FCSE 2017 SYMPOSIUM

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FCSE - 2017

8th Symposium on FUNCTIONAL COATINGS AND SURFACE ENGINEERING

Final program and Book of abstracts

MONTREAL • JUNE 4-7 2017

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AVS Science and Technology of Materials, Interfaces, and Processing: www.avs.org
Society of Vacuum Coaters: www.svc.org

Dear Participant,

We are very pleased to welcome you at the 8th Symposium on Functional Coatings and Surface Engineering, FCSE-2017, organized by the Regroupement québécois sur les matériaux de pointe (RQMP) in collaboration with the American Vacuum Society (AVS) and the Society of Vacuum Coaters (SVC), and hosted by École Polytechnique de Montréal and Université de Montréal on the Campus of the Université de Montréal between June 4 and 7, 2017.

The technical program of this Symposium reflects recent most significant progress and trends in the area of functional thin films, coatings and surface engineering. It focuses on latest advances in film fabrication processes, the synthesis of new materials, the fabrication of new thin film devices, and on process control. All these aspects represent the bases of new applications in fields that cover the spectrum from optics and optoelectronics, through biomedical and automotive, to energy, aerospace and outer space, manufacturing, and other industries and products, too numerous to mention them all.

The rich 4-day technical and educational programs include invited lectures, oral and poster presentations, vendor displays, short courses, and workshops. The Symposium has been designed so as to encourage student participation, to contribute to networking and to the exchange of scientific and technical information in these fast evolving fields.

We wish to thank all those who contributed to the organization and to the technical quality of this Symposium, to our invited speakers and presenters, and to the sponsors and exhibitors who supported it financially. We wish that all the participants will experience a stimulating and productive FCSE-2017 meeting and enjoy their stay in Montreal.

Ludvik Martinu and Jolanta E. Klemberg-Sapieha, Symposium Chairs

Montreal, June 4, 2017

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INTERCOVAMEX

FCSE-2017 Symposium program

Key to session numbers:

FF	Functional Films
FFS	Functional Films and Surfaces
PBP	Plasma-based Processes
PP	Poster Presentation
PC	Protective Coatings
TC	Tribological Coatings

Sunday, June 4, 2017

SHORT COURSES

Location: École Polytechnique, Main Building, 5th floor

8:30	**Continental breakfast**
9:00	**Short course A – Room B-505** **Nucleation and growth of self-assembled nanostructures: Materials science of small things – self-assembly and self-organization** **J.E. Greene** *University of Illinois at Urbana-Champaign, Urbana, IL, USA*
	Short course B – Room B-506 **Ionized physical vapor deposition and related technologies** **A. Anders** *Lawrence Berkeley National Lab, Berkeley, CA, USA*
	Short course C – Room B-530.2 **Fundamental aspects of reactive sputter deposition** **D. Depla** *University of Ghent, Ghent, Belgium*
10:30	**Break**
10:45 ⋮ 12:00	**Continuation of the short courses**
12:00	**Lunch (included) and discussions – Room B-512**
13:00 ⋮ 17:00	**Continuation of the short courses**

Monday Morning, June 5, 2017

ORAL PRESENTATIONS

Location: Jean-Coutu Building, Room S1-151

8:30	**OPENING CEREMONY** Welcome address, acknowledgements and introductory remarks: *L. Martinu and J.E. Klemberg-Sapieha, Polytechnique Montréal, QC, Canada, Symposium Chairs* *J.E. Greene, University of Illinois at Urbana-Champaign, Urbana, IL, USA, AVS Secretary* *G. Vergason, Vergason Technology, Inc., Van Etten, NY, USA, SVC President* *M. Hilke, McGill University, Montreal, QC, Canada, RQMP Director*
	Session 1: Plasma-based Processes I **Moderators:** **E. Chason**, *Brown University, CT, USA* **P. Mayrhofer**, *Technische Universität, Wien, Austria*
8:50	**PBP1** – <u>Invited</u> **Non-evaporative getter and other coatings for applications in ultrahigh vacuum** **A. Anders** *Lawrence Berkeley National Lab, Berkeley, CA, USA*
9:20	**PBP2** **The geometry of the race track and the magnetic field in a magnetron cathode** J. Cruz[1], J. Restrepo[2], **S.E. Rodil[1]**, S. Muhl[1] [1]*Universidad Nacional Autónoma de México, Coyoacan, Mexico City, Mexico* [2]*Sadosa S.A. de C.V., Aragón - La Villa México D.F., Mexico*
9:30	**PBP3** **Electron heating in magnetron sputtering facilitated by the potential structure of the ionization zone** **M. Panjan[1,2]**, A. Anders[1] [1]*Lawrence Berkeley National Laboratory, Berkeley, CA, USA* [2]*Jožef Stefan Institute, Ljubljana, Slovenia*
9:40	**PBP4** **Using HiPIMS for engineering the triad of adhesion, toughness and stress for premium cutting tool coatings** C. Morton[1], **G. Lake[1]**, T. Leyendecker[2], C. Schiffers[2] [1]*CemeCon Inc., Horseheads, NY, USA* [2]*CemeCon AG, Würselen, Germany*
9:50	**PBP5** **A novel process gas monitor based on plasma emission monitoring of a remote plasma** **F. Papa[1]**, J. Brindley[2], D. Monaghan[2], B. Daniel[2] [1]*Gencoa USA, Medina, OH, USA* [2]*Gencoa Ltd., Liverpool, UK*
10:00	Break

Monday Morning, June 5, 2017 - continued

ORAL PRESENTATIONS

Location: Jean-Coutu Building, Room S1-151

Session 2: Plasma-based Processes II

Moderators: **A. Anders**, *Lawrence Berkeley National Lab, Berkeley, CA, USA*
A. Subrahmanyam, *Indian Institute of Technology Madras, Chennai, India*

10:30	PBP6 – <u>Invited</u> **Non-conventional plasmas for reduced and high pressure processes** **L. Bardos,** H. Barankova *Uppsala University, Uppsala, Sweden*
11:00	PBP7 **Energetics of reactions in dielectric barrier discharges with argon carrier gas: thin hydrocarbon deposits** **B. Nisol**[1], S. Watson[1], S. Lerouge[2,3], M.R. Wertheimer[1] [1] *Polytechnique Montréal, Montreal, QC, Canada* [2] *Centre de Recherche du Centre Hospitalier de l'Université de Montréal, Montreal, QC, Canada* [3] *École de technologie supérieure, Montreal, QC, Canada*
11:10	PBP8 **Functional grafting via syngas photo-initiated chemical vapor deposition** **D. Farhanian**, G. De Crescenzo, J.R. Tavares *Polytechnique Montréal, Montreal, QC, Canada*
11:20	PBP9 **Electrostatics of RF plasmas and their influence on film morphology** **K.S.A. Butcher**[1,2], P.T. Terziyska[3,4], V. Georgiev[1], D. Georgieva[3], R. Gergova[3,5], P.W. Binsted[3] and S. Skergetc[3] [1] *Meaglow Ltd, Thunder Bay, ON, Canada* [2] *Macquarie University, Sydney, NSW, Australia* [3] *Lakehead University, Thunder Bay, ON, Canada* [4] *Institute of Solid State Physics, Bulgarian Academy of Sciences, Sofia, Bulgaria* [5] *Central Laboratory of Solar Energy and New Energy Sources, Bulgarian Academy of Sciences, Sofia, Bulgaria*
11:30	PBP10 – <u>Invited</u> **Some answers and a million of questions about reactive magnetron sputtering** **D. Depla,** K. Strijckmans, R. Schelfhout *Ghent University, Ghent, Belgium*
12:00 : 13:30	**Lunch, Beginning of Poster Session & Exhibit** Jean-Coutu Building, Morris and Rosalind Goodman Agora

Monday Afternoon, June 5, 2017

ORAL PRESENTATIONS

Location: Jean-Coutu Building, Room S1-151

Session 3: Functional Films I

Moderators: **S. Kéna-Cohen**, *Polytechnique Montréal, Montreal, Quebec, Canada*
A. Alpas, *University of Windsor, Windsor, Ontario, Canada*

13:30	**FF1** – <u>Invited</u> **Hemocompatible and inherently biofunctionalisable coatings for cardiovascular stents** **M. Bilek**[1], M. Santos[1], R. Ganesan[1], D.G McCulloch[2], M. Hiobb[3], A. Kondyurin[1], D.R. McKenzie[1], A.S. Weiss[3], M.K.C. Ng[4], S.G. Wise[4] [1] *School of Physics, University of Sydney, NSW, Australia* [2] *RMIT University, Melbourne, Victoria, Australia* [3] *School of Molecular Biosciences, University of Sydney, NSW, Australia* [4] *Heart Research Institute, Sydney, NSW, Australia*
14:00	**FF2** - <u>Invited</u> **High rate synthesis of self assembled Si quantum dots using radical and plasma control in RF/UHF high density plasmas at low temperature** **J.G. Han**, B.B. Sahu *Sungkyunkwan University, Suwon, South Korea*
14:30 : 17:00	**Poster Session & Exhibit Continued** Jean-Coutu Building, Morris and Rosalind Goodman Agora
17:00	**Evening Lecture** **Tracing the recorded history of thin-film sputter deposition: from the 1800s to 2017** **J.E. Greene** *University of Illinois at Urbana-Champaign, Urbana, IL, USA*
18:30 : 21:00	**Conference Dinner** *École Polytechnique* *Lassonde Buildings* *Trottier Atrium* 

Monday Afternoon, June 5, 2017

POSTER PRESENTATIONS

Location: Jean-Coutu Building, Morris and Rosalind Goodman Agora, 12:00 – 17:00

PP1	**Different effects of saccharin on electrodeposition of nanocrystalline nickel coating and electrodeposition of nanocrystalline iron coating** **A. Bahrololoomi**, M.E. Bahrololoom *Shiraz University, Shiraz, Iran*
PP2	**Formation of nanoparticles in HMDSO-based dusty plasma with pulsed injection of the precursor for the fabrication of nanocomposite layers** **V. Garofano**[1], R. Bérard[2,3], L. Stafford[1], B. Despax[2], F. Gaboriau[2], C. Joblin[3], K. Makasheva[2] [1] *Université de Montréal, Montreal, QC, Canada* [2] *LAPLACE, Université de Toulouse, Toulouse, France* [3] *IRAP-OMP, Université de Toulouse, Toulouse, France*
PP3	**Optical properties of 1-DT stabilized silver nanoparticles** **S. Hafezian**, S. Kéna-Cohen, L. Martinu *Engineering Physics Department, Polytechnique Montréal, Montreal, QC, Canada*
PP4	**Challenges and opportunities around the synthesis of nanocomposite thin films by cold dielectric barrier discharge at atmospheric pressure** **J. Profili**, L. Stafford *Université de Montréal, Montreal, QC, Canada*
PP5	**Optical and mechanical performance of Cd_2SnO_4 thin films deposited by sol-gel** **C.J. Diliegros-Godines**[1], N. Abundiz-Cisneros[2], R. Sangines[2], O. Hérnandez-Utrera[2], R. Castanedo-Pérez[3], R. Machorro-Mejía[2] [1] *Instituto de Física, Benemérita Universidad Autónoma de Puebla, Puebla., Mexico* [2] *CONACyT, Centro de Nanociencias y Nanotecnología UNAM, Ensenada, Baja California, Mexico* [3] *Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional, Querétaro, Mexico*
PP6	**Influence of internal stress on the failure modes of optical coatings during scratch testing** **T. Poirié**, T. Schmitt, E. Bousser, L. Martinu, J.E. Klemberg-Sapieha *Polytechnique Montréal, Montreal, QC, Canada*
PP7	**Maximizing light-to-solar-gain and clear-neutrality in a novel spectrally selective material system** **S.S. Balakrishnan**[1], Y. Ye[2], N.P. Kherani[1,3] [1] *Department of Electrical and Computer Engineering, University of Toronto, Toronto, ON, Canada* [2] *Division of Engineering Science, University of Toronto, Toronto, ON, Canada* [3] *Department of Materials Science and Engineering, University of Toronto, Toronto, ON, Canada*
PP8	**Strain-tunable optical properties of *a priori* designed structured nano-thin metal films** **A. El-Hadi Zeineddine**[1], N.P. Kherani[1,2] [1] *Department of Electrical & Computer Engineering, University of Toronto, Toronto, ON, Canada* [2] *Department of Materials Science & Engineering, University of Toronto, Toronto, ON, Canada*

Monday Afternoon, June 5, 2017

POSTER PRESENTATIONS

Location: Jean-Coutu Building, Morris and Rosalind Goodman Agora

PP9	**Wear behavior of Fe_3Al-TiN-TiB_2 HVOF coatings: a comparative study between *in situ* and *ex situ* powder processing routes** **F. Pougoum**[1], T. Schmitt[1], L. Martinu[1], J.-E. Klemberg-Sapieha[1], S. Savoie[2], R. Schulz[2] [1] *Polytechnique Montréal, Montreal, QC, Canada* [2] *Institut de recherche d'Hydro-Québec (IREQ), Varennes, QC, Canada*
PP10	**Solid solution hardening in nanolaminate ZrN-TiN multilayer coatings** **E. Herrera-Jiménez**[1], A. Raveh[2], Z. Rozek[1], T. Poirié[1], T. Schmitt[1], L. Martinu[1], J.E. Klemberg-Sapieha[1] [1] *Polytechnique Montréal, Montreal, QC, Canada* [2] *Rotem Industries Ltd., Arava, Negev, Israel*
PP11	**Towards perpetual dynamic component exchange using a surface immobilized anchor for azomethine substitution** **M. Lerond**[1], D. Bélanger[2], W.G. Skene[1] [1] *Université de Montréal, Montreal, QC, Canada* [2] *Université du Québec à Montréal, Montreal, QC, Canada*
PP12	**Tribological behavior of carbon and carbon-nitride films measured at the microscale levels** F.J. Flores-Ruiz[1], **A. Gallegos-Melgar**[2], M. Tucker[3], K. Bakoglidis[3], K.X. Yu[4], A.J. Gellman[4], L. Hultman[3], J. Rosen[3], E. Broitman[3] [1] *CONACYT and Physics institute of Benemerita University of Puebla, Mexico* [2] *Polytechnique Montreal, Montreal, QC, Canada* [3] *Linkoping University, Linkoping, Sweden* [4] *Carnegie Mellon University, Pittsburgh, PA, USA*
PP13	**A CMOS compatible, ferroelectric tunnel junction memory device** **F. Ambriz-Vargas**, G. Kolhatkar, A. Sarkissian, M.A. Gauthier, A. Ruediger *Institut national de la recherche scientifique (INRS), Varennes, QC, Canada*
PP14	**Effect of WC content on solid particle erosion behavior of cold-sprayed Ni-WC composite coatings** **S.A. Alidokht**, S. Yue, R.R. Chromik *McGill University, Montreal, QC, Canada*
PP15	**Investigation of metal/ceramic interfaces created by cold spray** **S.I. Imbriglio**, R. Gauvin, R.R. Chromik *McGill University, Montreal, QC, Canada*
PP16	**Cold spray and dry sliding wear of Ti6Al4V and Ti6Al4V+TiC metal matrix composite coatings** **M.V.N. Vamsi**, S.A. Alidokht, R.R. Chromik *McGill University, Montreal, QC, Canada*

Monday Afternoon, June 5, 2017

POSTER PRESENTATIONS

Location: Jean-Coutu Building, Morris and Rosalind Goodman Agora

PP17	**Surface patterning and tribochemistry of silicon-oxide containing diamond-like carbon (a-C:H:Si:O) films** **K. Koshigan**[1], J. Lengaigne[1], R.W. Carpick[2], J. Fontaine[3], L. Martinu[1], J. Sapieha[1] *[1]Polytechnique Montréal, Montreal, QC, Canada* *[2]University of Pennsylvania, Philadelphia, PA, USA* *[3]École Centrale de Lyon, Écully, France*
PP18	**Durability and wear mechanisms of easy-to-clean coatings on glass assessed by *in situ* tribometry** **J.C. Qian**[1], T. Schmitt[1], B. Baloukas[1], C.A. Kosik-Williams[2], J.J. Price[2], E.L. Null[2], C.A. Paulson[2], L. Martinu[1], J.E. Klemberg-Sapieha[1] *[1]Engineering Physics Department, Polytechnique Montréal, Montreal, QC, Canada* *[2]Corning Inc., Corning, NY, USA*
PP19	**Ion beam oxidation of vanadium thin films: structural characterization** **A. Fekecs**[1], C. Coia[2], L. Fréchette[1], N. Braidy[1] *[1]Université de Sherbrooke, Sherbrooke, QC, Canada* *[2]Teledyne Dalsa Semiconductor, MIQro Innovation Collaborative Center, Bromont, QC, Canada*
PP20	**Durable thermochromic VO_2 coatings on polymer substrates deposited by HiPIMS** **S. Loquai**, B. Baloukas, J.-E. Klemberg-Sapieha, L. Martinu *Engineering Physics Department, Polytechnique Montréal, Montreal, QC, Canada*
PP21	**All-thin-film color shifting electrochromic devices for security and architectural applications** **F. Blanchard**, B. Baloukas, L. Martinu *Engineering Physics Department, Polytechnique Montréal, Montreal, QC, Canada*
PP22	**The effect of polymer additives on femtosecond laser micromachining of UV cured urethane diacrylate** **M. Wood**[1], M. Coady[2], P. Ragogna[2], A.-M. Kietzig[1] *[1]McGill University* *[2]University of Western Ontario*
PP23	**Thermal sprayed CaviTec coatings for the protection against cavitation erosion** **S. Lavigne**[1], F. Pougoum[1], J.-E Klemberg-Sapieha[1], L. Martinu[1], S. Savoie[2], R. Schulz[2] *[1]Engineering Physics Department, Polytechnique Montréal, Montreal, QC, Canada* *[2]Materials Science Dept., Institut de recherche d'Hydro-Québec (IREQ), Varennes, QC, Canada*
PP24	**Application of suspension plasma spray process for fabricating titanium dioxide water filtration membranes** **E. Ale ebrahim**, F. Tarasi, S. Rahaman, A. Dolatabadi, C. Moreau *Concordia University, Montreal, QC, Canada*

Monday Afternoon, June 5, 2017

POSTER PRESENTATIONS

Location: Jean-Coutu Building, Morris and Rosalind Goodman Agora

PP25	**Effect of nanofluid stability on heat transfer enhancement** **A. Karthikeyan**[1,2], S. Coulombe[1], A.M. Kietzig[2] *[1]Plasma Processing Laboratory, [2]Biomimetic Surface Engineering Laboratory, Department of Chemical, Engineering, McGill University, Montréal, QC, Canada, H3A 0C5*
PP26	**Microstructural and mechanical characterization of three hardfacing alloys with different buffer layers** **Y. Wu**[1], T. Schmitt[1], E. Bousser[1], J. Klemberg-Sapieha[1], F. Khelfaoui[2], N. Tarfa[2] and M. Brochu[1] *[1]Polytechnique Montreal, Quebec H3T 1J4, Canada* *[2]Velan, 550 Rue McArthur, Saint-Laurent, Quebec H4T 1X8, Canada*
PP27	**High load-carrying capacity duplex-coated low strength steel** **M. Laberge**[1], J. Schmitt[1], M. Koshigan[1], T. Schmitt[1], E. Bousser[1], F. Khelfaoui[2], L. Vernhes[2], J.E. Klemberg-Sapieha[1] *[1]Department of Engineering Physics, Polytechnique Montréal, Montreal, QC H3T 1J4, Canada* *[2]Velan, 550 Rue McArthur, Saint-Laurent, QC H4T 1X8, Canada*
PP28	**Durability test of optical coatings on plastics with in situ tribo-imaging characterization of the degree of failure** **A. Gallegos-Melgar**[1], O. Zabeida[1], A. Dehoux[2], D. Poinot Cherroret[2], L. Martinu[1] and J.E. Klemberg-Sapieha[1] *[1]Department of Engineering Physics, Polytechnique Montréal, Montreal, QC H3T 1J4, Canada* *[2]Essilor International, 39-69 Boulevard Jean-Baptiste Oudry, 94000 Créteil, France*

Monday and Tuesday Afternoon, June 5-6, 2017

EXHIBIT

Location: Jean-Coutu Building, Morris and Rosalind Goodman Agora, 12:00 – 17:00

Agilent Technologies
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Intellivation
Representative: Mike Simmons
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Vacuum Products Canada Inc.
Representative: Jean-Francois Poncelet
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www.vpcinc.ca
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Intlvac Inc.
Representative: Dino Deligiannis
www.intlvac.ca
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247 Armstrong Ave, Georgetown, ON L7G 4X6, Canada

IHI Ionbond AG
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Uetlibergstrasse 132, CH-8045 Zürich, Switzerland

Monday and Tuesday Afternoon, June 5-6, 2017

EXHIBIT

Location: Jean-Coutu Building, Morris and Rosalind Goodman Agora, 12:00 – 17:00

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SFR (Systems For Research)
Representative: Laura Belmar
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T&C Power Conversion, Inc.
Representative: Tomasz Mokrzan
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Monday and Tuesday Afternoon, June 5-6, 2017

EXHIBIT

Location: Jean-Coutu Building, Morris and Rosalind Goodman Agora, 12:00 – 17:00

UC components, Inc.
Representative: Chris Malocsay
www.uccomponents.com
+1-408-782-1929, 510-506-5894
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Vergason Technology, Inc.
Representative: Michael Brazil
www.vergason.com
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166 State Route 224, Van Etten, NY 14889, USA

Tuesday Morning, June 6, 2017

ORAL PRESENTATIONS

Location: Jean-Coutu Building, Room S1-151

Session 4: Tribological Coatings

Moderators: **C. Stoessel**, *Eastman Chemical Co., Palo Alto, CA, USA*
D. Depla, *Ghent University, Ghent, Belgium*

8:30	**TC1** – <u>Invited</u> **Re-engineering of tribological interfaces toward more efficient and green transportation technologies** **A. Erdemir** *Argonne National Laboratory, Energy Systems Division, Argonne, IL, USA*
9:00	**TC2** – <u>Invited</u> **Relating thin film stress to the processing conditions and microstructure** **E. Chason** *Brown University, Providence, RI, USA*
9:30	**TC3** – <u>Invited</u> **Innovative ceramic-like coatings for tooling, machining, aerospace, energy and automotive industry** **P. Mayrhofer** *Technische Universität Wien, Vienna, Austria*
10:00	**Break**

Session 5: Protective Coatings

Moderators: **H. Barankova**, *Uppsala University, Uppsala, Sweden*
A. Erdemir, *Argonne National Laboratory, Energy Systems Division, Argonne, IL, USA*

10:30	**PC1** – <u>Invited</u> **Wear and corrosion resistant coatings for demanding environments** B. Strahin[1], D. Shreeram[2], **G.L. Doll**[1,2] [1] *Department of Mechanical Engineering, The University of Akron, Akron, OH, USA* [2] *Department of Chemical and Biomolecular Engineering, The University of Akron, Akron, OH, USA*
11:00	**PC2** **How to ease health monitoring of CFRP in aeronautics? Stimuli sensitive-coatings: a promising solution!** **S. Senani**, E. Campazzi, J. Wehr *Airbus Group Innovations, Suresnes, Ile de France, France*
11:10	**PC3** **Substrate rotation-induced chemical modulation in Ti-Al-O-N coatings synthesized by cathodic arc in an industrial deposition plant** **M. Hans**[1], M. to Baben[1,2], Y.-T. Chen[1], K.G. Pradeep[1], D.M. Holzapfel[1], D. Primetzhofer[3], D. Kurapov[4], J. Ramm[4], M. Arndt[4], H. Rudigier[5], J.M. Schneider[1] [1] *RWTH Aachen University, Aachen, Germany* [2] *GTT-Technologies, Herzogenrath, Germany* [3] *Uppsala University, Uppsala, Sweden* [4] *Oerlikon Balzers, Oerlikon Surface Solutions AG, Balzers, Liechtenstein* [5] *Oerlikon Balzers, Oerlikon Surface Solutions AG, Pfäffikon, Switzerland*
11:20	**PC4** **Phase stability and aluminum segregation in the nanocomposite ZrO_2-Al_2O_3 coatings** **A. Raveh**[1], I. Zukerman[2,3], S. Hayun[4], R.L. Boxman[3] [1] *Rotem Industries Ltd., Mishor Yamin, D.N. Arava, Israel* [2] *NRC-Negev, Beer-Sheva, Israel* [3] *Tel-Aviv University, Tel-Aviv, Israel* [4] *Ben Gurion University of the Negev, Beer-Sheva, Israel*

ORAL PRESENTATIONS

Location: Jean-Coutu Building, Room S1-151

11:30	PC5 – Invited **Carbon-based coatings for industrial applications** **A.T. Alpas**, S. Bhowmick, Z. Yang, F.G. Sen, A. Banerji *University of Windsor, Windsor, ON, Canada*
12:00 ⋮ 13:30	**Lunch, Continuation of Poster Session, Exhibit & Announcement of the Poster Awards** Jean-Coutu Building, Morris and Rosalind Goodman Agora

Session 6: Functional Films II

Moderators: **M. Bilek**, *School of Physics, University of Sydney, NSW, Australia*
G.L. Doll, *The University of Akron, Akron, OH, USA*

13:30	FF3 – Invited **Quantification of structure-property relationships at interfaces** **S.B. Sinnott** *Penn State University, University Park, PA, USA*
14:00	FF4 **Controlling friction and adhesion using supported two-dimensional responsive microgel arrays** **S. Giasson**, L. Giraud, P. Vialar-Trarieux *Université de Montréal, Montreal, QC, Canada*
14:10	FF5 **Tailoring the superconductivity in epitaxial ultrathin films of NbTiN** **F. Mercier**[1], N. Tsavdaris[1], M. Jacquemin[1], D. Hazra[2], M. Hofheinz[2], M. Pons[1], E. Blanquet[1] [1] *Université Grenoble Alpes, Grenoble, France* [2] *INAC/SPSMS, CEA-Grenoble, France*
14:20	FF6 **Efficient and low-damage N-doping of graphene by nitrogen late-afterglow plasma treatment** **X. Glad**, G. Robert Bigras, L. Stafford *Université de Montréal, Montreal, QC, Canada*
14:30	FF7 – Invited **Advances in non-destructive surface and interface analyses using the Kelvin probe** **A. Subrahmanyam** *Indian Institute of Technology Madras, Chennai, India*
15:00	**Break**

Tuesday Afternoon, June 6, 2017 - continued

ORAL PRESENTATIONS

Location: Jean-Coutu Building, Room S1-151

Session 7: Functional Films and Surfaces

Moderators: **S.B. Sinnott**, *Penn State University, University Park, PA, USA*
L. Bardos, *Uppsala University, Uppsala, Sweden*

15:30	FFS1 – Invited **Functional organic and metallic films for optoelectronics** **S. Kéna-Cohen** *Polytechnique Montréal, Montreal, QC, Canada*
16:00	FFS2 **X-ray absorption of nanostructured silicon carbon nitride: Interdependency of luminescence and structural properties** **Z. Khatami**[1], G.B.F. Bosco[2], P.R.J. Wilson[1], J. Wojcik[1], L. Tessler[2], P. Mascher[1] [1]*McMaster University, Hamilton, ON, Canada* [2]*University of Campinas, Campinas, São Paulo, Brazil*
16:10	FFS3 **Vacuum-based technique for production of silver nanostructures for double plasmon resonance with tunable properties** **O. Kylian**, J. Hanus, H. Libenska, H. Biederman *Charles University, Prague, Czech Republic*
16:20	FFS4 **Effect of doping on the conductivity of δ-Bi_2O_3 thin films** C.L. Gómez[1], O. Depablos-Rivera[2], **S.E. Rodil**[2] [1]*Centro de Investigación y de Estudios Avanzados, Unidad Querétaro, Mexico* [2]*National Autonomous University of Mexico, Mexico City, Mexico*
16:30	FFS5 **Hierarchical superhydrophobic/icephobic coatings developed through atmospheric pressure plasma deposition of HMDSO in nitrogen plasma** **S. Asadollahi**[1,2], Luc Stafford[2], M. Farzaneh[1] [1]*Université du Québec à Chicoutimi, Chicoutimi, QC, Canada* [2]*Université de Montréal, Montreal, QC, Canada*
16:40	FFS6 **How black holes relate to relaxation phenomena in amorphous oxide thin films** A. Ananyeva[1], B. Baloukas[2], G. Billingsley[1], A. Heptonstall[1], E. Gustafson[1], L. Martinu[2], A. Markosyan[3], C. Menoni[4], **S. Penn**[5], S. Roorda[6], F. Schiettekatte[6], R. Shink[6], C. Torrie[1], G. Vajente[1], L. Yang[4] [1]*LIGO Laboratory Caltech, Pasadena, CA, USA* [2]*Polytechnique Montréal, Montreal, QC, Canada* [3]*Stanford University, Stanford, CA, USA* [4]*Colorado State University, Fort Collins, CO, USA* [5]*Hobart & William Smith Colleges, Geneva, NY, USA* [6]*Université de Montréal, Montreal, QC, Canada*
16:50	FFS7 **How smart optical materials can help for energy saving and anticounterfeiting applications** **B. Baloukas**, F. Blanchard, S. Loquai, and L. Martinu *Polytechnique Montréal, Montreal, QC, Canada*
17:00	**Closing remarks and Visit of the facilities**

Wednesday, June 7, 2017

HANDS-ON WORKSHOPS ON CHARACTERIZATION TECHNIQUES

Location: École Polytechnique, Main Building

8:30	**Continental breakfast – Room A410**
9:00	**Worksop A – Room A-404** **Optical characterization – Spectroscopic ellipsometry** **Jianing Sun**[1], F. Blanchard[2], B. Baloukas[2] [1]*J.A. Woollam Co. Inc., Lincoln, NE, USA* [2]*Polytechnique Montréal, Montreal, QC, Canada*
	Workshop B – Room A-401 **Optimization of coating systems for in use condition with indentation, scratch and tribology techniques** **G. Favaro**[1], P. Morel[2], M. Dargahi[3], J. Lengaigne[4], T. Schmitt[4] [1]*Anton Paar TriTec SA, Switzerland* [2]*Anton Paar USA Inc., Ashland, VA, USA* [3]*Anton Paar Canada Inc., Montreal, QC, Canada* [4]*Polytechnique Montréal, Montreal, QC, Canada*
10:30	**Break**
10:45 ⋮ 12:00	**Continuation of the workshops**
12:00	**Lunch (included) and discussions – Room A-410**
13:00 ⋮ 17:00	**Workshops A: Hands-on workshop in the laboratory** **Location:** Room B-581
	Workshop B: Hands-on workshop in the laboratory – Scratch and indentation testing – theory and application **Location:** Room B-581

Wednesday, June 7, 2017

DEMONSTRATIONS OF CHARACTERIZATION EQUIPMENT (FREE)

Location: École Polytechnique, Main Building

Register during the exhibit

8:30	**Continental breakfast – Room B406**
9:00 : 12:00	**Demonstration A – Room B-406** **Introduction to modern spectrophotometric tools with Agilent Technologies - Cary 7000 spectrophotometer and the Universal Measurement Unit (UMS)** **J.-L. Cabral**[1], G. Prosser[1], F. Blanchard[2], B. Baloukas[2] [1] *Agilent technologies, Wilmington, DE, USA* [2] *Polytechnique Montréal, Montreal, QC, Canada*
12:00	**Lunch (included) and discussions – Room A-410**
12:00 : 16:30	**Demonstration B – Room B-401** **Introduction to high-resolution optical and stylus profilers for surface metrology with Bruker and Systems For Research (SFR)** **L. A. Belmar**[1], S. Basu[2], J. Lengaigne[3], T. Schmitt[3] [1] *Systems for Research, Kanata, ON, Canada* [2] *Bruker Nano Surfaces Division, Eden Prairie, MN, USA* [3] *Polytechnique Montréal, Montreal, QC, Canada*

FCSE-2017 Symposium abstracts

Key to session numbers:

FF	Functional Films
FFS	Functional Films and Surfaces
PBP	Plasma-based Processes
PP	Poster Presentation
PC	Protective Coatings
TC	Tribological Coatings

Sunday, June 4, 2017

SHORT COURSE A

ÉCOLE POLYTECHNIQUE, MAIN BUILDING, **ROOM B-505**
9:00 – 17:00

■ Nucleation and growth of self-assembled nanostructures: Materials science of small things: self-assembly and self-organization

INSTRUCTOR:
J.E. Greene
University of Illinois at Urbana-Champaign, Urbana, IL, USA

Course Objectives

- Understand the primary experimental variables and surface reaction paths controlling nucleation/growth kinetics and microstructural evolution during vapor-phase deposition.
- Learn about the primary classical and quantum effects which controllably alter the properties of increasingly small nanostructures.
- Understand the mechanisms controlling self-assembly and self-organization during nanostructure growth.
- Learn how to better design nanostructure growth processes.

Course Description

The study of nanotechnology is pervasive across widespread areas including microelectronics, optics, magnetics, hard and corrosion resistant coatings, mechanics, etc. Progress in each of these fields depends upon the ability to selectively and controllably deposit nanoscale structures with specified physical properties. This, in turn, requires control — often at the atomic level — of nanostructure, nanochemistry, and cluster nano-organization.

Decreasing size scales of solid clusters can result in dramatic property changes due to both "classical" effects associated with changes in average bond coordination and, as cluster sizes become of the order of the spatial extent of electron wavefunctions, quantum mechanical effects. The course will start with examples including reduced melting points, higher vapor pressures, increased optical bandgaps, decreased magnetic hysteresis, and enhanced mechanical hardness. Essential fundamental aspects, as well as the technology, of nanostructure formation and growth from the vapor phase will be discussed and highlighted with "real" examples using insights obtained from both in-situ and post-deposition analyses.

Course Content

The course provides an understanding of:

- The classical and quantum effects controlling the dramatic property changes observed in nanostructures as a function of cluster size and dimension (3D → 2D → 1D);
- Self-assembly and self-organization during film growth;
- Nucleation and growth modes;
- The role of the substrate template and defect structures in mediating growth kinetics;
- The development, and control, of film stress (strain engineering);
- The use of film stress to controllably manipulate nanostructure;

- Other mechanisms (including surface segregation, surfactant effects, low-energy ion bombardment, cluster coarsening, etc.) for controlling nanostructures;
- The design of nanostructures with specified properties.

Nanostructure case studies include

- Examples of template, size, and coarsening effects: self-assembled Si/Si(001), Cu/Cu(001),TiN/TiN(001), TiN/TiN(111) nano-clusters;
- Examples of controlled template plus strain effects: self-organized Ge wires on Si(111), Ge wires on Si(187 72 81), Au chains on Si(553), InAs metal wires on GaAs(001), insulated metal wires on Si(111);
- Quantum dot engineering: formation, shape transformations, and ordering in self-organized SiGe/Si(001); InAs/GaAs(001), CdSe/ZnSe(001), PbSe/PbEuSe(111), Ag/Pt(111), and MnN/Cu(001) quantum dots;
- Nano-catalysis: Au/TiO_2;
- Examples of 3D nanostructures: $(Ti,Ce)N/SiO_2$, TiB_x/SiO_2, and d-TaN/g-Ta_2N/SiO_2.

Joe Greene is the D.B. Willett Professor of Materials Science and Physics at the University of Illinois, the Tage Erlander Professor of Materials Physics at Linköping University, Sweden, and a Chaired Professor at the National Taiwan University of Science and Technology. The focus of his research has been the development of an atomic-level understanding of adatom/surface interactions during the dynamic process of vapor-phase crystal growth in order to controllably manipulate nanochemistry, nanostructure, and, hence, physical properties. His work has involved nanoscience and film growth by all forms of sputter deposition, solid and gas-source MBE, UHV-CVD, MOCVD, and ALE. Joe has published more than 550 papers and review articles, 28 book chapters, and co-edited 4 books in the general areas of crystal growth, thin-film physics, and surface science. In particular, he has used hyperthermal condensing species and UV photochemistry for probing as well as stimulating surface reactions that do not proceed thermally. Joe has presented over 500 invited talks and 100 Plenary Lectures at international meetings.

He is currently Editor-in-Chief of Thin Solid Films and past Editor of CRC Critical Reviews in Solid State and Materials Sciences. He is active in the AVS where he has served on the Trustees, twice as a member of the Board of Directors, as President of the society in 1989, and is currently Secretary. He has also Chaired the AVS Thin Film and Advanced Surface Engineering Divisions, the IUVSTA Education and Thin Film Committees, and served on the Governing Board of the American Institute of Physics and the Executive Committee of the APS Division of Materials Physics. He is currently the US representative to the International Union of Vacuum Science and Techniques and is serving on the Executive Committee of ASED.

SHORT COURSE B

ÉCOLE POLYTECHNIQUE, MAIN BUILDING, ROOM **B-506**
9:00 – 17:00

Ionized physical vapor deposition and related technologies

INSTRUCTOR:
A. Anders
Lawrence Berkeley National Laboratory, Berkeley, CA, USA

Course Description

This course is intended for students, engineers, technicians, and others interested in plasma-assisted deposition of thin film and functional coatings. A good portion of the course is dedicated to introduce and review the basics of low-temperature plasmas and discharges to produce them. While gas plasmas are often used, emphasis is put on discharges that lead to ionization of condensable metal or metal-containing plasmas vapor, arc, and sputtering sources. In contrast to many other courses, the role of plasmas and sheaths will be clearly distinguished and explained. This distinction will be appreciated when examples of processes with plasmas are given, including but not limited to plasmas made by ion plating, filtered cathodic arcs and by high power impulse magnetron sputtering (HiPIMS). HiPIMS has become a much-researched field in the last years because it emerged as an extension of widely used sputtering technology. With sputtered metals ionized the texture of coatings can be tuned by energetic condensation even when substrates are kept near room temperature. Recent developments of HiPIMS will be discussed, including reactive HiPIMS and so-called “hybrid technology” where one of the components is HiPIMS.

André Anders is a Senior Scientist and Leader of the Plasma Applications Group at Lawrence Berkeley National Laboratory, Berkeley, California, and also the Editor-in-Chief of Journal of Applied Physics published by AIP Publishing. He grew up in East Germany and studied physics in Wrocław (Poland), Moscow (Russia, then Soviet Union), and Berlin, to obtain his PhD in physics from Humboldt University, (East) Berlin. After the fall of the Berlin Wall he joined Berkeley Lab in Berkeley, California, where he worked in different fields of plasma and material sciences. He has extensively published especially on cathodic arc and sputtering plasmas. His publications, including three books, have been cited approximately 12,000 times. Dr. Anders has been the recipient of several awards and was elected Fellow of the American Physical Society (APS), the American Vacuum Society (AVS), the Institute of Electrical and Electronic Engineers (IEEE), and the Institute of Physics (IoP, UK).

SHORT COURSE C

ÉCOLE POLYTECHNIQUE, MAIN BUILDING, **ROOM B-530.2**
9:00 – 17:00

Fundamental aspects of reactive sputter deposition

INSTRUCTOR:
D. Depla
University of Ghent, Belgium

Course Description

Reactive magnetron sputter deposition is a mature technique often used in laboratories and at industrial level to grow compound thin films. The growth of these films is defined by the deposition conditions, and therefore a good knowledge of the deposition process is essential to tune the growth as well as the film properties. After a short introduction on the physics of sputtering, the magnetron discharge and the transport of sputtered atoms through the gas phase, the course starts with a few definitions regarding reactive sputtering to show that the processes driving this technique are generally applicable. This introduction will assist the attendee toward the next step: the description of the most common experiment during reactive magnetron sputtering – the hysteresis experiment. The simplicity of this experiment fools initially the scientist because it hides a complex interplay between different processes at the target, in the plasma and at the substrate. During the course the details of this experiment are analyzed, and modeling is used to introduce different processes. In this way, the attendee will gain knowledge of the wealth of important processes controlling thin film growth such as reactive ion implantation, chemisorption, preferential sputtering, deposition profile, discharge voltage behavior etc. A good knowledge of these processes will help the attendee to analyze and to control the reactive sputtering process.

Course Content

- **Chapter 1** – Sputter deposition; Sputtering – ion solid interaction, sputter yield; Secondary electron emission; The magnetron discharge;
- **Chapter 2** – Definitions;
- **Chapter 3** – A first experiment; Key aspects of reactive magnetron sputtering; Target poisoning;
- **Chapter 4** – A first model; The Berg model – gas balance equations; Feedback control; Process stability;
- **Chapter 5** – Important process parameters; The discharge power; The deposition profile – influence of the deposition geometry; The magnetic field – the racetrack;
- **Chapter 6** – More complex conditions; Dual reactive sputtering – two sources, one reactive gas; Mixed reactive gasses – oxynitrides; Reactive sputtering from an alloy target;
- **Chapter 7** – Dynamics of reactive sputtering; Feedback control again; Gas pulsing;
- **Chapter 8** – A second series of experiments; Target sputter cleaning – balance between oxide formation and removal; Influence of the argon pressure; Influence of the pumping speed;
- **Chapter 9** – Improving the model; Ion beam experiments; Reactive ion implantation; Knock on implantation; Fitting an experiment; New questions and some answers;
- **Chapter 10** – Discharge voltage behavior during reactive sputtering; Secondary electron emission – relationship between electronic properties and electron emission; Preferential sputtering; Predicting the discharge voltage behavior during reactive sputtering; Negative ion emission – origin, and influence on the thin film properties;
- **Chapter 11** – Influence of redeposit ion on the target – Rotating cylindrical magnetrons; influence of the rotating speed on the hysteresis;

- **Chapter 12** – The influence of the deposition regime on the thin film growth; Structure zone models – origin and correlation with the deposition parameters; Energy flux measurements – the concept of the available energy per arriving atom.

Prof. Dr. D. Depla has received his Master Degree in Chemistry in 1991 at Ghent University (Belgium). In 1996 he promoted with a PhD thesis in Solid State Chemistry on spray drying of precursors for superconductors. After a short period as senior scientist in the Department of Solid State Sciences, he became in 1999 Professor at the same department. His research focuses on the fundamental aspects of reactive magnetron sputter deposition. He has shown the importance of ion implantation on this process, and explained the discharge voltage behavior during reactive sputter deposition. In this way, his continuous research in this area resulted in several publications. He is now head of the research group "Dedicated research on advanced films and targets (DRAFT)" in the same department. More details can be found on www.draft.ugent.be.

ORAL PRESENTATIONS

JEAN-COUTU BUILDING, ROOM S1-151

Session 1 – Plasma-based Processes I

MODERATORS:
E. Chason
Brown University, CT, USA
P. Mayrhofer
Technische Universität, Wien, Austria

8:50 PBP1 – Invited – Non-evaporative getter and other coatings for applications in ultrahigh vacuum

A. Anders
Lawrence Berkeley National Lab, Berkeley, CA, USA

Ultrahigh vacuum (UHV) is required for many applications, and coatings play an increasingly important role for both attaining UHV as well as applying processes that need to be done in UHV because high vacuum (HV) is just not good enough. A good portion of this talk is dedicated to how to achieve UHV for the next generation of synchrotron light sources based on diffraction-limited electron storage rings. The challenging part is to obtain UHV conditions in very narrow vacuum chambers with extreme aspect ratios. Narrow chambers have severe pumping speed limitations and therefore it is difficult to satisfy the ultrahigh vacuum (UHV) requirements with conventional pumps such as ion getter pumps or non-evaporative getter (NEG) cartridges. A solution to this problem is to turn the narrow vacuum chambers into vacuum pumps by NEG coatings in them. NEG materials are alloys of Ti-V-Zr, a technology originally developed at CERN. Going to very narrow chambers, less than 10 mm in diameter, pushes the envelope of this technology. Coatings in vacuum chambers as small as 6 mm in diameter with a length of 1.2 m has been demonstrated. However, for even smaller diameter chambers, wire sputtering becomes impractical, and therefore alternatives are contemplated. Besides NEG coatings, other UHV-compatible coatings are of importance to applications, for example high emissivity coatings for radiative cooling of accelerator components, and coatings that either promote or suppress the emission of secondary electrons.

Advanced coating development is supported by the Office of Basic Energy Sciences of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

André Anders is a Senior Scientist and Leader of the Plasma Applications Group at Lawrence Berkeley National Laboratory, Berkeley, California, and also the Editor-in-Chief of Journal of Applied Physics published by AIP Publishing. He grew up in East Germany and studied physics in Wrocław (Poland), Moscow (Russia, then Soviet Union), and Berlin, to obtain his PhD in physics from Humboldt University, (East) Berlin. After the fall of the Berlin Wall he joined Berkeley Lab in Berkeley, California, where he worked in different fields of plasma and material sciences. He has extensively published especially on cathodic arc and sputtering plasmas. His publications, including three books, have been cited approximately 12,000 times. Dr. Anders has been the recipient of several awards and was elected Fellow of the American Physical Society (APS), the American Vacuum Society (AVS), the Institute of Electrical and Electronic Engineers (IEEE), and the Institute of Physics (IoP, UK).

9:20 PBP2 - The geometry of the race track and the magnetic field in a magnetron cathode

J. Cruz[1], J. Restrepo[2], **S.E. Rodil**[1], S. Muhl[1]
[1] *Universidad Nacional Autónoma de México, Coyoacan, Mexico City, Mexico*
[2] *Sadosa S.A. de C.V., Aragón - La Villa México D.F., Mexico*

Magnetron sputtering involves the exchange of momentum between ions from the magnetically confined plasma and the cathode target, with this producing the emission of atoms from the target towards the substrate. The form of the racetrack in the target is determined by the distribution of the ions incident on the target, and this depends on a combination of the strength and configuration of the magnetic field. In this study, we have measured the spatial variation of the magnetic field of different diameter and type of magnetron cathodes, each of different maximum magnetic field strengths. We have compared that magnetic field data with the spatial distribution of the erosion racetrack in the corresponding targets. The results showed that the inner and outer edges of the racetrack correspond to given value magnetic field vector. We report the relationship between the racetrack profile and the configuration of the magnetic field.

9:30 PBP3 - Electron heating in magnetron sputtering facilitated by the potential structure of the ionization zone

M. Panjan[1,2], A. Anders[1]
[1]*Lawrence Berkeley National Laboratory, Berkeley, CA, USA*
[2]*Jožef Stefan Institute, Ljubljana, Slovenia*

It is now well documented that plasma in magnetron discharges, run either in continuous or pulsed regime, is in most cases localized in dense structures called ionization zones or spokes [1,2]. The old paradigm for magnetron sputtering was that plasma heating is predominantly governed by high-energy secondary electrons. In this talk we will present data which implies an additional, even dominating plasma heating mechanism. Namely, the electric fields associated with an ionization zone can provide enough energy to electrons to supplement plasma heating. This means that electrons created in the plasma by inelastic collisions also participate in the plasma heating. We derive such conclusions from measurements of plasma potential distribution carried out for a single ionization zone in DC magnetron sputtering [3].

[1] A. Anders *et al.*, J. Appl. Phys. 111 (2012) 053304
[2] M. Panjan *et al.*, Plasma Sources Sci. Technol. 24 (2015) 065010
[3] M. Panjan, A. Anders, J. Appl. Phys. 121 063302 (2017)

9:40 PBP4 - Using HiPIMS for engineering the triad of adhesion, toughness and stress for premium cutting tool coatings

C. Morton[1], **G. Lake**[1], T. Leyendecker[2], C. Schiffers[2]
[1]*CemeCon Inc., Horseheads, NY, USA*
[2]*CemeCon AG, Würselen, Germany*

Optimizing the three interrelated properties of adhesion, toughness and stress is the key to every successful coating for cutting tools. To be economically viable in industry, the coating process should also have a deposition rate as high as possible. This paper presents how a deeper understanding of the HiPIMS process has led to a new hardware concept and process design. The concept is based on the CemeCon door-assembly design, which avoids any cable between pulse unit and cathode, and features full synchronization between the HiPIMS sources and the dedicated table bias. Plasma characterization demonstrates that this offers more options to precisely tailor the energy of the gas ions and metal species coming from the target. Intensive film characterization reveals a strong correlation of film adhesion, toughness and stress data with the plasma conditions. Moreover, this new understanding of HiPIMS reduces re-sputtering and yields a currently unmatched deposition rate for HiPIMS. Case studies show how this new hardware and process design turn the advantages of the HiPIMS technology such as enhanced film adhesion, denser morphology and better coating uniformity into user benefits for cutting tool applications.

A considerable amount of research is currently dedicated to the machining process of titanium and heat resistant super alloys based on nickel, iron or cobalt. Jet engines and gas turbines made of this material group operate at higher working temperatures and thereby raise the energy conversion efficiency. Key obstacles to productive metal cutting are the extreme cutting temperatures, high strength and the tendency for workpiece materials to stick to the carbide substrate of the tool. TiB2 films are promising candidates due to the high hardness of this ceramic material and its low affinity to non-ferrous metals. An adapted HiPIMS process leads to fine-grain TiB2 morphology. The film shows hardness levels above 45 GPa, which is typical for TiB2 films, combined with a low Young's modulus. High toughness makes it quite suitable for operations like thin wall milling for jet engines. Milling tests in the aircraft sector demonstrate how the superb adhesion of HiPIMS improves the productivity of machining titanium and other high temp alloys.

Si doping of TiAlN is a known method for enhancing the hardness of the film. A second case study shows that HiPIMS further promotes this concept. The HiPIMS parameters such as pulse power, pulse length, on/off time offer a toolbox for precisely tailoring the morphology of the film. Nano indentation data show that the fine grain HiPIMS film gives an unsurpassed H^3/E^2 value. Such a favorable ratio of hardness to toughness is very beneficial for interrupted cutting, especially milling, and paves the way for using the HiPIMS technology for a wide range of component coatings.

9:50 PBP5 - A novel process gas monitor based on plasma emission monitoring of a remote plasma

F. Papa[1], J. Brindley[2], D. Monaghan[2], B. Daniel[2]
[1]*Gencoa USA, Medina, OH, USA*
[2]*Gencoa Ltd., Liverpool, UK*

Residual Gas Analyzers (RGAs) have long been used to monitor vacuum conditions. However, such analyzers have limitations with regards operating pressure, robustness and ease of use. A new process gas monitor has been developed which uses a spectrometer to measure the optical emission of gases from the process chamber which have been excited/ionized in a remote plasma generator connected directly to the chamber. It has an operating pressure of 1x10e-6 to 5x10e-1 mbar without the need for differential pumping. Qualitative and semi-quantitative information can be extracted from the emission data. Gas species can be automatically identified and the monitor can be used for PVD, CVD and ALD as well as other vacuum processes.

ORAL PRESENTATIONS

JEAN-COUTU BUILDING, ROOM S1-151

Session 2 – Plasma-based Processes II

MODERATORS:
A. Anders
Lawrence Berkeley National Lab, Berkeley, CA, USA
A. Subrahmanyam
Indian Institute of Technology Madras, Chennai, India

10:30 PBP6 – Invited – Non-conventional plasmas for reduced and high pressure processes

L. Bardos, H. Barankova
Uppsala University, Uppsala, Sweden

New challenges in modern plasma processing technologies require new types of non-equilibrium plasmas with high densities and controllable energies of interacting particles. Besides frequent employment of high frequency power generators or high power pulses there are more simple ways, where high degree of ionization can be reached due to geometrical confinement of the plasma in hollow cathodes. In this presentation, different non-conventional arrangements and processing applications utilizing hollow cathodes in a broad range of gas pressures will be described, including plasma systems working at atmospheric pressure. Such systems can be applied in fast PVD or PE CVD processes, in dry etching, as well as in many gas-phase plasma-chemical processes. Principles and applications of novel plasma systems capable of operation even inside liquids will be shortly presented, too.

Ladislav Bardos is Professor in Electricity at the Uppsala University in Sweden and Research leader of the Plasma group at the Angstrom Laboratory. He graduated from the Czech Technical University, Faculty of Nuclear Sciences and Engineering Physics in Prague and received his PhD degree in Applied Physics from the Czech Academy of Sciences and a Doctor of Science (DrSc) degree from the Charles University in Prague. In the Institute of Plasma Physics in Prague he co-founded a new Division of Applied Plasma. In 1984, he was awarded the Czechoslovak State Prize for outstanding research results in the plasma deposition of thin films. He is author of more than 200 publications and about 30 patents. Ladislav is an active member and course lecturer in the Society of Vacuum Coaters and 2010 SVC Mentor Award Recipient for his leading research in plasma processes. He is a member of the Editorial Board of Vacuum and a member of the Management Committee in the EU COST Action "Electrical discharges with liquids for future applications". He runs a consulting company BB Plasma Design AB in plasma sources and processing technology.

11:00 PBP7 – Energetics of reactions in dielectric barrier discharges with argon carrier gas: thin hydrocarbon deposits

B. Nisol[1], S. Watson[1], S. Lerouge[2,3], M.R. Wertheimer[1]
[1] *Polytechnique Montréal, Montreal, QC, Canada*
[2] *Centre de Recherche du Centre Hospitalier de l'Université de Montréal, Montreal, QC, Canada*
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A novel approach enables precise measurement of electrical energy, E_g, per discharge cycle in atmospheric pressure dielectric barrier discharges (DBD) with various gases [1]. This methodology can be applied to plasma polymerization (PP) using Ar. By comparing discharges with or without the addition of a monomer (‰), a ΔE_g value can be measured that varies as a function of monomer flow rate, F_d: for a given F_d, dividing E_g by the number of molecules passing across the discharge per unit of time yields E_m, the energy absorbed per monomer molecule (in eV) [2].

Here, the power of this approach is demonstrated on hand of $E_m(F_d)$ measurements with various hydrocarbons [3]. Systematic differences enabled us to draw important conclusions about fragmentation and polymerization mechanisms. These observations are in fair qualitative agreement with low-pressure radio-frequency PP data by Yasuda from the 1970s on the same compounds [4], but the present values are physically readily interpretable.

[1] M. Archambault-Caron, H. Gagnon, B. Nisol, K. Piyakis, M. R. Wertheimer, Plasma Sources Sci. Technol. 2015, 24, 045004 (16 pp).
[2] B. Nisol, H. Gagnon, S. Lerouge, M. R. Wertheimer, Plasma Process. Polym. 2016, 13, 366.
[3] B. Nisol, S. Watson, S. Lerouge, M. R. Wertheimer, Plasma Process. Polym. 2016.
[4] H. K. Yasuda, T. Hirotsu, J. Polym. Sci., Polym. Chem. Ed. 1978, 16, 743.

11:10 PBP8 – Functional grafting via syngas photo-initiated chemical vapor deposition

D. Farhanian, G. De Crescenzo, J.R. Tavares
Department of Chemical Engineering, Polytechnique Montréal, Montreal, QC, Canada

Syngas photo-initiated chemical vapor deposition (PICVD) is a new, low-energy technique to tailor the deposition of functional organic films. This process works under atmospheric pressure and near room temperature, using UVC lamps to initiate the formation of functional oligomeric films on both macro-sized (e.g. silicon) and nano-sized (e.g. magnetic iron oxide nanoparticles) substrates. We report on the nature of the deposition technique, synthesis mechanism as well as growth kinetics, leading to a better understanding of the requirements for industrial scale surface modification. XPS, TOF-SIMS as well as FTIR provide insight into the chemical structure, illustrating the effect of photo-generated radicals in the formation of aliphatic, anhydride and cyclic structures (with covalent bonding to the substrate). SEM and AFM identify an island-like morphology for the deposit, based on the Volmer–Weber growth mode, and TEM confirms the presence of a coating on the treated nanoparticles.

11:20 PBP9 – Electrostatics of RF plasmas and their influence on film morphology

K.S.A. Butcher[1,2], P.T. Terziyska[3,4], V. Georgiev[1], D. Georgieva[3], R. Gergova[3,5], P.W. Binsted[3], S. Skergetc[3]
[1]*Meaglow Ltd, Thunder Bay, ON, Canada*
[2]*Department of Physics and Astronomy, Faculty of Science, Macquarie University, Sydney, NSW, Australia*
[3]*Semiconductor Research Lab, Lakehead University, Thunder Bay, ON, Canada*
[4]*Institute of Solid State Physics, Bulgarian Academy of Sciences, Sofia, Bulgaria*
[5]*Central Laboratory of Solar Energy and New Energy Sources, Bulgarian Academy of Sciences, Sofia, Bulgaria*

The DC component of RF plasmas is shown to provide an electrostatic influence on the migration of metal species deposited during film deposition. The positive charge presented by an RF plasma has an attractive electrostatic attraction to the electrons in metal wetting layers, this can cause an unwanted roughening of sample surfaces. Shielding of the plasma charge allows smooth samples to be grown.

11:30 PBP10 – Invited - Some answers and a million of questions about reactive magnetron sputtering

D. Depla, K. Strijckmans, R. Schelfhout
Ghent University, Ghent, Belgium

Magnetron sputtering is a mature technique for the deposition of thin films, both at laboratory and industrial level. Conceptually, the technique is quite simple and the process can be summarized in a few lines. But this apparent simplicity quickly vanishes, when one aims to model the process. The RSD model developed within the research group DRAFT reveals that reactive sputter deposition is a complex interplay between different physical and chemical processes. At the target, different processes such as chemisorption, knock-on and direct ion implantation, and re-deposition influence the target condition as a function of the reactive gas flow. A detailed description of these processes, together with the strategies to get quantitative input parameters, will form the first part of the talk. In the second part of the talk, some modelling results for DC magnetron sputtering and HiPIMS will be discussed.

The authors hope to provide at least some answers to the attendees' questions. However, we also hope that the talk will puzzle the attendees. Indeed, with the RSD model we aim, as mentioned by Samuel Karlin, at a model that not (only) fits the data, but also sharpens the questions.

Prof. Dr. D. Depla has received his Master Degree in Chemistry in 1991 at Ghent University (Belgium). In 1996 he promoted with a PhD thesis in Solid State Chemistry on spray drying of precursors for superconductors. After a short period as senior scientist in the Department of Solid State Sciences, he became in 1999 Professor at the same department. His research focuses on the fundamental aspects of reactive magnetron sputter deposition. He has shown the importance of ion implantation on this process, and explained the discharge voltage behavior during reactive sputter deposition. In this way, his continuous research in this area resulted in several publications. He is now head of the research group "Dedicated research on advanced films and targets (DRAFT)" in the same department. More details can be found on www.draft.ugent.be.

ORAL PRESENTATIONS

JEAN-COUTU BUILDING, ROOM S1-151

Session 3 – Functional Films I

MODERATORS:
S. Kéna-Cohen
Polytechnique Montréal, Montreal, Quebec, Canada
A. Alpas
University of Windsor, Windsor, Ontario, Canada

13:30 FF1 – Invited – Hemocompatible and inherently biofunctionalisable coatings for cardiovascular stents

M. Bilek[1], M. Santos[1], R. Ganesan[1], D.G McCulloch[2], M. Hiobb[3], A. Kondyurin[1], D.R. McKenzie[1], A.S. Weiss[3], M.K.C. Ng[4], S.G. Wise[4]
[1]*School of Physics, University of Sydney, NSW, Australia*
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[3]*School of Molecular Biosciences, University of Sydney, NSW, Australia*
[4]*Heart Research Institute, Sydney, NSW, Australia*

Cardiovascular disease is a leading cause of death and cardiovascular devices such as stents are an increasingly important treatment modality. Cardiovascular stents are made from metals to provide the mechanical strength needed to hold blood vessels open. Metals are thrombogenic so patients need to take blood thinning medication, increasing their risk of serious bleeding episodes. Metal stents typically occlude due to the inflammatory response (known as restenosis), while drug eluting stents which eliminate restenosis, impede healing of the endothelium, leading to potentially fatal late stent thrombosis.

In this work, we show that carbon-based coatings deposited using processes where substantial ion energy can be delivered to the coating during deposition provide a coating with strikingly low thrombogenicity and adhesion capable of withstanding major mechanical deformation, that is also easily functionalisable. We describe the conditions required in plasma synthesis to achieve this combination of properties and demonstrate the covalent attachment of inherently hemocompatible biomolecules to inhibit restenosis and accelerate endothelium formation. As the biofunctionalisation is achieved by a simple buffer incubation without linker chemistry the process is easily translated to practice.

Professor Marcela Bilek is Professor of Applied Physics at the University of Sydney. Previously she was a visiting Scientist at the Lawrence Berkeley National Laboratory, USA, a visiting Professor at the Technische Universitat Hamburg-Harburg, Germany and a Research Fellow at Emmanuel College, University of Cambridge, UK.

She has published over 270 refereed journal articles, 1 book, 4 book chapters in the field of plasma surface engineering and materials synthesis. For her work, she was awarded the Malcolm McIntosh Prize for Physical Scientist of the Year (2002), ARC Federation Fellowship (2003), the Australian Academy of Science Pawsey Medal (2004) Australian Innovation Challenge Award (2011) and an ARC Future Fellowship (2012). She was elected to the Fellowships of the American Physical Society and the IEEE in 2012 and 2015, respectively.

14:00 FF2 – Invited – High rate synthesis of self assembled Si quantum dots using radical and plasma control in RF/UHF high density plasmas at low temperature

J.G. Han, B.B. Sahu Sungkyunkwan
Center for Advanced Plasma Surface Technology (CAPST), NU-SKKU Joint Institute for Plasma Nano Materials (IPNM), Department of Advanced Materials Science and Engineering, Sungkyunkwan University, Suwon, South Korea

The discovery of light emission in nanostructured silicon has opened up new avenues of research in nano-silicon based devices. One such pathway is the application of silicon quantum dots in advanced photovoltaic, light emitting, and optoelectronic devices. Recently, there is increasing interest on the silicon nanocrystals familiar as Si quantum dots embedded in an amorphous dielectric matrix. However, due to the limitation of the requirement of a very high deposition temperature along with post annealing and a low growth rate, extensive research are being undertaken to elevate these issues, for the point of view of applications, using plasma assisted deposition methods by using different non-thermal plasmas. Different plasma parameters like electrons, ions, radical species and neutrals play a critical role in nucleation and growth and corresponding film microstructure as well as plasma-induced surface chemistry. Consequently, there is the necessity of the integrated studies on the fundamental physical properties that govern the plasmas seek to determine their surface structure and modification capabilities under specific experimental conditions. The purpose of this contribution is to study and extend analysis using advanced plasmas and dedicated plasma diagnostics to optimize and in-situ monitoring of the deposition process. Plasma enhanced chemical vapour deposition technique using radio frequency (RF) and ultra-high frequency (UHF) dual frequency power is utilized for the single step deposition of Si QD embedded in amorphous hydrogenated amorphous silicon nitride (a-SiN_x: H) at a low-temperature. Experimental observation reveals that a high plasma density along with high-densities of atomic H and N is very crucial for the control of film properties and the QD size. Small-to-big sized Si QDs in the range of 3.5 to 18 nm are fabricated using a reactive mixture of ammonia/silane/hydrogen utilizing dual-frequency capacitively coupled plasmas that can generate very high atomic H and N radical densities by the electron impact dissociation due to the presence of very high density plasmas. Systematic data analysis using different film and plasma characterization tools reveals that the quantum dots with different sizes exhibit size dependent film properties, which are sensitively dependent on plasma characteristics. Additionally, these films exhibit intense photoluminescence in the visible range with violet to orange colors and with narrow to broad widths (~0.3–0.9 eV). The present results are highly relevant to the development of the next-generation plasma process for devices that rely on effective control of the QD size and film properties.

[1] B. B. Sahu, Y. Yin, S. Gauter, J. G. Han, and H. Kersten, Phys. Chem. Chem. Phys. 18, 25837 (2016).
[2] B. B. Sahu, Y. Yin, J. G. Han, and M. Shiratani, Phys. Chem. Chem. Phys. 18, 15697 (2016).
[3] B. B. Sahu, Y. Yin, J. S. Lee, J. G. Han, and M Shiratani, J. Phys. D: Appl. Phys. 49, 395203 (2016).

Jeon Geon Han is the director of the Excellency Center for Advanced Plasma Surface Technology (CAPST) and Professor at the School of Advanced Materials Science and Engineering of the Sungkyunkwan University (SKKU) in South Korea.

He received his Ph.D. in Materials Engineering in 1985 from the Georgia Institute of Technology, U.S.A. In 1987, he was appointed an Assistant Professor, and later promoted to Associate professor in Department of Metallurgical Engineering, and subsequently, become a professor in the School of Advanced Materials Science and Engineering in the year 1996, at SKKU. His main interest has been based on the fundamental design and synthesis of next-generation multifunctional film materials, development of advanced plasma surface and film processes using novel plasmas, biomedical, and engineering applications of nanomaterials in the industry, development of novel plasma sources, studies on plasma discharges, development of plasma diagnostics especially for plasma processing, etc.

During 1985-1986, he was a Research Associate of the Georgia Institute of Technology. Since then he has worked on novel plasma deposition technology, focusing on the fundamentals of both plasma, as well as on the surface processes occurring in plasma processing of functional materials. He specializes in applying new advanced plasma sources and diagnostics for plasma species detection as well as in situ analysis and control of the physical and chemical properties of the materials processed. He has authored and co-authored over 300 papers in peer-reviewed international and national journals and is the co-inventor of > 60 patents.

He serves on numerous scientific and advisory committees of international conferences and presents more than 50 invited and scientific talks in various places across the world. He has been actively involved and consulted for several Industries and research organizations. He is a committee member of KVS, and Surface Technology Division of National Projects of Korean Government and has served as a President of Korea Institute of Surface Engineering in 2006-2008, as a Head of Institute of Industrial Vacuum Technology in 1998-2000, and as a Director of Korea-Germany Cooperation Project on Vacuum and Plasma Technology in 1999-2001. He has been serving as an executive committee member of surface engineering division, IUVSTA since 2010.

As an eminent expert in the advanced and applied field, he was the Editor in the special proceedings of international conferences to Surface Coatings and Technology and Thin Solid Films (1998, 2002, 2003). He has also served as a guest editor for the special issues of the AEPSE 2015 conference for the Journal Surface and Coatings technology. Also, he is an active reviewer of several Journal series but not limited to AIP, IOP, IEEE, RSC, and Elsevier.

He is also the recipient of Sungkyunkwan University's "Best Professor Fellowship", the "President award of Republic of Korea-2006", and "Honorary doctor-2015, Chiangmai University, Thailand".

EVENING LECTURE

JEAN-COUTU BUILDING, ROOM S1-151

17:00 Tracing the recorded history of thin-film sputter deposition: from the 1800s to 2017

J.E. Greene
University of Illinois at Urbana - Champaign, Urbana, IL, USA

Thin films, ubiquitous in today's world, have a documented history of more than 5000 years. However, thin-film growth by sputter deposition, which required the development of vacuum pumps and electrical power in the 1600s and 1700s, is a much more recent phenomenon. First reported in the early 1800s, sputter deposition already dominated the optical-coating market by 1880. Preferential sputtering of alloys, sputtering of liquids, multi-target sputtering, and optical spectroscopy for process characterization were all described in the 1800s. Measurements of threshold energies and yields were carried out in the late 1800s, and results in reasonable agreement with modern data were reported in the 1930s. Roll-to-roll sputter coating on flexible substrates was introduced in the mid-1930s and the initial demonstration of sustained self-sputtering (i.e., sputtering without gas) occurred in 1970.

The term magnetron dates to 1921 and the results of the first magnetron sputtering experiments were published in the late 1930s. The earliest descriptions of a parallel-plate magnetron were provided in a patent filed in 1962, rotatable magnetrons appeared in the early 1980s, and tunable "unbalanced" magnetron sputtering was developed in 1992. Two additional forms of magnetron sputtering evolved during the 1990s, both with the goal of efficiently ionizing sputter-ejected metal atoms: ionized-magnetron sputtering and HiPIMS, the later now available in several variants.

rf glow discharges were reported in 1891, with the initial results from rf deposition and etching experiments published in the 1930s. Modern capacitively-coupled rf sputtering systems were developed and modeled in the early 1960s and a patent was filed in 1975 that led to pulsed-dc and mid-frequency-ac sputtering.

The purposeful synthesis of metal-oxide films goes back to at least 1907, leading to early metal-oxide and nitride sputtering experiments in 1933, although the term "reactive sputtering" was not used in the literature until 1953. The effect of target oxidation on secondary-electron yields and sputtering rates was reported in 1940. The first kinetic models of reactive sputtering appeared in the 1960s; high-rate reactive sputtering, based on partial-pressure control, was developed in the early 1980s.

While abundant experimental and theoretical evidence already existed in the late 1800s to early 1900s demonstrating that sputtering is due to momentum transfer via ion-bombardment-induced near-surface collision cascades, the concept of sputtering resulting from local "impact evaporation" continued in the literature into the 1960s. Modern sputtering theory is based upon a linear-transport model published in 1969.

No less than eight Nobel Laureates in Physics and Chemistry played major roles in the evolution of modern sputter deposition.

Joe Greene is the D.B. Willett Professor of Materials Science and Physics at the University of Illinois, the Tage Erlander Professor of Materials Physics at Linköping University, Sweden, and a Chaired Professor at the National Taiwan University of Science and Technology. The focus of his research has been the development of an atomic-level understanding of adatom/surface interactions during the dynamic process of vapor-phase crystal growth in order to controllably manipulate nanochemistry, nanostructure, and, hence, physical properties. His work has involved nanoscience and film growth by all forms of sputter deposition, solid and gas-source MBE, UHV-CVD, MOCVD, and ALE. Joe has published more than 550 papers and review articles, 28 book chapters, and co-edited 4 books in the general areas of crystal growth, thin-film physics, and surface science. In particular, he has used hyperthermal condensing species and UV photochemistry for probing as well as stimulating surface reactions that do not proceed thermally. Joe has presented over 500 invited talks and 100 Plenary Lectures at international meetings.

He is currently Editor-in-Chief of Thin Solid Films and past Editor of CRC Critical Reviews in Solid State and Materials Sciences. He is active in the AVS where he has served on the Trustees, twice as a member of the Board of Directors, as President of the society in 1989, and is currently Secretary. He has also Chaired the AVS Thin Film and Advanced Surface Engineering Divisions, the IUVSTA Education and Thin Film Committees, and served on the Governing Board of the American Institute of Physics and the Executive Committee of the APS Division of Materials Physics. He is currently the US representative to the International Union of Vacuum Science and Techniques and is serving on the Executive Committee of ASED.

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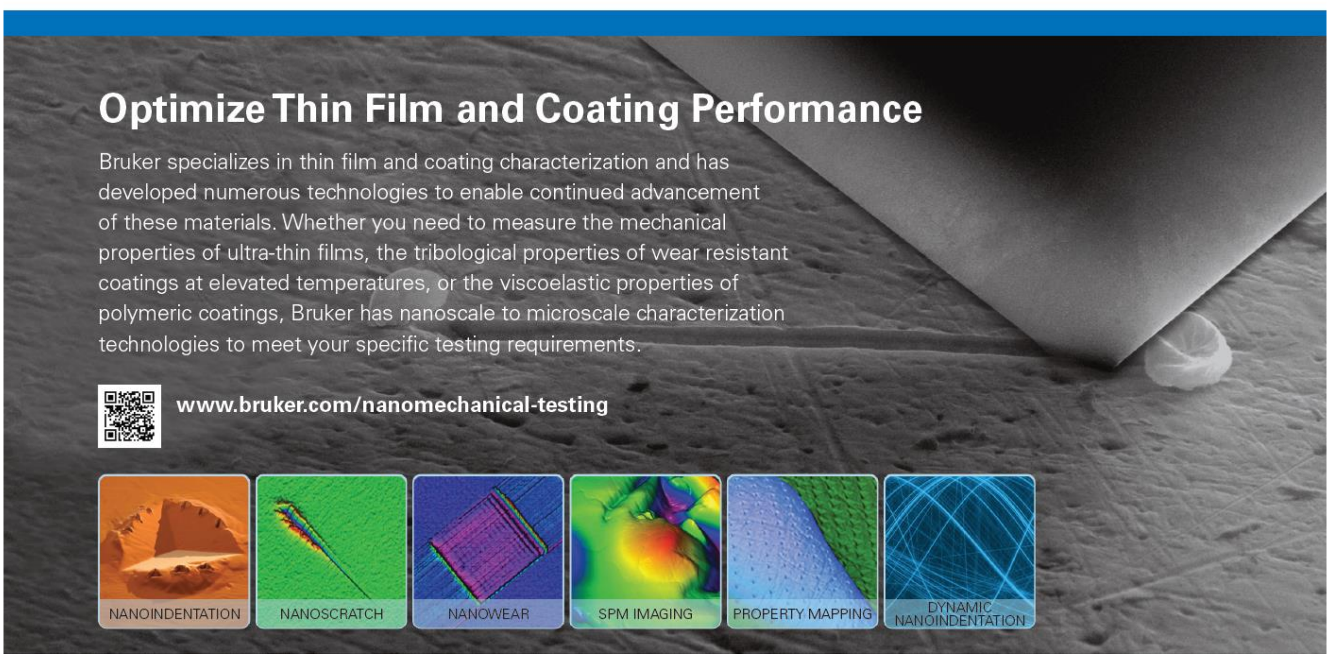

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POSTER PRESENTATIONS

JEAN-COUTU BUILDING, MORRIS AND ROSALIND GOODMAN AGORA

PP1- Different effects of saccharin on electrodeposition of nanocrystalline nickel coating and electrodeposition of nanocrystalline iron coating

A. Bahrololoomi, M.E. Bahrololoom
Department of Materials Science and Engineering, Shiraz University, Shiraz, Iran

Saccharin has been added to nickel plating baths previously to reduce the grain size and thus electrodeposit nanocrystalline nickel coatings. In a recent investigation, the role of each functional group of saccharin on electrodeposition of nanocrystalline nickel also has been studied. When saccharin molecules are adsorbed on the cathode surface they block many sites and thus nucleation is promoted, grain size is reduced and consequently nanocrystalline nickel coating is electrodeposited. The presence of a benzene ring in saccharin molecule might have an effective role in the grain refining process in electrodeposition of nanocrystalline nickel coatings. It seems that stereochemistry, i.e. the direction of the nickel ions approaching a saccharin molecule, can be an important factor determining whether saccharin can act as a grain refiner for electrodeposition of nanocrystalline nickel coatings.

The present research proved that the beneficial effect of adding saccharin to the nickel bath and its role as a grain refiner cannot be generalised for electrodeposition of nanocrystalline iron coatings. The results of the present investigation showed that addition of saccharin to the iron electroplating bath deteriorates the bath, changes the bath colour and chemistry, forms precipitates and produces dull, rough non-metallic coatings. X-ray diffraction (XRD) analysis showed that the coatings were iron oxides (106 nm grain size) while without addition of saccharin, the coatings were metallic iron with 43 nm grain size. In conclusion, addition of saccharin to the bath for electrodeposition of nanocrystalline iron can be very destructive with regards to the bath stability and also the composition and quality of the coating. This might be due to the occurrence of a reaction between iron (II) ions and saccharin. If this reaction occurs, saccharin would act as a ligand to form a complex ion rather than acting as a grain refiner.

PP2 - Formation of nanoparticles in HMDSO-based dusty plasma with pulsed injection of the precursor for the fabrication of nanocomposite layers

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In the past years, the PECVD/PVD Hybrid Plasma Deposition Method with pulsed injection of the precursor has proved high efficiency for controlled growth of Nanocomposite thin layers. In this particular low-pressure, axially-asymmetric capacitively-coupled discharge process, silver atoms are brought into the plasma through sputtering while the pulsed injection of hexamethyldisiloxane (HMDSO) precursor prevents from complete target poisoning. It was observed that under particular experimental conditions, a dust cloud is grown inside the plasma. Knowledge on the plasma behaviour is required in order to design the structural and electrical properties of the deposits. In this study, we bring information about many facets of the complex phenomenon of nanoparticle formation in HMDSO-based Dusty Plasma. Namely, we identify acetylene as the right promoter for the dust nucleation, we demonstrate the impact of the dust formation on the plasma parameters and we present the possible tailoring of the nanoparticles size, density and composition with the relevant operating parameters.

PP3 – Optical properties of 1-DT stabilized silver nanoparticles

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Silver nanostructures possess a wide range of applications ranging from conductive transparent films, wavelength selective absorbers to metamaterials and more. These applications are enabled by the high density of free electrons and high mobility allowing them to couple to the visible electromagnetic radiation as nanoparticles or to conduct efficiently as thin films. However, silver readily oxidizes in ambient conditions by forming an outer layer of oxide which will negatively impact their desirable properties and disallow reliable measurements. Therefore, silver nanostructures must be protected from oxygen and humidity to function properly. In this work, we present the use of the 1-DT dodecanethiol self-assembled monolayer to protect evaporated silver thin films (continuous and discontinuous) from ambient oxidation. By using an ultrathin, transparent organic monolayer, we minimize the impact of the surrounding medium on the nanostructures, and thus we can obtain more reliable intrinsic properties.

PP4 - Challenges and opportunities around the synthesis of nanocomposite thin films by cold dielectric barrier discharge at atmospheric pressure

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Dielectric barrier discharges (DBD) at atmospheric pressure are now routinely used for the growth of functional coatings on heat-sensitive samples by plasma enhanced chemical vapour deposition. In recent years, we have examined the possibility of producing nanocomposite, multifunctional coatings in plane-to-pane DBD using colloidal suspension as growth precursors. In this work, Scanning Electron Microscopy (SEM) is used to highlight the relationship between the voltage excitation waveform and the transport dynamics of TiO_2 nanoparticles (NPs). Dynamic light scattering (DLS) observations of the colloidal suspension coupled with transmission electron microscopy (TEM) analyses are also used to describe the link between the atomized colloidal suspension and the spatial distribution of NPs in the SiO_x coating.

PP5 - Optical and mechanical performance of Cd_2SnO_4 thin films deposited by sol-gel

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The effects of Ar/CdS annealing on the optical properties of polycrystalline sol-gel Cd_2SnO_4 films are studied by spectroscopic ellipsometry (SE). The optical constants of the as-deposited and annealed films were obtained at 45°, 55°, 65° and 75°. A dielectric layer for the quartz substrate followed by the CTO layer simulated by a Cauchy oscillator form the optical model used for the films without annealing. Two layers need to be taken into account when simulating the films annealed in Ar/CdS; a Tauc-Lorentz oscillator describes the first one, while the second layer is an EMA consisting of a Tauc-Lorenz oscillator and voids. The model proposed is the most simple one compared with the literature. It was found that as the temperature increases the values of n decrease, keeping these values comparable to the ones reported by other authors. We quantitatively study the evolution of wear, friction coefficient and roughness of the films by multiple-pass measurements using a depth-sensing instrumented indentation system.

PP6 - Influence of internal stress on the failure modes of optical coatings during scratch testing

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Considering the increased use of compliant plastic substrates in the optical thin film industry for a wide variety of applications such as touch screens and ophthalmic lenses, it is crucial to understand the failure mechanisms occurring during the abrasive loading of these new coating systems in order to optimize their architecture for combined optical and mechanical performance. In this study, we present a new in situ setup and a new approach to perform and analyze scratch tests on optical coatings on compliant transparent substrates. The proposed instrument allows one to observe and image the contact region in real-time during the scratch test and to evaluate the shear stress distribution surrounding the contact using the photoelasticity principle. The studied films consist of thin evaporated TiO_2 layers (~ 300 nm thick) deposited on a plastic substrate. The use of ion gun assistance during the deposition allows one to tailor the residual stress and to produce coatings which exhibit varying stress levels: from tensile to compressive states. The failure mechanisms were assessed for two situations: (i) an increasing load scratch sequence, and (ii) a novel decreasing load scratch sequence. Subsequently, the observed failure modes are linked to the internal stresses of the coatings. This study significantly enhances the understanding of the failure mechanisms occurring during scratch testing of optical films on highly compliant substrates and, with this new knowledge, we demonstrate a novel methodology using the scratch test results to extract the yield strength of thin TiO_2 optical coatings.

PP7 - Maximizing light-to-solar-gain and clear-neutrality in a novel spectrally selective material system

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Spectrally selective coatings permit effective modulation of the visible, infrared and mid-infrared energies in the solar and thermal regimes of the electromagnetic spectrum, thus enabling the vision of net/near-zero energy buildings. Advancing the current state-of-the-art of energy modulating coatings requires the development of an optimization model with an emphasis on prioritized integration of standard optical and energy performance metrics; specifically, high light-to-solar-gain ratio (LSG) and clear-neutrality. Using an algorithmic approach, we have mapped out the parametric space for our unique nano-material system with the underlying objective of maximizing LSG commensurate with clear-neutrality while minimizing the number of layers in the multilayered structure. Specifically, we show that it is possible to achieve LSG of 2.665 which significantly exceeds the state-of-the-art value of 2.27. This poster will demonstrate functional prototypes and show correspondence with our computationally optimized theoretical predictions.

PP8 - Strain-tunable optical properties of a priori designed structured nano-thin metal films

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Pliable metal thin-films have been investigated extensively within the framework of flexible electronics wherein the objective has been substantial preservation of electrical continuity under large strains. Recently our group has examined the influence of strain on the optical properties of nano-thin metal films deposited on polydimethylsiloxane. We have shown that a range of micro and nano length scale cracks develop in strained metal films depending on the synthesis techniques employed. Further, a range of strain-tunable optical phenomena were observed including surface plasmon resonances and optical scattering. In contrast, herein we report on the potential of achieving specifically preferred optical response under strain through apriori designed structuring of metal thin films on a pliable substrate. Our COMSOL study shows that a set of optical responses correspond to specific sets of micro and nano structured thin metal films under strain, which in turn opens the prospect of engineered strain-tunable optical devices.

PP9 -Wear behavior of Fe_3Al-TiN-TiB_2 HVOF coatings: a comparative study between in situ and *ex situ* powder processing routes

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In the present study, the tribological properties of High Velocity Oxy-Fuel (HVOF) coatings prepared from Fe_3Al-based composite powders were investigated. The iron aluminide matrix of the composite powders was reinforced with TiN and TiB_2 particles made using two different processing routes: a) an *in situ* method where fine ceramic particles were formed in the matrix by the reaction between Ti and BN, and b) an ex situ method where preformed coarse TiN and TiB_2 particles were added to the matrix. The tribomechanical performance of the coatings was assessed using indentations and pin-on-disc wear tests. Compared to ex situ samples, the Fe_3Al-based coatings strengthened with in situ ceramic particles exhibit higher microhardness and wear resistance regardless of the sliding velocity. The presence of voids, cracks and scratches/grooves in the wear track of the *in situ* coatings and the coating material transferred to the corresponding counterpart suggest that coatings with fine reinforcing particles fail predominantly via delamination and adhesive wear mechanisms. In the case of the ex situ coatings, the presence of a significant amount of hard ceramic particles within the wear track indicates that abrasive wear plays a dominant role in the degradation mechanism. Oxidation wear also contributed to material removal at high sliding velocity since transfer materials inside the wear track contain a high oxygen content compared to the unworn region regardless of the coating type.

PP10 - Solid solution hardening in nanolaminate ZrN-TiN multilayer coatings

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The development of nanocomposite coatings has opened new possibilities for the fabrication of functional and protective coatings with unusual combinations of mechanical and chemical properties, such as stability at elevated temperatures, high hardness and toughness, wear and corrosion resistance. In this study, different combinations of ZrN and TiN coatings were prepared with various modulation periods by pulse-dc magnetron sputtering. The coatings were deposited on nitrided Ti-6Al-4V alloys (duplex treatment) and simultaneously on (100) silicon wafers. The Zr and Ti targets, both of 51 mm diameter, were pulsed in asynchronous mode, both at 300 kHz and 1.1 μs reverse time (duty cycle ~70%). A total thickness of approximately 1 μm and ~4 μm for each coating was prepared by adjusting the deposition time. The structure of the coatings was studied by X-ray diffraction and High-Resolution Scanning Electron Microscopy, and the hardness and the reduced Young's modulus, were determined by depth-sensing indentation (Hysitron Inc.) using a Berkovich pyramidal tip. In the case of the nanolaminate coatings, various individual modulation periodicities, L, were designed. The nanolaminate coatings with L=1 to 10 nm displayed a single phase of solid solution with Zr-rich composition, $Ti_{0.35}Zr_{0.65}N$. This finding indicates mixing or diffusion between the two phases which might have occurred during growth. The grain size was found to vary with the modulation periodicities, and it was observed that the grain size of the solid solution $Ti_{0.35}Zr_{0.65}N$ is ~8-12 nm, while that of the laminate structure is ~10-25 nm. The solid solution structure was found to be the main cause of the hardening of the nanolaminate structure. The hardness of the solid solution coatings was 32-35 GPa which was significantly higher than the 21 GPa of TiN or 18 GPa of the ZrN single-layer coatings. The hardness and the grain size varied with the modulation periodicity of the multilayer coating, which was found to affect the wear resistance and tribological characteristics of the coatings (friction coefficient, μ, and resistance to plastic deformation, H^3/E^2, and toughness, H/E).

PP11 - Towards perpetual dynamic component exchange using a surface immobilized anchor for azomethine substitution

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An aryl aldehyde was grafted onto an ITO coated glass substrate and it served as an anchor for preparing electroactive azomethines. The reversibility of the covalent N=H bond was exploited for dynamic component exchanges. The immobilized azomethines underwent multiple step-wise component exchanges with different arylamines. We first studied the capacity of the azomethines to be reversibly hydrolyzed several times. Then, multiple component exchange cycles were done by immersing the ITO substrate in an arylamine solution followed by rinsing. In presence of a large excess of arylamine, the azomethines component exchange was spontaneous. Each erase-write sequence was electrochemically confirmed. Both the reversibly hydrolysis and component exchange cycles served as a proof of concept for perpetual dynamic component exchange.

PP12 - Tribological behavior of carbon and carbon-nitride films measured at the microscale levels

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We study the microtribological behavior of amorphous and fullerene-like (FL) carbon and carbon nitride coatings deposited by filtered cathodic arc under ambient conditions. Films deposited at 0 and 0.5mTorr N_2 partial pressure with substrate temperature (TS) of 20 °C have amorphous structure, while films deposited at TS= 300 °C possess a fullerene-like structure. Films deposited under a N_2 partial pressure of 5mTorr have amorphous structure at both deposition temperatures. All films exhibit a low friction coefficient of 0.06-0.07 throughout the tribological tests, however, their wear mechanisms are different. For amorphous films, deposited at 0 and 0.5 mTorr N_2 partial pressure, the wear process is both tribomechanical and tribochemical but dominated by the first mechanism, while the second process controls the behavior of the films deposited at 5 mTorr with TS = 20 and 300°C. The wear mechanisms are discussed in terms of sp^2-sp^3 content into of the wear track.

PP13 - A CMOS compatible, ferroelectric tunnel junction memory device

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The present work reports the fabrication and characterization of a ferroelectric tunnel junction device (FTJ). It is an emerging memory that could replace the current dynamic random access (DRAM) memory, which has gradually reached its physical scalability limits.
In the last couple of years, successful fabrication of FTJ devices based on different perovskite tunnel barriers have been reported and promising properties have been demonstrated; this includes good scalability, low operating energy, high operation speed, high endurance, non-volatility and a simple structure. However, FTJ's based on perovskite tunnel barrier require of specific substrates and high processing temperatures which makes them incompatible with the complementary metal oxide semiconductor process (CMOS).
The originality of the present work relies on the demonstration of the tunneling electroresistance effect in a FTJ memory device based on a CMOS compatible tunnel barrier $Hf_{0.5}Zr_{0.5}O_2$ (6 unit cells thick) on an equally CMOS compatible TiN electrode.

PP14 - Effect of WC content on solid particle erosion behavior of cold-sprayed Ni-WC composite coatings

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Metal matrix composites (MMCs) of WC in Ni matrixes are widely used due to a good combination of hardness and toughness, and good wear resistance. Previous studies showed that an optimum content of WC particles with tailored mechanical properties extend the practical uses of the MMCs. In this study, composite coatings of Ni with various WC content ranging between 10 to 63 vol% were deposited using cold spray. Using micro-indentation, a relationship between coatings mechanical properties and feedstock powder type, size and volume fraction of WC was studied. Cold-sprayed coatings were subjected to ASTM standard G76 solid particle erosion (SPE) at two 30 and 90 impact angles. Wear loss measurements and detailed microstructural analyses were conducted to study the mechanism involved in SPE of coatings. Changes in erosive wear performance as a function of WC content was explained using the mean free path between the WC-based reinforcing particles.

PP15 - Investigation of metal/ceramic interfaces created by cold spray

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Metal/ceramic interfaces have long been studied for applications in biomedical and aerospace industries among others. Cold spray is a newer technology used for deposition of metal matrix composites with ceramic reinforcement or metallization of ceramics. However, few studies evaluate bonding in metal/ceramic interfaces produced by high speed impact. For this work, single metal splats were deposited on alumina and silicon carbide to quantify the bond strength of metal/ceramic interfaces created by cold spray. Bond strength was measured using a specialized splat adhesion test [1]. Deposition conditions had little effect on bond strength, but comparisons among the material combinations revealed significant differences. For instance, low bond strengths in titanium/silicon carbide interfaces were associated to extensive cracking of the ceramic while titanium/alumina interfaces appeared continuous and well bonded. Bond strength will be discussed in the context of the deposition mechanisms and the quality of the metal/ceramic interfaces observed by scanning electron microscopy.

[1] R.R. Chromik, D. Goldbaum, J.M. Shockley, S. Yue, E. Irissou, J.G. Legoux and N.X. Randall, "Modified ball bond shear test for determination of adhesion strength of cold spray splats," *Surface & Coatings Technology* 205 (5), 1409-1414 (2010).

PP16 - Cold spray and dry sliding wear of Ti6Al4V and Ti6Al4V+TiC metal matrix composite coatings

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Ti6Al4V is used in various engineering applications due to its high strength-to-weight ratio and corrosion resistance. However, its poor wear resistance sometimes limits its usage for tribological applications. In the present study, Ti6Al4V and Ti6Al4V+TiC composite coatings were deposited using cold spray process and sliding wear tests were performed on these coatings at 0.5 N normal load, sliding velocity of 3 mm/s in dry air. Ti6Al4V+TiC coatings showed improved hardness, wear resistance and lower coefficient of friction (CoF) compared to pure Ti6Al4V coatings. To directly observe transfer film behavior, in situ tribometry was performed using a sapphire hemisphere. Transfer films grew, detached and were reformed throughout the test. Ploughing by wear debris led to the high wear and CoF in Ti6Al4V, whereas, formation of a protective tribolayers lowered the wear and CoF in composite coatings. Raman analysis on tribolayers revealed a mixture of TiO_2 and amorphous carbon that contributed to easy shear and reduced CoF.

PP17 - Surface patterning and tribochemistry of silicon-oxide containing diamond-like carbon (a-C:H:Si:O) films

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a-C:H:Si:O films are generally described as fully amorphous films consisting of two interpenetrating and interbonded networks, one being a silica glass (SiO_x) network and the second one an amorphous hydrogenated carbon network (a-C:H) [1]. Their outstanding mechanical durability and tribological performances increase their attractiveness as solid lubricants in various mechanical systems.

In this work, we investigated the effect of environment on the tribological performance of a-C:H:Si:O films by using a linear reciprocating pin-on-flat tribometer under controlled environment. We were thus able to show that the frictional response strongly depends on the mechanics of the interface. Furthermore, tribochemical reactions occurring while sliding patterned and non-patterned a-C:H:Si:O against a 52100 steel were also studied by different analytical techniques.

[1] V.F. Dorfman, Diamond-like nanocomposites (DLN). *Thin Solid Films* 212, 267–273 (1992).

[2] K.D. Koshigan, *et al.*, Understanding the hydrogen and oxygen gas pressure dependence of the tribological properties of silicon oxide–doped hydrogenated amorphous carbon coatings. *Carbon* 93, 851–860 (2015).

[3] T.W. Scharf, J.A. Ohlhausen, D.R. Tallant, S.V. Prasad, Mechanisms of friction in diamondlike nanocomposite coatings. *J. Appl. Phys.* 101, 063521–063521–11 (2007).

PP18 - Durability and wear mechanisms of easy-to-clean coatings on glass assessed by *in situ* tribometry

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In the present work, *in situ* tribometry was used to evaluate the durability and to study the wear mechanisms of perfluoropolyether (PFPE) based easy-to-clean (ETC) coatings on glass substrates for applications such as displays. The *in situ* tribometer (TribTik) equipped with a camera imaging system allows one to obtain and correlate the instantaneous friction coefficient and the contact area's status *in situ*. Therefore, the test can be aborted at critical stages of the wear process, and the wear mechanisms can be analyzed by further examining the morphology and composition of the wear tracks. With the support of optical, SEM and EDX analyses, the instantaneous friction coefficient and the *in situ* images correlate very well with the wear process. The progression of the wear mechanism can be defined as follows: 1) generation of unconsolidated debris, 2) formation of layered tribofilms, 3) cracking of the tribofilms, and 4) damage to the underlying glass substrate.

PP19 - Ion beam oxidation of vanadium thin films: structural characterization

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Vanadium oxide thin films are important functional materials for making smart windows, electronic switching elements or temperature sensors. Oxides are often deposited reactively but can also be obtained by oxidation of metallic layers. Our study aims at understanding the oxidation of metallic vanadium surfaces by low energy oxygen ions. E-beam evaporated vanadium metal films, of about 100 nm thick, were deposited on Si substrates and were subsequently exposed to an oxygen plasma produced by an end-Hall Kaufman-type ion source. We used a discharge voltage of 78 V, oxidation times were varied between 10 s and 600 s and the process was carried out near room temperature. X-ray reflectometry and atomic force microscopy results suggest that ion beam oxidation produced thin oxidized layers, around 5 nm thick, buried under surface morphology. The competing surface sputtering effect by the ion beam was also detected. Compositions of these surface oxides were also studied by angled-resolved X-ray photoelectron spectroscopy.

PP20 -Durable thermochromic VO_2 coatings on polymer substrates deposited by HiPIMS

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Vanadium dioxide (VO_2) is one of the most studied thermochromic materials due its metal-to-insulator transition (MIT) at a critical temperature of 68°C, close to room temperature. The MIT changes VO_2 optical and electrical properties from a high-temperature infrared reflecting metal to a low-temperature infrared transparent insulator. Because of this reversible change in properties, VO2 has been considered as a candidate for energy control applications such as 'smart-windows' or 'smart radiator devices'. However, industrial development of such devices is limited by the complex control of stoichiometry and the required high deposition temperature, typically above 400°C. In this research, we applied reactive High Power Impulse Magnetron Sputtering (HiPIMS) to lower the deposition temperature of VO_2 to 300°C, and as a result, to deposit thermochromic VO_2 coatings on polymer substrates. These films are also shown to exhibit superior oxidation resistance in a water-containing environment compared other film fabrication technologies, e.g., radio-frequency magnetron sputtering.

PP21 - All-thin-film color shifting electrochromic devices for security and architectural applications

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Counterfeiting is the source of significant economic as well as safety/security-related issues worldwide. Staying ahead of counterfeiters thus represents a constant struggle for developers of anticounterfeiting devices. As passive optical features, based on metal-dielectric filters, are becoming easier to copy, the need for an additional level of complexity and protection is also increasing. Here, we propose to add an active component to these devices, through the use of an electrochromic material.

Indeed, electrochromic (EC) materials, such as WO_3, change color upon the application of a current resulting in electron and ion insertion. The material can then be brought back to its original state upon inverting the current. We have combined the typical battery-like architecture of standard EC devices with the design of a Fabry-Perot-like thin film interferometer, resulting in a feature which displays a passive angular color change, as well as a contrasting coloration upon voltage application. This results in a promising two-level authentication device for the next generation of optical security features. Possible applications in implementing the color-shifting EC devices in building envelopes are also discussed.

PP22 - The effect of polymer additives on femtosecond laser micromachining of UV cured urethane diacrylate

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Femtosecond laser micromachining has emerged recently as a one-step process to modify surface topology on the nano and micrometer scale for use in anti-wetting, anti-icing, microfluidic, electrical and optical applications. The fs-laser ablation of a UV-cured urethane diacrylate base polymer has been studied alongside the ablation of this base polymer doped with six different additive species. The additives studied include ethyl acrylate, methacrylic acid, styrene, benzyl methacrylate, and ethyl methacrylate. The additive included, and the weight percentage thereof, has indeed influenced the threshold fluence of the material with respect to a 275-nm wavelength fs-laser beam and has altered the incubation effects the material exhibits with subsequent laser pulses. Although these materials have different threshold fluences and incubation coefficients, they all exhibit strikingly similar microstructure when patches are ablated onto their surfaces. This suggests that the base urethane diacrylate polymer dominates with regards to microstructure formation. Further, no relationships are seen between the ethyl, methyl, or benzene chemical groups present in the additives used and the threshold fluence or incubation coefficient exhibited by the material. This suggests that the laser micromachining characteristics of these materials is a result of physical parameters, rather than the chemical bonds present.

PP23 - Thermal sprayed CaviTec coatings for the protection against cavitation erosion

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CaviTec® is an austenitic stainless steel known for its high resistance to cavitation. Under cavitation, this material exhibits a long incubation period before erosion starts, and small erosion rates are observed afterwards. During the incubation period, no degradation of the material is observed. CaviTec's structure absorbs the cavitation impact energy due to a structural transition. In this work, Cavitec powders were prepared by water atomization to produce HVOF CaviTec coatings. Compared to the bulk alloy, the coatings exhibit a relatively poor cavitation resistance and no incubation period. The defects present in the coating's microstructure (splats boundaries, pores and oxides) initiate cracks during erosion, and this leads to the removal of dense CaviTec particles. However, by milling the powder at high energy prior to deposition, the cavitation resistance can be improved by a factor of 2. Moreover, deposition at high velocity leads to a much higher cavitation resistance of such coatings. Finally, the cavitation resistance of CaviTec HVOF coatings were found to be comparable to the well-known cavitation resistant HVOF coatings such as WC-CoCr and Stellite-6.

PP24 – Application of suspension plasma spray process for fabricating titanium dioxide water filtration membranes

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Porous ceramic water filtration membranes with asymmetric structures are effective tools for removing pollutants from water. Depending on the contaminants of concern, submicron to a few micron-sized pores are essential for this application. Suspension plasma spray enables deposition of a few microns to nano-sized particles in a suspension to generate such a microstructure. Titanium dioxide has gained interest as water treatment membrane due to its mechanical, chemical and thermal stability. This study is conducted to evaluate the potential of suspension plasma spray technique as an emerging process in membrane fabrication. Aqueous suspension of titanium dioxide will be used in fabrication of water treatment membranes. SEM and X-ray diffraction will be used to characterize the microstructure and the crystalline structure of the coating. Porosity measurements will be performed using image analysis technique and mercury intrusion porosimetry. Water permeability of the membranes will be evaluated in a laboratory-scale dead end filtration cell.

PP25 – Effect of nanofluid stability on heat transfer enhancement

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Nanofluids are colloidal dispersions of nanoparticles in base liquids. They captivate the interests of researchers and technologists since their introduction in literature in the late 1990's. A rich literature reports that the heat transfer properties of nanofluids vary from those of the base liquids. Researchers have reported an increase of up to 125 % in critical heat flux and more than 200 % in heat transfer coefficient. But at the same time, some researchers reported heat transfer deterioration with nanofluids. Thus, there exists controversy in the literature. We see that all these nanofluids used for experiments have been prepared by different methods and their stability for long periods of time or after heating has not been reported. From a literature review we hypothesize that instability of nanofluids might be the reason for the contradicting results. In this work, we measure the heat transfer ability of multi-walled carbon nanotube (MWCNT) water nanofluids prepared using different methods, to test our hypothesis.
We prepared nanofluids of varying stability with MWCNTs in water and ethanol. The nanofluids prepared using as prepared (non-functionalized) MWCNTs in water (NF W) were unstable, and agglomerated within one day. We prepared surfactant-stabilized nanofluids in water (NF SS1 W, NF SS2 W) using 2000 and 20,000 ppm of sodium dodecyl sulfate surfactant. These nanofluids remained stable until they were heated during the experiments. Stable nanofluids were prepared using plasma functionalized MWCNTs (F-MWCNTs) in water (F-W) and ethanol (F-E). Their stability over a period of two months was ascertained not only by visual inspection but also by particle size measurement and UV-Vis absorption.
A simple heat transfer experiment was conducted to measure the change in cooling rate when different fluids are used to quench a heated copper disc. The copper disc was heated to 170 °C and quenched with 20 ml of the respective test coolant. The rate at which the surface cooled from 170 °C to 90 °C was measured to determine the rate of cooling. Each experiment was repeated three times. It was seen that the NF W, NF SS1 W, NF SS2 W and F-W gave similar or lower cooling rates compared to that of pure water. Also, we noted that all of these nanofluids destabilized as they cooled the

copper disc. Or in other words, these nanofluids destabilize when heated. The reduction in cooling rate for the unstable nanofluids is due to the deposition of MWCNT agglomerates on the heater disc. However, we observed that the cooling rate using F-E (120 ppm F-MWCNTs) was 5 °C/min higher than that with pure ethanol. F-E nanofluid remained stable even after it boiled during the process of quenching the surface. We confirmed the stability of F-E nanofluid by particle size measurement. We understand that with unstable nanofluids, the results are not promising and inconsistent but with stable nanofluids we achieve an increase in the cooling rate. This proves our hypothesis that unstable nanofluids containing agglomerates deteriorate heat transfer, and that the stability of nanofluid at higher temperatures (upto boiling point) is essential for heat transfer enhancement.

PP26 - Microstructural and mechanical characterization of three hardfacing alloys with different buffer layers

Y. Wu[1], T. Schmitt[1], E. Bousser[1], J.-E. Klemberg-Sapieha[1], F. Khelfaoui[2], N. Tarfa[2] and M. Brochu[1]
[1]*Polytechnique Montreal, Quebec H3T 1J4, Canada*
[2]*Velan, 550 Rue Mcarthur, Saint-Laurent, Quebec H4T, Canada*

Disbonding and delamination of Stellite hardfacing have caused serious problems in power plants in recent years. Stellite 6 hardfacing as well as Stellite 21 buffer layer are deposited onto F91 steel using plasma transfer arc welding. In addition to Stellite 21, we have studied two alternative hardfacing systems with IN625 and IN82 as buffer layers. A series of aging experiments simulating service conditions have been conducted at different temperatures and exposure times. Using Energy Dispersive Spectroscopy (EDS), we show that the three buffer layers have a varying amount of iron (Fe) which can affect the microhardness of the Stellite 6 hardfacing. The results show that the hardness of Stellite 6 decreases with an increasing amount of Fe which could compromise its wear resistance. Stellite 21 buffer layer contains a lower Fe level when compared to nickel-based buffer layers. On the other hand, F91-Stellite 21 interface is unstable during aging. A hard and brittle interlayer that significantly reduces the impact energy of the assembly is observed after exposing for 1008 hours at 650oC. This layer thickness increases with longer time and higher temperature. However, no interlayer has been observed in IN625 and IN82 hardfacing systems up to 8760 hours at 650oC. Nickel-based buffer layers are good alternatives for the Stellite hardfacing of valves since their chemistry and impact energy are more stable than the Stellite 21 buffer layer.

PP27 – High load-carrying capacity duplex-coated low strength steel

M. Laberge[1], J. Schmitt[1], M. Koshigan[1], T. Schmitt[1], E. Bousser[1], F. Khelfaoui[2], L. Vernhes[2], J.-E. Klemberg-Sapieha[1]
[1]*Department of Engineering Physics, Polytechnique Montréal, Montreal, QC H3T 1J4, Canada*
[2]*Velan, 550 Rue McArthur, Saint-Laurent, QC H4T 1X8, Canada*

In the present study, we investigate the load carrying capacity and wear resistance of a duplex coated 316 stainless steel and we develop a numerical approach by finite element modeling to support and predict our experimental observations. For highly demanding valve applications, low strength steels are often imposed as the standard materials considering their relatively superior chemical stability, galvanic corrosion resistance and lower susceptibility to stress corrosion cracking failure. Hardfacing (Thermal spray, Laser cladding, Plasma transferred arc welding) is currently the most commonly used solution to protect valve components by providing a thick hardened case which significantly improves the tribological performance. However, compared to vacuum-deposited hard coatings, the wear resistance of such hardfacing layers is still lacking. One solution to further improve the performance is a duplex approach where both processes are combined. The materials under investigation in this work are the base 316 stainless steel, hardfaced by laser cladded Co-Cr superalloys, on top of which a CVD nanostructured W/WC coating is deposited. Tribological properties of the different configurations were assessed in terms of their ability to delay initiation of plastic deformation and surface cracking under quasi-static loading, and their wear resistance to dry reciprocal sliding. Comparison and prediction of the coated system tribological behaviors using finite element modeling has been demonstrated.

PP28 – Durability test of optical coatings on plastics with in situ characterization of the degree of failure

A. Gallegos-Melgar[1], O. Zabeida[1], A. Dehoux[2], D. Poinot Cherroret[2], L. Martinu[1] and J.E. J.-E. Klemberg-Sapieha[1]
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[2]*Essilor International, 39-69 Boulevard Jean-Baptiste Oudry, 94000 Créteil, France*

Despite a wide use of inorganic optical coatings deposited on plastic, their resistance to the mechanical solicitations remains a challenge. Their durability and failure mechanisms are still the subject of active investigation. In this work, we carried out the characterization of optical coatings, deposited on CR39TM substrate by e-beam evaporation under different conditions. A reciprocal movement sliding test was performed at different loads: 10, 15 and 20N, and at different humidity levels, ranging from 10% to 70%. Tribtik tribo-scratch tester developed in our lab allows for in-situ characterization that combines a real-time monitoring of the friction coefficient (COF) and an observation a damaged area. This permits to precisely determine the moment of appearing the first defects and to follow their propagation. We discuss different failure mechanisms observed in our samples at variable test conditions.

EXHIBIT

JEAN-COUTU BUILDING, MORRIS AND ROSALIND GOODMAN AGORA

Agilent Technologies

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ORAL PRESENTATIONS

JEAN-COUTU BUILDING, ROOM S1-151

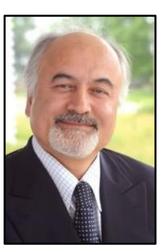
Session 4 – Tribological Coatings

MODERATORS:
C. Stoessel
Eastman Chemical Co., Palo Alto, CA, USA
D. Depla
Ghent University, Ghent, Belgium

8:30 TC1 – Invited – Re-engineering of tribological interfaces toward more efficient and green transportation technologies

A. Erdemir
Argonne National Laboratory, Energy Systems Division, Argonne, IL, USA

About one-third of the fuel's energy in our car's engine is still consumed by friction, and on average, only about 20% of the total energy is actually used to move our cars. Globally, transportation sector accounts for about 20% of the world's energy consumption and some 23% of total greenhouse-gas emissions every year. In this talk, I will survey some of the latest trends in surface engineering which can ultimately lead to more efficient and green transportation technologies. In particular, diamonlike carbon films have made significant positive impact on efficiency and environmental compatibility of current engines. Along these lines, we have been persistently designing, developing, and implementing superlow-friction materials and coatings with great success in our lab and quite recently pioneered the development of a new breed of nanocomposite coatings that are able to extract their own diamondlike carbon tribofilms in-situ and directly from the hydrocarbon molecules of lubricating oils to provide some of the lowest friction and wear coefficients. Overall, development and implementation of these and other emerging technologies will be crucial for a sustainable transportation future that is also environmentally desirable.



Dr. **Ali Erdemir** is a Distinguished Fellow and a Senior Scientist at Argonne National Laboratory with international recognition and significant accomplishments in the fields of materials science, surface engineering, and tribology. He received his B.S. degree from Istanbul Technical University in 1977 and M.S. and Ph.D. degrees in Materials Science and Engineering from the Georgia Institute of Technology in 1982 and 1986, respectively. In recognition of his pioneering research, Dr. Erdemir has received numerous coveted awards and honors, including the University of Chicago's Medal of Distinguished Performance, six R&D 100 Awards, Mayo D. Hersey Award of ASME, two Al Sonntag Awards and an Edmond E. Bisson Award from the Society of Tribologists and Lubrication Engineers (STLE). He is a Fellow of ASME, STLE, AVS, and ASM-International. He has authored/co-authored more than 300 research articles (240 of which are peer-reviewed) and 18 book/handbook chapters, edited three books, presented more than 160 invited/keynote/plenary talks, and holds 17 U.S. patents. His current research is directed toward nano-scale design and large-scale manufacturing of new materials, coatings, and lubricants for a broad range of applications in transportation, manufacturing, and other energy conversion and utilization systems.

9:00 TC2 – Invited – Relating thin film stress to the processing conditions and microstructure

E. Chason
Brown University, Providence, RI, USA

Thin films often develop residual stress while they are being grown with a magnitude that can be large enough to cause film failure by delamination, cracking, etc. The amount of stress depends on the processing conditions and also on the film's microstructure. A better understanding of the origins of film stress would enable us to predict and control it. We present experimental results and modeling that attempt to provide a quantitative understanding of stress evolution during film growth. To determine the dependence on growth conditions, we have performed real-time stress measurements using a wafer curvature technique. Cross-sectional measurements after the growth enable us to determine the grain size at different stages of the growth. The model is based on describing the different stress-generating kinetic processes occurring during growth of polycrystalline films. We show how the model is able to explain the observed dependence on temperature, growth rate and microstructural evolution in several different studies. We also describe how the model can be extended to include the effects of energetic deposition processes (sputtering) on stress.

Eric Chason is a Professor in the School of Engineering at Brown University. His research focuses primarily on the evolution of surfaces and thin films during materials processing. This work has led to the development of several in situ diagnostics that enable monitoring of thin film stress, surface morphology, microstructure and interfacial reactions. An example is the development of a multi-beam optical technique (MOSS) for monitoring stress evolution in situ during processing. Recent projects include residual stress in polycrystalline films, whisker formation in Sn, anodes for Li-ion batteries and ion-induced surface nano-patterning. Before moving to Brown University in 1998, he was a senior member of the technical staff at Sandia National Laboratories in Albuquerque. He received his Ph.D. degree in physics in 1985 from Harvard University.

9:30 TC3 – Invited – Innovative ceramic-like coatings for tooling, machining, aerospace, energy and automotive industry

P. Mayrhofer
Technische Universität Wien, Vienna, Austria

This work summarizes recent developments on applying thin film structure and architecture concepts to hard coatings for optimized performance in various application fields. Hard coatings deposited by plasma-assisted vapour deposition are widely used to reduce friction and wear of tools and engineering components in energy, automotive and aerospace industry.

We will look in more detail into the correlation between microstructure and mechanical and thermal properties of hard ceramic coatings (like Ti-Al-N, Cr-Al-N, Mo-Al-N, Ta-Al-N and combinations thereof). Their microstructure can be designed by choice of the deposition techniques (understanding the growth processes taking place, sequential deposition of layers or self-organization processes) or by thermally induced self-organization. Furthermore, the superlattice effect on hardness and toughness will be discussed in detail and how a multilayer arrangement can significantly improve the thermal stability.

Paul Mayhofer is University Professor of Materials Science at the Institute of Materials Science and Technology, Technische Universiaet Wien, TU Wien, since 2012. Paul is also Guest Professor at the Central South University, Changsha, Hunan (China). He received a Ph.D. in 2001 and Habilitation in 2005 in Materials Science at the University of Leoben. Paul spent his post-doc and Erwin-Schrödinger-Fellowship at University of Illinois at Urbana-Champaign, RTWH Aachen, and Linkoping University. His research activities focus on the development and characterization of vapor phase deposited nanostructured materials by a combination of computational and experimental material science. He has pioneered age hardening within hard ceramic thin films based on ternary nitrides and borides and given more than 40 invited presentations (including plenary and key note lectures). Paul is member of the Young Academy of the Austrian Academy of Sciences, President of the Austrian Vacuum Society, and Editor for the Elsevier Journal Vacuum. At TU Wien he also is Dean of Academic Affairs at the Faculty Mechanical and Industrial Engineering and chairs the Master Study Program for Materials Science.

ORAL PRESENTATIONS

JEAN-COUTU BUILDING, ROOM S1-151

Session 5 – Protective Coatings

MODERATORS:
H. Barankova
Uppsala University, Uppsala, Sweden
A. Erdemir
Argonne National Laboratory, Energy Systems Division, Argonne, IL, USA

10:30 PC1 – Invited – Wear and corrosion resistant coatings for demanding environments

B. Strahin[1], D. Shreeram[2], **G. L. Doll**[1,2]
[1] *Department of Mechanical Engineering, The University of Akron, Akron, OH, USA*
[2] *Department of Chemical and Biomolecular Engineering, The University of Akron, Akron, OH, USA*

Mechanical systems that function in agricultural, construction, and mining and mineral processing applications for example often operate in abrasive, corrosive, and/or boundary lubrication environments. Consequently, the operational periods of mechanical components in these applications are usually much less than their designed and desired lifetimes. Surface treatments in the form of thin film coatings can sometimes increase the lives of mechanical components that must operate in demanding environments. Examples of coatings that have significantly improved the performance of steel mechanical components that operate in boundary lubrication are the families of diamondlike carbon (DLC) and dichalcogenides (e.g., MoS_2), which are applied by vacuum deposition processes. However, these coatings do not usually function well in highly abrasive and/or corrosive environments. Metal carbide coatings applied by thermal reactive diffusion, and metallic coatings applied by electrodeposition can sometimes offer substantial improvements to component performance when operating in abrasive and/or corrosive environments, but do not perform nearly as well as DLC in boundary lubrication environments. This presentation shall review the properties and performances of some of the more successful thin film coatings that have been developed and utilized in demanding environments.

Gary Doll is the Timken Professor of Surface Engineering and the Director of the Timken Engineered Surfaces Laboratories at the University of Akron. He holds joint appointments in the Civil Engineering, Mechanical Engineering, and Chemical and Biomolecular Engineering Departments. His current research includes surface engineering of materials to address friction, wear, and corrosion, nanocomposite materials, and lubrication strategies for challenging environments. He received his Ph.D. in Condensed Matter Physics from the University of Kentucky where he studied the optical and structural properties of layered materials. As a postdoctoral fellow in Physics at the Massachusetts Institute of Technology he conducted research on a wide range of materials including copper oxide superconductors, composites, carbon fibers, and polyimides. After MIT, he joined the General Motors Research Laboratories where he began his research in thin film coatings, surface engineering, and tribology. Later, he became the Chief Technologist of Tribology at the Timken Company where he was responsible for global research and development activities in tribology, lubrication, surface engineering, and non-ferrous materials. Dr. Doll was elected as an ASM Fellow in 2009 for his contributions to the field of Surface Engineering. He currently serves as chair of the STLE/ASME Wind Energy Tribology Committee and is an assistant editor for Tribology Transactions. He is a member of the SVC, STLE, ASME, and ASM organizations. Over his career, Dr. Doll has published over 200 articles and book chapters, edited numerous proceedings, and received more than 25 US Patents.

11:00 PC2 – How to ease health monitoring of CFRP in aeronautics? Stimuli sensitive-coatings: a promising solution!

S. Senani, E. Campazzi, J. Wehr
Airbus Group Innovations, Suresnes, Ile de France, France

Because of their very light weight, excellent in-plane properties and high specific strength CFRP have found many uses in structural applications.
Nevertheless, over a certain threshold of energy density, impacts could lead to internal serious structural damages which can be barely visible, necessitating the use of expensive and high time-consuming ultra-sonic non-destructive inspection.
Thus constant growing use of CFRP rises up new challenges in NDT for health-monitoring of structural parts, easy to implement for daily inspection in Final Assembly Line or during service life.

Additional “visible” detection system on parts, like indicative coatings, will allow focusing US inspection only on required areas. Investigations to develop stimuli-sensitive coatings will be presented. In one hand, the aim is to obtain a coating not only able to highlight part’s area exposed above critical energy density, but also to fulfil aeronautic requirements adding highly severe constrains about adhesion performance or coating’s life time… One more challenge here is to properly translate industrial requirements to match coatings properties and vice versa.

11:10 PC3 – Substrate rotation-induced chemical modulation in Ti-Al-O-N coatings synthesized by cathodic arc in an industrial deposition plant

M. Hans[1], M. to Baben[1,2], Y.-T. Chen[1], K.G. Pradeep[1], D.M. Holzapfel[1], D. Primetzhofer[3], D. Kurapov[4], J. Ramm[4], M. Arndt[4], H. Rudigier[5], J.M. Schneider[1]
[1] *RWTH Aachen University, Aachen, Germany*
[2] *GTT-Technologies, Herzogenrath, Germany*
[3] *Uppsala University, Uppsala, Sweden*
[4] *Oerlikon Balzers, Oerlikon Surface Solutions AG, Balzers, Liechtenstein*
[5] *Oerlikon Balzers, Oerlikon Surface Solutions AG, Pfäffikon, Switzerland*

Reactive cathodic arc evaporation of Ti-Al-O-N was carried out in an industrial deposition system with two-fold substrate rotation. The structural and compositional evolution of the coatings was studied by combining scanning transmission electron microscopy and 3D atom probe tomography (APT). The formation of alternating O and N-rich sublayers was identified by APT and can be understood by considering the substrate rotation-induced variation in plasma density and fluxes of film-forming species. The effect of plasma density and fluxes on the incorporation of reactive species was studied in stationary deposition experiments and preferred N incorporation occurs, when the growing coating surface is facing the arc source. Thus, the growing surface is positioned in a region of high plasma density characterized by large fluxes of film forming-species. Preferred O incorporation takes place in a region of low plasma density where small fluxes are present, when growing surface is blocked from the arc source by the substrate holder. Hence, compositional modulations are caused by substrate rotation as the growing coating surface is periodically exposed to regions of high plasma density and large fluxes of film-forming species and regions of low plasma density and small fluxes [1]. These findings are highly relevant for all reactive industrial plasma assisted physical vapor deposition processes utilizing substrate rotation.

[1] M. Hans, M. to Baben, Y.-T. Chen, K. G. Pradeep, D. M. Holzapfel, D. Primetzhofer, D. Kurapov, J. Ramm, M. Arndt, H. Rudigier, J. M. Schneider, Surf. Coat. Technol. 305 (2016) 249-253.

11:20 PC4 – Phase stability and aluminum segregation in the nanocomposite ZrO_2-Al_2O_3 coatings

A. Raveh[1], I. Zukerman[2,3], S. Hayun[4], R.L. Boxman[3]
[1] *Rotem Industries Ltd., Mishor Yamin, D.N. Arava, Israel*
[2] *NRC-Negev, Beer-Sheva, Israel*
[3] *Tel-Aviv University, Tel-Aviv, Israel*
[4] *Ben Gurion University of the Negev, Beer-Sheva, Israel*

The formation mechanism of nanocomposite oxide-based coatings with high thermal stability is still open to question. In this context, we propose that in the case of zirconia-alumina coatings, the formation of the nc-ZrO_2/a-Al_2O_3 structure (nc-nanocomposite, a-amorphous) is governed by the driving force of the aluminum segregation because of the immiscibility of the two phases.

The ZrO_2-Al_2O_3 coatings were deposited on a floating substrate and at a temperature of 370ºC. Various coating compositions, ranging from pure zirconia to 50% alumina content, were deposited by a reactive pulsed-DC magnetron sputtering technique using two 51 mm diameter Zr and Al targets. The coating had a Zr-Al-O solid solution structure that was composed of nano-size cubic-ZrO_2 grains (20 ± 5 nm) with aluminum cations distributed inside them. The deposited coatings were annealed up to 1350ºC and their structural changes were studied using high temperature Differential Scanning Calorimetry (DSC), X-ray diffraction (XRD) and High Resolution Transmission Electron Microscopy (HRTEM) and Vickers hardness measurements. Two exothermic events were observed. The first event appeared at 700-750ºC and contributed both to aluminum segregation to the grain boundaries and to the formation of the nc-ZrO_2/a-Al2O_3 structure. The second event appeared at 1000-1200ºC and was related to coarsening ("Ostwald ripening") of the ZrO2 grains. The coating hardness after the first event was stabilized to 19.5 ± 1.1 GPa value because of the segregation effect, which hindered the grain growth. However, after a second DSC cycle of the coating only one sharp endothermic transformation peak was observed at 1060 ± 5°C. This is because the grain growth was accompanied by the zirconia transformation from the cubic to the monoclinic phase.

11:30 PC5 – Invited - Carbon-based coatings for industrial applications

A. T. Alpas, S. Bhowmick, Z. Yang, F. G. Sen, A. Banerji
University of Windsor, Windsor, ON, Canada

This talk focusses on the tribological applications of diamond-like carbon (DLC) coatings and multilayered graphene (MLG) in manufacturing of lightweight engineering components. Adhesion of softer materials to stamping dies and machining tools limit the efficiency and quality of lightweight alloy manufacturing processes. Accordingly, the need for identifying adhesion mitigating low friction coatings has become a critical topic in tribology. While the carbon-based coatings provide low adhesion surfaces that increase energy efficiency during manufacturing, their environmental stability and high temperature performances should be improved for specific applications like warm and hot forming. The study evaluates the friction reduction mechanisms and interfacial material transfer processes that occur when DLC and MLG are placed in sliding contact with aluminum and titanium alloys.

Dr. Ahmet T. Alpas, professor of Materials Science and Engineering at the University of Windsor (Ontario, Canada), has joined the Department of Mechanical Automotive and Materials Engineering in 1989 following a post-doctoral fellowship appointment at McMaster University. Dr. Alpas is international leader in the area of tribology of lightweight alloys and composites through microstructural design to control materials' properties and allow for new and efficient manufacturing methods. His transformative work consisting of more than hundred fifty publications in a peer reviewed journals and transactions has been cited over 5,700 times and forms the basis for the use of new core enabling manufacturing technologies and processes by industry. Dr. Alpas research initiatives have led to the establishment of a world-class centre of excellence in tribology of materials research at the University of Windsor. Dr. Alpas work as an Industrial Research Chair has contributed significantly to the expansion of non-traditional and innovative applications of lightweight alloys, in particular for development of efficient and durable and low friction automotive engines that feature improved fuel economy and a lesser environmental impact. He currently serves on the editorial board of the international journal of Wear. Dr. Alpas was awarded General Motors' Campbell Award for contributions to "Fundamentals of Interfacial Tribology" and "Most Valuable Colleague Award". Dr. Alpas contributions to science and engineering were also acknowledged by the University of Windsor's Excellence in Research and Scholarship. Dr. Alpas received NSERC Synergy Award from the Governor General of Canada for contributions to lightweight automotive products and manufacturing processes.

ORAL PRESENTATIONS

JEAN-COUTU BUILDING, ROOM S1-151

Session 6 – Functional Films II

MODERATORS:
M. Bilek
School of Physics, University of Sydney, NSW, Australia
G. L. Doll
The University of Akron, Akron, OH, USA

13:30 FF3 – Invited – Quantification of structure-property relationships at interfaces

S. B. Sinnott
Penn State University, University Park, PA, USA

The role of coatings described in this presentation is considered for providing functionality, lubrication, and protection to material surfaces. The focus will be on providing an atomic-level understanding of the structure-property relationships that control the performance at material interfaces. A computational approach is used at the level of many-body, classical atomistic simulations of the structure of coherent and semicoherent interfaces formed between TiC (111) and Ti (0001). A two-dimensional misfit dislocation network is predicted to form in the case of the semicoherent interfaces, the properties of which are predicted to change with temperature. Additionally, the properties of the interface of various orientations of Pt with oxidized Pt are explored. The simulations provide insights into the performance of heterogeneous material interfaces that are helpful for interpreting macroscopic behaviors.

Susan B. Sinnott received her B.S. in chemistry from the University of Texas at Austin and her Ph.D. in physical chemistry from Iowa State University. She was a National Research Council Postdoctoral Associate at the Naval Research Laboratory and was on the faculty at the University of Kentucky prior to joining the University of Florida in 2000. In 2015 Susan joined the Pennsylvania State University as Professor and Department Head of Materials Science and Engineering. Research in the Sinnott Group is focused on the application of computational methods at the electronic-structure and atomic scales to examine a variety of materials and processes. These include the design of new materials and the investigation of the influence of grain boundaries, point defects, dopants, and heterogeneous interfaces on material properties.
A major area of emphasis is the development of inventive methods to enable the modeling of new material systems at the atomic level. Susan is the author of over 220 technical publications, including over 200 refereed journal publications and 8 book chapters. She is a Fellow of the Materials Research Society, American Physical Society, American Ceramic Society, American Vacuum Society, and of the American Association for the Advancement of Science. Susan is a past President of the American Vacuum Society and is the Editor-in-Chief of Computational Materials Science.

14:00 FF4 - Controlling friction and adhesion using supported two-dimensional responsive microgel arrays

S. Giasson, L. Giraud, P. Vialar-Trarieux
Université de Montréal, Montreal, QC, Canada

Adhesion and friction forces between supported two-dimensional (2D) colloidal arrays made of different nanoparticles were investigated and compared. Soft-responsive and non-responsive hard particles of different sizes were used to create homogeneous 2D arrays on substrates using self-assembly. We showed that friction could be successfully modulated, within nearly three orders of magnitude, using responsive polymeric particles robustly attached to substrates This unprecedented change in lubricating properties was correlated with the particle swelling behavior, i.e. the friction decreasing exponentially with an increase in the swelling ratio regardless of the particle size, degree of ionization of the particle and surface coverage. In addition, highly responsive and robustly attached microgel particles are able to sustain high-applied loads (up to 600 atm) without significant surface damage. 2D arrays of non-responsive hard particles also gave rise to superlubricity due to particles rolling. Different mechanisms of lubrication for the different structured coatings will be discussed.

14:10 FF5 - Tailoring the superconductivity in epitaxial ultrathin films of NbTiN

F. Mercier[1], N. Tsavdaris[1], M. Jacquemin[1], D. Hazra[2], M. Hofheinz[2], M. Pons[1], E. Blanquet[1]
[1] *Université Grenoble Alpes, Grenoble, France*
[2] *INAC/SPSMS, CEA-Grenoble, France*

The deposition of niobium titanium nitride films has an increasing interest in the field of superconducting applications, hard coatings and implants. However, such applications demand further improvements of the electrical

and mechanical properties of the films. The fundamental open questions also demand well-controlled deposited films where the disorder can be tuned. It is therefore of paramount importance to develop a controlled growth technique of these films and link their various properties – electrical, superconducting, and mechanical– with structural characteristics.
In this presentation, the deposition of epitaxial superconducting NbTiN thin films is addressed based on a new approach using chemical vapor deposition technique. We discuss the control of the structure, the composition and their impact on the superconducting properties. To provide a thorough study, we used thermodynamic, structural and electrical characterization tools. Precession electron diffraction and electron backscatter diffraction techniques provide the phase and orientation mapping of the films down to the nanometer scale.

14:20 FF6 - Efficient and low-damage N-doping of graphene by nitrogen late-afterglow plasma treatment

X. Glad, G. Robert Bigras, L. Stafford
Université de Montréal, Montreal, QC, Canada

The availability of versatile processing techniques is crucial to the development of graphene-based electronics and optoelectronics [1]. In this work, we explore the potential of the late afterglow of a microwave N_2 plasma at reduced pressure (6 Torr) for post-growth tuning of CVD-grown graphene films on copper foils.
A single graphene sample received five subsequent 30-second plasma treatments between which X-Ray photoelectron spectroscopy (XPS) and Raman spectroscopy were carried out. XPS measurements reveal both N-incorporation in aromatic and out-of-plane configurations with an N/C ratio reaching 29.4%. Furthermore, Raman spectroscopy assesses the uncommonly low damage generation for such N-incorporation (D/G ratio of 0.4). The low ion density ($<10^7$ cm^{-3}) and the high density of reactive neutral ($>10^{14}$ cm^{-3}) and metastable species of the nitrogen late-afterglow are believed to be the key of such tunable and low-defect N-incorporation in graphene.

[1] Vashist, S. K., & Luong, J. H. (2015). Carbon, 84, 519-550.
[2] Afonso Ferreira, J., Stafford, L., Leonelli, R., & Ricard, A. (2014). Journal of Applied Physics, 115(16), 163303.

14:30 FF3 – Invited – Advances in non-destructive surface and interface analyses using the Kelvin probe

A. Subrahmanyam
Indian Institute of Technology Madras, Chennai, India

The surface of metals and semiconductors, though advanced on technology-front, still pose unique challenges in their understanding. Most of the versatile analytical surface analytical techniques give abundant information but the tools do modify the surfaces. The Kelvin probe is a most powerful non-contact and non-destructive analytical tool for surface engineering of the metal and semiconductor surfaces; the surface remains virgin even after the measurement. The Kelvin probe technique measures the surface work-function. The surface work-function is very sensitive to the surface preparation, surface adsorption / absorption kinetics of reactive gases leading to oxidation or reduction. The technique has the unique advantage to follow the real-time changes that are taking place on the surface. The interfaces can also be analysed with Kelvin probe, known as Surface Photo-voltage (SPV) spectroscopy, by exciting the states in the interface with suitable wavelengths. The Kelvin technique can be employed both in ultrahigh vacuum and in the ambient. The Kelvin probe technique is so versatile, it is being used in the understanding of electronic behaviour of surfaces of metals and semiconductors, mechanical and tribological properties, interfacial phenomena, adhesion, corrosion, photovoltaic junction analysis, photocatalytic activity, electro-chromic behaviour, surface defects and morphology and bacterial biofilm adherence etc. The present work summarises the recent advances in the Kelvin probe to explore new areas, including the corrosion in (or failure of) bio-medical implants.

Dr. A.Subrahmanyam (Manu) is Professor in the Department of Physics, Indian Institute of Technology Madras, Chennai, India. He graduated from the Physics Department of Indian Institute of Technology (IIT) Kharagpur in 1980 and joined the Physics Department, IIT Madras in 1982. He has been awarded an Young Scientists Fellowship (BOYSCAST) by the Department of Science and Technology, Government of India in 1988; Humboldt Fellowship in 1989, Saint Gobain Chair in 2009 and DAAD Professor in TU Dresden in 2009-2010. He has established a laboratory for metal oxide thin films and surface engineering. Over the past ten years, his research efforts are on bio-medical engineering: development of lung assist devices (using the principles of photocatalysis) and on early warning systems in mechanical heart valve failures (executed an Indo – European project on mechanical heart valves). He has designed and developed Kelvin probe equipment for surface engineering and authored the first book and six patents. His teaching experience spans over 35 years. He has guided 17 doctoral theses, published over 160 papers in international peer reviewed journals, and executed 38 sponsored research projects funded both by the Government of India and various Multinational companies. He is member of the editorial board for Solar Energy Materials and Solar Cells, an Elsevier Journal.

ORAL PRESENTATIONS

JEAN-COUTU BUILDING, ROOM S1-151

Session 6 – Functional Films and Surfaces

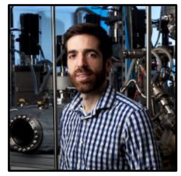
MODERATORS:
S. B. Sinnott
Penn State University, University Park, PA, USA
L. Bardos
Uppsala University, Uppsala, Sweden

15:30 FFS1 – Invited – Functional organic and metallic films for optoelectronics

S. Kéna-Cohen
Polytechnique Montréal, Montreal, QC, Canada

Functional optical coatings play an essential role in optoelectronics and can be useful for quantum information processing. We will discuss advances in two broad classes of materials: organic semiconductors and metallic thin films. We will first discuss strategies for the deposition of ultrathin continuous gold and silver films using self-assembled organic monolayers. These resulting films can have better transparency and sheet resistance than indium tin oxide, for use as transparent contacts, while also possessing advantageous mechanical properties. We will show how such films can be used to design simplified low-emissivity filters, light-emitting diodes and nanophotonic waveguides. In particular, we will highlight recent results where our use of metallic thin films on self-assembled monolayers allowed for the fabrication of multi-layered plasmonic structures for quantum information processing.

Then we will discuss new possibilities for using dielectric multilayers within organic light-emitting diodes and organic lasers to unveil new functionality. We will show how optimization techniques can be used to control near-field and far-field radiation patterns of light-emitting diodes and how optical confinement can be used to create new hybrid light-matter particles called polaritons. Finally, we will show some of the exotic phenomena recently demonstrated in our group using polaritons such as polariton lasing and room-temperature superfluidity.



Stéphane Kéna-Cohen is an Assistant Professor of Engineering Physics at Polytechnique Montréal and the Canada Research Chair in Hybrid and Molecular Photonics. He is known for his work on organic polaritons: hybrid light-matter particles that exist in optical microcavities. He has produced a number of important results in this field such as demonstrating the first organic polariton laser and observing room-temperature superfluidity of exciton-polaritons. He also pioneered some of the first observations of the quantum behaviour of surface plasmon-polaritons. At Polytechnique, Prof. Kéna-Cohen's group is actively working on the development of new families of optoelectronic devices for applications in quantum information, biophotonics and solar energy. He obtained his PhD in 2010 at Princeton University under the supervision of Stephen Forrest and prior to joining Polytechnique, he held a Junior Research Fellowship at Imperial College London.

16:00 FFS2 - X-ray absorption of nanostructured silicon carbon nitride: Interdependency of luminescence and structural properties

Z. Khatami[1], G. B. F. Bosco[2], P. R. J. Wilson[1], J. Wojcik[1], L. Tessler[2], P. Mascher[1]
[1] *McMaster University, Hamilton, ON, Canada*
[2] *University of Campinas, Campinas, São Paulo, Brazil*

Silicon, the cornerstone material of microelectronics, has seen growing interest in photonics and for applications in "all-silicon" tandem solar cells. The fundamentally inefficient lighting properties of bulk silicon suggested nanostructured silicon-based materials as one of the strategies to overcome the barriers to practical applications. Each of the proposed silicon-based materials has its own disadvantages to reach the commercialization wherein besides the desired optical and electrical properties, the mechanical behavior is of concern. Silicon carbonitride (SiCN) exhibits unique properties combined from silicon carbide, silicon nitride, and carbonitride (a choice after diamond). Despite reports of promising mechanical features of SiCN, it has not yet been optically explored and in effect therefore, understanding of the interdependency of the optical and mechanical properties is lacking. In this contribution, the origin of the luminescence in SiCN is investigated and compared to the submatrices. For both untreated and thermal treated SiCN films, the correlation between the optical, structural, and mechanical properties is addressed using X-ray absorption and photoluminescence measurements along with the other structural analysis.

16:10 FFS3 - Vacuum-based technique for production of silver nanostructures for double plasmon resonance with tunable properties

O. Kylian, J. Hanus, H. Libenska, H. Biederman
Charles University, Prague, Czech Republic

Noble metal nanoparticles are due to their intense light absorption and local electric field enhancement in the visible part of the spectrum at the resonance frequencies of localized surface plasmon suitable for biosensing applications. From the point of view of such applications highly interesting are materials that possess multiple plasmon resonances at different wavelengths enabling thus multiplex biodetection. This is commonly achieved either by combination of two metals or by tuning of geometry of produced nanoparticles. In this contribution, we present novel vacuum-based strategy for production of such materials using solely one metal - silver. This method is based on the combination of low-pressure magnetron sputtering of silver and deposition of Ag nanoparticles by means of gas aggregation source. It is shown that such strategy enables deposition of nanostructured coatings that are characterized by double localized surface plasmon resonances whose positions and intensities may be tuned by the deposition conditions.

16:20 FFS4 - Effect of doping on the conductivity of δ-Bi_2O_3 thin films

C. L. Gómez[1], O. Depablos-Rivera[2], **S. E. Rodil**[2]
[1] *Centro de Investigación y de Estudios Avanzados, Unidad Querétaro, Mexico*
[2] *National Autonomous University of Mexico, Mexico City, Mexico*

The defect fluorite bismuth oxide phase (δ-Bi_2O_3) exhibit the highest oxygen ion conductivity, which is intrinsic of the structure containing about 25% of vacancies, making it of great interest for use in energy conversion devices such as solid oxide fuel cells or as sensors. However, the δ-Bi_2O_3 phase exhibit thermal instabilities limiting its use. As a nanostructured thin film, it can be stabilized in a limited temperature range between room temperature and ~250°C. In this work, we show that the stability range of the δ-Bi_2O_3 thin films can be extended by using certain dopants; Ta, W and Nb allow the stabilization up to 500°C, while Al-doped films only extended the range to 300°C. The structural and electrical properties of dopant (Ta, Nb, W, Al) stabilized bismuth oxide thin films deposited by reactive magnetron sputtering onto glass substrates are presented.
Acknowledgements: CONACYT 251279

16:30 FFS5 - Hierarchical superhydrophobic / icephobic coatings developed through atmospheric pressure plasma deposition of HMDSO in nitrogen plasma

S. Asadollahi[1,2], Luc Stafford[2], M. Farzaneh[1]
[1] *Canada Research Chair on Atmospheric Icing Engineering of Power Networks (INGIVRE), Université du Québec à Chicoutimi, Chicoutimi, QC, Canada*
[2] *Laboratoire de physique des plasmas, Department of physics, Université de Montréal, Montreal, QC, Canada*

During the past few decades, atmospheric pressure plasma treatment techniques have gained a lot of interest due to several environmental and economical factors. Here, the development of a superhydrophobic/icephobic organosilicon-based coating on Al-6061 through atmospheric pressure plasma deposition of HMDSO in nitrogen plasma is reported. Aluminum samples are first treated with multiple passes of air plasma to generate a micro-porous roughened structure on the surface (details not reported here). This structure is subsequently used for further coating deposition. The effects of precursor flow rate and plasma power on various process characteristics such as plasma and coating chemical composition, precursor fragmentation, surface morphology, wetting, and icephobic behavior are studied through SEM, XPS, FTIR, contact angle goniometry and ice adhesion strength measurement. It is shown that the hierarchical surface structure achieved through pre-treatment and subsequent deposition can improve surface hydrophobicity and icephobicity, leading to coatings that can maintain their superhydrophobic / icephobic properties even after 10 cycles of icing/deicing.

16:40 FFS6 - How black holes relate to relaxation phenomena in amorphous oxide thin films

A. Ananyeva[1], B. Baloukas[2], G. Billingsley[1], A. Heptonstall[1], E. Gustafson[1], L. Martinu[2], A. Markosyan[3], C. Menoni[4], **S. Penn**[5], S. Roorda[6], F. Schiettekatte[6], R. Shink[6], C. Torrie[1], G. Vajente[1], L. Yang[4]
[1] *LIGO Laboratory Caltech, Pasadena, CA, USA*
[2] *Polytechnique Montréal, Montreal, QC, Canada*
[3] *Stanford University, Stanford, CA, USA*
[4] *Colorado State University, Fort Collins, CO, USA*
[5] *Hobart & William Smith Colleges, Geneva, NY, USA*
[6] *Université de Montréal, Montreal, QC, Canada*

Science Magazine's 2016 Breakthrough of the Year was the observation of gravitational waves from a black hole binary merger by the Laser Interferometer Gravitational-Wave Observatory (LIGO). Several decades of careful design, research, and development were required to construct the LIGO detectors, which has a relative length sensitivity of $< 10^{-19}$ m/$Hz^{-1/2}$. For frequencies in the 40 – 400 Hz band, the Advanced LIGO sensitivity will be limited by thermal noise in the test mass mirror coatings. The thermal noise arises from the mechanical loss in the coating materials. LIGO's current coating research efforts are aimed at reducing the coating mechanical loss by a factor of 4 within the next few years. This and other improvements should allow the event detection rate to increase from a few per year to a few per week.

The coatings consist of a 34-layer stack of TiO_2-doped Ta_2O_5/SiO_2 deposited by ion beam sputtering (IBS) on 34-cm diameter, 20-cm thick ultra-pure silica substrates (a.k.a. the test masses). It has been shown that mechanical loss in the high-index, TiO_2-doped Ta_2O_5 layer dominates the coating loss. Consequently, future research efforts are focused on reducing the loss in the high index layers. In this talk, we show the results of investigations on Ta_2O_5 films deposited both by magnetron sputtering (MS) and by Dual Ion Beam Sputtering (DIBS). In the case of MS, the samples' deposition temperature was varied between room temperature (RT) and 480°C. The mechanical loss was measured by exciting resonant modes in the substrates and analyzing the ring down. Samples were further characterized by Rutherford backscattering spectrometry, spectrally-resolved ellipsometry and X-ray diffraction (XRD). It is found that the layers deposited at higher temperatures than RT possess lower mechanical loss. However, after annealing at 500°C, all layers demonstrated essentially equivalent and lowered mechanical loss. Interestingly, XRD measurements indicate a link between the coating's relaxation state and mechanical loss, thus opening the way to a better understanding of the mechanical loss and possible future enhancements.

16:50 FFS7 - VO_2 and silver – a winning combination for smart window applications

B. Baloukas, S. Loquai, L. Martinu
Polytechnique Montréal, Montreal, QC, Canada

Active thermochromic VO_2 thin films are of considetation for smart window applications. However, the material itself in its intrinsic state presents multiple drawbacks which prohibit direct implementation into commercial use. One of such limitations, is its absorption in the visible spectrum, which for building envelopes should be maintained at a minimum.

While multiple avenues have been considered to circumvent this issue, such as increasing the material's porosity or implementing VO_2 nanoparticles in a dielectric matrix (so-called nanothermochromics), most of these approaches require complex fabrication technologies. In the present work, we show how by simply incorporating a VO_2 thin film inside a typical silver-based low-emissivity type of coating, one can significantly decrease the film's thickness and consequently reduce absorption without compromising its solar transmission variation as a function of temperature. Furthermore, due to the presence of silver, the fabricated stacks display the additional benefit of possessing low-emissivity properties.

WORKSHOP A

ÉCOLE POLYTECHNIQUE, MAIN BUILDING, **ROOM A-404**
8:30 – 17:00

Optical characterization – Spectroscopic ellipsometry (sponsored by J. A. Woollam Co. Inc.)

INSTRUCTOR:
J. Sun
J.A. Woollam Co. Inc.

MODERATORS:
B. Baloukas
Polytechnique Montréal, Montréal, QC, Canada

F. Blanchard
Polytechnique Montréal, Montréal, QC, Canada

Ellipsometry is used to optically characterize all material types: semiconductors, dielectrics, metals, and organics possessing various structures, such as nanostructured and multilayer thin films. With recent advances in optical instrumentation, material research and production development in many fields now rely on the high accuracy of spectroscopic ellipsometry (SE) for the characterization of film thickness and optical properties from VUV to IR. Shorter wavelengths increase sensitivity to ultra-thin films, while IR data allow identification and quantification of chemical bonds, as well as accurate n and k determination.

This one day workshop will feature the following:

- Introduction to spectroscopic ellipsometry: basic theories
- Overview of ellipsometry applications, including In-situ and real-time ellipsometry and advanced applications, such as graded refractive index, anisotropy and Mueller matrix;
- Demonstration of ellipsometry Data analysis;
- Ellipsometry Instrumentation;
- Hands-on laboratory session using the RC2® and IR-VASE® instruments

During the laboratory session, it will be possible to test a limited number of your own samples. In such a case, please contact Bill Baloukas at bill.baloukas@polymtl.ca.

WORKSHOP B

ÉCOLE POLYTECHNIQUE, MAIN BUILDING, **ROOM A-401**
8:30 – 17:00

■ Optimization of coating systems for in use condition with indentation, scratch and tribology techniques (sponsored by Anton Paar)

INSTRUCTOR:
Gregory Favaro
Anton Paar TriTec SA, Switzerland

Pierre Morel
Anton Paar USA Inc.

Mahdi Dargahi
Anton Paar Canada Inc.

MODERATORS:
J. Lengaigne
Polytechnique Montréal, Montréal, QC, Canada

T. Schmitt
Polytechnique Montréal, Montréal, QC, Canada

In order to properly design wear resistant coatings it is necessary to optimize the tribo-mechanical properties of the coating/substrate-system (Elastic modulus, yield strength, adhesion, intrinsic stresses, fracture, etc). The ultimate goal is to find materials and structural solutions that keep the stress-strain field below the stability limits of the system in typical operating conditions.

In this workshop, the process of designing a wear resistant coating system for a given application using indentation, scratch and tribological testing will be reviewed. The process will be illustrated with the help of several case studies.

More specifically, we will present the capabilities of testing materials in various in use conditions in order to understand the effects of humidity, testing speed or temperatures.

Finally, we will illustrate our presentation with a numerical modeling part. Modelization tools are now very important to reduce the cost of development. During our presentation, we will combine empirical and modeling results to calculate the stresses and behavior within the sliding contact. This will help the users optimize the test parameters in function of the required test.

Workshop content:

- Presentation of a real case studies to optimize a wear resistant coating-system;
- Advance presentation of Scratch testing for hard coatings and scratch test modelization;
- Tribology of hard coatings: various aspects of high temperature and vacuum testing;
- Explanation and challenges of high temperature Nanoindentation.

Live demos of the Nanoindentation Tester, Scratch Tester, Calotest and Tribometer will be shown as well.

DEMONSTRATION A

ÉCOLE POLYTECHNIQUE, MAIN BUILDING, **ROOM B-406**
8:30 – 12:00

■ Introduction to modern spectrophotometric tools with Agilent Technologies - Cary 7000 spectrophotometer and the Universal Measurement Unit (UMS)

INSTRUCTOR:
J.-L. Cabral
Agilent technologies, Wilmington, DE, USA

G. Prosser
Agilent technologies, Wilmington, DE, USA

MODERATORS:
B. Baloukas
Polytechnique Montréal, Montréal, QC, Canada

F. Blanchard
Polytechnique Montréal, Montréal, QC, Canada

As part of the 8th Symposium on Functional Coatings and Surface Engineering, Agilent Technologies would like to invite you to a free product training on Wednesday June 7th from 9AM to noon. This training will focus on modern spectrophotometric tools. Allowing you to expand your test & measurement proficiency by gaining insights and skills with the latest Agilent Cary devices. The training will be provided by our team of advanced application scientists who have been helping scientists within academia and organizations in developing a better understanding of their own materials. The training will include a series of topics including modern practice of spectrophotometry in production, advanced spectrophotogoniometry, scattering as well as case studies on the innovative Cary 7000 UMS spectrophotometers. During the hands-on session, participants will be able to develop the basic skill sets for multi-angle absolute measurements, cube Beam Splitter, and other advanced Experiments with the Cary 7000 UMS. A free breakfast and lunch will be provided for registered participants.

To register or for any questions, please reach out to Gael Prosser at gael.prosser@non.agilent.com.

DEMONSTRATION B

ÉCOLE POLYTECHNIQUE, MAIN BUILDING, **ROOM B-401**
12:00 – 16:30

■ Introduction to high-resolution optical and stylus profilers for surface metrology with Bruker and Systems For Research (SFR)

INSTRUCTOR:
L. A. Belmar
Systems for Research, Kanata, ON, Canada

S. Basu
Bruker Nano Surfaces Division, Eden Prairie, MN, USA

MODERATORS:
J. Lengaigne
Polytechnique Montréal, Montréal, QC, Canada

T. Schmitt
Polytechnique Montréal, Montréal, QC, Canada

Surface metrology plays a critical role in understanding nano/micro-scale functional behavior for various applications in semiconductors, micro-electronics, biomedical and precision machining. Systems For Research, in collaboration with Bruker Nano Surfaces, would like to invite you to an informative and interactive session in the afternoon on Wednesday June 7. The session will include seminars on 3D surface metrology based on non-contact white light interferometers and stylus profilers – their fundamentals and applications, followed by hands-on demonstration on Bruker's latest ContourGT and DektakXT instruments. We will discuss and demonstrate how Bruker's 3D optical microscopes – based on white light interferometry (WLI) – make it possible to characterize surface features with Å-scale vertical resolution. In this session, we will also show how this method can be used for measurements of transparent thin and thick films. Besides the optical method, we will see that for certain applications a contact-probe method is preferred and how Bruker's Dektak stylus profiler – that brings with it a long history of innovation – enables fast measurement of height variation on a surface with sub-nm precision. Some of the key applications will be demonstrated during the hands-on sessions.

To register or for any questions, please reach out to Laura Belmar at Laura@sfr.ca.