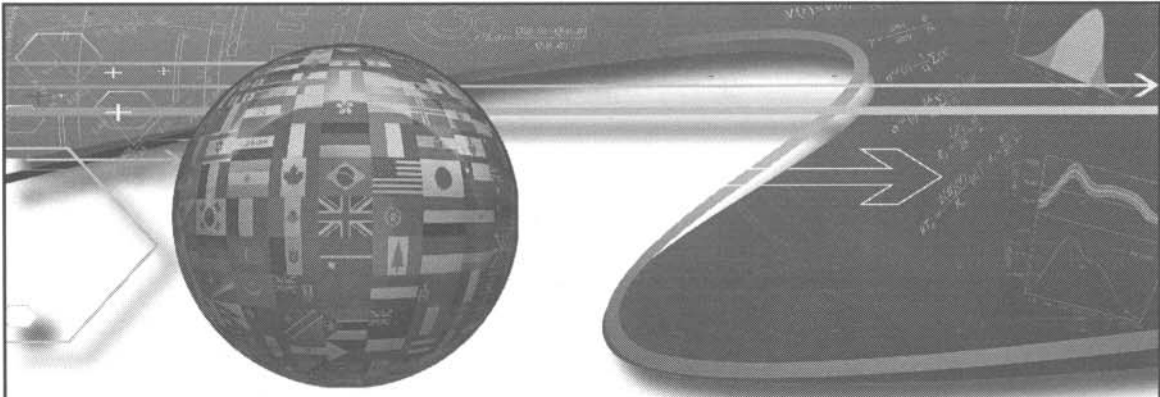


**Mg Magnesium  
Technology  
2011**



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The Minerals, Metals & Materials Society (TMS)

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# TABLE OF CONTENTS

## Magnesium Technology 2011

Preface .....	xi
About the Editor .....	xiv
About the Organizers .....	xiv

## Magnesium Technology 2011

### Opening Session

Magnesium in North America: A Changing Landscape..... <i>S. Slade</i>	3
Global Magnesium Research: State-of-the-Art and What's Next? ..... <i>K. Kainer</i>	5
Environmental Challenges for the Magnesium Industry ..... <i>R. Brown</i>	7
Predicting Mg Strength from First-principles: Solid-solution Strengthening, Softening, and Cross-slip..... <i>D. Trinkle, J. Yasi, and L. Hector</i>	13
Biodegradable Magnesium Implants - How Do They Corrode in-vivo? ..... <i>F. Witte, N. Hort, and F. Feyerabend</i>	17
The Next Generation of Magnesium Based Material to Sustain the Intergovernmental Panel on Climate Change Policy..... <i>F. D'Errico, G. Garces, and S. Farè</i>	19
JIM INTERNATIONAL SCHOLAR AWARD WINNER: Fracture Mechanism and Toughness in Fine- and Coarse-Grained Magnesium Alloys..... <i>H. Somekawa, A. Singh, and T. Mukai</i>	25

### Primary Production; Characterization and Mechanical Performance

The Development of the Multipolar Magnesium Cell: A Case History of International Cooperation in a Competitive World..... <i>O. Sivilotti</i>	31
Effect of KCl on Liquidus of LiF-MgF <sub>2</sub> Molten Salts..... <i>S. Yang, F. Yang, X. Hu, Z. Wang, Z. Shi, and B. Gao</i>	35
Efficiency and Stability of Solid Oxide Membrane Electrolyzers for Magnesium Production ..... <i>E. Gratz, S. Pati, J. Milshtein, A. Powell, and U. Pal</i>	39
Magnesium Production by Vacuum Aluminothermic Reduction of A Mixture of Calcined Dolomite and Calcined Magnesite ..... <i>W. Hu, N. Feng, Y. Wang, and Z. Wang</i>	43
Multiphase Diffusion Study for Mg-Al Binary Alloy System..... <i>Y. Kim, S. Das, M. Paliwal, and I. Jung</i>	49

Experiments and Modeling of Fatigue of an Extruded Mg AZ61 Alloy .....	55
<i>J. Jordon, J. Gibson, and M. Horstemeyer</i>	
Low-Cycle Fatigue Behavior of Die-Cast Mg Alloy AZ91 .....	61
<i>L. Rettberg, W. Anderson, and J. Jones</i>	
Small Fatigue Crack Growth Observations in an Extruded Magnesium Alloy .....	67
<i>J. Bernard, J. Jordon, and M. Horstemeyer</i>	
Applicability of Mg-Zn-(Y, Gd) Alloys for Engine Pistons .....	73
<i>K. Okamoto, M. Sasaki, N. Takahashi, Q. Wang, Y. Gao, D. Yin, and C. Chen</i>	
Compressive Creep Behaviour of Extruded Mg Alloys at 150 °C .....	79
<i>M. Fletcher, L. Bichler, D. Sediako, and R. Klassen</i>	
The Effect of Thermomechanical Processing on The Creep Behavior and Fracture Toughness of Thixomolded® Am60 Alloy .....	85
<i>Z. Chen, A. Shyam, J. Howe, J. Huang, R. Decker, S. LeBeau, and C. Boehlert</i>	

### **Casting and Solidification**

Simulation of Porosity and Hot Tears in a Squeeze Cast Magnesium Control Arm .....	93
<i>C. Beckermann, K. Carlson, J. Jekl, and R. Berkmortel</i>	
Dendritic Microstructure in Directional Solidification of Magnesium Alloys .....	101
<i>M. Amoozrezaei, S. Gurevich, and N. Provatas</i>	
Microstructures and Casting Defects of Magnesium Alloy Made by a New Type of Semisolid Injection Process ..	107
<i>Y. Murakami, N. Omura, M. Li, T. Tamura, S. Tada, and K. Miwa</i>	
Macrostructure Evolution in Directionally Solidified Mg-RE Alloys .....	113
<i>M. Salgado-Ordorica, W. Punessen, S. Yi, J. Bohlen, K. Kainer, and N. Hort</i>	
Microstructure and Mechanical Behavior of Cast Mg AZ31-B Alloy Produced by Magnetic Suspension Melting Process .....	119
<i>N. Rimkus, M. Weaver, and N. El-Kaddah</i>	
Investigations on Hot Tearing of Mg-Zn-(Al) Alloys .....	125
<i>L. Zhou, Y. Huang, P. Mao, K. Kainer, Z. Liu, and N. Hort</i>	
Proportional Strength-Ductility Relationship of Non-SF6 Diecast AZ91D Eco-Mg Alloys .....	131
<i>S. Kim</i>	
Estimation of Heat Transfer Coefficient in Squeeze Casting of Magnesium Alloy AM60 by Experimental Polynomial Extrapolation Method .....	137
<i>Z. Sun, X. Niu, and H. Hu</i>	
Wide Strip Casting Technology of Magnesium Alloys .....	143
<i>W. Park, J. Kim, I. Kim, and D. Choo</i>	
Microstructural Analysis of Segregated Area in Twin Roll Cast Mg Alloy Sheet .....	147
<i>J. Kim, W. Park, and D. Choo</i>	
Development of the Electromagnetic Continuous Casting Technology for Mg Alloys .....	151
<i>J. Park, M. Kim, J. Kim, G. Lee, U. Yoon, and W. Kim</i>	

## **Alloy Design/Development; Grain Refinement and Severe Plastic Deformation**

Effect of Zn/Gd Ratio on Phase Constitutions in Mg-Zn-Gd Alloys.....	157
<i>S. Zhang, G. Yuan, C. Lu, and W. Ding</i>	
Optimization of Magnesium-Aluminum-Tin Alloys for As-Cast Microstructure And Mechanical Properties.....	161
<i>X. Kang, A. Luo, P. Fu, Z. Li, T. Zhu, L. Peng, and W. Ding</i>	
Thermodynamic Analysis of As-cast and Heat Treated Microstructures of Mg-Ce-Nd Alloys.....	167
<i>M. Easton, S. Zhu, M. Gibson, J. Nie, J. Groëbner, A. Kozlov, and R. Schmid-Fetzer</i>	
Compressive Strength and Hot Deformation Behavior of TX32 Magnesium Alloy with 0.4% Al and 0.4% Si Additions .....	169
<i>K. Rao, Y. Prasad, K. Suresh, C. Dharmendra, N. Hort, and K. Kainer</i>	
An Analysis of the Grain Refinement of Magnesium By Zirconium .....	175
<i>P. Saha, and S. Viswanathan</i>	
Study on the Grain Refinement Behavior of Mg-Zr Master Alloy and Zr Containing Compounds in Mg-10Gd-3Y Magnesium Alloy .....	181
<i>G. Wu, M. Sun, J. Dai, and W. Ding</i>	
The Effect of Rare Earth Elements on the Texture and Formability of Shear Rolled Magnesium Sheet.....	187
<i>D. Randman, B. Davis, M. Alderman, G. Muralidharan, T. Muth, W. Peter, T. Watkins, and O. Cavin</i>	
Improvement of Strength and Ductility of Mg-Zn-Ca-Mn Alloy by Equal Channel Angular Pressing.....	195
<i>L. Tong, M. Zheng, S. Xu, P. Song, K. Wu, and S. Kamado</i>	
Deformation Behavior of a Friction Stir Processed Mg Alloy .....	199
<i>Q. Yang, S. Mironov, Y. Sato, and K. Okamoto</i>	
Effect of Heat Index on Microstructure and Mechanical Behavior of Friction Stir Processed AZ31 .....	205
<i>W. Yuan, and R. Mishra</i>	
Strengthening Mg-Al-Zn Alloy by Repetitive Oblique Shear Strain.....	211
<i>T. Mukai, H. Somekawa, A. Singh, and T. Inoue</i>	

## **High-Temperature Alloys; High-Strength Alloys; Precipitation**

Creep and Elemental Partitioning Behavior of Mg-Al-Ca-Sn Alloys with the Addition of Sr.....	217
<i>J. TerBush, O. Chen, J. Jones, and T. Pollock</i>	
Effect of Mn Addition on Creep Property in Mg-Al-2Ca Systems .....	223
<i>T. Homma, S. Nakawaki, K. Oh-ishi, K. Hono, and S. Kamado</i>	
The Effect of Precipitate State on the Creep Performance of Mg-Sn Alloys .....	227
<i>M. Gibson, X. Fang, C. Bettles, and C. Hutchinson</i>	
Microstructure and Mechanical Properties of Mg-Zn-Y-M (M: Mixed RE) Alloys with LPSO Phase .....	229
<i>J. Kim, and Y. Kawamura</i>	
Application of Neutron Diffraction in Characterization of Texture Evolution During High-Temperature Creep in Magnesium Alloys.....	233
<i>D. Sediako, S. Shook, S. Vogel, and A. Sediako</i>	

Improved Processing of Mg-Zn-Y Alloys Containing Quasicrystal Phase for Isotropic High Strength and Ductility .....	239
<i>A. Singh, Y. Osawa, H. Somekawa, and T. Mukai</i>	
Precipitation Hardenable Mg-Ca-Al Alloys .....	245
<i>J. Jayaraj, C. Mendis, T. Ohkubo, K. Oh-ishi, and K. Hono</i>	
Microstructure, Phase Evolution and Precipitation Strengthening of Mg-3.1Nd-0.45Zr-0.25Zn Alloy.....	249
<i>G. Atiya, M. Bamberger, and A. Katsman</i>	
Precipitation Process in Mg-Nd-Zn-Zr-Gd/Y Alloy.....	255
<i>J. Li, G. Sha, P. Schumacher, and S. Ringer</i>	
Mechanical Properties and Microstructures of Twin-roll Cast Mg-2.4Zn-0.1Ag-0.1Ca-0.16Zr Alloy.....	261
<i>C. Mendis, J. Bae, N. Kim, and K. Hono</i>	
The Solidification Microstructure and Precipitation Investigation of Magnesium-rich Alloys Containing Zn and Ce.....	267
<i>C. Zhang, A. Luo, and Y. Chang</i>	

## **Deformation Mechanisms I**

Crystal Plasticity Analysis on Compressive Loading of Magnesium with Suppression of Twinning.....	273
<i>T. Mayama, T. Ohashi, K. Higashida, and Y. Kawamura</i>	
Crystal Plasticity Modeling of Pure Magnesium Considering Volume Fraction of Deformation Twinning.....	279
<i>Y. Tadano</i>	
Nucleation Mechanism for Shuffling Dominated Twinning in Magnesium.....	285
<i>S. Kim, H. El Kadiri, and M. Horstemeyer</i>	
On the Impact of Second Phase Particles on Twinning in Magnesium Alloys.....	289
<i>M. Barnett, N. Stanford, J. Geng, and J. Robson</i>	
Influence of Crystallographic Orientation on Twin Nucleation in Single Crystal Magnesium .....	295
<i>C. Barrett, M. Tschopp, H. El Kadiri, and B. Li</i>	
Twinning Multiplicity in an AM30 Magnesium Alloy Under Uniaxial Compression .....	301
<i>Q. Ma, H. El Kadiri, A. Oppedal, J. Baird, and M. Horstemeyer</i>	
Inhomogeneous Deformation of AZ31 Magnesium Sheet in Uniaxial Tension.....	307
<i>J. Kang, D. Wilkinson, and R. Mishra</i>	
Limitation of Current Hardening Models in Predicting Anisotropy by Twinning in HCP Metals: Application to a Rod-textured AM30 Magnesium Alloy .....	313
<i>A. Oppedal, H. El Kadiri, C. Tomé, J. Baird, S. Vogel, and M. Horstemeyer</i>	
Deformation Behavior of Mg from Micromechanics to Engineering Applications .....	321
<i>E. Lilleodden, J. Mosler, M. Homayonifar, M. Nebebe, G. Kim, and N. Huber</i>	
Effect of Substituted Aluminum in Magnesium Tension Twin.....	325
<i>K. Solanki, A. Moitra, and M. Bhatia</i>	



## **Deformation Mechanisms II: Formability and Forming**

Influence of Solute Cerium on the Deformation Behavior of an Mg-0.5wt.% Ce Alloy .....	333
<i>L. Jiang, J. Jonas, and R. Mishra</i>	
Texture Weakening Effect of Y in Mg-Zn-Y System.....	339
<i>S. Farzadfar, M. Sanjari, I. Jung, E. Es-Sadiqi, and S. Yue</i>	
In-Situ Scanning Electron Microscopy Comparison of Microstructure and Deformation Behavior between WE43-F and WE43-T5 Magnesium Alloys .....	345
<i>T. Sano, J. Yu, B. Davis, R. DeLorme, and K. Cho</i>	
A Molecular Dynamics Study of Fracture Behavior in Magnesium Single Crystal .....	349
<i>T. Tang, S. Kim, M. Horstemeyer, and P. Wang</i>	
Microstructural Relationship in the Damage Evolution Process of an Az61 Magnesium Alloy .....	357
<i>M. Lugo, J. Jordon, M. Horstemeyer, and M. Tschopp</i>	
Formability Enhancement in Hot Extruded Magnesium Alloys.....	363
<i>R. Mishra, A. Gupta, R. Sikand, A. Sachdev, and L. Jin</i>	
Deformation and Evolution of Microstructure and Texture during High Speed Heavy Rolling of AZ31 Magnesium Alloy Sheet .....	369
<i>T. Sakai, A. Hashimoto, G. Hamada, and H. Utsunomiya</i>	
Formability of Magnesium Sheet ZE10 and AZ31 with Respect to Initial Texture .....	373
<i>L. Stutz, J. Bohlen, D. Letzig, and K. Kainer</i>	
Hot Workability of Alloy WE43 Examined using Hot Torsion Testing.....	379
<i>F. Polesak, B. Davis, R. DeLorme, and S. Agnew</i>	
Enhancement of Superplastic Forming Limit of Magnesium Sheets by Counter-Pressurizing .....	385
<i>W. Bang, H. Lee, H. Kim, and Y. Chang</i>	
Microstructural Evolution during Roller Hemming of AZ31 Magnesium Sheet .....	389
<i>A. Levinson, R. Mishra, J. Carsley, R. Doherty, and S. Kalidindi</i>	
The Warm Forming Performance of Mg Sheet Materials .....	395
<i>P. Krajewski, P. Friedman, and J. Singh</i>	

## **New Applications (Biomedical and Other)**

Current Research Activities of Biomedical Mg Alloys in China.....	399
<i>Y. Zheng</i>	
Design Considerations for Developing Biodegradable Magnesium Implants .....	401
<i>H. Brar, B. Keselowsky, M. Sarntinoranont, and M. Manuel</i>	
Coating Systems for Magnesium-Based Biomaterials - State of the Art.....	403
<i>M. Staiger, and J. Waterman</i>	
Corrosion, Surface Modification and Biocompatibility of Mg and Mg Alloys .....	409
<i>S. Virtanen, and B. Fabry</i>	

Magnesium Alloys For Bioabsorbable Stents: A Feasibility Assessment .....	413
<i>C. Deng, R. Radhakrishnan, S. Larsen, D. Boismier, J. Stinson, A. Hotchkiss, J. Weber, T. Scheuermann, and E. Petersen</i>	
Processing Aspects of Magnesium Alloy Stent Tube .....	419
<i>R. Werkhoven, W. Sillekens, and K. van Lieshout</i>	
Ballistic Analysis of New Military Grade Magnesium Alloys for Armor Applications.....	425
<i>T. Jones, and K. Kondoh</i>	
Mg <sub>17</sub> Al <sub>12</sub> Intermetallic Prepared by Bulk Mechanical Alloying.....	431
<i>K. Sakuragi, M. Sato, T. Honjo, and T. Kuji</i>	
Corrosion Behaviour of Mg Alloys in Various Basic Media: Application of Waste Encapsulation of Fuel Decanning from UNGG Nuclear Reactor .....	435
<i>D. Lambertin, A. Blachere, F. Frizon, and F. Bart</i>	

### **Advanced Materials and Processing**

Characterization of Hot Extruded Mg/SiC Nanocomposites Fabricated by Casting .....	443
<i>S. Nimityongskul, N. Alba-Baena, H. Choi, M. Jones, T. Wood, M. Sahoo, R. Lakes, S. Kou, and X. Li</i>	
Effects of Silicon Carbide Nanoparticles on Mechanical Properties and Microstructure of As-Cast Mg-12wt.% Al-0.2wt.% Mn Nanocomposites .....	447
<i>H. Choi, H. Konishi, and X. Li</i>	
Thermally-Stabilized Nanocrystalline Mg-Alloys.....	453
<i>S. Mathaudhu, K. Darling, and L. Kecskes</i>	
TiNi Reinforced Magnesium Composites by Powder Metallurgy.....	457
<i>Z. Esen</i>	
Nanocrystalline Mg-Matrix Composites with Ultrahigh Damping Properties .....	463
<i>B. Anasori, S. Amini, V. Presser, and M. Barsoum</i>	
Effect of Fiber Reinforcement on Corrosion Resistance of Mg AM60 Alloy-based Composites in NaCl Solutions .....	469
<i>Q. Zhang, and H. Hu</i>	
The Production of Powder Metallurgy Hot Extruded Mg-Al-Mn-Ca Alloy with High Strength and Limited Anisotropy .....	475
<i>A. Elsayed, J. Umeda, and K. Kondoh</i>	
Thermal Effects of Calcium and Yttrium Additions on the Sintering of Magnesium Powder .....	481
<i>P. Burke, C. Petit, S. Yakoubi, and G. Kipouros</i>	
Microstructure and Mechanical Properties of Solid State Recycled Mg Alloy Chips.....	485
<i>K. Matsuzaki, Y. Murakoshi, and T. Shimizu</i>	

### **Corrosion and Coatings**

Salt Spray Corrosion of Mechanical Junctions of Magnesium Castings .....	493
<i>S. Grassini, P. Matteis, G. Scavino, M. Rossetto, and D. Firrao</i>	

Comparing the Corrosion Effects of Two Environments on As-Cast and Extruded Magnesium Alloys .....	501
<i>H. Martin, C. Walton, J. Danzy, A. Hicks, M. Horstemeyer, and P. Wang</i>	
Influence of Lanthanum Concentration on the Corrosion Behaviour of Binary Mg-La Alloys .....	507
<i>D. Höche, R. Campos, C. Blawert, and K. Kainer</i>	
Cryogenic Burnishing of AZ31B Mg Alloy for Enhanced Corrosion Resistance .....	513
<i>Z. Pu, G. Song, S. Yang, O. Dillon, D. Puleo, and I. Jawahir</i>	
Advanced Conversion Coatings for Magnesium Alloys.....	519
<i>S. Nibhanupudi, and A. Manavbasi</i>	
Development of Zirconium-based Conversion Coatings for the Pretreatment of AZ91D Magnesium Alloy Prior to Electrocoating.....	523
<i>J. Reck, Y. Wang, and H. Kuo</i>	
Use of an AC/DC/AC Electrochemical Technique to Assess the Durability of Protection Systems for Magnesium Alloys .....	531
<i>S. Song, R. McCune, W. Shen, and Y. Wang</i>	
Effects of Oxidation Time on Micro-arc Oxidized Coatings of Magnesium Alloy AZ91D in Aluminate Solution.....	537
<i>W. Mu, Z. Li, J. Du, R. Luo, and Z. Xi</i>	
Composite Coatings Combining PEO layer and EPD Layer on Magnesium Alloy .....	543
<i>Y. Jiang, K. Yang, and Y. Bao</i>	

### **Poster Session**

Growth Kinetics of $\gamma$ -Al <sub>12</sub> Mg <sub>17</sub> and $\beta$ -Al <sub>3</sub> Mg <sub>2</sub> Intermetallic Phases in Mg vs. Al Diffusion Couples .....	549
<i>S. Brennan, K. Bermudez, N. Kulkarni, and Y. Sohn</i>	
Development and Characterization of New AZ41 and AZ51 Magnesium Alloys .....	553
<i>M. Alam, H. Samson, A. Hamouda, Q. Nguyen, and M. Gupta</i>	
Engineering a More Efficient Zirconium Grain Refiner For Magnesium .....	559
<i>S. Viswanathan, P. Saha, D. Foley, and K. Hartwig</i>	
Microstructure and Mechanical Properties of Mg-1.7Y-1.2Zn Sheet Processed by Hot Rolling and Friction Stir Processing.....	565
<i>V. Jain, J. Su, R. Mishra, R. Verma, A. Javaid, M. Aljarrah, and E. Essadiqi</i>	
The Microstructure and Mechanical Properties of Cast Mg-5Sn Based Alloys .....	571
<i>M. Keyvani, R. Mahmudi, and G. Nayyeri</i>	
Effect of Cooling Rate and Chemical Modification on the Tensile Properties of Mg-5wt. % Si Alloy .....	577
<i>F. Mirshahi, M. Meratian, M. Zahrani, and E. Zahrani</i>	
On Predicting the Channel Die Compression Behavior of HCP Magnesium AM30 using Crystal Plasticity FEM.....	583
<i>Q. Ma, E. Marin, A. Antonyraj, Y. Hammi, H. El Kadiri, P. Wang, and M. Horstemeyer</i>	
Investigation of Microhardness and Microstructure of AZ31 Alloy after High-Pressure Torsion .....	589
<i>J. Vrátná, M. Janecek, J. Stráský, H. Kim, and E. Yoon</i>	
Plastic Deformation of Magnesium Alloy Subjected to Compression-First Cyclic Loading .....	595
<i>S. Lee, M. Gharghoury, and J. Root</i>	

Microstructure Evolution in AZ61L During TTMP and Subsequent Annealing Treatments .....	599
<i>T. Berman, W. Donlon, R. Decker, J. Huang, T. Pollock, and J. Jones</i>	
Modeling the Corrosive Effects of Various Magnesium Alloys Exposed to Two Saltwater Environments .....	605
<i>H. Martin, C. Walton, J. Danzy, A. Hicks, M. Horstemeyer, and P. Wang</i>	
Corrosion Performance of Mg-Ti Alloys Synthesized by Magnetron Sputtering.....	611
<i>Z. Xu, G. Song, and D. Haddad</i>	
Structure and Mechanical Properties of Magnesium-Titanium Solid Solution Thin Film Alloys Prepared by Magnetron-sputter Deposition .....	617
<i>D. Haddad, G. Song, and Y. Cheng</i>	
Effect of Adding SiO <sub>2</sub> -Al <sub>2</sub> O <sub>3</sub> Sol into Anodizing Bath on Corrosion Resistance of Oxidation Film on Magnesium Alloy.....	623
<i>H. Liu, L. Zhu, and W. Li</i>	
Monotonic and Fatigue Behavior of Mg Alloy in Friction Stir Spot Welds: An International Benchmark Test in the "Magnesium Front End Research and Development" Project .....	629
<i>H. Badarinarayan, S. Behraves, S. Bhole, D. Chen, J. Grantham, M. Horstemeyer, H. Jahed, J. Jordon, S. Lambert, H. Patel, X. Su, and Y. Yang</i>	

## **Appendix**

Controlling the Biodegradation Rate of Magnesium-Based Implants through Surface Nanocrystallization Induced by Cryogenic Machining Implants through Surface Nanocrystallization Induced by Cryogenic Machining .....	637
<i>Z. Pu, D. Puleo, O. Dillon, and I. Jawahir</i>	
Author Index.....	643
Subject Index .....	647

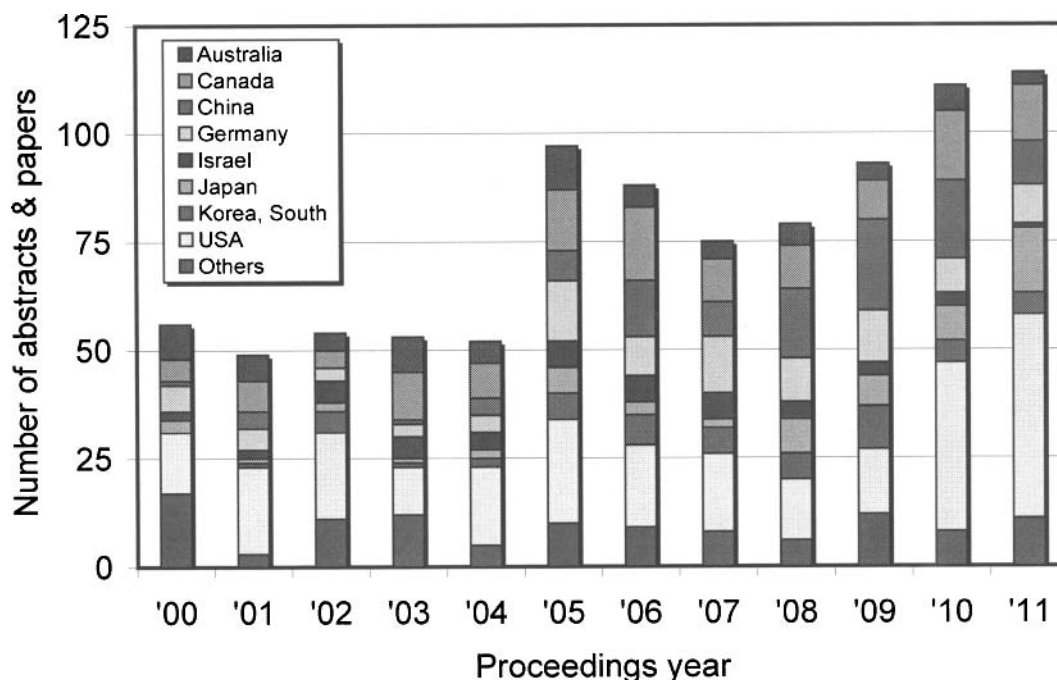
# PREFACE

The world of today faces a number of immense challenges relating to such diverse issues as sustainability (environmental concerns, long-term availability of energy and mineral resources), security and quality of life. Most interestingly, magnesium can – and likely will – increasingly contribute to the resolution of several of these issues. Weight saving by introducing magnesium alloy components in vehicles is a recognized means of enhancing fuel efficiency and thus of reducing energy consumption and greenhouse gas emissions. Different from several other metals, magnesium is virtually inexhaustibly available from natural resources. By using attributes of magnesium-based materials other than low density (such as impact resistance, biocompatibility and chemical affinity), a variety of new applications relating to ballistic armor, biomedical implants and hydrogen storage rises at the horizon.

It is against this background that the Magnesium Committee of the Light Metals Division of TMS has organized and sponsored its 12th edition of the Magnesium Technology Symposium, held at the TMS Annual Meeting in San Diego, CA (USA) from February 28 to March 3, 2011. The symposium was organized in an opening session, a poster session and nine technical oral sessions, covering a broad range of topics. This included primary production and characterization, casting and solidification, alloy design, high-temperature and high-strength alloys, deformation mechanisms, formability and forming, new applications, advanced materials and processing, and corrosion and coatings.

The volume at hand represents the Proceedings of this Symposium. Like in previous years, contributions come from countries around the globe that are active in magnesium research and development and reflect the latest advancements in the field. To ensure TMS standards, all papers were peer reviewed by a pool of volunteers acting on behalf of the Magnesium Committee. In addition to these Proceedings, some Symposium contributions on biomedical applications will be published in full in an upcoming JOM Special Issue sponsored by the Magnesium Committee and entitled “Biomedical Applications of Magnesium” (issue 63/4, April 2011).

The bar chart on the next page visualizes the development of the TMS Magnesium Technology Symposium since its inception in the year 2000 in terms of size and international participation. In the initial years, the number of contributions was quite steady, but as of 2005 when parallel sessions were introduced this number rose steeply – although variations between the successive years exist. Contributing countries can roughly be divided into two categories, depending on if their market emphasis is on magnesium supply (e.g., China and Israel) or consumption (e.g., Germany, Japan and the USA). The largest share of the Proceedings publications comes from the listed eight countries while the remaining category “others” comprises more than 20 other countries from Europe and Asia (with the United Kingdom and Norway being the most prominent of these). Overall, the USA accounts for roughly a quarter of all abstracts and papers to date, followed by Canada (14%), China (11%) and Germany (10%). Notably, the chart also reflects the market changes that the magnesium sector has seen over the last decade, the most pronounced example of this being the large increase in Chinese contributions along with the country’s development of primary and alloy production during the more recent years.



*Keystone data of the TMS Magnesium Technology Proceedings (country of origin of each contribution is based on the affiliation of the main author)*

The organization of the Magnesium Technology Symposium and the realization of its Proceedings would not have been possible without the support of numerous engaged volunteers. Hence this is the place to acknowledge the contribution of all authors, reviewers and session chairs that have been instrumental in making this happen. Further, the continued support by TMS staff has definitely facilitated the job and is well-appreciated.

While Symposium Proceedings traditionally reflect the state-of-the-art and spirit of the age, may this volume become a valuable part of your reference library for the years to come and in retrospect mark a memorable period in advancing the field of magnesium technology.

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 Sean R. Agnew  
 Neale R. Neelameggham  
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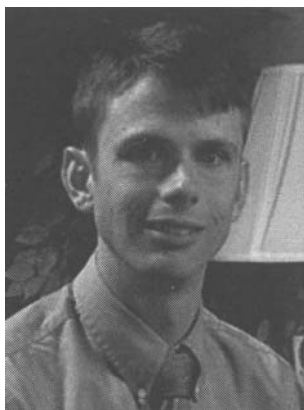
## ABOUT THE EDITOR



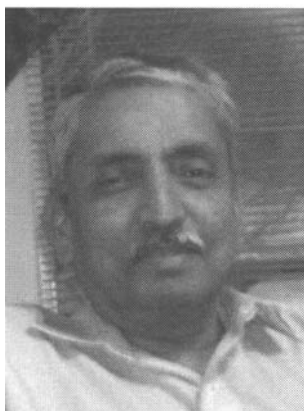
### **WIM SILLEKENS MAGNESIUM TECHNOLOGY 2011 EDITOR**

**Wim H. Sillekens** (1963) is a Senior Scientist at the Netherlands Organization for Applied Scientific Research (TNO), where he is involved in national and European research projects. He obtained his Ph.D. from the University of Technology Eindhoven, Netherlands, on a subject relating to metal-forming technology. Since he has been engaged in light-metals research (aluminum and magnesium), amongst others on (hydro-mechanical) forming, (hydrostatic) extrusion, forging, recycling/refining, and more recently on biomedical applications. His professional career includes positions as post-doc researcher at his alma mater and as a research scientist / project leader at TNO. International working experience covers a placement as a research fellow at the Mechanical Engineering Laboratory (AIST-MITI) in Tsukuba, Japan, and – more recently – shorter stays as a visiting scientist at GKSS in Geesthacht, Germany, and at PNNL in Richland WA, USA. He has co-authored a variety of journal and conference papers (about 50 entries to date). Current research interests are in the physical and mechanical metallurgy of light metals in general and magnesium wrought alloys in particular.

## ABOUT THE ORGANIZERS



**Sean R. Agnew** is the Heinz and Doris Wilsdorf Distinguished Research Chair and Associate Professor in the Department of Materials Science and Engineering at the University of Virginia. He earned his Ph.D. in Materials Science and Engineering at Northwestern University in 1998. His dissertation focused on fatigue behavior and texture of ultrafine grain copper produced by severe plastic deformation. He first began working on magnesium as a Wigner post-doctoral fellow at the Oak Ridge National Laboratory in 1999, with research into the mechanical behavior of both cast and wrought alloys. Since moving to UVA in 2001, his magnesium research has focused on the development of constitutive models that account for dislocation- and twinning-based deformation mechanisms; modeling and control of texture development; measurement and modeling of the hot workability and sheet metal formability; and alloy design. His research group also conducts research on fatigue, creep, diffraction-based characterization, and non-destructive testing of a variety of metallic alloys.



**Neale R. Neelameggham** is the Technical Development Scientist for US Magnesium LLC. He has 38 years of expertise in magnesium production technology, having been with the plant from its startup company NL magnesium. Dr. Neelameggham's expertise includes all aspects of the magnesium process, from solar ponds through the cast house including solvent extraction, spray drying, molten salt chlorination, electrolytic cell and furnace designs, lithium ion battery chemicals and by-product chemical processing. In addition, he has an in-depth and detailed knowledge of alloy development as well as all competing technologies of magnesium production, both electrolytic and thermal processes worldwide. Dr. Neelameggham holds 13 patents and has several technical papers to his credit. As a member of TMS, AIChE, and a former member of American Ceramics Society he is well versed in energy engineering, bio-fuels and related processes. Dr. Neelameggham has served in the Magnesium Committee of LMD since its inception in 2000, chaired it in 2005, and has been a co-organizer of the Magnesium Symposium since 2004. In 2007 he was made a Permanent Co-organizer for the Magnesium Symposium. He has been a member of the Reactive Metals Committee, Recycling Committee and Programming Committee Representative of LMD. In 2008, LMD and EPD created the Energy Committee following the symposium on CO<sub>2</sub> Reduction Metallurgy Symposium initiated by him. Dr. Neelameggham was selected as the inaugural Chair for the Energy Committee with a two-year term. He is also a member of LMD council. Dr. Neelameggham holds a doctorate in extractive metallurgy from the University of Utah.





**Suveen N. Mathaudhu** is a Program Manager with the US Army Research Office (ARO), Materials Science Division. Dr. Mathaudhu also concurrently serves as an Adjunct Assistant Professor in the Department of Materials Science and Engineering at North Carolina State University. Dr. Mathaudhu received his B.S.E. from Walla Walla College and his Ph.D. in Mechanical Engineering from Texas A&M University. Upon graduating in 2006, he accepted a post-doctoral fellowship, and subsequently a civil servant position at the US Army Research Laboratory with the purpose of establishing deformation-processing laboratories for research on advanced metallic and composite materials. Since joining ARO in 2010, he manages programs which focus on the use of innovative approaches for processing high performance structural materials reliably and at lower costs. Dr. Mathaudhu's current research interests include: ultrafine-grained and nanostructured materials by severe plastic deformation, microstructural optimization and homogenization, consolidation of metastable particulate materials and processing-microstructure-property relationships of refractory metals and lightweight metals, integrated computational materials engineering, and thermally stable nanocrystalline materials. He has co-authored over 40 technical publications in these areas. He is also an active member of TMS where he is the primary organizer of the Ultrafine-Grained Material Symposium, and also serves on the Magnesium Technology Committee, and the Nanomaterials Committee.