

# **Table of contents**

## **Preface**

## **Time Schedule**

## **Lectures**

### **Plasma Spraying I**

PENTA: A novel high spray rate APS gun.....	1
T. Schläfer, A. Wank, C. Schmengler and K. Müller-Roden, Luckenbach/DE	
Novel approaches for thermal spray deposition of fully dense ceramic and metal coatings with well bonded lamellae .....	1
C. Li, S. Yao, J. Tian, C. Li, G. Yang, X. Luo and Y. Wei, Xi'an/CN	
Porosity characterization and its effect on thermal properties of APS sprayed alumina coatings .....	1
W. Tillmann, O. Khalil and M. Abdulgader, Dortmund/DE	
New investigations of the arc instabilities in a one-cathode-one-anode plasma generator via special wavelet-analysis.....	2
S. Zimmermann, M. Mudra, O. Bornschlegl, S. Schein, G. Haderer, J. Marques and J. Schein Neubiberg/DE	

### **Aviation & Power Generation Industry I**

Practical aspects of suspension plasma spray for thermal barrier coating on potential gas turbine components.....	2
X. Ma and P. Ruggiero, Charlotte/US	
Effect of spray parameters on the microstructure and porosity content of gadolinium zirconate TBCs deposited by suspension plasma spray.....	3
S. Mahade, Trollhättan/SE, D. Zhou and R. Vassen, Jülich/DE	
High feed rate plasma spraying of YSZ from various suspensions.....	3
R. Musalek, J. Medicky, J. Kotlan, T. Tesar, F. Lukac, P. Ctibor, K. Illkova and T. Chraska, Prague/CZ	

### **Medical Industry I**

Sporcidal efficacy of thermal spray copper alloy coating with varying degrees of roughness.....	3
R. Shafaghi, L. Pershin, M. Riguette and J. Mostaghimi, Toronto/CA	
Transpiring thermally sprayed alumina layers with integrated fluid flow tubes .....	4
M. Rodriguez Diaz, K. Möhwald, N. Loftfield, M. Kästner, E. Reithmeier, S. Knigge, B. Glasmacher and H. J. Maier, Garbsen/DE	
Experimental analysis of impact behavior of ultra-high molecular weight polyethylene-nano ceramics composite particles by isolated particle deposition method using downstream injection cold spray technique.....	4
K. Ravi, Sendai/JP and Lyon/FR, K. Ogawa, Sendai/JP, O. Lame, Lyon/FR, and J.-Y. Cavaillé, Sendai/JP	

### **Process Diagnostics, Sensors & Controls**

The arc movement as a source of process instability for single-cathode-anode systems – a new method for direct investigation .....	4
G. Thomas, Technical University of Berlin, Berlin/DE, S. Mihm, Mägenwil/CH, M. Limburg, Berlin/DE, and H. Gruner, Mägenwil/CH	
Investigation of the usefulness of particle jet monitoring in a production environment .....	5
L. Leblanc, R. Hinckley and C. Spinicci, Malta/US	

In situ acoustic monitoring of thermal spray process using high-frequency impulse measurements .....	5
W. Tillmann, F. Walther, W. Luo, M. Haack, J. Nellesen and M. Knyazeva, Dortmund/DE	

## Ceramic Coatings

Epitaxial growth during the rapid solidification of plasma-sprayed molten TiO <sub>2</sub> splat .....	5
S. Yao, C. Li, G. Yang and C. Li, Xi'an/CN	

## Cold Gas Spraying I

Broken characteristics of the oxide film in cold spray.....	6
Y. Xie, C. Chen, M. Planche, R. Raoelison, C. Verdy and H. Liao, Belfort/FR	

Essential factors influencing the bonding strength of cold sprayed aluminum coatings on ceramic substrates .....	6
R. Drehmann, T. Grund, T. Lampke, B. Wielage, Chemnitz/DE, C. Wüstefeld, M. Motylenko and D. Rafaja, Freiberg/DE	

Metallization of various polymers by cold spray .....	6
H. Che, P. Vo and S. Yue, Montreal/CA	

## Maritim Industry & Off-Shore Technologies

A case study of repair work on ship engine valve stems.....	7
P. T. Nielsen, D. B. Bangsgaard, K. G. Soerensen, Brøndby/DK, and P. Pallesen, Hirtshals/DK	

Partial repair of thermally sprayed and sealed corrosion protection – Organic coating material or thermal spraying? .....	7
T. Wilhelm, C. Klesen and T. Maghet, Duisburg/DE	

Improvements of coating properties and residual stress states in arc sprayed aluminium bronze coatings by using an alternative gas mixture .....	7
M. Hauer, Rostock/DE, S. Krebs, Hamburg/DE, W. Krömmmer, Unterschleißheim/DE, and K.-M. Henkel, Rostock/DE	

## Power Generation – Fuel Cell

Experimental and numerical study of the effect of gas-shrouded plasma spraying on cathode coating of alkaline electrolysis cells.....	8
T. Liu and A. Ansar, Düsseldorf/DE	

Thermally sprayed porous copper coatings for capillary transport of liquids .....	8
C. Feng, S. Yugeswaran and S. Chandra, Toronto/CA	

A new technology for spraying advanced low-temperature (300 ~ 600 °C) solid oxide fuel cells.....	8
K. Yuan, Y. Yu, X. Lu, X. Ji, Beijing/CN, and B. Zhu, Stockholm/SE	

## Medical Industry II

Microstructure and mechanical properties of cold sprayed titanium coatings .....	9
W. Żórawski, Kielce/PL, J. Madry, Mielec/PL, J. Sienicki, Mielec/PL, M. Makrenek, Kielce/PL, A. Góral, Cracow/PL, and S. Kowalski, Kielce/PL	

The influence of spray parameters on the characteristics of hydroxyapatite in-flight particles, splats and coatings during micro-plasma spraying .....	9
X. Liu, Y. Wang, Z. Zhou, G. Wang, Z. Tan and D. He, Beijing/CN	

## Wear Protection I

The protection against spray wear using pseudoalloys applied with the method of spraying.....	9
R. Winkelmann, Senftenberg/DE, and H. Pokhmurska, Chemnitz/DE	

Cavitation erosion characteristics of HVOF thermal sprayed WC-cermet coatings .....	10
A. Kanno and K. Takagi, Akashi/JP, and M. Arai, Tokyo/JP	

## **Suspension Spraying I**

SPS coating microstructure controlled by the surface topography using laser texturing .....	10
R. Kromer, Belfort/FR, P. Sokolowski, Limoges/FR and Wroclaw/PL, R. T. Candidato, Limoges/FR, S. Costil, Belfort/FR, and L. Pawłowski, Limoges/FR	

Characteristics of dense Al <sub>2</sub> O <sub>3</sub> coating prepared by suspension plasma spraying.....	11
H. Ibe, T. Masuda, K. Sato and N. Kato, Gifu/JP	

## **Equipment / Consumables & Powders, Wires, Suspensions I**

Influence of feedstock powder modification by heat treatments on the properties of APS-sprayed Al <sub>2</sub> O <sub>3</sub> -40%TiO <sub>2</sub> coatings .....	11
L.-M. Berger, Dresden/DE, R. Vaßen and Y.J. Sohn, Jülich/DE	

Dry-sliding wear of laser clad nickel aluminide / chromium carbide coatings against cast iron .....	11
S. Bengtsson, S. Dizdar, Höganäs/SE, and K. Gong, Göteborg/SE	

## **Session Young Professionals**

Twin wire arc torch with optimized flow parameters .....	12
A. Farrokhanah, L. Pershin and J. Mostaghimi, Toronto/CA	

Lamellar bonding enhanced NiCr-Mo coating with comparable erosion resistance to similar bulk by plasma-spraying shell-core-structured powders.....	12
J. Tian, Y. Wang, C. Li, G. Yang and C. Li, Xi'an/CN	

Development of wear-resistant high-entropy alloy coatings produced by thermal spray technology .....	12
M. Löbel, T. Lindner, T. Lampke, Chemnitz/DE, and C. Kohrt, Rheinberg/DE	

Thermal spraying of thin metallic coatings .....	13
F. Trenkle, R. Koehler, M. Winkelmann, F. Wuest, J. Luth and S. Hartmann, Bad Krozingen/DE	

Cold gas spraying of lead-free bearing bronzes.....	13
S. Theimer, P. Brethack, F. Gärtner and T. Klassen, Hamburg/DE	

Nozzle-internal particle velocity measurements and loading effect on particle acceleration inside a cold spray nozzle.....	13
M. Meyer, F. Caruso and R. Lupoi, Dublin/IE	

## **Automotive Industry**

New mechanical roughening processes as surface preparation of engine cylinder bores before thermal spraying .14	
A. Roffe, M. Morgan-Hague, Belton/UK, M. Waiblinger, Ostfildern/DE, G. Sanuk, M. Joschko, Albstadt/DE, M. Kesting, Salching/DE, T. Birkner, Eislingen/DE, K. Over, M. Silk, C. Verpoort, Aachen/DE, and R. Wilton, Köln/DE	

Development of novel fe-based coating systems for internal combustion engines.....	14
K. Bobzin, M. Öte, T. Königstein, Aachen/DE, K. Dröder, H. W. Hoffmeister, G. Mahlfeld, Braunschweig/DE, and T. Schläfer, Luckenbach/DE	

Effects of carbon contents and gas type on hardness and wear resistance of ferrous coating fabricated by twin wire arc spray process .....	14
J. Lee, J. Kim and C. Lee, Seoul/KR	

## **Industrial Forum I**

Significance of personnel qualification and quality management for thermal spray plants .....	15
H. Cramer, R. Huber and A. Ohliger-Volmer, München/DE	

## **Wear Protection II**

Effect of ball milling of Al <sub>2</sub> O <sub>3</sub> particle deposition behavior on polycarbonate substrate using vacuum kinetic spray .....	15
H. Kwon, H. Park and C. Lee, Seoul/KR	

Understanding the influence of micro- and sub-micro structural features on the mechanical properties of HVO/AF sprayed WC-CoCr cermets .....	15
M. Parco, I. Fagoaga, G. Barykin, C. Vaquero, Irun/ES, and A. Chuvilin, San Sebastian/ES and Bilbao/ES	

Effect of different shroud principles on the performance of a NiTi coating produced by means of twin-wire arc spraying (TWAS) process .....	16
W. Tillmann, M. Abdulgader, D. Bezerra, Dortmund/DE, M. Pohl and J. Gembaczka, Bochum/DE	

## **Suspension Spraying II**

Microstructural characteristics and performances of Cr <sub>2</sub> O <sub>3</sub> and Cr <sub>2</sub> O <sub>3</sub> -15% TiO <sub>2</sub> S-HVOF-coatings obtained from water-based suspensions .....	16
F. Toma, N. Kulissa, S. Langner, A. Potthoff, M. Barbosa and C. Leyens, Dresden/DE	

The effects of substrate preheating temperature and torch power on crystallization and microstructure of ZnO films via SPPS .....	17
Z. Yu, Y. Zhao, M. Moliere, H. Liao, Belfort/FR, Z. Feng and W. Wang, Shanghai/CN	

## **Modeling & Simulation I**

A comparative CFD study of the influence of combustion chamber geometry in the HVSFS process .....	17
M. Plachetta, P. Eckert, M. Kroner, A. Killinger, P. Krieg and R. Gadow, Stuttgart/DE	

Interaction between rotary arc and injected particles in a non-transferred DC plasma spray with externally applied magnetic field .....	17
H. Saito and T. Fujino, Tsukuba/JP, H. Takana, Sendai/JP, and J. Mostaghimi, Toronto/CA	

Numerical investigation of the melting degree of ceramic powder particles during air plasma spraying .....	18
K. Bobzin, M. Öte, M. A. Knoch, I. Alkhasli, Aachen/DE	

## **Aviation & Power Generation Industry II**

Thermal conductivity and interfacial thermal resistance of thermal barrier coatings .....	18
S. Takahashi, Tokyo/JP, M. Akoshima, Tsukuba/JP, A. Kanno and T. Suidzu, Akashi/JP	

Mechanical properties of yttria-stabilised-zirconia for thermal barrier coating systems: effects of testing procedure and thermal aging .....	18
P. Planques, Toulours/FR, Albi/FR and Bordes/FR, V. Vidal, P. Lours, Albi/FR, V. Proton, F. Crabos, Bordes/FR, J. Huez and B. Viguier, Toulouse/FR	

## **Characterization & Testing Methods I**

Porosity measurements on heat treated suspension plasma sprayed YSZ coatings using NMR cryoporometry .....	19
J. Ekberg, U. Klement, S. Creci, and L. Nordstierna, Gothenburg/SE	

Study of the interface strength and residual stresses within plasma sprayed alumina coatings involving LASAT (Laser Shock Adhesion Test) .....	19
H. Sapardanis, V. Guiport, F. Borit, A. Debray, A. Koster and V. Maurel Evry/FR	

On the determination of delamination toughness in multi-layer thermal barrier coating systems .....	20
M. Adam, M. Elsaß, M. Frommherz, A. Scholz and M. Oechsner, Darmstadt/DE	

Microscale adhesion strength evaluation of cold sprayed copper deposit .....	20
Y. Ichikawa, R. Tokoro and K. Ogawa, Sendai/JP	

## **HVAF Spraying**

Effect of nozzle geometry on the microstructure and properties of HVAF sprayed hard metal coatings ..... 20  
V. Matikainen, H. Koivuluoto, P. Vuoristo, Tampere/FI, J. Schubert and Š. Houdková, Pilsen/CZ

Development of HVAF-sprayed novel Fe-based coatings for large area applications ..... 21  
K. Bobzin, M. Öte, M.A. Knoch and J. Sommer, Aachen/DE

Development of HVAF ID coating technology and materials ..... 21  
A. Verstak, Benicia/US, B. Gries Goslar/DE, and M. Breitsameter, Newton/US

## **Tribological Coatings**

A study on the tribological behavior of arc sprayed vanadium doped stellite coatings ..... 21  
W. Tillmann, L. Hagen and D. Duda, Dortmund/DE

Practical experiences using HVOF sprayed tungsten carbide coatings in the plastic foil industry ..... 22  
O. Brandt, Thun/CH, K. Möhwald, Witten/DE, W. Reimche and O. Bruchwald, Garbsen/DE

Thermally sprayed hydrodynamic main bearings for wind turbines ..... 22  
K. Bobzin, M. Öte, T. Königstein, W. Wietheger, T. Schröder, G. Jacobs and D. Bosse, Aachen/DE

Tribological behaviour of flame-sprayed HDPE/Cu composite coatings ..... 22  
Y. Xu, Y. Liu, Z. Jia, X. Suo, H. Li, Ningbo/CN

Hybrid powder-suspension Al<sub>2</sub>O<sub>3</sub>-ZrO<sub>2</sub> coatings by axial plasma spraying: Processing, characteristics & tribological behaviour ..... 23  
S. Goel and S. Björklund, Trollhättan/SE, U. Wiklund, Uppsala/SE, and SV. Joshua, Trollhättan/SE

## **Aviation & Power Generation Industry III**

An assessment of thermal spray technologies for deposition of environmental barrier coatings (EBC) ..... 23  
E. Bakan, G. Mauer and R. Vaßen, Jülich/DE

Multilayered suspension plasma sprayed thermal barrier coatings for high temperature gas turbine applications ... 23  
M. Gupta, N. Markocsan, Trollhättan/SE, R. Rocchio-Heller, J. Liu, Westbury/US, X. Li, Finspång/SE, and L. Östergren, Trollhättan/SE

Comparing the microstructures and properties of YSZ TBCs manufactured via air plasma spray (APS), suspension plasma spray (SPS) and finely-dispersed-particle air plasma spray (FAPS) ..... 24  
R. Lima, B. Guerreiro and B. Marple, Boucherville/CA

## **Laser Cladding & PTA**

Iron based hardfacing alloys for abrasive and impact wear ..... 24  
B. Maroli, S. Dizdar and S. Bengtsson, Höganäs/SE

Advanced processes and system technology for high-performance laser cladding ..... 24  
S. Nowotny, H. Hillig, F. Kubisch, F. Toma and C. Leyens, Dresden/DE

High speed steel deposited by pulsed PTA – frequency influence ..... 25  
P. Rohan, M. Boxanová, L. Zhang, T. Kramar and F. Lukac, Praha/CZ

Alloyed carbides beyond WC as a new material platform for solving challenges in hardfacing ..... 25  
P. Fiala, Fort Saskatchewan/CA, R. Hepp, Barchfeld/DE, and A. Zikin, Wohlen/CH

Aptitude of different types of carbides for production of durable rough surfaces by laser dispersing ..... 25  
A. Wank, C. Schmengler, K. Müller-Roden, F. Beck and T. Schläfer, Luckenbach/DE

## **Pre- & Post-Treatment**

Influence of the surface structure on the adhesion strength of ZnAl2 coatings on thermally instable polymers printed by means of fused layer modelling (FLM) .....	26
W. Tillmann, C. Schaa and K. Bleicher, Dortmund/DE	

Microstructural evolution and mechanical property enhancement of a cold sprayed Cu-Zn alloy coating by post-spray friction stir processing .....	26
C. Huang, Y. Xie, C. Verdy, M. Planche, H. Liao, G. Montavon, Belfort/FR, W. Li and Y. Feng, Xi'an Shaanxi/CN	

Understanding the infiltration behaviour of sealers into thermally sprayed coatings .....	26
K. Bobzin, M. Öte, M. A. Knoch, Aachen/DE, C. Kunde and P. Dettloff, Mönchengladbach/DE	

## **Equipment / Consumables & Powders, Wires, Suspensions II**

Development and application of binary suspensions in the ternary system Cr <sub>2</sub> O <sub>3</sub> -TiO <sub>2</sub> -Al <sub>2</sub> O <sub>3</sub> for S-HVOF spraying .....	27
R. Kratzsch, A. Potthoff, M. Barbosa, N. Kulissa, O. Kunze and F. Toma, Dresden/DE	

Suspension plasma spray YSZ feedstocks and delivery system for improved spray distance and cost effective throughput.....	27
B. W. Callen, Ft. Saskatchewan/CA, R. Roccio-Heller, J. Liu and O. Sabouni, Westbury/US	

Ultrafine powders for low-power HVOF and HV-APS spraying .....	27
G. Matthäus and V. Verlotzki, Dortmund/DE	

Nanostructural WC-Co coatings by utilizing novel powder manufacturing route using water soluble raw materials.....	28
M. Karhu, J. Lagerbom, K. Kaunisto, T. Suhonen, T. Lindroos and E. Turunen, Espoo/FI	

## **Aviation & Power Generation Industry IV**

Isothermal oxidation behavior of HVAF-sprayed NiCoCrAlY coatings: Effect of surface treatment .....	28
P. Zhang, Linköping/SE, E. Sadeghimeresht, Trollhättan/SE, R. Peng, Linköping/SE, X. Li, Finspång/SE, N. Markocsan, S. Joshi, Trollhättan/SE, and S. Johansson, Linköping/SE	

Heat treatment of the thermally sprayed coating system NiCrSi/NiCoCrAlY/Al for repair brazing high pressure turbine blades .....	28
M. Nicolaus, K. Möhwald and H. J. Maier, Garbsen/DE	

The influence of the coating deposition process on the interdiffusion behavior between nickel-based superalloys and MCrAlY bond coats .....	29
M. Elsaß, M. Frommherz and M. Oechsner, Darmstadt/DE	

## **Wear & Corrosion Protection**

A comparative study of the wear performance of Stellite 6 hardfacing coatings applied by HVOF and GTAW hot wire cladding onto steel substrates.....	29
C. Lima, M. Belém, F. Camargo and R. Libardi, São Paulo/BR	

Influence of the stand-off distance and spray angle on the coating formation and properties during three-cathode plasma spraying .....	29
K. Bobzin, L. Zhao, M. Öte, T. Königstein, Aachen/DE, M. Oechsner, M. Siebers, G. Andersohn and J. Ellermeier, Darmstadt/DE	

Impact of the stand-off distance and spray angle on the corrosion, cavitation and erosion behaviour of the thermal spray layers deposited by the three-cathode spraying.....	30
M. Oechsner, M. Siebers, G. Andersohn, J. Ellermeier, Darmstadt/DE, K. Bobzin, L. Zhao, M. Öte and T. Königstein, Aachen/DE	

## **HVOF Spraying**

Substrate preparation by laser texturing for improved coating adhesion on AZ91D magnesium alloy.....	30
S. S. Aulakh, Shinas/OM, and G.Kaushal, Talwandi Sabo/IN	
Effect of nozzle-length, powder feed-rate and spray distance on HIPOJET® 2700 HVOF sprayed Cr <sub>3</sub> C <sub>2</sub> -NiCr coatings.....	30
S. Matthews, J. Woo, and J. Daniel, Auckland/NZ	
New developments in HVOF spraying for internal diameter coatings .....	31
J. Gutleber, R. Molz, J. He, C. Weber and J. Colmenares, Westbury/US	
Thermal spraying of pure nickel via HVOF: Effect of fuel and shroud gas variation on particle in-flight characteristics and final coating properties .....	31
C. Hambrock, C. Grill, G. Schimo and A.W. Hassel, Linz/AT	

## **Cold Gas Spraying II**

Coldgas coatings with adjusted curie temperatures for influencing the magnetic susceptibility .....	31
F. Trenkle, E. Schopp and S. Hartmann, Bad Krozingen/DE	
An experimental approach to gain insight into cold gas spraying of ceramics .....	32
H. Gutzmann, I. Irkhin, F. Gärtner and T. Klassen, Hamburg/DE	
Spray pattern and microstructure of copper coatings with the optimized rectangular cross-section nozzle by the computational fluid dynamics (CFD) in high-pressure cold spraying .....	32
K. Sakaki and S. Arai, Nagano/JP	

## **Aviation & Power Generation Industry V**

Evolution of residual stresses in PS-PVD TBCs with thermal cycling .....	32
S. Tao, Shanghai/CN, J. Yang, Shanghai/CN and Beijing/CN, H. Zhao, J. Ni, X. Zhong and Y. Zhuang, Shanghai/CN	
Tribological performance of NiCrAlYSi-BaF <sub>2</sub> /CaF <sub>2</sub> -polyester coating deposited by air plasma spray .....	33
Q. Li and S. Li, Beijing/CN	

## **Characterization & Testing Methods II**

Wetting properties of ceramic reinforced metal matrix composites on varied roughness profiles .....	33
S. Vijay, B. Roy, Pilani/IN, N Markocsan and C. Lyphout, Trollhättan/SE	
The effect of components content in fire-proof coating for protection of metal surfaces against open flame in fire conditions is investigated .....	33
R. Ismagilova, S. Baldaev, I. Mazilin, L. Baldaev and M. Fedorova, Moscow/RU	
Influence of alloying elements on properties of arc sprayed Fe-C-Cr-B-Al Y coatings from cored wires .....	34
Y. Korobov, V. Shumiakov, S. Nevezhin, M. Filippov, A. Makarov, I. Malygina, R. Savrai, N. Soboleva and G. Tkachuk, Ekaterinburg/RU	

Energy efficient production of thermally sprayed coatings through the use of modified twin wire arc spraying processes – Final results of a Bavarian research foundation funded project.....	34
A. Atzberger, K. Hartz-Behrend, J. Schein, Neubiberg/DE, E. Steiner, L. Blau, W. Mayr, Munich/DE, M. Szulc, J. Zierhut, Munich/DE, W. Krömmer, F. Lang, Unterschleißheim, M. Aumiller, Friedberg/DE, and E. Abler, Waltenhofen/DE	

## **Metal Coatings**

The effect of Mo substrate oxidation on splat formation.....	34
J. Wang and C. Li, Xi'an/CN	
Characterization of aluminum based coatings deposited by Very Low Pressure Plasma Spray .....	35
X. Fan, M.-P. Planche, G. Darut, N. Kang and G. Montavon, Belfort/FR	

Detonation spraying of refractory metals .....	35
V. Ulianitsky, I. Batraev, A. Shtertser, D. Dudina, N. Bulina, Novosibirsk/RU, and I. Smurov, Saint-Etienne/FR	

Effect of electromagnetic field during solidification of Ni-based alloyed splats .....	35
O. Recalde, W. Castro, M. L. Bejarano, M. Vargas and A. Valarezo, Quito/EC	

## **Modeling & Simulation II**

Effect of substrate roughness and thickness on the gas-substrate convective heat transfer during cold spraying ...	36
A. Mahdavi and A. McDonald, Edmonton/CA	

Open FOAM modelling of particle heating and acceleration in cold spraying .....	36
K.-H. Leitz, M. O'Sullivan, A. Plankenstein, H. Kestler, L. S. Sigl, Reutte/AT	

Design of cold spray nozzle to optimize the particle velocity by numerical simulation.....	36
T. Han and W. Li, Xi'an/CN, X. Guo, Xiamen/CN, and X. Yang, Xi'an/CN	

## **Power Generation – Steam**

The high temperature wear and oxidation behavior of CrC-based HVOF coatings .....	37
Š. Houdková, Z. Česánek and E. Smazalová, Plzeň/CZ	

Amorphous thermal spray coatings to extend life of boiler tubes.....	37
E. Vogli, P. Kim, J. Kang and R. Salas, Lake Forest/US	

Effect of carbide dissolution in the metal matrix of HVOF and HVAF sprayed Cr <sub>3</sub> C <sub>2</sub> -NiCrMoNb coatings on the initial stage of chlorine high temperature corrosion.....	37
D. Fantozzi, V. Matikainen, M. Uusitalo, H. Koivuluoto and P. Vuoristo, Tampere/FI	

Post-plasma-spraying gas nitriding of some metallic coatings on a Fe-based superalloy and their high temperature corrosion behavior.....	38
V. Chawla, Kapurthala/IN	

Oxidation behaviour of HVAF-sprayed NiCr coating in moisture-laden environment .....	38
E. Sadeghimeresht, Trollhättan/SE, J. Eklund, J. Phother Simon, J. Lyske, Gothenburg/SE, N. Markocsan and S. Joshi, Trollhättan/SE	

## **Electronics & Sensoric**

Demonstrating usability of thermally sprayed coatings for mechatronics and power electronics applications .....	38
J. Luth, Bad Krozingen/DE, R. Trache, F. Toma, Dresden/DE, S. Hartmann and F. Trenkle, Bad Krozingen/DE	

Transfer of wire arc sprayed metal coatings onto plastic parts .....	39
K. Bobzin, M. Öte, M.A. Knoch, X. Liao, Ch. Hopmann and P. Ochotta, Aachen/DE	

Liquid flame spray fabrication of WO <sub>3</sub> -graphene nanocomposite coatings for gas-sensing applications .....	39
Y. Liu, J. Huang, Y. Gong and H. Li, Ningbo/CN	

## **Corrosion Protection**

Enhanced corrosion resistance of magnesium alloys by transplantation of thermally sprayed coatings.....	39
M. Rodriguez Diaz, P. Knödler, M. Otten, K. Möhwald, Hannover/DE, D. Freiburg, P. Kersting and D. Biermann, Dortmund/DE	

Fe-based powder alloys deposited by HVOF and HVAF spraying – a salt spray test ranking .....	40
S. Dizdar, Höganäs/SE	

Comparative study of the corrosion and cavitation resistance of HVOF and HVAF FeCrMnSiNi and FeCrMnSiB coatings .....	40
L. L. Silveira, A. G. M. Pukasiewicz, Ponta Grossa/BR, S. Björklund, P. Nylén, Trollhättan/SE, and A. J. Zara, Ponta Grossa/BR	

## **Suspension Spraying III**

Comparison of wear performance of thermal sprayed cermet (WC-Co) coatings from suspension and feedstock powders .....	40
O. Ali, R. Ahmed, Edinburgh/UK, H. Alawadhi, M. Shameer, Sharjah/AE, N. Faisal, Aberdeen/UK, N. Al-Anazi, Dhahran/SA, and M. Goosen, Riyad/SA	

## **Cold Gas Spraying III**

Low pressure warm spray of stainless steel coatings; particle strain localization process .....	41
R. Maev, V. Leshchynsky, E. Strumban, D. Dzhurinskiy and E. Maeva, Windsor/CA	
Effect of spraying parameters on the bonding strength of detonation sprayed WC-Ni coatings .....	41
L. Baldaev, B. Khamitsev, S. Baldaev, A. Ahmetgareeva and M. Prokofjev, Moscow/RU	

## **Aviation & Power Generation Industry VI**

Effect of the microstructural design of plasma-sprayed thermal barrier coatings on its the thermal cycling behaviour .....	41
T. Liu, J. Yang, G. Yang and C. Li, Xi'an/CN	
Deposition mechanism of quasi-columnar YSZ coatings during plasma spray physical vapor deposition .....	42
L. Gao, J. Ji, X. Lu, D. Zhang, J. Shen and Y. Yu, Beijing/CN	
Influence of the interface healing between the splashed particles and underlying bond coating on the cyclic oxidation behavior of LPPS MCrAlY bond coats .....	42
B. Zhang, G. Yang, C. Li and C. Li, Xi'an/CN	

## **Additive Manufacturing**

Layer-by-layer buildup strategy for cold spray additive manufacturing .....	42
P. Vo and M. Martin, Boucherville/CA	
Experimental and numerical study of the influence of powder characteristics in the cold spraying of Al-based alloys for additive manufacturing using low-pressure, medium-pressure and high-pressure cold spray facilities.....	43
M. Bunel, F. Borit, F. Delloro, M. Jeandin, Evry/FR, A. Bacciochini, P. Lemeille, Saint Antoine La Fôret/FR, E. Hervé, E. Meillot, Monts/FR, K. Roche and G. Surdon, Argenteuil/FR	
Functional WC cemented carbide by the direct selective laser forming .....	43
J. Yamada, H. Ibe, K. Sato, N. Kato, Gifu/JP	
Large size Fe-based bulk metallic glass composite prepared by additive manufacturing via HVOF thermal Spraying.....	43
W. Wang, C. Zhang and L. Liu, Wuhan/CN	

## **Amorphous Coatings**

Microstructure and wear behavior of Fe-based amorphous metallic coating by HVOF thermal spraying .....	44
H. Yao, Z. Zhou, K. Tang, Z. Tan, G. Wang and D. He, Beijing/CN	
Amorphous steel coatings deposited by HVOF and cold gas spray processes ((226)) .....	44
M. Tului, A. Bezzon, A. Marino, F. Marra, S. Matera and G. Pulci, Rome/IT	
Tribological performances of Al <sub>2</sub> O <sub>3</sub> /YAG amorphous ceramic coating fabricated by atmospheric plasma spraying .....	44
K. Yang, Shanghai/CN, J. Rong Shanghai/CN and Beijing/CN, Y. Zhuang, L. Wang, S. Tao and C. Ding, Shanghai/CN	
A review on the improvement of wear, impact and corrosion resistance of iron based amorphous coating by addition of alumina particles .....	45
M. Yasir, Wuhan/CN and Islamabad/PK, A. Qayyum, Islamabad/PK, C. Zhang and L. Liu, Wuhan/CN	

## **Plasma Spraying II**

Influence of oxidation of Ti particle during laser remelting process on the microstructure of laser remelted NiTi coatings.....	45
Y. Wang, J. Liu, G. Darut, Belfort/FR, T. Poirier, Limoges/FR, J. Stella, Caracas/VE, H. Liao and M.-P. Planche, Belfort/FR	

On the validity of continuum computational fluid dynamics approach in very low pressure plasma spray conditions .....	46
D. Ivchenko, Limoges/FR, T. Zhang, X'ian/CN, G. Mariaux, A. Vardelle, S. Goutier, Limoges/FR, and T. Itina, Saint-Étienne/FR	

## **Cold Gas Spraying IV**

Cold spraying of WC-Co-Ni coatings using porous WC-17Co powders.....	46
S. Yin, T. Lupton, M. Meyer, R. Lupoi, E. Ekoi and D. Dowling, Dublin/IE	

Solution heat treatment of gas atomized aluminium alloy (7075) powders: microstructural changes and resultant mechanical properties .....	46
A. Sabard, Nottingham/UK, H. de Villiers Lovelock, P. McNutt, D. Harvey, Cambridge/UK, and T. Hussain, Nottingham/UK	

Fatigue strength of Mg alloy coated with Al coatings via in-situ shot-peening assisted cold spray .....	47
Y. Wei, X. Luo, C. Li and C. Li, Xi'an/CN	

Simulation of effect of interface evolution on the bonding during the high-velocity particle impacts in cold spray by using Eulerian approach .....	47
Y. Li, X. Luo and C. Li, Xi'an/CN	

## **Posters**

### **Applications – Aviation Industry**

S/TEM and TEM investigations of thermal barrier coatings based on $Gd_2Zr_2O_7$ zirconate.....	48
G. Moskal, R. Swadźba, R. Bialecki, T. Kruczek and W. Adamczyk, Gliwice/PL	

Effect of powder granularity in the pack on microstructure and anti-oxidation properties of SiC coatings for C/SiC composites .....	48
F. Jia, X. Ji, H. Peng, J. Shen, D. Zhang and Y. Yu, Beijing/CN	

Coupled thermo-mechanical analysis of the ceramic thermal barrier coatings .....	48
G. Kokot, A. Jasik, G. Moskal, R. Bialecki, W. Adamczyk and T. Kruczek, Gliwice/PL	

A high bond strength interlayer for metal coating on polymer composites fabricated by super-detonation spray .....	49
C. Wang, J. Gao, H. Tian, Y. Cui, M. Guo, H. Zhang and Z. Tang, Beijing/CN	

Corrosion performance of WC <sub>10</sub> Co <sub>4</sub> Cr coatings on high strength steel .....	49
W. Yang, Beijing/CN	

### **Applications – Maritim Industry**

An investigation of the corrosion and cavitation resistance of different thermally sprayed coatings in the river and marine environment .....	49
M. Fedorova, L. Baldaev, S. Baldaev, N. Baldaev, A. Akhmetgareeva and V. Martyanova, Moscow/RU	

### **Applications – Medical Industry**

A review of utilization of niobium and tantalum for the enhancement in corrosion resistance and biocompatibility of bio-implants .....	49
G. Singh, Patiala/IN, B. Singh Sidhu, Bathinda/IN, and B. Singh, Patiala/IN	

## **Applications – Metals Processing**

High velocity atmospheric plasma sprayer .....	50
Y. Chivel, Saint Etienne/FR	
New approach in thermal spraying-laser thermal spraying .....	50
Y. Chivel, Saint Etienne/FR	
An alternative die coating method on low pressure die casting mould by thermal spraying .....	50
E. Altincu, F. Ustel, Sakarya/TR, and Ö. Burak Çe, Izmir/TR	
Abrasive wear resistance of NiCrBSi composite claddings with different type of reinforcement .....	50
A. Gerasimov, V. Krivopusk, S. Nevezhin, S. Merchev and S. Baldaev, Moscow/RU	

## **Applications – Power Generation – Fuel Cells & Solar**

Plasma processing of AB <sub>2</sub> alloy as negative electrode material for NiMH batteries .....	51
E. Onur Şahin, C. Eyoglu and T. Öztürk, Ankara/TR	

## **Applications – Power Generation – Industrial Gas Turbines**

Thermal gradient cyclic lifetime of La <sub>2</sub> Zr <sub>2</sub> O <sub>7</sub> /YSZ double ceramic layer thermal barrier coatings with equivalent thermal insulation performance .....	51
B. Cheng, G.-J. Yang, Q. Zhang, N. Yang, M. Zhang, Y. Zhang, C.-X. Li and C.-J. Li, Xi'an/CN	
Non-parabolic isothermal oxidation kinetics of low pressure plasma sprayed MCrAlY bond coat .....	51
B.-Y. Zhang, G.-J. Yang, C.-X. Li and C.-J. Li, Xi'an/CN	

## **Applications – Power Generation – Steam**

Microstructural and mechanical investigations of dissimilar metal joints of T91 and T22 ferritic steels.....	52
R. Mittal, Malout/IN, and B. Singh Sidhu, Kapurthala/IN	
Thermal gradient cyclic lifetime of DVC and lamellar thermal barrier coatings with equivalent thermal insulation performance .....	52
B. Cheng, G.-J. Yang, C.-X. Li and C.-J. Li, Xi'an/CN	
Heat treatment of cold spray copper on the closure weld zone of used nuclear fuel containers .....	52
J. D. Giallonardo, Toronto/CA, D. Poirier, J.-G. Legoux, P. Vo, C. Hoang, Boucherville/CA, and D. Doyle, Toronto/CA	

## **Equipment / Consumables – Process Diagnostics, Sensors & Controls**

New expansion of mobile particle shape imaging and comparative measurements with other diagnostics.....	53
C. Franetzky, S. Zimmermann and J. Schein, Neubiberg/DE	

## **Properties – Ceramics Coatings**

The effect of splats morphology and post-treatment on the micro-structure of sprayed coating .....	53
A. Pakseresht and A. Shahbazkhan, Tehran/IR	
Influence of bondcoat surface characteristics on lifetime in suspension plasma sprayed thermal barrier coatings ..	53
M. Gupta, N. Markocsan, Trollhättan/SE, X.-H. Li, Finspång/SE, and B. Kjellman, Trollhättan/SE	
Micro structure and characterization of hydroxyapatite coating (HAP) by rod flame spray process .....	54
R. Upadhyaya, S. Shrivastava, Pilani/IN and Jodhpur/IN, S. C. Modi and A. Modi, Pilani/IN	
Study on thermal shock performance of dense vertically cracked thermal barrier coatings .....	54
X. Lu, X. Ji, Y. Yu and J. Shen, Beijing/CN	

Improving erosion resistance of plasma-sprayed ceramic coatings by elevating the deposition temperature based on the critical bonding temperature .....	54
S.-W. Yao, G.-J. Yang, C.-X. Li and C.-J. Li, Xi'an/CN	
Examination of lamellar pores under thermally sprayed splats using white light interferometry .....	55
L. Chen, Y.-M. Zhang, G.-J. Yang, C.-X. Li and C.-J. Li, Xi'an/CN	
Investigation of interfacial microstructures between LZ splats and YSZ substrate by HR-TEM .....	55
L. Chen, G.-J. Yang and C.-X. Li, Xi'an/CN	
Morphology and durability of Sm <sub>2</sub> Zr <sub>2</sub> O <sub>7</sub> +8YSZ TBC systems during oxidation test at temperature 1100°C .....	55
S. Jucha, G. Moskal and M. Mikuśkiewicz, Gliwice/PL	
Development of methodology of cohesive strength evaluation of thermally sprayed coatings .....	55
J. Schubert and Z. Česánek, Pilsen/CZ	
Cavitation wear characteristics of Al <sub>2</sub> O <sub>3</sub> -ZrO <sub>2</sub> -ceramic coatings deposited by APS and HVOF-processes .....	56
J. Kiilakoski, Tampere/FI, F. Lukac, Prague/CZ, H. Koivuluoto and P. Vuoristo, Tampere/FI	
Reactive plasma sprayed nitride coatings with improved conductivity .....	56
M. Shahien, Toyohashi/JP and Cairo/EG, M. Yamada and M. Fukumoto, Toyohashi/JP	

## **Properties – Corrosion Protection**

Corrosion behavior of HVAF-sprayed Bi-layer coatings; Effect of intermediate layer's microstructure and chemical composition .....	56
E. Sadeghimeresht, N. Markocsan and P. Nylén, Trollhättan/SE	
KCl-induced corrosion behavior of HVAF-sprayed Ni-based coatings in ambient air .....	57
R. Jafari, Teheran/IR, E. Sadeghimeresht, Trollhättan/SE, T. Shahrabi Farahani, Teheran/IR, N. Markocsan and S. Joshi, Trollhättan/SE	
Comparison of oxidation resistance and TGO zone morphology of NiCrAlY plasma sprayed coating and sintered alloy .....	57
D. Niemiec, G. Moskal, R. Bialecki, W. Adamczyk, T. Kruczak and K. Szymański, Gliwice/PL	

## **Properties – Metal Coatings**

The influence of deposition temperature and thermal conductivity of substrate on the splat formation .....	58
J. Wang and C.-J. Li, Xi'an/CN	
Performance of CoCrAlSiY alloy powder .....	58
S. Zhang, K. Du, R. L. Peng, Beijing/CN, J. Shi, Linköping/SE, and J. Liu, Beijing/CN	

## **Properties – Polymer Coatings**

Liquid flame spray construction of polyimide-copper layers for marine antifouling applications .....	58
Y. Liu, X. Suo, Z. Wang, Y. Gong, X. Wang and H. Li, Ningbo/CN	

## **Properties – Pre- & Post-Treatment**

Investigation of pretreatment and coating of vulcanized fiber by means of thermal spraying .....	59
W. Tillmann, A. Brinkhoff, I. Baumann, K. Schmidt and R. Zielke, Dortmund/DE	
The influence of post treatment presence on high temperature corrosion resistance of YSZ thermal barrier coatings .....	59
A. Akhmetgareeva, S. Baldaev, I. Mazilin, L. Baldaev, Moscow/RU, and T. Il'inkova, Kazan/RU	

## **Properties – Properties Characterization & Testing Methods**

Investigation of microstructure and mechanical properties of alumina-titania coatings by flexicord flame spraying .....	59
E. Altincu and F. Ustel, Sakarya/TR	
Evaluation of low-pressure cold spray MMC coatings by acoustic emission-coupled four-point flexural testing.....	60
Y. T. R. Lee, Edmonton/CA, M. Shibly, T. Hussain, Nottingham/UK, G. Fisher and A. McDonald, Edmonton/CA	
Characterization of CrMoBW-Fe base in-flight particles and splats fabricated by nano-structured cored wire arc spraying.....	60
M. Tuiprae, Chiang Mai/TH, K. Meekhanthong, Ayutthaya/TH, K. Chokethawai and S. Wirojanupatump, Chiang Mai/TH	
The oxidation behavior and mechanism of plasma spraying ZrB <sub>2</sub> ceramic coating with SiC addition .....	60
X. Feng, X. Wang, L. Deng and J. Xie, Chengdu/CN	
Effect of thermal aging on properties and microstructure of AISi-hBN coating .....	61
J. Liu, Y. Yu, Shenyang/CN and Beijing/CN, T. Liu, S. Yang and X. Cheng, Beijing/CN	
Research on abradability of different abradables rubbed against Ti <sub>2</sub> AlNb blades .....	61
X. Cheng, J. Liu, Y. Yu, Beijing/CN and Shenyang/CN, T. Liu, D. Zhang and J. Shen, Beijing/CN	

## **Properties – Tribological Coatings**

Effect of Mo content on tribological properties of atmospheric plasma-sprayed Mo-NiCrBSi composite coatings under dry and oil-lubricated conditions .....	61
H. F. Xu, L. M. Liu, J. K. Xiao, C. Zhang, Yangzhou/CN, G. Zhang, Qingdao/CN, and H. Liao, Belfort/F	

## **Properties – Wear Protection**

Direct Metal Laser Sintering (DMLS) technique for prospective wear related applications .....	62
G. Grewal, Patiala/IN, G. Kaushal and B. Krishan, Talwandi Sabo/IN	
Deposition of PVD thin films on thermal barrier coatings for a wear resistant thermal insulation.....	62
W. Tillmann and M. Dildrop, Dortmund/DE	

## **Thermal Spray Processes – Additive Manufacturing**

Production advantages using laser cladding as an additive manufacturing method.....	62
U. D. Bihlet, M. Honoré and P. T. Nielsen, Brøndby/DK	

## **Thermal Spray Processes – Arc Spraying & Laser Spraying**

The influence of size and speed of drops on the structure and properties of electric-arc sprayed coatings .....	63
H. Pokhmurs'ka, M. Student, V. Hvozdetskyi, T. Stupnytskyi and V. Posuvailo, Lviv/UA	
Cold sprayed alumina-silicon dioxide composite coatings on AZ31 magnesium alloy .....	63
L. J. Fang, J. G. Gong, J. Huang, Z. M. Jia, X. K. Suo and H. Li, Ningbo/CN	

## **Thermal Spray Processes – Cold Gas Spraying**

Studies on the cold sprayability of mixed 316L/Fe powders .....	63
X. Chu, Montreal/CA, P. Vo, Boucherville/CA, and S. Yue, Montreal/CA	
A novel way to analyze the residual strain and stress in cold-sprayed coatings.....	63
Y. Ye, R. Huang, J. Huang, Guangzhou/CN, H. Fukunuma, Saitama/JP, and T. Shobu, Ibaraki/JP	
Comparison of microstructure and tribological behavior of WC reinforced maraging steel 300 composites prepared by cold spraying and selective laser melting.....	64
X. C. Yan, C. J. Huang, R. Bolot, D. Lucas, H. L. Liao, Belfort/FR, R. Z. Huang, W. Y. Ma and M. Liu, Guangzhou/CN	

Post deposition heat treatment of cold sprayed C355 deposits for repair: Microstructure and mechanical properties.....	64
M. V. Zuccoli, Nottingham/UK and Milano/IT, A. Sabard, Nottingham/UK, M. Guagliano, Milano/IT, H.L. de Villiers Lovelock, Cambridge/UK, and T. Hussain, Nottingham/UK	
Development of high-performance cold-sprayed nanostructured Ni-20Cr coatings for harsh environment of power plant boilers.....	64
M. Kumar, Mohali/IN, H. Singh, N. Singh, Rupnagar/IN, N. M. Chavan, S. Kumar and S. V. Joshi, Hyderabad/IN	

## **Thermal Spray Processes – HVOF/HVAF Spraying**

Design of Fe-based amorphous composite coatings .....	65
C. Zhang, W. Wang, P. Xu, M. Yasir and L. Liu, Wuhan/CN	
High temperature hot corrosion behavior of selected thermally sprayed coatings in an aggressive environment ....	65
Z. Česánek, Š. Houdková and J. Schubert, Pilsen/CZ	
Effect of particle and carbide grain sizes on a HVOAF WC-Co-Cr coating for the future application on internal surfaces: microstructure and wear.....	65
J. Pulsford, Nottingham/UK, S. Kamnis, North Shields/UK, J. Murray, M. Bai and T. Hussain, Nottingham/UK	

## **Thermal Spray Processes – Laser Cladding**

The influence of process parameters on structure and functional properties of laser clad WC-NiCrBSi coating .....	66
M. Vostřák, Š. Houdková and Z. Česánek, Plzeň/CZ	

## **Thermal Spray Processes – Modeling & Simulation**

Transient coating buildup and thermal analysis of cold spray process by finite element modelling .....	66
C. Chen, Y. Xie, C. Verdy, H. Liao, S. Deng, Belfort/FR, and Z. Ren, Shanghai/CN	
Cold-gas sprayed deposition of metallic coatings onto ceramic substrates using laser surface texturing pre-treatment.....	66
R. Kromer, Y. Danlos and S. Costil, Belfort/FR	
Effects of momentum and heat transfer between plasma and suspensions on an axial injection plasma spraying..	67
T. Suzuki, H. Saito, T. Fujino and M. Suzuki, Tsukuba/JP	
Submodeling of alumina coatings by APS.....	67
V. Martínez García, R. Gadow, A. Killinger, Stuttgart/DE, and J. A. Moreno Nicolás, Cartagena/ES	

## **Thermal Spray Processes – New Processes**

Modelling of heating the particles of powders in the new detonation system .....	67
A. Rigin, A. Maximov, O. Maximova and S. Parygina, Cherepovets/RU	

## **Thermal Spray Processes – Plasma Spraying**

Adhesive-corrosion resistance of high velocity metal droplet on atmospheric plasma sprayed Ni-WSe <sub>2</sub> -BaF <sub>2</sub> ·CaF <sub>2</sub> -Y-Ag-hBN solid lubricant coatings.....	68
X.-J. Yuan, X.-H. Chen, B.-L. Zha and C. Yao, Xi'an/CN	
Investigating influences of suspension plasma spray parameters on photocatalytic activity of TiO <sub>2</sub> coatings .....	68
T. P. Vu, N. Otto, A. Vogel, F. Kern, A. Killinger and R. Gadow, Stuttgart/DE	
Influence of substrate properties on the formation of suspension plasma sprayed coatings.....	68
Y. Zhao, Z. Yu, M.-P. Planche, Belfort/FR, A. Lasalle, A. Allimant, Cavaillon/FR, G. Montavon and H. Liao, Belfort/FR	

Numerical analyzing the in-flight particle temperature and velocity in plasma spray ..... 69  
W. Ma, R. Huang and J. Huang, Guangdong/CN

Pulsed current and pulsed powder operation of the One-Cathode-One-Anode-Plasma-Generator (OCOAPG) ..... 69  
S. Zimmermann, A. Atzberger, M. Szulc and J. Zierhut, Neubiberg/DE

## **Thermal Spray Processes – PTA – Plasma Transferred Arc**

Self-lubricating cobalt-based composite coatings deposited by plasma transferred arc..... 69  
L. Baiamonte, G. Pulci, Roma/IT, E. Hlede, San Dorligo della Valle/IT, C. Bartuli, T. Valente and F. Marra, Roma/IT

## **Thermal Spray Processes – Suspension Spraying**

Development of bondcoat layer for long lifetime suspension plasma sprayed thermal barrier coatings ..... 70  
M. Gupta, N. Markocsan, Trollhättan/SE, X.-H. Li, Finspång/SE, and L. Östergren, Trollhättan/SE

Axial feeding features of low power suspension plasma spraying ..... 70  
M. Shahien, Tsukuba/JP and Cairo/EG, and M. Suzuki, Tsukuba/JP

The possibility of using ultrasonic waves to support suspension plasma spraying process  
P. Sokołowski, M. Gałafin, S. Kozerski and M. Korzeniowski, Wrocław/PL

**List of authors .....** ..... 71