International Surfaces, Coatings & Interfaces Conference

SURFCOAT KOREA 2018

Book of Abstracts

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SurfCoat Korea 2018 Preliminary Program

28 - 30 March, 2018 | Seoul, Republic of Korea

March 28th, 2018

Session I: Surface treatments and coatings deposition processes

Conference Room 116/117

Session Chairs:
Prof. Norbert Koch, Humboldt-Universität zu Berlin, Germany
Prof. Han Cheol Choe, Chosun University, Rep. of Korea

08:00-10:00 Registration + Welcoming coffee

10:00-10:40	Electrodeposition of ceria-based coatings on metal substrates **F. Pedraza**	**Prof. Fernando Pedraza**, University de La Rochelle, **France**
10:40-11:20	Development of Thermal Barrier Coating with High Oxidation Resistance by Grit Blasting K. Ito, T. Shima, **M. Arai**, T. Suidzu and A. Kanno	**Prof. Masayuki Arai**, Tokyo University of Science, **Japan**
11:20-12:00	Transfer-Free Large-Scaled High Quality Graphene Synthesized Directly on Flexible Substrates B-J. Park, J-S. Choi,Y. Kim, C. Jeon, S. Lee, H. Shin, J-H. Eom and **S-G. Yoon**	**Prof. Soon-Gil Yoon**, Chungnam National University, **Rep. of Korea**

12:00-14:00 Lunch Break / Posters Session I

Session I.A: Coatings deposition and processing

Conference Room 116/117

Session Chairs:
Prof. Soon-Gil Yoon, Chungnam National University, Rep. of Korea
Prof. Fernando Pedraza, University de La Rochelle, France
Dr. David Ruch, Luxembourg Institute of Science and Technology, Luxembourg

14:00-14:15	Processing of an organosilazane-based glass/ZrO2 composite coating system by laser pyrolysis **A. Horcher**, K. Tangermann, G. Barroso, W. Krenkel and G. Motz	**Mr. Alexander Horcher**, University of Bayreuth, **Germany**
14:15-14:30	Effect of annealing Nickel feedstock powder to produce WC-5wt%Ni cold sprayed coatings **T. Chingosho**, N. Sacks and I. Botef	**Mr. Tatenda Chingosho**, University of the Witwatersrand, **South Africa**
14:30-14:45	Multi-technical characterization of the impact of S3P surface heat treatments on galling in stainless steels **T. Lesage**, S. Bouvier, P. Jacquot, M. Risbet, Y. Chen and P.-E. Mazeran	**Mr. Thibault Lesage**, FRE UTC-CNRS 2012-Sorbonne University- **France**
14:45-15:00	Effect of External Magnetic Fields on Iron Oxide Nanoparticulate Films Prepared by Sparking Process **R. Siriariyachai**, E. Kantarak, W. Sroila, T. Kumpika, P. Singjai and W. Thongsuwan	**Mr. Rukpat Siriariyachai**, Chiang Mai University, **Thailand**

Session I.B: Functional/ Multi-functional, composite/ hybrid, graded and multilayers coatings

Session Chairs:
Dr. David Ruch, Luxembourg Institute of Science and Technology, Luxembourg
Dr. Quanshun Luo, Sheffield Hallam University, United Kingdom

15:00-15:30	Multi-functional nanocomposites thin films: from molecules to applications **D. Ruch**	**Dr. David Ruch,** Luxembourg Institute of Science and Technology, **Luxembourg**
15:30-15:45	Polydimethylsiloxane-Polythiourethane polymer blend with potential as Fouling-Release coating H. Qui , A. Gapeeva, I. Hölken, R. Adelung and **M. Baum**	**Dr. Martina Baum**, Kiel University, **Germany**
15:45- 16:00	Estimation of barrier properties of the composite hydrophobic coatings on PEO-pretreated metals	**Dr. Vladimir Egorkin**, Institute of Chemistry FEB RAS,

	S.V. Gnedenkov, S.L. Sinebryukhov, **V.S. Egorkin** and I.E. Vyaliy	Vladivostok, **Russia**
16:00-16:30 Coffee Break / Posters Session I		
16:30-16:45	Functionalised Silica based Surface Coating for Enhancing the Hygroscopic Properties of Bio-based Building Insulation Materials **A. Hussain**, J. Calabria- Holley and M. Lawrence	**Mr. Atif Hussain**, University of Bath, **United Kingdom**
16:45-17:00	Flame retardancy surface coating with functionalised silica-based for wood waterborne coatings **T. D-T. Hoang**, V. Landry, P. Blanchet and C. Dagenais	**Ms. Thi Doan Trang Hoang**, Laval University, **Canada**
17:00-17:15	An efficient method for three-dimensional thermoelastic contact of functionally graded materials under frictional heating **H. Zhang** and W.Wang	**Mr. Haibo Zhang**, Beijing Institute of Technology, **China**
17:15-17:30	Adjustment of the composition Al, Cr, Si, Ti in AlCrSiTi nitride film by Taguchi method to obtain optimal composition **P-Y. Lu** and S-J. Lin	**Ms. Pei-Yu Lu**, National Tsing Hua University, **Taiwan**
17:30-17:45	Bioorthogonal in situ Hydrogels based on Polyether-Polyols for new Biosensor Materials with high Sensitivity **A. Herrmann**, U. Schedler and R. Haag	**Mrs. Anna Herrmann**, Free University of Berlin, **Germany**

March 29th, 2018
Session II: Thin Films characterization and properties

Conference Room 116/117

Session Chairs:
Prof. Alessandro Lavacchi, Institute of Chemistry of Organometallic Compounds (ICCOM), Italy,
Prof. Masayuki Arai, Tokyo University of Science, Japan
Dr. David Ruch, Luxembourg Institute of Science and Technology, Luxembourg
Prof. Sandra Carvalho, University of Minho, Portugal

09:30-10:00	Using the Concept of Self-Adaption for Improving the Performance of Tribological Coatings **A. Cavaleiro**, F. Fernandes and T. Polcar	**Prof. Albano Cavaleiro**, University of Coimbra, **Portugal**
10:00-10:15	Micro/ macroscopic elastic constants of thin films determined by using Impulse Excitation Technique and X-ray diffraction **A. Alhussein**, M.F. Slim and M. François	**Prof. Akram AlHussein**, University of Technology of Troyes, **France**
10:15-10:30	Industrial X-ray Fluorescence Coating Thickness Analyzer Application for Phosphate Coating Thickness on Steel A.Sokolov, E.Hasikova, A.Pechersky,V.Gostilo, H.B. Jeong, J.H.Lim and K.Y.Lee	**Mr HB Jung**, Euro Science Co., Ltd, **Rep.of Korea**

10:30-11:00 Coffee Break / Posters Session II

11:00-11:15	Wetting of highly super-hydrophobic textures **L. Vonna**	**Dr. Laurent Vonna**, CNRS, IS2M UMR 736/ University of Upper Alsace, **France**.
11:15-11:30	Prediction Model for Oil-water Separation Based on Membranes with Special Wettability **S. Oh**, S. Ki, S. Ryu, M-C. Shin, J. Lee, C. Lee and Y. Nam	**Mr. Seungtae Oh**, Kyung Hee University, **Rep. of Korea**
11:30-11:45	Direct influence of the surface roughness on contact angle and surface free energy **J. Korpela**, H. Auvinen, A. Junnila, G. Ohlsson and S. Lauren	**Mr. Jyrki Korpela**, Biolin Scientific Oy, **Finland**
11:45-12:00	An Analysis on effects of Weathering on EPDM Vehicle Sealing System Surfaces Y.Güner, **S. Yildiz**, A.E. Kutlu and U.Olgun	**Mrs. Sevgi Yıldız**, Standard Profil Automotive Sealing Systems, **Turkey**
12:00-12:15	Smart coatings with interfacial thermoreversible properties **M. Vauthier**, L. Jierry, V. Roucoules and F. Bally-Le Gall	**Ms. Madeline Vauthier**, UMR-CNRS/ University of Upper Alsace, **France**

12:00-14:00 Lunch Break / Posters Session II

Focused session on thin film/ coatings tribology

Session chairs: Prof. Albano Cavaleiro, University of Coimbra, Portugal
Dr. Quanshun Luo, Sheffield Hallam University, United Kingdom
Prof. Sandra Carvalho, University of. Minho, Portugal

14:00-14:30	The dry sliding wear and self-adaptive friction property of transition metal nitride coatings **Q. Luo**, M Kitchen, P Allender, F Huang, Q Wang and S Yang	**Dr. Quanshun Luo,** Sheffield Hallam University, **United Kingdom**
14:30-15:00	Catalytically active coating for tribological applications **G. Ramirez**, O. Erilmaz and A. Erdemir	**Dr. Giovanni Ramirez**, Bruker Nano Surfaces, CA, **USA**
15:00-15:30	Zinc and Zinc-Iron Nanoparticles as Oxygen Scavengers I. Carvalho, S. Calderon, P. J. Ferreira, A. Cavaleiro and **S. Carvalho**	**Prof. Sandra Carvalho**, University of Minho, **Portugal**
15:30-16:00	Development of robust and self-lubricating coatings of nickel-nanoparticle Composite **S.C. Wang**, N. Zhou, F.C. Walsh and Y. He	**Dr. Shuncai Wang**, University of Southampton, **United Kingdom**

16:00-16:30 Coffee Break / Posters Session II

16:30-17:00	Nanoscale friction: From solid lubricants to electricity nanogenerators **T. Polcar**	**Dr. Tomas Polcar**, University of Southampton, **United Kingdom**
17:00-17:15	An examination of structural and mechanical properties of carbon doped CrAlN thin films deposited by HiPIMS/DC-hybrid processes	**Mr. Dominic Stangier**, TU Dortmund University, **Germany**

	W. Tillmann and **D. Stangier**	
17:15-17:30	Atomic Force Microscopy PinPoint Nanomechanical Mode for Nanoscale Modulus Mapping Wenqing Shi, Gerald Pascual, **Byong Kim**, and Keibock Lee	**Dr. Byong Kim**, Park Systems, Inc., Santa Clara, CA, **USA**
17:30-17:45	Growth and characterisation of Fe-Ti-N coatings **S. Thirumalai** and A.L. Greer	**Mr. Sundararajan Thirumalai**, University of Cambridge, **United Kingdom**
17:45-18:00	Evaluation of tribological properties of water-based nanolubricant added with TiO2 nanoparticles at elevated temperatures **H. Wu**, J. Zhao, S.Huang, L. Wang, H. Huang, S. Jiao and Z. Jiang	**Mr. Hui Wu**, University of Wollongong, **Australia**
18:00-18:15	The effect of chromium content on cutting performance and oxidation resistance of TiAlCrN coatings **M.Danek**, F. Fernandes, T.Polcar and A. Cavaleiro	**Mr. Martin Danek,**Technical University in Prague, **Czech Republic**

March 30th, 2018
Session III: Coatings for energy and environmental applications

Conference Room 116/ 117		
Session chairs: **Prof. Akram AlHussein, University of Technology of Troyes, France** **Prof. Alessandro Lavacchi, Institute of Chemistry of Organometallic Compounds (ICCOM), Italy**		
09:00-09:30	Functionalization of electronic material interfaces with organic molecular agents **N. Koch**	**Prof. Norbert Koch,** Humboldt-Universität zu Berlin, **Germany**
09:30-10:00	Coatings: Opportunities and Challenges in Fuel Cells and Electrolysis **A. Lavacchi**	**Prof. Alessandro Lavacchi,** Institute of Chemistry of Organometallic Compounds (ICCOM), **Italy**
10:00-10:30 Coffee Break		
10:30-10:45	Effect of novel treatment based on PLD-Deposited PbS Nanoparticles:porous Si on the optoelectronic properties of mc-Silicon **M. Gaidi**, Hajjaji, M. Ben Rabha, K. Trabelsi, B. Bessais and M. A. El Khakani	**Prof. Mounir Gaidi**, University of Sharjah, **United Arab Emirates**
10:45-11:00	Development of a silica-gel coated finned-tube heat heat exchanger for the performance enhancement of adsorption technologies **S. J. Oh**, M. W. Shahzad, M. Burhan and K. C. Ng	**Dr. Seung Jin Oh**, King Abdullah University of Science & Technology, **Kingdom of Saudi Arabia**
11:00-11:15	Corrosion Inhibition Properties of Cerium Doped Waterborne Polyurethane/Clay Coatings on Mild Steel **M.M. Rahman**	**Dr. Mohammad Mizanur Rahman**, King Fahd University of Petroleum and Minerals, **Saudi Arabia**

Posters Sessions

March 28th, 2018
Session I: Surface treatments and coatings deposition processes

Conference Room 118

N.	Poster Title	Author/Affiliation/Country
1	Graphite Raman vibrations as a probe of thermal degradation in hydrophobic graphite-based thin film coatings. **V. Gutiérrez-Cano**, F. Rodríguez and J.A. González	**Ms. Vanessa Gutiérrez Cano**, University of Cantabria, **Spain**
2	Investigation of robust hydrophobic coating on glass surface by an atmospheric pressure plasma jet for plasma-polymerization of Hexamethyldisiloxane conjugated with (3-Aminopropyl) triethoxysilane. **M. M. Hossain**, Q. Hung Trinh, D. Ba Nguyen, M.S.P. Shdhakaran and Y. Sun Mok	**Mr. Md Mokter Hossain**, Jeju National University, **Rep. of Korea**
3	Acetone sensing properties of WO3–ZnO core–shell nanorods S. M. Lee, **J. K. Lee**, W. S. Lee, C. Lee and W. I. Lee	**Ms. Jae Kyung Lee**, Inha University, **Rep. of Korea**
4	Photocatalytic activity of Fe2O3-doped TiO2 Nanoparticulate Films Prepared by Sparking off Fe Electroplated Ti Tips under external electric fields **A. Hankhuntod**, E. Kantarak, W. Sroila, T. Kumpika, P. Singjai and W. Thongsuwan	**Ms. Apinya Hankhuntod**, Chiang Mai University, **Thailand**
5	Transparent (Sn, Nb)O2 thin film with high conductivity as high-rate anode for Lithium-ion Batteries **S. Zhang**, J. Zhang, G.Cao, J. Hu and G. Shao	**Mr. Shilin Zhang**, Zhengzhou University, **China**
6	Modification of the Phase Structure of the Nanocrystalline ZrO2 Thin Films by Argon-ion Irradiation at Room Temperature **Y. Yun**, G.Cao, J.Hu and G. Shao	**Mr. Yifan Yun**, Zhengzhou University, **China**
7	Synthesis and mechanism study of Samarium Cobalt Particles us-ing Modified Spray Pyrolysis–Calcination and reduction-diffusion process **T-Y. Hwang**, J. Lee, G-M. Go and Y-H. Choa	**Dr. Tae-Yeon Hwang**, Hanyang University, **Rep. of Korea**
8	Electrospun porous SnO2-CuO hollow nanofiber mat for H2S gas sensing with high performance **K-R. Park**, Y. Song, H-B. Cho and Y-H. Choa	**Mr. Kee-Ryung Park**, Hanyang University, **Rep. of Korea**
9	Fabrication of uniform sized hexagonal boron nitride nanopowder for thermal applications **Y. Song**, S. Ryu, J.Kim and Y-H. Choa	**Mr. Yoseb Song**, Hanyang University**, Rep. of Korea**
10	Electrostatic coupling of graphite nanoplates and poly(methyl methacrylate) particles using ethylene maleic anhydride copolymer for highly conductive polymer composites **S.H. Ryu**, S. Kim, Y-T. Kwon, S-O. Kang, H-B. Cho, M. Hussain, Y-J. Lee and Y-H. Choa	**Mr. Seung Han Ryu**, Hanyang University**, Rep. of Korea**
11	Electromagnetic and Microwave Absorption Properties of Fe@SiO2 Core-Shell Composites with Tunable Shell Thickness **H-R. Lim**, S-J. Jung, T-Y. Hwang, J. Lee, Y. Song, H-B. Cho and Y-H. Choa	**Ms. Hyo-Ryoung Lim**, Hanyang University, **Republic of Korea**
12	Facile synthesis of prussian blue-reduced graphene oxide nano-composites by irradiation **C. Roh**, S-C. Jang, I. Lee and Y.S. Huh	**Prof. Changhyun Roh,** Korea Atomic Energy Research Institute**, Rep. of Korea**
13	A facile approach to fabrication of hollow ZnO nanoparticles **G.R. Cho**, D. H. Kim and D-H. Lee	**Mr. Gwang Rae Cho**, Uiduk university**, Rep. of Korea**
14	The relationship between wettability and glass transition temperature of nanoparticles on the paper **Y. Kim**, K. S. Hwang, J.H. Ahn and J-Y. Lee	**Mr. Yongsoo Kim**, Korea Institute of Industrial Technology, **Rep. of Korea**
15	Influences of current density on cavitation damage characteristics of marine grade Al alloy in seawater J.H. Lee, **K.H. Jung** and S.J. Kim	**Mr. Kwang-Hu Jung**, Mokpo Maritime University, **Rep. of Korea**
16	Meniscus Line-Induced Molecular Misorientation of Chemically Patterned Organic Semiconductor in Solution Blade Coating **D.-K. Kim** and J.-H. Bae	**Mr. Do-Kyung Kim**, Kyungpook National University, **Rep. of Korea**

March 29th, 2018

Session II: Surfaces and Coatings applications

Conference Room 118

N.	Poster Title	Author/Affiliation/Country
1	Analyse of TiO2 Oxide Multilayer by X-ray Photospectroscopy **H-C. Choe** and J-M. Jang	**Prof. Han Cheol Choe**, Chosun University, **Rep. of Korea**
2	Bioactive Surface Formation on Ti-6Al-4V alloy by PEO-treatment after Anodic Titanium Oxide (ATO) **S-G. Lim** and H.C. Choe	**Mr. Sang-Gyu Lim**, Chosun University, **Rep. of Korea**
3	Effects of Alloying Elements on the Morphology of PEO-treated Ti-40Ta-xZr Alloys for Dental Implant Materials **J-M. Yu** and H-C. Choe	**Ms. Ji-Min Yu**, Chosun University, **Rep. of Korea**
4	Ion Release of Hydroxyapatite Film on theTi-6Al-4V after Hybrid Surface Modification by Electrochemical Oxidation **M-G. Park** and H-C. Choe	**Mr. Min-Gyu Park**, Chosun University, **Rep. of Korea**
5	Precipitation of Functional Elements on PEO-treated Ti-6Al-4V Al-loy after Nanotube Formation **S-P. Kim** and H-C. Choe	**Mr. Seung-Pyo Kim**, Chosun University, **Rep. of Korea**
6	Matrix Coated Fuel Powder for Research Reactor Fuel **K. Lee**, S. Kim, K. Kim, Y. J. Jeong and J.M. Park	**Dr. Kyuhong Lee,** Korea Atomic Energy Research Institute, **Rep. of Korea**
7	Removal of radioactive cesium from surface by polyvinyl alcohol/boronate-grafted alginate hydrogel with Cs adsorbent **H-M. Yang**, C.W. Park, K-W. Lee, I. Kim and I-H. Yoon	**Dr. Hee Man Yang**, Korea Atomic Energy Research Institute, **Rep. of Korea**
8	Effects of U3MoSi2 and Ti-rich layers on the diffusion between U and Al **S.H. Kim**, Y.J. Jeong, K.H. Lee, K.N. Kim and J.M. Park	**Dr. Sunghwan Kim**, Korea Atomic Energy Research Institute, **Rep. of Korea**
9	Low-Temperature Solution-Processed Sn-doped TiO2 as Electron Transporting Layer for Efficient Perovskite Solar Cells **C. Qingbin**, L. Chao, L. Pengwei, H. Junhua, Z. Yiqiang and S. Guosheng	**Mr. Qingbin Cai**, Zhengzhou University, **China**
10	Interfacial behaviors of hybrid thin films constituted by organic bulk-heterojunction and amorphous silicon layers **Y. Kim**, H. Park, J. Stuchlik, T. H. Stuchlikova, B. Jin, Z. Remes, J. Micova and C. Im	**Mr. Yonghyun Kim**, Konkuk University**, Rep. of Korea**
11	AlSi-Al2O3 Nanocomposite Coatings Prepared by Plasma Spraying C. Banjongpraserta, C. Chairuangsria, **S. Moonngama** and S. Jiansirisomboonb	**Ms. Suphitcha Moonngam**, Chiang Mai University, Chiang Mai, **Thailand**
12	Grain growth of Ag reflective p-type electrode by electron beam irradiation for 32x32 pixelated micro-LED arrays. I.Y. Hong, Y-J. Cha, J. Bong So, J. H. Lee, **T.K. Kim**, J.H. Choi, S.H. Oh and J. S. Kwak	**Mr. Tae Kyoung Kim**, Sunchon National University, **Rep. of Korea**

Session I:
Surface treatments and coatings deposition processes

Electrodeposition of ceria-based coatings on metal susbtrates

F. Pedraza[1*]

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Abstract:

The growth mechanisms of ceria-based layers elaborated by cathodic electrodeposition from relatively concentrated cerium nitrates solutions will be presented in this work.

The thermodynamic analysis of the aqueous solutions appeared as a useful tool to to predict the relevant precipitation mechanisms and species involved during the growth of cerium-containing films and to draw correlations with the characteristics of the as-deposited film [1]. The hysteresis of the cyclic voltammetry curves increaseD with increasing the cerium nitrate concentrations [2]. This was indicative of a greater coverage of the surface. Therefore, 0.1 and 0.25 M concentrations were employed to grow the ceria based layers as a function of time and of applied current density. Clearly, the metal surface was more homogeneously covered with increasing both parameters. However, an excessive growth of the deposits increased the shear stresses between the coating and the substrate thereby resulting in cracks. The mechanisms of formation of the layers mainly involved alkalinization of the metal interface with the electrolotye, precipitation of cerium hydroxides and further oxidation of cerium and release of water to result in ceria (CeO_2). Therefore, all the coatings were mostly composed of Ce oxy-hydroxides and ceria according to the XPS, Raman spectroscopy and XRD analyses. [3] In addition, the crystallite size of ceria decreased with increasing current density while the number of oxygen vacancies increased. These features could be altered by increasing the temperature of the electrolytic solution [4]. An example of the corrosion and oxidation resistance supplied by these coatings to, respectively, carbon steel and nickel based superalloys will be given [5].

Keywords: cathodic electrodeposition, ceria, mechanisms, characterization, corrosion resistance.

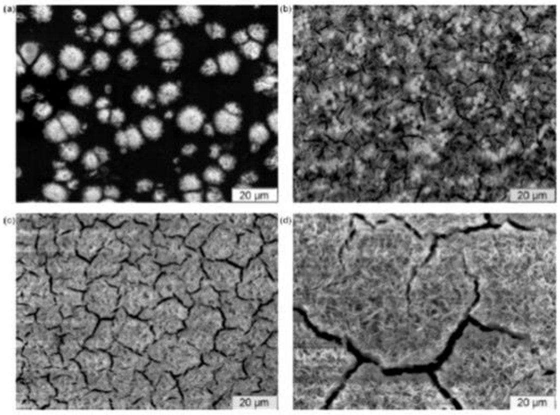

Figure 1: Evolution of the surface morphology of the ceria-based coatings on carbon steel with increasing applied current density. The deposits were elaborated for 20 min in $0.25MCe(NO_3)_3$ with the applied current density (mA/cm_2) (a) 0.5, (b) 1, (c) 1.5 and (d) 3.

References:

1. Bouchaud, B., Balmain et al. (2012) pH-distribution of cerium species in aqueous systems, *J. Rare Earths*, 30, 559-562.
2. Hamlaoui, Y., Pedraza, F., et al. (2009), Cathodic electrodeposition of cerium based oxides on carbon steel from cerium nitrate. Part I: Electrochemical and analytical characterisation. *Mater. Chem. Phys.*, 113, 650-657.
3. Martinez, L. Roman E., et al. (2011) Surface study of cerium oxide based coatings obtained by cathodic electrodeposition on zinc, Appl. Surf. Sci. 257, 6202-6207.
4. Hamlaoui, Y., Tifouti, L., et al. (2010), Cathodic electrodeposition of cerium based oxides on carbon steel from cerium nitrate. Part II: Influence of the electrodeposition parameters and of the addition of PEG. *Mater. Chem. Phys.*, 120, 172-180.
5. Pedraza, F., Balmain, J. et al. (2014) Novel concept of functional oxide coatings providing enhanced oxidation resistance to Ni-based superalloys. *Mater. Res. Bull.* 49, 384–387.

Development of Thermal Barrier Coating with High Oxidation Resistance by Grit Blasting

K. ITO[1], T. SHIMA[1], M. ARAI[1], T. SUIDZU[*2], A. KANNO[2]

[1] Tokyo University of Science, Department of Mechanical Engineering, Tokyo, Japan
[2] TOCALO Co., Ltd., Hyogo, Japan

Abstract:

Thermal Barrier Coating (TBC) is applied to gas turbine components to protect from high temperature environment. TBC system is composed of top coat (TC) as thermal barrier layer and bond coat (BC) for improving oxidation resistance and adhesion strength. During long time operation, thermally grown oxide (TGO) with Al_2O_3 and mixed oxide is formed and developed at TC/BC interface. The development of TGO, especially, mixed oxide leads to delamination of TC layer. In this study, we develop TBC system with high oxidation resistance by grit blasting with Al_2O_3 grits to the BC surface. The high oxidation resistance can be achieved by pre-formed Al_2O_3 layer at TC/BC interface[1)]. In addition, optimization of TC/BC interfacial roughness can inhibit the growth of TGO. The grit blasting with Al_2O_3 grits is expected to form the Al_2O_3 layer and otimize the interfacial roughness simultaneously. TBC specimens with different TC/BC interfacial roughness were prepared by grit blasting using different sizes of Al_2O_3 grits. From cross-sectional observation by scanning electron microscope (SEM), uniform distribution of fine Al_2O_3 particles of diameter less than 1 µm was observed along TC/BC interface of blasted TBC specimen (B-TBC). High-temperature exposure treatment at 1000°C led to growth of homogeneous TGO in the B-TBC specimens in contrast to formation of complex TGO in non-blasted TBC (S-TBC). The TGO areas in each specimen were evaluated. Figure 1 shows the relationship between the TGO areas and exposure time. The TGO areas in the B-TBC specimens were much lower than that in the S-TBC. This is definitely attributed to the fine Al_2O_3 particles uniformly distributed at the TC/BC interface. Furthermore, the TGO thickness was depending on the interfacial roughness. It was indicated that adequate interfacial roughness for inhibition of TGO can be formed by the grit blatsitng. These results revealed that the grit blasting with Al_2O_3 grits is an effective technique for improvement of oxidation resistance of the TBC system.

Keywords: gas turbine, thermal barrier coating, thermally grown oxide, grit blasting, oxide barrier layer, interfacial roughness.

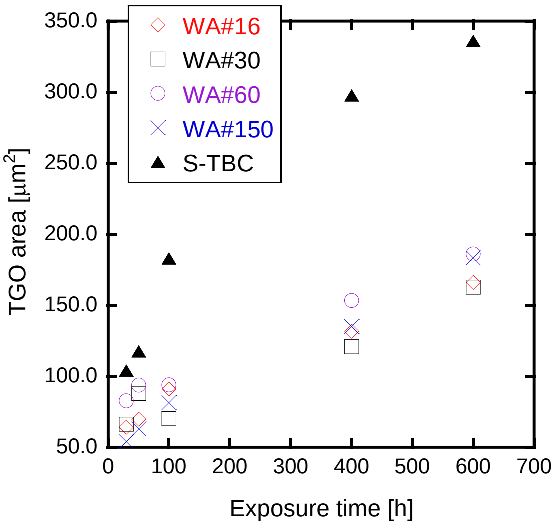

Figure 1: Relationship between TGO area and exposure time: the TGO areas in all specimens increased with increasing the exposure time, however, the TGO areas in the B-TBC specimens were much lower than that in the S-TBC.

References:

1. Sato, A., Matsunaga, Y., Yoshizawa, H., Takahashi, K., Mori, N. (2007), Current Status of Thermal Barrier Coating System for Aero-Engines, *Journal of High Temperature Society*, 33(5), 252-256.

Transfer-Free Large-Scaled High Quality Graphene Synthesized Directly on Flexible Substrates

Byeong-Ju Park[1], Jin-Seok Choi[1,2], Yooseok Kim[3], Cheolho Jeon[3], Seonhee Lee[4], Hyunjung Shin[4], Ji-Ho Eom[1] and Soon-Gil Yoon[1]

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Abstract:
Direct graphene growth on flexible substrates via chemical vapor deposition (CVD) is an attractive approach to manufacturing flexible electronic devices, as it avoids the drawbacks of transferred graphene. To fabricate flexible devices on plastic substrates, the growth temperature must be below ~200 °C to prevent substrate deformation. We show that the high-quality graphene can be directly grown on a variety of substrates via the introduction of ultra-thin titanium, due to a strong affinity of carbon with the titanium. We further demonstrate that the titanium oxidized naturally upon exposure to air after graphene growth did not influence the various functions of graphene and substrates. We report experimental evidence for large-scaled (4 cm × 4 cm size) high-quality graphene grown on 10 nm-thick titanium-catalyzed substrates at low temperatures below 150 °C in a CH4/H2 atmosphere via plasma-assisted thermal CVD. We applied the proposed methodology to fabricate flexible and transparent thin-film capacitors with direct grown top- and bottom-graphene electrodes. These findings could pave the way to the practical exploitation of flexible electronic devices via large-scaled high-quality monolayer graphene grown directly with no transfer processes.

Session I.A:
Coatings deposition and processing

Processing of an organosilazane-based glass/ZrO_2 composite coating system by laser pyrolysis

A. Horcher,[1*] K. Tangermann,[2] G. Barroso,[1] W. Krenkel,[1] G. Motz[1]

[1] University of Bayreuth, Department of Ceramic Materials Engineering, Bayreuth, Germany
[2] Bayerisches Laserzentrum GmbH, Erlangen, Germany

Abstract:

Protective ceramic-based coatings are frequently the most suitable and cost-effective solutions for engineering problems like corrosion, oxidation and wear. However, the traditional methods for the preparation of ceramic coatings are relatively expensive and have some limitations. As an alternative, the polymer-derived ceramics (PDC) technology has been successfully applied for the processing of various ceramic coatings. In this method, preceramic polymers, usually silicon-based compounds, are converted into amorphous ceramics by a pyrolysis between 500 and 1000 °C in a furnace. However, the furnace based PDC-technology can only applied in combination with temperature-resistant, high melting substrate materials like steels, super-alloys and ceramics. A very innovative approach to overcome this restriction is the use of laser radiation as an energy source for the pyrolysis of the preceramic polymer.

For this reason, a composite coating system composed of an organosilazane (Durazane 1800) with ZrO_2 and glass particles as fillers was developed suitable for pyrolysis with a Nd:YAG laser (Figure 1). Firstly, the mild steel substrates were dip-coated with perhydropolysilazane (PHPS) as a bond coat, onto which the composite coating slurry was applied by spraying. After drying, laser pyrolysis led to the formation of a dense semi-crystalline ceramic coating system with a thickness up to 20 μm in a short time. Furthermore, laser irradiation led to the unexpected formation of oxygen vacancies in the crystalline lattice of ZrO_2, which increased the absorption of the laser radiation, enabling the transformation into a ceramic coating. Reactions between the glasses and the monoclinic ZrO_2 fillers were activated, resulting in the formation and stabilization of dendritic tetragonal-stabilized ZrO_2 crystals. The resulting coatings were investigated by attenuated total reflectance infrared spectroscopy (ATR-FTIR), scanning electron microscopy (SEM) and X-ray diffraction (XRD). The adhesion of the coating systems on the substrate was determined with a Pull-Off test. To investigate the functionality of the laser-pyrolyzed coating as an environmental barrier coating, oxidation tests were performed in a furnace for 100 h in air. The corrosion resistance of the coatings was examined with salt spray test.

Keywords: Polymer-derived ceramic, Laser pyrolysis, Nd:YAG laser, tetragonal-stabilized ZrO_2, environmental barrier coating

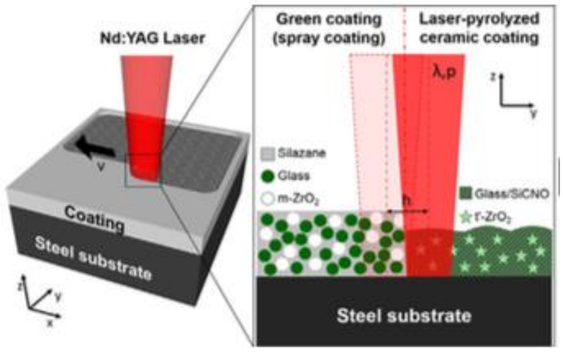

Figure 1: Schematic illustration of the laser-pyrolysis for processing of ceramic composite coatings.

References:

1. Tangermann-Gerk, K., Barroso, G., Weisenseel, B., Greil, P., Fey, T., Schmidt, M., Motz, G. (2016) Laser pyrolysis of an organosilazane-based glass/ZrO_2 composite coating system, *Materials and Design.*
2. Günthner, M., Schütz, A., Glatzel, U., Wang, K., Bordia, R.K., Greißl, O., Krenkel, W., Motz, G. (2011) High performance environmental barrier coatings, Part I: Passive filler loaded SiCN system for steel, *J. Eur. Ceram. Soc.*

Effect of annealing Nickel feedstock powder to produce WC-5wt%Ni cold sprayed coatings

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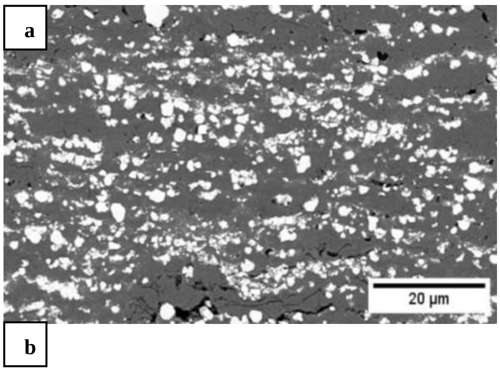
Abstract:

Cold spray is a solid-state powder deposition process with several unique characteristics, which has been successfully applied in various industries[1]. To date research on tungsten carbide(WC)-based cold spray coatings has shown positive results [2-3]. However there are various aspects which still need to be addressed in order to produce viable cold sprayed coatings for specific commercial applications which require high wear resistance. It is well-known that feedstock powder properties have a significant influence on the coating properties. Hence in the current research the effect of using a gas atomized Nickel(Ni) powder to produce a wear resistant WC-Ni coating was investigated. In order to improve coating deposition, the Ni powder was annealed prior to being milled with the WC powder. A low pressure cold spray system was used to deposit WC-5wt%Ni coatings onto mild steel substrates. The microstructure was characterized in terms of porosity, WC retention, contiguity and grain size, and Ni binder mean free path. Coating thickness, surface roughness, hardness and fracture toughness were also determined. The coatings were subjected to slurry abrasion testing and the resulting wear mechanisms identified. The results of this investigation will provide a basis for further investigation on the possible application of these coatings in the steel industry.

Keywords: cold spray, cemented carbides, tungsten, nickel, slurry abrasion



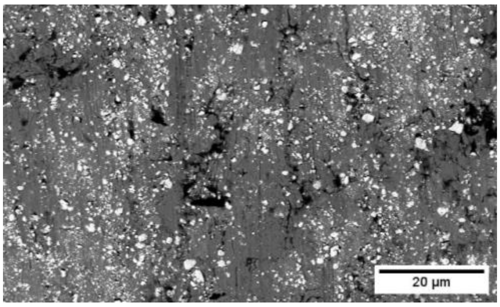


Figure 1: (a) Coating microstructure: white phase = WC; gray phase = Ni matrix; black = pores. (b) Worn coating surface after slurry abrasion showing carbide grain cracking and fragmentation, and Ni binder smearing and grooving.

References:

1. Champagne, V.K. (2007) the cold spray materials deposition process: *fundamentals and applications*. Cambridge, CRC Press.
2. N.M. Melendez and A.G. McDonald (2013), *Surface & Coatings Technology* 101-103.
3. Nunthavarawong, P., Sacks, N., Botef, I. (2016) Effect of powder feed rate on the mechanical properties of WC-5 wt % Ni coatings deposited using low pressure cold spray, *Int. J. of Refr Met & H Met.*, 232-234.

Multi-technical characterization of the impact of S^3P surface heat treatments on galling in stainless steels

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Abstract:
Galling is a severe case of adhesive wear; it goes with the appearance of undesirable surface modifications leading to the deterioration of materials in contact. While the best way to avoid galling is clearly the use of lubrication, the latter are not always possible regarding selected application. In dry contact, the most efficient way to avoid galling is probably surface treatments. Among them, S^3P surface heat treatments (formerly known as Kolsterising®), developed by Bodycote, are worldwide known to highly improve galling resistance without affecting corrosion resistance. Several S^3P surface treatments are available for stainless steels and some of them are specially developed for different stainless steels phases. A focus is herein made on three grades, namely AISI 316L (austenitic), 17-4PH (martensitic) and Uranus45N (austenitic-ferritic duplex). Galling tests according to ASTM G98 norm have been performed on both untreated and S^3P heat treated stainless steels in order to quantify galling threshold. All selected samples in untreated condition display a very low galling threshold, lower than 11 MPa. While S^3P-K33 treatment, developed for austenitic microstructure has been proved to be particularly effective, avoiding galling even at 350 MPa, treatments for martensitic and dual phase stainless steels are more challenging. Heat treatments have been successfully performed for martensitic steels, using S^3P-M heat treatment, showing a galling threshold higher than 300 MPa. However, dual phase treatments S^3P-K-Duplex are yet to be improved, since it slightly improves galling threshold, from 11 MPa to 94 MPa. An EBSD investigation of samples after galling test with different treatments (untreated, S^3P-K33, S^3P-M and S^3P-K-Duplex) is presented on Figure 1. Multi-technical study (nanoindenting, EBSD analysis, DRX…) of both treated and untreated samples have been performed in order to determine the effects of galling test on considered grades. With each S^3P treatment (included untreated condition) goes different galling features and a focus is herein made to better understand the underlying galling mechanisms.

Keywords: Galling, galling threshold, galling mechanisms, S^3P heat treatments, stainless steels

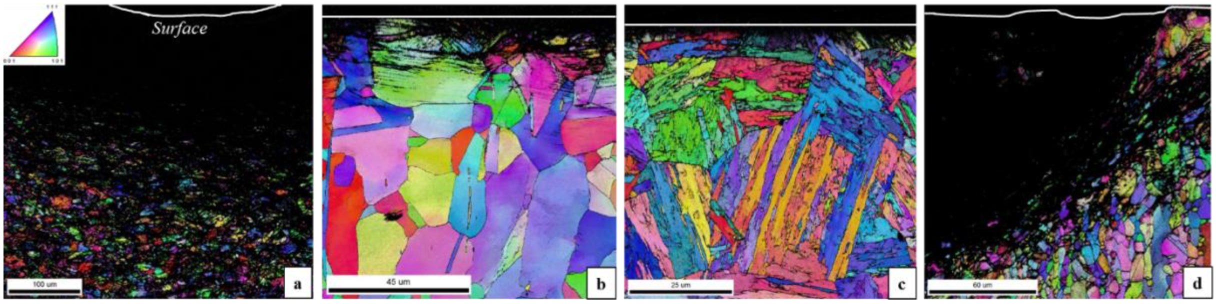

Figure 1: Cross sections EBSD investigation after galling test at 350 MPa for a- 316L in untreated condition, b- 316L treated S^3P-K33, c- 17-4PH treated S^3P-M and d- Uranus45N treated S^3P-K-Duplex

Effect of External Magnetic Fields on Iron Oxide Nanoparticulate Films Prepared by Sparking Process

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Abstract:

Iron oxide nanoparticulate films was successfully prepared using sparking off Fe wires [1-3]. The experiment was carried out by using external electric and magnetic fields under atmospheric pressure to improve the film morphology, crystallinity and magnetic properties. Surface morphology, structural and optical properties of the films were characterized by scanning electron microscopy (SEM), Raman spectroscopy, X-ray diffraction (XRD) and UV/vis spectroscopy. Furthermore, the effect of external magnetic field on their properties will be reported and discussed.

Keywords: Iron oxide, sparking process, surface morphology, magnetic fields

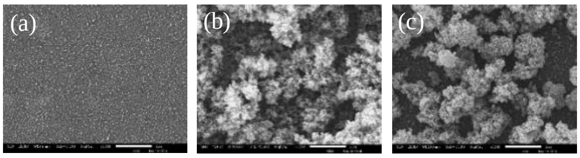

Figure 1: SEM images of iron oxide nanoparticulate films prepared by sparking process (a) without the field, (b) under electric field and (c) under magnetic field.

References:

1. Hankhuntod, A., Kantarak, E., Sroila, W., Kumpika, T., Singjai, P., Thongsuwan, W. (2017), α-Fe_2O_3 modified TiO_2 nanoparticulate films prepared by sparking off Fe electroplated Ti tips, *Appl. Surf. Sci.*,
2. Thongsuwan, W., Singjai, P. (2016), Influence of TiO_2/Fe_2O_3 interfacial layers on optical properties undervisible light, *Int. J. Surf. Coat. Technol.*, 306, 49-53.
3. Thongsuwan, W., Kunpika, T., Singjai, P. (2011), Effect of high roughness on a long aging time of superhydrophilic TiO_2 nanoparticle thin films, *Int. J. Curr. Appl. Phys.*, 11, 1237-1242.

Session I.B:
Functional / Multi-functional, composite / hybrid, graded and multilayers coatings

FUNCTIONAL HYBRID NANOCOMPOSITE THIN FILMS : PREPARATION, CHARACTERIZATION AND APPLICATIONS

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Abstract:

The success of modern materials is partially or totally due to the high performances of their functional surfaces. In this frame, developing high efficient polymer-based coatings and composite thin films is of growing interest when issues linked to flexible microelectronics, adhesion, energy or even healthcare are concerned. The combined recent advances in surface coatings engineering and in polymer science can nowadays lead to the design and fabrication of increasingly efficient surfaces with functionalities answering very precise, strict and high level requests depending on the dedicated application.

The present work is mainly focused on the design of functional hybrid nanocomposite surfaces. In order to generate this type of hybrid coatings, different approaches combining nanoparticles and polymers thin films will be described: from the direct injection of nanoparticles previously dispersed in a liquid plasma polymerizable to get ultimetaly a one step deposition process to the in-situ generation of nanoparticles inside polymer thin films.

This contribution will insist on the importance of the control of the chemical structures and molecular architectures at the molecular level [1,2] in order to apply polymer coatings, in application domains as diversified superhydropbic and anti bacterial surfaces [3], fireproofing [4] and materials for PEM fuel-cells [5].

References:

1. Fouquet, T., Petersen, J., Ziarelli, F., Ruch, D., Charles, L. (2013) Insights in the Architecture of Silicon-Based Plasma Polymers Using Partial Network Ethanolysis Combined with Electrospray Tandem Mass Spectrometry, *Plasma Process. Polym.*, 10, 271-284.
2. Boscher, N.D., Hilt, F., Duday, D., Frache, G., Fouquet, T., Choquet, P. (2015) Atmospheric Pressure Plasma Initiated Chemical Vapor Deposition Using Ultra-Short Square Pulse Dielectric Barrier Discharge, *Plasma Process. Polym.*, 12, 66-74.
3. Petersen, J., Michel, M., Toniazzo, V., Ruch, D., Schmerber, G., Ihiawakrim, D., Muller, D., Dinia, A., Ball, V. (2012) Atmospheric plasma polymer films as templates for inorganic synthesis to yield functional hybrid coatings, *RSC Adv.*, 2, 9860-9866.
4. Bardon, J., Apaydin, K., Laachachi, A., Jimenez, M., Fouquet, T., Hilt, F., Bourbigot, S., Ruch, D. (2015) Characterization of a plasma polymer coating from an organophosphorus silane deposited at atmospheric pressure for fire-retardant purposes, *Prog. Org. Coat.*, 88, 39-47.
5. Michel, M., Bour, J., Petersen, J., Arnoult, C., Ettingshausen, F., Roth, C., Ruch, D. (2010) Atmospheric plasma deposition: A new pathway in the design of conducting polymer-based anodes for hydrogen fuel cells, *Fuel Cells*, 10, 932-937.

Polydimethylsiloxane-Polythiourethane polymer blend with potential as Fouling-Release coating

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Abstract:

All surfaces immersed into the aquatic environment, be it sea or fresh water, become covered with proteins and colonized by aquatic organisms, which is called biofouling (Dobretsov, Teplitski, & Paul, 2009). The settlement of micro- and macroscopic organisms on anthropogenic surfaces is accompanied by disadvantages for plenty of technical applications, e. g. the clogging of heat exchangers in power plants as well as filling facilities in food production, the occurrence of pathogenic biofilms on biomaterials, material degradation by biocorrosion or the increase in surface roughness and weight gain of ship hulls. The latter one can result in increased fuel consumption of up to 40 %, accompanied by an increase in greenhouse gas emissions and transport costs (Carteau et al., 2014; Yebra, Kiil, & Dam-Johansen, 2004). Due to the prohibition of the toxic and very potent tributyltin (TBT)-based antifouling paints in 2008 and the lack of alternatives which are both mechanically stable and environmentally friendly (Carteau et al., 2014; Swain, Kovach, Touzot, Casse, & Kavanagh, 2007), there is a huge demand to develop new long lasting antifouling coatings. Dhe mechanisms of interaction between solid surfaces and the aquatic environment including all its abiotic and biotic entities are incredibly various. Some antifouling strategies have been considered as effective, but they all have their disadvantages like negative environmental impact or mechanical instability (Swain et al., 2007). One of the approaches considered as promising is the usage of materials with hydrophobic and thereby satisfactory fouling-release properties like silicones. However, their material properties are disadvantageous for the application as ship coating. The aim of this study is to develop a mechanically stable polymer blend combining the hydrophobic surface properties of silicone with the material properties of another polymer. Therefore the full solid polymer polythiourethane (PTU) which shows adequate antifouling properties (Hölken et al., 2016) is combined with the well known fouling-release material polydimethylsiloxane (PDSM). The material, surface and fouling-release properties of the PDMS/PTU blend were characterized and the polymer blend shows promising properties for potential applications within the maritime sector.

Keywords: Environmentally-friendly antifouling coating. Ship coating, fouling release, biocorrosion, polymer blend, polyurethane, polydimethylsiloxane;

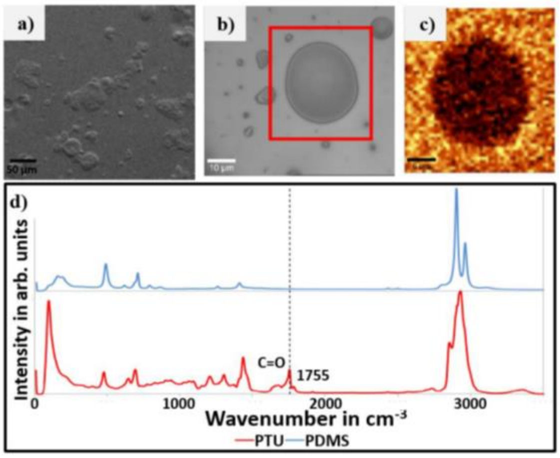

Figure 1: Distinct domains of PDMS and PTU. a) SEM micrograph of the composite surface. b) Light microscopic image and c) corresponding filtered Raman image. Areas containing the signal at 1755 cm^{-1} appeared bright (PTU) while areas where this peak was missing are dark (PDMS). Investigated PDMS/PTU composites contained 1 wt% PDMS. c) Characteristic Raman spectra of pure PTU and PDMS. PTU exhibits a peak at 1755 cm^{-1} which can be attributed to a C=O vibration (D. Lin-Vien, N. B. Colthup, W. G. Fateley, 1991), which is absent in the spectrum of PDMS.

References:

1. Carteau, D., Vallée-Réhel, K., Linossier, I., Quiniou, F., Davy, R., Compère, C., … Fay, F. (2014). Development of environmentally friendly antifouling paints using biodegradable polymer and lower toxic substances. *Progress in Organic Coatings* , *77*(2), 485–493. Retrieved from http://www.sciencedirect.com/science/article/pii/S0300944013002920
2. D. Lin-Vien, N. B. Colthup, W. G. Fateley, J. G. G. (1991). *The Handbook of Infrared and Raman Characteristic Frequencies of Organic Molecules* (1st ed.).
3. Dobretsov, S., Teplitski, M., & Paul, V. (2009). Mini-review: quorum sensing in the marine environment and its relationship to biofouling. *Biofouling*, *25*(5), 413–427. Retrieved from file:///C:/Users/Martina Baum/CloudStation/Science_CAU/Literature/Antifouling_Polymers/Papers - Fouling/Dobretsov_etal_2009_mini-review_quorum sensing in the marine enviroment.pdf
4. Hölken, I., Hoppe, M., Mishra, Y. K., Gorb, S. N., Adelung, R., & Baum, M. J. (2016). Complex shaped ZnO nano- and microstructure based polymer composites: mechanically stable and environmentally friendly coatings for potential antifouling applications. *Phys. Chem. Chem. Phys.*, *18*(10), 7114–7123. https://doi.org/10.1039/C5CP07451G
5. Swain, G. W., Kovach, B., Touzot, A., Casse, F., & Kavanagh, C. J. (2007). Measuring the Performance of Today ' s Antifouling Coatings. *Journal of Ship Production*, *23*(3), 164–170.
6. Yebra, Kiil, S., & Dam-Johansen, K. (2004). Antifouling technology: past, present and future steps towards efficient and environmentally friendly antifouling coatings. *Progress in Organic Coatings* , *50*(2), 75–104. Retrieved from http://www.sciencedirect.com/science/article/pii/S0300944003001644

Estimation of barrier properties of the composite hydrophobic coatings on PEO-pretreated metals

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Abstract:

One of the most important priority direction of the advanced material science development - is the search for efficient methods of metals and alloys protection against corrosion. The following approaches are conventionally used to decrease the corrosion rate: cathodic protection, application of protective and barrier layers, in particular, lacquer/paint and oxide coatings. The efficiency of such protection is directly related to the quality of the deposited protective layer and determined by its material and formation conditions.

The field of practical applications of constructional and functional materials such as titanium, magnesium, aluminium and even steel might be extended using plasma electrolytic oxidation (PEO) to form the protective oxide layer on their surface.

Formation of hydrophobic and superhydrophobic coatings on magnesium [1], titanium, steel [2], aluminium, other metals and alloys and study of their electrochemical behaviour comprise important stages of the development of anticorrosion coatings characterized by reliable barrier properties not only under atmospheric conditions, but also in the more harsh aggressive media.

In the present work, we have studied the protective hydrophobic composite coating/solution interface by means of electrochemical impedance spectroscopy. EIS-data was fitted and analyzed using equivalent electrical circuits. Hydrophobic layers were formed on PEO-pretreated surfaces, subjected to different additional procedures. Such composite coatings in contact with brine solution possess contact angles higher than 150° with low rolling angles. The level of corrosion protective properties of the formed composite superhydrophobic coatings depends on the treatment procedures.

Keywords: electrochemical impedance spectroscopy, plasma electrolytic oxidation, hydrophobic coatings.

Acknowledgments:

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References:

1. Gnedenkov, S.V., Sinebryukhov, S.L., Mashtalyar, D.V., Egorkin, V.S., Sidorova, M.V., Gnedenkov, A.S. (2014), Composite polymer-containing protective coatings on magnesium alloy MA8, *Corros. Sci.*, 85, 52-59.
2. Boinovich, L.B., Gnedenkov, S.V., Alpysbaeva, D.A., Egorkin, V.S., Emelyanenko, A.M., Sinebryukhov, S.L., Zaretskaya, A.K. (2012), Corrosion resistance of composite coatings on low-carbon steel containing hydrophobic and superhydrophobic layers in combination with oxide sublayers, *Corros. Sci.*, 55, 238-245.

Functionalised Silica based Surface Coating for Enhancing the Hygroscopic Properties of Bio-based Building Insulation Materials

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Abstract

This study focuses on a novel method for the surface treatment of a natural plant material, hemp shiv, using silica based sol-gel coatings for building insulation. Bio-based materials are extremely hydrophilic due to their chemical composition and porous structure. For the first time, sol-gel technology has been applied to enhance the hydrophobicity of a bio-based thermal insulation material without compromising its hygroscopic properties. The functionalised sol-gel coatings were produced by cohydrolysis and polycondensation of tetraethoxyorthosilicate (TEOS) using an acidic catalyst and hexadecyltrimethoxysilane (HDTMS) was added as the hydrophobic precursor. It was found that the sol-gel coatings modified the hemp shiv providing hydrophobicity to the surface with water contact angles up to 118° and reduced the water uptake by 250% over 24 hours. The surface morphology and roughness has been altered by the deposition of the coating layer as seen with the scanning electron microscopy and 3D optical profilometer. The moisture buffering property of hemp shiv was retained even after the surface treatment as the sol-gel layer refined the pore structure of hemp shiv, blocking water molecules but allowing moisture to penetrate through the shiv. Fourier transformed infrared spectroscopy (FTIR) revealed that hydroxyl groups in the structure were reduced with additional peaks arising from the silica coating. Thermal analysis showed that the surface coating enhanced the thermal stability of the hemp shiv. Therefore, hemp shiv modified with silica based sol-gel coating shows potential for the development of new robust building materials and sustainable thermal insulation composites with engineered hydrophobic properties.

Keywords: hydrophobicity; surface engineering; bio-based, sol-gel; porosity; hygroscopicity.

Flame retardancy surface coating with functionalised silica-based for wood waterborne coatings

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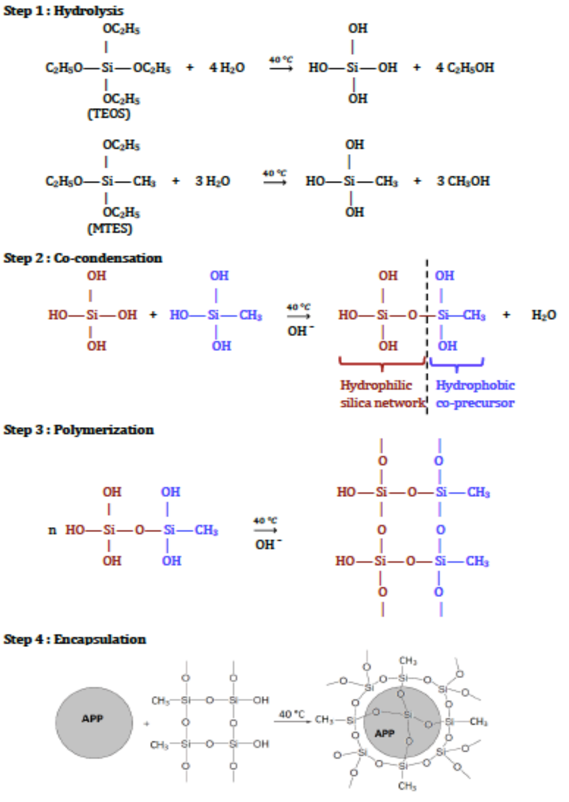
Abstract:

The use of timber products in construction has been growing over the past years not only due to their outstanding properties, but also because of their visually pleasing. However, their high degree of flammability has also become a major disadvantage of using as building material. At present, intumescent fire retardant (IFR) coatings are considered as the most effective flame retardant (FR) treatment. A classical IFR coating is composed of three principal active components including an inorganic acid source/catalyst (e .g. ammonium polyphosphate), a carbon-rich source (e.g. pentaerythritol) and a blowing agent/spumific (e.g. melamine), which are linked together by a polymeric binder. When heated beyond a critical temperature, an IFR coating starts swelling and then expanding to a thick multicellular charred layer to protect the underlying substrate against the heat generated by flame. Therefore the structural integrity is maintained.

Nevertheless, ammonium polyphosphate (APP), the principal compound in IFR coating, tends to hydrolyze to water-soluble monoammonium phosphate when exposed to relative high humidity. Inorganic salts from the intumescent coating migrate towards the surface of the polymer matrix, which deteriorates fire protection performance. Therefore, the IFR coating effectiveness decreases rapidly, especially for outdoor use. The main objective of this project is to develop a hydrophobic silicon-based coating to protect the APP from humidity. Meanwhile, the synergy of silicon and the intumescent mixture further enhances the flame retardancy of the coating. Coating APP by an inorganic-organic hybrid silica was prepared through sol-gel process by using alkoxysilane tetraethyl orthosilicate (TEOS) precursor and methyltriethoxysilane (MTES) as hydrophobic modifier under alkaline conditions. The morphology and structure of both APP and encapsulated ammonium polyphosphate (EAPP) were assessed by Scanning electron miscroscopy (SEM) and Fourier transform infrared spectroscopy (FTIR). The X-ray photoelectron spectroscopy (XPS) results indicated that the surface of APP was coated by the polysiloxane. The thermal degradation of APP and EAPP additives was characterized by thermogravimetric and differential thermogravimetric analysis (TG/DTG). The EAPP has higher yield of residual char at 800 °C than APP. The hydrophobicity of APP encapsulated by inorganic-organic hybrid coating increased significantly. Cone calorimetry was performed on white spruce samples (*Picea glauca* (Moench Voss)) coated with the fire retardant treatment to investigate flame retardant properties of both waterborne coatings with APP and EAPP before and after accelerated aging.

Keywords: intumescent flame retardant, inorganic-organic sol-gel hybrid coating, water resistance, waterborne coatings, exterior wood protection.



Schematic illustration of sol-gel coating process of APP

An efficient method for three-dimensional thermoelastic contact of functionally graded materials under frictional heating

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Abstract:

functionally graded materials (FGM) offer a possibility to design the surface according to the different requirements, which attracts intense attentions from engineering and research community. The coupled thermo-mechanical contact problem of a multilayered material is of great interest. This paper firstly derives the frequency response functions (FRF) of thermoelastic fields through thermoelastic governing equations. Multilayered approximation is used to model the FGM. The unknown coefficients in the FRFs are assembled in a linear system of matrix equations according to the thermal and mechanical loadings on surface and continuity condition of heat flux, temperature, displacement and stresses at each interface; then the coefficients are solved and expressed recursively. Based on the closed-form solution of FRFs, a fast semi-analytical method (SAM) is developed to solve the three-dimensional thermoelastic contact problem involved in arbitrary multilayered materials. There are no limits on the number or the thickness of layers, and material parameters can be varied arbitrarily. The present model is verified by literature and FEM and shows a high robustness and efficiency. Thermoelastic contact of multilayered materials with different coating designs under friction heating is further studied and the thermal effect is explored.

Keywords: Functionally graded materials, three-dimensional thermoelastic contact, frequency response functions, recursive method, frictional heating.

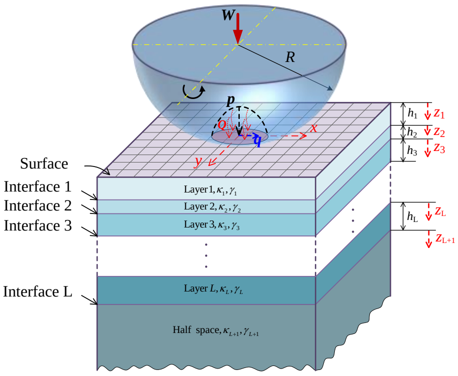

Figure 1: The schematic of thermoelastic contact of multilayered material with a rigid ball. The material properties are homogeneous in each layer and all the interfaces are perfectly bonded without heat loss. This method has no limit on the number of layers so that FGM can be modeled.

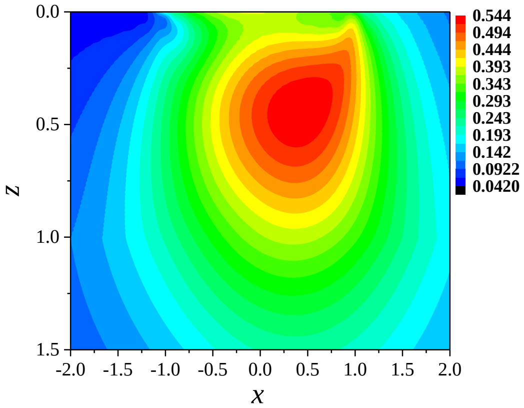

Figure 2: The dimensionless von Mises stress distribution in exponentially varying FGM when thermoelastic contact is considered. The frictional coefficient is *f*=0.2.

References:

1. Yu C., Wang Z., Wang Q.J., Analytical frequency response functions for contact of multilayered materials, Mechanics of Materials, 76 (2014) 102-120.
2. Zhang H., Wang W., Zhang S., Zhao Z., Semi-analytic solution of three-dimensional temperature distribution in multilayered materials based on explicit frequency response functions, Int J Heat Mass Tran, 118 (2018) 208-222.

Adjustment of the composition Al, Cr, Si, Ti in AlCrSiTi nitride film by Taguchi method to obtain optimal composition

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Abstract:

Dry machining of materials at hardened state has great importance due to its advantages on manufacturing costs and environmental waste formation; however, the tool wear in machining of the materials at hardened state limits the use of these tools in hard machining applications. A number of studies have been investigated that a corresponding suitable hard coating, such as TiN and CrN, can protect the tool and increase the tool-life.

The hardness and oxidation resistance are the most important properties of coated tools during cutting test. Several studies have noted that adding Al and Si atoms into TiN and CrN extensively enhance the hardness and oxidation resistance, respectively [1, 2]. According to the previous research, the AlCrSiTiN coated tools are promising and show better cutting performance than other coating systems [3]; however, the best combination of hardness and antioxidation performance of AlCrSiTi nitride film still requires further research. In the present study, the composition of AlCrSiTiN film would be studied by Taguchi method in order to find the optimal composition with the best mechanical and oxidation properties.

In the present work, nine targets with different Al, Cr, Si and Ti composition were designed by Taguchi method. The AlCrSiTi nitride film were deposited with nine different composition targets by RF reactive magnetron sputtering. The hardness and oxidation resistance of AlCrSiTi nitride films with different composition were investigated and then analyzed by factor effects and SN ratios. The experimental results show that the AlCrSiTi nitride film with the least Al and Si content and medium Ti content possesses the highest hardness of 30 GPa. From the results of factor effects, the content of Al atom has the most obvious effect on the hardness, in contrast, the different content of Ti has little impact on hardness of films. In addition, thermal-gravimetric analysis (TGA) was conducted to evaluate the dynamic oxidation characteristics of the AlCrSiTi nitride films. The AlCrSiTi nitride film with the most Si and Ti content and medium Al content shows the best antioxidation performance with the least mass gain about 5.64 μg/mg at 1000 ºC. According to other studies, the Ti atoms have a negative influence on the antioxidation performance of the nitride films [4]. However, in the present study, the antioxidation performance of nitride film doesn't become better with less Ti content. In other words, there will be a optimal content of Ti in the AlCrSiTi nitride film instead of endlessly decrement of the Ti content.

Keywords: hard coating, Taguchi method, ternary coating, silicon-contained coating, AlCrSiTi nitride film.

References:

1. Lin, J., et al., *A study of the oxidation behavior of CrN and CrAlN thin films in air using DSC and TGA analyses.* Surface and Coatings Technology, 2008. **202**(14): p. 3272-3283.
2. Cai, F., et al., *Effect of nitrogen partial pressure on AlTiN films deposited by arc ion plating.* Applied Surface Science, 2011. **258**(5): p. 1819-1825.
3. Zhang, S., et al., *Structural optimisation and synthesis of multilayers and nanocomposite AlCrTiSiN coatings for excellent machinability.* Surface and Coatings Technology, 2015. **277**: p. 23-29.
4. Chang, Y.-Y. and C.-Y. Hsiao, *High temperature oxidation resistance of multicomponent Cr-Ti-Al-Si-N coatings.* Surface and Coatings Technology, 2009. **204**(6-7): p. 992-996.

Bioorthogonal in situ Hydrogels based on Polyether-Polyols for new Biosensor Materials with high Sensitivity

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Abstract:

Developing more sensitive and specific biosensors remains a great challenge since the specific verification of analytes plays a major role in biomedical analysis. We here present a novel surface-bound *in situ* hydrogel for highly sensitive biosensors. In this new approach the biomolecule is already present while the gel is formed from two different building blocks, which are azide functionalized dPG (a multivalent macromolecular crosslinker) and cyclooctyne functionalized PEG (a linear macromolecular spacer/crosslinker). It encapsulates the biomolecule upon cross-linking or alternatively, the interacting sensor molecule can also be immobilized covalently using residual functional groups of the hydrogel. This not only ensures a high loading with enhanced sensitivity due to the 3-dimensional structure but also an optimal distribution of the biomolecule without any diffusion limitation. Since the gel components are bioorthogonal there is no interaction with the binding site of the biomolecule and also the hydrogel mimics a solution like environment for a more natural accommodation of the immobilized biomolecule. Furthermore the network can act as a prefilter and prevent larger molecules to enter the network. The enhanced loading capacity and sensitivity is shown for Streptavidin, ANTI-FLAG antibody and covalently bound oligonucleotides. The hydrogels are studied by many analytical methods, such as rheology, AFM and IR to characterize their properties. The ultimate goal is to offer a feasible approach to solve a diverse number of biosensing issues. We want to make use of the different approaches of designing the hydrogel by varying the length of PEG linker, changing the degree of functionalization and altering the PEG/dPG ratio. By doing so we plan to increase the scope of applicability to biomolecules and substrates of different kinds.

Keywords: biosensors, biointerface, 3D matrix, surfaces, *in situ* hydrogel, microarray, immunoassay

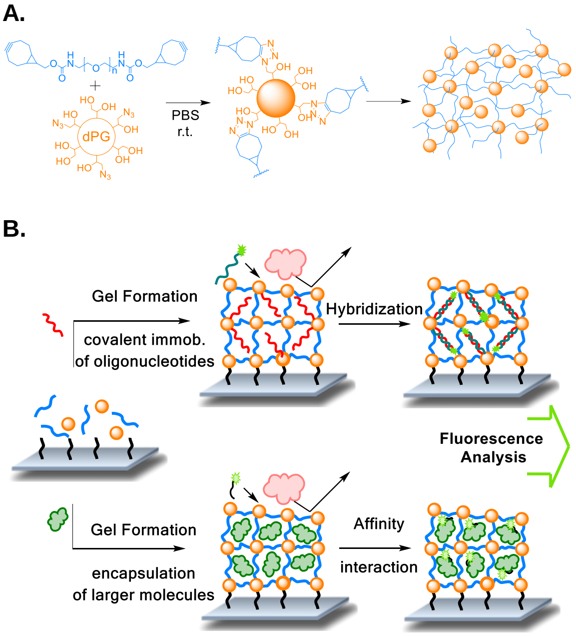

Figure 1: **A.** illustrates the gel components and how the network is built. **B**. gives a 2D representation of the network and visualizes the *in situ* hydrogel formation with simultaneous biomolecule entrapment. Larger entities will be excluded whereby smaller molecules can freely interact with the capture molecule within the solution like environment of the hydrogel. The detection is realized by flupescence analysis.

Session II:
Thin Films characterization and properties

Using the Concept of Self-Adaption for Improving the Performance of Tribological Coatings

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Abstract:

There are two important achievements to be reached for improvement the performance of tribological coatings: wear resistance and low friction. In most part of cases, these achievements are antagonic in relation to the mechanical behavior of a material. In fact, usually low friction in sliding contacts requires materials with low shear strength, to induce low friction forces. On the other hand, wear resistance is typically attained with materials with very high hardness, i.e. with very high mechanical strength. What would be perfect for accomplishing both objectives would be to have a material with intrinsic high mechanical strength which, in the surface close to the mechanical contact, would present low shear strength. Even though it could be easy to built a component fabricated in this way, with a bulk hard material covered with a low friction layer, this would not work in service since the soft surface layer would wear immediately. Therefore, the only possibility is to have an intrinsic high strength material which, during service, can form a low friction layer on the sliding contact, i.e. to have a hard material with a self adaption ability to transform the high strength material in a low strength one. As friction and wear are typically surface materials properties, all this thematic should be understood when materials are considered under the form of coatings, themselves already a potential solution for those situations where it is necessary to provide a mechanical component with additional functions related to superficial loading.

In this talk, examples of how to improve the performance of tribological coatings by self adaption mechanisms will be presented. In the first example, the advantages and drawbacks of transition-metal dichalgogenides (TMDs) will be presented as low friction materials. The solutions to overcome the drawbacks will be discussed based on the addition of third elements to the TMD coatings, mainly to improve their mechanical strength. Then, we will show the way how initial structural arrangement permits, simultaneously, multiply the hardness and achieve friction coefficients at reasonably low values when tested in humidity containing atmospheres. In all cases, the good friction performance is achieved by structural transformations in the contact zone motivated by the shear stresses and/or local increasing temperatures.

In a second case, solutions for decreasing the friction coefficient when sliding at high temperatures will be presented. The chemical transformation of the sliding interface by forming low friction transition-metal oxides will be explored as self-adaption mechanism. The examples will involve transition metal nitride coatings based on Ti alloyed with Cr and V. For the first, the direct formation of Cr-oxide will contribute for improving the cutting performance of coated tools by decreasing the friction coefficient. In the second one, a special structural arrangement for controlling the outwards diffusion of V in the coatings will allow to have a permanent self-lubrication activity in the coatings.

Keywords: Tribological behavior; hard coatings; low friction, wear resistance, self adaption, self-lubrication, transition-metal dichalcogenides, lubricating oxides, cutting performance.

Micro/ macroscopic elastic constants of thin films determined by using Impulse Excitation Technique and X-ray diffraction

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Abstract:

Many methods were developed to obtain the elastic constants of coated materials, which are classified into two groups: static and dynamic techniques. The elasticity of thin films may be different from this of bulk materials and depends on the elaboration technique. The analytical models, reported in the literature, used to determine the Young's modulus of a coating are based on two different theories: the flexural rigidity of a composite beam and the classical laminated beam theory (CLBT). The problem is that the validity of these models depends on coating's thickness and physical properties of both coating and substrate.

This work presents a new methodology on the determination of the elasticity constants of thin films using the impulse excitation technique (IET). It is non-destructive technique with high precision and with which the elastic constants are easy to measure. The tests rely on the measurement of the sample resonance frequency before and after deposition.

This study was carried out on pure metallic thin films of aluminum and tungsten deposited on glass and steel substrates by DC magnetron sputtering. The thickness of these films was in the range 3-6 µm deposited on substrates of 1 mm thick. Many experimental tests were employed: IET, Nanoindentation, SEM and XRD.

Finite element model (FEM) was developed on ABAQUS software, and then the comparison with the analytical approaches allowed to identify the limits and drawbacks of each one. The best model to determine the film Young's modulus was identified.

A new analytical model was developed to determine the macroscopic shear modulus of a coating. The model was numerically (FEM) and experimentally confirmed by studying tungsten films deposited on glass substrates. The choice of tungsten was done because it is well known that its elastic behavior at crystal scale is ideally isotropic.

In our study, we focus also on the determination of the microscopic elastic constants of tungsten coating revealing the presence of two phases: W-α and W-β. These phases are respectively stable with a CC structure and a metastable phase with a cubic structure. The goal is to determine the elasticity constants of the W-β phase not sufficiently known in the literature. The macroscopic elastic constants, pole figures made by X-ray diffraction and the crystalline orientations of the two phases were determined. The relationship between strain and stress has been established using the self-consistent model. This relation is a function of the elasticity constants of the W-β phase, the W-α phase and the macroscopic elastic constants of the tungsten film.

Keywords: Mechanical characterizations, Young's modulus, shear modulus, Poisson's ratio, elastic constants, thin films, coatings, Impulse Excitation Technique, PVD, XRD.

References:

1. Slim, M.F., Alhussein, A., Sanchette, F., Guelorget, B., François, M. (2017) A new enhanced formulation to determine Young's and shear moduli of thin films by means of Impulse Excitation Technique, *Thin solid films*, 631, 172-179.
2. Slim, M.F., Alhussein, A., Billard, A., Sanchette, F., François, M. (2017) On the determination of Young's modulus of thin films with Impulse Excitation Technique, *Journal of Materials Research,* 32 (3), 497-511.

Industrial X-ray Fluorescence Coating Thickness Analyzer Application for Phosphate Coating Thickness on Steel

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Abstract

The results of industrial application of the online X-ray fluorescence coating thickness analyzer (CTA-02) for measuring the thickness of phosphate coating on a moving steel strip are considered in the article. The target range of coating thickness to be measured is from tens to hundreds of mg / m2 with a measurement time of 10 seconds. The measurement accuracy shown during long-run factory acceptance test is 10-15%. The system consists of two XRF analyzers mounted above and below the steel strip and capable of moving across the moving strip. Fully automated software was developed for automatic and continuous (24/7) control of two CTA-02 coating thickness analyzers, scanning both sides of the steel strip, developing and testing methods for measurement of new coatings, offline storage and reviewing of measurement results and remote control of analyzer components and measurement modes from the plant level. The CTA-02 system can also be used for real-time measurement of other types of coatings, both metallic and non-metallic.

Keyword: XRF, Surface coating, Phosphate, On-line

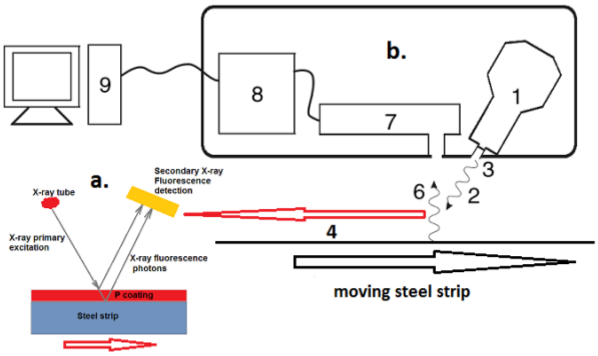

Figure 1. XRF emission of phosphorus fluorescence line from phosphate coating on steel substrate (a) and schematic diagram of XRF on-line coating thickness analyzer (b)

Reference

1. T. Narayanan, Rev. Adv. Mater. Sci., 2005, 9(2), 130–177
2. D. Zimmermann, A. G. Munoz and J. W. Schultze, Surf. Coat. Technol., 2005, 197(2–3), 260–269
3. MOW Richardson, RE Shaw In book: Corrosion, 1994, pp.15:22-14:37, DOI 10.1016/B978-0-08-052351-4.50119-9].
4. Australian Standard No. 1627.6-1977. Phosphate Treatment of Iron and Steel Surfaces.
5. Tables of phosphate coating thicknesses : http://www.kiesow.org/en/products/phosphating-processes/
6. Coating Thickness Measurement by Means of the Radioisotope X-Ray Fluorescence Technique. M. Salmi, G. Gigante, Isotopenparxis, 1978.
7. Portable XRF spectrometer for coating thickness measurements, A.Carapelli et al, Review of Scientific Measurements, 2007, v.78, issue 12.
8. Handheld modern computer brings new features to portable X-ray fluorescence coating thickness measurement device, A.Carapelli et al, Computer Physics Communications, 2011, 182, 1304-1306].
9. AXIC Application Report No. 1, Analysis of Phosphorus in PSG and BPSG with the AXIC-100 XRF System, 1988
10. Sokolov, A. D., et al. On-line analysis of chrome–iron ores on a conveyor belt using x-ray fluorescence analysis. X-Ray Spectrometry, 2005; **34**, pp. 456–459
11. http://bsi.lv/en/applications/analytical-applications/-line-multichannel-coating-thickness-analyzer/
12. R. E. Van Grieken and A. A. Markowicsz, *Handbook of X-Ray Spectrometry*, Practical Spectroscopy Series Vol. 29, 2nd ed. Dekker, New York, 2002 p. 366.
13. *Handbook of X-Ray Spectrometry Second Edition*, edited by R. E. Van Grieken and A. A. Markowicsz, Practical Spectroscopy Series Dekker, New York, 2002, Vol. 29, p. 243.

Wetting of highly superhydrophobic textures

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Abstract:
Some natural or recently developed artificial surface textures show extremely high liquid repellent features for which the classical sessile drop technique, usually considered for determining the wetting properties, is not applicable anymore (the drop does not adhere at all, even with liquids of very low surface tension). The potential functional properties of such surfaces requires however to characterize the ability of theses textures to resist wetting (*i.e.* to characterize the stability of the air pockets trapped in between the liquid and the surface).

Here we discuss the Wilhelmy plate tensiometer as an alternate technique to explore the wetting resistance of model textured surfaces as compared to the sessile drop and bouncing drop approaches. We have considerd in this work, micropillared surfaces, as well as superhydrophobic femtolaser textured surfaces, for which the characterization of wetting properties is not possible with the sessile drop technique.

In the case of the micropillared surfaces, extremely good correlation was found between the wetting hysteresis measured with the Wilhelmy plate tensiometer, and that measured with the sessile drop technique. In the case of the superhydrophobic surfaces, the Wilhelmy plate tensiometer allowed measuring wetting forces (*i.e.* wetting hysteresis) that was not possible with the sessile drop technique. Additionally, the wetting transitions observed on the micropillared surfaces and the superhydrophobic surfaces while using the Wilhelmy plate tensiometer was related to the wetting transitions produced with the bouncing drop technique

Our results demonstrate that the Wilhelmy plate tensiometer is particularly suitable for the characterization of the wetting properties of highly liquid repellent surfaces through the measure of the liquid anchoring force. Moreover it allows characterizing the underwater sustainability of these repellency features which cannot be determined with the commonly used techniques (sessile drop or bouncing drop), and which are of fundamental importance for many applications.

Keywords: wetting, superhydrophobic, Wilhelmy plate tensiometer, drop rebound.

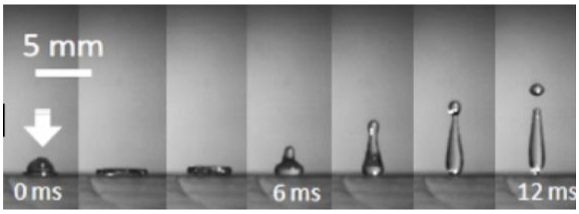

Figure 1: High-speed images sequence of a water droplet hitting a superhydrophobic surfaces at an impact velocity of 1.1 $m \cdot s^{-1} \pm 0.1$ $m \cdot s^{-1}$.

References:

1. Hisler, V., Jendoubi, H. Hairaye, C., Vonna, L., Le Houérou, V., Mermet, F. Nardin, M., Haidara, H. (2016), Tensiometric characterization of superhydrophobic surfaces, as compared to the sessile and bouncing drop methods, *Langmuir*, 32 (31), 7765–7773.
2. Hisler, V., Vonna, L., Le Houerou, V., Knopf, S., Gauthier, C., Nardin, M., Haidara, H. (2014), Model Experimental Study of Scale Invariant Wetting Behaviors in Cassie–Baxter and Wenzel Regimes, *Langmuir*, 30 (31), 9378–9383.

Prediction Model for Oil-water Separation Based on Membranes with Special Wettability

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Abstract:

In this study, we fabricated superhydrophilic (SHPi), superhydrophobic(SHPo) wettability on SUS mesh using spray coating method. Figure 1 shows the FE-SEM images of the modified mesh. One can see that the modified mesh is uniformly covered with SHPo SiO_2 (Figure1 a-b) or SHPi TiO_2 nanoparticles. To characterize the surface wettability, we measured the contact angles of water drop in the air and under oil environment as well as those of oil drop in the air and under water environment (Figure 2). As shown in left panels of Figure 2a, the modified surface with SiO_2 particles shows a high contact angle of water drop (>150°) and a low contact angle of soybean oil in the air, exhibiting superhydrophobicity. Meanwhile, the surface modified with TiO_2 particles exhibits the low contact angle of both water and oil drops in the air because of high surface energy of SHPi surface (Figure 2b).

Using fabricated samples, we investigate three separation performance parameters, i.e., separation efficiency, liquid intrusion pressure and particularly mass flow rate, as a function of pore geometries and liquid properties using fabricated meshes.

We tested the separation efficiency through the water-wetted SHPi mesh. Figure 3(a-b) show images of before / after water separation through water-wetted SHPi mesh. All tested cases demonstrate high separation efficiency over 98%.

The intrusion pressures of water (or oil) on oil-wetted SHPo (or water-wetted SHPi) mesh were measured to quantify the maximum static pressure below which the prepared mesh can successfully separate the oil-water mixture. The intrusion pressure is determined by the balance between the static pressure and the Laplace pressure. As shown in Figure 4, the balance with the Laplace pressure reasonably captures the influence of pore size.

The mass flow rate through the mesh is measured as a function of the pore size and liquid viscosity, and is explained using the semi-empirical model based on the mechanical energy balance. As shown in Figure 5, there is excellent agreement between the experimental values and modeling values.

As one application example of our performance analysis, we successfully predict the required time for gravity-driven separation of the oil-water mixture (Figure 6).

We hope that our work provides the useful framework, which helps to plan efficient settlement of issues by oil.

Keywords: oil-water separation, Selective wettability, Membrane, Mass flow rate, Separation efficiency.

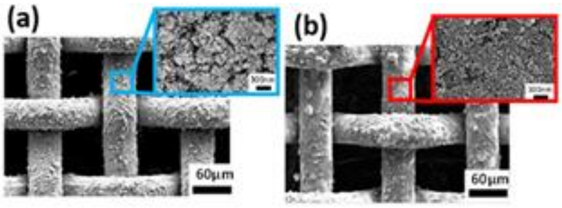

Figure 1. FE-SEM images of the modified mesh by a spray coating method. (a) SHPo mesh and (b) SHPi mesh**.**

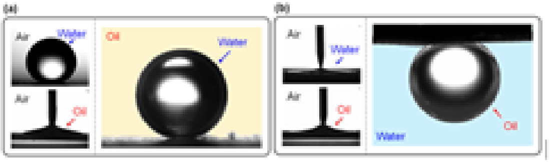

Figure 2. Image of droplet at selective-wetting samples.

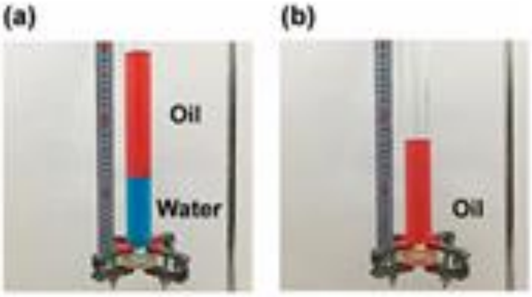

Figure 3. (a-b) Images of before / after water separation through water-wetted SHPi mesh.

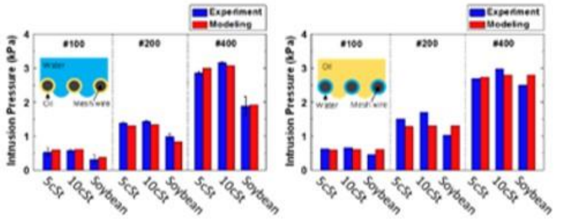

Figure 4. Results of intrusion pressrue test at SHPo wetted by oil and SHPi wetted by water.

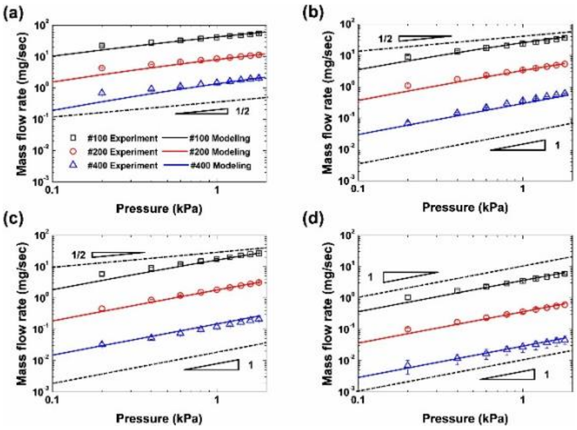

Figure 5. Mass flow rates per single pore as a function of hydrostatic pressure; (a) water, (b) silicone (5cSt), (c) silicone (10cSt) and (d) soybean oil.

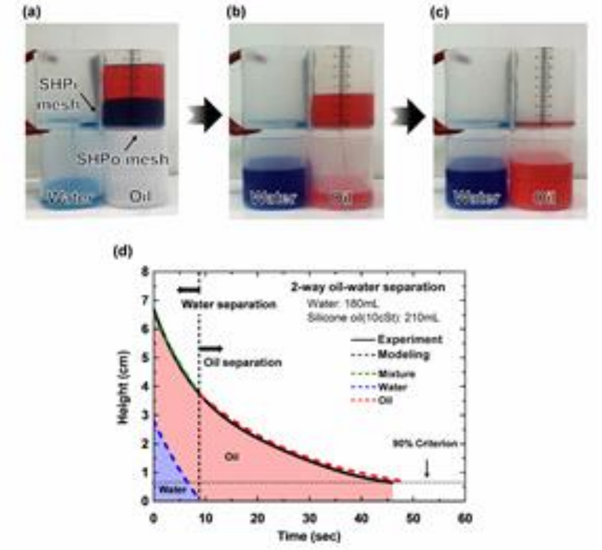

Figure 6. Oil-water separation sequence in 2-way oil-water separation. (a-c) Sequential images of 2-way oil-water separation, (d) experimentally measured liquid height over time along with the modeling value.

Acknowledgments

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References:

1. Li, J., Yan, L., Hu, W., Li, D., Zha, F., Lei, Z. (2016), Facile Fabrication of Underwater Superoleophobic TiO_2 Coated Mesh for Highly Efficient Oil/Water Separation, Colloids Surf. A, 489, 441– 446.
2. Basu, B. B. J., Paranthaman, A. K. (2009), A simple method for the preparation of superhydrophobic PVDF–HMFS hybrid composite coatings, Appl. Sur. Sci., 255, 4479-4483.

Direct influence of the surface roughness on contact angle and surface free energy

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Abstract:
Optimiziation of material surface properties is crucial in numerous applications including biomaterials, industrial coatings and printing. Surface topography, chemical composition and surface energy of the material have all been recognized as vital parameters in these processes. Water contact angle is a widely utilized method predicting the wettability and adhesion of a surface. However, measuring only the contact angles will result in overestimation of the hydrophilicity or hydrophobicity as surface roughness will enhance the existing chemical properties. By measuring both surface roughness and contact angle at the same sample area, it is possible to separate the effect of the roughness from the effect of the surface chemistry, providing more meaningful contact angle and surface free energy through Wenzel correction [1].

In this study, a novel instrument is presented for an automated measurement of roughness-corrected contact angle and surface free energy. The system consists of a contact angle meter combined to an optical 3D topography module which measures surface roughness based on the principle of fringe projection phase shifting in which a structure illumination pattern of sinusoidal intensity is projected on a surface [2]. After measuring the surface roughness, the contact angle is automatically measured from the exact same spot where the roughness was measured, and a roughness-corrected contact angle and surface free energy is provided.

The novel system was used for measuring several surfaces. It is shown that the surface roughness in these surfaces has a significant effect on the measured contact angle and surface free energy values which should be taken into account while considering the properties of the surface. This technology makes it possible to combine both surface chemical and microscale topographical characterization for better characterization of surfaces.

Keywords: contact angle, surface roughness, surface free energy, roughness-corrected contact angle

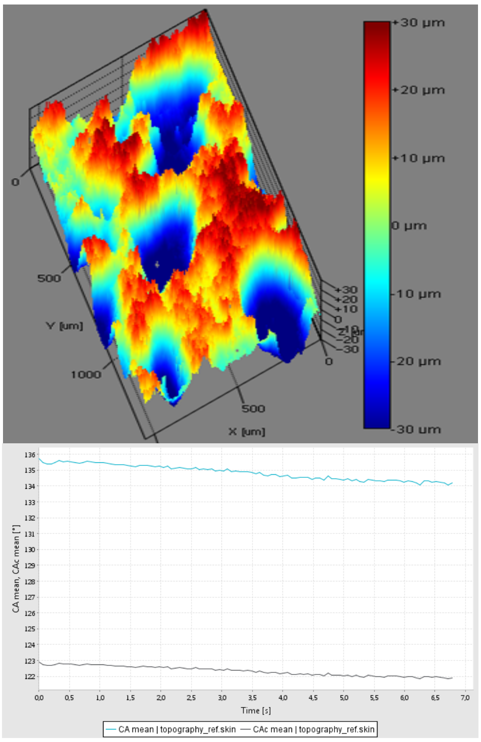

Figure 1: 3D Topography image, and measured and roughness corrected contact angles on artifical skin show the effect of roughness on wettability.

References:

1. Wenzel, R.N., “Resistance of solid surfaces to wetting by water”, Industrial and engineering chemistry, 28, 8, 1936, 988- 994.
2. Zhang, S. and Huang, P., “High-resolution, real-time 3D shape acquisition”, Conference on computer vision and pattern recognition workshop 2004 (CVPRW ’04).

An Analysis on Effects of Weathering on EPDM Vehicle Sealing System Surfaces

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Abstract:

Weatherstrips are used in vehicles for avoiding noise, dust and water infiltration to the vehicle. The sealing profiles which are applied on doors, glass run channels (GRC), outer/inner belt line, hoods and trunks are generally made of synthetic ethylene propylene diene monomer (EPDM) rubber and TPX materials. EPDM rubbers have acceptable resistance to heat, light, oxidation, ozone deterioration; thus ageing. The ageing process depends on compound design mixing and extrusion. The aim of this study is evaluating the UV resistance of profile surface compound coating. For this purpose selected roof and outer belt line profiles, which are directly effected from the sun light, are left under environmental conditions and subsequent weathering tests for one year. The changes, that are occurring on the surface are quantified by visual assessment and CIELab measurements. Referring to the obtained data a new compound more resistant to uv degradation is designed. In this paper, the fundamental research is scientifically explained.

Keywords: EPDM, Sealing Profiles, Weathering, UV aging, Surface coating

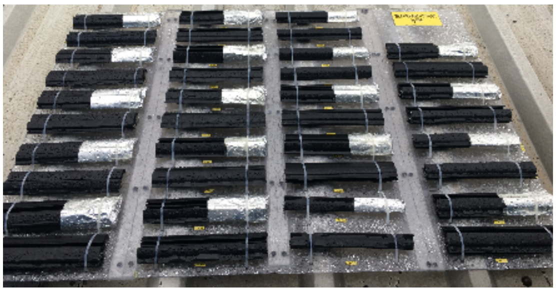

Figure 1: Figure illustrating the outside testing bench where profiles are exposed to changing weather conditions without noise factors like car shampoos, insect cleaners. These profiles are shielded partially for comperative purposes to evaluate UV aging.

References:

1. N. Saleema, D. Gallant, Applied Surface Science, 282(2013) 98-104.
2. S. Kucuk, H. Gerengi, Y. Guner. “Effect of ultraviolet (uv) stabilizers on rubber-based automotive sealing profiles.” 4th International Symposium on Innovative Technologies in Engineering and Science, Alanya, Turkey, 3-5 November 2016.
3. E. Altuncu, U. Olgun, A.E. Kutlu, Y. Güner, M. Çağlayan. “Surface Characterization Study on EPDM Rubber Seal Profiles”. 18th International Metallurgy & Materials Congress, İstanbul, Turkey, 29 September-01 November 2016.

Smart coatings with interfacial thermoreversible properties

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Abstract:

Stimuli-responsive materials have properties that depend on the environment in which they are used. In most cases, the material itself is formulated to react to the corresponding stimulus. However, many phenomena occur at the surface of the material. In this context, our group works on stimuli-responsive surfaces based on plasma polymer thin films whose properties vary according to their environment. More precisely, the aim of this study is the investigation of the reactivity of functional coatings fabricated by plasma polymerization and subsequent surface post-modification. The smart polymer films are designed to react via Diels-Alder chemistry, a thermoreversible reaction, which make them responsive to a temperature change. This [4+2] cycloaddition between a diene and a dienophile has been mainly studied in solution.[1] In this work, the Diels-Alder reaction is investigated onto plasma polymers, which can be deposited on any material (nature, geometry). Experimentally, poly(maleic anhydride) is first deposited on various types of substrates by plasma polymerization, a solvent-free surface functionalization process.[2] Then, an aminolysis reaction, performed in vapor phase, enables the grafting of furan-terminated compounds onto the functional plasma polymer. These reactive surfaces, having diene groups, are subsequently immersed into a dienophile solution in order to investigate their interfacial reactivity regarding Diels-Alder reaction. The reaction progress of cycloaddition was monitored by several surface characterization techniques (PM-IRRAS, XPS, contact angle measurements). A thermodynamics methodology has then been developped to characterize finely Diels-Alder interfacial reaction on coatings with various physico-chemical properties. It can be noticed that coatings with different crosslinking rates strongly differ in entropy and enthalpy contributions of Gibbs energy. Of course, the reversibility of this reaction was also investigated (Figure 1) and outstanding results have been obtained without any alteration of the functional polymer coating even after five Diels-Alder / retro-Diels-Alder cycles. The development of these functional polymer coatings with thermoreversible properties is, among others, a promising milestone for controlled immobilization and release of biomolecules onto/from a multitude of substrate materials.

Keywords: smart polymer coating, thermoreversible chemistry, interfacial Diels-Alder reaction, plasma polymerization.

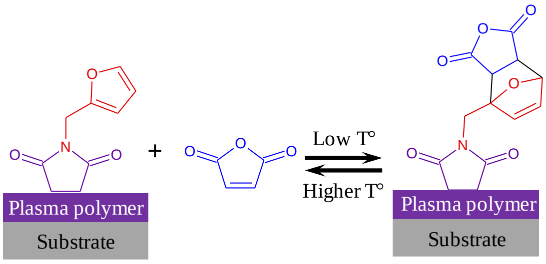

Figure 1: Interfacial Diels-Alder and retro-Diels-Alder reactions between a furan-terminated compound (diene) grafted on a plasma polymer coating and maleic anhydride (dienophile) in solution.

References:

1. Gandini, A., Coelho, D., Silvestre, A.J.D. (2008), Reversible click chemistry at the service of macromolecular materials. Part 1: Kinetics of the Diels–Alder reaction applied to furan–maleimide model compounds and linear polymerizations, *Elsevier*, 44, 4029-4036.
2. Siffer, F., Ponche, A., Fioux, P., Schultz, J., Roucoules, V. (2005), A chemometric investigation of the effect of the process parameters during maleic anhydride pulsed plasma polymerization, *Analytica Chimica Acta*, 539, 289-299.

Focused session on thin film / coatings tribology

The dry sliding wear and self-adaptive friction property of transition metal nitride coatings

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[4]Teer Coatings Ltd., Miba Coating Group, Droitwich, UK

Abstract:

This keynote presentation provides a survey on our research on the self-adaptive friction of transition metal nitride (TMN) coatings grown by physical vapour deposition (PVD). Nitride hard coatings are widely used in various wear resistant applications such as in metal machining tools and forming moulds. Good wear resistance relies not only on the high hardness but also on the low friction. In particular, some metal elements are able to bring about self-adaptive low friction properties. Regarding the friction mechanisms, our previous experiments of cross-sectional transmission electron microscopy (XTEM) and the associated energy dispersive X-ray spectroscopy (EDX) and electron energy loss spectroscopy (EELS) have found that, a nano-scale amorphous or nanocrystalline tribofilm can be generated on the worn surface. The tribofilm then works as an intermediate layer between the sliding couple surfaces to govern the severity of frictional force. Consequently, the friction coefficient varies with the chemical compositions of the nitrides and is environmental dependent. More recently, a group of magnetron sputtered nitride coatings of various transition metal components have been investigated in dry sliding wear tests against an alumina ball to evaluate the friction and wear properties. The results reveal that, the TMN coatings containing V, Cr or Mo have remarkably lower friction coefficients than other TMN coatings, including TiN, TiAlN and AlTiSiN. Both the nanocomposite VSiN and nano-multilayer TiAlN/VN coatings show the lowest wear coefficients owing to the combined properties of super hardness and self-adaptive low friction coefficient. On the other hand, the hard coatings of high friction coefficients show much more pronounced wear.

Keywords: Friction coefficient; Wear; Tribofilms; Physical vapour deposition; Hard coatings; Transition metal nitride (TMN)

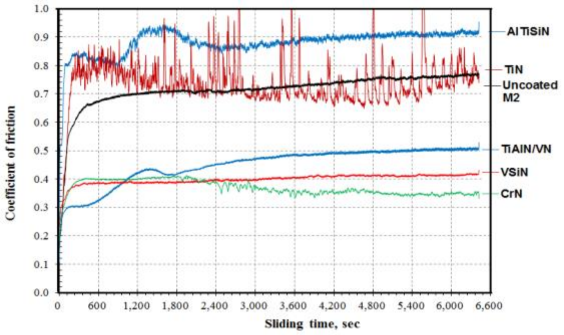

Figure 1: Friction coefficient curves of selected transition metal nitride coatings in dry reciprocating sliding against an alumina ball.

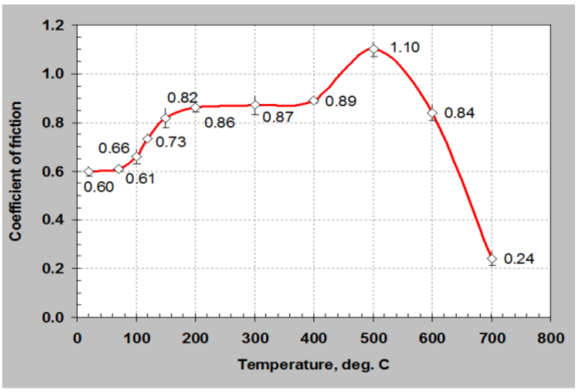

Figure 2: The average friction coefficients of TiAlN/VN coating plotted versus the testing temperature.

References:

1. Q. Luo, Tribofilms in solid lubricants, in ***Encyclopedia of Tribology***, edit. Q. Jane Wang and Yip-Wah Chung, Springer Science, 2013, p3760-3767.
2. Q. Luo, Origin of friction in running-in sliding wear of nitride coatings. ***Tribo. Lett.*** 2010, 37, 529–539.
3. F. Huang, F Ge, P. Zhu, H. Wang, F. Meng, S. Li, Superhard V-Si-N coatings (>50 GPa) with the cell-like nanostructure prepared by magnetron sputtering, Surf Coat Technol. 232, 2013, 600-605.

CATALYTICALLY ACTIVE COATING FOR TRIBOLOGICAL APPLICATIONS

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Abstract:

Coatings are extensively used to mitigate wear of components in mechanical systems, and they can reduce energy consumption trough decreasing friction on sliding surfaces. Here, we present an active coating that interact very well with unformulated and formulated lubricants and is able to reduce the friction at least 20%, while avoiding wear of the sliding surfaces [1]. We will describe in detailed manner how a tribo-catalysis phenomena enables the formation of a protective and lubricious carbon based tribofilm, which is extracted directly from hydrocarbon molecules of the lubricant. The metal catalysts that compound the coating enable the process that breaks the hydrocarbon molecules of oils and subsequently deposit as solid tribofilm on the contact areas. In this work the use of different tribometers (i.e., Pin-on-Disc and High Frequency Reciprocating Rig) and advance characterization techniques (such as Raman Microscopy, TOF-SIMS and HR-TEM) allow us to visualize and confirm the presence of the amorphous carbon-based tribofilms. Furthermore, the use of MD and ab-initio molecular dynamic simulations help us to confirm the important steps that that lead to the formation of this solid lubricious film extracted from a hydrocarbon precursor.

Keywords: catallyitically active coatings, sputtering, tribocatalysis, wear and friction studies.

References:

1. Ali Erdemir, Giovanni Ramirez, Osman L. Eryilmaz, Badri Narayanan, Yifeng Liao, Ganesh Kamath, Subramanian K. R. S. Sankaranarayanan. Carbon-based Tribofilms from Lubricating Oils. Nature (536) 67-71 (2016)

Zinc and Zinc-Iron Nanoparticles as Oxygen Scavengers

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Abstract:
In the last decade, nanoparticles (NPs) have attract a lot of attention because of their unusual characteristics when compared to bulk material, such as reactivity, antibacterial, optical and magnetic properties among others. In this study, ZnFe bimetallic NPs and AgAu bimetallic NPs were produced by plasma gas condensation process onto carbon substrates to exploit the galvanic couple formed for such dissimilar metals. ZnFe NPs are expected to provide oxygen scavenging promoted by galvanic corrosion properties for food packaging applications; while AgAu NPs are expected to form a galvanic pair promoting the Ag^+ release to incorporate in carbon matrix for biomaterials applications, namely ureteral stents with the purpose of reducing microbial encrustation.

The bimetallic NPs were produced by plasma gas condensation process consisting in a gas aggregation cluster source connected to the main deposition chamber of a magnetron sputtering equipment. In the case of ZnFe NPs production, a Fe (99.5 %) target with an area of 2000 mm^2 was connected to the magnetron head of cluster source. In the deposition chamber, a Zn (99.99%) target with 100 × 200 mm^2 was connected. For the production of AgAu NPs, an Ag (99.99%) target modified with Au pellets (99.99%) with an area of 2000 mm^2 was connected to the magnetron head. All depositions were performed in Ar atmosphere.

The structure, morphology and composition of the NPs were determined using both a JEOL 2100F TEM and an FEI Titan-ChemiSTEM. STEM/EDX elemental maps were used to evaluate the evolution of ZnFe NPs oxidation as a function of time and relative humidity (RH) and to AgAu NPs were used to evaluate the distribution of Ag related with Au.

The results demonstrate that for ZnFe NPs produced by gas agglomeration system, the oxidation is potentiated, showing a higher dissolution rate compared to ZnFe nanoalloys created by conventional magnetron sputtering. These results demonstrate the possibility of controlling the oxidation/dissolution of the nanoparticles, which may regulate the oxygen scavenger capabilities and the migration of the nanoparticles. For AgAu NPs, the results shown a shell formed by silver on the gold. Some particles also show the formation of Ag satellites on the gold which can promote the oxidation of Ag and thus become an antimicrobial agent.

Keywords: Zinc, Iron; galvanic potential, nanoparticle; oxidation; relative humidity; TEM, food packaging, magnetron sputtering.

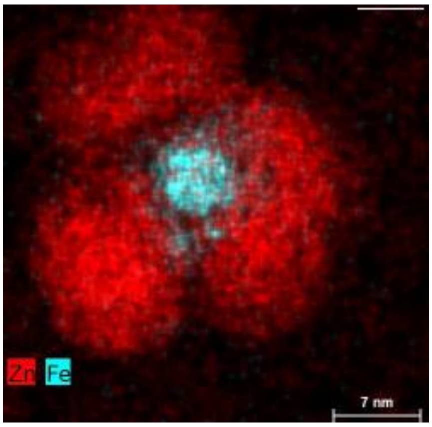

Figure 1: Zn-Fe Bimettalic NP

References:

1. S. Calderon Velasco, B. Gomes, P. Ferreira and S. Carvalho (2017), Zinc Nanostructures for Oxygen Scavenging, Nanoscale, 9, 5254-5262.

Development of robust and self-lubricating coatings of nickel-nanoparticle Composite

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Abstract:

Composite coatings via codeposition of inert particles suspended in the electrolyte offer a robust and versatile tribological performance compared to the deposition of pure metals. In particular, the incorporation of solid lubricant particles such as graphite, molybdenum disulphide (MoS_2) and tungsten disulphide (WS_2) enables self-lubrication on surface, which results in significant reduction of wear loss in engineering components. In comparison with direct application of solid lubricants, the composite deposits offer a wide range of advantages such as improved adhesion to metallic substrates, increased heat conductance for the deposit and lower wear rate, hence longer service life, which are beneficial for applications in demanding conditions.

One major challenge for the electrodeposition of self-lubricating composites is the dispersion of micro / nano solid lubricant particles in the plating bath. These composite coatings suffer from poor adhesion and low hardness due to the accumulation and porous of MoS_2 dendrites throughout the deposit which may lead to a premature coating failure. Agglomerated particles from insufficient dispersions may have some adverse effects on the tribological performance and corrosion resistance. The dispersion of micro / nanoparticles in an aqueous plating bath should be achieved via a combination of appropriate surfactants and vigorous agitation, especially for hydrophobic solid lubricant particles. However, particle dispersion is often overlooked in literature which may contain little description on the dispersion technique or characterisation of particle-bath suspension stability.

High-shear mixing has been proposed for the first time for particle dispersion. The dynamic light scattering technique "Zetasizer" proved its facile and effective way to achieve stable and narrow particle dispersions. In comparison, other agitation techniques including magnetic stirring and ultrasound vibration were much less effective in breaking down nano-particle agglomerates in the bath. The Ni-MoS_2 composite coating via high-shear mixing had the compact structure, lower coefficient of friction and thus enhanced wear resistance in dry wear tests, where the other agitation techniques led to porous and fragile deposits with poor tribological properties due to particles agglomerates. This keynote will review a number of process parameters in electrodeposition can affect the composition and structure of Ni-MoS_2 deposits to understand their influence on the dendritic growth of Ni-MoS_2 deposits, and highlight the importance of agitation effectiveness for particles particular nanoparticles dispersion during electrodeposition, which resulted in a significant influence on the tribological performances of the composite coatings.

Keywords: High-shear mixing; Self-lubrication; Friction; Electrodeposition; MoS_2

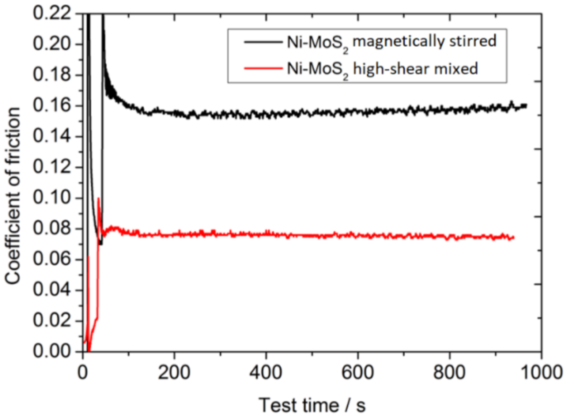

Figure 1: Coefficient of friction as a function of test time for Ni-MoS_2 composite coatings.

References:

1. Y. He, W.T. Sun, S.C. Wang, et al, An electrodeposited Ni-P-WS_2 coating with combined super-hydrophobicity and self-lubricating properties, Electrochimica Acta, 2017, 245, 872-882
2. Y. He, S.C. Wang, F.C. Walsh et al, Self-lubricating Ni-P-MoS_2 composite coatings, Surface and Coatings Technology, 2016, 307, 926-934

Nanoscale friction: From solid lubricants to electricity nanogenerators

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Abstract:

2D materials, such as graphene or transition metal dichalcogenides, may be used as lubricants in nanoscale contacts, but their applicability as externally supplied lubricants in mainstream engineering applications is questionable. Preferably, low dimensional materials minimizing friction should be produced continuously during the sliding process. We show our recent results on solid lubricant coatings with self-adaptive nanostructure. Our ultimate ambition is to prepare thin films, which will produce an ultra-low friction interface based on optimised low-dimensional structures in situ, i.e. during sliding.

We try to establish links between fundamental properties of selected 2D materials obtained by ab initio methods (electronic structure, covalency, etc. [1,2]), molecular dynamics and measured friction [3]. Moreover, we will show that research in friction can open new suprising capabilities of solid lubricants, namely ability to generate electrical charge by sliding.

Keywords: friction, ab initio, molecular dynamics, AFM, KFM, transition metal dichalcogenides, nanogenerator, thin film, CVD, magnetron sputtering

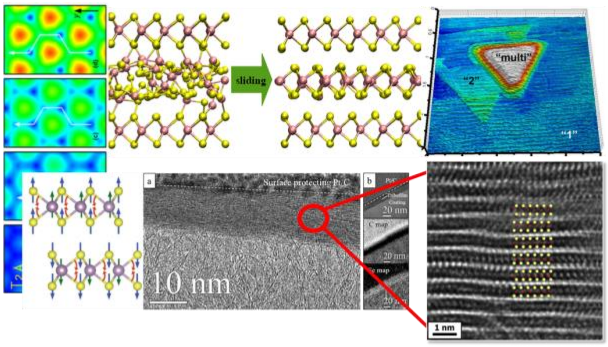

Figure: Nanosclae investigation, both experimental and computational, of sliding interfaces of amorphous/layered/2D transition metal dichalcogenides.

References:

1. G. Levita et al, J. Phys. Chem. C 118 (2014) 13809; Phys. Rev. B 92 (2015) 085434;
2. A. Cammarata & T. Polcar, Inorganic Chemistry 54 (2015) 5739; RSC Advances 5 (2015) 106809; Phys Chem Chem Phys 18 (2016) 4807 – 4813; B. Irving et al, Nanoscale 9 (2017) 5597
3. T. Polcar & A. Cavaleiro, Surf Coat Technol 206 (2011) 686; J. Zekonyte & T. Polcar, ACS Applied Materials & Interfaces 7 (2015) 21056

An examination of structural and mechanical properties of carbon doped CrAlN thin films deposited by HiPIMS/DC-hybrid processes

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[1] TU Dortmund University, Institute of Materials Engineering, Dortmund, Germany

Abstract:
Due to their outstanding properties that allow to enhance the performance and service life of tools, nanocomposite coatings, synthezid by PVD-processes, have aroused enormous interest in the field of production engineering. Especially, the mechanisms involved in the phase separation during which two unmiscible phases (e.g. nc-TiAlN and a-Si_3N_4) are formed are widely used for maching applications to improve the oxidation and wear resistance of coatings. Nevertheless, within the field that works with highly stressed forming tools (such as Sheet-Bulk Metal Forming (SBMF), using bulk forming operations on sheet metals) the high mechanical normal and sheer stresses are the most challenging factors and demand hard protective coatings.

To handle these challenges, a new approach by systematically doping CrAlN coatings, which are well known for their tribological properties, with carbon is presented using hybrid HiPIMS/DC processes. During the reactive sputtering process, the ratio of the acetylene and the nitrogen flow is varied to change the chemical composition in the CrAlCN coatings. With respect to the stoichiometry and the microstructure, a detailed study using synchrotron radiation, including high resolution phase analysis of the crystalline parts as wells as of the formed a-C phases is presented. In addition, the development of the residual stresses in correlation with the changes of the microstructure are discussed. Based on these findings, the macroscopic properties such as hardness, the Young's Modulus, roughness, and the adhesion of the coatings to a AISI M3:2 steel substrate are analyzed. Finally, the results are contextualized for SBMF applications to evaluate the benefits of a carbon induced phase separation.

Keywords: PVD-technology, Nanocomposite, CrAlCN, Carbon doping, HiPIMS/DC

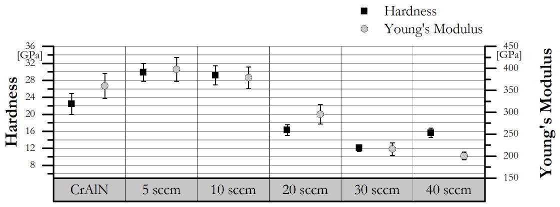

Figure 1: Mechanical properties (hardness and Young's Modulus) of the HiPIMS/DC CrAlCN coatings in dependency of the carbon content

Atomic Force Microscopy PinPoint Nanomechanical Mode for Nanoscale Modulus Mapping

Wenqing Shi, Gerald Pascual, Byong Kim, and Keibock Lee

Park Systems, Inc., 3040 Olcott St., Santa Clara, CA, USA

Abstract:
Nanomechanical property measurement is among one the most popular functions of atomic force microscopy (AFM). Conventional techniques for nanomechanical measurements are mainly based on AFM force-volume spectroscopy, which collects force-distance (F-d) curves at each pixel to calculate material elastic properties. However, these techniques have been recognized as being extremely slow and it usually takes hours to acquire an elasticity map. Driven by the demand for a faster and more efficient technique, Park Systems developed the PinPoint^{TM} Mode to provide a solution that is at least 100 times faster compared to the traditional techniques. Using this mode, an elasticity map with correlated topography image can be acquired within minutes. This mode represents a new application tool for acquiring real-time topography and quantitative mechanical property maps of various materials, ranging from hard disks to soft tissues.

Herein, to better access the capability of the PinPoint Nanomechanical Mode, we selected three cantilevers with stiffness ranging from 0.2 N/m to 25 N/m and investigated the influence of cantilever stiffness on the measured modulus values. In addition, for all three cantilevers, we also examined the influence of applied force on the resulted modulus. Results show that cantilevers with smaller force constants will lead to smaller measured modulus values, and vice versa. With the same cantilever, larger applied force will result in larger measured modulus compared to that obtained with smaller force values. Most important finding present in this report is that, with Park PinPoint^{TM} mode, the relative modulus difference/ratio within a sample can be accurately acquired, regardless of the force constant of the cantilever or the applied setpoint force valuesta.

Keywords: Nanomechanical measurements, Atomic Force Microscopy, Copolymer

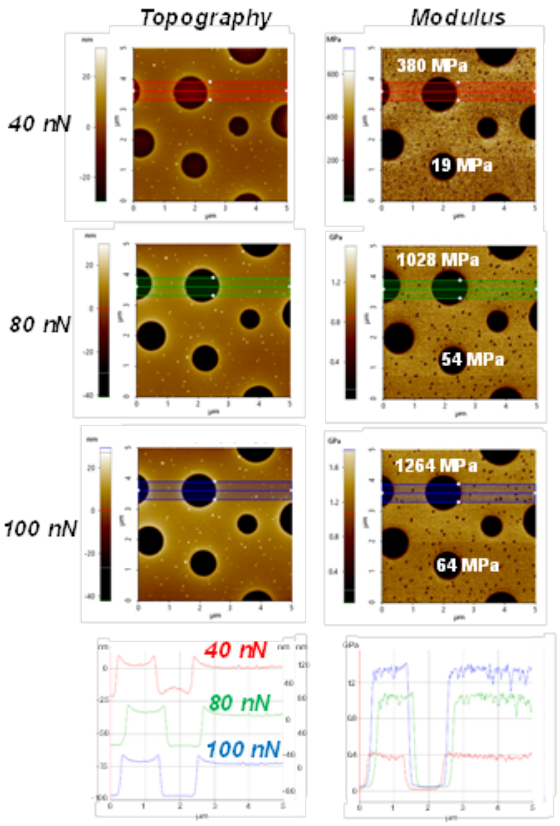

Figure 1: Topography and modulus images taken with typical noncontact mode AFM cantilever (having a ~30N/m nominal spring constant) at setpoint values of 40 nN, 80 nN and 100 nN, along with the corresponding overlaid topography and modulus line profiles.

Growth and characterisation of Fe-Ti-N coatings

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Abstract:
There is sustained interest in the environmental impact of new materials and the need to consider the sustainability aspects associated with their processing. This project focuses on how to replace existing hard coatings with alternatives that are more sustainable, and on how to achieve hard materials in a form compatible with the manufacture of microdevices. The Cambridge Department of Materials Science is a partner in the EU project SELECTA [1] targeting these issues. Herein we report some preliminary studies performed on the development and characterization of a sustainable coating system of the type Fe-Ti-N.

The coatings with compositions in the Fe-Ti-N system were fabricated by a combinatorial direct-current magnetron sputter deposition. The effects of deposition pressure, substrate cooling, and composition of the coating on the mechanical properties were reported. The coating deposited at 0.5 Pa at room temperature showed a nanohardness value of about 11 GPa and had a water-contact angle (88°) close to the hydrophobic range. Liquid nitrogen cooling of the substrates during deposition led to higher nanohardness and wear resistance, independent of the coating composition and thickness. Furthermore, liquid-nitrogen cooling affected the texture of the films, which was composition dependent.

Keywords: hard coatings, magnetron sputtering, mechanical properties, microdevices application.

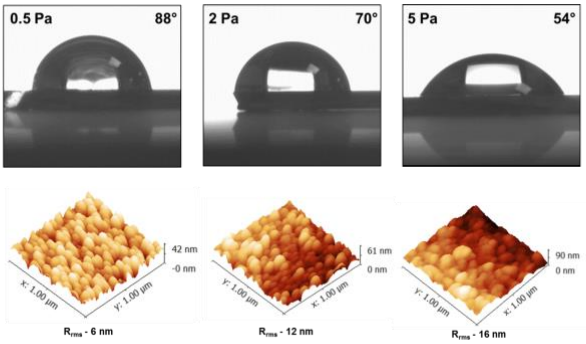

Figure 1: AFM images and water contact-angle (WCA) measurement goniometer pictures of Fe-Ti-N coatings deposited at various deposition pressures (DP). The DP and WCA values are given in the labels on the goniometer pictures.

References:

1. http://cordis.europa.eu/project/rcn/193932_en.html
2. U. Klement, E. Pellicer, J. Sort, “Mid-term meeting of SELECTA: a European Training Network on smart electrodeposited alloys for environmentally sustainable applications”, Transactions of the IMF, The International Journal of Surface Engineering and Coatings, 95 (2017) 124-125. DoI: http://dx.doi.org/10.1080/00202967.2017.1299307

Evaluation of tribological properties of water-based nanolubricant added with TiO_2 nanoparticles at elevated temperatures

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Abstract:

As the working conditions of lubricants used in hot steel rolling always involve high pressure and high temperatures in the contact zone between the work roll and the workpiece [1, 2], and the lubricants are continuously sprayed onto the work roll surface in practical hot steel rolling, it is of great significance to investigate the friction and wear characterisation of applied lubricants at elevated temperatures by providing the lubricants in a similar way. In this study, an innovative experimental method was introduced to evaluate the tribological properties of water-based nanolubricants containing TiO_2 nanoparticles (NPs) at elevated temperatures of 100-500 ℃. A Cr steel ball and a mild steel disk were used for friction pairs. Dry condition and water lubrication were applied to be benchmarks. As is shown in Fig. 1, various lubricants flowed along a plastic pipe that was connected to a copper pipe, and continuously dropped onto the rotating pre-heated disk. The temperature of the disk can be controlled prior to each tribological test, and the flowing rate of the lubricants can be adjusted by a flow regulator equipped. The results indicate that the TiO_2 NPs are well dispersed in distilled water, showing desirable suspension stability. The developed nanolubricnats with varying concentraions of 0.4-8.0 wt% TiO_2 NPs exhibit excellent friction-reduction and anti-wear properties at all temperatures. In particular, the nanolubricant containing 4.0 wt% TiO_2 as an optimal concentration results in the lowest coefficient of friction and the smallest ball wear among all the lubrication conditions. The lubrication mechanisms are primarily attributed to the formation of tribofilm and the rolling effect of TiO_2 NPs. This study o an innovative and effective way to evaluate the feasibility and applicability of water-based nanolubricants in hot steel rolling.

Keywords: TiO_2 nanoparticles, water-based nanolubricant, coefficient of friction, ball-on-disk.

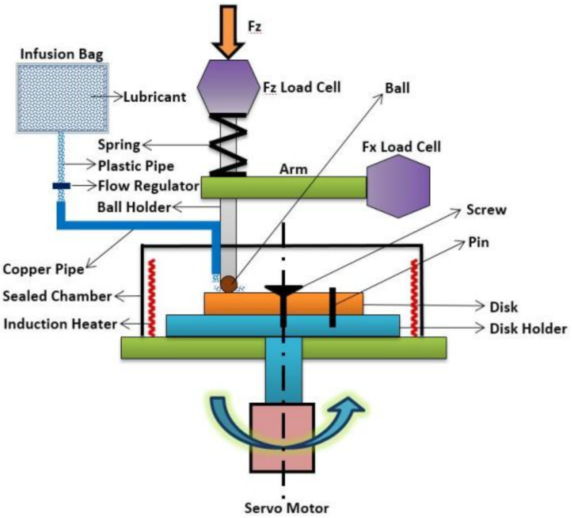

Figure 1: Schematic of ball-on-disk tribometer equipped with continuous dropping configuration for tribological test at elevated temperatures.

References:

1. Jiang, Z.Y., et al., Analysis of tribological feature of the oxide scale in hot strip rolling. Tribology International, 2010. **43**(8): p. 1339-1345.
2. Wu, H., et al., Analysis of TiO_2 nano-additive water-based lubricants in hot rolling of microalloyed steel. Journal of Manufacturing Processes, 2017. **27**: p. 26-36.

The effect of chromium content on cutting performance and oxidation resistance of TiAlCrN coatings

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[2] National Centre for Advanced Tribology, Faculty of Engineering and Environment, University of Southampton, UK
[3] University of Coimbra, Coimbra, Portugal
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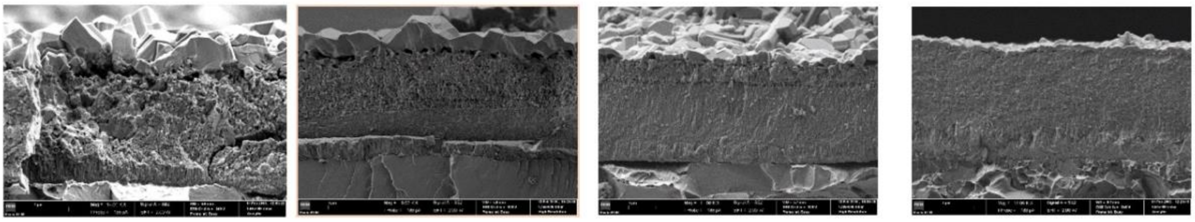
Abstract

Improvement of the durability and cutting performance of coatings designed for tools is an ongoing engineering challenge. There are two main paths to achieve such ambitious goal: to enhance oxidation resistance and/or to decrease friction. In this investigation we is focused on laboratory and industrial performance of TiAlN coating with higher oxidation resistance due to various content of chromium. The objective of the work is to increase the cutting speed of drillers.

TiAlCrN coatings with different content of chromium were deposited by unbalanced pulsed magnetron sputtering CemeCon 880 MLT industrial apparatus. TiAlN coatings were deposited as reference. The coatings were deposited on WCCo standard drills and cutting inserts to test their performance either in laboratory by drilling high-speed steel and Inconel as in real production by industrial partner. To measure oxidation resistance, oxidation speed was measured by thermogravimetric analysis (TGA); in this case fecralloy substrates were used. Tribological measurements were performed on CSM tribometer at temperatures up to 800°C. The worn surfaces, both from tribometer and real tools, were investigated by scanning electron microscopy equipped with Energy-dispersive X-ray spectroscopy (EDX) and by Raman spectroscopy. The wear was measured by 3D white light optical profilometry. Oxidation tests and tribological properties obtained in laboratory were compared with the behavior of the coatings deposited on tools.

Keywords: TiAlCrN, coating tribology, thermal stability.



EM micrograph of annealed coating cross-sections with increasing amount of Cr from left to right.

References

1. Forsén R., Johansson M.,Odén M., Ghafoor N., Decomposition and phase transformation in TiCrAlN coatings, J. Vacuum Technology A 30(6), 2012
2. Polcar T., Cavaleiro A., High temperature behavior of nanolayered CrAlTiN coating: Thermal stability, oxidation, and tribological properties, Surf. Coat. Technol. 257 (2014) 70

Session III:
Coatings for energy and environmental applications

Functionalization of electronic material interfaces with organic molecular agents

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Abstract:
The function and efficiency of electronic and optoelectronic devices crucially depend on the electron energy level alignment at interfaces, such as semiconductor heterojunctions (impacting interfacial energy and charge transfer) and between electrodes and semiconductors (impacting charge injection). To optimize device performance it is desirable to have methods that allow modifing the intrinsic interfacial level alignment. Strong molecular electron acceptor and donor monolayers are capable of tuning the work function of most inorganic electronic materials between < 3 eV to > 6 eV *via* interfacial charge transfer [1,2]. This, for instance, enables using the same electrode material (metals, transparent conductive oxides) for either electron or hole injection into organic semiconductors, just depending on the molecular agent employed. Also the work function of inorganic semiconductor (e.g., ZnO, GaN, Si) surfaces can be tuned over such wide ranges with these molecular donors/acceptors, which allows adjusting the energy level offset at hybrid inorganic/organic semiconductor heterojunstions. This can be used to tune the energy of charge transfer excitations at hybrid junctions (Fig. 1) or allow selecting a junction to support either charge or energy transfer [4]. Dynamic switching of energy levels is enabled by adding photochromic molecular interlayers [5], which facilitates the realization of multifunctional devices.

Keywords: electronic materials, energy materials, interfaces, energy level alignment, photoelectron spectroscopy.

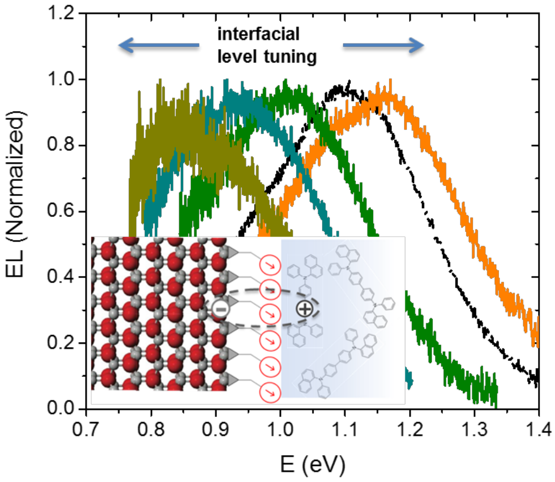

Figure 1: Inserting molecular monolayers with different dipoles between an organic and and inorganic semiconductor changes the electroluminescence (EL) emission energy (E) [3].

References:

1. Akaike, K., et al. (2016) Effective work function reduction of practical electrodes using an organometallic dimer, *Adv. Funct. Mater.*, 26, 2493.
2. Hofmann, O.T., et al. (2017) Orientation-dependent work-function modification using substituted pyrene-based acceptors, *J. Phys. Chem. C*, 121, 24657-24668.
3. Piersimoni, F., et al. (2015) Charge transfer absorption and emission at ZnO/organic interfaces, *J. Phys. Chem. Lett.*, 6, 500−504.
4. Schlesinger, S., et al. (2015) Efficient light emission from inorganic and organic semiconductor hybrid structures by energy-level tuning, *Nat. Commun.*, 6, 6754.
5. Wang, Q., (2017) Electronic properties of optically switchable photochromic diarylethene molecules at the interface with organic semiconductors, *ChemPhysChem*, 18, 722-727.

Coatings: Opportunities and Challenges in Fuel Cells and Eletrolysis

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Abstract:
A sustainable transition to hydrogen economy requires devices that efficiently store renewable energy in hydrogen and that deliver on-demand electric power from it. The key enabling technologies to achieve these targets are: i) water electrolysis (hydrogen production) and ii) fuel cells (hydrogen conversion into electric power).

Current electrolysis and fuel cells employ critical raw materials, a fact that severely hampers the exploitation. The application of coatings to the manufacturing of fuel cells and electrolysers can save much critical resources.

In this talk, I will review some the most relevant applications of coatings to low temperature electrolysis and fuel cell with a special emphasis on the following aspects:

1) Coatings to reduce the use of Platinum Group Metals in Polymer Electrolyte Membrane Fuel Cells.
2) Coatings in the fabrication of conductive components resistant to corrosion in aggressive environment under high anodic stress.
3) R&D opportunities.

Effect of NOVEL TREATMENT BASED ON PLD-DEPOSITED PbS NANOPARTICLES/POROUS Si ON THE OPOTOELECTRONIC PROPERTIES OF mc-SILICON

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Abstract:

In this work, PbS nanoparticles (PbS-NPs) were deposited onto porous silicon (PS)/multicrystalline Si (mc-Si) using the PLD technique. The PbS microstructure was characterized by X-ray diffraction (XRD), transmission electron microscopy observations (TEM) and photoluminescence spectroscopy. The TEM analysis confirmed the effective decoration of the PS –mc Si surface by PbS-NPs. The average size of the PbS- NPs, was estimated to be in the range of 15 nm .an optimal Photoluminescence (PL) response was observed for PS/mc-Si decorated with PbS-NPs obtained after 200 laser pulses (LP). The infrared PbS photoluminescence energy and intensity was found to be tuned depending on concentration and size of the PbS NPs.

Our results demonstrate that this dual treatment not only provides strong passivation of the mc-Si substrate but decreases also the total surface reflectivity at 500 nm (from 30% for untreated mc-Si samples to 15% for the N_{Lp} = 200 and 400 of PbS /PS treated ones). A strong enhancement of the mc-si minority carrier lifetime (τ_{eff}) has been achieved using 200 LP PbS decoration. The τ_{eff} has been find to increase from 2 µs for untreated mc-Si to 157 µs for PbS/PS treated samples.

Keywords PbS nanoparticles, Porous silicon, mc-Si, PL

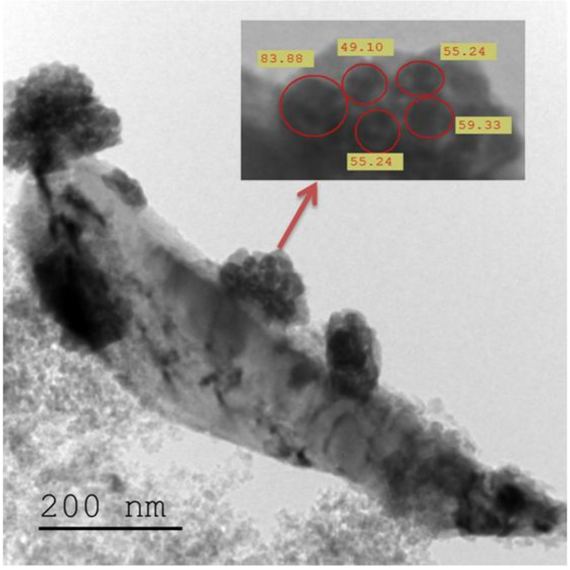

Figure 1: Typical TEM images of PbS (NLp=1200)/PS-Si mc

References:

1. L.T. Canham, 'Silicon Quantum Wire Array Fabrication by Electrochemical and Chemical Dissolution of Wafers', Applied Physics Letters, N°57, N°10, pp. 1046 - 1048, 1990.
2. L. Stalmans, J. Pootrmans, M. Bender, M. Caymax, K. Said, E. Vazasonyi, J. Nijs and R. Mertens, 'Porous Silicon in Crystalline Silicon Solar Cells: A Review and the Effect on the Internal Quantum Efficiency', Progress in Photovoltaics: Research and Applications, Vol. 6, N°4, pp. 233 - 246, 1998.
3. M. Bengston, S. Ekstrom, J. Dratt, A. Collins, E. Csoregi, G. Marko and T. Laurell, 'Application of Microstructured Porous Silicon as Biocatalytic Surface', Physica Status Solidi (a), Vol. 182, N°1, pp. 495 – 504, 2000

Development of a silica-gel coated finned-tube heat heat exchanger for the performance enhancement of adsorption technologies

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Abstract:

The efficacy of adsorption systems such as adsorption cooling and desalnination systems depend on the sorption characteristics of adsorbent (silica gel) and adsorbate (water vapor). Water vapor uptake by the adsorbent is a direct function of cycle performance. Thus, the adsorbent to be used in the cycle should possess good uptake of the adsorbate (water vapor) as well as the ability to regenerate at reasonably low temperature. One of the core components is the adsorption / desorption bed, also named as adsorber / desorber. It is a set of finned tube heat exchangers embedded with adsorbent materials. Conventionally, the adsorbent solids are packed in between the heat exchanger fins and fixed in position by wire meshes. The major drawback of this method is the poor contact not only between adsorbent and metal fins, but also among adsorbent solids, inducing very low heat transfer efficiency. The adsorption heat attenuates the adsorption capacity of the system, being away from the ideal isothermal system, which leads to more irreversibility loss, generating high entropy during the operation processes that severely affect the coefficient of performance of the system. In this study, we delveoped a silica-gel coated finned-tube heat exchanger by a dipping method with a binder so as to enhance the heat and mass transfer between adsorbent and adsorbate. Isotherms of micronized silica-water vapor working pair were presned in order to analyze equilibrium uptake under various operating temperature and pressure ratios.

Keywords: Adsorption, Coating, Heat exchanger, Micronized silica gel, Equilibrium uptake, Isotherm.

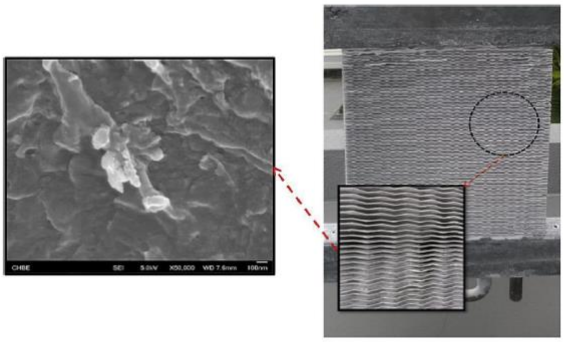

Figure 1: Pictorial views of the silica gel powder coated heat exchanger with the coating thickness of 0.1 mm. A total of 70 g of RD powder was coated on both sides of the aluminum fins. The finned tube heat exchanger has a dimension of 200 mm x 150 mm x 22 mm, fin thickness 0.1 mm and spacing 1.5 mm, and 4 tube passes with tube diameter 9.5 mm

References:

1. B. B. Saha, S. Koyama, T. Kashiwagi, A. Akisawa, K. C. Ng, and H. T. Chua (2003). Waste heat driven dual-mode, multi-stage, multi-bed regenerative adsorption system. International Journal of Refrigeration, 26, 749-757.
2. G. Cacciola and G. Restuccia (1994). Progress on adsorption heat pumps. Heat Recovery Systems and CHP, 14, 409-420.
3. Ang Li, Kyaw Thu , Azhar Bin Ismail and Kim Choon Ng (2016). A heat transfer correlation for transient vapor uptake of powdered adsorbent embedded onto the fins of heat exchangers. Applied Thermal Engineering, 93, 668–677.

Corrosion Inhibition Properties of Cerium Doped Waterborne Polyurethane/Clay Coatings on Mild Steel

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Abstract:

Since last decade, all toxic inhibitors and solvents are being slowly phased out and replaced by benign alternatives in coating industries. It already established that volatile organic compounds (VOCs) and toxic inhibitors must be controlled to the lowest possible levels. The harmful impact of VOC and toxic inhibitor in coatings has led to the substitution of solvent-borne systems with waterborne systems and green/less toxic inhibitors, respectively. Among the recently developed different coating systems, polyurethane (PU) exhibits a special value over other waterborne coatings, therefore, PU coatings are being widely used in many industrial applications [1].

By many Researchers it has been demonstrated that inhibitors are excellent corrosion protectors when used properly in coatings; however, their effectiveness also depends on the overall synthesis criteria, the interaction between the doped inhibitor and coating matrices, as well as the final deposited coating (thickness, adhesion, hydrophobicity, etc.) on the substrates. Inhibitor solubility is another important criterion when using inhibitors in coatings. Usually, freely water-soluble inhibitors are less attractive than water non-soluble inhibitors since the former have a chance in the coating industry as those inhibitors have a chance of being easily leached, which decreases the life time of the dried coatings. However, the water-soluble inhibitors can be mixed easily with environmentally friendly water-based coatings. Therefore, water-soluble inhibitors might prove useful when the inhibitor can be retained in the coating for a longer time. Different water soluble cerium salts such as cerium nitrate $Ce(NO_3)_3$ and cerium chloride $CeCl_3$ have been used as inhibitors for the corrosion process. However, both inhibitors leach easily at wet condition.

The leaching of inhibitors can be delayed by different ways such as changing PU structure, make crosslinking, nanocomposite and barrier resistance. In this study a seriesof cerium doped waterborne polyurethane (WBPU)/clay nanocomposite coatings prepared with different poytetramethyleneoxideglycol (PTMG) molecular weight. XPS spectra (Figure 1)confirmed cerium doped WBPU coatings. The coatings hydrophobicity, water swelling (%), water contact angle, leaching, and corrosion protection efficiency evaluated.

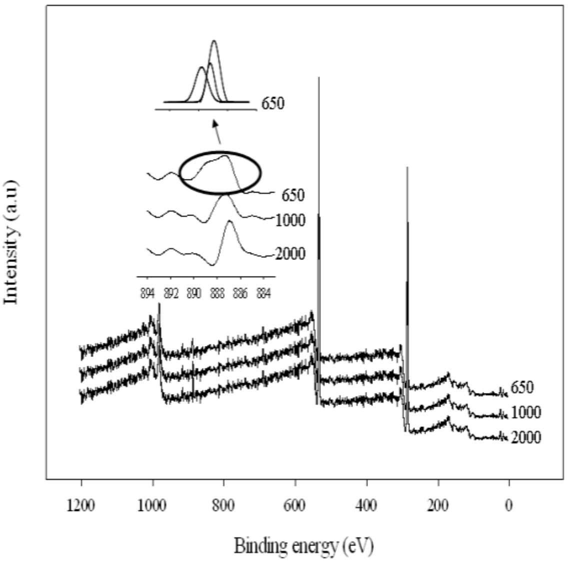

Figure 1: XPS spectra of WBPU coatings with different molecular weight of PTMG (Mn=650, 1000, 2000) with fixed cerium salt (0.08 mole).

Keywords: polyurethane, corrosion, cerium.

References:

1. Rahman, M.M., Kim, H.D. (2006) Synthesis and characterization of waterborne polyurethane adhesives containing different amount of ionic groups (I)., *J. Appl. Polym. Sci.*, *102*, 5684-5691.

Posters Session I:
Surface treatments and coatings deposition processes

Graphite Raman vibrations as a probe of thermal degradation in hydrophobic graphite-based thin film coatings.

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Abstract:
Hydrophobic and superhydrophobic coatings have lately attracted a huge scientific interest due to their wide range of applications. Depending on the application, some common properties like thermal resistance or anti-scratching, and the development of eficient characterization techniques for the coating, are worth to find novel coatings with enhanced properties. So far, only few studies have been carried out to quantify coated surface degradation as a result of thermal treatments, except for the widely used contact angle measurement technique [1].

In this work, a new method to characterize thermal coating degradation of graphite-based thin film coatings is presented. Raman experiments show that D and G vibrational modes of graphite are a powerful probe for determining the degradation of graphite-based coatings. By studying the temperature dependence of the G and D modes, the temperature of the coating degradation was determined. Raman results were compared with contact angle measurements and thermogravimetric analysis, to check the method feasibility. Though simple, this novel and eficient method is useful for determining coating degradation by temperature in hydrophobic and superhydrophobic graphite-based coatings, but it could be extended to other coatings based on carbon materials like graphene oxide or carbon nanotubes.

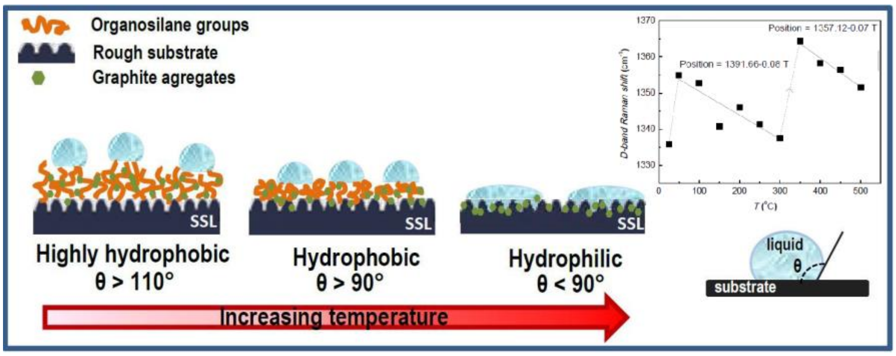

Figure 1: Figure illustrating the problem of organoceramic coatings degradation and the proposed method based on Raman study of vibrational graphite modes.

Keywords: Raman spectroscopy; carbon-based materials; graphite; thermal degradation; hydrophobic; coatings, contact angle.

References:

1. Kwok, D. Y., Gietzelt, T., Grundke, K., Jacobasch, H. J., & Neumann, A. W. (1997). Contact angle measurements and contact angle interpretation. 1. Contact angle measurements by axisymmetric drop shape analysis and a goniometer sessile drop technique. *Langmuir*, *13*(10), 2880-2894.

Investigation of robust hydrophobic coating on glass surface by an atmospheric pressure plasma jet for plasma-polymerization of Hexamethyldisiloxane conjugated with (3-Aminopropyl) triethoxysilane

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Abstract:
Hexamethyldisiloxane (HMDSO) is one of the common promoter of making hydrophobic surface for its low surface energy character but its thin film is really poor in strength. On the other hand (3-Aminopropyl)triethoxysilane (APTES) is one of the most used silanes for its covalent characteristic. Due to its covalent characteristic, its surface energy is higher than HMDSO which makes surface hydrophilic. To make robust thin film on glass surface at atmospheric pressure these two precures were used at different proportions by non-thermal dielectric barrier discharge (DBD) plasma jet.
The goal of the work to fine optimum mixture of these two precursors that will make robust hydrophobic thin film on glass surface. Atomic force microscopy (AFM), Scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR), X-ray photoelectron spectroscopy (XPS), static water contact angle (WCA), and scratch test were done to analyze the coating. Only HMDSO plasma coating on the glass surface was achieved WCA of 162 degree but only APTES was achieved WCA of 47 degree. Hence, 75% of HMDSO and 25% of APTES was selected the best mixture by observing the WAC(136 degree) and scratch test

Keywords: HMDSO, APTES, Plasma jet, Thin film

Acetone sensing properties of WO_3–ZnO core–shell nanorods

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[3] Department of Chemistry, Inha University, 253 Yonghyun-dong, Nam-gu, Incheon 402-751, Republic of Korea

Abstract:
WO_3–ZnO core–shell nanorods were synthesized by a simple two-step process. WO_3 nanorods were synthesized by a hydrothermal method, which was followed by atomic layer deposition of a ZnO shell. The phase and crystallinity of the synthesized products were examined by X-ray diffraction, and the morphological features were studied by scanning and transmission electron microscopy.

Gas sensing tests were performed on both pristine WO_3 nanorods and WO_3–ZnO core–shell nanorods. Sensors containing the pristine WO_3 nanorods and WO_3–ZnO core–shell nanorods showed responses of 1.38 and 8.7, respectively, to 200 ppm ethanol at 300 °C. Therefore, the response of the WO_3–ZnO core–shell nanorod sensors to acetone gas was significantly better than that of pristine WO_3 nanorods. The underlying mechanisms for the enhanced sensing performance are discussed in detail.

Keywords: WO_3 nanorods, core–shell, gas sensing, acetone, heterojunction

Photocatalytic activity of Fe_2O_3-doped TiO_2 Nanoparticulate Films Prepared by Sparking off Fe Electroplated Ti Tips under external electric fields

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Abstract:

Fe_2O_3-doped TiO_2 nanoparticulate (NP) films was successfully prepared by sparking off Fe-coated Ti wires using electroplating process [1-3]. The sparking process was then modified using an external electric fields of 3, 6 and 9 kV/cm under atmospheric pressure to improve the film morphology. Surface morphology, chemical and optical properties of the films were characterized by scanning electron microscopy (SEM), X-ray photoelectron spectroscopy (XPS); X-ray diffraction (XRD) and UV/vis spectroscopy. Photocatalytic activity of the applied films with differents external electric field under visible-light irradiation were investigated. Furthermore, the optimum electric field which can be decompose methylene blue (MB) and methyl orange (MO) were discussed.

Keywords: TiO_2, Fe_2O_3, sparking process, electroplating, photocatalysis, Methylene blue , Methyl orange

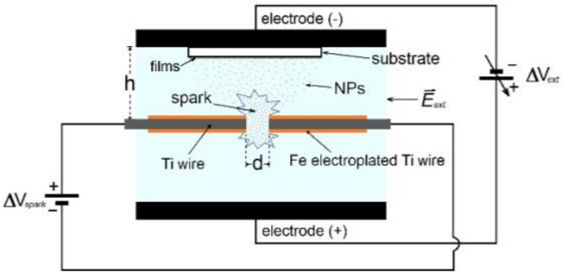

Figure 1: Schematic diagram of the sparking process under external electric field.

References:

1. Hankhuntod, A., Kantarak, E., Sroila, W., Kumpika, T., Singjai, P., Thongsuwan, W. (2017), α-Fe_2O_3 modified TiO_2 nanoparticulate films prepared by sparking off Fe electroplated Ti tips, *Appl. Surf. Sci.*.
2. Thongsuwan, W., Singjai, P. (2016), Influence of TiO_2/Fe_2O_3 interfacial layers on optical properties undervisible light, *Int. J. Surf. Coat. Technol.*, 306, 49-53.
3. Thongsuwan, W., Kunpika, T., Singjai, P. (2011), Effect of high roughness on a long aging time of superhydrophilic TiO_2 nanoparticle thin films, *Int. J. Curr. Appl. Phys.*, 11, 1237-1242.

Transparent (Sn, Nb)O_2 thin film with high conductivity as high-rate anode for Lithium-ion Batteries

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[3]University of Bolton, Institute for Renewable Energy and Environmental Technologies, Bolton, UK

Abstract:

Tin dioxide as anode for LIBS have aroused widespread attention due to its high theoretical capacity in recent years.[1] However, poor electronic conductivity hinders its application for high power LIBS. [2] In our work, (Sn, Nb)O_2 thin films were prepared by the remote plasma sputtering deposition technology, which were as anode materials for lithium ion batteries. The (Sn, Nb)O_2 anodes with 6 at% Nb doping display the specific capacity of 785 and 657 mAh g^{-1} at rates of 10C and 20C, respectively. The superior rate capability performance is because of high electronic conductivity by niobium doped. In addition, we displayed satisfactory conductivity and transparency by the electrical resistivity about $4.73 \times 10^{-3}\Omega$ cm and average optical transmittance up to 84% in visible range (400-800 nm) of (Sn, Nb)O_2 thin films with 6 at% Nb doping. These encouraging findings demonstrate great potential of (Sn, Nb)O_2 thin films as transparent electrodes for high power LIBS to meet the development of next-generation transparent electronics.

Keywords: transparent conductive oxide, amorphous thin film, remote plasma sputtering deposition technology.

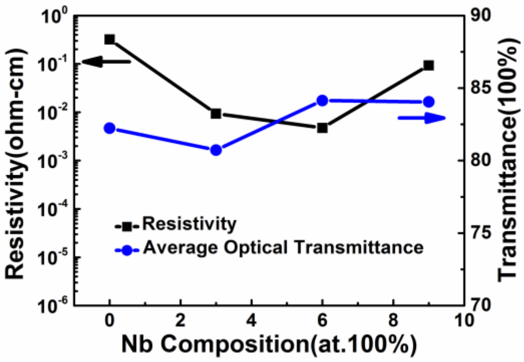

Figure 1: Effect of Nb percentage on the resistivity and transparency of (Sn, Nb)O_2 samples.

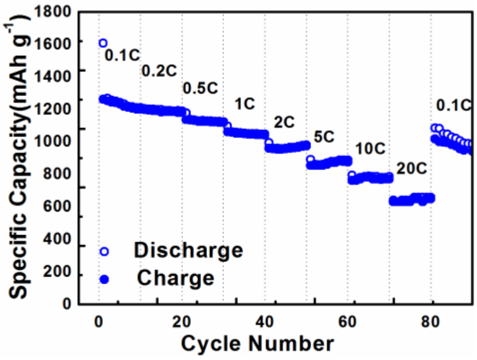

Figure 2: Rate capability for the (Sn, Nb)O_2 sample with 6 at% Nb doping.

References:

1. J. R. Szczech and S. Jin. (2011) Nanostructured silicon for high capacity lithium battery anodes, *Energy & Environmental Science*, 2011, **4**, 56-72.
2. L. Liu, F. Xie, J. Lyu, T. Zhao, T. Li and B. G. Choi. (2016) Tin-based anode materials with well-designed architectures for next-generation lithium-ion batteries, *Journal of Power Sources*, 2016, **321**, 11-35.

Modification of the Phase Structure of the Nanocrystalline ZrO2 Thin Films by Argon-ion Irradiation at Room Temperature

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[2] Zhengzhou University, State Centre for International Cooperation on Designer Low-carbon & Environmental Materials, Zhengzhou 450001, China
[2] University of Bolton, Institute for Renewable Energy and Environmental Technologies, Bolton BL3 5AB, UK

Abstract:
Remote plasma sputtered nanocrystalline ZrO_2 films were investigated as a protective coating of zirconium material for nuclear fuel cladding[1,2]. The prepared ZrO_2 films were irradiated with Ar-ions at an acceleration voltage of 270 kV in the dose range from 4.32×10^{15} ions/cm^2 to 8.64×10^{15} ions/cm^2 at room temperature. The phase composition and morphology of the ZrO_2 films were characterized by XRD/Raman and SEM. The mechanical behaviors of the ceramic coatings were also studied using nanoindentation. The results show that, after magnetron sputtering, the coating layers are mainly composed of m-ZrO_2 and t-ZrO_2 phase. Then after heavy ion irradiation process, the phase structure showed a drastic modification at different irradiation doses, we found m-ZrO_2 phase gradually changed to t-ZrO_2 phase with increasing Ar-ion irradiation dose. These remarkable changes in the phase structure could be correlated to changes performance of the protective coating in nuclear operating environment[2].

Keywords: Plasma deposition, oxygen vacancy, lattice distortion, oxidation resistance

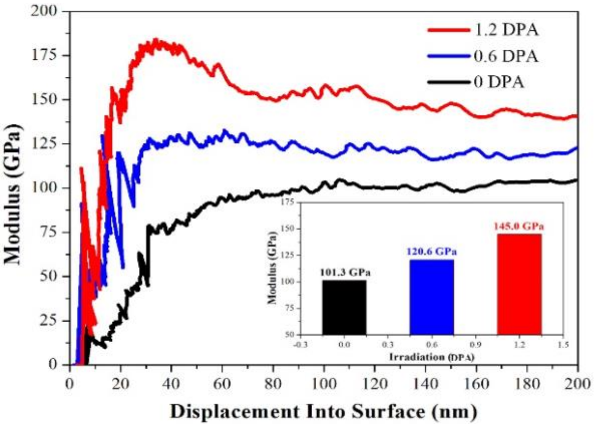

Figure 1: Nanoindentation (in the depth of 0~200 nm) of ZrO_2 thin films with different irradiation damage (0 DPA, 0.6 DPA, 1.2 DPA). The insert shows the average value of the elastic modulus in the range of 100~200nm.

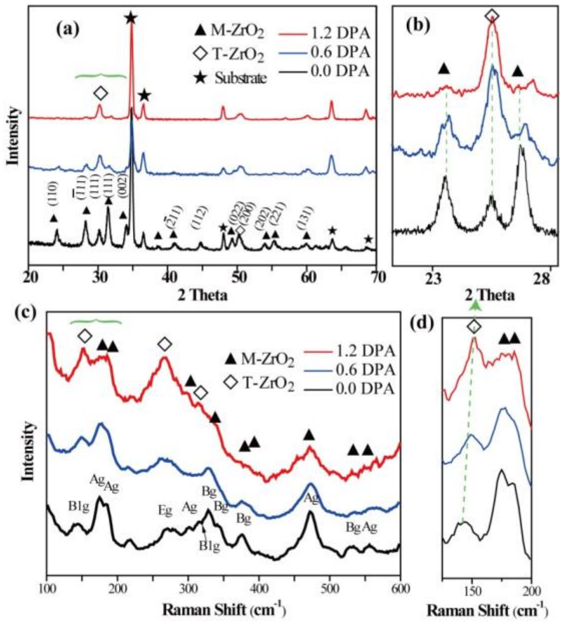

Figure 2: X-ray diffraction pattern (a) and Raman spectra (c) of ZrO_2 thin films under different irradiation damage (0 , 0.6 , 1.2 DAP). (b) XRD patterns in detail of selected scope by a brace in (a); (d) is Selected Raman spectra containing T-ZrO2 from 125 - 200 cm^{-1}.

References:

1. S.J. Zinkle and G.S. Was, Acta Materialia , 61 (2013) 735–758.
2. K.E. Sickafus , Hj. Matzke , Th. Hartmann, K. Yasuda, J.A. Valdez, P. Chodak III, M. Nastasi, R.A. Verrall, Journal of Nuclear Materials, 274 (1999) 66-77.

Synthesis and mechanism study of Samarium Cobalt Particles using Modified Spray Pyrolysis–Calcination and reduction-diffusion process

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Abstract:

Samarium-cobalt ($SmCo_5$ or Sm_2Co_{17}) magnets are a kind of rare earth magnet which have high uniaxial magneto-crystalline anisotropy (Ku = 2.0 x 10^8 erg cm^{-3}) and high Curie temperature (Tc = 1020 K). In general, the maximum energy product (BH_{max}) of Sm-Co based magnets (16 – 33 MG*Oe) are lower than sintered neodymium based magnets ($Nd_2Fe_{14}B$, ~64 MG*Oe). But, owing to their high Curie temperature, samarium-cobalt magnets are superior to sintered neodymium magnets at high temperature applications. So far, Sm-Co particles have been fabricated via ball-milling or melt-spinning and chemical synthesis with Ca or CaH_2 assisted reduction-diffusion process. Reduction-diffusion (R-D) method is a kind of reduction process using metallic calcium or calcium hydride as a reductant and have been applied for the synthesis of trasition metal-rare earth alloys such as Nd-Fe-B and Sm-Co. During the R-D process, the rare earth elecments are recued by calium and diffuse into the transition metal froming alloys with veryous composition. Here, we attempted a synthesis of Sm_2Co_{17} particles by the combination of salt-assisted ultrasonic spray pyrolysis and reduction-diffusion process by Ca. We observed that the addition of salt during reduction-diffusion process refined the growth of the particles and Sm_2Co_{17} particles successfully synthesized. We investigated the synthesis mechanism especially for R-D process.

Keywords: Ultrasonic spray pyrolysis, samarium cobalt magnets, reduction-diffusin process

References:

1. Li, Y., X. L. Zhang, R. Qiu and Y. S. Kang (2008), Synthesis and investigation of SmCo5 magnetic nanoparticles, *Colloids and Surfaces A: Physicochemical and Engineering Aspects,* 313(Supplement C), 621-624..
2. Zhang, H., S. Peng, C.-b. Rong, J. P. Liu, Y. Zhang, M. J. Kramer and S. Sun (2011), Chemical synthesis of hard magnetic SmCo nanoparticles, *Journal of Materials Chemistry,* 21, 16873-16876.
3. Li, W. F., H. Sepehri-Amin, L. Y. Zheng, B. Z. Cui, A. M. Gabay, K. Hono, W. J. Huang, C. Ni and G. C. Hadjipanayis (2012), Effect of ball-milling surfactants on the interface chemistry in hot-compacted SmCo5 magnets, *Acta Materialia*, 60, 6685-6691.

Electrospun porous SnO_2-CuO hollow nanofiber mat for H_2S gas sensing with high performance

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Abstract:
Electrospun porous SnO_2-CuO hollow nanofiber mats are synthesized and envisaged for H_2S gas sening with high performance. Various attemtps of SnO_2-based gas sensors due to stable semiconductor with excellent gas sensitivity have been made of that various structure of nanowire and particle have lack of appreciable response and selectivity to analyte gas for accurate discrimination of interfering gas molecules.[1,2] Resistive sensors composed of SnO_2 and CuO are known to be highly efficient in detection of detrimental H_2S gas in terms of sensitivity, selectivity and detection time. One of reaserch, the SnO_2-CuO mixed nanofiber sensor were fabricated through electrospinning using two neelds.[3] the mixed sensor need to have high operating temperature and gas detect limit.

Enhancement of surface reactions demands robust porous nanostructures, which offer high surface area required for interaction with analyte gas and easy gas diffusion into the nanotube. Our SnO_2-CuO nanotubes are synthesized via facile process of electrospinning with a mixed solutions of Sn and Cu precursors followed by heating process owing to Kirkendall effect drawing on the different diffusion rate between SnO_2/CuO and Sn/Cu. The SnO_2/CuO nanotube sensor have low operating temperature and high H_2S sensing performance from porous surface and tubular morphology. The CuO nanoparticles are homogeneously distributed within SnO_2 tubular shape having 15 nm wall thickness. The calcinated SnO_2-CuO has rough surface and some pore in nanotube (Figure 1). The increased surface area for detecting H_2S has high enhancement of the sensitivity (R_a/R_g) of 170 and very fast response time of 10 s with a stable recovery time to a low concentration of H_2S to 1 ppm at 150°C. Porous SnO_2-CuO hollow nanofiber gas sensor is exhibited as a promising candidate for gas sensor system due to increased surface area with metal oxide catalyst.

Keywords: Tin oxide, Electrospinning, Nanotube, Kirkendall effect, Gas Sensor, H_2S gas sensor

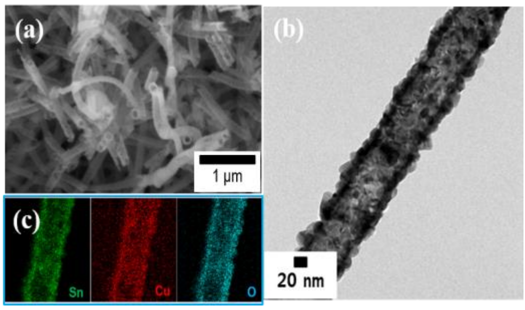

Figure 1: (a) SEM image, (b) TEM image and (c) EDS elemental mappings from SnO_2-CuO hollow nanofiber

References:

1. A. Cirera, A. Dieguez, R. Diaz, A. Cornet, J. R. Morante, (1999) New method to obtain stable small-sized SnO_2 powders for gas sensors, *Sens. Actuator B*, 58, 360-364.
2. B. Wang, L. F. Zhu, Y. H. Yang, N. S. Xu, G. W. Yang, (2008) Fabrication of a SnO_2 Nanowire Gas Sensor and Sensor Performance for Hydrogen, *J. Phys. Chem. C*, 112, 6643-6647.
3. A. Katoch, J-H. Kim, and S. Kim, (2015) CuO/SnO_2 mixed nanofibers for H_2S detection, *J. Nanosci. Nanotechnol.*, 15, 8637-8641

Fabrication of uniform sized hexagonal boron nitride nanopowder for thermal applications

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Abstract:

Hexagonal boron nitride (h-BN) is one of structural graphene family. Because of structural similarity with graphene, h-BN has high thermal conductivity and low frictional resistance, while it has different properties such as large band gap, strong anti-oxidation and electrical insulation property. Recently, according to the high-technology development in semiconductor industry, thermal management problem has appeared as one of crucial issues. While large sized h-BN can be preferentially applied to high thermal conducting materials, the nano-sized h-BN can be applied as thermal insulating materials if the size can be reduced to nano dimension. However, synthetic technology of h-BN with uniform size distribution, in particular, in nano dimensional size tuning has been limited.

Therefor, technologies to synthesize nano-dimensional h-BN with narrow size distribution are required to guarrent uniform quality in commercial applications. Although h-BN nanopowder is mainly synthesized by chemical vapor deposition (CVD) process for a large-scale production assisted high-temperature or vacuum reactant to vaporize[1, 2]. The high-temperature and/or vacuum-assisted CVD method uses toxic reactants vapor of boron and nitrogen sources. Moreover it is focused on synthesizing of micro-sized h-BN particles.

In this research, a simple fabrication for single-step massive production of size controlled h-BN nanopowder for thermal application was investigated. The noble concept for the synthesis of h-BN nanopowder lies in application of liquid-vapor phased reactants coupled with calcination at reduced temperature rather than other synthetic process of h-BN in semi-closed system. h-BN film was then fabricated by hot compaction method for thermal application. The h-BN nanosheets were characterized by X-ray diffraction, transmission electron microscopy and field emission scanning electron microscopy (FE-SEM). Thermal conductivity was measured as h-BN film by thermal wave method. Analysis showed that synthesized h-BN nanopowder is comtrolled ranging from 20 to 225 nm (Figure 1) of lateral dimension with narrow distribution. The thermal properties of resulting composites and mechanisms over the synthesis of h-BN and thermal propagation with interface will be presented and discussed.

Keywords: Hexagonal boron nitride, Thermal management, Nanopowder

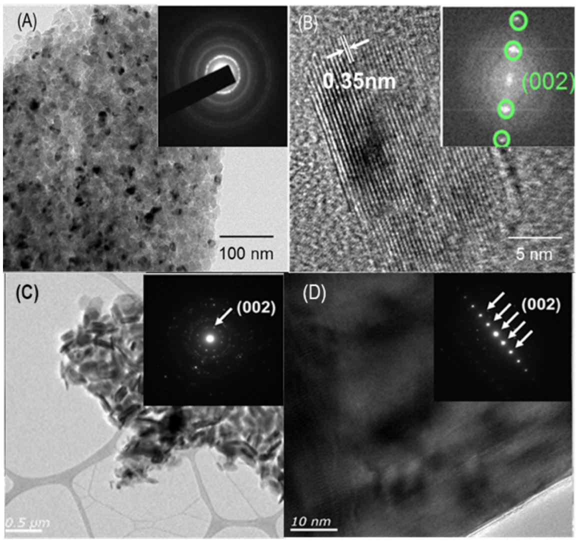

Figure 1: Low resolution and high resolution FE-SEM images of synthesized h-BN nanopowder sized 20 nm(A, B) and 225 nm (C, D).

References:

1. Rui G. *et al*. (2009) High-Yield Synthesis of Boron Nitride Nanosheets with Strong Ultraviolet Cathodoluminescence Emission, *J. Phys. Chem. C,* 113, 15160–15165
2. Kang Hyuck L. *et al*. (2012), Large-Scale Synthesis of High-Quality Hexagonal Boron Nitride Nanosheets for Large-Area Graphene Electronics, *Nano Lett*., 12, 714-718.

Electrostatic coupling of graphite nanoplates and poly(methyl methacrylate) particles using ethylene maleic anhydride copolymer for highly conductive polymer composites

Seung Han Ryu[1], Seil Kim[1], Young-Tae Kwon[1], Sung-Oong Kang[1], Hong-Baek Cho[1], Manwar Hussain[1], Yoo-Jin Lee[2] and Yong-Ho Choa[1],*

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Abstract:
In order to achieve high electrical conductivity with lower filler content in electrically conductive polymer composites, the surfaces of carbon-based fillers and polymer particles have been conventionally modified through various complicated multistep surface-treatment processes. Here, we report a facile approach to electrostatically couple the surface charges of graphite nanoplate (GNP) fillers and poly(methyl methacrylate) (PMMA) polymer particles using ethylene maleic anhydride (EMA) copolymer as an electrostatic coupling agent. Our strategy involved switching the intrinsic repulsive electrostatic interactions between the GNPs fillers and the PMMA particles to attractive electrostatic surface interactions. As a result, the electrical conductivity of the composites dramatically increased by a factor of 16.7 in the EMA-coupled GNPs/PMMA composites compared with that of the EMA-free GNPs/PMMA composites. In addition, the percolation threshold was also notably reduced from 0.32 vol % to 0.159 vol % after electrostatic coupling of the GNPs fillers and PMMA particles.

Keywords: Polymer nanocomposites, Electrostatic interaction, Graphite nanoplates, Percolation threshold

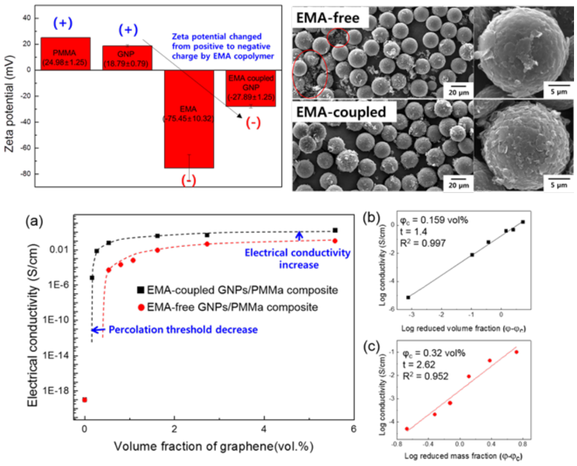

Figure 1: Graphical abstract of the surface coating improved GNP-PMMA particles by electrostatic coupling agent (EMA) and their electrical properties.

Electromagnetic and Microwave Absorption Properties of Fe@SiO$_2$ Core-Shell Composites with Tunable Shell Thickness

Hyo-Ryoung Lim[1], Seung-Jae Jung[1], Tae-Yeon Hwang[1], Jimin Lee[1], Yoseb Song[1], Hong-Baek Cho[1], Yong-Ho Choa[1]

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Abstract:
The electromagnetic (EM) wave absorbers have been attracting considerable interest in the research community and industry alike, given their critical roles not only in suppressing electromagnetic waves into the external environment but also in reducing internal crosstalk. As is well known, the necessary conditions for high-performance absorption such as a broad bandwidth, strong absorption ability, light weight and minimum thickness are tuned by the relative complex permittivity, complex permeability and conductivity of the absorber materials. At present, a growing amount of research for the magneto-dielectrics as a novel approach has been reported due to the high magnetic and dielectric losses, however the demand for the development of the insulation and dispersion method is urgently required. In this study, the electromagnetic wave absorber consisting of iron (Fe) particles coated by silica (SiO$_2$) shell were synthesized via the sol-gel method, in which tetraethyl orthosilicate (TEOS) was used as the precursor. The 100-nm Fe nanoparticles were used as platforms to examine the effect of shell thickness on microwave absorption properties. Uniform Fe@SiO$_2$ core-shell nanoparticles with tunable shell thickness, from 2 to 10 nm, were obtained by controlling the precursor concentration, chemical composition ratio TEOS:ethanol of the sol-gel solution and the reaction time. Also, we optimized both the selective reduction process in hydrogen and the blending composition with polydimethylsiloxane (PDMS) to improve the electromagnetic properties. The remarkable shielding effectiveness reaches -54 dB at 5.5 GHz with a matching thickness of 2.0 mm, and the absorption bandwidth for reflection loss (RL) less than -20 dB is about 2.6 GHz. This surface coating approach can be extended to realize magneto-dielectric materials with tailored absorption frequency in the research community and industry alike.

Keywords: sol-gel method, silica coating, core-shell composites, magneto-dielectrics, microwave absorption property

Facile synthesis of prussian blue-reduced graphene oxide nano-composites by irradiation

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[2] Radiation Biotechnology and Applied Radioisotope Science, University of Science and Technology (UST), Daejeon, 34113, Korea
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Abstract:

Gamma-rays are electromagnetic radiation of high frequency (very short wavelength), usually naturally produced on Earth by decay of high energy states in atomic nuclei (γ-decay). As an important civil nuclear technique, gamma-ray irradiation has been used widely and safely in sterilization and material processing based on well-rounded radiation protection. As a well-established noncontact process, the gamma-ray irradiation technique has already been used to create reductive medium for preparation of metallic nanoparticles, which is deemed as the simpler, purer and less harmful than conventional chemical reduction. We are interested in using gamma-ray irradiation to reduce GO sheets. To the best of our knowledge, there is no published report on this research subject. According to the radiation chemistry of water, gamma-ray irradiation can decomposed the water molecules to both oxidative (hydroxyl radical, $^{\cdot}$OH) and reductive (hydrogen radical and hydrated electron, $H^{\cdot}$ and e^{-} aq) species [1]. Whilst alcohols can eliminate the oxidative $^{\cdot}$OH as radical scavengers and transform into reductive radicals, which can be used to create a reducing medium for chemical reaction under the gamma-ray irradiation in the absence of oxygen. Recently, graphene-based composite materials, derived from the integration of graphene oxide (GO) sheets with functional nanomaterials, have been intensively developed [2].

In this study, we demonstrated that graphene-based nanocomposites could be implemented by γ-ray irradiation in ethanol/water in the absence of oxygen. This method is favourable to build up Prussian Blue/reduced graphene oxide (PB/rGO) for efficient removal of cesium. A simple and environmentally friendly approach for the preparation of graphene nanosheets decorated with Prussian blue nanoparticles (PB NPs) has been developed by gamma irradiation at room temperature.

Keywords: Prussian blue, grapheme oxide, irradiation, gamma-ray, nanocomposites.

References:

1. Zhang, Y., Ma, H.-L., Zhang, Q., Peng, J., Li, J., Zhai, M., Yu, Z.-Z. (2012) Facile synthesis of well-dispersed graphene by γ-ray induced reduction of graphene oxide, *J. Mater. Chem.,* 22. 13064-13069.
2. Bai, S., Shen, X. (2012) Graphene–inorganic nanocomposites, *RSC Advances*, 2. 64-98.

A facile approach to fabrication of hollow ZnO nanoparticles

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Abstract:
Well-defined, monodipersed hollow ZnO nanoparticles were successfully synthesized by a facile one-pot solution method at room temperature. Hollow ZnO nanoparticles were fabricated using polystyrene nanoparticles as seed particles. The removal of core particles via solvent extraction yields hollow nanoparticles. The formation mechanism of the hollow structure of the ZnO nanoparticles was also investigated. The technique developed here is expected to be useful in the preparation other metal oxides and hollow architectures.The structures and morphologies of the obtained products were characterized with Fourier transform infrared (FT-IR), Thermogravimetric analysis (TGA), X-ray photoelectron spectroscopy (XPS), X-ray diffraction pattern (XRD) and Scaning electron microscopy (SEM).

Keywords: ZnO, Hollow particles, Core-shell, Nanoparticles

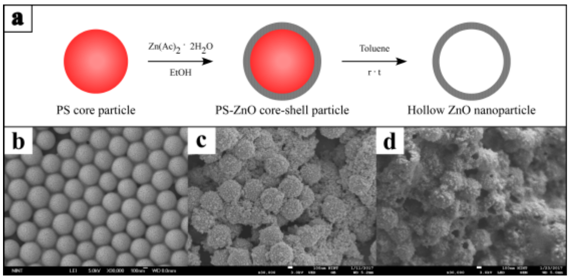

Figure 1: (a). It consisted of three steps. First, PS nanoparticles were prepared as a template via ATRP process, which was followed by a growth step to form ZnO shells and finally a washing step to remove excess PS particles. During the formation of the ZnO shell, the PS core particles were dissolved to obtain hollow ZnO nanoparticles. The morphology of the as-prepared hollow ZnO nanoparticles was characterized by scanning electron microscopy (SEM).

References:

1. C. Zhu, B. Lu, Q. Su, E. Xie, W. Lan, A simple method for the preparation of hollow ZnO nanospheres for use as a high performance photocatalyst, Nanoscale. 4(2012)3060-3064
2. J. Zhang, S. Wang, Y. Wang, M. Xu, H. Xia, S. Zhang, W. Huang, X. Guo, S. Wu, ZnO hollow spheres: Preparation, characterization, and gas sensing properties, Sens. Actuators. B. 139(2009) 411-417

The relationship between wettability and glass transition temperature of nanoparticles on the paper

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Abstract:

We carried out the study to relationship between wettability and glass transition temperature.

Poly(MMA-BA)/Poly(perfluorinated acrylate) nanoparticles as core-shell structure with various glass transition temperatures were polymerized with polymerizable surfactant.

The A4 copy paper was dip-coated in prepared nanoparticles and dried overnight at room temperature therefore obtain coated paper.

The contact angles for water and oil were measured to determine the wettability of coated paper. When the glass transition temperature was above the room temperature, the contact angle for oil was less than 20° and thewettability was increased. Because if the drying temperature is lower than the glass transition temperature of the core, it maintains its shape and has hydrophobic particles placed on the surface. This was explained by the change in mprpholgy through FE-SEM.

When the glass transition temperature is lower than the drying temperature, and then the nanoparticles lose their shape and spread, the shell fluorine group is located on the surface and wettability was reduced on the other hand contact angles was increased.

Figure 1 Difference in morphology image and contact angle of coating with low Tg (a) and high Tg (b)

Keywords: Olephobic, Hydrophobic/philc, Surface property, fluorinated acrylate, nanoparticles, core-shell structure, emulsion polymerization,

References:

1. [1]Wei Xu, Qiufeng An, *Applied Surface Science*, **2013**, *268,* 373-380
2. Secet Tolga, Fatih Buyukserin, *Journal of Colloid and Interface Science*, **2010**, *344*, 528-532

Influences of current density on cavitation damage characteristics of marine grade Al alloy in seawater

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Abstract:
In this study, the influences of electrolytic gas generation were investigated on surface of aluminum as a cushioning media against cavitation bubbles. The electrolytic gas was generated by applying electric current to the metal with different polarity and current densities. For characterization of the electrochemical behavior, various electrochemical methods were employed, including free corrosion potential measurement, potentiodynamic polarization test, Tafel analysis. The cavitation experiment for Al alloy under electrolytic gas evolution was carried out with an ultrasonic vibratory apparatus using piezoelectric effect. The specimen after the experiment was cleaned in an ultrasonic bath, dried in a vacuum oven for more than 24 h, and weighed with a precision scale. The surface was characterized with 3D analysis microscope and scanning electron microscope (SEM). It was found that the surface damage behavior was mainly dependent on the current densities applied to the metal. It is apparent from this study that moderate current densities applied cathodically can produce electrolytic gas evolution to cushion the cavitation bubbles sufficiently. However, application of too high current density may lead cathodic corrosion of Al alloys.

Keywords: cavitation, electrolytic gas generation, Al alloy, seawater.

Meniscus Line-Induced Molecular Misorientation of Chemically Patterned Organic Semiconductor in Solution Blade Coating

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Abstract:

Solution-processable organic semiconductors (OSC) have attracted considerable attention as next-generation materials for applications of displays, sensors and e-papers[1]. Especially, small-molecule OSC shows relatively higher electrical properties compared with polymer based OSC and amorphous silicon through molecular alignment methods which achieve efficient charge transport in OSC[2]. we investigated meniscus line-induced molecular misorientation effect of chemically patterned OSC in solution blade coating. To demonstrate its behavior and principle, 6,13-bis(triisopropylsilylethynyl)pentacene (TIPS-pentacene), representative small-molecule OSC, was coated on chemically pre-patterned layer with varying speed and pattern width. The different pattern widths induce the different shape of meniscus line, and corrseponding meniscus length was also changed. Especially, TIPS-pentacene coated on the 300 um pattern exhibits highest molecular misorientation due to the biggest meniscus curvature regardless of coating speed. (Fig. 1(a)) Interestingly, 50 um patterned TIPS-pentacene shows lowest molecular misorientation including the unpatterned layer due to the decrease of effective attractive force of wetting region and meniscus length. Finally, bottom-gate top-contact organic thin-film transistors (OTFTs) were fabricated in solution-process to demonstrate the effect of meniscus line-induced molecular misorientation effect. 50 um patterned TIPS-pentacene OTFTs show highest field-effect mobility as 0.30 cm2/Vs with low off current level of 10-11 A. By contrast, the 300 um patterned TIPS-pentacene OTFTs exhibit lowest mobility of 0.22 cm2/Vs owing to the large misorientation angle. (Fig. 1(b))

Keywords: solution-process, blade coating, organic semiconductor, thin-film transistors, chemical patterning, molecular misorientation

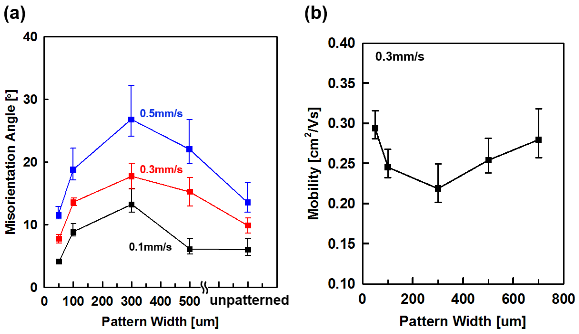

Figure 1: (a) Misorientation angles of TIPS-pentacene ribbons deposited on different pattern width and coated at different speed. (b) Field-effect mobility of TIPS-pentacene TFTs as a function of various OSC pattern width.

References:

1. Horowitz, G. (2004) Organic thin film transistors; From theory to real devices, *J. Mater. Res.,* 19, 1946-1962.
2. Li, H., Tee, B. C.-K, Giri, G., Chung, J. W., Lee, S. Y., and Bao, Z. (2012), High-performance transistors and complementary inverters based on solution-grown aligned organic single-crystals, *Adv. Mater.*, 24, 2588-2591.

Posters Session II: Surfaces and Coatings applications

Analyse of TiO_2 Oxide Multilayer by X-ray Photospectroscopy

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Abstract:

To improve the biocompatibility, various processes that aim at coating an implant material with a bioactive nanoparticles such as synthetic hydroxyapatite have been proposed[1]. For this purpose, barrier and porous/tubular type of anodic oxide films could be formed by electrochemical anodization using a set of specific conditions including optimized potential, electrolyte composition, and temperature. Also, the chemical component of the electrolyte is essential in determining the type of morphology that is eventually formed, and the geometric morphology of TiO_2 oxide film is mutually important in direct contact with biological tissue in dental or surgical implants. In addition, the specific ions in the contact surface with the bone site plays a critical role in terms of adhesion and stability for long periods in the living body.

Thus, in this work, the manufacture of the TiO2 barrier-type multilayer was accurately performed in a mixed electrolyte containing HAp, Pd, and Ag nanoparticles. The temperature of the solution was kept at approximatively 32℃and was regularly rotated by a magnetic stirring rod in order to increase the ionic diffusion rate. The manufactured specimens were carefully analyzed by XPS depth profile to investigate the result of chemical bonding behaviors. From the analysis of chemical states of the TiO_2 oxide multilayer using XPS, the peaks are showed with the typical signal of Ti oxide at 459.1 eV and 464.8 eV, due to Ti 2p(3/2) and Ti 2p(1/2), respectively. The Pd-3d peak was split into Pd-3d(5/2) and Pd-3d(3/2)peaks, and shows two bands at 334.7 and 339.9 eV for Pd-3d3 and Pd-3d5, respectively. Also, the peaks of Ag-3d have been investigated. The chemical states consisted of the O-1s, P-2p, and Ti-2p were identified in the forms of PO_4^{2-} and PO_4^{3-}. Based on the results of the chemical states, the chemical elements into the TiO_2 oxide multilayer were also inferred to be penetrated from the electrolyte during anodic process. The structure characterization of the modified surface were performed by using FE-SEM, and from the result of biological evaluation in simulated body fluid(SBF), the biocompatibility of TiO_2 oxide multilayer was effective for bioactive property(Supported by NRF: 2016R1D1A1B01016542;hcchoe@chosun.ac.kr).

Keywords: TiO2 oxide layer, Nanotubes, Ultafine structure, SBF

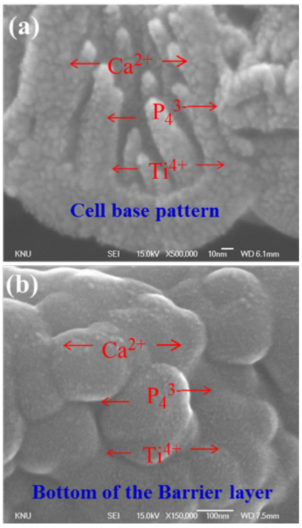

Figure 1: Schematic of ion behavior absorbed from the inner wall of the nanotube-type containing anions (a) and (b); from the bottom layer of the barrier-type oxide layer.

References:

1. A. Kodama, S. Bauer, A. Komatsu, H. Asoh, S. Ono, P. Schmuki, Acta Biomaterialia, Volume 5, Issue 6, July 2009, Pages 2322-2330

Bioactive Surface Formation on Ti-6Al-4V alloy by PEO-treatment after Anodic Titanium Oxide (ATO)

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Abstract:

In this study, we investigated plasma electrolytic oxidation (PEO) treatment in electrolyte containing bioactive substance after nanotube nucleation using anodic titanium oxide (ATO) technique.

Ti-6Al-4V alloy was used for the anodic titanium technology. Ti-6Al-4V alloys are widely used as orthopedic because they have good corrosion resistance and mechanical properties.

The formation of the nanotubes was carried out in 0.8 wt.% NaF and 1M H_3PO_4 electrolyte. After formation of the nanotubes, the nanotubes layer was ultra-sonication removed and then anodic oxidation was repeated.

Then, the electrolyte containing Si, Mn, Mg, Zn, and Sr ions as bioactive substances was subjected to PEO-treated. The PEO-treatment voltage and time were performed at 280 V for 3 minutes.

The surface of Ti-6Al-4V alloy was observed by field emission scanning electron microscopy (FE-SEM, S-4800 Hitachi, Japan). An energy dispersive X-ray spectrometer (EDS, Inca program, Oxford, UK) was used to analyze the spectra of physiologically active Si, Mn, Mg, Zn, and Sr ions. The PEO film formed on the Ti-6Al-4V alloy surface was characterized using an X-ray diffractometer (TF-XRD, X'pert Philips, Netherlands). This research was supported by National Research Fund of Korea (NRF: 2015H1C1A1035241 & NRF: 17GJ1006; hcchoe@chosun.ac.kr).

Keywords: Ti-6Al-4V alloy, Anodic titanium oxide (ATO), Nanotube, Plasma electrolytic oxidation (PEO), Bioactive elements.

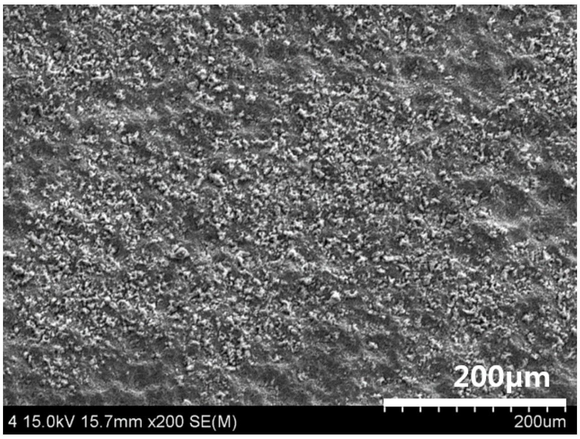

Figure 1: FE-SEM image of a PEO-treated surface in electrolyte containing a bioactive substance after the formation of a second nanotube by ATO technology.

References:

1. Hyun, Ju, K., Youg, Hoon, J., Han, Cheol, C. (2015), Nanotube Nucleation Phenomena of Titanium Dioxide on the Ti-6Al-4V Alloy Using Anodic Titanium Oxide Technique, J. Nanosci. Nanotech., 15, 467-470.
2. Jung-In, K., Mee-Kyoung, S., Han-Cheol, C., William, A, B. (2016), Bone-like apatite formation on manganese-hydroxyapatite coating formed on Ti-6Al-4V alloy by plasma electrolytic oxidation, Thin Solid Films., 620, 126-131.

Biocompatibility on the Functional Element-contained Hydroxyapatite Coatings by Plasma Electrolytic Oxidation

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Abstract:

In this study, biocompatibility on the functional element-contained hydroxyapatite(HA) coatings by plasma electrolytic oxidation(PEO) was researched using various experimental instruments.

Ti-6Al-4V ELI disk is used for PEO treatment in this study. Pulsed DC power of 280 V was applied to all specimens for 3 minutes. The electrolyte used in PEO was prepared by mixing calcium acetate monohydrate, calcium glycerophosphate, zinc acetate dehydrate, strontium acetate hemihydrate, magnesium acetate tetrahydrate, manganese(Ⅱ) acetate tetrahydrate, and sodium metasilicate nonahydrate. MC3T3-E1 mouse osteoblasts were cultured on the specimens for cell proliferation test. The morphology of the attached cells was observed using field-emission scanning electron microscopy (FE-SEM; S-4800 Hitachi, Japan). The surface characterization of the PEO-treated surface was analyzed by FE-SEM and energy dispersive X-ray spectroscopy. The surface area of the pores was measured using an image analyzer. And, the phase of the specimen was analyzed with a thin film X-ray diffractometer.

The PEO films except for specimen containing manganese element show a uniform porous surface. The porous structure has a very rough surface, and Mn can be easily precipitate around pores for PEO process. A large amount of Mn was detected from the pore inside of the precipitate, and a large amount of calcium, phosphorus, strontium, titanium, and oxygen were detected around pore compared to pore inside. These ions can be play role to control the pore shape and formation.

From the results of XRD analysis, peak of HA on PEO-treated surface in electrolyte containing 5 ions shows lower and broader, also peak of HA on was shifted to right side.

The pore were covered with MC3T3-E1 cells and extended well. Cells show spinning form of filopodia in lamellipodia and to grow in association with the cells, in the case of PEO-treated surface in electrolyte containing 5 ions. This research was supported by National Research Fund of Korea (NRF: 2015H1C1A1035241 & NRF: 17GJ1006; hcchoe@chosun.ac.kr).

Keywords: Ti-6Al-4V alloy, Plasma Electrolyte Oxidation (PEO), Hydroxyapatite (HA), Cell proliferation

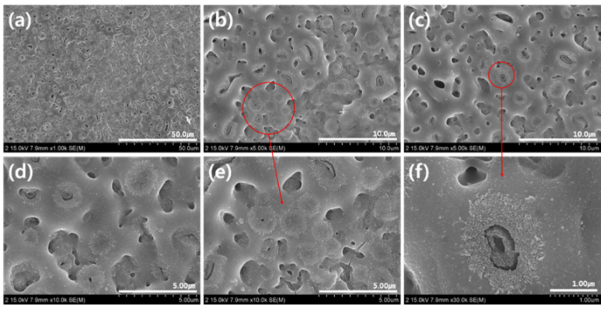

Figure 1: FE-SEM images of the PEO-treated Ti-6Al-4V surface at 280V in 5Zn/5Sr/5Mg/5Mn/5Si electrolyte (a) X 1,000, (b) 5,000, (C) 5,000, (d) 10,000, (e) 10,000, (f) 30,000.

References:

1. I.J. Hwang, H.C. Choe, W. A. Brantley(2017), Electrochemical characteristics of Ti-6Al-4V after plasma electrolytic oxidation in solutions containing Ca, P, and Zn ions, Surf. Coat. Technol. 320, 458-466.
2. Jung-In, K., Mee-Kyoung, S., Han-Cheol, C., William, A, B. (2016), Bone-like apatite formation on manganese-hydroxyapatite coating formed on Ti-6Al-4V alloy by plasma electrolytic oxidation, Thin Solid Films., 620, 126-131.

Ion Release of Hydroxyapatite Film on theTi-6Al-4V after Hybrid Surface Modification by Electrochemical Oxidation

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Abstract:

Plasma electrolytic oxidation (PEO) is considered to be a promising technology because it can create a surface layer with good adhesion to a Ti substrate and has a low cost advantage [1]. In addition, nanotubes show excellent biocompatibility, and the open volume in the tubes may be exploited as a drug release platform and so on [2]. Generally, dental implant is needed the hybrid surface for cell nucleation and proliferation.

In this study, the ion release of hydroxyapatite film after hybrid surface modification of Ti-6Al-4V alloy by plasma electrolytic oxidation and nanotube method was studied. Three experiments were conducted to form the hybrid surface. First, nanotubes were formed in a 1M H_3PO_4 solution containing 0.8 wt% NaF in a Ti-6Al-4V alloy, and the nanotubes were removed by ultrasonic cleaning. Second, the sample with the nanotubes removed is treated with a solution containing bioactive element at 280 V for 3 minutes. Third, the PEO-treated specimen was subjected to the nanotube test again to form a hybrid surface. Ion release test was carried out using potentidynamic and AC impedance method in 0.9% NaCl solution. After the experiments, hybrid surface properties of Ti-6Al-4V alloy were investigated using FE-SEM, XRD and EDS analysis.

(Supported by NRF: 2015H1C1A1035241 & NRF: 17GJ1006 ; hcchoe@chosun.ac.kr).

Keywords: Hybrid surface modification, Plasma electrolytic oxidation, Nanotube formation, Bioactive element.

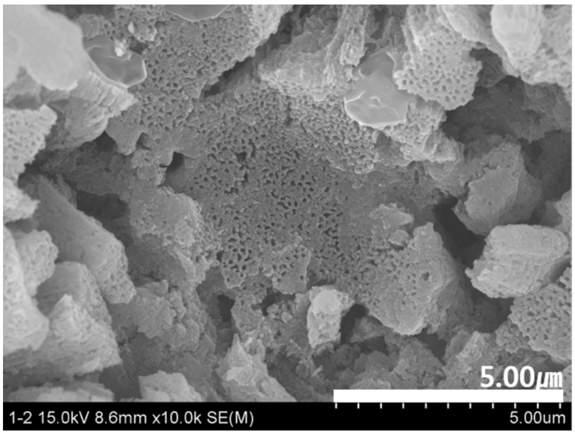

Figure 1: FE-SEM image showing nanotube-formed surface and PEO-treated surface on the Ti-6Al-4V alloy by hybrid surface modification.

References:

1. X. Lu, M. Mohedano, C. Blawert, E. Matykina, R. Arrabal, K.U. Kainer, M.L. Zheludkevich, , Surf & Coatings Technology. 307(2016)1165-1182
2. J.M. Jang, S.W. Chung, H.C. Choe, W.A. Brantley, Surf & Coatings Technology. 320(2017)383-390

Precipitation of Functional Elements on PEO-treated Ti-6Al-4V Alloy after Nanotube Formation

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Abstract:
Commercially pure titanium (CP Ti) and its alloys are widely used in the field of dental implant industry due to their excellent mechanical properties, corrosion resistance and excellent tensile strength. However, surface deformation of titanium and titanium alloys is necessary to improve osseointegration between implant surface and bone[1,2] Especially, plasma electrolytic oxide (PEO) coatings have little risk to health or safety, and coatings of uniform thickness can be created quickly and easily from components with complex surface shapes of varying sizes. Formation of titanium oxide nanotubes on the surface of a titanium alloy significantly improved cell attachment and adhesion[1,2]. In addition, hydroxyapatite (HA) can be provided for improving cell response and bone conduction on implant surfaces including magnesium (Mg), manganese (Mn), strontium (Sr), zinc (Zn) and silicon (Si) elements.

In this study, Ti-6Al-4V ELI disks were used as specimens for nanotube, PEO and HA coating. The solution for the nanotube formation experiment was 1 M H_3PO_4 + 0.8 wt. % NaF electrolyte was used. The electrochemical coating was carried out on the Ti-6Al-4V alloy in electrolyte containing calcium (Ca), phosphorus (P), Mg, Mn, Sr, Zn, and Si ions after PEO treatment in the solution containing Ca and P ions. And then, HA coatings with Mg, Mn, Sr, Zn, and Si ions were performed in the solution of $(NO_3)_2\cdot 4H_2O$ + $NH_4H_2PO_4$ + $Mg(NO_3)_2\cdot 6H_2O$, $MnCl_2\cdot 4H_2O$, M $Sr(NO_3)_2$, $Zn(NO_3)_2\cdot 6H_2O$, and $Na_2SiO_3\cdot 9H_2O$ using voltammetry with cycle of 5, 10, and 20 from −1.5 V to 0 V (vs. SCE electrode).

The morphology changes of the coatings on the PEO treated Ti-6Al-4V alloy surface were observed using FE-SEM, EDS, XRD, and scratch tester.(Supported by NRF: 2015H1C1A1035241 & NRF: 17GJ1006).

Keywords: Nanotube, Plasma Electrolytic Oxidation(PEO),Hydroxyapatite(HA)-Precipitation.

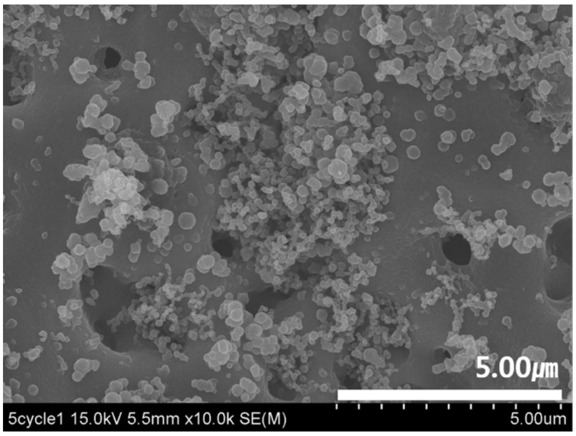

Figure 1: FE-SEM image showing the surface morphology of precipitated alloy in electrolytes containing Mg, Mn, Sr, Zn and Si ions after PEO treatment in electrolyte containing Ca and P ions.

References:

1. J.H. Jeong, H.C. Choe, W. A . Brantley, Nanostructured thin film formation on femtosecond laser-textured Ti–35Nb–xZr alloy for biomedical applications, Appl. Surf.Sci 519 (2011) 4668-4675
2. C. I. Jo, Y. H. Jeong, H.C. Choe, W. A . Brantley, Hydroxyapatite precipitation on nanotubular films formed on Ti-6Al-4V alloy for biomedical applications, Thin Solid Films 549 (2013) 135–140

Matrix Coated Fuel Powder for Research Reactor Fuel

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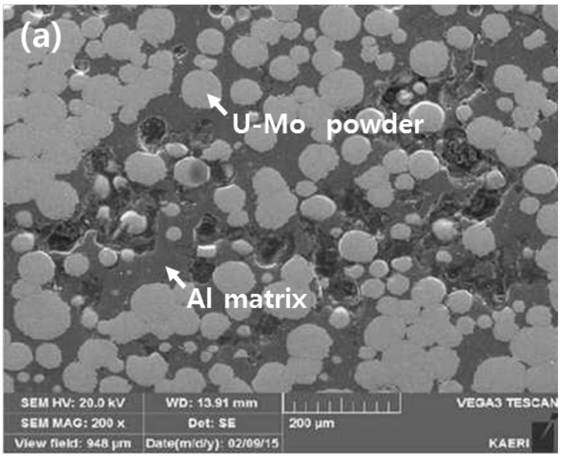
Abstract:
U-Mo/Al dispersion fuel is the most promising candidate for the conversion of a research reactor from HEU (highly enriched uranium) to LEU (low enriched uranium) fuel with its high uranium density [1, 2]. The fabrication process of dispersion fuels consists of mixing, compaction, assembly, rolling, etc. The segregation of fuel powder in the mixing process using Al powder as a matrix leads to a degradation of the fuel performance during the reactor operation. In this study, U-Mo spherical powder was fabricated through centrifugal atomization [2], and the Al matrix was coated on the fuel powder surface using a PVD method instead of a mixing method. Figure 1 shows the cross-sectional micrographs of compacts fabricated by each of mixing and PVD methods. The sectional microstructure reveals that the fuel powder homogeneity of the matrix coated fuel was drastically improved compared to the conventional dispersion fuel. In addition, the uranium density (gU/cm^3) of the fuel was easily controlled by adjusting the coating thickness of matrix.

Keywords: Matrix coated powder, nuclear fuel, research reactor, Physical vapor deposition



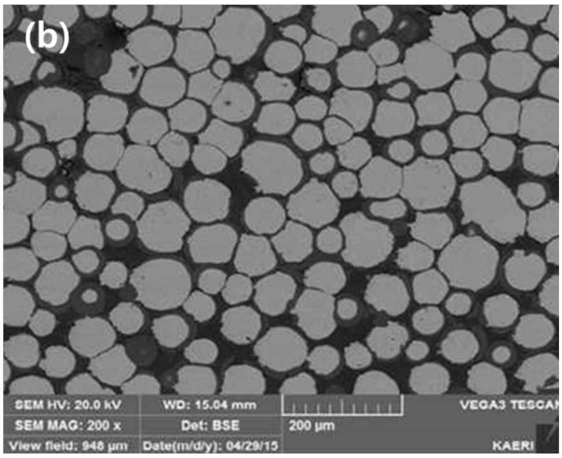


Figure 1: The cross-sectional SEM micrographs of compacts fabricated by (a) mixing methods and (b) PVD methods.

References:

1. Kim, Y.S., (2012) Uranium intermetallic fuels (U-Al, U-Si, U-Mo), in R.J.M konings (Ed., Comprehensive nuclear materials, vol. 3, Elsevier, 391.
2. Park, J.M., Tahk, Y.W., Jeong, Y.J., Lee, K., Kim, H.M., Jung, Y.H., Yoo, B.-O., Jin, Y.G., Seo, C.G., Yang, S.W., Kim, H.J., (2017) PIE analysis of the HANARO mini-plate-1 irradiation test for kijang research reactor, Nucl. Engin, Technol., 49, 1044
3. Kim, C.K., Kim, K.H., Park, J.M., Lee, E.S., Sohn, W.H., Song, S.H., (1999) Development of advanced research reactor fuels using centrifugal atomization tehchnology, Met. Mater., 5, 149.

Removal of radioactive cesium from surface by polyvinyl alcohol/boronate-grafted alginate hydrogel with Cs adsorbent

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Abstract:

A strippable hydrogel containing adsorbents have been developed for the enhanced removal of radioactive cesium from various surfaces of painted cement, aluminum, stainless steel, and cement by adsorption. Two aqueous polymeric solutions of polyvinyl alcohol (PVA) and phenylboronic acid grafted alginate (PBA-Alg) were simultaneously applied to ^{137}Cs-contaminated surface to induce the self-generation of hydrogel based on the reversible PBA-diol ester bond. The resulting hydrogel can easily peel away from the decontaminated surfaces due to its high elasticity.[1] The hydrogel displayed the highest removal efficiencies of 91.61% for painted cement, 97.505% for aluminum, 94.05% for stainless steel, and 53.5 % for cement when the magnetic adsorbent was used as Cs remover in hydrogel due to its excellent distribution coefficient of Cs (3.34×10^4 mL/g).[2] Compared with the commercial strippable coating (Decongel), our hydrogel having magnetic adsorbent exhibited 2.3 times higher decontamination factor (DF) than that of Decongel even from the porous surface of cement. Moreover, the generated volume of the radioactive wastes after surface decontamination was simply reduced by simple magnetic separation of the adsorbent from the used hydrogel, which can reduce the cost for waste disposal. Therefore, our hydrogel system has great potential as new cost-effective surface decontaminants for environmental remediation of wide urban area after nuclear accident and decontamination of various nuclear industry fields.

Keywords: strippable hydrogel, Phenylboronic acid-diol ester bond, radioactive cesium, surface decontamination, magnetic separation.

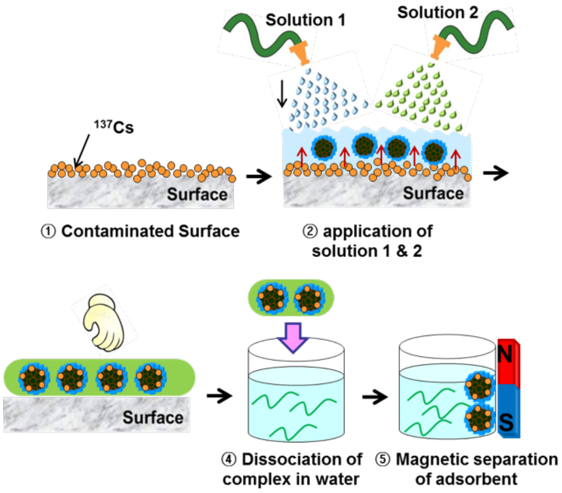

Figure 1: Schematic procedure of surface decontamination using phenylboronic acid grafted alginate (Alg-PBA)/polyvinyl alcohol (PVA) hydrogel containing a magnetic adsorbent.

References:

1. Yang, H. M., Hwang, K. S., Park, C. W. Lee, K.-W. (2017) Polyvinyl alcohol-borate hydrogel containing magnetic adsorbent for surface decontamination. Annals of Nuclear Energy, 109 359–364
2. Yang, H.-M., Jang, S.-C., Hong, S. B., Lee, K.-W., Roh, C., Huh, Y. S., Seo, B.-K. (2016), Prussian blue-functionalized magnetic nanoclusters for the removal of radioactive Cesium from water, *J. Alloy. Compd.* 657, 387-393.

Effects of U_3MoSi_2 and Ti-rich layers on the diffusion between U and Al

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Abstract:
U-Mo dispersion fuel has become promising candidate to allow conversion from HEU (High-Enriched Uranium, all enrichments > 20% ^{235}U) to LEU (Low-Enriched Uranium, all enrichments < 20% ^{235}U) for high power research reactors. Many efforts to identify irradiation characteristics of the U-Mo alloys showed that the alloys with Mo contents of 7-10 wt.% have a good irradiation behavior and sufficient high intrinsic density. However, local swelling by fission products in the high power zones was observed during some irradiation tests, and it was proved that it was caused by the formation of interaction layers (ILs) between U-Mo particles and Al matrix. As one of remedies, Si was added to Al matrix to stabilize swelling behavior of U-Mo fuel during the irradiation at high fission rates, but it was insufficient to suppress the formation of ILs. Another approach is the surface coating (or surface engineering) of U-Mo alloy particles using a PVD magnetron sputtering, or a pack cementation coating method developed by KAERI.

So far, Si, ZrN, uranium-nitrides, and uranium-silicides, etc. were proposed as a candidate material for the diffusion barrier between U-Mo alloy/Al matrix, and either in-pile test, or out-of-pile test on the surface-coated particles are still undergoing. W.J. Kim et al. reported that silicide coating had an effect on the suppression of interaction between U-Mo and Al in the out-of-pile annealing tests. It also shown that the type of ILs formed during the test was identical to that of ILs formed in U-Mo / Al-Si system. However, it only focused on the potential of a silicide coating as a diffusion barrier and phase analysis of formed ILs in silicide-coated U-Mo / Al matrix system.

In this study, we demonstrate the formation of silicide coating layers, U_3Si_5, U_3Si_2 and U_3MoSi_2, on the surface of U-7Mo-1Ti powders using the pack cementation method, and the suppression of Al diffusion into the U-7Mo-1Ti particle by the U_3MoSi_2 layer.

Keywords: Diffusion, Intermetallic alloys and compounds, Metals and alloys, Nuclear materials, Powder technology, Pack Cementation.

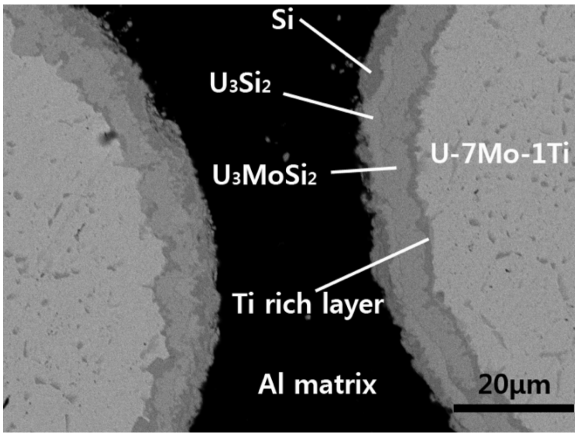

Figure 1: The SEM micrograph of U-7Mo-1Ti (uranium-silicide coated at 1273K for 30 min) / Al matrix compact

References:

1. A. Travelli, Transactions ANS, 35, 564 (1980).
2. A. Leenaers, S. Van den Berghe, C. Detavernier, J. Nucl. Mater., 440, 220 (2013).
3. H.J. Ryu, J.S. Park, J.M. Park, C.K. Kim, Ncl. Eng. Tech., 43(2), 159 (2011).
4. W.J. Kim, H. Palancherr, H.J. Ryu, J.M. Park, J.M. Nam, A. Bonnin, V. Honkimaki, F. Charollais, P. Lemoine, J. Al. Com., 589, 94 (2014).

Low-Temperature Solution-Processed Sn-doped TiO_2 as Electron Transporting Layer for Efficient Perovskite Solar Cells

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Abstract:

Transparent Perovskite solar cells (PSCs) are awesome compared to silicon solar cells due to their low cost and easy fabrication. Lead halide perovskite solar cells with the high efficiencies typically use high-temperature processed TiO_2 as the electron transporting layers (ETLs).[1,2] Here we demonstrate that low-temperature solution-processed nanocrystalline Sn-doped TiO_2 can be an excellent alternative ETL material for efficient perovskite solar cells. Sn-doped TiO_2 films were successfully deposited, whose influence on the performance of perovskite solar cell (PSC) was investigated. In this work, X-ray photoelectron spectroscopy and X-ray diffraction revealed that Sn^{4+} was successfully incorporated into the TiO_2 lattice as an effective metal ion dopant without forming secondary phases. Compared with pristine TiO_2, the Sn-doped TiO_2 is more efficient for photogenerated electron extraction and transport, showing lower trap-state density and higher conductivity. Higher short-circuit current (J_{sc}) is obtained due to the enhanced carrier transport velocity and improved charge collection efficiency, leading to a higher fill factor (FF) and better energy transfer efficiency. Our optimized planar solar cell using such a Sn-doped TiO_2 ETL has achieved power conversion efficiency (PCE) of 17.2%, which was almost 29.3% higher than that of sample using the undoped TiO_2. To the best of our knowledge, this is the lowest processing temperature for Sn-dope TiO_2 film at present, which provides an effective route towards flexible high-performance PSCs.

Keywords: perovskite solar cells, Sn-doped TiO_2, electron transporting layers, low-temperature solution method.

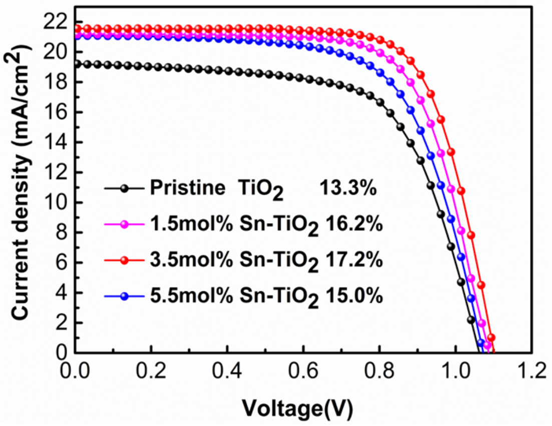

Figure 1: J–V curves of champion perovskite solar cells based on 3.5% Sn-doped TiO_2 and pristine TiO_2 compact layers measured under AM 1.5G one-sun (100 mW cm^{-2}) illumination.

References:

1. Xie F X, Zhang D, Su H, et al. Vacuum-assisted thermal annealing of $CH_3NH_3PbI_3$ for highly stable and efficient perovskite solar cells, ACS nano, 9, 639-646.
2. Zhou Y, Yang M, Vasiliev A L, et al. Growth control of compact $CH_3NH_3PbI_3$ thin films via enhanced solid-state precursor reaction for efficient planar perovskite solar cells, J. Mater. Chem. A, 3, 9249-9256.

Interfacial behaviors of hybrid thin films constituted by organic bulk-heterojunction and amorphous silicon layers

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Abstract:

Soluble polymer based organic bulk-heterojunction type solar cell have shown an impressive power conversion efficiency exceeding the symbolic barrier of 10% by hybridization with an amorphous silicon thin film.[1] Such a hybridization is crucial not only for solar cell applications but also for photodiode applications to cover a wide detection wavelength range by using cost effective polymer based absorber layers in conjunction with massproduction compatible inorganic semiconductor layers.[2]

Therefore, it is important to depict the optical as well as electrical properties of interfaces formed between typical organic bulk-heterojunction type layers and an amorphous silicon layers in depth. For organic bulk-heterojunction type layers, thin films of a narrow band-gap polymer as an electron donor blended with a proper fullerene derivative as an electron acceptor were used while various types of amorphous silicon layers being deposited on top of indium tin oxide covered glass substrates by means of plasma enhanced chemical vapor deposition method were used. The structure of used devices were presented in figure 1 schematically. In order to understand exciton generation facility within the devices used, spatially resolved internal optical field strengths for studied devices were calculated by using a transfer matrix method with experimentally estimated optical constants. Those data were compared with device characteristics obtained by current density versus voltage measurements in addition to incident photon to current conversion efficiency measurements. Finally, insights of the hybrid devices were discussed with the terms of external as well as internal quantum efficiencies.[3]

Keywords: amorphous silicon, organic bulk heterojunction, hybrid solar cell, narrow band-gap, interface, PECVD

Acknowledgment:

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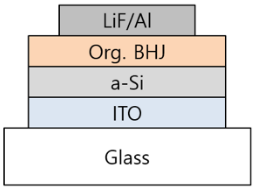

Figure 1: Schematic structure of a studied hybrid device.

References:

1. He, J., Gao, P., Liao, M., Yang, X., Ying, Z., Zhou, S., Ye, J., and Cui, Y. (2015) Realization of 13.6% Efficiency on 20 μm Thick Si/Organic Hybrid Heterojunction Solar Cells via Advanced Nanotexturing and Surface Recombination Suppression *ACS Nano* 9, 6, 6522-6531.
2. Jahnel, M., Thomschke, M., Fehse, K., Vogel, U., An, J.D. Park, H., Leo, K., Im, C. (2015) Integration of near infrared and visible organic photodiodes on a complementary metal–oxide–semiconductor compatible backplane, *Thin Solid Films* 592 94–98.
3. Park, H., An, J.D., Song, J., Lee, M., Ahn, H., Jahnel, M., Im, C. (2015) Thickness-dependent internal quantum efficiency of narrow band-gap polymer-based solar cells, *Solar Energy Materials & Solar Cells*, 143, 242–249.

AlSi-Al_2O_3 Nanocomposite Coatings Prepared by Plasma Spraying

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Abstract:
The thermal sprayed coatings of Aluminum-12wt% Silicon (AlSi) with nano-sized Al_2O_3 particles as reinforcements have been investigated. AlSi powder was mixed with 0, 2.5, 5 and 10 wt% Al_2O_3 powders (α-Al_2O_3 and meta-Al_2O_3) by ball milling and then plasma sprayed. The microstructure of the coatings has been examined using a wide range of characterization techniques: optical microscopy with image analysis, X-ray diffractometry (XRD), and scanning electron microscopy (SEM) with energy dispersive spectroscopy (EDS) to understand the microstructure evolution. The coatings were then cured with resins. The microstructure comprised (1) splats (2) oxide layers and (3) pores. Cured sealants were applied to the coatings in order to reduce porosity and increase hardness. Mechanical properties indicated improved hardness leading to better sliding wear resistance.

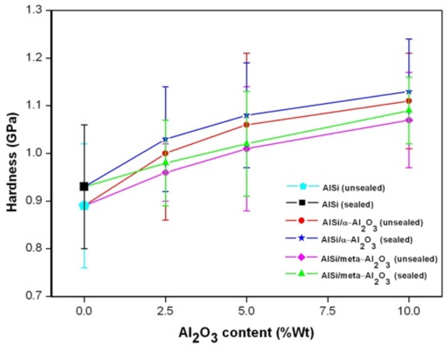

Figure 1. Hardness of AlSi-Al_2O_3 nanocomposite coatings at a different Al_2O_3 contents

Keywords: AlSi, Nanocomposite, Thermal spray coating, Al_2O_3, Plasma spray

References:

1. M. Harum, I.A. Talib and A.R. Daud, Effect of element additions on wear property of eutectic aluminum-silicon alloys, *Matter. Chem. Phys*. (1995) 55-59.
2. H.I. Faraoun, T. Grosdidier, J.-.L. Seichepine, D. Goran, H. Aourag and C. Coddet, Improvement of thermally sprayed abradable coating bymicrostructure control, *Surf. Coat. Technol*. (2006) 2304-2312.
3. S. Safai, H. Herman, Microstructural Investisation of Plama-Sprayed Aluminum Coatings, *Thin Solid Films*. 45 (1997) 295-307

Grain growth of Ag reflective p-type electrode by electron beam irradiation for 32x32 pixelated micro-LED arrays.

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Abstract:

Micro-light-emitting diode (μ-LED) arrays are attracting great attention due to their potential applications in large-size displays, visible light communication, and optogenetic neural stimulation [1-2]. Recently, μ-LED arrays having 1,024 μ-LED pixels having a pixel area of 115 μm x 115 μm was successfully implemented to a high-resolution adaptive driving beam (ADB) for a headlamp of a vehicle due to their unique benefits such as individual controllability, scalability, and design flexibility [3]. Realization of high brightness InGaN/GaN μ-LED arrays for the high-resolution ADB for headlamp requires the achievement of high external quantum efficiency (EQE).

In order to enhance the EQE of the μ-LED, the reflective layer with high reflectance is an essential. The reflective layers are such as Distributed Bragg reflector (DBR), omnidirectional reflector (ODR) and metal-based reflectors. Among metal-based reflectors, Ag is the well-known reflector due to its high reflectivity. This applies equally to flip chip μ-LEDs. However, it has a low contact resistance between Ag and p-GaN. Therefore, ITO was deposited between Ag and p-GaN to make an ohmic contact. Also, Ni is used as an adhesion metal due to the low adherence of Ag. The use of ITO and Ni layers lead to reduce reflectivity. In order to improve the reflectivity of ITO/Ni/Ag, the reflector was irradiated by electron beam [4]. The reflectivity was increased 7% with the e-beam irradiation time 5min. Out power of each u-LED cell was increasing approximately 9%. XRD and EBSD were analyzed to investigate the cause of the improvement of the reflectivity of the Ag reflective film according to the electron beam irradiation, and it was confirmed that the Ag grain size increased according to the electron beam irradiation time.

Keywords: electron beam irradiation, grain growth, Ag reflector, micro-LED array

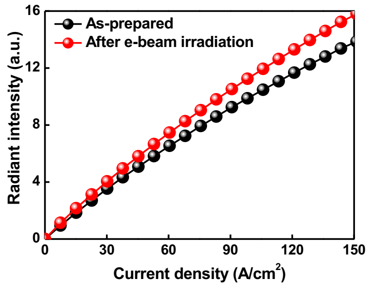

Figure 1. Radiant intensity–current curve of As-prepared and after electron-beam irradiation

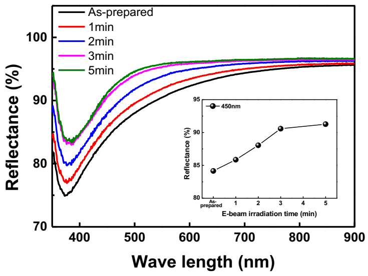

Figure 2. Variation of reflectance of Ag based reflector as a function of electron-beam irradiation time.

References:

1. J. Herrnsdorf, J. J. D. McKendry, S. Zhang, E. Xie, R. Ferreira, D. Massoubre, A. M. Zuhdi, R. K. Henderson, I. Underwood, S. Watson, A. E. Kelly, E. Gu, M. D. Dawson, *IEEE Trans. Electron Devices*, vol. 62, pp. 1918–1925, 2015.
2. V. Poher, N. Grossman, G. T. Kennedy, K. Nikolic, H. X. Zhang, Z. Gong, E. M. Drakakis, E. Gu, M. D. Dawson, P. M. W. French, P. Degenaar, M. A. A. Neil, *Journal of Physics D: Applied Physics*, vol. 41, p.094014, 2008.
3. S. Grötsch, M. Brink, R. Fiederling, T. Liebetrau, I. Möllers, J. Moisel, H. Oppermann, and A. Pfeuffer, *SAE Technical Paper*, 2016-01-1410, 2016, doi:10.4271, 2016-01-1410
4. Y. L. Lee,, Y. J. Cha, S. K. Oh, T. K. Kim, I. Y. Hong, Y. S. Kim, and J. S. Kwak, *Physica Status Solidi A*, 1600799, 2017.

Caviatation-erosion characterisitics of electroless nickel plated gray cast iron in seawater

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Abstract:
Copper alloys and stainless steels are mainly used to prevent cavitation erosion damage in marine environments. However, in this study, electroless nickel plating technology was applied to gray cast iron. Gray cast iron can be easily produced by casting process on products with complex shapes. In addition, it has the advantages of excellent productivity and low production costs. Therefore, gray cast iron was selected as an alternative material for expensive existing materials.

In order to evaluate durability of electroless nickel plating layer, cavitation experiment was carried out according to modified ASTM G32 regulation. It was conducted with opposite vibration method of the vibration generating device using the piezoelectric effect. The amplitude was set to 50 µm by static amplitude automatic control. An electronic balance that can measure down to 10^{-4} g was used to weight specimens before and after test to calculate the weight loss and cavitation rate. And scanning electron microscope (SEM) and 3D microscope were used to analyze the surface damage behavior after cavitation experiment. As a result, cavitation resistance of gray cast iron was significantly enhanced by the electroless nickel plating.

Keywords: electroless nickel plating, gray cast iron, cavitation erosion, seawater.

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