup>1</sup>Materials Research Centre, Indian Institute of Science, Bangalore 560012

**Asymmetrical spreading of a bubble in contact with a solid surface***Manas Mukherjee*

A three-phase contact (TPC) line forms when the intervening liquid film between a bubble and a solid surface ruptures. The spreading of the TPC line for a large bubble has been observed by using a high-speed digital video camera. Experiments were carried out in water-glycerol solution and wax surface was used as solid surface. It was shown in the literature that the profile of the TPC line is circular around the rupturing point for spherical as well as deformed bubble. Here it is shown that the spreading profile is not symmetrical around the rupturing point for a deformed bubble.

**Particulate suspension properties in the presence of polyelectrolytes***L. Saravanan and S. Subramanian*

The dispersing ability of anionic and cationic polyelectrolytes was examined with respect to alumina, zirconia and silicon carbide suspensions in aqueous medium, in the pH range of 2 to 11. The adsorption density of ammonium poly(methacrylate), an anionic polyelectrolyte onto alumina/zirconia decreased with the increase in pH, whereas a characteristic maximum in the adsorption density was observed at around neutral pH value ( $\sim 7$ ) for chitosan, a cationic polyelectrolyte onto silicon carbide. The isoelectric points (IEPs) of alumina and zirconia were shifted toward the acidic pH region in the presence of the anionic polyelectrolyte and that of silicon carbide was shifted towards the basic pH region in the presence of the cationic polyelectrolyte. Based on the turbidity measurements, the stability of the alumina, zirconia and silicon carbide suspensions were found to be higher in the pH regions of 6-11, 4-11 and 2-6 respectively, consequent to the addition of the optimum dosage of the chosen polyelectrolyte. The adsorption and electrokinetic data have been correlated with the turbidity results. The possible mechanisms of adsorption of the polyelectrolytes with the oxide and carbide ceramic suspensions have been discussed.

**Raceway size correlations based on cold model experiments***Sabita Sarkar*

It has been reported in the literature that raceway measurement made during the decreasing gas velocity is relevant to operating blast furnaces. However, no raceway correlation is available for decreasing gas velocity and none of the available correlations either in increasing or decreasing gas velocity take care of frictional properties of the material. Therefore, a systematic experimental study has been carried out on raceway hysteresis. Based on experimental data and using dimensional analysis, two raceway correlations, one each for increasing and decreasing gas velocity, have been developed. Results of these correlations have been compared with the data obtained from literature

on the cold models and plant data along with some experimental data. A good agreement exists between the correlations and other data.

### **Aging response and its effect on mechanical and functional properties of Cu-Al-Ni shape memory alloys**

*N. Suresh and U. Ramamurty*

The  $\beta$ -phase aging response of Cu-Al-Ni single crystal shape memory alloys (SMAs) within the temperature range of 473 to 573 K has been investigated. Alloys in austenitic (alloy A) and martensitic (alloy M) condition at room temperature, in the as grown state were considered. The calorimetry (DSC) and microscopy results of aged samples show successive martensitic transitions ( $\beta_1' \rightarrow \gamma_1'$ ) in both the alloys and precipitate formation ( $\gamma_2$ ) in the alloy A, leading to an increase in the transformation temperatures. The mechanical response of  $\beta$ -phase aged alloys was investigated at temperatures above and below the transformation regime. Compression tests show remnant permanent strain after unloading due to mechanical stabilization of  $\gamma_1'$  martensite. Moreover, a noticeable increase in critical stress for transformation in the aged samples vis-à-vis as quenched sample is seen. The uniaxial tensile testing of aged (473 K for 24 h) sample shows an increase in the critical stress for transformation for the alloy M, but not for the alloy A, when compared to the corresponding as-quenched samples. Dynamic mechanical analysis (DMA) was conducted to ascertain the role of precipitates or stabilization of the martensite on the damping properties of the SMAs. The aged samples show a decrease in the damping value with increase in the aging temperature.

## **Invited talk II**

### **Microwave synthesis and sintering of silicon carbide and silicon carbide-alumina composites**

*L. N. Satapathy*

Ceramic Technological Institute, Bharat Heavy Electricals Limited  
Bangalore-560012

Silicon carbide (SiC) is by far the most widely used non-oxide ceramics for many industrial applications because of its attractive high temperature properties such as high strength, high hardness and high wear and thermal shock resistance. It also possesses excellent chemical oxidation resistance. The carbothermal reduction of sand by coke, known as the Acheson process is the main method of SiC production. However, this method is an energy-intensive process and involves many steps in synthesizing a powder of phase-pure SiC. In the last decade, efforts have been made by various researchers to synthesize fine and pure SiC powder by alternative methods like sol-gel, plasma and laser. These latter methods are yet to establish commercial viability.

In the last few years, extensive research in the laboratories has completely changed the value of microwave sintering and synthesis of ceramic phases. The

microwave energy has been gaining importance in synthesis and sintering of ceramic materials because of its rapid heating, selective coupling and enhanced reaction kinetics. However, the detailed synthesis of SiC using microwave energy is scarce in the literature.

Fine, monophasic silicon carbide powder has been synthesized in this work by direct reaction between silicon and carbon, polymer pyrolysis and by carbothermal reduction in a 2.45 GHz microwave field. Optimum parameters for the silicon carbide phase formation have been determined by varying reaction time and reaction temperature. The powders have been characterized for their particle size, surface area, phase composition (x-ray diffraction) and morphology (scanning electron microscope). Alumina- silicon carbide composite powders have also been produced in a microwave field and the resulting powders have also been characterized. Preliminary sintering experiments in the microwave field have been carried out and the densification behavior of these powders has been analyzed. Fine and phase-pure SiC can be produced by these methods.

### **Infiltration kinetics of Al-Mg alloy into Al<sub>2</sub>O<sub>3</sub> preforms**

*Debdutt Patro and Vikram Jayaram*

Pressureless infiltration is an attractive technique to make near-net shape composites over a wide range of reinforcement volume fractions (typically 35-75%). In particular, reinforcements like Al<sub>2</sub>O<sub>3</sub> and SiC are extensively used with Al alloys because of their commercial importance. From a scientific viewpoint, the rate at which the liquid metal infiltrates into the preform porosity is a key parameter.

In this work, infiltration experiments of Al-2wt%Mg into loose Al<sub>2</sub>O<sub>3</sub> bed were conducted in flowing N<sub>2</sub>-H<sub>2</sub> at temperatures where spontaneous imbibition of the melt is favoured. The effect of temperature (in the range 800- 1000°C) and various starting particle sizes (25-125 μm) comprising the bed were investigated. The measured infiltration rate into the loose bed was found to be of the order of tens of μm/sec compared with the predicted rate of tens of mm/sec from capillary bundle theory.

Physico-chemical aspects such as reactive wetting at the melt-Al<sub>2</sub>O<sub>3</sub> interface and changes in surface tension of the infiltrating melt cannot explain the observed discrepancy between theoretical and experimentally observed kinetics of infiltration.

In this work, we will present a non-uniform capillary model taking into account the converging-diverging paths present inside the porous Al<sub>2</sub>O<sub>3</sub> bed. Solving Hagen-Poiseuille's equation we were able to predict rates commensurate with the extremely slow rates experimentally seen.

### **Precipitate growth kinetics: A phase field study**

*R.Mukherjee and T.A.Abinandan*

Phase field models are widely used for predicting mesoscale microstructure evolution in materials during solid state phase transformations. Here we describe a phase field model

to study the growth kinetics of a precipitate, growing in a solid solution of initially uniform composition. Using this diffuse interface model (with Fourier spectral implementation), we have shown that  $R = \alpha(Dt)^{1/2}$ , where  $R$  is the radius of the precipitate,  $D$  is the atomic diffusion coefficient,  $t$  is the time of growth and  $\alpha$  is the growth coefficient. For our model we have chosen the free energy density function in such a way that  $D$  always remains constant throughout the matrix phase. For different degrees of supersaturation in the matrix phase, we have computed the value of  $\alpha$ , which agrees well with the classical results of Zener and of Frank for sharp interface model of precipitate growth kinetics.

### **Glass forming ability of Al-La-Ni system: Miedema approach**

*Tripti Biswas*

Thermodynamic calculations are being extensively used in recent years to estimate the glass forming ability of different metals and alloys. Miedema's model can directly be used to determine the glass forming range in binary alloy systems and can be extended to ternary systems by neglecting the ternary interactions. According to Miedema's model (1976) an amorphous phase can be formed if the enthalpy of formation of the amorphous phase is less than that of the solid solution phase. The enthalpy of formation of solid solution comprises of three components: chemical, elastic and structural contributions. It is observed that this model can predict better than the regular solution model and the results match very well with experimental observations. This model has been chosen for calculating glass forming composition range for binary Al-La, Al-Ni and La-Ni systems and ternary Al-La-Ni system. The glass forming composition range for Al-La, Al-Ni and La-Ni systems extends approximately from 10 to 90 at% La, 25 to 75 at% Ni and 5 to 95 at% Ni respectively. In this system the predicted glass forming composition range is wider than the experimentally observed range.

### **Selective separation of pyrite from chalcopyrite in presence of *Acidithiobacillus ferrooxidans***

*M.N. Chandrababha and K.A. Natarajan*

Extraction of valuable metals and removal of sulphide minerals from abandoned mines holds the key for environmental protection. This talk discusses the utility of *Acidithiobacillus ferrooxidans* for the selective removal of pyrite from chalcopyrite. Interaction of bacterial cells with the sulphide minerals altered the surface chemistry of both the minerals, with the effect on pyrite being greater compared to chalcopyrite. The attachment of bacteria onto minerals was significant upto pH 6, beyond which there was a drastic decline in cell adhesion. The adsorption density was higher on pyrite. Interaction with cells rendered both the minerals hydrophilic. But, collector flotation of minerals, preconditioned with cells, resulted in depression of pyrite while chalcopyrite exhibited good flotability. Flotation of pyrite due to copper activation, when the minerals were conditioned together, was overcome by reversing the sequence of interaction with cells

and collector. Thus, it was possible to effectively depress pyrite from chalcopyrite at both acidic and neutral pH conditions.

### **Indentation strength of piezoelectric ceramics: simulations and experiments**

*S. N. Kamble, D. Kubair<sup>1</sup> and U. Ramamurty*

Due to the intrinsic coupling between mechanical and electrical fields, piezoelectric materials are used in many sensor and actuator applications. However, piezoelectric ceramics, such as the widely used  $\text{Pb}(\text{ZrTi})\text{O}_3$ , being brittle are susceptible to fracture during service. Hence, assessment of the strength of these materials becomes important in order to prevent failure during service as well as to predict reliable service life. In this study, we conduct an investigation to understand the strength of the piezoelectric ceramics under indentation loading. Finite element analysis is used to understand the nature of stress distribution during the spherical indentation of an elastic, linearly-coupled piezoelectric solid. Results show that region of high stress occurs underneath the indenter for poled material, whereas for unpoled material it is at contact perimeter. Complimentary experiments conducted on  $\text{Pb}(\text{ZrTi})\text{O}_3$  also show similar trend. Cone cracks for poled material and radial cracks for unpoled material have been observed. Effect of different electrical boundary conditions with respect to indenter being perfect conductor and insulator are also assessed.

<sup>1</sup>Department of Aerospace Engineering Indian Institute of Science, Bangalore-560 012

### **Dry sliding wear behaviour of saffil short fibre reinforced Mg-MMC**

*Ashok Kumar Mondal and Subodh Kumar*

The wear behaviour of AE42 magnesium alloy and AE42+20% saffil short fibre composite is investigated in dry sliding condition using a pin-on-disc set-up in the load range of 5 to 40 N with sliding velocities of 0.838, 1.676 and 2.513 m/s for a constant sliding distance of 2.5 km. In case of both alloy and the composite wear rate increases with increasing loads and the wear rate of the composite is lower at lower loads. At all sliding velocities, a crossover in wear rate is observed with the increase in load, i.e., above a certain load, the wear rate of the composite becomes greater than that of the alloy, and the crossover shifts to lower loads with increase in the sliding velocity. Severe sub-surface plastic deformation and fibre breakages were found to be the dominant mechanism for the un-reinforced alloy and the composite respectively.

**Structure-thermodynamic property correlation in 2-3 oxide spinels and their solid solutions:  
System Ni-Al-Cr-O**

*Kay Thi Lwin*

Nickel, aluminum and chromium are important base-constituent elements of high-temperature oxidation-resistant alloys. A spinel phase is usually found in the protective scale formed on the surface of the alloys. There is no thermodynamic data on spinel solid solution NiAl<sub>2</sub>O<sub>4</sub>-NiCr<sub>2</sub>O<sub>4</sub>. Thus, the phase relations and mixing properties of the spinel solid solution have been determined by the conventional tie-line rotation method at 1373 K. From the tie-line information and thermodynamic data on Al<sub>2</sub>O<sub>3</sub>-Cr<sub>2</sub>O<sub>3</sub> solid solution available in the literature, the activities in the spinel solid solution were derived by using a modified Gibbs-Duhem integration technique. Gibbs energy of mixing of the spinel solid solution has been calculated from the derived activity data.

A model approach has also been considered to analyze the activity-composition relationship in the NiAl<sub>2</sub>O<sub>4</sub>-NiCr<sub>2</sub>O<sub>4</sub> spinel solid solution in terms of the intra-crystalline exchange of cations between the tetrahedral and octahedral sites of the spinel structure governed by site preference energies of the cations. The thermodynamic mixing properties of spinel solid solution were computed from the cation distribution model at 1373 K. The strain energy caused by size mismatch was added as a separate term to the Gibbs energy of mixing. The Gibbs energy of mixing, calculated using the cation mixing model with that of the experimental tie-line data were compared. The thermodynamic mixing properties obtained in this study would be helpful in understanding the formation of complex spinel protective layers on alloys containing nickel, aluminium and chromium in high-temperature applications.

**On the development of an ultra-fine grain structure in commercial pure aluminium by a cyclic extrusion and upsetting route**

*Srinivasan. K*

Cyclic Extrusion and Upsetting (CEU) is a severe plastic deformation process in which a sample is alternately extruded and upset. This process introduces a large plastic strain in the material with no overall change of cross-section at the end of an extrusion-compression step, so that repetitive pressings can be undertaken to achieve very high total strains without any significant change in cross-section area. CEU process can be used to attain an ultra-fine grain size or substructure with dimensions lying typically in the submicro- or even nanometer range.

The main objective of this work was to study the grain refinement of commercially pure aluminium (98.8%) processed through a severe plastic deformation route involving CEU. Transmission Electron Microscopy (TEM) was carried out on the unprocessed and processed specimens in order to reveal the fine structures within the grain. The unprocessed specimen had a grain size of 75 μm and presence of a substructure could not be detected. On the other hand, an ultra-fine, equiaxed sub-grain structure of 0.8 μm was obtained in the material processed up to a true strain level of

about 5 and a sub-grain size of 1.7  $\mu\text{m}$  in case of the material processed up to a strain of 4. At lower strain levels of about 0.6 and 2.9, only elongated grains were visible and the substructures were too fine to be resolved in the TEM. Evidently, the potential for the production of ultra-fine grained bulk material by using the severe plastic deformation process such as CEU was demonstrated.

**Day –II (13<sup>th</sup> Januray,2005)****Stir casting of hybrid Al-SiC-fly ash composite***Sudarshan and M.K. Surappa*

There is an increasing interest in the development of metal matrix composites (MMCs) having low density, containing low cost reinforcements and having excellent wear resistance. Addition of SiC results in an increase in the strength, wear resistance and elastic modulus. However, the higher cost of these MMCs has been the major barrier towards their widespread applications. Fly ash is one of the most inexpensive and low-density reinforcement available in large quantities as solid waste by-product during combustion of coal in thermal power plants. Some of the properties of fly ash are also comparable with those of SiC. Therefore it is possible to replace (partially or totally) SiC with the fly ash and bring down the cost of MMCs. In the present study A356 Al - 6 vol. % (SiC + Fly ash particle) hybrid composite is fabricated using stir-casting technique. The cast billet was hot extruded at 530°C to 12 mm diameter rod. Physical and mechanical properties of the composite are studied and compared with 6 vol. % fly ash reinforced A356 Al composite and unreinforced alloy. The hybrid composite shows improved properties compared to A356 Al - 6 vol. % fly ash reinforced composite and unreinforced alloy.

**Micromechanisms of deformation and fracture in****Ti-B alloys***L. Maheshwari and U. Ramamurty*

Addition of small quantities of B (less than 2 wt%) to Ti alloys markedly improves their stiffness and strength, leading to higher structural efficiency and reduced cost (vis-à-vis the fiber reinforced TMCs) in aerospace and automobile applications. However, these alloys suffer from low tensile ductility (~2.2%) and hence their utility in fracture-critical components in the aerospace industry is limited. In this work, we examine the micro-mechanical reasons for the observed ductility through interrupted tensile tests and acoustic emission measurements coupled with quantitative assessment of the damage through microscopy. Experimental results suggest that, of the three different sizes of TiB whiskers present in the microstructure, fracture of the macro-needles (also referred as primary needles) leads to the catastrophic failure of the specimens and hence limits the ductility. In contrast, the micro-sized needle failure starts at very low strains and is effective only in reducing the elastic modulus, whereas the nanometer scale needles act as strengthening agents. These results are discussed in terms of suitable microstructural design methodologies for optimized property combinations in Ti-B alloys.

**Characterisation of boron carbide manufacturing process***Manjunath P.*

Commercially, boron carbide is produced in resistance heating furnaces. These furnaces are rectangular or cylindrical in shape. Present case cylindrical furnace with a graphite resistor at the centre was used. This resistor transmits heat to the charge (Petroleum coke and Boron Oxide), packed around the resistor rod and converts it into boron carbide.

The present study is aimed at finding out the conversion rate and also optimizing the conversion process. Conversion rate was determined using compositional analysis. XRD, SEM techniques were used to find it from microstructure. Chemical analysis of the specimens taken from different radial positions was also used to determine the conversion rate. Optimization of the process has been planned by using multiple electrodes, changing the electrode shape and dimension and also by varying the charge composition.

**Thermodynamic measurements and modeling in the Al-Bi-Sb system***S.. Acharya and J.P.Hajra*

Activities of aluminium in aluminium-bismuth-antimony alloys have been determined over the temperature range 1173K to 1323K by a concentration cell technique involving the chloride electrolytes. The measured activities in the system exhibit positive deviation from ideal behavior over the entire range of composition studied. The deviation increases progressively with the Bi content of the alloys for a constant compositional path of Sb. However, the deviation decreases substantially with the increase in Sb content in the system. The proposed equation is capable of interpreting the experimental data pertaining to the liquid-liquid immiscibility in the system. The ternary interaction parameters involved in the equation are susceptible to the physico-chemical interpretation based on the central atoms model.

**Processing and mechanical properties of multi-layer coatings of TiN/AlTiN on steel***S.J.Suresha, S.K.Biswas<sup>1</sup> and V.Jayaram*

Multi-layer TiN/AlTiN films have been produced by cathodic arc evaporation using sample rotation. Bi-layer spacing of as little as 4 nm may be produced by this method. In addition a complex set of microstructures was found in which alternate layers of TiN and AlTiN are separated, at the interface, by a finer banded microstructure. Mosaic of microstructure obtained under different processing conditions had no major influence on the mechanical properties of the coatings.

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### **Assessment of acid production potential of the Ajjanahalli gold tailings**

*Vidhya Lakshmi R, Evvie Chokalingam S. Subramanian,  
K. A. Natarajan and <sup>1</sup>J. J. Braun*

The generation of acidity resulting from the oxidation of sulphide mineral wastes, catalyzed by acidophilic microorganisms is known as Acid Mine Drainage. This is of major environmental concern to the mining industry, both during the operational period and after closure. In this context it becomes germane to establish the acid production potential of the cyanided Ajjanahalli gold tailing sample accumulated at the Chitradurga copper unit, Ingaldahl mines, Karnataka. Towards this, dynamic agitation leaching tests have been carried out in shake flasks together with column leaching experiments on typical gold tailing samples, in the absence and presence of *A. ferrooxidans*, with or without the 9K growth medium. The parameters monitored include pH, redox potential and ferrous, ferric and copper concentrations as a function of time. The acid consumption potential of the gold tailing samples has also been determined. The results of the agitation leaching tests carried out for a period of over 645 days and the column leaching experiments performed for 510 days, indicate that the maximum decrease in pH is about 2 units, for the inoculated samples, consequent to the buffering capacity of the tailing sample.

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### **Processing of bulk nanocrystalline materials by conventional deformation processes**

*Kanhaiya Kumar*

Characteristics of the deformation field associated with chip formation in plane strain machining are described. Conventional plane strain machining is shown to be a viable tool for examining the more fundamental research issues accompanying very large strain deformation. The creation of nano-scale and ultra-fine grained structures is demonstrated in 6061 Al alloy using this method. In this study chips from bulk alloy were generated. Microstructural examination and hardness measurement were done on bulk as well as chips sample. Chips have been cold compacted and warm extruded in to rod. Hardness measurement of extruded sample was also done. Large deformations induced by machining process refine the grain size. Grain size of bulk sample and chips were 33 $\mu$ m and 200 nm respectively. This in turn leads to increase in hardness. Micro hardness of bulk sample, chips and extruded sample were 70, 107, 145 respectively on vicker scale.

### **Strain Hardening and Fatigue in Metal Foams: The effect of Constraint**

*Shweta Gaonkar and U. Ramamurty*

The plastic response of the closed-cell metal foams is determined by the collective cell collapse. Progressive cell band collapse, from one band to another, results in a long plateau in the compressive stress-strain curve after an initial elastic regime. This phenomenon continues until all the cells have collapsed, which results in a steep rise in

the stress with further strain. The strain at which this transition occurs is referred to as the densification strain,  $\epsilon_d$ . This large plastic plateau upto a  $\epsilon_d$  of  $\sim 60$ -70% in Al foams has two important practical consequences. First, it allows for a large amount of energy absorption, making the Al foams attractive candidates for the impact energy absorbing applications. Second, by suitable design in blast amelioration systems, it is possible to limit the stress experienced by the protected components to that of plateau stress.

While the mechanical behavior of Al foams have been extensively investigated, their response to cyclic loading is yet to be studied in detail with only a few investigations reported in the literature. These studies, conducted without any constraint, show sigmoidal plastic strain accumulation due to progressive cell band collapses. However, the first cell-band collapse often leads to the shear displacement of one part of the specimen with respect to the other, due to the lack of lateral constraint, and hence the stress state afterwards is not simple uniaxial compression. To examine this issue, we have investigated the effect of lateral constraint on fatigue performance, which also happens to represent the practical scenario in application. First, the mechanical properties of a closed-cell Al foam under constraint were investigated. Experimental results indicate that the constraint induces a positive slope to the stress-strain curve in the plastic regime. This hardening was also found to affect the fatigue response pronouncedly. These results will be discussed in this presentation.

### **Solidification of a Ti/Ni dissimilar weld**

*S. Chatterjee, T.A. Abinandanan and K. Chattopadhyay*

Solidification of dissimilar metal welds brings up new issues which do not arise during similar welding. These include the effect of difference in thermo-physical properties of two the base metals on the movement of the isotherms and on fluid flow in the weld pool, and the importance of the metallurgy of the system as represented by the phase diagram of the system. We have studied microstructural evolution in a dissimilar weld of Ti/Ni binary couple which clearly demonstrates the influence of these factors on the solidification of the weld.

We have used a combination of optical microscopy, scanning electron microscopy, and energy dispersive spectroscopy of x-rays to characterize the welded samples. Formation of successive layers of Ni<sub>3</sub>Ti, (Ni<sub>3</sub>Ti+NiTi), and NiTi is observed at the fusion interface in the Ni side. The Ti fusion interface is characterized by the growth of Ti<sub>2</sub>Ni dendrites toward the base metal side. The central region of the pool consists of NiTi and Ti<sub>2</sub>Ni with segregation of (Ti) dendrites near the surface and NiTi chunks near the bottom of the weld pool. We rationalize our observations on the basis of fluid flow induced macrosegregation and the complex phase selection mechanisms in a thermally and compositionally inhomogeneous undercooled melt.

### **Punch tests: Is it equivalent to extrusion?**

*R. C. Shivamurthy and S.V. Kailas<sup>1</sup>*

With the aim of basic understanding of effect of hydrostatic stresses on extrusion, punch tests – punching the H11 hard die steel, called as “punch”, into the homogenized AA 6060 Aluminium alloy have been conducted at three different cross head speeds ( $10^{-5}$ ,  $10^{-3}$  m/s and  $10$  s<sup>-1</sup>), at three different temperatures (RT, 300 and 500 °C). All punch tests were conducted in a Dartech machine. In order to enhance the hydrostatic stresses, several steps made in punch, viz single, two, five and seventeen steps. In addition, the effect of surface roughness, which was given to the punch surface, has been studied. Cracks, debonding at the interface of punch and Al alloy are quantified in terms of disturbances. It was inferred from the SEM micrographs that there is no prominent effect of surface roughness on interface disturbances. The micrographs also revealed that as the crosshead speed increases the disturbances will increase. Inverse trend have been observed with change in temperature. The disturbances at the interface were decreasing along the length of the punch, means at the edges of punches that would be well inside the aluminium alloy. As the number of steps in punch increases, disturbances have been decreased along the interface. Based on these facts, an attempt has been made to design dies with steps and extrusion was done on aluminium alloy.

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### **Microstructure and mechanical properties of an extruded AZ21 Mg alloy**

*M.A. Azeem, A. Tewari<sup>1</sup> and U. Ramamurty*

Most of the Mg-based alloys are used in the as-cast form, because of the lack of extensive ductility in Mg (owing to its HCP crystal structure) which would have facilitated metal working processes. As a result, detailed understanding of the microstructural evolution during metal working process (such as extrusion) and in-turn the mechanical performance for the wrought Mg-based alloys is scarce. Such information is particularly important for assessing the performance and reliability of components such as tube extrusions etc., which have potential applications in automotive and aerospace industries.

In this work, the development of microstructure with heat treatment of a hot-extruded dilute Mg alloy (AZ21) was investigated. It was observed that the completion of recrystallization and grain growth gets initiated at annealing temperatures above 350 °C. Qualitative evaluation of the texture with the aid of x-ray diffraction reveals the reduction of the basal plane intensity with heat treatment. Tensile and fatigue properties of different heat treated materials are investigated in order to identify the microstructure that gives optimum mechanical performance.

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### **Tensile and Compressive Deformation, and Wear Behavior of as cast Mg<sub>97</sub>Zn<sub>2</sub>Y<sub>1</sub> Alloy**

*Manish Patel*

In the direction of alloy development to improve the performance of magnesium, Mg<sub>97</sub>Zn<sub>2</sub>Y<sub>1</sub> alloy has been chosen for study. The sand cast Mg<sub>97</sub>Zn<sub>2</sub>Y<sub>1</sub> alloy shows good tensile and compressive properties (UTS is 115 MPa, 0.2% Yield Strength is 105 MPa, Ultimate Compressive Strength is 228 MPa). The Compressive strength decreases with an increase in temperature. The UTS and 0.2% yield strength decrease with temperature upto 150<sup>0</sup>C but slightly increase after 200<sup>0</sup>C. The ductility increases with temperature. The fractography of this alloy reveals a transgranular cleavage mode of tensile fracture at low temperature and a transgranular quasicleavage (cleavage and tearing) mode at higher temperature. SEM micrographs reveal the grains instability near the cracks after hot compressive deformation. The wear resistance of this alloy is not good at high load and high speed. Also the wear mechanism changes at a higher load, as the relative speed between the pin and the disc increases. At low speed the wear mechanism is oxidative type and at high speed it is metallic type.

### **Crystal structures of a Mg-Zn-Y alloy: A first-principles study**

*A. Datta, U. Ramamurty, S. Ranganathan, U. V. Waghmare<sup>1</sup>*

We use first-principles density functional theory total energy calculations based on pseudopotential and plane-wave basis to examine the energetics of the periodic structures with different stacking sequences in Mg-Zn-Y alloys. For pure Mg, we find that the 6-layer structure with the ABACAB stacking is the second most stable (among the 2, 3, 4, and 6 layer structures considered), after the lowest energy hcp structure with ABAB stacking. The addition of 2% Zn leads to stabilization of the structure to 6-layer sequence. The stacking fault energies in the 4- and 6-layer structures were found to be significantly higher than that in the 2-layer structure. Charge density analysis show directional bonding and accumulation of charges in the basal plane case of 4 and 6-layer structures.

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### **Role of surface topography in tribology**

*Pradeep L. Menezes, Kishore, and Satish V. Kailas<sup>1</sup>*

Tribological interaction between two contacting surfaces is influenced by many factors such as relative motion, normal load, and lubrication apart from surface characteristics. Though surface characteristics such as roughness was dealt by many researchers for decades, the other important characteristic of surfaces, surface topography, has not got its share of attention.

In the present investigation, basic studies were conducted using *Inclined Scratch Tester* to understand the role of surface topography in tribological studies. Tests were conducted on a tribological couple made of an aluminium alloy pin against steel flat. Two surface parameters of steel flats – roughness and texture – were varied in tests. Flat surfaces were observed to possess roughness values in very close approximation even for different textures, namely *Uni-directional*, *8-ground*, and *Random*. Influence of the surface topography on material transfer and coefficient of friction were investigated. SEM was used to reveal the pin damage and morphology of the transfer layer formed on flats. It was observed that the coefficient of friction, thus the transfer layer formation, is controlled by the *nature of surfaces*.

<sup>1</sup>Department of Mechanical Engineering

### **Bubble formation and detachment at liquid-liquid reaction interface**

*Vikash Kumar Sinha*

Bubbles formed by liquid-liquid reaction play an important role in for example, iron making and steel making processes. In this study, experiments were carried out on a model system to determine the bubble nucleation site and the critical size, at which it leaves the interface. The system consists of two immiscible liquids viz. NaHCO<sub>3</sub> solution and caproic acid. The experimental results were compared with calculations based on theory.

### **Structural relaxation in metallic glasses: Effect of cooling rate**

*R. Raghavan, S. Ranganathan, U. Ramamurty*

Metallic glasses are often formed by rapidly quenching the alloy melts, which results in the containment of higher degree of structural disorder and residual stresses, the latter deleterious from an application stand-point. Upon annealing at temperatures below the glass transition temperature,  $T_g$ , the disorder gets reduced and the residual stresses anneal out. This process is referred to as structural relaxation (SR), which induces many property changes, the prominent being severe embrittlement in some alloy systems.

Recently, several alloy systems that do not require rapid quenching for obtaining amorphous materials were identified. These glasses, referred to as bulk metallic glasses (BMGs), are not expected to exhibit as pronounced SR characteristics as seen in the rapidly quenched (RQ) glasses, since it is generally accepted that higher the cooling rate ( $R_c$ ) used to process a glass, higher is the energy state it is trapped in, and hence higher degree of SR. Whether this hypothesis is correct is examined in this work, by comparing the relaxation behavior of melt-spun ( $R_c \sim 10^6$  K/s) and bulk ( $R_c \sim 1$  K/s) Pd<sub>40</sub>Cu<sub>30</sub>Ni<sub>10</sub>P<sub>20</sub> metallic glass. Both the glasses were observed to exhibit broadly similar SR characteristics, with an enthalpy peak at  $T_g$  in the annealed glasses. Variation in the enthalpy at  $T_g$  is plotted as a function of the annealing time is fitted using the Kolrausch-Williams-Watts function, which captures the non-exponential feature of relaxation, to

examine if there are any quantitative differences in the exponent,  $\beta$ , and the temperature dependence of the relaxation time,  $\tau$ . These values for RQ and BMG glasses are compared and mechanistic reasons for the differences will be discussed in this presentation.

### **Invited Talk III**

#### **Arsenic in drinking water: conflicting standards and beyond**

*Amitav Mukherjee*

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In a recent publication in *Toxicology* (2004) one of the leading US epidemiologist working on arsenic calamity, A. Smith advocated raising the guideline value for arsenic in drinking water to 50  $\mu\text{g/l}$  for developing countries like India and Bangladesh, while the WHO (World Health Organization) and US-EPA (US-Environmental Protection Agency) prescribed limit is set at 10  $\mu\text{g/l}$ . This paper deals with arguments against this dichotomy in arsenic standard. The per capita water intake values are higher in case of developing countries and nutritional status is poor too. Arsenic in its most toxic form [As (III)] sneaks into food chain through irrigation water in the affected areas. Dose response studies have shown that arsenic ingestion between 10 to 50  $\mu\text{g/l}$  may result in skin diseases and cancer depending on duration of consumption. These factors prove that the limit of arsenic in drinking water in case of developing countries should be set at least equal to 10  $\mu\text{g/l}$  if not lower.

Our 17-year long survey has established that a considerable part of GMB (Ganga-Meghna-Brahmaputra) plain covering a number of states like West Bengal, Bihar, Assam, Jharkhand, Uttar Pradesh in India and large areas of Bangladesh are arsenic affected. There are problems related to proper in-situ analysis of arsenic by field kits and inefficiency of imported arsenic removal technologies in the affected regions. Since arsenic diseases have no medical cure till date, supply of safe water and nutritious food is essential. Effective awareness campaigns stressing long-term effects of consuming contaminated water and proper water management with participation from all parts of society should be undertaken at the earliest.

#### **Monte Carlo study of interfacial properties of phase separating alloys**

*Saswata Bhattacharyya, Ferdinand Haider<sup>1</sup> and T.A. Abinandanan*

We have studied the interfacial properties of phase separating binary alloys using Monte Carlo simulations. In the model, we have considered vacancy-assisted phase separation and implemented residence time Monte Carlo algorithm. We have taken an A-B binary alloy with a highly diluted vacancy concentration on a rigid lattice with face-centered-cubic structure. We calculated the equilibrium thermodynamic properties of (100), (110) and (111) interfaces, and computed the interfacial free energy using a direct

thermodynamic integration. We have also studied the effect of temperature and interaction parameters on interfacial free energy, width and roughness. We determined the equilibrium shapes of precipitates from the simulations and compared them with the corresponding Wulff shapes. The equilibrium precipitate shapes differ from the Wulff shapes and this deviation is attributed to the roughness of the interface.

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### **Effect of grain aspect ratio on diffusion creep rate in bamboo structures**

*Vivek Srivastav*

Creep rates of bamboo structured fine copper wires (50-500 micron dia) were measured at 950 °C at applied stress 8-300 kPa. Experiments were carried out in Ar-H<sub>2</sub> atmosphere. The measured rates were found to be within a factor of two to those expected from theoretical Nabarro-Herring creep rate. The deviation from the theoretical rates was found to increase with decreasing wire diameter (and increasing aspect ratio). SEM investigations of the copper wires after creep showed localisation of vacancy flux near the grain boundary area for high aspect ratio grains. This effect was analysed using numerical simulation and the results show the consistency with experimental data. These are compared to analytical approaches from literature.

### **Dry sliding wear behaviour of Mg<sub>97</sub>Zn<sub>1</sub>Y<sub>2</sub> alloy: A comparative study in two different environments**

*P. Prakash, S. Ranganathan and Satish. V. Kailas<sup>1</sup>*

An attempt has been made to evaluate the wear behaviour of Mg<sub>97</sub>Zn<sub>1</sub>Y<sub>2</sub> alloy sliding against the counterface disc made of 316LN stainless steel. The wear tests were conducted under normal atmospheric conditions as well as in vacuum for different loads and sliding speeds. It is found that the wear rate in vacuum is less compared to the wear rate observed in an ordinary atmosphere. In the case of an ordinary atmosphere, at lower sliding speed, an abraded surface is observed. As the sliding speed is increased, a layer by layer deformation is observed on the worn surface. The subsurface deformation analysis showed the evidence of subsurface cracks parallel to the wear surface at higher sliding speed. The main mechanism of wear in this alloy is abrasion at lower sliding speed and delamination at higher sliding speed. The wear debris at lower sliding speed showed fine wear particle morphology and as the sliding speed is increased a flaky morphology of wear particles is observed. In the case of wear tests done in vacuum, the debris is long and continuous compared to that observed in an ordinary atmosphere. It is found that the oxygen has a negative effect on the wear resistance of this alloy.

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**Structural and optical studies on RF plasma polymerised furfural thin films**

*S. Saravanan , M. R. Anantharaman<sup>1</sup>, S. Venkatachalam<sup>2</sup>, D. K. Avasthi<sup>3</sup>*

Conducting polymers play an important role in the field of materials science because of their excellent electrical, optical and optoelectronic properties. Polymers can be synthesized by chemical, electrochemical or plasma methods. Plasma polymerization is an inexpensive and novel technique for preparing polymer thin films. Thin films prepared by employing RF plasma polymerization are pinhole free, uniform in thickness and highly conjugated. The electrical and optical properties of the plasma polymerized thin films can be tailored by varying the deposition parameters like deposition time, monomer flow rate and RF power. Modification of polymer thin films by swift heavy ion irradiation and by adding dopants is well established. Ion irradiation of polymers can induce irreversible changes in their structural, electrical and optical properties. In this communication, the effect of swift heavy Si<sup>+</sup> ions on the structural and optical properties of RF plasma polymerized furfural thin films were investigated. FTIR and UV Vis NIR Spectra were recorded on the pristine and silicon ion irradiated polyfurfural thin films for structural and optical studies. The results are interpreted.

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