The Minerals, Metals & Materials Series
Energy production is inherently a materials problem. Materials innovator Matthew Boulton and his team were as responsible for modern energy production as was the inventor of the steam engine itself, James Watt. Boulton and his team developed the metals and fabrication processes that made Watt’s engine commercially viable for any number of applications, marketing the innovation under the Boulton & Watt company name, revolutionizing energy production and industry in the process.

More than 225 years later, we face new challenges wrought from the combustion of the same fossil fuels that first powered the industrial revolution, especially climate change resulting in large part from carbon dioxide emissions. Commitments by the United States and China—two of the world’s largest CO₂ emitters—to reduce carbon dioxide emissions call for advanced energy systems that cry out for advanced materials. New materials and materials methods to enhance efficiency in the use of traditional fossil fuels, the safety of nuclear, and the affordability and practicality of renewable resources will form the foundation upon which next generation energy production systems will be built. Revolutionizing the way electricity is generated and transportation is driven remains inherently a materials problem. Scientists and engineers in the United States and China are leading today’s materials innovation revolution.

That is why in 2014 US-based The Minerals, Metals & Metals Society (TMS) with its long-standing, international membership dedicated to minerals, metals, and materials and the 92,000-member Chinese Society for Metals (CSM) together launched the Energy Materials Conference. The first conference was held in Xi’an, a fitting locale, the ancient Chinese imperial capital and eastern-most point of the Silk Road where East met West 2200 years ago, a crossroad for the trade of materials and ideas. Energy Materials 2014 featured invited talks by world-leading energy materials experts as well as contributed presentations from the global minerals, metals, and materials community highlighting materials research and industrial innovations for both established and emerging energy systems and technologies.

Energy Materials 2017, the second in the series, draws from the success of that first conference and the worldwide draw of TMS2017, the 146th annual meeting &
exhibit of the world’s foremost gathering of materials scientists and engineers, held in San Diego, California. This proceedings volume includes 40 papers from seven symposia covering energy and environmental issues in materials manufacturing and processing, materials in clean power, materials for coal-based power, materials for energy conversion with an emphasis on solid oxide fuel cells, materials for gas turbines, materials for nuclear energy, and materials for oil and gas.

These proceedings present recent advances in materials manufacturing and processing that incorporate methods and materials that are themselves environmentally sound. These proceedings also include discussions on the advancements in materials technologies to enable clean coal technologies, carbon capture, concentrated solar power, biomass fuels, and hydrogen-based power systems. Also presented are discussions about functional ceramic materials that will play an essential role in the commercialization of advanced fossil fuel conversion systems such as solid oxide fuel cells. Materials innovation within gas turbine technology particularly related to gas-fueled power plants is covered. Discussions about nanostructured and advanced materials revolutionizing oil and gas exploration and production in extreme conditions are presented as are discussions about the materials issues associated with improvements in nuclear energy.

These collected works demonstrates that—given the right materials—all energy sources have the potential to meet the world’s growing demand for next generation, clean, affordable energy.

Xingbo Liu
Zhengdong Liu
Lead Editors
Contents

Part I  Energy and Environmental Issues in Materials Manufacturing and Processing: Opportunities in the Steel Industry

Waste Energy Recovery Technology of Iron and Steel Industry in China  ...................................................... 3
Xu Zhang, Hao Bai, Juxian Hao and Zhancheng Guo

Green Manufacturing Process of Shougang Jingtang Steel Plant  .......... 17
Fuming Zhang and Jianxin Xie

The Introduction and Process Optimization Research of Oxygen Blast Furnace Ironmaking Technology  ................................ 31
Qingguo Xue, Zeshang Dong, Jingsong Wang, Zeyi Jiang, Haibin Zuo,
Xuefeng She and Guang Wang

Prediction and Optimal Scheduling of Byproduct Gases in Steel Mill: Trends and Challenges  .................................. 41
Xiancong Zhao, Hao Bai, Qi Shi and Zhancheng Guo

Processing Non-oriented Electrical Steels Using Inclined/Skew Rolling Schemes  ................................................. 51
Youliang He, Mehdi Sanjari and Erik J. Hilinski

A Possible Way for Efficient Utilization of Coal Energy:
The Combined Process of Ironmaking with Gasoline Synthesis and Electricity Generation  ........................................... 61
Zhancheng Guo

The Influence of Water Vapour on the Fuming Rate in a Ferromanganese System  ....................................................... 73
Sarel J. Gates, Gerrit Kornelius, Ida Kero and Gabriella M. Tranell

Approach for Pyrolysis Gas Release Modelling and Its Potential for Enhanced Energy Efficiency of Aluminium Remelting Furnaces

H. Bruns, A. Rücker and H. Pfeifer


R. Gültekin, A. Rücker and H. Pfeifer

Fluoropolymer Coated Condensing Heat Exchangers for Low-Grade Waste Heat Recovery

Youliang He, Afsaneh Edrisy and Robert W. Triebe

Nitrate and Other Anion Removal from Waste Water Using the Hydroflex Technology

David Dreisinger, Gary Kordosky, Todd Beers, Mike Schrock, Jianming Lu and Buming Chen

Mechanical Analysis of Raceway Formation in Bulk Bed of Blast Furnace

Qiuming Wang, Yuanxiang Lu and Zeyi Jiang

Part III  Materials for Coal-Based Power: Materials For Coal-Based Power: Session I

Ni-Fe Based Alloy GH984G Used for 700 °C Coal-Fired Power Plants

Changshuai Wang, Tingting Wang, Jianting Guo, Lanzhang Zhou, Haiping Zhao and Songqian Xu

Part IV  Materials for Coal-Based Power: Materials for Coal-Based Power: Session II

Creep Strength and Oxidation Resistance of Industrially Made G115 Steel Pipe

Zhengdong Liu, Hansheng Bao, Zhengzong Chen, Songqian Xu, Haiping Zhao and Qijiang Wang

Accelerated Creep Test for New Steels and Welds

Stan T. Mandziej
Part V  Materials for Coal-Based Power: Materials for Coal-Based Power: Session III

The Reliability Analysis of 12Cr1MoVG and T23 Used for USC Water Wall .......................... 173
Xiaoli Lu, Yu Wang, Jianyong Wang, Chongbin Wang and Jiongxiang Wang

Part VI  Materials for Coal-Based Power: Poster Session

Effect of High-Frequency Induction Hardening on Stress Corrosion of a 12%Cr Martensitic Stainless Steel ........................................ 183
Tong Kang, Sheng-qi Xi, Xian-ping Wei, Gong-xian Yang, Xiufang Gong and Yu-jiong Liu

Fireside Corrosion Behaviors of Inconel 740H Superalloy in Various SO₂ Contents .......................... 193
Jin-tao Lu, Yan Li, Zhen Yang, Jin-yang Huang, Ming Zhu and Y. Gu

High Cycle Fatigue Behavior of HAYNES282 Superalloy ............ 203
Ming Yang, Gongxian Yang, Xiufang Gong, Bangqiang Zhang, Xiaping Wei, Zhenhuan Gao, Liping Nie and Laohu Long

Recent Development in the Characteristics of Alloy 625 for A-USC Steam Turbine Casting .................. 213
Wenlong Yu, Songfeng Liu, Yu Wang and Lingen Sun

Part VII  Materials for Gas Turbines: Coatings

Evolution of the Thermal Conductivity of Sm₂Zr₂O₇ Under CMAS Attack .............................. 227
A. Bakal, K. Roebbecke, H. Wang, W. Deng, X. Zhang and J.W. Fergus

Part VIII  Materials for Gas Turbines: Hot Corrosion and New Materials

Development of a New High Strength and Hot Corrosion Resistant Directionally Solidified Superalloy DZ409 ..................... 239
Jun-tao Li, Ping Yan, Jian-tao Wu, Jian-xin Dong, Lei Wang and Qiang Zeng

Part IX  Materials for Gas Turbines: Microstructure and Processing

Modeling the Diffusion of Minor Elements in Different MCrAlY—Superalloy Coating/Substrates at High Temperature .......... 251
Krishna Praveen Jonnalagadda, Kang Yuan, Xin-Hai Li, Ru Lin Peng and Yueguang Yu
On Healing Mechanism of Cast Porosities in Cast Ni-Based Superalloy
by Hot Isostatic Pressing ........................................ 265
Chao Yuan, Jie Li, Kai-Xin Dong and Jian-Ting Guo

The Influence of Dendritic Segregation Degree to the Recrystallization Nucleation in U4720LI ........................................ 277
Jiayu Chen and Jianxin Dong

Part X Materials for Gas Turbines: Poster Session

Stress Rupture Properties of Alloy 783 ......................... 289
Yating Zhao, Mengxiao Chen and Shipu Wang

Study on the Undercoolability and Single Crystal Castability of Nickel-Based Superalloys .................................... 295
Haiwei Wang, Dexin Ma, Gongxian Yang, Xiufang Gong,
Qiongyuan Zhang and Xianping Wei

Part XI Materials for Nuclear Energy: Materials for Nuclear Applications I

Enhancing the High-Cycle Fatigue Property of 316 Austenitic Stainless Steels Through Introduction of Mechanical Twins by Cold-Drawing ............................................. 305
Xingfei Xie and Jian Sun

Part XII Materials for Nuclear Energy: Materials for Nuclear Applications II

Microstructure Evolution of a Reactor Pressure Vessel Steel During High-Temperature Tempering .................................. 317
Chuanwei Li, Jianfeng Gu, Lizhan Han and Qingdong Liu

Part XIII Materials for Nuclear Energy: Environmental Effects

Effect of Steam Pressure on the Oxidation Behaviour of Alloy 625 .... 329
Shengli Jiang, Xiao Huang, Wenjing Li and Pei Liu

Friction Stir Processing of Degraded Austenitic Stainless Steel Nuclear Fuel Dry Cask Storage System Canisters ......................... 343
Ben Sutton, Ken Ross, Glenn Grant, Gary Cannell, Greg Frederick and Robert Couch
Contents

Part XIV  Materials for Nuclear Energy: Accident Tolerant Fuels & Irradiation Effects

The Mechanical Response Evaluation of Advanced Claddings During Proposed Reactivity Initiated Accident Conditions ........... 355
M. Nedim Cinbiz, Nicholas Brown, Kurt A. Terrani, Rick R. Lowden and Donald Erdman, III

First Principles Investigations of Alternative Nuclear Fuels ........... 367
Barbara Szpunar, Linu Malakkal, Ericmoore Jossou and Jerzy A. Szpunar

Comparative Study of Thermal Conductivity of SiC and BeO from Ab Initio Calculations .................. 377
Linu Malakkal, Barbara Szpunar and Jerzy Szpunar

Part XV  Materials for Oil and Gas and AMREE Oil & Gas III

Anisotropic Behaviors for X100 High Grade Pipeline Steel Under Stress Constraints ................................. 387
Kun Yang, Ting Sha, Ming Yang, Cheng Shang and Qiang Chi

Co-relation of Microstructural Features with Tensile and Toughness Characteristics of X70 Grade Steel .................. 399
Tushal Kyada, J. Raghu Shant, Rajesh K. Goyal and T.S. Kathayat

Development and Applications of New Generation Ni-Containing Cryogenic Steels in PR China .................. 415
Zhenyu Liu, Meng Wang, Jun Chen and Guodong Wang

Microstructure Analysis and Weldability Investigation of Stainless Steel Clad Plate .................................................. 425

Microstructure and Properties of High Performance Pipeline Steels .................................................. 435
Lei Zheng

Sensitivity Variation of Nanomaterials at Different Operating Temperature Conditions .......................... 447
Enobong E. Bassey, Philip Sallis and Krishnamachar Prasad

Author Index ................................................ 453

Subject Index ................................................ 455
About the Editors

**Xingbo Liu** is Professor and Associate Chair for Research in Mechanical & Aerospace Engineering Department at West Virginia University. He is internationally renowned for his research on materials in energy conversion and storage, especially for high temperature alloys and electrochemical energy systems such as solid oxide fuel cells and batteries. During his career, Dr. Liu has received numerous prestigious awards. In 2010, Liu received the Early Career Faculty Fellow Award from The Minerals, Metals & Materials Society (TMS). In 2011, he received an R&D 100 award for inventing an electroplated Mn-Co coating for solid oxide fuel cell interconnects. In 2013, Liu was named Innovator of the Year by TechConnect WV. In 2015, Dr. Liu was elected as Fellow of ASM International “for his significant contribution on R&D of high temperature materials for energy production and conversion, including superalloys in advanced power systems and solid oxide fuel cells”. In 2016, he received the Brimacombe Medal from TMS “For significant contribution on research and development of high temperature materials and coatings for energy conversion, and extensive service to TMS”. Dr. Liu has extensively served TMS and other professional societies. From 2011 to 2013, he served as the chair of the TMS High Temperature Alloys Committee, chair of the TMS Energy Conversion & Storage Committee from 2012 to 2014, and TMS Functional Materials Division (FMD) programming committee representative (2016–). He is the chair for the American Ceramics Society (ACerS) Basic Science Division (2016–2017) and an executive committee member of the
Electrochemical Society (ECS) High Temperature Materials Division. He has been the lead organizer and co-organizer of more than 20 international conferences and symposiums, including serving as the co-chair for the 8th (2014) and chair of the 9th (2018) Superalloys 718 & Derivatives Conferences. Dr. Xingbo Liu (TMS) and Dr. Zhengdong Liu (Chinese Society for Metals—CSM) have been serving as co-chairs for the Energy Materials 2014 and Energy Materials 2017 conferences, jointly organized by TMS and CSM.

Dr. Xingbo Liu has published more than 80 peer-reviewed journal papers and given numerous invited talks in the international conferences. He also holds three granted and four pending patents in the areas of batteries and electrochemical devices. He received his training in materials science and engineering from the University of Science & Technology Beijing, completing his Ph.D. in 1999.

Zhengdong Liu earned a B.A.Sc. degree (1985–1990) in Mechanical Engineering from Tsinghua University, China; a M.A.Sc. degree (1990–1993) in Materials Science from Central Iron and Steel Research Institute (CISRI), China; and a Ph.D. degree in Metallurgical Engineering from the University of British Columbia (UBC), Canada. Dr. Liu has served as Deputy Director, Professor and senior engineer at the Institute for Structural Materials, Central Iron and Steel Research Institute (CISRI) since 2002. CISRI is the biggest and the most important specialty steel and alloy research facility in China.

Dr. Liu has served as the leader of nationally integrated research and development group on advanced boiler steels and alloys used for 600 °C ultra super critical (USC) power plants in China since 2003. He has also served as the vice-chairman of the National Technical Committee for 700 °C A-USC Fossil Power Plants in China and the head of Materials Sub-Committee, National Technical Committee for 700 °C A-USC Fossil Power Plants in China since 2010; authored and co-authored more than 300 technical papers, holds 26 issued materials patents and 11 issued computer software copyrights, and authored and co-authored seven published technical books.
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Sebastien Dryepondt

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Dr. Horita has received numerous awards including the Richard M. Fulrath Award, The American Ceramic Society, for the contribution to the fundamental studies of Solid Oxide Fuel Cells in 2005; the Ornzio DeNora Foundation Prize on Electrochemical Energy Conversion, International Society of Electrochemistry (ISE) in 2001; and the Excellent Papers award of the Electrochemical Society of Japan in 1994.

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Indranil Roy

Indranil Roy is a former University of California Regents Fellow. Indranil Roy pursued his Ph.D. on mechanical properties and origin of corrosion resistance of bulk nanocrystalline materials on a National Science Foundation (NSF), Nanoscale Interdisciplinary Research Team (NIRT) program on mechanical behavior of bulk nanostructured materials. Dr. Roy started with Schlumberger Technology Corporation in the fall of 2006 with Reservoir Evaluations. Since then he has worked in several different technology groups from Downhole Testing, Enabling Technologies to Infinity Product Line. Dr. Roy is currently the project manager, nanomaterials under the Multi Stage Stimulation (hydraulic fracturing) umbrella with a focus on water reactive materials technology. He has spearheaded materials development for the oil and gas industry’s first fully degradable plug and Perf system—Schlumberger’s Infinity. His main focus has been developing innovative solutions for oil and gas in the mechanical, materials and corrosion domains. His research encompasses understanding interactions of stressed alloys including nanomaterials deployed in corrosive downhole environments (rich in acid gases) at high pressures and temperatures (HPHT). His efforts also includes introduction and usage of nanostructured materials for HPHT sour service. Dr. Roy has been involved in the ultrafine grained materials group at The Minerals, Metals & Materials Society (TMS) and has organized several symposia including “Advance Materials and Reservoir Engineering for Extreme Oil and Gas Environments” organized bi-annually since 2013. He also serves as the vice chair of the TMS subcommittee for the Offshore Technology Conference (OTC) since 2014 and has organized many panels and technical sessions at OTC on behalf of TMS. Dr. Roy has served as a key reviewer for several journals, Materials Science and Engineering A, Metallurgical and Materials Transactions A, Corrosion, etc. Dr. Roy has authored several publications/proceedings and delivered numerous invited talks and seminars. He has over 50 U.S. and international patents/patent applications on some of his key findings on nanocrystalline materials and HPHT phase behavior of supercritical reservoir fluids.
Chengjia Shang is Professor at the University of Science and Technology Beijing (USTB), chief scientist at the State Collaborative Innovation Center of Advanced Steel and Technology, and the secretary general of the Materials Science Branch of the Chinese Society for Metals. For many years Prof. Shang has been dedicating himself into the research, development and application of high performance microalloyed steel, including the fields as follow: physical metallurgy for Nb bearing structural steel, microstructure design and control for high performance steel, and development of offshore platform, ship building, high-rising building, high performance bridge, and high grade pipeline steels. He has been managing and participating several national funded research projects. He has numerous experiences in collaboration with steel industries to develop high performance steel. He received second-place for the National Science and Technology Progress Award; three first-place, two second-place, and one third-place honor of the Provincial and Ministerial Science and Technology Progress Awards, and the Charles Hatchett Award from the Institute of Materials Minerals and Mining (IOMMM) in 2011. He has published approximately 150 academic papers, and participated in the composing of four academic writings, and was invited many times to conferences to present plenary lectures, keynotes, and invited speeches.

Ji Zhang