

International Thermal Spray Conference and Exposition (ITSC 2021)

**Versatile Surface Engineering
for Environmental Solutions**

**Online
24-27 May 2021**

Editors:

F. Azarmi	Y. Lau
X. Chen	R. Fernandez
J. Cizek	O. Ozdemir
C. Cojocaru	H. Salimi Jazi
B. Jodoin	F. Toma

ISBN: 978-1-7138-3130-3

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© (2021) by ASM International
All rights reserved.

Printed with permission by Curran Associates, Inc. (2021)

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

ASM International
9639 Kinsman Road
Materials Park, Ohio 44073-0002
USA

Phone: +1 440.338.5151

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: 845-758-2633
Email: curran@proceedings.com
Web: www.proceedings.com

Contents

Engineering and Testing of TBCs, Bond-Coats, EBCs and Abradables I

Influence of Rheological Characteristics and Stability of Water-Based YSZ Suspensions on the Morphology of Plasma Sprayed Thermal Barrier Coatings.....	1
Maryam Yaghtin ¹ , Amirhossein Yaghtin ^{1,2} , Zhaolin Tang ^{1,3} , Tom Troczynski ¹	
1. University of British Columbia, Vancouver, British Columbia, Canada	
2. Islamic Azad University, Shiraz, Iran	
3. Northwest Mettech Corp., Surrey, British Columbia., Canada	
Influence of Bondcoat Topography on the Properties of Suspension Sprayed YSZ Thermal Barrier Coatings.....	9
Filotfeia-Laura Toma ¹ , Julia Sagel ¹ , Christoph Leyens ^{1,2} , Karel Slámečka ³ , Serhii Tkachenko ³ , Ladislav Čelko ³	
1. Fraunhofer Institute for Material and Beam Technology (IWS), Dresden, Germany	
2. Technische Universität Dresden, Germany	
3. Brno University of Technology, Brno, Czech Republic	
High-Temperature Performance of Self-Healing SiC-YSZ Thermal Barrier Coatings Deposited by Using Various Plasma Spray Concepts.....	18
Mohammad Hassanzadeh ¹ , Paweł Sokołowski ² , Radek Musalek ³ , Jan Medrický ³ , Stefan Csaki ³	
1. University of Tehran, Iran	
2. Wroclaw University of Science and Technology, Poland	
3. Institute of Plasma Physics of the Czech Academy of Sciences, Czech Republic	

Engineering and Testing of TBCs, Bond-Coats, EBCs and Abradables II

Oxygen Permeability and Its Role in Governing Life of YbDS Environmental Barrier Coatings.....	23
Sonia Singh ¹ , Michel Nganbe ¹ , Kuiying Chen ²	
1. University of Ottawa, Ottawa, Ontario, Canada	
2. National Research Council of Canada, Ottawa, Ontario, Canada	
Contribution in Optimization of Honeycomb Abradable Seals Structure.....	31
P. Pathak ¹ , D. Dzhurinskiy ¹ , A. Elkin ¹ , P. Shornikov ¹ , S. Dautov ¹ , V. Ivanov ²	
1. Skolkovo Institute of Science and Technology, Moscow, Russian Federation	
2. Rotec JSC Company, Moscow, Russian Federation	
MCrAlX (X = Y, Hf and Si) Bond Coats by Cold Spray for High Temperature Applications.....	36
Cristian V. Cojocaru, Maniya Aghasibeig, Eric Irisso	
National Research Council of Canada, Boucherville, Québec, Canada	

Ensemble Methods for APS In-Flight Particle Temperature and Velocity Prediction Considering Torch Electrodes Ageing.....	44
<i>K.R. Yu, C.V. Cojocaru, F. Ilinca, E. Irisson</i>	
<i>National Research Council of Canada, Boucherville, Québec, Canada</i>	
Cold Spray MCrAlY Coatings on Single-Crystal Ni-Base Superalloys: A Substrate Perspective.....	51
<i>Deliang Guo¹, Bertrand Jodoin¹, Linruo Zhao²</i>	
1. University of Ottawa, Ottawa, Ontario, Canada	
2. National Research Council of Canada, Ottawa, Ontario, Canada	
Using a DOE Approach to Optimize a LVPS Bond Coat and APS Top Coat for TBC Systems.....	60
<i>Jose J. Loza, Komal Laul, Mickey Carroll, Bobby Pike</i>	
<i>Delta Air Lines, Atlanta, Georgia, USA</i>	
Principle and Practice to Achieve Improvements in TBC Thermal Cycle Lifetime.....	66
<i>Jianhong He, Timothy Sharobem, Naixie Zhou, Gopal Dwivedi</i>	
<i>Oerlikon Metco, Westbury, New York, USA</i>	
Research and Development of Protective Coatings for Aircraft Structural Parts	
Cold Spray Sn Coating on the Carbon Fiber Reinforced Polymer.....	75
<i>Jiayu Sun, Kenta Yamanaka, Akihiko Chiba, Yuji Ichikawa, Hiroki Saito, Kazuhiro Ogawa</i>	
<i>Tohoku University, Sendai, Japan</i>	
Novel Liquid Fuel HVOF Torches Fueled with Ethanol: Optimization and Erosion Wear Response of Cr3C2-NiCr Coatings.....	79
<i>Shaowu Liu, Michel Moliere, Hanlin Liao</i>	
<i>Univ. Bourgogne Franche-Comté, Belfort, France</i>	
Cold Spray of Metallic Coatings on Polymer Based Composites for the Lightning Strike Protection of Airplane Structures.....	87
<i>F. Delloro¹, A. Chebbi¹, H. Perrin², G. Ezoo³, A. Bastien³, J. Ascani⁴, A. Tazibt⁴</i>	
1. PSL Research University, Evry, France	
2. Luxembourg Institute of Science and Technology, Hautcharage, Luxembourg	
3. ICAR-CM2T, Moncèl les Luneville, France	
4. CRITT TJFU, Laboratoire Jet Fluide et Matériaux, Institut Carnot ICEEL, Bar le Duc, France	
Latest Innovation in Masking Solutions.....	96
<i>Jay Kapur¹, Francois Leroy²</i>	
1. AIMTEK, Auburn, Massachusetts, USA	
2. LESCAV Aero, Liege, Belgium	

Characterization and Testing Mechanical and Chemical Properties IB

Microstructure Development of an Electroplating Coated Nickel-Base SC Superalloy in Oxidation Processes—Simulation Results.....	101
--	------------

Kang Yuan, Zhaoran Zheng

BGRIMM Technology Group, Beijing, China

Beijing Engineering Technology Research Center of Surface Strengthening and Repairing of Industry Parts, Beijing, China

Hybrid Additive Manufacturing Technology—Induction Heating Cold Spray.....	107
---	------------

R. Ortiz-Fernandez, B. Jodoin

University of Ottawa Cold Spray Research Laboratory, Ottawa, Ontario, Canada

Mechanical and Fatigue Properties of Tungsten Heavy Alloy Prepared by RF-Plasma.....	115
---	------------

Ondřej Kovářík¹, Jaroslav Čech¹, Jan Cizek², Jakub Klečka^{1,2}, Michal Hajíček³

1. Czech Technical University in Prague, Czech Republic

2. Institute of Plasma Physics of the Czech Academy of Sciences, Prague, Czech Republic

3. ÚJP Praha a.s., Praha-Zbraslav, Czech Republic

Investigation on Microstructural Characteristics and Mechanical Properties of Thermally Sprayed Fe-Base Composites Reinforced with Different Ceramic Particulates.....	122
---	------------

Fardad Azarmi, X.W. Tangpong

North Dakota State University, Fargo, North Dakota, USA

Cold Spray Metals, Ceramics and Metal Matrix Composite Coatings I

Mechanical and Fatigue Properties of Diamond Reinforced Cu and Al Metal Matrix Composites Prepared by Cold Spray.....	131
--	------------

O.Kovarik, J. Cizek, S. Yin, R. Lupoi, M. Janovska, J. Capek, J.Siegl, T. Chraska

1. Czech Technical University in Prague, Prague, Czech Republic

2. Institute of Plasma Physics of the Czech Academy of Sciences, Prague, Czech Republic

3. Trinity College Dublin, The University of Dublin, Dublin, Ireland

4. Institute of Thermomechanics of the Czech Academy of Sciences, Prague, Czech Republic

Investigation of Agglomerated and Porous Ceramic Powders Suitable for Cold Spray.....	139
--	------------

Geoffrey Celeste, Vincent Guipont, Djamel Missoum-Benziane

Centre des matériaux — CMAT, MINES ParisTech, Evry, France

Influence of the Low-Pressure Cold Spray Operation Parameters on Coating Properties in Metallization of Ceramic Substrates Using Copper and Aluminum Composite Powder.....	147
---	------------

Minjae Yu, Hiroki Saito, Chrystelle Bernard, Yuji Ichikawa, and Kazuhiro Ogawa

Tohoku University, Sendai, Japan

Cold Spray Metals, Ceramics, and Metal Matrix Composite Coatings IIA

Cold Sprayed Tungsten Armor for Tokamak First Wall.....153

Jan Cizek¹, Monika Vilemova¹, Frantisek Lukac¹, Martin Koller¹, Jan Kondas³, Reeti Singh²

1. Czech Academy of Sciences, Prague, Czech Republic
2. Impact Innovations GmbH., Rattenkirchen, Germany
3. Politecnico di Milano, Milano, Italy

Effect of Secondary Component Properties when Cold Spraying Mixed Metal Powders on Carbon Fiber Reinforced Polymers.....157

Andre C. Liberati¹, Hanqing Che¹, Stephen Yue¹, Phuong Vo²

1. McGill University, Montreal, Canada
2. National Research Council of Canada, Boucherville, Canada

Cold Spray Technology for Oxidation-Resistant Nuclear Fuel Cladding.....167

Tyler Dabney, Hwasung Yeom, Kyle Quillin, Nick Pocquette, Kumar Sridharan

University of Wisconsin-Madison, Madison, Wisconsin, USA

Cold Spray Deposition of Heat-Treated Inconel 718 Powders.....171

Lorena Perez, Jake Colburn, Luke N. Brewer, Michael Renfro, Tim McKechnie

1. University of Wisconsin-Madison, Madison, Wisconsin, USA
2. Plasma Processes LLC, Huntsville, Alabama, USA

Cold Spray Metals, Ceramics, and Metal Matrix Composite Coatings IIB

Metallurgical Approach for the Development of Heat Treatment Applied to 316L Stainless Steel Cold Spray Coatings.....177

Laury-Hann Brassart^{1,3}, Anne-Françoise Gourgues-Lorenzon¹, Jacques Besson¹, Francesco Delloro¹, David Haboussa², Gilles Rolland³

1. MINES ParisTech, PSL University, MAT-Centre Des Matériaux, Évry, France
2. EDF-Lab Saclay, Electrotechnique et Mécanique des Structures (ERMES), Palaiseau, France
3. EDF-Lab Les Renardières, Matériaux et Mécanique des Composants (MMC), Moret-sur-Loing Cedex, France

Powder Impact Temperature Influence on Metallurgical Bonding—An Investigation for Soft Particle Deposition on Hard Substrate.....189

A. Nastic¹, B. Jodoin¹, D. Poirier², J.-G. Legoux²

1. University of Ottawa Cold Spray Research Laboratory, Ottawa, Ontario, Canada
2. National Research Council of Canada, Boucherville, Québec, Canada

Effect of Heat Treatment on Residual Stress of Cold Sprayed Nickel-Base Superalloys.....197

Deepika Shrestha, Fardad Azarmi, X.W. Tangpong

North Dakota State University, Fargo, North Dakota, USA

Effect of Pre-Treatment on Substrates for Metal Coatings Fabricated by Low Pressure Cold Spray Technique.....	203
<i>Hiroki Saito, Hiroaki Ebihara, Yuji Ichikawa, Kazuhiro Ogawa Tohoku University, Sendai, Miyagi, Japan</i>	

Wear and Corrosion Behavior of Cold Gas Sprayed Stainless-Steel Coatings Using Solution-Hardened AISI 316L Powder.....	209
<i>Thomas Lindner¹, Pia Kutschmann¹, Maximilian Grimm¹, Martin Löbel¹, Jochen Fiebig²</i>	
1. <i>Chemnitz University of Technology, Chemnitz, Germany</i>	
2. <i>Institute of Energy and Climate Research (IEK-1), Jülich, Germany</i>	

Cold Spray Processing, Simulation, Particle Impact IA

Spray Pattern of Aluminum Coatings with the Rectangular Cross-Section Nozzle Calculated by the Computational Fluid Dynamics (CFD) in High-Pressure Cold Spray.....	214
<i>Kazuhiro Sakaki, Tomiki Tsubata, Hikaru Isogami, and Koki Matsuda Shinshu University, Nagano City, Nagano, Japan</i>	

Parametric Redesign of a Convergent-Divergent Cold Spray Nozzle.....	221
<i>Florentina-Luiza Zavalan, Aldo Rona University of Leicester, Leicester, United Kingdom</i>	

Computational and Experimental Analysis of the Phenomenological Gas Flow Behavior and Particle Kinematics During Low Pressure Cold Spraying.....	229
<i>Rija Nirina Raoelison, Libin Lalu Koithara, Sophie Costil Université Bourgogne Franche-Comté, Belfort, France</i>	

Cold Spray Processing, Simulation, Particle Impact IB

A Novel Modeling Method to Study the Oxide Layer Effect on Metallic Bonding in Cold Gas Dynamic Spray Process.....	235
<i>Saeed Rahmati, Bertrand Jodoin, R.G.A. Veiga, A. Zúñiga</i>	
1. <i>University of Ottawa, Ottawa, Ontario, Canada</i>	
2. <i>Federal University of ABC, Santo André, SP, Brazil</i>	

Adhesion Strength Improvement by Laser Surface Texturing of Metallic Repair Coatings Deposited by Cold Spraying.....	241
<i>R. Kromer¹, R.N. Raoelison², Y. Danlos², C. Verdy², S. Costil², H. Liao²</i>	
1. <i>Univ. Bordeaux, Bordeaux, France</i>	
2. <i>Univ. Bourgogne Franche-Comté, Belfort, France</i>	

Cold Spray Processing, Simulation, Particle Impact IIA

Strengthening Mechanism of Additively Manufactured Cold Spray Al Deposits under Low Deposition Efficiency.....	247
<i>Ningsong Fan¹, Richard Jenkins¹, Pengfei Yu¹, Rocco Lupo¹, Shuo Yin¹, Jan Cizek^{2,3}</i>	
1. <i>The University of Dublin, Dublin, Ireland</i>	
2. <i>The Czech Academy of Sciences, Prague, Czech Republic</i>	
3. <i>Brno University of Technology, Brno, Czech Republic</i>	

Strain Gradient Plasticity Modeling to Evaluate Material Plastic Deformation Behavior During Cold Gas Dynamic Spray Process.....	256
<i>D. Dzhurinskiy, S. Dautov, P. Shornikov, I. Sh. Akhatov</i>	
<i>Skolkovo Institute of Science and Technology, Moscow, Russia</i>	

Study of the Effect of Thickness on the Residual Stress Profile of a Cold Spray Coating by Finite Element Analysis.....	261
<i>Felipe Torres, Ruben Fernandez</i>	
<i>University of Chile, Santiago, Chile</i>	

Enhanced Antibacterial Properties of Copper Surfaces Using Cold Spray Shot Peening.....	268
<i>Maryam Razavipour¹, Naveen Singh¹, Bertrand Jodoin¹, Mayte Gonzalez², Emilio Alarcon², Julio Villafuerte³</i>	
1. <i>University of Ottawa, Ottawa, Ontario, Canada</i>	
2. <i>University of Ottawa Heart Institute, Ottawa, Ontario, Canada</i>	
3. <i>Centerline Windsor, Ltd., Windsor, Ontario, Canada</i>	

Materials and Technology I

Effect of 316L Stainless Steel Powder Characteristics on Selective Laser Melting Process.....	274
<i>Du Kaiping, Li Shengfeng, Shen Jie, Pi Ziqiang, Chen Xing</i>	
<i>BGRIMM Technology Group, Beijing, China</i>	
<i>Beijing Key Laboratory of Special Coating Materials and Technology, Beijing, China</i>	
<i>Beijing Industrial Parts Surface Hardening and Repair Engineering Technology Research Center, Beijing, China</i>	

High Temperature Sliding of TiC Based Hardmetal Coatings Against TWIP Steel.....	278
<i>M. Varga¹, L. Janka¹, M. Rodríguez Ripoll¹, L.-M. Berger², S. Thiele², V. Matikainen³, P. Vuoristo³, L. Janka⁴, H. Ben Hamouda⁵</i>	
1. <i>AC2T Research GmbH, Wiener Neustadt, Austria</i>	
2. <i>Fraunhofer Institute for Ceramic Technologies and Systems IKTS, Dresden, Germany</i>	
3. <i>Tampere University, Tampere, Finland</i>	
4. <i>ikomet Oy, Jyväskylä, Finland</i>	
5. <i>lorMittal Global R&D Gent, Zwijnaarde, Belgium</i>	

Effect of the Spray Parameters on the Particle Behavior and the Coating Properties During ID Warm Spraying of Fine WC-12Co Powders (-10 + 2 µm).....	283
W. Tillmann ¹ , I. Baumann ¹ , A. Brinkhoff ¹ , S. Kuhnt ² , E.-C. Becker-Emden ² , A. Kalka ²	
1. TU Dortmund University, Institute of Materials Engineering, Dortmund, Germany	
2. Dortmund University of Applied Sciences and Arts, Dortmund, Germany	
Cavitation Resistance of Coatings with a Metastable Austenite Structure.....	290
Yu.S. Korobov ¹ , H.L. Alwan ¹ , M.A. Filippov ¹ , N.N. Soboleva ² , V.A. Sirosh ² , A.V. Makarov ² , S.Kh. Estemirova ²	
1. Ural Federal University, Yekaterinburg, Russian Federation	
2. Russian Academy of Sciences, Yekaterinburg, Russian Federation	
Pulsed-PTA Preparation of B4C-Based Titanium Matrix Cermet.....	298
Pavel Rohan, Marie Kolaříková, Stanislav Krum, Zdeněk Hazdra, Josef Šepitka, Jiří Kuchař	
CTU in Prague, Faculty of Mechanical Engineering, Praha, Czech Republic	
Materials and Technology IIA	
Oxidation Behavior of Coating Alloy CoCrMoSi and CoCrMoNiSi in Superheated Steam at 800 °C.....	307
Bingjie Xiao ¹ , Xiao Huang ¹ , Matthew Yao ²	
1. Carleton University, Ottawa, Ontario, Canada	
2. Kennametal Stellite, Belleville, Ontario, Canada	
The Effect of Water Absorption in Ceramic Coatings on High Frequency AC Resistance.....	315
K. Bobzin, W. Wietheger, E. Burbaum	
Aachen University, Aachen, Germany	
Influence of Ultrasonic Sealing Treatment with Aluminum Phosphate on Properties of Al₂O₃-TiO₂ Plasma Sprayed Ceramic Coating.....	322
Tuan Nguyen Van ¹ , Tuan Anh Nguyen ¹ , Phuong Nguyen Thi ¹ , Ha Pham Thi ¹ , Ly Pham Thi ¹ , Cuong Ly Quoc ¹ , Thuy Hoang Thi Bich ² , Duong Vu ³ , Quy Le Thu ⁴	
1. Vietnam Academy of Science and Technology, Cau Giay, Hanoi, Vietnam	
2. Hanoi University of Science and Technology, Hanoi, Vietnam	
3. Duy Tan University, Danang, Vietnam	
4. National Key Laboratory for Welding and Surface Treatment Technologies, Cau Giay, Hanoi, Vietnam	

**Sealing Treatment of Plasma Sprayed Cr₃C₂-NiCr/Al₂O₃-TiO₂ Coating by
Aluminum Phosphate Sealant Containing Al₂O₃ Nanoparticles.....331**

Tuan Nguyen Van¹, Tuan Anh Nguyen¹, Ha Pham Thi¹, Ly Pham Thi¹, Phuong Nguyen¹, Thuy Hoang Thi Bich¹, Trung Trinh Van², Duong Vu³, Quy Le Thu⁴

1. Vietnam Academy of Science and Technology, Cau Giay, Hanoi, Vietnam
2. Hanoi University of Science and Technology, Hanoi, Vietnam
3. Duy Tan University, Danang, Vietnam
4. National Key Laboratory for Welding and Surface Treatment Technologies, Cau Giay, Hanoi, Vietnam

Materials and Technology IIB

Aerosol Deposition of Ti₃SiC₂-MAX-Phase Coatings.....340

Andreas Elsenberg, Frank Gärtner, Thomas Klassen

University of the Federal Armed Forces, Hamburg, Germany

UV-Dual Curing Sealers for Short Cycling Times of Thermally Sprayed Parts.....346

A.-L. Elsner¹, C. Kunde¹, W. Togrund¹, K. Bobzin², W. Wietheger², E. Burbaum²

1. DIAMANT Metallplastic GmbH, Mönchengladbach, Germany
2. Surface Engineering Institute, Aachen University, Aachen, Germany

**Molecular Dynamics Simulations of Titanium Dioxide as Model System for Size Effects in
Aerosol Deposition.....354**

Bahman Daneshian^{1,3}, Frank Gärtner¹, Wolfgang Weber¹, Thomas Klassen^{1,3}, Hamid Assadi², Daniel Hoeche³

1. University of the Federal Armed Forces, Hamburg, Germany
2. Brunel University London, Uxbridge, Greater London, UK
3. Center for Materials and Coastal Research, Geesthacht, Germany

Modeling and Simulation

**Predicted Anode Arc Attachment by Local Thermodynamic Equilibrium and
Two-Temperature Arc Models in a Cascaded-Anode DC Plasma Spray Torch.....360**

Rodion Zhukovskii¹, Christophe Chazelas¹, Vincent Rat¹, Armelle Vardelle¹, Ron Molz²

1. Université de Limoges, Limoges, France
2. Oerlikon Metco (US) Inc., Westbury, New York, USA

**Analytical and Numerical Modelling of Interfacial Stress Distribution of a
Piezoresistive Coating Layer.....372**

Adekunle Sulaimon Ogunbadejo¹, André McDonald¹, Sanjeev Chandra²

1. University of Alberta, Edmonton, Alberta, Canada
2. University of Toronto, Toronto, Ontario, Canada

Capturing the Influence of Jet Fluctuations on Particles in Plasma Spraying.....379

K. Bobzin, H. Heinemann, A. O'Brien

RWTH Aachen University, Germany

3D Microstructure-Based FE Simulation of Cold-Sprayed Al-Al₂O₃ Composite**Coatings under Indentation and Quasi-Static Compression.....386**

Saman Sayahlatifi, Chenwei Shao, André McDonald, James David Hogan

University of Alberta, Edmonton, Alberta, Canada

Peridynamic Simulation of Particles Impact and Interfacial Bonding in Cold Spray**Process.....396**

Baihua Ren, Jun Song

McGill University, Montreal, Québec, Canada

Numerical Simulation of Solid Ti6Al4V Particles Impinging on a Stainless-Steel**Substrate at High Speed: Influence of the Particle Temperature.....402**

P. Khamsepour, C. Moreau, A. Dolatabadi

Concordia University, Montreal, Québec, Canada

New Coatings Materials Development IA**Novel Strategy for Developing Bulk-Like Dense Metallic Coatings by Plasma Spraying.....410**

Chang-Jiu Li, Xin-Yuan Dong, Li Zhang, Yong-Sheng Zhu, Zhe Zhou, Xiao-Tao Luo, Cheng-Xin Li

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

Microstructure and Corrosion Properties of AlCoCrFeNi High-Entropy Alloy**Coatings Prepared by HVAF and HVOF.....416**

Martin Löbel¹, Thomas Lindner¹, Thomas Mehner¹, Lisa-Marie Rymer¹, Thomas Lampke¹, Stefan Björklund², Shrikant Joshi²

1. Chemnitz University of Technology, Chemnitz, Germany

2. University West, Trollhättan, Sweden

New Coatings Materials Development IB**Electrical Properties of Half Heusler Coatings Depending on Spray Process.....422**

Geoffrey Darut¹, Axel Portebois¹, Ludovic Vitu¹, Marie Pierre Planche¹, Hanlin Liao¹, Shantanu Misra²,

Christophe Candolfi², Bertrand Lenoir²

1. UBFC, ICB-PMDM-LERMPS, Belfort, France

2. Université de Lorraine, Nancy, France

Thermal Spraying of FeMnCrSi Alloys: An Overview.....	431
<i>Rodolpho F. Vaz¹, Anderson G.M. Pukasiewicz², Irene B.A.F. Siqueira³, Gustavo B. Sucharski³, André Chicoski³, Romildo Tristante⁴</i>	
1. <i>University of Barcelona, Barcelona, Spain</i>	
2. <i>Federal University of Technology Paraná (UTFPR), Ponta Grossa-PR, Brazil</i>	
3. <i>Institute of Technology for Development Lactec, Curitiba-PR, Brazil</i>	
4. <i>Copel Geração e Transmissão S.A., Curitiba-PR, Brazil</i>	

Plasma-Sprayed (Bi2O3)0.705 (Er2O3)0.245 (WO3)0.05 Electrolyte for Intermediate-Temperature Solid Oxide Fuel Cells (IT-SOFCs).....	440
<i>Rui Chen, Cheng-Xin Li, Chang-Jiu Li</i>	
<i>Xi'an Jiaotong University, Xi'an, Shannxi, P.R. China</i>	

The Influence of Diamond Addition to Ni-Al powder on Oxidation Behavior of NiAl During Plasma Spraying for High Performance Oxide-Free Ni-Al Intermetallic Coating.....	447
<i>Li Zhang, Di Wang, Xian-Jin Liao, Xiao-Tao Luo, Chang-Jiu Li</i>	
<i>Xi'an Jiaotong University, Xi'an, Shannxi, P.R. China</i>	

Fabrication of Porous Aluminum Coating by Cored Wire Arc Spray for Anchoring Antifouling Hydrogel Layer.....	454
<i>Jianxin Wen^{1,2}, Ziheng Song^{1,2}, Xiuyong Chen¹, Hua Li¹</i>	
1. <i>Chinese Academy of Sciences, Ningbo, China</i>	
2. <i>University of Chinese Academy of Sciences, Beijing, China</i>	

Polymer Coatings and Nanomaterial Coatings

Exposure to Nanoparticles in Thermal Spraying – Vigilance Towards the Operator and the Outside Environment.....	461
<i>G. Darut¹, S. Dieu², L. Meunier², B. Schnuriger², A. Vignes², O. Le Bihan², M. Morgeneyer³, F. Lezzier⁴, F. Devestel⁵, A. Vion⁶, C. Berguery⁷, J. Roquette⁸</i>	
1. <i>UBFC, ICB-PMDM-LERMPS, Belfort, France</i>	
2. <i>INERIS, Verneuil-en-Halatte, France</i>	
3. <i>UTC, Compiègne, France</i>	
4. <i>APS Coating, Noisiel, France</i>	
5. <i>Phosphoris MP-Filter, Paris, France</i>	
6. <i>BVPROTO, Sévenans, France</i>	
7. <i>TOYAL, Accous, France</i>	
8. <i>Blue Industry and Science, Paris, France</i>	

Durability of Lubricated Icephobic Coatings under Multiple Icing/Deicing Cycles.....	473
<i>Valentina Donadei, Heli Koivuluoto, Essi Sarlin, Petri Vuoristo</i>	
<i>Tampere University, Tampere, Finland</i>	

Suspension and Solution Plasma and Thermal Spray I

Numerical Reconstruction of Porous Architecture for Suspension Plasma Sprayed Coatings.....482

Yongli Zhao^{1,2}, Zhimeng Yang¹, Juhong Wen¹, Marie-Pierre Planche², François Peyraut², Jan Ilavsky³, Bertrand Lenoir⁴, Hanlin Liao², Ghislain Montavon², Audrey Lasalle⁵, Alain Allimant⁵

1. *Shanghai University of Engineering Science, China*
2. *Université de Bourgogne Franche-Comté, Belfort, France*
3. *Argonne National Laboratory, Argonne, Illinois, USA*
4. *Université de Lorraine, Nancy, France*
5. *Saint-Gobain CREE, Cavaillon, France*

Development of Suspension-Based Plasma and HVOF Spray TiO₂ Coatings.....489

Garima Mittal, Alexandre Sabard, Francesco Fanicchia, Imran Bhamji, Shiladitya Paul

1. *University of Leicester, Leicester, UK*
2. *TWI Ltd., Cambridge, UK*

Hybrid Plasma Spraying —Discovering the Effects of Deposition Parameters.....493

Tomas Tesar¹, Radek Musalek¹, Jan Medricky¹, Jan Cizek¹, Frantisek Lukac¹, Tomas Chraska¹, Jonas Dudik²

1. *Institute of Plasma Physics of Czech Academy of Sciences, Prague, Czechia*
2. *Czech Technical University, Prague, Czechia*

Suspension and Solution Plasma and Thermal Spray II

Study of the In-Flight Characteristics of Particles for Different Configurations of Cascade Plasma Torches.....499

Geoffrey Darut¹, Marie Pierre Planche¹, Hanlin Liao¹, Christian Adam¹, Armando Salito², Manfred Rösl²

1. *UBFC, ICB-PMDM-LERMPS, Belfort, France*
2. *Guhlfii Consulting AG Switzerland*

Potential of Suspension Spraying for Development of Dense WC-12Co Coatings.....508

Filofteia-Laura Toma¹, Oliver Kunze¹, Anja Meyer², Annegret Potthoff², Markus Mayer², Johannes Pötschke²

1. *Fraunhofer Institute for Material and Beam Technology (IWS), Dresden, Germany*
2. *Fraunhofer Institute for Ceramic Technologies and Systems (IKTS), Dresden, Germany*

Formation of Solid Solution and Metallic Nickel Phases During Suspension Plasma Spraying of Co Oxide and Ni Oxide.....515

Vahid Jalilvand, Ali Dolatabadi, Christian Moreau, Saeed Mohammadkhani, Lionel Roué, Daniel Guay

1. *Concordia University, Montreal, Québec, Canada*
2. *Institut National de la Recherche Scientifique Centre Énergie Matériaux Télécommunications, Varennes, Québec, Canada*

Poster Session

Diffusion Simulation in SUS 430 Stainless Steel Interconnect with a MnCu Coating at 800 °C.....	522
<i>Kang Yuan^{1,2,3}, Shujiang Geng⁴</i>	
1. <i>BGRIMM Technology Group, Beijing, China</i>	
2. <i>BGRIMM Advanced Materials Science and Technology Co., Ltd, Beijing, China</i>	
3. <i>Beijing Engineering Technology Research Center of Surface Strengthening and Repairing of Industry Parts, Beijing, China</i>	
4. <i>Northeastern University, Shenyang, China</i>	
Next Generation Axial III Torch.....	527
<i>Ash Kamble</i>	
<i>Northwest Mettech Corp., Vancouver, British Columbia, Canada</i>	
Investigation of Mechanical Properties of Twin Wire Arc Repair of Cast Iron Components.....	530
<i>K. DePalma, M. Walluk, L.P. Martin, K. Sisak</i>	
<i>Rochester Institute of Technology, Rochester, New York, USA</i>	
The Influence of the Substrate Topography on the Plasma Jet Flow and Particle Deposition as a Determining Factor of Thermal Barrier Coatings Build-Up Mechanisms in Plasma Spraying.....	542
<i>Tomasz Kiełczawa, Paweł Sokołowski, Aleksandra Małachowska</i>	
<i>Wrocław University of Science and Technology, Wrocław, Poland</i>	
Suspension Spraying Tip: High Molecular Weight Solvent.....	548
<i>Jan Cizek¹, Radek Musalek¹, Jan Medricky¹, Tomas Tesar¹, Frantisek Lukac¹, Tomas Chraska¹, Daniel Dukovsky²</i>	
1. <i>Institute of Plasma Physics of the Czech Academy of Sciences, Prague, Czech Republic</i>	
2. <i>Institute of Materials Science and Engineering, Brno University of Technology, Brno, Czech Republic</i>	
Automotive, Rail, Heavy, and Marine Industries	
Fabrication of Cavitation Erosion Resistant Bronze Coatings by Thermal and Kinetic Spraying for Maritime Applications.....	553
<i>M. Hauer¹, F. Gärtner², S. Krebs², T. Klassen², M. Watanabe³, S. Kuroda³, W. Krömmer⁴, K.-M. Henkel⁵</i>	
1. <i>Fraunhofer IGP, Rostock, Mecklenburg Western Pomerania, Germany</i>	
2. <i>Helmut-Schmidt-University, Hamburg, Germany</i>	
3. <i>National Institute for Materials Science, Tsukuba, Ibaraki, Japan</i>	
4. <i>Linde AG, Unterschleißheim, Bavaria, Germany</i>	
5. <i>University of Rostock, Rostock, Mecklenburg Western Pomerania, Germany</i>	

Development of Metal-Ceramic-Lubricant Composite Coatings Obtained by Cold Spray for Tribological Applications in the Automotive Industry.....	561
<i>G. Garcin¹, F. Delloro¹, M. Jeandin¹, J-F. Hochepied¹, C. Grente², E. Bidault², S. Boutet², M. Jousset², E. Bonay², G. Rivaud³, A. Denoirjean³, J-C. Abry⁴, G. Bouvard⁴, T. Malhomme⁴, V. Fridrici⁴</i>	
1. <i>PSL Research University, Evry, France</i>	
2. <i>Renault Technocentre, Guyancourt, France</i>	
3. <i>Université de Limoges, Limoges, France</i>	
4. <i>Université de Lyon, Ecully, France</i>	

Low Temperature Soldering of Laser Structured and Metal Coated Fiber Reinforced Plastics.....	569
<i>K. Gustke¹, D. Kupke¹, R. Drehmann¹, T. Lampke¹, J. Gebauer², U. Klotzbach², A.F. Lasagni³</i>	
1. <i>Chemnitz University of Technology, Chemnitz, Germany</i>	
2. <i>Fraunhofer Institute for Material and Beam Technology, Dresden, Germany</i>	
3. <i>Technische Universität Dresden, Dresden, Germany</i>	

Biomedical Applications

Development of 45S5/PEEK Bioactive Coatings by Cold Gas Spray for Orthopedic Implants.....	578
<i>B.Garrido, V. Albaladejo-Fuentes, I.G. Cano, S. Dosta University of Barcelona, Barcelona, Spain</i>	

Effects of Composition on Antibacterial and Antiviral Properties of Suspension Plasma-Sprayed Hydroxyapatite / Titania Coating.....	585
<i>Mirazul Mahmud Abir, Yuichi Otsuka, Yukio Miyashita Nagaoka University of Technology, Nagaoka, Niigata, Japan</i>	

Cold Spray and Cold Spray Additive Manufacturing IA

Qualification of the Low-Pressure Cold Gas Spraying for the Additive Manufacturing of Copper-Nickel-Diamond Grinding Wheels.....	590
<i>W.Tillmann, J. Zajaczkowski, I. Baumann, C. Schaak, D. Biermann, M. Kipp TU Dortmund University, Dortmund, Germany</i>	

Cold Spray and Cold Spray Additive Manufacturing IB

Laser Assisted Cold Spray for Improved Adhesion of Soft Materials to Hard Substrates—Case Study for Copper Coatings on Steel.....	596
<i>Jean-Gabriel Legoux¹, Bruno Guerreiro¹, Dominique Poirier¹, Jason D. Giallonardo²</i>	
1. <i>National Research Council of Canada, Boucherville, Québec, Canada</i>	
2. <i>Nuclear Waste Management Organization, Toronto, Ontario, Canada</i>	

Novel Powder Modification Method for the Cold Spray of Hard Steels.....603
D. Poirier, Y. Thomas, B. Guerreiro, M. Martin, M. Aghasibeig, E. Irissou
National Research Council of Canada, Boucherville, Québec, Canada

Hybrid Metallic Coatings on Polymer-Based Composites.....611
Panteha Fallah¹, Stephen Yue¹, André McDonald²
1. *McGill University, Montreal, Quebec, Canada*
2. *University of Alberta, Alberta, Edmonton, Canada*

Tribological Properties of Cold Gas Spraying FeMnCrSi Alloy.....616
Rodolpho F. Vaz¹, Sergi Dosta¹, Irene G. Cano¹, Anderson G.M. Pukasiewicz²
1. *University of Barcelona, Barcelona, Spain*
2. *Ponta Grossa, Parana, Brazil*

Cold Spray Process to Combat Potential Stress-Corrosion Cracking in Used Nuclear Fuel Storage Canisters.....623
Nicholas Pocquette¹, Hwasung Yeom¹, Hemant Agiwal¹, Frank Pfefferkorn¹, Kumar Sridharan¹, Kenneth Ross², John Kessler³, Gary Cannel⁴
1. *University of Wisconsin-Madison, Madison, Wisconsin, USA*
2. *Pacific Northwest Research Laboratory, Richland, Washington, USA*
3. *J Kessler and Associates LLC, Charlotte, North Carolina, USA*
4. *Fluor Corporation, Irving, Texas, USA*

Combined Laser Shock and Micro-Compression Approach to the Mechanical Behavior of Powders for Cold Spray.....627
H. Durand, L. Lacourt, J.-C. Teissedre, F. Delloro, A. Thorel, I. Lahouij, F. Lavaud, X. Clausse
1. *PSL Research University, MAT – Centre des Matériaux, Evry, France*
2. *PSL Research University, CEMEF – Centre de Mise en Forme des Matériaux, Paris, France*
3. *TOYAL EUROPE, Accous, France*

Equipment, Consumables and Economics

Emissions from Metallic Powder and High Energy-Based Process —Thermal Spraying Knowledge Refresh.....635
G. Darut¹, S. Dieu², B. Schnuriger², A. Vignes², O. Le Bihan², M. Morgeneyer³, F. Lezzier⁴, F. Devestel⁵, A. Vion⁶, C. Berguery⁷, J. Roquette⁸
1. *UBFC, ICB-PMDM-LERMPS, Belfort, France*
2. *INERIS, Verneuil-en-Halatte, France*
3. *UTC, Compiègne, France*
4. *APS Coating, Noisiel, France*
5. *Phosphoris MP-Filter, Paris, France*
6. *BVPROTO, Sévenans, France*
7. *TOYAL, Accous, France*
8. *Blue Industry and Science, Paris, France*

Use of Different Process Gases for Manufacturing Isolating Alumina Coatings by Flame Spraying with Cords.....	648
<i>M. Hauer¹, M. Meyer¹, D. Billieres², C. Bricquet², F. Gerstgrasser², J. Kiilakoski², J. Lejay², K.-M. Henkel³</i>	
1. <i>Fraunhofer IGP, Thermal Joining Technology, Rostock, Mecklenburg Western Pomerania, Germany</i>	
2. <i>Saint-Gobain Coating Solutions S.A.S., Avignon, Vaucluse, France</i>	
3. <i>University of Rostock, Rostock, Mecklenburg Western Pomerania, Germany</i>	
Hydrogen Generation Supports Plasma Wire Arc Metal Additive Manufacturing Powder Production.....	657
<i>David Wolff¹, Chris Berghorn², David Cook², Joseph Strauss³</i>	
1. <i>Nel Hydrogen, Wallingford, Connecticut, USA</i>	
2. <i>Flame-Spray Industries, Inc., Port Washington, New York, USA</i>	
3. <i>HJE Co., Queensbury, New York, USA</i>	
Novel Thermal Spray Applications / Thermal Spray 4.0—Sensors, Data Analytics and Machine Learning	
Method for Identifying in Flight Particles Based on Digital Image Technologies in Thermal Spraying.....	664
<i>Yijun Yao, Shaowu Liu, Marie-Pierre Planche, Sihao Deng, Hanlin Liao</i>	
<i>Université de Bourgogne Franche-Comté, Belfort, France</i>	
A New One-Step Deposition Approach for a Low Friction Graphene Nanoflakes Coating.....	676
<i>Taki Aissou, Jocelyn Veilleux, Nadi Braidy</i>	
<i>Université de Sherbrooke, Sherbrooke, Québec, Canada</i>	
Characterization of Lithium Phosphate Deposit by Atmospheric Plasma Spraying.....	682
<i>Yin-Qiu Sun, Zheng Wei, Xiao-Tao Luo, Chang-Jiu Li</i>	
<i>University, Xi'an Shaanxi, China</i>	
Power Generation, Renewable Energy, and Environmental Applications	
High Temperature Cycling Behavior of Novel Thermal Barrier Coatings Deposited by High Enthalpy Plasma Torch.....	688
<i>Radek Musalek¹, Tomas Tesar¹, Jan Medricky¹, Rogerio S. Lima²</i>	
1. <i>Institute of Plasma Physics of Czech Academy of Sciences, Prague, Czechia</i>	
2. <i>National Research Council of Canada, Boucherville, QC, Canada</i>	
Development of Advanced TBC for 1650 °C Class Gas Turbine.....	695
<i>Yoshifumi Okajima¹, Taiji Torigoe¹, Masahiko Mega¹, Masamitsu Kuwabara², Naotoshi Okaya²</i>	
1. <i>Mitsubishi Heavy Industries, LTD., Hyogo, Japan</i>	
2. <i>Mitsubishi Power, LTD., Hyogo, Japan</i>	

Wear, Corrosion, and Tribology IA

Ni-5wt% Al Coatings Deposited by Twin Wire Arc Spraying for Molten Aluminum Attack Protection.....	700
<i>Natalia Brizuela-Colmenares, Juan Muñoz-Saldaña</i>	
<i>Unidad Queretaro, Queretaro, Mexico</i>	

Wear, Corrosion, and Tribology IIA

Effect of Ceramic Particle Reinforcement on the Erosion Resistance of Thermally Sprayed De-Icing Systems.....	708
<i>Shahed Taghian Dehaghani¹, André McDonald¹, Ali Dolatabadi²</i>	
1. <i>University of Alberta, Edmonton, Alberta, Canada</i>	
2. <i>University of Toronto, Toronto, Ontario, Canada</i>	

Influence of Fuel/Oxygen Ratio on Coating Properties and Cavitation Resistance of WC and Cr₃C₂ Cermet Coatings Deposited by HVOF.....	716
<i>A. Becker¹, K. Bertoul¹, A.G.M. Pukasiewicz¹, I.B.A.F. Siqueira², A. Chicoski², F. Caliari³, R.F. Vaz⁴, M.J. de Sousa⁵</i>	
1. <i>Federal University of Technology of Parana, Ponta Grossa, PR, Brazil</i>	
2. <i>Institute of Technology for Development LACTEC, Curitiba, PR, Brazil</i>	
3. <i>Center for Thermal Spray Research, Stony Brook, New York, USA</i>	
4. <i>Thermal Spray Center, Barcelona, Catalonia, Spain</i>	
5. <i>Santo Antonio Energia, Sao Paulo, SP, Brazil</i>	

The Cavitation Resistance of WC-10Co4Cr and WC-20CrC-7Ni HVAF Coatings.....	722
<i>S. Korobov¹, N.V. Lezhnin¹, A.V. Makarov¹, H.L. Alwan², V.I. Shumyakov², N.N. Soboleva¹, M. Antonov³, M.S. Deviatiarov⁴</i>	
1. <i>Ural Branch of the Russian Academy of Sciences, Yekaterinburg, Russian Federation</i>	
2. <i>Ural Federal University, Yekaterinburg, Russian Federation</i>	
3. <i>University of Technology, Tallinn, Estonia</i>	
4. <i>Ural Welding Institute-Metallurgy, Yekaterinburg, Russian Federation</i>	

Wear, Corrosion, and Tribology IIB

Tribological and Corrosion Behavior of HVOF Sprayed Cr₃C₂-NiCr with Nickel Cladded Graphite and Hexagonal Boron Nitride.....	732
<i>M. Oechsner¹, T. Engler¹, H. Scheerer¹, Y. Joung¹, K. Bobzin², W. Wietheger², M. Knoch², M. Schulz²</i>	
1. <i>Center of Structural Materials, State Materials Testing Institute Darmstadt, and Institute for Materials Technology, Darmstadt, Hessen, Germany</i>	
2. <i>RWTH Aachen University, Aachen, Germany</i>	

**Microstructure and Ablation Behavior of Very Low-Pressure Plasma Sprayed
ZrB₂-Based Coatings.....741**

Di Wang, Xiao-Tao Luo, Chang-Jiu Li

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

**Mechanical and Microstructural Properties of Post-Treated Zn4Al Sprayed Coatings
Using Twin Wire Arc Spraying.....750**

W. Tillmann, M. Abdulgader, L. Hagen, D. Biermann, A. Timmermann, A. Wirtz, F. Walther, M. Milz

TU Dortmund University, Dortmund, Germany

Oerlikon Metco Young Professionals Session

**Microstructure of Atmospheric Plasma Sprayed (Al, Cr)2O₃ – TiO₂ Coatings from
Blends.....758**

Maximilian Grimm¹, Rico Drehmann¹, Thomas Lampke¹, Susan Conze², Lutz-Michael Berger²

1. *Chemnitz University of Technology, Chemnitz, Germany*
2. *Fraunhofer IKTS, Fraunhofer Institute for Ceramic Technologies and Systems, Dresden, Germany*

**Thermally Sprayed Coating-Based Heating Systems for Boundary Layer Transition
Detection — An Experimental Approach.....765**

M. Machulla^{1,2}, S. Taghian Dehaghani³, P. Claußnitzer¹, S. Scheitz¹, A. McDonald³, C. Leyens^{1,2}

1. *Fraunhofer-Institute for Material and Beam Technology IWS, Dresden, Germany*
2. *Technische Universität Dresden, Germany*
3. *University of Alberta, Edmonton, Canada*