Mg Magnesium Technology 2014

Mg Magnesium Technology 2014

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PREFACE

The most significant structural field of application of magnesium alloys remains in the field of automotive die castings, where the mass saving and consequent fuel efficiency provide a life cycle benefit in terms of reduced carbon dioxide emissions, although this life cycle benefit is very dependent upon the source of primary energy. For this reason, the U.S. government has channelled new funding into alternative processes for the generation of primary magnesium outside of China, but it remains to be seen whether these will be commercialized in the timescale required to have a significant impact on the future of low-carbon vehicles. In Magnesium Technology 2014, we look forward to hearing more on this subject from Will Joost at the U.S. Department of Energy.

Although the lightweighting benefits of magnesium in large castings continues to be exploited in the rotorcraft industry to enhance performance, payload, and time on station, the use of magnesium in commercial fixed-wing structures declined in the 1970s. This decline was due to increased engine power and concern about corrosion and flammability. Seven years of work to change the opinion of the Federal Aviation Authority about the acceptability of magnesium inside the aircraft cabin is very close to bearing fruit, and the life cycle analysis of increased magnesium use in the cabin suggests that in aviation fuel saving alone a payback will be achieved in less than a month in the air. The industry however needs to continue to address the challenges of alternative materials such as carbon fibre composites and aluminium lithium alloys if it is to make headway into the structure of the aircraft. In 2014 the Magnesium Committee and Aluminum Committee of the TMS Light Metals Division have joined forces under the leadership of Wim Sillekens and Dmitry Eskin to offer our own view of potential strengthening mechanisms in nanocomposite materials based on both magnesium and aluminium.

There are, however, other applications for magnesium alloys beyond aerospace and automotive, and in 2013 we saw a significant number of papers at TMS in the field of magnesium biotechnology which is also represented in this year's program. The technical and economic press talks incessantly about the game changing nature of 3D printing or additive layer manufacturing in our world, and with the emerging availability of magnesium alloys powders the potential for lightweight innovative structures incorporating magnesium alloys is beginning to be explored.

The magnesium industry continues to need innovation in alloy design to remain competitive with alternative materials, and understanding deformation mechanisms in alloy systems with limited room temperature ductility and methods of reducing anisotropy and asymmetry remain important in widening structural applications whether it be automotive or aerospace. Ultimately if the technology presented in the volume is to be useful it must be affordable in its target market.

This year is the 15th of Magnesium Technology as a symposium within the TMS Annual Meeting. It will be held in San Diego from February 16 to 20, 2014, and there will again be a keynote session, a poster session, and a number of technical sessions in which the content of Magnesium Technology 2014 will be available to all to discuss these and other related issues.

This volume represents the proceedings of these sessions and contains content from over 16 countries. In addition there is a small addendum that includes papers that were submitted for Magnesium Technology 2013 that could not be published at that time. All contributions to Magnesium Technology are peer reviewed by volunteers acting on behalf of the Magnesium Committee. Our reviewers are critical to the success of the volume and are listed in the following pages, and we thank them and the volunteer chairs of our sessions for their contribution.

We continue to insist that our presenters provide a paper to this proceedings volume or other TMS approved journal as we believe our readers and participants wish to take the ideas away and explore them in more detail, and build upon them. Maintaining notes over four days of a diverse conference like the TMS Annual Meeting is difficult and this volume acts as a valuable source of reference throughout the following year, and in many cases for years to come. We thank all those who have contributed high quality written manuscripts to this volume.

2014 Magnesium Technology Symposium Organizers

Martyn Alderman - Chair

Michele V. Manuel - Co-Chair

Norbert Hort - Past Chair

Neale R. Neelameggham – Advisor

ABOUT THE LEAD EDITOR

MARTYN ALDERMAN
MAGNESIUM TECHNOLOGY 2014 LEAD EDITOR

Martyn Alderman is Divisional Director of Technology for the Magnesium Elektron Group Worldwide. He obtained a Master's Degree in Material Science from the University of Cambridge (United Kingdom) in 1979, and for the next 20 years he worked in aluminium rolling mills producing and developing Al-Cu-Zr, Al-Mn, Al Mg-Mn, Al-Zn-Mg, and Al-Li-Cu alloys for superplastic forming. He also has significant operational experience of direct chill casting and in the extrusion of high strength aluminium alloys.

In 2003 he joined Magnesium Elektron during the acquisition of their large Madison, Illinois rolling operation in the United States. For the next few years he was travelling between the United States and Europe encouraging the wider use of magnesium sheet in transport applications, in particular by use of superplastic forming, and later in managing the post-acquisition integration of the Revere North American Graphic Arts business. He chaired the 2010 International Magnesium Association Conference in Hong Kong, and in 2011-2012 was involved in editing and producing a 270-page *Handbook on Designing with Magnesium Alloys*.

More recently he has been involved in a UK Technology Strategy Board Project aimed at the design of a magnesium-intensive vehicle in conjunction with the Morgan Motor Company and as an advisor to the International Magnesium Association Life Cycle Study on automotive and aerospace applications.

As a member of TMS, SAE, and ASM, he is a regular attendee at worldwide magnesium conferences keeping abreast of global technology development with the aim of maintaining Magnesium Elektron's position as a world leader in magnesium alloys and their end use applications.

MAGNESIUM TECHNOLOGY 2014 EDITORS

Michele V. Manuel is an Assistant Professor in the Department of Materials Science and Engineering at the University of Florida. She received her Ph.D. in Materials Science and Engineering at Northwestern University in 2007 and her B.S. in Materials Science and Engineering at the University of Florida. Her postdoctoral work was in alloy design at the General Motors Technical Center in Warren, Michigan. She is the recipient of the National Science Foundation (NSF) CAREER and National Aeronautics and Space Administration (NASA) Early Career awards, ASM Bradley Stoughton Award for Young Teachers, AVS Recognition for Excellence in Leadership, TMS Young Leaders Professional Development, and University of Florida Excellence Award for Assistant Professors. Her research lies in the basic understanding of the relationship between processing, structure, properties, and performance. She uses a systems-based materials design approach that couples experimental research with theory and mechanistic modeling for the accelerated development of materials. Her current research is focused on the use of systems-level design methods to advance the development of new materials through microstructure optimization. Of specific interest are biodegradable, formable, and high temperature magnesium alloys; self-healing metals; shape memory alloys; nuclear fuels; and computational thermodynamics and kinetics.

Norbert Hort is the head of the Magnesium Processing Department at the Magnesium Innovation Centre (MagIC) within the Helmholtz-Zentrum Geesthacht Zentrum für Material- und Küstenforschung, Geesthacht, Germany (formerly the GKSS Research Centre). Concurrently he is lecturer at the Leuphana University, Lüneburg, Germany. He studied Materials Sciences at the Clausthal University of Technology (CUT), Germany, where he already got involved in magnesium research since the early 1990s. His diploma thesis (1994) dealt with gas-atomized, hot-extruded magnesium alloys. During 1994-1995 he worked as a researcher at the Institute of Materials Sciences (CUT) and he joined the HZG in 2000. He got his Ph.D. degree in Materials Sciences in 2002 from the Clausthal University of Technology. In the MagIC he is responsible for the development of new creep resistant magnesium alloys, grain refinement and the castability of magnesium alloys (viscosity and density of melts, fluidity, and mold filling). Additionally, a major focus of his research is the development of new magnesium alloys for biodegradable implants in a close collaboration with biologists and clinicians. He is co-author of more than 150 peer-reviewed journal papers and contributions to conference proceedings. In recent years he was involved in the organizing committees of the conference series Magnesium Alloys and Their Applications and of the conference Light Metal Technologies 2011 and acted as the organizer of the TMS 2013 Annual Meeting symposium, Magnesium Technology. Since 2009, he has also served as the chairman of the Magnesium Technical Committee of the German Society of Materials (DGM).

Neale R. Neelameggham is “The Guru” at IND LLC, involved in technology marketing and international consulting in the field of light metals and associated chemicals [boron, magnesium, titanium, lithium, and alkali metals], rare earth elements, battery and energy technologies, etc. Neale has been an advisor in various environmental extractive processes for metal production and energy process firms.

He has over 38 years of expertise in magnesium production technology from the Great Salt Lake brine in Utah, involved in Process Development of its startup company NL Magnesium through the present US Magnesium LLC from where he retired. Dr. Neelameggham was involved in most of the process and equipment development of all areas of the plant from the raw material source – the Great Salt Lake Brine, which is concentrated by solar evaporation into a plant feed, which was further purified of impurities, followed by spray drying and preparation of anhydrous magnesium chloride cell feed to electrolytic cells and then into magnesium metal product and chlorine.

In addition, Dr. Neelameggham’s expertise includes an in-depth and detailed knowledge of all competing technologies worldwide of magnesium production, both electrolytic and thermal processes (Pidgeon Process, Murex Process, Zuliani Process, etc.) , as well as alloy development. This expertise is used in engineering a tailor made magnesium process to fit any resources, and has developed a near zero-waste sustainable magnesium production process and equipment. He was a visiting expert at Beihang University of Aeronautics and Astronautics, Beijing, China.

Dr. Neelameggham holds 13 patents and a patent application on boron production, and has several technical papers to his credit. As a member of TMS, AIChE, and a former member of American Ceramic Society, he is well versed in energy engineering, bio-fuels, rare-earth minerals and metal processing and related processes. Dr. Neelameggham served in the TMS Light Metals Division’s Magnesium Committee since its inception in 2000 and chaired it in 2005; in 2007, he was made a permanent co-organizer for the Magnesium Technology symposium at the TMS Annual Meeting. He has been a member of the Reactive Metals Committee, Recycling Committee, Titanium Committee, Program Committee, and the Light Metals Division council.

In 2008, LMD and the TMS Extraction & Processing Division created the Energy Committee following the symposium on CO₂ Reduction Metallurgy Symposium, which he initiated. Dr. Neelameggham was the inaugural chair for the Energy Committee. He has been a co-editor of the Energy Technology symposium since 2008. He received the LMD Distinguished Service Award in 2010. Dr. Neelameggham holds a doctorate in extractive metallurgy from the University of Utah. He has been selected as the Chairman of Hydrometallurgy and Electrometallurgy Committee of EPD for the 2013-2015 term.

LIGHT-METAL MATRIX (NANO)-COMPOSITES EDITORS

Wim H. Sillekens is a project manager in the New Materials & Energy Unit at the research and technology center of the European Space Agency (ESA–ESTEC), where he is currently acting as the coordinator of the European Community research project ExoMet. He obtained his Ph.D. from Eindhoven University of Technology, Netherlands, on a subject relating to metal-forming technology. Since then he has been engaged in aluminum and magnesium research, among others on (hydro-mechanical) forming, recycling /refining, (hydrostatic) extrusion, forging, magnesium-based biodegradable implants, and as of late on light-metal matrix nanocomposites. His professional career includes positions as a post-doc researcher at his alma mater and as a research scientist / project leader at the Netherlands Organization for Applied Scientific Research (TNO). International working experience covers a placement as a research fellow at MEL (now AIST) in Tsukuba, Japan, and – more recently – shorter stays as a visiting scientist at GKSS (now HZG) in Geesthacht, Germany, and at PNNL in Richland Washington, USA. He has authored or co-authored book chapters, journal papers, patents, conference papers, (keynote/invited/contributed) oral presentations, and so on (about 135 entries to date). Other professional activities include an involvement in association activities (among others, as the lead organizer of TMS 2011 Annual Meeting Magnesium Technology symposium), international conference committees, and as a peer reviewer of manuscripts for scientific journals and conference proceedings as well as of research proposals. Research interests are in physical and mechanical metallurgy in general and in light-metals technology in particular.

Dmitry G. Eskin received his Engineering and Ph.D. degrees from Moscow Institute of Steel and Alloys (Technical University, Russia) in 1985 and 1988, respectively. After that he worked as a Senior Scientist in the Baikov Institute of Metallurgy (Russian Academy of Sciences) with a main research focus of alloy development, heat treatment and metal processing of aluminum alloys. From 1999 to 2011 he was a Fellow in Materials innovation institute and since 2008 also held a position of associate professor in Delft University of Technology (The Netherlands), where he conducted fundamental and applied research on solidification processing of metallic materials. In 2011, he joined Brunel University (UK) as professor in solidification research. His current research concerns application of ultrasonic cavitation to melt processing. He is a well-known specialist in physical metallurgy and solidification processing of light alloys, author and co-author of more than 180 scientific papers, 5 monographs, and a number of patents. Among his books are *Multicomponent Phase Diagrams: Applications for Commercial Aluminum Alloys* (2005), *Physical Metallurgy of Direct-Chill Casting of Aluminum Alloys* (2008), and *Direct-Chill Casting of Light Alloys: Science and Technology* (2013). Dr. Eskin has been a member of TMS since 2000 and is a regular speaker at TMS Annual Meetings.

MAGNESIUM TECHNOLOGY 2014

Session Chairs

Keynote Session

Martyn Alderman

Corrosion and Coatings

Adam Powell
Soobhankar Pati

Powders, Recycling, Hydrometallurgy, Primary Production, and Creep

Neale R. Neelameggham
Petra Maier

Biomedical Applications

Michele V. Manuel
Wim Sillekens

Deformation I

Fabrizio D'Errico
Alok Singh

Alloy Design

Alan Luo
Sean Agnew

Deformation II

Kiran Solanki
Warren Poole

SYMPOSIUM: LIGHT-METAL MATRIX (NANO)-COMPOSITES

Session Chairs

Melting, Modelling, and Solidification

Dallas Trinkle
James Saal

Microstructure-Property Relationships I

Wim Sillekens

Texture and Wrought Processing I

Julian Rosalie
Eric Nyberg

Microstructure-Property Relationships II; Modeling and Advanced Characterization

Xiaochun Li

Wrought Processing II and Joining

Amit Pandey
Suveen Mathaudhu

Emerging Processes

Manoj Gupta

In-Situ Synthesis and Novel Additions

Dmitry Eskin

MAGNESIUM TECHNOLOGY 2014

Reviewer Pool

The completion of this volume would not have been possible without the volunteer assistance of these individuals from 13 different countries. Their commitment to the advancement of magnesium research and scientific knowledge is to be commended. They are listed here in alphabetical order of their last names:

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DAS, Subodh	Phinix LLC
DAVIS, Bruce	Magnesium Elektron
DECKER, Ray	Thixomat
DEMIRCI, Gokhan	Aselsan Inc
D'ERRICO, Fabrizio	Polytecnico di Milano
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GIBSON, Mark	CSIRO
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SADAYAPPAN, Kumar	CANMET
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