

# **International Thermal Spray Conference & Exposition (ITSC 2015)**

**Long Beach, California, USA  
11-14 May 2015**

**Volume 1 of 2**

## **Editors:**

<b>A. Agarwal</b>	<b>G. Bolelli</b>
<b>A. Concustell</b>	<b>Y. C. Lau</b>
<b>A. McDonald</b>	<b>F. L. Toma</b>
<b>E. Turunen</b>	<b>C. A. Widener</b>

ISBN: 978-1-5108-1154-6

**Printed from e-media with permission by:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571



**Some format issues inherent in the e-media version may also appear in this print version.**

Copyright© (2015) by ASM International  
All rights reserved.

Printed by Curran Associates, Inc. (2015)

For permission requests, please contact ASM International  
at the address below.

ASM International  
9639 Kinsman Road  
Materials Park, Ohio 44073

Phone: (440) 338-5151

[memberservicecenter@asminternational.org](mailto:memberservicecenter@asminternational.org)

**Additional copies of this publication are available from:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
Phone: 845-758-0400  
Fax: 845-758-2634  
Email: [curran@proceedings.com](mailto:curran@proceedings.com)  
Web: [www.proceedings.com](http://www.proceedings.com)

# Contents

Scroll to the title and Click on it to link to the paper. After viewing the paper, use the bookmarks to the left to return to the beginning of the Contents.

## Advanced Coatings for the Aerospace Industry

### **Advanced Microscopic Study of Suspension Plasma Sprayed Zirconia Coatings with Different Microstructures** 1

Paweł Sokołowski<sup>1</sup>, Lech Pawłowski<sup>1</sup>, Dagmar Dietrich<sup>2</sup>, Thomas Lampke<sup>2</sup>, and David Jech<sup>3</sup>

(1) University of Limoges, Limoges, France

(2) Chemnitz University of Technology, Chemnitz, Germany

(3) Brno University of Technology, Brno, Czech Republic

### **Application of FEM for the Estimation of Thermomechanical Properties of Plasma Sprayed Composite Coatings** 9

R. Bolot, D. Aussavy, and G. Montavon, IRTES-LERMPS, UTBM, Belfort, France

### **Cold Spray and Reaction Sintering of Ti-TiAl<sub>3</sub> Composite Coatings** 15

Volf Leshchynsky<sup>1</sup>, Oleksandra Bielousova<sup>2</sup>, and Anatoli Papyrin<sup>3</sup>

(1) University of Windsor, Windsor, ON, Canada

(2) Ecole Nationale d'Ingenieurs de Saint-Etienne (ENISE), Saint-Etienne, France

(3) Cold Spray Technology, Albuquerque, NM, USA

### **Cold Sprayed MCrAlY as a Bondcoat Candidate for TBC Application** 20

X. Ma and P. Ruggiero, Curtiss-Wright Corporation, East Windsor, CT, USA

### **Comparison of Plasma Sprayed High Entropy Alloys with Conventional Bond Coat Materials** 27

Andrew S.M. Ang<sup>1</sup>, Christopher C. Berndt<sup>1</sup>, Mitchell L. Sesso<sup>1</sup>, Ameey Anupam<sup>2</sup>, Praveen. S. Ravi Sankar Kottada<sup>2</sup>, and B.S. Murty<sup>2</sup>

(1) Swinburne University of Technology, Victoria, Australia

(2) Indian Institute of Technology Madras, Chennai, India

### **Concept Optimization for Coating Application and Quality of APS Applied TBC on Gas Turbine Blades and Vanes** 33

Buecklers Tobias and Duda Thomas, Alstom AG, Birr, Switzerland

### **Development of a Two-Stage Hybrid Technology for Repairing Turbine Blades** 37

M. Nicolaus, K. Möhwald, and H.J. Maier, Leibniz University Hannover, Garbsen, Germany

### **Effect of Friction-Stir Processing on the Wear Rate of WC-Based MMC Coatings Deposited by Low-Pressure Cold Gas Dynamic Spraying** 41

H. Ashrafizadeh<sup>1</sup>, A. Lopera-Valle<sup>1</sup>, A. McDonald<sup>1</sup>, and A. Gerlich<sup>2</sup>

(1) University of Alberta, Alberta, Canada

(2) University of Waterloo, Ontario, Canada

**Eliminating Hexavalent Cr Emissions in Thermal Spray Alloys** 48

*Justin Cheney<sup>1</sup> and Daren Gansert<sup>2</sup>*

(1) Scoperta, San Diego, CA, USA

(2) HAI, Placentia, CA, USA

**Formation of a Continuous  $\beta$ -NiAl Layer Near the Interface in a  $\gamma+\beta$  MCrAlY** 54

*Kang Yuan<sup>1</sup>, Ru Lin Peng<sup>1</sup>, and Xin-Hai Li<sup>2</sup>*

(1) Linköping University, Linköping, Sweden

(2) Siemens Industrial Turbomachinery AB, Finspong, Sweden

**High Sintering-Resistant Plasma-Sprayed Thermal Barrier Coatings Designed with Large Two-Dimensional Inter-Lamellar Pores** 62

*Tao Liu, Shan-lin Zhang, Xiao-tao Luo, Guan-Jun Yang, Cheng-Xin Li, and Chang-Jiu Li  
Xi'an Jiaotong University, Xi'an, PR China*

**High Temperature Oxidation of Cold Gas Sprayed Bond Coats for TBC Application** 71

*C.R.C. Lima<sup>1</sup>, M.J.X. Belém<sup>1</sup>, V. Crespo<sup>2</sup>, I.G. Cano<sup>2</sup>, S. Dosta<sup>2</sup>, and J.M. Guilemany<sup>2</sup>*

(1) Methodist University of Piracicaba, São Paulo, Brazil

(2) University of Barcelona, Barcelona, Spain

**HVOF and HVAF Coatings of Nano-Agglomerated Tungsten Carbide–Cobalt Powders for Water Droplet Erosion Application** 76

*F. Tarasi, M.S. Mahdipoor, A. Dolatabadi, M. Medraj, and C. Moreau  
Concordia University, Montreal, Canada*

**Improving the Adhesion of Wear-Resistant Coatings on Aerospace Polymer Composites** 87

*Axelle Elrikh<sup>1</sup>, Simon Goutier<sup>1</sup>, Romain Bignon<sup>1</sup>, Armelle Vardelle<sup>1</sup>, and Gordon Armstrong<sup>2</sup>*

(1) Université de Limoges, Limoges, France

(2) University of Limerick, Limerick, Ireland

**Improving the Corrosion Resistance of Thermal Barrier Coatings against CMAS by Depositing Top Ceramic Layer of Enhanced Splat Bonding** 92

*Tao Liu, Li-Shuang Wang, Shu-Wei Yao, Guan-Jun Yang, Cheng-Xin Li,  
Xiao-Tao Luo, and Chang-Jiu Li  
Xi'an Jiaotong University, Shannxi, P.R. China*

**Influence of APS Process Parameters on Morphologies of YSZ-Polyester Abradable Coatings** 99

*D. Aussavy<sup>1</sup>, R. Bolot<sup>1</sup>, G. Montavon<sup>1</sup>, F. Peyraut<sup>2</sup>, G. Szyndelman<sup>3</sup>,  
J. Gurt-Santanach<sup>4</sup>, and S. Selezneff<sup>5</sup>*

(1) IRTES-LERMPS, Belfort, France

(2) IRTES-M3M, Belfort, France

(3) Oerlikon Metco, Wohlen, Switzerland

(4) Turbomeca, Bordes, France

(5) SNECMA, Moissy-Cramayel, France

**Influence of Pretreatment on the Growth Behavior of TGO on MCrAlY Bond Coat Surface** 107

*Bang-Yan Zhang, Guan-Jun Yang, Cheng-Xin Li, and Chang-Jiu Li  
Xi'an Jiaotong University, Xi'an, China*

**Investigation of the Deposition Mechanism of Cold Spray onto Carbon Fibre Reinforced Polymers** 114

*Hanqing Che<sup>1</sup>, Stephen Yue<sup>1</sup>, and Phuong Vo<sup>2</sup>*

*McGill University, Montreal, Canada*

*National Research Council Canada, Boucherville, J4B 6Y4, Canada*

**Laser Surface Patterning Pretreatment before Thermal Spraying—A Way to Adapt and Control the Surface Topography to the Considered Materials and the Stresses Imposed** 120

*Robin Kromer<sup>1</sup>, Sophie Costil<sup>1</sup>, Jonathan Cormier<sup>2</sup>, Laurent Berthe<sup>3</sup>, Patrice Peyre<sup>3</sup>, and Damien Courapied<sup>3</sup>*

*(1) Irtes-Lermeps Institute, Belfort, France*

*(2) Institut Pprime, Chasseneuil – Futuroscope, France*

*(3) PIMM – UMR, Paris, France*

**Manufacturing of Thick, Crack-Free Wear Protective Coatings on Complex Geometries for Gas Turbine Parts** 129

*Marcus Riedel and Thomas Duda, Alstom (Switzerland) Ltd., Birr, Switzerland*

**Mechanism of Calcareous Deposit Formation on TSA-Coated Steel Structures at Elevated Temperatures** 135

*S. Paul<sup>1</sup>, M.D.F. Harvey<sup>1</sup>, N.S. Zulkfli<sup>2</sup>, K. Yunus<sup>2</sup>, and A.C. Fisher<sup>2</sup>*

*(1) TWI, Cambridge, UK*

*(2) University of Cambridge, Cambridge, UK*

**Microstructure and Properties of Porous Abradable Alumina Coatings Flame-Sprayed by Semi-Molten Particles** 142

*Chang-Jiu Li, Jiao Zou, Hui-Bin Huo, Jian-Tao Yao, and Guan-Jun Yang*

*Xi'an Jiaotong University, Shaanxi Province, PR China*

**Preparation of Inorganic Phosphate Ceramic Coatings on  $\gamma$ -TiAl Based Alloys** 150

*Lingyan Kong<sup>1</sup>, Yang Yang<sup>1</sup>, Jiqiang Wang<sup>1</sup>, Qing Jia<sup>1</sup>, Lei Xu<sup>1</sup>,*

*Tianying Xiong<sup>1</sup>, and Xin Yue<sup>2</sup>*

*(1) Institute of Metal Research, Chinese Academy of Sciences, Shenyang, China*

*(2) Shenyang Institue of Chemical Technology, Shenyang, China*

**Process-Property Correlation of Heat-Treated Aluminium 6061 Cold Spray Coatings** 155

*Kelvin Loke<sup>1</sup>, Richard Kwok<sup>1</sup>, P.K. Koh<sup>2</sup>, T.C. Lim<sup>2</sup>, and Philip Cheang<sup>2</sup>*

*(1) ST Kinetics Integrated Engineering Pte Ltd, Singapore*

*(2) SIM University, Singapore*

**Spall Resistant HVOF Coatings** 162

*David Webb<sup>1</sup>, Richard Vander Straten<sup>1</sup>, Brad Martin<sup>2</sup>, and Ron Montgomery<sup>2</sup>*

*(1) ES3, Clearfield, UT, USA*

*(2) 417 SCMS/GUEA - HAFB, UT, USA*

**The Effect of Heat Treatment on Mechanical Properties of Thermally Sprayed Sandwich Structure Beams** 167

*Saeid Salavati, Larry Pershin, Thomas W. Coyle, and Javad Mostaghimi*

*Centre for Advanced Coating Technologies, Ontario, Canada*

## **The Micro Structure and Tribological Properties of Liquid-Fuel HVOF Sprayed Fine Wc-Co-Cr Coating** 173

*Rohit Upadhyaya<sup>1</sup>, Sharad Shrivastava<sup>1</sup>, S.C. Modi<sup>2</sup>, and A. Modi<sup>2</sup>*

*(1) Birla Institute of Technology and Science, Pilani, India*

*(2) Metallizing Equipment Company, Jodhpur, India*

## **Thermal Barrier Coatings Performed by Suspension Plasma Spraying—Development and Characterization** 179

*Benjamin Bernard<sup>1</sup>, Luc Bianchi<sup>1</sup>, André Malié<sup>2</sup>, Vincent Schick<sup>3</sup>, and Benjamin Remy<sup>3</sup>*

*(1) CEA-DAM Le Ripault, Monts, France*

*(2) Safran-Snecma, Châtellerault, France*

*(3) LEMTA-ENSEM, Vandoeuvre-lès-Nancy, France*

## **Thermal Gradient Behaviour of TBCs Subjected to a Laser Gradient Test Rig—Simulating an Air-to-Air Combat Flight** 184

*Rogerio S. Lima<sup>1</sup>, Basil R. Marple<sup>1</sup>, and Pierre Marcoux<sup>2</sup>*

*(1) National Research Council of Canada, Boucherville, Canada*

*(2) Vac Aero International, Boucherville, Canada*

## **Thermal Phase Stability of Various Plasma Sprayed TBCs** 192

*Li Li<sup>1</sup> and Benjamin Peterson<sup>2</sup>*

*(1) Praxair Surface Technologies, Inc., Indianapolis, IN, USA*

*(2) Honeywell Aerospace, Phoenix, AZ, USA*

## **Transient High Heat Load Performance of Thick VPS W Coating on Relatively Large CuCrZr Substrate** 198

*Chunming Deng, Min Liu, Liping Xu, Kesong Zhou, Changguang Deng,*

*Ziqi Kuang, and Xiaofeng Zhang*

*Guangzhou Research Institute of Non-Ferrous Metals, Guangzhou, China*

## **Fundamentals/Research and Development**

### **A Damage Based Finite Element Simulation of Cold Spray Coating under Indentation Loading** 205

*A. Moridi, S.M. Hassani-Gangaraj, and M. Guagliano, Politecnico di Milano*

### **A Novel coaxially Laser-Assisted (COLA) Cold Spray System** 210

*C.M. Allen<sup>1</sup>, T. Marrocco<sup>1</sup>, P. McNutt<sup>1</sup>, H. Koivuluoto<sup>2</sup>, J. Latokartano<sup>2</sup>,  
P. Vuoristo<sup>2</sup>, and R. Olsson<sup>3</sup>*

*(1) TWI Ltd., Cambridge, UK*

*(2) Tampere University of Technology, Tampere, Finland*

*(3) Luleå University of Technology, Luleå, Sweden*

### **A Numerical Investigation—Air Plasma Spraying by Means of a Three-Cathode Spraying Torch** 217

*K. Bobzin and M. Öte, RWTH Aachen University*

**A Three-Dimensional Analysis of the Suspension Plasma Spray Impinging on a Curved Substrate** 223

*K. Pourang, C. Moreau, and A. Dolatabadi, Concordia University*

**Al/Al<sub>2</sub>O<sub>3</sub> Cermets by Plasma Spraying—Optical Response of Experimental and Numerical Materials** 229

*D. Toru<sup>1</sup>, A. Quet<sup>1</sup>, H. Piombini<sup>1</sup>, L. Bianchi<sup>1</sup>, R. Echegut<sup>2</sup>, D. De Sousa Meneses<sup>2</sup>, L. Del Campo<sup>2</sup>, and P. Echegut<sup>2</sup>*

*(1) CEA DAM Le Ripault, Monts, France*

*(2) CNRS, Orléans, France*

**An Investigation on Microstructural Properties of Plasma Sprayed Tungsten Carbide Enhanced with Partially Stabilized Zirconia** 236

*S. Abuali Galedari, M. Salimi Jazi, F. Azarmi, A. Tangpong, and Y. Huang*

*North Dakota State University, Fargo, ND, USA*

**Application Mist Cooling Technique Various Type Thermal Spraying Guns** 241

*Takashi Kumai<sup>1</sup>, Yusuke Nishiura<sup>1</sup>, Yasuhiro Omori<sup>1</sup>, Yoshio Shin<sup>2</sup>, and Toshiharu Morimoto<sup>2</sup>*

*(1) Yoshikawa Kogyo, Himeji, Japan*

*(2) Nakayama Amorphous, Osaka, Japan*

**Ceramics Filler Rods Feeding for Plasma Flame Torch in Thermal Nanoparticles Spraying** 243

*Soshu Kirihara, Osaka University, Ibaraki, Japan*

**Comparison of Impact Crater Shape and Splat on Various Targets for Estimating Projectile Velocity** 247

*K. Sakata<sup>1</sup>, K. Tagomori<sup>1</sup>, N. Sugiyama<sup>1</sup>, D. Oka<sup>1</sup>, Y. Shinya<sup>1</sup>, H. Sasaki<sup>2</sup>, Y. Akahoshi<sup>3</sup>,*

*K. Norimatsu<sup>3</sup>, Y. Fujimura<sup>3</sup>, Y. Fukuda<sup>3</sup>, and T. Koura<sup>3</sup>*

*(1) Fujikikosan Corporation, Kitakyushu, Japan*

*(2) NAC Image Technology Inc., Tokyo, Japan*

*(3) Kyushu Institute of Technology, Kitakyushu, Japan*

**Comparison of Simulated and Experimental Particle Mean Temperature and Velocity for Thermal Spray Coating Process** 252

*S. Shang<sup>1</sup>, and R.C. Batra<sup>1</sup>, and M. Cybulsky<sup>2</sup>*

*(1) Virginia Polytechnic Institute and State University, Blacksburg, VA, USA*

*(2) Rolls-Royce Corporation, Indianapolis, IN, USA*

**Constrained Healing and Morphology Change Mechanism of 2D Cracks in Plasma Sprayed Thermal Barrier Coatings** 258

*Guang-Rong Li, Juan Lei, Guan-Jun Yang, Cheng-Xin Li, and Chang-Jiu Li*

*Xi'an Jiaotong University, Shaanxi, China*

**Controlling the Twin Wire Arc Spray Process Using Artificial Neural Networks (ANN)** 267

*K. Hartz-Behrend<sup>1</sup>, J. Schein<sup>1</sup>, J. Schaup<sup>1</sup>, and J. Zierhut<sup>2</sup>*

*(1) LPT, Universitaet der Bundeswehr Muenchen, Neubiberg, Germany*

*(2) Zierhut Messtechnik GmbH, Munich, Germany*

- Critical Velocity Window for the Deposition of Iron-Based Metallic Glass Particles Using Cold Spray** 273  
*D.E. Cipoletti<sup>1</sup>, C.W. Ziemian<sup>1</sup>, W.J. Wright<sup>1</sup>, K.V. Haile<sup>1</sup>, M.N. Okwara<sup>1</sup>,  
K.A. Hetherington<sup>1</sup>, and D.J. Helfritch<sup>2</sup>*  
(1) Bucknell University, Lewisburg, PA, USA  
(2) TKC Global at the U.S. Army Research Laboratory, Aberdeen Proving Ground, MD, USA

- Deformation Behavior of Alumina Particles in Compression for Room Temperature Solid-State Deposition** 281  
*Pylin Sarobol, Michael Chandross, Jay D. Carroll, William M. Mook, Daniel C. Bufford,  
Paul G. Kotula, Bonnie B. McKenzie, Brad L. Boyce, Khalid Hattar, and Aaron C. Hall*  
Sandia National Laboratories, Albuquerque, NM, USA

- Detection and Avoiding of Unmelted Wire Pieces during Wire Arc Spraying** 287  
*S. Eichler<sup>1</sup>, S. Kirner<sup>1</sup>, S. Zimmermann<sup>1</sup>, J. Schein<sup>1</sup>, W. Mayr<sup>2</sup>, and J. Zierhut<sup>3</sup>*  
(1) Universitaet der Bundeswehr Muenchen, Neubiberg, Germany  
(2) University of Applied Sciences Munich, Munich, Germany  
(3) Zierhut Messtechnik GmbH, Munich, Germany

- Development of the Microstructure and Mechanical Properties of Cold-Sprayed IN 718 Alloy Coating by a Novel In-Situ Shot Peening Process** 293  
*Xiao-Tao Luo, Meng-Lin Yao, Cheng-Xin Li, Guan-Jun Yang, and Chang-Jiu Li*  
Xi'an Jiaotong University, Shaanxi, China

- Development of Thin WC-12Co Coatings Manufactured by HVOF-Spraying** 299  
*Wolfgang Tillmann, Peter Hollingsworth, Igor Baumann, and Marcel Laschitzki*  
Technische Universität Dortmund, Dortmund, Germany

- Eddy Current Measurement Technique for Bi-Layer Thermal Barrier Systems** 305  
*Gregory M. Smith, Nicholas Erb, Mats-Olov Hansson, and Jimmy Johansson*  
GKN Aerospace Engines Sweden

- Effect of Alloying Active Elements of Powder on Spreading Behaviour of Plasma Spray Splats** 313  
*Yongang Zhang<sup>1</sup>, Margaret Hyland<sup>1</sup>, and A.T.T. Tran<sup>1</sup>, and Steven Matthew<sup>2</sup>*  
(1) The University of Auckland, Auckland, New Zealand  
(2) Massey University, Auckland, New Zealand

- Effect of Blasting and Spraying Parameters on the Adhesion of Arc Wire Sprayed Aluminum Coatings** 321  
*S. Paul, P.J. Aldhous and H.L. de Villiers Lovelock*  
TWI Ltd, Cambridge, UK

- Effect of Feedstock Characteristics and Operating Parameters on the Properties of Cr<sub>2</sub>O<sub>3</sub> Coatings Prepared by Suspension-HVOF Spraying** 329  
*Filofteia-Laura Toma<sup>1</sup>, Stefan Scheitz<sup>1</sup>, Richard Trache<sup>1</sup>, Stefan Langner<sup>1</sup>,  
Christoph Leyens<sup>1</sup>, Annegret Potthoff<sup>2</sup>, and Kathrin Oelschlägel<sup>2</sup>*  
(1) Fraunhofer Institute for Material and Beam Technology, Dresden, Germany  
(2) Fraunhofer Institute for Ceramic Technologies and Systems, Dresden, Germany

**Effect of Spraying Parameters on the Strain of  
Plasma Sprayed YSZ Coatings Measured by the  
Digital Image Correlation Method during the Tensile Test** 335

*Lele Ruan, Zexin Yu, Weize Wang, and Yufan Chen  
University of Science and Technology, Shanghai, China*

**Effect of Substrate Roughness on the Cratering Phenomenon on the  
Surface of Cold Sprayed Coating** 339

*S. Gojon, R. Kromer, S. Costil, G. Douchy, C. Verdy, and H. Liao  
IRTES-LERMPS, Belfort, France*

**Effect of Type and Amount of Tungsten Carbides on the Abrasive Wear of  
Laser Cladded Nickel Based Coatings** 345

*Barbara Maroli and Senad Dizdar, Höganäs AB, Höganäs, Sweden*

**Elastic Isotropy of Cold Sprayed Coatings** 353

*J. Cizek<sup>1</sup>, I. Dlouhy<sup>1</sup>, H. Seiner<sup>2</sup>, M. Landa<sup>2</sup>, and R. Huang<sup>3</sup>  
(1) Brno University of Technology, Brno, Czech Republic  
(2) Academy of Sciences of the Czech Republic, Prague, Czech Republic  
(3) Plasma Giken, Saitama, Japan*

**Electron Microscopy and EBSD Characterization of  
Cold-Sprayed IN 625® Coatings on 4130 Steel** 357

*Dheepa Srinivasan<sup>1</sup>, Ramar Amuthan<sup>2</sup>, Y.C. Lau<sup>3</sup>, Atanu Chaudhuri<sup>4</sup>, Y. Raghupathy<sup>4</sup>,  
Satyam Suwas<sup>4</sup>, and Chandan Srivastava<sup>4</sup>  
(1) GE Power and Water, Bangalore, India  
(2) GE Global Research, Bangalore, India  
(3) GE Power and Water, Schenectady, NY, USA  
(4) Indian Institute of Science, Bangalore, India*

**Epitaxial Grain Growth during 8YSZ Splat Formation on  
Polycrystalline YSZ Substrates by Plasma Spraying** 363

*Er-Juan Yang<sup>1</sup>, Xiao-Tao Luo<sup>1</sup>, Guan-jun Yang<sup>1</sup>, Cheng-xin, Li<sup>1</sup>,  
Chang-Jiu Li<sup>1</sup>, and Makoto Takahashi<sup>2</sup>  
(1) Xi'an Jiaotong University, Shaanxi, PR China  
(2) Osaka University, Ibaraki, Japan*

**Evaluation of the Influence of Flame Spraying Parameters on Microstructure and  
Electrical Conductivity of Al-12Si Coatings Deposited on Polyurethane Substrates** 370

*H. Ashrafizadeh, P. Mertiny, and A. McDonald  
University of Alberta, Alberta, Canada*

**Evolution of Microstructure and Wear Behavior of Heat-Treated and  
Fused Arc-Sprayed Coatings Containing Fe<sub>2</sub>B Crystals Dispersed in  
Different Steel-Based Matrices** 377

*S. Dallaire, Synthesarc Inc., Quebec, Canada*

**Experimental Investigation and Finite Element Simulation of  
Residual Stress Development in Thermally Sprayed Coatings** 384

*Mohamed Elhoriny, Martin Wenzelburger, Andreas Killinger, and Rainer Gadow  
Stuttgart University, Stuttgart, Germany*

**Fast Coating Deposition Simulation for Path Planning and Iterative Net-Shape Optimization on Complex Workpieces** 390

*T. Wiederkehr, H. Müller, D. Hegels, W. Tillmann, and L. Hagen  
Technische Universität Dortmund, Germany*

**Fatigue Crack Growth in Bodies with Thermally Sprayed Coating** 398

*O. Kovářík<sup>1</sup>, P. Haušild<sup>1</sup>, J. Medřický<sup>1</sup>, L. Tomek<sup>1</sup>, J. Siegl<sup>1</sup>, R. Mušálek<sup>2</sup>, N. Curry<sup>3</sup>, and S. Bjorklund<sup>3</sup>  
(1) Czech Technical University in Prague, Czech Republic  
(2) Institute of Plasma Physics ASCR, Czech Republic  
(3) University West, Trollhättan, Sweden*

**Fatigue Performance of TBCs on Hastelloy X Substrate during Cyclic Bending** 406

*Radek Musalek<sup>1</sup>, Jan Medricky<sup>1</sup>, Zdenek Pala<sup>1</sup>, Ondrej Kovarik<sup>2</sup>, Libor Tomek<sup>2</sup>, Nicholas Curry<sup>3</sup>, and Stefan Bjorklund<sup>3</sup>  
(1) Institute of Plasma Physics AS CR, Prague, Czech Republic  
(2) Czech Technical University in Prague, Prague, Czech Republic  
(3) University West, Trollhättan, Sweden*

**Fracture Behavior and Lifetime Performance of Thermal Barrier Coatings in Thermally Graded Mechanical Fatigue Environments** 413

*Zhe Lu<sup>1</sup>, Sang-Won Myoung<sup>1</sup>, Yeon-Gil Jung<sup>1</sup>, Jing Zhang<sup>2</sup>, and Ungyu Paik<sup>3</sup>  
(1) Changwon National University, Changwon-si, Gyeongsangnam-do, Republic of Korea  
(2) Indiana University-Purdue University Indianapolis, IN, USA  
(3) Hanyang University, Seoul, Republic of Korea*

**Fretting Behavior of Cold-Sprayed Cu and Cu-MoS<sub>2</sub> Coatings** 420

*Yinyin Zhang<sup>1</sup>, Richard R. Chromik<sup>1</sup>, Sylvie Descartes<sup>2</sup>, Edouard Regis<sup>2</sup>, and Phuong Vo<sup>3</sup>  
(1) McGill University, Montreal, Canada  
(2) Université de Lyon, Villeurbanne, France  
(3) National Research Council Canada, Boucherville, Canada*

**Fully Nano-Equiaxed-Structured Thermal Barrier Coating Deposited Using Very-Low-Pressure Plasma Spray** 427

*Yang Gao<sup>1</sup>, Yan Zhao<sup>1</sup>, Cheng-qì Sun<sup>1</sup>, D.-M. Yang<sup>1</sup>, and Jianyi Gao<sup>2</sup>  
(1) Dalian Maritime University, Liaoning, China  
(2) Arizona State University, Tempe, AZ, USA*

**High Dense Fe-Al Composites Made by Annealing of Cold-Sprayed Coatings** 434

*Evgeny Leshchinsky<sup>1</sup>, Elena Maeva<sup>1</sup>, and Oleksandra Bielousova<sup>2</sup>  
(1) The University of Windsor, Windsor, ON, Canada  
(2) Ecole Nationale d'Ingenieurs de Saint-Etienne, Saint-Etienne, France*

**High Stability, High Enthalpy APS Process Based on Combined Wall and Gas Stabilizations of Plasma (Part 1: Process and Coatings Introduction)** 437

*Gianpaolo Mor<sup>1</sup> and Vladimir Belashchenko<sup>2</sup>  
(1) Flame Spray North America, Fountain Inn, SC, USA  
(2) Thermal Spray Development, Waltham, MA, USA*

**High Stability, High Enthalpy APS Process Based on Combined Wall and Gas Stabilizations of Plasma (Part 2: Plasma Properties and Process Operating Window) 445**

Vladimir Belashchenko<sup>1</sup> and Alexander Zagorski<sup>2</sup>

(1) Thermal Spray Development, Waltham, MA, USA

(2) Baden, Switzerland

**Homogenization of Coating Properties in Three-Cathode Atmospheric Plasma Spraying by Use of Advanced Diagnostics and Numerical Simulation—Investigations of Suspension Plasma Spraying (SPS) 452**

Stephan Zimmermann<sup>1</sup>, Sven Schmettlach<sup>1</sup>, Sebastian Weber<sup>1</sup>, Jose Marques<sup>1</sup>, Guenter Forster<sup>1</sup>, Klaus Landes<sup>1</sup>, Jochen Schein<sup>1</sup>, Christin Lummer<sup>2</sup>, Patrick Knödler<sup>2</sup>, Simon Kresnik<sup>2</sup>, Jens Prehm<sup>2</sup>, Kai Möhwald<sup>2</sup>, and Hans J. Maier<sup>2</sup>

(1) University of Federal Armed Forces Munich, Neubiberg, Germany

(2) Leibniz Universitaet Hannover, Garbsen, Germany

**Improved Corrosion Resistance of Plasma-Sprayed NiCr-Mo Coating with Shell-Core-Structured Powder by Improving Lamellar Interface Bonding 460**

Jia-Jia Tian, Guan-Jun Yang, Cheng-Xin Li, Xiao-Tao Luo, and Chang-Jiu Li  
Xi'an Jiaotong University, Shaanxi, China

**Improvement of Corrosion Resistance of Thermal-Sprayed Stainless Steel Coating by Addition of Some Deoxidizing Elements 467**

H. Era<sup>1</sup>, K. Hashimoto<sup>1</sup>, N. Sakoda<sup>2</sup>, Z. Zeng<sup>2</sup>, and S. Sako<sup>2</sup>

(1) Kyushu Institute of Technology, Japan

(2) Kurashiki Boring Kiko Co., Ltd., Kurashiki Okayama, Japan

**Improving Cold Sprayability—Mixed Metal Powders 473**

Stephen Yue<sup>1</sup>, Wilson Wong<sup>1</sup>, Huseyin Aydin<sup>1</sup>, Rosaire Mongrain<sup>1</sup>, Rajib Barua<sup>1</sup>, Phuong Vo<sup>2</sup>, andn Richard Dolbec<sup>3</sup>

(1) McGill University, Montreal, Quebec, Canada

(2) National Research Council, Boucherville, Quebec, Canada

(3) Tekna, Sherbrooke, Québec, Canada

**Improving the Fatigue Resistance of Warm Sprayed WC-CoCr Coatings by Micro-Finishing 479**

W. Tillmann<sup>1</sup>, J. Nebel<sup>1</sup>, C. Schaak<sup>1</sup>, D. Biermann<sup>1</sup>, S. Goeke<sup>1</sup>, and G. Matthäus<sup>2</sup>

(1) TU Dortmund, Dortmund, Germany

(2) Thermico GmbH & Co KG, Dortmund, Germany

**Influence of Gas Flow Parameters and Nozzle Design on Secondary Atomization in a Rotating Twin-Wire Arc Spray System 486**

Jean-Baptiste Devillers<sup>1</sup>, Hanlin Liao<sup>1</sup>, Christian Coddet<sup>1</sup>, and Jean-Marie Malhaire<sup>2</sup>

(1) Université de Technologie Belfort-Montbéliard, Sevenans, France

(2) ECAM Rennes – Louis de Broglie, Bruz, France

**Influence of Grit Blasting on the Interface Roughness and Adhesion Strength of Cold Sprayed Copper Coatings 493**

R.Gr. Maev, V. Leshchynsky, E. Strumban, D. Dzhurinskiy, and E. Maeva

Institute for Diagnostic Imaging Research, Windsor, Ontario, Canada

**Influence of Microstructure on Thermal Properties of Columnar Axial Suspension Plasma Sprayed Thermal Barrier Coatings 498**

Ashish Ganvir<sup>1</sup>, Nicholas Curry<sup>1</sup>, Nicolaie Markocsan<sup>1</sup>, Per Nylen<sup>1</sup>,

Monika Vilemova<sup>2</sup>, and Zdenek Pala<sup>2</sup>

(1) University West, Trollhättan, Sweden

(2) IPP Prague, Czech Republic

**Influence of Process Parameter on Grit Blasting as a Pretreatment Process for Thermal Spraying 506**

K. Bobzin, M. Öte, T. F. Linke, and X. Liao

RWTH Aachen University, Aachen, Germany

**Influence of Surface Oxide Film on Deposition Behavior of Cold Spray Emulated Particle by Single Particle Shot System 513**

K. Ito, Y. Ichikawa, and K. Ogawa

Fracture and Reliability Research Institute, Tohoku University, Sendai, Japan

**Influence of the Plasma Radiation Scattered by Inflight Particles on Temperature Measurement in Suspension Plasma Spraying 520**

Bishoy Aziz and Christian Moreau, Concordia University, Montreal, QC, Canada

**Investigation of a Pulsed Current Wire Arc Spray Process 526**

S. Kirner, A. Atzberger, S. Zimmermann, J. Schein, and G. Forster

Universitaet der Bundeswehr Muenchen, Neubiberg, Germany

**Investigation of Alumina and Yttria Coating Microstructures Manufactured by Suspension Plasma Spray 532**

E. Aubignat<sup>1</sup>, M.-P. Planche<sup>1</sup>, G. Montavon<sup>1</sup>, A. Allimant<sup>2</sup>, and D. Billieres<sup>3</sup>

(1) IRTES-LERMPS, Belfort, France

(2) Saint-Gobain C.R.E.E., Cavaillon, France

(3) Saint-Gobain Coating Solutions, Avignon, France

**Investigation of Flow Parameters in Wire Arc Thermal Spraying Using CFD Simulation 538**

Amirsaman Farrokhpourah<sup>1</sup>, Larry Pershin<sup>1</sup>, Javad Mostaghimi<sup>1</sup>, and Julien Naffrechoux<sup>2</sup>(1)

University of Toronto, Toronto, ON, Canada

(2) Polytech Nantes, Graduate School of Engineering, Nantes, France

**Investigation of the Bonding Mechanisms of Al Coatings on Ceramic Substrates Deposited by Cold Gas Spraying and Magnetron Sputtering 544**

R. Drehmann<sup>1</sup>, T. Grund<sup>1</sup>, T. Lampke<sup>1</sup>, B. Wielage<sup>1</sup>, C. Wüstefeld<sup>2</sup>, M. Motylenko<sup>2</sup>,

G. Schreiber<sup>2</sup>, and D. Rafaja<sup>2</sup>

(1) Technische Universität Chemnitz, Germany

(2) Technische Universität Bergakademie, Freiberg, Germany

**Investigation of the Interface of Overlapping Splat for a WC-Based Cermet 553**

B. Hussong, V. Lünnemann, and W. Tillmann

Institute of Materials Engineering, Dortmund, Germany

**Joining of Dissimilar Materials by the Cold Spray Process 559**

Victor Kenneth Champagne III<sup>1</sup>, Michael K. West<sup>2</sup>, M. Reza Rokni<sup>2</sup>, and Todd Curtis<sup>2</sup>

(1) University of Massachusetts, Amherst, MA, USA

(2) South Dakota School of Mines and Technology, Rapid City, SD, USA

**Lithium Iron Phosphate Coatings Deposited by Means of  
Inductively-Coupled Thermal Plasma** 566

*K. Major, G. Brisard, and J. Veilleux*

*Université de Sherbrooke, Sherbrooke, Québec, Canada*

**Low Cost Suspension Plasma Spraying of YSZ Coatings** 571

*Mohammed Shahien and Masato Suzuki*

*(1) National Institute of Advanced Industrial Science and Technology, Ibaraki, Japan*

**Mechanisation of the Grit Blasting Process for Thermal Spray Coating Applications** 577

*Henry Begg, Melissa Riley, and Heidi de Villiers Lovelock*

*TWI Ltd, Cambridge, UK*

**Mechanistic Study and Characterization of Cold Sprayed**

**Ultra-High Molecular Weight Polyethylene-Nano Ceramic Composite Coating** 585

*Kesavan Ravi<sup>1</sup>, Yuji Ichikawa<sup>1</sup>, Kazuhiro Ogawa<sup>1</sup>, Tiana Deplanke<sup>2</sup>,*

*Olivier Lame<sup>2</sup>, and Jean-Yves Cavaille<sup>2</sup>*

*(1) Tohoku University, Sendai, Japan*

*(2) Laboratory of Material Engineering and Science, Insa Lyon, France*

**Metal-Ceramic Nanocomposite Coatings Produced by HVOF Thermal Spray and  
In-Situ Precipitation of Ceramic Components for Tribological Applications** 592

*R. Schulz and S. Savoie, Hydro-Quebec Research Institute, Varennes, QC, Canada*

**Modeling of the APS Process—From the Arc to the Coating Effective Properties** 598

*R. Bolot<sup>1</sup>, E. Aubignat<sup>1</sup>, M.P. Planche<sup>1</sup>, G. Montavon<sup>1</sup>, A. Allimant<sup>2</sup>, and D. Billières<sup>3</sup>*

*(1) IRTES-LERMPS, Belfort, France*

*(2) Saint-Gobain CREE, Cavaillon, France*

*(3) Saint-Gobain Coating Solutions, Avignon, France*

**Modeling of the Self-Assembly of Nanoparticles into  
Branched Solid Aggregates for a Suspension Droplet** 605

*He Zhang and Yanguang Shan*

*University of Shanghai for Science and Technology, Shanghai, China*

**Offline Acoustic Plasma Spray Nozzle Wear State and Characteristic Identification** 612

*Taylor Blair<sup>1</sup>, Gary Pickrell<sup>1</sup>, Romesh Batra<sup>1</sup>, Michael Cybulsky<sup>2</sup>, and Raymond Sinatra<sup>2</sup>*

*(1) Virginia Polytechnic Institute and State University, Blacksburg, VA, USA*

*(2) Rolls-Royce Corporation, Indianapolis, IN, USA*

**On the Relationship of Tungsten Composition to Coating Properties** 616

*Jose Colmenares-Angulo<sup>1</sup>, Ronald Molz<sup>1</sup>, David Hawley<sup>1</sup>, and*

*Ramachandran Chidambaram Seshadri<sup>2</sup>*

*(1) Oerlikon Metco Equipment R&D, Westbury, NY, USA*

*(2) Stony Brook University, Stony Brook, NY, USA*

**Output Signal Characteristics of Thyristor- and  
Transistor-Controlled Power Supplies and Their Influence on the  
Electric Discharge in a Plasma Spray Process** 622

*Hartmut Koschnitzke, Majid Nabavi, Uwe Jagow, and Alexander Schwenk  
Oerlikon Metco AG, Wohlen, Switzerland*

**Parametric Study of Plasma Torch Operation Using a MHD Model Coupling the Arc and Electrodes** 627

*M. Alaya, C. Chazelas, and A. Vardelle  
SPCTS UMR CNRS Limoges, France*

**Preparation and Characterization of Transparent Hydrophobic Al<sub>2</sub>O<sub>3</sub> Surface by Vacuum Cold Spray** 634

*J. Li, Y. Zhang, C.-X. Li, X.-D. Pan, G.-J. Yang, and C.-J. Li  
Xi'an Jiaotong University, Xi'an, Shaanxi, China*

**Residual Stresses in WC-Co Coatings in As-Sprayed and Surface-Ground Conditions** 641

*Vladimir Luzin<sup>1</sup>, Alfredo Valarezo<sup>2</sup>, Andrew Vackel<sup>2</sup>, and Sanjay Sampath<sup>3</sup>*

*(1) Australian Nuclear Science and Technology Organisation, Lucas Heights, Australia  
(2) San Francisco de Quito University, Quito, Ecuador  
(3) Stony Brook University, Stony Brook, NY, USA*

**Robot Kinematic Analysis for Torch Setup Optimization in Thermal Spraying** 647

*Chaoyue Chen, Sihao Deng, Hanlin Liao, and Ghislain Montavon  
Université de Technologie de Belfort-Montbéliard, Belfort, France*

**Spatial Mapping of Plasma Sprayed Coating Thickness Using X-Ray Fluorescence** 654

*Kendall J. Hollis, Deborah A. Summa, Velma M. Lopez, and George J. Havrilla  
Los Alamos National Laboratory, Los Alamos, NM, USA*

**Splat Formation of Copper and Copper Alloy on Ceramic Substrate in Plasma Spray Process** 661

*Anh T.T. Tran<sup>1</sup>, Margaret M. Hyland<sup>1</sup>, Masahiro Fukumoto<sup>2</sup>, and Paul Munroe<sup>3</sup>  
(1) The University of Auckland, Auckland, New Zealand  
(2) Toyohashi University of Technology, Toyohashi, Japan  
(3) The University of New South Wales, Sydney, Australia*

**Stress Formation within the First Layer in Plasma Sprayed Coatings** 669

*Markus Mutter<sup>1</sup>, Georg Mauer<sup>1</sup>, Robert Mücke<sup>1</sup>, Robert Vaßen<sup>1</sup>,  
Hyoung Chul Back<sup>2</sup>, and Jens Gibmeier<sup>2</sup>  
(1) Forschungszentrum Jülich GmbH, Jülich, NRW, Germany  
(2) Karlsruher Institut für Technologie, Karlsruhe, BW, Germany*

**Structure and Mechanical Properties of Thick Copper Coating Made by Cold Spray** 673

*V. Leshchynsky, R.Gr. Maev, E. Strumban, D. Dzhurinskiy, J. Kocimski, and E. Maeva  
Institute for Diagnostic Imaging Research, Windsor, Ontario, Canada*

**Study on Cu-Ag-Zn Abradable Seal Coatings by Cold Spraying** 679

*Yanfang Shen, Xinyu Cui, Jie Wu, Ming Li, and Tianying Xiong  
Chinese Academy of Sciences, Shenyang, China*

**Surface Preparation for Ceramics Functionalization by Thermal Spraying** 684

*S. Scheitz<sup>1</sup>, F.-L. Toma<sup>1</sup>, T. Kuntze<sup>1</sup>, C. Leyens<sup>1</sup>, and S. Thiele<sup>2</sup>  
(1) Fraunhofer Institute for Material and Beam Technology, Dresden, Germany  
(2) Fraunhofer Institute for Ceramic Technologies and Systems, Dresden, Germany*

**Synthesis of Thermal Spray Grade Silico Carbide Feedstock Powder for Plasma Spray Deposition** 689

*F. Mubarok and N. Espallargas*

*Norwegian University of Science and Technology, Trondheim, Norway*

**Taguchi Design and Analysis of 3D-Computer Fluid Dynamic (CFD) Experiments (TDACE) for the Optimization of Air-Cap Configuration in Arc Spraying** 695

*W. Tillmann, M. Abdulgader, N. Anjami, and D. Bezerra  
Technical University of Dortmund, Dortmund, Germany*

**The Effect of Fuel Ratio on Activity of Suspension Flame Sprayed Titania Coatings** 703

*B. Robinson<sup>1</sup>, I.P. Parkin<sup>1</sup>, J.A. Darr<sup>1</sup>, A. Tabecki<sup>2</sup>, H.L. de Villiers Lovelock<sup>2</sup>,*

*D. Jose<sup>3</sup>, and A. Mills<sup>3</sup>*

*(1) University College London, London, UK*

*(2) TWI Granta Park, Cambridge, UK*

*(3) Queen's University Belfast, Belfast, UK*

**The Importance of Optimizing Nozzle Dimensions for Cold Spray Process** 708

*Renzhong Huang and Hirotaka Fukanuma*

*Plasma Giken Co. Ltd., Toshima, Tokyo, Japan*

**The Importance of Temperature Management in Thermal Spraying and the Respective Advantages of CO<sub>2</sub> for Cooling** 713

*Werner Kroemmer, Linde AG, Unterschleissheim, Germany*

**The Influence of Residual Stress on Wear Resistance of Thermal Spray Coatings** 718

*W. Tillmann, W. Luo, and U. Selvadurai*

*TU Dortmund University, Dortmund, Germany*

**The Many Facets and Complexities of 316L and the Effect on Properties** 725

*Ingrid Hauer Miller, Höganäs AB, Höganäs, Sweden*

**The Shear Test According to DIN EN 15.340—Advantages, Disadvantages, Improvements, and Important Directions** 732

*S. Hartmann, obz innovation gmbh, Bad Brozingen, Germany*

**Three-Zone Anode Geometry—The Disengagement of Classic Nozzle Design for Atmospheric Plasma Spraying** 736

*Sebastian Mihm<sup>1</sup>, Georg Thomas<sup>2</sup>, and Rolf Kuhn<sup>3</sup>*

*(1) Alstom (Switzerland) Ltd., Baden, Switzerland*

*(2) Technical University of Berlin, Berlin, Germany*

*(3) Medicoat AG, Mägenwil, Switzerland*

**Ti<sub>x</sub>Al<sub>y</sub>N Coating Manufacturing by Reactive Very Low Pressure Plasma Spraying (R-VLPPS)** 746

*B. Vautherin<sup>1</sup>, M.-P. Planche<sup>1</sup>, G. Montavon<sup>1</sup>, A. Quet<sup>2</sup>, and L. Bianchi<sup>2</sup>*

*(1) IRTES-LERMPS, Belfort, France*

*(2) CEA Le Ripault, Mons, France*

**Transplantation of Thermal Sprayed Coatings 753**

P. Knödler<sup>1</sup>, M. Otten<sup>1</sup>, K. Möhwald<sup>1</sup>, H.J. Maier<sup>1</sup>, D. Freiburg<sup>2</sup>, A. Peuker<sup>2</sup>, and D. Biermann<sup>2</sup>

(1) Leibniz University Hannover, Hannover, Germany

(2) TU Dortmund University, Dortmund, Germany

**Tribological Performance of Cold-Sprayed Nanocrystalline and Conventional Cu-Al Coatings 756**

J.C. Liu<sup>1</sup> and Jishan Zhang<sup>2</sup>

(1) Jiangnan University, Wuxi, People's Republic of China

(2) University Science and Technology Beijing, Beijing, People's Republic of China

**Tribological Properties of Hard Metal Coatings Sprayed by High Velocity Air Fuel Process 761**

C. Lyphout<sup>1</sup>, K. Sato<sup>2</sup>, S. Houdkova<sup>3</sup>, E. Smazalova<sup>3</sup>, L. Lusvarghi<sup>4</sup>, G. Bolelli<sup>4</sup>, and P. Sassatelli<sup>4</sup>

(1) University West, Trollhättan, Sweden

(2) Fujimi Incorporated, Kakamigahara, Japan

(3) University of West Bohemia, Plzen, Czech Republic

(4) University of Modena and Reggio Emilia, Modena, Italy

**Understanding the Formation of the Limited Inter-Lamellar Bonding in Thermal Spray Ceramic Coatings Based on the Intrinsic Bonding Temperature Concept 767**

Shu-Wei Yao, Guan-Jun Yang, Cheng-Xin Li, Xiao-Tao Luo, and Chang-Jiu Li

Xi'an Jiaotong University, Shaanxi, China

**Posters****A Feasibility Study on Hybrid Use of Thermal Spray Coating and Ultrasonic Nanocrystalline Surface Modification 774**

Auezhan Amanov<sup>1</sup>, Jun-Hyong Kim<sup>1</sup>, Young-Sik Pyun<sup>1</sup>, Khagendra Tripathi<sup>1</sup>,

Soo-Wohn Lee<sup>1</sup>, Hae-Ryong Lee<sup>2</sup>, and Taehyung Kim<sup>3</sup>

(1) Sun Moon University, Asan, South Korea

(2) DawonSys Co., Ltd., Siheung, South Korea

(3) Gas Turbine Technology, Incheon, South Korea

**Columnar Structured YSZ Coating Formation by PS-PVD Using Conventional Plasma Spray System Assisted Through Droplet Filtering 783**

Qing-Yu Chen, Cheng-Xin Li, Chang-Jiu Li, Xiao-Tao Luo, and Guan-Jun Yang

Xi'an Jiaotong University, Shaanxi, P.R. China

**Composition Effects of La<sub>2</sub>Ce<sub>2</sub>O<sub>7</sub> Thermal Barrier Coatings against Calcium-Magnesium-Aluminum-Silicate (CMAS) at 1250°C 789**

Li-Shuang Wang, Guang-Rong Li, Cheng-Xin Li, Tao Liu, Guan-Jun Yang, and Chang-Jiu Li

Xi'an Jiaotong University, Shaanxi, China

**Effect of MCrAlY Bond Coat Temperature on Thermal Cyclic Lifetime of Plasma-Sprayed Thermal Barrier Coatings 795**

Hui Dong, Chang-Jiu Li, Hang Ding, Guan-Juan Yang, and Cheng-Xin Li

Xi'an Jiaotong University, Shannxi, P.R.China

**Effect of TGO Thickness on Isothermal Cyclic Lifetime of Plasma-Sprayed YSZ Thermal Barrier Coatings** 801

*Hang Ding, Hui Dong, Chang-Jiu Li, and Guan-Juan Yang  
Xi'an Jiaotong University, Shannxi, P.R. China*

**Examination of the Thermal Stability of Plasma-Sprayed**

**La<sub>2</sub>Ce<sub>2</sub>O<sub>7</sub>/YSZ Composite Coating** 806

*Ya-Xin Xu, Tao Liu, and Chang-Jiu Li  
Xi'an Jiaotong University, Shaanxi Province, PR China*

**High Thermal Conductivity Plasma Sprayed AlN Coating** 811

*Mohammed Shahien<sup>1</sup>, Motohiro Yamada<sup>1</sup>, Masahiro Fukumoto<sup>1</sup>,  
Kazumi Egota<sup>2</sup>, and Kenji Okamoto<sup>2</sup>  
(1) Toyohashi University of Technology, Aichi, Japan  
(2) Fuji Electric Co., Ltd., Hino, Japan*

**Influence of Elemental Evaporation on the Composition of La<sub>2</sub>Ce<sub>2</sub>O<sub>7</sub> Splats Deposited by Plasma Spraying** 818

*Li-Shuang Wang, Tao Liu, Guang-Rong Li, Guan-Jun Yang, Chang-Jiu Li, and Cheng-Xin Li  
Xi'an Jiaotong University, Shaanxi, China*

**Influence of Substrate Temperature on Adhesive Strength of SS 316L Cold Spray Coatings** 825

*Yingchun Xie<sup>1</sup>, Marie-Pierre Planche<sup>1</sup>, Rija Raoelison<sup>1</sup>, Hanlin Liao<sup>1</sup>,  
Philippe Hervé<sup>2</sup>, and Xinkun Suo<sup>3</sup>  
(1) Université de Technologie de Belfort-Montbéliard, Belfort, France  
(2) Université Paris Ouest Nanterre la Défense, Ville d'Avray, France  
(3) Chinese Academy of Sciences, Ningbo, China*

**Microstructure and Properties of Equiaxed 316L Stainless Steel Coating Deposited by LPPS** 831

*Deming Yang, Yang Gao, and Chengqi Sun  
Dalian Maritime University, Dalian, China*

**Numerical Study of the Arc Fluctuations in DC Plasma Torch** 836

*Esmaeil Safaei Ardakani and Javad Mostaghimi  
University of Toronto, Toronto, ON, Canada*

**Preparation and Characterization of Super-Hydrophobic Silica Coating by HVOF** 841

*J. Li, Y. Zhang, C.-X. Li, X.-D. Pan, G.-J. Yang, and C.-J. Li  
Xi'an Jiaotong University, Shaanxi, China*

**Residual Stresses Analysis of Cold Sprayed Coatings by Numerical Simulation** 846

*Wenya Li, Kang Yang, and Dongdong Zhang  
Northwestern Polytechnical University, Shaanxi, PR China*

**Scuffing Resistance of HVOF Sprayed Nanostructured Carbide Coatings** 851

*Wojciech Źórawski and Merard Makrenek  
Kielce University of Technology, Kielce, Poland*

**Shot Peening Effect on the Morphology and Roughness of HVOF Coatings** 856

Gustavo Bavaresco Sucharski<sup>1</sup>, Ramón Sigifredo Cortés Paredes<sup>1</sup>,  
Anderson Geraldo Marenda Pukasiewicz<sup>2</sup>, and Rodolpho Fernando Vaz<sup>3</sup>  
(1) UFPR Federal University of Paraná, Paraná, Brazil  
(2) UTFPR-PG Federal University of Technology - Paraná, Paraná, Brazil  
(3) Lactec Institute of Technology for Development, Paraná, Brazil

**Solution Precursor Plasma Spraying of Bismuth Titanate by Means of Inductively-Coupled Thermal Plasma** 863

B. Le Roux and J. Veilleux  
Université de Sherbrooke, Sherbrooke, Québec, Canada

**Synthesis and Thermophysical Properties of La<sub>2</sub>Zr<sub>2</sub>O<sub>7</sub>/SrZrO<sub>3</sub> Composite as a New Thermal Barrier Coating Material** 867

W. Ma, X.-L. Jin, Y. Ren, S.-P. Xing, Y. Bai, and H.-Y. Dong  
Inner Mongolia University of Technology, Hohhot, P.R. China

**TGO Formation and Failure Mode of TBC Systems Comprising PVD-Al Interlayers** 873

I. Ali, T. Grund, T. Lampke, D. Wett, D. Nestler, and G. Wagner  
Technische Universität Chemnitz, Chemnitz, Germany

## Thermal Spray Applications

**A Double Layer Thermal Barrier Concept Made of Gadolinium Zirconate and YSZ** 878

Emine Bakan, Daniel E. Mack, Georg Mauer, and Robert Vaßen  
Forschungszentrum Jülich GmbH, Jülich, Germany

**A Method for Mechanical Characterization of Cold Spray Sputter Targets in PV Manufacturing** 881

Johannes Vlcek, Kedar Hardikar, and Daniel R. Juliano  
MiaSolé Hi-Tech Corp., Santa Clara, CA, USA

**Advanced 3-D Surface Finish System for Quantifying Thermally Applied Cylinder Bore Surfaces Including the Effect of Surface Porosity** 888

Harold E. McCormick, William J. Pisoni, and John M. Crain  
C-K Engineering, Ellisville, MO, USA

**ALSTOM K4-Injector-Block—Advanced HVOF-Spraying for Future Applications** 895

J.C. Schab<sup>1</sup>, S. Olliges<sup>1</sup>, B.T. Zoller<sup>1</sup>, J.R.A. Zimmermann<sup>1</sup>, A. Stankowski<sup>1</sup>,  
P.-D. Grasso<sup>1</sup>, and C. Leyens<sup>2</sup>  
(1) ALSTOM (Switzerland) Ltd., Baden, Switzerland  
(2) Technische Universität Dresden, Dresden, Germany

**Anti-Adhesive, High Wear Resistant Coatings for the Paper Industry** 902

H. Jungklaus and A. Etschmaier  
Voith Paper Rolls, Laakirchen, Austria

**Assessment of Ni-20 Cr and WC-Co Coatings Applied by Detonation-Gun Process at 900°C** 911

G. Kaushal<sup>1</sup>, H. Singh<sup>2</sup>, and S. Prakash<sup>3</sup>

(1) Punjabi University, Punjab, India

(2) Indian Institute of Technology Ropar, Punjab, India

(3) Indian Institute of Technology Roorkee, Uttarakhand, India

**Assessment of the Spray Coated Properties for the Thermal Barrier Applied to the Piston Head of an Internal-Combustion Engine** 917

Sonya Keiji, Nakamura Masanobu, and Sekine Masashi

Yamanashi University, Yamanashi, Japan

**Bioactive Glass Coatings Manufactured by Plasma Spraying from 31SiO<sub>2</sub>-11P<sub>2</sub>O<sub>5</sub>-(58-x) CaO-X MgO Powders** 925

M. Monsalve<sup>1</sup>, H. Ageorges<sup>1</sup>, E. López<sup>2</sup>, F. Vargas<sup>2</sup>, and F. Bolívar<sup>2</sup>

(1) University of Limoges, Limoges, France

(2) University of Antioquia, Medellin, Colombia

**Breaking Behavior of Oxide Scale on the LPPS Bond Coat Surface during Pretreatment in Vacuum** 933

Bang-Yan Zhang, Guan-Jun Yang, Cheng-Xin Li, and Chang-Jiu Li

Xi'an Jiaotong University, Xi'an, China

**Characterisation and In Vitro Corrosion Resistance of Plasma-Sprayed Hydroxyapatite and Hydroxyapatite–Silicon Oxide Coatings on 316L SS** 941

Gurpreet Singh<sup>1</sup>, Hazoor Singh<sup>2</sup>, and Buta Singh Sidhu<sup>3</sup>

(1) Punjabi University Patiala, Punjab, India

(2) Yadavindra College of Engineering, Punjab, India

(3) Punjab Technical University, Punjab, India

**Chemical Composition Influence on the FeMnCrSi Alloy Microstructure Deposited by HVOF** 948

Anderson Geraldo Marendo Pukasiewicz<sup>1</sup>, Rodolpho Fernando Vaz<sup>2</sup>, and

Gustavo Bavaresco Sucharski<sup>3</sup>

(1) UTFPR-PG Federal University of Technology - Paraná, Paraná, Brazil

(2) Lactec Institute of Technology for Development, Paraná, Brazil

(3) UFPR Federal University of Paraná, Paraná, Brazil

**Coaxial Introductions of Resin Rods with Ceramics Nanoparticles into Gas Flame Spraying** 955

Kazuto Takai<sup>1</sup> and Soshu Kirihara<sup>2</sup>

(1) Nippon Coating Industry Co. Ltd, Gyouda, Japan

(2) Osaka University, Ibaraki, Japan

**Comparative Study of the Erosive Wear of Thermally Sprayed Coatings Using Powder and Flexi-Cord Feedstock Materials** 959

C.R.C. Lima<sup>1</sup>, R. Libardi<sup>1</sup>, M.A.R. Mojena<sup>2</sup>, H.C. Fals<sup>2</sup>, C.V. Leal<sup>3</sup>, and F. Camargo<sup>4</sup>

(1) UNIMEP - Methodist University of Piracicaba, SP, Brazil

(2) Oriente University, Santiago de Cuba, Cuba

(3) UNICAMP - State University of Campinas, SP, Brazil

(4) OGRAMAC - Surface Engineering, Santo Antônio de Posse, Brazil

**Corrosion Testing of Thermally Sprayed Aluminum** 964

S. Paul<sup>1</sup>, M.D.F. Harvey<sup>1</sup>, Q.Y. Ho<sup>2</sup>, K. Yunus<sup>2</sup>, and A.C. Fisher<sup>2</sup>

(1) TWI, Cambridge, UK

(2) University of Cambridge, Cambridge, UK

**Design of Experiment for Advanced Nanostructured WC-12Co Coating HVOF—****Dry Solid Particle Erosion Tests** 971

A.A. Al-Hamed<sup>1</sup>, M.S.J. Hashmi<sup>1</sup>, J. Stokes<sup>1</sup>, K.Y. Benyounis<sup>1</sup>, H.Y. Al-Fadhli<sup>2</sup>, and B.S. Yilbas<sup>3</sup>

(1) Dublin City University, Dublin, Ireland

(2) Saudi Aramco, Dhahran, Saudi Arabia

(3) King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia

**Development of Processing Windows for HVOF Carbide-Based Coatings** 976

Andrew Siao Ming Ang<sup>1</sup>, Christopher C. Berndt<sup>1</sup>, Scott A. Wade<sup>1</sup>, and Hugo Howse<sup>2</sup>

(1) Swinburne University of Technology, Victoria, Australia

(2) United Surface Technologies Pty. Ltd., Victoria, Australia

**Development of Protective Coatings for A390 Alloy** 982

Ildiko Peter<sup>1</sup>, Christian Castella<sup>1</sup>, Mario Rosso<sup>1</sup>, and Avi Bendavid<sup>2</sup>

(1) Politecnico di Torino, Torino, Italy

(2) CSIRO Manufacturing Flagship, Sydney, Australia

**Effects of Powder Characteristics and High Velocity Flame Spray Processes on Cr<sub>3</sub>C<sub>2</sub>-NiCr-Coatings** 988

R. Trache<sup>1</sup>, F.-L. Toma<sup>1</sup>, C. Leyens<sup>1</sup>, L.-M. Berger<sup>2</sup>, S. Thiele<sup>2</sup>, and A. Michaelis<sup>2</sup>

(1) Fraunhofer Institute for Material and Beam Technology, Dresden, Germany

(2) Fraunhofer Institute for Ceramic Technologies and Systems, Dresden, Germany

**Enhancing Plasma-Sprayed LSCF Cathode Performance by Infiltration Method** 996

Ying Li, Cheng-Xin Li, Shan-Lin Zhang, Guan-Jun Yang, and Chang-Jiu Li

Xi'an Jiaotong University, Xi'an, P.R. China

**Erosion-Corrosion Interactional Effect of CeO<sub>2</sub> Modified HVOF WC-Co Coating** 1001

Yan Liu<sup>1</sup>, Hui Chen<sup>1</sup>, Shengbo Ceng<sup>1</sup>, Guoqing Gou<sup>1</sup>, Xiaomin Wang<sup>1</sup>,

Mingjing Tu<sup>2</sup>, and Xiangyang Wu<sup>3</sup>

(1) Southwest Jiaotong University, Chengdu, P.R. China

(2) Sichuan University, Chengdu, P.R. China

(3) CSR SIFANG Co., Ltd., Qingdao, P.R. China

**Fe-Based Powder Alloys Deposited by HVOF and HVAF for Applications Exposed to Solid Particle Erosion** 1013

Senad Dizdar<sup>1</sup> and Manish Kumar<sup>2</sup>

(1) Höganäs AB, Höganäs, Sweden

(2) Höganäs India Pvt. Ltd., Pune, India

**Fireside Corrosion Performance of NiCr Coatings in Simulated Coal-Biomass Combustion Environment** 1020

Tanvir Hussain<sup>1</sup>, Nigel J. Simms<sup>2</sup>, and John R. Nicholls<sup>2</sup>

(1) University of Nottingham, Nottingham, UK

(2) Cranfield University, Bedfordshire, UK

**High Velocity Oxygen Fuel Sprayed Insulation Coatings for Applications in High Power Electronics 1026**

*J. Luth, M. Cichosz, M. Lehmann, S. Hartmann, and F. Trenkle  
obz innovation gmbh, Bad Krozingen, Germany*

**Hybrid Co-Cr/W-WC and Ni-W-Cr-B/W-WC Coating Systems 1031**

*L. Vernhes<sup>1</sup>, M. Azzi<sup>2</sup>, E. Bousser<sup>3</sup>, and J.E. Klemburg-Sapieha<sup>3</sup>  
(1) Velan Inc., Montreal, Canada  
(2) Lebanese University, Roumieh, Lebanon  
(3) Polytechnique Montreal, Montreal, Canada*

**Influence of Metal Bond Coat Thickness on Adhesion Strength of APS Ceramic Coatings 1039**

*John Barr<sup>1</sup>, Christopher Estrada<sup>1</sup>, Nelson Victoria<sup>1</sup>, Bob White<sup>2</sup>, and Jerome Harrison<sup>2</sup>  
(1) Watson Coatings Laboratory, Houston, TX, USA  
(2) Watson Grinding & MFG, Houston, TX, USA*

**Influence of Substrate on Cold Sprayed Titanium Coatings 1047**

*M. Villa Vidaller, F. Haußler, H. Assadi, F. Gärtner, and T. Klassen  
Helmut Schmidt University, Hamburg, Germany*

**In-Situ Sensors Deposited by Laser Cladding 1055**

*Yanli Zhang, Daniel Emil Mack, Georg Mauer, Robert Vaßen, and Olivier Guillon  
Forschungszentrum Jülich GmbH, Jülich, Germany*

**Investigation of Oxidation Behavior and Evolvement of Grain Morphology of Fe-Cr-Al Alloy at 1200°C and 1300°C 1060**

*Yan Zhao and Yang Gao  
Thermal Spray Center of Dalian Maritime University, Liaoning, China*

**Latest Developments at OBZ Innovation GmbH with Focus on Cold Spraying 1067**

*F. Trenkle, J. Schmidt, M. Lehmann, M. Cichosz, I. Dresel, and S. Hartmann  
obz innovation gmbh, Bad Krozingen, Germany*

**Mitigating Corrosion of Carbon Steel in Supercritical CO<sub>2</sub> Environments Using HVOF Coatings 1072**

*S. Paul, TWI, Cambridge, UK*

**Modular Coating for Flexible Gas Turbine Operation 1078**

*J.R.A. Zimmermann<sup>1</sup>, J.C. Schab<sup>1</sup>, A. Stankowski<sup>1</sup>, P.D. Grasso<sup>1</sup>,  
S. Olliges<sup>1</sup>, and C. Leyens<sup>2</sup>  
(1) ALSTOM (Switzerland) Ltd., Baden, Switzerland  
(2) Technische Universität Dresden, Dresden, Germany*

**Multi-Scale Structured Composite Coatings by Plasma Transferred Arc for Nuclear Applications 1086**

*A. Werry<sup>1</sup>, C. Chazelas<sup>1</sup>, A. Denoirjean<sup>1</sup>, S. Valette<sup>1</sup>, A. Vardelle<sup>1</sup>, and E. Meillot<sup>2</sup>  
(1) SPCTS UMR CNRS, Limoges, France  
(2) CEA, Monts, France*

## **Navy Valve Actuator Repair Using Cold Spray** 1092

C.A. Widener<sup>1</sup>, M.J. Carter<sup>1</sup>, R.H. Hrabe<sup>2</sup>, B. Hoiland<sup>3</sup>, T.E. Stamey<sup>4</sup>, V.K. Champagne<sup>5</sup>, and T.J. Eden<sup>6</sup>

(1) South Dakota School of Mines and Technology, Rapid City, SD, USA

(2) VRC Metal Systems, Rapid City, SD, USA

(3) MOOG – Mid-America Aviation, West Fargo, ND, USA

(4) Puget Sound Naval Shipyard, Bremerton, WA, USA

(5) Army Research Laboratory, Aberdeen Proving Ground, MD, USA

(6) Penn State Applied Research Laboratory, State College, PA, USA

## **Optimizing Cavitation Resistance—An Approach by Cold Spraying of Several Bronze Materials** 1098

Sebastian Krebs, Frank Gärtner, and Thomas Klassen  
Helmut-Schmidt University, Hamburg, Germany

## **Performance Characteristics of Strain Tolerant TBC** 1105

Purush Sahoo, American Surface Modifications, Houston, TX, USA

## **Performance of Pyramidal Fin Arrays Using**

## **Streamwise Anisotropy Material Manufactured by Cold Gas Dynamic Spray** 1113

Y. Cormier<sup>1</sup>, P. Dupuis<sup>1</sup>, B. Jodoin<sup>1</sup>, and A. Corbeil<sup>2</sup>

(1) University of Ottawa, Ottawa, ON, Canada

(2) Brayton Energy Canada, Gatineau, QC, Canada

## **Plasma Spray-Physical Vapor Deposition of $\text{La}_{1-x}\text{Sr}_x\text{Co}_y\text{Fe}_{1-y}\text{O}_{3-\delta}$ Oxygen Transport Membranes on Porous Metallic Supports—Controlling Stress State and Phase Composition** 1121

D. Marcano<sup>1</sup>, G. Mauer<sup>1</sup>, Y.J. Sohn<sup>1</sup>, R. Valßen<sup>1</sup>, J. Garcia<sup>2</sup>, and J. Serra<sup>2</sup>

(1) Forschungszentrum Jülich GmbH, Jülich, Germany

(2) Universidad Politécnica de Valencia, Valencia, Spain

## **Porosity Measurement of YSZ Ceramic Coating Deposited with Different Parameters Deposition by Different Methods of Characterization** 1128

João Paulo Gabre Ferreira<sup>1</sup>, Karen Juliana Vanat<sup>1</sup>, Luciano Augusto Lourençato<sup>1</sup>, Anderson Geraldo Marenda Pukasiewicz<sup>1</sup>, André Ricardo Capra<sup>2</sup>, Frederico Hackbart<sup>3</sup>, Newton Reis de Moura<sup>3</sup>, and Paulo Sérgio<sup>3</sup>

(1) UTFPR-PG Federal University of Technology - Paraná, Paraná, Brazil

(2) Lactec Institute of Technology for Development, Paraná, Brazil

(3) Petróleo Brasileiro S.A., Rio de Janeiro, Brazil

## **Protecting Threaded Surfaces in Pump and Compressor Pipes Used in the Oil and Gas Industry** 1134

L. Baldaev, S. Mankovsky, D. Ishmukhametov, and A. Rigin  
Technological Systems for Protective Coatings, Moscow, Russia

## **Self-Healing Plasma Sprayed Ceramic Coatings** 1138

Z. Ilhan<sup>1</sup>, A. Hornes<sup>1</sup>, N. Sata<sup>1</sup>, O. Freitag<sup>1</sup>, A. Ansar<sup>1</sup>, G. Schiller<sup>1</sup>, A. Friedrich<sup>1</sup>, V. Guski<sup>2</sup>, U. Weber<sup>2</sup>, A. Krebs<sup>2</sup>, and S. Schmauder<sup>2</sup>

(1) German Aerospace Centre, Stuttgart, Germany

(2) University of Stuttgart, Stuttgart, Germany

**The Microstructure Stability of Atmospheric Plasma-Sprayed MnCo<sub>2</sub>O<sub>4</sub> Coating under 1148  
Dual Atmosphere (H<sub>2</sub>/Air) Exposure**

*Ying-Zhen Hu, Cheng-Xin Li, Shan-Lin Zhang, Guan-Jun Yang, Xiao-Tao Luo, and Chang-Jiu Li  
Xi'an Jiaotong University, Shaanxi, P.R. China*

**The Percarbonate Stripping System for Thermal Spray (TS) Coatings—  
A Success Story at Tinker Air Force Base (TAFB) 1155**

*John P. Sauer<sup>1</sup>, Justin Sneed<sup>2</sup>, and Dave Fairbourn<sup>3</sup>*

*(1) Sauer Engineering, Cincinnati, OH, USA*

*(2) TAFB Oklahoma City, OK, USA*

*(3) Aeromet, Sandy, UT, USA*

**The Possibility of Cold Spray Process Application to  
Obtain Electrically Conductive Coatings on Polymers 1159**

*A. Małachowska<sup>1</sup>, L. Pawłowski<sup>1</sup>, M. Winnicki<sup>2</sup>, T. Piasecki<sup>2</sup>, and A. Ambroziak<sup>2</sup>*

*(1) University of Limoges, Limoges, France*

*(2) Wrocław University of Technology, Wrocław, Poland*

**Thermally Sprayed Coatings as Corrosion Protection for Steel Structures—  
Influence of Manufacturing Processes on the Coatings Quality 1165**

*Teodora Maghet<sup>1</sup>, Thomas Wilhelm<sup>1</sup>, Monica Sallai<sup>1</sup>, Jörg Mährlein<sup>1</sup>,*

*Susanne Friedrich<sup>2</sup>, and Romy Regensperger<sup>2</sup>*

*(1) GSI GmbH, Duisburg, Germany*

*(2) Institut fuer Korrosionsschutz Dresden GmbH, Dresden, Germany*

**Tribological Behaviour of the Bare and Thermal Sprayed Hot Forming Tool Steels 1171**

*Nipun Sharmaa and Manpreet Kaurb*

*Baba Banda Singh Bahadur Engineering College, Punjab, India*

**Ultraflex Coatings for Protection of Non-Line of Sight Surfaces 1177**

*Douglas Kimball and James Faust*

*Kennametal, New Albany, IN, USA*

**Use of Flame-Sprayed Coatings as Heating Elements for  
Polymer-Based Composite Structures 1183**

*Adrián Lopera-Valle and André McDonald*

*University of Alberta, Edmonton, AB, Canada*

**Wear and Corrosion Resistance of Fe-Based Coatings Reinforced by  
TiC Particles for Application in Hydraulic Systems 1191**

*K. Bobzin, M. Öte, T.F. Linke, and K.M. Malik*

*RWTH Aachen University, Aachen, Germany*

**Wear Behaviour of Conventional and Nanostructured Thin Films of  
Titanium Aluminium Nitride 1199**

*Jasmaninder Singh Grewal<sup>1</sup>, Buta Singh Sidhu<sup>2</sup>, and Satya Prakash<sup>3</sup>*

*(1) Guru Nanak Dev Engineering College, Ludhiana*

*(2) Dean Academics, PTU, Kapurthala*

*(3) IIT Roorkee, Roorkee, India*

**Author Index**