ICM7 2020
Shenyang · China

The 7th International Conference on Magnesium

China • November 19-22, 2020

PROGRAM & ABSTRACTS

The 7th International Conference on Magnesium (ICM7)

Hosted by

Chinese Materials Research Society (C-MRS)
The Nonferrous Metals Society of China (NFsoc)
China Magnesium Association (CMA)
ISO/TC 79/SC 5 (The Technical Committee of Magnesium and Magnesium Alloys)
International Magnesium Society (IMS)

Organized by

Institute of Metal Research, Chinese Academy of Sciences, China
Chongqing University, China
Shanghai Jiao Tong University, China
Northeastern University, China
Beijing University of Technology, China
Xi'an Jiaotong University, China
Helmholtz-Zentrum Geesthacht, Germany
The University of Queensland, Australia
Seoul National University, Korea
The Ohio State University, USA

Co-organized by

APG Galaxy Trade and Technology LLC, USA
Shandong Academy of Science, China
Chongqing Materials Society, China

Supported by

Ministry of Science and Technology of China
National Natural Science Foundation of China
Chinese Academy of Sciences
Shenyang Association for Science and Technology
Chongqing Association for Science and Technology

The 7th International Conference on Magnesium

China • November 19-22, 2020

PROGRAM

Contents

Introduction

The 7th International Conference on Magnesium (ICM7) will be held from 19 through 22 Nov 2020 in China. Since the 1st International Conference on Magnesium was held in Beijing in 2003, ICM conferences were held in Beijing (2005), Qingdao (2008, 2011, and 2013) and Shenyang (2017). As a continuation of the previous successful International Conferences on Magnesium, ICM7 is aimed to further promote the understanding, development and applications of magnesium and its alloys. ICM 7 will be supported by Chinese Academy of Sciences, the Ministry of Science and Technology of China and the National Natural Science Foundation of China.

Due to the low-density and high-specific strength, and many attractive characteristics, magnesium alloys are expected to enjoy increasing use in automotive, aerospace, computers, and communication and consumer industries. Many encouraging innovations and progresses in Mg smelting technologies, new alloy development, new processing techniques and innovative applications have taken places around the world in recent years. The wrought magnesium alloys, especially the magnesium alloy extrusion sheets, have been applied in a wider range, like 3C products and aerospace. The Conference is, therefore, aimed to provide a forum for exchanges and discussions of new ideas and the latest achievements related to magnesium and its alloys. A further objective of the conference is to highlight the global and regional trends crucial to future research fields and potential applications.

Committee

Honorary Chairs:

Prof. Tieyong Zuo, Chinese Materials Research Society, China
Prof. Jilin He, Zhengzhou University, China
Prof. Wenjiang Ding, Shanghai Jiao Tong University, China
Prof. David St John, The University of Queensland, Australia

Chair:

Prof. Fusheng Pan, Chongqing University, China

Co-Chairs:

Prof. Karl Ulrich Kainer, Helmholtz-Zentrum Geesthacht, Germany
Prof. Kwang Seon Shin, Seoul National University, Korea
Prof. Alan Luo, Ohio State University, USA
Prof. Yuansheng Yang, Institute of Metal Research, CAS, China

International Committee:

Andrej Atrens, The University of Queensland, Australia
John Allison, University of Michigan, USA
Sean Agnew, University of Virginia, USA
Matthew R. Barnett, Deakin University, Australia
Dan Eliezer, Ben-Gurion University, Israel
Zhongyun Fan, Brunel University, UK
Enhou Han, Institute of Metal Research, CAS, China
Rui Jin, The Nonferrous Metals Society of China, China
A. Kaya, Mugla Sitki Kocman University, Turkey
Shigeharu Kamado, Nagaoka University of Technology, Japan
Yoshihito Kawamura, Kumamoto University, Japan
Nack Joon Kim, POSTECH, Korea
Enrique J. Lavernia, University of California at Irvine, USA
Ruhai Lin, Magnesium Branch of China Nonferrous Metals Industry Association, China
Jian Lu, City University of Hong Kong, Hong Kong
L.M. Lobanov, National Academy of Sciences of Ukraine, Ukraine
Qing Liu, Jiangsu Industrial Technology Research Institute, China
Siyuan Long, Chongqing University, China
Toshiji Mukai, Kobe University, Japan
Warren Poole, The University of British Columbia, Canada
E.A. Rokhlin, Baikov Institute of Metallurgy and Materials Science, Russia
E.F. Volkova, All-Russian Scientific-Research Institute of Aviation Materials,Russia
M.A. Wells, University of Waterloo, Canada

BongSun You, Korea Institute of Materials Science, Korea
Yutian T Zhu, NC State University, USA

Program Committee:

Chairs

Prof. Fusheng Pan, Chongqing University, China
Prof. Mingxing Zhang, The University of Queensland, Australia

Secretary General

Prof. Bin Jiang, Chongqing University, China

Members

Eiji Abe, University of Tokyo, Japan
Carsten Blawart, Helmholtz-Zentrum Geesthacht, Germany
Daolun Chen, Ryerson University, Canada
Hahn Choo, University of Tennessee, USA
Kyung-Mox Cho, Korea Institute of Materials Science, Korea
Rongshi Chen, Institute of Metal Research, CAS, China
Yasumasa Chino, National Institute of Advanced Industrial Science and Technology, Japan
Wenbo Du, Beijing University of Technology, China
Shaokang Guan, Zhengzhou University, China
A. Kaya, Mugla Sitki Kocman University, Turkey
Qizhi Le, Northeastern University, China
Xiaochun Li, University of California, Los Angeles, USA
Qian Ma, RMIT University, Australia
Tsuyoshi Mayama, Kumamoto University, Japan
Gaowu Qin, Northeastern University, China
Joe Robson, The University of Manchester, UK
Rainer Schmid-Fetzer, Clausthal University of Technology, Germany
Junsheng Wang, Beijing Institute of Technology, China
Guohua Wu, Shanghai Jiao Tong University, China
Jian Wang, Los Alamos National Laboratory, USA
Peidong Wu, McMaster University, Canada
Dingfei Zhang, Chongqing University, China
Jianmin Zeng, Guangxi University, China
Jin Zhang, University of Science & Technology, Beijing, China
Jing Zhang, Chongqing University, China
Zhimin Zhang, North University of China, China
Mingyi Zheng, Harbin Institute of Technology, China

Secretariats

Associate Prof. Xiaohui Feng, Institute of Metal Research, CAS, China
Associate Prof. TianjiaoLuo, Institute of Metal Research, CAS, China
Associate Prof. Jiangfeng Song, Chongqing University, China
Dr. Jia She, Chongqing University, China

Organizing Committee:

Chairs

Prof. Yuansheng Yang, Institute of Metal Research, CAS, China
Prof. Yuanding Huang, Helmholtz-Zentrum Geesthacht, Germany

Secretary General

Prof. Xianhua Chen, Chongqing University, China

Members

Alankar Alankar, Indian Institute of Technology Bombay, India
Shinji Ando, Kumamoto University, Japan
Carsten Blawert, Helmholtz-Zentrum Geesthacht, Germany
Xiaobo Chen, Royal Melbourne Institute of Technology, Australia
Yong Du, Central South University, China
Hua Hou, North University of China, China
Henry H. Hu, University of Windsor, Canada
Bailing Jiang, Nanjing Tech University, China
Xianquan Jiang, Chongqing Academy of Science and Technology, China
Haitham Kadiri, Mississippi State University, USA
Sooho Kim, Korea Institute of Materials Science, Korea
Runxia Li, Shenyang University of Technology, China
Zheng Liu, Shenyang University of Technology, China
Xiaodong Peng, Chongqing University, China
Dong Qiu, Royal Melbourne Institute of Technology, Australia
Zhiwei Shan, Xi'an Jiaotong University, China
Jixue Zhou, Shandong Academy of Sciences, China
Huiyuan Wang, Jilin University, China
Jingfeng Wang, Chongqing University, China
Ruizhi Wu, Harbin Engineering University, China
Yingda Yu, Norwegian University of Science and Technology, Norway
Xiaoqin Zeng, Shanghai Jiao Tong University, China
Fan Zhang, The Ohio State University, USA
Kui Zhang, Beijing General Research Institute for Nonferrous Metals, China
Shaojun Zhang, Zhengzhou University, China

Secretariats

Prof. Jun Tan, Chongqing University, China
Associate Prof. Yingju Li, Institute of Metal Research, CAS, China
Associate Prof. Yan Yang, Chongqing University, China
Associate Prof. Hucheng Pan, Northeastern University, China

Conference Information

ICM7 will be held both online and offline.

Registration

- **On-site**

Shenyang: The Registration Desk is set on the lobby (Ground Floor) of Shenyang Royal Wanxin Hotel.

Chongqing: The Registration and Supporting Desks are set on the lobby (Ground Floor) of Wanda Realm Chongqing.

Open time: 14:00, Thursday Nov 19.

Registration Fee: 1,800 CNY for regular participant and 800 CNY for student. Registration fee should be paid on site.

- **Online**

Online registration is open until Nov 22. Online registration is free.

Oral Presentations

- Time Duration:
  Plenary Presentation: 40 minutes presentation including Q&A;
  Keynote/Invited Presentation: 20 minutes presentation including Q&A;
  Parallel Presentation: 15 minutes presentation including Q&A.
- Speakers on site should copy their presentation files to the session laptop before starting of the session.

Poster Presentations

- All posters are presented **on the conference web** during the Conference.
- The electronic version of posters should be sent to e-mail icm7@imr.ac.cn by 19 Nov.
- The size of poster is 1.2m×0.8m.

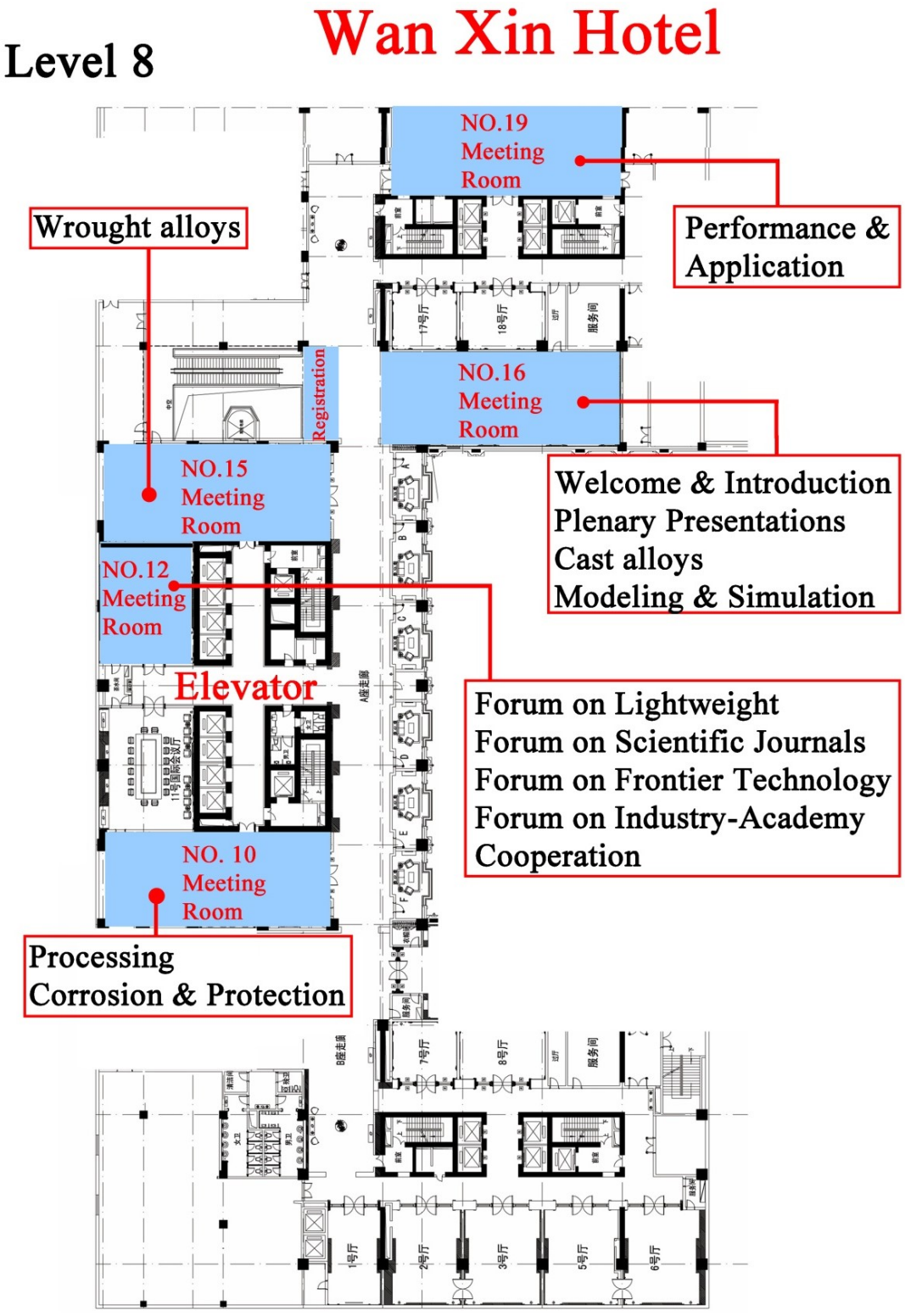
Conference language

- Presentation: All oral reports and posters are in English.
- Working language: English / Chinese.

AGENDA

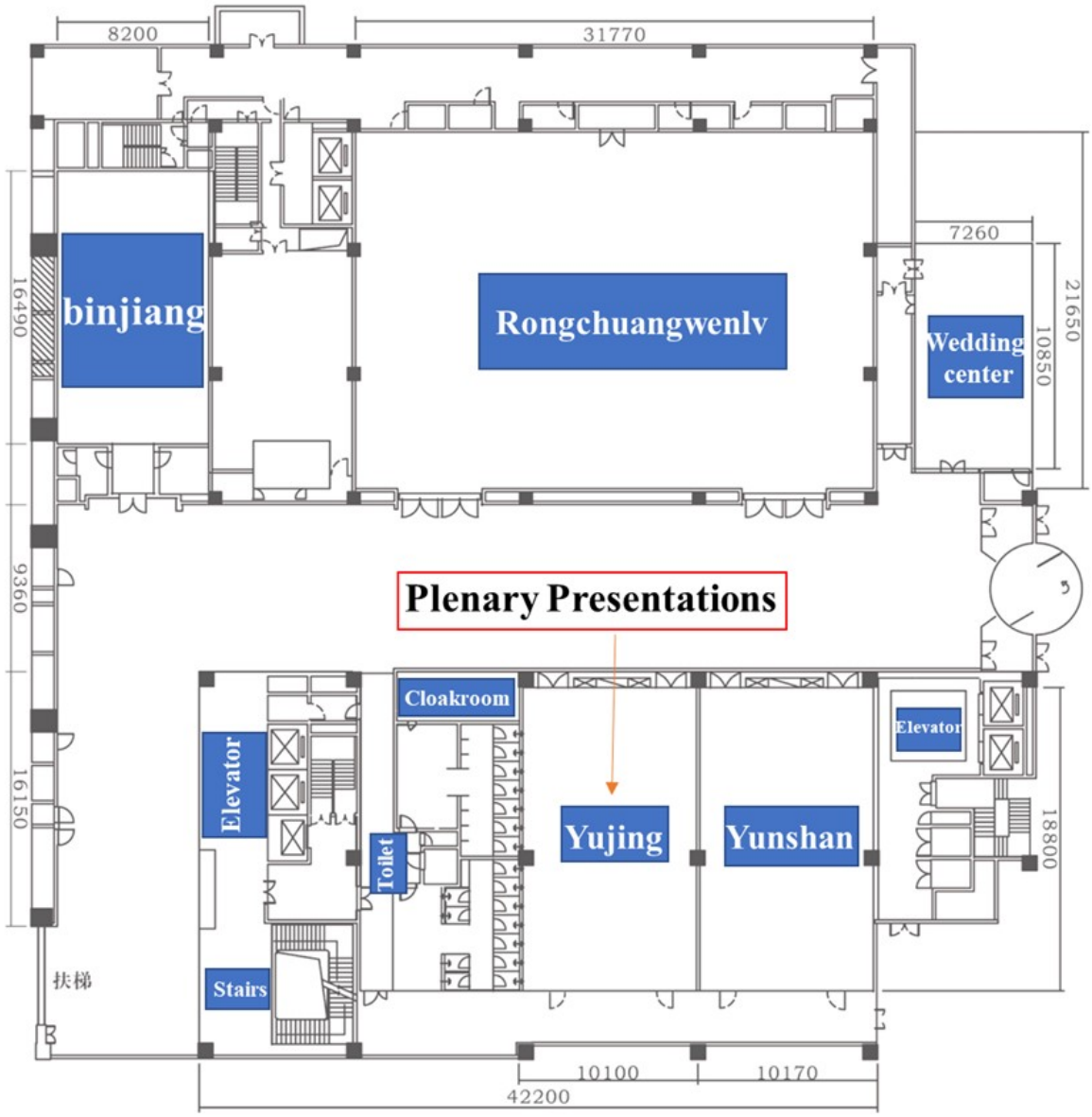
(Beijing Time. Online, offline in Shenyang & Chongqing)

Thursday, Nov 19, 2020					
14:00-	Registration				
18:00-20:00	Dinner				
Friday, Nov 20, 2020					
11:30-13:00	Welcome Reception				
14:00-16:00	Forum on Standardization of Mg Alloys (Invited only, offline)				
16:00-16:30	Welcome & Introduction				
16:30-18:30	Plenary Presentations, Session 1				
18:30-19:30	Dinner				
19:30-21:30	Plenary Presentations, Session 2				
21:30-21:40	Break				
21:40-23:00	Plenary Presentations, Session 3				
Saturday, Nov 21, 2020					
9:00-12:00	Forum on Lightweight (Online & Shenyang offline)				
12:00-13:00	Lunch				
16:00-17:20	Plenary Presentations, Session 4				Forum on Scientific Journals(15:00-18:00) (Online & Chongqing offline)
17:20-18:20	Dinner				
18:20-23:00	Parallel Oral Presentations				Forum on Frontier Technology (19:00-22:00) (Online & Shenyang offline)
	Wrought alloys Session 1	Cast alloys Session 1	Processing Session 1	Performance & Application Session 1	
20:30-20:40	Break				
20:40-23:00	Wrought alloys Session 2	Cast alloys Session 2	Processing Session 2	Performance & Application Session 2	JMA Editorial Board Meeting (19:00-22:00) (Member only. Online & Chongqing offline)
Sunday, Nov 22, 2020					
9:00-12:00	Forum on Industry-Academy Cooperation (Online & Shenyang offline)				
12:00-13:00	Lunch				
14:00-16:00	Poster Presentations (On Conference Web)				
15:00-18:00	Parallel Oral Presentations				
	Wrought alloys Session 3	Modeling & Simulation Session 1	Corrosion & Protection Session 1	Performance & Application Session 3	
18:00-19:30	Dinner				
19:30-21:30	Plenary Presentations, Session 5				
21:30-22:00	Award Ceremony (International Mg Sci & Tech Award, Best Poster Award)				
22:00-22:30	Closing Ceremony				

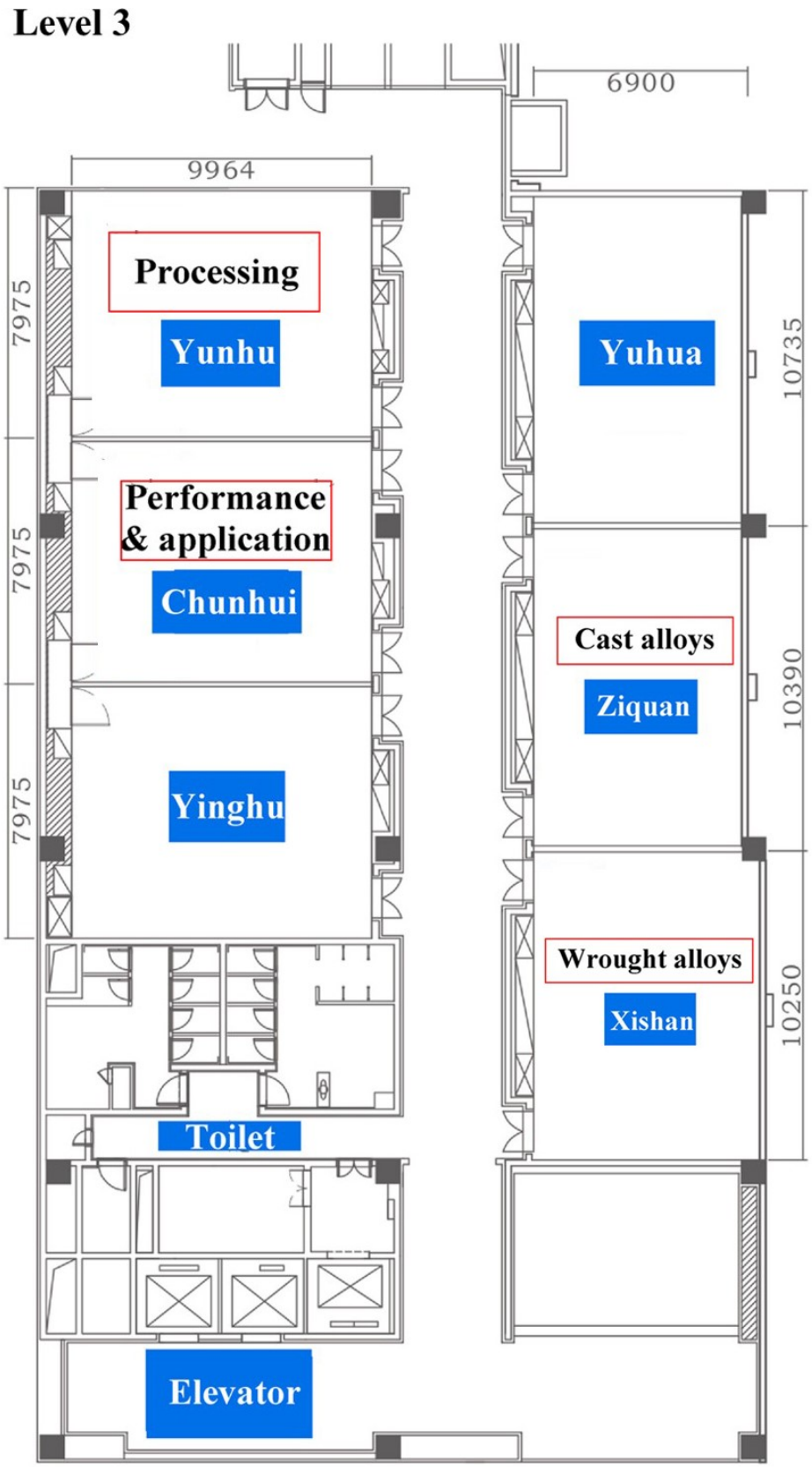

Level 8
Wan Xin Hotel
NO.19 Meeting Room
Performance & Application
Wrought alloys
Registration
NO.16 Meeting Room
NO.15 Meeting Room
Welcome & Introduction
Plenary Presentations
Cast alloys
Modeling & Simulation
NO.12 Meeting Room
Elevator
Forum on Lightweight
Forum on Scientific Journals
Forum on Frontier Technology
Forum on Industry-Academy Cooperation
NO. 10 Meeting Room
Processing
Corrosion & Protection

Wanda Realm Chongqing

Level 2



Wanda Realm Chongqing



Honorary Chairs

Tieyong Zuo

Tieyong Zuo, academician of the Chinese Academy of Engineering. He serves as the director of Academic Board at Beijing University of Technology, concurrently as member of National Education Advisory Committee, deputy director of the National Advisory Committee on Circular Economy, and other social titles. Prof. Zuo has been engaged in education and scientific research for over 60 years, responsible for “National Superior Course” and the prize winner of “Top Teachers for Higher Learning” and “State-level Teaching Award”. He has made significant contributions to fields like refractory metal material, rare earth functional material, aluminum and magnesium alloys and their processing, and he is one of the leaders in disciplines of refractory metal, aluminum and magnesium alloys and their processing in China. During the 1990s, he took the initiative to explore the research field of ecological environment material, advocated and probed deep into the circular economy with resource saving and environmental protection. Over recent years, he strongly advanced the research of green development and ecological civilization, posing wide influence both at home and abroad. He has gained significant achievements in dozens of national key scientific research tasks undertaken by himself, published nearly 400 academic papers, among which over 200 are included in SCI and EI. Besides, he has published more than ten monographs, and been awarded 15 prizes at national, provincial and ministerial levels.

Jilin He

Academician Jilin He has been for years in the field of the research and development of the smelting and processing of nonferrous and rare metals, with a number of achievements having been obtained in the research of such new materials as Ta, Nb, Be, special copper alloy, titanium processing materials, magnesium and magnesium alloy. He has, in addition, chaired and implemented the seven state-designated key technical renovation projects. He has been successively awarded the First Prize of the National Torch Plan, the Second National Technical Inventions Prize, the Second Prize of National Scientific and Technological Advancement, two third prizes for the national advancement in science and technology, and a number of the first and second prizes for scientific and technological advancement awarded by the authorities on provincial and ministerial levels. He has, moreover, applied for and authorized nine patents for inventions and has had more than 40 papers published in journals and was elected the Academician of the Chinese Academy of Engineering in 2001.

Wenjiang Ding

Professor Wenjiang Ding (1953-), worldwide expertise in light alloys research. Born in Shanghai in 1953, and got his Bachelor degree in 1981 and Master Degree in 1983 from Shanghai Jiao Tong university. Now he is a professor of Shanghai Jiao Tong University as well as the director of the National Engineering Research Center of Light Alloy Net-Forming (NERC-LAF) and the co-director of SJTU-GM Advanced Materials and Processing Collaborative Laboratory (AMP CRL). Also he was the former Vice-president of the university and the former Vice-director of Shanghai Science and Technology Commission. He is the Chairman on duty of International Light Alloy Center Alliance, the Chinese director of Sino-Norway Joint Research Center of Light Alloy and the member of the External Evaluation Committee of Kyushu University Japan. He became the Academician of Chinese Academy of Engineering.

He has focused on the research of advanced magnesium alloy's design, development and precision processing technology for more 35 years, and developed several high-performance novel magnesium alloys by rare earth alloying and microstructure control, which has been widely applied in Aerospace, Aviation and Automotive industries. He is leading a big research group of more 300 researchers and engineers, and his group has published more 600 academic paper and been authorized 157 patents on magnesium alloy field. He also got more than 10 research awards, including a National Prize for Progress in Science and Technology (2003) and a National Prize of Technological Invention (2006).

David StJohn

Professor StJohn's main interests are the solidification and microstructure-property relationships of Al, Mg and Ti alloys and has published over 350 papers in journals and conference proceedings. He has held appointments in Canada, RMIT University and CRA-Advanced Technical Development in Perth as well as a long association with UQ. Prof StJohn has made a significant contribution to developing research – industry partnerships. For example, the CAST Cooperative Research Centre becoming CEO from August 2002 until 2008, the Materials Technology Centre (DMTC) in 2008 and initiated the Centre for Advanced Materials Processing and Manufacturing (AMPAM) at UQ in 2009. Current industry partners include Magontec, Cook Medical, Bluescope Steel, Nihon Superior and Baosteel. Funding was also received from the Queensland State Government and the Australian Federal Government for the Advanced Engineering Building (AEB) and he was Chair of the Project Control Group for the construction of the AEB, completed in 2013. He was awarded the John Campbell Medal in 2014, the Materials Australia Silver Medal in 2011, the Amercian Society of Metals Henry Marion Howe Medal in 2006 and the TMS Magnesium Technology Award in 2003. Prof StJohn is currently Emeritus Professor at The University of Queensland.

Conference Chair

Fusheng Pan

Fusheng Pan is an Academician of Chinese Academy of Engineering, professor in Chongqing University, China. He received his Doctor's degree in Materials Science & Engineering at Northwestern Polytechnical University in 1995. Prof. Pan also studied and/or worked in Oxford University, Stuttgart University, Chiba University, University of California, Queen Mary, and University of Queensland. He is an honorary professor in University of Queensland, foreign member of Academy of Mining Sciences in Russia, member of Asian Pacific Academy of Materials. He also serves as chairman of Chongqing Association for Science & Technology, director of National Engineering Research Center for Magnesium Alloys (CCMg), vice president of Chinese Material Research Society (C-MRS).

Prof. Pan's research fields mainly focus on the magnesium alloys, aluminum alloys, metal matrix composites, etc.. He was awarded 4 National Awards, over 10 Provincial Awards, HLHL Prize, and USA Dupont S&T Innovation Prize. He holds over 150 authorized patents, and has over published 600 SCI journal papers and over 20 international, national and industrial standards, 16 of his developed magnesium alloys are included in the national standards (GB/T). Prof. Pan is now the chairman of ISO TC 79/SC 5 (Magnesium and Magnesium Alloys), editor in chief of Journal of Magnesium and Alloys (JMA, IF in 2019: 7.115, Q1), chairman of the 3rd, 4th, 5th , and 6th International Conference on Magnesium Alloys, chairman of the 1st and 2nd UK-China Advanced Materials Symposium. He is also Co-Chair of the 10th International Conference on Magnesium Alloys and Their Applications 2015(Mg2015) and 2017 E-MRS Spring Meeting.

fspan@cqu.edu.cn

Co-Chairs

Karl Kainer

Karl Kainer studied Materials Science at University of Applied Science Osnabrueck and University of Technology Clausthal. He obtained his Ph.D degree in Materials Science at the University of Technology Clausthal in 1985 and his Habilitation on Magnesium Matrix Composites in 1996. From 1985 to 1999, he was Head of the Light Metal and P/M Group at the Institute for Materials Science and Technology at Clausthal University. 2000-2019 Prof. Kainer was Director of the Institute of Materials Research and the Magnesium Innovation Centre at Helmholtz-Zentrum Geesthacht (HZG) and Professor on Materials Technology at Hamburg University of Technology. In 2006, he became Visiting Professor of Chongqing University. 2019 he retired and was consultant for the HZG from 2019-2020. October 2020 he was appointed Professor at the Chair of Light Elements Engineering, Foundry and Automation at Wrocław University of Science and Technology, Poland. 2007-2019 he was member of the Board of Directors of the International Magnesium Association (IMA) and their President 2012-2014. In 2014 he received the Alexander von Humboldt Polish Honorary Research Fellowship, and in 2020 the TMS Fellow Award. The research topics of Prof. Kainer are development of advanced magnesium alloys and their processing. He has published more than 470 publications.

Kwang Seon Shin

Kwang Seon Shin received his Ph.D. in Materials Science and Engineering from Northwestern University. He was assistant/associate professor of Materials Engineering at Arizona State University and became professor of Material Science and Engineering at SNU. Prof. Shin established the Magnesium Technology Innovation Center at SNU in 2006. He acted as Vice President (2008~2009), and President (2013) of the Korean Institute of Metals and Materials (KIM). He started the Magnesium Committee at KIM and served as Chair (2007~2012). Prof. Shin has been a member of the National Academy of Engineering of Korea since 2009. He was appointed as Chairman of the Korea Magnesium Technology Research Association in 2014. His research focuses on the development, processing, and characterization of advanced structural materials, including magnesium, aluminum, and copper alloys, particularly the development of advanced processing technologies and high-performance magnesium alloys with high strength, ductility, formability, and corrosion resistance.

Alan Luo

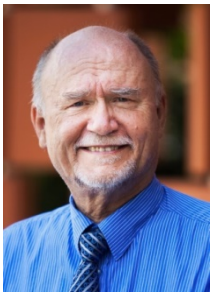
Alan Luo is Professor of Materials Science and Engineering and Integrated Systems Engineering at The Ohio State University (OSU) in Columbus, OH, USA. Prof. Luo is also Director of OSU Lightweight Materials and Manufacturing Research Laboratory (LMMRL). Prof. Luo is an elected Fellow of ASM (American Society of Metals) International and SAE (Society for Automotive Engineers) International. Prior to joining OSU in July 2013, Dr. Luo was a GM Technical Fellow at General Motors Global Research and Development Center (Warren, MI, USA) with 20 years of industrial experience. Prof. Luo is presently a director of the board of IMA (International Magnesium Association) and serves as chair of its annual conference program committee. Prof. Luo is a past chair of TMS Light Metals Division and SAE Materials Engineering Activities. He has 20 patents and more than 300 technical publications on advanced materials and manufacturing, specializing in lightweight materials and applications.

Yuansheng YANG

Yuansheng Yang is Professor of Institute of Metal Research, Chinese Academy of Sciences. He is also a Professor at the University of Science and Technology of China, and Director of Key Lab for Light-Strength Alloy, Shandong Academy of Sciences, China. He received his Doctor's degree at China University of Mining and Technology-Beijing in 1992. Prof. Yang also studied and worked in Oxford University, Imperial College London, UK. Prof. Yang's academic positions including Vice-Chairman of the Committee of Magnesium Alloys, Chinese Materials Research Society, Vice-Chairman of the Committee of Electromagnetic Processing of Materials, Chinese Society for Metals, Executive Member of the Committee of Solidification Science and Technology, Chinese Materials Research Society, Vice-Chairman of the Committee of Physical and Numerical Simulation, Chinese Mechanical Engineering Society, Member of the International Federation of Physical and Numerical Simulation of Materials Processing(IFPNS), and Member of Editorial Board of Journal of Magnesium and Alloys. Prof. Yang's research focuses on magnesium alloys and high temperature structural materials. He and his team developed a series of new magnesium alloys and received the International Magnesium Association (IMA) Award of Excellence for Wrought Product in 2017. He has charged more than 30 national projects, published more than 300 papers, more than 30 invited talks, and holds over 50 authorized patents.

ysyang@imr.ac.cn

Plenary Speakers



Andrejs Atrens

- graduated with BSc(Hons) from The University of Adelaide in 1970;
- earned a PhD also from The University of Adelaide in 1976;
- was awarded a D.Eng from the The University of Queensland in 1997;
- became Fellow of the Higher Education Academy in 2018; and
- has a h-index of 62.

Atrens is Professor of Materials at The University of Queensland (UQ), where he has been since 1984.
His significant contributions to magnesium corrosion include:

- An understanding of the Mg corrosion mechanism,
- An understanding of the biocorrosion of Mg
- An understanding of how Mg corrosion relates to environmental composition, and Mg alloy chemistry, metallurgy and microstructure.

Jian Lu

Prof. Jian LU is an academician of the National Academy of Technologies of France, Chair Professor of Mechanical Engineering and Vice President (Research and Technology) at City University of Hong Kong. He obtained the Dip. Ing., Master(DEA) degree and Doctoral degree from University of Technology of Compiegne in 1984 and 1986 respectively. From 1986 to 1994, he was appointed as Senior Research Engineer at the CETIM (French Technical Centre for Mechanical Industry). From 1994 to 2005, he was appointed as Professor; Head of Department of Mechanical Systems Engineering (1994-2004) and Director of Mechanical Systems and Concurrent Engineering Laboratory (1994-2005) jointly supported by the French Ministry of Education and CNRS at the University of Technology of Troyes, France. From 2005 to 2010, he was Chair Professor and Head of Department of Mechanical Engineering at the Hong Kong Polytechnic University. He has published more than 360 SCI journal papers including papers in top journals of structural materials such as: Nature (Cover Story), Science, Nature Materials, Science Advanced, Nature Communications, Materials Today, Advanced Materials, Acta Materialia, Physical Review Letters and Journal of Mechanics and Physics of Solids.

Maximilian Fichtner

Prof. Maximilian Fichtner is director at the Helmholtz-Institute Ulm (HIU) for Electrochemical Energy Storage, professor for Solid State Chemistry at the Ulm University and head of the department ”Energy Materials” at the Institute of Nanotechnology, Karlsruhe Institute of Technology. He is scientific director of CELEST (Center for Electrochemical Energy Storage Ulm-Karlsruhe) and spokesperson of the German Excellence Cluster on battery research, entitled “Energy Storage Beyond Lithium (POLiS)“, with about 100 new employees. He is also member of the core team of an upcoming European Large Scale Research Initiative (formerly known as “Flagship”), named “BATTERY2030+” and has been scientific co-ordinator of several European collaborative projects on batteries and on hydrogen storage. His current research interest is on resource- and sustainability issues, novel principles for energy storage and the synthesis and investigation of related storage materials. He is author and co-author of more than 350 research-, conference papers and book chapters, 20 patent applications and editor of a book on magnesium batteries. His h index is 50.

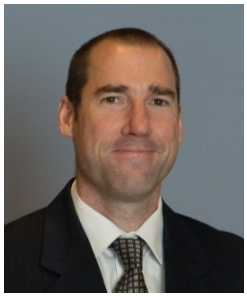
Wenjiang Ding

Professor Wenjiang Ding (1953-), worldwide expertise in light alloys research. Born in Shanghai in 1953, and got his Bachelor degree in 1981 and Master Degree in 1983 from Shanghai Jiao Tong university. Now he is a professor of Shanghai Jiao Tong University as well as the director of the National Engineering Research Center of Light Alloy Net-Forming (NERC-LAF) and the co-director of SJTU-GM Advanced Materials and Processing Collaborative Laboratory (AMP CRL). Also he was the former Vice-president of the university and the former Vice-director of Shanghai Science and Technology Commission. He is the Chairman on duty of International Light Alloy Center Alliance, the Chinese director of Sino-Norway Joint Research Center of Light Alloy and the member of the External Evaluation Committee of Kyushu University Japan. He became the Academician of Chinese Academy of Engineering.

He has focused on the research of advanced magnesium alloy's design, development and precision processing technology for more 35 years, and developed several high-performance novel magnesium alloys by rare earth alloying and microstructure control, which has been widely applied in Aerospace, Aviation and Automotive industries. He is leading a big research group of more 300 researchers and engineers, and his group has published more 600 academic paper and been authorized 157 patents on magnesium alloy field. He also got more than 10 research awards, including a National Prize for Progress in Science and Technology (2003) and a National Prize of Technological Invention (2006).

Xiaoqin Zeng

Professor Xiaoqin Zeng received his Ph.D. degree in Materials Science and Engineering from Professor Xiaoqin Zeng received his Ph.D. degree at Materials Science and Engineering in Shanghai Jiao Tong University in 2001. He is currently a professor at School of Materials Science and Engineering in Shanghai Jiao Tong University. He has conducted research on Mg for more than 20 years. He has published more than 200 peer-reviewed articles and coauthored 2 monographs on Magnesium alloys. He has applied for 80 National invention patents related to Mg alloys and participated in the formulation of 2 National standard. His research activities focused in the basic theory in strengthening-toughening of Magnesium alloys, development of high corrosion resistance Magnesium and Material Genome Engineering for advanced materials. His main contributions to the magnesium research community include (1) having proposed the micro-alloying approach to retard combustion of Mg and accordingly developed non-combustible Mg alloys (combustion temperature>850°C); (2) having developed high strength Mg alloys (UTS>500MPa) by the introduction and control of rare earth containing precipitates. These works were written into the Chinese national standard and enable a wider application of Mg. He is a key member of GM-SJTU Collaborative Research Laboratory that focuses on the development of both new Mg alloys and advanced processing technologies to provide light-weighting solutions for the automotive industry. He received a few prestigious research awards such as "Science and Technology Achievement Award" by Chinese government in 2003, "Innovation award of Automotive Industry" by Minister of Education (MOE) and General Motors Company in 2007, and "Magnesium Research Award" granted by German Helmholtz-Zentrum Geesthacht in 2011.

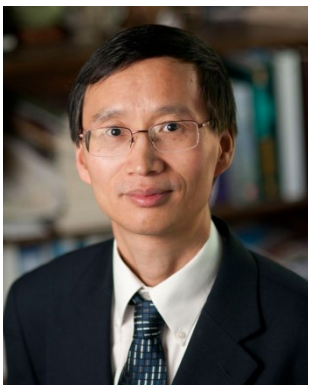


Matthew R. Barnett

Professor Barnett is Director of the Institute for Frontier Materials and Director of the ARC Training Centre in Alloy Innovation for Mining Efficiency at Deakin University. He obtained his Bachelor's degree from RMIT University in Melbourne and his PhD from McGill University in 1997. He has a background in metallurgical research, beginning his career in BHP Steel and has worked on wrought magnesium alloys for over 20 years. His current research focusses on understanding magnesium deformation and how it responds to alloying additions. At a more general level, Professor Barnett is passionate about research into alloy design that stimulates circularity of material use – designing alloys can last longer and be more easily recycled and reused.

Alan Luo

Alan Luo is Professor of Materials Science and Engineering and Integrated Systems Engineering at The Ohio State University (OSU) in Columbus, OH, USA. Prof. Luo is also Director of OSU Lightweight Materials and Manufacturing Research Laboratory (LMMRL). Prof. Luo is an elected Fellow of ASM (American Society of Metals) International and SAE (Society for Automotive Engineers) International. Prior to joining OSU in July 2013, Dr. Luo was a GM Technical Fellow at General Motors Global Research and Development Center (Warren, MI, USA) with 20 years of industrial experience. Prof. Luo is presently a director of the board of IMA (International Magnesium Association) and serves as chair of its annual conference program committee. Prof. Luo is a past chair of TMS Light Metals Division and SAE Materials Engineering Activities. He has 20 patents and more than 300 technical publications on advanced materials and manufacturing, specializing in lightweight materials and applications.



Yuntian Zhu

Dr. Yuntian Zhu, Chair Professor, City University of Hong Kong, Hong Kong, China

Yuntian Zhu has recently joined the City University of Hong Kong as a Chair Professor, before which he was a Distinguished Professor in North Carolina State University, where he worked from 2007 to 2020. He worked as a postdoc, staff member and team leader in Los Alamos National Laboratory (LANL) until 2007 after obtaining his Ph.D. degree from the University of Texas at Austin in 1994. In recent years has focused on the deformation mechanisms at dislocation level and mechanical behaviors of heterostructured materials, nano/ultrafine-grained materials, and carbon nanotube composites. He is an experimentalist with primary interest in fundamental aspects of materials research and also in designing materials with superior strength and ductility. He and his colleagues are pioneers of the emerging field of heterostructured materials. As of June 27, 2020, his publications have been collectively cited for over 39,000 times with h-index of 104 according to Google Scholar. He recently received the Institute of Metals Lecture and Robert Franklin Mehl Award , ASM International Albert Sauveur Award, IUMRS Sômiya Awar, TMS SMD Distinguished Scientist/Engineer Award, and TMS Leadership Award. He has been elected Fellows of TMS, MRS, APS, ASM, and AAAS. More information can be found in his personal website: https://www.mse.ncsu.edu/zhu/

En-Hou Han

Prof. En-Hou Han is the director of National Center for Corrosion Control in the Institute of Metal Research, Chinese Academy of Sciences. He has published more than 400 peer reviewed scientific papers, 130+ plenary and invited lecture, and hold 110 patents. His papers was cited more than 15,000 times. His research interests include (1) Development of advanced magnesium alloy and its corrosion prevention techniques. (2) Interaction of mechanics and chemistry, including stress corrosion cracking, corrosion fatigue and hydrogen embrittlement for various materials. (3) R & D of various coatings for corrosion protection. (4) Corrosion in severe corrosive industrial environments. (5) Service lifetime prediction and failure analysis for engineering structure and components. Prof. Han was elected as president of UN World Corrosion Organization, president of Asia Pacific Academy of Materials. Prof. Han received Fellow (2008) and Whitney Award (2016) of NACE International, Ho-Leung-Ho-Lee Technology Science Award (2012), Ryukiti Hasiguti Foundation Prize (2010), Distinguished Scientist from Chinese Association for Science and Technology (2010), National Science and Technology Awards of China (2009), National Technique Invention Awards of China (2006, 2018), Science and Technology Government Awards of China (2006), Top 100 person in Science and Technology in New Century of China (2006), etc.

Zhongyun Fan

Professor Fan is the founder and current Director of BCAST at Brunel University London. He is the principal investigator/director of the EPSRC Future LiME Research Hub, a national centre of excellence in liquid metal engineering. He obtained his first degree in Metallurgy from University of Science and Technology, Beijing in 1982 and his PhD in Materials Science and Engineering from Surry University in the UK in 1993. He has published over 400 scientific papers with an H-Index of 54 and a total currently of 10869 citations. Fan has initiated, managed and delivered research projects funded from a wide range of grant sources with grants totalling over £50M. He has been chairman of 6 major international conferences and members international scientific committee of 6 international conferences. He is the co-chairmen of the Casting and Solidification Society (IOM3), Board Member of the Light Metals Division (IOM3), a Fellow of the Institute of Materials, Minerals and Mining (IOM3) and the Institute of Cast Metal Engineers (ICME) as well as a member of the American Society of Materials (ASM) and the EPSRC Metals College. He was the recipient of the Elegant Work Prize (1995), the Cook/Ablett Award (2003) and Dowding Medal and Prize (2012) of the Institute of Materials, Minerals and Mining (IOM3). Fan's research has been focused on (1) Understanding of early stages of solidification covering prenucleation, heterogeneous nucleation, grain initiation and grain refinement; (2) phase transformation and alloy development; and (3) developing innovative techniques for light metal processing.

Karl Kainer

Karl Kainer studied Materials Science at University of Applied Science Osnabrueck and University of Technology Clausthal. He obtained his Ph.D degree in Materials Science at the University of Technology Clausthal in 1985 and his Habilitation on Magnesium Matrix Composites in 1996. From 1985 to 1999, he was Head of the Light Metal and P/M Group at the Institute for Materials Science and Technology at Clausthal University. 2000-2019 Prof. Kainer was Director of the Institute of Materials Research and the Magnesium Innovation Centre at Helmholtz-Zentrum Geesthacht (HZG) and Professor on Materials Technology at Hamburg University of Technology. In 2006, he became Visiting Professor of Chongqing University. 2019 he retired and was consultant for the HZG from 2019-2020. October 2020 he was appointed Professor at the Chair of Light Elements Engineering, Foundry and Automation at Wrocław University of Science and Technology, Poland. 2007-2019 he was member of the Board of Directors of the International Magnesium Association (IMA) and their President 2012-2014. In 2014 he received the Alexander von Humboldt Polish Honorary Research Fellowship, and in 2020 the TMS Fellow Award. The research topics of Prof. Kainer are development of advanced magnesium alloys and their processing. He has published more than 470 publications.

Kwang Seon Shin

Kwang Seon Shin received his Ph.D. in Materials Science and Engineering from Northwestern University. He was assistant/associate professor of Materials Engineering at Arizona State University and became professor of Material Science and Engineering at SNU. Prof. Shin established the Magnesium Technology Innovation Center at SNU in 2006. He acted as Vice President (2008~2009), and President (2013) of the Korean Institute of Metals and Materials (KIM). He started the Magnesium Committee at KIM and served as Chair (2007~2012). Prof. Shin has been a member of the National Academy of Engineering of Korea since 2009. He was appointed as Chairman of the Korea Magnesium Technology Research Association in 2014. His research focuses on the development, processing, and characterization of advanced structural materials, including magnesium, aluminum, and copper alloys, particularly the development of advanced processing technologies and high-performance magnesium alloys with high strength, ductility, formability, and corrosion resistance.

Manoj Gupta

Dr Manoj Gupta was a former Head of Materials Division of the Mechanical Engineering Department and Director designate of Materials Science and Engineering Initiative at NUS, Singapore. He did his BEng from VRCE-Nagpur in 1984 (First Class with Distinction), MEng from IISC- Bangalore in 1987 (Gold Medalist) Ph.D. from University of California, Irvine, USA (1992), and postdoctoral research at University of Alberta, Canada (1992). In August 2017 he was highlighted among **Top 1% Scientist of the World** Position by The Universal Scientific Education and Research Network and **among 2.5%** among scientists as per ResearchGate. To his credit are: (i) Disintegrated Melt Deposition technique and (ii) Hybrid Microwave Sintering technique to synthesize alloys/micro/nano-composites. He has published over 590 peer reviewed journal papers and owns two US patents and 1 Trade secret. His current h-index is 68, RG index is 48 and citations are greater than 17500. He has also co-authored six books, published by John Wiley, Springer and MRF – USA and edited many others. **He is Editor-in-chief/Editor of twelve international peer reviewed journals.** In 2018 he was announced **World Academy Championship Winner** in the area of Biomedical Sciences by International Agency for Standards and Ratings**.** A multiple award winner, he actively collaborate/visit as invited researcher, visiting and chair professor in Japan, France, Saudi Arabia, Qatar, China, USA and India.

Warren J. Poole

Warren J. Poole is the professor in University of British Columbia, the Canada Research Chair in in Through Process Modelling of Advanced Structural Materials (Tier 1) and Rio Tinto Aluminium Chair in Materials Process Engineering. He was the former department Head of the University of British Columbia. He did his BEng in University of Western Ontario in 1987 and got his Ph.D in McMaster University in 1993. In 1993-1994 he worked as Post Doctoral Fellow in the University of Cambridge, UK. To his credit are: (i) Deformation and fracture of metals, physical metallurgy of light alloys, (ii) microstructure engineering of materials, mechanical testing of materials, (iii) advanced characterization of materials (electron microscopy, diffraction techniques). He has published more than 200 papers in multiple international peer reviewed journals and conference papers in the past 6 years. He was honored with 2017 Dean's Medal of Distinction and 2017 Acta Materialia Holloman Award for Materials and Society in 2017. He was also endowed with multiple Best Paper and Poster Awards in 37 lifetime conference and 38 invited conference presentations in the past 5 years.

Program

Plenary Presentation

Friday 20 Nov 2020	
16:00-16:30	Welcome & Introduction ***Chair: Yuansheng Yang***
Session 1	***Chairs: Yuansheng Yang , Shinji Ando***
16:30-17:10	Recent development of nanostructured magnesium alloys: concept, processing, properties and applications **Jian Lu** *City University of Hong Kong, China*
17:10-17:50	The Effect of Alloying on Ductility of magnesium alloys **Wenjiang Ding, Xiaoqin Zeng** *Shanghai Jiao Tong University, China*
17:50-18:30	Review of recent research on Mg alloys with low corrosion rates **Andrej Atrens** *The University of Queensland, Australia*
18:30-19:30	Break, Dinner
Session 2	***Chairs: Mingxing Zhang, Bin Jiang***
19:30-20:10	Method to lightweight-the lightweight magnesium for mitigating enviromental damage **Manoj Gupta** *National University of Singapore, Singapore*
20:10-20:50	Magnesium Technology Development: Opportunities and Challenges **Alan Luo** *Ohio State University, USA*
20:50-21:30	Magnesium as an Energy Storage Material **Maximilian Fichtner** *Helmholtz-Institute Ulm (HIU) , Germany*
21:30-21:40	Break

Session 3	***Chairs: Yuanding Huang, Wenbo Du***
21:40-22:20	Mg-Alloys Are Self-Grain Refining **Zhongyun Fan** *Brunel University London, UK*
22:20-23:00	Application of Instrumented Indentation to Develop Mg alloys **Warren J. Poole** *University of British Columbia, Canada*
Saturday 21 Nov 2020	
Session 4	***Chairs: Mikhail L. Zheludkevich, Guohua Wu***
16:00-16:40	Heterostructured Material: New Science Produces Superior Properties **Yuntian Zhu** *City University of Hong Kong, Hong Kong, China*
16:40-17:20	Corrosion and control techniques for magnesium alloys **Enhou Han** *Institute of Metal Research, Chinese Academy of Sciences*
Sunday 22 Nov 2020	
Session 5	***Chairs: Mark Easton, Xianhua Chen***
19:30-20:10	Progress in the development of high quality magnesium alloys for structural and functional applications **Karl Ulrich Kainer** *Chair of Light Elements Engineering, Foundry and Automation, Wroclaw University of Science and Technology, Poland* *Helmholtz-Zentrum Geesthacht, Magnesium Innovation Centre, Germany*
20:10-20:50	Some aspects of the ductile failure of magnesium alloys **Matthew R. Barnett** *Deakin University, Australia*
20:50-21:30	Magnesium Research and Development in Korea **Kwang Seon Shin** *Seoul National University, Korea*
Session 6	***Chair: Xiaodong Peng***
21:30-22:00	Award Ceremony (International Mg Sci & Tech Award, Best Poster Award)
22:00-22:30	Closing Ceremony

Parallel Oral Presentation

Saturday 21 Nov 2020	
Wrought Alloys ***Session 1&2***	
Session 1	***Chairs: Bin Jiang, Zhimin Zhang***
18:20-18:40 Keynote	High Formability Mg Alloy Plate and Its Novel Process **Bin Jiang** *Chongqing University, China*
18:40-19:00 Keynote	Uniform strengthening and toughening forming technology of large thin walled magnesium alloy structural parts with inner ring rib **Zhimin Zhang, Jianmin Yu** *North university of China, China*
19:00-19:20 Keynote	The microstructure, properties and performance of Mg-Al-RE alloys **[1]Mark Easton, [1]Suming Zhu, [2]Trevor Abbott, [1]Hua Qian Ang, [3]Kazuhiro Nogita, [4]Jian-Feng Nie, [1]Dong Qiu** *[1]RMIT University, [2]Magontec Ltd, [3]University of Queensland, [4]Monash University, Australia*
19:20-19:40 Invited	Texture effect on grain boundary strengthening in HCP metals **Yunchang Xin** *Nanjing Tech University, China*
19:40-20:00 Invited	Strengthening mechanism of precipitates in Mg-RE alloys: A first-principles study Yanlin Guo, Qun Luo, **Qian Li** *Shanghai University, China*
20:00-20:20 Invited	Highly deformable Mg-Al-Ca alloy with Al2Ca precipitates **Gaoming Zhu, Leyun Wang, Jie Wang, Jian Wang, Jun-Sang Park, 1iaoqin Zeng** *Shanghai Jiao Tong University, China*
20:20-20:35	Coupled Crystal Plasticity Finite Element-Phase Field Model with Kinetics-controlled Twinning Mechanism for Hexagonal Metals **Guisen Liu, Hanxuan Mo, Jian Wang, Yao Shen** *Shanghai Jiao Tong University, China*
Session 2	***Chairs: Rongshi Chen, Tianjiao Luo***
20:40-21:00 Keynote	Mg alloys: Shifting structural materials to structured catalysts **Gaowu Qin** *Northeastern University, China*

21:00-21:20 Keynote	Formation mechanism of typical texture in magnesium alloys **Rongshi Chen, Hong Yan, Lingyu Zhao, Mingguang Jiang** *Institute of Metal Research, Chinese Academy of Sciences*
21:20-21:40 Invited	Revealing the role of bimodal grain structure in the strength-ductility synergy of wrought Mg-RE alloy **Chao Xu** *Harbin Institute of Technology, China*
21:40-22:00 Invited	Effect of Pulsed Magnetic Field on the Residual Stress of Rolled Magnium Alloy AZ31 Sheet **Tianjiao Luo, Meng Yan, Yuansheng Yang** *Institute of Metal Research, Chinese Academy of Sciences*
22:00-22:20 Invited	Development of high performance wrought Mg based alloys via caliber rolling **Hui Yu, S.J. Meng, J.H. Feng, W. Yu, F.X. Yin, J.X. Zhang** *Hebei University of Technology, China*
22:20-22:40 Invited	{1012} twinning nucleation in magnesium assisted by alternative sweeping of partial dislocations via an intermediate precursor **Zhen Zhang** *Hefei University of Technology , China*
22:40-23:00 Invited	Basal slip mediated tension twin variant selection in magnesium WE43 alloy **Dikai Guan, Mark Rainforth** *The University of Sheffield, UK*
Cast Alloys *Session 1&2*	
Session 1	***Chairs: Yuansheng Yang, Qiang Yang***
18:20-18:40 Keynote	Development of cost-effective creep-resistant Mg-Gd-Ca based cast magnesium alloys **Mingxing Zhang** *The University of Queensland, Australia*
18:40-19:00 Keynote	Solidification behavior and cast abilities of microalloyed magnesium alloys **Yuansheng Yang** *Institute of Metal Research, Chinese Academy of Sciences*
19:00-19:20 Invited	Ultrasonic melt treatment and its influence on microstructure and properties of Mg alloys **Qichi Le, Xingrui Chen** *Northeastern University, China*
19:20-19:40 Invited	Research on Hot Cracking Behavior of Magnesium Alloy **Feng Wang, Zheng Liu** *Shenyang University of Technology, China*
19:40-20:00	Grain refinement in laser surface remelted Mg alloys

Invited	**Dong Qiu** *RMIT University，Australia*
20:00-20:15	Intermetallic phase and phase transformation in high-pressure die casting Mg-Al-RE based alloys **Qiang Yang, Xin Qiu, Shuhui Lv** *Changchun Institute of Applied Chemistry, China*
20:15-20:30	Thermal analysis during solidification of Mg-xLi-Al alloy **Ruihong Li** *Inner Mongolia University of Science &Technology, China*
Session 2	***Chairs: Liming Peng, Yuhong Zhao***
20:40-21:00 Keynote	Creep properties of cast Mg-Y-Ca-Zr alloys **Sihang You, Yuanding Huang, Karl Kainer, Norbert Hort** *Helmholtz-Zentrum Geesthacht, Germany*
21:00-21:20 Keynote	Research progress on additive manufacturing of magnesium alloys **Qingchen Deng， Yujuan Wu, Liming Peng, Penghuai Fu, Wenjiang Ding** *National Engineering Research Center of Light Alloy Net Forming and State Key Laboratory of Metal Matrix Composites, School of Materials Science and Engineering, Shanghai JiaoTong University, China*
21:20-21:40 Invited	Phase-field crystal simulation for the dislocations on GBs during solidification **Yuhong Zhao** *North University of China*
21:40-22:00 Invited	Grain refinement and integrated computation of casting process microstructure- property of magnesium alloys **Hai Hao, Wenxue Fan, Xingyang Chang** *Dalian University of Technology, China*
22:00-22:20 Invited	Preliminary investigation of microstructure and corrosion behaviours of magnesium WE43 alloy manufactured by selective laser melting **Zhuoran Zeng** *Australian National University, Australia*
22:20-22:40 Invited	Al8Mn5 settling and clustering on oxides in liquid AZ91 **Chris Gourlay, Liuqing Peng, Guang Zeng, Te-Cheng Su, Kazuhiro Nogita, Hideyuki Yasuda** *Imperial College London, UK*
22:40-23:00 Invited	Effects of Substance of Zn with Co, Ni and Co/Ni on Microstructures and Mechanical Properties of LPSO Dominant Mg-Y-Zn Alloys **Jonghyun Kim, Heng Xue, Hongxin Liao, Wang Fengxue, Kong Kong qingzhi** *Chongqing University, China*

Processing	***Session 1&2***
Session 1	***Chairs: Guosong Wu, Baodong Shi***
18:20-18:40 Invited	Mathematical analysis and its experimental comparisons on Mg-Li alloy for accumulative roll bonding (ARB) process **Rui Zhi Wu** *Harbin Engineering University, China*
18:40-19:00 Invited	Evaluating the orientation relationship of prismatic precipitates generated by detwinning in Mg alloys **Feiya Liu, Renlong Xin, Ming-Xing Zhang, María Teresa Pérez-Prado, Qing Liu** *Chongqing University, China*
19:00-19:20 Invited	Microstructure characteristics of AZ80 magnesium alloy under rotating backward extrusion with open punches **Qiang Wang, Xin Che, Jian-min Yu, Zhi-min Zhang** *Engineering Technology Research Center for Integrated Precision Forming of Shanxi Province, North University of China, China*
19:20-19:40 Invited	Self-layered hydrothermal coating for corrosion mitigation and surface functionalization of magnesium alloys **Guosong Wu** *Hohai University, China*
19:40-20:00 Invited	Numerical Investigations on the Anisotropy of AZ31 Alloy by Evolution of Yield Functions **Baodong Shi, Chong Yang, Yan Peng** *Yanshan University, China*
20:00-20:20 Invited	Fabrication of high-strength magnesium alloy tubes through porthole die extrusion **Shengwen Bai, Bin Jiang, Fusheng Pan** *CCMg, College of Materials Science and Engineering, Chongqing University, China*
20:20-20:35	Optimization of Microstructure, Mechanical Properties and Degradation Behavior of a Degradable Orthopaedic Mg-Zn-Y-Nd Alloy **Beining Du, Liyuan Sheng, Yufeng Zheng, Tingfei Xi** *Peking University, China*
Session 2	***Chairs: Lifeng Ma, Hongyang Zhao***
20:40-21:00 Invited	Deformation mechanism analysis of ZK60 magnesium alloy during radial forging process: mathematical modeling and experimental discussion **Lifeng Ma, Jingfeng Zou** *Taiyuan University of Science and Technology, China*
21:00-21:20 Invited	Frabication thechnolgy and the forming mechanism of thin foil of magnesium alloys with tensile rolling **Hongyang Zhao**

	University of Science and Technology Liaoning, China
21:20-21:40 Invited	Preparation and Mechanical Properties of bimodal AZ91 Alloy **Jianfeng Fan** *Taiyuan University of Technology, China*
21:40-22:00 Invited	Processing of biodegradable magnesium alloy microtubes for vascular stent **Shijie Zhu** *Zhengzhou University, China*
22:00-22:15	Laser cleaning pretreatment on the welding of magnesium and Steel **Dan Wang, Juming Gao, Xinyan Li, Wenbin Wang** *Jiangsu University, China*
22:15-22:30	Mechanical properties, microstructures and deformation mechanisms in several Mg-Li alloys fabricated by different approaches **Furong Cao** *Northeastern University, China*
22:30-22:45	In-situ hybrid phase reinforced Mg-based metallic glass matrix Composites **Wei Guo, Shusen Wu** *Huazhong University of Science and Technology, China*
Performance & Application ***Session 1&2***	
Session 1	***Chairs: Zhiwei Shan, Norman Chen***
18:20-18:40 Keynote	The importance of magnesium purification and our recent research achievement **Zhiwei Shan** *Xi'an Jiaotong University, China*
18:40-19:00 Keynote	Effect of Gradient Nanostructure on Microstructure and Mechanical Properties of AZ31 Magnesium Alloy **Meng Duan, Minghang Zhou, Yong Liu** *Nanchang University, China*
19:00-19:20 Keynote	Application development of highly thermal conductive Mg alloy in diecasting for consumer electronics industry **Norman Chen** *Ka Shui Metal Manufacturing Co., Ltd.*
19:20-19:40 Keynote	An Outlook for High-Volume Application of Magnesium Road Wheel **Jianfeng Wang, Henry Zhan** *General Motors, China*
19:40-20:00 Invited	Development of new flame-retardant wrought magnesium alloys and application of the alloys to high-speed railway body **Yasumasa Chino, Kazunori Shimizu, Futoshi Kido, Takeshi Ishikawa, Makoto Taguchi,**

	Takao Horiya *National Institute of Advanced Industrial Science and Technology, Japan*
20:00-20:20 Invited	International Standardization for Magnesium and Magnesium Alloys industry **Huan Xi** *Nonferrous metal technology and Economic Research Institute Co., Ltd*
20:20-20:40 Invited	Theoretical Research, Technical Development and Engineering Application of New Magnesium Smelting Process **Jinhui Liu, Shaojun Zhang** *Zhengzhou University, China*
Session 2	***Chairs: Xiaojun Wang , Lili Tan***
20:50-21:10 Keynote	Hydrogen storage and hydrolysis properties of core-shell structured Mg based nanocomposites **Jianxin Zou** *Shanghai Jiaotong University, China*
21:10-21:30 Keynote	Novel Magnesium Extrusion Alloy Developed for Aerospace Applications **Scott Sutton** *Mag Specialties Inc, USA*
21:30-21:50 Invited	Carbon Nanomaterials Reinforced Mg Matrix Composites **Xiaojun Wang** *Harbin Institute of Technology, China*
21:50-22:10 Invited	The development of biodegradable magnesium alloys and their application: challenge and chance **Lili Tan** *Institute of Metal Research, Chinese Academy of Sciences*
22:10-22:30 Invited	Work hardening and softening behavior of Mg-5Zn matrix influenced by particle deformation zone **Kunkun Deng, Q.X Shi, K.B. Nie, W.M. Gan, W. Liang** *Taiyuan University of Technology, China*
22:30-22:50 Invited	On a nanoscale phase in as-extruded Mg-Gd-Li based alloys **Zijian Yu, Ke Liu, Shubo Li, Wenbo Du** *Beijing university of technology, China*

Sunday 22 Nov 2020	
Wrought Alloys *Session 3*	
Session 3	***Chairs: Hucheng Pan, Xiao-Zhi Tang***
15:00-15:20 Keynote	Interaction between basal and non-basal dislocations in pure magnesium single crystals **Shinji Ando, Yuta Ishikura, Takuya Nakahara, Masayuki Tsushida, Hiromoto Kitahara** *Kumamoto University, Japan*
15:20-15:40 Keynote	Microstructure and deformation behavior of ultrahigh strength of Mg-Y-Ni alloys containing LPSO phase **Zhikang Ji, Li Li, Xiaoguang Qiao, Mingyi Zheng** *Harbin Institute of Technology, China*
15:40-16:00 Keynote	Examination of the characteristic deformation behavior of lamellar structured Mg-based eutectic alloys, compared to the LPSO phase **Koji Hagihara** *Osaka university, Japan*
16:00-16:20 Invited	Three dimensional twin growth and twin-twin interactions in Magnesium **Yue Liu** *Shanghai Jiao Tong University, China*
16:20-16:40 Invited	Newly developed low-cost Mg wrought alloys **Hucheng Pan** *Northeastern University, China*
16:40-17:00 Invited	Bimodal microstructure with balanced texture-a strategy for achieving strength-ductility synergy in Mg-Al-Zn alloys **Min Zha, Huiyuan Wang** *Jilin University, China*
17:00-17:15	Dynamic recrystallization and dynamic precipitation in the hot extruded Mg89Y4Zn2Li5 alloy **[1]Wei Liu, [1]Ruopeng Lu, [1]Liwen Chen , [1]Hua Hou, [1]Yuhong Zhao, [2]Jinshan Zhang, [3]Yuman Zhu** *[1]North University of China, China; [2]Taiyuan University of Technology, China; [3]Monash University, Austrilia*
17:15-17:30	Grain boundary (co-)segregation and texture modification in magnesium alloys with multiple substitutional elements **Risheng Pei, Talal Al-Samman** *RWTH-Aachen University, Germany*
17:30-17:45	The engulfment of precipitate by extension twinning in Mg–Al Alloy **Xiao-Zhi Tang, Ya-Fang Guo** *Beijing Jiaotong University, China*

17:45-18:00	The effects of deformation parameters and cooling rates on ageing behaviour of AZ80+0.4%Ce **Yongbiao Yang, Cuiying Wang, TingYan Zhang, Qingfeng Qin, Zhimin Zhang, Qiang Wang, Guojun Li** *North University of China, China*
Modelling &Simulation *Session 1*	
Session 1	***Chairs: Lijun Zhang, Jiangfeng Song***
15:00-15:20 Keynote	CALTPP: A general program to calculate thermophysical properties **Yong Du** *State Key Lab of Powder Metallurgy, Central South University, China*
15:20-15:40 Keynote	A New Constitutive Model for Thermal Deformation of Magnesium Alloys and Its Application **Jian Zeng, Jie Dong** *Shanghai Jiaotong University, China*
15:40-16:00 Invited	Numerical and experimental investigation into crystal plasticity behaviors of extruded magnesium alloy **Gang Fang, Baili Xi** *Tsinghua University, China*
16:00-16:20 Invited	Development of ICME framework for Mg alloys and its application **Lijun Zhang** *Central South University, China*
16:20-16:40 Invited	Modeling of dendrite growth and gas porosity evolution under convection in magnesium alloys **Ang Zhang, Bin Jiang, Fusheng Pan** *Chongqing University, China*
16:40-17:00 Invited	Effect of surface defects on the corrosion behaviour of AZ80 alloy with CPCC coating **Jiangfeng Song** *Chongqing University, China*
17:00-17:20 Invited	Investigation of corrosion resistance of Mg-based alloys based on thermodynamic calculations **Shuhong Liu, Hui Feng, Seng Yao, Xiaojing Li, Yong Du** *Central South University, China*
17:20-17:35	Augmented thermodynamic database for magnesium alloys **Hai-Lin Chen, Qing Chen** *Thermo-Calc Software, Sweden*
17:35-17:50	In-situ experimental observation and kinetic numerical inversion of the diffusion growth of multiple intermetallic compounds in Mg-Al-Zn system **Kaiming Cheng, Jixue Zhou, Jiaxing Sun, Jin Wang, Huixia Xu, Chengwei Zhan** *University of Technology (Shandong Academy of Sciences), China*

17:50-18:05	Molecular dynamics study on the effect of temperature on generalized stacking fault energy in magnesium alloys **Yuye Wang, Yuling Xu, Aitao Tang** *Chongqing University, China*

Corrosion & Protection *Session 1*

Session 1	***Chairs: Tao Zhang, Jixue Zhou***
15:00-15:20 Keynote	Suppressing self-corrosion of Mg anodes via synergistic inhibition **Mikhail L. Zheludkevich** *Helmholtz-Zentrum Geesthacht, Germany*
15:20-15:40 Keynote	Exfoliation corrosion of magnesium alloys **Rong-Chang Zeng, Gui-Jia Gao, Zi-You Ding** *Shandong University of Science and Technology, China*
15:40-16:00 Keynote	Ratio of total acidity to pH value of coating bath: A new strategy towards phosphate conversion coatings with optimized corrosion resistance for magnesium alloys **Tao Zhang, Fuhui Wang, Peng Zhou** *Northeastern University, China*
16:00-16:20 Keynote	Ignition behavior of microarc oxidation coating sealed with aluminum phosphate applied on AZ91D alloy **Dong Han, Jin Zhang, Yong Lian** *University of Science and Technology Beijing, China*
16:20-16:40 Invited	Synergistic Coating Strategy Combining Photodynamic Therapy and Fluoride-Free Superhydrophobicity for Eradicating Bacterial Adhesion and Reinforcing Corrosion Protection **Xiaobo Chen, Wei Wang, Yong Fan, Ivan Cole, Mingshi Song** *RMIT University, Australia; Jilin University, China*
16:40-17:00 Invited	Effect of grain size and orientation on the corrosion behavior of an extruded dilute Mg-0.5Bi-0.5Zn-0.5Sn alloy **Weili Cheng, Yang Liu, Yanhui Liu** *Taiyuan University of Technology, China*
17:00-17:20 Invited	Effects of lattice constants on MgO wettability and its relationship with corrosion of magnesium alloys: A molecular dynamics study **Chi Zhang, Xin Li, Junsheng Wang** *Beijing Institute of Technology, China*
17:20-17:40 Invited	Overall micro-arc oxidation treatment for magnesium–aluminium dissimilar metal connecting parts **Jixue Zhou** *Advanced Materials Institute, Shandong Academy of Sciences, China*
17:40-18:00 Invited	Simultaneously improving corrosion resistance and mechanical properties of a magnesium alloy via equal-channel angular pressing and post water annealing **Dan Song, Jinghua Jiang, Aibin Ma, Xiaolong Ma** *Hohai University, China*

Performance & Application *Session 3*	
Session 3	***Chairs: Xianhua Chen, Yan Yang***
15:00-15:20 Keynote	Microstructure and properties of high-strength Mg-Zn-Y-Ce-Zr alloy with low RE content **Xianhua Chen** *Chongqing University, China*
15:20-15:40 Keynote	Advances in the research on magnesium alloys for biomedical applications **Yufeng Zheng** Peking University，China
15:40-16:00 Keynote	New Mg-Zr-Sr-Sc alloys for biodegradable implant material Applications **Khurram Munir, Jixing Lin, Paul Wright, Yuncang Li, Cuie Wen** *RMIT University, Australia*
16:00-16:20 Invited	Development and issue of Mg and Mg alloy production in China and the life cycle assessment **Zisheng Zhen** *Magontec Xian Co. Ltd.,China*
16:20-16:40 Invited	Study on microstructure and properties of modified AZ80 high yield strength magnesium alloy **Gaofeng Quan, Yangyang Guo, Lingling Fan, Yuwenxi Zhang** *Southwest Jiaotong University, Sichuan, China*
16:40-17:00 Invited	Research Progress on Duplex Structured Mg-Li-X Alloys **Yan Yang** *Chongqing University, China*
17:00-17:15	Enhanced mechanical and thermal properties of grapheme nanoplatelets reinforced Mg-Zn-Zr alloy **Xian Du, Wenbo Du, Zhaohui Wang** *Beijing University of Technology, China*
17:15-17:30	The mechanical, triboligical and damping campacity of Ti2AlC reinforced Mg composite **Wenbo Yu, Xufeng Pi, Antoine Guitton** *Beijing Jiaotong University, China*
17:30-17:45	Causes for abnormal electrode in pipeline magnesium electrolysis and its control **Fuxing Zhu, Liang Li, Shangrun Ma, Kehui Qiu** *Chengdu University of Technology, China*
17:45-18:00	Potentiostatic Growth of Hazenite Mineral Coating on AZ31 Magnesium Alloy and Its Degradation Performance **Liping Wu** *Institute of Metal Research, Chinese Academy of Sciences, China*

Forums

Saturday 21 Nov 2020	
Forum on Lightweight	
Session 1	***Chairs: Michael North, Yuansheng Yang***
9:00 - 9:30	Business Investment Strategies for the Growth of the Global Magnesium Industry **Michael North** Chairman, Galaxy Trade and Technology, USA
9:30 - 10:00	Magnesium Optimization Strategies for the Automotive Industry **Dan Panoz** President of Galaxy Motion, USA
10:00-10:15	The role of Competitive Motorsports in Stimulating the Adoption of Magnesium **Greg Gill** President of SRO Motorsports America, USA
10:15-10:45	*****TBA***** **Allight** USA
10:45-11:00	IMA Supports the Global Growth of Magnesium Industry **Rick McQueary** President of IMA, USA
11:00-11:15	*****TBA***** **Roger Epstein** CFO of Galaxy, USA
11:15-11:30	Global Market Strategies for Magnesium **Matt Lorin** Vice President of Galaxy, USA
11:30-11:35	**Signing Ceremony** Galaxy & Institute of Metal Research, Chinese Academy of Sciences
11:35-12:05	Q&A

Saturday 21 Nov 2020	
Forum on Frontier Technology	
	Chairs: Yuansheng Yang, Liming Peng, Zhiwei Shan
19:00-19:30	Application of pure magnesium implants **Lugee Li** Dongguan Eontec Co., Ltd
19:30-20:30	Preliminary Research on Hydrogen-Chromic Magnesium-Based Thin Films **Liming Peng** Shanghai Jiaotong University, China
20:30-21:00	*****TBA***** **Bin Jiang** Chongqing University, China
21:00-21:30	The importance of magnesium purification **Zhiwei Shan** Xi'an Jiaotong University, China
21:30-22:00	Research progess on Mg-based chargable battery **Jianxin Zou** Shanghai Jiaotong University, China
Sunday 22 Nov 2020	
Forum on Industry-Academy Cooperation	
Session 2	***Chairs: Xiaofang Zhou，Qiuyan Huang***
9:00-9:30	China's Leadership Role in the Magnesium Industry **Xiaofang Zhou** Vice Chairman of Galaxy, USA
9:30-10:00	*****TBA***** **Zhou Junhu** CEO of Shaanxi Yulin Magnesium Group, China
10:00-10:30	*****TBA***** **Zheng Songyuan** Vice President of Shenzhen Sea Energy, China

10:30-11:00	*****TBA***** **Dong Yuming** CEO of Galaxy China (Yulin) Technology and Trade LLC, China
11:00-11:05	**Singing Ceremony** Galaxy & Shaanxi Yulin Magnesium Galaxy & Shenzhen Sea Energy Shanxi Regal Advanced Material Co.,Ltd & Institute of Metal Research, CAS
11:10-11:40	Q&A

Poster Presentation

Sunday, 22 Nov 2020

P1 **In-situ TEM investigation on pyramidal dislocation slip in Mg. Fei Liu, Bo Yu Liu, Zhi Wei Shan.** Xi'an Jiaotong University, China

P2 **Hot Tearing Behavior in Double Ternary Eutectic Alloy System: Mg-Ce-Al Alloys. Bo Hu, Dejiang Li, Jingya Wang, Zixin Li, Xueyang Wang, Xiaoqin Zeng**. Shanghai Jiao Tong University, China

P3 **Correlation of 3D defect-band morphologies and mechanical properties in high pressure die casting magnesium alloy. Wenbo Yu, Chaosheng Ma, Yihu Ma, Shoumei Xiong.** Beijing Jiaotong University, China

P4 **Tailoring the texture through twinning and its effect on the dynamic compressive mechanical behavior of ZK61 magnesium alloy. Abdul Malik.** Beijing Institute of Technology, China

P5 **Development of wrought Mg-Gd-Er-Zn-Zr alloy with excellent strength-ductility balance. Linyue Jia, Wenbo Du, Zhaohui Wang, Ke Liu, Shubo Li, Xian Du.** Beijing University of Technology, China

P6 **Texture evolution and LPSO kinking of Mg-Gd-Y-Zn-Zr alloy under combined compression-torsion processing. Ce Zheng, Ming Cheng, Shuaifeng Chen, Shi-Hong Zhang.** Institute of Metal Research, China

P7 **The specific role of Yb content on the microstructure mechanical properties of cast Mg-9Gd-0.5Zn-0.5Zr alloy. He Xie.** Shanghai Jiao Tong University, China

P8 **Research on Continuous Variable Channel Extrusion-Shear Forming Process of AZ31 Magnesium Alloy Thin-walled Tube. Songlin Gan, Hongjun Hu.** Chongqing University of Technology, China

P9 **Thermodynamic prediction of thermal conductivity in Mg-La/Ce-Zn system. Xie TianCi, Shi Hui, Luo Qun, Li Qian.** Shanghai University, China

P10 **Coupled CA-FE Simulation for Dynamic Recrystallization of Magnesium Alloy during Hot Extrusion. Yuying He, Gang Fang.** Tsinghua University, China

P11 **Quasi-in-situ observations of twins, nuclei orientation and texture evolution during continuous annealing in a cold-rolled Mg-Zn-Gd alloy. Lingyu Zhao, Hong Yan, Rongshi Chen, En-hou Han.** Institute of Metal Research, Chinese Academy of Sciences

P12 **Mg-Mn extrusion alloys with superior ductility at room temperature. Chongchao Li, Zihan Xia, Xiaoguang Qiao, Mingyi Zheng.** Harbin Institute of Technology, China

P13 **Study on Microstructure and Corrosion Properties of Biodegradable Mg-Zn-Mn-Ca Alloys. Junjian FU, Wenbo Du, Zhaohui Wang, Ke Liu, Shuobo Li, Xian Du**. Beijing University of Technology, China

P14 **Microstructure and tensile properties of Al/Cu dissimilar alloy joint via electromagnetic pulse welding. Puquan wang[1], Xianquan Jiang[2].** [1] College of Engineering and Technology ,[2] College of Materials and Energy, Southwest University, China

P15 **Mechanical properties and annealing behavior of rolled MgY1Zn0.85 sheets fabricated by twin roll casting and direct chilling casting .Xiaorui X iaorui Dong, Hui Yu.** Hebei University of Technology, China

P16 **Accurate thermodynamic description for Mg-Al-Zn-Sn quaternary system and its application to composition design of Sn-modified AZ91 alloys. Ting Ting Cheng, Lijun Zhang.** Central South University, China

P17 **Effect of Y on Microstructural Evolution and Mechanical Properties of Mg-13Li-3Al Alloy.** Xiaojing Su, Jing Guo, Li Li Chang. Shandong University, China

P18 **Research on Microstructure and Mechanical Properties of Magnesium Alloy Produced by Cyclic Expansion Extrusion with an Asymmetrical Extrusion Cavity. Jie Zheng, Zhaoming Yan, Zhimin Zhang, Qiang Wang, Yong Xue.** North university of china, China

P19 **Preparation Technology and Properties of Graphene Nanoplatelets/ AZ91D Magnesium Matrix Composites Using Thixomolding Process. Liwen Chen, Yuhong Zhao, Muxi Li, Limin Li, Hua Hou.** North University of China, China

P20 **Effect of Al addition on the age hardening behavior of as-extruded Mg-Sn-Ca alloys. Yang Liu, Jianguang Feng, Yi Zhang, Qiuyan Huang.** Institute of Metal Research, Chinese Academy of Sciences, China

P21 **Effect of cooling rate on the microstructure and microsegregation in sub-rapidly solidified Mg-6Al-4Zn-1.2Sn magnesium alloy. Jie Cui, Tiaojiao Luo, Cong Wang, Yingju Li, Xiaohui Feng, Qiuyan Huang, Yuansheng Yang.** Institute of Metal Research, Chinese Academy of Sciences, China

P22 **Corrosion properties and mechanism of three directionally solidified Mg-Zn-Ca alloys. [1]Yi Zhang, [1]Xiaohui Feng, [1]Qiuyan Huang, [2]Xuehui Hao, [2]Changzheng Wang, [1]Yuansheng Yang.** [1]Institute of Metal Research, Chinese Academy of Sciences, [2]School of Materials Science and Engineering, Liaocheng University, China

P23 **Numerical simulation of low-pressure die casting of ZA81M magnesium Alloy Wheel Hub. Jianguang Feng, Tianjiao**

Luo, Yuansheng Yang. Institute of Metal Research, Chinese Academy of Sciences.

P24 **The dynamic recrystallization and mechanical properties response during hot screw rolling on pre-aged ZM61 magnesium alloys. [1]Wang Lifei, [2]Hua Zhang, [3]Kwang Seon Shin.** *[1]Taiyuan University of Technology, [2]Yantai University, [3]Seoul National University, China*

P25 **Hot deformation behavior and microstructure evolution of dualphase Mg-9Li alloys. Guo Li, Guobing Wei.** Chongqing University, China

P26 **A novel Mg-6Bi-3Al-1Zn alloy with excellent mechanical properties. [1]Shuaiju Meng, [2]Tianshui Zhou, [2]Qianqian Li, [3]Hui Yu, [4]Young Min Kim, [4]Bong Sun You.** [1]State Key Laboratory of Advanced Processing and Recycling of Nonferrous Metals, Lanzhou University of Technology, [2]School of Materials Science and Engineering, Lanzhou University of Technology, [3]School of Materials Science and Engineering, Hebei University of Technology, [4]Magnesium Department, Korea Institute of Materials Science, China

P27 **Influence of texture on Hall-Petch relationships in an hot-extruded AZ31 magnesium alloy. ling wang.** Ying Kou Institute of Technology, China

P28 **The mechanical anisotropy and deformation mechanism of extruded Mg-2Zn-0.4Ce-0.4Mn alloy tube. Dandan Li, Qichi Le, Xiaoqiang Li, Ping Wang,** Northeastern University, China

P29 **The high strength and plasticity Mg-Li alloy reinforced by Al3La phase formed in-situ through submicron La2O3 particle. Xiaoqiang Li.** Northeastern University, China

P30 **Influence of Long-Period-Stacking Ordered Structure on the Damping Capacities and Mechanical Properties of Mg-Zn-Y-Mn As-cast Alloys. Lu ruopeng, Kai Jiao, Yuhong Zhao, Hua Hou.** College of Materials Science and Engineering, North University of China, China

P31 **Notch tensile behavior of a cast Mg-Gd-Y-Zr alloy. Jianxiong Wei, Hong Yan, Rongshi Chen.** Institute of Metal Research, Chinese Academy of Sciences, China

P32 **Precipitation behaviors and mechanical properties of Mg-Zn-Cu-Zr alloys. Ye Zhou, Pingli Mao, Le Zhou, Zhi Wang, Feng Wang, Zheng Liu.** Shenyang University of Technology, China

P33 **Microstructure and fracture toughness of Mg-9Gd-4Y-1Zn-0.5Zr alloy containing LPSO phase. Zhikang Ji, Li Li, Xiaoguang Qiao, Mingyi Zheng.** Harbin Institute of Technology, China

P34 **Microstructure and mechanical properties of extruded Mg-2Zn-0.3Gd alloy pipes. Xihai Li, Rongshi Chen.** Institute of Metal Research, Chinese Academy of Sciences, China

P35 **Investigation on strain hardening behavior of AZ31B magnesium alloy subjected to various friction stir welding methods. Ruonan Feng.** College of Mechanical and Electrical Engineering, Hohai University, China

P36 **Enhanced mechanical** properties **and degradability of hollow microsphere/Mg alloy composite by adding nickel particle for degradable fracturing tool application. Lin Liu, Sirong Yu, Enyang Liu, Yafeng Niu, Xiaojian Bi.** School of Materials Science and Engineering, China University of Petroleum (East China), China

P37 **Influence of CaF_2 on extraction magnesium by prefabricated pellets in flowing argon. Junhua Guo, Daxue Fu, Jibiao Han, Yaosong Wang, Tingan Zhang.** Northeastern University, China

P38 **Condensation behavior of magnesium vapor in vacuum by Pidgeon process. Jibiao Han, Zonghui Ji, Daxue Fu, Junhua Guo, Zhihe Dou, Ting'an Zhang.** Northeast University, China

P39 **Variation of microstructure and mechanical properties of ZW61 magnesium alloy solidified under 800MPa. Shusen Wu, Jing Wang, Xiaogang Fang, Shulin Lv, Wei Guo.** Huazhong University of Science and Technology, China

P40 **Dynamic Tension-Compression Asymmetry and Microstructure Evolution of Extruded EW75 Magnesium Alloy at High Strain Rates. Jincheng Yu.** Wuxi Institute of Technology, China

P41 **3D image reconstruction of dislocations in submicron magnesium. Jing Xiao, Fei Liu, Bo Yu Liu, Zhi Wei Shan.** Xi'an Jiaotong University, China

P42 **Atomic-scale three-dimensional structural characterization of twin interface in Mg alloys. Lei Li.** Nanjing University of Science and Technology, China

P43 **Effects of strain rate on the dynamic recrystallization behavior and hot formability of basal-textured AZ80 alloy. [1]Hongyi Zhan, [2]Zeng Guang, [2]Yingjie Huang, [3]Lixin Huang.** [1]General Motors Company, [2] Central South University, [3]Dicastal

P44 **Orientation dependence in fatigue behavior of magnesium-cerium alloy single crystals. [1]Guojun Lu, [1]Kensuke Miyazaki, [2]Masayuki Tsushida, [3]Hiromoto Kitahara, [4]Shinji Ando.** [1]Graduate School of Science and Technology, Kumamoto University, [2]Faculty of Engineering, Kumamoto University, [3]Institute of Pulsed Power Science, Kumamoto University, [4]Magnesium Research Center, Kumamoto University, Japan

P45 **Comparison of the effects of pre-activators on microstructure and corrosion resistance of phosphate conversion coating on magnesium alloy. [1]Tao Li, [1]Zhongjun Leng, [1]Shifang Wang, [2]Yuansheng Yang, [1]Jixue Zhou, [1]Xitao Wang.** [1]Qilu University of Technology (Shandong Academy of Sciences), [2]Institute of Metal Research, Chinese Academy of Sciences, China

P46 **Ignition behavior of microarc oxidation coating sealed with aluminum phosphate applied on AZ91D alloy. Dong Han, Jin Zhang, Yong Lian.** University of Science and Technology Beijing, China

P47 **Effect of REs (Y, Nd) addition on high temperature oxidation behavior and activation energy of AZ80 alloy. Cheng Chunlong, Ruizhen Guo, Qichi Le, Xiaoqiang Li .** Northeastern University, China

P48 **Study on Extrusion Shear Composite Forming Technology and Microstructure Properties of Al/Mg Bimetals. Ye Tian, Hongjun Hu.** Chongqing University of Technology, China

P49 **A near-isotropic ultrafine-grained Mg-Gd-Ag alloy with high strength-ductility synergy. Bingqian Xu, Jiapeng Sun.** Hohai University, China

P50 **High strength and ductility AZ91 Mg alloy with multi-heterogenous microstructures. Jiapeng Sun.** Hohai University, China

P51 **Fabrication and corrosion properties of the zinc alloy coating on magnesium alloy by hot-dip process. Chenglu Hu, Xiong Zhou, Qichi Le.** Northeastern University, China

P52 **Interfacial dislocations dominated lateral growth of long period stacking ordered phase in Mg alloys. Qianqian Jin[1,2], Xiaohong Zhao[1], Xiuliang Ma[1].** [1]Institute of Metal Research, Chinese Academy of Sciences, [2]Guangxi University of Science and Technology, China

The 7th International Conference on Magnesium

China • November 19-22, 2020

ABSTRACTS OF CONFERENCE

Edited by

Qiuyan Huang, Xiaohui Feng, Yuansheng Yang

Plenary

Session 1, Chairs: Yuansheng Yang, Shinji Ando
Session 2, Chairs: Mingxing Zhang, Bin Jiang
Session 3, Chairs: Yuanding Huang, Wenbo Du
Session 4, Chairs: Mikhail L. Zheludkevich, Guohua Wu
Session 5, Chairs: Mark Easton, Xianhua Chen
Date: 20-22 Nov 2020

Recent development of nanostructured magnesium alloys: concept, processing, properties and applications

Jian LU [1,2]
1. Center for Advanced Structural Materials, Shenzhen Research Institute
2. Department of Mechanical Engineering, City University of Hong Kong

Abstract: The ability to create structural materials of high yield strength and yet high ductility has been a dream for materials scientists for a long time. Magnesium (Mg) alloys are good candidates for applications with requirement of energy saving, taking advantage of their low density. However, the fewer slip systems of the hexagonal - close - packed (hcp) structure restrict ductility of Mg alloys. We will also report our research work on the supra nanostructured magnesium alloys. It is not easy to fabricate materials that exhibit their theoretical 'ideal' strength. Most methods of producing stronger materials are based on controlling defects to impede the motion of dislocations, but such methods have their limitations. For example, industrial single-phase nanocrystalline alloys and single-phase metallic glasses can be very strong, but they typically soften at relatively low strains (less than two per cent) because of, respectively, the reverse Hall–Petch effect and shear-band formation. Here we describe an approach that combines the strengthening benefits of nanocrystallinity with those of amorphization to produce a dual phase material that exhibits near-ideal strength at room temperature and without sample size effects. Our magnesium-alloy system consists of nanocrystalline cores embedded in amorphous glassy shells, and the strength of the resulting dual-phase material is a near-ideal strength. This strength results from the quasi-dislocation-free nanocrystals and the fully relaxed glass shells. The deformation mechanism is dominated by shear-band arrest by the $MgCu_2$ nanocrystals, followed by the multiplication of embryonic shear bands and strain hardening of the nanocrystals. This work demonstrates a way of producing a supra-nanostructure in a controllable manner. Then a hybrid nanostructure concept is presented by combining nano - dual - phase metallic glass (NDP - MG) and gradient nanograin structure in Mg alloys to achieve a higher yield strength (230 MPa, 31% improvement compared with the reference base alloy) and larger ductility (20%, threefold higher than the SMAT - H sample), which breaks the strength–ductility trade - off dilemma. This hybrid nanostructure design provides a general route to render brittle alloys stronger and ductile, especially in hcp systems.
We anticipate numerous applications related to the material's exceptional mechanical properties and other functional properties such as optical propetry, for example as biodegradable implants with excellent wear resistance and lightweight structural for automobile and aerospace industries.. An example of full - color reflective filters for large area applications with potentially unprecedented color saturation and excellent mechanical properties deposited by one - step magnetron sputtering will be presented. This paradigm can pave the way for the efficient fabrication of large area color filtering devices for diverse applications, such as surface decorations, optical components, color display devices, structural color printing, and photovoltaic cells with optimum efficiency.

The effect of alloying on ductility of magnesium alloys

Wenjiang Ding[1,2], **Xiaoqin Zeng**[1,2]
1. School of Materials Science and Engineering, Shanghai Jiao Tong University, China
2. National Engineering Research Center of Light Alloy Net Forming, Shanghai Jiao Tong University, China

Abstract: Mg alloys have been widely used in aerospace, automotive industries and military industry, due to their excellent properties including low density, high specific strength and superior recyclability. However, the main limitation of Mg alloys in the industry applications is the poor ductility and formability, originated from their low-symmetry hexagonal closed packed (hcp) lattice structure and the limited deformation modes activated during the plastic deformation. Basal slip and tensile twin, which possess lower critical resolved shear stress (CRSS), could be easily activated during deformation, whilst pyramidal slip and prismatic slip are strongly suppressed because of high CRSS values, that leads to the low ductility of Mg alloys. The ductility of Mg alloys can be improved by alloying, which could reduce the differences in the CRSS values between weak deformation modes and hard ones, and promote the activation of more slip systems in the plastic deformation. In this work, the effect of alloying on the ductility of Mg alloys were explored through micro-mechanical testing by in-situ single crystal micropillars compression and macro-mechanical testing in polycrystal materials by in-situ 3DXRD. It has been confirmed that the addition of alloying elements (Y, Zn, Ca, Al…) could reduce the CRSS ratio between non-basal slip and basal slip and efficiently improve the ductility of Mg alloys. More slip systems were activated during the plastic deformation, that has been proven by the slip trace analysis in the deformed materials. It provides an effective strategy for design and development the novel high performance Mg alloys.

Review of recent research on Mg alloys with low corrosion rates.

Andrej Atrens [1,2]
1. The University of Queensland, Materials Engineering Division, School of Mechanical & Mining Engineering, Brisbane, Australia
2. The University of Queensland, Centre for Advanced Materials Processing and Manufacturing (AMPAM), Australia

Abstract: Review of the literature confirmed that the intrinsic corrosion rate of high-purity Mg as measured by weight-loss is 0.3 mm/y in a concentrated chloride solution. Atmospheric corrosion of Mg alloys has produced corrosion rates of Mg-Al alloys an order of magnitude lower than the intrinsic corrosion rate of Mg in a concentrated chloride solution of 0.3 mm/y. The only successful strategy to produce a Mg alloy with a corrosion rate in a concentrated chloride solution substantially less than the intrinsic corrosion rate as measured by weight loss of Mg of 0.3 mm/y has been to improve the protectiveness of the corrosion product film.

Some aspects of the ductile failure of magnesium alloys
Matthew R. Barnett
Deakin University, Australia
Abstract: Magnesium alloys often display a lower tensile ductility than aluminium alloys of similar strength. The reason typically given for this observation is the lack of easily activated slip systems in the magnesium hcp structure. Sharp basal textures in wrought alloys are known to exacerbate the problem. The present talk will examine some of the ways of overcoming the challenge with a focus on the mechanisms responsible. The role of texture is well known so more attention will be paid to the role of the crystallographic grain size, which is less understood. It is well known that refining the grain size in magnesium alloys leads to higher levels of tensile ductility. The reasons for this are examined by using X-ray microtomography to characterize void nucleation, growth and linkage during tensile loading. The impact of grain size on void growth is a critical factor. Voids grow more rapidly in coarser grained samples and this accelerates failure. It is also shown that this mechanism does not operate during compression and so in compression, the grain size has no appreciable impact on the strain to failure, all else constant. This enables us to draw some conclusions regarding the role of twinning. Finally, the implications of the findings on bending and forming are explored.

Magnesium Technology Development: Opportunities and Challenges
Alan A. Luo
The Ohio State University, USA
Abstract : This talk will provide an overview of latest developments of magnesium technologies, including alloy development and process innovations for structural lightweighting and biomedical applications. Firstly, a new Mg sheet alloy has achieved a yield strength of 270 MPa, tensile elongation of 30% and Erichsen Index of 7.8 mm, promising room-temperature forming applications. The second example is on a Mg-Zn-Ca based bioresorbable alloy with outstanding mechanical and corrosion properties for biomedical such as skeletal fixation and cardiac stent devices. Both alloys and their thermomechanical processing have been designed and developed using an integrated computational materials engineering (ICME) approach.
Finally, future opportunities and technical challenges with magnesium technology implementation are discussed with examples given in automotive applications.

Magnesium as an Energy Storage Material
Maximilian Fichtner, Zhirong Zhao-Karger
Helmholtz-Institute Ulm, Helmholtzstr. UlmInstitute of anotechnology, Karlsruhe Institute of Technology, Karlsruhe
Abstract: Magnesium has been an attractive element for various energy storage applications, mostly due to its light weight, low toxicity, low cost and good handling and safety properties. It is also the 8th most abundant element in the earth crust and the long-term supply risk is low.
The lecture will review the application of magnesium in H storage and in battery applications, starting with the binary MgH_2 and how it was enabled as H storage material since the 1980´s. In early studies, it was shown that the H exchange kinetics can be improved by finely dispersing the metal or the hydride and mixing it with catalytic additives - a concept, which was also transferred to other solid H storage materials based on binary hydrides, complex hydrides, and solid-state reaction systems. While the kinetics of MgH_2 could be considerably improved, attempts to effectively change its thermodynamics, e.g. by nanostructuring, failed. As a consequence, H desorption in technical applications need temperatures considerably above 300 °C and current commercial solutions for H storage are rare and need a combined thermal storage for recovery of heat in order to avoid large efficiency losses. As a matter of fact, any attempts to integrate the H storage material in a car have failed, mainly due to the unsuitable thermodynamic properties of MgH_2. Instead, the high enthalpy of formation of -76 kJ/mol makes the material attractive for storage of heat in a dedicated high temperature window. The application of Mg as an anode material in Mg batteries has been investigated since the 1980s. Also here, Mg has been regarded as attractive for the abovementioned reasons. Moreover, it offers very high theoretical volumetric energy densities for batteries. What makes Mg even more attractive is that it can be used as metallic anode because it does not form dangerous dendrites upon plating, an effect which currently prevents the use of metallic Li anodes in battery cells with liquid electrolytes.
The initial progress was slow, however, as there were no well working and/or only chemically aggressive electrolytes available. Meanwhile, there have been new generations of electrolytes, allowing fast and efficient Mg shuttling without aggressive chemistry and corrosion problems. Such systems allow the combination of Mg anode with a sulfur cathode, an electrochemical couple which is particularly attractive due to its sustainable composition, low toxicity, low cost, and a high theoretical energy density of 3200 Wh/L. The state-of-the art will be presented on Mg-S batteries and recent developments for a fast and high-capacity cathode material for the reversible insertion of Mg will be presented.

Mg-Alloys Are Self-Grain Refining
Zhongyun Fan
BCAST, Brunel University London, UK
Abstract: A grain-refined structure is always desirable for Mg-alloys in the as-cast state. Grain refinement not only contributes to the enhanced mechanical performance of the final components, but also facilitates the casting process for reducing/eliminating the cast defects, such as porosity and macro-segregation. The conventional wisdom for grain refinement is addition of grain refiners that contain potent nucleating particles, for example, addition of Zr based grain refiners for Al-free Mg-alloys. However, this approach is neither applicable universally nor effective for all Mg-alloys. The recent theoretical advance in grain refinement (explosive grain initiation) suggests that more significant grain refinement can be achieved by impotent particles (either endogenous or exogenous) as long as no other more potent particles of significance present during solidification. This insight provides us with a new approach to grain refinement. This talk aims to demonstrate that Mg-alloys are self-grain refining without the need for grain refiner addition. I will cover the following topics:

- Introduction to the concepts of explosive grain initiation and progressive grain initiation.
- Nature of native MgO particles in Mg-alloy melts.
- Grain initiation behaviour of native MgO particles in Mg-alloys.
- Grain refining Mg-alloys without grain refiner.

Methods to Lightweight the Lightweight Magnesium for Mitigating Environmental Damage
Manoj Gupta
National University of Singapore, Singapore
Abstract: Magnesium is the lightest of all metallic elements that can be used in load bearing structural applications in both engineering and biomedical sectors. From the perspective of controlling global warming, the replacement of aluminum and steels in many applications by magnesium based materials is ongoing and will exponentially grow in immediate future. In view of rapidly growing transportation sector (automobile,

aerospace, marine and rail), further light weighting of magnesium will be desirable so as to mitigate land, air, water and electromagnetic pollutions. In order to address this challenge, the present talk will emphasize on different methods being attempted to lightweight magnesium. Particular emphasis is placed to take the density of magnesium based materials to less than 1.5 g/cc so that it can also replace plastics which have entered our food chain. Experimental results that validates our approaches will be presented in this context.

Keywords: Magnesium, Sustainable, non-toxic, greenhouse gases, light weighting.

Heterostructured Material: New Science Produces Superior Properties

Yuntian Zhu
Department of Materials Science and Engineering, City University of Hong Kong, Hong Kong, China

Abstract： Strong and tough materials are desired for light-weight applications such as electric cars and aerospace applications. Recently, heterostructures are found to produce unprecedented strength and ductility that are considered impossible from our textbook knowledge and materials histor. Heterostructured materials consist of heterogeneous zones with dramatic (>100%) variations in mechanical and/or physical properties. The interaction in these hetero-zones produces a synergistic effect where the integrated property exceeds the prediction by the rule-of-mixtures. Importantly, HS materials can be produced by current industrial facilities at large scale and low cost. There are many scientific issues with such materials that challenge the communities of experimental materials science and computational material mechanics. Heterostructured materials is quickly becoming a hot research field in the post-nanomaterials era. In this talk I'll present the current advances as well as future challenges and issues in this emerging field.

Corrosion and control techniques for magnesium alloys

Enhou Han
Institute of Metal Research, Chinese Academy of Sciences

Abstract： Due to the light weight and abundance of magnesium, magnesium alloy become one of the hot topics in materials science and engineering in last two decades. However, the corrosion property is quite poor which limited its application. The corrosion mechanism understanding for magnesium and its alloys were explained. The phosphase chemical conversion was developed with low cost, simple process, and high corrosion resistance. A compact high corrosion-resistant self-sealing pore micro-arc oxidation (MAO) film was developed based on the sealing effect of film constitutes with different melting points. The corrosion resistance of this MAO film is 3-5 times higher than other traditional MAO films. A multi-functional metallic electroless Ni-P coating is developed. A novel pretreatment and plating process was developed to overcome the poor adhesion in view of the great difference of Mg and Ni. The coating exhibits excellent adhesion based on the "Pinning effect". All above three coatings were applied in various real industries.

Some new techniques also were developed. Hydrotalcite compounds film on lower aluminium Mg alloys was developed. A duplex self-healing coating, loading interphase inhibitor into the pores of MAO film and doping an organic inhibitor MBT into the top paint, is also developed.

Progress in the development of high quality magnesium alloys for structural and functional applications

Karl Ulrich Kainer[1,2]
1. Chair of Light Elements Engineering, Foundry and Automation, Wrocław University of Science and Technology, Poland
2. Helmholtz-Zentrum Geesthacht, Magnesium Innovation Centre, Germany

Abstract: In recent years, magnesium alloys have proven their efficiency as lightweight materials for the transport industry and have achieved a breakthrough in some areas of application. The dominant technology for the production of magnesium components is still die casting. Wrought alloys therefore only played a minor role. Alloy and process development over the last decade has led to an improvement in the property profile and economic efficiency of wrought magnesium alloys. This also makes magnesium materials attractive for applications in the aerospace industry. In addition, the development of Mg nanocomposites can lead to further improvements in the property profile because it provides economical solutions to the flammability problems of magnesium alloys, which is a key issue for applications in civil aviation and rail transport. These materials have a high potential for cabin applications such as seats and substructures. A breakthrough in the cost-effective production of sheet metal components made of Mg alloys has been achieved by means of the technology of casting-rolling, which allows large-area components to be produced cost-effectively. However, acceptable corrosion behavior is an important prerequisite for any type of application. This makes it necessary to develop a corrosion protection strategy to protect the material from corrosion e.g. by misuse during maintenance. Especially galvanic corrosion in a multi-material mix requires special attention. New application areas such as degradable implants or anodes for batteries require a tailor-made design of the microstructure and functionalization of the surface for complex environments and functionalities. This presentation gives an overview of the development of advanced magnesium alloys and their technology. The second part of the presentation presents solutions for corrosion protection concepts and functional applications to extend the range of applications of Mg alloys.

Magnesium Research and Development in Korea

Kwang Seon Shin
Seoul National University, Korea Magnesium Technology Research Association, Korea

Abstract: The demand for lightweight magnesium components has steadily expanded due to the rapid increase in the global market for new energy cars and 3C products. In order to meet the demand for new magnesium alloys with enhanced properties that can overcome technical challenges, there has been active research in Korea to develop high-performance magnesium alloys and advanced processing technologies including the twin-roll casting (TRC) process. This lecture will introduce major magnesium R&D activities and key achievements in Korea.

Wrought Alloys

Session 1, Chairs: Bin Jiang, Zhimin Zhang
Session 2, Chairs: Rongshi Chen, Tianjiao Luo
Session 3, Chairs: Hucheng Pan, Xiaozhi Tang
Date: Saturday/Sunday, 21/22 Nov 2020

Uniform strengthening and toughening forming technology of large thin walled magnesium alloy structural parts with inner ring rib

Zhimin Zhang, Jianmin Yu
College of Materials Science and Engineering, North University of China, China

Abstract: With the development of equipment, the demand of lightweight becomes more urgent. It is necessary to use light materials and design of lightweight structure in order to realize the lightweight of equipment. Magnesium alloy is the lightest metal structure material at present, which has great potential in application. Aiming at the characteristics of the difficult forming of magnesium alloy structural parts, the research has been carried out, and the key technologies are broken through: 1. The technology of controlling the microstructure uniformity of "large size rod" by expanding extrusion and upsetting; 2. New process of forming force saving extrusion for controlling orderly metal flow by auxiliary stretch forming and distributive flow; 3. Rotary extrusion technology and equipment. High mechanical properties billets are obtained by using these technologies. And the cone tube component with inner ring rib structure is rapidly and efficiently formed. The tensile strength of the formed component is more than 410MPa, the consistency of mechanical properties in different parts and directions of components is more than 95%; the anisotropy is greatly reduced (the pole density strength of the basal texture is reduced from 6.142 to 2.634).

Keywords: Forming technology; Magnesium alloy structural parts; Mechanical properties

The microstructure, properties and performance of Mg-Al-RE alloys

Mark Easton[1], Suming Zhu[1], Trevor Abbott[2], Hua Qian Ang[1], Kazuhiro Nogita[3], Jian-Feng Nie[4], Dong Qiu[1]
1. RMIT University
2. Magontec Ltd
3. University of Queensland
4. Monash University, Australia

Abstract: Magnesium–Aluminium–Rare Earth alloys are the most commonly used specialty alloy system with alloys such as AE42 and especially AE44 being commonly used in powertrain applications. Over the past few years, we have been investigating the microstructure, properties and performance of these alloys. The microstructure of the alloys include intermetallics found at grain boundaries (and sometimes within grains). The morphology and identity of these intermetallics and the ternary phase diagrams are not fully consistent with what has been reported previously including the identification of a previously unknown phase. Whilst the particular rare earth additions affect the identity of the intermetallic phase, it is actually the Mn content that leads to the excellent age hardening and creep response of these alloys. This means that the use of low cost REs such as La and Ce to produce alloys without Nd and Pr additions does not significantly degrade the properties. With strength matching AZ91 and ductility matching AM60 these alloys, particularly AE44 are excellent candidates for structural applications. However, since they are primarily strengthened through grain refinement, dispersion strengthening by grain boundary intermetallics and precipitation hardening, they do behave differently to AZ91 and AM60 which have a significant contribution from dynamic strain ageing. In particular, AE44 is more strain rate sensitive and has a smaller maximum contribution of anelastic behavior at low strain rates compared with AZ91, particularly in the T5 aged condition.

Keywords: High pressure die casting; Rare earths

Texture effect on grain boundary strengthening in HCP metals

Yunchang Xin[1, 2], Xiaoxu Huang[2], Qing Liu[1, 2]
1. Key Laboratory for Light-weight Materials, Nanjing Tech University, China.
2. International Joint Laboratory for Light Alloys, College of Materials Science and Engineering, Chongqing University, China

Abstract: The high texture dependence of a Hall–Petch slope (k) for Mg alloys has been frequently reported. Several important equations used to calculate k have been previously developed, and although they seem to work well for fcc and bcc materials, they often fail to predict the highly texture-dependent k in Mg alloys. A new equation based on the dislocation pile-up model was developed in this study. The validity of this new equation was tested through a comparison of the predicted k values with the experimental values as well as the calculations from older equations. The results indicate that the new equation can achieve an accurate prediction for several previously reported texture effects on k, whereas the k values predicted by the older equations often exhibit a clear deviation. The reasons for this were analyzed and discussed. The strong deformation anisotropy for Mg alloys leads to a complex texture effect on k, including the effects from both external and internal stresses. Both effects are well expressed in the new equation. In contrast, the old equations consider the external stress effect, but do not express well the internal stress effect. In addition, the old equations consider only the predominant deformation mode. However, our results indicate that the activation of a portion of another deformation mode other than the predominant one plays an important role in the k value. Using the important parameters of the new equation, the mechanisms for several texture effects on k as previously reported were discussed and new understandings were obtained.

Keywords: HCP alloys; Texture effect; Grain boundary strengthening

Strengthening mechanism of precipitates in Mg-RE alloys: A first-principles study

Yanlin Guo, Qun Luo, Qian Li
Shanghai University, China

Abstract: Precipitation strengthening is an effective method that provides about 60% yield strength increment for casting Mg-rare earth (RE) alloys. The effect of precipitation strengthening is affected by various intrinsic properties of the precipitates. The anti-phase boundary energy (APBE) of β series precipitates and the elastic properties of long-period-stacking-ordered phases (LPSO) are investigated by first-principles calculations to clarify the structure and composition dependence of these properties and provide the guidance for strength improvement of Mg alloys. The APBE results indicate that the APBEs of β’’’p phases are higher than

that of β's, and precipitates in Mg-Nd system possess higher APBEs than their counterparts in Mg-Y system. The higher APBEs enable larger strength increments of precipitates in Mg-Nd system than Mg-Y system when the amount of Y and Nd are the same. However, when both elements reach their solubility limit, the large amount of Y makes up the low APBE and achieves superior strength increment than the precipitates in Mg-Nd system. The investigations on LPSO illustrate that 14H-type LPSO (14H) is the stable phase and the transformation energies from other LPSO to 14H are small, implying their appearance as metastable phases in Mg alloys. All LPSO phases contribute to the strength increment, especially for 14H that has the maximum effect. These results are expected to help clarify the strengthening mechanism of precipitates and guide the future design of Mg alloys.
Keywords: Magnesium alloys; Precipitation strengthening; β series precipitates; Long-period-stacking-ordered phase; First-principles calculation.

Highly deformable Mg–Al–Ca alloy with Al2Ca precipitates
Gaoming Zhu, Leyun Wang, Jie Wang, Jian Wang, Jun-Sang Park, Xiaoqin Zeng
Shanghai Jiao Tong University, China
Abstract: Magnesium (Mg) is the lightest structural metal. However, the poor formability of Mg alloys to great extent limits their applications in making structural parts. Formability is strongly correlated to both high tensile elongation and large work hardening capacity. Here, we report a new Mg-Al-Ca alloy in which a majority of deformable Al2Ca precipitates form while the formation of Laves phases of $Mg_{17}Al_{12}$ and Mg_2Ca seems suppressed. Al2Ca precipitates imped dislocation motion, leading to large work hardening. Then, Al_2Ca precipitates deform with dislocations and stacking faults under the enhanced flow stress, which relieve local stress concentration and improve tensile elongation. In addition, solutes Al and Ca suppress twin nucleation while promoting <c+a> dislocations in Mg. This new Mg-Al-Ca alloy demonstrates one of the highest combinations of tensile elongation and work hardening capacity among existing Mg alloys.
Keywords: Precipitation strengthening; Ductility

Coupled Crystal Plasticity Finite Element-Phase Field Model with Kinetics-controlled Twinning Mechanism for Hexagonal Metals
Guisen Liu, Hanxuan Mo, Jian Wang, Yao Shen
Shanghai Jiao Tong University, China
Abstract: Hexagonal metals plastically deform through evolution of dislocations and twins. Deformation twinning is unidirectional and results in twin domain associated with crystal reorientation. Growth of a twin domain is accomplished through nucleation and motion of twinning dislocations/ disconnections (TDs) at atomic scale, and described by migration of twin boundaries (TBs) at micro/macro-scales. Corresponding to kinetics-controlled migration mechanisms of twin boundaries, a coupled crystal plasticity finite element-phase field (CPFE-PF) model was developed through implementing microscale twinning model with anisotropic mobilities of twin boundaries. Crystal plasticity finite element model (CPFEM) is used to solve elastic fields and plastic deformation (carried by both dislocation slip and twinning). Phase field (PF) method is adopted to spatially distinguish twin domains from matrix and track the migration of TBs. Migration of TBs is controlled by both anisotropic mobility coefficients that are correlated to experimental measured twinning strain rate, and the twin driving force contributed by strain energy that is calculated from CPFEM, and change of interface energy including chemical energy and gradient energy that is calculated using finite volume method. It is worth mentioning that experimental measured interface energies of TBs and a critical gradient criterion are adopted in PF model to confine the width of TBs. Our CPFE-PF model exhibits the capability of predicting twin growth with experimental observed twin morphologies, and can be further developed to study twinning related microstructural evolution and mechanical behavior for hexagonal metals..
Keywords: Twinning, crystal plasticity; Phase field; Magnesium; Anisotropic mobility

Mg alloys: Shifting structural materials to structured catalysts
Song Li[1], Hucheng Pan[2], Jun Zhou[1], Xiaoqin Cao[1], Hongbo Xie[1], Gaowu Qin[2]
1. Research Center for Metallic Wires, Key Laboratory for Anisotropy and Texture of Materials (MoE), Northeastern University, China
2. State Key Laboratory of Rolling and Automation, Northeastern University, China
Abstract: This report will review the recent progress of high strength rare-earth-free Mg alloys, mainly focusing on our proposed grain refinement effect via alloying-element-segregation (Ca, Zn, etc) at defects (sub- and grain boundary, dislocation). The maximum ultimate strength 460 MPa achieved in Mg-2Ca-2Sn alloy, 435 MPa in Mg-1Ca alloy, and 443 MPa in Mg-1Ca-1Al-0.2Zn-0.1Mn alloy with good ductility of 11%. The alloying-element-segregation does also facilitate the thermal stability of microstructures of these alloys, having good high temperature performance. More interestingly, we shifted Mg alloys to be structured catalysts via one-step interfacial plasma electrolytic oxidation technology (PEO), making the Au/Ru nano-catalysts embedded into the porous MgO layer adhered on surface of Mg alloy. These catalysts exhibit much higher catalytic activity and stability compared to the previous preparation of traditional noble catalysts. The related mechanism will be discussed in the report.
Keywords: High strength magnesium alloy; Rare-earth-free; Alloying-element-segregation; Structure catalysts

Formation mechanism of typical texture in magnesium alloys
Rongshi Chen, Hong Yan, Lingyu Zhao, Mingguang Jiang
Institute of Metal Research, Chinese Academy of Sciences
Abstract: Texture is one of the key characteristics that affect the plasticity and formability of wrought magnesium alloys. Commercial AZ31 alloy develops a basal texture after hot processing, resulting in poor ductility and formability at room-temperature. The newly developed rare-earth contained Mg-Zn alloys form a non-basal texture after hot processing, showing excellent room-temperature ductility and formability. To clarify the formation mechanism of these two typical textures, the hot procedure and dynamic/static recrystallization behavior of AZ31 and Mg-Zn-Gd alloys were studied. In-situ electron backscatter diffraction method was used to track the orientation evolution during static recrystallization nucleation and grain growth. It is proposed that the basal texture is mainly formed during the plastic deformation stage, while the non-basal texture is formed during the recrystallization stage. The phenomenon of oriented nucleation and preferential migration of grain boundaries has been discovered, and the formation mechanism of the recrystallization texture has been revealed. The results will provide theoretical guidance for the design and control of texture in magnesium alloys.
Keywords: Magnesium alloys; Texture

Effect of Pulsed Magnetic Field on the Residual Stress of Rolled Magnium Alloy AZ31 Sheet
Tianjiao Luo, Meng Yan, Yuansheng Yang
Institute of Metal Research, Chinese Academy of Sciences, China
Abstract: A novel method of pulsed magnetic field (PMF)

treatment was developed to eliminate the residual stress of rolled magnesium alloy AZ31 sheet in this study. The effect of PMF on residual stress of rolled AZ31 sheet was investigated and its mechanism was analyzed. The experimental results revealed that the pulse frequency had a significant impact on residual stress. After 10.0 Hz PMF treatment, the average and maximum reduction rates of residual stress along the rolled direction were 26.6% and 30.3%, respectively. It was found that the dislocation density and parallel dislocation in grains of the rolled sheet increased after it was treated by the pulsed magnetic field. The simulation results showed that the Lorentz force generated by the pulsed magnetic field can lead to basal slip, thereby resulting in local plastic deformation. Besides, the Joule heat produced during the PMF treatment was conducive to the elimination of residual stress.
Keywords: Wrought magnesium alloy; Residual stress; Pulsed magnetic field; Rolled AZ31 sheet

Newly developed high strength-ductility Mg-Al-Ce wrought alloy
Qiuyan Huang, Yang Liu, Jianguang Feng, Yuansheng Yang
Institute of Metal Research, Chinese Academy of Sciences
Abstract: A traditionally one-step extruded micro-alloyed Mg-Al-Ce alloy is explored with tensile yield strength of 370MPa and elongation of about 10%. The alloy has bimodal grain structure which contains both surprisingly ultra-fine grains (~ 0.5μm) and big grains of around 2μm. The ultra-fined grains are mainly associated with Al and Ce atoms segregations at both dislocations and grain boundaries, which can inhibit grain growth during extrusion. Moreover, this Al and Ce atoms segregations can effectively inhabit dislocations and grain boundaries movement, contributing to strength of the alloy. Mono-dispersed nano-size AlCe particles are observed, which can thus additively improve yield strength. The high ductility of the alloy is owed to the grain-size gradient which can promote different types of slips in ultra-fine recrystallization grains and un-recrystallized grains.
Keywords: Grain refinement; Mg wrought alloys; Mechanical properties

Development of high performance wrought Mg based alloys via caliber rolling
H. Yu, S.J. Meng, J.H. Feng, W. Yu, F.X. Yin, J.X. Zhang
Hebei University of Technology, China
Abstract: In this study, we developed a new high ductility mg-bi-ca (BX) alloy via hot extrusion, then the 3pass caliber rolling was applied in order to further improvement of strength of such alloy. The results show that the as-rolled BX alloy presents necklace-like microstructure, that is, ultrafine grains are formed around the micron sized deformed grains (bimodal structure), which is significantly different from that of the extruded Mg alloy. The BX alloy has strong basal texture, which is mainly attributed to the micron-scale deformed grains. In addition, this alloy also exhibits excellent comprehensive mechanical properties with yield strength of 351 MPa and elongation at break of 13.2%. The main reason for strength enhancement is discussed.
Keywords: Mg alloy; Extrusion; Caliber rolling; Microstructure; Mechanical property

{1012} twinning nucleation in magnesium assisted by alternative sweeping of partial dislocations via an intermediate precursor
Zhen Zhang
Hefei University of Technology , China
Abstract: Twinning plays as an important plastic mechanism in Magnesium alloys due to the less symmetrical hexagonal close packed (h.c.p.) structure. The most common twinning type in magnesium alloy is {101-2} twinning, which gives extension along the c-axis. Such twinning mode has been investigated early since middle 20th-century, based on the work on single crystals; the twinning related plastic flow behaviors, anisotropy, etc. has been reported extensively in literature. However the underlying mechanism for twinning nucleation from atomic level have attracted more debate than in cubic metals. In this work, molecular dynamic simulation and transmission electron microscopy (TEM) characterization was employed to investigate the {101-2} twinning mechanism in magnesium. A partial dislocation assisted twinning nucleation mechanism was proposed based on simulation results, in which the twin lattice was reconstructed from parental matrix by twostep sweeping of partial dislocations on different close packed planes from matrix and the subsequently formed twin precursor respectively. A {101-2} twin precursor was observed adjacent to matrix/twin interface by a spherical aberration corrected TEM, which indicated the hexagonal-close-packed(h.c.p) matrix → quasi face-centered cubic(f.c.c) twinning precursor → h.c.p twin transformation sequence during {101-2} twinning process..
Keywords: Twinning; Basal slip

Basal slip mediated tension twin variant selection in magnesium WE43 alloy
Dikai Guan, Mark Rainforth
The University of Sheffield, UK
Abstract: Tension twinning nucleation and evolution in Mg WE43 alloy over a large sampling area was investigated using a quasi-in-situ EBSD/SEM method during interrupted compression testing. The results showed tension twins with both high and low macroscopic Schmid factor (MSF) were activated under a compressive stress of 100MPa with a strain rate of 10−1 s−1. Basal slip in most grains dominated at this stress, so nucleation of twin variants required little interaction with non-basal slip, which was different from other studies that reported prismatic slip and/or tension twinning were required to activate some low MSF tension twin variants. The geometric compatibility factor (m') was demonstrated to be an important factor to determine tension twin variant selection assisted by basal slip. The analysis indicated m' played a critical role over MSF in tension twin variant selection during twin nucleation stage, and final twin variant types were insensitive to increasing stress, but they inherited twin variant types determined at twin nucleation stage. Moreover, which specific grain boundary of a grain with hard orientation for basal slip would nucleate which twin variant could be also validated by m' and largely depended on two factors: (a) high value of m' with 1st or 2nd rank between the tension twinning of nucleated twin variant and basal slip in adjoining grains; and (b) intensive basal slip activity in the neighbouring grains before twin nucleation.
Keywords: Deformation twinning; EBSD; Twin variant selection

Interaction between basal and non-basal dislocations in pure magnesium single crystals
Shinji Ando, Yuta Ishikura, Takuya Nakahara, Masayuki Tsushida, Hiromoto Kitahara
Kumamoto University, Japan
Abstract: Five independent slip systems are required in uniform deformation of crystals. In deformation of magnesium, not only a basal slip but non-basal slip systems should occur to satisfy number of slip systems. In such situation, <c+a> dislocations of pyramidal slips glide through forest of basal <a> dislocations. In this study, interaction of the basal dislocations with the <c+a> dislocations was considered. The multiple tensile test of magnesium single crystals were employed to investigate the interaction of the dislocations. In primary tensile or compression tests, basal dislocations were introduced to the crystal. In secondary tensile tests, the crystal was pulled along [11-20] to activate the <c+a> dislocations. Interaction of <a> and <c+a>

dislocations were observed by using TEM. As a result, CRSS of second order pyramidal slip didn't change. Interaction mechanisms of <a> and <c+a> dislocations were discussed based of change of dislocation density.
Keywords: Single crystal; Pyramidal slip; Basal slip; CRSS

Microstructure and deformation behavior of ultrahigh strength of Mg-Y-Ni alloys containing LPSO phase
Zhikang Ji, Li Li, Xiaoguang Qiao, Mingyi Zheng
Harbin Institute of Technology, China
Abstract: The effect of LPSO phase on mechanical properties and fracture toughness of Mg-9Gd-4Y-1Zn-0.5Zr (wt.%) alloy was studied. Through controlling the cooling medium after homogenization treatment at 510 oC for 8h, the samples with block-shaped LPSO phase distributed along the grain boundaries and lamellar-shaped LPSO phase within grain interior were obtained, respectively. The results reveal that the block-shaped LPSO phase could increase the ultimate tensile strength and elongation, while the lamellar-shaped LPSO phases improve the yield strength but deteriorate the ductility. The plane-strain fracture toughness of the alloy with block-shaped LPSO phase and the alloy with the lamellar-shaped LPSO phase are 13.7 and 10.8 MPa m0.5, respectively. The micro-cracks tend to initial at the interface of a-Mg matrix and LPSO phases, which is parallel to the LPSO in the grain interior. The higher fracture toughness value of alloy with block-shaped LPSO phase is ascribed to the larger dimples and the larger size of plastic zone ahead of the crack tip.
Keywords: Mg-Gd-Y-Zn-Zr alloy; LPSO phase; Microstructure; Fracture toughness

Examination of the characteristic deformation behavior of lamellarstructured Mg-based eutectic alloys, compared to the LPSO phase
Koji Hagihara
Osaka university, Japan
Abstract: LPSO phase is known to contribute to increase in both of strength and ductility of Mg alloys. As a deformation mode in it, kink-band formation is recently focused. However, its formation criteria have not yet been clarified. According to the study on the LPSO phase, its unique crystal structure which is constructed by the alternative stacking of soft and hard layers, called mille-feuille structure, are supposed as plausible factors to govern the formation of deformation kink bands. To confirm these assumptions, we examined the deformation behavior of several directionally solidified Mg-based two-phase eutectic alloy with lamellar microstructure as a model material, such as $Mg/Mg_{17}Al_{12}$ and some other systems. As a result, the formation of kink-bands was confirmed in them as expected. The results provide new insight into a strategy for the aggressive use of kink band to improve the mechanical properties of structural materials. By the crystallographic analysis, the similarity and the differences in the kink band in the Mg-based eutectic alloys and the LPSO phase were examined. The controlling factors of the formation behavior of the kink-bands are discussed in the presentation.
Keywords: LPSO phase; Plastic deformation behavior

Three dimensional twin growth and twin-twin interactions in Magnesium
Yue Liu
Shanghai Jiao Tong University, China
Abstract: As one of the representative hexagonal close-packed metals, magnesium deforms plastically via dislocation slip and twinning at room temperature. Understanding its mechanical properties and deformation twinning mechanisms including nucleation, propagation, growth and interaction is of great significance for optimizing material processing and improving performance. By performing in situ micropillars compression, we quantified the critical stresses associated with basal slip, twin propagation and twin growth in singlecrystal magnesium. Twinning shear and twinning dislocation/disconnections (TDs) are key factors to influence the motion of semi-coherent twin boundaries (TBs). By combining multi-scale characterization and simulation, we characterized: the atomic structure of TBs that is lateral to the shear direction; the local elastic strain gradients at TBs and twin tips; twin shapes along three orthogonal viewing directions; and twin morphology during twin interactions under cyclic loading. Our findings on irregular twin shape and serrated coherent TBs are attributed to the differences in the mobility and pinning effect of the edge and screw components of the TDs. In addition, twin-twin boundaries (TTBs) that is formed by twin interactions can prevent twin propagation and growth, inhibit direct twin transmission, retard de-twinning, and form secondary twins.
Keywords: Three dimensional twin growth; Twin-twin interactions

Newly developed low-cost Mg wrought alloys
Pan Hucheng
Northeastern University, China
Abstract: High strength–ductility synergy is difficult to achieve in Mg alloys. Although high strength has been achieved through considerable alloying addition and low-temperature extrusion, these techniques result in low ductility (2%-5%). In this work, a novel low-alloy Mg–Cabased alloy that overcomes this strength–ductility trade-off is designed. The alloy has an excellent tensile yield strength (425 MPa) and exhibits a reasonably high elongation capacity (11%). A microstructure examination reveals that a high density of submicron grains and nano-precipitates provides the alloy high strength, and the leaner alloy additions and higher extrusion temperatures initially improve ductility. As a result, the density of residual dislocations is reduced, and the formation of low-angle grain boundaries (LAGBs) is enhanced. With fewer residue dislocations, it becomes less probable for the newly activated mobile dislocations to be impeded and transformed into an immobile type during the subsequent tensile test. The LAGBs function as potential sites to emit new dislocations, thus enhancing the dislocation–multiplication capability. More importantly, they can induce evident sub-grain refinement hardening and guarantee that the alloy achieves high strength. The findings lead to a controllable Mg alloy design strategy that can simultaneously afford high strength and ductility.
Keywords: Mg wrought alloy; Mechanical property

Bimodal microstructure with balanced texture – a strategy for achieving strength-ductility synergy in Mg-Al-Zn alloys
Min Zha, Huiyuan Wang
Jilin University, China
Abstract: Magnesium alloys are highly desirable for a wide range of lightweight structural components. However, Mg alloys usually have low plasticity and hence poor plate forming ability, which limits their further engineering applications. In the present work, we fabricated novel Mg-Al-Zn alloys having bimodal grain structures with balanced texture, gaining a simultaneous high strength and ductility by using hard-plate rolling (HPR). The high strengthductility synergy is attributed mainly to the typical bimodal grain structure and the balanced texture. Thus, achieving a bimodal grain structure with balanced basal texture could be a feasible strategy for preparing Mg alloys with superior mechanical performance. Moreover, the designing principle and formation mechanism of bimodal grain structure in Mg-Al-Zn alloys are explored in terms of the effects of alloy compositions and processing parameters. We found that a high Al content leads to high-volume fraction of dynamic precipitations, which promotes multimodal grain structure formation. Also, for a specific alloy composition, lower

processing temperature favors maintain the multimodal grain structure. This strategy could be applicable to hard-to-deform hcp metallic materials, and thus has a promising prospect for industrial application.
Keywords: Bimodal microstructure; strength-ductility synergy

Dynamic recrystallization and dynamic precipitation in the hotextruded Mg89Y4Zn2Li5 alloy
Wei Liu[1], Ruopeng Lu[1], Liwen Chen[1], Hua Hou[1], Yuhong Zhao[1], Jinshan Zhang[2], Yuman Zhu[3]
1. North University of China, China
2. Taiyuan University of Technology, China
3. Monash University, Austrilia
Abstract: Dynamic recrystallization (DRX) and dynamic precipitation often occur in the deformed Mg alloys and eventually affect the mechanical properties of materials. In this work, the DRX process, dynamic precipitation behavior and mechanical properties of the hot-extruded Mg89Y4Zn2Li5 alloys with different extrusion conditions are systematically investigated. The results reveal the formation details of DRX grains and thin LPSO precipitates inside the DRX grains during hot extrusion at 350 ºC. Under a low extrusion ratio of 4, the DRX grains start to emerge discontinuously along the fluctuant 18R/α-Mg interface and continuously along the 14H kink boundaries with high misorientation angles. As increasing of extrusion ratio from 4 to 16, besides discontinuous and continuous DRX, particle-stimulated nucleation (PSN) of recrystallized grains appear around small 18R and 14H fragments. Meanwhile, various thin LPSO lamellae including 14H, 18R and 24H as well as γ′ phase are dynamically precipitated within the DRX grains. In extrusion with a high ratio of 25, the DRX is mainly produced by PSN mechanism, leading to an almost completely DRX microstructure. Besides, most of the 18R blocks are broken down to small fragments while the 14H lamellae in the original α-Mg matrix are dissolved at the large deformation strain. Furthermore, decreasing extrusion speed from 1 to 0.1 mm/s at this extrusion ratio can effectively limit the growth of DRX grains and facilitate the dynamic precipitation of thin 14H lamellae within the fine DRX grains. Consequently, the full and fine DRX microstructure, small 18R fragment and deformation kinking, abundant thin 14H lamellae in fine DRX grains result in the excellent strength-ductility balance through hot extrusion with ratio of 25 and speed of 0.1mm/s.
Keywords: Magnesium alloys, Plasticity; LPSO; Recrystallization; Kink boundary; Dynamic precipitation

Grain boundary (co-)segregation and texture modification in magnesium alloys with multiple substitutional elements
Risheng Pei, Talal Al-Samman
RWTH-Aachen University, Germany
Abstract: Tweaking precipitations and solute atoms is one of the most successful methods to modify the microstructure and texture in micro-alloyed magnesium alloys. In the current work, an alloying strategy by adding Ca and /or Y in AZ31B alloy is designed to tailoring the precipitations and solute concentration towards weaker textures. In this way, the complexity of the alloys is increased. Several characterization techniques on different length scales (HRTEM, 3D-APT, EBSD and XRD) were performed to characterize the elemental distribution of alloying elements (in the bulk and vicinity of grain boundary), precipitation, microstructure and texture evolution after different annealing treatments. Among several important findings, it is found that the type and level of segregation are important in controlling the growth behavior during recrystallization and grain growth. Co-segregation of Zn and Ca in the AZX (AZ31B+0.3wt.% Ca) and AZWX (AZ31B+0.9wt.% Y+0.3wt.% Ca) alloys weakens and modifies the texture by granting an additional growth advantage to the non-basal grains. However, the sole segregation of Zn in the AZW (AZ31B+0.6wt.% Y) alloy does not exhibit such an effect, resulting in a sharp basal texture as in AZ31B alloy. Preferential growth of non-basal grains during grain growth at high temperature is observed in the AZWX alloy, which leads to a promising quadruple texture for sheet forming. Deeper knowledge in this area can be expected to advance current alloy design strategies by tweaking the solute species and concentration on the grain boundary.
Keywords: Magnesium alloy; Co-segregation; Texture modification; Recrystallization; Grain growth

The engulfment of precipitate by extension twinning in Mg–Al Alloy
Xiao-Zhi Tang, Ya-Fang Guo
Beijing Jiaotong University, China
Abstract: To understand the strengthening mechanism of precipitate against twin-mediated plasticity in magnesium–aluminum alloys, the measurements of the increase in the critical resolved shear stress due to impediment on twin thickening are accomplished based on atomistic simulation, specifically at a significantly low strain rate of $1.7 \times 106\ s^{-1}$. Results show conspicuous coupled effect of temperature and strain-rate on the precipitation strengthening. The strengthening effect vanishes if coherent twin boundary migration is purely stress-driven without thermal activations, due to the back-stress dominating over Orowan stress. At a finite temperature the strengthening effect becomes observable, and is distinctly amplified by high strain rates.
Keyword: Precipitation; Twinning to understand

The effects of deformation parameters and cooling rates on ageing behaviour of AZ80+0.4%Ce
Yongbiao Yang, Cuiying Wang, TingYan Zhang, Qingfeng Qin, Zhimin Zhang, Qiang Wang, Guojun Li
North University of China, China
Abstract: Hot torsion deformation behaviour of the extruded AZ80+0.4% Ce magnesium alloy were investigated in the temperatures range of 300-380 ℃ and at a twist rate of 0.7 rad /s by using a Gleeble 3500 thermal simulation test machine. Hot torsion deformation were carried out to investigate the effects of a wide range of hot deformation parameters on ageing behaviour because the strains and strain rates vary along the radius of the specimens during deforming. The deformed specimens were cooled at a rate of 10℃/s and 0.1 ℃/s respectively, then aged at 170 ℃ up to 36 hours. The microstructure analysis was carried out with optical microscopy (OM) and scanning electronic microscopy (SEM). The results showed that the microstructure were gradient in terms of the grain size, which decreased with increasing radius of the cylindrical specimen, and that the strong initial basal texture of the extruded magnesium alloy were weakened, irrespective of deformation temperatures. The deformation parameters and cooling rates had strong influences on the ageing behavior of the AZ80+0.4% Ce in terms of the morphology, spacing and area percentage of the precipitates $Mg_{17}Al_{12}$ phase. Dynamically precipitated granular discontinuous $Mg_{17}Al_{12}$, which decorated the grain boundaries, changed the competition pictures for the continuous and discontinuous precipitations established by Duly. D. for the AZ series cast magnesium alloys. The effects of the shear strain, shear strain rate, temperature, cooling rate and ageing on micro hardness evolution were quantified using sensitivity index to micro hardness. Low temperature and high speed deformation, followed by high cooling rate, were recommended for increasing the micro hardness for the studied magnesium alloy.
Keywords: Hot torsion; Cooling rate; AZ80+0.4% Ce magnesium alloy; Deformation parameters; Texture; Micro hardness

Cast Alloys

Session 1, Chairs: Yuansheng Yang, Qiang Yang
Session 2, Chairs: Liming Peng, Yuhong Zhao
Date: Saturday, 21 Nov 2020

Development of cost-effective creep-resistant Mg-Gd-Ca based cast magnesium alloys
Mingxing Zhang
The University of Queensland, Australia
Abstract: In order to lower the cost, Ca was used to partially replace the more expensive rare-earth elements, and a few new Mg-Gd-Ca based magnesium alloys were designed with similar or better creep resistance compared to most commercial Mg-RE based alloys. But, raw materials cost of the new alloys are around 24% lower. Gd and Ca solutes in the α-Mg solid solution were experimentally verified having strong preference to form co-clusters with short-range order, which offered local ordering strengthening, leading to higher solid solution strengthening effect and contributing to the higher creep resistance of the alloys containing Gd and Ca. Furthermore, additions of Nd and Mn were found to further improve the creep resistance of the Mg-Gd-Ca alloys through cooperative strengthening effect from Nd and enhanced precipitation hardening by Mn.
Keywords: Creep-resistant Mg alloy; Cast Mg alloy; Rare-earth containing Mg alloy

Solidification behavior and cast abilities of microalloyed magnesium alloys
Jie Cui, Jianguang Feng, Tianjiao Luo, Yuansheng Yang
Institute of Metal Research, Chinese Academy of Sciences
Abstract: The evolution of microstructure and microsegregation in new type of micro-alloyed cast magnesium alloys, solidified at different cooling rates, are investigated. Mg–6Al–4Zn–1.2Sn (wt%) cast alloy, the secondary dendrite arm spacing and the average grain sizes decrease from 14.3 to 2.9 μm and from 187 to 78 μm, respectively, as the cooling rate increases from 4.5×101 °C s^{-1} to 2.3×103 °C s^{-1}. Secondary dendrite arm spacing and the average grain sizes decrease sharply as the cooling rate increases. The relationship between the secondary dendrite arm spacing (λ2) and cooling rate (R) is fitted. When the alloy solidifies in the range of cooling rates, a new quasi-crystalline I phase is formed due to faster solidification. The microsegregation ratios of micro-alloying elements decrease significantly with the increase in cooling rate. Some of these new cast magnesium alloys have good casting property and cold forming property. The fluidity of ZA81M is better than that of AZ91D, and was used to produce magnesium alloy wheel by die casting.
Keywords: Micro-alloyed magnesium alloys; Solidification behavior; Cast ability

Ultrasonic melt treatment and its influence on microstructure and properties of Mg alloys
Qichi Le, Xingrui Chen
Northeastern University, China
Abstract: The magnesium alloy is the lightest structural material until now, which has great application potential in many aspects. However, some issues such as low strength, poor formability and high corrosion rate hinder the development and wider application of Mg-based alloys. To this end, ultrasonic melt treatment has been used in the melting process of Mg alloys, which shows much improvement in many aspects. This report will give a comprehensive review of the influence of ultrasonic melt treatment on microstructure evolution, degassing, strength enhancement and the melt structure. Also, this report gives information about how these microstructural changes can affect the formability, corrosion behavior and electrochemical properties of Mg-based alloys.
Keywords: Ultrasonic melt treatement; Grain refinement; Prorperties

Research on Hot Cracking Behavior of Magnesium Alloy
Feng Wang
School of Materials Science and Engineering, Shenyang University of Technology, China
Key Laboratory of Magnesium Alloys and the Processing technology of Liaoning Province, China
Abstract: In recent years, magnesium alloy has become an essential material for aerospace, automotive lightweight, electronics 3C, and biomedical fields. However, the occurrence of hot tearing in as-cast magnesium alloys limits its application greatly owing to the wide solidification range, large solidification contraction, and so on. It has important practical significance to expand the application of magnesium alloy throughout the investigations on in-depth development of magnesium alloy hot tearing behavior and preventing magnesium alloy hot tearing defects. The current article mainly introduces the relevant progress of our team on the hot tearing behaviors of magnesium alloys. The optimization and application of the hot tearing prediction model, the optimization of the hot tearing test device, and the influence of alloy composition, casting process parameters, and magnetic field on the hot tearing behavior of magnesium alloy are described. The mechanism of hot tearing is discussed as well.
Keywords: Magnesium alloys; hot tearing; alloying elements; microstructure

Grain refinement in laser surface remelted Mg alloys
Dong Qiu
RMIT，Australia
Abstract: Columnar grains are normally favoured with the high cooling rate and steep thermal gradient in welding and laser-based additive manufacturing. In this study, we demonstrate that fine, fully equiaxed grains can be achieved in Mg-3Nd-1Gd-0.5Zr (EV31) alloy by laser surface remelting. The grains in the melt pool are remarkably refined from 74 μm to 3.5 μm, which can be attributed to the constitutional supercooling delieved by Zr solute in combination with the high thermal underrcooling imposed by laser surface remelting. This novel finding could be applied for the control of grain morphology and alloy design for furture additive manufacturing applications of Mg alloys.
Keywords: Grain refinement; Laser processing

Intermetallic phase and phase transformation in high-pressure die casting Mg-Al-RE based alloys
Qiang Yang, Xin Qiu, Shuhui Lv
Changchun Institute of Applied Chemistry, China
Abstract: Compositions and crystal structures of intermetallic phases are various with different REs in the high-pressure die casting Mg-Al-RE based alloys. A novel intermetallic phase in a MgAl-La-Mn alloy was revealed by our team and we indicated that it would provied satisfactory strength-ductility balance. In addition, additional non-RE alloying elements would result in

phase transformation of the dominant intermetallic phases irregardless of their high thermal stability.
Keywords: TEM; Mechanical properties

Thermal analysis during solidification of Mg-xLi-Al alloy
Ruihong Li,
Inner Mongolia University of Science&Technology, China
Abstract: The solidification behavior and microstructure evolution of cast Mg- xLi-1Al alloy (named as LAx1 alloys, x= 1, 3, 5, mass fraction, %) were characterized by thermocouple thermal analysis technology and SEM. The grain sizes of the alloys were quantitatively determined by EBSD technology. Thermodynamic calculations were applied in Pandat software for phase diagram calculation, Scheil model solidification simulation and growth restriction factor values (GRF or Q values). The results show that solidification of LAx1 alloys follows non-equilibrium solidification paths. $LiMgAl_2$ phase is the only secondary phase in as- cast microstructure of LA51 alloy. With the increase of the Li content, the amount of $LiMgAl_2$ phase increase. Calculated equilibrium phase diagram shows that in the LAx1 alloys $LiMgAl_2$ phase can be dissolved into α-Mg under proper heat treatment conditions. The results also indicate that higher Li content alloys have higher Q values and smaller grain size, and lower solid fraction at dendrite coherency point (fsDCP). The relationship of Q values, grain size and fsDCP has been also discussed.
Keywords: Mg-Li alloy; Grain size; Casting

Creep properties of cast Mg-Y-Ca-Zr alloys
Sihang You, Yuanding Huang, Karl Kainer, Norbert Hort
Helmholtz-Zentrum Geesthacht, Germany
Abstract: Poor elevated temperature creep property is a key issue that limits the use of Mg alloys for high temperature applications in industry, such as automotive power train components. At present, most commercially available creep resistant Mg alloys contain a large amount of expensive and relatively heavy alloying elements such as rare-earth (RE) elements, which leads to an unaffordable cost and an increased density. Among all the non-RE elements, Ca is regarded as a promising element that could partially replace RE elements to help reduce the cost of creep resistant alloys. In order to explore the possibility of developing a new creep resistant Mg alloy system with lower cost and to deeply understand the creep mechanism of the newly developed alloy, a systematic investigation on the effects of Ca and Y on the microstructure and creep behavior of Mg alloys is necessary. In this investigation, the influences of Y, Ca and their combined additions on the microstructure, mechanical properties and creep behavior of as-cast and hot-extruded Mg alloys have been investigated. A consistent concentration of Zr (0.5 wt.%) was added as a grain refiner to maintain homogeneous grain morphologies between alloys investigated. Casting and hot extrusion processes were used to prepare alloys with different distributions of solutes and intermetallic phases. This was done to investigate the different influences of grain boundary reinforcement, solid solution strengthening and precipitation strengthening on the creep behavior of Mg-Y-Ca-Zr alloys.
Keywords: Mg-Y-Ca-Zr alloys; Creep property

Grain refinement and integrated computation of casting processmicrostructure- property of magnesium alloys
Hai Hao, Wenxue Fan, Xingyang Chang
Dalian University of Technology, China
Abstract: Magnesium is the lightest constructional metal, which makes it an important material for different applications like automotive, transportation, aviation and aerospace. There are many studies with respect to the improvement of the mechanical properties of magnesium alloys. An important way to improve properties of magnesium alloys is to decrease grain size that results almost in increasing all kinds of properties of the materials. Our research group has been committed to studying the grain refinement of magnesium alloys by adding grain refiners, alloying elements and applying electromagnetic field combined with ultrasonic treatment. The research showed that the grain refiners like Al-Ti-B, Al-C, Al-Ti-C(-RE) master alloys have efficient grain refinement. Adding rare earth (RE) elements like Gd, Y, Nd and Sm and non-RE elements including Ca, Sr and Si also exhibit remarkable refinement effect. The application of electromagnetic field and ultrasonic treatment is beneficial to the uniform distribution of the nuclei particles in the magnesium melt, which can further improve the refinement performance of the grain refiner. In order to shorten the research period of magnesium alloys and reduce research costs, our research team also builds a magnesium alloy simulation integrated platform (MASIP). The MASIP can achieve the complete automated operation of the casting process-microstructure-performance of magnesium alloys and realize the cross-scale integrated calculation of the microstructure simulation, process optimization and mechanical properties prediction magnesium alloys. The construction of this platform can provide a technical support for vigorous widespread industrial applications of lightweight magnesium alloys.
Keywords: Magnesium alloys; Grain refinement; Properties; Integrated computation

Preliminary investigation of microstructure and corrosion behaviours of magnesium WE43 alloy manufactured by selective laser melting
Zhuoran Zeng
Australian National University, Australia
Abstract: The production of magnesium alloy WE43 was achieved by selective laser melting (SLM). The alloy was investigated after SLM, hot isostatic pressing (HIP), and solutionising heat treatment. The microstructure and corrosion behaviour of the specimens were carefully characterised, whilst assessed and contrast relative to the conventionally cast alloy counterpart. The SLM prepared specimens possess a unique microstructure comprising fine grains growing with a strong [0001] texture along the building direction with a low fraction of process-induced and metallurgical defects, reaching < 0.1 %, after optimising the SLM parameters and the HIP treatment. Electrochemical measurements demonstrated that the SLM prepared WE43 is cathodically more active as compared with its cast counterpart. It is proposed that this behaviour is due to a high density of rare-earth and zirconium-rich oxide particles uniformly distributed throughout the alloy microstructure as well as the alterations in the chemical composition of the solid-solution matrix originating from the high cooling rates of SLM. It was also noted that the oxide particles are mainly sourced by powder. The present results suggest that the corrosion of SLM prepared Mg alloys could be greatly improved once the influence of powder characteristics is further understood and controlled.
Keywords: Magnesium; Selective laser melting; Corrosion resistance

Al_8Mn_5 settling and clustering on oxides in liquid AZ91
Chris Gourlay, Liuqing Peng, Guang Zeng, Te-Cheng Su, Kazuhiro Nogita, Hideyuki Yasuda
Imperial College London, UK
Abstract: During melt handling, Al_8Mn_5 often form above the Mg liquidus temperature and settle under gravity in holding pots. This can lead to sludge formation, and the Al_8Mn_5 particles can also cluster on oxide films generating deleterious casting defects. Here, we quantify Al8Mn5 particle settling, study the formation of a sludge layer, and explore how Al8Mn5 develop into clusters on entrained oxides in AZ91. The settling behaviour is well described with a standard modification of Stokes' law, and

Al_8Mn_5-oxide interactions are directly observed with X-ray imaging..
Keywords: Solidification; Intermetallics

Effects of Substance of Zn with Co, Ni and Co/Ni on Microstructures and Mechanical Properties of LPSO Dominant Mg-Y-Zn Alloys
Jonghyun Kim, Heng Xue, Hongxin Liao, Wang Fengxue, Kong Kong qingzhi
Chongqing University, China
Abstract: The microstructures of Mg96Y2Zn2 (MYZ), Mg96Y2Zn1Co1 (MYZC), Mg96Y2Zn1Ni1 (MYZN) and Mg96Y2Zn1Co0.5Ni0.5 (MYZCN) (at. %) alloys were investigated by XRD, SEM/EDS and TEM. The -Mg matrix, the LPSO phase and the bright compounds were observed in the as-cast alloys. The ability of Co to form LPSO phase with Mg and Y is weaker than the ability of Zn, but it can produce some new intermetallic compounds. The effect of Ni on phase content of alloys was opposite to that of Co. After replacing Zn with Co and Ni, the increase of the content of the LPSO phase is more obvious than that of Co or Ni alone to replace Zn. The ability to form LPSO phase with Mg and Y atoms in Mg-Y-TM alloys can be ranked as: Co/Ni＞Ni＞Zn＞Co. From the mechanical performance point of view, the substitution of Co and Ni for partial replacement of Zn exhibited the best yield strength, the TYS, UTS, CYS and UCS of which were 345MPa, 453MPa, 335MPa and 470MPa, respectively. However, the ductility has not improved much.
Keywords: LPSO; Microstructure; mechanical properties

Processing

Session 1, Chairs: Guosong Wu, Baodong Shi
Session 2, Chairs: Lifeng Ma, Hongyang Zhao
Date: Saturday, 21 Nov 2020

Mathematical analysis and its experimental comparisons on Mg-Li alloy for accumulative roll bonding (ARB) process
Ruizhi Wu
Harbin Engineering University, China
Abstract: Based on the traditional two-layer accumulative roll bonding (TARB), the geometrical variations and mathematical relationship during the four-layer accumulative roll bonding (FARB) were derived and summarized. Furthermore, the multi-layer accumulative roll bonding (MARB) technology was proposed and the geometrical variations and mathematical relationship of MARB were simultaneously derived and summarized. Experimentally, Mg-14Li-3Al-2Gd (LAGd1432) sheets were fabricated by TARB and FARB, respectively. The relationship between equivalent strain and mechanical properties and the relationship between grain refinement and accumulative efficiency are established. Compared with the TARB, the FARB has a higher accumulative efficiency in terms of accumulative layers, total number of interfaces, interface spacing, total deformation and equivalent strain, which leads to the excellent performance of FARB under low cycles.
Keywords: ARB; Equivalent strain; Mg-Li alloy

Evaluating the orientation relationship of prismatic precipitates generated by detwinning in Mg alloys
Feiya Liu, Renlong Xin, Ming-Xing Zhang, María Teresa Pérez-Prado, Qing Liu
Chongqing University, China
Abstract: It is commonly accepted that prismatic precipitates in Mg alloys are more potent strengtheners than the ones formed on basal planes. However, in most rare-earth (RE) free Mg alloys, precipitation commonly occurs on basal planes. Recent results showed that coupling {101(_)2} twinning, aging and detwinning (a process termed TAD) promotes prismatic precipitation in Mg-Al alloys by a mechanism that remains unclear. The present work aims to theoretically and experimentally evaluate possible crystallographic orientation relationships (ORs) between the prismatic precipitates and the detwinned matrix in TAD processed samples in order to understand their formation mechanism. A crystallography-based algorithm is proposed to predict such ORs and the predictions are subsequently validated through experimental observation in a transmission electron microscopy (TEM). Three new ORs between $Mg_{17}Al_{12}$ precipitates and the -Mg-Al matrix are experimentally determined, which agree well with the predictions of the proposed algorithm after considering the 3.69o rotation of precipitates at twin boundaries. Additionally, the proposed algorithm is validated in other RE free Mg alloys produced via the TAD process, including Mg-Sn-Zn, Mg-Al-Ca, Mg-Zn and Mg-Ca-Zn systems. This work provides a clearer understanding of the ORs between prismatic precipitates and the matrices of Mg alloys that is deemed critical to fully exploit their potential for precipitation hardening.
Keywords: Precipitate; Orientation relationship; Twin

Microstructure characteristics of AZ80 magnesium alloy under rotating backward extrusion with open punches
Qiang Wang, Xin Che, Jian-min Yu, Zhi-min Zhang
North University of China, China
Abstract: This paper presented a novel severe plastic deformation (SPD) technique, rotating backward extrusion (RBE), for fabricating magnesium alloy cups. Five kinds of open punch were designed and entitled as G0, G1, G4, G6 and G8 in terms of the number of grooves, respectively. The effect of different RBE processes on the microstructures, texture evolutions and mechanical properties of AZ80 cups was investigated. The results indicated that the grain refinement and volume fraction of recrystallized grains gradually increased with increasing number of grooves, especially at the cup bottom. And, the G6 sample obtained the minimum grain size 3.90 μm and the maximum DRX proportion of 85.3% at the cup bottom. Furthermore, the lower basal pole intensity was also obtained with increasing number of grooves. The G6 sample exhibited the highest microhardness value of 96HV compared to the G0 sample with 83HV at the cup wall. Consequently, this study suggested that the RBE process, which introduced shear deformation and accumulated strain, could be an effective method to refine grains and weaken texture of AZ80 magnesium alloy.
Keywords: Rotating backward extrusion; Magnesium alloy; Microstructure; Microhardness

Self-layered hydrothermal coating for corrosion mitigation and surface functionalization of magnesium alloys
Guosong Wu
Hohai University, China
Abstract: Corrosion is still a big problem in the application of magnesium alloys. Inspired by the skin characteristics of animals and plants in nature, we proposed the concept of heteromorphic laminated structure. Accordingly, we attempted to modify magnesium alloys by hydrothermal treatment and successfully prepared a self-layered coating with dissimilar shapes on magnesium alloys. This self-layered hydrothermal

coating can not only mitigate the corrosion effectively, but also endow the surface with other interesting functions including self-cleaning, sterilization and cytocompatibility. Hopefully, this kind of hydrothermal coating may play an active role in developing new magnesium alloys.
Keywords: Corrosion; Coating

Numerical Investigations on the Anisotropy of AZ31 Alloy by Evolution of Yield Functions
Baodong Shi, Chong Yang, Yan Peng
Yanshan University, China
Abstract: Focusing on non-proportional loading condition during forming process of HCP metals, the distortional evolution of yield surfaces and equivalent plastic work contours of AZ31 Mg alloy are investigated experimentally and numerically under combined tension-torsion test. Strong anisotropy including initial strength differential effect and subsequent distortional hardening are observed. The underlying deformation mechanisms are discussed based on microstructure observation. It is found that the number of twinning decrease with pre-axial tension stress increasing, resulting from the restricted activity of twinning with c/a ratio decreasing. Furthermore, the subdivision of twin boundaries leads to large strain hardening rate. Therefore, the strain hardening rate and flow stress under pure torsion are much higher than other loading paths. Consequently, the strong anisotropy is obtained during large plastic deformation.
Keywords: Anisotropy; Yield Functions; AZ31 Alloy; Numerical Investigations

Optimization of Microstructure, Mechanical Properties and Degradation Behavior of a Degradable Orthopaedic Mg-Zn-Y-Nd Alloy
Beining Du, Liyuan Sheng, Yufeng Zheng, Tingfei Xi
Peking University, China
Abstract: A new type of Mg-Zn-Y-Nd alloy for degradable orthopedic implants was developed. In the present study, the Zn and Y contents were adjusted, and different processing technologies were applied, and then the influences of alloying elements and processing techniques on the microstructures, mechanical properties and degradation behaviors were discussed. The results showed that the change of Zn content has little influence on the microstructure and mechanical properties of Mg-Zn-Y-Nd alloy, while Y content could affect its microstructure and mechanical properties greatly. Moreover, The increase of alloying elements would decrease the corrosion resistance of the Mg-Zn-Y-Nd alloy. In addition, the increase of extrusion passes would not only enhance the mechanical properties, but also improve the corrosion resistance of the alloy remarkably.
Keywords: Mg-Zn-Y-Nd alloy; Microstructure; Mechanical Property; Degradation Behavior

Deformation mechanism analysis of ZK60 magnesium alloy during radial forging process: mathematical modeling and experimental discussion
Lifeng Ma, Jingfeng Zou
Taiyuan University of Science and Technology, China
Abstract: Radial forging (RF) is an economical manufacturing forging process in which four dies radially arranged around a workpiece simultaneously act on the workpiece with highfrequency radial movement. In this study, to analyze the deformation mechanism of ZK60 Mg alloys for the RF process, a regionalized multiscale strain field model is proposed and used. ZK60 magnesium alloy bars were processed under different accumulated strains by RF at 350°C. Based on theoretical calculation results, the microstructures, texture evolution, and mechanical responses of the bars were systematically investigated. At the early deformation stage of forging, the material underwent pronounced grain refinement; however, an inhomogeneous grain structure was formed owing to the strain gradient along the radial direction (RD). The grains in different radial parts were gradually refined by increasing the RF pass, resulting in a bimodal grained structure comprising coarse (~16.2 μm) and fine (~2.1 μm) grains. The texture of as-RFed bars changed as the RF strain increased, and the c-axis of most of the coarse grains rotated in the RD. Further, the basal pole intensity exhibited a downward trend, followed by the large-scale activation of recrystallization mechanism. Additionally, excellent mechanical properties including higher values of tensile strengths (341MPa) and ductility (27.6%) were attained after the three passes，compared to the as-received sample.
Keywords: Radial forging; Regionalized multi-scale strain field model; Magnesium alloy; Microstructure evolution; Mechanical properties

Laser cleaning pretreatment on the welding of magnesium and Steel
Dan Wang, Juming Gao, Xinyan Li, Wenbin Wang
Jiangsu University,China
Abstract: Laser cleaning considered as a feasible technology was employed to pretreat the surface before lap welding of magnesium and steel due to not only its good dirt-removing power, such as, the removal of oxide, rust or oil spots, but also shock effect. Effect of scanning speed of laser cleaning on the welding of magnesium and steel was studied based on the microstructure characterization and mechanical property test. A good joint could be achieved under the appropriate parameters. Laser cleaning is supposed to improve the quality of welded joint in the future.
Keywords: Laser cleaning; Lap welding

Mechanical properties, microstructures and deformation mechanisms in several Mg-Li alloys fabricated by different approaches
Furong Cao
Northeastern University, China
Abstract: The ambient and high-temperature mechanical properties, microstructures and deformation mechanisms in several ultralight Mg-Li alloys fabricated by rolling (R), multidirectional forging (MDF), friction stir processing (FSP), and so forth were investigated. Particular attention is paid to the superplastic flow and deformation mechanisms in Mg-Li alloys. Firstly, the ultimate tensile strength (UTS) of 299 MPa and elongation of 15.7% were demonstrated in a dual phase LA72 (Mg-7.28Li-2.19Al-0.091Y) alloy with a density of 1.42g/cm3 fabricated by rolling ,and the contributions of various strengthening mechanisms were calculated by physical models; the UTS of 286 MPa and elongation of 31.8% were achieved in dual phase LZ64 (Mg-6.4Li-3.6Zn-0.37Al-0.36Y) alloy with a density of 1.546g/cm3 subjected to MDFR, and the grain refinement mechanisms were proposed for the first time. Secondly, maximum elongations to failure of 566.7%, 712.1%, and 489.5% were demonstrated at high temperatures in a fine-grained LAZ922 (Mg-9.3Li-1.79Al-1.61Zn) processed by rolling, a fine-grained LAZ1022-0.2Sr (Mg-10.2Li-2.1Al-2.23Zn-0.2Sr) alloys processed by MDFR, and an ultra-fine-grained LAZ822 (Mg–8.41Li–1.80Al–1.77Zn) alloy processed by FSP, respectively. Thirdly, phenomenological constitutive equations were established in Mg-Li alloys; a deformation mechanism map (DMM) incorporating the number of dislocations inside a grain was constructed in eutectic Mg-Li alloy. The predication of DMM is consistent with the experimental characteristic values. Fourthly, a model of cavity growth rate considering cavity interlinkage was established, and a cavity growth diagram was constructed in the superplastic LAZ1022 (Mg-10Li-2Al-2Zn-0.2Sr) alloy. The experimental

cavity growth data is in good agreement with the predication of the cavity growth diagram newly constructed. Plasticity-controlled cavity growth is the cavity growth mechanism in this alloy.
Keywords: Magnesium-lithium alloy; Thermomechanical processing; Mechanical property; Microstructure; Superplasticity

In-situ hybrid phase reinforced Mg-based metallic glass matrix Composites
Wei Guo, Shusen Wu
Huazhong University of Science and Technology, China
Abstract: In this study, we have successfully induced NiTi(Nb) and NiTi(Nb)-β-Nb hybrid reinforcing structures into a Mg-based amorphous matrix by using the novel selective phase leaching process. The size of secondary phase can be refined by increasing the cooling rate of prealloys and the NiTi(Nb)-β-Nb hybrid structure can be obtained with followed annealing treatment. The best mechanical properties have been obtained with NiTi(Nb)-β-Nb hybrid reinforcing structures. The average size of NiTi(Nb) is ~2 mm, very close to the plastic processing zone size of the matrix. The precipitated β-Nb is very fine to nanoscale size. The fracture strength for the present hybrid structure reinforced BMGMCs is ~1010 MPa, improved by ~21% compare with the monolithic BMG. The plastic strain is ~13.5%, very different from the brittle fracture of the BMG. The reinforcing phases are found to be effective in hindering the rapid propagation of main shear band, and helping generate multiple shear bands to accommodate the plastic deformation. The hybrid reinforcing structure can further contribute to the multiple initiations of shear bands and the work-hardening behavior. Further work should be done to vary the mechanical testing temperature to introduce the stress induced martensitic transformation from the reinforcing phases, as well as optimization of the composition to induce more secondary phases.
Keywords: Mg-based metallic glass; Composite; Hybrid reinforcing structure

Performance & Application

Session 1, Chairs: Zhiwei Shan, Shanrong Chen
Session 2, Chairs: Xiaojun Wang, Lili Tan
Session 3, Chairs: Xianhua Chen, Yan Yang
Date: Saturday/Sunday, 21/22 Nov 2020

Effect of Gradient Nanostructure on Microstructure and Mechanical Properties of AZ31 Magnesium Alloy
Meng Duan, Minghang Zhou, Yong Liu
Nanchang University, China
Abstract: Studies have shown that gradient nanostructure can improve the mechanical properties on copper and iron. In order to investigate the effect of gradient nanostructure on the microstructure and mechanical properties of magnesium alloy, a graded nanostructured AZ31 magnesium alloy was prepared by surface mechanical wear treatment (SMAT). The microstructure evolution and mechanical properties were studied. The OM and SEM were used to analysis the microstructure evolution of the alloy. The mechanical properties was tested and investigated by nanoindentation machine and traditional tensile testing apparatus. The results show that the microhardness of the surface layer and the tensile strength of the alloy are significantly improved, but with a certain loss of fracture elongation. To investigate the effect of SMAT on the textural evolution of AZ31 Mg alloy, electron backscatter diffraction is used to analyze the as-received sample and samples after SMAT. The non-basal plane orientation is increased and the basal texture is significantly weakened in the finegrained layer after SMAT.
Keywords: Magnesium alloy; Surface mechanical attrition treatment; Gradient nanostructure; Grain orientatio; Textural evolution

Application development of highly thermal conductive Mg alloy in diecasting for consumer electronics industry
Norman Chen
Ka Shui Metal Manufacturing Co., Ltd., China
Abstract: Along with the technology evolution for dense integration of high-power, high-frequency devices in electronics, the accompanying interfacial heat transfer problem leads to urgent demands for advanced thermal material with high thermal conductivity and good mechanical properties. it is a great challenge to develop a light-weight metallic material for thermal conductivity application.
In this study, the effects of die-casting processes on the thermal conductivity, mold flow ability & mechanical properties were studied. This study solves this problem by constructing a rare-earth magnesium die-casted product with coral surface microstructure used in the modern die casting process. The resultant metallic structure has a thermal conductivity of 100-130W/mK, while compared to traditional die casting alloy of AZ91D which is only ~50 W/mk. In the actual TIM performance measurement, the notebook system cooling efficiency with our die-casted magnesium alloy, the CPU temperature has dropped by 3 ℃ with our modified casing. Therefore, improving the thermal conductivity of die castings will have significant performance and cost benefits for the 3C applications utilizing high-performance electronics.

An Outlook for High-Volume Application of Magnesium Road Wheel
Jianfeng Wang, Henry Zhan
General Motors, China
Abstract: Significant effort has been devoted to commercialize Mg wheel in China. This study analyzes the pro's and con's of various existing technologies for producing Mg wheel, with perspectives from the full supply chain (i.e., from Mg ingot to finished wheel), and outlines the challenges to enable high-volume application of Mg wheel. Specific attention was drawn to potential cost reduction opportunities by inventing new alloy and optimizing manufacturing process. A model was built to account for both the cost of Mg ingot and manufacturing, from which two significant contributors to the cost of a finished Mg wheel are identified: price for Mg ingot and recycled scrap. Mg wheel can be competitive in comparison to forged Al wheel if high-quality raw Mg billet can be economically produced and machining scrap can be easily recycled with a high residual value.
Keywords: Magnesium wheel; High volume

Development of new flame-retardant wrought magnesium alloys and application of the alloys to high-speed railway body
Yasumasa Chino, Kazunori Shimizu, Futoshi Kido, Takeshi Ishikawa, Makoto Taguchi, Takao Horiya
National Institute of Advanced Industrial Science and

Technology, Japan
Abstract: High flame retardance is essential for application to railway vehicle components. Application of "flame retardant magnesium (Mg) alloy", which is defined as Mg-Al alloy with 0.5-2.0mass%Ca, is effective way to improve flame retardance, because its alloy shows 200-300 ℃ higher ignition temperature than Mg-Al alloys. In Japan, the national project of "Innovative Structural Materials R&D" has been launched since 2013FY. As a one of R&D theme of the project, new flame-retardant Mg wrought alloys for its allocation to highspeed railway body have been conducted, and related processing technologies have been developed for producing railway vehicle body. Concerning to the development of new flame retardant Mg alloy, wrought Mg-Al-Ca alloys corresponding to A6N01 (Al-Mg-Si) and A7N01 (Al-Zn-Mg) Al alloys have been developed. Concerning to A6N01 alloy, AX41 (Mg-4%Al-1%Ca (mass%)) alloy with superior extrudability corresponding to A6N01 alloy has been developed. Concerning to A7N01 alloy, AX92 (Mg-9%Al-2%Ca) alloy for extrusion and AX81 (Mg-8%Al-1%Ca) alloy for plate, which have good balance in mechanical properties corresponding to 7N01 alloy, has been developed. After development of the new alloys, as a next step, a prototype, which imitates railway vehicle body with 1/1 scale cross section and 1m length, has been produced with the purpose of verifying their assembling ability, forming ability, joining ability, cutting ability, surface treatment ability and so on, where double skin and single skin type extrusions and press-formed plates processed from the newly developed alloys have been utilized to production of prototype.
Keywords: High speed railway body; Extrusion; Mechanical properties; Microstructures; profile

International Standardization for Magnesium and Magnesium Alloys industry
Huan Xi
Nonferrous metal technology and Economic Research Institute Co., Ltd, China
Abstract: Standardization is the best way to uniform behavior of multiple sides of products, and ISO/TC79/SC5 is the only International Committee on standardization of Magnesium and its alloys. Professor XI, as the Committee Manager (Secretary) managed SC5 and leading members, prepared lots of ISO standards in the past 12 years. This talk shows a brief introduction of International Standardization for Magnesium Industry and future imagine on construction for Standards Systems on Magnesium and its Alloys, internationally and domestically.
Keywords: Standardization

Theoretical Research, Technical Development and Engineering Application of New Magnesium Smelting Process
Jinhui Liu, Shaojun Zhang
Zhengzhou University, China
Abstract: During the past decades, the silicothermal process, which is also known as the Pidgeon process, has become the major approach to magnesium production in China. Over 90% of the primary magnesium output of our country is produced by means of the Pidgeon process. However, the low mechanization, low productivity and large amount of residue of this process has become a significant issue in recent years. It is necessary to develop a high mechanization, high productivity and small amount of residue technology to produce magnesium in industry.The Pidgeon process is composed of calcination, reduction and refining. If high-purity magnesium could be produced in the reduction stage directly, the refining stage would be needless, and as a result, the energy and cost would be saved. Through a series of theoretical research and experiments, our team developed a new "two-step" technology, which is able to produce high-purity magnesium in the reduction stage, without refining stage. In addition, a composite vertical retort (ceram-refractory steel-ceram) is used in the magnesium reduction furnace, which prevents slag ball from adhering to the tank wall and prolongs life of the retort. Consequently, the improved silicothermic process has no refining residue and waste gas discharge, improve the mechanization, and reduce cost. On the other side, we developed a new carbothermal process, a catalyst was introduced into this technology, which is capable to separate the mixed products of magnesium vapor and carbon monoxide to prevent the reverse reaction of them.
Keywords: Silicothermic; Carbothermic

Hydrogen storage and hydrolysis properties of core-shell structured Mg based nanocomposites
Jianxin Zou
Shanghai Jiaotong University, China
Abstract: The high operating temperature and the sluggish de-/hydrogenation kinetics seriously impede the commercial applications of MgH_2 for the onboard/stantionary hydrogen storage. Nanostructuring of Mg/MgH_2 has been widely proved to be a strategic approach to enhance the overall thermodynamics and kinetics of Mg-based material. In this study, the core-shell structured Mg-based nanocomposites coupling with various catalysts including metal, metal oxides (MOx), metal sulfides, and 2D MXenes have been performed to improve the hydrogen storage and hydrolysis properties of Mg/MgH_2. The core-shell structured Mg@catalysts (i.e. Pt, MOx, MXene, CoS) nanocomposites exhibited significantly improved hydrogen storage properties as compared to pure Mg. For instance, the core-shell MgH2-Ni@Ti-MX composite absorbed 5.4 wt % H2 in 25 s at 125 °C and released 5.2 wt % H2 in 15 min at 250 °C. During the de/hydriding processes, the evolution of various phases implying the different catalytic mechanisms in these core-shell nanocomposites. The multifunctional nanosizing and catalyzing effects in these Mg-based nanocomposites contribute to the significant enhancement on the hydrogen storage performances of Mg/MgH_2 system.
Keywords: Hydrogen storage; Mg-based nanocomposites; Hydrolysis; Core-shell structure

Novel Magnesium Extrusion Alloy Developed for Aerospace Applications
Scott Sutton
Mag Specialties Inc, USA
The current global need for reduction of greenhouse gases is driving increased demand for lightweight materials in automotive and aerospace industries. However, application of wrought magnesium in the transportation industries is limited due to high material property demands. In order to be competitive with other metals, wrought magnesium alloys must: be flame resistant, have high specific strength, have hot workability, and have low cost. Mag Specialties has developed a new magnesium-based extrusion alloy which meets all of these criteria. The alloy is ignition resistant, has mechanical properties similar to AZ80, is extrudable in tubes and complex hollow forms, and is relatively low cost. The benefits and properties of the new alloy are reviewed and are compared to existing commercial extrusion alloys.

The development of biodegradable magnesium alloys and their application: challenge and chance
Lili Tan
Institute of Metal Research, Chinese Academy of Sciences, China
Abstract: From the early of this century Mg alloys as a kind of biodegradable metal have emerged a rapid development. Up to now, four companies, from Germany, Korean and China,

respectively, have gained registration certificates on biodegradable Mg based metal implants. However the development of biodegradable Mg alloys are also faced with some challenges, not only from the traditional biomedical materials, such as Ti and Ti alloys, biodegradable polymers, etc., but also from the newly developed biodegradable metals, such as Zn and Fe based alloys. From the author's point, the most attracting advantage of biodegradable Mg alloy is its biological property, based on which, there are many chances for its application in biomedical field. So in this presentation, the challenges and the accompanying chances were reviewed and some application explorations by the author were also introduced and discussed.
Keywords: Biodegradable metal; Application

Work hardening and softening behavior of Mg-5Zn matrix influenced by particle deformation zone
Kunkun Deng, Q.X Shi, K.B. Nie, W.M. Gan, W. Liang
Taiyuan University of Technology, China
Abstract: The effect of particle deformation zone (PDZ) size on the microstructure and mechanical properties of SiCp/Mg-5Zn composites was studied. Meanwhile, the work hardening and softening behavior of SiCp/Mg-5Zn composites influenced by PDZ size were analyzed and discussed using neutron diffraction under in-situ tensile deformation. Evolution of FWHM (full width at half maximum) extracted from the diffraction pattern of SiCp/Mg-5Zn composites was used to interpret the modification of dislocation density during in-situ tension, which discovers the effect of dislocation on work hardening behavior of SiCp/Mg-5Zn composites. In addition, the tensile stress reduction (ΔPi) values during in-situ tension test were calculated to analyze the effect of PDZ size on softening behavior of SiCp/Mg-5Zn composites. The results show that the work hardening rate of SiCp/Mg-5Zn composites increased with the enlargement of PDZ size, which was attributed to the grain size of composites increased with the enlargement of PDZ size. Moreover, the stress reduction (ΔPi) values increased continuously during in-situ tensile for SiCp/Mg-5Zn composites due to the stored energy produced during plastic deformation increased, which provided a driving force for softening effect. However, the effect of grain size on softening behavior is greater than that of stored energy, which led to the tensile stress reduction (ΔPi) values of P30 (dPDZ=30μm) -SiCp/Mg-5Zn composite both were higher than that of P60 (dPDZ=60μm) -SiCp/Mg-5Zn composite when the εri were 0.25, 0.5, 0.75 and 1, respectively.
Keywords: PDZ size; Work hardening; Softening; In-situ tensile

On a nanoscale phase in as-extruded Mg-Gd-Li based alloys
Zijian Yu, Ke Liu, Shubo Li, Wenbo Du
Beijing university of technology, China
Abstract: In this study, we report a novel nanoscale phase in as-extruded Mg-Gd-Li based alloys. The results show that this nanoscale phase forms in the α-Mg during hot extrusion. The formation of nanoscale phase is due to the local shearing of atoms. The nanoscle phase provides an effective precipitation strengthening effect to the studied alloys.
Keywords: Magnesium; Rare earth; Hot extrusion; Lithium

Microstructure and properties of high-strength Mg-Zn-Y-Ce-Zr alloy with low RE content
Xianhua Chen
Chongqing University, China
Abstract: To develop high-strength wrought Mg alloys, we designed a Mg-Zn-Y-Ce-Zr alloy system with different alloy elemental ratio. Combined with extrusion and aging treatment, Mg-5Zn-0.5Y-1Ce-0.5Zr (wt.%) alloy with a bimodal structure achieved a yield strength (YS) of 407 MPa, ultimate tensile strength (UTS) of 421 MPa and elongation of 7.1 %, which mainly attributed the nano precipitates including MgZn2 and W phase ($Mg_3Zn_3Y_2$). Mg-6Zn-0.2Y-0.5Ce-0.5Zr (wt.%) extrusion sheet showed a relatively low YS of 322 MPa and UTS of 378 MPa. Further, surface friction treatment was conducted on sheet surface, which successfully fabricated an ultrafine grain (UFG) layer with average grain size of 98 nm. The UFG layer exhibited abundant plastic deformation behaviors and a different aging response compared with coarse grains. Mg-2Zn-6Y-0.5Ce-0.4Zr alloy containing LPSO phase showed comprehensive mechanical properties including YS of 229 MPa, UTS of 362 MPa and elongation of 17.9%, respectively.
Keywords: Mg-Zn-Y-Ce-Zr alloys; Mechanical property; Second phase; Ultrafine grains

New Mg-Zr-Sr-Sc alloys for biodegradable implant material Applications
Khurram Munir, Jixing Lin, Paul Wright, Yuncang Li, Cuie Wen
RMIT University, Australia
Abstract: Magnesium (Mg) and its alloys are considered promising biodegradable implant materials because of their metal strength and inherent ability to degrade in the human body. However, the high corrosion rate of pure Mg in the physiological environment leads to rapid degradation before adequate bone healing. This mismatch between bone healing and the degradation of Mg implants impedes their practical clinical applications and there have been calls for the development of new Mg alloys with the addition of other suitable alloying elements in order to achieve simultaneously high corrosion resistance and desirable mechanical properties. The current study systematically investigates the microstructure,mechanical properties, corrosion behavior, and biocompatibility of a new series of Mg-based alloys with the addition of different concentrations of scandium (Sc), i.e., Mg-0.6Zr-1Sr-xSc (x=0.5, 1, 2, 3 wt.%). Results indicated that the addition of Sc not only enhanced the mechanical properties of Mg alloys through solid-solution strengthening, but also improved corrosion resistance by forming chemically stable Sc oxide layers on the surfaces of the Mg alloys. Cytotoxicity assessment revealed that the addition of Sc did not significantly alter the viability of human osteoblast-like SaOS2 cells. This study highlights the advantages of using Sc as an alloying element to simultaneously tune Mg alloys with higher strength and slower degradation.
Keywords: Biocompatibility; Biodegradation; Mechanical properties; Mg-Zr-Sr-Sc alloys

Development and issue of Mg and Mg alloy production in China and the life cycle assessment
Zisheng Zhen
Magontec Xian Co. Ltd.,China
Abstract: This talk is going to summarize some of the recent development and issues on Mg and Mg alloy production in China. A particular focus will be on the sustainability and environmental impact. Some recent life cycle assessment study conducted by International Magnesium Association will be also reported.
Keywords: Mg and Mg alloys; Life cycle assessment; Environmental impact

Study on microstructure and properties of modified AZ80 high yield strength magnesium alloy
Gaofeng Quan, Yangyang Guo, Lingling Fan, Yuwenxi Zhang
Southwest Jiaotong University, Sichuan, China
Abstract: In the application of lightweight transition couplings for rail vehicles, the yield strength of conventional high-strength magnesium alloys is relatively

low ($Rp_{0.2}$ < 200MPa). In order to ensure neither damage nor deformation during use, the low cost magnesium alloy with high yield strength has been successfully developed through rare earth multi-element microalloying, forging + hot extrusion + aging and other processes. The mechanical properties test showed that the yield strength was up to 262MPa, the tensile strength was up to 377MPa, and at the same time it had a good elongation of 14%. It not only meets the application requirements of rail vehicles, but also can be applied to the motherboard of the new generation of mobile communication terminals on a large scale, showing great application potential.
Keywords: High yield strength; Multiple microalloying; Forging

Research Progress on Duplex Structured Mg-Li-X Alloys
Yan Yang, Xiaodong Peng
National Engineering Research Center for Magnesium Alloys, Chongqing University, China
Abstract: Duplex Structured Mg-Li-X (Sn, Ca and Mn) alloys were designed and prepared in National Engineering Research Center, Chongqing University. The microstructure of Mg-Li-X alloys has been characterized by optical microscopy, scanning electron microscopy and transmission electron microscopy; the mechanical properties were investigated by tensile tests while the corrosion properties were determined by electrochemical measurements and immersion measurements in 3.5% NaCl solution. The superlight duplex structured Mg-Li-X alloys with high performance was developed successfully.
Keywords: Mg-Li Alloys; Microstructure; Mechanical properties; Corrosion resistance properties

Enhanced mechanical and thermal properties of grapheme nanoplatelets reinforced Mg-Zn-Zr alloy
Xian Du, Wenbo Du, Zhaohui Wang
Beijing University of Technology, China
Abstract: Graphene nanoplatelets (GNPs), 2-D materials composed of single-carbon-atom layers, with inherent chemical and physical stability under high temperature and excellent mechanical properties, are good candidates for reinforcement of metal matrix composites (MMCs). Mg-Zn-Zr (ZK60) alloys reinforced by ultra-low content (<0.1 wt.%) of graphene nanoplatelets (GNPs) were fabricated via stirring cast and extrusion processes. The simultaneously enhanced mechanical and thermal properties of composite largely benefit from the well interface combination between GNPs and Mg matrix. GNPs thoroughly dispersed and formed a continuous interface contact with ZK60 matrix. Only 0.04 wt.% GNPs can improve the dynamic impact toughness twice that of ZK60 alloy, indicating the effective toughening function of GNPs in matrix. Notably, GNP(0.04)/ZK60 composite performed not only enhanced strength (256 MPa) but also improved thermal conductivity (139.4 W•(mK)-1, RT) than ZK60 alloy. The dispersed GNPs form beneficial networks for efficient load and heat transfer, providing a strategy to achieve the balance between mechanical and thermal performances of Mg alloys for the growing demand in electronic equipment, automobile industry and aerospace field.
Keywords: Graphene; Magnesium; Interface; Mechanical property; Thermal conductivity

The mechanical, triboligical and damping campacity of Ti2AlC reinforced Mg composite
Wenbo Yu, Xufeng Pi, Antoine Guitton
Beijing Jiaotong University, China
Abstract: The Ti2AlC reinforced Mg composite was fabricated and systematically characterized. Compared with the textured AZ91D and as-cast 10%volTi_2AlC -AZ91D composite, the textured 10%volTi_2AlC reinforced AZ91D magnesium composite's cross section in parallel (// ED) and perpendicular (ED) to extruded axis was investigated. As Ti_2AlC particles were reoriented after hot extrusion, tensile and compressive tests provide evidence of stronger anisotropy in textured composite than the textured AZ91D alloy. Tthe changes in slope of the resistivity with temperature (dp/dT) and electrical resistivity ratio R293K/R77K (RRR) between // ED and ED specimens confirm Ti2AlC do contribute in the AZ91 alloy to the scattering of the conductive free electrons. Ti2AlC significantly contributes to the damping capacity and to dynamic moduli of composites. With increasing temperature, especially above 200℃, the interfacial damping capacity becomes dominant and dynamic moduli of composites decrease. The composites exhibit superior wear resistance and self-lubricated ability than the AZ91 Mg alloy and SiC-Mg composite, the main mechanisms were characterized as the magnesium matrix oxidation and self-lubrication of Ti2AlC MAX phase.
Keywords: Magnesium composite; Characterization

Causes for abnormal electrode in pipeline magnesium electrolysis and its control
Zhu Fuxing, Li Liang, Ma Shangrun, Qiu Kehui
Chengdu University of Technology, China
Abstract: The frequently anodic fracture and cathodic eccentricity were studied in the process of pipeline magnesium production. Results showed that the current overload of the electrode was the main causes of the anodic fracture and cathodic eccentricity. Among them, the difference in thermal expansion coefficients between electrode material and clay brick was the root cause of abnormal electrode in bottom anode cell, while partial electrode overheating may cause the anodic fracture in top anode cell. The rate of abnormal electrode was obviously decreased through bottom blowing argon, cleaning out sludge, and polishing and tightening electrode surface. Adopting above methods, service life of the electrolyte adjusting cell, top anode cell and bottom anode cell could reach 40 months, 44 months and 60 months. This was contributed to guarantee the pipeline running long period.
Keywords: Pipeline magnesium electrolysis; Abnormal electrode; Bottom anode cell; Top anode cell

Potentiostatic Growth of Hazenite Mineral Coating on AZ31 Magnesium Alloy and Its Degradation Performance
Liping Wu
Institute of Metal Research, China
Abstract: AZ31 Magnesium alloy was polarized at −0.8 V in a deaerated phosphate solution containing 0.1 M K_2HPO_4 and 0.1 M Na_2HPO_4 (Na0.1K0.1) with pH 9 for 50 ks. The formation mechanism of the resulting coating was elucidated by establishing the relationship between in situ potentiostatic current decay and the coating evolution. The degradation resistance of the produced coating was measured in simulated body fluid maintained at 37℃ by potentiodynamic polarization. The results showed that brucite (Mg(OH)2) was deposited first, followed by the transformation of magnesium hydroxide to newberyite ($MgHPO_4•3H_2O$), subsequently the conversion of newberyite into crystallized struvite-K ($KMgPO_4•6H_2O$), finally the crystallization of hazenite ($NaKMg_2(PO_4)_2•14H_2O$). The deposited coating consisted of brucite as the innermost layer, brucite and newberyite as the inner layer, brucite, newberyite and struvite-K as the middle layer, brucite, newberyite, struvite-K and hazenite as the top layer and brucite, newberyite and hazenite as the topmost layer. The obtained coating decreased the degradation rate of AZ31 magnesium alloy by two orders of magnitude.
Keywords: Hazenite conversion coating; Magnesium alloy; Potentiostatic technique

Modeling & Simulation

Session 1, Chairs: Lijun Zhang, Jiangfeng Song
Date: Sunday, 22 Nov 2020

CALTPP: A general program to calculate thermophysical properties
Yong Du, Shuhong Liu, Yuhui Zhang, Huiyun Guo, Lei Huang
State Key Lab of Powder Metallurgy, Central South University, China
Abstract: Thermophysical properties including diffusion coefficient, interfacial energy, thermal conductivity, viscosity and molar volume are of fundamental importance in the field of materials science and engineering. A program CALTPP (CALculation of ThermoPhysical Properties) is developed in order to provide these thermophysical properties mainly as function of temperature and composition. The general structure of CALTPP is briefly described, and the CALPHAD-type models for the description of these thermophysical properties are presented. Two case studies including (a) the calculation of diffusion coefficient and optimization of atomic mobility and (b) the calculation of thermal conductivity in binary and ternary magnesium alloys are demonstrated to show the features of CALTPP. It is expected that CALTPP will be an effective contribution in both scientific research and education.
Keywords: Thermophysical properties; Calculations; Thermal conductivity; Diffusion coefficient

A New Constitutive Model for Thermal Deformation of Magnesium Alloys and Its Application
Jian Zeng, Jie Dong
Shanghai Jiaotong University, China
Abstract: Based on the stress-strain curves of as cast Mg-8Gd-3Y alloy, which were obtained by isothermal compression tests at temperatures ranging from 350 to 450℃ and strain rates from 0.001 to 1.5 s^{-1}, a new constitutive model for thermal deformation of magnesium alloys was proposed from the function relationship between the ratio of instantaneous stress to peak stress (σ/σ_p) and that of instantaneous strain to peak strain (ε/ε_p). The undetermined parameters of the model were calculated through parameter regression, and the predicted results agree well with the experimental results. To study the applicability of the new model, the stress-strain curves of the compression tests of AZ31B and ZK60 alloys in the literature were modeled and calculated by parameter regression, and their predicted values are very close to the experimental values. Then, the new constitutive model was integrated into a finite element software to simulate the load-stroke curves of isothermal upsetting of the specimen with variable cross-section and plane strain forging of Mg-8Gd3Y alloy. Under six different process parameters, the simulated load-stroke curves are well consistent with the experimental curves. To study the accuracy of using the new constitutive model to predict the three-dimensional complex deformation, a flat bottom cylindrical part (with outer diameter of 235 mm, wall thickness of 34 mm and height of 255mm) was taken as the research object. An outer flange was added to increase the overall deformation amount and strain uniformity of materials, and the forming process of cylindrical parts was simulated and the load-stroke curves were obtained. Finally, the hot backward extrusion experiments of flanged cylindrical parts were conducted. The experimental results exhibit that the flanged cylindrical parts with relatively uniform structure and performance could be properly formed with good surface quality, and the error between the experimental load and the simulated load was very small. All the results verify the accuracy of the new model for thermal deformation of magnesium alloys.
Keywords: Constitutive model; Magnesium alloy; Hot deformation; Finite element simulation

Numerical and experimental investigation into crystal plasticity behaviors of extruded magnesium alloy
Gang Fang, Baili Xi
Tsinghua University, China
Abstract: In this research, we developed reliable crystal plasticity finite element (CPFE) models and predicted the deformation behavior of extruded magnesium alloys. The CPFE models were implemented into the ABAQUS through user subroutine UMAT. The initial texture of extruded magnesium alloy was depicted by the representative volume element (RVE) with Voronoi grains. The applicability and reliability of the models of single crystal and polycrystal were then verified experimentally. The relation between macroscopic mechanical response and the activities of microscopic deformation mechanisms was analyzed for magnesium single crystals using the CPFE models. It was also confirmed that pyramidal I slip is the predominant <c+a> dislocation slip in the deformation of magnesium single crystals. The relation between the deformation heterogeneity and the dominant deformation mechanisms is determined, where both the Schmid factor and geometric compatibility factor were employed to shed light on the heterogeneous deformation at various grain boundaries. Additionally, we also performed in-situ in-plane tensile tests of magnesium alloy based on SEM and EBSD. For these deformed samples, we investigated the Schmid factor and slip/twin that were used to decide whether an activated slip/twin mechanism should contribute to global deformation or accommodate local deformation. Based on the trace analysis and fractographic examination, the relation between contraction twinning and the premature fracture was revealed. Two kinds of relaxation mechanisms were summarized, which could help to avoid premature fracture during the deformation at room temperature.
Keywords: Crystal Plasticity; Finite Element; Magnesium alloy; Deformation

Development of ICME framework for Mg alloys and its application
Lijun Zhang
Central South University, China
Abstract: In this paper, an ICME framework by integrating the CALPHAD (CALculation of PHAse Diagram) tools, phase-field modeling and machine learning technique was developed for Mg alloys. In this framework, different types of the available and in-house CALPHAD tools can be first employed to establish various materials genome databases of thermodynamics, atomic mobility, and other thermophysical parameter databases for the target Mg alloys in combination with the experimental and atomistic simulation data. After that, with the wellestablished genome databases, quantitative descriptions of microstructure evolution during solidification, homogenization, aging and even service process by using either series of CALPHAD-type tools or phase-field modeling. The machine learning technique can be then utilized to obtain the quantitative link between the microstructure and mechanical properties. With the present framework, the quantitative "composition-process-property" relation for the target Mg alloys can be established, and serve as the important basis for the future alloy design and preparation. Furthermore, the presently

developed ICME framework was successfully applied in two typical Mg alloys, Mg-Gd-based and Mg-Al-Zn-based alloys, for a demonstration.
Keywords: Mg alloys; ICME; CALPHAD; Phase-field modeling; Machine learning; Mg-Gd; Mg-Al-Zn

Modeling of dendrite growth and gas porosity evolution under convection in magnesium alloys
Ang Zhang, Bin Jiang, Fusheng Pan
Chongqing University, China
Abstract: Gas porosities are recognized as one of the most detrimental defects that can severely deteriorate mechanical properties of solidified materials. Simulating the formation of gas porosities in castings is challenging due to large liquid-gas density ratio, complex topological morphology, and intricate interaction involving multiphysics and multiphase. In this work, a multiphase-field lattice-Boltzmann model is developed to simulate the growth, deformation and motion of gas porosities during dendrite solidification in Mg-La binary alloy. Model validation is performed by testifying the Gibbs-Thomson effect and bubble dynamics under different configurations, and good agreements are achieved between the simulation results and analytical solutions. To facilitate a large-scale simulation, a parallel- adaptive mesh refinement algorithm is employed to reduce the computing overhead. Gas porosity evolution coupled with dendrite growth under convection is reproduced. Results show that the size, distribution, and initial pressure inside the porosity have remarkable influence on the final microstructure, which compares reasonably well with the available experimental data.
Keywords: Magnesium alloys; Gas porosity; Dendrite growth; Phase-field simulation; Solidification

Effect of surface defects on the corrosion behaviour of AZ80 alloy with CPCC coating
Jiangfeng Song, Xuejiao Jia
Chongqing University, China
Abstract: Scratches, pits and other defects are inevitably generated by stones or other objects on the surface of a magnesium alloy wheel hub during auto service. Hence, the effect of surface defects on the corrosion resistance of a calcium phosphate conversion coating (CPCC) on a forged AZ80 with wheel hub was studied. The corrosion resistance of AZ80, AZ80 with CPCC and coated AZ80 with surface defects was studied using electrochemical testing, immersion tests and hydrogen evolution. Scanning vibrating electrode technique, scanning electron microscopy and confocal microscopy were used to investigate the corrosion activity of the specimens with surface defects. The results show that CPCC improved the corrosion resistance of the AZ80 substrate, and the surface defects reduced the corrosion resistance of CPCC. Besides, the micro corrosion mechanism of the specimens with surface defects was clarified.
Keynote: Magnesium alloys; Surface defects; Corrosion; coating

Investigation of corrosion resistance of Mg-based alloys based on thermodynamic calculations
Shuhong Liu, Hui Feng, Seng Yao, Xiaojing Li, Yong Du
Central South University, China
Abstract: Magnesium alloys have superior mechanical property for industry applications as structural materials, but their poor corrosion resistance is still a bottleneck problem. Thus, understanding of the factors that influence corrosion performance and the corrosion mechanism is of great importance. Thermodynamic calculations based on CALPHAD (calculation of phase diagram) type thermodynamic databases have proved to be effective in precipitation and corrosion of Mg alloys. It is undisputed that the accuracy of the thermodynamic database is primarily important for the related calculations and predictions. Al, Zn and Mn are common alloying elements tin Mg alloys. The work udated thermodynamic description
of some binary and ternary subsystems of the Mg-based alloys and prepared some Mg-Al-Zn and Mg-Al-Mn alloys based on thermodynamic calculations and combined microstructure observations, thermodynamic calculations, and corrosion examinations to investigate the influence of Al, Zn and Mn on corrosion behavior. Thermodynamic calculations can help explain some experimental observation on microstructure and corrosion behavior.
Keywords: Corrosion resistance; Thermodynamic calculations; Mg-Al-Zn; Mg-Al-Mn; The second phases

Augmented thermodynamic database for magnesium alloys
Hai-Lin Chen, Qing Chen
Thermo-Calc Software, China
Abstract: We present an augmented thermodynamic database, TCMG6, which has been developed within a 33-element framework and covers all the major alloying elements and most of the minor ones. 102 ternary systems have been assessed and 92 % of them are Mg-containing. This update includes the modelling of important Mg-RE (rare earth) metastable precipitates, molar volume and thermal expansion, electrical resistivity and thermal conductivity, and viscosity and surface tension of liquid. As to be demonstrated here, TCMG6 can be employed in many aspects of Mg alloys design and process optimization, in addition to the calculation of phase equilibria, thermodynamic properties and the aforementioned thermophysical properties with the Thermo-Calc software. For example, it can be used to simulate the non-equilibrium solidification process and predict its phase formation sequence, phase amount and composition, micro-segregation, and as-cast microstructure. Together with a compatible atomic mobility database, it can be applied to simulate the kinetics in typical material manufacturing scenarios, such as the back diffusion in solids during non-equilibrium solidification, homogenization of the (Mg) matrix and dissolution of grain boundary phases during solution treatment, and precipitation of stable and metastable “phases” (including GP Zones) during age hardening. As to be demonstrated finally, one can apply the TC-Python API to perform high-throughput calculations and conduct customized simulations for Mg-based alloys.
Keywords: Augmented thermodynamic database; Magnesium alloys

In-situ experimental observation and kinetic numerical inversion of the diffusion growth of multiple intermetallic compounds in Mg-Al-Zn system
Kaiming Cheng, Jixue Zhou, Jiaxing Sun, Jin Wang, Huixia Xu, Chengwei ZhanQilu
University of Technology (Shandong Academy of Sciences), China
Abstract: The thermal stability of multiple intermetallic compounds is closely related to the hightemperature properties of alloys, so it is of great significance to study the diffusion kinetics of intermetallic compounds affected by alloy composition and temperature. However, due to the difficulties of experimental methods and calculation methods, the existing data on the diffusion kinetics of intermetallic compounds is very lacking. This work selects binary and ternary intermetallic compounds in Mg-Al-Zn based light alloys (including γ-$Mg_{17}Al_{12}$, β-Mg_2Al_3 and ϕ-$Mg_5Zn_2Al_2$) as the research object. The intermetallic multielement compound diffusion couples were designed and successfully prepared. The hightemperature laser confocal in-situ experimental method is then applied to measure the multi-element intermetallic compound in the Mg-Al-Zn system at different temperatures. The diffusion growth data were subjected to numerical inversion methods to compute the diffusion coefficient matrix of multi-element

intermetallic compounds with composition and temperature changes. The experimental and calculated results of this work can provide key kinetic information for the research on the heat-resistant mechanism of Mg- Al-Zn system alloys.
Keywords: Mg-Al-Zn system; intermetallic compound; Diffusion growth; high temperature insitu observation; Numerical inversion

Molecular dynamics study on the effect of temperature on generalized stacking fault energy in magnesium alloys
Wang Yuye[1], Yuling Xu[1], Aitao Tang[2]
1. Shanghai Spaceflight Precision Machinery Institute
2. Chongqing University, China
Abstract: The effects of temperature on generalized stacking fault energy (GSFE) of Mg–Al, Mg–Zn and Mg–Y alloys are investigated by using molecular dynamics with the second nearest neighbor modified embedded-atom method (2NN MEAM). The GSFE curves of basal {0001}<112 0>, {0001}<101 0> and pyramidal II {112 2}<112 3> slip systems show that elevated temperature can significantly decrease unstable stacking fault energy (unstable SFE) in different slip systems. However, temperature has little effect on stable stacking fault energy (stable SFE). In this study, the parameters χpyr and χpyrT are defined to reflect effects of solutes or temperature on activation of pyramidal slip. The results found that Y or Zn solute would improve the possibility of activation of pyramidal slip, and rising temperature is more effective for promoting pyramidal slip.
Keywords: Magnesium; Molecular dynamics; Generalized stacking fault energy

Corrosion & Protection

Session 1, Chairs: Tao Zhang, Jixue Zhou
Date: Sunday, 22 Nov 2020

Suppressing self-corrosion of Mg anodes via synergistic inhibition
Mikhail Zheludkevich, Linqian Wang, Min Deng, Bahram Vaghefinazari, Sviatlana Lamaka, Daniel Höche, Darya Snihirova
Helmholtz-Zentrum Geesthacht, Germany
Abstract: Mg-air primary battery recently become more and more attractive for special applications thanks to their environmental benignity, economic viability, and high theoretical specific power density. However, the high tendency to self-corrosion of Mg-based anodes and their fouling during discharge lead to relatively low specific energy efficiency. This work reports the strategy on decreasing the self-corrosion of Mg anodes via microalloying with Ca and design of the electrolyte additives in order to improve the energy efficiency of Mg-air batteries. It was shown previously, addition of Fe^{3+} complexing agents into electrolyte significantly inhibits parasitic self-corrosion and improves the Mg behaviour under anodic polarization. However, in many cases, hydrogen evolution reaction is not completely suppressed. The relevant method to thoroughly control hydrogen evolution reaction is to use combination of different inhibitors. Herein we combined Fe^{3+}-complexing agents, that prevent detrimental iron re-deposition, with efficient magnesium inhibitors (sodium nitrate and nitrite) that reduce parasitic hydrogen evolution reaction. The combination of inhibitors was chosen based on knowledge of magnesium corrosion mechanism and experience with corrosion inhibitors of Mg. In this work the effect of single additives and their combination was studied. Additionally, localised measurements of pH and dissolved oxygen above magnesium surface during polarisation were done in order to give insights on the inhibition mechanism. The results show that use of combination of inhibitors reduce significantly the self-corrosion and in addition prevent formation of $Mg(OH)_2$. The most effective was the mixture of sodium salicylate-sodium nitrate. This work is a step further to the improvement of the Mg-air battery performance.
Keywords: Corrosion inhibition; Magnesium battery

Exfoliation corrosion of magnesium alloys
Rong-Chang Zeng, Gui-Jia Gao, Zi-You Ding
Shandong University of Science and Technology, China
Abstract: Exfoliation corrosion of magnesium alloys has scarcely been reported. Here a recent study reveals exfoliation corrosion occurred on extruded Mg-Li-Ca alloys exposed to marine atmosphere in an island field for almost one year. Also, exfoliation occurred on Mg-1Li-1Ca soaking in 3.5% NaCl solution for 3-5 months. The results are due to elongated microstructure, and delamination of the lamellar structure resulted from galvanic and wedge effects. Galvanic effect between Mg_2Ca particles and their neighboring α-Mg matrix facilitated dissolution of Mg2Ca particles and α-Mg matrix; wedge effect was caused by formation of corrosion products. Exfoliation corrosion of extruded Mg-Li-Ca alloys might be a synergic effect of pitting corrosion, filiform corrosion, intergranular corrosion and stress corrosion.
Keywords: Magnesium alloy; Exfoliation corrosion

Ratio of total acidity to pH value of coating bath: A new strategy towards phosphate conversion coatings with optimized corrosion resistance for magnesium alloys
Tao Zhang, Fuhui Wang, Peng Zhou
Northeastern University, China
Abstract: Corrosion is a fatal flaw for Mg alloys to compete with traditional structural materials. The chemical conversion coating has been regarded as the most efficient, low-cost, and easyto-perform technology. Chromate conversion coatings (CCCs) are the most successful product in the last century, but the toxicity from Cr(VI) urges worldwide legislatures to phase them out. The development of alternatives for CCCs, i.e., chromate-free conversion coatings (CFCCs), are of critical scientific and economic significance. The formulation of the conversion bath is the most important and most valuable component of conversion treatment, but the design of the treatment bath relies heavily on “trial and error”. The lack of comprehensive knowledge towards the design of the conversion bath is obviously detrimental to the development of the technology. Although many researchers proposed to use the ion-pH diagram and pH value to design and optimize the conversion bath, the lack of universality of these strategies urges new principles. In this presentation, we propose to use the ratio of total acidity to pH value of the conversion bath (TA/pH), as a new indicator to design and optimize the conversion bath. This indicator takes into account both the thermodynamic and kinetic factors. A group of 48 phosphate conversion bath with different TA/pH values was prepared to treat the AZ91D.By measuring the hydrogen evolution rate (HER), one can see the decrease of HER accompanied by the decrease of TA/pH. The data mining performed by an artificial neural network validates the reliability of TA/pH as an indicator to predict the quality of conversion bath. The surface / cross-sectional morphology indicates that the TA/pH does not affect the chemical composition and the bi-layered structure of conversion coating, but affects the formation process of the outer Mn-rich layer. The

lowering of TA/pH is beneficial to minimize the convection effect, since the emission of hydrogen bubbles simultaneously blows Mn-rich particles away from the Mg surface. The TA/pH is also strongly related to the growth and crystallization of conversion particles, by affecting the extent of supersaturation and the preferential growth of the deposited crystals. The proposed indicator is applicable to all conversion coatings with different compositions. By referring to many published works, a similar relationship between the TA/pH and the corrosion resistance was established. The proposed strategy by using TA/pH as an indicator outperforms other strategies by its unique sensitivity to the chemical composition of conversion bath and the comprehensive incorporation of thermodynamics and kinetics.
Keywords: Conversion coating; Corrosion; Magnesium alloy

Ignition behavior of microarc oxidation coating sealed with aluminum phosphate applied on AZ91D alloy
Dong Han, Jin Zhang, Yong Lian
University of Science and Technology Beijing, China
Abstract: Magnesium alloys have important applications in aviation, rail transit and automotive industries, while the corrosion and flammability are common and real problems that must be solved for these applications. At present, enhancing the flammability resistance of magnesium alloys mainly by alloying rather than surface technology. The work aims to develop a method of synthesizing denser coatings with improved flammability resistance on AZ91. Prepared aluminum phosphate sealing layer on the microarc oxidation ceramic coating on the surface of the magnesium alloy (AZ91D) to achieve the function of non-flammability. The aluminum phosphate sealing coating with $Al(OH)_3$ and SiO_2 as fillers by dipping repeatedly on the uniform porous micro-arc oxide bottom layer. The microstructure, composition, sealing effect and flammability resistance of coatings were investigated. The results of flammability test showed that the sealed coating consisted of $Al(PO_4)_3$, Al_2O_3 and SiO_2 remained intact and compact and the Mg alloy substrate did not ignite. The aluminum phosphate sealant could block the pores of MAO coatings by forming a barrier layer and enhance ignition-proof performance. In addition, physical adsorption and chemical reactions between the aluminum phosphate sealing agent and the micro-arc oxidation ceramic layer enable to exhibited excellent interfacial adherence.
Keywords: Magnesium alloys; Coating; Ignition resistance; Aluminum phosphate

Synergistic Coating Strategy Combining Photodynamic Therapy and Fluoride-Free Superhydrophobicity for Eradicating Bacterial Adhesion and Reinforcing Corrosion Protection
Xiaobo Chen, Wei Wang, Yong Fan, Ivan Cole, Mingshi Song
RMIT University, Australia; Jilin University, China
Abstract: Device-associated infection is one of the significant challenges in the biomedical industry and clinical management. Controlling the initial attachment of microbes upon the solid surface of biomedical devices is a sound strategy to minimize the formation of biofilms and infection. A synergistic coating strategy combining superhydrophobicity and bactericidal photodynamic therapy is proposed herein to tackle infection issues for biomedical materials. A multifunctional coating is produced upon pure Mg substrate through a simple blending procedure without involvement of any fluoride-containing agents, differing from the common superhydrophobic surface preparations. Superhydrophobic features of the coating are confirmed through water contact angle measurements (152.5 ± 1.9°). In vitro experiments reveal that bacterial-adhesion repellency regarding both Gram-negative (Escherichia coli) and Gram-positive (Staphylococcus aureus) strains approaches over 96%, which is evidently ascribed to the proposed synergistic strategy, that is, superhydrophobic nature and microbicidal ability of photodynamic therapy
Keywords: Hydrophobic coatings; Photodynamic treatment; Biodegradable Mg implants

Effect of grain size and orientation on the corrosion behavior of an extruded dilute Mg-0.5Bi-0.5Zn-0.5Sn alloy
Weili Cheng, Yang Liu, Yanhui Liu
Taiyuan University of Technology, China
Abstract: Microstructural observation, hydrogen evolution and electrochemical tests were carried out to investigate the corrosion behavior of as-extruded dilute Mg-0.5Bi-0.5Zn-0.5Sn alloy. The studied alloy presents selective corrision mode, under which pitting preferentially propagats in the aggregation area of non-basal grains and fine grains during the first 24 hours immersion. As the immersion process proceeds, the corrosion morphology changes to groove dominated. With the immersion time exceeds 72 hours, uniform pitting corrosion mode is ocuurred in the studied alloy with the corroison morphlogy being characteristics of uniform shallow corrosion cavities together with tiny pits. Furthermore, the overall corrosion mechanism during 9 days' immersion in the simulated body fluid (SBF) solution was also proposed.
Keywords: Magnesium alloy; Corrosion behavior; EIS measurements; Grain orientation

Effects of lattice constants on MgO wettability and its relationship with corrosion of magnesium alloys: A molecular dynamics study
Chi Zhang, Xin Li, Junsheng Wang
Beijing Institute of Technology, China
Abstract: In a humid environment, water droplets on the solid surface can act as a medium to accelerate corrosion. If the solid material has hydrophobic properties, the surface of the material will remain "clean" and corrosion may be retarded to a certain extent. In theory, MgO itself is a hydrophilic material, and we can apply additional stress or strain to change its lattice constant and adjust the wetting behavior of water on the MgO surface, resulting in changes of corrosion resistance. In order to study the effects of MgO lattice expansion or contraction on the wetting behavior of nano-water, molecular dynamics simulations have been performed in this study. We expect to provide theoretical guidance to improve the hydrophobicity and corrosion resistance of Mg alloys in the future.
Keywords: Wettability; Lattice constant; MgO surface

Overall micro-arc oxidation treatment for magnesium–aluminium dissimilar metal connecting parts
Jixue Zhou
Advanced Materials Institute, Shandong Academy of Sciences, China
Abstract: The magnesium–aluminium connecting parts are important application form for lightweight structural materials. But the conductive connect of magnesium and aluminium will cause serious galvanic corrosion problems. Therefore, the overall corrosion protective treatment is necessary. A ceramic coating was prepared via overall micro-arc oxidation to wrap the magnesium–aluminium connecting part integrally. The surface morphologies and compositions of the coatings were analysed by scanning electron microscopy and X-ray energy dispersive spectroscopy. The corrosion behaviour of the coatings was investigated with potentiodynamic polarisation tests in 3.5 wt-% NaCl solution. The growth process of ceramic coating on aluminium and magnesium surface was investigated, which showed the micro-arc oxidation reaction priority and the balanced growth process of ceramic coating under unbalanced micro-arc distribution. The results demonstrated that the overall

micro-arc oxidation treatment improved the corrosion resistance and reduced the corrosion potential difference of each metal of magnesium–aluminium connecting part.
Keywords: Micro-arc oxidation; Magnesium-aluminium dissimilar metals

Simultaneously improving corrosion resistance and mechanical properties of a magnesium alloy via equal-channel angular pressing and post water annealing
Dan Song, Jinghua Jiang, Aibin Ma, Xiaolong Ma
Hohai University, China
Abstract: Developing magnesium alloys with both high corrosion resistance and superior mechanical properties is a longstanding challenge for the lightweight metal community. Herein, processing route combining equalchannel angular pressing (ECAP) and water annealing to achieve simultaneous improvements on both anticorrosion and mechanical performances of a Mg-2Zn-Mn-Ca-Ce alloy is proposed. The cast alloy was ECAP-processed at 573 k for 12 passes to obtain ultra-fine grains (UFG), followed by water annealing in the autoclave under 160°C for 3 h. The treated sample exhibits significantly improved corrosion resistance, presenting less corrosion current density and hydrogen evolution rate in the Hanks' solution. The doubled yield/ultimate strength and elongation, as well as the better-maintained mechanical integrity after corrosion, were achieved simultaneously. The profuse dislocations and grain boundaries in the UFG substrate offer intensive hydrothermal- reaction driving force, favoring the formation of a thicker and more compact Mg(OH)2 coating layer. Such a protective coating layer together with the annealed substrate with fewer crystal defects effecively retards the corrosion degradation and preserves the mechanical integrity afterwards. Meanwhile, the modified heterogeneous substrate microstructure results in the observed superior strength-ductility synergy. The proposed processing route and the resulted comprehensive properties should be applicable to other magnesium alloys as well.
Keywords: Magnesium alloy; High strength and corrosion resistance; Materialsprocessing; Heterogeneous microstructure

Forums

Forum on Lightweight, Chairs: Michael North, Yuansheng Yang
Date: Saturday, 21 Nov 2020
Forum on Industry-Academy Cooperation, Chairs: Xiaofang Zhou，Qiuyan Huang
Date: Sunday, 22 Nov 2020

Business Investment Strategies for the Growth of the Global Magnesium Industry
Michael North
Galaxy Trade and Technology, USA
Abstract: Magnesium has been a presence in industry for almost 100 years. But it has always been on the fringe of the industrial metals field. In this presentation, we will answer why this is so, what is being done about it, and the role China can have in building a high-velocity global industry. Michael North, head of a key export trade group that is committed to the success of China and all its international partners in magnesium, makes recommendations about the economic and trade policies that China could make today, to lead the magnesium industry into the center of global commerce.

China's Leadership Role in the Magnesium Industry
Zhou Xiaofang
Galaxy China, China
Abstract: As magnesium emerges as an important choice among industrial metals, the role of China, as the premier producer of 70% of the world's magnesium, grows more important. Xiaofang offers historic perspective on China's diplomatic and trade directions, which are rooted even before 1949, and continue to unfold. What is the best role for China to take now -- competition or cooperation, or a combination of the two? How can China maximize its own advantage, and at the same time be a responsible leader of the world economic community, using its strategic advantage in the magnesium industry for the benefit of all? What are the lessons from China's recent past, and what principles should China support and encourage others to understand, that can lead to a more balanced, environmentally -sound economy?

Magnesium Optimization Strategies for the Automotive Industry
Dan Panoz
Galaxy Motion, USA
Abstract: The field where the the benefits of strong, lightweight magnesium can be seen first, and most dramatically, is the automotive industry. A very effective focus for automotive, especially in the expanding electric vehicle industry, is in competitive auto racing, where the laws of physics, mechanics and human reflex are stretched to the limit. Dan Panoz, the design engineer at the heart of Panoz Racing for the past 30 years, talks about the coming transformation of the auto industry, as intelligent strategies are developed for magnesium optimization of vehicles of all kinds -- from bicycles to cars to buses and high-speed rail.

The role of Competitive Motorsports in Stimulating the Adoption of Magnesium
Greg Gill
SRO Motorsports America, USA
Abstract: SRO, originally based in France, has now extended the reach of its competitive motorsports all over Europe, America and Asia. Mr. Gill heads the SRO organization in the United States, where the sport of auto racing is growing very quickly. His work connects with magnesium in fascinating ways: as a way of making powerful cars lighter, faster, more efficient, stronger and safer, diversifying the types of competition and reaching new audiences around the world. Greg will talk about the expansion plans of SRO in China, and their plans to bring magnesium lighweighting to racetracks around the world.

Global Market Strategies for Magnesium
Matt Lorin
Galaxy Magnesium, USA
Abstract: Matt will address the strategies that are making magnesium more universally available, at reasonable prices, guarantee quantities and quality. How will magnesium compete in global markets, taking its place alongside aluminum and steel, and what actions can governments, banks and private enterprise take to accelerate industry growth? From his background in international relations, especially at the White House and the United Nations, Matt offers some strategic visions, and immediate actions.

IMA Supports the Global Growth of Magnesium Industry
Rick McQueary
International Magnesium Association, USA
Abstract: The International Magnesium Association (IMA) has been in existence for over 77 years. We continue to be viewed as the global voice of for the magnesium industry representing members in all corners of the world. The Mission of the IMA is to promote the use of the metal Magnesium in material selection and encourage innovative applications of the versatile metal. This presentation will provide a short overview of how the IMA adds value to its members and supports the global growth of the Magnesium industry. At the end the presentation, we hope that you too will see the value of membership and want to be a part of a great group of companies that work to promote the advancement of Magnesium.

Novel Magnesium Extrusion Alloy Developed for Aerospace Applications
Dr Scott Sutton
Mag Specialties Inc., USA
Abstract: The current global need for reduction of greenhouse gases is driving increased demand for lightweight materials in automotive and aerospace industries. However, application of wrought magnesium in the transportation industries is limited due to high material property demands. In order to be competitive with other metals, wrought magnesium alloys must: be flame resistant, have high specific strength, have hot workability, and have low cost. Mag Specialties has developed a new magnesium-based extrusion alloy which meets all of these criteria. The alloy is ignition resistant, has mechanical properties similar to AZ80, is extrudable in tubes and complex hollow forms, and is relatively low cost. The benefits and properties of the new alloy are reviewed and are compared to existing commercial extrusion alloys.

Posters

Sunday, 08:00-17:00
Date: 22 Nov, 2020

P1. In-situ TEM investigation on pyramidal dislocation slip in Mg
Fei Liu, Bo Yu Liu, Zhi Wei Shan
Xi'an Jiaotong University, China
Abstract: Magnesium is the lightest structural metal with promising applications for achieving energy efficiency. However, magnesium has limited ductility, which imposes severe constraints on cost-sensitive processing and hampers its widespread applications. The ductility of magnesium is intimately related to the pyramidal <c+a> dislocations. Controversies now abound surrounding the fundamental behavior of <c+a> dislocations, such as their ability to accommodate plastic strain and their slip pathways, causing difficulties in rationalizing the mechanical behavior and in alloy design. The present work exploits in-situ TEM mechanical testing and 3D image reconstruction to study the <c+a> dislocations in magnesium. The motion of <c+a> dislocations of various characters and the slip pathways are investigated. Our experimental strategy can be extended to understanding the dislocation behaviors in other hexagonal metals
Keywords: Magnesium; Dislocation; Plastic deformation; In-situ TEM

P2. Hot Tearing Behavior in Double Ternary Eutectic Alloy System: Mg-Ce-Al Alloys
Bo Hu, Dejiang Li, Jingya Wang, Zixin Li, Xueyang Wang, Xiaoqin Zeng
Shanghai Jiao Tong University, China
Abstract: The hot tearing behaviors of double ternary eutectic alloy system, Mg-4Ce-xAl (x=0-9wt.%) alloys, were evaluated by a CRC mold. The occurrences of hot tearing were determined by the Volumetric contraction force-Temperature-Time curves combining the solidification paths simulated by Thermo-Calc software. The ratio of drop-in force to final force reflected the severity of hot tearing from the point of micro perspective, its tendency was consistent with the hot tearing susceptibility. Affected by the double ternary eutectic reactions and solidification phases evolution, unlike general alloys, the hot tearing susceptibility curve of Mg-4Ce-xAl alloys contained two peak points. Compared with the hot tearing susceptibility of binary Mg-Al and Mg-Ce alloys, the peak points in Mg-4Ce-xAl alloys were later than that in Mg-Al and Mg-Ce alloys due to the faster diffusion accelerated by the solidification phase of Al11Ce3. The nucleation, propagation and healing of hot tear cracks were affected by the types, fractions, sizes and distributions of solidification phases which mainly included Mg12Ce, Al11Ce3 and Mg17Al12 in addition to the matrix Mg.
Keywords: Hot tearing susceptibility; Mg-Ce-Al alloys; Drop-in force; Peak points; Solidification phases

P3. Correlation of 3D defect-band morphologies and mechanical properties in high pressure die casting magnesium alloy
Wenbo Yu, Chaosheng Ma, Yihu Ma, Shoumei Xiong
Beijing Jiaotong University, China
Abstract: For understanding the processing-microstructure-properties correlation of high pressure die casting (HPDC) AZ91D alloy, 3D reconstruction was carried out to characterize the microstructural morphologies of castings produced by four designed HPDC processes. The influence of different parameters (vacuum, slow-shot speed, fast-shot speed) on porosity volume and morphology, defect band width and average externally solidified crystals(ESCs) size of castings were systematically studied. Microstructural characterization revealed that the defect band width was strongly related with the size and quantity of ESCs, rather than the porosity volume. Meanwhile, ESCs were mainly influenced by the slow-shot speed in shot sleeve (ESCs growth time) and fast-shot speed into the die cavity (shear stress of melt flow). Tensile fracture revealed that cracks easily propagated within the defect bands due to the accumulated ESCs and connected irregular pores, while the cracks were restrained in center zone. The mechani cal properties of HPDC castings was inversely proportional to the defect band width, and is not dependent on the average volume fraction porosity
Keywords: HPDC parameters; Defect band; Porosity; 3D; Tensile fracture

P4. Tailoring the texture through twinning and its effect on the dynamic compressive mechanical behavior of ZK61 magnesium alloy
Abdul Malik
Beijing Institute of Technology, China

Abstract: The abstract is already submitted and accepted, the reviewer needs to put the Title. The previous entry was not editable, therefore, the new submission was used for Title submission.
Keywords: Texture; Pre-compression

P5. Development of wrought Mg-Gd-Er-Zn-Zr alloy with excellent strength-ductility balance
Linyue Jia, Wenbo Du, Zhaohui Wang, Ke Liu, Shubo Li, Xian Du
Beijing University of Technology, China
Abstract: Due to the great potential for weight reduction in aerospace and automotive industries, magnesium-rare earth (Mg-RE) based alloys with outstanding mechanical performance have been widely investigated for decades. However, magnesium alloys are still restricted in engineering applications because of their lower strength and ductility, hence, there are large spaces and challenges in achieving high-performance Mg alloys. This work reports a Mg-Gd-Er-Zn-Zr alloy with ultrahigh strength and good ductility developed via hot extrusion, pre-deformation and two-stage aging. The extruded alloy comprises fine dynamically recrystallized (DRXed) grains and coarse worked grains with large aspect ratio. Predeformation has little effect on the microstructure and macro-texture, and serves primarily to introduce a large number of dislocations, resulting in strain hardening and higher precipitation strengthening during subsequent aging due to more nucleation sites. As a result, the alloy exhibits a yield strength (YS) of 506 MPa, an ultimate tensile strength (UTS) of 549 MPa and an elongation (EL) of 8.2% at room temperature, showing superior strengthductility balance than the other wrought Mg-RE alloys previously reported. The current study proposes a combination of pre-deformation and two-stage aging to further improve the mechanical properties of wrought Mg alloys for engineering application.
Keywords: Magnesium alloys; Mechanical properties; microstructure; Pre-deformation

P6. Texture evolution and LPSO kinking of Mg-Gd-Y-Zn-Zr alloy under combined compression-torsion processing
Ce Zheng, Ming Cheng, Shuaifeng Chen, Shi-Hong Zhang
Institute of Metal Research, China
Abstract: The texture evolution and LPSO kinking of Mg-Gd-Y-Zn-Zr alloy under wide compression-torsion ratios (1:1.4, 1:2.3, 1:4 and 1:9) were investigated at 450 ℃ by using a hot compression-torsion experimental setup. It is found that a "mixed texture" with weaker intensity was induced during the combined compression-torsion process, which synthesizes the features of “compression texture” in uniaxial compression and “torsion texture” in pure torsion. With increasing of the ratio between compression and torsion, the characteristics of compression texture turn to be dominated. With the analysis of effective Schmid factor (ESF) newly proposed by us, the formation mechanism of the “mixed texture” was further clarified, indicating that the most active basal slip <a> plays an essential role during the compression-torsion process. Beside that for compression, the shear stress/strain from torsion introduces extra stable positions for basal slip <a> (e.g., low ESF regions), which also evolve with the change in compression-torsion ratio. In addition, the kink behavior of LPSO phase strongly depends on the loading direction and matrix grain orientation. The LPSO phases with low ESF values for basal slip are superior to be kinked easily. For uniaxial compression condition, the regions for low effective Schmid factor are calculated to be 0-20°to 60-80°, respectively, which are larger than those of pure torsion and combined compression-torsion conditions, and thus results in the more kink bands in compressed samples.
Keywords: Mg-Gd-Y-Zn-Zr alloy; Torsion; Texture evolution; LPSO phase; Kinking; Effective Schmid factor

P7. The specific role of Yb content on the microstructure mechanical properties of cast Mg-9Gd-0.5Zn-0.5Zr alloy
He Xie
Shanghai Jiao Tong University, China
Abstract: This work was undertaken to investigate the specific role of Yb content on the microstructure and mechanical properties of cast Mg-9Gd-0.5Zn-0.5Zr alloy. It was found that, as the Yb content increasing, the eutectic phases change from Mg5Gd to Mg3Gd and the formation of LPSO phases is suppressed. Tensile tests reveal that, the addition of Yb (1wt%) could lead to substantial enhancements of the strength (72 MPa) of peak-aged alloys, while the alloy elongation would be remarkably reduced from 11.8% to 1.5%. The TEM observation indicates that, compared with the sparse distribution of precipitates (including β′ phases, β1 phases) in Mg-9Gd-0.5Zn-0.5Zr alloy, the remarkable improvement in precipitation-hardening in Mg-9Gd-1Yb-0.5Zn-0.5Zr alloy is associated with a much denser vertical distribution of prismatic precipitates (including β′ phases, β1 phases) and basal precipitates (γ″ phases). Moreover, it should be noted that, the coarsening β1 phases tend to connect with each other, which is harmful to the ductility of alloy.
Keyword: Mg-Gd-Zn-Zr alloy; Yb addition; Strengthening mechanism

P8. Research on Continuous Variable Channel Extrusion-Shear Forming Process of AZ31 Magnesium Alloy Thin-walled Tube
Songlin Gan, Hongjun Hu
Chongqing University of Technology, China
Abstract: In this paper, AZ31 magnesium alloy thin-walled pipes were obtained by the continuous variable channel extrusion-shear process (CVCES) of large plastic deformation, which weakened the base surface texture of the formed pipes, refined the grains, and improved the comprehensive mechanical properties. In order to study the deformation mechanism in the extrusion process, the plastic deformation behavior of wrought magnesium alloy in the extrusion process was studied by numerical simulation, including the influence of temperature and stress distribution on the extrusion results. In addition, the mechanical properties and grain size of the pipe were studied. The results of pipe extrusion indicated that the effect of the grain refinement was obvious, and the final formed pipe structure was mostly 10μm grains. Furthermore, the hardness value of each position of the pipe was significantly improved, and the higher the extrusion temperature, the lower the hardness value. The results of numerical simulation showed that the cumulative strain of thin-walled pipes formed by continuous variable channel extrusion-shearing was considerably increased.
Keyword: Finite element simulation; Microstructure evolution

P9. Thermodynamic prediction of thermal conductivity in Mg-La/Ce-Zn system
Xie TianCi, Shi Hui, Luo Qun, Li Qian
Shanghai University, China
Abstract: Thermal conductivity is a critical parameter for evaluating heat dissipation performance. Solute atoms and the secondary phases are important factors affecting heat dissipation performance, which can improve mechanical properties while deteriorating the heat dissipation performance. This paper found that the solute atoms have more negative influences on thermal conductivity of Mg-La/Ce-Zn alloys than secondary phases. For clarifying the influences of solute atoms and secondary phases on thermal conductivity, a set of selfconsistent of parameters for expression of thermal diffusivity of Mg-RE (La/Ce)-Zn alloys was constructed. According to the calculated approach, the thermal conductivity of Mg-La/Ce-Zn system are predicted,

which agrees with experimental data with calculation error of 1.6 % and standard error of ±3.0 W/(m•K). Among these as-cast alloys, Mg–(0.17~0.57)La–(1.53~2.38)Zn (at.%) and Mg–(0.14~0.52)Ce–(1.60~2.02)Zn (at.%) possess excellent thermal conductivity greater than 120 W/m•K with yield strength higher than 85 MPa.
Keywords: Mg–La/Ce–Zn alloys; Thermal conductivity; Secondary phase; Solidatoms; Thermodynamic

P10. Coupled CA-FE Simulation for Dynamic Recrystallization of Magnesium Alloy during Hot Extrusion
Yuying He, Gang Fang
Tsinghua University, China
Abstract: The dynamic recrystallization (DRX) behavior of a newly-developed Mg-Al-Zn-RE alloy during hot extrusion is investigated by coupling finite element (FE) and cellular automaton (CA) models. The changes in process variables (strain, strain rate, and temperature) with time at local regions of workpieces during hot extrusion are extracted from the results of FE analysis, and then submitted to a two-dimensional CA model to quantitatively and topologically evaluate the DRX process. Models of DRX nucleation and grain growth velocity in the CA model are modified to consider the role of second phase particles in the DRX behavior of the magnesium alloy. Employing the established CA-FE model, we investigated the microstructures of the studied magnesium alloy at different positions of extrudate as well as the influence of extrusion conditions on microstructural evolution. The homogeneous microstructure in the inner of the extrudate is found due to uniform deformation while finer grains near the edge results from higher strain and strain rate. After hot extrusion under the studied forming condition, as-cast and solution-treated grains are refined drastically from 372 μm to 6-13 μm by DRX. High initial billet temperature or extrusion speed lead to coarse recrystallized grains. At the initial billet temperature of 623 K and the extrusion speed of 7.83 mm/s, the finest grain size (about 6 μm) is obtained. With decreasing initial billet temperature or increasing extrusion speed, grain distribution gets more homogeneous. The simulated results agree well with experimental ones.
Keyword: Cellular automaton; Finite element; Dynamic recrystallization; Magnesium alloy; Extrusion

P11. Quasi-in-situ observations of twins, nuclei orientation and texture evolution during continuous annealing in a cold-rolled Mg-Zn-Gd alloy
Lingyu Zhao, Hong Yan, Rongshi Chen, En-hou Han
Institute of Metal Research, Chinese Academy of Sciences
The orientation rotation of grains during annealing at 250 ℃ for 45-60 min was tracked by quasi-in-situ electron backscatter diffraction method. The grown grains during annealing were selected and the results show that the orientation (including c axis orientation and the crystal direction parallel to rolling direction) of the same grain changes during the growth process. For most grains, the changing degree during 45-51 min annealing process is larger than that during 51-60 min annealing which may be related to the larger area change during 45-51 min annealing. The grain orientation evolution does not show a specific law which may be associated with the diversity of orientation in surrounding swallowed grains. Moreover, the orientation of some grains rotates around the c axis, which may provide a new insight to the study on the relationship between “rare earth” texture formation and preferential grain growth.
Keyword: Orientation, Rotation, Grain growth, Mg alloys, Quasi-in-situ EBSD

P12. Mg-Mn extrusion alloys with superior ductility at room temperature
Chongchao Li, Zihan Xia, Xiaoguang Qiao, Mingyi Zheng
Harbin Institute of Technology, China
Abstract: Magnesium alloys usually have a poor ductility at room temperature, which restrict their commercial application. Grain refinement and grain boundary control are effective routes to improve the ductility of Mg alloys at room temperature. In order to develop magnesium alloys with high ductility at room temperature, the effects of Mn content and extrusion temperature on the microstructure and mechanical properties of Mg-Mn binary alloys were studied and mechanism for superior room temperature ductility of the Mg-Mn extrusion alloy was investigated. With the increase of Mn content, the proportion of unrecrystallized area is increased and the dynamic-recrystallized grain is refined, leading to the increase of strength and decrease of ductility of the Mg-Mn extrusion alloy. When extruded at lower temperatures both strength and ductility of the Mg-Mn alloys are increased. The Mg-0.7wt%Mn alloy extruded at 125°C has an average recrystallization grain size of about 1.0~2.0μm, and Mn element is segregated at the dynamic-recrystallized fine grain boundaries. The Mg-0.7wt%Mn alloy extruded at 125°C exhibits superior elongation-to-failure of 82% when tensile-tested at strain rate at 1.1×10-3s-1 at room temperature. The Mg-Mn alloy with superior ductility has a strain rate sensitive exponent m of 0.15, indicating that grain boundary sliding contributes greatly to the superior ductility of the Mg-0.7Mn extrusion alloy at room temperature. The segregation of Mn at the fine dynamic recrystallized grains may promote the grain boundary sliding during tensile test at room temperature.
Keyword: Mg-Mn alloys; Extrusion; Ultrafine grains; Grain-boundary segregation; Superior ductility at room temperature

P13. Study on Microstructure and Corrosion Properties of Biodegradable Mg-Zn-Mn-Ca Alloys
Junjian FU, Wenbo Du, Zhaohui Wang, Ke Liu, Shuobo Li, Xian Du
Beijing University of Technology, China
Abstract: Magnesium alloys, as a new type of biodegradable medical metal material, have a promising application in the field of interventional medical devices. In this work, Mg-4Zn-0.2Mn-xCa (0.05~1 wt.%) alloys were designed to study the effect of Ca element on the mechanical and corrosion properties of the alloy. Results showed that the alloy with 0.2wt.% Ca element has the best comprehensive properties. The micro-tubes for vascular stent application of Mg-4Zn-0.2Mn-0.2Ca alloy with 3.6 mm in outer diameter and 0.4 mm in thickness were prepared by hot extrusion-drawing composite process. It indicated that the crystal slip, twins and recrystallization occurred during the plastic deformation, and the work hardening was significant. This drawn tube exhibited a tensile strength of 427.3 MPa, yield strength of 383.4 MPa, and elongation of 5.2%. After annealing at 300 ℃ for 30 min, the microstructure became uniform and the elongation increased to 18.0%. In vitro degradation of micro-tubes were investigated by means of immersion test in Hank’s simulated solution. The long-term immersion test revealed that the corrosion process of the micro-tubes was relatively uniform. The corrosion rate after immersion in for 180 days was 0.3094 mm/y, before complete biodegradable when soaked for 202 days.
Keyword: Magnesium alloys; Micro-tube; Microstructure; Hank's simulated solution; Corrosion properties

P14. Microstructure and tensile properties of Al/Cu dissimilar alloy joint via electromagnetic pulse welding
Puquan wang[1], Xianquan Jiang[2]
1. College of Engineering and Technology
2. College of Materials and Energy, Southwest University, China
Abstract: Electromagnetic pulse welding of Al/Cu dissimilar joint can achieve superior joint via ultra-fast impact at ambient temperature and has the potential to limit the formation of undesirable IMCs and metallurgical defects that are commonly

observed in most fusion welding technologies. In this report, the interfacial microstructures and tensile properties of joints at different discharge voltages were discussed. The EMPWed joints consisted of annular weld zone and central non-weld zone. The outer and inner regions of annular weld zone exhibited mainly diffusion bonding and mechanical interlocking, respectively, representing a well-bonding interface. Distinctive discontinuous "droplet-like" pseudo-eutectic (α-Al + Al2Cu) particles or patches were observed to eject in the adjacent transition region in the non-weld zone. The highly non-equilibrium eutectic-like liquid or slurry at the Al/Cu interface was formed due to the ultra-high strain rate experienced by the interface and ensuing instant temperature rise beyond the eutectic temperature of Al-Cu system during high-velocity impact. The higher the discharge voltage was, the more obvious the interfacial diffusion layer and mechanical interlocking were, with "wave-like" and "inverted hook-like" interfacial characteristics observed. While interfacial failure occurred during the tensile lap shear tests for the joints made at a discharge voltage of 12 kV, the failure loads were still significantly higher than those specified in the AWS D17.2 standard. The EMPWed joints made at 14 kV and 16 kV remained intact and only base metal failure occurred, with the tensile lap shear failure loads reaching over twice those specified in the AWS D17.2 standard. Thus the well-bonded robust Al/Cu dissimilar welds were successfully achieved via EMPW.

Keyword: Electromagnetic pulse welding; Al/Cu dissimilar joint; Interfacial microstructure; Tensile properties

P15. Mechanical properties and annealing behavior of rolled MgY1Zn0.85 sheets fabricated by twin roll casting and direct chilling casting

Xiaorui X iaorui Dong, Hui Yu
Hebei University of Technology, China

Abstract: In the present work, by comparing the effect of twin-roll casting (TRC) and direct-chill casting (DC) on the microstructure and mechanical properties of MgY1Zn0.85 alloy, revealing the evolution of the center segregation and the changes of its strain hardening ability during homogenization, finish rolling and annealing. The center segregation in twin-roll cast MgY1Zn0.85 strip experiences vanishing in as-homogenized states (530 ℃, 12h) and reappearing through intermediate annealing with final rolling (530℃, 1h). In the subsequent annealing process, as the annealing temperature increases, the segregation gradually grows (350 ℃-400 ℃, 1h), then to disappear (450℃-500℃, 1h), and finally reappear (530℃, 1h). Furthermore, the process of disappearance and reappearance of the intermediate segregation, the phase compositions, and morphology of which change at the same time. Changing from the discontinuous network W phase in as twin-roll cast to disappear through homogenization, and reappeared after the subsequent intermediate annealing, and as the final annealing temperature increased, gradually change from the LPSO phase and W phase mixed network structure (350℃, 1h) into clusters of LPSO phase (400℃, 1h), to dispersed LPSO phase (450℃, 1h), to mixed granular and net W phase (500℃, 1h), and finally to continuous network-like W phase (530℃, 1h). Moreover, through comparing the strengthening effect of the phase composition and the morphology of the segregation in the sheets prepared by TRC and DC, it was found that the chain network W phase exhibits excellent strain hardening ability and can significantly increase the yield strength of the matrix.

Keyword: Mg-Zn-Y; Twin-roll casting; Segregation

P16. Accurate thermodynamic description for Mg-Al-Zn-Sn quaternary system and its application to composition design of Sn-modified AZ91 alloys

Ting Ting Cheng, Lijun Zhang
Central South University, China

Abstract: Based on the experimental phase equilibria and thermodynamic properties available in the literature, thermodynamic descriptions for binary Mg-Sn, ternary Mg-Al-Sn and Al-Zn-Sn were first updated to achieve better fit to the experimental information by means of CALPHAD approach. Then, a thermodynamic description of Mg-Al-Zn-Sn quaternary system was developed by directly extrapolating the four sub-ternary systems (Mg-Al-Zn, Mg-Al-Sn, Mg-Sn-Zn, and Al-Sn-Zn), and its reliability was validated by comparing the predicted solidification microstructures and phase transformation temperatures of some key AZ91-xSn cast alloys with the experimental ones. After that, based on the accurate thermodynamic description of Mg-Al-Zn-Sn system, the solidification phase diagram of AZ91-Sn was constructed from the huge amount of Scheil-Gulliver simulations. With the solidification phase diagram, the influence of different Sn contents on the solidification behavior of AZ91 cast alloys can be clearly analyzed, and the qualitative relationship between the mechanical properties and the solidified microstructures can be established. Finally, the optimal additional amounts of Sn in AZ91 alloy were predicted to be 0.22 wt.% and 2.90 wt.%, which were nicely confirmed by the measured microstructure and mechanical properties of several key alloys.

Keyword: Mg-Al-Zn-Sn system; AZ alloys; CALPHAD; Composition design; Solidified microstructure

P17. Effect of Y on Microstructural Evolution and Mechanical Properties of Mg-13Li-3Al Alloy

Xiaojing Su, Jing Guo, Li Li Chang
Shandong University, China

Abstract: Mg-13Li-3Al-xY (x=0, 0.5, 1, 1.5, 2 wt.%) magnesium alloys were prepared by vacuum melting followed by hot-extrusion process. Microstructure evolution and mechanical properties of Mg-13Li-3Al alloys were investigated by optical microscopy (OM), scanning electron microscopy (SEM), X-ray diffraction (XRD) and tensile test. The results show that the strength and ductility of Mg-13Li-3Al alloys at room temperature are simultaneously improved largely due to hot extrusion. The best comprehensive mechanical properties are obtained in hot-extruded Mg-13Li-3Al-0.5Y alloy, the ultimate tensile strength at room temperature of hot-extruded Mg-13Li-3Al-0.5Y alloy is ~239MPa, and its elongation reaches ~25%. The improvement of strength and ductility of hot-extruded Mg-13Li-3Al alloys is the result of combined effect of grain refinement due to dynamic recrystallization during hot extrusion, second phase strengthening by $MgLiAl_2$, Al_2Y particles and solid solution strengthening by Al and Y in β-Li matrix.

Keywords: Mg-Li-Al alloys; Hot-extrusion; Microstructure; Mechanical properties

P18. Research on Microstructure and Mechanical Properties of Magnesium Alloy Produced by Cyclic Expansion Extrusion with an Asymmetrical Extrusion Cavity

Jie Zheng, Zhaoming Yan, Zhimin Zhang, Qiang Wang, Yong Xue
North university of china, China

Abstract: For developing Mg alloys with high strength and toughness, we proposed a novel severe plastic deformation method entitled of cyclic expansion extrusion with an asymmetrical extrusion cavity (CEE-AEC) to fabricate the thick plate Mg alloys of 50 mm × 100 mm × 220 mm (Length × Width × Height) with fine grain structure and excellent properties. Introducing the shear strain by attaching an asymmetrical extrusion cavity is the core advantage of this technology. The CEE-AEC process was applied to commercial alloys Mg-Al-Zn and rare earth Mg alloys Mg-Gd-Y-Zn-Zr. The effects of processing parameters and the alloy composition on microstructure, texture and mechanical properties were investigated systematically. Furthermore, microstructural

evolution and strengthening mechanism were analyzed in depth, and the main contributions of grain boundary strengthening, solid solution strengthening, precipitation strengthening and texture optimization to the properties of different Mg alloys were discussed.

Keyword: Magnesium alloy; Microstructure; Deformation; Cyclic expansionextrusion; Mechanical property

P19. Preparation Technology and Properties of Graphene Nanoplatelets/ AZ91D Magnesium Matrix Composites Using Thixomolding Process

Liwen Chen, Yuhong Zhao, Muxi Li, Limin Li, Hua Hou
North University of China, China

Abstract: Graphene composed of sp2 hybrid carbon atoms is a two-dimensional material with single atom thickness. It has excellent mechanical, thermal and electrical properties, which is considered as an ideal reinforcement of magnesium matrix composites. However, due to the uniform dispersion of graphene in the metal matrix and the complex preparation processes, the progress of graphene-reinforced magnesium matrix composites has not achieved the expected results. In this paper, semi-solid thixomolding process was used to prepare graphene nanoplatelets (GNPs) reinforced magnesium matrix composites. The relationships between preparation technology, mechanical properties and microstructures of composites were studied, so as to reveal the GNPs uniform dispersion mechanism, fracture mechanism and strengthening mechanism. The effect of process parameters such as GNPs contents (C), the barrel temperature (TB), screw rotate rate (RS) and injection velocity (VI) on the properties of the composites was studied. The interface bonding between GNPs and the metal matrix was studied by means of SEM, TEM and other characterization methods.

Keyword: Graphene nanoplatelets; Magnesium matrix composites; Strengthening mechanism

P20. Effect of Al addition on the age hardening behavior of as-extruded Mg-Sn-Ca alloys

Yang Liu, Jianguang Feng, Yi Zhang, Yuansheng Yang, Qiuyan Huang
Institute of Metal Research, Chinese Academy of Sciences, China

Abstract: To explore the age hardening response of the Mg-Sn-Ca-Al alloys with a wide range of Al, the different concentration levels of Al atoms were added into the benchmark Mg–2.5 Sn–1.5 Ca–x Al (x = 2.0, 4.0, 9.0 wt. %) samples, and the microstructural and mechanical properties of have been investigated in the both as-extruded and as-aged conditions. The grain sizes of TXA322，TXA324，TXA329 ingots have been decreased to ~ 16 μm, ~ 10 μm and ~ 12 μm, respectively. A number of <a> and <c+a> dislocations can be observed in the as-extruded samples. The G.P. zones are profusely detected in the TXA322 alloy, while only few Mg17Al12 phases can be found in the TXA324 and TXA329 alloys. After aging treatment, a higher density of G.P. zones precipitates within the matrix of the TXA322 alloy, while there is no obvious nano-precipitates after aging treatment in the TXA324 alloy. Numerous nano-precipitations of Mg17Al12 phases occur during the following aging of TXA329 alloy. In accordance with that, the UTS increments of ~ 46 MPa and ~ 40 MPa have been achieved in the peak-aged TXA322 and TXA329 alloys, while no obvious change of UTS in TXA324 alloy is detected, as compared with the extruded counterpart.

Keyword: Magnesium alloys; Age hardening; Precipitations; Dislocations; Mechanical properties

P21. Effect of cooling rate on the microstructure and microsegregation in sub-rapidly solidified Mg-6Al-4Zn-1.2Sn magnesium alloy

Jie Cui, Tiaojiao Luo, Cong Wang, Yingju Li, Xiaohui Feng, Qiuyan Huang, Yuansheng Yang
Institute of metal research，Chinese Academy of Sciences

Abstract: The evolution of the microstructure and microsegregation in a new type of Mg-6Al-4Zn-1.2Sn (wt.%) cast magnesium alloy solidified at cooling rates from 4.5×101 °C s^{-1} to 2.3×103 °C s^{-1} is investigated. The results indicate that the secondary dendrite arm spacing (λ2) and the average grain sizes decrease from 14.3 μm to 2.9 μm and from 187 μm to 78 μm, respectively, as the cooling rate increases from 4.5×101 °C s^{-1} to 2.3×103 °C s^{-1}. The relationship between the λ2 and cooling rate (R) is fitted as λ2=69.7·R-0.42. When the alloy solidifies in the range of cooling rates, a new quasi-crystalline I phase is formed due to faster solidification. The microsegregation ratios of Al, Zn, and Sn elements decrease significantly with the increase of cooling rate. Compared with the specimen solidified at 4.5×101 °C s^{-1}, the microsegregation ratios of Al, Zn, and Sn of that solidified at a cooling rate of at 2.3×103 °C s^{-1} decrease by 37.4%, 45.7%, and 31.6%, respectively.

Keyword: Magnesium alloy; Sub-rapid solidification; Grain refinement; Quasi-crystalline phase; Microsegregation

P22. Corrosion properties and mechanism of three directionally solidified Mg-Zn-Ca alloys

[1]Yi Zhang, [1]Xiaohui Feng, [1]Qiuyan Huang, [2]Xuehui Hao, [2]Changzheng Wang, [1]Yuansheng Yang
1. Institute of Metal Research, Chinese Academy of Sciences
2. School of Materials Science and Engineering, Liaocheng University

Abstract: Mg-Zn-Ca alloy has become a promising candidate for biodegradable Mg alloys, which deserve much more effort into its research. Three Mg-Zn-Ca alloys with 3 wt.% Zn and 0.2 wt.% to 0.8 wt.% Ca have been fabricated by directional solidification in this work. The corrosion behavior of the alloys in 0.9 wt.% NaCl solution was investigated, and the influence of the amount of Ca alloying to the dissolution rate was summarized. Columnar dendritic structures with Ca2Mg6Zn3 eutectics distributed between dendrites were observed in these alloys. The primary dendritic arm spacing decreased with the increase of Ca alloying. On the contrary, the volume fraction of $Ca_2Mg_6Zn_3$ increased with it. Immersion tests and electrochemical measurements have been used to evaluate the corrosion resistance. The results showed that corrosion rates accelerate monotonously with the increase of Ca alloying. Combined with the microstructure characterization and the corrosion rate, it can be speculated that both the primary dendritic arm spacing and the volume fraction of the secondary phase decide the corrosion rate, while the volume fraction of the secondary phase dominated it. From the observation of the corrosion morphologies, it can be found that the corrosion processes mainly include the dissolution of α-Mg around Ca2Mg6Zn3 and grain boundaries and the breakdown and recovery of the corrosion product film.

Keyword: Mg-Zn-Ca alloy; Directional solidification; Electrochemical characterization; Corrosion mechanism

P23. Numerical simulation of low-pressure die casting of ZA81M magnesium Alloy Wheel Hub.

Jianguang Feng, Tianjiao Luo, Yuansheng Yang
Institute of Metal Research, Chinese Academy of Sciences.

Abstract: In order to study the casting technology of low-pressure die casting process of low cost and high strength ZA81M magnesium alloy. Using commercial software ProCAST, the temperature field and shrinkage defects in casting process was identified under different mold temperature and different pouring temperature. The numerical simulation results show that, the number of shrinkage defects in the hub are the least when the pouring temperature is 710℃and the mold temperature is 450℃. Meanwhile, the simulation of the solidification process shows

that the hot joint still exists at the joint between the spoke and the rim, the shrinkage defects exist at hot joints and wheel flanges. The shrinkage defects at the wheel hub are difficultly to reduce by only changing the pouring temperature and mold temperature. According to the simulation analysis, it is considered that the hot joint is formed by the inadequate feeding. The cooling rate of hot joint is obviously smaller than that at the spoke which lead to the spoke solidified before the hot joint then the hot joint can not obtain adequately liquid feeding.

Keynote: Magnesium alloys; Numerical simulation; Low-pressure die casting; Shrinkage defects

P24. The dynamic recrystallization and mechanical properties response during hot screw rolling on pre-aged ZM61 magnesium alloys

Wang Lifei[1], Hua Zhang[2], Kwang Seon Shin[3]
1. Taiyuan University of Technology
2. Yantai University
3. Seoul National University

Abstract: In order to investigate the microstructure, texture evolution induced by precipitations during severe plastic deformation (SPD), pre-aging is conducted on ZM61 alloys then a special SPD technology namely screw rolling are carried out at 300 ℃.The mechanical properties are measured by uniaxial tensile test at room temperature. The results show that a gradient structure is obtained after screw rolling and the grain size is refined more in the outer region along the radial direction. All of the samples express a basal texture and the intensity weakens gradually when the pre-aging time increases. The strength and ductility improve at the same time. Especially for the ductility, the fracture elongation improves from 15.2 % on as-received sample to 27.8 % after pre-aging for 12 h, increasing by 82.9 %. This is mainly related to the dynamic recrystallization mechanisms, including continuous dynamic recrystallization (CDRX), discontinuous dynamic recrystallization (DDRX) and particle simulated nucleation (PSN).

Keyword: Precipitation; Pre-aging; recrystallization; screw rolling

P25. Hot deformation behavior and microstructure evolution of dualphase Mg-9Li alloys

Guo Li, Guobing Wei
Chongqing University, China

Abstract: The hot deformation behavior of dual-phase Mg-9Li-3Al alloys was investigated by hot isothermally compression test on the Gleeble-3800 thermal simulation test machine in the temperature range from 473K to 623K and in the strain rate range of $0.001^{-1}s^{-1}$. The flow curves exhibited obvious serrations of periodic fluctuation in high strain rates, which can be considered as Portevin-Le Chatelier effect. The relationships among flow stress, strain rate, and deformation temperature were analyzed, and the deformation activation energy(Q) and some basic material factors (A, n and α) were calculated based on Zener-Hollomon equation. An approach of processing map composed of power dissipation maps and instability maps was established by Dynamic Material Model, which was used to reveal the hot workability during the hot deformation. The flow instability domain only occurred in low temperature and high strain rate. When the Mg-9Li-3Al alloy deformed at 473K and strain rate of 1 s^{-1}, lots of deformation twinning formed in α-Mg phases, and the β -Li phases were deformed and broken severely. When the temperature increased to 573K, the coordination deformation ability between α-Mg and β-Li phases improved by more active slip systems, but the proportion of dynamic recrystallization is very low in strain rate of 0.001 s^{-1}. The needle-shaped α-Mg phases precipitated in β-Li matrix when the alloy deformed at 627K and strain rate of 0.001 s^{-1}, which is described as Deformation-induced transformation. The α-Mg phases with micron scale promoted the nucleation of DRX of α-Mg and β-Li phases, which contribute to grain refinement. Moreover, the α-Mg phases can retard the dislocation movement and grain growth during deformation, which may lead to precipitation/dispersion hardening.

Keyword: Mg-Li alloy; Processing map; Microstructure evolution

P26. A novel Mg-6Bi-3Al-1Zn alloy with excellent mechanical properties

Shuaiju Meng[1], Tianshui Zhou[2], Qianqian Li[2], Hui Yu[3], Young Min Kim[4], Bong Sun You[4]
1. State Key Laboratory of Advanced Processing and Recycling of Nonferrous Metals, Lanzhou University of Technology
2. School of Materials Science and Engineering, Lanzhou University of Technology
3. School of Materials Science and Engineering, Hebei University of Technology
4. Magnesium Department, Korea Institute of Materials Science, China

Abstract: The microstructure, texture, mechanical performance and strain hardening behaviour of a new rare-earth-free Mg-6Bi-3Al-1Zn (BAZ631) alloy were investigated. The as-cast BAZ631 billet mainly consists of dendritic α-Mg grain matrix, Mg_3Bi_2 and $Mg_{17}Al_{12}$ phases. After homogenization, only part of the Mg_3Bi_2 intermetallic compounds remain undissolved with the volume fraction of ~5.6%. The extruded BAZ631 sample exhibits fully dynamic recrystallization microstructure with a mean size of ~3.2 μm and a weak fiber basal texture with the intensity of ~ 4.58 multiples of the random distribution. Besides, large amount of nanoscale precipitates including both Mg3Bi2 and $Mg_{17}Al_{12}$ phases are detected in the matrix. Due to the comprehensive effects of grain boundary strengthening, precipitation hardening, dispersion and solution strengthening, the as-extruded BAZ631 alloy demonstrates a high ultimate tensile strength (402MPa), a good tensile elongation (15%) and a low compression-tension yield anisotropy with the asymmetry ratio of ~0.97. Furthermore, the strain hardening characteristics were also analyzed and enhanced strain hardening ability of BAZ631 are obtained with high hardening capacity and strength coefficient values of 0.54 and 0.21, respectively.

Keyword: Mg-Bi-Al-Zn; High strength; Low yield asymmetry; Strain hardening

P27. Influence of texture on Hall-Petch relationships in an hot-extruded AZ31 magnesium alloy

Ling Wang
Ying kou institute of Technology, China

Abstract: Mg alloy AZ31 with ~79% and ~95% (volume fraction of scattering less than 30°) basal-fiber texture through hot extrusion exhibits strong grain-size dependent yield strength. Samples with grain sizes varying from 4.5 to 52.8 μm were obtained by altering annealing time durations. The Hall-Petch relations of tension are, for two AZ31 alloys. The Hall-Petch relations of compression are, for two AZ31 alloys. The grains were classified 0-15°, 15-30°, 30-45°, 45-60°, 60-75°and 75-90° by the degree of c-axis tilted from extrusion direction. The Hall-Petch relations of uniaxial tension and compression in as-extruded AZ31 Mg alloy are very different, and the discrepancy of texture component also has great impact on factors of Hall-Petch relation. Besides, there has a large possibility that more than one deformation mechanisms are activated in different classified grains during plastic deformation process of Mg samples. Considering all these effects in the calculation of the friction stress σ0 by using weighted method, the theoretical value will be more accurate. According to the experimental results, the value of the grain size sensitivity k rises with the increase of texture intensity.

Keyword: Texture; Hall-Petch; AZ31 Mg alloys

P28. The mechanical anisotropy and deformation mechanism of extruded Mg-2Zn-0.4Ce-0.4Mn alloy tube

Dandan Li, Qichi Le, Xiaoqiang Li, Ping Wang
Northeastern University, China

Abstract: Here, the microstructure evolution, mechanical anisotropy and deformation mechanism of extruded Mg-2Zn-0.4Mn-0.4Ce alloy tube were systematically investigated during tensile deformation along the extrusion direction (ED), 45° towards extrusion direction (45°ED) and transverse direction (TD). The initial extruded alloy tube showed an obvious {0001} basal fiber texture with the symmetrical pole position deviating about 20° from the TD to the ED. This initial texture resulted in the mechanical anisotropy along the ED, 45°ED and TD. The deformation behaviors of the alloy tube consisted of three stages. Ⅰ (before yielding): ED: prismatic <a> and pyramidal <c+a> slips, 45°ED and TD: basal <a> and pyramidal <c+a> slips, and accompanied with a small number of twins only along the 45° ED; Ⅱ (In the initial stage after yielding): previous slips and accompanied with twinning along the three directions; Ⅲ (In the later deformation stage): non-basal slips and accompanied with twinning along the three directions.

Keyword: Mg alloy tube; Texture; Mechanical anisotropy; Deformation mechanism

P29. The high strength and plasticity Mg-Li alloy reinforced by Al3La phase formed in-situ through submicron La2O3 particle

Xiaoqiang Li
Northeastern University, China

Abstract: Here, an ultralight Mg-Li metal matrix composites with high strength and plasticity were prepared by a new controllable in-situ generation process. The low-cost submicron La2O3 particle modified by lithium salt as a precursor was added to Mg-5Li-3Al-2Zn (LAZ532) alloy melt to form in-situ plenty of submicron Al3La phase. Finally, the composites with high strength, plasticity and outstanding yield symmetry were obtained. The results showed that the Al3La phase formed in situ not only had coherent boundary with Mg matrix, but also refined the grain size and weakened the {0001} basal texture, which greatly improved the strength and plasticity of the composites. In addition, the innovation of fabrication method not only solves the difficult problem of uncontrollable in the in-situ generation method, such as the content, shape and size of the second phase, but also has the potential to realize industrial production in light of simple operation and low cost.

Keyword: Mg-Li alloys, Mechanical property, In-situ reaction

P30. Influence of Long-Period-Stacking Ordered Structure on the Damping Capacities and Mechanical Properties of Mg-Zn-Y-Mn As-cast Alloys

Lu ruopeng, Kai Jiao, Yuhong Zhao, Hua Hou
College of Materials Science and Engineering, North University of China, China

Abstract: Magnesium alloys are concerned for its high proportional strength and high damping performance. The influence of Mn on the organization morphology of long-period stacking ordered (LPSO) phase and the corresponding damping capacities in Mg-Zn-Y-Mn have been studies in this work. It shown that the addition of Mn tends to diffuse to the LPSO interface and causes the LPSO phase to expand in the arc direction. The circular structure of LPSO can optimize the damping property of the alloy better than the structure with strong orientation, especially at the strain of 10^{-3} and 250 ℃. With more additions of Mn, damping would have a reduction due to the dispersed fine LPSO phases and α-Mn particles. When the Mn content is higher than 1%, the Mn element can obviously make thin the grain, and the mechanical properties of the alloys have been significantly improved.

Keyword: Magnesium alloys; Damping; Mechanical Properties; Long-Period-Stacking Ordered Structure

P31. Notch tensile behavior of a cast Mg-Gd-Y-Zr alloy

Jianxiong Wei, Hong Yan, Rongshi Chen
Institute of Metal Research, Chinese Academy of Sciences, China

Abstract: In the current work, the effect of notch on the tensile deformation and fracture behavior has been investigated in a cast and T6 heat treated Mg-Gd-Y-Zr alloy at ambient temperature. Finite element analysis is conducted to determine the stress-strain distribution under the fracture loads in notched samples. EBSD analysis on samples interrupted before complete failure, as well as fractographic examination under SEM is performed to depict the microstructure-related fracture behavior. Experimental and numerical results show that notch degrades tensile strength through the accelerated process of fracture initiation, which is a direct result of strain concentration in the notch vicinity. The micro-mechanism of fracture initiation is found to be the formation and accumulation of grain-sized transgranular microcracks due to incompatible plastic deformation between randomly oriented crystals, while their coalescence finally triggers catastrophic failure.

Keyword: Notch effect; Mg-Gd-Y alloy; Fracture behavior; Finite element analysis

P32. Precipitation behaviors and mechanical properties of Mg-Zn-Cu-Zr alloys

Ye Zhou, Pingli Mao, Le Zhou, Zhi Wang, Feng Wang, Zheng Liu
Shenyang University of Technology, China

Abstract: The current work deals with the precipitation behaviors and mechanical properties of the high zinc content of the Mg-Zn-Cu system alloys using the gravity casting method. Differential scanning calorimetry (DSC) was conducted to describe the solidification process and precipitation behaviors. Thermodynamic calculations were carried out to determine the precipitation conditions using Thermo-calc software. The microstructures were characterized by optical microscope (OM), scanning electron microscopy (SEM), electron probe micro analysis (EPMA), transmission electron microscopy (TEM), and confocal laser scanning microscope (CLSM). Tensile tests and micro-hardness tests were applied to investigated the mechanical properties. The results substantiate that the MgZnCu phase precipitates in Cu-containing alloys, and the content and the precipitated temperature increases with the increasing of Cu content from 0~3 wt.% according to the thermodynamic calculation results and DSC results. The micro-hardness measurements of the alloys are 52.5, 53.2, 55.8, 57.9 VHN, respectively, which presents an increasing trend with Cu addition. The ultimate tensile strength (UTS), yield strength (YS), and elongation (EL) reveal a λ-like trend of the alloys, and Mg-7Zn-1Cu-0.6Zr alloy exhibits the optimum tensile properties with the ultimate tensile strength of 258.9 MPa, yield strength of 126.2 MPa, and elongation of 14.2%.

Keyword: Mg-Zn-Cu alloy; Microstructure; Mechanical properties; Thermodynamic calculation

P33. Microstructure and fracture toughness of Mg-9Gd-4Y-1Zn-0.5Zr alloy containing LPSO phase

Zhikang Ji, Li Li, Xiaoguang Qiao, Mingyi Zheng
Harbin Institute of Technology, China

Abstract: The effect of LPSO phase on mechanical properties and fracture toughness of Mg-9Gd-4Y- 1Zn-0.5Zr (wt.%) alloy was studied. Through controlling the cooling medium after homogenization treatment at 510 ℃ for 8h, the samples with block-shaped LPSO phase distributed along the grain boundaries and lamellar-shaped LPSO phase within grain interior were obtained, respectively. The results reveal that the block-shaped

LPSO phase could increase the ultimate tensile strength and elongation, while the lamellar-shaped LPSO phases improve the yield strength but deteriorate the ductility. The plane-strain fracture toughness of the alloy with block-shaped LPSO phase and the alloy with the lamellar- shaped LPSO phase are 13.7 and 10.8 MPa m0.5, respectively. The micro-cracks tend to initial at the interface of a-Mg matrix and LPSO phases, which is parallel to the LPSO in the grain interior. The higher fracture toughness value of alloy with block-shaped LPSO phase is ascribed to the larger dimples and the larger size of plastic zone ahead of the crack tip.

Keyword: Mg-Gd-Y-Zn-Zr alloy; LPSO phase; microstructure; Fracture toughness

P34. Microstructure and mechanical properties of extruded Mg-2Zn-0.3Gd alloy pipes

Xihai Li, Rongshi Chen
Institute of Metal Research, Chinese Academy of Sciences, China

Abstract: Mg-2Zn-0.3Gd (wt.%) magnesium alloy was extruded under different extrusion ratios and two sizes of pipes were fabricated successfully. The surface of extruded pipes was smooth without any cracks, indicating the potential commercial value. The microstructure, texture and mechanical properties of the extruded pipes were analyzed. After extrusion, the extruded pipes showed a fully recrystallized microstructure and <11-20> fiber texture was aligned parallel to extrusion direction. The pipes showed similar strength during tensile and compressive deformation. However, the ductility of two pipes was different with elongation of 7.5% and 13.0% during tensile deformation. It was believed that the early occurrence of {10-11} contraction and {10-11}-{10-12} secondary twins was attributed to the low room-temperature ductility of these pipes.

Keyword: Magnesium pipes; mechanical properties; microstructure; texture

P35. Investigation on strain hardening behavior of AZ31B magnesium alloy subjected to various friction stir welding methods

Ruonan Feng
College of Mechanical and Electrical Engineering, Hohai University, China

Abstract: In this work, strain hardening behavior of AZ31B sheets, which were joined by two different welding methods—conventional friction stir welding (CFSW) and rapid cooling friction stir welding (RCFSW), was studied. True tensile stress–strain curves for the welded joints were measured through tensile tests at room temperature. The Kocks-Mecking type plot of strain hardening rate θ vs. net flow stress (σ - σ 0.2) curves were studied, in which the stages Ⅲ and Ⅳ of magnesium alloy strain hardening can be observed. The strain hardening behavior was measured by hardening capacity Hc without consideration of the elastic stage and strain hardening index n calculated by the redefined Hollomon equation. Strain hardening behavior was related to the accumulation and migration of dislocations during plastic deformation, which can be significantly affected by the storage rate of grain size, texture, twins, and second relative dislocations. This work proves that the better strain hardening ability of RCFSWed joint compared with BM and CFSWed joint.

Keyword: Friction stir welding; Magnesium alloys; Strain hardening

P36. Enhanced mechanical properties and degradability of hollow microsphere/Mg alloy composite by adding nickel particle for degradable fracturing tool application

Lin Liu, Sirong Yu, Enyang Liu, Yafeng Niu, Xiaojian Bi
School of Materials Science and Engineering, China University of Petroleum (East China), China

Abstract: The effect of Ni addition on mechanical properties and degradability of hollow microsphere/Mg alloy degradable composite was investigated. The results show that the addition of Ni in the composite resulted in the formation of the new phase Al_3Ni_2 and the reduction of the β-$Mg_{17}Al_{12}$ phase. The Al_3Ni_2 phase was distributed within the β-$Mg_{17}Al_{12}$ phase. The addition of Ni improved the Brinell hardness and the compressive strength of the composite but reduced its ductility, which can be attributed to the combined action of the fine grain strengthening and the precipitation hardening. The composites with 3 wt.% Ni addition have a compressive strength of 374 MPa and Brinell hardness of 105 HB. The Al_3Ni_2 phase can act as a micro-galvanic cathode relative to the magnesium matrix, which helps produce more micro-thermocouples to accelerate the galvanic corrosion. The degradation rate of the composite increased at first and then decreased with the increase of Ni addition. When the Ni addition increased from 0 to 2 wt.%, the average degradation rate of the composite increased from 60.4 to 95.7 mg • cm^{-2} • h^{-1} in 3 wt.% KCl solution at 93 ℃, an increase of 58.4 %.

Keyword: Degradable Mg alloy; Hollow microsphere; Ni addition; Mechanical properties; Degradation behavior

P37. Influence of CaF_2 on extraction magnesium by prefabricated pellets in flowing argon

Junhua Guo, Daxue Fu, Jibiao Han, Yaosong Wang, Tingan Zhang
Northeastern University, China

Abstract: In order to realize continuous magnesium smelting, based on the magnesium smelting technology of prefabricated pellets in flowing argon, the influence of additive calcium fluoride on the calcination and reduction process was investigated. The product and crystalline magnesium were analyzed by XRD and SEM. The reaction process of CaF_2 in the reduction process and the mechanism of accelerating the reduction reaction were discussed. The experimental results show that the addition of CaF_2 in the reduction process can reduce the activation energy of the reduction reaction, accelerate the reduction rate, increase the reduction rate of MgO by more than 5%, and reduce the calcination temperature of the preformed pellets.

Keyword: Calcium fluoride; Silicothermal process; Prefabricated pellets; Flowing argon

P38. Condensation behavior of magnesium vapor in vacuum by Pidgeon process

Jibiao Han, Zonghui Ji, Daxue Fu, Junhua Guo, Zhihe Dou, Ting'an Zhang
Northeast University, China

Abstract: The production of magnesium by Pidgeon process is in vacuum, which resulting in discontinuous, it is necessary to study the condensation behavior of magnesium vapor in vacuum, which can provide theoretical support for continuous production. The condensation behavior of magnesium vapor at different volatilization temperatures and temperature gradients is studied. The results show that the increase of volatilization temperature, the initial condensation temperature decreases, the condensation region span of magnesium vapor increases, and the particle size of condensation products decreases. The volatilization temperature increased from 1000 ℃ to 1200 ℃, the initial condensation temperature of magnesium vapor decreased from 400.1 ℃ to 344.7 ℃, the span of magnesium condensation area increased from 11.5 cm to 16 cm, and the particle size of magnesium vapor condensation decreased from 68.33 μm to 24.60 μm. The temperature gradient increases, the span of condensation region becomes shorter, and has little effect on particle size.

Keyword: Magnesium vapor; Condensation behavior; Volatilization temperature; Temperature gradient

P39. Variation of microstructure and mechanical properties of ZW61 magnesium alloy solidified under 800MPa

Shusen Wu, Jing Wang, Xiaogang Fang, Shulin Lv, Wei Guo
Huazhong University of Science and Technology, China

Abstract: The pressure of 100 MPa~800MPa is able to be reached in industrial squeeze casting process. The variations of microstructure and mechanical properties of Mg-6Zn-1.4Y (ZW61) alloy solidified under 100MPa to 800MPa were investigated. The results show that a remarkable microstructure refinement and porosity reduction can be reached through solidification under high pressure. The average grain size and the volume fraction of second phase, i.e. quasicrystal I-phase, decrease continuously with the increase of applied pressure. The tensile properties, especially elongation, are obvious enhanced because of the microstructure refinement and castings densification under high pressure. The ultimate tensile strength and elongation of ZW61 alloy in as-cast state are 243 MPa and 18.7% when the applied pressure is 800 MPa, which are increased by 35% and 118% respectively, compared with that of the gravity castings.

Keyword: High pressure; Mg-Zn-Y alloy; Squeeze casting; Microstructure; Mechanical property

P40. Dynamic Tension-Compression Asymmetry and Microstructure Evolution of Extruded EW75 Magnesium Alloy at High Strain Rates

Jincheng Yu
Wuxi Institute of Technology, China

Abstract: The dynamic tension-compression asymmetry (DTCA) of an extruded EW75 magnesium alloy deformed at high strain rates (from 1000 s^{-1} to 3000 s^{-1}) along extrusion direction (ED) was investigated by Split Hopkinson Tension Bar (SHTB) and Split Hopkinson Pressure Bar (SHPB). The specimens after dynamic tension and dynamic compression were examined with optical microscope (OM), scanning electron microscope (SEM), electron back-scatter diffraction (EBSD) and transmission electron microscope (TEM). The results show that extruded EW75 magnesium alloy along ED exhibits positive strain-rate sensitivity both in dynamic tension and dynamic compression. Due to the strong basal texture, extruded EW75 magnesium alloy exhibits a reversed dynamic tension-compression asymmetry that dynamic compressive flow stresses are higher than dynamic tensile flow stresses. The dynamic tensile σ0.005 at the strain rate of 3010 s^{-1} is only 63 MPa while the dynamic compressive σ0.005 at the strain rate of 2826 s-1 is 160 MPa (dynamic tensile σ0.005 / dynamic compressive σ0.005 = 0.39).The dynamic tensile σmax at the strain rate of 3010 s^{-1} is only 271 MPa while the dynamic compressive σmax at the strain rate of 2826 s-1 is 534 MPa (dynamic tensile σmax / dynamic compressive σmax = 0.51). Microstructure analysis demonstrates that {101 2} <111 0> tensile twinning causes the dynamic tension-compression asymmetry of extruded EW75 magnesium alloy along ED. A kind of Nanocrystalline were observed after dynamic deformation. Fracture surfaces are relatively flat and significant amounts of deformed micro-dimples are produced during dynamic compression. It can be observed that this area consists of continuous tiny steps which suggests the dynamic compressive behavior of extruded EW75 magnesium alloy becomes more ductile at higher strain rate.

Keyword: High strain rates; Dynamic tension compression asymmetry

P41. 3D image reconstruction of dislocations in submicron magnesium

Jing Xiao, Fei Liu, Bo Yu Liu, Zhi Wei Shan
Xi'an Jiaotong University, China

Abstract: <a> and <c+a> dislocations are main types of dislocations in magnesium and its alloys. Understanding their behavior is of critical importance for revealing the plastic deformation mechanism of magnesium. Traditional methods for studying the constructions of dislocations are mainly based on trace analyses. For example, using optical microscope or scanning electron microscope to analyze the slip plane. Transmission electron microscopy (TEM) characterization on dislocations can provide crystallographic features of dislocations (e.g. burgers vector, slip plane, dislocation type). However, this method is difficult to obtain the geometric features in 3D. In this report, we use 3D image reconstruction based on series tilted TEM images to characterize <a> and <c+a> dislocations in deformed submicron magnesium. The dislocation structure, configurations and slip plane of these dislocations are analyzed. This method is expected to be extended to analyze the 3D information of dislocations in magnesium alloys, for example, to investigate the dislocation configuration around precipitates.

Keyword: Mg; Dislocation; TEM; 3D reconstruction

P42. Atomic-scale three-dimensional structural characterization of twin interface in Mg alloys

Lei Li
Nanjing University of Science and Technology, China

Abstract: Twinning plays important roles in plastic deformation of Mg alloys. However, it is difficult to obtain accurate twinning structure through transmission electron microscope observations. Here, we developed a new method to reconstruct the three-dimensional structure of twin boundary. The {10-12} twin was observed from three directions, i.e. in [11-20], [20-21], and [4-2-23] zone axes, and the atomic model of twin boundary was established. Additionally, we also proposed that the observed directions for {10-11} and {10-13} twins should be [11-23] & [10-11] and [2-1-11] & [5-1-43], respectively.

Keyword: Mg alloys; Twinning; Transmission electron microscope; Three-dimensional structure

P43. Effects of strain rate on the dynamic recrystallization behavior and hot formability of basal-textured AZ80 alloy

Hongyi Zhan[1], Zeng Guang[2], Yingjie Huang[2], Lixin Huang[3]
1. General Motors Company
2. Central South University
3. Dicastal

Abstract: It is commonly thought that the cracking of basal-textured Mg alloys in thermomechanical processing (TMP) at high strain rates is closely correlated to severe strain localization in deformation bands which originate from the coalescence of DRXed grains or compression twins. In the present study, by detailed EBSD characterizations and intra-grain misorientation analysis on the commodity AZ80 alloy of a typical basal texture which were compressed to varied strain levels at 350 °C and 10 s^{-1}, it is revealed that the significant cracking of the alloy was actually caused by the micro-cracks formed at the grain boundary interface between the deformed matrix and its surrounding DRXed grains in the very incipient stage of compression. This probably resulted from the influence of high strain rate on the deformation mechanism and DRX behaviors of AZ80. The study provides insight and alternative perspective to improve formability of Mg alloys in high-strain-rate TMPs.

Keyword: Dynamic recrystallization; High strain rate

P44. Orientation dependence in fatigue behavior of magnesium-cerium alloy single crystals

Guojun Lu[1], Kensuke Miyazaki[1], Masayuki Tsushida[2], Hiromoto Kitahara[3], Shinji Ando[4]
1. Graduate School of Science and Technology, Kumamoto University
2. Faculty of Engineering, Kumamoto University
3. Institute of Pulsed Power Science, Kumamoto University
4. Magnesium Research Center, Kumamoto University, Japan

Abstract: Mg alloy is expected for the lightweight of structural materials owing to its low density and high specific strength. As a structural material, it is important to understand the fatigue properties. Mg has a hcp structure with low crystal symmetry, and it is known that there is a crystal orientation dependence in the deformation behavior. It has been also reported that the cold-workability of Mg-0.035 at% Ce alloy has significantly improved compared with pure Mg. Up to now few studies have investigated the orientation dependence in fatigue properties and fatigue crack growth behavior of Mg-Ce alloy. The purpose of this study is to investigate the orientation dependence in fatigue behavior of Mg-Ce alloy single crystals by plane bending fatigue tests In this work, it was found that the fatigue behavior of Mg-Ce alloy has a strong orientation dependence. The cracks initiated at the early stage of fatigue life regardless of fatigue stress. It was proved that with the addition of Ce, the crack propagation rate reduced and the fatigue life extended. It is considered that the activities of basal slips at the crack tips required a larger stress, and it leads to the decreasing of crack propagation rate. The change of loading axis caused by the basal slips activated around the main crack is considered as the reason of earlier crack initiation and decrease of fatigue life.
Keyword: Single crystal; Plane bending fatigue; S-N plot; Crack; Orientation dependence

P45. Comparison of the effects of pre-activators on microstructure and corrosion resistance of phosphate conversion coating on magnesium alloy

Tao Li[1], Zhongjun Leng[1], Shifang Wang[1], Yuansheng Yang[2], Jixue Zhou[1], Xitao Wang[1]
1. Qilu University of Technology (Shandong Academy of Sciences)
2. Institute of Metal Research, Chinese Academy of Sciences, China
Abstract: In this study, Mg-6.0Zn-3.0Sn-0.5Mn (ZTM630) magnesium alloy was firstly pre-activated by colloidal Ti, oxalic acid, or phosphoric acid and then a phosphate conversion coating (PCC) was prepared on the alloy surface. The microstructure and corrosion resistance of the prepared PCCs were investigated. Surface morphology studies showed that the phosphate crystals making up the coating were the smallest for the sample pre-activated by phosphoric acid. The coating on the colloidal Ti sample had the largest thickness and surface roughness, and the coating on the phosphoric acid sample had the smallest ones. The reason was analyzed by comparing the surface morphologies of alloy samples just after the pre-activation treatment and with phosphating for various times. X-ray diffraction (XRD) analysis revealed that all three PCCs consisted of the same compounds. Based on the corrosion resistance time from the copper sulfate drop test and the electrochemical data from the potentiodynamic polarization (PDP) curves, it could be concluded that the coating pre-activated by phosphoric acid had the best corrosion resistance. At last, the 1500 h neutral salt spray corrosion test confirmed that the phosphating treated magnesium alloy which had been pre-activated by phosphoric acid presents excellent corrosion resistance and corrosion behavior.
Keyword: Phosphate conversion coating; Surface pre-activator; Corrosion

P46. Ignition behavior of microarc oxidation coating sealed with aluminum phosphate applied on AZ91D alloy

Dong Han, Jin Zhang, Yong Lian
University of Science and Technology Beijing, China
Abstract: Magnesium alloys have important applications in aviation, rail transit and automotive industries, while the corrosion and flammability are common and real problems that must be solved for these applications. At present, enhancing the flammability resistance of magnesium alloys mainly by alloying rather than surface technology. The work aims to develop a method of synthesizing denser coatings with improved flammability resistance on AZ91. Prepared aluminum phosphate sealing layer on the microarc oxidation ceramic coating on the surface of the magnesium alloy (AZ91D) to achieve the function of non-flammability. The aluminum phosphate sealing coating with $Al(OH)_3$ and SiO_2 as fillers by dipping repeatedly on the uniform porous micro-arc oxide bottom layer. The microstructure, composition, sealing effect and flammability resistance of coatings were investigated. The results of flammability test showed that the sealed coating consisted of $Al(PO4)_3$, Al_2O_3 and SiO_2 remained intact and compact and the Mg alloy substrate did not ignite. The aluminum phosphate sealant could block the pores of MAO coatings by forming a barrier layer and enhance ignition-proof performance. In addition, physical adsorption and chemical reactions between the aluminum phosphate sealing agent and the micro-arc oxidation ceramic layer enable to exhibited excellent interfacial adherence.
Keyword: Magnesium alloys; Coating; Ignition resistance; Aluminum phosphate

P47. Effect of REs (Y, Nd) addition on high temperature oxidation behavior and activation energy of AZ80 alloy

Cheng Chunlong, Ruizhen Guo, Qichi Le, Xiaoqiang Li
Northeastern University, China
Abstract: The oxidation behaviors of AZ80, AZ80-0.32 Y and AZ80-0.38 Nd (wt. %) alloys were researched at 413 °C, 420 °C, 427 °C and 433 °C for up to 6 h in air environment via a high precision analytical balance, a laser confocal microscope, differential scanning calorimeter (DSC) analysis, X-ray diffraction (XRD) analysis, scanning electron microscope (SEM) observation, and X-ray photoelectron spectroscopy (XPS) analysis. The results show that the weight gain and oxidation rate of AZ80 are reduced significantly, the initiation form and propagation of cracks in oxide layer are changed. Compact and protective oxide layer forms on alloy surface with Y or Nd addition. And the activation energies of AZ80, AZ80-0.32Y and AZ80-0.38Nd alloys calculated via Arrhenius equation are 82.556 kJ/mol, 177.148 kJ/mol and 136.738 kJ/mol, respectively.
Keyword: Magnesium; Rare-earth; Oxidation kinetics; Activation energy

P48. Study on Extrusion Shear Composite Forming Technology and Microstructure Properties of Al/Mg Bimetals

Ye Tian, Hongjun Hu
Chongqing University of Technology, China
Abstract: In this paper, Al/Mg bimetallic material extrusion and shear composite forming technology and microstructure properties were studied.Combined with DEFORM-3D, it is numerically simulated and analyzed.The distribution of stress field, strain field and temperature field was investigated. According to the numerical simulation and experimental results, the thickness of the diffusion layer of the extruded shear sample is greater than that of the ordinary extrusion at the same temperature. At low temperature, the sample formed by ordinary extrusion has a gap and no diffusion layer. The binding layer of the extruded and shear samples at 420℃ has no hole defect, forming a relatively stable binding diffusion layer with a thickness of about 22um, in which the stable layer is 11um.The binding properties of Mg/Al bimetals were improved by this process.
Keywords: Al/Mg bimetal; Bonding layer

P51. Fabrication and corrosion properties of the zinc alloy coating on magnesium alloy by hot-dip process

Chenglu Hu, Xiong Zhou, Qichi Le
Northeastern University, China
Abstract: The Zinc–Magnesium (Zn–Mg) alloy coating with excellent corrosion resistance was fabricated on the surface of

magnesium substrate (AZ31) by hot-dipping process. The microstructure of the coating was analyzed by scanning electron microscopy (SEM), Energy Dispersive Spectrometer(EDS), and X-ray diffractometry (XRD). And the electrochemical behavior of the coating was studied by electrochemical methods such as Tafel polarization measurements and electrochemical impedance spectroscopy(EIS). The effect of immersion time on diffusion layer and was studied. Besides, The growth process of coating and the anti-corrosion mechanism was investigated. The results reveal that the AZ31 alloy with coating have a significant improvement of corrosion coating, the coating have a good metallurgical bonding and optimal anti-corrosion property when the immersion time is 4s. The coating produced by too short immersion time has not continuous MgZn phase, resulting in the lower combination. The diffusion layers mainly consist of the MgZn and Mg-Zn2 Phase, which can dramatically improve the corrosion resistance of magnesium alloy substrates.
Keyword: Zinc coating, Hot-dip process, magnesium alloy

Enhancement of corrosion resistance and discharge performance of Mg-5Li-3Al-1Zn sheet for Mg-air battery via rolling
Huabao Yang, Bin Jiang
Chongqing University, China
Abstract: The corrosion behavior at open circuit potential (OCP) and the discharge performance under impressed anodic current of Mg-5Li-3Al-1Zn (LAZ531) alloy sheets with different rolling reductions are investigated using hydrogen evolution, potentiodynamic polarization, electrochemical impedance spectroscopy, and galvanostatic discharge measurements. The results show that rolling increases the corrosion resistance and strengthens the discharge ability of LAZ531 alloy, which is attributed to the increased density of twins and the change of grain orientation. Of those, the LAZ531 alloy with 20% rolling reduction (LAZ531-20%) has high and steady discharge voltage at small current density for long time, with the values of 1.490 V at 2.5 mA cm-2 and 1.411 V at 10 mA cm-2. The grain boundaries and twins play the same roles on the corrosion and discharge processes, which are attacked preferentially than the grain interiors and accelerate the dissolution of LAZ531 alloy.
Keyword: Rolling; Microstructure; Corrosion resistance; Discharge performance; Mg-air battery

Facile preparation of a self-healing composite coating on Mg Alloys
Wenhui Yao
Chongqing University, China
Abstract: The poor corrosion resistance of magnesium (Mg) alloys severely limits their extensive applications in practice. A protective coating is generally applied to decrease their corrosion, while the defect appearing on the coating during its service can further accelerate the corrosion process. Consequently, a self-healing coating that can simultaneously repair the defects is highly desired to provide good corrosion protection for Mg alloys. Herein, a triple self-healing composite coating is successfully developed on the AZ31 Mg alloy, based on the formation of a slippery liquid-infused porous surface (SLIPS) by infusing an improved layered double hydroxides (LDHs) coating that simultaneously carries cation inhibitor of lanthanum (La) and anion inhibitor of benzoate. The prepared composite coating presents good performance in the electrochemical tests, significantly improving the corrosion resistance of the Mg alloy. Besides, it shows superior self-healing property to guarantee the good corrosion protection for Mg alloy in practice.
Keyword: Triple Self-healing; Magnesium alloy; Corrosion and protection; Slippery liquid-infused porous surface; Layered double hydroxide

Effect of squeeze casting pressure on microstructure and properties of CNTs/Mg Composites
Xiaohui FENG, Yuansheng YANG
Institute of Metal Research, Chinese Academy of Sciences, China
Abstract: The cup-shaped samples of 1.0% CNTs/AZ91D composite were made by squeeze casting experiment. It is found that the solidification structure of squeeze casting samples is closely related to the pressure. Under 100 MPa, the solidification structure was improved significantly, the grain size was refined and the microstructure was more compact. When the squeeze casting pressure increase from 25 MPa to 100 MPa, the yield strength, tensile strength and elongation of the sample wall increase from 103.2 MPa, 199.7 MPa and 6.4% to 113.3 MPa, 217.9 MPa and 7.3%, respectively; the yield strength and tensile strength at the bottom of the sample increase from 87.3 MPa and 244.1 MPa to 91.4 and 249.5 MPa respectively, and the elongation remained 20%. Under the proper temperature condition, the castings with excellent microstructure and properties can be prepared by adjusting the squeeze casting pressure
Keynote: squeeze casting; solidification; CNTs/Mg composites

Study on hot rolling deformation texture and twin deformation mechanism of ME21 rare earth magnesium alloy sheet
He Sun, Ming Chen
University of Science and Technology LiaoNing, China
Abstract: At present, the price of rare earth magnesium alloy sheet is generally higher, and as a kind of low price sheet, ME21 rare earth magnesium alloy sheet can be widely applied to new energy automobile sheet and has a broad prospect. Asynchronous hot rolling is an effective method to improve the properties of sheet. In this paper, the finite element method (FEM) is used to simulate the hot rolling process of ME21 magnesium alloy sheet. The results of equivalent plastic strain and strain rate are obtained, which are used as initial boundary conditions and coupled with VPSC (Visco Plastic Self Consistent) model to realize multi-scale joint solution. The stress and strain in macro scale and deformation texture in micro scale were obtained. The deformation texture prediction of ME21 magnesium alloy sheet during hot rolling was realized. On this basis, by introducing Schmidt factor, the starting modes of compression twin and tensile twin are achieved, and the twin deformation mechanism of ME21 rare earth magnesium alloy sheet is discussed. The deformation textures of hot-rolled ME21 magnesium alloy sheet under different rolling conditions were verified by EBSD (Electron backscatter diffraction technique).
Keyword: Magnesium alloy; Viscoplastic self-consistent model; Multi-scale; Compression twin; Tensile twin

Effects of Sb addition on microstructure and mechanical properties of Mg-9Al-5Sn alloy
Chunhua Ma
Nanyang Normal University, China
Abstract: The effects of Sb element on the mechanical properties, yield strength ratio and compression fracture morphology of Mg-9Al-5Sn-xSb extruded magnesium alloy bars were studied under uniaxial compression. The effects of Sb on the microstructure and properties of the Mg-9Al-5Sn-xSb magnesium alloy were studied by means of optical microscopy, X-ray diffraction), Transmission Electron Microscope, scanning electron microscopy equipped with an energy dispersive X-ray spectrometer and tensile test. The results prove that the phase compositions of α-Mg matrix, Mg_2Sn, Mg_3Sb_2 and $Mg_{17}Al_{12}$ phases exist in the as-cast Sb-containing alloys, Sb addition results in the precipitation of Mg_3Sb_2.The results show that with the increase of element Sb, the compressive properties of Mg-9Al-5Sn-xSb magnesium alloy increase gradually. When the

Sb content reaches 1.5 wt. %, the properties of Mg-9Al-5Sn-xSb magnesium alloy are the best. The ultimate compressive strength, compressive yield strength and compression elongation of the alloy are 528MPa, 307MPa and 11.0%, respectively. With the increase of element Sb content, the yield ratio increased first and then decreased. When the content of Sb was 0.6 wt. %, the yield ratio reached the maximum value of 0.66, with the continuous increase of Sb content, the yield ratio decreased gradually.
Keyword: Magnesium alloy; Extrusion; Mg_3Sb_2; Mg-9Al-5Sn

Deformation behavior of Mg-13Gd-4Y-2Zn-0.5Zr alloy under compression-torsion deformation conditions
Wenlong Xu, Jianmin Yu, Leichen Jia, Guoqin Wu, Ping Xu, Zhimin Zhang
North University of China, China
Abstract: In this paper, compression-torsion experiments were used to study the hot deformation behavior of as-homogenized Mg-13Gd-4Y-2Zn-0.5Zr alloy at different deformation temperatures and strain rates. The influence of different deformation conditions on the microstructure and texture of the alloy were analyzed emphatically. Under the same deformation temperature (400℃), with the gradual increase of strain rate, the dynamic recrystallization (DRX) grains size gradually decreases, the texture strength gradually increases. And the texture component will develop from simplex basal texture to non-basal texture. Under the same strain rate ($0.1s^{-1}$), with the gradual increase of deformation temperature, the non-basal slip systems are activated. The combined effect of basal and non-basal dislocation slip causes the degree of DRX gradually increase and the texture gradually weaken. In addition, in order to coordinate the stress concentration generated during compression- torsion deformation, the lamellar long period stacking ordered (LPSO) phases kinked and the block-shaped LPSO phases broken. The deformed degree and quantity of LPSO phases were negatively correlated with deformation temperature, and positively correlated with strain rate.
Keyword: Mg-13Gd-4Y-2Zn-0.5Zr alloy; compression-torsion; Dynamic recrystallization; Long period stacking ordered phases; Texture; Basal and non-basal dislocation slip

Effect of aging time on microstructure evolution and mechanical properties of as-forged Mg-6Gd-2Y-1Zn-0.3Zr alloy
Yujiao Wang, Haitao Jiang, Panpan Wang, Bowen Yu, Yun Zhang
University of Science and Technology Beijing, China
Abstract: As the high strength value and excellent creep resistance, Mg-6Gd-2Y-1Zn-0.3Zr alloy with special long period stacking order (LPSO) phase has attracted much attention. Aging-treatment plays a vital role in enhancing mechanical properties by modifying the microstructure. This paper investigates the microstructure evolution and mechanical properties of Mg-6Gd-2Y-1Zn-0.3Zr alloy with LPSO phase after different aging time at 225℃. After forging, portion LPSO phases in homogenized alloys were broken and replaced by fine equiaxed dynamic recrystallization grains (DRX). The volume fraction of recrystallization grains increased at the first 12h aging treatment and kept stable with further ageing. Almost no precipitation occurred at initial 4h aging stage, fine precipitation dispersedly distributed on 8h-aged-alloys. Once aging time over 12h, aged-precipitations were accumulated and grew up to coarse grains. Thus, aging response reached the peak value at aging 12h. The Vickers hardness at peak age is 89.6HV; yield strength, tensile strength and elongation reached 227.6MPa, 303.8MPa and 10.9% at aging 12h, respectively. It's ascribed to the precipitate strength effect of aged-precipitations, the decrease of mechanical properties after aging 12h may be due to the size increase of aged-precipitations.
Keyword: Mg-6Gd-2Y-1Zn-0.3Zr; Microstructure; Mechanical properties; Aging treatment

Effect of precompression and subsequent annealing on the texture evolution and bendability of Mg-Gd binary alloy
Chao He, Bin Jiang
Chongqing university, China
Abstract: Mg-Gd binary alloy at room temperature is significantly improved through the pre-compression and subsequent annealing (PCA) process. The results show that the formed angle of PCA sample (36°) is more excellent compared with the as-extruded (AE) sample (115°) during three-point bending test, which is mainly attributed to the variation of deformation mechanisms in the tension region. Basal slip dominates the tension strain in the extrados of AE sample, while {10-12} tension twinning and basal slip are activated simultaneously in the same region of PCA sample. The activation of {10-12} twins leads to higher Schmid factor (SF) for basal slip. It provides more prismatic <a> slip activity in the twined areas, which enhance the coordination in thickness strain of PCA sample during the bending test. Therefore, the PCA process gives an insightful information for ameliorating bendability of Mg alloy.
Keyword: Mg-2Gd alloy; Bendability

Microstructure and mechanical properties of Mg-Gd-Y-Zn-Zr alloy after repetitive-upsetting extrusion followed by heat treatment
Beibei Dong, Xin che, zhimin zhang, jianmin yu, Mu Meng
North University of China, China
Abstract: As one of severe plastic deformation (SPD) methods, repetitive upsetting-extrusion (RUE) technology is an effective way to refine grains in the billing stage. The paper is aimed to a large sized as-homogenized Mg-9Gd-3Y-2Zn-0.4Zr alloy after thermal deformation processing. The microstructure, texture evolution and mechanical properties of the RUEed samples in the different regions were investigated. According to the results, the microstructure and mechanical properties exhibit obvious anisotropy due to the uneven deformation temperature and strain during the RUE processing. The average grain size is smallest in the region of ERD. In order to study the effect of the subsequent heat treatment on the RUEed samples, the microstructure, texture evolution and mechanical properties were also surveyed. Compared with the RUEed samples in the same regions, mechanical properties slightly improved due to the solid solution strengthening and ageing strengthening and bring about the precipitation strengthening.
Keyword: Repetitive upsetting-extrusion (RUE); Mg-9Gd-3Y-2Zn-0.4Zr alloy; Microstructure; Mechanical properties; Heat treatment

Improved strength and ductility of AZ31B Mg alloy sheets processed by accumulated extrusion bonding with artificial cooling
Tingzhuang Han
Northwestern Polytechnical University, China
Abstract: In this study, accumulated extrusion bonding (AEB) process with application of artificial water cooling was successfully performed to fabricate fined-grains AZ31B Mg alloy sheets at 150℃, 200℃ and 250℃. The resultant microstructure and mechanical properties are systematically investigated. It reveals that the processing temperature has an important effect on the microstructural evolution during extrusion. During AEB process at 150℃ and 200℃, {10-12} tensile twinning was activated at early stage of extrusion, and subsequently continuous dynamic recrystallization (CDRX) occurred and dominated the further deformation. However, for the sample extruded at 250℃, hardly any twins can be observed, and new fined dynamic recrystallized grains were found along grain boundaries. Artificial cooling was utilized to reduce the

rate of grain growth out of the extrusion die, resulting the grains significantly refined from 11 μm to 2.5 μm. Local high dislocation density region was also observed in the microstructure of sample processed at 150℃ in artificial cooling condition, and the degree decreased with the processing temperature increase. The results summarized from tensile tests indicated that due to the grain refinement the strength and ductility was significantly enhanced (YS of 186 MPa vs. 145 MPa, UTS of 391 MPa vs. 336 MPa and FE of 31.5% vs. 24.5% compared with the as-received sample). Subsequently, annealing treatment at different temperatures was applied to eliminate the high dislocation density. The sample annealed at 200 ℃ exhibited the best comprehensive mechanical property with YS of 179 MPa, UTS of 390 MPa and FE of 33.0%. As the annealing temperature increasing, the dislocation density was reduced by static recrystallization (SRX) and grain growth, leading to a decreased strength and ductility.
Keyword: Magnesium alloy; Texture

Review: Application of synchrotron radiation technology in the study of magnesium alloys
Yongbiao Wang, Yaqing Sun, Xintian Liu
Zhengzhou University of Light Industry, China
Abstract: Magnesium alloys have the advantages of low density, high ratio strength and good casting, which make they have been the focus in the automotive, aerospace industry and other fields, have been become the most potential green lightweight structural materials. The synchrotron radiation technology has become a powerful tool for studying alloy materials because of its strong penetration, high resolution and non-destructiveness. The high efficiency and accurate characterization of the microstructure of magnesium alloys can be achieved by using synchron radiation technology. Based on the basic principles of synchrobic radiation technology, this paper summarizes the application progress of synchrotron radiation technology in the solidification microstructure, deformation behavior, phase transformation mechanism, hydrogen storage capacity and other characterization of magnesium alloys, and looks forward to the application prospect of synchrotron radiation technology in the field of magnesium alloy materials.
Keyword: Synchrotron radiation; X-ray; Magnesium alloys

Electrical resistivity of binary magnesium alloys
Xiao Zhang[1], Yuanding Huang[1], Veronika Kodetová[2], Karl Kainer[1], Martin Vlach[2], Norbert Hort[1].
1. Helmholtz-Zentrum Geesthacht
2. Faculty of Mathematics and Physics, Charles University, Australia
Abstract: The electrical resistivity of four binary Mg alloys (Mg-Al, Mg-Gd, Mg-Sn and Mg-Zn) at different temperatures were investigated in as-cast, T4, and T6 states. The corresponding microstructures were observed using optical and scanning electron microscopy. In the as-cast and T4 states, the resistivity of magnesium alloys increases with the content of solute. It has a linear relationship with the content of solute at the T4 state. Its slope varies for different alloying elements following the sequence: Gd>Sn>Al>Zn. The increase in the resistivity of magnesium alloys is mainly due to the distortion caused by the addition of solute atoms. Among all the states, the T4 treated alloys have the highest resistivity. The alloying elements with solid solution in Mg matrix influence more on the resistivity than those existed in the intermetallic phase. During isothermal ageing, the resistivity decreases monotonously with ageing proceeding due to the depletion of solute atoms from the matrix and the formation of intermetallic phases. The relationship between the resistivity and the volume fraction of precipitates can be described using the Reynolds and Hough mixture rule. All alloys have a positive temperature coefficient of resistivity (TCR); the varied TCR illustrates the deviation from the Matthiessen's rule.
Keyword: Resistivity; Binary magnesium alloys

Comparative study on the high temperature tensile mechanical properties of as-extruded AZ80 magnesium alloy at strain rates of 3 s^{-1} and 0.15 s^{-1}
Wenjun Liu[1], Jiang Bin[2]
1. Chongqing University of Technology
2. Chongqing University, China
Abstract: The mechanical properties of as-extruded AZ80 magnesium alloy at temperatures of 450-525°C and strain rates of 3 s^{-1} and 0.15 s^{-1} were investigated by tensile tests. The results indicated that a higher strain rate delayed the emergence of the properties of zero strength and zero ductility. Zero strength and zero ductility were obtained nearly simultaneously at 525°C and a strain rate of 3 s^{-1}. At the lower strain rate of 0.15 s^{-1}, zero ductility appeared at 500°C. As the temperature increased, the failure mode of the alloy developed from transgranular fracture to cleavage fracture, and then to intergranular fracture with the feature of sugar-like grains and fusion traces. The existence of the low-melting composite of beta $Mg_{17}Al_{12}$, an Mg matrix and segregated Zn was demonstrated to be the reason for the brittle fracturing of the AZ80 alloy at high temperatures. Furthermore, microstructural evolution at temperatures approaching the solidus temperature was discussed as a method to assist in the elucidation of the high temperature deformation mechanism of magnesium alloy.
Keyword: AZ80 alloy; Strain rate; Microstructural evolution; Phase diagram; Fracture morphology

Effects of particle/matrix transition interface on elastic modulus for YAl_2 particle reinforced magnesium-lithium matrix composites
Yuting Li, Guoqing Wu, Dianwen Xu, Dengchuan Zhao
Beihang University, China
Abstract: A randomly distributed multi-particle model considering transition interface layer and strengthening mechanisms was constructed to study the effects of the particle/matrix interface on the elastic modulus of the YAl_2p/Mg-Li matrix composite, and the influence of the volume fraction and size of the YAl_2 particles on the elastic modulus of the composite was analyzed. Based on the analysis of the stress and strain around the reinforcement particles, the influence mechanism of the interface layer on the elastic modulus was explored. The simulation results show that the transition interface layer slows down the stress-strain concentration at the particle/matrix interface. With the increase of the thickness of the transition interface layer, the elastic modulus increases. The volume fraction and size of particles have significant influence on the elastic modulus. The elastic modulus increases linearly with the increase of the content of particles, and increases exponentially with the decrease of the particle radius.
Keyword: Metal-matrix composites (MMCs); Elastic modulus; Numerical analysis

The role of Al_2Gd cuboids in the discharge performance and electrochemical behaviors of AZ31-Gd anode for Mg-air batteries
Xuan Liu, Jilai Xue
University of Science and Technology Beijing, China
Abstract: for Mg-air batteries have been investigated in detail, in order to discuss the role of Al2Gd particles. The AZ31-Gd anode is an ideal candidate for Mg-air batteries. It can output both high specific capacity and energy density of 1271 mAh$g1 and 1623mWh$g1, respectively at 10mA$cm2. The outstanding performance should be due to the cubic Al2Gd particles. They can suppress the hydrogen evolution reaction kinetics and generate the protective surface film to avoid local aggressive consumption of Mg phase during the discharge at small current

densities. However, this protective film should be also responsible for the strong cell voltage drop and inferior discharge performance of AZ31-Gd anode at large current densities. The electrochemical behaviors and microstructures characterization have been discussed to connect the discharge performance in details.
Keyword: Mg-air batteries; Anode performance

Role of element Al in the solution strengthening of Mg-Al binary Alloy
Tingting Liu[1], Bo Song[1], Fusheng Pan[2]
1. Southwest University
2. Chongqing University, China
Abstract: Mg-Al binary alloys with concentrations between 0 and 3.9 wt.% Al have been prepared and processed via hot extrusion at 623K. The specimens after solution treatment show that alloying element has a positive influence on grain refinement and solution strengthening. The as-extruded Mg-Al alloys are fully recrystallized, and the yield strength of the binary alloys is twice than that of pure Mg. In addition, Mg and Mg-Al alloys are further studied by the viscoplastic self-consistent (VPSC) model to explore the activation and evolution of deformation modes. The effects of Al on the critical resolved shear stress (CRSS) of basal slip, non-basal slip, tensile twinning and compression twinning are discussed based on the simulated results of hardening parameters. According to the simulation results, basal slip is almost the only deformation mode in Mg, however, extension twin is activated in the early stage and the activity of prismatic slip is promoted greatly to replace some of basal slip with the content of Al. The relative activity of other slips and contraction twin is also investigated.
Keyword: Magnesium; Solution strengthening; Critical resolved shear stress; Viscoplastic self-consistent model

Enhancement of corrosion resistance and discharge performance of Mg-5Li-3Al-1Zn sheet for Mg-air battery via rolling
Huabao Yang, Bin Jiang
Chongqing University, China
Abstract: The corrosion behavior at open circuit potential (OCP) and the discharge performance under impressed anodic current of Mg-5Li-3Al-1Zn (LAZ531) alloy sheets with different rolling reductions are investigated using hydrogen evolution, potentiodynamic polarization, electrochemical impedance spectroscopy, and galvanostatic discharge measurements. The results show that rolling increases the corrosion resistance and strengthens the discharge ability of LAZ531 alloy, which is attributed to the increased density of twins and the change of grain orientation. Of those, the LAZ531 alloy with 20% rolling reduction (LAZ531-20%) has high and steady discharge voltage at small current density for long time, with the values of 1.490 V at 2.5 mA cm^{-2} and 1.411 V at 10 mA cm^{-2}. The grain boundaries and twins play the same roles on the corrosion and discharge processes, which are attacked preferentially than the grain interiors and accelerate the dissolution of LAZ531 alloy.
Keyword: Rolling; Microstructure; Corrosion resistance; Discharge performance; Mg-air battery

Facile preparation of a self-healing composite coating on Mg Alloys
Wenhui Yao
Chongqing University, China
Abstract: The poor corrosion resistance of magnesium (Mg) alloys severely limits their extensive applications in practice. A protective coating is generally applied to decrease their corrosion, while the defect appearing on the coating during its service can further accelerate the corrosion process. Consequently, a self-healing coating that can simultaneously repair the defects is highly desired to provide good corrosion protection for Mg alloys. Herein, a triple self-healing composite coating is successfully developed on the AZ31 Mg alloy, based on the formation of a slippery liquid-infused porous surface (SLIPS) by infusing an improved layered double hydroxides (LDHs) coating that simultaneously carries cation inhibitor of lanthanum (La) and anion inhibitor of benzoate. The prepared composite coating presents good performance in the electrochemical tests, significantly improving the corrosion resistance of the Mg alloy. Besides, it shows superior self-healing property to guarantee the good corrosion protection for Mg alloy in practice.
Keyword: Triple Self-healing; Magnesium alloy; Corrosion and protection; Slippery liquid-infused porous surface; Layered double hydroxide

The 7th International Conference on Magnesium

Edited by

Qiuyan Huang, Xiaohui Feng, Yuansheng Yang