MATERIALS ENGINEERING POSTGRADUATE CONFERENCE

Monday 2nd June 2008

Lecture Theatre E7, Bld72

PROGRAM

10:00am **Invited Speaker – Prof. George Simon**

10:30am **Andrew Phillips -** Crystallisation of oriented isotactic polypropylene in the presence of nucleating agents

10:50am **Tracey Markley -** Corrosion Mitigation of Aerospace Alloys using Rare Earth Diphenyl Phosphates

11:10 - 11:30pm: Morning Tea

11:30am **Invited Speaker – Dr. Matthew Weyland,** Monash Centre for Electron Microscopy

12:00pm **Medhi Behrouzvaziri -** The effect of La(Hydroxy cinnamate) on the rate of corrosion of mild steel in 0.01 M NaCl at neutral pH

12:20pm **Deniece Fon** – Design and Modification of Electrospun Scaffolds for Guided Neurite Outgrowth

12:40pm **Aaron Sudholz -** Corrosion behaviour of Mg-alloy AZ91E with atypical alloying additions

1:00 - 2:20pm:MatES bbq

2:20pm **Stavroula Moutsos –** Effects of Grain Size on Age-Hardening and Fracture Behaviour of an Al-Li-Cu-Mg-Zr (8090) Alloy

2:40pm **Simon Thompson –** The Role of the Scattering Layer in Monolithic Dye Sensitised Solar Cells

3:00pm **Arun Kumar** - The Effect of Mechanical Preparation on the Surface Electrochemistry of AA2024-T3 Alloy and its constituents

3:20pm **Steven Petinakis -** Enhancing the Mechanical Performance of Poly(lactic acid)/Wood-flour Composites by Improved Matrix-particle Interfacial Adhesion

3:40pm **Pejman Hojati-Talemi –** Effect of Different Microwave-Based Treatments on Multi-Walled Carbon Nanotubes

4:00pm - : Afternoon Tea, Beer & Snacks . . .

Invited Speakers – Prof. George Simon (10:00 am)

WELCOME AND OPENING REMARKS

Andy Phillips (10:30 am)

CRYSTALLISATION OF ORIENTED ISOTACTIC POLYPROPYLENE IN THE PRESENCE OF NUCLEATING AGENT

Supervisor: Assoc. Prof. Graham Edward

Injection moulding is arguably the most important polymer manufacturing process. In the injection moulding process, molten polymers are exposed to varying levels of shear flow and temperature profiles prior to crystallization. The resulting morphology is substantially different from that observed under quiescent conditions. Typically, a multi-layer 'skin-shear-core' structure is formed. The dimensions and specific morphologies of these zones have a significant influence on physical, optical and mechanical properties of the final moulded article. The crystallisation process is further complicated by the addition of nucleating agents which a) improve the rate of crystallisation and therefore the productivity and b) alter the solid-state morphology with the aim of improving the physical properties. This presentation will first review the current understanding of the shear induced crystallisation of polymers in the presence of nucleating agents. Particular attention will be paid to deficiencies in the knowledge. An in-situ time resolved reo-X-ray diffraction technique employing high intensity synchrotron radiation is then proposed to address these deficiencies.

Tracey Markley (10:50 am)

CORROSION MITIGATION OF AEROSPACE ALLOYS USING RARE EARTH DIPHENYL PHOSPHATES

Supervisors: Prof. Maria Forsyth, Dr. Tony Hughes (CSIRO)

The corrosion protection of aluminium alloys is of high importance, particularly in the aerospace industry. The most widely used technologies utilise Chromium(VI) compounds for conversion coatings and primer additives in paint systems to provide corrosion protection to these alloys. These compounds are highly toxic, carcinogenic and detrimental to the environment, therefore the identification of alternative systems that are safe and environmentally benign, that meet or exceed the current levels of corrosion protection is vital.

The inhibiting efficiency, mechanism of inhibition and surface interaction of rare earth diphenyl phosphates ($RE(dpp)_3$ on aluminium alloys AA2024-T3 and AA7075-T6 were characterised using a range of electrochemical and surface techniques. The $RE(dpp)_3$ inhibitor compounds were also incorporated into an epoxy coating system, and demonstrated that the initiation of filiform corrosion could be reduced and the growth rate of filaments was also impeded.

Dr. Matthew Weyland (11:30 am)

OVERVIEW OF EQUIPMENT AND ACTIVITIES AT MCEM

Medhi Behrouzvaziri (12:00 pm)

THE EFFECT OF La(HYDROXY CINNAMATE) ON THE RATE OF CORROSION OF MILD STEEL IN 0.01 M NACL AT NEUTRAL pH

Supervisor: Prof. Maria Forsyth

This paper discusses the effectiveness, capability and mechanism of inhibition of a number of green corrosion inhibitors for mild steel, based on Cerium (III) and Lanthanum (III). These compounds include cerium hydroxy naphthoate ($Ce(3OH,2NPT)_3.5H_2O$), lanthanum hydroxy naphthoate ($La(3OH, 2NPT)_3.5H_2O$), cerium hydroxy cinnamate ($Ce(4OH\ Cin)_3.5H_2O$) and lanthanum hydroxy cinnamate ($La(4OH\ Cin)_3.5H_2O$). Linear Polarization Resistance (LPR) measurements have shown that lanthanum compounds even in very low concentrations (100ppm and 200ppm) are able to noticeably inhibit corrosion; however there were only a factor of a 5-6 decrease the corrosion rate in the case of cerium compounds. The mechanism of corrosion inhibition was investigated by using Potentiodynamic Polarization techniques. The results suggest that lanthanum based compounds perform as an anodic inhibitors and improve the resistance of mild steel against pitting corrosion and localized attack. Scanning Electron Microscopy (SEM) combined with Energy Dispersive X-ray Spectroscopy (EDXS) indicated the presence of an adherent film in the case of lanthanum based compounds in comparison with the cerium compounds.

Deniece Fon (12:20 pm)

DESIGN AND MODIFICATION OF ELECTROSPUN SCAFFOLDS FOR GUIDED NEURITE OUTGROWTH

Supervisor: Dr. John Forsythe

The regenerative capacity of neurons in the central nervous system (CNS) following disease or injury is very limited, as a result therapy is largely limited to rehabilitative measures. Efforts aimed at promoting neural repair involves trying to recapitulate the events of embryonic development, guiding neurite/axon outgrowth to an appropriate target to reform a precise pattern of connection. A growth cone exists at the tip of a growing neurite, where its interactions with the extracellular environment determines the direction of neurite outgrowth. The aim of this study is to incorporate various structural, mechanical, chemical, and biological cues within an electrospun nanofibrous scaffold to direct neurite outgrowth.

Various structural cues can be presented to a growth cone by changing fiber orientation – aligned nanofibers were shown to be capable of guiding neurite extension in the direction of fiber alignment. Furthermore, substrate modulus is known to affect neurite outgrowth; substrate modulus can be modified via chemical crosslinking of the electrospun polymer nanofibers. Concentration gradients of appropriate growth factors are known to provide chemotactic cues to the growth cone in vivo, such that neurites will grow towards increasing concentrations of a growth factor. Concentration gradients were generated within the 3-D electrospun scaffolds using chromatography-based techniques, and were analyzed using fluorescence microscopy.

The mechanism of neurite guidance provided by each cue, and the relative importance of individual and combined cues will be examined. Properties of the scaffold will be optimized to enhance neuronal regeneration.

Aaron Südholz (12:40 pm)

CORROSION BEHAVIOUR OF MG-ALLOY AZ91E WITH ATYPICAL ALLOYING ADDITIONS

Supervisor: Dr. Nick Birbilis

Magnesium alloys are the lightest of all the structural metals with good strength/weight ratio and castability, however their application continues to be severely limited by relatively poor resistance to corrosion. Unlike most passivating metallic materials which develop their own protective surface oxide, magnesium suffers continued dissolution in neutral chloride solutions. AZ91E is a widely used magnesium-based alloy which exhibits a balance between mechanical properties and moderate corrosion resistance; this work explores the affect of atypical alloying additions on the corrosion behaviour of this alloy. Results are presented in the form of a survey, along with an ensuing discussion of

electrochemical test results and microscopy.It is noted that several elements are beneficial in improving corrosion resistance of AZ91E, whilst others accelerate corrosion rather dramatically.

Stavroula Moutsos (2:20 pm)

EFFECTS OF GRAIN SIZE AND OTHER VARIABLES ON AGE-HARDENING AND FRACTURE BEHAVIOUR OF Al-Li BASED Alloys

Supervisors: Prof. Barry Muddle and Dr. Stan Lynch

The age-hardening response and fracture behaviour of an 8090 (Al 2.2Li 0.7Mg 1Cu 0.11Zr) alloy, after friction-stir processing (FSP) and high pressure torsion (HPT) with grain sizes ranging from 600nm to 170nm has been studied.
The age hardening response of coarse-grained, CG (30μm) material, FSP (600nm) material and HPT (170nm) material differed significantly. The age-hardening response of the FSP material (600nm) was lower than that of the CG material. The age-hardening response of 170nm HPT 8090 at low temperatures (below 170ºC) resulted in small increases in hardness, but ageing at higher temperatures (200ºC) a substantial decrease was observed. The age-hardening behaviour is discussed in terms of precipitation strengthening, grain size strengthening, and PFZ volume fraction.
The differences in hardness in 8090 from 75 HV in CG material to 95 HV in FSP material and 200 in HPT material were probably mainly due to differences in grain size. This is shown by plotting hardness on the Hall-Petch plot.
The fracture resistance of the 8090 alloy improved with decreasing grain size, and was manifest by a transition from a brittle intergranular fracture to a transgranular dimpled fracture mode at a grain size of about 1μm. The reasons for the change in fracture behaviour are discussed in terms of planar slip lengths and lithium segregation at grain boundaries.

Simon Thompson (2:40 pm)

THE ROLE OF THE SCATTERING LAYER IN MONOLITHIC DYE SENSITISED SOLAR CELLS

Supervisor: Prof. Yibing Cheng

Monolithic dye sensitised solar cells (DSSCs) have been investigated with regard to the role of the scattering layer. Monolithic DSSCs have the same general operating procedure as a standard DSSC, but with an alternate architecture. This structure involved replacing the platinum coated FTO glass counter electrode with a graphite/carbon black layer on top of the TiO2 layer and its accompanying scattering layer, thus removing the need for a second piece of FTO glass in the counter electrode. This is advantageous as the conducting glass is known to contribute to a considerable portion of the cost of materials for DSSCs. The monolithic design may also have advantages in that it allows for simplified manufacture, via the screen printing process, and better sealing of cells, especially with solid state devices.
A scattering layer is employed both because of its ability to improve light harvesting (and thus cell efficiency) as well as separating the working and counter electrodes. However the role and structure of this layer has not yet been fully understood in the monolithic DSSC. Scattering layers considered here are made from 400nm TiO2 and/or 300nm ZrO2. These are then compared to cells without scattering layers to investigate the function of this layer and its optimal composition.

Arun Kumar (3:00 pm)

THE EFFECT OF MECHANICAL PREPARATION ON THE SURFACE ELECTROCHEMISTRY OF AA2024-T3 ALLOY AND ITS CONSTITUENTS

Supervisors: Prof. Barry C. Muddle

The electrochemical evaluation of the effect of surface preparation on open circuit potential of AA2024-T3 alloy and its major constituents is presented. The open circuit potential of the AA2024-T3 alloy in NaCl solution is found to depend on surface preparation. The AA2024-T3 alloy subjected to aqueous grinding and mechanical polishing with a non-aqueous diamond slurry has open circuit potential identical to that of the mechanically polished Al-4Cu solid solution. This is caused by the depletion of magnesium from the solid solution matrix and Mg-containing secondary phase particles. The magnesium depletion is restricted to top few nm of the surface region. Mechanical polishing of the AA2024-T3 alloy in the absence of aqueous environment yields open circuit potential identical to that of AA2024-T3 alloy not subjected to any surface

preparation. In addition, the open circuit potential of the alloy is affected by aging and supersaturation.

Steven Petinakis (3:20 pm)

ENHANCING THE MECHANICAL PERFORMANCE OF POLY(LACTIC ACID)/WOOD-FLOUR COMPOSITES BY IMPROVED MATRIX-PARTICLE INTERFACIAL ADHESION

Supervisors: Assoc. Prof. Graham Edward and Dr Long Yu (CSIRO)

Increasing concerns about environmental issues, such as global warming and diminishing landfill availability, and the reported dwindling oil reserves, is resulting in a renewed demand for polymeric materials that are more ecologically sound than oil-derived materials and that can be manufactured from sustainable raw materials. Poly(lactic acid) (PLA), being a compostable synthetic polymer produced using monomer feedstock derived from corn starch, satisfies many of the environmental impact criteria required for an acceptable replacement for oil-derived plastics.
The focus of this work has been to investigate two techniques of improving the interface between Poly(lactic acid) and wood-flour: (1) grafting of wood-flour using a coupling agent and (2) introducing a toughening agent into the PLA phase. The composites were prepared by melt compounding using a twin screw extruder and were then injection molded. The microstructure, mechanical properties and fracture of the composites were studied by SEM, DSC, DMA, tensile and impact testing. The influence of wood-flour content on the mechanical properties, and methods employed for improving the interface between PLA and wood-flour, were investigated. Grafting of the wood-flour using methylenediphenyl diisocyanate (MDI) was shown to improve the interface between PLA and wood-flour, whereas the addition of a toughening agent was shown to improve the toughness of the PLA matrix, but reduced the tensile strength and modulus. In the PLA/wood-flour systems interfacial improvement has demonstrated the efficiency to improve mechanical properties such as tensile strength but not improve the toughness of the composite.

Pejman Hojati-Talemi (3:40 pm)

EFFECT OF DIFFERENT MICROWAVE-BASED TREATMENTS ON MULTI-WALLED CARBON NANOTUBES

Supervisors: Prof. George Simon

Three new methods for functionalization of multi-walled carbon nanotubes (MWCNT)s by using microwave energy and water as a mild chemical agent are developed. In the first method we studied the effect of microwave irradiation on a dispersion of MWCNTs in deionized water, in the second method we studied the microwave heating of carbon

nanotubes in the flow of water steam, and finally in the third method we used microwave oven generated plasma for functionalization of MWCNTs. We also performed thermal oxidation and acid treatment as two conventional methods for oxidative functionalization of carbon nanotubes to compare their effect with our results. Transmission Electron Microscopy (TEM) and Raman spectroscopy results show that although in these methods some defects has been introduced to carbon nanotubes but in comparison to conventional treatment no sever damage to structure of carbon nanotubes has been observed. X-ray photoelectron spectroscopy (XPS) measurements have confirmed functionalization of carbon nanotubes in these methods with introduction of more hydroxyl groups. The intensive heat release in of our methods was high enough to be successfully used for welding carbon nanotubes to different substrates.