16th Joint Vacuum Conference (JVC-16)
14th European Vacuum Conference (EVC-14)
23rd Croatian-Slovenian Vacuum Meeting

PROGRAMME AND BOOK OF ABSTRACTS

6–10 June 2016
Grand Hotel Bernardin
Portorož, Slovenia

16th Joint Vacuum Conference (JVC-16)
14th European Vacuum Conference (EVC-14)
23rd Croatian-Slovenian Vacuum Meeting

PROGRAMME AND BOOK OF ABSTRACTS

Editors:
Janez Kovač, Gregor Jakša

Slovenian Society for Vacuum Technique (DVTS)
2016

16th Joint Vacuum Conference / 14th European Vacuum Conference / 23th Croatian-Slovenian International Scientific Meeting on Vacuum Science and Technique
6–10 June 2016, Portorož, Slovenia

Organized by Slovenian Society for Vacuum Technique (DVTS).

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Welcome letter

Dear participant of the conference,

it is my great pleasure to welcome you in Slovenia at the 16th Joint Vacuum Conference (JVC-16), the 14th European Vacuum Conference (EVC-14) and the 23th Croatian-Slovenian International Scientific Meeting on Vacuum Science and Technique organized by Slovenian Society for Vacuum Technique. The conference joins three international meetings in the hope of opening new opportunities for collaboration at regional and international levels. The Joint Vacuum Conference is the 16th in the row bringing together the vacuum societies of Austria, Croatia, Czech Republic, Hungary, Slovakia and Slovenia. It has been organized biennially in one of the member countries. The European Vacuum Conference is the 14th in a series of conferences organized every two years by one of the European vacuum societies with support of IUVSTA (International Union for Vacuum Science, Technique and Applications). The Croatian-Slovenian Vacuum Meeting is a meeting between two neighbouring societies with an aim of open scientific communication and mutual cooperation.

Scientists, engineers and students working in the vacuum-related fields will meet at the conference to present their recent scientific achievements. The conference will cover several thriving fields in vacuum science and research; including: Applied surface science, Surface science, Vacuum science and technology, Thin films and coatings, Nanotechnology, Plasma science and technology, Electronic materials, Surface engineering and Biointerfaces. In five days of the conference, 5 plenary, 20 invited and 75 regular oral contributions will be presented accompanied with 55 posters. During the conference you will have a chance to get informed about the latest vacuum-related equipment, which will be presented by several companies. Participants of the conference will have the opportunity to publish their scientific papers in a special issue of the Vacuum journal.

The conference will take place in pleasant atmosphere of the Mediterranean sea near the medieval town of Piran and the modern seaside resort of Portorož. To offer you the best possible experience we are organizing the conference at the five star congress centre in the Grand Hotel Bernardin. Feel free to explore the surroundings and venture beyond the sea resort to discover pleasant surprises.

We hope you will enjoy the conference and have a great experience in Slovenia.

Sincerely,

Janez Kovač,
Chairman of JVC-16/EVC-14/Cro-SloVM-23

General information

CONFERENCE LOCATION

The 16th Joint Vacuum Conference and 14th European Vacuum Conference will be held in Grand Hotel Bernardin in Portorož at 11th floor (ground floor) in the Emerald ballroom. This location is at a convenient walking distance between the Portorož city centre and historical city Piran.
The plenary sessions and one of the parallel oral sessions will take place in Hall 1. The other parallel session will take place in Hall 2 and the poster session will be situated in Hall 3. Exhibitors as well as coffee breaks will be located in a lobby in front of the halls.

Please use your badge as identification to access to all conference events.

OFFICE HOURS

The conference registration desk will open Sunday from 16.30–20:00.
From Monday to Thursday it will be open from 8:30–12:30 and 15:00–18:00 and on Friday from 8:30–13:00.

SOCIAL PROGRAMME

Welcome reception

Sunday, 5th June, 19:00–21:00 (Grand Hotel Bernardin, lobby and terrace near the hotel reception)

Lunches

Lunches are included in the fee and will be served from Monday to Thursday in the hotel restaurant (10th floor). There will be no lunch on Friday.

Conference Excursion

Wednesday, 8th June, visit of Škocjan Caves (UNESCO world heritage site).
You are advised to wear good walking shoes and to dress in warm clothes because the temperature in the cave is about 10 °C. The tour of the cave will last approximately one and a half hour. A bus transport will be organised. The departure will be at 15:00 in the front of the hotel.

Conference Dinner

Thursdays, 9th June, 19:30–23:00.
A conference dinner will be organized either on the hotel beach or in the hotel restaurant depending on weather conditions. Exact location will be announced at the conference.

INTERNET ACCESS

An access to free WiFi will be provided for the conference participants in the conference centre.

POSTER PRESENTATIONS

Poster sessions will be on Monday and Tuesday 17:30–19:30. Posters should be removed the next day till 9:00.

Committees

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Tinkara Bezovšek

Time	**Sunday 5th June**	**Monday 6th June**		**Tuesday 7th June**	
9:00–9:20		**Opening**		**V. Baglin (plenary)**	
9:20–9:50		**J. S. Colligon (plenary)**			
9:50–10:10				M. Amati	R. Cimino
10:10–10:30		A. Eder	K. Marti	L. Walczak	S.M. Scolari
10:30–10:50		S. Peter		T. Wadayama	H.P. Spoelstra
10:50–11:20		Coffee break		Coffee break	
11:20-11:40		M. Petrović	C. Stambaugh	S. Bernstorff	V. Rohde
11:40–12:00				D. Gracin	
12:00–12:20		M. Kratzer	M.J. Ferreira	J. Bruncko	A. Drenik
12:20–12:40		J. Cervenka	M. Sefa		
12:40–13:00			A.P. Fonseca	A. Hannah	S. Milošević
13:00–15:00		Lunch		Lunch	
15:00–15:20		M. Ivanda	E. Punzon-Quijorna	W. Werner	T. Porcelli
15:20–15:40			M. Manso-Silvan		A. Schopphoff
15:40–16:00		J. Novak	P. Pellacani	M. Menyhard	A. Tikhomirov
16:00–16:30		Coffee break		Coffee break	
16:30–16:50	**Registration**	M. Karlušić	M. Jenko	A. Tolstoguzov	S. Wilfert
16:50–17:10		G. Radnóczi	J. Hanuš	Yu.A. Minaev	
17:10–17:30			I. Junkar		M. Flämmich
17:30–17:50		**Poster session 1**		**Poster session 2**	
17:50–19:30					
19:30–21:00	**Welcome**				

🟨 Thin films and coatings	🟥 Applied surface science
🟫 Vacuum science and technology	🟩 Plasma science and technology
🟦 Surface science	🟪 Nanotechnology

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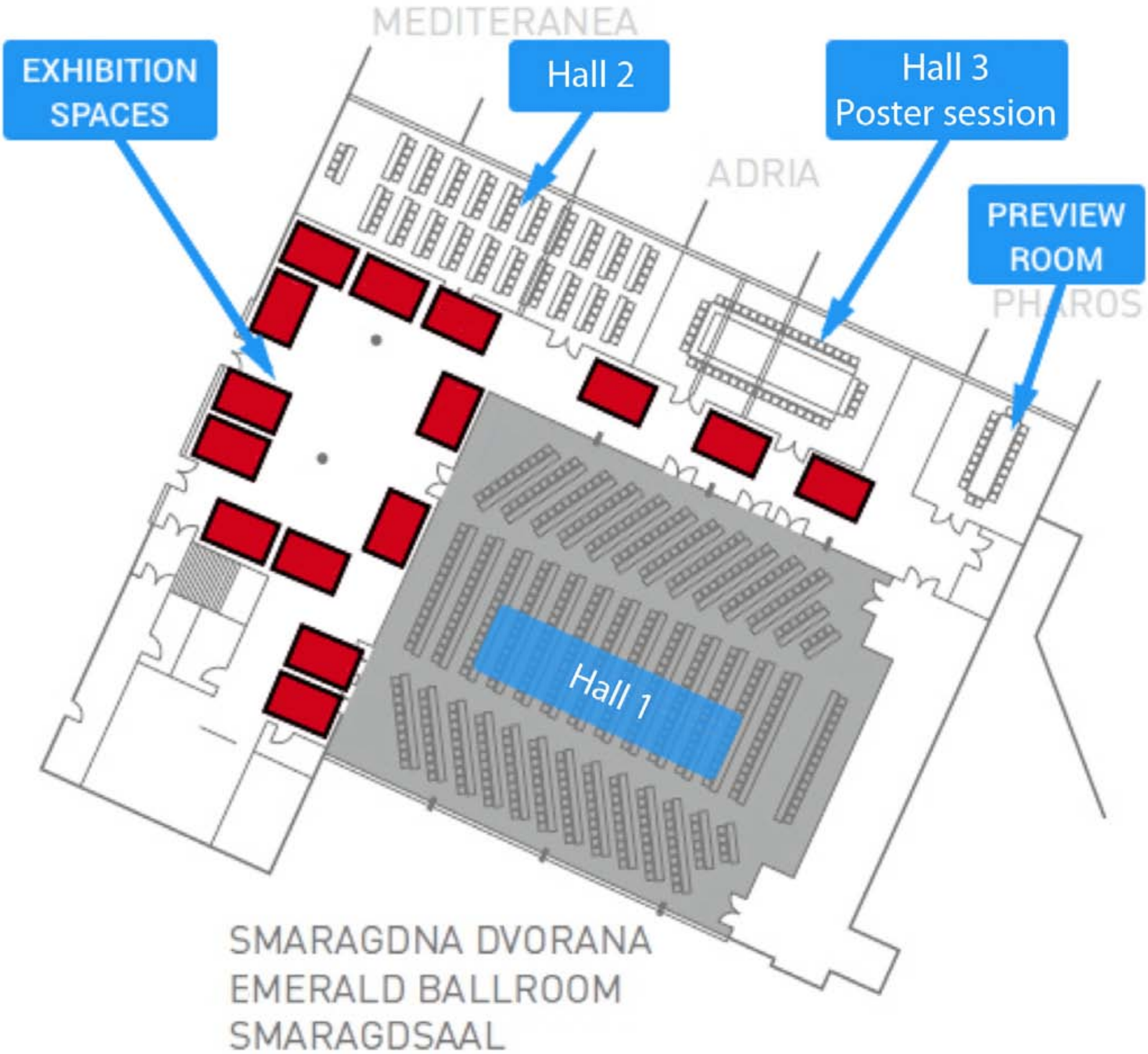
🟧 Biointerfaces
🟩 Electronic materials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ADRIA
PREVIEW ROOM
PHAROS
Hall 1
SMARAGDNA DVORANA
EMERALD BALLROOM
SMARAGDSAAL

Plenary Speakers

John Colligon (University of Huddersfield, Huddersfield, UK)
Ions, surfaces and thin films: 55 years of pressure-free study
This is the John Yarwood Memorial lecture which is associated with the 2015 British Vacuum Council Senior Prize awarded to John Colligon "for distinguished research in ion-surface interactions and its application to coatings and novel materials"

Vincent Baglin (CERN, Geneva, Switzerland)
The LHC vacuum system: Operation, challenges and upgrades

Vladimír Matolin (Charles University in Prague, Prague, Czech Republic)
PVD of advanced nano-catalysts for sustainable energetics

Alberto Morgante (CNR-IOM, Trieste University, Trieste, Italy)
Ultrafast charge injection at complex interfaces: organic-organic, organic-inorganic and organic-graphene

Hans-Peter Steinrück (University Erlangen-Nürnberg, Erlangen, Germany)
In situ studies of surface reactions - from small molecules to liquid organic hydrogen carriers

Invited Speakers

Eric Daniel Glowacki (Johannes Kepler University, Linz, Austria)
Nature-inspired organic hydrogen-bonded thin films for sustainable and biocompatible electronics

Wolfgang Werner (Vienna University of Technology, Vienna, Austria)
Managing low energy electrons (LEE): emission from solids, analytical probes, generation (or avoidance!) for technological applications

Frank Moerman (Catholic University of Leuven, Belgium)
Hygienic design of vacuum systems for the food industry

Mile Ivanda (Rudjer Bošković Institute, Zagreb, Croatia)
Development and applications of silicon nanostructuring

Marin Petrović (Institute of Physics, Zagreb, Croatia)
Epitaxial graphene hybrids - beyond a 2D sheet of carbon

Jiří Červenka (Institute of Physics ASCR, Prague, Czech Republic)
Graphene field-effect transistors as molecule specific probes of molecules

Jiří Tesař (Czech Metrology Institute, Brno, Czech Republic)
Modern methods of XHV metrology

Jakub Drnec (European Synchrotron Radiation Facility, Grenoble, France)
From vacuum to fuel cells

Stefan Wilfert (GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany)
Challenges in the development of the vacuum system of the heavy ion synchrotron SIS100 at FAIR

Volker Rohde (Max Planck Institut für Plasmaphysik, Garching, Germany)
ASDEX Upgrade: vacuum systems at a midsize tokamak experiment

Wladimir Sabuga (Physikalisch-Technische Bundesanstalt, Braunschweig, Germany)
Industrial standards in the intermediate pressure-to-vacuum range – outline of a European joint research project

Levente Tapasztó (Hungarian Academy of Sciences, Centre for Energy Research, Budapest, Hungary)
Revealing the atomic and electronic structure of 2D crystals by scanning tunneling microscopy

Dezső Beke (University of Debrecen, Debrecen, Hungary)
Peculiarities of diffusion and solid state reactions on nanoscale in thin films and multilayers

Aleksander Drenik (Jožef Stefan Institute, Ljubljana, Slovenia)
Study of plasma-wall interaction in fusion devices by residual gas analysis

Matjaž Panjan (Jožef Stefan Institute, Ljubljana, Slovenia)
Magnetron sputtering: Why is magnetron plasma organized in dense, periodic regions?

Jaroslav Bruncko (International Laser Centre, Bratislava, Slovakia)
Pulsed laser deposition of transparent conductive oxides based on ZnO

Ivo Vavra (Institute of Electrical Engineering, Slovak Academy of Sciences, Bratislava, Slovakia)
Nanoporous metallic films for catalysis

Kilian Marti (Federal Institute of Metrology METAS, Bern, Switzerland)
Effect of vacuum-air transfer on new materials used for mass standards

Corey Stambaugh (National Institute of Standards and Technology, Gaithersburg, MD, USA)
Bridging the great pressure divide with magnetic suspension: Vacuum-air mass metrology at NIST

Jack Stone (National Institute of Standards and Technology, Gaithersburg, MD, USA)
Picometers to pascals: Dimensional measurements and new photonic pressure standards

PROGRAMME of the JVC-16 / EVC-14

Sunday, 5th June 2016

16:30–19:00	Registration
19:00–21:00	Welcome Reception

Monday, 6th June 2016 – Hall 1

9:00–9:20	Opening
9:20–10:10 **Plenary**	**Ions, surfaces and thin films: 55 years of pressure-free study** John S. Colligon *Surface Coatings and Characterisation, School of Computing and Engineering, The University of Huddersfield, Huddersfield HD1 3DH, UK*
	THIN FILMS AND COATINGS
10:10–10:30	**PVD coatings on arbitrary shaped granular materials, prediction and measurement of film properties** Andreas Eder, Gerwin Schmid, Lukas Stöttinger, Harald Mahr, Christoph Eisenmenger-Sittner *Vienna University of Technology, Institute of Solid State Physics, Wiedner Hauptstrasse 8-10, 1040 Vienna, Austria*
10:30–10:50	**Analysis of a-SiCN:H films by X-Ray photoelectron spectroscopy** Siegfried Peter, F. Speck, M. Lindner, T. Seyller *Technische Universität Chemnitz, Institut für Physik, Professur für Technische Physik, D09107 Chemnitz, Germany*
10:50–11:20	**COFFEE BREAK**
	SURFACE SCIENCE
11:20–12:00 Invited	**Epitaxial graphene hybrids: Beyond a 2D sheet of carbon** Marin Petrović *Institute of Physics, Bijenička 46, 10000 Zagreb, Croatia*
12:00–12:20	**Graphene and other 2D materials as substrates for organic thin film growth** Markus Kratzer, S. Klima, A. Matkovic, J. Genser, C. Teichert *Institute of Physics, Montanuniversität Leoben, Franz Josef Straße 18, 8700 Leoben, Austria*
12:20–13:00 Invited	**Graphene field-effect transistors as molecule specific probes of molecules** Jiri Cervenka *Department of Thin Films and Nanostructures, Institute of Physics ASCR, v. v. i., Cukrovarnicka 10/112, 162 00 Prague, Czech Republic*
13:00–15:00	**LUNCH**

	NANOTECHNOLOGY
15:00–15:40 Invited	**Development and applications of silicon nanostructuring** Vedran Đerek[1], Lara Mikac[1], Hrvoje Gebavi[1], Marijan Marciuš[1], Mira Ristić[1], Eric Daniel Głowacki[2], Serdar Niyazi Sariciftci[2], Mile Ivanda[1] *[1]Center of Excellence for Advanced Materials and Sensing Devices, Ruđer Bošković Institute, Bijenička c. 54, 10000 Zagreb, Croatia, [2]Johannes Kepler University Linz, Linz Institute for Organic Solar Cells (LIOS) / Institute of Physical Chemistry, Altenbergerstraße 69, 4040 Linz, Austria*
15:40–16:00	**Reinforcement role of GaP nanowires in ZnO layer prepared by RF sputtering** Jozef Novák,[1] Agata Laurenčíková,[1] Stanislav Hasenohrl[1], Ivan Novotný,[2] Jaroslav Kováč,[2] Marian Valentin[3], Jaroslav Kováč jr.[2] *[1]Institute of Electrical Engineering, SAS, 841 04 Bratislava, Slovakia, [2]Slovak University of Technology, Institute of Microelectronics and Photonics, 812 19 Bratislava, Slovakia, [3]Polymer Institute SAS, 845 41 Bratislava, Slovakia*
16:00–16:30	**COFFEE BREAK**
	NANOTECHNOLOGY
16:30–16:50	**Nanostructuring surfaces and 2D materials using swift heavy ions** Marko Karlušić,[1] Maja Buljan,[1] Oliver Ochedowski,[2] Roland Kozubek,[2] Ulrich Hagemann,[2] Henning Lebius,[3] Brigitte Ban-d'Etat,[3] Zdravko Siketić,[1] Branko Šantić,[1] Ivančica Bogdanović-Radović,[1] Milko Jakšić,[1] Sigrid Bernstorff,[4] Marika Schleberger[2] *[1]Ruđer Bošković Institute, Bijenička cesta 54, 10000 Zagreb, Croatia, [2]Fakultät für Physik and CENIDE, Universität Duisburg-Essen, D-47048 Duisburg, Germany, [3]CIMAP, (CEA-CNRS-ENSICAEN-UCN), blvd Henri Becquerel, F-14070 Caen, France, Elettra-Sincrotrone Trieste, SS 14 km 163.5, 34149 Basovizza, Italy*
16:50–17:10	**Size dependent spinodal decomposition in Cu-Ag nanoparticles** G. Radnóczi[1], E. Bokányi[1], Z. Erdélyi[2], F. Misják[1] *[1]Research Centre for Energy Research, Hungarian Academy of Sciences, H-1525 Budapest, PO Box 49, Hungary, [2]Department of Solid State Physics, University of Debrecen, P.O. Box 2, H-4010 Debrecen, Hungary*

Monday, 6th June 2016 – Hall 2

	VACUUM SCIENCE AND TECHNOLOGY
10:10–10:50 Invited	**Effect of vacuum-air transfer on new materials used for mass standards** Kilian Marti *Federal Institute of Metrology METAS, Lindenweg 50, 3003 Bern-Wabern, Switzerland*
10:50–11:20	**COFFEE BREAK**
	VACUUM SCIENCE AND TECHNOLOGY
11:20–12:00 Invited	**Bridging the great pressure divide with magnetic suspension: Vacuum-air mass metrology at NIST** Corey Stambaugh *National Institute of Standards and Technology Gaithersburg, MD 20899, U.S.A.*

12:00–12:20	**The ESS outgassing test facility** Marcelo J. Ferreira, Simone Maria Scolari *European Spallation Source ERIC, Lund, Sweden*
12:20–12:40	**Reducing the hydrogen outgassing rate of stainless steel vacuum chambers by a medium temperature heat treatment** Makfir Sefa, James A. Fedchak, Julia Scherschligt *National Institute of Standards and Technology, 100 Bureau Drive, Gaithersburg, MD 20899 USA*
12:40–13:00	**Vacuum technology methods to study gas permeation through cork stoppers** Ana P. Fonseca, Orlando M.N.D. Teodoro *CEFITEC, Dep. Física, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 2829-516 Caparica, Portugal*
13:00–15:00	**LUNCH**
	BIOINTERFACES
15:00–15:20	**Development of biofunctional patterns on Porous Silicon by MeV ion implantation. Study of implantation effects** Esther Punzón-Quijorna[1,2], Vicente Torres-Costa[1,2], Sarah Kajari-Shrönder[3], M. Dolores Ynsa[1,2], Josefa Predestinación García-Ruiz[4], Miguel Manso-Silván[1], Aurelio Climent-Font[1,2] *[1]Department of Applied Physics, Universidad Autónoma de Madrid, Campus de Cantoblanco, 28049 Madrid, Spain, [2]Centro de Micro-Análisis de Materiales (CMAM), Universidad Autónoma de Madrid, Campus de Cantoblanco, 28049 Madrid, Spain, [3]Institut für Solarenergieforschumg Hameln, 31860 Emmerthal, Germany, [4]Molecular Biology Department, Universidad Autónoma de Madrid, Campus de Cantoblanco, 28049 Madrid, Spain*
15:20–15:40	**UV activated self assembly of perfluoro and amino silanes on porous silicon** Chloé Rodriguez,[1] Vicente Torres-Costa,[1] Sylvie Morin,[2] Alexander Bittner,[2] Miguel Manso Silvan[1] *[1]Departamento de Física Aplicada, Universidad Autónoma de Madrid, 28049 Madrid, Spain, [2]Self Assembly Group, CIC Nanogune, 20018 Donostia – San Sebastian, Spain*
15:40–16:00	**Versatile preparation of large area-crystalline monolayers for colloidal lithography** P. Pellacani[1], L. Fornasari[2], F. Floris[2], F. Carpignano[3], F. Marabelli[2,3], C. Morasso[4], M. Manso[1] *[1]Universidad Autónoma de Madrid, Departamento de Física Aplicada, M-XII, Cantoblanco, 28049 Madrid, Spain, [2]Universitá degli Studi di Pavia, Dipartimento di Fisica, via Bassi 6, 27100 Pavia, Italy, [3]Plasmore Srl, via Deledda 4, 21020 Ranco, Italy, [4]IRCCS "S. Maria Nascente" Fondazione Don Carlo Gnocchi, Via Capecelatro 66, Milan, Italy*
16:00–16:30	**COFFEE BREAK**
	BIOINTERFACES
16:30–16:50	**Characterization of surface modified NiTi shape memory alloy by AES, XPS, and SIMS** Monika Jenko[1] Janez Kovač,[2] Tadej Kokalj[1], Matjaž Godec[1] *[1]Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana, Slovenia, [2]-RåH6WHDQ Institute, Jamova 39 Ljubljana, Slovenia*

16:50–17:10	**Gas aggregation source – effective tool for functional coating deposition** Jan Hanuš,[1] Mykhailo Vaidulych,[1] Ondřej Kylián,[1] Jana Beranová,[2] Andrei Choukourov[1], Hynek Biederman[1] *[1]Charles University in Prague, Faculty of Mathematics and Physics, Department of Macromolecular Physics, V Holešovičkách 2, 180 00, Prague 8, Czech Republic, [2]Charles University in Prague, Faculty of Science, Department of Genetics and Microbiology, Viničná 5, 12844 Prague 2, Czech Republic*
17:10–17:30	**Toward novel plasma inspired medical devices** Ita Junkar,[1] Mukta Kulkarni,[2] Barbara Drašler[3], Neža Rugelj[3], Damjana Drobne[3], Janez Kovač[1], Aleš Iglič[3] and Miran Mozetič[1] *[1]Jožef Stefan Institute, Jamova cesta 39, Ljubljana SI-1000, Slovenia, [2]Laboratory of Biophysics, Faculty of Electrical Engineering, University of Ljubljana, Tržaška 25, Ljubljana SI-1000, Slovenia, [3]Department of Biology, Biotechnical Faculty, University of Ljubljana, Večna pot 111, 1000 Ljubljana, Slovenia*

Poster Session 1 - Monday, June 6 – Hall 3

17:30–19:30	**APPLIED SURFACE SCIENCE**
ASS1	**The effect of AA7075 and AA2024 substrate pre-treatment and alkaline cleaning procedures on the surface morphology and composition** Urša Tiringer,[1] Janez Kovač[2], Ingrid Milošev[1] *[1]Jožef Stefan Institute, Department of Physical and Organic Chemistry, Jamova c. 39, SI-1000 Ljubljana, Slovenia, [2]Jožef Stefan Institute, Department of Surface Engineering and Optoelectronics, Jamova c. 39, SI-1000 Ljubljana, Slovenia*
ASS2	**Influence of different solvents on the morphology of APTMS-silane modified Al-oxide surfaces: ToF-SIMS, XPS and AFM study** Gregor Jakša,[1] Janez Kovač,[1] Tatjana Filipič,[1] Bogdan Štefane[2] *[1]Jožef Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia, [2]Faculty of Chemistry and Chemical Technology, Večna pot 113, 1000 Ljubljana, Slovenia*
ASS3	**Surface analysis of EVOH and its nanocomposite** Ievgeniia Topolniak[1,2,3,4], Andrej Vincze[1], Daniel Hasko[1], Alexander Satka[1,2], Frantisek Uherek[1,2] *[1]International Laser Centre, Ilkovičova 3, 841 04 Bratislava, Slovakia, [2]Institute of Electronics and Photonics, Slovak University of Technology, Ilkovicova 3, 812 19 Bratislava, Slovakia, [3]CNRS, UMR 6296, Institut de Chimie de Clermont-Ferrand, Equipe Photochimie, BP 80026, F-63171 Aubière, France, [4]Université Blaise Pascal, Institut de Chimie de Clermont-Ferrand, BP 10448, F-63000 Clermont-Ferrand, France*
ASS4	**Preparation and characterization of structures for inorganic - organic integrated photonics** Daniel Haško[1], Jozef Chovan[1], František Uherek[1,2] *[1]International Laser Centre, Ilkovičova 3, 841 04 Bratislava, Slovakia, [2]Institute of Electronic and Photonics, Faculty of Electrical Engineering and Information Technology, Slovak University of Technology, Ilkovičova 3, 812 19 Bratislava, Slovakia*
ASS5	**Thin Au film decomposition by annealing on prestructured Si substrates** Barbara Šetina Batič, Tim Verbovšek, Janez Šetina *Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana, Slovenia*

ASS6	**Investigating the effect of iodine bombardment on glassy carbon** O.S. Odutemowo,[1] J.B. Malherbe, [1] D.F. Langa, [1] A.J. Botha, [1] L. Prinsloo, E. Wendler[2] *[1]Department of Physics, University of Pretoria, Pretoria, 0002, South Africa, [2]Institut für Festkörperphysik, Friedrich-Schiller University, Jena, Germany*
ASS7	**Detection by sputtering of deformed areas hidden under a surface** K.A. Tolpin, K.F. Minnebaev, V.E. Yurasova *Physics faculty of Moscow State University, Moscow 119991, Russia*
ASS8	**Increasing the lifetime of the glow plugs** Irena Paulin, Matjaž Godec *Institute of Metals and Technology, Lepi pot 11, SI-1000 Ljubljana, Slovenia*
ASS9	**Evolution of Tool-Steel Microstructures Influenced by Rare-Earth Modifications** Klemen Zelič, Jaka Burja, Črtomir Donik, Darja Jenko, Matjaž Godec *Institute of Metals and Technology, Lepi pot 11, Ljubljana, Slovenia*
	PLASMA SCIENCE AND TECHNOLOGY
PST1	**Influence of O$_2$ gas addition on cell adhesion on polymer surface treated in SO$_2$ plasma** Alenka Vesel[1], Nina Recek[1], Matic Resnik[1], Miran Mozetič[1], Helena Motaln[2], Tamara Lah Turnšek[2] *[1]Jozef Stefan Institute, Jamova cesta 39, 1000 Ljubljana, Slovenia, [2]National Institute of Biology, Večna pot 111, 1000 Ljubljana, Slovenia*
PST2	**Modifications of carbon composites upon exposure to oxygen plasma at high temperatures** Miran Mozetič,[1] Alenka Vesel[1], Blaž Tropenauer[2], Mariane Balat-Pichelin[3] *[1]Jožef Stefan Institute, Jamova cesta 39, 1000 Ljubljana, Slovenia, [2]Talum d.d., Tovarniška cesta 10, 2325 Kidričevo, Slovenia, [3]PROMES-CNRS, Font-Romeu, Odeillo, France*
PST3	**Plasma treatment of polyvinyl chloride and polypropylene tubes** M. Resnik,[1,2] I. Junkar,[1] J. Kovač,[1] M. Mozetič[1] *[1]Jožef Stefan Institute, Jamova cesta 39, 1000 Ljubljana, Slovenia, [2]Jožef Stefan International Postgraduate School, Jamova cesta 39, 1000 Ljubljana, Slovenia*
PST4	**Recombination of oxygen atoms along a glass tube loaded with a copper sample** Gregor Primc, Alenka Vesel, Miran Mozetič, Gregor Dolanc, Damir Vrančić *Jožef Stefan Institute, Jamova cesta 39, 1000 Ljubljana, Slovenia*
PST5	**Probability for neutral atom recombination on polymer surfaces** Rok Zaplotnik, Alenka Vesel, Miran Mozetič *Jožef Stefan Institute, Jamova cesta 39, 1000 Ljubljana, Slovenia*
PST6	**Study of surface properties of human enamel and dentine treated using helium and argon atmospheric pressure plasma jet** Marijan Bišćan[1], Vedran Šantak[1,2], Rok Zaplotnik[3], Dean Popović[1], Alenka Vesel[3], Iva Šrut Rakić[1], Slobodan Milošević[1] *[1]Institute of Physics, Bijenička cesta 46, HR-10000 Zagreb, Croatia, [2]Dental office – Community Health Center, Runjaninova 4, 10000 Zagreb, Croatia, [3]Jožef Stefan Institute, Jamova cesta 39, 1000 Ljubljana, Slovenia*
PST7	**Study of cold plasma jets in different ambiental gases** Dean Popović, Marijan Bišćan, Robert Beuc, Slobodan Milošević *Institute of Physics, Bijenička cesta 46, HR-10000 Zagreb, Croatia*

PST8	**Xenon plasma velocity measurement in electrically thruster using laser-induced fluorescence with high temporal resolution** D. Krivoruhko, A. Skrylev *Moscow Institute of Physics and Technology (State University), Dolgoprudny, Moscow Region, 141700, Russian Federation*
PST9	**Extreme ultraviolet emission from laser-induced plasma relevance to neutral gas environment simulation in low earth orbit** Kumiko Yokota[1], Junki Ohira[1], Kaoru Morimoto[1], Hiroaki Nishimura[2], Masahito Tagawa[1] *[1]Kobe University, Rokko-dai 1-1, Nada, Kobe 657-8501, Japan, [2]Institute of Laser Engineering, Osaka University, Yamada-oka 2-6, Suita, Osaka 565-0871, Japan*
PST10	**New atmospheric pressure plasma technology for advanced wound care products developed in „IP4Plasma“ EU project** Janez Kovač[1], Gregor Jakša[1], Tatjana Filipič[1], Andrej Zabret[2], Tijana Ristić[2], Marjetka Kralj Kunčič[2], Bert Verheyde[3], Erwin Van Hoof[3], Dirk Vangeneugden[3], Pirjo Pasanen[4] *[1]Jožef Stefan Institute, Ljubljana, Slovenia, [2]Tosama d.d, Domžale, Slovenia, [3]Flemish Institute for Technological Research (VITO), Mol, Belgium, [4]Spinverse OY, Espoo, Finland*
	THIN FILMS AND COATINGS
TFC1	**Thermal stability of zinc-oxide layer** Riku Lovics, Attila Csik, Viktor Takáts, József Hakl, and Kálmán Vad *Institute for Nuclear Research, Hungarian Academy of Sciences (Atomki), H-4001 Debrecen, P.O. Box 51, Hungary*
TFC2	**Flattening and thinning of amorphous silicon carbonitride diaphragm for environmental-cell transmission electron microscope by nitrogen plasma irradiation** Takaomi Matsutani,[1] Masanori Murano,[1] Kayo Yamasaki,[1] Tadahiro Kawasaki[2] *[1]Kindai University, 3-4-1 Kowakae Higashi-osaka, Osaka, Japan, [2]Japan Fine Ceramics Center, 2-4-1 Mutsuno, Atsuta, Nagoya, Aichi, Japan*
TFC3	**Investigation of residual chlorine in TiO_2 films grown by atomic layer deposition** Iva Saric[2], Robert Peter[1], Ivna Kavre Piltaver[1], Ivana Jelovica Badovinac[1], Gabriela Ambrozic[1], Mladen Petravic[1] *[1]Department of Physics and Center for Micro and Nano Sciences and Technologies, University of Rijeka, Ulica Radmile Matejcic 2, 51000 Rijeka, Croatia, [2]Faculty of Civil Engineering and Center for Micro and Nano Sciences and Technologies, University of Rijeka, Ulica Radmile Matejcic 3, 51000 Rijeka, Croatia*
TFC4	Cu Nanoparticles: formation dynamics and plasmon properties in and on dielectric films Branko Pivac[1], Pavo Dubček[1], Jasna Dasović[1], Vesna Janicki[1], Sigrid Bernstorff[2] *[1]Ruđer Bošković Institute, HR10000 Zagreb, Croatia, [2]Elettra-Sincrotrone Trieste, SS 14 km 163.5, 34149 Basovizza (TS), Italy*
	VACUUM SCIENCE AND TECHNOLOGY
VST1	**The primary national vacuum standards of Korea Research Institute of Standards and Science (KRISS) in Korea** S. S. Hong,[1] Wakil Khan,[2] *[1]Korea Research Institute of Standards and Science (KRISS), Daejeon 305-340, Rep. of Korea, [2]National Institute of Vacuum Science and Technology (NINVAST), National Center for Physics, QAU, Islamabad, Pakistan*

VST2	**Development of vacuum calibration apparatus in high and low temperature environment** Wen-jun Sun,[1] De-tian Li,[2] Yong-jun Cheng,[3] Zheng-nan Yuan[4] *Lanzhou Institute of Physics, Lanzhou 730000, China*
VST3	**PDMS Permeability measurement with capillary manometer** Tim Verbovšek,[1] Tadej Kokalj,[1,2] Janez Šetina[1] *[1]Institute of Metals and Technology, IMT, Lepi pot 11, 1000 Ljubljana, Slovenia, [2]Biosensors group, KU Leuven, 3000 Leuven, Belgium*
VST4	**Extension the lower limit of pressure leak calibration with constant pressure method** Ruifang Zhang, Yongjun Cheng *Lanzhou Institution of Physics, Lanzhou 730000, China*
VST5	**A fast piezoelectric-driven pulsed supersonic valve using displacement enlargement mechanism for atomic/molecular beam applications** Masahito Tagawa[1], Yusuke Ogata[1], Kumiko Yokota[1], Minoru Iwata[2] and Chee Sze Keat[3] *[1]Kobe University, Rokko-dai 1-1, Nada, Kobe 657-8501 Japan, [2]Kyushu Institute of Technology, 1-1, Sensui-cho, Tobata, Kita-Kyushu 804-8550 Japan, [3]Mechano Transformer Corp., 1-10-10, Kaji-cho, Chiyoda, Tokyo 101-0044 Japan*
VST6	**Influence of noise of pressure data points on the uncertainty of gas flow measurement by pressure rise method** Tim Verbovšek, Janez Šetina, Igor Belič *Institute of Metals and Technology, IMT, Lepi pot 11, 1000 Ljubljana, Slovenia*

Tuesday, 7th June 2016 – Hall 1

9:00–9:50 **Plenary**	**The LHC vacuum system: operation, challenges and upgrades** Vincent Baglin *CERN, 1211 Geneva 23, Switzerland*
	SURFACE SCIENCE
9:50–10:10	**Towards ambient pressure in the micro- and nano-materials characterization by scanning photoemission imaging and spectromicroscopy** Matteo Amati, Hikmet Sezen, Luca Gregoratti *Elettra-Sincrotrone Trieste, Strada Statale 14 – km 163,5 in AREA Science Park, 34149 Basovizza, Trieste, Italy*
10:10–10:30	**The new generation of the hemispherical energy analyzer in the novel surface science research** Lukasz Walczak *R&D Departament, PREVAC Sp z o.o., Rogow, Poland*
10:30–10:50	**Topmost surface structures and oxygen reduction reaction activities for MBE-prepared Pt/Pt_xNi_{1-x}(111) bimetallic surfaces** Ryutaro Kawamura, Masato Asano, Ren Sasakawa, Naoto Todoroki, Toshimasa Wadayama *Graduate School of Environmental Studies, Tohoku University, Sendai 9808579, Japan*
10:50–11:20	**COFFEE BREAK**
	THIN FILMS AND COATINGS
11:20–11:40	**Self-assembly of Ge quantum dots on periodically corrugated Si surfaces – a GISAXS analysis** Maja Buljan[1], Stefan Facsko[2], Sigrid Bernstorff[3], Ida Delač Marion[4], Vesna Mikšić Trontl[4], Marko Kralj[4], Marko Jerčinović[1], Carsten Baehtz[2], Arndt Muecklich[2], Václav Holý[5], Nikola Radić[1], Jörg Grenzer[2] *[1]Rudjer Bošković Institute, Bijenička cesta 54, 10000 Zagreb, Croatia, [2]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstrasse 400, 01328 Dresden, Germany, [3]Elettra-Sincrotrone Trieste, SS 14 km 163.5, 34149 Basovizza (TS), Italy, [4]Institute of Physics, Bijenička cesta 46, 10000 Zagreb, Croatia, [5]Charles University in Prague, Ke Karlovu 5, 12 161 Prague, Czech Republic*
11:40–12:00	**The influence of thermal annealing on structural, optical and electrical properties of ZnO thin films deposited by magnetron sputtering** Daniel Meljanac,[1] Krunoslav Juraić,[1] Vilko Mandić[1], Hrvoje Skenderović,[2] Sigrid Bernstorff,[3] Andrea Lausi,[3] Davor Gracin[1] *[1]Ruđer Bošković Institute, Bijenička 54, Zagreb, Croatia, [2]Institute of Physics, Bijenička 46, 10000 Zagreb, Croatia, [3]Elettra-Sincrotrone Trieste, SS 14, Km 163.5, I-34049 Basovizza (TS), Italy*
12:00–12:40 Invited	**Pulsed laser deposition of transparent conductive oxides based on ZnO** Jaroslav Bruncko,[1] Miroslav Michalka,[1] Marie Netrvalova[2], Andrej Vincze,[1] Jaroslav Kovac, jr.[3] *[1]International Laser Centre, Ilkovicova 3, 841 03 Bratislava, Slovakia, [2]University of West Bohemia, New technologies – research centre, Univerzitni 8, 306 14 Plzen, Czech Republic, [3]Faculty of Electrical Engineering and Information Technology, Slovak University of Technology, Ilkovicova 3, 812 19 Bratislava, Slovakia*

12:40–13:00	**Activation temperature and surface metallisation of 2 alternative quaternary non evaporable getter alloys** A. Hannah,[1,2] R. Valizadeh,[1] V. Dhanak[2] [1]STFC, Daresbury Laboratory Warrington WA4 4AD, [2]University Of Liverpool, Liverpool L69 3BX, UK
13:00–15:00	**LUNCH**
	APPLIED SURFACE SCIENCE
15:00–15:40 Invited	**Managing low energy electrons (LEE): emission from solids, analytical probes, generation (or -avoidance!) for technological applications** Wolfgang Werner *Institute for Applied Physics, Vienna University of Technology Wiedner Hauptstr. 8-10 A 1040 Vienna, Austria*
15:40–16:00	**Electron irradiation induced SiO_2 growth at Al_2O_3/Si interface** Miklós Serényi[1], Attila Sulyok[1], Miklós Menyhárd[1], Eszter Baradács[2], Bence Parditka,[2] Csaba Cserháti[2], Gábor A. Langer[2], Zoltán Erdélyi[2] *[1]Thin Film Physics Department, Institute for Technical Physics and Materials Science Centre for Energy Research Hungarian Academy of Sciences P.O.B. 49, H-1525 Budapest, Hungary, [2]Department of Solid State Physics, University of Debrecen, P.O. Box 2, H-4010 Debrecen, Hungary*
16:00–16:30	**COFFEE BREAK**
	APPLIED SURFACE SCIENCE
16:30–16:50	**Quantitative depth profiling of $Si_{1-x}Ge_x$ structures by TOF-SIMS and SNMS techniques** A. Tolstoguzov,[1] M.N. Drozdov,[2] A. Csik,[3] O.M.N.D. Teodoro[1], K. Vad[3] *[1]Centre for Physics and Technological Research (CeFITec), Dept. de Física da Faculdade de Ciências e Tecnologia (FCT), Universidade Nova de Lisboa, 2829-516 Caparica, Portugal, [2]Institute for Physics of Microstructures of the Russian Academy of Sciences (IPM RAS), 603950 Nizhniy Novgorod, Russian Federation, [3]Institute for Nuclear Research (INR), Hungarian Academy of Science, Bem tér 18/C, 4026 Debrecen, Hungary*
16:50–17:10	**Grain Boundaries Phase Transition in Respect of Transport Phenomena** Yu. A. Minaev *RANS, Russian Academy of Natural Sciences, Bajkov Institute of Metallurgy and Material Science Russian Academy of Science*

Tuesday, 7th June 2016 – Hall 2

	VACUUM SCIENCE AND TECHNOLOGY
9:50–10:10	**Vacuum and material science challenges for future circular colliders** R. Cimino,[1] M. Angelucci,[1] Eliana La Francesca,[1] L. A. Gonzalez,[1] A. Di Trolio,[2,1] Rosanna Larciprete[2,1] *[1]LNF –INFN Via E. Fermi 40, 00044 Frascati, Italy, [2]CNR-ISC Via Fosso del Cavaliere 100, 00133 Roma, Italy*

10:10–10:30	**Vacuum design of drift tube linac for the European Spallation Source** Simone Maria Scolari,[1] Carlo Roncolato,[2] Marcelo Juni Ferreira[1] *[1]European Spallation Source ESS ERIC, Tunavägen 24, SE-221 00 Lund, Sweden, [2]INFN Laboratori Nazionali di Legnaro, Viale Università 2, I 35020 Legnaro (Padova), Italy*
10:30–10:50	**The ESS vacuum control system** Hilko-Peter Spoelstra[1], François Bellorini[2] *[1]European Spallation Source ERIC, Lund, Sweden, [2]European Spallation Source ERIC, Lund, Sweden*
10:50–11:20	**COFFEE BREAK**
	PLASMA SCIENCE AND TECHNOLOGY
11:20–12:00 Invited	**ASDEX Upgrade: vacuum systems at a midsize tokamak experiment** Volker Rohde and the ASDEX Upgrade Team *Max-Planck-Institut fur Plasmaphysik, Boltzmannstraße 2, D-85748 Garching, Germany*
12:00–12:40 Invited	**Study of plasma-wall interaction in fusion devices by residual gas analysis** A. Drenik[1,2], D. Alegre[3, 4], S. Brezinsek[5], A. de Castro[4], T. Dittmar[5], A. Hakola[6], K. Krieger[2], U. Kruezi[7], G. Meisl[2], M. Mozetič[1], M. Oberkofler[2], M. Panjan[1], G. Primc[1], V. Rohde[2], R. Zaplotnik[1], the ASDEX Upgrade team and JET contributors** *EUROfusion Consortium, JET, Culham Science Centre, Abingdon, OX14 3DB, UK, [1]Jožef Stefan Institute, Jamova 39, SI-1000 Ljubljana, Slovenia, [2]Max-Planck-Institut für Plasmaphysik, 85748 Garching b. München, Germany, [3]Departamento de Ingeniería Energética, UNED, C/ Juan del Rosal 12, 28040 Madrid, Spain, [4]Laboratorio Nacional de Fusión, CIEMAT, Avda Complutense 40, 28040 Madrid, Spain, [5]Forschungszentrum Jülich GmbH, IEK – Plasmaphysik, 52425 Jülich, Germany, [6]VTT Technical Research Centre of Finland, P. O. Box 1000 (Otakaari 3K), FI-02044, Finland, [7]Culham Centre for Fusion Energy, Abingdon, Oxon, OX14 3DB, UK,* **See the Appendix of F. Romanelli et al., Proceedings of the 25th IAEA Fusion Energy Conference 2014, Saint Petersburg, Russia
12:40–13:00	**Diagnostics of atmospheric pressure plasma jets during treatment of various samples** Dean Popović,[1] Rok Zaplotnik,[1,2] Marijan Bišćan[1], Slobodan Milošević[1] *[1]Institute of Physics, Bijenička cesta 46, 10000 Zagreb, Croatia, [2]Jožef Stefan Institute, Jamova cesta 39, 1000 Ljubljana, Slovenia*
13:00–15:00	**LUNCH**
	VACUUM SCIENCE AND TECHNOLOGY
15:00–15:20	**NEG coating deposition and characterisation for narrow-gap insertion devices and small-diameter chambers of light sources and particle accelerators** Tommaso Porcelli, Marco Puro, Stefano Raimondi, Fabrizio Siviero, Enrico Maccallini, Paolo Manini, Gero Bongiorno *SAES Getters S.p.A., viale Italia 77 – 20020 Lainate (MI), Italy*
15:20–15:40	**Generation of UHV with high compression turbo pump** Andreas Schopphoff, Mirko Mekota *Pfeiffer Vacuum GmbH, Berliner Str. 43, 35614 Asslar, Germany*
15:40–16:00	**Modelling of vacuum conditions for designing vacuum systems of heavy ion accelerators** A.Tikhomirov, G.Gulbekyan, B.Gikal, I.Kalagin, M.Khabarov *Joint Institute for Nuclear Research, Flerov Laboratory of Nuclear Reaction, 141980 Dubna, Moscow Region, Russian Federation*

16:00–16:30	**COFFEE BREAK**
	VACUUM SCIENCE AND TECHNOLOGY
16:30–17:10 Invited	**Challenges in the development of the vacuum system of the heavy ion synchrotron SIS100 at FAIR** Stefan Wilfert, Ivan Pongrac, Lars Bozyk, Frederic Chill, Seong Yeub Shim, Marcel Lotz, Andreas Krämer, Peter Spiller *GSI Helmholtz Centre for Heavy Ion Research, Planckstrasse 1, D-64220 Darmstadt, Germany*
17:10–17:30	**Aluminium CF components for UHV applications** Michael Flämmich, Christian Worsch, Sophie Gottschall, Stephan Wolfgramm, René Bauer, Ute Bergner *VACOM Vakuum Komponenten & Messtechnik GmbH, Gabelsbergerstraße 9, 07749 Jena*

Poster Session 2 - Tuesday, June 7 – Hall 3

17:30–19:30	**NANOTECHNOLOGY**
NANO1	**Surface control of colloidal silica beads in hybrid bottom up/top-down nanopatterning** P. Pellacani, E. Punzón, D. Gallach, M. Manso *Universidad Autonoma de Madrid, Departamento de Física Aplicada, M12, Cantoblanco, 28049 Madrid, Spain*
NANO2	**Closely packed Ge quantum dots in ITO matrix: influence of Ge crystallization on optical and electrical properties** Tihomir Car[1], Nikolina Nekić[1], Marko Jerčinović[1], Krešo Salamon[2], Iva Bogdanović-Radović[1], Ida Delač Marion[2], Jasna Dasović[1], Goran Dražić[3], Mile Ivanda[1], Sigrid Bernstorff[4], Branko Pivac[1], Marko Kralj[2], Nikola Radić[1] and Maja Buljan[1] *[1]Ruđer Bošković Institute, Bijenička cesta 54, 10000/Zagreb, 10000, Croatia, [2]Institute of Physics, Bijenička cesta 46, Zagreb, 10000, Croatia, [3]National Institute of Chemistry, Hajdrihova 19, Ljubljana, 1000, Slovenia, [4]Elettra Sincrotrone Trieste, Basovizza, Italy*
NANO3	**Si_3N_4/graphene nanocomposites for tribological application in aqueous environments prepared by attritor milling and hot pressing** Zsolt Fogarassy[1], Orsolya Tapasztó[1], Csaba Balázsi[1], Andreas Kailer[2], Christian Schroder[2], Dusan Galusek[3], Ján Dusza[4], and Katalin Balázsi[1] *[1]Institute of Technical Physics and Materials Science, Konkoly Thege M. út 29-33, H-1121 Budapest, Hungary, [2]Fraunhofer IWM, Wöhlerstraße 11, 79108 Freiburg, Germany, [3]Vitrum Laugaricio – Joint Glass Center of the Institute of Inorganic Chemistry, SAS, Alexander Dubček University of Trenčín, and RONA, j.s.c., Študentská 2, 911 50 Trenčín, Slovakia, [4]Institute of Materials Research, SAS, Watsonova 47, 040 01 Košice, Slovakia*
NANO4	**Magnetron sputtered Ti as a substrate for TiO_2 nanotube array preparation by anodization** Krunoslav Juraić[1], Milivoj Plodinec[1], Irena Kereković[1], Davor Gracin[1], Andreja Gajović[1], Krešimir Salamon[2], Miran Čeh[3], Sigrid Bernstorff[4] *[1]Ruđer Bošković Institute, Bijenička cesta 54, 10000 Zagreb, Croatia, [2]Institute of Physics, Bijenička cesta 46, 10000 Zagreb, Croatia, [3]Jožef Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia, [4]Elettra-Sincrotrone Trieste, SS 14, km 163.5, 34149 Trieste, Italy*

NANO5	**Monitoring swift heavy ion damage kinetics using in situ RBS/c** Marko Karlušić,[1] Zdravko Siketić,[1] Tonči Tadić,[1] Milko Jakšić,[1] Stjepko Fazinić[1] *Ruđer Bošković Institute, Bijenička cesta 54, 10000 Zagreb, Croatia*
NANO6	**Ion tracks in pyrochlores** Marko Karlušić *Ruđer Bošković Institute, Bijenička cesta 54, 10000 Zagreb, Croatia*
	SURFACE SCIENCE
SS1	**How X-ray photoelectron spectroscopy contributes to the development of organic electronics** Johannes Bintinger[1], Markus Sauer[2], Annette Foelske-Schmitz[2], Ioannis Kymissis[3], Nathan Cernetic[4], Alex Jen[4], Hannes Mikula[1], Johannes Fröhlich[1] *[1]Faculty of Technical Chemistry, Vienna University of Technology, Getreidemarkt 9, 1060 Vienna, Austria, [2]Analytical Instrumentation Center, Vienna University of Technology, Getreidemarkt 9, 1060 Vienna, Austria, [3]Dep. of Electrical Engineering, Columbia University, 500 W120th Street, New York, NY 10027, USA, [4]Dep. of Materials Science & Engineering, University of Washington, 302 Roberts Hall, Seattle, WA 98195, USA*
SS2	**Study of Graphene Formation by Benzene and P-terphenyl at Various Temperatures** Ivan Jedovnicki, Vesna Mikšić Trontl, Petar Pervan *Institut za fiziku, Bijenička 46, 10000 Zagreb, Croatia*
SS3	**On the roll of adsorbed formate in the oxidation of C_1 surface species on clean and modified Pd surfaces** Imre Kovács,[1] János Kiss,[2] Frigyes Solymosi[2] *[1]University of Dunaújváros, Dunaújváros, Pf; 152., Hungary, [2]MTA-SZTE Reaction Kinetics and Surface Chemistry Res. Group, University of Szeged, Szeged, Dóm tér 7., Hungary*
SS4	**Tungsten oxide one-dimensional nanostructures** Romana Šedivá,[1] Karel Mašek,[1] Carolina Pistonesi,[2] María E. Pronsato,[2] Tomáš Duchoň,[1] Vitalii Stetsovych,[1] Josef Mysliveček[1], Vladimír Matolín[1] *[1]Department of Surface and Plasma Science, Faculty of Mathematics and Physics, Charles University, V Holešovičkách 747/2, CZ-180 00, Prague 8, Czech Republic, [2]Department of Physics, Universidad Nacional del Sur, 12 de Octubre 991, 8000 Bahía Blanca, Buenos Aires, Argentina*
SS5	**Electronic structure of CeO_x/Cu(110) system studied by ultraviolet photoelectron spectroscopy** Marie Aulická, Tomáš Duchoň, Kateřina Veltruská *Department of Surface and Plasma Science, Faculty of Mathematics and Physics, Charles University in Prague, V Holešovičkách 2, 180 00 Prague 8, Czech Republic*
	SURFACE ENGINEERING
SE1	**PVD surface treatment of heat-treated cast aluminum alloys** T. Tański, M. Staszuk, Ł. Krzemiński, M. Wiśniowski *Institute of Engineering Materials and Biomaterials, Silesian University of Technology, Konarskiego 18A, 44-100 Gliwice, Poland*

	THIN FILMS AND COATINGS
TFC1	**The influence of topography and atmosphere on tribological properties of PVD hard coating** Aljaž Drnovšek[1,2], Peter Panjan[1], Matjaž Panjan[1], Miha Čekada[1] *[1]Jožef Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia, [2]Jožef Stefan International postgraduate school, Jamova 39, 1000 Ljubljana, Slovenia*
TFC2	**Growth defects in PVD films deposited in UHV environment** Miha Čekada,[1] Nikola Radić,[2] Marko Jerčinović,[2] Matjaž Panjan,[1] Peter Panjan,[1] Aljaž Drnovšek,[1,3] Tihomir Car[2] *[1]Jožef Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia, [2]Rudjer Bošković Institute, Bijenička 54, 10000 Zagreb, Croatia, [3]Jožef Stefan International Postgraduate School, Jamova 39, 1000 Ljubljana, Slovenia*
TFC3	**Characterization of nanocrystalline AlTiSiN coatings deposited by a LARC-CAE process** Klaudiusz Gołombek, Miroslawa Pawlyta, Błażej Tomiczek *Institute of Engineering Materials and Biomaterials, Silesian University of Technology, ul. Konarskiego 18a, 44-100 Gliwice, Poland*
TFC4	**Stability of multilayered Ti/Ta thin film structures upon laser irradiation** Davor Peruško[1], Janez Kovač[2], Suzana Petrović[1], Branislav Salatić[3], Vladimir Lazović[3], Gregor Jakša[2], Momir Milosavljević[1] *[1]VINČA Institute of Nuclear Sciences, University of Belgrade, P.O. Box 522, 11001 Belgrade, Serbia, [2]Jožef Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia, [3]Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11080 Zemun, Serbia*
TFC5	**Phase mapping of MnAl thin films by combinatorial TEM** György Sáfrán, János Szívós *Thin Films Physics dept. MFA, Centre for Energy Research, Hungarian Academy of Sciences, Hungary*
	VACUUM SCIENCE AND TECHNOLOGY
VST1	**The KIT vacuum flow toolbox** Chr. Day, V. Hauer, X. Luo, S. Varoutis *Karlsruhe Institute of Technology (KIT), 76021 Karlsruhe, Germany*
VST2	**3D-simulation of ionization gauges and benchmark measurements** Berthold Jenninger, Przemysław Juda, Paolo Chiggiato and Thibaut Richard *CERN, 1211 Geneva, Switzerland*
VST3	**Investigation of a field emitter based-vacuum gauge for the operation in cryogenic vacuum systems** Marcel Lotz,[1,2] Stefan Wilfert,[2] Oliver Kester[1,2] *[1]Goethe University, Max-von-Laue Str. 1, D-60438 Frankfurt, Germany, [2]GSI Helmholtzzentrum für Schwerionenforschung, Planckstr. 1, D-64291 Darmstadt, Germany*
VST4	**Development of the prototype vacuum control system for RAON Accelerator** Hyungjoo Son, Sangil Lee *Institute for Basic Science, 70, Yuseong-Daero 1689-gil, Yuseong-gu , 305-811, Korea*

VST5	**Pressure distribution with various pumping combinations and pumping speed in one cell of the Super-Fragment Separator (Super-FRS) of the GSI future accelerator facility FAIR** Jörg Kurdal, Alexander Bergmann, Edgar Renz *GSI Helmholzzentrum für Schwerionenforschung GmbH Planckstraße 1, 64291 Darmstadt, Germany*
VST6	**Specific topics on the way to the realization of the cryogenic UHV system of the SIS100 synchrotron: dipole vacuum chambers and cryoadsorption pumps** I. Pongrac, St. Wilfert, M. C. Bellachioma, J. Cavaco Da Silva, C. Kolligs, C. Schroeder, F. Walter *GSI Helmholtzzentrum für Schwerionenforschung GmbH, Planckstr. 1, D-64291 Darmstadt, Germany*
VST7	**Jet process simulation in vacuum environment simulation device** Li Qiang, Zhang Lei, Han Xiao *Beijing Institute of Spacecraft Environment Engineering, Beijing 100094, China*

Wednesday, 8th June 2016 – Hall 1

9:00–9:50 **Plenary**	**PVD of advanced nano-catalysts for sustainable energetics** Vladimir Matolin *Department of Surface and Plasma Science, Charles University in Prague, Prague, Czech Republic*
	THIN FILMS AND COATINGS
9:50–10:10	**Silicon-based plasma polymer nanoparticles deposited by means of a gas aggregation cluster source** A. Shelemin, D. Nikitin, A. Choukourov, O. Kylian, J. Kousal, D. Slavinska, H. Biederman *Charles University in Prague, Faculty of Mathematics and Physics, Department of Macromolecular Physics, V Holesovickach 2, 18000, Prague, Czech Republic*
10:10–10:30	**Antibacterial activity of silver containing nanocomposites prepared by means of gas aggregation source** [1]A. Kuzminova, [1]A. Shelemin, [2]J. Beranova, [1]O. Kylian, [1]J. Hanus [1]H. Biederman *[1]Charles University in Prague, Faculty of Mathematics and Physics, Prague 8, Czech Republic, [2]Charles University in Prague, Faculty of Science, Prague 2, Czech Republic*
10:30–10:50	**Preparation of crystalline tungsten oxide nanoclusters by means of gas aggregation cluster source with IR heating** Jan Polášek,[1] Karel Mašek[1], Aleš Marek[2], Jozef Veselý[3], Vladimír Matolín[1], Jiří Vyskočil[2] *[1]Dept. of Surface and Plasma Science, Faculty of Mathematics and Physic, Charles University, V Holesovickach 2, Prague 8, CZ-18000, Czech Republic, [2]HVM Plasma Ltd., Na Hutmance 2, Prague 5, CZ-158 00, Czech Republic, [3]Department of Physics of Materials, Faculty of Mathematics and Physic, Charles University, Ke Karlovu 5, Prague 2, CZ-12116, Czech Republic*
10:50–11:20	**COFFEE BREAK**
	PLASMA SCIENCE AND TECHNOLOGY
11:20–12:00 Invited	**Magnetron sputtering: Why is magnetron plasma organized in dense, periodic regions?** Matjaž Panjan[1,2], André Anders[2] *[1]Jožef Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia, [2]Lawrence Berkeley National Laboratory, 1 Cyclotron Road, MS 53, Berkeley, CA 94720, USA*
12:00–12:20	**Stabilized reactive HiPIMS deposition of HfN and TiO_2** Michelle Marie S. Villamayor,[1] Tetsuhide Shimizu,[2] Daniel Lundin,[3] Ulf Helmersson[1,†] *[1]Plasma and Coatings Physics Division, IFM Materials Physics, Linköping University, Linköping, SE 581 83, Sweden, [2]Division of Intelligent Mechanical Systems, Graduate School of System Design, Tokyo Metropolitan University, 6-6, Asahigaoka, Hino-Shi, 191-0065 Tokyo, Japan, [3]Laboratoire de Physique des Gaz et Plasmas – LPGP, UMR 8578 CNRS, Université Paris-Sud, 91405, Orsay Cedex, France*
12:20–12:40	**Growth of nanostructured surfaces in pulsed systems** V. Stranak[1], Z. Hubicka[2], M. Čada[2], S. Drache[1], H. Wulff[2], C.A. Helm[2], R. Hippler[2] *[1]University of South Bohemia, Faculty of Science, Branisovska 31, 37005 Ceske Budejovice, Czech Republic, [2]Academy of Science of the Czech Republic, Inst. of Physics, Na Slovance 2, 182 21 Prague, Czech Republic, [3]University of Greifswald, Institute of Physics, Felix-Hausdorff-Str. 6, 17489 Greifswald, Germany*

12:40–13:00	**On-site SiH_4 generation using high-density microwave H_2 plasma generated in narrow slit-type discharge gap** Hiromasa Ohmi,[1,2] F. Shinoda,[1] N. Takei,[1] H. Kakiuchi,[1], K. Yasutake[1,2] *[1]Dept. of Precision Sci. & Tech. Osaka University, 2-1 Yamadaoka, Suita, Osaka 565-0871, Japan, [2]Research center for Ultra Prec.Sci. and Tech. Osaka University, 2-1 Yamadaoka, Suita, Osaka, Japan*
13:00–15:00	**LUNCH**
15:00	**EXCURSION**

Wednesday, 8th June 2016 – Hall 2

	VACUUM SCIENCE AND TECHNOLOGY
9:50–10:30 Invited	**Picometers to pascals: dimensional measurements and new photonic pressure standards** Jack A. Stone, Patrick Egan, Jacob E. Ricker, and Jay H. Hendricks *NIST, 100 Bureau Drive, Gaithersburg, MD 20899-8363, USA*
10:30–10:50	**Photonic realization of the pascal** Jay H. Hendricks, Jacob E. Ricker, Patrick Egan, Jack A. Stone, Gregory Scace, Douglas Olson, Gregory Strouse *NIST, 100 Bureau Drive, Gaithersburg, MD 20899-8363, USA*
10:50–11:20	**COFFEE BREAK**
	VACUUM SCIENCE AND TECHNOLOGY
11:20–11:40	**New theoretical effective cross sectional area for a NIST primary pressure standard piston-cylinder assembly** F. Sharipov, Y. Yang, J.H. Hendricks, J.E. Ricker *National Institute of Standards and Technology, 100 Bureau Drive, Gaithersburg, Maryland 20899, USA*
11:40–12:20 Invited	**Modern methods of XHV metrology** Jiří Tesař[1,2] *[1]Czech Metrology Institute, Okružní 31, 63800 Brno, Czech Republic, [2]Slovak University of Technology in Bratislava, Faculty of Mechanical Engineering, Nám. slobody 17, 81231 Bratislava, Slovakia*
12:20–12:40	**Half of a millennium of Slovenian vacuum techniques (on 400th anniversary of birth of the Prince Johann Weikhard Auersperg)** Stanislav Južnič *Head of Slovenian Jesuits Archive, Slovenia*
12:40–13:00	**Vacuum demonstrations for school children at the science festival SciFest** Lars Westerberg, Staffan Yngve *Uppsala University, Department of Physics and Astronomy, Box 116, S-751 20 Uppsala, Sweden*
13:00–15:00	**LUNCH**
15:00	**EXCURSION**

Thursday, 9th June 2016 – Hall 1

9:00–9:50 **Plenary**	**In situ studies of surface reactions – from small molecules to liquid organic hydrogen carriers** Hans-Peter Steinrück *Lehrstuhl für Physikalische Chemie II, Universität Erlangen-Nürnberg, Germany*
	THIN FILMS AND COATINGS
9:50–10:10	**Increasing the thermo-mechanical properties of Ti-Al-N coatings by alloying Ta and modifying the coating architecture** Christian M. Koller,[1,4] Robert Hollerweger, [1] Richard Rachbauer,[2] Peter Polcik,[3] Jörg Paulitsch,[1] Paul H. Mayrhofer[1,4] *[1]Christian Doppler Laboratory for Application Oriented Coating Development, Institute of Materials Science and Technology, TU Wien, Getreidemarkt 9, 1060 Vienna, Austria, [2]Oerlikon Balzers, Oerlikon Surface Solutions AG, Iramali 18, 9496 Balzers, Liechtenstein, [3]Plansee Composite Materials GmbH, Siebenbürgerstraße 23, 86983 Lechbruck am See, Germany, [4]Institute of Materials Science and Technology, TU Wien, Getreidemarkt 9, 1060 Vienna, Austria*
10:10–10:30	**Thermal stability and mechanical properties of $Ta_{1-x}Hf_xC_y$ coatings for ultra-high temperature applications** Helmut Riedl,[1] Heloise Lasfargues,[1] Szilárd Kolozvári,[2] Andreas Limbeck,[3] Paul H. Mayrhofer[1] *[1]Institute of Materials Science and Technology, TU Wien, A-1060 Wien, Austria, [2]Plansee Composite Materials GmbH, D-86983 Lechbruck am See, Germany, [3]Institute of Chemical Technologies and Analytics, TU Wien, A-1060 Wien, Austria*
10:30–10:50	**Ductile behavior of hard partially crystalline Mo_2BC nanolaminates** Petr Vasina[1], Pavel Soucek[1], Vilma Bursikova[1], Lukas Zabransky[1], Jiri Bursik[2], Vratislav Perina[3] *[1]Department of Physical Electronics, Faculty of Science, Masaryk University, Brno, Czech Republic, [2]Institute of Physics of Materials, Academy of Sciences of the Czech Republic, Brno, Czech Republic, [3]Nuclear Physics Institute, Academy of Sciences of the Czech Republic, v.v.i., Rez, Czech Republic*
10:50–11:20	**COFFEE BREAK**
	THIN FILMS AND COATINGS
11:20–12:00 Invited	**Peculiarities of diffusion and solid state reactions on nanoscale in thin films and multilayers** D.L. Beke *Department of Solid State Physics, University of Debrecen, Hungary*
12:00–12:20	**Comparison of oxidation resistance of single layer CrVN and nanolayer CrN/(Cr,V)N/VN hard coatings** Peter Panjan, Aljaž Drnovšek, Janez Kovač, Miha Čekada, Matjaž Panjan *Jožef Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia*

12:20–12:40	**Exploration of the structure of the TiC/a:C nanocomposite thin films as well as the understanding of their mechanical and corrosion behavior** Nikolett Oláh[1], Zsolt Fogarassy[1], Attila Sulyok[1], Mónika Furkó[2], Endre Zsolt Horváth[1], Levente Illés[1], Tamás Csanádi[3], Katalin Balázsi[1] *[1]Thin Film Physics Department, Institute for Technical Physics and Materials Science, Centre for Energy Research, Hungarian Academy of Sciences, Konkoly-Thege M. str. 29-33, 1121 Budapest, Hungary, [2]Bay Zoltán Nonprofit Ltd for Applied Research, Engineering Devision, Fehérvári str. 130, 1116 Budapest, Hungary, [3]Institute for Materials Research, Slovak Academy of Sciences, Watsonova 47, 040 01 Košice, Slovakia*
12:40–13:00	**Influence of abrasive particle size and service conditions on the abrasive wear behavior of multilayer nanocomposite coatings** Halil Caliskan,[1] Mustafa Sabri Gok,[1] Peter Panjan[2], Miha Čekada[2] *[1]Bartin University, Department of Mechanical Engineering, 74100, Bartin, Turkey, [2]-RåH Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia*
13:00–15:00	**LUNCH**
	APPLIED SURFACE SCIENCE
15:00–15:20	**Structural characterization and chemical properties of Pd/CeO_2/Cu(111) model system** Karel Mašek, Jan Beran, Tomáš Skála, Natália Tsud, Vladimír Matolín *Charles University, Faculty of Mathematics and Physics, Department of Surface and Plasma Sciences, V Holešovičkách 2, CZ-180 00 Prague 8, Czech Republic*
15:20–15:40	**Study the chemical reactivity of ZDDP additive in mineral oil onto steel and different DLC coatings** Somayeh Akbari[1], Janez Kovac[2] and Mitjan Kalin[1] *[1]University of Ljubljana, Laboratory for Tribology and Interface Nanotechnology, Bogišičeva 8, SI-1000 Ljubljana, Slovenia, [2]Jozef Stefan Institute, Jamova 19, 1000 Ljubljana, Slovenia*
15:40–16:00	**Structure and stability of boron doped titanate nanotubes and nanowires** Balázs Buchholcz,[1] Erika Varga,[2] Tamás Varga,[1] János Kiss,[2,3] Zoltán Kónya[1,3] *[1]Department of Applied and Environmental Chemistry, University of Szeged, H-6720 Rerrich B. 1, Hungary, [2]Department of Physical Chemistry and Materials Science, University of Szeged, H-6720 Aradi vértanúk tere 1, Hungary, [3]MTA-SZTE Reaction Kinetics and Surface Chemistry Research Group, University of Szeged, H-6720 Rerrich B. 1, Hungary*
19:30	**CONFERENCE DINNER**

Thursday, 9th June 2016 – Hall 2

	NANOTECHNOLOGY
9:50–10:30 Invited	**Revealing the atomic and electronic structure of 2D crystals by Scanning Tunneling Microscopy** Levente Tapaszto *Hungarian Academy of Sciences, Centre for Energy Research, Institute of Technical Physics and Materials Science, Hungary*
10:30–10:50	**Complex characterization of Pd/γ-Fe_2O_3 nanoparticle mixtures applied in acetone vapour sensors** Stefan Luby,[1] Matej Jergel,[1] Dmytro Kostyuk,[1] Peter Svec,[1] Peter Svec Jr.,[1] Eva Majkova[1], Simonetta Capone,[2] Roberto Rella,[2] Milan Timko[3] *[1]Institute of Physics SAS, Dubravska 9, 845 11 Bratislava, Slovakia, [2]Institute of Microelectronics and Microsystems CNR, Via Monteroni, Campus Ecotekne, 73100 Lecce, Italy, [3]Institute of Experimental Physics SAS, Watsonova 47, 040 01 Košice, Slovakia*
10:50–11:20	**COFFEE BREAK**
	VACUUM SCIENCE AND TECHNOLOGY
11:20–11:40	**Thermal and gas-dynamic properties of the KATRIN source and transport section** Moritz Hackenjos for the KATRIN Collaboration *Karlsruhe Institute of Technology (KIT), PO box 3640, 76021 Karlsruhe, Germany*
11:40–12:00	**Calculation and TPMC simulation of the reduction of radioactive decays of a noble gas by cryo-panels** J. Wolf for the KATRIN Collaboration *KCETA, Karlsruhe Institute of Technology (KIT), Postfach 3640, 76021 Karlsruhe, Germany*
12:00–12:20	**Gas separation analysis of rarefied binary gas mixture flows through circular capillaries driven by various pressure gradients** Steryios Naris, Christos Tantos, Dimitris Valougeorgis *Department of Mechanical Engineering, University of Thessaly, Pedion Areos, 38334 Volos, Greece*
12:20–13:00 Invited	**Hygienic design of vacuum systems for the food industry** Frank Moerman *Catholic University of Leuven – KU Leuven, Celestijnenlaan 200F, B-3001 Heverlee, Belgium*
13:00–15:00	**LUNCH**
	VACUUM SCIENCE AND TECHNOLOGY
15:00–15:20	**The study of multiopening orifices real conductivity for upstream pressures in the medium vacuum range and different gases** Martin Vičar[1], Dominik Prazak[1], Ladislav Peksa[2], Tomáš Gronych[2], Martin Jeřáb[2], Zdeněk Krajíček[1], František Staněk[1], Jiří Tesař[1] *[1]Czech Metrology Institute, Okružní 31, 638 00 Brno, Czech Republic, [2]Faculty of Mathematics and Physics, Charles University in Prague, Ovocný trh 3–5, 116 36 Praha 1, Czech Republic*

15:20–16:00 Invited	**Industrial standards in the intermediate pressure-to-vacuum range – outline of a European joint research project** Wladimir Sabuga *Physikalisch-Technische Bundesanstalt (PTB), Bundesalle 100, 38116 Braunschweig, Germany*
16:00–16:30	**COFFEE BREAK**
	VACUUM SCIENCE AND TECHNOLOGY
16:30–16:50	**Digital Pirani and passive wide range gauges** Jaroslaw Iwicki, Detlev Tietjen, Ruben Gerhardt, Michael Flämmich, Ute Bergner *VACOM Vakuum Komponenten & Messtechnik GmbH, Gabelsbergerstraße 9, 07749 Jena, Germany*
16:50–17:10	**New low cost contactless sensor for vacuum measurement in vacuum insulation panels** Martin Anton Škoberne[1], Borut Šolar[2], Gorazd Vrabič[1], Janez Šetina[3] *[1]Strip's, Kandrše 7, Vače, Slovenia, [2]Dromedar, Zgornje Bitnje 26, Žabnica, Slovenia, [3]Institute of Metals and Technology, Lepi pot 11, Ljubljana, Slovenia*
17:10–17:30	**Lifetime improvements of inverted magnetrons in industrial applications** Martin Wüest, Janos Marki *INFICON AG, Alte Landstrasse 6, LI-9496 Balzers, Liechtenstein*
17:30–17:50	**Pressure gauge with integrated He-leak detector based on a novel ion source** M. Granovskij, J. Bdzoch, J. Iwicki, M. Flämmich, U. Bergner *VACOM Vakuum Komponenten & Messtechnik GmbH, Gabelsbergerstraße 9, 07749 Jena, Germany*
19:30	**CONFERENCE DINNER**

Thursday, 9th June 2016 – Hall 3

	SURFACE SCIENCE
9:50–10:30 Invited	**Nanoporous metallic films for catalysis** Ivo Vávra,[1] Milan Hronec[2] *[1]Institute of Electrical Engineering, Slovak Academy of Sciences, Dúbravská cesta 9, 84104 Bratislava, Slovakia, [2]Department of Organic Technology, Slovak University of Technology, Radlinského 9, 81237 Bratislava, Slovakia*
10:30–10:50	**Gold on hexagonal boron nitride nanomesh prepared on Rh(111): growth and intercalation** László Óvári,[1] András Berkó,[1] Richárd Gubó,[2] Gábor Vári,[2] János Kiss,[1] Arnold Farkas,[3] Zoltán Kónya,[1,2] *[1]MTA-SZTE Reaction Kinetics and Surface Chemistry Research Group, [2]Department of Applied and Environmental Chemistry, University of Szeged, [3]Department of Physical Chemistry and Materials Science, University of Szeged, [1,2,3]Postal address: 6720 Szeged, Rerrich. B. ter 1, Hungary*
10:50–11:20	**COFFEE BREAK**

	SURFACE SCIENCE
11:20–11:40	**X-ray photoelectron spectroscopy of ionic liquids – how to close the pressure gap in electrochemistry research** Annette Foelske-Schmitz *Technische Universität Wien, Getreidemarkt 9, 1060 Vienna, Austria*
11:40–12:00	**Metalation of porphyrins and the role of the oxidation in metal surfaces** A. Verdini[1], A. Goldoni[2], G. Di Santo[2], M. Caputo[3], D. Passerone[4], P. Shinde[4], C. Pignedoli[4], G. Montanari[5], L. Floreano[1], *[1]Istituto Officina dei Materiali IOM-CNR, Lab. TASC, s.s. 14 km 163,5, 34149 – Trieste, Italy, [2]ST-INSTM lab., Elettra – Sincrotrone Trieste S.C.p.A. s.s.14 km. 163.5, 34149 – Trieste, Italy, [3]Laboratoire de Physique des Solides, CNRS-UMR 8502, Universitè Paris-Sud, 91405 Orsay, France, [4]EMPA – Theory and atomistic simulation group, Ueberlandstrasse 129, CH-8600 Dübendorf, Switzerland, [5]Trieste University, Via Valerio 2, 34100 – Trieste, Italy*
12:00–12:40 Invited	**From Vacuum to Fuel Cells** Jakub Drnec *European Synchrotron Radiation Facility, Grenoble, France*
12:40–13:00	**Benchmark spectra for secondary electron emission by means of (e,2e)-coincidence spectroscopy** Alessandra Bellissimo,[1] Wolfgang S.M. Werner[2], Giovanni Stefani,[1] Alessandro Ruocco,[1] Francesc Salvat-Pujol,[3] Rahila Khalid,[4] Werner Smekal,[5] Mihály Novák[6] *[1]Dipartimento di Scienze e Unità CNISM, Università Roma Tre, via della Vasca Navale 84, I-00146 Rome, Italy, [2]Institut für Angewandte Physik, Vienna University of Technology, Wiedner Hauptstraße 8-10/134, A-1040 Vienna, Austria, [3]Universitat de Barcelona, Departament d'Estructura i Constituents de la Matèria, Marti i Franquès 1, 08028 Barcelona, [4]Carbon Based Nanotechnology and Accelerator Laboratory, PINSTECH, PO Box Nilore, Islamabad, Pakistan, [5]IMS Nanofabrication AG, Schreygasse 3, A-1020 Vienna, Austria, [6]Institute for Nuclear Research, Hungarian Academy of Sciences (MTA ATOMKI), 18/c Bem tér, H-4026 Debrecen, Hungary*
13:00–15:00	**LUNCH**
	ELECTRONIC MATERIALS
15:00–15:40 Invited	**Nature-inspired organic hydrogen-bonded thin films for sustainable and biocompatible electronics** Eric Daniel Głowacki *Institute of Physical Chemistry, Johannes Kepler University Linz, Austria*
15:40–16:00	**Measurement of critical cracking strain of organic thin films prepared by wet coating process** T. Kobayashi,[1] M. Munkhzul,[1] Y. Utsumi,[2] H. Kanematsu,[3] T. Masuda[4] *[1]Department of Electronics & Control Engineering, National Institute of Technology, Tsuyama College, Okayama, Japan, [2]Laboratory of Advanced Science and Technology for Industry, University of Hyogo, Hyogo, Japan, [3]Department of Materials Science & Engineering, National Institute of Technology, Suzuka College, Mie, Japan, [4]Q-Light co., Ltd., Iwate, Japan*
16:00–16:30	**COFFEE BREAK**

	ELECTRONIC MATERIALS
16:30–16:50	**Nanostructured silicon heterojunctions for NIR optoelectronics** Vedran Đerek,[1] Eric Daniel Glowacki,[2] Niyazi Serdar Sariciftci[2], Mile Ivanda[1] *[1]Center of Excellence for Advanced Materials and Sensing Devices, Research Unit for New Functional Materials, Ruđer Bošković Institute, Bijenička c. 54, 10000 Zagreb, Croatia, [2]Johannes Kepler University Linz, Linz Institute for Organic Solar Cells (LIOS) / Institute of Physical Chemistry, Altenbergerstraße 69, 4040 Linz, Austria*
16:50–17:10	**Nitride layers grown over graphene/SiC** B. Pécz,[1] A. Kovács,[2] R. E. Dunin-Borkowski,[2] R. Yakimova,[3] H. Behmenburg,[4] C. Giesen[4], M. Heuken[4] *[1]Institute for Technical Physics and Materials Sci., Research Centre for Natural Sciences, Hungarian Academy of Sciences, 1121 Budapest, Konkoly-Thege u. 29-33, Hungary, [2]Affiliation Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons, Peter Grünberg Institute, Forschungszentrum Jülich, D-52425, Germany, [3]Department of Physics, Chemistry and Biology, Linköping University, S-581 83 Linköping, Sweden, [4]AIXTRON SE Kaiserstrasse 98, 52134, Herzogenrath, Germany*
17:10–17:30	**Lattice matched $NiSi_2$ tetrahedrons in Si whiskers** György Zoltán Radnóczi,[1] Daniel Knez[2], Erzsebet Dodony,[1] Nikos Frangis[3], Nikos Vouroutzis[3], John Stoemenos[3], Béla Pécz[1] *[1]Institute for Technical Physics and Matl. Sci., Centre for Energy Research, Hungarian Academy of Sciences, MTA EK MFA, H-1121 Konkoly-Thege u. 29-33 Budapest, Hungary, [2]Institute for Electron Microscopy and Nanoanalysis & Graz Centre for Electron Microscopy, TU Graz, Steyrergasse 17, A-8010 Graz, Austria, [3]Department of Physics, Aristotle University of Thessaloniki, GR-54124 Thessaloniki, Greece*
19:30	**CONFERENCE DINNER**

Friday, 10th June 2016 – Hall 1

9:00–9:50 **Plenary**	**Ultrafast charge injection at complex interfaces: organic-organic, organic-inorganic and organic-graphene** Alberto Morgante[1,2] *[1]CNR-IOM Institute, Trieste, Italy, [2]Physics Department, Trieste University, Italy*
	SURFACE SCIENCE
9:50–10:10	**Growth of graphene from benzene on Ir(111)** Vesna Mikšić Trontl, Ivan Jedovnicki, Petar Pervan *Institut za fiziku, Bijenička 46, HR-10000 Zagreb, Croatia*
10:10–10:30	**Nuclear spin conversion of D_2O molecules trapped in a CH_4 matrix** Koichiro Yamakawa, Namika Ehara, Ichiro Arakawa *Department of Physics, Gakushuin University, 1-5-1 Mejiro, Toshima-ku, Tokyo 171-8588, Japan*
	VACUUM SCIENCE AND TECHNOLOGY
10:30–10:50	**Research on the leak testing technology for large spacecrafts** Yong Wang, Yueshuai Zhao, Xiaopeng Hong *Beijing Institute of Spacecraft Environment Engineering, Youyi Road 104, Haidian District, Beijing, P.R.China*
10:50–11:20	**COFFEE BREAK**
	THIN FILMS AND COATINGS
11:20–11:40	**An in situ assessment of the roughness of a uniformly eroded cylindrical magnetron target** Muhammad Arif, C. Eisenmenger-Sittner *Institute of Solid State Physics, E-138, Vienna University of Technology, Wiedner Hauptstrasse 8-10, Vienna A-1040, Austria*
11:40–12:00	**Structure of nanocrystalline and amorphous thin films by electron diffraction in the TEM** János L. Lábár *Institute for Technical Physics and Material Science, Centre for Energy Research, Hungarian Academy of Sciences (MTA EK MFA), 1121 Budapest, Konkoly Thege M. u. 29-33, Hungary*
12:00–12:20	**A comparison of linearly combined nozzle model and full DSMC simulation result for thermal PVD (Physical vapor deposition)** Seungbok Yang, Joowon Lee, Junghan Kim *Production engineering Research Institute, LG Electronics, 222-ro Jinwi-myeon, Pyeongtaek-si, Gyeonggi-do, 451-713, Korea*
12:20–12:40	**CONFERENCE CLOSING**

BOOK OF ABSTRACTS

PLENARY

“Ions, surfaces and thin films: 55 years of pressure-free study”

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Ion-surface interactions lead to sputtering, hence to surface coatings and, in turn, to ion-assisted sputtering for coatings with micro- and nano-features. Recent reports indicate that the surface coating industry is worth USD10 billion per annum; a figure that is rapidly rising. Examples of some successful coatings for engineering applications will be given. Coating methods have developed rapidly over the last 50 years with plasma-based methods taking a lead in commercial coating work. Ion beams are however still of importance in the search for new multi-element materials and in controlling their microstructure and physical properties. Focused ion beams have special ion etching capability of value for sectioning samples for TEM, for production of nano-electro-mechanical devices, or, with suitable precursors, depositing materials to produce nano-size 3-dimensional objects.

A comparison with the status of ion-surface applications cited in the first review of the ion-surface field in 1968 [1] shows there has been a significant development in the understanding and application of this process. These range from ion implantation studies made 55 years ago by the present author showing a limit in the number of ions that can be trapped [2] to more-recent ion-assisted deposition currently used to form high temperature MAX phase coatings at low substrate temperatures. [3]. These and other key points in the development of improved coatings in the intervening years will be discussed.

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PVD coatings on arbitrary shaped granular materials, prediction and measurement of film properties

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Granular materials attract increased attention in the field of material science and catalysis especially if coated with functional surface layers. With Physical Vapor Deposition (PVD) in general and DC magnetron sputtering in special, various layers ranging from metals via oxides and nitrides to multilayer structures can be deposited. To achieve homogeneous layers each particle surface has to be exposed equally to the vapor beam therefore continuous intermixing is necessary and in addition the agglomeration taking place while coating has to be suppressed effectively.

In this work different coating geometries and agglomeration suppression systems will be presented, based on a coating mechanism developed on the Vienna University of Technology [1,2]. It is capable to coat up to one liter of granular material with particle diameters ranging from 10 µm to 500 µm. Since the total surface area depends on the particle diameter the coating process duration with the given sputter device can take up to several hours. Therefore one can easily understand the need of estimating the film thickness on the particles in advance to keep the time effort as low as possible. A theoretical film thickness prediction model will be presented and verified on granulates of different size and shape. Special focus will be laid on assessing the film thickness and uniformity with different methods such as gravimetric measurements, optical and electron microscopy to verify the model. In addition a method to measure electrical conductivity on granular materials and coated granulates will be shown, and different influences e.g. of film thickness and particle diameter will be discussed.

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Analysis of α-SiCN:H films by X-Ray photoelectron spectroscopy

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The aim of the study was the utilization of X-ray photoelectron spectroscopy (XPS) for the characterization of µm-thick hydrogenated amorphous silicon carbonitride films (a-SiCN:H). The films have been deposited by plasma enhanced chemical vapour deposition from mixtures of trimethylsilane ($SiH(CH_3)_3$), nitrogen, hydrogen and argon.

XPS provides information on the near-surface elemental composition (all elements except hydrogen and helium). Photoelectron spectra of the films were recorded using a SPECS spectrometer with X-ray source XR 50 M, X-ray monochromator FOCUS 500 (adjusted to Al Kα) and PHOIBOS 150 MCD-9 hemispherical energy analyzer. To remove the oxygen-rich contamination layer at the surface of the films and to uncover the film bulk, Ar^+-ion sputtering was applied. A data evaluation based on photoionisation cross sections, electron inelastic mean free paths (IMFPs), angular asymmetry factors and the spectrometer transmission function was performed to determine atomic ratios (like [N]/[C]) from the XPS peak intensities. Therefore, the spectrometer transmission function was determined for a set of analyser pass energies using the so called bias method.

In addition, the elemental composition in a-SiCN:H films was measured by elastic recoil detection analysis (ERDA). ERDA has a several orders of magnitude larger information depth and therefore it provides the composition in the film volume. It is sensitive to all film-forming elements (including hydrogen). Furthermore, secondary ion mass spectrometry (SIMS) depth profiles show the transition from the surface to the films bulk composition.

The discussion includes a comparison of the reference-free XPS results with ERDA and SIMS elemental composition data, the hydrogen content in the films, as well as the sputtering process, which is essential for the characterisation of the film volume by both XPS and SIMS.

INVITED

Epitaxial graphene hybrids: Beyond a 2D sheet of carbon

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Epitaxial graphene on iridium (111) surface is often considered to be one of the best systems for studying fundamental properties of graphene due to its uniform orientation and weak binding to the substrate. In such systems, graphene can be additionally modified by intercalation or adsorption of various atoms underneath or on top of it. Therefore, a detailed understanding of the formation and properties of such hybrid graphene-based structures is highly desirable.

By depositing different amounts of various atoms (Cs, Li, O and Eu) on monolayer and sub-monolayer graphene on Ir(111), hybrid systems with novel features are formed. Low-energy electron microscopy (LEEM) and scanning tunneling microscopy (STM) are used for morphological characterization of the samples while the electronic structure is investigated by means of angle-resolved photoemission spectroscopy (ARPES). The presented results explain the intercalation mechanism of epitaxial graphene where an important role is assigned to graphene wrinkles which facilitate the penetration of atoms through the graphene layer [1,2]. Moreover, intercalation induces preference of adsorption onto non-intercalated graphene areas in which case regular adatom superlattices can be formed [3]. It is found that the major governing forces in hybrid graphene systems are the Coulomb repulsion between adsorbed atoms and van der Waals interaction between graphene and iridium, where the former originates from charge transfer to the graphene. Besides on graphene properties, intercalation also has an impact on the substrate, more specifically on the binding energy and coherence of the electronic surface states of iridium [4].

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Graphene and other 2D materials as substrates for organic thin film growth

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Since Novoselov and Geim [1] first realized graphene by a simple exfoliation process, two dimensional (2D) materials have attracted considerable attention in research. Still the most intensively studied 2D material is graphene, a single atom thick honeycomb arrangement of carbon atoms. The extraordinary mechanical and electrical properties of graphene bear potential for technological applications. Therefore research on graphene is a vastly expanding field. Due to the close structural and chemical relationship to conjugated organic molecules (aromatic systems) good interface properties between such organic thin films and graphene are expected, which makes it a promising candidate to act as a transparent electrode material in organic electronics and optoelectronics. The highly anisotropic and spatially extended molecular building blocks lead to a complex nucleation and growth behavior.[2] Here, we set the focus on the thin film growth of the rod-like molecule para-hexaphenyl (6P) on various graphene substrates.[3-6] Differences arising from the various routes of graphene fabrication (CVD graphene and exfoliated graphene) that affect both, the graphene-molecule interfacing and the involved molecular diffusion processes will be discussed. In addition, an outlook towards recent results of organic thin film growth on other 2D materials, like hexagonal boron nitride, will be presented.

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INVITED

Graphene field-effect transistors as molecule specific probes of molecules

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Graphene's two dimensional nature, highly sensitive unique electrical properties and low intrinsic noise characteristics make it a prime candidate for the creation of a new generation of molecular sensors. The long standing target of molecular sensing is to develop sensors with single molecule sensitivity and capability of selective determination of the detected molecules. Although graphene sensors have been demonstrated to be extremely sensitive, their selectivity remains a major problem for their practical use. Our recent experiments have, however, found that graphene field-effect transistors (GFETs) are able to measure distinct, coverage dependent, conductance signatures upon adsorption of small organic molecules in vacuum.[1,2] This method allowed electronic discrimination of individual DNA nucleobases on GFETs, [1] providing a first step towards graphene based electronic DNA sequencing. The existence of molecule specific signatures in electronic transport measurements was verified by independent synchrotron-based X-ray photoelectron spectroscopy (XPS) measurements. To get a deeper insight into the origin of the sensing mechanism and molecular recognition in GFET measurements we performed *ab initio* electronic structure calculations using density functional theory (DFT). The molecular recognition was found to be closely linked with specific noncovalent molecular interactions with graphene. The absorption of molecules resulted in the electronic structure change of graphene which is driven by complex interplay between molecule-graphene and intermolecular interactions, interface dipole moment, charge transfer, work function change and screening effects. These effects open up a range of new opportunities for molecular recognition in electronic and optical sensor devices.[3]

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INVITED

Development and applications of silicon nanostructuring

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Silicon nanomaterials, known as one of the most important types of nanomaterials, feature a number of unique merits, such as excellent electronic/mechanical/optical properties, huge surface-to-volume ratios, and facile surface modification [1]. Fast development of silicon nanomaterials with well-defined structures and required functionalities has vastly promoted the advancement of silicon nanotechnology. Structuring surface and bulk of (poly)crystalline silicon on different length scales can significantly alter its properties and improve the performance of opto-electronic devices and sensors based on silicon. Different dominant feature scales are responsible for modification of some of electronic and optical properties of silicon. We present several chemical methods for easy structuring of silicon on nano and micro-scales, based on both electroless and anodic etching of silicon in hydrofluoric acid based etchants, and chemical anisotropic etching of silicon in basic environments. We show how successive micro and nano structuring creates hierarchical silicon surfaces, which can be used to simultaneously exploit the advantages of both structuring feature length scales. We present some final results of application of silicon nano structuring in development of SERS substrates [2] and silicon/organic heterojunctions for IR light sensing [3].

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Reinforcement role of GaP nanowires in ZnO layer prepared by RF sputtering

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This paper presents a new type of antireflection coating based on a thin semiconductor layer braced with a dense forest of NWs. We prepared a thin nanocrystalline ZnO layer with embedded GaP NWs. Such NWs are compatible with InGaP, and they can be easily integrated on top of the InGaP layer of a multi-junction solar cell. If they are covered in ZnO, reflection of light is further decreased as a result of two effects working together: (1) antireflection at the NW structure with dimensions smaller than incident light wavelengths (size effect), and (2) optical properties – mainly absorption at ZnO. The NWs were grown in vapour-liquid-solid (VLS) mode by metal organic vapour phase epitaxy (MOVPE) at Au seeds formed from a very thin Au layer. The NWs were finally embedded in ZnO using deposition by RF sputtering combined with etching steps that resulted in a compact antireflection layer. We studied optical properties of such compact NWs structure by means of photoluminescence, angular dependence of reflection and Raman spectroscopy. The study of mechanical properties was performed by nanoindentation measurements. The nanoindentation measurement showed that the incorporation of GaP nanowires into a ZnO layer led to increased hardness compared with that of a pure ZnO layer. The compact GaP NW/ZnO layer structure also exhibited some degree of pseudoelasticity. In addition, the mechanical properties of the compact nanowire layer are sufficiently robust to allow the thermo-compression bonding on the top of the structure.

Nanostructuring surfaces and 2D materials using swift heavy ions

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Swift heavy ion irradiation emerged as a versatile tool to modify material properties on the nanoscale, due to very intense yet extremely localized excitation of the material. Even single ion impacts can induce drastic changes in the materials in the regime of the so called "swift heavy ions" ($m > 20$ amu, $E > 1$ MeV/amu). Nanoscale material transformation along a swift heavy ion trajectory, that is straight and several micrometers long, is in essence derived from a 1D excitation source. This feature is in particular interesting for structuring 2D materials and surfaces, when a swift heavy ion beam is applied under grazing angles of incidence [1,2,3].

In the first part of our contribution, we present recent advances in surface modifications using swift heavy ions. Novel features of the ion impact sites morphology we found in GaN [4], SiC [5] and ITO thin film [6]. After high fluence ion irradiation, yet another new feature was found: straight, uniform, nanoscale ripples were observed in a narrow range of irradiation parameters for the first time [6]. A multitechnique approach is presented for the rutile TiO_2 system [7], where atomic force microscopy, grazing incidence small angle X-ray scattering, and elastic recoil detection analysis provide complementary information. Finally, manipulation of these nanoscale surface modifications by means of etching and annealing are presented [6].

In the second part, the focus will be on the results of swift heavy ion irradiation of graphene. This wonder material shows a great deal of susceptibility to this kind of irradiation, and nanoscale modifications in the shape of ruptures and foldings were reported [3]. The threshold for this kind of nanostructuring was established [8], and we demonstrated that even small scale accelerators can be utilized for this purpose. The role of other system parameters (substrate, interfacial water layer) is discussed as well [9].

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Size dependent spinodal decomposition in Cu-Ag nanoparticles

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Nanoparticles are of considerable interest, as they often possess properties, different from those of bulk materials. In the last few years, many investigations have focused on bimetallic nanoparticles, owing to their promising characteristics. Growth and phase separation processes are of primary interest for describing their structure and atomic processes of their formation. For revealing internal atomic processes in them, individual nanoparticles of Cu-Ag alloys were grown by direct current (DC) magnetron sputtering. Phase-separation during growth in Cu-Ag particles was found to be size- and composition-dependent. Particles below 5 nm in diameter grow as a solid solution of the components for all compositions (15–80 at% Ag). In the low Ag content range (15 and 30 at% Ag) phase-separation occurs for particles above 5 nm in diameter. The separation into Cu-rich and Ag-rich domains takes place by spinodal decomposition. In the higher Ag content range (60-80 at%), however, no phase-separation is observed up tol 10 nm particle size, when coalescence sets in. Calculation of composition dependence of critical size for spinodal decomposition provided quantitative explanation for the observed phenomena. According to the results, decomposition occurs in particles, for which the critical (Chan-Hillard) wavelength of concentration fluctuations (for the given composition) is smaller than the diameter of the particle.

INVITED

Effect of vacuum-air transfer on new materials used for mass standards

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As the new definition of the kilogram will be realized in vacuum, mass standards will undergo vacuum-air transfers that affect the surface chemical state and hence the mass of the standard. The precise knowledge of these transfer effects on the surface materials and the accurate prediction of mass changes are essential for disseminating the kilogram and for maintaining the mass scale.

We studied the suitability of potential new materials for future mass standards in terms of surface cleanliness and surface contamination. We used selected metallic samples and 1 kg surface artefacts consisting of cylinders and stacks of discs and exposed them to multiple cyclic transfers between vacuum, air and inert gas. The effect of cyclic venting was quantified using surface analysis by X-ray photoelectron spectroscopy (XPS) and gravimetric weighing both in air and in vacuum. In addition, the influence of different cleaning methods, such as the traditional nettoyage-lavage, low-pressure hydrogen plasma and UV/ozone, on the surface cleanliness and on the subsequent recontamination due to cyclic venting was investigated.

By means of surface artefacts made of steel, gold, rhodium and platinum-iridium we found the material-specific sorption coefficients to be between 0.2-0.4 $\mu g/cm^2$ for a vacuum-air transfer. We delved into the phenomena of sorption and desorption more deeply using a quartz crystal microbalance (QCM). Through the use of a QCM during venting processes, we could separate reversible and irreversible sorption. Based on these findings, we developed mathematical models describing (a) the reversible and irreversible change in mass due to vacuum-air transfers and (b) the short- and long-term mass evolution. Finally, we could generate a ranking list of best materials for future mass standards and best processes for cleaning and transferring these materials.

INVITED

Bridging the great pressure divide with magnetic suspension: vacuum-air mass metrology at NIST

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Mass realization is currently set to go through a radical shift starting in 2018. At that time, the kilogram, the unit of mass in the International System of Units (SI), will no longer be defined as the mass of the International Prototype of the Kilogram (IPK); instead Planck's constant will become a fixed constant and experiments, like the Watt balance, will be used to realize the kilogram. Of particular significance, is the fact that the new realization will be carried out in high vacuum. This stands in stark contrast to the current realization of the kilogram by the IPK, which is stored in air at atmospheric pressure. Although the new realization will occur in vacuum, dissemination of the mass unit to air is still required and necessitates some sort of vacuum-to-air transfer. To bridge this divide, NIST has developed a Magnetic

Suspension Mass Comparator (MSMC) to facilitate direct mass comparison between an artifact in air and one in vacuum. This system uses magnetic suspension to couple a mass comparator located in a vacuum chamber to a mass tray located in a separate chamber held at atmospheric pressure. The details of the apparatus, our mass transport system for shuttling a mass under vacuum between experiments, and our most recent results will be discussed.

The ESS outgassing test facility

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The European Spallation Source (ESS) is a multi-disciplinary research center based on the world's most powerful neutron source being built in Lund, Sweden. The facility design and construction includes the most powerful linear proton accelerator ever built, helium-cooled tungsten target wheel, 22 state-of-the-art neutron instruments, a suite of laboratories, and a supercomputing data management and software development center.

The ESS vacuum team has overall responsibility for all technical vacuum systems used on the Accelerator, Target and Neutron Scattering Instrument Systems and has the responsibility to provide guidance and on-going support and oversight to ensure the implementation of compatible vacuum designs for e.g. vacuum chambers, components and other equipment exposed to a technical vacuum environment.

The Outgassing Test Facility will provide the capability to assess the vacuum performance and investigate various materials and components that could be used in the ESS accelerator vacuum systems especially for new developments on accelerator instrumentation and on the Neutron instruments detector chambers as coatings, cables, connectors, polymers and glues. The system was design on UHV standards, pumped by turbo-molecular pump and load-lock what allows testing very high or lower outgassing rates. It will be presented the description of the system and the first results of the samples provided by in kind partners of ESS project.

Reducing the hydrogen outgassing rate of stainless steel vacuum chambers by a medium temperature heat treatment

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The outgassing rates of identical stainless steel vacuum chambers were measured to determine the effect of medium temperature heat treatments. The chambers were first tested without any heat treatments, and then treated by baking at 430 ^{0}C for a period of time of 15 days. During baking time one chamber was exposed to atmospheric air, one was exposed to dry air and one was exposed to vacuum. The outgassing rate of each chamber was measured at room temperature. The experimental results and measurement procedure will be discussed at the conference.

Vacuum technology methods to study gas permeation through cork stoppers

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Does cork breathe? In a bottle of wine, does the gas exchange happens by permeation through the cork, or by lateral leaks that may occur between the cork stopper and the bottleneck?

In this work we applied common vacuum technology methods to study the helium permeation, trough cork stoppers used in wine industry.

First, several bottles were pumped and then were filled with 1 atmosphere of helium. Then bottles were sealed with different types of cork stoppers. The helium permeability was measured by a mass spectrometer leak detector in sniffing mode.

The effect of cork compression on gas permeation was also studied by inserting the cork stoppers into cylinders (bottlenecks) having decreasing diameters. The volume from one side of the cork was pumped and filled with 1 atmosphere of helium. The cork stayed in every position (diameter) for several days until a stable reading is achieved and then is moved to a lower diameter. The mass spectrometer leak detector was also used to directly measure the helium flow through the cork stoppers.

Corks having surface treatments showed a better performance when compared with those without. However, the effect of compression was not as pronounced as one could expect. These results will be discussed in this communication.

Development of biofunctional patterns on porous silicon by MeV ion implantation. Study of implantation effects

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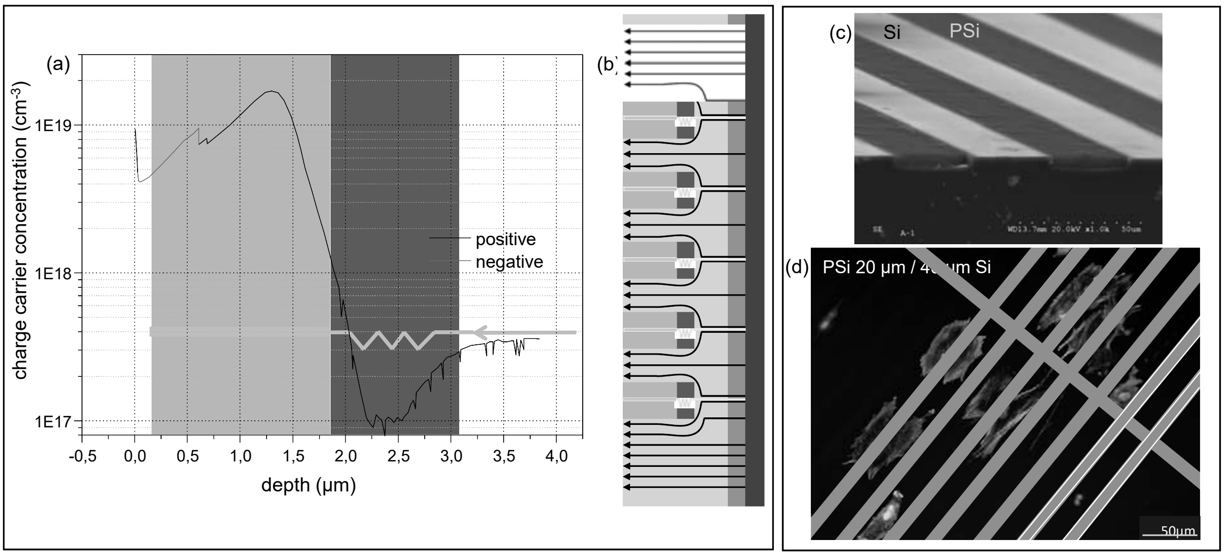
The recent breakthrough in Biomedicine implies an intrinsically interdisciplinary approach. In this context, science and technology of surfaces opens new opportunities to exploit the biomaterials potential. Porous Silicon (PSi) is a low-cost nanomaterial with applications in a wide range of fields, in the form of particles, layer or multilayer structures. There is an increasing interest on fabrication of patterned PSi structures, with interest in optoelectronic or bio- applications. As previously reported by other groups, irradiation of silicon with H and He KeV ions can inhibit the formation of PSi [1, 2]. A heavier ion allows achieving the PSi inhibition at lower implantation doses and, at the same time, provides higher lateral resolution due to its lower lateral straggling.

In this work, MeV Si ion implantation has been probed as an effective tool for the selective inhibition of PSi formation, resulting in good lateral contrasted Si/PSi patterns [3]. Fluorescence, electron and atomic force microscopy reveal the proper transfer of the mask motives into PSi/Si structure. Patterns present well defined lateral contrast and flat surface without height variations. These patterns have been used in cell migration studies, employing human mesenchymal stem cells [4].

MeV ion implantation increases the resistivity of B doped Silicon, on irradiated areas, leading the PSi inhibition during subsequent electrochemical etching. To deepen the study of implantation effects in Si, Elastic Backscattering Spectroscopy (EBS) measurements in channeling configuration have concluded that PSi inhibition does not necessarily require the crystal amorphization. Electrochemical Capacitance Voltammetry (ECV) measurements show a decrease in the charge carrier concentration in the area of maximum probability of ion implantation, supporting the assumption of Boron doping deactivation, by losing their positions in the lattice, as reported by other groups [5].



ECV measurement on sample irradiated with 1.5 MeV Si ions and 5E13 cm^{-2} (a). Current lines during PSi formation (b). (c) Obtained pattern after 20 MeV Si ions implanted with 5E13 cm^{-2} + electrochemical etching with 80 mA/cm^{2} during 62 s (5 μm). (d) Human mesenchymal stem cells cultured on PSi/Si pattern.

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UV activated self assembly of perfluoro and amino silanes on porous silicon

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Biofunctionalization of semiconductor structures is an expanding field of research in view of the increasing use of these materials in biomolecular environments, mainly for diagnosis. In particular, the functionalization of such structures with capping molecules providing controlled interaction with proteins is of main relevance. Functionalization with aminosilanes can determine coulombic interaction with charged residues of a protein, while surface activation with fluoropolymers inhibits polar interactions and yields hydrophobic interactions with different residues of the protein [1]. In this work we have successfully demonstrated the functionalization of porous silicon (PSi) luminescent surfaces by using an aminosilane (aminopropyl-triethoxy-silane, APTS) and a perfluorosilane (Perfluoro-decyltriethoxysilane, PFDS) in a process activated by UV light. After the electrochemical formation of the PSi structuctures, the formation of spongiform PSi was confirmed by scanning electron microscopy (SEM). Silane self assembly was carried out at low concentration in ethanol, under N_2 atmosphere and UV light excitation. The self assembled layers have been characterized using Fourier Transformed Infrared Spectroscopy and X-ray photoelectron spectroscopy which confirmed the incorporation of the chemical groups on the PSi surface. The modification was observed to alter the wetting properties. On the one hand, water contact angles were hydrophilic for APTS functionalized PSi, while highly hydrophobic interaction was observed on PFDS. A preliminary study to predict molecular interactions was performed by permeation of functionalized PSi with phosphotungstic acid (PTA) in water and observation by SEM. It could be derived that the APTS functionalized PSi is permeable, while PTA does not diffuse into PFDS functionalized PSi. The translation of these results to interactions with real protein solutions are in progress.

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Versatile Preparation of Large Area-Crystalline Monolayers for Colloidal Lithography

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Large-area nanostructured surfaces have promising applications in the field of photonics and plasmonics, which are fundamental disciplines for the development of advanced biosensing devices [1]. Surface fabrication techniques based on colloidal lithography and plasma processes have been intensively studied during the last years due to their ability to obtain low cost production of large area patterned surfaces [2]. Among the methods suited for the formation of crystalline film of colloidal particles, the Langmuir-Blodgett technique enables a fast, easy and controllable formation of latex monolayers, which can be transferred on different solid substrates by vertical dipping method and used as sacrificial etching mask to obtain a nanostructured surface.

In our investigation, after the bottom up formation of crystalline monolayers of colloidal latex particles we conditioned the surfaces by different top down vacuum based processes. In order to define the initial conditions for the formation of a 2D crystal, we investigated the Langmuir-Blodgett isotherms obtained by combining different suspension-related parameters. Once optimized the monolayer formation, the Langmuir-Blodgett films were transferred on different solid substrates with a wide coverage and good control over defect formation. These monolayers were then used as sacrificial mask to nanostructure the underlying layer through reactive ion etching. The sequential etching process, gold deposition and particle lift off allow one to obtain a surface made of 2D plasmonic crystals. By adjusting the etching parameters is possible to finely tune the geometric properties of the structure and tailor the surface plasmon resonance in a spectral position which is convenient for the required optical investigation. The versatility of this fabrication method shows great potential for easy and massive parallel fabrication of gold cavities with a tunable shape, diameter and periodicity and makes these surfaces particularly promising for applications where signal enhancement is useful, such as SPR and SERS detection.

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Characterization of surface modified NiTi shape memory alloy by AES, XPS and SIMS

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The most common shape memory alloy Nitinol (Nickel Titanium Naval Ordinance Lab), a group of nearly equiatomic Ni-Ti alloys, have unique mechanical properties, shape memory effect (SME), superelasticity, its biocompatibility and mechanical compatibility. Variations in the ratio of nickel to titanium create different nitinol characteristics. A number of useful items have already been produced, such as orthodontic implants and stents [1]. Medical applications are still hindered by the concern for the release of Ni into surrounding human tissues. Concerns have been raised about the composition of Nitinol, specifically with the presence of nickel, a known allergenic carcinogen that exhibits one of the highest sensitivities in metallic allergen tests [2]. The patterns of Ni release from Nitinol modify depending on the type of material; NiTi alloys with low or no processing versus commercial sheets [3]. Nitinol forms a self-protecting native Ti oxide on its surface that protects it from further oxidation. A thick TiO_2 layer is often considered as a reliable barrier against Ni release, but it was shown that Nitinol with the thickest oxide TiO_2 showed the highest Ni release [4]. The corrosion resistance of nitinol alloys is highly dependent on the surface condition.

In order to improve the biocompability and to prevent Ni release, the material surface has been modified by exposure to different oxidation processes (air, pure oxygen and oxygen plasma) at different temperatures and different time exposures.

The modified surfaces were characterized by Auger electron spectroscopy (AES), X-ray photoelectron spectroscopy and time of flight secondary ion mass spectrometry (TOF SIMS). In all cases the oxide film contained TiO_2 and TiO_x, near the surface and no Ni. We have also studied the mechanical properties of oxides.

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Gas aggregation source – effective tool for functional coating deposition

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Different types of polymeric coating prepared by vacuum methods are nowadays used in biomedical applications for promoting cell adhesion on the surface. Such coatings can be used e.g. as a biocompatible interface for bone implants. In this case high sterility of the implants is demanded to prevent undesirable infection. This can be achieved by functional nanocomposite coatings containing copper or silver inclusions. Usually, deposition of such coatings is based on matrix deposition by plasma polymerization with embedded metals using magnetron sputtering. It does not allow independent control of the matrix properties and filling factor of the metal. This issue can be overcome by deposition of the metal nanoparticles by means of Gas Aggregation Source (GAS) which allows independent control of the filling factor and matrix. This method was already successfully used for fabrication of hard Cu/a-C:H nanocomposites [1]. It was found that metal content over 3% leads to undesirable worsening of mechanical properties of the film. Plasma post-treatment in different types of plasmas was applied in order to increase surface concentration of the metal which is a crucial parameter for intense short term antibacterial activity of the coating.

It was found that low pressure nitrogen plasma post-treatment of Cu/aC:H coatings increased surface Cu concentration from about 1 at% up to 7 at%. Similar results were obtained also in case of Ag/aC:H nanocomposites and oxygen plasma. Very promising results were achieved also in case of nanocomposite post-treatment by means of atmospheric pressure plasma jest.

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Toward novel plasma inspired medical devices

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Plasma technologies have been increasingly employed in different industrial applications, while in the last decade their potential use in the medical field is foreseen. Gaseous plasma treatment techniques enable surface modification of various implantable materials without influencing on the bulk attributes. In the present work we will focus on surface modification by highly reactive oxygen plasma on titanium implants, which are commonly used in orthopaedic surgery, dentistry as well as for vascular implants. Although vast use of titanium (Ti) implants, their biological response is still not optimal, mainly due to insufficient cell adhesion on these surfaces. Many reports have already shown that nanostructured surfaces highly influence on biological response, while little is known on the influence of nanostructures in combination with plasma modification. Thus the aim of our work was to study the influence of various nanostructures and plasma modification on the in vitro biological response. Titanium dioxide (TiO_2) nanotubes with 15, 50 and 100 nm in diameter were obtained by electrochemical anodization of Ti foils (Figure 1). While further surface modification was done by the use of radiofrequency (RF) oxygen plasma, operating at 13.56 MHz and at output power of 200 W. The surface morphology of fabricated and treated nanotubes was analysed by scanning electron microscopy (SEM) and atomic force microscopy (AFM), while surface chemical composition was analysed by X-ray photoelectron spectroscopy (XPS). The influence of surface modification on *in vitro* biological response was determined from colorimetric assay and from images taken by SEM. From the assay changes in viability of cells on different substrates was determined, while thir cell-surface interactions were studied from SEM images.

Results from our studies showed that surface nanotopographic features in combination with plasma surface modification significantly influence on *in vitro* biological response, which makes such procedures highly prospective for development of novel titanium implants.

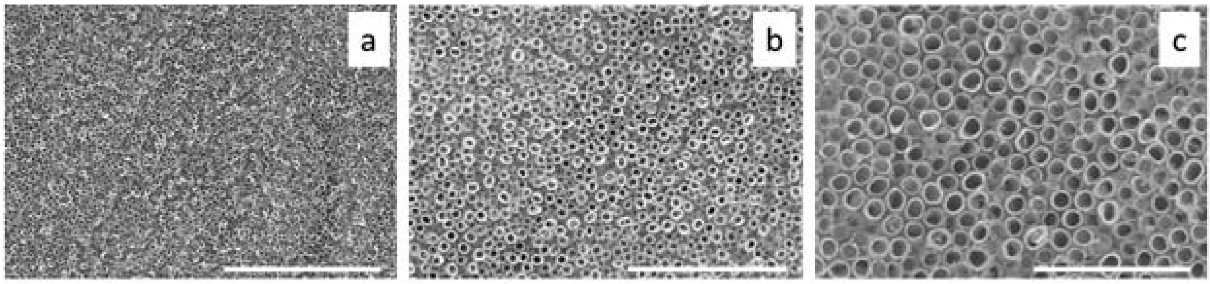

Figure 1. Nanotubes with a.) 15 nm, b.) 50 nm and c.) 100 nm in diameter. Scale bar is 1µm.

The effect of AA7075 and AA2024 substrate pre-treatment and alkaline cleaning procedures on the surface morphology and composition

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Surface pre-treatment is necessary before applying coating on aluminium alloys. Grinding and polishing are the most common mechanical pre-treatments. Chemical cleaning is carried out after mechanical pre-treatment to remove surface contamination originating from mechanical pre-treatment and to partially remove existing oxide at the metal surface. Cleaning is followed by desmutting aiming to remove residues of prior alkaline cleaning and to increase surface roughness to facilitate the adhesion of coating on the surface. The aim of this study was to investigate the effect of various pre-treatments of aluminium alloys 7075-T6 and 2024-T3. As mechanical pre-treatments water-based grinding and non-water polishing were tested. The chemical pre-treatments consisted of non-commercial cleaner NaOH and the commercial SurTec cleaner, both followed by nitric acid desmutting. Surface characteristics and corrosion properties were analysed using electrochemical potentiodynamic polarization, scanning electron microscopy (SEM) with chemical analysis (EDS), X-ray photoelectron spectroscopy (XPS) and tenziometer. Mechanical pre-treatment has stronger effect on AA7075. SEM images revealed the difference in morphology of AA7075 and AA2024 surfaces depending on the mechanical pre-treatment. Polished AA7075 and AA2024 have better corrosion properties compared to ground samples. According to the XPS results, SurTec removes inclusions, while NaOH followed by desmutting decreases the amount of some inclusions and increases the amount of other inclusions. Alkaline cleaning affects the electrochemical results as well. Results indicate the necessity of choosing the optimal pre-treatment for individual aluminium alloy.

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Influence of different solvents on the morphology of APTMS-silane modified Al-oxide surfaces: ToF-SIMS, XPS and AFM study

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In this study 3-aminopropyltrimethoxysilane (APTMS) was applied for the modification of Al-oxide surfaces. Surfaces modified with organosilanes are now widely used in many industries due to their large number of application: adhesion promoters, in chromatography, as sensors or biosensors, in medicine, corrosion protection, etc. [1, 2]. The influence of the different solvents on the morphology of the modified Al-oxide surfaces was studied since the possible heterogeneity may significantly influence the application of such surfaces [3]. Before the modifications all the Al-oxide surfaces were cleaned with HF and then oxidized in a controlled manner using oxygen plasma. We deposited the self-assembled silane layers from a diluted solution of APTMS in three solvents with different polarities (toluene, acetonitrile and ethanol) under various reaction conditions. Surfaces were characterized using Time-of-flight secondary ion mass spectrometry (ToF-SIMS), X-ray photoelectron spectroscopy (XPS) and Atomic force microscopy (AFM). The chemical structure was determined with ToF-SIMS; surface composition and the chemical bonding were determined by XPS; and surface morphology and roughness was investigated using AFM. Our results show successful bonding of APTMS molecules to the Al-oxide surface and that amount of coatings strongly depends on the type of solvent. Using ToF-SIMS technique we have proved the covalent bonding of the APTMS molecules with Al-oxide surface (signals at 71 = $SiOAl^+$, at 103 = SiO_2Al^-…) even in polar solvents which may cause solvolysis of deposited layers.

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Surface analysis of EVOH and its nanocomposite

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Photostability of materials used in organic photovoltaics (OPVs) is one of key factors of further development and expansion of these devices in the market. The photoageing of new polymer nanocomposite developed for encapsulation and protection of electronic devices against external factors has been studied in this work. The ethylene vinyl alcohol copolymer (EVOH) has been chosen as a polymer matrix due to its good initial properties for coating applications. On the other hand, zeolite nanoparticles were used as nanofiller due their high water sorption properties what has to improve water barrier properties of OPV encapsulation and to increase overall device lifetime. The nanocomposite was prepared using melt-mixing of the zeolite particles and the polymer powder in 2-screw extruder. The photodegradation of obtained EVOH/zeolite nanocomposite under accelerating photoageing conditions was followed by monitoring morphology and chemical changes of the film surface. The evolution of surface roughness was investigated in order to identify the applicability of the material in long-term exposure application. The complex approach of analysis combining ToF-SIMS, SEM and AFM methods has been used in this research. Obtained data showed the difference in initial properties as well as in photochemical behavior of the film surfaces caused by the presence of inorganic particles. Observed particles accumulation showed by all used methods leads to different trends of morphology evolutions, which effected the film roughness.

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Preparation and characterization of structures for inorganic – organic integrated photonics

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Inorganic – organic integrated photonics (IOIPH) integrate the organic material, as a part of active layer, with inorganic structure and right organic component extends the functionalities as compared to inorganic photonics. IOIPH system can be used for production of wearable sensors and sensing interfaces in continuous health monitoring applications.

We present results of preparation and characterization of inorganic and organic layers, as well as of combined inorganic – organic structures. Inorganic oxide materials and structures Si/SiO_x, $Si/SiO_x/Si_xN_y$ and $Si/SiO_x/SiO_x$:N were grown using plasma enhanced chemical vapor deposition (PECVD). Organic layers were spin-coated on SiO_2 created by thermal oxidation on Si. Then the combined inorganic – organic structures were prepared by spreading of organic materials on inorganic structures. As the basic photonics devices the inorganic as well as inorganic – organic waveguides were fabricated using reactive ion etching (RIE).

The results obtained by 3D optical microscopy (3D OM) and atomic force microscopy (AFM) showed that roughness of both inorganic and organic layers increased with their thickness and the surface of organic layers was smoother. The shape of fabricated inorganic waveguides was trapezoidal (5.4×7.2 µm) and etched structures were able to guide the radiation. The presented technology enabled to prepare combined inorganic – organic structures of comparable dimensions and shape. The fabricated waveguides dimensions and shape will be used for optimization and design of new lithographic mask to prepare photonic components with required characteristics.

Acknowledgement

This work was financially supported by Scientific Grant Agency of the Ministry of Education, Science, Research and Sport of the Slovak Republic No.VEGA-1/0907/13 and by the Slovak Research and Development Agency under the contract No. APVV-14-0716.

Thin Au film decomposition by annealing on prestructured Si substrates

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A very thin film, with thickness in the nanometer range, becomes unstable upon melting and breaks up into small particles that form complex surface patterns, ranging from percolated networks to isolated dots with characteristic sizes in the nanometer regime. This process is known as dewetting and, in the case of flat substrates, results in a periodic structure with characteristic wavelengths that are directly connected to the initial thickness of the film.

This contribution will present studies of thin film break-up in the case of pre-structured substrates. Using a broad Ar^+ ion beam, we produced a rippled silicon substrate with a well defined periodicity of the ripples. On this substrate, thin Au films (with thickness ranging from 3 nm to 10 nm) were deposited. The films were then annealed in vacuum environment and the resulting patterns were observed by scanning electron microscopy to determine the role of the pre-existing substrate structure and the thin film thickness.

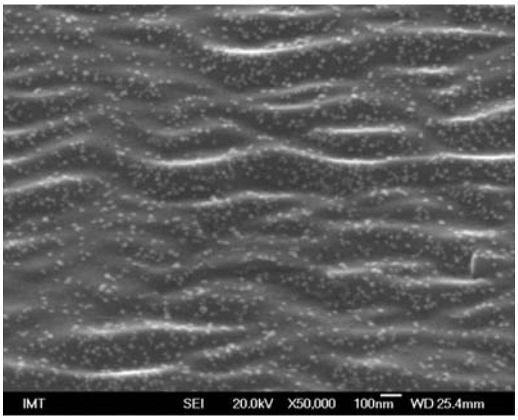

Figure 1: An example of rippled Si surface with dewetted Au particles.

Investigating the effect of iodine bombardment on glassy carbon

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360 keV iodine ions were implanted in glassy carbon to a fluence of 2×10^{16} ions/cm^2 at room temperature. The implanted samples were then annealed isochronally in vacuum from 100°C to 1000°C for 1 h. The diffusion behaviour of the implanted iodine in glassy carbon was investigated using Rutherford backscattering spectrometry (RBS) while the structural and surface changes in the glassy carbon substrate due to strontium bombardment and annealing were monitored using Raman spectroscopy and scanning electron microscopy (SEM) respectively. RBS analysis showed that there was diffusion

of the implanted iodine towards the surface of the glassy carbon when the annealing temperature was increased to 400°C. Annealing the sample at 500°C resulted in a significant drop in the iodine peak height with only about 40 % of the iodine retained within the glassy carbon substrate. The diffusion of iodine towards the surface and loss of iodine (sublimation) was enhanced as the annealing temperature was increased. No iodine was retained within and on the glassy carbon substrate at 1000°C. The Raman spectrum obtained after ion bombardment showed that the D and G peak merged into a single peak which indicates amorphisation. The results also showed that the glassy carbon structure was not recovered even after all the implanted iodine had sublimed (at 1000°C). This implies that the radiation damage introduced after implantation were not successfully annealed out. The SEM micrographs show that some of the glassy carbon atoms were sputtered away during annealing especially along the polishing lines. The sputtering away of the glassy carbon layer became more apparent after annealing the sample at 500°C which indicates that the sputtering effect is perhaps responsible for the enhanced diffusion at higher annealing temperatures.

Detection by sputtering of deformed areas hidden under a surface

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The deformed areas in metals have been detected earlier using a sputtering in glow discharge [1,2]. However, a sensitivity of this method is insufficient to identify the areas of deformation when the most of the top layer is removed.

In this work we have determined by molecular dynamic modelling and experimentally the particular parameters of sputtering when the deformed regions, hidden deeply under surface, can be detected with the high resolution. As a target, we choose the $Cu_{87}Sn_{13}$ alloy that is used for coin manufacturing. Energy and angular distributions of sputtering are studied by considering segregation and changing of lattice constant and atom binding energy after deformation [3]. The obtained results are shown in Fig.1, where the solid and the dashed lines correspond to sputtering yields before and after compressive deformation of a target, respectively.

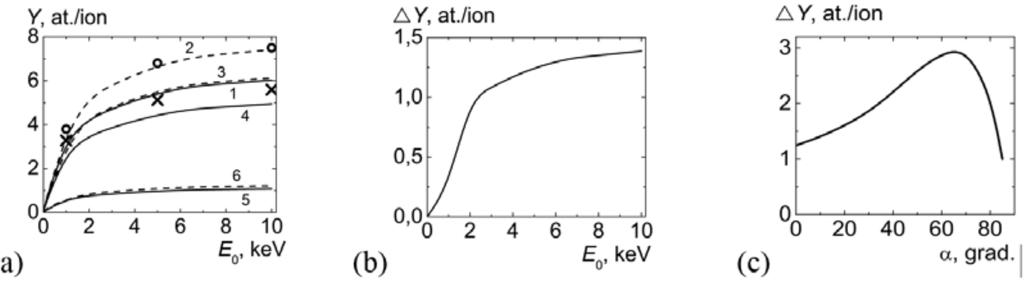

Fig. 1. (a) Energy dependence of sputtering yield Y of $Cu_{87}Sn_{13}$ polycrystal; 1, 2 – Cu+Sn, 3,4 – Cu, 5,6 – Sn; ○, × – Cu+Sn, taking into account the segregation with and without deformation, respectively. (b) Difference between $Y(E_0)$ without and with deformation. (c) Difference between $Y(\alpha)$ (Kr^+, E_0=7 keV) before and after deformation.

According Fig.1, the difference between the sputtering yield after and before deformation is greater for higher E_0 and for the inclined direction of incident ions. Precisely, under these conditions we recommend to carry out ion-irradiation. The result is presented in Fig.2.

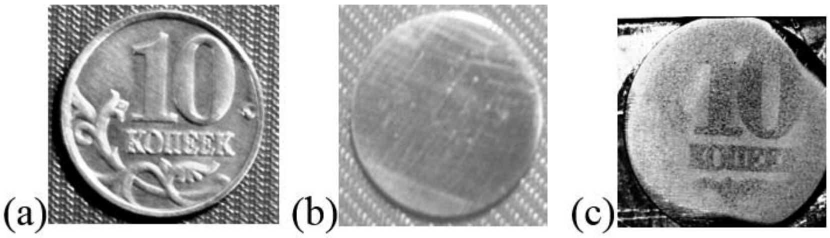

Fig. 2. (a) Bronze coin of 10 kopeks. (b) The coin when the type is totally deleted. (c) The same coin after inclined ion bombardment (7keV Kr^+, α= 70°).

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Increasing the lifetime of the glow plugs

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Nowadays, automotive industry with advanced technology of stop-start engine is reducing the fuel consumption and therefor lowering the CO_2 emission. With implementing this technology the need to develop heating elements with extended lifetime compared to the standard product used in the automotive industry in the glow plugs and glow plugs with an integrated pressure sensor groves. Stringent requirements of automotive manufacturers are increasing lifetime expectancy.

Resistance heating wire in glow plug is made of FeCrAl alloys and due to their special composition forms a continuous protective layer of Al_2O_3. In temperature range above 1200 °C SiO_2 and Al_2O_3 are two oxides that are capable of forming a potent protective barrier against further oxidation. The alloy therefor normally requires about 4 % Al to form a continuous protective layer. The problem is in porosity and continuity of the protective oxide layer which is at high temperature transparent for the oxygen diffusion interior the wire and therefor the oxide degradation continues.

The main cause of failure of glow plugs and therefore, the shorter lifetime, is high temperature oxidation resistance in the tip of the filament heater. Our aim is to improve the ignition resistance and resistance to corrosion at high temperatures and thus to extend the lifetime of glow plugs. Material improvements and SEM/EDS characterization was perform to understand the mechanism of better corrosion resistance of the heating wire.

Evolution of tool-steel microstructures influenced by rare-earth modifications

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Cast tool steels produced using conventional methods have a high tendency to segregate and form large carbides, thereby leading to a carbide net. To improve the properties additional processes must be performed, e.g., electro-slag remelting, forging, hot and cold rolling and heat treatment. However, the final microstructure is heavily influenced by the as-cast microstructure, even if all the production processes are applied. Therefore, it is essential to study the as-cast microstructure in order to find the route to a finer microstructure. One option is to use expensive powder metallurgy; the other could be to micro-alloy the steel using rare-earth elements. Some authors [1,2] have reported the positive effects of rare-earth modifications on microstructure evolution, influencing the size and shape of the carbide distribution. However, it is not clear how such elements influence the texture, by increasing seeds or preferentially promoting some particular growth direction.

We manufactured several tool-steel grades with and without rare-earth additions. Scanning and transmission electron microscopy with micro-chemical analyses tools were employed in order to find the microstructural differences between the modified and unmodified steels. Using thermal analyses the temperature solidification profile was measured. Then from the combination of electron microscopy and thermal analyses we developed a model that explains the reasons for the differences between the modified and unmodified steel structures.

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Influence of O_2 gas addition on cell adhesion on polymer surface treated in SO_2 plasma

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Adhesion and proliferation of Human umbilical endothelial cells (HUVEC) on polyethylene terephthalate (PET) surfaces was studied. PET surfaces were treated in electrode-less radiofrequency plasma created in different SO_2/O_2 mixtures. Gas mixtures with the following O_2:SO_2 ratios were used: 90%:10%, 70%:30%, 50%:50%, 30%:70% and 10%:90%. HUVEC cell adhesion and morphology was investigated by scanning electron microscopy. The influence of plasma treatment on HUVEC cell adhesion and viability was evaluated with metabolic activity assay (MTT assay), while cytotoxicity was investigated by cell density determination, based on the measurement of cellular protein content (sulforhodamine B (SRB) assay). The best HUVEC proliferation was obtained when 30%-50% of oxygen was added to SO_2 plasma.

Modifications of carbon composites upon exposure to oxygen plasma at high temperatures

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Oxygen plasma was used to reduce carbon-content in composites. The composites composed mostly of carbon and NaF with the presence of some minor impurities (Al, Mg, Si) were exposed to microwave plasma created at 700 W. The oxygen pressure was 100 Pa. The density of oxygen atoms in plasma as estimated by catalytic probes was approximately $2 \times 10^{21}\ m^{-3}$. During plasma treatment, the samples were additionally heated by concentrated solar radiation. The temperature was measured by a pyrometer and was varying between 1100 K and 2000 K as determined by taking into account the sample emissivity of 0.8. Strong degassing of samples was observed during oxygen plasma treatment indicating volatilization of unstable compounds formed during reaction of reactive oxygen species with the samples. Degassing was observed at temperatures above threshold temperature of 1400 K.

Plasma treatment of polyvinyl chloride and polypropylene tubes

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Polymeric tubes are used in numerous applications in a vast variety of fields. In the past, different characteristics of tubes could only be obtained by using different polymers and manufacturing procedures. Certain limits existed and surface energy was difficult to change. A new era started with the emergence of plasma technologies, offering novel ways of changing polymer surface characteristics.

The aim of our work was to improve the wettability (increase surface energy) of the polyvinyl chloride (PVC) and polypropylene (PP) tubes with plasma. Different plasma setups and plasma parameter were used to decrease water contact angle (WCA). Two separate factors affect wettability, first being surface morphology and second surface chemistry. Plasma (especially oxygen plasma) is a source of different species including positive ions that etch the surface of polymers. An evenly etched nanostructured surface is obtained after a period of time, due to different etching rates of the polymer matrix. This effect is permanent and can be observed with atomic force microscopy (AFM) where average surface roughness is one of the main parameters. On the other hand, plasma changes surface chemistry, which is observed as an increase in oxygen groups on plasma treated surfaces. The technique for determining the surface chemical composition is X-ray photoelectron spectroscopy (XPS), where C/O ratio is used to provide comparable results. Ageing of plasma treatment occurs because surfaces tend to restore to lower energy state after time. Water contact angle measurements were performed to better characterize the rate of ageing of different samples.

Recombination of oxygen atoms along a glass tube loaded with a copper sample

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A movable catalytic probe was used for measuring the loss of oxygen atoms along a Pyrex tube loaded with a copper sample. The atom source was a microwave discharge created in the surfatron mode. Molecular oxygen was leaked into the discharge tube though a calibrated flow controller at different rates between 18 and 1035 sccm. The discharge tube was connected to a Pyrex tube which was pumped with a two-stage rotary pump of a nominal pumping speed 80 m^3/h. A flow restrictor was mounted between the pump and the Pyrex tube allowing for adjustable effective pumping speed between 7 and 36 m^3/h. A copper foil was mounted into the Pyrex tube and the O-atom density was measured along the tube at various leak rates and effective pumping speeds. The measurements of the O-atom density showed reduction in the atom density along the tube which was the most effective at low leakages and pumping speeds. The results were explained by gas kinetics and heterogeneous surface recombination.

Probability for neutral atom recombination on polymer surfaces

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Probability for recombination of neutral oxygen, nitrogen or hydrogen atoms on polymer surfaces has been studied. The source of neutral atoms was plasma created by an electrode-less radio-frequency discharge in H-mode. Plasma was created either in oxygen, nitrogen or hydrogen atmosphere at the pressure of 30 Pa. Samples of polymer polystyrene (PS) and polyethylene terephthalate (PET) were placed in the afterglow chamber made from borosilicate glass 30 cm away from the glowing plasma. The chamber was pumped with a two-stage rotary pump with a nominal pumping speed of 80 m^3/h. After ignition of plasma, the rise of the polymer temperature due to energy dissipation during surface recombination of neutral atoms was measured. The density of neutral atoms in the vicinity of the polymer sample and resulting atom flux was measured with a catalytic probe. The measured polymer temperature and flux of neutral atoms allowed for calculation of recombination probability for $H+H\rightarrow H_2$, $O+O\rightarrow O_2$ and $N+N\rightarrow N_2$ atoms on PET and PS polymers.

Study of surface properties of human enamel and dentine treated using helium and argon atmospheric pressure plasma jet

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This study presents investigation of chemical composition and surface properties of human teeth upon treatment using helium and argon atmospheric pressure plasma jets. Teeth were treated for various treatment times both on their outer surface (enamel) and inside the pulp (dentine). The plasma source was a single-electrode discharge; it consisted of an electrode (a copper wire 0.1 mm in diameter) inserted inside a borosilicate glass capillary (50 mm long and with inner diameter of 1 mm). Input voltage was around 2.5 kV at 25 kHz yielding average power of 2 W. The flow of processing gases was set to 2 sL/min and controlled using a mass flow controller. Distance between the treated surface and the electrode tip was 1 cm.

The tooth samples have been analysed prior and after the plasma treatment. Surface composition was measured using X-ray photoelectron spectroscopy (XPS), while surface morphological properties have been studied by using atomic force microscopy (AFM) and contact-angle measurements.

From XPS measurements, it was found that exposure to 9-minute APPJ treatment resulted in removal of carbon and nitrogen from the enamel surface and increased the rate of calcium, phosphor and oxygen under present conditions. This means that this kind of treatment results in degradation of organic matrix with an increase of Ca/P ratio which is important for the process of remineralisation. AFM measurements showed somewhat decreased micro-roughness of the enamel which. Measurements of the contact-angle revealed that for both the enamel and dentine, wettability increases with prolonged treatment time.

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Study of cold plasma jets in different ambiental gases

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Atmospheric pressure plasma jets (APPJs) are being developed for various applications in plasma medicine, plasma agriculture, biotechnologies and for materials modifications [1]. Specific applications are made possible by tailoring plasma sources and choosing operating parameters. Some of those parameters are voltage shape/amplitude/duration/rise time. For example, when the pulse width is short enough (few hundred ns), increasing the pulse width leads to higher discharge currents and longer plasma jets. Another parameter important for application is the ambiental pressure. Here we are interested in a transition from a typical atmospheric pressure plasma jet to a diffuse plasma at the low pressure. The transition is made possible by inserting a capillary plasma source into a glass tube (11.5 cm diameter, 150 cm length) that is connected to a rotary vacuum pump and vacuum gauge. The APPJ electrode was a copper wire with a diameter of 0.1 mm inserted in a 70 mm long and 1.5 mm outer diameter borosilicate glass capillary tube [2]. Both working gas and background gas were controlled with the mass flow controllers in the range of several L/min. Input voltage was either sinusoidal (about 25 kHz, 2.5 kV) or rectangular (with short rising time). Plasma diagnostics was performed using imaging accompanied with the optical emission spectroscopy, along with determination of voltage-current curves, with respect to the total pressure and mass flow in the tube, for different gas combinations.

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Xenon plasma velocity measurement in electrically thruster using laser-induced fluorescence with high temporal resolution

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In this paper the results of applicability study for nanoseconds lasers for laser induced fluorescence velocimetry of one charge xenon ions in the plume of a thruster with closed electron drift (300 W) are described. Since signal intensity hard depends on transition, the velocity distributions from LIF spectra are observed at different transitions such as: 484 nm to 546.039 nm; 484 nm to 547.261 nm; 484 nm to 699.088 nm; 484 nm to 821.485 nm; 534 nm to 477.918 nm; 534 nm to 597.647 nm; 534 nm to 609.759 nm; 534 nm to 669.432 nm; 605.1 nm to 529.222 nm. Calculation of radial and axial components of Xenon ions velocities is based on Doppler Effect [1]. The fluorescence signal at high temporal resolution was measured, but investigated area was increased to 6 mm. Getting velocity depending on the transition have insignificant fluctuations, but the average value coincide with date from invasive methods.

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Extreme ultraviolet emission from laser-induced plasma relevance to neutral gas environment simulation in low Earth orbit

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Ground-based space environmental tests involving atomic oxygen-induced erosion, which are intended to simulate the neutral gas environment in low Earth orbit, often result in disagreement between ground-based data and space data for certain materials. This disagreement is believed due to differences in the atomic oxygen test environments in space and in the laboratory. We need to consider not only atomic oxygen but also side products (such as ions or photons) produced in a laser-detonation atomic oxygen beam source, which has been used for many atomic oxygen ground-based simulation studies. We measured extreme ultraviolet (EUV) spectra (5-50 nm) from the laser-induced oxygen plasma in the laser-detonation atomic oxygen beam source with a flat-filed EUV spectrometer (Figure 1). The experimental results clearly indicated that many spectral lines between 30 and 50nm were present in the photon emission from the laser-induced oxygen plasma. These spectral lines originated from the electron transitions of O III and O II. It was confirmed that ground-based atomic oxygen exposure test samples experienced EUV with a wavelength of 30 nm (photon energy as high as 40 eV) during hyperthermal atomic oxygen exposures. The impact of such high-energy photons on space environmental testing of UV-sensitive materials is not yet fully understood. However, absorbance of this wavelength in solids is quite large and the effect of EUV is limited to the topmost surface, similar to that of atomic oxygen collisions. Because the intensity of EUV increases with increasing translational energies of atomic oxygen, the effect of EUV should be taken into account in ground-based "hyperthermal" atomic oxygen beam exposure experiments.

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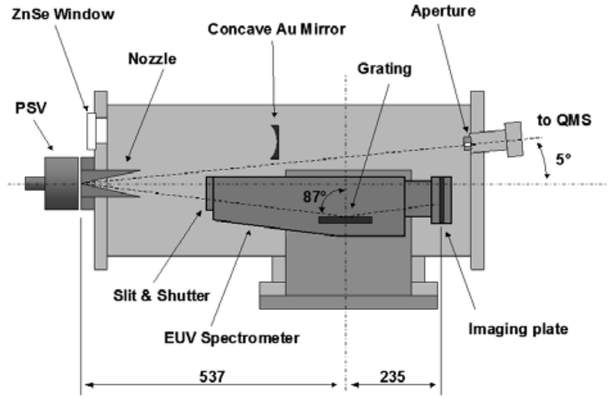

Figure 1 Experimental setup of the EUV and TOF spectra measurement system on the laser-detonation beam source.

New atmospheric pressure plasma technology for advanced wound care products developed in „IP4Plasma" EU project

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Surface modifications by atmospheric pressure plasma (APP) technology for advanced wound care products has been developed in the frame of European project IP4Plasma: "Industrial innovations based on EU intellectual property assets in the field of atmospheric pressure plasma technology", funded by European Union under the 7th Framework Programme for Research and Innovation (http://ip4plasma.eu/en/home). In the IP4Plasma project, plasma equipment manufacturers and end-users work with leading experts in research to demonstrate the suitability of the atmospheric pressure plasma technology for existing and new industrial applications in the advanced medical diagnostics sector and health care products. In the project nine European partners from research and industry areas are involved. IP4Plasma project aims to improve the properties of wound dressings by improving the wound draining behavior like hydrophobic surface with hydrophilic core for optimal adsorption and confinement of exudates and add antibacterial properties to the surface of materials instead of the bulk by plasma deposition of non-silver-containing chemistries.

The APP plasma reactor has been constructed which enables the combination of an atmospheric plasma and the injection of chemicals. It has been designed for industrial production lines, and allows for easy cleaning and maintenance. APP reactor was used for activation of nonwoven substrates by pre-treatment with nitrogen gas and for thin layer deposition of antibacterial coatings. Different parameters of surface plasma treatment were studied. Surface composition and chemical structure of treated materials were analysed by surface sensitive techniques such as X-ray photoelectron spectroscopy (XPS) and Time of flight secondary ion mass spectrometry (ToF-SIMS). Plasma treated materials were tested for application oriented properties to evaluate surface wettability and antibacterial properties. Surface analyses of the APP treated materials showed an increase of O/C surface ratio and change of C 1s spectra showing successful bonding of deposited coatings. These results were accompanied by change of surface energy of treated substrates and improvements of antibacterial properties.

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Thermal stability of zinc-oxide layer

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Doped zinc oxide layers can be used as transparent conductive oxide (TCO) layers in thin film solar cells and they are usually deposited directly on substrates. The long life time of a thin film photovoltaic (PV) module requires a stable TCO layer with an optimized deposition process because its degradation induces the degradation of the whole solar cell. While ZnO layers produced by physical vapour deposition must be annealed in hydrogen atmosphere to reach a good electrical conductivity, ZnO layers produced by Chemical Vapour Deposition (CVD) do not require this extra annealing procedure. However, some other problems can appear if the film deposition parameters are not optimal during deposition time. Results of annealing experiments of boron-doped zinc oxide layers prepared by CVD on soda-lime glass for windows are presented. It is shown that a short annealing of samples at 150 ^{o}C and 300 ^{o}C can cause a serious surface degradation. The characteristic feature of degradation is the formation of bubbles on sample surface which can still fully destroy the continuity of the layer. Depth profile analyses of zinc oxide layers show that the degradation due to annealing takes place in those samples which have a gradient in depth distribution of oxygen prior to annealing. The oxygen distribution changes during annealing and becomes more uniform. The samples prepared with uniform depth distribution do not show any surface degradation.

Flattening and thinning of amorphous silicon carbonitride diaphragm for environmental-cell transmission electron microscope by nitrogen plasma irradiation

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An amorphous silicon carbonitride (a-SiCN) diaphragm for environmental-cell transmission electron microscope (E-cell TEM) has been developed by magnetic-field and pulsed plasma enhanced chemical vapor deposition method (MPECVD). The E-cell TEM has a specimen holder with small chamber in conventional TEM to observe in liquid and ambient gas such as biological or catalyst specimen [1]. The diaphragm is the most important component of the E-cell TEM system because it both maintains the pressure difference between the vacuum and the reaction gas and allows an electron beam to pass through it. MPECVD has the advantage of high deposition rate than conventional PECVD [2]. In this method, however, around 200-nm-thickness film was required to obtain continuous film (pin-hole free film). And, the deposited film was include small grains under some conditions by dusty plasma.

In here, to obtain a high hardness, smooth surface and thinner a-SiCN diaphragm, the prepared diaphragms were irradiated with nitrogen plasma after the deposition. The prepared diaphragms were placed on a Cu

grid that was used as a TEM specimen holder and were characterized by optical microscopy, TEM and X-ray photoelectron spectroscopy and their capacity to resist pressure were measured.

a-SiCN films for diaphragm in E-cell TEM were applied to a Cu grid with 100-∝m-diameter holes by MPECVD, and then, nitrogen plasma was irradiated. The diaphragm became smooth surface, thinner (15 nm thickness) and harder (0.34 MPa resist pressure) because the thickness of the diaphragm was decreased by sputtering and hardening of the diaphragm was enhanced to nitridation of Si.

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Investigation of residual chlorine in TiO_2 films grown by atomic layer deposition

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Among metal-oxide semiconductors, titanium dioxide (TiO_2) is one of the most promising materials for many applications, ranging from microelectronics to photo catalysis or medical device materials. In recent years, Atomic Layer Deposition (ALD) technique has been extensively used for the growth of thin TiO_2 films. The main advantages of ALD are excellent thickness control and the high conformity of the obtained films. In comparison with the conventional thermal ALD, plasma-enhanced ALD (PEALD) enables the higher growth rate at reduced substrate temperatures, which is especially important for the growth of thin films on temperature sensitive materials. In the case when titanium tetrachloride ($TiCl_4$) is used as the ALD precursor for the synthesis of thin TiO_2 films, some chlorine impurities remain present in the resulting inorganic material. The assessment of Cl impurities is particularly important for the photocatalytical applications where the incorporated chlorine lowers the energy gap of TiO_2, thus enabling its absorption to higher wavelength, or affecting performances of the TiO_2-based catalytic systems including fuel cells, alkane dehydrogenation and water splitting systems and lithium−O_2 batteries. In the present work we present a comprehensive study of residual chlorine impurities within the TiO_2 films grown on silicon substrates using ALD and PEALD techniques at a wide temperature range. By using plasma, it was possible to significantly lower the deposition temperatures and achieve better quality of films with lower amount of impurities. We have employed Secondary Ion Mass Spectrometry for the in-depth elemental analysis and the determination of the thickness of TiO_2 layers, while chemical bonding of Cl was determined from X-ray Photoemission Spectroscopy measurements. In addition, the surface topography, conformity, composition and film thickness was studied with Scanning Electron Microscopy.

Cu Nanoparticles: formation dynamics and plasmon properties in and on dielectric films

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Some metals, like Cu, Ag, and Au in nanometer size and various shapes, present different optical properties with respect to their bulk properties, due to the presence of the plasmon effect. This phenomenon originates from the collective oscillations of the conduction electrons, the plasmons, and corresponds to a narrow absorption band in the visible spectral range. Using this effect, the optical properties of a dielectric material can be substantially modified by introducing metallic nanoparticles. Controlling the size, shape and chemical environment of nanoparticles, one can modify for example, in a controlled manner, the plasmon band and therefore the macroscopic properties of the host matrix. In this context, our research focuses on the synthesis of Cu nanoparticles in and on silica, forming thus composite materials.

The samples were formed by thermal evaporation in high vacuum of a single Cu layer on top of Si substrate and/or one capped with a thin SiO_2 layer. The samples were deposited on substrates held at different temperatures and were ex-situ annealed in high vacuum. Grazing incidence small-angle X-ray scattering (GISAXS) was used to study the morphology development and the structural properties. The GISAXS results are compared with those from Atomic Force Microscopy and Scanning Electron Microscopy measurements, and the fractality of the formed nanostructures will be explored. The formation of Cu nanodots was additionally monitored by Rutherford Backscattering Spectroscopy. However, when the clustering of Cu was explored within dielectric layers, GISAXS was the only choice to provide reliable results. It is shown that the Cu production is critically dependent on the starting configuration of the layers. The plasmonic effect was monitored by UV-Vis reflectance spectroscopy. The oxidation of nanoparticles was further studied by photoluminescence and time-resolved photoluminescence spectroscopy.

The primary national vacuum standards of Korea Research Institute of Standards and Science (KRISS) in Korea

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The calibration of vacuum gauges is mainly carried out in two ways; i) using the primary standards in which the readings of a test gauge are compared with the pressures generated by the standard, and ii) by comparison method in which the readings of the gauge under test are compared with the output signal of a secondary standard. The former type of standards are, usually, large and complicated systems comprising of vacuum pumps, chambers, valves, and gauges etc. while the later type are simply vacuum gauges, with superior qualities, which are attached to a properly designed calibration system. The Vacuum Measurement Lab at Korea Research Institute of Standards and Science (KRISS), Rep. of Korea, maintains primary standards as well as systems for calibration by comparison method. The KRISS primary standards can be used for the calibration purpose in the pressure range from ~ 10^{-7} Pa to 133 kPa. An absolute pressure standard, usually referred to as a primary standard, is an instrument whose calibration is calculated from the knowledge of its significant dimensions and physical constants. The values of such instruments are accepted without reference to other standards of the same quantity. They are mainly categorized into manometers, static (volume, series) expansion systems, and dynamic expansion (orifice) systems. For bilateral as well as key comparison of these standards, KRISS has participated in the past where its standards have good degree of equivalence and hence international recognition, with other national standards like that of NMIJ, NIST, PTB, NPL(UK), etc. Besides, the KRISS Vacuum Measurement Lab also has which can be used for calibration by comparison method. However, here the KRISS primary vacuum gauge calibration standards are discussed briefly with the aim to provide enough information to the readers in a single paper.

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Development of vacuum calibration apparatus in high and low temperature environment

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The vaccum gauges used in the high and low temperature environment are always calibrated in the laboratory. The temperature in the laboratory is about 23°C±3°C, which is different from the environment temperature the vaccum gauges used in. It will lead to the uncertainty of measurement results for vacuum gauge. Base on the requirement of the calibration for vacuum gauge in operational site, the vacuum calibration apparatus in high and low temperature environment has been designed. The calibration apparatus is made up of gas supply system, pump system, temperature control system, pressure measurement and calibration system, bake system, data acquisition and control system. The calibration method has been put forward. Take the capacitance diaphragm vacuum gauge as the standard vacuum gauge and joint it on one junction of calibration chamber. Take the calibrated gauge in the auxiliary vacuum chamber and joint it on another junction of calibration chamber. The static comparison method has been adopted. Set the temperature point value of auxiliary vacuum chamber and inject the gas into the calibration chamber. The values of standard vacuum gauge and calibrated vacuum gauge are recorded synchronously. The calibration factor in the temperature is the quotient of the value of standard vacuum gauge dividing the value of calibrated vacuum gauge. The experimental results shows that the vacuum calibration range of the apparatus is 1.63×10^{-4}Pa$\approx1.33\times10^{5}$Pa, the temperature range of the apparatus is –112°C≈+93°C and the temperature fluctuations is ±1.3°C. The combined standard uncertainty is 6.6%. It can content the requirement.

PDMS permeability measurement with capillary manometer

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Degassed polydimethylsiloxane (PDMS) slabs have been proposed as a pumping method in microfluidic chips [1], where air from inside of a microchannel is absorbed into the PDMS, resulting in a liquid flow into the channel. We present a study on permeability of a PDMS ring whose outer edge is exposed to air. The pressure inside the ring is measured continuously with a calibrated home-made manometer (Figure 1). The manometer consists of a thin glass capillary with a mercury plug. The capillary is sealed at one end so the droplet initially rests at distance x_0 from the sealed end at atmospheric pressure p_0. The pressure p at the open end of the capillary is thus inversely proportional to the distance between the sealed end and the mercury droplet x; $p/p_0 = x_0/x$. After the capillary manometer was calibrated in a vacuum chamber, its open end was inserted into the PDMS ring and the ring was closed by two glass plates (so air permeates through the ring only from the outer edge). The ensemble was exposed to air at absolute pressure between few 100 mbar and 1500 mbar for 2-3 days until equilibrium pressure in the PDMS ring and in the cavity was established. After that, it was exposed to atmospheric pressure and the pressure inside the ring was measured as a function of time. Permeability was measured for various degassing pressures, ring dimensions and PDMS thicknesses and the results were compared to numerical simulations.

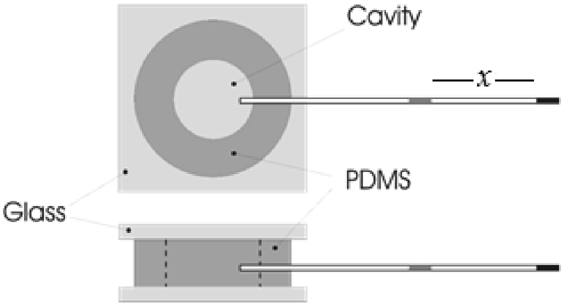

Figure 1: PDMS ring with inserted capillary is placed between glass plates

[1] Hosokawa, Kazuo, et al., *Lab on a Chip* 4 (2004), 181-185.

Extension the lower limit of pressure leak calibration with constant pressure method

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With the rapid development of science and technology in recent years, pressure leak detectors with high dependability are widely used in many fields such as spaceflight, aviation, automotive production, refrigerator systems. The existing detectors cannot meet the demand for these applications totally. Therefore, in order to extend the lower limit of pressure leak detector, four measures were adopted in this work.

First, the diameter of piston is accurately designed, and the mutative vessel connected with fixed vessel and piton just like a pipeline, and the piston can move in the pipeline. During the pressure leak calibration process, the volume of mutative vessel changed by means of piston movement. Pressure leak calibration equipment use three standard pistons distinguished by dimension of piston, which have been verified by authorized department.

Second, the volume of fixed vessel designed as small as possible, The fixed vessel is connected with pressure leak, vacuum gauge, charge pipeline and piston, thus it is expected to big enough, which is reverse to view of decreasing the fixed vessel as small as possible. The pipeline is optimized as short as possible to solve this issue, the fixed vessel is about 15mL, which cannot meet the demand. Therefore, a metal cylinder is put in the vessel to decrease the volume to be 10mL.

Third, a constant temperature system by circulating water is used, initiative and passive method is utilized to hold constant temperature during experimental period. Temperature is the key factor to influence the background of pressure leak calibration, and the false leak caused by temperature is 10^{-8}Pa•m^3/s level.

At last, pressure saw-tooth wave method is adopted to calibrate the pressure leak. The piston speed, width and amplitude of wave are reset to calculate the pressure leak accurately.

From these measurements, the lower limit of pressure leak calibration could reach up to 10^{-8}Pa m^3/s level.

A fast piezoelectric-driven pulsed supersonic valve using displacement enlargement mechanism for atomic/molecular beam applications

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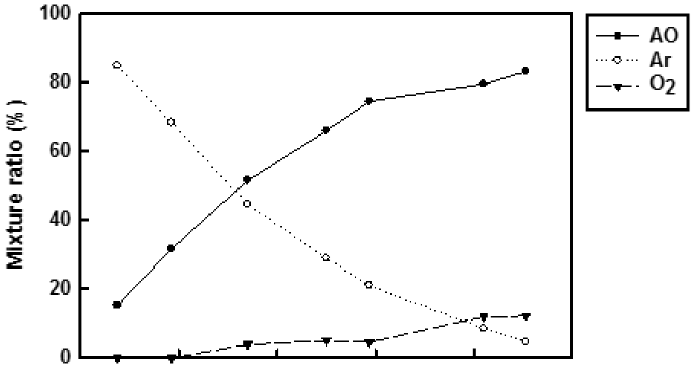
A pulsed supersonic valve (PSV) with fast operation capability is essential for many molecular/atomic beam experiments. A reliable PSV is a key device for not only scientific molecular beam experiments, but also engineering applications such as future digital molecular beam epitaxy (MBE) and molecular beam-induced etching. Among these applications, laser-detonation hyperthermal beam source, which has been used for space environmental effect researches, requires highly reliable and fast response PSV system. A solenoid valve has been generally used in this application; however, it consists of a PTFE poppet that is easily damaged by a carbon dioxide laser pulse. A poppet made of Viton O-ring and Au reflector is feasible for this purpose. We have developed a fast piezoelectric-driven PSV system with a displacement enlargement mechanism. Figure 1 shows the photograph of the PSV system. It consists of conventional low-voltage piezoelectric actuator (max 150V) with a displacement enlargement mechanism. Viton O-ring and Au reflector were specially designed for laser-detonation applications. A pressure profile of ejected gas form the nozzle clearly indicated that the PSV is able to operate less than 100 microseconds (rise-up time). It should be mentioned that even faster operation is possible with a high-power PSV driver. Time-of-flight spectra of "thermal" molecular beam generated with this PSV system were measured. Also the capability of forming "hyperthermal" atomic beam with laser-detonation for space environmental simulation as well as a wide variety of applications for this fast and reliable PSV system will also be discussed.



A part of this research was supported by the Grant-in-Aids for Scientific Research from JSPS under contract Nr. 25289307, 26289322, 15K14252 and 15K14253. Financial support through the Coordination Funds for Promoting Aerospace Utilization from the MEXT was also appreciated.

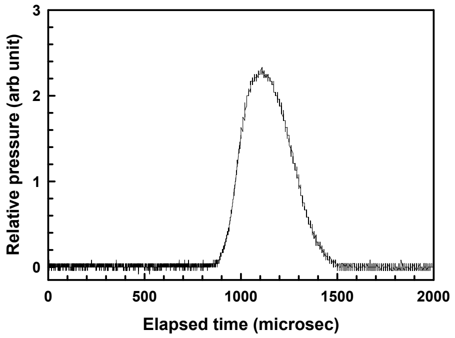


Figure 1: A photograph of the PSV developed in this study.

Figure 2: Pressure profile of single pulse measured at 7mm downstream from the nozzle.

Influence of noise of pressure data points on the uncertainty of gas flow measurement by pressure rise method

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Accurate measurements of low gas flows are important in vacuum metrology in applications such as calibration of vacuum gauges and quadrupole mass spectrometers by continuous expansion or throughput method, and calibration of vacuum reference leaks. One possibility to realize a gas flowmeter is a constant volume-variable pressure method. In this method a gas flow to be measured is introduced into a measurement chamber with known volume. Before flow measurement the chamber is continuously pumped until steady flow is established. Then the valve between the measurement chamber and the pump is closed and pressure starts to increase. If the flow and temperature of the chamber are constant, the gas pressure increases at a constant rate. Slope of pressure versus time is calculated by linear regression of measured data points using least squares method. Uncertainty of the calculated slope depends on the noise of data points and overall number of data points.

The spinning rotor gauge (SRG) and capacitance diaphragm gauge (CDG) are most suitable devices for rate of pressure rise measurement in a sealed chamber. Each type of gauge has different noise of measured values depending on integration time and measurement range.

Since the strict study of measurement uncertainty caused by the changing pressure is a very time consuming process, we have simulated the measurement conditions (integration time of gauge and number of measured points). Various flows were simulated where the white noise sequences were added to the simulated pressure values. Standard deviations of calculated slopes of simulated data give information on expected standard uncertainty of real measurement under equivalent measurement conditions. The results of simulation were validated by real measurements.

Keywords: measurement uncertainty, gas flow measurement, pressure measurement, spinning rotor gauge, capacitance diaphragm gauge, simulation.

The LHC vacuum system: operation, challenges and upgrades

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The Large Hadron Collider (LHC), currently under commissioning at CERN, is colliding intense proton beams, ~ 0.6 A per beam, at the world's highest energy frontier, up to ~14 TeV in the centre of mass. This 27 km circumference storage ring is at the origin of the discovery in 2012 of the so-called Higgs Boson explaining the mass generation mechanism of weak gauge bosons, W^+, W^- and Z also discovered at CERN in 1983. The 8 arcs of the ring consist of superconducting quadrupole and dipole magnets cooled with superfluid helium. The arc vacuum system is built with a 1.9 K cold bore into which is inserted a beam screen operating in the 5 to 20 K range. The beam screen provides pumping via slots perforations, intercepts the beam induced heat load and its co-laminated to P506 stainless steel Cu surface minimize the machine impedance. Beam collisions are performed inside Non-Evaporable-Getter (NEG) coated beam pipes located in long straight sections held at room temperature. These high tech vacuum systems were designed to guarantee vacuum stability under ion bombardment, to cope with intense VUV synchrotron radiation flux and to mitigate beam induced multipacting effects. In this paper, the LHC beam vacuum system key design aspects are recalled with emphasis on surface properties. The beam vacuum system operation, challenges and achieved performances are discussed in detail. The upgrades, consisting of an increase by one order of magnitude of the particle production rate, to be implemented during the next decade, are also introduced.

Towards ambient pressure in the micro- and nano-materials characterization by scanning photoemission imaging and spectromicroscopy

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Due to the short escape depth of electrons, less than a few nm, photoelectron spectroscopy is the best surface sensitive analytical techniques for probing surface and interface chemical composition and electronic properties. Nevertheless the standard approach to this technique suffers from two major limitations: spatial resolution, and the requirement for UHV conditions.

The Scanning PhotoEmission Microscope (SPEM) uses a direct approach to add the spatial resolution and characterize materials at the submicron scale i.e. the x-ray photon beam is down-sized to a submicron spot and the sample surface is mapped by scanning the sample with respect to the focused beam. With the SPEM hosted at the Escamicroscopy beamline (Elettra-Sincrotrone Trieste) the beam can be downsized, by using Zone Plates, to a diameter of 120nm which allows imaging resolution of less than 50nm. The overall energy resolution is better than 200meV.

Only recent electron energy analyzer with differentially pumped lens systems allow to perform in situ XPS up to few mBar (near ambient pressure). Nevertheless due to their cost, technical complexity and low

efficiency it was not possible to export such solution to photoemission spectromicroscopy so far. Results of innovative solutions developed for photoemission microscopes, based respectively on environmental cells with graphene or graphene oxide windows transparent to low-energy electrons[1], effusive cells where high- and low-pressure regions are separated by a small pinhole of 200µm diameter[2], and a dynamic controls of the amount of gas injected into the chamber toward the sample[3], will be presented and discussed.

[1] Kolmakov et al., *Nature Nanotechnology*, Vol. 6 (2011), 651
[2] Sezen H et al., *ChemCatChem*, Vol 7 – 22 (2015), 3665–3673
[3] Amati M et al., *Journal of Instrumentation*, Vol. 8 – 05 (2013), T05001

The new generation of the hemispherical energy analyzer in the novel surface science research

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The complexity and the range of materials and their surfaces studied will be expanded across a wide range of topics, including surface science, catalysis, corrosion, semiconductors research, photoelectrochemical energy conversion, battery technology, or energy-saving technologies. An unique and exceedingly flexible analysis cluster with a detection system is needed for these fundamental and applied research. Here it will be described a new energy and angle resolved analyser for photoelectron spectroscopy. The analyser has a hemisphere shape with a mean radius of 150 mm and is based on combining an advanced focusing electron lens system, which can be operated in different modes, transmission, spatial resolution or angular resolution. An angular resolution of better than 0.06° and spatial resolution 100 µm can be obtained. The spectrometer includes highly stable 6 kV power supply, where each independent voltage module achieves temperature stability below 0.5 ppm of the voltage span per degrees Celsius. The modern 2-D low noise CCD-MCP assembly with a noise level of < 0.01 cps/channel and a 70 fps fast camera are used. Fully automation and environmental software system make it a user-friendly tool for the conducted researches. The combination of the new generation hemispherical energy analyser with a modular PREVAC surface analysis system as part of multi-technique surface analysis systems will be presented, in order to permit complete characterization of the surface structure via XPS, UPS, ISS and APRES mapping. We will report the first results from this techniques, using analyser and induced by four interaction sources: X-ray, UV, electron or ion impact. Also the results of temperature dependent study on the metallic crystal will be presented. The application of the system will be shown on photovoltaic materials, graphene, or self-assembled organic monolayers of organic molecules. This analyser opens up new possibilities for angular/spatial resolved electron spectroscopy, band-mapping and other applications.

Topmost surface structures and oxygen reduction reaction activities for MBE-prepared $Pt/Pt_xNi_{1-x}(111)$ bimetallic surfaces

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Pt is the most active for oxygen reduction reaction (ORR) in monometallic catalyst. However, its slow kinetics limit widespread utilization of polymer electrolyte fuel cells and, therefore, Pt-based bimetallic alloy catalysts have been intensively studied. Because atomic alignments and compositions of alloy surfaces determine catalysis, filling gaps between the topmost atomic level surface structure and activity is essential for understanding the reaction mechanisms. In this study, ORR activity for molecular-beam-epitaxially(MBE)-grown Pt shell layers formed on $Pt_xNi_{1-x}(111)$ ordered single crystal substrate surfaces are evaluated.

Pt was deposited onto clean $Pt_{0.5}Ni_{0.5}(111)$ and $Pt_{0.25}N_{0.75}(111)$ substrates by an electron-beam evaporator and LEED, STM, XPS, LEISS analysis conducted in UHV. After the sample-transfer from UHV to electrochemical (EC) environment without air exposure, cyclic voltammetry (CV) and linear sweep voltammetry (LSV) were carried out in 0.1M $HClO_4$ by an EC apparatus set in a N_2-purged glove-box [1].

STM images for 2-monolayer(ML)-thick Pt on $Pt_{0.5}Ni_{0.5}(111)$ and $Pt_{0.25}Ni_{0.75}(111)$ substrates showed Moire-like height modulations of 0.05 – 0.08 nm, suggesting surface strains induced by underlying substrates (Fig. 1). The EC-STM image for the 2ML-$Pt/Pt_{0.25}Ni_{0.75}(111)$ showed that such height modulations partly remained in the N_2-purged solution. CV curves for the 2ML-$Pt/Pt_{0.5}Ni_{0.5}(111)$ and 2ML-$Pt/Pt_{0.25}Ni_{0.75}(111)$ surfaces showed that remarkable reductions of H_{ads}-related and OH_{ads}-related charges: the former and latter surfaces showed ×18 and ×25 higher activities than clean Pt(111). The results suggest that surface strains of the topmost Pt(111) lattice that induced by the mismatch between the underlying Pt–Ni(111) substrate contribute to the ORR activity enhancements for the Pt–M(111) bimetallic surfaces.

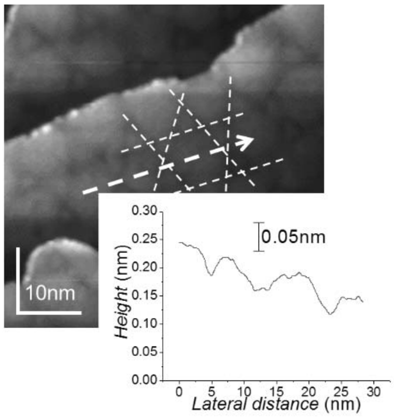

Fig. 1 Moire-like height modulations for the 2ML-$Pt/Pt_{0.25}Ni_{0.75}(111)$ observed by UHV-STM.

[1] T.Wadayama et al. Electrochem.Commun.12(2010)1112. N.Todoroki et al., PCCP,15 (2013)17771.

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Self-assembly of Ge quantum dots on periodically corrugated Si surfaces – a GISAXS analysis

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We demonstrate a simple method for the fabrication of ordered Ge quantum dots with highly tunable ordering parameters on rippled Si surfaces. The ordering is achieved by magnetron sputter deposition, followed by annealing in high vacuum. We show that the type of ordering and lattice vector parameters of the formed Ge quantum dot lattice are determined by the crystallographic properties of the ripples, i.e., by their shape and orientation [1]. Moreover, the ordering is achieved regardless of the initial amorphisation of the ripples surface and the presence of a thin oxide layer. Additionally, we apply GISAXS (grazing incidence small angle x-ray scattering) for the structural analysis of these surfaces. These results are important because the fabrication of regularly ordered Ge quantum dot arrays on Si surfaces usually required extensive preparation processing, ensuring clean and atomically ordered substrates, while the ordering parameters are quite limited by the surface properties of the substratecm margins.

[1] M. Buljan, S. Facsko, I. Delač Marion, V. Mikšić Trontl, M. Kralj, M. Jerčinović, C. Baehtz, A. Muecklich, V. Holý, N. Radić, and J. Grenzer, Appl. Phys. Lett. 107 (2015), 203101.

The influence of thermal annealing on structural, optical and electrical properties of ZnO thin films deposited by magnetron sputtering

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Zinc oxide is a material which is suitable for many applications due to the large band gap, (3.37 eV) high carrier mobility and the relatively high exciton binding energy (60 meV). The combination of high conductivity and transparency for visible light makes this material a possible candidate for front electrodes in thin film solar cells. For this purpose, it is important to have deposition method that is reproducible and can be easy up scaled.

Thin ZnO:Al films were deposited by magnetron sputtering on non-heated quartz substrate. As deposited

samples have nano-crystalline structure, high transparency in visible part of spectrum but relatively low conductivity. After deposition, films were isochronal annealed by one hour in hydrogen atmosphere at 200, 300 and 400 °C. The influence of such treatment on structural properties was analyzed by GISAXS and GIWAXS and correlated with uv-vis transmittance, luminescence and conductivity.
Structural investigation demonstrated that heat treatment reduces the stress in the material, the volume of the crystal lattice decreases and the crystal size grows. By measuring the optical properties, it was shown that heating increases the optical gap and gradually reduces point defects, mostly related to interstitial atoms. As result of this process, the room temperature conductivity increased for more than 7 orders of magnitude.
The increase in conductivity was found as a result of enhancement of mobility and concentration of free carriers. The mobility increase due to passivisation of defects at the grain boundaries and due to reducing the number of defects in bulk of material. The activation energy for defect annihilation was estimated to be 1 eV and corresponds to the diffusion of interstitial atoms with the annihilation of vacancies. The concentration of free carriers increase as result of the activation of the dopands that act as shallow donors.

INVITED

Pulsed laser deposition of transparent conductive oxides based on ZnO

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Pulsed laser deposition (PLD) is a vacuum technique which is widely used in thin films growth. High versatility regarding to composition of deposited materials is the most distinctive feature of PLD technique. The main drawback – restricted deposited area and low growth rate is the main factor of its relatively rare occurrence in industrial use. On the other hand, simple principle and ability to vary process parameters in wide ranges make PLD the perfect tool for laboratory research. The contribution deals with transparent conductive oxides based on ZnO which were prepared by PLD and there are compared their different properties in the scope of applied ablating lasers: (1) a solid state Nd:YAG laser working at third harmonic generation (wavelength 355 nm, 15 ns pulse length and 10 Hz pulsing frequency) and (2) an excimer laser working with KrF gas composition (248 nm, 20 ns and 10 Hz). Moreover influence of different doping elements, aluminum and gallium respectively, are analyzed.. These elements are considered as the most promising dopants for reliable controlling of electrical properties of ZnO based films. Experimental results compares influence of applied elements (Al, Ga), different levels of their concentration and deposition parameters (substrate temperature, ambient pressure, etc.) on electrical properties (resistivity, carrier concentration, carrier mobility) ZnO based films. Furthermore, there is investigated optical properties (transmittances, energy band-gap shift, photoluminescence, etc). The results showed that small amount (~ 1% wt. content) of Al (or Ga respectively) substantially improved carrier concentration with adequate decreasing the resisitivity. Moreover, higher photoluminescence response of doped films points to decreasing level of structural defects for doped films. The results showed that there is a complex dependence among chemical composition, growth conditions and final properties of the ZnO doped films which can be effectively controlled by using of PLD.

Activation temperature and surface metallisation of 2 alternative quaternary Non Evaporable Getter alloys

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Thin film Non Evaporable getter (NEG) has been used in particle accelerators around the globe for the past 15 years due to its unique combined properties of evenly distributed pumping speed, very low thermal outgassing, low electron and photon induced desorption and low photon and secondary electron yields. The ternary alloys NEG (TiVZr) which has been used extensively in particle accelerators has an activation temperature of 180 ◦C while the quaternary alloy NEG (TiVZrHf) introduced by ASTeC has an activation temperature of 150 ◦C due to its even smaller grain size as compared to ternary alloy. In this study we will report on the activation temperature and surface metallisation of new alternative quaternary alloy such as TiZrAlV and TiZrHfAl. The bulk composition of the film is determined with Rutherford back scattering (RBS) and the surface composition and chemical bonding are determined by X-ray photo-electron spectroscopy XPS. The surface topography is determined with scanning electron microscope (SEM), scanning tunnelling microscope (STM) and the film grain size is calculated by X-ray diffraction (XRD) and electron back scattered diffraction (EBSD).

INVITED

Managing low energy electrons (LEE): emission from solids, analytical probes, generation (or -avoidance!) for technological applications

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Low energy electrons (LEE) near solid surfaces are of paramount importance for many fields in modern science and technology. comprising (1) the paradigmatic example of various (very diverse) electron microscopy techniques, (2) plasma-wall interaction in fusion reactors, (3) operational stability of charged particle storage rings, such as the large hadron collider (LHC), (4) components for particle detection and gaseous electronics, (5) (nano-particle enhanced) radiotherapy, (6) interaction of ionising radiation with biological tissue and (7) EUV-lithography. The generation of secondary electrons (SE) can either be desirable (examples 1,4 and 5) or has negative or even prohibitive implications for the considered phenomena (examples 3,6, and 7).

In all cases (including example 2), the understanding concerning the fundamental processes leading to generation of secondary electrons (SE), is a prerequisite for controlling LEEs. State of the art models for SE generation and emission are still unable to predict the SE-yield with the desired accuracy and numerical guidance is predominantly provided by empirical data.

The EU-funded Marie-Curie Initial Training Network SIMDALEE2 (Sources, Interaction with Matter, Detection and Analysis of Low Energy Electrons[1]) was established to deepen the understanding of the interaction of LEEs with solid surfaces and to develop related key technologies. The devised strategy to accomplish these goals will be outlined and essential techniques and applications will be highlighted, including: very low energy electron microscopy, near-field secondary electron microscopy, 3-D field emission theory, electron holography, Coincidence techniques to correlate electron energy losses with SE-emission and, finally, suppression of multipacting in the LHC.

[1] www.simdalee2.net, Marie Curie Initial Training Network (ITN) Grant number 606988 under FP7-PEOPLE-2013-ITN

Electron irradiation induced SiO_2 growth at Al_2O_3/Si interface

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It has been known for a long time that either electron or X ray beams might cause changes of the irradiated surface. This is annoying for surface sensitive analyses but can be utilized for various purposes. E.g. low energy electron irradiation is used for analytical purposes (electron-stimulated desorption) and to accelerate chemical reaction on the surface. To our best knowledge low energy electron irradiation induced layer growth has not been observed; in this communication we report the later. Electron irradiation with energy and current density in the range of 2–5 keV and 10^{-2} A/cm^2 was applied on 5 nm Al oxide / substrate systems made by ALD and RF sputtering. Using such irradiation parameters the heating of the sample due to the irradiation could be neglected. The electron irradiation, typical total doses of about 10^{21} electrons*cm^{-2}, took place at various (30°C–800°C) sample temperatures. After the irradiation AES depth profiling was applied to determine the structure of the sample. The irradiation induced changes strongly depended from the sample temperature. In case of irradiation at 500°C the Al_2O_3 was partially reduced; the system lost oxygen, and mixture of metallic Al, Si and Al_2O_3 has formed. This process will be explained by irradiation induced bond breaking and subsequent oxygen diffusion and desorption. At room temperature irradiation no oxygen loss has been observed. Rather SiO_2 formation has been detected, that is, formally Si reduced the Al_2O_3. The SiO_2 layer had nucleated at the interface and grown partially into the Al oxide layer. The kinetics of this process will be explained by irradiation induced bond breaking and field assisted diffusion. The compound formation at ambient temperature, however, will be explained by electron bombardment induced excited states. Part of the work was supported by the Hungarian Grant NKFI – NF 101329.

Quantitative depth profiling of $Si_{1-x}Ge_x$ structures by TOF-SIMS and SNMS techniques

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An unceasing progress in Si-Ge technology stimulates interest in quantification of $Si_{1-x}Ge_x$ structures by different analytical techniques. In our study, quantification was carried out by TOF-SIMS and electron-gas SNMS. For calibration, the peak intensity ratios of $GeCs_2^+/SiCs_2^+$ and $^{74}Ge^-/^{30}Si^-$ secondary ions and post-ionized $^{70}Ge^+/^{28}Si^+$ sputtered neutrals were employed. A good linear correlation ($R^2>0.9997$) of these dependencies with Ge content for the x-value ranged from 0.092 to 0.78 was revealed for both techniques. That confirms the validity of the constant yield ratio assumption in $Si_{1-x}Ge_x$ structures, especially for TOF-SIMS measurements.

The calibration data were used for quantitative depth profiling of $10\cdot$(12.3 nm $Si_{0.63}Ge_{0.37}$/34 nm Si) structures grown on Si (001) substrate. In case of TOF-SIMS, the degradation of the profiles with depth of sputtering was not observed. The FWHM of the first SiGe layer was found of 10.8 nm, and the maximal Ge content in this layer was estimated ca. 40 at. %. On the contrary, an evident degradation of the SNMS profile towards deeper layers was observed due to the influence of crater geometry and inherent surface roughening by plasma erosion. The FWHM of the first SiGe layer was 15 nm, and the maximal Ge content was estimated ca. 25 at. %.

The reconstruction of sputter depth profiles of $10\cdot$(12.3 nm $Si_{0.63}Ge_{0.37}$/34 nm Si) structures was performed using the Hofmann's MRI depth model in stationary and nonstationary modes for TOF-SIMS and SNMS, respectively. A good fitting of both experimental profiles was obtained using the same test model of Ge in-depth distribution and, for SNMS experiments, with proper accounting of the developing roughness. However, in case of TOF-SIMS, the quality of the reconstruction was better than for SNMS since not only the progressing roughening, but also crater effect and other processes unaccounted in the MRI simulation could have significant impact on plasma sputter depth profiling.

Grain boundaries phase transition in respect of transport phenomena

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The description of the kinetics regularities controlled by diffusion requires fundamental understanding of the phenomena which define the mechanism of mass transfer. In the author early works [1, 2] the phenomena of the melting point difference between a bulk and an interfacial boundaries were described by the methods of thermodynamics. The phenomenology description of the grain boundary diffusion mechanism in solids have was done on the base on these results. In this case the changes on the surface defects amount are providing the interfacial tension and the temperature of grain boundaries transition in quasi-liquid state changes. On these conditions the mass transfer occurs no only as molecular diffusion in liquids, but it maybe of way of convection or filtration. The kinetics regularity description has been done in terms of dispersion theory for stationary regime by using solution of equation: $dC/dt = D^*d^2c/dx^2 - w.dc/dx - a(c)$. Here dispersion coefficient $D^* = R^2/D_m$, where R-the grain boundary size, D_m molecular diffusion coefficient, w – make in account the filtration and a (c) the chemical interaction. For mathematical description the data of Cu diffusion from liquid Cu on the surface of solid Nb -Zr alloys was used. The fact of dispersion in solid metals are providing by ultra-sound influence on the length of Cu penetration. The experimental data was obtained by sessile drop technique with fixing the map of mass transfer using the electron scanner JSM-25S, X-ray analyzer JXA and Comebax. The experimental data confirm the results of theoretical analysis.

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Vacuum and material science challenges for future circular colliders

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To allow particle physicists to work at the highest energy frontier even after the LHC era, a worldwide effort is ongoing to study future accelerators to best meet such new ambitious objectives. It is essential to study the feasibility and the technological challenges of proton-proton and electron-positron Future Circular Collider (FCC) with a circumference of as 80 up to 100 Km.

In this framework, the foreseen high beam current and ultra-small high energy beam size require extremely high pumping speed in reduced beam pipe opening and in presence of extremely high heat loads and Synchrotron Radiation (SR) emission [1]. Moreover, FCC working with positively charged beams may suffer from unconventional interaction between beam and Vacuum components [1-3], and the chosen vacuum system has to cope with a number of standard and exceptional constrains imposed by the desired operating conditions. One very relevant one is the low cryogenic temperature at which dipole magnets needs to operate.

Such vacuum and material science issues have been pinned down as essential topics to be studied in the preparatory R&D phase, and a common effort is underway to address such scientific issues of high interest and potentialities.

In this contribution we will briefly present the framework of this research, reporting on some of the most challenging and interesting aspects of such ongoing research.

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Vacuum design of Drift Tube Linac for the European Spallation Source

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The European Spallation Source (ESS) is a multi-disciplinary research center based on the world's most powerful neutron source being built in Lund, Sweden. This new facility will be up to 100 times brighter than today's leading facilities, enabling new opportunities for researchers in the fields of life sciences, energy, environmental technology, cultural heritage and fundamental physics. The facility design and construction includes the most powerful linear proton accelerator ever built, a 4-tonne, helium-cooled tungsten target wheel, 22 state-of-the-art neutron instruments, a suite of laboratories, and a supercomputing data management and software development center.

This work is focused on the design of the vacuum system for one of the accelerator element, the Drift Tube Linac (DTL). The DTL design and manufacturing is under the responsibility of the INFN in Legnaro (Italy) [1], [2], [3] while ESS is responsible of the interfaces of the DTL with other modules (MEBT and LEDP) and the accelerator subsystems. In particular the following topics, related to the vacuum system design, will be treated in this work:

- General design strategy in terms of vacuum requirements, selection of vacuum components, instruments and materials
- Cleaning procedures and results of outgassing tests of particular components required in the design
- MolFlow vacuum simulations with the implementation of outgassing and water permeability data and the interaction of the DTL vacuum with that of adjacent modules
- Effect of RF power on vacuum equipment (pumps and gauges)

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The ESS vacuum control system

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The European Spallation Source (ESS) is a high current proton LINAC to be built in Lund, Sweden. The LINAC will deliver 5 MW of power to the target at 2000 MeV, with a nominal current of 64 mA. Ground break took place in September 2014 and the construction of the accelerator tunnel and adjacent buildings progresses rapidly.

Although the different LINAC sections will be in-kind contributions from the several member countries, the accelerator vacuum control system and the machine protection system, will be mainly designed and build in-house which requires a tight collaboration between the Integrated Control System Division (ICS) and the Vacuum Team of the Accelerator Division (AD) of ESS.
The Vacuum control system is based on PLC (Programmable Logic Controller) technology and EPICS (Experimental Physics and Industrial Control System) architecture. Each accelerator section has one or more PLCs to control the different valves and pumps by acting on configurable interlock outputs from the gauge- and pump-controllers through a pre defined voting scheme. EPICS IOC (Input and Output Controller) will be used as the interface between the operator screen and the vacuum controllers. Besides local interlocks for vacuum, machine protection interlocks shall be integrated in the control system for the protection of the LINAC. This integration will provide beam permission to the beam interlock system when all nominal conditions for beam vacuum are met.
A set of control and machine protection functions will define the vacuum controls system architecture and implementation. This contribution will discuss the design of the ESS proton LINAC vacuum control system, strictly complying with all identified control and protection functions.

INVITED

ASDEX Upgrade: vacuum systems at a midsize tokamak experiment

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Tokamaks devices as ASDEX Upgrade (AUG) are the most developed concept in fusion research. Although operation started already in 1991, AUG is still one of the world leading fusion experiments, thanks to continuous upgrades and renewal of components. The versatile plasma heating system of up to 20 MW neutral beam power, 6 MW ion cyclotron and 4 MW of electron cyclotron heating offers the possibility to study future reactor relevant plasma conditions. Typical plasma parameters are currents of 1 MA, magnetic fields of 2.5 T, temperatures up to 10 keV and plasma duration of up to 10 s. Good vacuum and wall conditioning are essential to reach the plasma performance required.
AUG consists out of a toroidal SS vessel with a volume of 45 m^3 pumped by 11 turbo molecular pumps (Pfeiffer TPU 2301) and a vessel LHe cryo pump to the 1×10^{-8} mbar range. The plasma facing components (PFCs) consist out of bulk tungsten tiles at the outer divertor and tungsten coated fine grain graphite tiles elsewhere. The PFCs are weakly cooled by water. After a discussion of the conditioning procedure the new glow anode system, used for wall cleaning and coating will be described. For plasma operation in total 19 piezo valves with feed-back flow control are installed at different positions of the vessel. To enable change of the gas in between discharges they are fed by a gas matrix, which connects the individual valves to different gas species or pumps. A control system manages 40 gate valves, which connect different devices, needed for measurements of plasma properties or heating, to AUG. Finally the monitoring system, which allows determining the status of the conditioning will be presented. To obtain reliable data during and in between plasma discharges a set of gauges (hot cathode and capacitative) and quadrupole analyzers (partly pumped and magnetically shielded) are used.

INVITED

Study of plasma-wall interaction in fusion devices by residual gas analysis

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**See the Appendix of F. Romanelli et al., Proceedings of the 25th IAEA Fusion Energy Conference 2014, Saint Petersburg, Russia
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The most promising way to commercial exploitation of fusion energy is thermonuclear fusion by magnetic confinement, where the burning fuel is contained by magnetic fields in a toroid-shaped vessel. Despite the magnetic confinement, a certain amount of plasma-wall interaction (PWI) is unavoidable. While PWI is necessary for the removal of fusion burn products from the plasma, the impact of energetic ions on the surfaces of plasma facing components (PFCs) causes erosion of the PFCs and increases the presence of impurities in the plasma. This is linked to plasma dilution, increased energy loss through radiation and promotion of sputtering of PFCs by heavier ions.

However, impurities (noble gases and N_2) may also be deliberately introduced (seeded) into the plasma to promote radiation in the plasma edge and thereby lessen the heat load of the PFCs. The seeded impurities are implanted in the PFCs and released by subsequent plasma exposure. In the case of N_2 seeding, N_2 is also converted into ammonia (NH_3), which poses a safety and operational issue for fusion devices operating with a tritium-containing fuel mixture. Impurities which form volatile molecules can be detected by residual gas analysers (RGAs). Thus, RGA studies of impurities can provide insight into PWI and overall machine conditions.

The impurity content has been studied by RGAs in the exhaust of ASDEX-Upgrade and JET. While the most abundant impurities in the post-discharge phase are N_2 and water, the impurity content in the discharge-phase of non-seeded discharges is dominated by methane, most likely produced in the erosion of carbon surface contaminants by hydrogen species. In impurity-seeded discharges, the seeded impurity dominates the impurity content. A legacy effect, linked to the implantation of the impurities in the first wall, is observed in the subsequent non-seeded discharges. With N_2 seeding, ammonia production is also observed. The amount of ammonia increases with the amount of seeded N_2, however the ammonia content also exhibits a gradual build-up and a strong legacy effect. In D_2 plasmas, the isotope ratio in methane is very close to that of the plasma, while water and especially ammonia have significantly higher H/(H+D) ratios, indicating that the local atmosphere of RGAs can impact the detected impurities. In H_2 plasmas, all of the three impurity species appear fully protonated.

Diagnostics of atmospheric pressure plasma jets during treatment of various samples

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We report on reciprocal influence between the atmospheric pressure plasma jet (APPJ) and sample surface which is a common situation in various plasma applications. This relationship is often disregarded. We implemented optical emission spectroscopy (OES), absorption pulsed cavity ring-down spectroscopy (CRDS) and electromagnetic (EM) characterization of atmospheric plasma needle jet. Characterization was performed during treatment of various samples versus distance to the sample. We have shown that sample material and its distance from the tip of the electrode have a pronounced influence on electromagnetic and optical characteristics of atmospheric pressure plasma jet, such as jet length, shape, color, voltage, current, power, electromagnetic field and concentrations of plasma species. Special attention is given to the metastable He($^3S_1$) atoms which play an important role in atmospheric pressure plasma jet chemistry processes both at surfaces and inside the plasma. The maximum measured density in a spatially-resolved density distribution of a free jet (without sample), at a flow of 2 slm, was around 7×10^{11} cm^{-3}, while the sample insertion increased the densities by up to 10 times. Eight different samples of the same sizes but different electrical conductivities were used to investigate the influence of a sample material on the He metastable densities. The correlation between sample conductivities and metastable He densities above the sample surface was found. Metastable He density can also be further increased by decreasing sample distance, increasing conductive sample surface area and by increasing He flow. Further studies with the aim of real-time monitoring to control APPJ surface treatments will be discussed.

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NEG coating deposition and characterisation for narrow-gap insertion devices and small-diameter chambers of light sources and particle accelerators

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Since their introduction, sputtered non-evaporable getter (NEG) coatings have been extensively adopted in several light sources and particle accelerators working in the ultra-high vacuum (UHV) regime.
Besides providing a very effective and distributed pumping for all the getterable gas species, the use of a NEG coating leads to a significant reduction of the thermal outgassing along a beam pipe, as well as

of its secondary electron yield.

As the current trends in the high-energy physics community seek the design of increasingly compact machines—driven by both scientific and technical reasons—NEG coatings are nowadays becoming more and more essential: small-aperture beam pipes (<10 mm) and long and narrow tubes cannot be efficiently pumped by traditional UHV lump pumps due to conductance reasons and they should therefore necessarily rely on the adoption of distributed NEG coatings. Beam pipes having an inner diameter down to 4 mm are envisaged for the next-generation machines, aiming in general at even lower emittances and higher luminosities.

These severe geometry constraints push the NEG coating technology to its limits and pose a number of issues in terms of process limitations and performance assessment of the NEG coating itself.

SAES' expertise on NEG coating of narrow-gap insertion devices has steadily grown over the past ten years; a review of both current R&D activities and future perspectives in this field is proposed, together with an overview of the analytical techniques employed for the characterisation of the deposited layer on small-diameter chambers. These include SEM morphological inspections, chemical composition analyses and thickness profiling made by EDX and measurements of the getter film's sorption capacity for CO.

Generation of UHV with high compression turbo pump

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To generate UHV pressures (< E7- hPa) there are different options. In order to find the best pump solution it has to be taken into account that the majority of the gas composition at UHV is Hydrogen. Hydrogen being a light gas needs a high pumping speed e.g. compression ratio to generate UHV. In very many cases one needs up to 3 different pump types to reach such low pressures.

Looking at nowadays possibilities with modern turbo pumps, generation of UHV can be simplified. With standard turbo pumps it has be considered that such a device has a gas type depending pump characteristic. It will be shown that optimization in the rotor design will improve the compression ratio for Hydrogen of a turbo pump, which makes it possible to generate UHV with relatively simple backing pumps.

Modelling of vacuum conditions for designing vacuum systems of heavy ion accelerators

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The main parameters of vacuum systems for accelerator complexes are determined by means of computer programs GENAP and VACLOS. They have been developed and tested on the basis of experiments in four heavy ion cyclotrons of the FLNR. The modelling programs have been used for design of the vacuum systems for newly created cyclotron complexes: for the DC-72 cyclotron complex of the Slovak Republic, for the DC-60 cyclotron complex of the Republic of Kazakhstan, for the DC-110 cyclotron complex of the Dubna Centre of Nano and Nuclear Technology and for many others. The DC-280 heavy ion cyclotron complex is created at the FLNR, JINR. It is intended to accelerate the wide range of ion beams with ion mass 10÷238, ion mass to charge ratio 4 – 7, energy 4 – 8 MeV/nucleon and intensity up to 10 pmcA. It will be launched in 2017. The modelling programs estimate ion beam losses based on the numerical simulation of pressure distribution in vacuum chambers practically of any arbitrary geometry as well as on calculation of cross sections for a recharge of ions during acceleration in exchange reactions by electrons with molecules of the residual gas. The results of simulation researches have the good accordance both to experimentally measured pressure distributions and to transmission efficiencies of accelerated ions.

INVITED

Challenges in the development of the vacuum system of the heavy ion synchrotron SIS100 at FAIR

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With the international accelerator complex FAIR currently being constructed in Darmstadt, Germany, a highly innovative and sophisticated large-scale accelerator facility of the next generation is scheduled to be commissioned in 2022. The facility will provide heavy ion beams of highest brilliance, intensity, and energy for basic research and applied sciences as well. The main machine of the complex will be the heavy ion synchrotron, SIS100, having a hexagonal-shaped lattice structure and a circumferential length of about 1.1 km. About 80% of entire beam vacuum system will be operated at cryogenic temperatures; only 20% are designed as bakeable room temperature vacuum sections. Within the framework of the vacuum system development, an intensive R&D program was conducted to optimize the system layout and the pumping concept according to the high demands on vacuum quality for beam operation. One of the major problems in heavy ion accelerators such as SIS100 are dynamic vacuum instabilities which are mainly driven by ion-induced desorption effects, whose skilful suppression is one of the most challenging and difficult ventures. To overcome this problem, a unique and elaborated ion catcher system used for the controlled collection of charge-exchanged ions at well-defined ring positions was developed and successfully tested. Its implementation into the ion optical lattice of SIS100 will be of fundamental importance for ensuring stable vacuum conditions during machine operation.

The talk presents some sophisticated solutions for vacuum-related problems in SIS100 and provides results on studies carried out during the development stage, such as adsorption isotherms for hydrogen on stainless steel in a temperature range between 7...20K and long-term dynamic gas density profile calculations in non-isothermal vacuum systems using a newly developed simulation code based on said adsorption isotherms. Furthermore, details on the pumping performance of a compact cryosorption pump, which was developed especially for SIS100 beam vacuum, and a field emitter-based extractor gauge, applicable in cryogenic UHV/XHV environments, will be discussed briefly.

Aluminium CF components for UHV applications

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The requirement of high quality vacuum components for ultra high vacuum (UHV) has become stronger over the last years, especially driven by research institutions and accelerator facilities. For these applications stainless steel has been and still is the most commonly used raw material. The challenge of suppressing hydrogen outgassing from the bulk material has extensively been discussed in the past resulting in some well-established methods as well as new approaches to achieve extremely low hydrogen outgassing rates needed for UHV applications. Some approaches seem to be promising, but at the same time they are quite expensive and economically hardly viable. As an alternative to stainless steel, aluminium is regarded as a promising raw material due to some fundamental advantages, even though metal sealed CF components and chambers made from aluminium are hardly available and rarely used.

The present talk focusses on metal-sealed CF vacuum components and chambers made from aluminium. In this context, adequate knife edge stability, complicated weldability and reliable outgassing properties have always been discussed as major challenges. Supported by numerous results from extensive experimental testing (with dedicated focus to long-term knife edge stability and outgassing properties of in-situ baked components) it will be shown that these challenges have been solved lately and that Aluminium CF components and chambers are today a serious alternative to the established components made from stainless steel.

Surface control of colloidal silica beads in hybrid bottom up/top-down nanopatterning

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The production of large-area nanopatterned surfaces is a generalized challenge for the application of advanced materials. When considering a nanopatterning process, control of feature parameters is faced to production cost/efficiency optimization. High control of the nanostructure shape and distribution are obtained by electron and ion lithographies, but self-assembly leads to considerably higher efficiency. Silica colloids stand as extremely attractive structures for their self-assembly and ulterior use as colloidal masks. In particular, they offer higher resistance to Ar/O2 plasma treatments than their organic (mainly polystyrene) counterparts, allowing the production of higher aspect ratio motives. The formation of colloidal silica monolayers through the Langmuir-Blodgett technique is challenging in view of the density and hydrophilic character of silica, which prevent buoyancy in the subphase.

In this work we have carried out a two-step surface modification process of monodisperse colloidal silica (1 µm diameter). In the first step the colloidal silica is etched in HF at different concentrations to produce colloidal silica of different diameter. In the second step, the activated surfaces are silanized with perfluoro-octyl-triethoxysilane (PFOS) to induce a hydrophobic transition. The outcome of this process was characterized by solid state NMR. The resulting colloidal suspensions have been studied for the formation of colloidal monolayers after optimization of the spreading solvent. The obtained monolayers were characterized by SEM and XPS showing compact hexagonal arrangements with clear PFOS traces. Plasma etching processes have been applied to transfer the colloidal mask structures to inorganic/organic substrates, which opens their application to optical and biomedical devices.

Closely packed Ge quantum dots in ITO matrix: influence of Ge crystallization on optical and electrical properties

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Simple methods for fabrication of semiconductor quantum dots in transparent oxide matrices play an important role in various nanotechnology applications. Here we present a method for the low-temperature production of the material consisting of closely packed Ge QDs embedded in ITO matrix. The films are produced by magnetron sputter deposition followed by thermal annealing. The dependencies of the films conductivity and their optical properties on the structure, Ge content in the ITO matrix and the annealing conditions are demonstrated. The conductivity of the films changes up to seven orders

of magnitude in dependence on the annealing conditions, i.e. on the films structural properties. The films optical properties are also strongly affected by the preparation and annealing conditions, so both conductivity and optical properties can be controllably manipulated. In addition, the crystallization of Ge is found to occur already at 300 °C, what is significantly lower than the crystallization temperature of Ge produced by the same method in silica and alumina matrices.

Si_3N_4/graphene nanocomposites for tribological application in aqueous environments prepared by attritor milling and hot pressing

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Advanced ceramic materials have proved their superior wear resistance as well as mechanical and chemical properties in a wide range of industrial applications. Today there are standard materials for components and tools that are exposed to severe tribological, thermal or corrosive conditions. The main aim of this work is to develop novel, highly efficient tribological systems on the basis of ceramic/graphene nanocomposites as well as to prove their superior quality and to demonstrate their suitability for technical applications e.g. for slide bearings and face seals in aqueous media. Current research in the field of ceramic nanocomposites shows that is possible to make ceramic materials with improved mechanical and tribological properties by incorporating graphene into the Si_3N_4 structure.

Multilayered graphene (MLG) was prepared by attritor milling at 10 hours intensive milling of few micrometer sized graphite powders. The large quantity, very cheap and quick preparation process are a main strengths of our MLG. Si_3N_4 / MLG nanocomposites were prepared by attritor milling and sintered by hot pressing (HP). The Si_3N_4 ceramics were produced with 1wt%, 3wt%, 5wt% and 10wt% content of MLG. Their structure was examined by Transmission electron microscopy (TEM). The tribological behavior of composites in different environments was investigated and showed the decreasing character of wear at increased MLG content. This new approach is very promising, since ceramic microstructures can be designed, that are electrically conductive, possess high toughness and provide improved wear resistance at low friction. Furthermore, electrical conductivity can be utilized for monitoring and electrochemical protection devices.

Magnetron sputtered Ti as a substrate for TiO_2 nanotube array preparation by anodization

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Large effective surface area and superior electron transport properties are required characteristics for photoanode material in dye sensitised and perovskite solar cells. Nanostructured TiO2 thin films with various shape forms (porous layer, nanoparticles, nanorods, nanotubes) are widely used for that purpose. In this work, we will examine vertically aligned TiO_2 nanotube array thin films as possible photoanode material. TiO_2 nanotube arrays usually are prepared by anodization of titanium metal foil. TiO_2 nanotube arrays structural properties (nanotube diameter, wall thickness) are influenced by anodization parameters (applied voltage, Flour ions concentration in the electrolyte) and surface morphology of starting Ti layer. Instead of thick Ti foil, in this work Ti thin films prepared by DC magnetron sputtering will be used as a substrate for anodization process. SnO and ZnO coated glass will be used as a substrate for magnetron sputtering. Ar working gas pressure and substrate temperature will be varied in order to obtain Ti thin films with different surface morphology.

It will be presented and discussed structural properties of starting Ti thin films and TiO_2 nanotubes arrays be examined by using simultaneous small and wide angle X-ray scattering under grazing incidence geometry, X-ray reflectivity, scanning electron microscopy and Raman spectroscopy.

Monitoring swift heavy ion damage kinetics using in situ RBS/c

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The passage of a swift heavy ion ($m > 20$ amu, $E > 1$ MeV/amu) through a solid material can result in permanent damage along the ion's trajectory that is commonly called an ion track. Origin of this nanoscale damage is due to ultrafast heating of the material by the incoming ion, and its subsequent rapid cooling. Thermal spike models describing this process predict ion track formation only when attained temperature on the position of ion impact surpasses melting point. In that case, amorphous phase is formed upon rapid quenching of the melt, and nanoscale amorphous inclusion can be found later as evidence of ion impact.

In the present contribution we investigate ion tracks in quartz and fluorite using *in situ* Rutherford backscattering spectrometry in channeling (RBS/c). This novel approach enables detailed monitoring of damage build up within the material during swift heavy ion irradiation. This is in particular of interest close to the ion track formation threshold, when damage kinetics can provide additional information about ion track morphology [1].

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Ion tracks in pyrochlores

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Contemporary investigations of swift heavy ion irradiated A2B2O7 pyrochlores are driven by the interest in their use for the immobilisation of nuclear waste [1,2]. Employed techniques (X-ray diffraction, transmission electron microscopy, Raman spectroscopy) provide detailed insight into pyrochlore response to fission-fragment like radiation. Here we describe present status in this field and compare experimental results on ion track size and structure against theoretical predictions.

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How X-ray photoelectron spectroscopy contributes to the development of organic electronics

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Electronics based on organic molecules have attracted great interest both from research and industry due to their versatility from which a manifold of possible applications might emerge. Specifically, monolayers of large molecules that self-assemble on substrate surfaces (self-assembled monolayers/SAM) have been shown to be of use in a wide range of applications like organic photovoltaics [1], thin-film transistors [2] and non-volatile memories [3].

However for the development of SAM-field effect transistor (SAMFET) several open questions need to be answered. The coverage of the surface area as well as the alignment of the molecules are crucial parameters in the fabrication of such devices, which can only be precisely assessed using surface sensitive techniques like X-ray photoemission spectroscopy (XPS) and atomic force microscopy (AFM).

In this contribution we show how XPS can aid the improvement of novel organic FETs which should be able to work as highly effective gas sensing devices by using known SAMFET structures as templates. Long linear molecule structures are anchored by reactive groups to HfO_2/Si substrates. The building process of these molecules has been followed step-by step by angle-resolved XPS.

We are able to evidence an "upright" alignment of the molecules in the SAM by XPS which is additionally confirmed by AFM measurements. Furthermore, the study deals with the question how electronic properties vary due to differences in coverage of the HfO_2 surface with organic molecules. Concomitantly, we aim to establish a parameter for a critical surface coverage which is crucial to achieve a working FET device.

We thereby demonstrate how these analytical methods can aid the development of future electronic devices based on organic materials.

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Study of graphene formation by benzene and p-terphenyl at various temperatures

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It had been investigated that graphene growth on a stepped Ir(332) surface by chemical vapour deposition (CVD) of ethylene causes surface restructuring (step bunching) of the Ir(332) surface, making it difficult to infer the effects of periodic deformation on structural and electronic properties of graphene. The objective of this experiment is to lower the temperature needed for graphene growth by studying various deposition methods of p-terphenyl and benzene on a Ir(111) surface. Here, we report our findings at various temperatures and deposition pressures via LEED (low energy electron diffraction) and STM (scan tunnelling microscopy).

On the roll of adsorbed formate in the oxidation of C_1 surface species on clean and modified Pd surfaces

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The formation of adsorbed HCOO was confirmed during several catalytic reaction conditions. High concentration of surface HCOO species were easily formed by the decomposition of formic acid so its chemical and physical properties has been widely studied on transition metal surfaces. While on the group VIII and Ib metals HCOO was produced by this way, the lack of HCOO formation on clean Pd(100) was the only exception [1]. The HCOOH/Pd(100) adsorbed layer readily decomposed to CO and H_2 but no HCOO was found by UPS. The presence of formate was also discussed in the oxidation

of surface CH_2 groups [2]. Pre adsorbates, such as K have a dramatic effect on the formation, thermal stability and decomposition pathways. The stability is increased to 400-480K and the CO/CO_2 ratio increased from 0.5 to 3 at θ_K=0.2 and 0.5, respectively.
We also investigated the adsorption HCOOH as well as H_2CO on $O_{(a)}$ precovered surfaces. The bands at 4.2, 7.9-8.7, 10.9, 13.4 eV in UPS are due to formate. Its, stability is 300 K for the $O_{(a)}$+$HCOOH_{(a)}$ reaction and for $O_{(a)}$ +$H_2O_{(a)}$ 230-240 K. The products were CO_2 and H_2O, which desorbed with a coincidence peak temperature at 310K. We can conclude that more adsorbed oxygen is necessary for the formation HCOO from H_2CO which is reflected in the lower stability. The various surface chemical transformations: i.) HCOOH on clean, ii.) HCOOH+O, iii.) H_2CO+O, iv.) CH_2+O as well as the dramatic effects of modifiers (O, K, I) will be discussed in details.

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Tungsten oxide one-dimensional nanostructures

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Tungsten oxide is a reducible oxide and it serves as an important material in the fields of heterogeneous catalysis and gas sensing. Particularly one-dimensional nanostructures with high surface to volume ratio can have unique physicochemical properties compared to their bulk counterparts. However the real systems are not suitable for fundamental research due to their complex structure. Thin epitaxial layer of the tungsten oxide supported on metal can serve as a substrate for model studies although an ability to prepare such a system in-situ under UHV conditions is quite rare. We present a preparation method of highly ordered tungsten oxide thin film onto Cu (110) single crystal substrate using physical vapor deposition in reactive atmosphere of atomic oxygen. Owing to oxygen induced reconstruction of the copper substrate it gives rise to unique self-organised one-dimensional structures of tungsten oxide parallel with Cu [1-10] crystallographic direction. Electron diffraction methods (RHEED, LEED) and STM were used for investigation of the system's structure and morphology. Chemical properties were studied by the means of photoelectron spectroscopy (XPS, ARPES). This highly anisotropic system exhibits momentum dependent modulation of the valence band electron structure shown by ARPES measurement and our experimental observations were supported by the results of DFT calculations. Unusual character of the one-dimensional oxide structures can lead off to new applications in the field of heterogeneous catalysis and described system can prove itself useful for further investigation of tungsten oxide's reactivity.

Electronic structure of CeO$_x$/Cu(110) system studied by ultraviolet photoelectron spectroscopy

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The copper-ceria combination has a prominent place in heterogeneous catalysis. The electronic properties of their interface are dominated by a charge transfer from the copper metal to the ceria which results in occupation of the 4f level of cerium atoms, creating a population of Ce^{3+} sites at the interface, which are considered catalytically active. Among the low index copper surfaces the Cu(110) has been found to facet especially easily. Typically, surface faceting of otherwise stable low index metal surfaces is caused by changes in surface free energy induced by chemisorptions. Structural rearrangement is allowed by sufficient surface mobility of the substrate atoms and adsorbate-substrate interaction.

Very thin ordered films of CeO$_x$ were prepared by cerium evaporation on Cu(110). X-ray photoelectron spectroscopy (XPS), low-energy electron diffraction (LEED), scanning tunneling microscopy (STM), low-energy electron microscopy (LEEM) and (angle-resolved) ultraviolet photoelectron spectroscopy ((AR)UPS) were used for a characterization of the prepared system.

Independently of type of preparation, degree of reduction and thickness of prepared films, CeO$_x$ layers exhibit carpet-like structure in thermodynamic equilibrium. The rearrangement of copper substrate into regular terraces with average length of 23.5 Å due to ceria overlayer was observed [1].

The carpet-like growth overlayer has modified electronic structure at the copper steps due to a loss of binding energy to the substrate. The local vicinal Cu(110) surfaces have modified surface states as a consequence of the regular 1D step array, possibly leading to electron confinement and superlattice effects. The modification of the electronic properties of the ceria-copper interface can be exploited in preparation of functional nanostructures. This modified surface of ceria on Cu(110) have been used to study the interaction with platinum.

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PVD surface treatment of heat-treated cast aluminum alloys

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Newly developed coatings on surface layers of structural materials are currently one of the most important issues in material engineering, where vacuum techniques are often used for improvement of the mechanical properties of the surface. Gradient/monolithic coatings (Cr/CrN-gradient/TiN), Cr/CrN-gradient/CrN, and Ti/Ti(C,N)/(Ti,Al)N) were deposited onto aluminium alloy (Al-Si-Cu) substrates by the cathodic arc evaporation method. A thin metallic layer (Cr and Ti) was deposited prior to deposition of gradient coatings to improve adhesion. This work presents the results of investigation concerning the microstructure and mechanical properties, especially the microhardness of the bi-layer coatings (gradient/ multicompound) deposited onto the aluminium alloy substrates using the PVD method (electric arc evaporation). Investigations of the CrN/CrN, CrN/TiN, and Ti(C,N)/(Ti,Al)N coating types were performed using transmission electron microscopy (TEM), scanning electron microscopy (SEM), glow discharge optical emission spectrometry (GDOS), the ball-on-disk method, and microhardness tests. The fracture morphology is characterized by a lack of columnar structures. The metallographic examinations carried out give grounds to state that the coatings were deposited uniformly onto the investigated substrate materials, so the coatings' properties depend on the type of coating employed, and that the particular layers adhere tightly to each other and to the substrate. This investigation with application of the Physical Vapour Deposition (PVD) method makes it possible to obtain interesting solutions that are very attractive for the automobile and aviation industries.

The influence of topography and atmosphere on tribological properties of PVD hard coatings

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Physical vapor deposition (PVD) hard coatings are used to protect the manufacturing tools from abrasive wear. The hard coatings ability to protect the tools against the wear is evaluated in laboratory tests by measuring the wear and friction during sliding. There are several stages of friction mechanisms in sliding contact. In the initial stage, called *the running-in period* the contacting asperities – nodular defects form the first junctions between the hard coatings and the counter body. In this work we reveal how TiAlN nodular defects response on every sliding cycle of two different counterbody materials: relatively soft 100Cr6 steel and hard alumina. By tracking the wear progress of a selected group of nodular defects we encounter different wear mechanisms depending on the counter body material mechanical properties [As the wear/friction of the hard coating enters in the stable phase called *the steady state friction* the wear mechanism is governed by surface chemical reactions in the sliding contact. The chemistry is influenced by environment in dry sliding. Changing the atmosphere from air to pure oxygen accelerates the chemical reactions while the use of nitrogen atmosphere represses the surface oxidation. The atmosphere change causes the changes in friction coefficient and relative wear rate of the hard coating [2]. To study this phenomenon we used cold work steel coated with conventional TiN, CrN and TiAlN hard coatings and compared the friction and wear behavior to advanced multilayered CrN/CrAlN and CrN/CrVN hard coatings.

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Growth defects in PVD films deposited in UHV environment

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Growth defects are undesired imperfections in thin films, deposited by physical vapor deposition (PVD). Despite their negative influence on film properties, few publications have been dedicated to their study. Among these studies the emphasis has been put on industrial-scale deposition systems where there are many possible sources of growth defect generation. They include arcing, droplet formation in targets, unlubricated moving parts, dust from previous production steps, etc. Indeed, many of these mechnisms have been demonstrated to contribute to the appearance of growth defects. However, there is an open question, to which extent are the growth defects pertinent to the PVD process as such, and what is the contribution of the industrial-scale environment of such studies. In this work, similar analytical work was performed on growth defects, however, the deposition procedure was conducted in a UHV (rather than HV) lab-scale environment with a low deposition rate.

The depositions were made in a load-locked stainless-steel magnetron sputter deposition system KJLC CMS18. A residual pressure in the main chamber was maintained in the range of 10^{-8} mbar. Pure Ti and Cr targets were DC sputtered in argon atmosphere with admixture of pure nitrogen gas. The substrates were stainless steel discs and pieces of Si wafers. The films were deposited onto electrically-floating substrates, either at nominally room temperature or at 450°C. Three types of films were deposited: single-layer TiN, single-layer CrN and multilayer TiN/CrN; in all cases the film thickness was about 1 μm. The growth defect density was evaluated by stylus profilometry and optical microscopy, while individual growth defects were studied by SEM and FIB. We found that while the defect size and defect density are lower, their overall appearance does not differ much to the growth defects generated in industrial-scale deposition systems.

Characterization of nanocrystalline AlTiSiN coatings deposited by a LARC-CAE process

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Many aspects pertaining to forming of coatings, including also the process conditions effect on their properties, still remain inexplicable in spite of the enormous interest paid in them by many industrial centres and research laboratories. Moreover, each combination of the substrate material – coating type – deposition method calls for determining properties of the coated material and defining, basing on them, the range of its possible applications. Research in this area is concentrated among other on searching new composite coatings, both multicomponent and multilayer ones, and adding of new elements to coating combinations used since many years, like silicon or chromium to TiAlN.

The paper presents the results of research studies involving the ceramic-metal tool materials with the deposited nitride coatings on the basis of aluminium, titanium and silicon. Lateral Arc Rotating Cathodes method was used to deposition of nanocrystalline, wear resistant nitride coatings – AlTiSiN type. The coatings had a preset system of layers and appropriately shaped structure and properties in the surface zone as well as in the interface zones between particular layers of the coating, and also between the substrate and core-adjacent layer, whereby it was possible to furnish cutting tools with numerous desirable qualities, ensuring among others better operating durability. Structural examinations are presented of the applied coatings and their substrate made on the scanning electron microscope (SEM) and on the scanning/transmission electron microscope (STEM). Examinations of the phase composition of the coatings applied onto the substrate from ceramic-metal tool materials were carried out on the X-ray diffractometer as well as their chemical composition analysis as a function of the distance from the specimen surface, the so called profile analysis; moreover, changes were investigated of concentration in the interface between the coating and the substrate material, basing on the examinations in the glow discharge optical emission spectroscope.

Stability of multilayered Ti/Ta thin film structures upon laser irradiation

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Multilayered thin films are interesting for wide application due to their specific properties (such as enormous hardness or unusual phase composition) compared to single component systems. It was shown that multilayered Ti/Ta system is immiscible for irradiation with ions of inert gasses. The aim of this experiment was to investigate stability of Ti/Ta multilayer system upon irradiation with picoseconds laser pulses.

Multilayer structures, consisting of 5 alternate Ti and Ta films, and covered with thicker Ti layer, were deposited on a Si substrate to a total thickness of 205 nm. They were deposited in a Balzers Sputtron II system, using 1.2 keV argon ions. Multilayers were grown in a single vacuum run at an average deposition rate of ~ 0.14 nm s^{-1} at ambient temperature. Laser treatment was performed in air by defocused Nd:YAG laser pulses (duration of 150 ps) with two different energies, covering an area of 3 mm in diameter. Laser beam was scanned over the 5x5 mm^2 surface area. Scanning speed was chosen on that way to provide different overlapping of laser spots. Characterizations were done by Auger electron spectroscopy, X-ray photoelectron spectroscopy, atomic force microscopy and scanning electron microscopy.

Obtained results show that irradiation with unfocused picoseconds laser beam with energy of 4 mJ induces penetration of oxygen deeper inside the top titanium layer, and this effect is limited only to this layer. Interdiffusion between Ti and Ta layers, beneath the cover titanium, was not registered for both values (2670 and 4175) of applied laser pulses. For energy of 7 mJ and for lower value of applied laser pulses (2670) there is almost complete ablation of all layers without any evidence of their intermixing.

This experiment demonstrates that the multilayered Ti/Ta system is immiscible for this rapidly heating and quenching process, until the energy of laser beam does not exceed the threshold of ablation.

Phase mapping of MnAl thin films by combinatorial TEM

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The application of magnetic thin films is widespread in information technology. These films usually contain Pt (Co-Pt, Fe-Pt) and are used in magnetic recording media (hard disk drives). Mn-Al alloys exhibit a metastable $L1_0$ phase (τ-phase) at about 50-50% composition, which has magnetic properties very similar to Fe-Pt $L1_0$ so it can be a cheap option for magnetic recording. The Mn-Al phases in thin films form are still unexplored, in contrary to bulk materials published in the database "Binary Phase Diagrams". Thus, we developed a combinatorial method to prepare and study samples of variable composition on a single TEM grid that cover the 0-100% Mn-Al concentration range. The MnAl combinatorial samples were DC magnetron sputter deposited at room temperature on TEM grids covered with amorphous C films. In order to form alloys the samples were heat treated in an Ar-H_2 mixture at 400, 500 and 600 ^{o}C. The formed phases were investigated by TEM, EDS and SAED.

Typically, a primitive (p) cubic phase (a=0.7 nm, PCPDF 21-0547) was found due to heat treatment in the range of 50-100% Mn content. This phase described in [1] forms in the presence of C under annealing in H_2. Mn-oxide phase was also present in the samples as deposited, or annealed below 500°C. At and above 500°C oxygen disappears from the system, due to the reducing effect of H_2. In further experiments, instead of carbon, we applied SiO_x coatings that proved to be a perfect protection against oxygen penetration. Except some cases, most phases formed in thin films of MnAl were found different from that of the bulk. Under the above conditions we have found no $L1_0$ Mn-Al phase (τ-phase). The identified phases of the Mn-Al are summarized in the thin films „phase diagram" in Fig. 1.

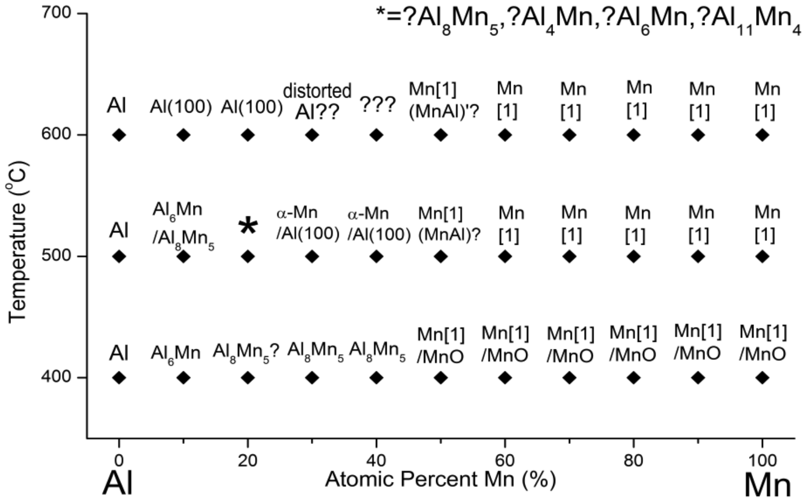

Fig. 1: Thin film phase diagram of Mn-Al heat treated in the presence of hydrogen

The KIT vacuum flowt oolbox

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Since many years, the Vacuum Department at the Karlsruhe Institute of Technoloy (KIT) is active in development and application of methods and codes to predict vacuum flows for all regimes of rarefaction. All methods have their weaknesses and strengths, and specific limitations for practical use. This has finally resulted in a versatile toolbox of approaches.

This paper first introduces in the methodology of vacuum flows. It then presents and discusses the developed computational tools. The focus of the contribution will be laid on highlight examples for components and complete vacuum systems to show how the methods can be utilized to address practical questions. This includes examples for collision-free and collisional flows under various boundary conditions.

3D-simulation of ionization gauges and benchmark measurements

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Extensive 3D-simulations using the Vector Fields OPERA 3D software have been carried out on the CERN type Bayard-Alpert gauges with modulators. The program allows to simulate the ion creation inside the gauge and takes into account space charge effects. Parameters such as sensitivities, ion and electron path lengths inside and outside the ionization grid, location of ion creation, collection efficiency and potential distribution as function of emission current were studied and their investigation resulted in interesting insights of what is happening inside the gauge. We found that the simulated behavior agrees with measurements and confirmed the relevance of such simulations.

Investigation of a field emitter based-vacuum gauge for the operation in cryogenic vacuum systems

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Hot-cathode ionization gauges are typically used to measure pressures in the high vacuum range and below. However, since decades it is known that the thermionic filament used in this gauge type implicates some disadvantages through its huge localized heat generation. The disturbance of the thermal equilibrium by the filament inevitably causes an erroneous pressure reading due to the thermal transpiration effect, as the gas temperature in the ionization volume of the gauge does not correspond to the gas temperature of the atmosphere whose pressure is to be measured. Our approach to avoid this metrological problem is the substitution of the traditional thermionic filament in a standard extractor ion gauge by three individual field emission cathode spots.

The field emitter-based gauge presented here is an advancement of our original gauge design [1,2] and primarily designed for the operation in the cryogenic beam line sections of the SIS100, a 1.1 km long heavy ion synchrotron and main accelerator of the FAIR complex in Darmstadt [3]. Our goal is to realize a compact and easy-to-handle extractor gauge which is able to measure residual gas densities in the ultra-high vacuum range without the disturbing influence of the thermal transpiration effect. The poster presents simulation results of the temperature and gas density distribution in a cryogenic vacuum system which is locally heated up due to the operation of a hot-cathode gauge. Furthermore, we show computations of electron and ion trajectories in our new gauge and compare the results with that of the charge carrier trajectories in an extractor gauge equipped with a standard thermionic cathode.

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Development of the prototype vacuum control system for RAON accelerator

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The Rare Isotope Science Project of the Institute for Basic Science constructs a heavy ion accelerator (RAON) facility in South Korea. In order to accelerate the heavy ion beam without beam loss on path of the beam, a vacuum system should be designed optimally according to the requirements of each part such as injector, accelerator and experiment system. The interlock logic of the vacuum system for RAON should be configured to control each device and protect them. The interlock logic and sequence to control the system is configured by Programmable Logic Controller (PLC). The PLC system will be integrated into Experiment Physics and Industrial Control System (EPICS) for data management. And their data are monitored and remotely accessed through Control System Studio (CSS) which is user interface. Also, the data are archived with text file and graph form for set duration through quick appliance tools on local server.

We performed operation and communication test for each device using prototype vacuum control system. The prototype vacuum control system consists of several units, which are Allen-Bradley (AB) PLC, valves and device controllers. In this report, we will discuss methods to configure EPICS IOC (Input Output Controller) and to communicate between EPICS IOC and PLC, and to use quick appliance tools for data archiving.

Pressure distribution with various pumping combinations and pumping speed in one cell of the Super-Fragment Separator (Super-FRS) of the GSI future accelerator facility FAIR

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The Super-FRS will be the most powerful in-flight separator for exotic nuclei up to relativistic energies. Rare isotopes of all elements up to uranium can be produced and spatially separated within some hundred milliseconds, thus very short-lived nuclei can be studied efficiently. The Super-FRS is large-acceptance superconducting fragment separator with three branches serving different experimental areas including a new storage ring complex.

Motivation for these simulations is the aim of a static pressure in the range from 10^{-7} mbar for the Super-FRS, therefore only UHV compatible materials should be used inside the vacuum chambers. For the pump-down a combination of TMP and roughing pump is foreseen.

Pressure calculations are mandatory to estimate the number of needed pumps, their pumping speed and their position in the specific cells of the Super-FRS.

The shown cell (see Figure 1) of the Super-FRS consists of two long super-ferric multiplets, the beam pipe in the multiplets has a small temperature gradient from the outside to the center; further three super-ferric dipole magnets have their beam pipe at room temperature. Additionally, a focal plane chamber for experiments and beam diagnostic is being considered in the pressure calculations.

In the calculations the pumping speed is adjustable and also the number of the pumps, thus different results should lead to a decision about the required number of pumps and their specific pumping speed.

Figure 1: From left to right: multiplet, three dipoles, multiplet and the focal plane chamber

Specific topics on the way to the realization of the cryogenic UHV system of the SIS100 synchrotron: dipole vacuum chambers and cryoadsorption pumps

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The cryogenic beam vacuum system of the heavy ion synchrotron SIS100 being envisaged within the scope of the FAIR accelerator complex features unique and challenging requirements.

As the maximum ramp rate of the dipole magnets will be in the range of up to 4 T/s, eddy currents induced in the thin-walled vacuum chamber walls will lead to considerable warm-up of the chambers, imposing a significant risk due to desorption of cryoadsorbed gas particles from the inner surfaces of the vacuum chambers within the magnets. For this reason, an appropriate cooling concept consisting of LHe cooling tubes on the perimeter of the vacuum chambers has been developed. Several different implementations pertaining to this cooling concept of the vacuum chambers and therefore several manufacturing design concepts are presented. The cooling efficiency and heat dissipation, respectively, of each vacuum chamber type was investigated in a setup by subjecting each chamber with appropriate DC Joule heating, approximately analogous to the anticipated heat power loss due to induced eddy currents in the vacuum chamber walls.

It became evident that the continuous gas influx from adjacent room temperature regions as well as permanent gas desorption (at LHe cryogenic temperatures predominantly H_2 and He at UHV conditions) from interior cryogenic surfaces of beam vacuum chambers has to be counteracted by utilization of custom-designed cryoadsorption pumps, which are mandatory for stable operation of the SIS100 synchrotron. In order to be able to assess the suitability of the specific charcoal type to be used as effective cryogenic pumping surface for the series production of the pump, the corresponding pumping speed of H_2 and He at cryogenic temperatures of two charcoal types has been investigated and compared.

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Jet process simulation in vacuum environment simulation device

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Jet process is very normal phenomenon that used in chemistry industry, food, water treatment. In fact, jet process simulation in vacuum condition is the very important work. Compared with experiment method, the numerical simulation is the simple and low cost tool. It could guide the experiment design. In this paper, the jet process in a vacuum environment is simulated by CFD method. The model is constructed by 2D axis symmetry method in order to reduce the compute load. The k-e turbulent model and wall function is also adopted. In fact, the system is with one jet inlet, a gas inlet with N_2 in order to stable the jet process, and outlet of mixed gas including the jet gas and N_2. The jet gas mass, temperature and pressure of vacuum condition is considered. The temperature, pressure and velocity, mass fraction of jet gas distribution is well studied. The results show that the jet process is supersonic process. In order stable the jet, the inlet position of gas N_2 must be carefully considered. We changed N_2 inlet position and shape. Compared with the one point inlet, the circle inlet has the well results.

PLENARY

PVD of advanced nano-catalysts for Sustainable Energetics

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Bridging the gap between fundamental knowledge of physical and chemical properties of nanostructured catalysts and applied catalysis allows designing of new grounbreaking catalytic systems. Deep exploring of physical properties of catalyst nanostructures is helping chemists to develop or improve new catalysts through an interactive interdisciplinary loop involving fundamental solid state physics, advanced material synthesis, surface science, in-situ operando spectroscopy, theory and characterisation.

A rapid transition from fossil fuels to renewable energy sources is becoming every day more and more necessary. Water electrolysers (WE) and hydrogen fuel cells (FC) represent a promising and flexible technology for converting wind and solar electrical energy to hydrogen, and hydrogen stored energy into electricity with a high environmental sustainability.

Platinum and iridium are the most versatile elements in hydrogen energy storage catalysis, but they are rare and their high price limits large-scale applications of fuel cell and electrolysis technology. Still, conventional catalysts use only a small fraction of the Pt content, i.e. those atoms located at the catalyst's surface. To maximize the noble metal efficiency, metals should be atomically dispersed and located at the very surface layer of the material.

Preparation of catalysts using thin film techniques is not used yet in heterogeneous catalysis because TF technologies are generally considered as incompatible with the preparation of sufficiently large surface areas. However, high-surface-area nanoporous catalyst films containing very low amount of precious metal can indeed be prepared by suitable deposition techniques.

The new class low cost electro-catalysts were prepared by magnetron sputtering deposition of ultrathin Pt and Ir films on ion conductive polymer composites containing conductive ceramic nanoparticles. The WE and FC tests revealed their high stability and activity. Advanced synchrotron radiation and near ambient pressure XPS, electron and scanning probe microscopies were used for materials and surface characterisation.

Silicon-based plasma polymer nanoparticles deposited by means of a gas aggregation cluster source

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In the last decade, magnetron-based gas aggregation cluster source (GAS) proved to be an effective tool for deposition of nanoparticles. The GAS enables controlling the morphology and chemical composition of the particles by relatively simple variation of the main deposition parameters. In this work, such type of the cluster source was used for the deposition of $SiO_x(CH)$ plasma polymer nanoparticles with tunable properties. Mixture of hexamethyldisiloxane with Ar at ratio of 1:10 was used as a precursor.

Under the GAS pressure of 45 Pa, the discharge power of 30 W and the aggregation length of 10 cm, mainly organic particles with the mean dimeter of 220 nm were created. The morphology of the particles as well as their deposition rate strongly depended on the value of the electrode power and the aggregation length. Addition of oxygen to the gas mixture significantly changed the plasma chemistry and enabled the preparation of completely different kind of the particles. In this case, the power and the composition of the Ar/HMDSO mixture were kept constant whereas the percentage of O_2 was gradually increased. The study of the morphology revealed that the particle size does not depend on the amount of added oxygen. On the other hand, the detailed investigation of the chemical composition showed that the addition of O_2 led to the gradual growth of the silicon and oxygen content in the particles while the amount of carbon decreased. The oxygen to silicon ratio also gradually increased and gained the value of 2 which corresponds to the stoichiometry of SiO_2.

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Antibacterial activity of silver containing nanocomposites prepared by means of gas aggregation source

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Silver based nanocomposites are widely used in different applications. This is due to the unique optical, electrical and bio-related properties of such materials. One of the applications, which experiences renewed interest is the use of Ag containing nanocomposites as antibacterial coatings that is connected with their ability to release silver ions known to be strong antimicrobial agent.

In this study, silver nanoparticles (Ag NPs) were prepared using gas aggregation source and were embedded into different matrixes (plasma polymerized HMDSO and SiOx, magnetron sputtered PTFE and AlxOy) in the form of sandwich structures by sequential deposition of Ag NPs and matrix. This method of preparation enabled to fabricate coatings with well-defined properties of the individual layers. Produced nanocomposites were studied from the point of view of their chemical composition, morphology as well as antibacterial efficiency using *Escherichia coli* and *Bacillus subtilis* as model bacteria. It was proved that all prepared nanocomposites were capable to reduce significantly the number of viable bacteria. However, the antibacterial potency was found to be strongly influenced by the matrix material, amount of Ag NPs in the nanocomposite and thickness of the top-most overcoat layer. As demonstrated in detailed study of Ag/HMDSO and Ag/SiOx nanocomposites, observed dependencies were related to the release rate of silver ions from the coatings.

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Preparation of crystalline tungsten oxide nanoclusters by means of gas aggregation cluster source with IR heating

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In this contribution, we examine possibilities of preparation of the monocrystalline tungsten and tungsten oxide nanoclusters by means of magnetron sputtering with gas aggregation. Tungsten oxide clusters are prepared in the reactive atmosphere (Ar + O_2) and heated in flight by IR radiation. Their structure and morphology are examined by QMS, SEM, HRTEM, AFM and RHEED, their chemical state by XPS. Strong influence of even a small amount of oxygen in the working gas on the clusters size, aggregation speed and chemical state was found. Depending on the argon flow, increasing amount of O_2 admission led to the peak in the cluster aggregation speed with maximum approx. four times higher than without O_2 admission just before the inhibition of the aggregation process. QMS showed that this peak is linked with the increase of the cluster mass. XPS measurement showed that clusters were composed of tungsten trioxide, metallic tungsten and a small amount of intermediate phases. It was found that the influence of oxygen admission gets stronger with the increasing argon flow. IR heating of the cluster beam led to the crystallisation and reduction of the clusters. Depending on the intensity of the heating, both tungsten and tungsten oxide crystalline clusters were observed by RHEED and HRTEM after the deposition. These findings will lead to the preparation of well defined tungsten oxide inverse catalysts suited for investigation of various catalytic reactions over tungsten oxide (e. g. methanol oxidation for use in PEM fuel cells).

INVITED

Magnetron sputtering: Why is magnetron plasma organized in dense, periodic regions?

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Magnetron sputtering is commonly used PVD technique for the preparation of thin films and coatings. Until recently it was believed that magnetron plasma is homogeneously distributed in the ring-shaped region above the cathode. Investigations by ICCD cameras and other time-resolved techniques changed this view. Namely, plasma is concentrated in dense regions – called “ionization zones” or “spokes”, which commonly form periodic patterns. Ionization zones were first observed in pulsed discharges (i.e., HiPIMS) [1] and later in continuously run discharges (i.e., DCMS) [2]. They usually exhibit an arrowhead-like shape that points in the E×B direction. In general, ionization zones in DCMS have a

longer azimuthal length, whereas in HiPIMS they are more numerous and azimuthally shorter. Dynamics of zones strongly depends on the discharge conditions. In a low-current DCMS discharges zones move in the -E×B direction, while in a high-current DCMS or HiPIMS discharges they move in the E×B direction [3].
The aim of this talk is to review the phenomenon of ionization zones. We will examine formation, sustainability, organization and dynamics of ionization zones. Our probe measurements show that ionization zones cause highly non-uniform plasma potential distribution with large gradients in the azimuthal direction, which strongly affect motion of electrons and ions. Consequently, processes related to the sustainability of the discharge, including electron-gas collisions, secondary electron emission and sputtering, are also azimuthally non-homogenous processes. Since ionization zones play an important role in the transport of charged particles [4] they can also influence microstructural properties of the deposited films.

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Stabilized reactive HiPIMS deposition of HfN and TiO_2

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A method to stabilize reactive high power impulse magnetron sputtering (HiPIMS) has been developed and is demonstrated on the two materials systems; Hf-N and Ti-O. The method is based on real-time monitoring and control of the discharge current waveforms[1]. A well-known phenomenon in reactive sputtering is the appearance of a process hysteresis in the transition region between target metallic state and target compound state[2]. Operation in the transition zone is often required for the growth of stoichiometric thin films. To be able to operate within the hysteresis region a fast feedback control loop is needed, where, for example the reactive gas flow is controlled based on the partial pressure of the reactive gas or on other measurable process parameters. In the present work the HiPIMS pulse curves were monitored by an oscilloscope and showed to be representative of the target condition. When the target is in metal mode or when the reactive gas flow rate is low, the current has a positive slope concaved down and ends in a relatively flat peak. On the other hand, when the target is already poisoned or passivated due to film deposition on the target surface, the current pulse shows an increasing slope concaved up and has a sharp peak with high peak current (I_{pk}). In this work, based on the I_{pk} in the pulse, the pulse repetition frequency was altered, and thereby the amount of material sputtered from the target, to maintain a constant I_{pk} and a constant chemical state of the target surface. With this method it was possible to stabilize the deposition in the transition region maintaining a uniform diffraction peak pattern and power normalized deposition rate among the films using different flows of the reactive gas.

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Growth of nanostructured surfaces in pulsed systems

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Metal nanoclusters, i.e. aggregates of atoms in the nanometer size scale (10–100 nm), gain deserved interest because of possible utilization in semiconductor, electronic, optic, and bio-medicine applications. Hence, formation of different metal clusters (e.g. Cu, Ti, Pt, Si, Ag, Co, Au) and nanocomposites consisting of metal nanoparticles has been recently studied. Clusters can be formed in systems that combine magnetron sputtering with subsequent condensation of sputtered metal atoms in the gas phase, so-called Haberland concept. The contribution is focused on investigation of enhanced growth of metal (Cu) clusters. The aggregation Ar gas was delivered into the cluster source in a pulse regime, which results in the formation of well pronounced aggregation pressure peaks. Time-resolved measurements of cluster mass distribution were performed to estimate the mass and particle flux. The paper demonstrates that pulse gas aggregation influences growth of Cu nanoparticles, i.e., cluster mass/size, mass flux, and particle flux emitted from the cluster source. It was found that cluster mass related quantities are strongly influenced by pulsed gas frequency; the highest value of mass flux appears at the most pronounced pressure peaks. Such system was used for deposition of Cu-TiOx nanostructured composite films. Two possible oxidation processes have been revealed in respect of discharge properties and film morphology.

On-site SiH_4 generation using high-density microwave H_2 plasma generated in narrow slit-type discharge gap

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SiH_4 gas is not easy to try out because of its toxicity and flammability. The heavy facilities to stock the gas cylinder and to clean up the waste gas are necessary to utilize it. Moreover, keeping a large amount of hazardous material is also psychological burden for the users, despite its usage for an experiment, such as a film synthesis, is very small amount.

From above background, we aim to establish the on-site silane generator using high-density hydrogen plasma. By the reaction between Si and H, SiH_4 can be generated without chlorine. In our previous study[1-3], it was revealed that both the large plasma area and the short resident time of the gas in the plasma are required to simultaneously achieve more SiH_4 production rate and higher utilization efficiency of resource and energy. Thus, in this study, the slit-type narrow gap plasma source was developed and its improved property was demonstrated.

In the experiment, the dependences of the SiH_4 production rate and the SiH_4 yield on various experimental parameters (input power, H_2 flow rate, process pressure, and narrow gap length) are investigated. The reaction products and SiH_4 production rate were evaluated by FT-IR. The inversion rate of the Si source to SiH_4 was also evaluated. The Si sources were electronic-grade c-Si wafers and metallurgical-grade poly-Si plates of 98 % purity.

The SiH_4 production rate attained to more than 10 sccm while maintaining utilization efficiency of more than 70 %. This SiH_4 generator can operate stably more than 1 hour. Moreover, epitaxial Si films can be obtained by using the generated SiH_4 regardless of the Si sources.

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INVITED

Picometers to pascals: dimensional measurements and new photonic pressure standards

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Dimensional metrology at the picometer level can provide the basis for new pressure standards. The dimensional metrology is provided by Fabry-Perot interferometers, which can measure a change in optical path length associated with the presence of a gas inside the Fabry-Perot cavity. The change in path length is due to the refractive index of the gas, which depends on the gas density and on the atomic/molecular properties of the gas (primarily polarizability). For helium, the atomic properties can be calculated quantum mechanically from first principles, so a measurement of the gas refractivity determines density, which in turn determines pressure if temperature is known.

We are investigating two approaches to using Fabry Perot cavities for pressure measurement. We have carried out initial tests of a device based on two fixed length optical cavities (FLOC). One cavity is maintained at vacuum, serving as a reference which is compared to the second filled with gas at the pressure to be measured. The FLOC has smaller uncertainties than a manometer at low pressures and can also be expected to achieve parts-per-million uncertainties at pressures well above the range of manometers.

Currently under construction is a second device base on variable length optical cavities (VLOC). The VLOC is a more mechanically complex instrument than the FLOC, but it avoids pressure-related distortions which limit the absolute accuracy of the FLOC. If we can generate equal physical displacements in helium gas and in vacuum, the displacement in helium appears slightly longer due to the refractive index. The goal is to measure atmospheric pressure with a fractional uncertainty of $1 \cdot 10^{-6}$, which requires comparing the two paths with picometer accuracy. Fabry Perot interferometers have exquisite sensitivity, but the great challenge here is to generate displacements in different interferometers that are equal to each other at the picometer level.

Photonic realization of the Pascal

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NIST is actively developing a new paradigm in the methodology of pressure and vacuum gauging and metrology. In a break with nearly 400 years of mercury based primary standards, we are now poised to develop a new standard that is based on the fundamental physics of light interacting with a gas. For the vacuum community, this represents a shift in how we think about the unit of the Pascal in that it will be directly related to the density of a gas, the temperature, the refractive index, and the Boltzmann constant. The photonic technique has now achieved important benchmarks in performance when compared to the existing primary standards based on mercury manometers: The photonic technique has a 20X smaller footprint, 100X faster sensing response time, 100X lower pressure range, and for an emerging technique has demonstrated impressive accuracy, reproducibility and hysteresis. Photonic sensing of the pascal has the potential to be further miniaturized, and has the key advantage that the light used for sensing the pressure can be transmitted over light-weight, high-speed fiber optic cables and networks. This talk will highlight the NIST efforts to replace our mercury Ultrasonic Interferometer Manometers (UIMs) with the new quantum-based, photonic technique. Data will be presented that shows that the optical technique has now reached or surpassed mercury manometer performance which now opens up a new paradigm for vacuum metrology and realization of the SI unit, the pascal.

New theoretical effective cross sectional area for a NIST primary pressure standard piston-cylinder assembly

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Currently, the piston-cylinder assembly known as NIST PG39 is used as a primary pressure standard in the range of 20 kPa to 1 MPa with a standard uncertainty of 3 ppm (k=1) as evaluated by Schmidt et al. [1] in 2006. The aim of this work is to revise the previous effective cross sectional area of PG39 and its uncertainty by carrying out more exact calculations that consider the effects of rarefied gas flow [2] in the crevice between piston and cylinder. The effective cross sectional area is completely determined by the pressure distribution in the crevice. Once the pressure distribution is known, the elastic deformations of both piston and cylinder are calculated by finite elements analysis (FEA). Once this is done, the pressure distribution is recalculated iteratively for the new crevice dimension. As a result, a new value of the effective area was obtained which differs from the previous one for 3 ppm. Moreover, this approach allows us to reduce the standard uncertainty to 0.8 ppm (k=1). In this presentation, the details of the rarefied gas flow calculations and analysis of the cross sectional area uncertainty will be discussed.

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INVITED

Modern methods of XHV metrology

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Metrological ensuring of XHV is a bold target of contemporary struggle of widening the scope of etalonnage of vacuum. However, definition of XHV is not settled, partly because also the definition of the beginning of the foregoing UHV range is not settled and is either given as 1 ∝Pa or 0.1 ∝Pa. Consequently also the XHV definition is blurred somehow, its beginning being put at 1 nPa or even 0.1 nPa. Hence this range is by at least 14 decadic orders lower than the atmospheric pressure, resulting its utilization only in the most demanding applications as the particle accelerators, particle detectors, photoemission electron sources, gravity wave observations and metrology. This last field is crucial for all the others and demands it has for the XHV parameters are generally the strictest here.

The last review of this topic was published 7 years ago [1] and this period was characterized by the increased activity. The presentation will focus mainly on the primary etalonnage of XHV. It will firstly give an overview of the older and outdated methods as are the molecular beam or dynamic reduction methods. Secondly, the modern methods based on the dynamic expansion or the dynamic extension principles will be highlighted. In connection with these an interim attention will be kept on the topic of the extremely low gas flows into the vacuum, the construction principles of the primary flowmeters and the flow-division method. The related problems of the low-outgassing construction materials and the necessary parameters of the ionization gauges serving as the transfer standards will also be discussed.

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Half of a millennium of Slovenian vacuum techniques (on 400th anniversary of birth of the Prince Johann Weikhard Auersperg)

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The Prince Johann Weikhard Auersperg was nearly the only person whom Otto Guericke mentioned in his book about the pioneering vacuum experiments. Guericke reported that Auersperg's doubts forced him to modify and approve his tools. Auersperg just became prince and was employed as the prime minister of the Emperor in Vienna. He was born in castle Žužemberk of the present days Slovenia and died in his amazing baroque palace of Ljubljana where he collected many vacuum-related curiosities and the best private European library of his era where no vacuum-related item was missing. He collaborated with leading Jesuits vacuum researchers of his times including Gaspar Schott who was the first to publish the data about Guericke's vacuum equipment. Schott's teacher Athanasius Kircher who witnessed the early barometer experiments in Rome dedicated to Auersperg a part of his book Oedipus and donated many of his book to the Auersperg's library. Later Auersperg became to mighty and the new Emperor forced him to live Vienna for Ljubljana where Auersperg began to spread his knowledge through his high society circle which included leading local Jesuit literati and Valvasor. Soon after his death the public higher Jesuit studies were established in Ljubljana and Gorizia to match the already existing ones in Vienna, Prague, Olomouc, Graz, Trnava, Košice, Klagenfurt, and Zagreb of the same Jesuit Province. The Jesuit professors frequently rotated between those colleges and spread their knowledge initially based on Kircher and Schott's ideas of vacuum. A century after Guericke-Auersperg Regensburg experiments a physics laboratory was established in Ljubljana Jesuit College under the leadership of the grandson of Auersperg's customs officer baron Erberg. In next decades the Ljubljana Jesuits shared their laboratory equipment with similar laboratories along the province to provide the relevant knowledge to their students who build up the present day Slovenian Vacuum Techniques.

Keywords: Johann Weickhard Auersperg, History of Vacuum Techniques, Ljubljana.

Vacuum demonstrations for school children at the science festival SciFest

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SciFest [1] is an annual science festival organized by Uppsala University since 5 years ago to experience hands-on research and science in the form of bookable workshops for school classes for two days. This is followed by a third day with public access with non-stop demonstrations. The total attendance in 2015 was 5500 persons. We participate with a show called "Professor Vacuum" aimed at 10-12 years old school children.

To promote participation we have an information package with the following questions to be answered in the show: Are there winds on the moon? How empty is the Space? Can we hear sound in Space like in Star Wars? Why do we pump vacuum on sausages? Can we boil potatoes on high mountain peaks?

In the demonstrations we go back to Aristotle, Archimedes and Torricelli and start by explaining pressure, discuss number of gas particles per volume and perform basic demonstrations with balloons with different amounts of air in a bell jar, Magdeburg hemispheres etc. We tell about Gallileo and his experiment at the Pisa leaning tower, an experiment which was finally proven on the Moon by the Apollo 15 team as "Feather and Hammer drop on the Moon" [2] and by Brian Cox in the world's largest vacuum chamber at NASA's Space Power Facility in Ohio [3]. We demonstrate vacuum packaging and pump on Marshmallows and other goodies to the delight of the participants who can check if there is a taste difference after the process. The construction of packages for coffee and other items are discussed. Furthermore, we demonstrate gas laws and discuss what materials in the surrounding have been manufactured by vacuum technology. If time permits we show how vacuum can make water boil at lower temperature or how we can freeze by pumping vacuum.

[1] http://www.scifest.uu.se/?languageId=1
[2] https://www.youtube.com/watch?v=5C5_dOEyAfk
[3] https://www.youtube.com/watch?v=E43-CfukEgs

In situ studies of surface reactions – from small molecules to liquid organic hydrogen carriers

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X-ray photoelectron spectroscopy (XPS or ESCA) is a versatile tool to investigate chemical reactions on surfaces. At third generation synchrotron radiation facilities, such as BESSY II in Berlin, XPS studies can be performed with high resolution and *in situ*, during adsorption or during heating. From the binding energies of the adsorbate and substrate core levels, detailed information not only on the chemical composition, chemical state and adsorption sites, but also on the vibronic final state in the photoemission process itself can be derived. From isothermal measurements, the activation energies of surface reactions are directly accessible. In this presentation, different examples ranging from small molecules to the liquid organic hydrogen carrier (LOHC) dodecahydro-N-ethylcarbazole, on metal surfaces, will be addressed [1,2]. The latter molecules are promising candidates for chemical storage of hydrogen, a possible future technology to circumvent present challenges [3].

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Increasing the thermo-mechanical properties of Ti-Al-N coatings by alloying Ta and modifying the coating architecture

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In recent years, different approaches towards the enhancement of physical vapor deposited TiAlN hard coatings were made. Among these, the alloying of additional elements to form quaternary compounds proved to be extremely efficient. In addition to as-deposited film properties also the coatings' thermo-mechanical behavior and the performance in oxidizing environments, both constitute fundamental requirements for cutting applications, can be significantly increased.

One example is the substitution of Ti or Al by Ta, which chemically strengthens the face-centered cubic cell, leading to higher hardness values and increased Young's moduli [1,2]. Furthermore, Ta prevents the formation of anatase TiO_2 by directly promoting rutile-structured TiO_2. Consequently, a thermal-induced phase transformation of anatase into rutile TiO_2 and its therewith associated generation of crack networks is avoided [3].

Here, multilayered TiAlN and TaAlN coatings using powder-metallurgically prepared $Ti_{0.5}Al_{0.5}$, $Ta_{0.75}Al_{0.25}$, and $Ti_{0.45}Al_{0.45}Ta_{0.10}$ targets, as well as monolithically grown TiAlN, TaAlN, and TiAlTaN films are subject to post-deposition annealing and oxidation studies. The TiAlN layers were arc evaporated (arc), whereas the TaAlN layers were either arc evaporated or reactively sputtered (rsd) [4,5]. The overall Ta-content and TaAlN–layer thickness is furthermore varied by different power settings of the $Ta_{0.75}Al_{0.25}$ cathode.

We can show that a coating architecture of $TiAlN^{arc}$ and $TaAlN^{arc}$ allows for thermo-mechanical properties comparable to TiAlTaN, whereas superior oxidation resistance only can be achieved by a $TiAlN^{arc}$/$TaAlN^{rsd}$ arrangement. The critical factor in terms of mechanical stability and oxidation resistance is the TaAlN layer thickness, as complementary investigations reveal a complex phase transformation sequence in this system.

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Thermal stability and mechanical properties of $Ta_{1-x}Hf_xC_y$ coatings for ultra-high temperature applications

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A limiting factor in several industrial applications, e.g. combustion processes or milling operations, is the thermal stability of the applied coating materials. In the last decades the application of nitride based thin films lead to a tremendous increase of the applicable temperatures. Nevertheless, the exploration of new coating systems, exhibiting higher stabilities, is from scientific and industrial point of view inevitable.

Transition metal carbides such as TaC_y or HfC_y are due to their ultra-high melting points promising candidates for such applications. Especially the combination of these two binaries leads to the ternary material system $Ta_{1-x}Hf_xC_y$, which currently exhibits the highest melting point among all materials. In addition, TaC_y as well as HfC_y prefer the face centered cubic crystal structure, which is highly attractive for coating materials synthesized by plasma assisted deposition systems.

Therefore, we study in detail the structure, morphology, thermal stability and mechanical properties of magnetron sputtered TaC_y, HfC_y, and $Ta_{1-x}Hf_xC_y$ thin films. All coatings deposited showed very dense, smooth, and fibrous like structures with very low amounts of amorphous carbon phase fractions, which is essential for outstanding thermal stability. Based on their single phase cubic structure, all coatings exhibit excellent mechanical properties with hardness and Young's moduli comparable to $Ti_{1-x}Al_xN$. In addition, increasing bias potentials during deposition leads to increased residual stresses up to 6 GPa. Various annealing treatments (vacuum annealing and differential scanning calorimetry) proved the excellent thermal stability up to 1600°C and higher for these coatings.

Ductile behavior of hard partially crystalline Mo_2BC nanolaminates

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State-of-art ceramic materials nowadays used as protective coatings such as TiN,TiAlN, c-BN etc. generally exhibit high hardness and high stiffness. These positive features are often accompanied by negative brittle deformation behaviour. To overcome this limitation a new generation of materials with high hardness and moderate ductility is desired. Recently, there has been an increased interest in boron and carbon based nanolaminatessuch as Mo_2BC [1] which exhibit a very similar structure to the MAX phases. According to the ab-initio models, these materials were predicted to exhibit unusual combination of high stiffness and moderate ductility [1].The coatings were deposited either by DCMS at extremely high substrate temperature of 900°C [1] or at moderate temperature of 380°C employing HiPIMS [2]. In our research, co-sputtering of Mo, C and B4Ctargets to finely tune the coating composition was used. Mid-frequency pulsed DC plasma excitation was employed to enhance the ion flux on the substrate by factor of 3 compared to DCMS case which promoted the crystallization of Mo_2BC.Coatings with the same XRD patterns as those deposited by HiPIMS at the same substrate temperature were prepared. The moderate deposition conditions resulted in grown of partially crystalline Mo_2BCcoatings with nanocomposite structure where small Mo_2BC crystallites of approx. 10 nm size were embedded in an amorphous matrix. These coatings showed high hardness of 31.6 ± 0.8 GPa and extremely high fracture toughness – it was even impossible to form a crack in these coatings at extremely high indentation load with cube corner indenter where both the coatings and the underlying hard-metal substrate were severely plastically deformed. This required ductile behavior of hard coating observe for partially crystallite Mo_2BC with nanocomposite structure is hard to be met with other commercial coatings tested by similar manner.

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INVITED

Peculiarities of diffusion and solid state reactions on nanoscale in thin films and multilayers

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Nanoscale diffusion as well as formation and growth of intermetallic phases in bi- and multilayers will be discussed.

- Deviations from the usual (Fickian-type) behaviour in ideal binary systems: sharpening of originally smeared out interface and linear – instead of parabolic – interface shift if the diffusion asymmetry is large (the ratio of diffusion coefficients differs by orders of magnitude).

- Deviations during phase growth: initially existing AB compound can be dissolved; transition from linear to parabolic growth with increasing time.
- Applying the usual scheme “a) formation and lateral growth b) planar growth of a new phase” care should be taken when the experimental methods provide information only about the increase of the amount of the reaction product and there is no information *where and how* the new phase grows.
- In low temperature experiments (bulk diffusion processes are frozen) fully homogeneous phases can be formed by cold homogenization called Grain Boundary Diffusion Induced Solid State Reaction (GBDIREAC). First the reaction starts by grain-boundary, GB, diffusion and nucleation of the new phase at GBs or their triple junctions, then the growth of the new phase happens by the shift of the new interface perpendicular to the original GBs. In this case the interface shift, at least in the first stage of the reaction until the parent phases have been consumed, can be considered constant. This means that the amount of the phase increases linearly with time, giving a plausible explanation for the linear kinetics frequently observed in stage a).
- The system can reach the phase equilibrium, as dictated by the equilibrium phase diagram, with the above GBDIREAC mechanism in nanostructured thin films.

Comparison of oxidation resistance of single layer CrVN and nanolayer CrN/(Cr,V)N/VN hard coatings

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We studied the oxidation resistance of single layer CrVN and nanolayer CrN/(Cr,V)N/VN hard coatings in dependence of the Cr:V atomic ratio. For nanolayer coatings we also studied the influence of the modulation period and layer sequence on their functional properties. All coatings were deposited by DC magnetron sputtering in the CC800/9 (CemeCon) industrial unit with four magnetron sources arranged in the corners of the vacuum chamber. The rotation table provided a threefold planetary rotation of the substrates, which moved alongside Cr, V and Cr-V triangular targets. The two triangular targets of the Cr and V were combined in single magnetron source. Together with a single Cr and V targets we were able to prepare a series of samples with different Cr:V ratio, which changed with the axial position of the substrate. The following types of coating were deposited:

a) single layer CrVN coating with different Cr:V atomic ratio was prepared using only two sources with triangular Cr/V targets
b) nanolayer CrN/(Cr,V)N coating was deposited using two triangular Cr/V (positioned on opposite sides of vacuum chamber) and two Cr targets
c) two nanolayer CrN/(Cr,V)N/VN nanolayer coatings with different modulation periods were prepared using two triangular Cr/V targets (positioned on opposite sides of the vacuum chamber), one Cr and one V target.

The analysis of oxidation mechanisms for all types of coatings showed that the formation of a thin chromium oxide layer slows down the diffusion of vanadium towards the surface. However, at the locations where the growth defects are present the vanadium keeps diffusing at a high rate and forms V_2O_5 dendritic structures at the surface. Vanadium oxide is known to have good lubricating properties at elevated temperature, thus (Cr,V)N-based hard coatings could be potentially useful for the protection of hot forging tools operating at high temperatures.

Exploration of the structure of the TiC/a:C nanocomposite thin films as well as the understanding of their mechanical and corrosion behavior

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Nowadays, using different nanocomposite coatings in order to improve the mechanical properties (high hardness, elastic modulus and low friction coefficient) are wide spread. Thus, TiC / amorphous C (TiC/a:C) nanocomposite thin film may be a potential candidate for such a surface protection coating to the different implant materials which serves as barrier layer. Magnetron sputtering of carbon and titanium were performed simultaneously on different substrates (SiO_x/Si, TiAl6V4 alloy and Titanium) in argon at room temperature. The relationship between the structural, mechanical, tribological and corrosion properties of TiC/a:C nanocomposite thin film was investigated. The film´s composition and morphology were studied by Transmission Electron Microscopy (TEM), X-ray Photoelectron Spectroscopy (XPS) and X-ray Diffraction (XRD). The mechanical characteristics of the thin film were investigated by nanoindentation technique while the tribological behavior of the film was examined by a nanotribometer (CSM NTR2) with rotational and reciprocal movement. The simulated body fluid (SBF) was developed initially to evaluate the surface structural changes of the film. The applied pH was 7.25. The potential changes in the surface structure of the thin film were investigated by Scanning Electron Microscope (SEM). In all cases, combination of columnar TiC nanostructure and thin amorphous carbon was showed. H=26 GPa and E=140 GPa with μ=0,268 was observed in case of the film prepared at ~ 40 at% Ti content. The H^3/E^2 ratio was 0.9 GPa that predicts high resistance to plastic deformation of film. The corrosion study confirmed that TiC/a:C thin film deposited on TiAl6V4 showed 2 times higher corrosion resistance – thanks to the better adhesion – than film sputtered on pure Ti implant. However, preliminary studies [1] have proved that the best adhesion has the TiC/a:C thin film deposited on roughened surface of TiAl6V4 (sandblasting with 180 grit aluminium oxide) with the best corrosion resistant property.

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Influence of abrasive particle size and service conditions on the abrasive wear behavior of multilayer nanocomposite coatings

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Multilayer and nanocomposite coatings have attracted attention of researchers for few decades due to their superior properties such as higher hardness and toughness when compared to single layer coatings. In this study, multilayer nanocomposite TiAlSiN/TiSiN/TiAlN coatings were deposited onto cemented carbide substrates by magnetron sputtering using four unbalanced magnetron sources (two TiAl and two TiSi) in a nitrogen atmosphere. The purpose of this study is to reveal the wear behavior of this coating against abrasive particles of workpiece materials with different size. In addition, the idea is to investigate the relationship between friction coefficient and service conditions by micro-abrasion wear tests. Single layer TiAlN coating was used to compare the performance of the nanocomposite coating. The abrasion wear resistance of the multilayer nanocomposite TiAlSiN/TiSiN/TiAlN coating was measured by a fixed-ball micro-abrasion tester using a slurry of SiC with different sizes (800-1000-1200 mesh). It was performed in distilled water under different normal loads (1–3N) and different sliding speeds (70–215rpm). The diameter of the wear craters was measured by an optical microscope, and volume loss was calculated. Wear behavior of the coatings was observed by scanning electron microscopy on the perforated films. It was found that the coating has superior hardness due to the nano-sized grains of the TiAlSiN top layer and thereby higher abrasive wear resistance than conventional TiAlN coating in the case of SiC abrasives with 1000 and 1200 mesh. However, it was opposite in the case of the 800 mesh. The mass loss increased with the load but decreased slightly with the sliding speed. The highest friction coefficient was measured at 2N normal load and 140rpm sliding speed. Medium abrasive size (1000 mesh), the lowest normal load (1N) and the highest sliding speed (215rpm) can be suggested as optimal conditions for multilayer nanocomposite TiAlSiN/TiSiN/TiAlN coating/carbide substrate system.

Structural characterization and chemical properties of Pd/CeO_2/Cu(111) model system

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Cerium dioxide is an attractive material for various catalytic, electronic and optical applications. Doping of its surface by any active metal leads to the metal-oxide interaction and modification of chemical activity of the system. In the present studies we investigated structural and electronic properties of epitaxial Pd/CeO_2 model system prepared on Cu(111) single-crystal surface. The structural and electronic properties were characterized by means of electron diffraction (RHEED) and photoelectron spectroscopy (XPS, SRPES) techniques. Cerium dioxide grew with a cubic fluorite lattice and (111) terraces parallel to the substrate surface. Terrace size depended on the substrate temperature during deposition. Pd deposition led to the growth of 3D clusters exhibiting FCC structure, (111) epitaxial plane and double positioning along [110] direction. The deformation of crystal lattice of Pd was determined from electron diffraction patterns. Photoelectron spectroscopy showed that the deposition of Pd led to partial reduction of the cerium oxide layer, indicated by appearance of peaks corresponding to the Ce^{3+} in the Ce 3d photoelectron spectra.

The reactivity of the system was investigated by adsorption of methanol performed at low temperature of 140 K. The temperature of the sample was increased in several steps up to 600 K. At each step SRPES measurement with high surface sensitivity and energy resolution was performed. At low temperature multilayer adsorption of methanol was observed. With increasing temperature methoxy was formed on the surface by OH bond scission (200 K). Dehydrogenation of the bonded methoxy species proceeded via formyl to CO. The C 1s spectra have indicated also low amount of formate and formaldehyde species above 300 K and carbon formation due to the partial decomposition of CO. All traces of residual carbon disappeared at high temperatures. Resistance to the carbon poisoning is important for using of these systems in the real catalytic applications.

Study the chemical reactivity of ZDDP additive in mineral oil onto steel and different DLC Coatings

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In this paper we used Attenuated Total Reflection Fourier Transform Infrared spectroscopy (ATR-FTIR) and X-ray Photoelectron Spectroscopy (XPS) to study the chemical reactivity of 1, 5 and 20 wt.% of ZDDP additive in mineral oil onto steel surface and different diamond-like carbon coatings (DLC and Si-DLC), at different temperatures (20, 80 and 150 °C). Our results clearly show that chemical reaction of the ZDDP and DLC happens only at 150° C, where the adsorbed layers consist of the same chemical products irrespective of the ZDDP concentration used. The results show that, on the three surfaces, the structure of the ZDDP thermal film consist of identical groups of pyrophosphate and zinc oxide, while sulphuric groups are dissimilar. On steel surface, the sulphuric part consists of a mixture of organic sulphide and sulphohydryl groups, but on DLC and Si-DLC only organic sulphide groups are found but not sulphohydryl groups. In addition, XPS results show that the reactivity of the ZDDP is higher on steel surface (~ 60 nm for 20 wt% ZDDP) than DLC coatings (~ 36 nm for 20 wt% ZDDP). Based on these findings, three different models (one for each surface) for the empirical mechanisms of the ZDDP thermal film formation has been proposed. It has to be noted that the reaction mechanism between ZDDP and DLC surfaces is still greatly missing in the available literature.

Structure and stability of boron doped titanate nanotubes and nanowires

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Elongated titanate nanostructures have been synthesized via alkaline hydrothermal method at different temperatures then decorated with boron by impregnation with B_2O_3 solution. In order to investigate the effect of boron on the titanates, a series of samples with different Ti:B ratios were prepared (0.1, 1 and 10%) and the materials underwent thermal annealing processes. The doped nanowires and nanotubes were investigated by XPS, XRD and HRTEM. The nanotubes length are 10-120 nm with 10 nm outer and 5-6 nm inner diameter. Associated nanotubes form nanowires with a few µm length and 70-80 nm width [1,2]. XRD results revealed that the lowest Ti:B ratio favors the transformation of the nanotubes to anatase TiO_2. Furthermore, the increasing boron concentrations do not cause significant structural changes compared to the pristine counterpart. The phase transformation of the nanowires does not depend on the boron atomic ratio up to 873 K, but at this temperature the transition is enhanced at higher boron content. On the other hand, TEM images show the formation of hexagonal shaped nanoobjects opposing the pristine nanowire. In the B 1s region of the XPS spectra a peak appears around 192.4 eV in all cases, which can be ascribe to Ti-O-B bond. The formed Ti-O-B structure suggests that B could be located at the interstitial position or act as substitute for H in the lattice of titanate around 500 K.

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INVITED

Revealing the atomic and electronic structure of 2D crystals by Scanning Tunneling Microscopy

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Transition metal dichalcogenide (TMDC) single layers have recently emerged as strong competitors of graphene in electronic and optoelectronic applications due to their intrinsic direct bandgap. However, transport measurements reveal strong deviations from the theoretically expected electrical characteristics that can be attributed to a high concentration of defect-induced electronic mid-gap states. Scanning Tunneling Microscopy (STM) is a versatile and noninvasive technique that can provide information on both the atomic and electronic structure of the native defects of various 2D crystals. However, such measurements turned out quite challenging. Here, we report the successful atomic resolution STM observation of a high density of native structural point defects in exfoliated single layers of various TMDC crystals. Besides resolving the atomic structure and the intrinsic concentration of native point defects, we have also been able to identify the defect induced electronic mid-gap states, through combining topographic STM images and *ab intio* calculations. Our results provide experimental insight into the electronic properties of the native defects of various 2D TMDC crystals, essential for understanding the operation of realistic electronic devices based on such single layers.

Complex characterization of Pd/γ-Fe_2O_3 nanoparticle mixtures applied in acetone vapour sensors

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Iron oxide nanoparticles (NPs) are used as sensing medium in chemiresistive gas sensors [1]. They often benefit from doping by metals, like Pd. Here γ-Fe_2O_3 NPs (6.4 ± 0.6 nm) covered by 1 nm thick oleic acid and oleylamine capping were prepared from Fe acetylacetonate. Pd NPs (6 – 7 nm sized) with oleyl amine capping were purchased. Four NP monolayers were deposited from mixtures of both NP colloidal solutions by Langmuir-Schaeffer technique onto Al_2O_3 sensor substrates. Alternatively NP colloids were drop-casted onto Si chips for analyses. The ratios of Fe_2O_3:Pd NPs were 100:1 and 100:5. Samples were studied by GI-XRD, DLS, XRD, EDAX, DSC-TG, XPS, SEM, TEM, magnetization and ZFC/FC measurements. From isochronal (1 h) annealing and XRD it follows that $\gamma \rightarrow \alpha$ Fe_2O_3 transformation observed at 600 °C in pure oxide is shifted ≈ 100 °C down due to Pd doping. The conductivity was changed from n to p type and it increased considerably, therefore the sensor working voltage could be decreased 10 times to 1 V, which is beneficiary for sensors integration. Simultaneously magnetization was suppressed. DSC-TG showed that capping removal in order to have good electrical connectivity of NP layers proceeds in two steps documented by two exothermic peaks at about 310 °C and 375 °C. The response of sensor with the composition 100 Fe_2O_3:1 Pd NPs towards 5 ppm of acetone vapours in dry air at 450 °C was 2 (200 %) and the low detection limit for response → 0 was 350 ppb. These values are better than those reported by us previously without Pd doping. XPS data and Arrhenius plots of conductivity vs. temperature are used to explain the conduction process in our samples.

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Thermal and gas-dynamic properties of the KATRIN source and transport section

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The Karlsruhe Tritium Neutrino (KATRIN) Experiment is targeted to determine the effective mass of the electron-antineutrino $m_{\nu e}$ with a sensitivity of 200 meV/c^2 (90% C.L.) by investigating the kinematics of tritium β-decay. The setup of the 70-m long experiment consists of two major parts, the Source and Transport Section (STS), where molecular tritium gas will be injected and decay, and the Spectrometer and Detector Section (SDS) where the energies of the decay electrons are measured with high accuracy. A total all of 10^{11} β-decays per second will take place in the Windowless Gaseous Tritium Source (WGTS) of the SDS, in a 10-m long section of the beam tube. The uncertainties of the $m_{\nu e}$-measurement are closely related to the thermal and gas-dynamic stability of the WGTS. The beam tube itself will be operated at 30 K. Key operating parameters, such as injection pressure and temperature, have to be stabilized at a challenging 0.1% level.

The STS beam line is surrounded by a series of superconducting solenoids, providing the magnetic guiding field to adiabatically guide electrons to the SDS. However, the remaining tritium gas must not reach the spectrometer, where it would increase the background rate. Accordingly, the pumping system of the STS has to reduce the tritium flux from the WGTS by 14 orders of magnitude. This is done by combining two techniques, a 7-stage differential pumping section (DPS) with turbo-molecular pumps, followed by a cryogenic pumping section (CPS), which cryosorbs tritium in three 1-m long beam tubes, each covered by a thin layer of argon frost at a temperature of 3 K.

This talk will give an overview on the thermal and gas-dynamic properties of the Source and Transport Section (STS) and its ongoing commissioning.

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Calculation and TPMC simulation of the reduction of radioactive decays of a noble gas by cryo-panels

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In low count rate particle physics experiments radioactive decays can increase the background rate considerably, and thus diminish the sensitivity for the actual signal. This is the case for the KATRIN neutrino mass experiment, where radon, emanated into the large UHV chamber of the Main Spectrometer, can produce several electrons when it decays.

In order to remove radon atoms from the volume before they decay, three LN2-cooled cryogenic baffles (1.7-m diameter), made of L-shaped copper panels, have been installed in front of the NEG-pumps, which are a known source of ^{219}Rn ($T_{1/2}$ = 3.9 s). The walls and welds of the vacuum chamber can be another source, emanating ^{220}Rn ($T_{1/2}$ = 56 s) directly into the main volume. While the cryogenic baffles can prevent most of the ^{219}Rn isotopes from entering the main volume, they also have to remove quickly the ^{220}Rn isotopes already in the main volume. However, radon does no not stick to a cold surface indefinitely. It either desorbs after a limited residence, or it decays into polonium. In the first case, it can contribute again to the background rate.

This talk compares two methods which describe the vacuum performance of the cryogenic baffles. The first method calculates the radon suppression factor analytically, using the effective pumping speed of the baffles simulated with MolFlow+ with an “effective sticking coefficient”, which depends on the radon lifetime and on the residence time on the cold copper panels. The second method employs a modified version of the MolFlow+ code, which adds an exponential lifetime to each radon atom and an exponential residence time to each surface element of the geometrical model. This new MolFlow+ code also stores the coordinates of decays in the volume of the vacuum chamber, allowing to produce a 3-dimensional decay map.

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Gas separation analysis of rarefied binary gas mixture flows through circular capillaries driven by various pressure gradients

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Rarefied binary gas mixture flows are characterized by gas separation which occurs due to the fact that in the transition and free molecular flow regimes, the mean molecular speed of each species of the mixture varies with respect to the mean molecular speed as well as to the bulk velocity of the mixture. These relative velocities, which do not exist in single gases, result to gas flow separation, which greatly influences the overall flow description and it is very important in several technological applications (e.g. sampling, filtering, etc.).

Gas separation for pressure driven gas mixture flow expansion into vacuum has been analyzed, at some extend, in [1,2]. More specifically, the case of very long tubes, based on the assumption of fully developed flow has been considered in [1], while the flow through a short tube of a specific tube aspect ratio, based on the DSMC method, has been tackled in [2].

In the present work this analysis is extended to binary gas flows through capillaries of any length subject to arbitrary pressure differences. The issues of the intensity of gas separation, the computation of conductance and the implementation of the equivalent single gas approach are investigated in terms of the binary gas mixture composition and its molar fraction in a wide range of the Knudsen number. The effects of the tube aspect ratio and of the downstream over the upstream ratio are also examined. The analysis is based on the computed flow rates of each component of some typical binary gas mixtures consisting of monatomic gases. Practical guidelines, which may be useful in industrial applications and measurements under vacuum conditions, are deduced.

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INVITED

Hygienic design of vacuum systems for the food industry

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Vacuum allows food manufacturing processes to proceed under sub-atmospheric conditions, especially offering a huge advantage in the packaging and processing of heat- and oxygen-sensitive food products. In the food industry, absolute vacuums in the 1–600 mbar range are applied for transport, processing, filling and packaging of foodstuffs (e.g., picking robots, MAP or vacuum packaging), as well as in cleaning operations and the creation of appropriate hygienic conditions. As most food equipment manufacturers and food producers are not aware of the potential food safety hazards associated with the use of vacuum systems in the food industry, designers and users need support in identifying and reducing these hazards. Food or beverage residues can carryover from the vacuum process into the vacuum system, contaminating the piping, valves and vacuum source, as well as condensers and tanks if used. Food safety hazards may arise from air, vapours, liquid and/or solid contaminants rushing back towards and into the upstream vacuum application, especially if any of the downstream components of the vacuum system become idle due to failure, air leaks or improper operation (e.g., relieving vacuum at the far downstream end of the vacuum system). In this lecture, we will (i) review different vacuum applications in the food industry with emphasis on the most appropriate vacuum source to generate the minimum vacuum absolute required, (ii) give an overview of the different components that could be found in vacuum systems intended for use in the food industry, (iii) outline how a complete hygienic vacuum infrastructure can be designed by selecting the appropriate materials of constructions and by hygienic assembly of easy-cleanable components prone to minimal contamination, (iv) discuss the commissioning of new and repaired vacuum systems with special emphasis on leak detection and control, and (v) explain how vacuum systems in the food industry should be cleaned, disinfected and/or maintained.

Key words: process – packaging – food safety – hygienic design – carryover – contaminant – cleaning

The study of multiopening orifices real conductivity for upstream pressures in the medium vacuum range and different gases

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Czech Metrology Institute has developed a prototype of the primary standard for the medium vacuum range to cover at least the absolute pressure range from 0.1 Pa to 10 Pa. Transitional gas flow regime occurs at these pressures in the vacuum chambers of usual dimensions. It makes accurate theoretical treatment of processes in gas more difficult.

There developed primary standard shifts upper range limit of common orifice flow systems towards higher pressures. This is achieved keeping the molecular flow regime through the measuring duct (orifice) by minimizing the dimension of the duct. A multi-opening orifice (MOO) with 80 000 openings of approx. 0.02 mm diameter is used in the new CMI primary vacuum standard [1], called a molecular MOO. It can be alternated in situ under vacuum with another MOO so called geometrical MOO, consisting of 367 larger openings of known shapes and well measurable dimensions of each duct. Its conductance was calculated from the dimensions.

The results of conductivity measurement for two different gases (Ar, N_2) from the lowest upstream pressures up to the pressure limiting the molecular regime in the geometrical MOO are presented, compared to the expected theoretical values and discussed.

This research is supported by EMPIR Project “Industrial standards in the intermediate pressure-to-vacuum range”.

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Industrial standards in the intermediate pressure-to-vacuum range – outline of a European joint research project

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Sixteen partners including 10 national metrology institutes, 4 universities and 2 industrial companies from 13 European countries are jointly carrying out a research project (JRP) within the European Metrology Programme for Innovation and Research. The purpose of this JRP is to enable the SI traceable measurement of absolute, positive and negative gauge pressures (p) in the intermediate range from approximately 1 to 10^4 Pa with an accuracy of $3\times10^{-5}\cdot p + 0.005$ Pa in order to increase the efficiency of industrial productions and processes. These objectives include providing primary and transfer standards for dissemination of the pressure scale and developing appropriate calibration methods for high-accuracy state-of-the-art pressure devices in order to establish a calibration service in this pressure range. Progress beyond the state of the art will be achieved by

- developing an interferometric oil liquid column micromanometer with a capability of *in situ* measurement of the oil density,
- characterization of force-balanced piston gauges as primary and secondary pressure standards by state of the art dimensional measurements on piston and cylinder as well application of modern gas flow models,
- investigation of alternative pressure measurement systems based on optical methods to provide new traceability capabilities and improved linkage of static and dynamic pressure measurements,
- investigation of pressure standards alternative to mercury manometers,
- development and characterization of transfer pressure standards based on new generation capacitance diaphragm gauges and highly stable resonance silicon gauges,
- comparison of novel standards for the intermediate pressure range with classical pressure and vacuum standards such as pressure balances, mercury manometers, static and continuous expansion systems,
- developing accurate, weather-independent calibration methods for low positive and negative gauge pressure standards,
- An outline of the JRP and the results achieved so far are presented.

Digital Pirani and passive wide range gauges

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The Pirani gauge, named after its inventor Marcello Stefano Pirani, has become one of the workhorses in vacuum technology and corresponding industries. As a stand-alone gauge, this thermal conductance based principle is widely used in industrial environments for moderate pressure determination. Despite existing needs for such a measuring tool equipped with versatility, accuracy, robustness and low cost, however, in UHV applications the Pirani gauge is rarely used. Primarily this is due to its bake-out restrictions attributed to the location of the signal processing electronics. Latter is to be installed directly onto the gauge, so that bakeable Pirani gauges are hardly or not available. Moreover, complete wide range gauges – consisting of a Pirani and a hot or cold cathode – do not exist.

In this talk we introduce a novel Pirani gauge setup which enforces signal processing by a digital, microcontroller driven processing unit. Here, the electronics can be spatially separated from the vacuum gauge. Measuring the reference residual temperature directly, instead of commonly using comparator resistances in the Wheatstone bridge, enables the use of more complex algorithms in the data processing. Eventually, this digital setup allows integrating the Pirani sensor in a wide range gauge in a way that boundaries between transducers and passive gauges may disappear in the future. In the presentation, the seminal features of the novel Pirani gauge concept will be introduced along with decent theoretical data and experimental results.

New low cost contactless sensor for vacuum measurement in vacuum insulation panels

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The presented project aims to develop an advanced technique for measurement of quality of Vacuum Insulation Panels (VIPs). STRIPRES technology enables to control the quality of VIPs at the end production, during storage, logistics and while installed in end applications for many years.

VIPs are considered to be one of the most efficient insulation materials known today. Nowadays, the majority of VIP producers cannot control the quality of VIPs during or after the production adequately. In addition, users cannot monitor the quality of VIPs after they have been installed into end applications. VIP consists of a core with high-insulating fibres which is surrounded by special PET foil. In the manufacturing process the VIP is evacuated to a vacuum of a few Pa, thus minimizing the thermal conductivity. The better vacuum provided the better is the quality of VIP; and with time the pressure inside the VIP may increase due to permeation of atmospheric air through the PET foil. The main purpose of measuring pressure inside the VIP is quality assurance. There already exist several measurement techniques; however ours establishes a quick contactless and relatively accurate measurement of absolute pressure which is independent of the outside pressure. Sensor is encapsulated in the VIP panel and enables long term monitoring of insulating vacuum, even weeks or years after VIP fabrication.

The pressure sensor operates on the principle of weighing gas molecules with the quartz crystal. The molecules of the surrounding gas have a damping effect on the oscillations of the quartz crystal, which results in the change of its impedance.

For the purpose of testing the pressure sensor we constructed a special calibration vacuum system that had to be designed in a way that it resembled the measurement conditions inside the VIP at best.

Lifetime improvements of inverted magnetrons in industrial applications

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Since the invention of cold cathode gauges in 1937, cold cathode gauges have become popular in industry because they are robust and have no filament to break. However, these gauges also suffer from degradations through effects such as self-sputtering or deposition of coatings on sensitive surfaces. We have tested several features that allow tailoring the gauge to a particular application thereby improving the lifetime of the gauge in the process several fold. First we use a dual chamber system that reduces the sensitivity degradation by process material thin film deposition. Adapted operating parameters reduce self-sputtering or reduce thin film build-up. Furthermore, different cathode materials can be chosen to better withstand the process chemistries.

Pressure gauge with integrated He-leak detector based on a novel ion source

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In practice, users often face problems achieving the desired operating pressure of their vacuum chamber due to small leaks, most likely produced during assembly. While the determination of pressures in HV/UHV-processes is properly carried out with well-known Bayard Alpert gauges or cold cathodes, the localization and identification of leak sites can turn into a very time-consuming procedure. Strong leaks can be identified with isopropanol or acetone, which can temporarily stuff the leak sites and lead to a measurable pressure rise. However, for very small leaks which are crucial in the HV/UHV region, a different approach needs to be found. Rather accurate methods are carried out using separate leak detectors or mass spectrometers. While leak detectors are highly cost-intensive, the application of a mass spectrometer seems to be oversized and somewhat laborious since only the Helium signal is relevant.

In the talk we present a vacuum gauge with an integrated TOF Mass Spectrometer capable of both: a precise total pressure measurement over a wide range and, simultaneously, the determination of Helium partial pressure. Moreover, due to the usage of the novel, recently developed ion source, the gauge achieves a high dynamic range without the utilization of a cost-intensive electron multiplier, even in the UHV. Above all, the gauge comes up with a simple and compact design.

The underlying physical principles of the novel ion source will be presented along with numerous experimental results in comparison with theoretical simulations. Next to total pressure and low mass spectrum measurements, the capability of detecting the gas composition up to 50 m/z at high repetition rates is evaluated.

INVITED

Nanoporous metallic films for catalysis

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It is well known that several materials, if they are in nano- or well- ordered form, exhibit catalytic properties different from those in bulk phase [1]. Gold nanoparticles [2], thin vanadium oxide layers [3], respectively, are typical examples of materials that gained industrial importance.

We present the fabrication technology of discontinuous MoO_2 films. These layers were formed by oxidation of nano-porous pure molybdenum films in oxygen atmosphere. The monoclinic phase of MoO_2 particles with mean size lower than 10 nm exhibits 42 % selectivity to propylene oxide. Microstructure of PVD deposited metallic layers is described by Thornton diagram of film growth. [4] Detailed study of Thorntons model was published by Petrov et al. [5] They showed the possibility to deposit non-continuous films with various aspect ratio of individual metallic columns.

Then we also present results on discontinuous tungsten films consisting of needle-shaped separated nanocrystals that were examined for direct conversion of cellulose tohydrogen by aqueos phase reforming reaction [6]. The dc magnetron sputtering at relatively high argon pressure was used to deposit the nano-structured Mo and W films, respectively. Their nanostructured morphology was investigated by transmission electron microscopy on in-plane and cross-sectional TEM specimens. Both proposed catalyst are found to be very perspective in catalytic technology.

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Gold on hexagonal boron nitride nanomesh prepared on Rh(111): growth and intercalation

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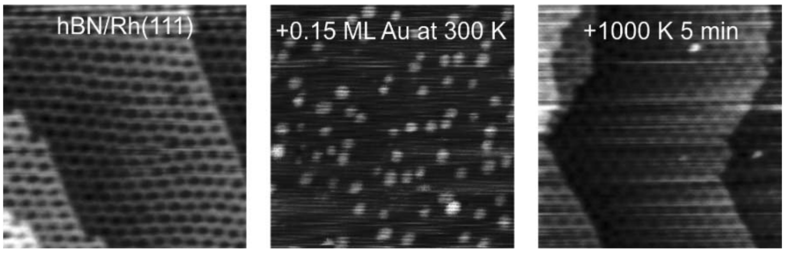
Two dimensional (2D) hexagonal boron nitride (hBN) monolayers (MLs) are promising insulator components for nanoelectronics. When prepared on Rh(111), a periodic buckling of the single hBN layer takes place, and a so-called nanomesh is formed consisting of "wires" and "pores", which can be used as a nanotemplate [1,2]. Here we report on the growth and thermal properties of Au on the hBN/Rh(111) surface, studied by STM, XPS, and low energy ion scattering spectroscopy (LEIS). The latter technique detects very selectively the chemical composition of the outermost atomic layer. The growth of gold starts in a nearly two-dimensional mode at 300 K, while 3D nanoparticles appear at somewhat higher coverages (> 0.2-0.3 monolayer). Although on inert surfaces small gold particles are characterized by a Au $4f_{7/2}$ binding energy higher than the bulk value (84.0 eV) due to final state effects, here the gold peak was observed at a rather low position (83.7 eV), indicating a significant electronic interaction either with hBN or indirectly with the rhodium substrate. The intercalation of gold is the dominant process upon stepwise thermal annealing up to 1050 K, accompanied by some agglomeration and evaporation. Interestingly, gold and rhodium, which are bulk-immiscible, form a surface alloy after the intercalation, but the presence of ~0.15-0.5 ML of Au below the hBN layer does not significantly influence the nanomesh structure (see figure; image size: 50 nm × 50 nm).



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X-ray photoelectron spectroscopy of ionic liquids – how to close the pressure gap in electrochemistry research

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Electrochemical reactions occur at the electrode/electrolyte interface. In order to understand the manifold reactions taking place at that interface, the development and application of analytical tools probing this interface *in situ* in an electrochemical cell are of outmost importance. Although, X-ray Photoelectron Spectroscopy (XPS) is widely accepted to be a powerful tool to study electrochemically induced changes of electrode surfaces, it can usually not be applied *in situ* as common electrolytes evaporate into the ultrahigh vacuum (UHV). Therefore, the so-called electrode emersion technique was established, which can be described as a *quasi in situ* analysis of the electrode/electrolyte interface [1]. However, all these measurements require the critical step of electrode preparation and subsequent transfer from ambient pressure into vacuum.

Unlike common electrolytes, ionic liquids (IL) provide the unique opportunity to overcome this issue as these electrolytes are UHV compatible [2]. IL are also known to provide large electrochemical stability windows making them attractive for electrochemical applications such as electrochemical double layer capacitors or lithium ion batteries. In this presentation, quasi *in situ* [3] and *in situ* [4] electrochemical XPS setups will be presented and discussed in terms of opportunities and limits of both approaches with respect to investigations of interfacial behavior, stability windows of IL, and interpretation of XPS data.

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Metalation of porphyrins and the role of the oxidation in metal surfaces

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Metallo-porphyrin are a very important class of organic molecules for their possible use in novel devices based on the interaction of an active nanoscale site with the surrounding medium. The fine control on the self-assembling and, possibly, on the metalation of the molecules represent a key issue in the development of these organic-substrate interfaces with the aim of tailoring suitable properties for organic-based devices [1-3]. Therefore it is fundamental to understand how porphyrins (metalated or not) interact with the substrates and in which way the self-assembled organic monolayer can be controlled and modified. Here we show several methods to metalate the metal-free porphyrins on surfaces in Ultra High Vacuum, the modification of these molecules with temperature and the interaction of porphyrins with the substrate. In particular, the formation of water molecules in the intermediate step of the REDOX reaction of porphyrins self-metalation on O/Cu(111) is demonstrated. Photoemission measurements show that the temperature on which porphyrins pick-up a substrate metal atom on O/Cu(111) is reduced by about 180±20 K with respect to the pure Cu(111). Density Functional Theory (DFT) calculations clearly indicate that the formation of water molecule is less expensive than the formation of H2 on the O/Cu(111) substrate and, in some cases, it can be also exothermic. This behaviour is also found in the case of the Pd(100) surface. Pd(100) is unreactive for the self-metalation of metal-free Tetraphenyl-Porphyrin (2H-TPP) up to 600 K and using photoemission and DFT calculations we show that 2H-TPP self-metalize on O/Pd(100) surface by forming water molecule. The reaction stops when oxygen is no more present on the surface and the temperature of the reaction depends on the amount of oxygen. The temperature where the REDOX reaction takes place in a reasonable time decreases as the adsorbed oxygen increases.

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INVITED

From vacuum to fuel cells

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The future of our energy security depends on our ability to sustainably and efficiently harvest the sun's energy and store it. For this, we need a range of technologies based on stable catalyst materials capable of speeding up several key chemical reactions to the practical rates. Research and development of such materials is currently high priority on the global scientific agenda list and it is approached by a combination of diverse fields, such as surface physics, electrochemistry and inorganic synthesis. Hand in hand go advancements of new surface science techniques, which could be used in vacuum, in-situ and in operando conditions, effectively complementing the standard electron based in-vacuum methods. The electron diffraction techniques are a good example of well-established tools providing us with the information about catalyst's surface structure with atomic precision. However, the demand of the vacuum environment disqualifies those techniques for the research on working model catalysts in operando conditions. Such studies are important as the surface structure can be significantly different in the vacuum environment and in the presence of the electrolyte or at ambient pressures. The Surface X-ray Diffraction (SXRD) and High Energy Surface X-ray Diffraction (HESXRD) are techniques which overcome this limitation and are currently increasingly used for surface crystallography under different conditions and in catalysis research.

In this talk I will discuss recent advances in the SXRD and HESXRD as well as their advantages and limitations when compared to the standard electron diffraction techniques. Various examples will be given on surface characterization in vacuum and in operando conditions. In addition, I will also discuss the value of the standard electron based vacuum methods in electrocatalysis research, the used electrochemical equipment, and the possible obstacles.

Benchmark spectra for secondary electron emission by means of (e,2e)-coincidence spectroscopy

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Electron-induced secondary electron emission (SEE) is a fundamental phenomenon, upon which a broad variety of technological applications and analytical techniques are based. Several theoretical models [1,2] and a series of semi-empirical theories [3] regarding secondary electron emission yields have been developed over the past 50 years and have been used to calibrate Monte Carlo (MC) simulations [4-6]; an important tool to obtain information about angle- and energy-dependent SEE for a material. Spectra of secondary electrons (SEs) have been frequently used to get information about the main SE-creation-ejection mechanisms involved and to test the models describing the secondary electron yield (SEY). The evident lack of distinctive features encountered in any experimental spectrum of SEs makes it inherently difficult to test the validity of theoretical models for SE-emission. In 1977, Chung and Everhart [5] demonstrated that plasmon decay plays a relevant role in SEE. However, based on the featurelessness of SE-spectra it was very difficult for them to compare experimental results with the theoretical description of the processes.

Making a comparison between an extensive experimental data compilation and the theory describing SEE, Lin and Joy [3] found non-negligible discrepancies of up to a factor of 7 (!) for a thoroughly investigated material such as Al. These inconsistencies between experiment and theory, demonstrate that the exact mechanisms involved in the creation of SEs are not fully understood yet and that more detailed knowledge and *quantitative* understanding are desirable.

In the present work, it is demonstrated that by measuring spectra of SEs *in coincidence* with the energy loss processes leading to the SE-emission, i.e. by measuring *correlated* electron pairs (e,2e) emitted from an Al-surface [7,8] and from various C allotropes [9], it becomes possible to discriminate the processes involved in the production and the emission of SEs, thus decisively improving the quantitative understanding of SEE. Differently from a singles spectrum, a double-differential (e,2e)-coincidence spectrum exhibits prominent spectral features. Such spectra enable to discriminate the scattering and the energy dissipation processes leading to SE-emission and they also allow one to *experimentally* separate the contribution of surface and bulk plasmon decay to the SE-yield. [7,8]. By means of (e,2e)-coincidence spectroscopy it becomes possible to obtain *benchmark spectra* allowing one to test and to assess the validity of the SEE-models for the individual electron scattering processes.

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INVITED

Nature-inspired organic hydrogen-bonded thin films for sustainable and biocompatible electronics

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Many natural chromophores feature intra- and inter-molecular hydrogen bonding. Our motivation for exploring such molecules is the realization of biodegradable and biocompatible electronics fabricated from cheap and nontoxic materials. These hydrogen-bonded building blocks are highly insoluble due to strong intermolecular interaction, and are very stable. These properties preclude solution processing techniques but make these materials ideal candidates for vacuum processing by sublimation. In the form of vacuum-evaporated thin films, natural and nature-inspired chromophores can form high performance semiconducting solids, with application in traditional (opto)electronic devices as well as biointegratable devices such as sensors. This talk will cover work on biocompatible FET devices and biosensors, with particular attention to techniques for preparing devices that can operate stably in highly-demanding aqueous environments without any passivation. Next application of these semiconductors for aqueous photo- and photoelectrochemical catalysis will be discussed. Finally, an introduction to semiconductor/cellular interfaces with these devices and materials will be covered.

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Measurement of critical cracking strain of organic thin films prepared by wet coating process

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In the present study, the critical cracking strains of organic thin films mainly prepared by wet coating method were investigated, further the light emitting performance of some organic LEDs whose transparent conductive oxide (TCO) electrode was replaced by a transparent conductive polymer were examined. The final target of the present research is the improvement of flexibility of organic devices, flexible displays and flexible organic light emitting diodes (OLEDs). The tensile tests of PVK for OLEDs, P3HT for organic solar cells, three types of PEDOT for transparent conductive polymer, which were prepared on PEN substrates, were conducted then the critical cracking strains were compared with those of the organic thin films prepared by vacuum process. Furthermore, for the preparation of tensile test during light emission, the light emission performance of some OLED devices which TCO were replaced with PEDOT from indium thin oxide (IZO) were measured. As the result, it was found that the PVL thin film caused cracking same as the organic thin films prepared by vacuum deposition [1] although no cracks were observed in the films of P3HT and the three types of PEDOT, further it has been suggested that the pattern and layered structure of the specimens is applicable for the light emission tensile test.

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Nanostructured silicon heterojunctions for NIR optoelectronics

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Silicon sensitivity for IR sensitive optoelectronic devices is limited by the 1.11 eV band-gap of bulk silicon. Extension of silicon's spectral sensitivity to NIR wavelengths beyond 1250 nm while keeping the CMOS compatibility would be beneficial to possible telecom or other optoelectronic uses. By making heterojunction optoelectronic devices based on thin films of vacuum-deposited organic semiconductors on silicon substrates it is possible to vary the barrier height of the heterojunction, and thus also the spectral response of the devices. By using micro and nano-structured silicon substrates, electronic and optical properties of structured substrates can be used to improve the device performance in comparison to using flat substrates. We present example of heterojunctions based on silicon/organic thin films of hydrogen-bonded pigment tyrian purple (6,6’-dibromoindigo) formed by vacuum evaporation. Though the band-gap of both materials in the heterojunction is relatively high, our devices show sub silicon-bandgap IR sensitivity up to 2500 nm with responsivity of ~5 mA/W in the telecom C-band [1,2]. We show how micro- and nano-structuring of silicon substrates prior to vacuum evaporation of organic layer significantly improves the responsivity of hybrid silicon-organic photodiodes.

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Nitride layers grown over graphene/SiC

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Self-heating of high power devices is a major problem in GaN high electron mobility transistors (HEMT), in which the power reached the values of 10 W/mm (the length of the gate in mm). Implementation of graphene layers in gallium nitride heterostructure growth can solve the self-heating problem in nitride-based high-power electronic and light-emitting optoelectronic devices.

Now we explore the possibilities of nitride layer growth on graphene/SiC. The task is challenging thanks to the lack of chemical reactivity between the two materials. Therefore instead of direct growth on graphene we present how high quality nitrides can be grown on patterned graphene/SiC templates. The grown samples are analysed by transmission electron microscopy (TEM). The dislocation density is practically the same as in GaN grown on SiC. The results show, that the used graphene is a multilayer of 3-5 graphene sheets, but this is advantageous for the high heat conductivity [1]. The nitride heterostructures deposited on patterned graphene layers are grown via lateral overgrowth, which results in the formation of a single-crystalline GaN layer that has a relatively low defect density and a smooth surface. Optimization of the plasma etching process and growth procedure promises to offer a simple route to produce nitride based device structures with better thermal management due to graphene layer incorporation.

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Lattice matched $NiSi_2$ tetrahedrons in Si whiskers

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Small tetrahedral $NiSi_2$ inclusions were studied by transmission electron microscopy in Si whiskers obtained during Ni induced lateral crystallization of amorphous silicon. Nickel induced crystallization is a widely used to produce cheap crystalline Si films for less demanding applications like flat panel displays and solar cells. In this process a small amount of Ni is used to induce crystallization in an amorphous layer by forming $NiSi_2$ clusters. Small $NiSi_2$ clusters then migrate through the amorphous material and leave a crystalline trail behind. Whiskers formed this way serve as seeds for further crystallization of the layer. When studying this process at low temperature (413°C for 11days + 420°C for 11days) resulting in very low whisker growth rate we observed small inclusions inside the Si whiskers. Tetrahedral $NiSi_2$ inclusions, coherently lattice matched to the Si matrix were found with sizes ranging from a few nm to about 20 nm. The interface of the inclusions are all {111} type planes perfectly flat in most cases, however steps of several lattice plane height rarely occur. The Ni content inside the inclusions was confirmed by EELS. The whisker axis orientation is random in contrast to the usual 111 whisker growth direction, however parallel whiskers often have the same orientation.

Considering the Ni amount in the inclusions, which exceeds the solubility limit of Ni in Si by several orders of magnitude these inclusions could not form as precipitates, rather they were trapped inside the growing Si whisker at the moving $Si/NiSi_2$ interface. The morphology and interface structure of the inclusions are discussed in detail.

Ultrafast charge injection at complex interfaces: organic-organic, organic-inorganic and organic-graphene

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Interface processes strongly affect performances and efficiency of organic based devices. The integration of 2D materials like graphene in organic devices (for example as electrodes) is expected, on the other hand, to improve overall device performances. There is a need, therefore, for a deeper understanding and control of processes like charge transfer (CT) at interfaces between organic films, graphene and metals. Charge injection across molecular junctions can occur on femtosecond time scale or even faster. In most cases this time frame is still out of reach of the pump and probe spectroscopies. Here, we use X-ray spectroscopies to investigate charge injection in complex hetero-structures that include organic molecules, graphene and metallic substrates. We show that the Core hole clock implementation of the Resonant Photoemission spectroscopy (RESPES) allows us to determine charge dynamics at these interfaces and can give clues on the interface parameters that can increase/decrease the charge transfer efficiency. Examples of model systems will be discussed.

It will be shown how RPES allows us to elucidate the role of inter-molecular interaction on through-space charge transfer characteristics, the electronic coupling, morphology and charge transfer rates at the donor-acceptor (D/A) interfaces between C60 and either flat- or contorted hexabenzocorones (HBC) and map charge delocalization times from different sites on a molecule. Comparison of charge transfer rates between a prototypical organic molecule and different substrates (metal, graphene and graphene nanoribbons) will be discussed elucidating the role of the local density of states of these materials and the level alignment in the charge transfer process. We will show how to measure ultrafast charge transfer across the pyridine/Au(111) interfaces, in a system where we can also control the molecular orientation on the metal surface. The electronic states of excited pyridine are shifted on a femtosecond time scale, opening an ultra short time window for efficient 2-way charge transfer at the Au-molecule interface, occurring within a few femtoseconds. Through theoretical calculations (based on density functional methods), we show that the alignment of molecular energy levels is strongly altered when a core-hole is created, allowing the lowest empty molecular orbital - LUMO* to lie partially below the Fermi level. Additionally, we identify the molecular tilt orientation to control the charge transport time, as demonstrated by both, experiments and calculations.

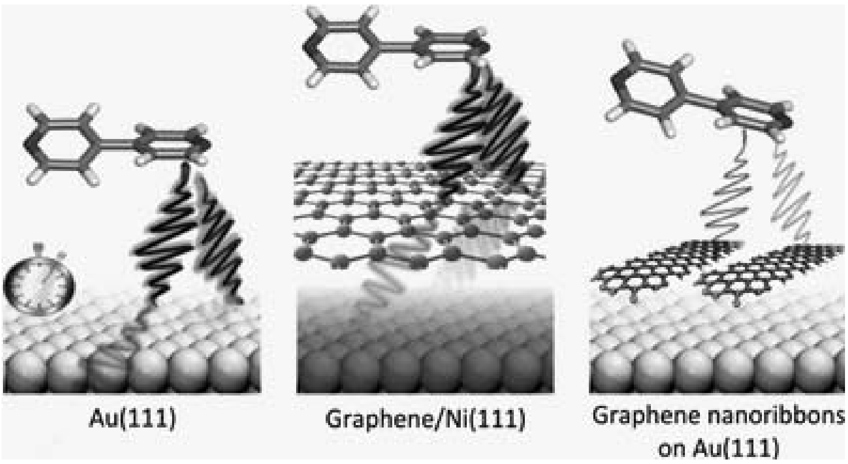

Figure 1.

Growth of graphene from benzene on Ir(111)

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The study of producing graphene extends from mechanically exfoliated graphene flakes transferred to different substrates to chemical vapor deposition (CVD) growth process on different metal surfaces. The most frequently used carbon source in CVD process is ethylene. To obtain a single domain (R0) graphene on Ir(111) surface from ethylene high growth temperature (~1000°C) is required. As already reported, reduction of growth temperature is realized by using aromatic carbon sources in CVD process on Cu(111) in the region of atmospheric pressure [1]. The use of benzene reduces the growth temperature as low as 300°C. This finding opens the opportunity to the possibility of low temperature growth on Ir(111), but in ultra high vacuum (UHV) conditions. To investigate this possibility we used scanning tunneling microscopy (STM) and low energy electron diffraction (LEED). Our findings point to the CVD growth with predominantly R0 oriented graphene achieved at 700°C.

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Nuclear spin conversion of D_2O molecules trapped in a CH_4 matrix

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The nuclear spin conversion of a water molecule has been studied in cryomatrices of rare gases [1] and para-H_2 [2] by infrared spectroscopy, using the specific combinations of the rotational and nuclear-spin states. We have found that CH_4 plays a splendid role as the matrix species because it has not only a chemically inert nature, but also infrared-active vibrational modes, which enable us to obtain structural information of the matrix [3]. In the present study, we performed infrared spectroscopy of D_2O in a CH_4 matrix to investigate the nuclear spin conversion.

The pressure of a sample chamber equipped with a liquid helium cryostat was as low as 10^{-8} Pa after baking at 373 K for 24 hours. A gold-coated copper block mounted on the bottom of the cryostat was used as the substrate. CH_4 and D_2O were mixed in a gas handling system, and were dosed onto the substrate at 7.5 K. Infrared spectra were recorded with a HgCdTe detector in the reflection configuration. In addition to intense absorption peaks due to solid CH_4, we detected D_2O-bending-vibratioal peaks at 1175 and 1187 cm^{-1}, which were attributed to the para- and ortho-species, respectively. The intensity of the para-peak increased with time whereas that of the ortho-peak decreased. This means that the nuclear spin conversion of D_2O took place in the matrix. We analyze the time dependence of the intensities to derive the conversion rate. On the basis of the temperature dependence of the rate, the mechanism of the nuclear spin conversion of D_2O is discussed.

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Research on the leak testing technology for large spacecrafts

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With the development of the space technology, the spacecraft is more and more large. This trend takes a strict challenge for the leak testing of spacecrafts. The tradition method is to divide the large spacecraft into several parts and make these parts leak testing respectively. But this method cannot provide its total leakage rate. In this paper, a non-vacuum accumulation leak testing method based on the flexible accumulation chamber is provided to solve this problem. If this method is adapted, two key problems must be solved. That is how to build the sealed space for accommodating the large spacecraft and whether the trace gas (helium) in the flexible accumulation chamber is layered. The feasibility of building a large flexible accumulation chamber for testing the total leakage rate of large spacecraft is firstly analyzed and the detail process of building the flexible accumulation chamber is also provided. Secondly, the helium gas distributing rules in the large accumulation chamber is also given from the theoretic analysis and computer emulation. It validates the feasibility of adapting the helium mass spectrum leak testing technologies for large spacecraft further. The results here indicate that the non-vacuum accumulation method based on the flexible accumulation chamber is suitable for testing the total leakage rate of large spacecraft.

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An in situ assessment of the roughness of a uniformly eroded cylindrical magnetron target

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We present an experimental approach for the in situ characterization of the surface roughness of an eroded magnetron target based on the reflectance pattern of a laser beam. The surface of the eroded region was modeled as a random arrangement of tilted plane facets with large surface extensions as compared to the wavelength of the laser. The target surface was hit by a laser beam and the reflection of the laser was captured on a screen. A simple algorithm was used to reconstruct the surface profiles form the intensity values reflected from the facets of the eroded surface. The surface profiles of Al, Cu and Ti targets were reconstructed under high vacuum conditions without disturbing the processing parameters of the magnetron sputtering plant. From these generated profiles, the roughness parameters, root mean square (rms) roughness, correlation length, skewness and kurtosis of different target materials were calculated by this in situ technique. The results measured with this in situ technique are in good agreement with comparable measurements using a mechanical profilometer outside the sputtering system. However, some deviation was observed in rms roughness measurement for surfaces with higher roughness and mean tilt angles. This method can be used for in situ monitoring of sputter targets during the operation to extract the surface features which may correlate with thin film properties and may precede dangerous events like target melting or other catastrophic failures.

Structure of nanocrystalline and amorphous thin films by electron diffraction in the TEM

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Electron diffraction provides a wealth of information about thin films. Computer programs facilitate unravelling this information. Phases are identified in samples ranging from thin single crystals [1] through polycrystalline films down to nanocrystalline thin films [2]. Phase fractions and the fraction of preferentially oriented components can be quantitatively determined from ring patterns of nanocrystals [2]. The whole diffraction pattern, containing diffuse rings of amorphous materials can be transformed to discover the local order manifested in pair distribution functions [3] that can be distinct from the average structure, which appears in the Bragg-peaks alone. Types and orientations of grain boundaries in polycrystalline films can be determined by combining diffraction data with imaging [4], and even more, they can be determined from diffraction data alone [5]. Grain boundaries, dislocations, segregations and other defects can also be qualitatively visualized using only diffraction data, without taking any images [6] better than as they appear in virtual bright field images. The talk will also present a new method to accurately find a pattern center, which is outside of the recorded pattern (when it is shifted out of the CCD, to protect the detector from the strong direct beam).

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A comparison of linearly combined nozzle model and full DSMC simulation result for thermal PVD (Physical vapor deposition)

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Physical vapor deposition (PVD) covers a broad range of vacuum coating process in which material is physically removed from a source by evaporation or sputtering. In this paper, we will mainly focused on PVD by thermal evaporation by heating. The source particles are then transported through a vacuum, and condensed as a film on the surfaces of substrate. Distribution of vapor particles that are deposited on the substrate surface is extremely important in semiconductor industry as well as newly booming OLED industry: it is important to accomplish uniformly distributed deposition.

This paper presents a gas kinetic study on high speed rarefied jets expanding into vacuum from nozzle exit. Based on the corresponding deposition simulation data for one nozzle jet simulation, this paper predicts a distribution result of multiple nozzle jet by linearly combining the simulation data of one nozzle. It is then compared with the simulation result of multiple nozzle jets.

Bird's direct simulation Monte Carlo (DSMC) method have been used for this study to understand the fundamental phenomena of nozzle jet and distribution of deposited materials. Evaporation pressure, number of nozzles, distance between the nozzle and substrates are considered in this study. Additionally, we vary exit nozzle geometries by tilting the nozzle with different angle to study the amount of shift of distribution for different conditions.

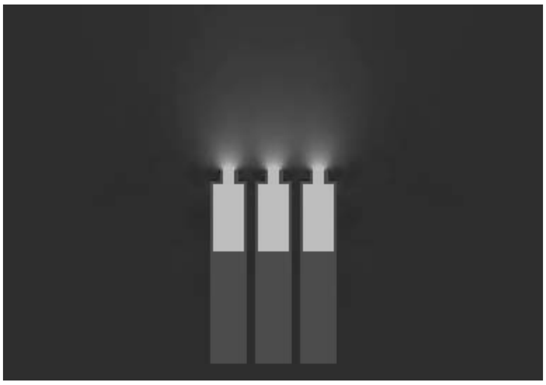
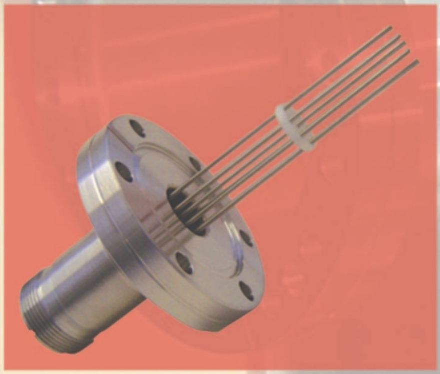
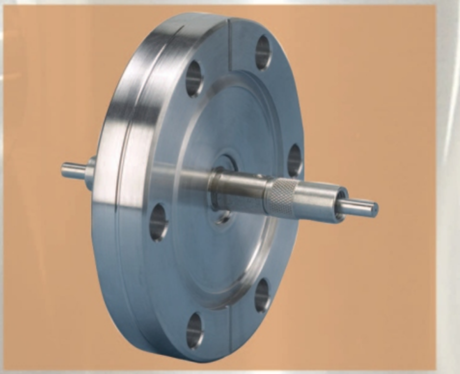
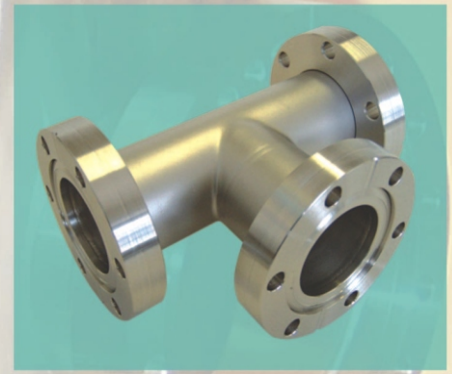


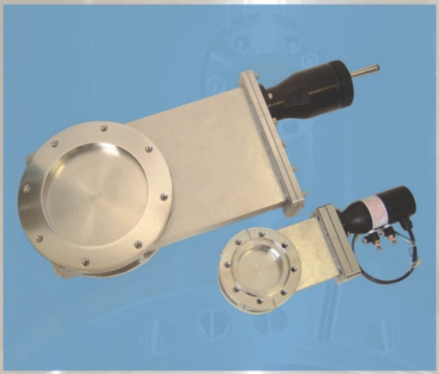
Fig. 1. Density contour of multiple nozzle jet in vacuum chamber from DSMC simulation result.

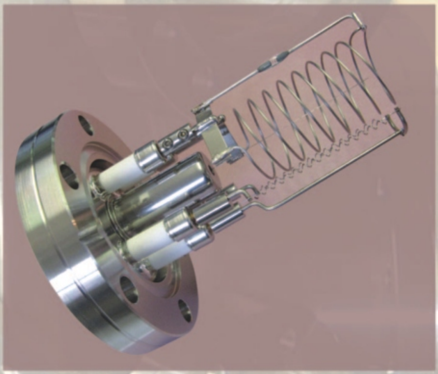
AUTHOR INDEX

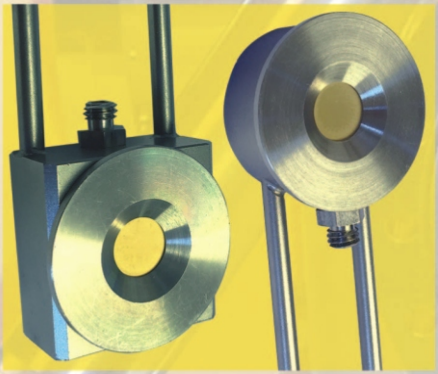


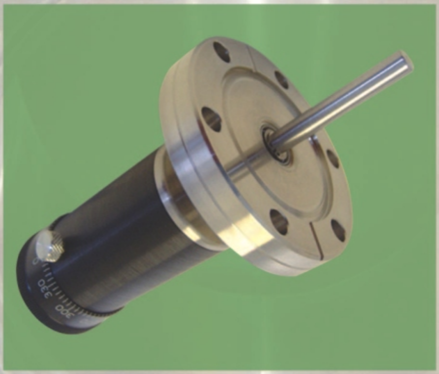












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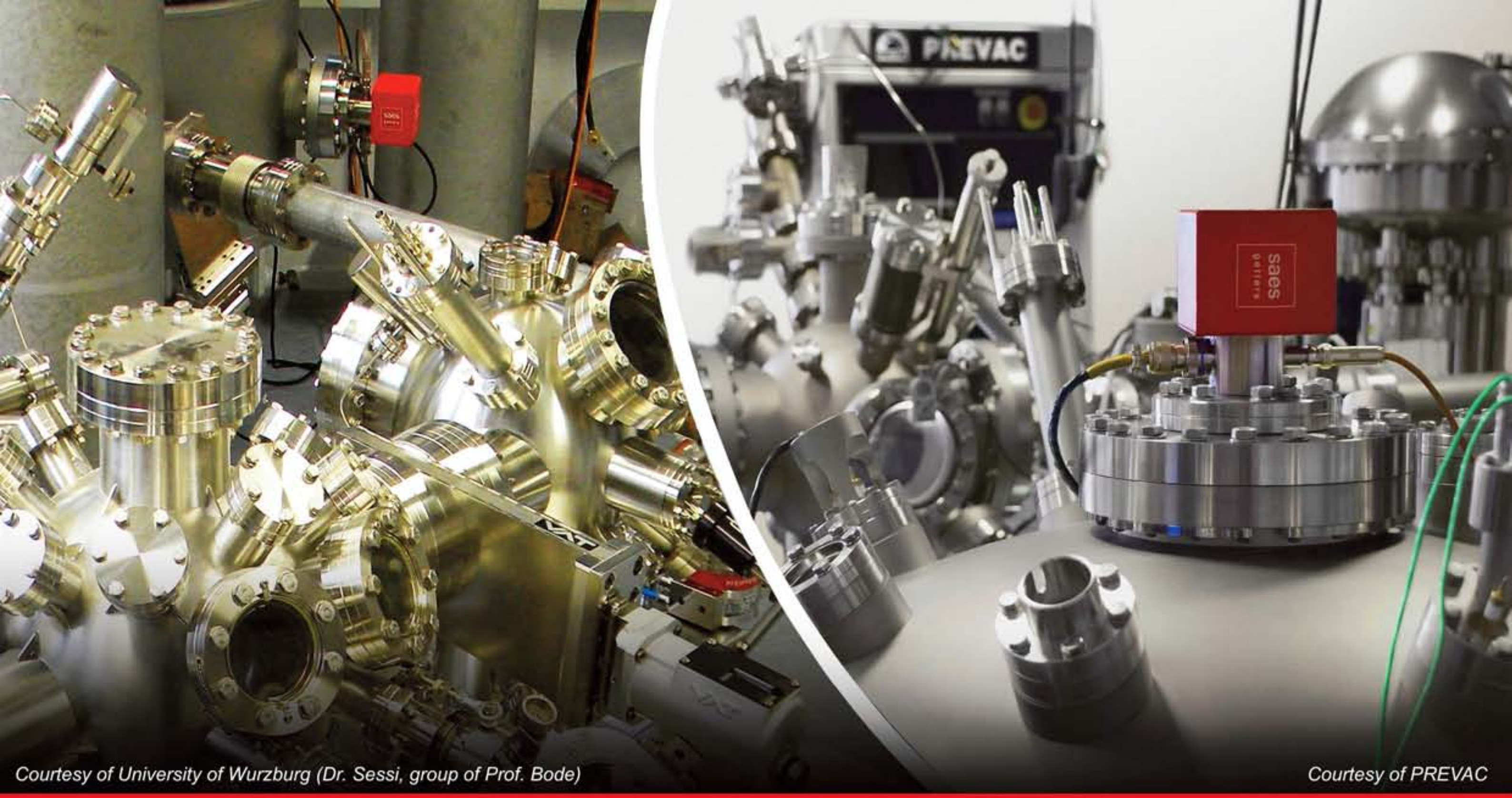


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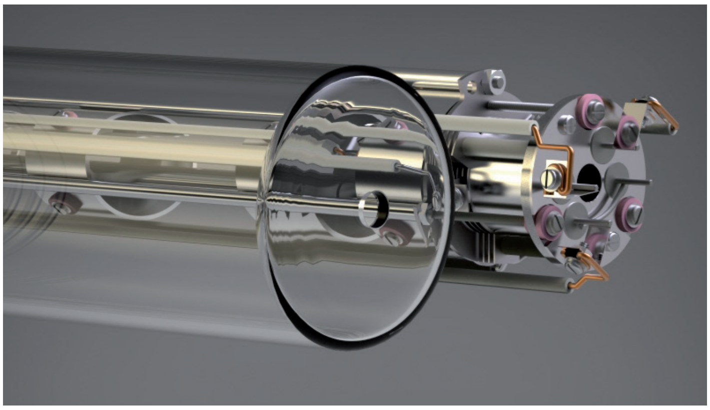

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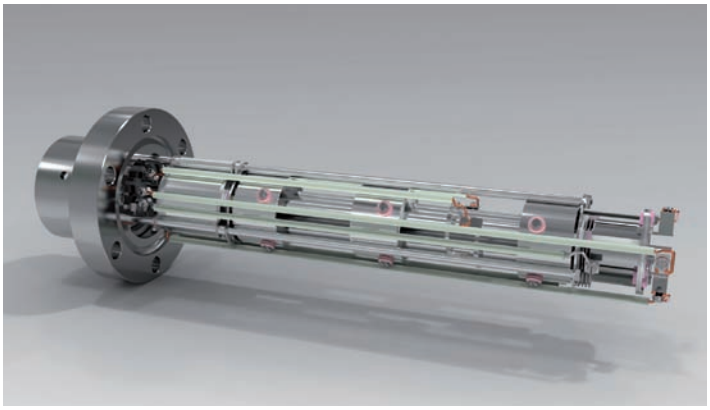


3F-PIC - pulse ion counting detection for fast event studies

- Ultra-fast pulse ion counting detection provides seven decade continuous dynamic range with optimum sensitivity at UHV/XHV.

W **www.HidenAnalytical.com** **E** **info@hiden.co.uk**

Pra.Ma.

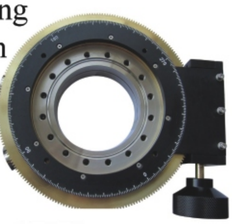
Via Carlo Pisacane, 1 – 23035 – SONDALO (SO) – ITALY - P.IVA IT00668970148
Phone +39 0342 802236 – Mobile +39 338 6496807 – Fax +39 0342 803365
http://www.pra-ma.com e-mail: info@pra-ma.com - office@pramashop.com

Catalog on http://www.pramashop.com

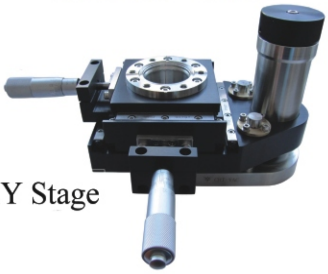

Z-Only Transporter

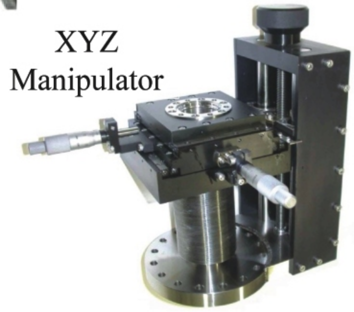

Rotary Drives


Linear Drives


Differential Pumping Rotation Platform

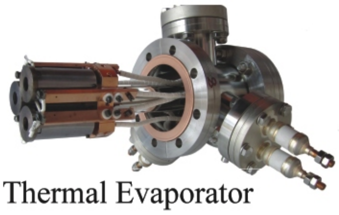

Magnetic Coupling Transporter


XY Stage

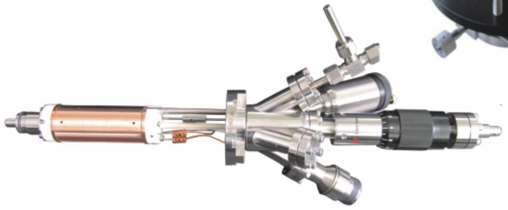

XYZ Manipulator

Various Linear Actuator


High Duty XYZ Manipulator


Thermal Evaporator


High Temperature Effusion Cell


Electron Bombardment Evaporator

Beam energy : 2keV (Max.)
Beam current: 10μA (Max.)
Beam size: < φ10mm
Focus: Yes


Ar Ion Gun

Electron energy: 0-30kV
Beam size: <φ100μm
Focus: Yes
Deflection: Yes


RHEED Electron Gun

Magnetron Sputter Target


Spherical Chamber


Box Chamber


Cylindrical Chamber

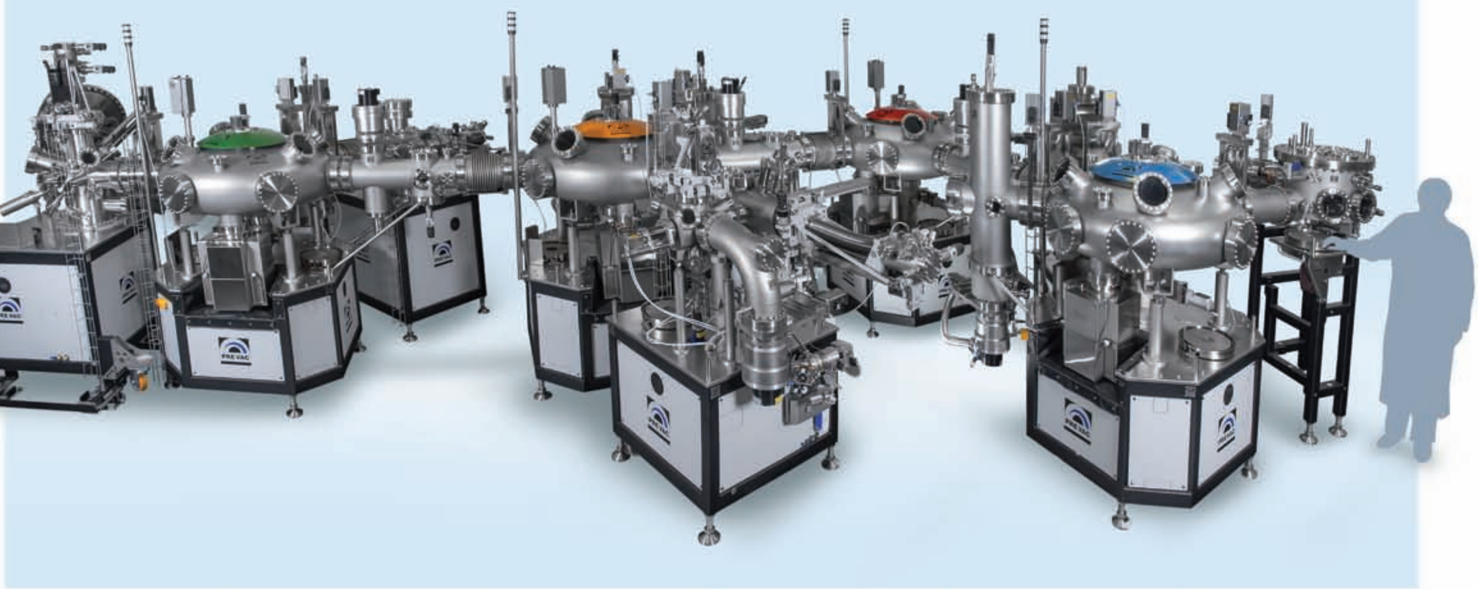
Pra.Ma was founded in 1994, built on the already established experience of dr. Mario da Prada in the sale of scientific instruments. The main focus of the company has always been the study of surfaces and thin films.

From 2015, Pra.Ma entered the field of vacuum, being agent of Hiden Analytical (RGAs) in Italy and Slovenia, and European reseller of Chi-Vac, which produces components and instruments for Ultra High Vacuum.

Distributor of

齐维
CHI–VAC

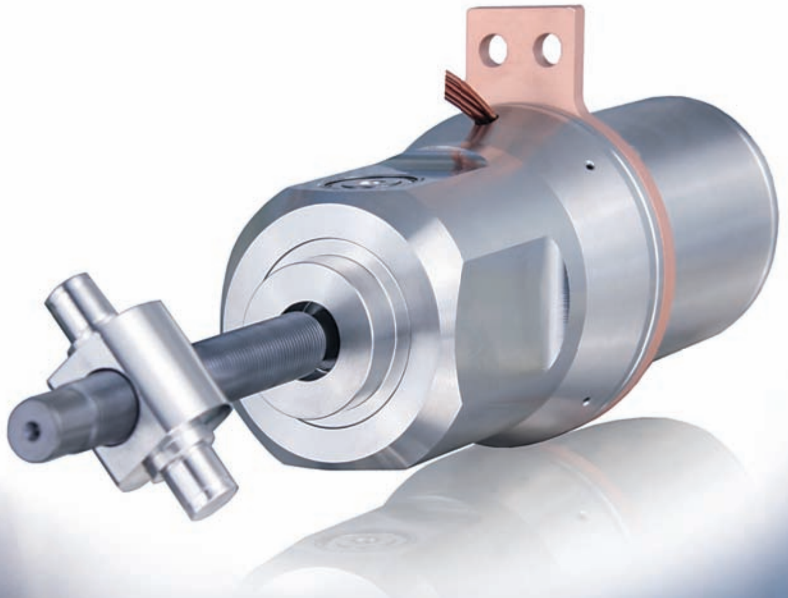
CHI-VAC
Research & Development Co.,Ltd.



Extreme. Precision. Positioning.

Stepper Motors for EXTREME Environments

Vacuum. Cryogenics. Radiation.



The VSS / VSH series extreme environment stepper motors are specially designed for Vacuum, Cryogenics and Radiation environments while maintaining high performance and long life.

Placing the motor directly in the environment simlifies the customers design by eliminating the need for cumbersome mechanics, feed-troughs and shields against heat and radiation.

From engineering to manufacturing, our facilities allow for greater flexibility in custom design and provide for a quick turn around.

Phytron has built a reputation for building motors for extreme environments since 1947.
Today, we continue to embody the same passion for quality and excellence while pursuing further challanges.

Phytron – A World Of Solutions.

Environment

- Vacuum to 10^{-11} hPa
- Winding-Temperature -270 °C to +300 °C
- Radiation hardened up to 10^{6} J/kg
- Clean room class 100

Design

- Diameters 19 to 125 mm
- Bake-out temperature up to 250 °C
- Outgassing TML 1 %, CVCM < 0,1 %
- Integrated Thermocouple
- Superconducting wire optional for T_C <18K
- Integrated Gearheads available

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E info@phytron.de

www.phytron.de


DISCOVER
VACUUM
SOLUTIONS

JAMP-9510F Field Emission Auger Microprobe

SCAN d.o.o., Preddvor
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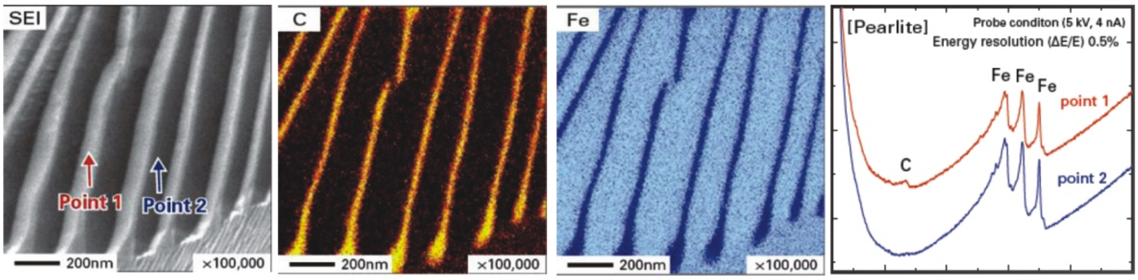
www.scan.si · info@scan.si

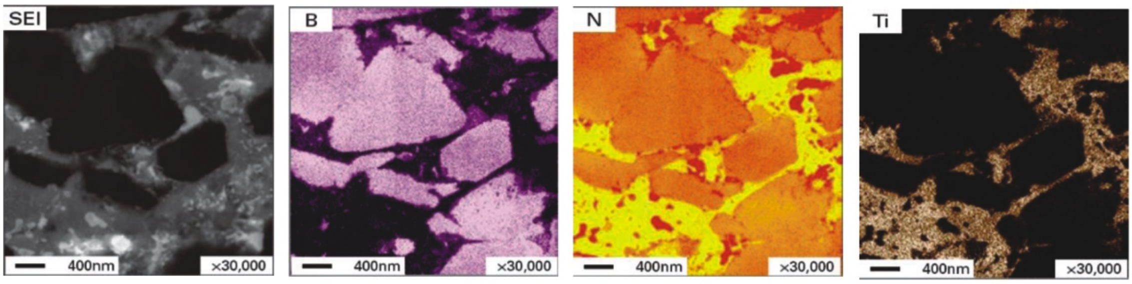
Field Emission Gun (In-lens - JEOL patent)
High resolution: 8nm
Hemispherical Analyzer (HSA)
Energy resolution 0.05 à 0.6% (ΔE/E)
BED, EBSD, fracturing device ...

High sensitivity mode for Auger map

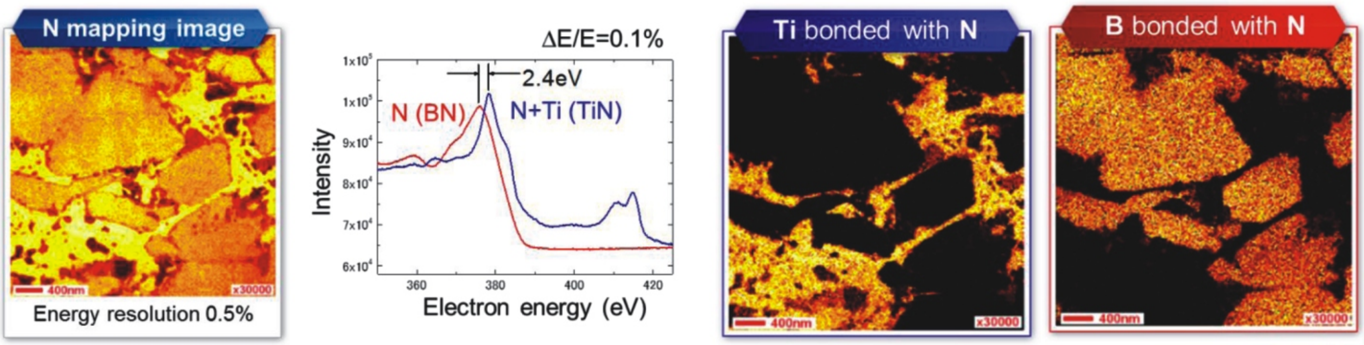


Trace element map

High energy resolution mode for Auger maps



Chemical state analysis (JEOL data base)



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