17th INTERNATIONAL CONFERENCE ON PLASMA PHYSICS AND APPLICATIONS

June 15 – 20
Magurele, Bucharest
ROMANIA

Book of Abstracts

Edited by:
Silviu-Daniel Stoica
Gheorghe Dinescu

National Institute for Lasers, Plasma and Radiation Physics

"Alexandru Ioan Cuza" University

Romanian Physical Society

We would like to thank the sponsors for their generous support:

Conference Chairs

Gheorghe Dinescu	National Institute for Lasers, Plasma and Radiation Physics, Bucharest, Romania
Gheorghe Popa	“Alexandru Ioan Cuza” University Iasi, Romania

International Scientific Committee

F. Arefi - Khonsari	Paris, France
T. Belmonte	Nancy, France
H. Biederman	Praga, Czech Republic
A. Bogaerts	Antwerpen, Belgium
M. Braic	Bucharest, Romania
V. Colombo	Bologna, Italy
M. Echim	Brussels, Belgium
P. Favia	Bari, Italy
E. Gogolides	Athens, Greece
C. Grisolia	Cadarache, France
H. Kersten	Kiel, Germany
L. Kravets	Dubna, Russia
A. Lacoste	Grenoble, France
C. Leys	Gent, Belgium
D. Maric	Belgrade, Serbia
T. Minea	Orsay, France
M. Mozetic	Ljubljana, Slovenia
C. Oehr	Stuttgart, Germany
M.C.M. van de Sanden	Eindhoven, The Netherlands
D.C. Schram	Eindhoven, The Netherlands
E. Stamate	Roskilde, Danemark
M. Vlad	Bucharest, Romania

Local Organizing Committee

T. Acsente	Natl. Inst. Lasers, Plasma & Radiation Physics, Bucharest
M. Bazavan	University of Bucharest, Bucharest
G. Borcia	“Alexandru Ioan Cuza” University, Iasi
V. Braic	Nat. Inst. Optoelectronics, Bucharest
A. Chiper	“Alexandru Ioan Cuza” University, Iasi
M. Cristea	University Polytechnica of Bucharest, Bucharest
A. Lazea-Stoyanova	Natl. Inst. Lasers, Plasma & Radiation Physics, Bucharest
C.P. Lungu	Natl. Inst. Lasers, Plasma & Radiation Physics, Bucharest
M. Magureanu	Natl. Inst. Lasers, Plasma & Radiation Physics, Bucharest
B. Mitu	Natl. Inst. Lasers, Plasma & Radiation Physics, Bucharest
M. Nistor	Natl. Inst. Lasers, Plasma & Radiation Physics, Bucharest
M. Osiac	University of Craiova, Craiova
L. Sirghi	“Alexandru Ioan Cuza” University, Iasi
F. Spineanu	Natl. Inst. Lasers, Plasma & Radiation Physics, Bucharest
C. Ticoş	Natl. Inst. Lasers, Plasma & Radiation Physics, Bucharest
I. Topala	“Alexandru Ioan Cuza” University, Iasi
S. Vizireanu	Natl. Inst. Lasers, Plasma & Radiation Physics, Bucharest
R. Vladoiu	Ovidius University, Constanta
G. Voitcu	Natl. Inst. Lasers, Plasma & Radiation Physics, Bucharest

Scientific Secretariat

C. Costin	“Alexandru Ioan Cuza” University, Iasi
S.D. Stoica	Natl. Inst. Lasers, Plasma & Radiation Physics, Bucharest

Table of contents

Invited lectures

Oral presentations

Regular contributions

Topic 1: Fundamental processes in plasmas, modeling and simulation, space plasmas

Topic 2: Gas discharge physics and plasma diagnostics

Topic 3: Plasma sources and reactors at low and atmospheric pressure, dusty plasma

Topic 4: Plasma processing, surface modification, deposition, etching

Topic 5: Biological and medical applications of plasmas, plasmas in liquids

Topic 6: Application of plasmas in nanoscience and nanotechnology

Topic 7: Fusion plasma physics and technology

Topic 8: Laser plasmas and their applications

Exhibition and companies

Invited lectures

I-01

Antibacterial activity of cold atmospheric plasma jets and novel drug-loaded nanoparticles embedded in scaffolds or patches

S. Maheux[1], G. Frache[1], J.-S. Thomann[1], G. Corne[1], T. Belmonte[2], F. Clément[3], J.-N. Audinot[1], D. Duday[1]

[1] *Luxembourg Institute of Science and Technology (LIST), Materials Research and Technology (MRT), Nano-enabled medicine and cosmetics group, and Environment Research and Innovation (ERIN), 41, Rue du Brill, L-4408 Belvaux, Luxembourg*

[2] *Institut Jean Lamour, Département CP2S, Equipe 201*
UMR 7198 CNRS - Université Lorraine
Parc de Saurupt - CS 5084054011 Nancy Cedex, France

[3] *Université de Pau et des Pays de l'Adour, LCABIE - IPREM / UMR 5254*
Technopôle Hélioparc2 Avenue du Président Angot, 64000 Pau, France
david.duday@list.lu

The use of plasma (ionized gas) devices as well as nanoparticles embedded in patches/scaffolds for bactericidal treatments are two very promising approaches for the next decades. However, a better understanding of the interaction of plasma effects and nanoparticle with bacteria, biofilms and healthy cells is needed before to go further in the clinical translation of these technologies. For cold atmospheric plasma applications, several approaches can be used to generate bactericidal effects from direct plasma treatments [1] to plasma activated medium [2].

In the first part of this presentation, the main different plasma approaches will be compared. Then our approach based on plasma treatment of liposome suspensions to obtain more quantitative data and a better understanding of interaction between cells and plasma effects will be briefly presented. Liposome's composition has been tuned in order to mimic different membranes of cells or extracellular vesicles. A very few papers are dealing with treatment of liposomes by atmospheric cold plasma [3, 4] but no one have investigated both simultaneously structural and chemical degradations of liposomes [5] and the effect of composition of the liposomes on their degradation by plasma.

In the second part of the presentation dealing with antibacterial effects of nanoparticles, the main approaches involving nanoparticles to generate bactericidal effects will be presented and compared. Then our approach to better understand the interaction of nanoparticles with cells will be presented. Penetration of silica based mesoporous nanoparticles with different films and payloads into cells is studied by using confocal laser microscopy, TEM and nanoSIMS.

In the last part, a few examples will be given showing how nanoparticles and cold atmospheric plasma can be combined to generate stronger or more selective bactericidal effects.

[1] S. Maheux, D. Duday, T. Belmonte, C. Penny, H.-M. Cauchie, F. Clément, P. Choquet, RSC Adv. **5**, (2015), 42135-42140
[2] J.L. Brisset, J. Pawlat, Plasma Chemistry and Plasma Process. **36**, (2016), 355-381
[3] P. Svarnas, S. H. Matrali, K. Gazeli, S. Aleiferis, F. Clément, S. G. Antimisiaris, Appl. Phys. Lett. **101**, (2012), 264103
[4] E.J. Szili, S.-H. Hong, R. D. Short, Biointerphases **10**, (2015), 029511
[5] S. Maheux, G. Frache, T. Belmonte, F. Clément, J.-S. Thomann, D. Duday, J. Applied Physics **49**, (2016), 344001

Keywords: *Bactericidal treatments, cold atmospheric plasma, nanoparticles, mechanisms.*

I-02

Deposition of polymeric films and co-deposition of nanocomposite coatings by means of a cold atmospheric pressure plasma jet

A. Liguori[1], T. Gallingani[2], R. Laurita[2], F. Barletta[2], M.L. Focarete[3,4], C. Albonetti[5], A. Pollicino[6], V. Colombo[1,2], M. Gherardi[1,2]

Alma Mater Studiorum-Università di Bologna, Bologna, Italy
[1]Industrial Research Centre for Advanced Mechanics and Materials
[2]Department of Industrial Engineering
[3]Department of Chemistry "G. Ciamician"
[4]Health Sciences and Technologies – Interdepartmental Centre for Industrial Research
[5]Research division on Nanotechnology of Multifunctional Materials, Bologna Italy
[6]Department of Industrial Engineering, Università di Catania, Italy
matteo.gherardi4@unibo.it

1. Introduction

Cold atmospheric plasmas (CAPs) are able to support innovative processes for material modification. While the use of low pressure plasmas is well assessed, CAPs potentialities are still largely unexplored notwithstanding their advantages of cost and ease of use. In this contribution, two different processes performed by means of a CAP jet are presented: (i) Acrylic acid (AA) plasma-polymerization for the deposition of polyacrylic acid (pPAA) coatings [1] and (ii) a single-step plasma process for the synthesis and co-deposition of nanocomposite coatings containing silver nanoparticles (AgNPs) embedded in a pPAA matrix, named AgNPs/pPAA coatings [2]. The morphology of the coatings was investigated by SEM analysis and optical profilometry, while their chemical composition was characterized by ATR-FTIR and XPS. The antibacterial efficacy of the co-deposited nanocomposite coatings was assessed against a test microorganism (*E. coli*) by means of agar disk diffusion tests.

2. Results and discussion

The thickness of the deposited pPAA coatings drastically increased by varying the mass flow rate of the precursor introduced into the plasma region and, even more relevantly, by increasing the deposition time. The chemical characterizations underlined that the deposited pPAA coatings presented a high amount of –COOH groups, generally higher than 21%.

The co-deposition process resulted in the production of nanocomposite coatings with AgNPs embedded into a pPAA polymeric matrix having thickness 30 µm after 3 min of plasma treatment; a high retention of –COOH groups in the pPAA chemical structure (21%) was observed also in this case. Finally, the antibacterial efficacy of the co-deposited AgNPs/pPAA coatings was demonstrated since a clear zone with no bacterial growth could be detected around the AgNPs/pPAA coated PE samples, while no growth inhibition area could be observed around the uncoated PE and pPAA coated PE samples.

[1] A. Liguori, A. Pollicino, A. Stancampiano, F. Tarterini, M. L. Focarete, V. Colombo, M. Gherardi, Plasma Process. Polym. 13, (2016), 03, 375-386

[2] A. Liguori, E. Traldi, E. Toccaceli, R. Laurita, A. Pollicino, M. L. Focarete, V. Colombo, M. Gherardi, Plasma Process. Polym. 13, (2016), 06, 623-632

I-03

Plasma electrolytic oxidation: stakes and limits

G. Henrion

Institut Jean Lamour, Nancy, France
gerard.henrion@univ-lorraine.fr

The Plasma Electrolytic Oxidation process (PEO) is a promising plasma-assisted surface treatment of light metallic alloys (e.g., Al, Mg, Ti). Although the PEO process makes it possible to grow oxide coatings with interesting corrosion and wear resistant properties, the physical mechanisms of coating growth are not yet completely understood. Typically, the process consists in applying a high voltage difference between a metallic piece and a counter-electrode which are both immersed in an electrolyte bath. Compared to anodizing, the main differences concern the electrolyte composition and the current and voltage ranges which are at least one order of magnitude higher in PEO. These significant differences in current and voltage imply the dielectric breakdown and, consequently, the appearance of micro-discharges on the surface of the sample under processing. Those micro-discharges are recognized as being the main contributors to the formation of a dielectric porous crystalline oxide coating. However, despite the PEO process makes it possible to achieve oxide layer exhibiting promising properties, the mechanisms that govern both the dielectric breakdown and the coating growth still remain not well understood. Moreover, the physics of the micro-discharges that govern the process is quite complex since those short lived micro-scale discharges develop in a multi-phase medium – including solid, liquid and gas -, with multiple interfaces.

The goal of this presentation is to shed light on this plasma assisted process with a plasma concern rather than a material science one, although both aspects can hardly be disconnected. After a brief presentation of what does really the PEO process consist of, the following aspects will be addressed:

- Fast video imaging (> 125 000 fps) coupled with optical emission spectroscopy, allows us to investigate the behavior and parameters of the micro-discharges. It will be shown for instance that discharges appear as cascades on the sample surface, with duration of ~ 100 µs separated by 100s µs. Estimation of the plasma electron density and temperature will be discussed from spectral line broadening; an attempt to determine the gas temperature will be reported as well

- PEO is still a high energy consuming process, which strongly limits its large sale industrial use. However, an analysis of the required energy for the various phenomena inherent to the process (oxidation, material melting, discharge ignition and sustainment, electrolyte heating and vaporization, etc.) shows that most of the supplied energy is not used for the oxidation process itself, but for many other physical and chemical phenomena resulting in large energy waste.

- From investigations of both the micro-discharges and the resulting oxide layer, empirical description of the breakdown and growth mechanisms will be discussed.

I-04

Low-pressure plasma synthesis of nanomaterials

O. Kylian, A. Choukourov, J. Hanus, P. Solar, H. Biederman

[1]*Charles University, Faculty of Mathematics and Physics, Department of Macromolecular Physics, V Holešovičkách 2, 180 00 Prague 8, Czech Republic*
ondrej.kylian@gmail.com

Non-equilibrium plasmas are nowadays routinely employed in already impressive range of technological applications where they are used for treatment of surfaces or for deposition of various kinds of thin films. Related to later numerous strategies were developed in the last decades for production of smooth thin films of metals, alloys, ceramics or plasma polymers. In addition, recent interest in the production of nanomaterials with unique optical, electrical and biomedical properties triggered off development of novel plasma-based approaches for synthesis of such materials. Among them vacuum deposition techniques based on so-called gas aggregation sources (GAS) of nanoparticles are highly interesting from the point of view of possible applications. The GAS systems based on magnetron sputtering were introduced by Haberland and his co-workers in the 90s of the last century [1]. In such sources the nanoparticles are created by spontaneous condensation of supersaturated vapor generated by magnetron. Created nanoparticles are then transported by a buffer gas flow through an orifice from the aggregation chamber to the main deposition in the form of focused beam of nanoparticles.

The key advantages of GAS systems responsible for their increasing popularity are wide range of materials from which nanoparticles may be produced including metals, metal-oxides or polymers as well as the possibility to combine them with other low pressure plasma-based deposition techniques (e.g. PE-CVD, magnetron sputtering). As it will be shown this enables fabrication of nanostructured and nanocomposite coatings with various architectures ranging from randomly distributed nanoparticles in a supporting matrix, sandwiched multi-layer structures, multi-component systems, nanocolumnar surfaces or gradient coatings. The application potential of such materials will be demonstrated on examples of coatings with tailorable and temporally stable wettability, coatings with antibacterial character or materials with tunable optical properties.

This work was supported by grant GACR 16-14024S from the Grant Agency of the Czech Republic.

[1] H. Haberland, M. Karrais, M. Mall, Y. Thurner, J. Vac. Sci. Technol. **A 10,** (1992), 3266

I-05

Process diagnostics during nanocarbon growth by RF plasma jet

B. Mitu, S.D. Stoica, S. Vizireanu, G. Dinescu

[1] *National Institute for Lasers, Plasma and Radiation Physics,*
409 Atomistilor Street, Magurele- Bucharest, 077125, Romania
mitub@infim.ro

The process diagnostic and control during material synthesis by plasma techniques is a key issue for obtaining advanced materials with improved performances and new functionalities [1-2]. The present work focuses on the investigation of a low-pressure RF plasma jet operating in argon and injected with hydrogen and acetylene as carbon precursors in order to establish a correlation between the material properties and the plasma characteristics.

We show that various forms of carbon-based materials, like amorphous hydrogenated carbon, carbon nanotubes and nanofibers, carbon nanowalls or combined growth can be obtained by tuning the experimental parameters used during plasma processing. Optical Emission Spectroscopy (OES), Langmuir probe measurements and Mass Spectrometry (MS) investigations were involved to determine the main plasma species assisting the deposition.

The identification of optimum plasma conditions for carbon nanowalls synthesis, as well as those conducting to carbon nonanofibres and combined growth will be revealed. Some of the potential applications based on the obtained materials will be discussed [3].

References

[1] S Vizireanu, S. D. Stoica, C. Luculescu, L. C. Nistor, B. Mitu, G Dinescu, Plasma Sour. Sci. Technol., 19, (2010) 034016

[2] S. Vizireanu, B. Mitu, C.R. Luculescu, L.C. Nistor, G. Dinescu, Surf. Coat. Technol. 211 (2012) 2-8

[3] T. M. Dinh, A. Achour, S. Vizireanu, G. Dinescu, L. Nistor, K. Armstrong, D. Guay, D. Pech, Nano Energy 10, (2014) 288-294

Keywords: *RF plasma jet, carbon nanomaterials, plasma diagnostics*

Acknowledgement

This work has been financed by the Romanian Ministry of Research and Innovation in the frame of Nucleus programme - contract 4N/2016 and by the Romanian Executive Unit for Financing Higher Education, Research, Development and Innovation under the PCCA 253/2014 contract.

I-06

Plasma deposition of antibacterial coatings

A. Nikiforov[1], Ch. Leys[1], I. Kuchakova[1], M. Vanneste[2], P. Heyse[2], M. De Vrieze[2], A. Zille[3], G. Dinescu[4], B. Mitu[4], M. Modic[5], U. Cvelbar[5]

[1] *Ghent University, Sint-Pietersnieuwstraat 41, 9000, Belgium*
[2] *CENTEXBEL, Technologiepark 7, BE-9052 ZWIJNAARDE, Belgium*
[3] *2C2T - Centre for Textile Science and Technology, University of Minho, Campus de Azurém, 4800-058 Guimarães, Portugal*
[4] *National Institute for Lasers, Plasma and Radiation Physics and Faculty of Physics, University of Bucharest, IO7*
[5] *Jozef Stefan Institute, Jamova Cesta 39, Ljubljana 1000, Slovenia*
anton.nikiforov@ugent.be

1. Introduction

Industrial demands for antibacterial coatings are intensively growing during last decade. One of most promising areas of applications is hospital use and health care. Metal compounds like Ag nano-particles (AgNPs) or Cu nano-particles (CuNPs) are well known for intrinsic antimicrobial property. Unfortunately, the emergence of NPs cytotoxicity goes against some practical applications. Correspondingly, it is important to fabricate new class of antibacterial surfaces with firmly loading of nano-materials and with precise release of antibacterial constituent from the materials. In this way, the release of NPs to the microenvironment is limited and only ions are released locally.

2. Results and discussion

We proposed plasma assisted route to engineer polymer films and non-woven fabrics with antimicrobial nano-composite coatings [1,2]. Atmospheric pressure plasma is used for deposition of nano-composites. Nano-particles Ag, Cu and ZnO are tested as antimicrobial agents. Nanoparticles are incorporated in between two layers of organosilicon film with impregnation process or alternatively through aerosol injection step. Incorporation is made in “sandwich-like structure” where top layer coating (barrier) is used for precise control of metal ions release and reservation layer of about 200 nm is used for NPs load. Antibacterial efficiency of the samples against different microorganisms shows that all treated samples exhibit higher antibacterial efficiency against *S. aureus*. The antibacterial efficiency of AgNPs and CuNPs is above 90% which is practically interested for medical application while ZnONPs shows lower antibacterial efficiency [3]. Cytotoxicity of the coatings and materials is investigated for different deposition conditions and analyzed in terms of possible medical applications.

This work is supported by the M-Era.Net project IWT 140812 “PlasmaTex”.

[1] X. Deng, A. Nikiforov, D. Vujosevic, V. Vuksanovic, B. Mugoša, U. Cvelbar, N. De Geyter, R. Morent, Ch. Leys, Materials Letters. **149**, (2015), 95-99
[2] X. Deng, A. Yu Nikiforov, T. Coenye, P. Cools, G. Aziz, R. Morent, N. De Geyter & Ch. Leys, Scientific Reports. **1**, (2015)
[3] A. Nikiforov, X. Deng, Q. Xiong, U. Cvelbar, N. DeGeyter, R. Morent, Ch. Leys, J.Phys. D: Appl. Phys. **49**, (2016), 204002

Keywords: *nano-composite, antibacterial biomaterials, plasma deposition*

I-07

Time resolved optical spectroscopy of high frequency atmospheric pressure plasma jets

N. Puač[1], D. Maletić[1], N. Selaković[1], G. Malović[1] and Z.Lj. Petrović[1,2]

[1]Institute of Physics, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia
[2]Serbian Academy of Sciences and Arts, Knez Mihailova 35, 11000 Belgrade, Serbia
nevena@ipb.ac.rs

Low temperature plasma systems that operate at atmospheric pressure are nowadays in the forefront of the plasma applications that involve medicine, biology, stomatology, food industry and, lately, agriculture. Until now various types of plasma sources operating at atmospheric pressure were used for medical and dental applications [1-4]. The variety of the atmospheric plasma sources is the result of their simple construction and a relatively low price. The most common devices are atmospheric pressure plasma jets (APPJ). Usually APPJ are relatively small in diameter (order of few mm), but with chemistry rich in RONS (N, O, N^+, O^+, N_2^+, O_2^+, O_3, NO etc).

In our laboratory we have studied several types of APPJs with different electrode configurations and designs [5-7]. The detailed diagnostics was necessary in order to efficiently use them in biomedical applications. The electrical properties were mainly obtained by using current and voltage probes, plasma chemistry was investigated by using mass energy spectroscopy and time and spatial profiles of emission coming from the discharge were recorded by an ultra fast ICCD. An interesting feature of the APPJ is that even if jet is seen as a continuous plasma flow it is in fact composed of sequences of fast moving pulsed atmospheric-pressure streamers (PAPS) or plasma “bullets”. Here we will present results of time and spatially resolved optical spectroscopy of several geometries of APPJs obtained by using fast imaging.

Acknowledgments: This research has been supported by MESTD projects III41011 and ON171037 and SASA project F 155.

[1] G. Lloyd, G. Friedman, S. Jafri, G. Schultz, A. Fridman and K. Harding, Plasma Process. Polym, **7**, (2010), 194–211
[2] M. Vandamme, E. Robert, S. Dozias, J. Sobilo, S. Lerondel, A. Le Pape and J-M. Pouvesle, Plasma Medicine, **1**, (2011), 27–43
[3] N. Puač, Z. Petrović, G. Malović, A. Đorđević, S. Živković, Z. Giba and D. Grubišić, J. Phys. D: App. Phys., **39**, (2006), 3514-3519
[4] E. Simoncelli, D. Barbieri, R. Laurita, A. Liguori, A. Stancampiano, L. Viola, M. Gherardi and V. Colombo, V. Clinical Plasma Medicine, **3** (2), (2015), 77–86
[5] N. Puač, D. Maletić, S. Lazović, G. Malović, A. Đorđević and Z.Lj. Petrović, Appl. Phys. Lett., **101**, (2012), 024103
[6] D. Maletić, N. Puač, N. Selaković, S. Lazović, G. Malović, A. Đorđević and Z.Lj. Petrović, Plasma Sources Sci. Technol., **24**, (2015), 025006
[7] M. Gherardi, N. Puač, D. Marić, A. Stancampiano, G. Malović, V. Colombo and Z.Lj. Petrović, Plasma Sources Sci. Technol., **24**, (2015), 64004

I-08

Bonding of composite materials by means of atmospheric plasma jet

J. Pulpytel[1], F. Arefi-Khonsari[1]

[1]Sorbonne Universités, UPMC Univ Paris 06, CNRS, Laboratoire Interfaces et Systèmes Electrochimiques, 4 place Jussieu, F-75005, Paris, France
jerome.pulpytel@upmc.fr

Atmospheric pressure plasma jet (APPJ) are nowadays used to promote the adhesion of composite materials, such as polymer/rubber or polymer/metal hybrid structures. Such materials are the key of success for the new developments in the industrial sector of transportation, e.g. the replacement of metals parts by polymers lead to weight savings for vehicles and therefore to reduction of fuel consumption [1].

APPJs are very attractive for industrial in-line treatments because no vacuum is required, and the very short treatment times are compatible with the line speed of manufacturing industry. Moreover, since plasma jets are produced inside specific devices, their properties are usually not or weakly affected by the distance between the source and the substrate, which is a requirement to treat 3D objects with complex shapes (fig.1).

In this work, we will present different results and discuss on the role of plasma treatments and the induced surface modification of substrates to promote adhesion between different composite materials [2].

Fig 1. Hybrid load bearing structural part treated by APPJ

[1] S.T. Amancio-Filho, J.F. dos Santos, Polym. Eng. Sci. (2009), 1461-1476
[2] WO2013178538A1, H. Decorps, D. Doisneau, E-A. Filiol, J. Pulpytel, X. Callies, F. Arefi-Khonsari, L. Henao, O. Carton, (2013)

Keywords: *Atmospheric Pressure Plasma Jet, Adhesion, Surface treatments, Thin films, Polymer, Rubber, Metal*

I-09

Plasma non-equilibrium at work: key to success of energy technologies?

R. van de Sanden

Dutch Institute for Fundamental Energy Research, 5612 AJ Eindhoven,
and Department of Applied Physics, Eindhoven University of Technology, The Netherlands
M.C.M.vandeSanden@differ.nl

The use of plasma non-equilibrium in the mitigation of the enormous heat and particles fluxes in divertor sections of fusion reactors is probably the key to the success of fusion. Detailed studies on plasma detachment in combination with advanced control and the use of alternative divertor concepts are needed to provide answers to this fusion challenge. Some of the highlights in recent years investigated at the Plasma-Surface-Interaction facilities (Magnum-PSI and Pilot-PSI) of the DIFFER institute will be discussed.

On the shorter term sustainable energy generation by means of photovoltaics or wind, will form a significant part of the energy mix. The intermittency as well as the temporal variation and the regional spread of this energy source, however, requires a means to store and transport energy on a large scale. Moreover, when fossil fuels resources dry up, ways of carbon dioxide re-use to provide platform molecules will be required. In this presentation plasma chemistry as a means to convert renewable electricity into fuels and chemical feedstock will be discussed. Results on activation of CO_2 by microwave generated plasma, attaining over 50% energy efficiency will be discussed as a potential way of conversion of (intermittent) renewable electricity and the feedstock (CO_2, N_2 and H_2O) to fuels and chemicals.

I-10

Plasma biofilm decontamination: What happens to the underlying surface?

M. Modic[1,3], J. Kovač[1], J.R. Nicholls[2], U. Cvelbar[1], MI. Hasan[3] and J.L. Walsh[3,4]

[1]*Department of Surface Engineering and Electronics, Jozef Stefan Institute, Ljubljana, 1000, Slovenia*
[2]*School of Aerospace, Transport and Manufacturing, Cranfield University, Cranfield, MK43 0AL, UK*
[3]*Department of Electrical Engineering and Electronics, University of Liverpool, Liverpool, L69 3GJ, UK*
[4]*jlwalsh@liverpool.ac.uk*

1. Introduction

In natural and manmade environments, bacterial biofilms are ubiquitous, yet the significance of biofilm contamination in a clinical setting is often underestimated [1]. Such contamination presents a particularly virulent form of infection that is shielded from systemic antibiotics, providing ideal conditions for the emergence of multidrug-resistant colonies [2]. There is an unprecedented need to establish new strategies to manage the colonization of clinical surfaces with these complex bacterial communities. This contribution explores the use of cold atmospheric pressure air plasma for the inactivation of *Staphylococcus epidermidis* biofilms grown on titanium. Furthermore, the impact of the plasma treatment on the properties of the host surface is investigated.

2. Results

Using a 1D air plasma model [3], supported by experimental measurements, the chemistry of a Surface Barrier Discharge (SBD) suitable for biofilm inactivation was shown to contain a wealth of long-lived species such as O_3, NO_2 and N_2O. Under the influence of a convective flow, the presence of species that are traditionally considered to be too short-lived to reach a downstream sample are predicted, *e.g.* OH. [4]

The SBD system was shown to be highly effective for the decontamination of *Staphylococcus epidermidis* biofilms, achieving a multiple log reduction within 60 seconds of exposure. Given that the surface composition and morphology are key factors influencing biofilm formation, the impact of the plasma decontamination process on the surface characteristics was assessed and shown to induce considerable changes. The impact of these changes on the ability of bacteria to adhere to plasma treated titanium surfaces was examined. It was shown that biofilm formation on surfaces subjected to the plasma treatment was found to be accelerated in comparison to untreated surfaces.

3. Summary

This study demonstrates that cold air plasma is an effective tool for biofilm elimination on clinically relevant surfaces, yet the choice of plasma system must be carefully considered as such treatments can significantly alter the ability of bacteria to attach to the surface.

[1] D. Lindsay, A. von Holy, Journal of Hospital Infection. **64**, (2006), 313-25
[2] J. Davies, D. Davies, Microbiol. Mol. Biol. Rev. **74**, (2010), 417-33
[3] M. Hasan, J.L. Walsh, J. Appl. Phys. **119**, (2016), 203302
[4] M. Hasan, J.L. Walsh, Appl. Phys. Lett. **110**, (2017), 13410

I-11

Extreme Light Infrastructure – Nuclear Physics (ELI-NP): status and perspectives

N.V. Zamfir

ELI-NP, National Institute for Physics and Nuclear Engineering, Bucharest-Magurele, Romania
victor.zamfir@eli-np.ro

Extreme Light Infrastructure – Nuclear Physics (ELI-NP), a new Research Center under construction in Bucharest-Magurele, will use extreme electromagnetic fields for nuclear physics research. The status of the Project implementation, which started in 2013, will be presented. The new Center, valued approximately 300 Meuros, will be operational in 2019. At ELI-NP, a high power laser system (2x10PW) together with a very brilliant gamma beam (up to 20 MeV) are the two main pieces of research equipment and their targeted operational parameters will be described. The related experimental set-ups under implementation will be presented, together with the main directions envisioned in both fundamental and applied research.

Oral presentations

O-01

Tailoring the morphology and structural properties of tungsten nanoparticles produced by magnetron sputtering and gas aggregation

T. Acsente[1], E. Matei[2], C. Logofatu[2], L.C. Nistor[2], R.F. Negrea[2], R. Birjega[1], C. Grisolia[3], and G. Dinescu[1]

[1]INFLPR, Atomistilor 409, RO077125, Magurele-Bucharest, Romania
[2]INCDFM, Atomistilor 105, RO077125, Magurele-Bucharest, Romania
[3]IRFM, CEA/Cadarache - bât. 513, F-13108, Saint Paul lez Durance, France
tomy@infim.ro

We present the synthesis of tungsten nanoparticles (WNPs) with various morphologies using a cluster source based on condensation in a flow of argon of the metallic vapours produced by magnetron sputtering. The cluster source consists in a cylindrical aggregation chamber with water cooled stainless steel walls, axially enclosing a magnetron sputtering gun equipped with a tungsten target. Facing the target is mounted a conical shaped nozzle, ending in a 2 mm diameter orifice, through which the communication with a vacuum deposition chamber is performed. The pressure difference between the cluster source (80 Pa) and the deposition chamber (0.5 Pa) drives the WNPs in the deposition chamber, where they are collected on substrates. Synthesis of WNPs was performed using both continuous and pulsed modes of the radiofrequency power (13.56 MHz) applied to the magnetron discharge. In the continuous mode the applied powers were 60 W and 100 W, while in the pulsed mode the mean power was 60 W ($t_{ON} = t_{OFF} = 0.2$ s, P_{max}=120 W). The WNPs were investigated by Analytical High Resolution Transmission Electron Microscopy, X-ray Diffraction and X-ray Photoelectron Spectroscopy. The continuous plasma mode leads to WNPs with flower-like (60 W) and concave hexapod (100 W) shapes. These nanoparticles present a dendritic growth, specific for W deposited by sputtering at high pressures. The WNPs obtained in pulsed mode are single crystalline with cube-octahedral shape, suggesting a strong heating of the nanoparticles in the pulsed plasma, followed by their recrystallization. All types of WNPs contain both αW (stable) and βW (metastable) phases. The flower like and hexapode nanoparticles are assembled from around 5 nm W grains. These are arranged in nanoflowers in a slightly textured or totally disordered manner, while in the nano-hexapods the order increases substantially. A remarkable result is the high purity of the βW phase in the concave hexapod WNPs (αW phase being only residual); also, we note the stability of this phase over two years. XPS investigations show the incorporation of small amounts of oxygen in WNPs during their synthesis. This result, in correlation with the decrease in time of the deposition rate, suggest that the residual oxygen inside the cluster source may play an active role in the nucleation of the WNPs.

The presented results show the ability of this synthesis method to produce tungsten nanoparticles with pre-determined shape and structure.

Acknowledgements: This work was financed by the Romania Ministry of Research and Innovation in the frame of Core Programs 4N/2016 (INFLPR), PN16-480102 (INCDFM), Romania France cooperation project IFA-CEA code C5-07/2016, and by the A*MIDEX project(n°ANR-11-IDEX-0001-02) funded by the “Investissements d’Avenir” French Government program.

Keywords: *Tungsten nanoparticles, Magnetron sputtering, Gas aggregation.*

O-02

1D Particle in Cell (PiC) Simulation of Slow Mode Shock in Magnetized Plasma

T. Ahmadi[1]

[1] *Saint Petersburg State University, Saint Petersburg, Russia*

[1] *st022109@student.spbu.ru*

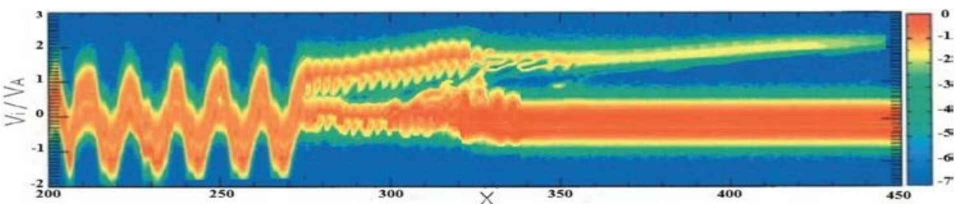
1. Introduction

In this work, we investigated the effect of anisotropy and shock angle on the shock structure by using PIC simulation. The dynamics of slow shocks are examined using PIC which uses a conventional adiabatic fluid model for the massless electrons, so the shock dissipation is provided by the ion dynamics alone. The PIC method treats both electrons and ions kinetically using the same techniques. The simulations are 1D in space (x) but have three components of velocities and two components of fields. The upstream magnetic field is in the x- z plane at an angle with respect to the x axis. The simulations are carried out in the normal incidence frame and the shock is formed using the piston method by injecting the upstream plasma from the right simulation boundary and reflecting it off the piston at the left boundary. The shock forms through the interaction of the incident and reflected ion streams via ion inertial Length waves on the Alfvén branch that propagate at large angles with respect to the magnetic field.

2. Results

Before modeling the structure of shock in 1D PiC (particle in cell) code, the solution of Rankine-Hugoniot equations has been gotten [1]. For steady one-dimensional flow, equations relating initial and final conditions are readily derived. A useful way to visualize the various solutions of the RH relations is to plot the square of upstream modified intermediate Mach number versus downstream value. Here intermediate Mach number refers to the flow speed in shock rest frame divided by the modified intermediate speed ($\mathrm{V_{I0}}\sqrt{1-(\beta_{\parallel}-\beta_{\perp})/2}$) where V_{I0} is the intermediate speed in an isotropic plasma, and $\beta_{\parallel}, \beta_{\perp}$ are plasma parameters in the direction parallel and perpendicular to the magnetic field.

Strong localized electron/ion heating occurs in the PIC simulations. In the shock ramp, spiky structures occur in density and electron parallel temperature like other similar works [2]. The downstream electron parallel temperature anisotropy affects the shock structure, it has been shown that a slow shock can form in the hybrid simulation by including the electron full pressure tensor calculation to produce a downstream state (parallel temperature > perpendicular temperature) that mimics the PIC results. The following figure is the ion phase diagram at the middle of simulation ($t\omega_{ci}$=945).



[1] Karimabadi H, Temperature anisotropy effect and generation of anomalous slow shock, GRL 20, (1995)V 22

[2] Yin L, Kinetics Alfven waves and electron physics, PHYSICS OF PLASMAS 14, (2007) 062105

O-03

Understanding the bullet evolution and its interaction with dielectrics in a capillary helium plasma jet

C. Anastassiou[1,*], C. Lazarou[1], A. S. Chiper[2], V. Pohoata[2], I. Mihaila[3], I. Topala[2] and G.E. Georghiou[1]

[1] *FOSS Research Centre for Sustainable Energy, Department of Electrical and Computer Engineering, University of Cyprus, Nicosia, 1678, Cyprus*
[2] *Iasi Plasma Advanced Research Center (IPARC), Faculty of Physics, Alexandru Ioan Cuza University of Iasi, Iasi 700506, Romania*
[3] *Integrated Center of Environmental Science Studies in the North-Eastern Development Region (CERNESIM), Alexandru Ioan Cuza University of Iasi, Iasi 700506, Romania*
[*] *anastassiou.charalambos@ucy.ac.cy*

In the last two decades, the atmospheric pressure plasma jet has gained much attention, due to its low production cost and the wide range of applications such as plasma medicine, local surface modification, local sterilization etc. The plasma jet device has been extensively studied and significant understanding has been gained through analytical/simulation models and experiments. However, deep understanding of the detailed mechanisms of plasma jet evolution and its interaction with material surfaces needs further research.

A two dimensional axisymmetric plasma fluid model was used [1], in order to study the evolution and interaction of a capillary helium plasma jet with a dielectric surface. In Figure 1, the plasma jet device and the distribution of air concentration in the domain are presented. The results of the simulation have been verified with experimental results.

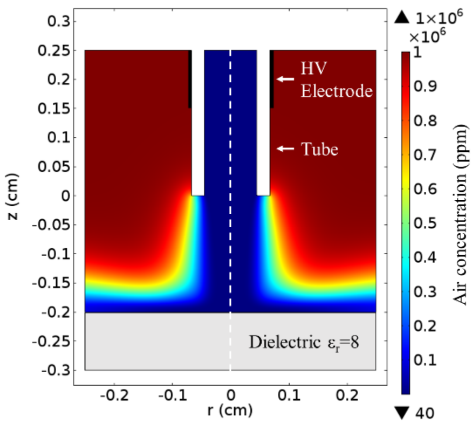


Figure 1: Simulation domain of the capillary plasma jet device and the air concentration (ppm) in the domain.

The simulation results showed that (during the discharge) the plasma bullet propagates towards the dielectric surface and has a torus like shape centred on the axis of symmetry of the tube. When the plasma bullet almost reaches (~50 μm) the dielectric, its propagation continues tangentially along the dielectric surface. For the interpretation of the results, the most important reaction pathways for the plasma bullet propagation have been studied, as well as the dependence of these reactions on the electric field and the air concentration in the domain. This fundamental analysis provides useful insight behind the evolution and interaction of the plasma bullet with dielectric surfaces, which is an important prerequisite for developing and optimizing existing applications of the plasma jet.

This work was supported by the European Union under Horizon 2020, MSCA-IF-2016, grant number 703497.

[1] C. Lazarou, T. Belmonte, A. S. Chiper and G. E. Georghiou 2016 *Plasma Sources Sci. Technol.* **25** 055023

O-04

Study of the plasma polymerization of 3-aminopropyltrietoxysilane (APTES) by an open-air atmospheric arc plasma jet for in-line treatments

S. Ben Saïd*, F. Arefi-Khonsari, J. Pulpytel

[1] *Sorbonne Universités, UPMC Univ Paris 06, CNRS, Laboratoire Interfaces et Systèmes Electrochimiques, 4 place Jussieu, F-75005, Paris, France*

bensaidsarab@gmail.com

Non-equilibrium atmospheric pressure plasma jet (APPJ) are extensively used for many in-line industrial treatments related to cleaning, bonding, surface activation or coating. In this work, an open-air arc plasma jet has been used to polymerize 3-aminopropyelthrietoxysilane (APTES), which is the most commonly used reagent to functionalize silica surfaces with amine groups, on various substrates from air/APTES mixtures.

Nitrogen containing silicon oxide coatings have indeed many interesting applications ranging from cell culture or protein adhesion to bonding, and the challenge of plasma deposition is to control the retention of functional groups to satisfy the desired application. The plasma jet was generated by introducing 1000 L/h of compressed air into a blown arc plasma torch, with a pulse frequency of 25 kHz. The precursor was introduced as a vapor by using an evaporator system at heated 220°C for different APTES flow and a varied interval treatment. The pulsed arc plasma jet used in this work has been characterized by different diagnostics elsewhere [1].

Briefly, the rotational and vibrational temperatures are respectively around 1000-1500K and 3000-4000K, while the emission spectra is dominated by the NO_2 continuum chemiluminescence of NO_2. Therefore, in such a hot and oxidative environment, one would not except to have any retention of amine groups which are sensitive to temperature and oxidation.

Indeed, APTES polymerization has been reported at atmospheric pressure in He DBD [2], N_2 plasma jet [3, 4] or post-discharge of Ar-O_2 (1-2%) or Ar-N_2 (8%) microwave plasma [5, 6], but not in hot air discharges.

The results show that the 500 nm thick plasma polymerized APTES coatings deposited by arc plasma jet are characterized by a relatively high content of nitrogen (2%-8%) as compared to the monomer (7%). The effect of the APTES Flow and the interval treatment on the structure of APTES films was investigated via ATR-FTIR, XPS and (SEM)-FEG in order to analyze the coatings and Both of XPS and ATR-FTIR analysis indicated the presence of amine nitrogen groups, up to 86% in the films [7], as well as amides or oximes.

[1] Dowling et al., Plasma Process. Polym. **8, (**2011), 717-727;
[2] Lachmann et al., Proc. of ISPC 20, **24-29 July**, (2011), Philadelphia, US;
[3] Alba-Elias et al., Thin Solid Films (2013), 540, 125-134;
[4] Mugica-Vidal et al., Surf. Coat. Technol. (2014), 259374-385;
[5] Lecoq et al., Plasma Process. Polym. (2013),10, 250-261;
[6] Gueye et al., Proc. of ISPC 22, **5-10 July** (2015), Antwerp, Belgium;
[7] Ben Saïd et al., Plasma Process. Polym. (2016), 13(10), 1025-1035.

Keywords: *Atmospheric Plasma Jet, APTES polymerization, precursor.*

O-05

Reactive species in water activated by surface DBD plasma in air

A. Dascalu[1], A. Demeter[1], L. Sirghi[1, 2]

[1]*Iasi Plasma Advanced Research Center (IPARC), Faculty of Physics, Alexandru Ioan Cuza University of Iasi, Blvd. Carol I nr. 11, Iasi 700506, Romania*
[2]*lsirghi@uaic.ro*

Plasma treatment of water generates long-living reactive species as hydrogen peroxide H_2O_2, hydroxide OH^-, nitrites NO_2^-, nitrates NO^{3-}, and peroxynitrites/peroxynitrous acid ONOO-/ONOOH [1]. The water thus treated is called plasma activated water (PAW) and have applications in agriculture and medicine [2]. In the present work, we use a surface DBD plasma working in a closed volume of air (0.5 L) at atmospheric pressure to treat a small amount (5 mL) of deionized water. Then, the reactive species generated in water during the discharge and after the discharge was cut off are investigated by means of UV absorption spectroscopy. The surface DBD plasma was generated on a device formed by two copper electrodes (18 μm in thickness) deposited on the two sides of a thin polyimide (Kapton) foil (14 μm in thickness). The hot (on upper side) electrode was structured as 23 equidistant and parallel stripes (0.2 mm in width and 30 mm in length) with a gap width of 0.8 mm. The grounded electrode (on the bottom side) had a rectangular shape (30 mm ×24 mm). The discharge was powered (around 0.5 W) by a high voltage amplifier that applied on the DBD electrodes a sinusoidal waveform voltage with the peak-to-peak amplitude of 1700 V and at a frequency around 10 kHz. The water to be treated was placed in a small Petri dish (diameter of 40 mm) positioned side by side to the discharge device. The UV absorption spectra of PAW were fitted with Gaussian absorption peaks corresponding to absorption of H_2O_2, OH^-, NO_2^- and NO^{3-} reactive species. The measurements showed that the concentration of these reactive species rose during the discharge, but continued to rise for a few tenths of minutes when the water is kept in the closed post-discharge medium. Moreover, the measurements showed that these reactive species in the PAW stored in normal laboratory conditions have a very long life time, their concentration decreasing slowly in weeks after the treatment.

[1] D.P. Park, K. Devis, S. Gilani, C.A. Alonzo, A.J. Drexel, Plasma Institutem Drexel Universitym Philadelphia, USA, Current Applied Physics 13 (2013) S19-S29
[2] Fridman G, Friedman G, Gutsol A, Shekhter A B, Vasilets V N, Fridman A, Applied plasma medicine. Plasma Process. Polym. 5 (2008) 503–533.

Keywords: *plasma activated water, reactive species, surface DBD*

O-06

Plasma complexity: methods and observations

M. Echim[1, 2], E. Teodorescu[1], C. Munteanu[1], G. Consolini[3], T.T.S. Chang[4]

[1]*Institute of Space Science, Atomistilor 409, 077125, Magurele, Romania*
[2]*Royal Belgian Institute for Space Aeronomy, 1180 Brussels*
[3]*Istituto di Astrofisica e Planetologia Spaziali, Rome, Italy*
[4]*Kavli Institute for Astrophysics and Space Science, MIT, Cambridge, USA*
echim@spacescience.ro

Complexity is perhaps one of the few plasma physics topics where space plasma research contributes fundamental insight unmatched in laboratory and fusion plasmas. Nevertheless, complexity is a universal property of magnetized plasmas. Intrinsically interdisciplinary, the science of complexity has only recently been acknowledged by the space plasma community [1,2]. We first provide a definition of the relevant terminology and then give a brief review of data analysis methods adapted to capture signatures of complexity. We discuss analysis methods designed to extract the multi-scale behavior of magnetic fluctuations (Probability Distribution Functions – PDFs, fractals and multifractals) and discuss their importance for plasma turbulence and intermittency. The Rank Ordered Multifractal Analysis (ROMA) technique [3] is particularly optimized for the analysis of multi-scale plasma processes and complexity. ROMA extracts the topological properties of fluctuations based on their ranks and is not affected by the uncertainties of the classical partition (fractal) and structure function analysis whose statistics is dominated by the most numerous (small amplitude) fluctuations. We use ROMA to discuss two examples of plasma complexity observed in turbulent solar wind (from Ulysses data) and the terrestrial magnetosheath (from Cluster). We show that in both cases the topology of magnetic fluctuations changes significantly with scale, from kinetic to the magnetohydrodinamic range, with a clear cross-over behavior in between. The similarities between the ROMA spectrum of magnetic field fluctuations in the solar wind (whose characteristic turbulent scale/autocorrelation length, L, is of the order of 10^6 km) and the terrestrial magnetosheath (L~10^4 km) suggest a universal process, in coherence with another recent study [4].

[1] T.T.S. Chang, *Space Plasmas, Dynamical Complexity in*, Encyclopedia of Complexity and Systems Science, Springer, (2009), 8521-8554;

[2] T.T.S. Chang, An introduction to space plasma complexity, Cambridge University Press, (2015);

[3] T.T.S. Chang, and C.-C. Wu, *Rank-ordered multifractal spectrum for intermittent fluctuations*. Phys. Rev. E, **77**, (2008);

[4] T. Chang, C-C Wu, M. Echim, et al., *Complexity Phenomena and ROMA of the Earth's Magnetospheric Cusp, Hydrodynamic Turbulence, and the Cosmic Web*, Pure and Applied Geophysics, **172**, 7, (2015), 2025-2043.

O-07

Study of surface topography and antifungal activity of fluorocarbon nanostructures, formed on polyethyleneterephthalate surface by ion-plasma technique

V. Elinson[1], A. Lyamin[1], V. Kuzkin[1], E. Deshevaya[2], O. Silnitskaya[1]

[1]MoscowAviation Institute (National Research University),125993, Volokolamskoye Shosse, 4, Moscow, Russia
[2]Institute of Medical and Biological Problems RAS, 123007, Horoshovskoye Shosse, 76a, Moscow, Russia
dronozavr@inbox.ru

Duration of effective exploitation of polymeric materials and wares is connected with the processes of their destruction. Destruction under the influence of microorganisms (biodestruction) plays a special role in these processes. One of the most promising ways for fight with biodestruction is formation of barrier layers on the surface of polymers and wares, preventing adhesion of microorganisms on the surface, what, in its turn, prevents biofilms formation and the subsequent biodestruction [1].

Formation of nanostructured fluorocarbon films, obtained by ion-plasma technique with the use of two-component plasmaforming mixture $C_6H_{12} + CF_4$, containing the component for films deposition (C_6H_{12}) and the component for their etching (CF_4), allow to obtain the area of transient processes (from films deposition to films etching) which may be the base of barrier layer, preventing adhesion of microorganisms and, consequently, preventing biofilms formation [2].

The present paper is devoted to study of relief parameters of the surface of polyethyleneterephthalate (PET), as one of the widely used polymers, by atomic-force microscopy ("Veeco Dimension Icon 3110", Veeco Instruments, USA) and to study of antifungal activity of obtained fluorocarbon nanostructures. For contamination of the samples the suspension was used, containing the following straines: *Pennicillium expansum*, *Pennicillium aurantiogriseum*, *Aspergillus versicolor*, *Aspergillus sydowii* and *Cladosporum cladosporioides.*

Investigations confirmed the presence of area of transient processes with specific relief on PET surface, preventing fungal adhesion and providing antifungal activity of obtained nanostructures.

Key words: *polymers, adhesion, biodestruction, nanostructured fluorocarbon films, antifungal activity, atomic-force microscopy.*

[1] L.V. Didenko, T.A. Smirnova, N.V. Shevlyagina, G.A. Avtandilov, V.N. Tsarev, I.Yu. Lebedenko, V.M. Elinson and oth., Russian Journal of microbiology, epidemiology and immunobiology, (2015), 5, 64-69
[2] V.M. Elinson, L.V. Didenko, G.A. Avtandilov, A.Kh. Gaidarova, A.N. Lyamin, Bulletin of Experimental Biology and Medicine, vol 162,1, (2016) Microbiology and Immunology, 71-74

O-08

Characterization of a cylindrical shaped plasma jet with axisymmetric injection of precursors

E.R. Ionita[1], G. Dinescu[1], M.D. Ionita[1], B. Mitu[1], A.Y. Nikiforov[2], C. Leys[2] and I. Kuchakova[2]

[1]*National Institute for Laser, Plasma and Radiation Physics, Atomistilor 409, 077125, Magurele, Romania*
[2]*Department of Applied Physics, Ghent University, Sint-Pietersnieuwstraat 41 B4, 9000, Gent, Belgium*
ionita.rosini@infim.ro

In this work we present a plasma source which operate at atmospheric pressure, in a continuous flow of argon (1-10 slm). The discharge is capacitively coupled and powered by radio-frequency (RF) at 13.56 MHz in a range of forward power 2-25 W. The discharge configuration consists into cylindrical coaxial layout of two pipes (tube) with unequal diameters, which served as discharge electrodes. The electrode with the higher diameter is connected to the ground (GND) and the other electrode is connected to RF voltage, so it remains shielded GND electrode. The space for discharge is defined by inner diameter of GND electrode and outer diameter of RF electrode, here in space between the cylindrical electrodes is a gap of 1 mm, which means the inter-electronic distance of cylindrical capacitor. At one end, in between the two cylinders electrodes, the working gas (Ar) is inserted. Plasma generated between two cylindrical electrodes comes out to the other end, forming a circular plasma jet curtain. The intake of precursor gas is through inner of RF electrode. The vaporised precursor (HMDSO) is coercing to come into contact with plasma jet curtain, leading to decomposition and its polymerisation as a thin film onto the substrate. The plasma source was investigated as regarding its electrical properties (I - V characteristics, mean active power) and operating domain in respect to mass flow of the working gas and RF power. For the typical operation parameters, we show that only ¾ of the injected forward power is actually used in discharge. Evaluation of the treatment uniformity and meanings for increasing it are also reported.

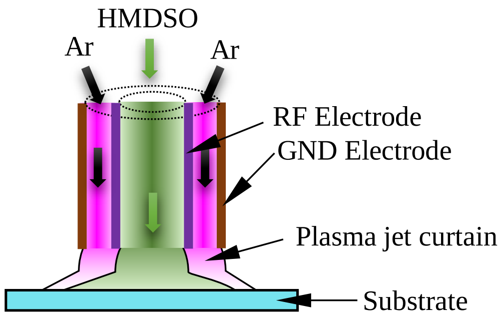


Figure 1. Detail of discharge configuration.

Acknowledgment

This work was performed in the frame of M-ERA.NET project PlasmaTex code IWT 140812, and in the frame of Nucleus programme-contract 4N/2016 -INFLPR financed by the Romanian National Authority for Research and Innovation.

Keywords: *plasma source; atmospheric pressure plasma jet; polymerization.*

O-09

Transient plasmas generated by femtosecond laser ablation of selected metals: Influence of the target physical properties on the plume dynamics

S.A. Irimiciuc[1,2], S. Gurlui[2], P. Nica[3], M. Agop[3], C. Focsa[1]

[1]*Univ. Lille, CNRS, UMR 8523 - PhLAM - Physique des Lasers, Atomes et Molécules, F-59000 Lille, France*
[2]*Atmosphere Optics, Spectroscopy and Lasers Laboratory, Faculty of Physics, "Alexandru Ioan Cuza" University, 700506 Iasi, Romania*
[3]*Department of Physics, "Gh. Asachi" Technical University, 700050 Iasi, Romania*
cristian.focsa@univ-lille1.fr

Langmuir Probe investigations were performed on laser produced plasma generated by femtosecond laser ablation on metallic targets (Mn, Ni, Cu, Al, W, Te and In). The aim of this work was to explore the link between target physical properties (atomic mass, electrical and thermal conductivities, melting, boiling points etc.) and the plasma plumes dynamics. The experiments were performed in similar conditions of laser fluence (~ 8.5 $J.cm^{-2}$) and background pressure (p = 10^{-5} Torr) for all the investigated targets. By sampling the ionic and electronic temporal traces at 6.5 mm from the target and reconstructing the *I-V* characteristics at different moments during plasma expansion (t = 2 - 10 μs), we were able to determine the temporal evolution of various plasma parameters (i.e. T_e, n_i, v_{th}). Additionally, the ionic temporal traces were analyzed in terms of a shifted Maxwell-Boltzmann distribution function and additional information concerning the ion temperature and drift velocity was extracted. By positively biasing the probe, the collected charge – probe voltage characteristic is in general vertically shifted and for low negative probe potentials, an effect consisting in an abnormal decrease of the ion current is observed. Periodic falls of total collected charge vs. probe voltage are experimentally recorded, the effect being more significant at high background pressure, result attributed to secondary ionizations.

Some plasma parameters were found to be dependent on the target physical properties. Supposing a direct connection between the probe ionic signal and the charge carrier mobility in the target, a logarithmic fit was proposed for the plasma potential variation with electrical conductivity, while a derivative of this function was applied for the electron temperature [1]. The saturation charge derived from the time-integrated probe ionic signals was found to be influenced by the electrical conductivity of the target and also by the atomic weight of the metal.

[1] S.A. Irimiciuc, S. Gurlui, G. Bulai, P. Nica, M. Agop, C. Focsa, Appl. Surf. Sci., in press (2017).

Keywords: *femtosecond laser ablation, transient plasma dynamics, Langmuir probe.*

O-10

Estimation of the tritium retention in ITER Tungsten divertor target using macroscopic rate equation simulations

A. Hodille[1], E. Bernard[2], S. Markelj[3], J. Mougenot[4], C.S. Becquart[5], R. Bisson[1], C. Grisolia[2,6,*]

[1]Aix-Marseille Université, CNRS, PIIM, UMR 7345, F-13397 Marseille, France
[2]CEA, IRFM, F-13108 Saint Paul lez Durance, France
[3]Jozef Stefan Institute, Jamova cesta 39, 1000, Ljubljana, Slovenia
[4]LSPM, CNRS, Université Paris 13, Sorbonne Paris Cité, 93430 Villetaneuse, France
[5]Université Lille I, UMET, UMR 8207, ENSCL, 59655 Villeneuve d'Ascq cédex France
[6]National Research Nuclear University "MEPhI", Moscow, 115409 Russian Federation
christian.grisolia@cea.fr

During ITER operation, the tungsten (W) divertor will experience a heat flux (up to 10 MW/m^2) with a tritium/deuterium ions flux of 25 eV (up to 1024 $m^{-2}s^{-1}$). These ions are implanted in the W materials where they can be trapped. This fuel retention is an important ITER safety issue with an in vessel limit of 700g of tritium. In this study, the tritium retention in the ITER W divertor target is estimated with the MHIMS code, a macroscopic rate equation model. MHIMS simulates the Hydrogen Isotopes (HIs) retention in actively cooled W plasma facing components (PFCs) coupled to a cooling loop (343 K). Two cases will be considered: W materials experiencing only HIs irradiation (standard W) and W materials submitted to HIs irradiation and neutron damaging (damaged W). In both cases, MHIMS has been crosschecked with thermal desorption experiments. In standard W, the experimental data are reproduced using 3 traps with detrapping energies of 0.85, 1.00 and 1.50 eV (traps concentration of 10^{-4} – 10^{-3} at.fr.). In neutron damaged W, three higher detrapping energies need to be added to the previous ones: 1.65, 1.85 and 2.06 eV (traps concentration ~ 10-3 at.fr). Then, the tritium retention during consecutive ITER relevant plasma cycles is simulated. Each cycle is divided in 4 parts: a 20 s plasma ramp up, a 400 s plasma burning phase during which the W PFCs are exposed to a 25 eV/tritium ions flux, a plasma ramp down and 1000 s plasma off phase. 40 cycles are simulated for different incident particles/heat fluxes (from 1021 $m^{-2}s^{-1}$/6 kWm^{-2} to 1024$m^{-2}s^{-1}$/6 MWm^{-2}). It is shown: i) for neutron damaged W, the tritium retention increases with the plasma fluxes due to high detrapping energy traps that can retain tritium at high temperature, ii) for standard W, the maximum of retention is for an intermediate flux of about 1023 $m^{-2}s^{-1}$/0.6 MWm^{-2}. Here, W material experiences a low temperature and a sufficiently high particles flux to efficiently retain tritium in the low detrapping energy traps. For higher fluxes, the temperatures are too high to allow tritium trapping. Using these simulations, the tritium retention in an ITER W divertor is estimated using a variable distribution of the fluxes onto the divertor surfaces. After 40 cycles, the tritium retention for standard W is 0.2 g and 0.5 g for damaged W. From these simulations, extrapolation laws are built and it is shown that retention, when the tritium reaches the cooling system, is 0.6 g after 350 cycles for standard W and 17 g after 60000 cycles in the case of neutron damaged W.

Keywords: *Tungsten, tritium trapping/inventory, ITER prediction, modeling.*

O-11

Theoretical investigation of x-ray lasing in argon by photo-ionization from K and L shells

C. Iorga[1, 2], V. Stancalie[1]

[1]*National Institute for Laser, Plasma, and Radiation Physics, Atomistilor 409, P. O. Box MG-36, Magurele-Ilfov, 077125, Romania*
[2]*University of Bucharest, Faculty of Physics, Atomistilor 405, CP-MG 11, Magurele-Bucharest, 077125, Romania*
iorga.cristian@inflpr.ro

The realization of high brilliance X-ray free electron lasers (XFELs) has enabled x-ray lasing in gas at 1.46 nm [1], and in solid target at 0.15nm [2] by means of photo-ionization of atoms from deep inner-shells. Operating the XFEL in the two-color mode allows for seeding of radiation leading to higher amplification and better coherence [2]. The most suitable modeling for radiation amplification within the fs transient regime and at nanometer or below nanometer wavelength scale is performed via the Maxwell-Bloch equations [3, 4].

As an alternative to the neon gas reported lasing results [1], we theoretically investigate the x-ray lasing in argon gas. The authors have previously studied the amplification dynamics of two competing K shell transitions belonging to Ar II [5].

In the present work, we searched for optimal conditions for high gain amplification of (~0.42 nm) 1s-2p, (~0.39 nm) 1s-3p, (~15.4 nm) 2s-2p, (~3.8 nm) 2s-3p, and (~5.8 nm) 2p-3s transitions belonging to Ar II by means of computer simulation. For each particular lasing transition we assumed an incoming XFEL radiation tuned well above the ionization potential corresponding to the upper lasing level and high enough brilliance to result in a photo-ionization rate that is comparable to the depopulation rate of that level. By employing the Generalized Maxwell-Bloch equations [4] we simulated the amplification of radiation process arising from the spontaneous emission along the plasma column. Separate calculations have been performed for the case where seeded radiation (resulted from operating the XFEL in the two-color mode) was included in the amplification process. The atomic data necessary for this simulation, such as energy levels, radiative decay probabilities, Auger rates, photo-ionization cross section, have been computed within the Flexible Atomic Code (FAC) framework [6], which has previously been proven to be suitable for these calculations [7,8].

We report on x-ray pulse characteristics, such as number of photons, time duration, frequency band, for the five transitions mentioned above as output from the simulation.

Keywords: *x-ray laser, Maxwell-Bloch equations, computer simulation.*

[1] N. Rohringer et al., Nature(London), vol. 481, (2012), 488-491.
[2] H. Yoneda et al., Nature, vol. 524, (2015), 446-449.
[3] C. Weninger and N. Rohringer, Phys. Rev. A, vol. 88, (2013), 053421.
[4] C. Weninger and N. Rohringer, Phys. Rev. A, vol. 90, (2014), 063828.
[5] C. Iorga and V. Stancalie, IBWAP (2016), S2 O3 (unpublished).
[6] M. F. Gu, Can. J. Phys., vol. 86(5), (2008), 675-689.
[7] C. Iorga, V. Stancalie, Can. J. Phys., vol. 93(11), (2015), 1413-1419.
[8] V. Stancalie, C. Iorga, V. F. Pais, Rom. Rep. Phys., vol 67(4), (2015), 1261-1270.

O-12

Non-destructive analysis of fusion relevant tungsten coatings by X-ray methods

M. Lungu[1,2,3], C. Dobrea[1], I. Porosnicu[1], I.Tiseanu[1]

[1]*National Institute for Laser, Plasma and Radiation Physics (INFLPR), Magurele, 077125, Romania*
[2]*Faculty of Physics, University of Bucharest, Magurele, Romania*
[3]*mihail.lungu@inflpr.ro*

Abstract

In the last decades, a continuously growing community presented an increasing interest in the fusion plasma field. The plasma confinement process isn't perfect, therefore, the plasma-wall interaction presents high importance in the fusion domain.

In order to determine the proper material to be used as plasma facing component (PFC), the need for fast and non-destructive methods is recognized. These methods allow the quantitative determination of the thickness of refractory metal coatings on large areas of PFC. In particular, standardless 2D thickness mapping for erosion or redeposition studies is needed.

In this study, we propose a combined X-ray transmission/backscattering method that provides us information on the coating integrity which highlights different plasma-wall process such as delamination, melting, arching etc. X-ray transmission method represents an alternative to the X-ray fluorescence method that has successfully been applied in our laboratory for the past few years [1].

The measurements rely in the determination of the transmission factor at different energies for the X-rays which are passing through or backscattered by the investigated sample surface. The set of X-ray energies used in this procedure is selected such as an overdetermined system of equations that is solved for the unknown thicknesses of the layers. The measurements are assisted by realistic Monte Carlo simulations of the X-ray generation and transport in the measurement configurations.

Both methods were applied on plasma sputtered tungsten coated layers on carbon based substrates with different degree of surface roughness. 2D thickness mappings are compared with the results of the established X-ray fluorescent methods. Non-destructive structural integrity analysis of tungsten coated surfaces are presented.

Keywords: *X-ray imaging, fusion, erosion re-deposition, structural integrity inspection.*

[1] I. Tiseanu, M. Mayer, T. Craciunescu, A. Hakola, S. Koivuranta, J. Likonen, C. Ruset, C. Dobrea, ASDEX Upgrade Team, Surface & Coatings Technology, **205,** (2011), S192.

O-13

Investigating the Seasonal Variability of the Mid-Latitude Traveling Ionospheric Disturbances using Dynasonde Data and a New Spectral Analysis Technique

C. Negrea[1], Z. Nikolay[2], B. Terence[3,4]

[1] *Institute of Space Science, Măgurele, România,*
[2] *Department of Electrical and Computer Engineering, University of Colorado Boulder, Boulder, Colorado, USA*
[3] *Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder, Boulder, Colorado, USA,*
[4]*NOAA/NCEI, Boulder, Colorado, USA*
negreacatalin@spacescience.ro

Abstract:

Traveling ionospheric disturbances (TIDs) are wave-like oscillations of the ionospheric plasma, often caused by underlying acoustic gravity waves (AGWs). This paper investigates the seasonal variation in TID activity over Wallops Island, VA, using Dynasonde derived measurements of the local three-dimensional distribution of plasma density and Doppler speed, between May 2013 and August 2016, covering the bottom-side ionospheric F-Layer. Such studies are generally difficult either due to a lack of data or because of the inherent data gaps caused by the natural ionospheric variability. In this paper, the mean power spectral density (PSD) is determined separately for each month for the zonal (west-east) and meridional (south-north) ionospheric tilts and for the vertical component of the Doppler speed. The results cover the altitude range 140-320 km with a 2-km resolution. This is accomplished using a new spectral analysis technique based on the Lomb-Scargle and Welch methods, with additional filtering criteria imposed. Synthetic datasets are used to validate our approach, which successfully accounts for the effects of data gaps in the case of ionospheric data. We then investigate the seasonal variability of the PSD integral and highlight a semi-annual variation in TID activity, with increased activity during the summer and winter seasons in the Northern hemisphere. This result provides a more complete picture than any other recent work focused on the same geographical sector. Finally, the relative amplitude of the two peaks in TID activity is shown to vary significantly during the three years investigated and also as a function of the altitude.

Key Terms: *Dynasonde technique, Spectral analysis of non-uniformly sampled data, Lomb-Scargle and Welch methods, Seasonal variability of TIDs, Semi-annual variation.*

O-14

Laser evaporation of polymers for medical applications

A. Palla Papavlu, M. Filipescu, M. Dinescu

National Institute for Lasers, Plasma, and Radiation Physics, Atomistilor 409, Magurele, Romania
Alexandra.papavlu@inflpr.ro

This work is focused on the application of matrix-assisted pulsed laser evaporation (MAPLE) for the deposition of different polymers, i.e. polyisobutylene (PIB), ethylcellulose (EC), and hydroxypropyl methylcellulose (HPMC) aiming at their usage in proof-of-concept drug-delivery systems.

Matrix-assisted pulsed laser evaporation is an attractive method for the deposition of organic thin films. In MAPLE, a polymer or a biomolecule, is suspended in a solvent in concentrations of 0.1-5%, and the mixture is frozen, resulting in a solid target. When the laser light irradiates the target, the solvent evaporates and the suspended material is collected on a substrate as a thin film.

The MAPLE as deposited thin films are investigated using optical microscopy, atomic force microscopy, and scanning electron microscopy. Morphological investigations indicate that under a careful choice of the experimental parameters different domain structures such as islands or pits may be avoided and the prepared thin films indicated good physical stability. In addition, by tuning the experimental deposition parameters i.e. laser fluence, wavelength, etc. the formation of pores in the HPMC polymer thin films can be controlled. This is important as pores have been reported as the pathway for drug transport. More insight on surface morphology, drug distribution and content in the deposited thin films has been achieved by contact angle measurements, Fourier transformed infrared spectroscopy, and UV-VIS spectroscopy.

Our results indicate that the polymer thin films prepared by MAPLE represent an excellent alternative to the orally administered drugs.

Keywords: *MAPLE, polymers, medical applications.*

This work was supported by National Authority for Research and Innovation in the frame of Nucleus program- contract 4N/2016 and a grant from UEFISCDI, project PN-PCCA 34/2014.

O-15

Stoichiometry of thin oxide films deposited by reactive high power impulse magnetron sputtering

L. Sirghi[1] and V. Tiron

Iasi Plasma Advanced Research Center (IPARC), Faculty of Physics, Alexandru Ioan Cuza University of Iasi, Blvd. Carol I nr. 11, Iasi 700506, Romania
[1]lsirghi@uaic.ro

High power impulse magnetron sputtering (HiPIMS) of metal targets in reactive gases is a very convenient technique for synthesis of oxide, nitride or oxynitride thin films because the good control and stability of the process [1]. In this technique, short unipolar high-voltage pulses (duty cycle < 10%) are applied to the magnetron cathode to generate pulses of high density plasma and highly ionized deposition fluxes. In previous works we have employed reactive HiPIMS using ultra short discharge pulses (pulse width < 25 μs) for synthesis of substoichiometric TiO_x [2], ZnO_xN_y [3] and TiO_xN_y [4] thin films. In all these depositions, we have modified the HiPIMS pulsing frequency to control the chemical composition of the deposited films. We have showed that this control is possible by the transition of the target sputtering mode from metallic to compound. In the present work, we analyze the processes determining this transition of the target sputtering mode and film stoichiometry. Cases of TiO_x and ZnO_x thin film obtained by HiPIMS depositions in argon/oxygen mixture gas are investigated. A parametric model, similar to the Berg model of reactive d.c. magnetron sputtering deposition [5], is proposed to explain the experimental findings.

[1] M. Aiempanakit, P. Larsson, K. Sarakinos, J. Jensen, T. Kubart, U. Helmersson, Thin Solid Films 519 (2011) 7779.
[2] V. Tiron, I. L. Velicu, M. Dobromir, A. Demeter, F. Samoila, C. Ursu, L. Sirghi, Thin Solid Films 603 (2016) 255-261.
[3] V. Tiron, L. Sirghi, Surf. Coat. Technol. 282 (2015) 103-106.
[4] A. Demeter, F. Samoila, V. Tiron, D. Stanescu, H. Magnan, M. Straticiuc, I. Burducea, L. Sirghi, Surface & Coatings Technology, in press.
[5] S. Berg, E. Särhammar, T. Nyberg, Thin Solid Films 565 (2014) 186–192.

Keywords: *reactive sputtering deposition, HiPIMS, parametric deposition model, thin film stoichiometry.*

O-16

Formation of an Internal Transport Barrier due to neutral beam injection during current ramp-up in tokamak

F. Spineanu[1], M. Vlad[1], A.M. Croitoru[1]

[1]*National Institute of Laser, Plasma and Radiation Physics, 409 Atomistilor, 077125 Magurele, Romania*
f.spineanu@ifa-mg.ro

1. The physical picture

An interesting set of experimental observations has been examined at the end of the JET Campaign C36 (M15-01, Baseline Scenarios). Mainly two discharges have been retained for the strange difference that cannot be simply attributed to the basic parameters (almost the same). The discharge #92436 shows a substantial increase of the neutron production, relative to the reference #92432. We have proposed to investigate the possible generation of an Internal Transport Barrier (ITB) near R=3.6 (m), which sensibly increase the conditions for fusion reactions in #92436. The formation of the ITB is however difficult to explain, taking the character of a threshold event. We develop in the present work a qualitative explanation of this difference. It is based on the concurrent effect of several components of the start-up scenario. We consider that the ramp-up phase of the current, accompanied by the Neutral Beam Injection, leads to an effective skin distribution of the current density. This is because of the heavy impurities present in the central region around the magnetic axis: the hot electrons resulting from NBI are decelerated more than the hot ions and a toroidal current is produced on short time scale. The current density tends to a skin-type distribution, pushing radially toward the edge a poloidally circular layer of current, which however is limited by the higher resistivity of the plasma far from the axis. The fast time variation accumulates current density at the limit of the higher resistivity in a this layer. Then the MHD invariant that connects the current density, the particle density and the vorticity imposes that a radial derivative of the poloidal rotation is formed and coincides with the current layer. This is the ITB

2. Quantitative model

The physical picture is implemented in a numerical model for the current density evolution under the effect of NBI, in the presence of the heavy impurities and with radial variation of the resistivity. In this phase we use a one-dimensional (radial) transport code which includes NBI and compute at every step the poloidal rotation that would be sustained if it overcomes the “Transit Time Magnetic Pumping” damping.

We still have to understand the role of the Ion Cyclotrone Radiation Heating, which seems to contribute substantially to the formation of the ITB.

[1] F. Spineanu, M. Vlad and A.M. Croitoru, in preparation, 2017.

O-17

Modeling and experimental Study of a Wurster type fluidized bed reactor coupled with an atmospheric pressure plasma jet (APPJ) for the treatment of polypropylene (PP) powders

S. Tabibian[1, 2, 3], F. Arefi-Khonsari[1],
S. Khashayar[2], M. Leturia[2], A. Moussalem[1], J. Pulpytel[1]

[1]*Sorbonne Universités, UPMC Univ Paris 06, CNRS, Laboratoire Interfaces et Systèmes Electrochimiques, 4 place Jussieu, F-75005, Paris, France*
[2]*UTC, TIMR, rue Roger Coutolenc, 60200 Compiègne, France*
[3]*Tabibian_shayan@yahoo.com*

Polypropylene (PP) powders are used for various purposes. However, its good mechanical properties are accompanied by poor wettability. The PP powder was therefore modified by a pulsed arc atmospheric pressure plasma jet (APPJ) in a homemade Wurster fluidized bed reactor (Wurster-FBR). The physical and chemical modifications of the treated PP powders as compared to the non-treated ones were determined by water contact angle (WCA) measurements, X-ray photoelectron spectroscopy (XPS), attenuated total reflection Fourier transform infrared spectroscopy (ATR-FTIR) and SEM for morphology observations.

The average diameter of our PP powders being determined to be 700 µm, they can be classified as particles of category B according to Geldart classification which can be easily fluidized. PP powders are basically hydrophobic but after plasma treatment with our hand-made reactor they became strongly hydrophilic, because of increase the atomic concentration of oxygen on the surface of particles.

The plasma torch was introduced into transparent glass reactor with 118mm inside diameter, placed in the middle of a bronze gas distributor (Fig.1). An internal Wurster tube was added to control the residence time of particles in the plasma jet, and therefore the homogeneity of the treatments. The innovative design of wurster tube improved the powders treatment process by increasing the interaction between plasma torch and the particles, therefor the efficiency of system increased.

A 2D CFD model was developed using Comsol Multiphysics 5.2 along with this experimental study. The multiphase flow was calculated by using the k-ε turbulent Euler-Euler model which solves one set of Navier-Stokes equations per phase to accurately describe the particles velocity and volume fraction inside the reactor.

Keywords:

Atmospheric Pressure Plasma Jet,
Fluidized Bed Reactor,
Wurster Reactor,
Polypropylene Plasma Treatment,
CFD Modeling

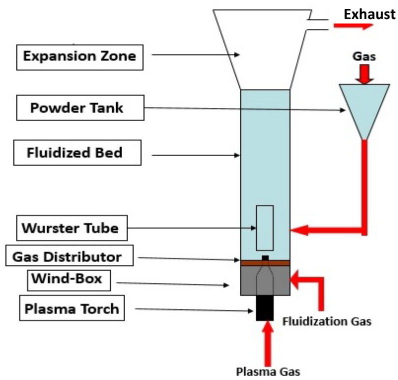


Fig1. The schematic of reactor

O-18

A pulsed plasma jet for dusting off surfaces on Mars

C. M. Ticoş[1,2], A. Scurtu[1], D. Ticoş[1]

[1]*National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor Str., PO BOX MG-36, 077125 Bucharest, Romania*
[2]*cata_Ticoş@yahoo.com*

Dust is a challenge for the design and operation of equipment on the Martian surface, particularly for solar cells. An efficient and robust technique for removing dust and sand from surfaces immersed in CO_2 at low pressure is presented. The working principle is based on a pulsed plasma jet produced between two coaxial electrodes biased at voltages between 1 kV and 2 kV [1]. A demonstration is presented using dust particles whose chemical composition mimic the Mars soil [2]. An array of connected photovoltaic cells fully covered with dust and sand is exposed to the plasma jet. The cells' open circuit voltage is monitored in real-time thus providing the means to measure the dust removal efficiency. A good cleaning efficiency is attained after a few shots in a geometry where the plasma jet is directed perpendicularly to the dusty surface. The main advantage of this approach lies in the opportunity to apply it directly at about 5 torr, the pressure of the Martian environment. A numerical evaluation shows that the plasma drag force on a dust particle is orders of magnitude higher than its weight depending on plasma density and flow speed, hence validating the principles of this cleaning technique.

[1] C.M. Ticoş, A. Scurtu, D. Toader, N. Banu, Review of Scientific Instruments **86**, 033509 (2015)
[2] C.M. Ticoş, A. Scurtu, D. Ticoş, New Journal of Physics (in press, Febr 2017)

Keywords: *plasma jet, dust, Mars, surface, photovoltaic cell.*

O-19

Deposition of interstellar carbon dust analogs using barrier discharge driven by nanosecond high voltage pulses

B. Hodoroaba[1], D. Ciubotaru[1], A.S. Chiper[1], V. Pohoata[1], I. Mihaila[2], I. Topala[1]

[1]*Iasi Plasma Advanced Research Center (IPARC), Faculty of Physics, Alexandru Ioan Cuza University of Iasi, Romania*
[2]*Integrated Center of Environmental Science Studies in the North-Eastern Development Region (CERNESIM), Alexandru Ioan Cuza University of Iasi, Romania*
ionut.topala@uaic.ro

In the last decade, the need for laboratory experiments aiming at delivering results involving dust particles astrophysical processes increased significantly, but the possibilities to produce them is still very limited by conventional chemistry. Although dust particles do not represent the major component of the interstellar medium, they have an important role in star formation, absorption and scattering of UV or optical radiation and modification of chemical reaction kinetics by surface catalysis processes. We discuss here the possibility to deposit carbon based dust products on various substrates using a hydrocarbon containing dielectric barrier discharge and a high power operation regime.

The discharge is excited at 1 kHz using positive nanosecond voltage pulses (< 500 ns, 100 ns rise time) of 5.7 kV amplitude applied on the power electrode of a parallel plate configuration [1]. The electrode assembly was hosted by a stainless steel chamber, vacuumed prior all experiments and then a mixture of helium / hydrogen (1%) / hydrocarbon (C_nH_{2n+2}, n = 1 - 4) (10%) was introduced at atmospheric pressure. Plasma operation was monitored by various electrical and optical methods and the deposition products were investigated by electron microscopy and several spectroscopic methods (UV-VIS, FTIR, Raman, XPS).

Typical values for the instantaneous total discharge power are of 10 kW order for the hydrocarbon containing discharges. The electron density, obtained from the Ohm's law applied only for the electron current is 1.3×10^{17} m^{-3}. Fast imaging observation of ionization front revealed velocities of around 5×10^4 m/s.

The IR spectra of plasma deposited carbonaceous material shows many similarities with the astronomical observations, including the aliphatic sp^3-C-H stretching at 3.4 μm and the aliphatic sp^3-C-H bending at 6.8 μm and 7.2 μm. Scanning electron microscopy studies revealed the formation of inhomogeneous aggregates of micron and submicron sized grains, proving that this type of plasma represents a good solution for dust synthesis.

Acknowledgements

This research was financially supported by Romanian Space Agency (ROSA) under the project STAR CDI ID 486/2017-2019. The POSCCE-O 2.2.1, SMIS-CSNR 13984-901, no. 257/28.09.2010 Project, CERNESIM, is gratefully acknowledged for the infrastructure used in this study.

[1] I. Mihaila, V. Pohoata, R. Jijie, A.V. Nastuta, I.A. Rusu, I. Topala, Adv. Space Res. **58**, (2016), 2416-2423

Keywords: *barrier discharge, hydrocarbons, interstellar carbon dust analogs.*

O-20

Atmospheric pressure surface modification and cross-linking of UHMWPE film by transporting discharge

A. Valinataj Omran[1, 2, 3, 4], A. Baitukha[1, 2], J. Pulpytel, F. Sohbatzadeh[3], F. Arefi-khonsari[1, 2]

[1] *Sorbonne Universités, UPMC Univ Paris 06, UMR 8235, Laboratoire Interfaces et Systèmes Electrochimiques, F-75005 Paris, France*

[2] *CNRS, UMR8235, LISE, F-75005 Paris, France*

[3] *Department of Atomic and Molecular Physics, Faculty of Basic Sciences, University of Mazandaran, Babolsar47416-95447, Mazandaran, Iran*

[4]*a_valinataj@hotmail.com*

Ultra-high-molecular-weight polyethylene (UHMWPE) has been widely used because of its excellent mechanical properties. However, despite these excellent characteristics, UHMWPE needs some additional treatment to increase the surface activity, for better wettability. Plasma treatment is a promising technique that enables the surface modification of polymers without affecting the textural characteristics of the bulk material. In the present work, the helium transporting discharge was applied to improve the surface properties of UHMWPE film. The hydrophilicity of the UHMWPE film was characterized by measuring the contact angle as a function of exposure time. The surface morphology was analyzed using AFM and SEM. The functionalization of the plasma treated UHMWPE film surfaces were characterized by ATR-FTIR, XPS and TOF-SIMS.

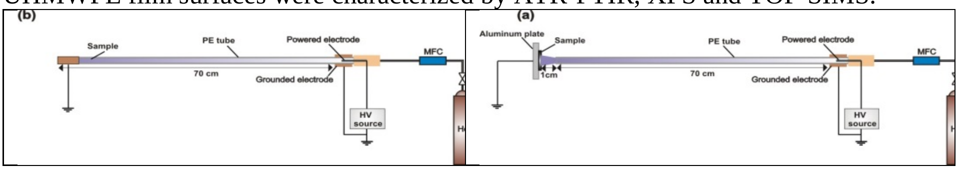


Fig1. Schematics of the transporting treatment system (a) jet configuration (b) glow configuration.

A schematic of the plasma reactors are shown in Fig.1. A transporting discharge was generated by applying a homemade AC power supply at 5 kHz [1]. A high voltage power supply was connected to the stainless needle electrode which was embedded in the center of a HDPE tube with length of 70 cm allowing the working gas to flow through. In the jet configuration (Fig.1(a)), the plasma jet was directed towards the substrate located at a variable distance from the nozzle and placed on a grounded aluminum substrate holder. In the glow configuration, another grounded electrode was wrapped around the tube outlet and the sample is inside the tube (Fig.2(b)).

FTIR results show that besides surface oxidation which is very commonly identified in the case of plasma treated polymer surfaces, in the case of the UHMWPE, we also observe crosslinking which is also a process taking place with the formation of unsaturation. Furthermore, we can point out that the glow plasma-treated sample inside the tube presents for the same treatment time of 7 minutes more crosslinking than the jet one outside the tube. The XPS results confirm those of FTIR i.e. besides oxidized groups such as C-O/C-OH, C=O and O-C=O (acid or ester groups) detected on the surface, C=C bondings can be also detected at the surface. AFM and SEM images show a smoother surface after the plasma treatment, where a lamellar structure can be identified. A comparison of the mass spectra from untreated and treated sample showed significant differences of signal intensities of ions that could be specifically related to the presence of oxygen-containing and nitrogen-containing species in different setups.

[1] F. Sohbatzadeh, and A.V. Omran. *Phys. Plasmas*, **21**, (2014), 11, 113510.

O-21

Reactive magnetron sputtering of oxides, nitrides and oxy-nitrides: from process characterization to tunable thin films

C. Vitelaru[1], I. Pana[1,2], A.C. Parau[1], N.C. Zoita[1], A.E. Kiss[1], M. Braic[1]

[1]*National Institute for Optoelectronics, 409 Atomistilor St., Magurele-Bucharest, P.O. Box MG 05, Romania*

[2]*Faculty of Physics, University of Bucharest, 405 Atomistilor St., 077125, Magurele-Bucharest, Romania*

catalin.vitelau@inoe.ro

This contribution proposes a systematic approach of the reactive sputtering process, starting from the identification and characterization of the deposition process intervals, aiming to tune the thin film properties. All the experiments were performed in the same setup, using a planar 2" cathode, using different target/gas combinations, such as: Cu target in Ar/O_2 gas mixture, Si target in Ar/N_2 gas mixture, and Ta target in $Ar/O_2/N_2$ gas mixture. For the deposition process characterization we used: optical emission spectroscopy, current voltage characteristics and total pressure measurements. The combined use of these methods offers a complementary view on the process, covering both surface and plasma volume elementary phenomena. Coupled with these methods, different approaches for process intervals scanning were implemented, which are related mainly to process parameters, such as pumping speed, total pressure and total gas flux, which were kept constant. To identify the deposition process intervals of discharge stability, we used as main variable parameter the mass flow of the reactive gas, in conjunction with the gas flows ratio if more than one reactive gas was used.

The process tunability and correspondingly the thin film properties were assessed for three materials with high applicative potential: SiN_x, CuO_x and TaO_xN_y, because their synthesis is highly dependent on the deposition process conditions. Since most of the applications of these materials are related to their optical or electrical properties, the refractive index and the optical band gap were used as key parameters to demonstrate the tunability of their properties. For SiN_x thin films the refractive index was shown to vary from ~ 2.75 to ~ 1.7, and the optical band gap spans from 1.86 eV to 4.56 eV [1]. Due to the variable oxidation state of Cu, the optical band gap of CuO_x thin films changed from 1.09 eV to 1.85 eV, depending on the deposition conditions. In particular, the transition from a rich Cu layer to CuO, going through different polymorphs of Cu_2O was also assessed by XRD analysis. Eventually, TaO_xN_y thin films exhibited a large band gap variation, from 1.7 to 3.63 eV, and the refractive index varied from 2.15 to 3. Summarizing, we made evident the direct relation between the deposition process intervals and the films' properties.

Keywords: *reactive sputtering, optical emission spectroscopy, thin film deposition.*

[1] I. Pana, C. Vitelaru, N.C. Zoita, M. Braic, Plasma Processes and Polymers, **13** (2016) 208-216

This work was supported by the Romanian Research and Innovation Ministry, projects PN 16.40.01.01/02 and PNCDI III project TANDEM No 56/2016

O-22

Radial pinch produced by the gradient of turbulence amplitude in tokamak plasmas

M. Vlad[1], F. Spineanu[1]

[1]*National Institute of Laser, Plasma and Radiation Physics, 409 Atomistilor, 077125 Magurele, Romania*
madalina.vlad@inflpr.ro

Energy and particle turbulent transport in magnetically confined plasma is one of the important problems in fusion research. This process is not completely understood and it represents a very active research field. The turbulence is shown to produce a diffusive transport as well as an average velocity (pinch), which often leads to peaked profiles and to impurity accumulation. The turbulent pinches are determined by the magnetic field gradient or by the temperature gradient. We present here an alternative pinch mechanism, which is caused by the existence of radial variation of turbulence amplitude.

Experiments and numerical simulations for ITG and TEM turbulence show the radial variation of the amplitude Φ of the stochastic potential. The gradient of Φ has a characteristic length L of the order of several radial correlation lengths. We have shown that this gradient is a new source of radial pinch.

A realistic test particle model of the turbulence was considered. The spectrum corresponds to the ITG or TEM turbulence. We have determined the diffusion coefficient D_r and the average radial velocity V_r using a semi-analytic statistical approach, the decorrelation trajectory method. The relative importance of the pinch and diffusive transport was estimated by the calculation of the peaking factor. The radial pinch is approximately proportional with the gradient of the amplitude 1/L. The dependence on turbulence parameters of both D_r and V_r is characterized by two regimes: the quasilinear regime that corresponds to small Φ and the nonlinear or trapping regime that appears at large amplitudes. The latter is rather complex due to the existence of quasi-coherent aspects in particle trajectories.

The conclusion of the study is that the maximum of the pinch velocity appears in the range of the transition from quasilinear to nonlinear transport. However, the maximum effect on plasma profiles (maximum peaking factor) does not correspond to these range but to the nonlinear regime.

Keywords: *fusion plasmas, turbulence, particle and energy transport.*

O-23

Kinetic simulations of plasma jets interaction with increasing magnetic fields

G. Voitcu[1] and M. Echim[1]

[1]*Institute of Space Science, Atomistilor 409, 077125, Magurele, Romania*
gabi@spacescience.ro

The interaction of collisionless plasma jets (or beams, clouds, blobs, plasmoids) with transverse magnetic fields is a fundamental research topic that is highly relevant for both laboratory and space plasmas [1]. In this paper we used particle-in-cell simulations to study the propagation of a plasma jet/cloud across a parallel magnetic field geometry typical for a tangential discontinuity. Our setup reproduces a regional and simplified configuration of the Earth's magnetosphere that is likely to be observed at the frontside magnetopause, described as a tangential discontinuity. The numerical experiments emphasize fundamental kinetic effects and their role on the transport and entry of localized plasma structures across increasing magnetic fields [2]. The three-dimensional simulations allow the simultaneous investigation of the plasma electrodynamics in all relevant directions. The results reveal the formation of a polarization electric field inside the main bulk of the plasma jet. This field is established self-consistently in the early stages of the simulation and sustains the forward propagation of the plasma jet across the magnetic field. Our investigations have shown that plasma jets with enough dynamical pressure are able to penetrate the tangential discontinuity when the magnetic field increase does not exceed a certain critical threshold. Otherwise, the forward transport is fully stopped, the plasma jet is pushed back and simultaneously deflected tangential to the discontinuity. The convection motion of the penetrating plasmoids is slowed down while streaming into stronger magnetic fields. Our simulations revealed that the transport and entry of three-dimensional plasma jets across tangential discontinuities in a parallel geometry are mainly controlled by the dynamic and kinetic pressure of the incoming plasma, its dielectric constant and the magnetic field jump. We discuss physical processes advocated previously by the theoretical model of impulsive penetration and revealed in laboratory experiments.

[1] M. Echim, J. Lemaire, Space Sci. Rev. **92**, (2000), doi:10.1023/A:1005264212972.
[2] G. Voitcu, M. Echim, J. Geophys. Res. **121**, (2016), doi: 10.1002/2015JA021973.

Keywords: *plasma jets, polarization electric field, magnetopause, particle-in-cell simulations, impulsive penetration mechanism*

O-24

Performance of the neutron attenuators for the JET gamma-ray cameras

V. Zoita[1], T. Craciunescu[1], A. Fernandes[2], V. Kiptily[3], M. Anghel[1], D. Croft[3], M. Curuia[1], L. Giacomelli[4], D. Kina[3], I. Lengar[5], S. Soare[1], and JET contributors(*)

EUROfusion Consortium, JET, Culham Science Centre, Abingdon, OX14 3DB, UK
[1]Institute of Atomic Physics, Magurele, Ilfov, Romania
[2]Instituto de Plasmas e Fusao Nuclear, Instituto Superior Tecnico, Universidade de Lisboa, Lisboa, Portugal
[3]Culham Centre for Fusion Energy (CCFE), Culham Science Centre, Abingdon, UK
[4]Istituto di Fisica del Plasma "P. Caldirola", CNR, Milano, Italy
[5]Slovenian Fusion Association (SFA), Jozef Stefan Institute, Reactor Physics Department, Ljubljana, Slovenia
vlzoita@dmp.plasma.ro

The JET gamma-ray diagnostics provide information on the evolution of fast particles within the tokamak configuration. Information on the spatial distribution of the interacting fast particles is obtained from the JET KN3 gamma-ray cameras. The imaging technique based on the two KN3 cameras has been very successfully applied so far in fast particle simulation experiments (RF accelerated particles) on JET [1]. The extension of these diagnostics to high power (high neutron yield) discharges is not straightforward and requires adequate methods for the reduction of the neutron-induced gamma-ray background [2]. To this aim a set of three neutron attenuators of different shape and attenuation length have been designed and constructed for the horizontal and vertical KN3 cameras [3]. The radiation performance of the KN3 neutron attenuators has been evaluated by neutron/photon transport (MCNP) calculations [2] and it resulted that they should provide fast neutron attenuation factors between 10^4 and 10^2 depending on the incident neutron energy (2.45 or 14.1 MeV) and the attenuating material. The two attenuators designed to work on JET during deuterium pulses (2.45 MeV neutrons) have been installed on the tokamak and their performance has been tested on a number of high power JET pulses. The paper will present the analysis of the experimental results. This analysis has shown that the experimental values for the neutron attenuation factor obtained for the vertical camera neutron attenuator agreed with the MCNP calculations, while those provided by the horizontal camera attenuator showed a significant difference (65 instead of 100) with respect to the numerical simulations. The difference is considered to be due to the limitations of the present MCNP model. This model can deal successfully with the neutron field in the region of the vertical attenuator, but cannot take into account the much more complex geometry surrounding the horizontal attenuator.

[1] V.G. Kiptily, et al., Nucl. Fusion, **42**, (2002), 999;
[2] V. Zoita, et al., Fus. Eng. Des., **84**, (2009), 2052;
[3] M. Curuia et al., Fus. Eng. Des., **86**, (2011), 1196.

*See the author list of "Overview of the JET results in support to ITER" by X. Litaudon et al. to be published in Nuclear Fusion Special issue: overview and summary reports from the 26th Fusion Energy Conference (Kyoto, Japan, 17-22 October 2016).

O-25

Synthesis of exotic carbon material in non-equilibrium dense plasmas

A. Zubarev[1,2,*], I. Stamatin[2]

[1]*National Institute for Laser, Plasma and Radiation Physics. Str. Atomistilor, Nr. 409. PO Box MG-36, 077125. Magurele, Bucharest Romania*
[2]*University of Bucharest, Faculty of Physics, Atomistilor 405, P.O 38, Bucharest-Magurele, Romania, 077125*
[*]*alxzubarev@gmail.com*

Discovery and applications of new forms of nanocarbon play very important role in modern society. Existence of new types of nanocarbon besides the well known forms of fulerene, graphene, carbon nanotubes is widely discussed in the scientific community. In our work we analyze and synthesize a innovative type of new spiro-conjugated carbon nanostructure[1]: carbon crystal spirographene. Spirographene is a 2-dimensional carbon sheet in which some of aromatics are perpendicular to sheet plane due to spiro-conjugation.

We theoretically study energetic structure of spirographene, electronic properties of spirographene quantum dots like density of states, band-gap, and first excitation level and simulate Raman and IR spectra for spirographene. For simulations was used the Accelrys and HyperChem simulation programs. The physical structure of the quantum dots was simulated using PM3 and Entended Hunkel methods after the optimization of the spatial structure.

In the experimental part of research we obtained samples by electrical arc discharge in organic solutions. Arc discharge creates nonequilibrium plasmas, which give us the opportunity to realize unusual chemical reactions and obtain new kind of materials [2]. For synthesis was implemented special cavity, where the arc discharge can be controlled by varying of the distance between two graphite electrodes.

The properties of obtained solutions ware widely determined by the compounds of solutions, the results of the probes varying from graphene and nanocarbons to spirographene. The best result was given by decahydronaphthalene solution of phenol. To analyze the probes were used Raman spectroscopy, XRD, FTIR, HRTEM and DLS.

The possible application of the synthesized spirographene include its usage for nano-sensors, medicine, nano-electronics, photovoltaics.

[1] Gleiter, R., et al. "Spiroconjugation in orthothiocarbonates." *Tetrahedron* 33.4 (1977): 433-439;
[2] Fridman, Alexander. *Plasma chemistry*. Cambridge university press, (2008).

Keywords: *Spirographene, arc discharge, nanocarbon.*

Topic 1

Fundamental processes in plasmas, modeling and simulation, space plasmas

P1-01

Modelling of wall currents excited by plasma wall-touching kink and vertical modes during a tokamak plasma disruption

C.V. Atanasiu[1], L.E. Zakharov[2], K. Lackner[3], M. Hoelzl[3], E. Strumberger[3]

[1]*National Institute for Laser, Plasma and Radiation Physics, Atomistilor 409, P.O. Box MG-36, 077125 Magurele, Romania*
[2]*LiWFusion, P.O. Box 2391, Princeton, NJ 08543, USA*
[3]*Max Planck Institute for Plasma Physics, Boltzmannstr. 2, 85748 Garching, Germany*
[1]*cva@ipp.mpg.de*

To understand plasma disruptions in tokamaks and predict their effects realistic simulations of electric current excitation in three-dimensional vessel structures by the plasma touching the walls are required. At JET, it has been discovered in 1996 that the wall-touching kink modes are frequently excited during vertical displacement events which gives another source of current excitation in the wall. It is to note that both instabilities are causing large sideways forces on the vacuum vessel which are difficult to withstand in large tokamaks, as ITER mainly.

In order to model these surface currents density in the conducting shell we have splited these currents into two components: (i) a divergence-free surface current [1], and (ii) a source/sink current with potentially finite divergence in order to describe the current sharing between the plasma and the wall [2]. For each of both surface components, we developed and energy principle [3] and deduced a matrix circuit equation via a finite element approach. By minimizing the quadratic forms of the energy principle equations, we have obtained a linear system of equations with symmetric positively defined matrices which can be solved using the Cholesky decomposition. Finally, we have deduced some analytical solutions for the multiply-connected domain of a real ITER wall and checked the numerical results.

The numerical code we have developed (SSC) received the status of “open source license” and can be used by the EUROfusion community.

Keywords: *fusion plasmas, MHD, tokamak, disruptions, modelling.*

[1] C.V. Atanasiu, L.E. Zakharov, Phys. Plasmas **20**, (2013), 092506.
[2] L. E. Zakharov, C. V. Atanasiu, K. Lackner, M. Hoelzl, and E. Strumberger, J. Plasma Phys.**81**, (2015) , 515810610.
[3] C. V. Atanasiu, L. E. Zakharov, K. Lackner, M. Hoelzl, and E. Strumberger, JOREK Meeting, March 20-24 (2017), Prague, Czech Republic

P1-02

Simulation of magnetron sputtering deposition of titanium nanopatterns on substrates with colloidal masks

C. Costin[1], A. Demeter, V. Tiron, L. Sirghi

Iasi Plasma Advanced Research Center (IPARC), Faculty of Physics, Alexandru Ioan Cuza University of Iasi, Bd. Carol I nr. 11, 700506 – Iasi, Romania
[1]claudiu.costin@uaic.ro

In the recent years, nanosphere lithography (NSL) was intensely investigated for fabrication of nanopatterned surfaces with applications in biology, sensors, photonic crystals, and optoelectronic devices. The whole NSL process includes depositions of colloidal masks, material deposition or etching, and mask lift-off. The characteristics of the patterned surface obtained by this technique depend on each of the fabrication steps mentioned above. Therefore, in the case of the nanopatterns obtained by magnetron sputtering deposition, a detailed analysis of deposition process is very valuable for understanding of pattern properties.

This work reports results of a 3D Monte Carlo simulation of titanium nanopatterns obtained by magnetron sputtering deposition on substrates covered by colloidal masks formed by a monolayer of close-packed nanospheres of polystyrene (500 nm in diameter). The magnetron target (titanium) was sputtered in argon, in two distinct modes, DCMS (Direct Current Magnetron Sputtering) and HiPIMS (High Power Impulse Magnetron Sputtering), at two sputtering gas pressures (3 and 30 mTorr). The entire mask can be regarded as a multiplication of a 'unit cell' - a hexagon delimited by the centres of the first 6 neighbours of a central sphere. The simulation domain (1000×866×900 nm) covered a single 'unit cell'.

The flux of the sputtered particles arriving to the substrate is simulated by injecting particles in the simulation volume, very close to the substrate, at random spatial positions. The trajectory of each particle is collisionless in the simulation volume, but its transport through the plasma is considered via the injection velocity, which can obey an isotropic distribution if the transport was collisional or an anisotropic distribution for a ballistic transport. Thus, the depositing flux has two components with their ratio controlled by the gas pressure and the operation mode. The sputtered particles can deposit on the substrate surface or on the spheres of the colloidal mask. Therefore, a film is growing simultaneously on the colloidal mask and on the substrate. The opening spaces of the colloidal mask determine growth of the nanopatterns on the substrate. When encountering the surface of the growing film, the particles may reflect or deposit with diffusion on the surface to reach a more stable energy configuration. The height profiles of the deposited nanopatterns resulting from the simulation were compared with the experimental ones extracted from AFM topography images obtained before and after removal of the colloidal mask. A very good agreement has been obtained for depositions at low pressure of the sputtering gas, when the flux of the sputtered particles is predominantly anisotropic.

Keywords: *3D Monte Carlo simulation, magnetron sputtering deposition, nanosphere lithography, titanium nanopatterned surface*

P1-03

Transport of cold ions in tokamak microturbulence

A. Croitoru[1,2]

[1] *National Institute for Laser, Plasma and Radiation Physics, Atomistilor 409, 077125 Magurele, Romania*

[2] *Faculty of Physics, University of Bucharest, Atomistilor 405, 077125 Magurele, Romania*

**c.m.andreea@gmail.com*

1. Introduction

The efficiency of magnetic fusion experiments is conditioned by the transport of thermal energy from the hot core of the plasma to the colder edge as well as by the transport of particles. Radial gradients in density and in temperature excites plasma microturbulence which is responsible for the transport of thermal energy. The interaction between this type of turbulence and the transport of plasma particles has been long studied. While the behavior of energetic ions has reached some satisfactory level of understanding, with studies offering scalings of transport with microturbulence [1, 2], cold ions have received little to no attention despite studies suggesting that the diffusivity of cold test particles is similar to that of fast particles [3]. We study the transport of cold ions in low-frequency drift-type turbulence and provide the diffusion regimes using a semi-analytic method, the decorrelation trajectory method(DTM).

2. Statistical Model

We study the effects of the neoclassical magnetic drifts on the turbulent transport of small energy ions within a realistic model that has the characteristics of ITG or TEM driven turbulence using a test particle approach. The diffusion coefficients are obtained in the DTM as weighted averages on deterministic trajectories determined by the Eulerian autocorrelation of the stochastic potential which is given by the Fourier transform of the turbulence spectrum. The stochastic equations of motion are studied in subensembles of realisations of the stochastic fields defined by fixed values of the stochastic fields in the starting points. The shape of the potential autocorrelation leads to strong modifications of the transport regimes both in the nonlinear and in the quasilinear case because of the drift of the potential with the effective diamagnetic velocity.

The transport regimes are obtained as functions of the parameters of the turbulence spectrum.

Keywords: *turbulence, anomalous transport, tokamak, plasma, cold ions.*

[1] T. Hauff, F. Jenko, Phys. Plasmas **15**, (2008), 1123.
[2] A. Croitoru, D.I. Palade, M. Vlad, F. Spineanu, Nucl. Fusion **57**, (2017), 036019.
[3] S. Gunter, G. Conway et al., Nucl. Fusion **47**, (2007), 920-928

P1-04

Self-modulation of the discharge current oscillations in the presence of a complex space charge configuration in low-temperature plasma

S.A. Irimiciuc[1], D.G. Dimitriu[1], M. Agop[2]

[1]*Faculty of Physics, "Alexandru Ioan Cuza" University, 11 Carol I Blvd., 700506, Iasi, Romania*

[2]*Department of Physics, "Gh. Asachi" Technical University, 59A Mangeron Blvd., 700050, Iasi, Romania*

**stefan.irimiciuc@yahoo.com*

By using a spherical grid cathode with hole to obtain a low-temperature plasma discharge, a very complex space charge configuration develops inside and around it (see Fig. 1), extensively described in [1,2]. This configuration consists of a plasma bubble [3], produced inside the spherical cathode, which is coupled with the negative glow of the discharge through a fireball in a shape of an asymmetric dumbbell, called firedumbbell. By recording and analyzing the time series of the discharge current, different dynamic states of the system were evidenced. The discharge current oscillations are the result of the nonlinear interaction between the dynamics of the inner bubble and the firedumbbell. Both structures are in dynamic states, while the corresponding oscillation frequencies depend on the current intensity. The inner bubble periodically release bunches of electrons, which act as forcing drive of the oscillating firedumbbell. Thus, the firedumbbell passes through different dynamic states as the forcing frequency changes due to modification of the discharge current value. In other words, the forcing frequency determines the dynamic state, i.e. the discharge current oscillations, which, at their turn, modify the frequency of the inner bubble dynamics, i.e. the forcing frequency. In this way, a continuous self-modulation of the discharge current establishes.

In order to describe this complex dynamics, a theoretical non-differentiable (fractal) model was developed in the frame of the scale relativity theory [4], by considering that all the plasma particles move on continuous but non-differentiable curves (due to particle collisions). In this model, the electrons dynamics is described using a forced damped oscillating model. The response of the global discharge current to different changes in the resolution scale, oscillating frequency and damping coefficient is investigated. The model emphasizes the self-modulation of the discharge current oscillations, the obtained results being in good agreement with the experimental ones.

Fig. 1: Complex space-charge configuration inside and around a spherical grid cathode with hole

[1] C.T. Teodorescu-Soare *et al.*, Phys. Scripta **91**, (2016), 034002
[2] R.W. Schrittwieser *et al.*, Phys. Scripta **92**, (2017), 044001
[3] R.L. Stenzel, J. M. Urrutia, Phys. Plasmas **19**, (2012), 082105
[4] D.G. Dimitriu *et al.*, Phys. Plasmas **22**, (2015), 113511

P1-05

Numerical and experimental investigation of the effect of N_2 and O_2 admixtures in a helium dielectric barrier discharge

C. Lazarou[1 *], A.S. Chiper[2 *], C. Anastassiou[1], V. Pohoata[2], I. Mihaila[3], I. Topala[2] and G.E. Georghiou[1]

[1]FOSS Research Centre for Sustainable Energy, Department of Electrical and Computer Engineering, University of Cyprus, Nicosia, 1678, Cyprus
[2]Iasi Plasma Advanced Research Center (IPARC), Faculty of Physics, Alexandru Ioan Cuza University of Iasi, Iasi 700506, Romania
[3]Integrated Center of Environmental Science Studies in the North-Eastern Development Region (CERNESIM), Alexandru Ioan Cuza University of Iasi, Iasi 700506, Romania
[*]lazarou.constantinos@ucy.ac.cy, alina.chiper@uaic.ro

Low temperature atmospheric pressure plasma sources have received much attention in the last decades, due to low production cost, easy implementation and applications ranging from surface modification, sterilization, plasma medicine etc. For applications dealing with temperature-sensitive materials, plasma sources usually operate with inert gases such as argon, neon or helium, and their electrodes are covered with dielectric layers in order to prevent arcs. The inert gases are preferred because they create the conditions for low power and low gas temperature requirements and still they can produce a wide range of excited and reactive species. However, in several applications, extra admixtures of nitrogen or oxygen species are added in the inert gases, in order to enhance the production of the reactive species. In the literature, there is a very limited number of studies regarding the effect of these admixtures on the evolution of helium discharge over a wide range. Consequently, understanding the effect of these admixtures (nitrogen and oxygen) on the discharge evolution is very crucial for the utilization of helium atmospheric pressure plasma devices.

With this in mind, a one dimensional plasma fluid model is developed, in order to study the effect of nitrogen and oxygen admixtures in a helium parallel plate dielectric barrier discharge [1]. The model takes into account the analytical chemistry of helium with nitrogen, oxygen and water species and it was verified with experimental results [2] (pure He, He + N_2 and He + O_2) in order to ensure its validity. In the plasma chemistry, 52 species and 445 reaction channels are considered.

The simulation and experimental results show that the nitrogen and oxygen admixtures highly affect the discharge characteristics and evolution. In particular, for the case of pure helium discharge, it has been observed that the discharge has homogeneous characteristics with a single current peak per half voltage period. By adding nitrogen in the helium gas, extra current pulses have been observed per half voltage cycle, and after a certain level of nitrogen admixtures the discharge loses the homogeneous characteristics. On the other hand, when oxygen is added in the helium gas, it is observed that the discharge continues to have one current pulse per half voltage cycle, but loses the homogeneous characteristics at very low level of oxygen admixture. In an attempt to interpret the results, the most important reactions pathways for the production of ions are examined through the simulations. This provides very useful information for the understanding of plasma behaviour.

[1] C. Lazarou, T. Belmonte, A. S. Chiper and G. E. Georghiou, *Plasma Sources Sci. Technol.* **25,** (2016), 055023.
[2] A. S. Chiper, R. Cazan and G. Popa, *IEEE Trans. Plasma Sci.* **36**, (2008), 2824–30.

P1-06

Momentum deposition by acoustic gravity waves in the thermosphere-ionosphere above wallops island, VA.

C. Negrea[1], N. Zabotin[2], O. Godin[3], T. Bullett[4,5]

[1]*Institute of Space Science, Măgurele, Romania*
[2] *Department of Electrical, Computer and Energy Engineering, University of Colorado, Boulder, Colorado, USA*
[3] *Naval Postgraduate School, Monterey, California*
[4] *Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder*
[5] *NOAA/NCEI, Boulder, Colorado*
**negreacatalin@spacescience.ro*

Abstract:

One of the main areas of interest in the study of Acoustic Gravity Waves (AGWs) and associated Travelling Ionospheric Disturbances (TIDs) is the impact they have on the background thermosphere-ionosphere through deposition of energy and momentum. The momentum is dumped into the background flow and/or transferred to secondary waves, depending on background conditions. The overall effect due to this extra momentum source is already known to be significant in the middle atmosphere (stratosphere and mesosphere, 20-80 km altitude). This acts as an additional forcing with a complex temporal, geographical and altitude variability. The global impact on the thermosphere-ionosphere due to AGW dissipation has only been roughly estimated because of a data deficit in the altitude range 140-320 km. Existing work has focused mainly on theoretical and numerical simulations, highlighting the likely impact of AGW dissipation, but also the need for measurements to constrain existing models and aid in developing of more accurate parameterization schemes This paper proposes such a method, using measurements of the ionospheric plasma above Wallops Island, VA, obtained with a Dynasonde-capable radar. The instrument emits a complex sequence of pulses that are then reflected back by the ionosphere, and records the total travel time for each pulse. This is then used to infer the spatial distribution of the ionospheric plasma above the radar, as well as its Doppler speed. This information about the local 3D electron density distribution and vertical Doppler speed is used to fully characterize the disturbances in the ionosphere. Second, results from an empiric thermospheric model and theoretical knowledge of the thermosphere-ionosphere coupling is added to produce height profiles of the momentum flux, and associated acceleration on the background thermosphere-ionosphere. This is the only method currently capable of providing such results, which are essential for the modelling of the thermosphere-ionosphere and its space-weather applications.

Keywords: *Travelling Ionospheric Disturbances and Acoustic Gravity Waves, Dynasonde Technique, Ionospheric measurements, Momentum Deposition, Gravity Wave Drag*

P1-07

Kinetic corrections and rotational flows in the 2D turbulence of quantum plasmas

D.I. Palade[1,2], V. Baran[2]

[1]National Institute of Laser, Plasma and Radiation Physics, PO Box MG 36, RO-077125 Magurele, Bucharest, Romania
[2]Faculty of Physics, University of Bucharest, Romania
**dragos.i.palade@gmail.com*

When thermal energy becomes comparable with the Fermi energy, the quantum effects start to come in play in the physics of plasmas. In such conditions we enter the field of quantum plasmas. Due to recent advances in nano-technology, the dynamics associated with such systems has become highly relevant for the next generation of nano-scale electronic devices (based on metallic nanoparticles, nano-tubes, metal clusters, spinotronics, etc.).

Recently [1, 2], the problem of fluid-like turbulence in quantum plasma systems has been investigated. The theoretical model used presents two main drawbacks: the solenoidal component of the velocity field associated with the quantum fluid has been neglected and the approximation used for the kinetic pressure tensor it is known to break-down at small scales (which becomes important when dealing with the turbulence spectrum).

In the present work we take into account such corrections providing simultaneously an extension of the Schrodinger-Poisson [1] model, as well as an approximation for the kinetic pressure tensor at small wavelengths.

The theoretical model is used to simulate numerically the turbulence in a 2D quantum electron plasma. While the qualitative dual-cascade is confirmed by our simulations, we find quantitative deviations from the existing results regarding the transport coefficients and the associated turbulence spectrum.

Keywords: *quantum plasma, fluid, turbulence, Schrodinger-Poisson.*

[1] Shaikh, Dastgeer, and P. K. Shukla, Physical review letters **99**, (2007), 12, 125002.
[2] Shukla, Padma Kant, and Bengt Eliasson, Physics-Uspekhi **53**, (2010), 1, 51-76.

P1-08

Mathematical modelling of plasma treatment parameters for the hydrophobization process of fabrics

I.R. Radulescu[1], L. Surdu[1], L. Dinca[1], E. Visileanu[1],
V. Satulu[2], B. Mitu[2]

[1]INCDTP, Str. L. Patrascanu 16, 030508, Bucharest, Romania
[2]INFLPR, Str. Atomistilor 409, 077125 Magurele Bucharest, Romania
razvan.radulescu@certex.ro

Plasma treatment of textile materials is considered an eco-friendly approach as compared to the classical finishing methods [1-2]. In this work, hydrophobic functionality was envisaged on fabrics by the SF_6 plasma treatment. An experimental factorial plan was conducted in order to be able to obtain data for a polynomial mathematical model of the hydrophobization of the fabrics [3]. The applied RF power and the treatment time were selected as independent variables with main influence upon the process, while the contact angle of the resulting fabrics was selected as dependent variable.

Three values were set for the generator power [10, 20, 30 W] and for the process time [2, 3, 4 min] and a simple factorial plan of the type 3^2 was chosen. The experimental matrix was populated with the results of the plasma treatment with different parameters, while the regression analysis was processed using specific software.

The coefficients of the mathematical model were computed and the obtained diagram is presented in Fig. 1. By computing the partial derivative of the model, we obtained that a maximum Water Contact Angle of 137.72° would be obtained for the experimental values (RF Power = 25.3 W, Time = 5.03 min).

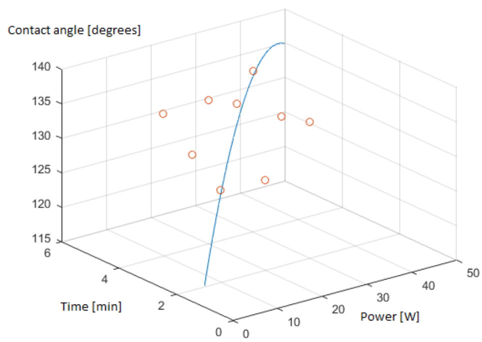


Fig. 1 – Polynomial mathematical model for plasma treated fabrics

Acknowledgements

This work has been financed by the Ministry of Research and Innovation in the frame of Nucleus programme - contract 4N/2016 and 26N /2016-additional agreement 1/2017 and SIINN-ERA NET Grant Agreement No. 265799.

Keywords: *plasma, textiles, hydrophobic, mathematics, modelling.*

[1] M. Sarmadi, Proceeding of 21st International Symposium on Plasma Chemistry (ISPC 21), (2013), Queensland, Australia.
[2] R. Shishoo, Plasma Technologies for Textiles; The Textile Institute and Woodhead Publishing Limited: Cambridge, (2007)
[3] M. Țâțu, C. Oprean, A. Boroiu, Cercetarea experimentală aplicată în creșterea calității produselor și serviciilor, Editura AGIR, (2011)

P1-09

Turbulence in space plasmas – a statistical approach

E. Teodorescu[1], M. Echim[1,2]

[1]Institute of Space Science, Atomistilor 409, 077125, Magurele, Romania
[2]Royal Belgian Institute for Space Aeronomy, 1180 Brussels, Belgium
**eliteo@spacescience.ro*

Venus Express (VEX) provides a unique set of measurements in the solar wind at approximately 0.72 Astronomical Units (AU) from the Sun while orbiting planet Venus. We correlate information provided by two of VEX scientific instruments, the Venus Express Magnetometer (VEX-MAG) and the Analyser of Space Plasma and Energetic Atoms (ASPERA), to investigate the turbulent behavior of magnetic field fluctuations. We consider data for both fast or slow solar wind as well as in the planetary magnetosheath – the region bounded by the bowshock and the magnetopause. We analyze 1 Hz and 32 Hz magnetic field data collected between 2007 and 2009, for the minimum phase of the solar cycle. The power spectral densities (PSD) are computed for the components and the total magnetic field; the spectral index is estimated through linear fits in log-log space. The statistical analysis shows a dependence of the spectral index with the type of solar wind, slow versus fast [1]. We also investigate the turbulent state of the magnetosheath in response to the upstream turbulence. In this case we use a higher order analysis method based on the computation of the moments of the probability distribution functions - known as the Structure Function (SF) analysis. The log-log dependence of second order SF with scale yields a power-law exponent which is related to the PSD spectral index [2]. We employ an automatic fit method [3] to identify ranges of scales governed by power-law behavior and extract the corresponding exponent. We analyze the statistical distribution of the exponents and describe their properties as a function of magnetosheath region and plasma parameters.

Keywords*:* *space plasma, turbulence, solar wind, magnetosheath.*

[1] E. Teodorescu, M. Echim, C. Munteanu, T. Zhang, R. Bruno and P. Kovacs, ApJL, **804**, (2015), 2.
[2] A. S. Monin and A. M. Yaglom, MIT Press, (1975).
[3] S. W. Y. Tam and T. Chang, Nonlin. Processes Geophys., **18**, (2011), 405-414.

P1-10

Role of textured dielectric layer on the time–space behavior of the barrier discharge

I. Topala, G. Borcia

IPARC, Faculty of Physics, Alexandru Ioan Cuza University, Iasi, Romania

1. Introduction

Woven materials raise specific issues related to their surface processing, due to particular 3D nature. These are heterogeneous structures, from mechanical, electrical and chemical point of view, and may shift the behavior of the discharge and its parameters, depending on their 3D characteristics [1]. Taking this into account, we are exploring the relation between the woven structural characteristics, the plasma electrical parameters during sample exposure and the time–space evolution of the discharge.

2. Experimental

The plasma is produced using DBD, in asymmetrical electrode arrangement [1]. The discharge is generated using positive voltage pulses: 5 kV amplitude, 5 kHz frequency, 100 μs width. The DBD parameters are established by electrical measurement. Then, a fast imaging technique using an ICCD is employed to complete the information on the plasma parameters and the time–space behavior of the ionization front.

3. Results

The voltage and current waveforms show two temporally distinct discharges, so-called primary and secondary discharge, respectively, associated to the HV rising and falling slope. The current profile for the primary discharge, which ignites due to externally applied electric field, is different in presence of different samples, whereas the current profile for the secondary discharge, igniting by the so-called “memory effect”, due to the charge deposited on the dielectric surface during the primary discharge, is similar for all samples.

The amplitude of the current pulse and the discharge energy vary for different samples and behave differently for the primary and the secondary discharge, resulting that the aspects related to the permeability of the structure, due to its weaving characteristics, play the major role in the behavior of the discharge.

The structure with interlaced yarns is modifying the plasma gas flow in a significant region of the discharge, and may generate supplementary ionization in interspaces filled with entrapped gas and vapors and enhanced diffusion of the plasma into the fiber matrix, depending on its permeability.

The total light intensity shows different distribution of the discharge regions, for the primary and the secondary discharge, depending on the 3D dielectric layer.

4. Acknowledgement

CASPIA project, Executive Agency for Higher Education Research Development and Innovation, Romania, PN-II-PT-PCCA-2013, grant 254/2014.

[1] G.B. Rusu, I. Topala, C. Borcia, N. Dumitrascu, G. Borcia, Plasma Chem. Plasma Process. **36**, (2016), 341-354

Keywords: barrier discharge, ionization front, woven, permeability

P1-11

Low frequency instabilities based on electron and ion temperature anisotropies in non-Maxwellian plasmas

M.N.S. Qureshi[1]

[1]*Department of Physics, GC University, Lahore 54000, Pakistan*
**nouman_sarwar25@hotmail.com*

In this study we first observe Alfven waves in the solar wind using CLUSTER data and then analyze the ion distributions for the same time interval. We then fit the observed ion distributions using the generalized (r,q) distribution function which is the generalized form of kappa and Maxwellian distribution functions and apply this distribution to study the Alfven cyclotron instability using both the ion and electron temperature anisotropies for the first time, based on the observed parameters from the solar wind as well as from downstream region of bow shock. We studied the role of electron to ion temperature ratios and found that by increasing the anisotropy ratio $\frac{T_{\perp e}}{T_{\parallel i}}$ growth rate of Alfven cyclotron instability decreases whereas by increasing the ratio $\frac{T_{\parallel e}}{T_{\parallel i}}$ growth rate increases. We also found that left-hand circularly polarized wave becomes unstable not only when $T_{\perp i} > T_{\parallel i}$ as reported in the literature but also for $T_{\perp i} < T_{\parallel i}$. Theoretical values of frequency and growth rates are then compared with Maxwellian results as well as with the observations and found in good agreement with the data.

Keywords: *Non-Maxwellian distribution, Micro-instabilities, Alfven waves.*

P1-12

Terrestrial lion roars and non-Maxwellian distribution

W. Masood[1,2]

[1]COMSATS Institute of Information Technology, Islamabad, Pakistan
[2]National Center of Physics (NCP), Quaid-i-Azam University Campus Islamabad, Pakistan

Low frequency waves (~ 100Hz), popularly known as Lion roars, are ubiquitously observed by satellites in terrestrial magnetosheath. By dint of both wave and electron data from the Cluster spacecraft and employing the linear kinetic theory for the electromagnetic waves, Masood et al. [1] examined the conjecture made by Thorne and Tsurutani [2] that whistler waves with electron temperature anisotropy are the progenitors of lion roars. It turned out that the study based upon the bi-Maxwellian distribution function did not come up with a satisfactory explanation of certain disagreements between theory and data. In this paper, we revisit the problem using the generalized (r, q) distribution to carry out the linear stability analysis. It is shown that good qualitative and quantitative agreements are found between theory and data using this distribution.

Keywords: *Whistler waves with electron temperature anisotropy, Magnetosheath, Non-Maxwellian electron distributions.*

Topic 2

Gas discharge physics and plasma diagnostics

P2-01

On the validity of using the spectra of diatomic molecules for determination of gas temperatures in plasmas

M. Bazavan[1], M. Teodorescu[2], G. Dinescu[2]

[1]*Faculty of Physics- University of Bucharest, Atomiştilor 405, Magurele, Bucharest, 077125, Romania*

[2]*National Institute for Laser, Plasma and Radiation Physics, Atomistilor 409, Magurele-Bucharest,077125, Romania*

**m_bazavan@yahoo.com*

A simple method is proposed here to prove that the temperatures determined from rotational molecular spectra describe accurately the actual gas temperatures in an atmospheric pressure plasma jet expanding in a controlled hot ambient atmosphere.

The controlled hot ambient atmosphere is provided by an oven. When operated in the heated oven, the rotational temperatures of the OH radical obtained by comparing recorded OH spectra with simulated spectra, were higher than the oven temperature. This is explained by the fact that the discharge which generates the plasma jet produces additional heating. It is expected that the decreasing of power injected per unit of volume will cause the decrease of the rotational temperature which eventually, if the hypothesis of rotational and translational equilibrium is valid, will converge to oven temperature at zero power injection. The decreasing of injected power per volume was realized in two series of experiments by decreasing of RF power applied to discharge, and by increasing the mass flow rate, respectively. We point out that the extrapolation of the rotational temperature curves obtained from such experimental series to zero injected power per volume lead to the true oven temperature. Thus, we have validated indirectly the OH radical as good thermometric species for gas temperature determination in the case of an argon plasma jet evolving in hot ambient from room temperature to 500ºC. The method can be applied easily to check the validity of using other radicals as thermometric species.

Keywords: *gas temperature, spectral analysis, atmospheric pressure, plasma jet, hot atmosphere*

Acknowledgement: This work has been financed by the National Authority for Research and Innovation in the frame of Nucleus programme-contract 4N/2016 and contract PN-III-P2-2.1-PED-2016-0287.

P2-02

Opto-spectral analysis of a single filament atmospheric plasma jet generated in argon

M. Teodorescu[1], M. Bazavan[2], G. Dinescu[1]

[1]*National Institute for Laser, Plasma and Radiation Physics, Atomistilor 409, Magurele-Bucharest, 077125, Romania*
[2]*Faculty of Physics- University of Bucharest, Atomiştilor 405, Magurele, Bucharest, 077125, Romania*
**maximilian.teodorescu@infim.ro*

Atmospheric pressure non-thermal plasmas have applications in biomedicine, pollution control, and surface treatment. In order to have a good understanding of plasma interaction with the surfaces/materials/liquids, it is necessary to characterize the plasma jets. Mostly used in these studies are the OES (Optical Emission Spectroscopy), photographic and electrical measurements.

In this contribution, we present results of two analyses performed onto a single-filament DBD plasma jet operated at atmospheric pressure using radiofrequency power (13.56 MHz). The jet is generated using argon, inside a thin glass tube. The main characteristic of this plasma source is that the discharge it maintained using only one external electrode. This configuration produces a long (40-60 mm), thin (~600μm), and stable filamentary plasma (Figure 1).

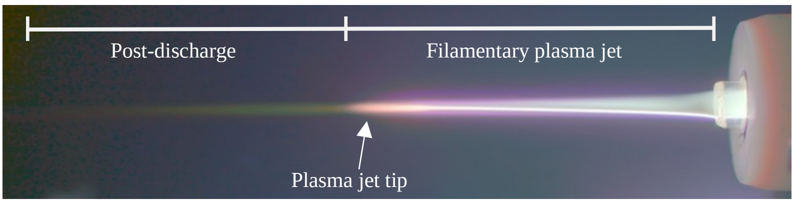


Figure 1. Image of the plasma jet with the filamentary component and the post-discharge

The present study aims at identifying the active species along the plasma jet and inside the post-discharge. The post-discharge extends around 30 mm from the tip of the plasma jet itself, making the total length of the plasma jet around 70 to 90 mm, depending on the applied power (60-100 W). The plasma species identification is performed via OES using a 0.1 nm resolution setup, which also enables us to determine the gas and electron temperatures using the OH radical emission and Argon red and blue lines. The spectral investigation is performed along the entire plasma jet length, with good spatial resolution (1 mm steps) and using high signal-to-noise data by acquiring multiple spectra for each position.

The imaging study is also performed along the plasma jet length with a good spatial resolution, using a high sensitivity optical imaging setup. The spectral data is correlated with the imaging study, and the results point to a detailed description of species behaviour along the flow axis.

Keywords: *filamentary plasma jet, spectral analysis, gas temperature.*
Acknowledgement: This work has been financed by the National Authority for Research and Innovation in the frame of Nucleus programme-contract 4N/2016 and contract PN-III-P2-2.1-PED-2016-0287.

P2-03

Electron temperature determination of Bismuth containing electrodeless light sources during self-modulation regime

Z. Gavare[1,2], M. Zinge[1], A. Skudra[1], E. Bogans[1]

[1]*Institute of Atomic Physics and Spectroscopy, University of Latvia, LV-1050, Skunu Str. 4, Riga, Latvia*

[2]*Department of Physics, Faculty of Information Technologies, Latvia University of Agriculture, 2 Liela Street, Jelgava, LV-3001, Latvia*

zanda.gavare@gmail.com

Our work is concerned with development and optimization of high-frequency electrodeless lamps (HFEDL) containing one or several working elements and buffer gas. Such light sources are used in number of scientific devices, for instance, absorption spectrometers. For optimization of light source it is important to understand processes inside the lamp. Different parameters can give insight into these processes, for example, gas temperature and electron temperature.

In some cases, besides the stable regime, at higher values of excitation generator values we have observed self-modulation regime – the regime during which the intensity of emission from the lamp changes periodically. In this work we study the changes of electron temperature and spectral lines intensities during the self-modulation regime.

The light sources under study were HFEDLs with slightly different fillings: (1) BiI_3+Ar (p = 3,1 Torr) and (2) Bi+SbI_3+Ar (p = 2,8 Torr). These lamps are prototypes for use in atomic absorption spectrometers, particularly, Lumex MGA-915M. These HFEDLs consist of spherical part (with diameter of 1cm) and small side-arm. The discharge is ignited at the spherical part of the lamp by placing it into the electromagnetic field of 250 MHz frequency. The emission from lamps was registered using JobinYvon SPEX 1000M spectrometer. The working regime was chosen so that HFEDLs work in self-modulation regime.

Electron temperature was determined using emission spectra of argon atom. In this study it was assumed that electron energy distribution follows Maxwell-Boltzmann distribution, and excited levels are mostly populated by collisions between electrons and atoms in the ground state. For chosen atomic lines of argon the electron impact excitation rate coefficients were used in exponent approximation [1-3]. Spectroscopic data of the chosen transitions together with measured intensities of spectral lines was used to prepare Boltzmann plots. Electron temperature was then estimated from the slope of these plots.

The analysis of the experimental results showed that the estimated electron temperature in both lamps was around 0.4 eV during maximum phase of the emission and around 0.75 eV during the minimum phase.

Keywords: *electron temperature, argon, bismuth, self-modulation.*

[1] F J Gordillo-V´azquez, M Camero and C G´omez-Aleixandre, PSST 15 (2006) 42-51.
[2] H.W.Drawin, F.Klan, and H.Ringler, Zeitschrift fur Naturforschung, Part A, A 26(2), 186-197
[3] Kramida, A., Ralchenko, Yu., Reader, J., and NIST ASD Team (2015). NIST Atomic Spectra Database (ver. 5.3), [Online].

Acknowledgments: The work was partially supported by program “Multifunctional materials and composites, photonics and nanotechnology” (IMIS 2, Project No 1, Photonics and materials for photonics).

P2-04

Studies of thallium containing high-frequency electrodeless lamps

Z. Gavare[1], G. Revalde[2], A. Abola[1], A. Skudra[1], N. Zorina

[1] *Institute of Atomic Physics and Spectroscopy, University of Latvia, Skunu str 4, Riga, LV 1050, Latvia*
[2] *Institute of Technical Physics, Faculty of Materialsciences and Applied Chemistry, Riga Technical University, P.Valdena 3/7, Riga, Latvia*
zanda.gavare@gmail.com

Our research is connected with the preparation and investigation of high-frequency electrodeless lamps (HFEL). HFELs are applied in various scientific devices such as radiation and absorption spectrometers, spectrometers–goniometers, frequency standards, magnetometers, etc. HFELs are known to be extremely bright radiators with the line spectrum characterized by high intensities and narrow line shapes. HFEL balloons are mostly made of glass or quartz and filled with a working element and buffer gas. These light sources must be optimized for each application in accordance with the specific requirements of radiation quality, life time and stability.

For these studies lamps were prepared filled with: (1) Tl^{205}+Ar and (2) Tl^{205}+Hg+Ar. Tl perturbation by Ar has been investigated for example by Dygdaa et al. [1]. The idea of this work is to study the influence of adding Hg to the Tl + Ar discharge. In this kind of discharge Tl atoms can be excited only by the excitation transfer [2]. The buffer gas pressure was about 3 Torr. The plasma was excited by placing lamp in electromagnetic field of 100MHz frequency. Lamps were operated at excitation generator voltage values from 21V till 31V. The spectral line profile registration was performed using Fourier Transform spectrometer Bruker IFS-125HR. For the real spectral line calculations, the instrumental function was approximated by the Lorenz function with the FWHM of 0.03 cm^{-1}.

It was observed that thallium line intensities of lamps filled with Tl^{205}+Hg+Ar were higher compared to line intensities of Tl^{205}+Ar lamp at the same excitation generator voltages. This can be explained by the fact that mercury combines with thallium creating amalgam, which is easier to evaporate than pure thallium. It means that there will be more thallium atoms in the discharge at lower temperature.

Analysis of Tl 351,9 nm spectral line profiles showed that broadening of this line is bigger in emission of Tl^{205}+Hg+Ar lamp compared to Tl^{205}+Ar lamp. This indicates that there is energy transfer process from excited mercury atoms to thallium atoms in ground state in HFELs.

It was noticed that adding some mercury to lamps filled with thallium, helped it to evaporate more thus resulting in higher line intensities.

Another effect observed was thallium spectral line broadening due to the thallium atom collisions with mercury atoms.

Keywords: *high-frequency electrodeless plasma, plasma diagnostics, mercury, thallium*

[1] Dygdaa, R. S., Bobkowski, R., Lisicki, E., Journal of Physics B: Atomic, Molecular, and Optical Physics, Volume 22, Issue 10 (1989) 1563-1572
[2] Cario G., Franck J., Zeit. Phys., 17 (1923) 202.

P2-05

Reactive magnetron sputtered SiC_x thin films: a correlation between their optical properties and OES process characterization

I. Pana[1,*], C. Vitelaru[1], A. Kiss[1], M. Braic[1]

[1]*National Institute for Optoelectronics, 409 Atomistilor St., 077125, Magurele-Bucharest, Romania*

[2]*Faculty of Physics, University of Bucharest, 405 Atomistilor St., 077125, Magurele-Bucharest, Romania*

**iulian.pana@inoe.ro*

Silicon carbide (SiC_x) exhibits interesting thermal, mechanical and electronic valuable properties, being a suitable candidate for a substantial number and variety of applications, including optics. Amorphous SiC_x thin films have been successfully used as coatings for extreme UV optics and therefore a good understanding of their optical properties is necessary [1].

In this work, the RF magnetron sputtering technique was used for thin films deposition. The optical emission spectroscopy technique (OES) was used to describe the reactive sputtering process of Si target under RF bias in an Ar/CH_4 gas mixture environment. The hysteresis behavior of the emission line intensities and discharge electrical parameters was investigated by keeping constant the total gas flow and the total pressure. The CH_4 mass flow ratio, $F_R=CH_4/(CH_4+Ar)$, was used as the main control parameter. In order to identify the relevant process intervals for plasma chemistry/thin films deposition, the F_R was varied in the interval 0 to 50 %. By monitoring the evolution of the selected emission lines intensities vs. F_R excursion, which was successively increased and then decreased, a process interval helpful for deposition was identified for $F_R \sim 15\%$.

The SiC_x films were characterized using Fourier transform infrared (FTIR) and UV-Vis-NIR spectroscopy. The deposition rates, refractive indices (2.15 ÷ 1.78) and optical band gaps (2.1 ÷ 2.42 eV) were determined and correlated with the OES measurements carried out in the F_R range:10 - 25 %.

Keywords: *magnetron sputtering, silicon carbide, optical emission spectroscopy (OES).*

[1] A. Guerra, L. Montanez, O. Erlenbach, G. Galvez, F.D. Zela, A. Winnacker, R. Weingartner, Journal of Phys.: Conf. Ser, **274,** (2011), 012113

Acknowledgements. This work was funded by the Romanian Ministry of Research and Innovation, through projects PN 16.40.01.01 and PN 16.40.01.02.

P2-06

Influence of C_2H_2/H_2 ratio on the plasma parameters and on the morphology of carbon films obtained by PECVD

S.D. Stoica*, S. Vizireanu, B. Mitu, G. Dinescu

National Institute for Lasers, Plasma, and Radiation Physics, Magurele, 077125, Romania
**daniel.stoica@infim.ro*

The role of hydrogen during the growth of carbon based nanostructured materials is well known, first as an etching agent of the amorphous phase. Also, hydrogen plays an important role in the formation of sp^2 and sp^3 bonds, as it leads to structuring and ordering of the material phase during deposition made [1].

The process discussed in this contribution is focused on the growth of carbon nanowalls (CNW-vertical graphene) by PECVD. In a previous work, we have reported the synthesis of this material from a radiofrequency plasma jet, initiated in argon and injected with a mixture of H_2 and C_2H_2 [2]. The key parameters which control the deposition process were explored and we presented the effects of $Ar/H_2/C_2H_2$ gas flow ratios, power, substrate nature and temperature on the material and plasma characteristics [3]. The present study aims to investigate the effect of acetylene/hydrogen ratio on the plasma species and material characteristics. The depositions were carried out by keeping constant all the values of the experimental parameters, and only the H_2 flow rate was varied in the domain 0 – 100 sccm. The measurements were taken at the substrate level. The electron temperature, density, energy distribution and plasma potential have resulted from Langmuir probe investigations, and other species as neutrals and ions, were studied by mass spectrometry. The material was studied by scanning electron microscopy (SEM).

We have obtained values in range of 0.6–2.2 $x10^{17}$ m^{-3} for the electron density, 1–3 eV for the electron temperature and 30–40 V for the plasma potential, respectively. The most important feature obtained from mass spectroscopy measurements is the presence of hydrocarbon clusters $C_nH_x^+$ (x=1, 2, 3) with ascending number of carbon atoms, up to n = 9. For the neutral mass of acetylene (26 u.a.m.) we obtained a decrease of the consumption from 90% for 5 sccm H_2, to 15% for 100 sccm of H_2.

From the SEM images, we could observe that the deposited films are very different at various C_2H_2/H_2 ratios, the morphology changing from cauliflower like nanomaterial in the absence of H_2, to well defined CNW for high ratios.

Keywords: *hydrogen flow, plasma diagnostics, vertical graphenes, RF PECVD.*

This work has been financed by the National Authority for Research and Innovation in the frame of the Nucleus programme-contract 4N/2016 and contract PN-III-P2-2.1-PED-2016-0287.

[1] C. Reynolds, B. Duong, S. Seraphin, Journal of Undergraduate Research in Physics (2010);
[2] S. Vizireanu, L. Nistor, M. Haupt, V. Katzenmaier, C. Oehr, G. Dinescu, Plasma Process. Polym., **5**, 3 (2008) 263;
[3] S. Vizireanu, S.D. Stoica, C. Luculescu, L.C. Nistor, B. Mitu, G. Dinescu, Plasma Sources Sci T, **19** (2010) 034016.

P2-07

Reactive sputtering of carbon target under HiPIMS conditions for the deposition of DLC coatings

C. Vitelaru[1], M. Dinu[1], A.C. Parau[1], L. Constantin[1], A.E. Kiss[1]

[1]*National Institute for Optoelectronics, 409 Atomistilor St., Magurele-Bucharest, P.O.Box MG 05, Romania*
[*]*catalin.vitelau@inoe.ro*

The high power impulse magnetron sputtering (HiPIMS) technique enables high ionization degrees and corresponding high ion fluxes to the substrate. This is a key parameter when depositing diamond like carbon (DLC) films, as a higher energy input to the substrate is available with proper biasing. Additional increase of the ionization degree of C is obtained by using Ne as the sputtering gas [1]. One of the solutions to increase the deposition rate, a typical issue with HiPIMS in general and with C sputtering in particular, is to introduce a hydrocarbon gas into the process, delivering a supplementary amount of C to the substrate by its decomposition [2].

In this contribution we present an experimental study of the Ne-HiPIMS process, with variable Ne/Ar ratios and CH_4 addition, ranging from 0 to 0.5%. The ion saturation current at substrate position, measured with a planar probe with guard ring, is used as the main indicator of each process to delivering highly ionized fluxes. One of the limitations in increasing the ion flux is the transition towards a mixed functioning mode, characterized by frequent arching [3]. The main focus of the current study is to maintain the process within the limits of stable functioning with no or very rare arcs, typically less than 1/1000 pulses. The main parameters used for tuning the process and the corresponding ion flux are: the peak voltage, the total pressure, the gas composition (i.e Ar/Ne/CH_4 ratio), whilst the time characteristics of the pulses are kept constant, at 60 μs and 100 Hz pulse frequency.

The results show that both the total pressure and the peak voltage are essential parameters for the establishing of the high current regime, playing also an important role into stabilizing the process. The addition of Ne or CH_4, or a mixture of the two, to the process gas increases both the current intensity and the ion saturation current to the substrate. Fine tuning of the key parameters, only few mTorrs or few volts, increases the stability of the process, enabling peak currents as high as 100 A on a 2” target, significantly higher than the typical 50-60 A obtained in the pure Ar process. This corresponds to high ion fluxes to the substrate, with ~300mA/cm^2 ion saturation current at a distance of 4.5 cm from the target.

Keywords: *HiPIMS, diamond like carbon, reactive sputtering*

[1] A. Aijaz, K.Sarakinos, D. Lundin, N. Brenning, U. Helmersson, Diam. Relat. Mater. **23** (2012) 1;
[2] A. Aijaz, S. Louring, D. Lundin, T. Kubart, J. Jensen, K. Sarakinos, U. Helmersson, Journal of Vacuum Science & Technology A **34** (2016) 061504;
[3] R. Ganesan, D. G. McCulloch, N. A. Marks, M. D. Tucker, J. G. Partridge, M. M. M. Bilek and D. R. McKenzie, J. Phys. D: Appl. Phys. **48** (2015) 442001.

This work was supported by the Romanian Research and Innovation Ministry, projects PN 16.40.01.01/02 and PNCDI III project TANDEM No 56/2016

P2-08

Rotational and electron temperature determination in argon and hydrogen containing high-frequency electrodeless lamps

M. Zinge[1], Z. Gavare[1,2], A. Skudra[1]

[1]*Institute of Atomic Physics and Spectroscopy, University of Latvia, LV-1050, Skunu Str. 4, Riga, Latvia*
[2]*Department of Physics, Faculty of Information Technologies, Latvia University of Agriculture, 2 Liela Street, Jelgava, LV-3001, Latvia*
**madara.zinge@gmail.com*

In this work we present results for rotational and electron temperature in high-frequency electrodeless light sources (HFEDL) filled with Ar and H_2. HFEDLs are known to emit bright spectrum from ultraviolet to infrared region, and they are widely used in different scientific devices, for instance, absorption spectrometers. For each particular use the light source needs to be optimized, and it helps to have information about processes inside the plasma, as well as different plasma parameters (like temperature of various species).

Taking into account that HFEDLs are closed vessels it is necessary to use non-invasive methods, for instance, for rotational temperature determination of molecules (like, OH, H_2, C_2 or N_2, etc.) usually the relative intensities of rotational lines are used.

For this study we chose HFEDLs of two different designs: (1) cylindrical and (2) dumbbell form. In both HFEDLs gas pressure was following: p_{Ar}=0,9 Torr, p_{H2} = 0,1 Torr. The discharge is ignited by placing lamp into the electromagnetic field of 100 MHz frequency. For dumbbell form lamp the emission was analyzed for each part of the lamp: (1) spherical, (2) capillary and (3) cylindrical. The emission from lamps was registered using JobinYvon SPEX 1000M spectrometer. The working regime was changed by varying the current in excitation generator from 100 mA until 200 mA.

For rotational temperature determination we used rotational line intensities of Fulcher-α H_2 and OH.

Electron temperature was estimated using Ar I spectral line intensities. In this approach we make several assumptions: (1) electron energy distribution follows Maxwell-Boltzmann distribution, (2) excited levels are mostly populated by collisions between electrons and atoms in the ground state, and (3) electron impact excitation rate coefficients were used in exponent approximation [1-3]. Electron temperature was then estimated from the slope of Boltzmann plots.

The analysis of the experimental results showed that the estimated electron temperature in Ar+H_2 cylindrical lamp was around 0.6 eV, and slightly decreased with increasing value of current. For dumbbell lamp estimated electron temperature was around 0.4 eV (for all three parts). In cylindrical lamp rotational temperature of H_2 was in the range from 750 K until 900 K. In dumbbell form lamp the rotational temperature of OH was different in each of the part: higher in the spherical part (~1000-1700 K) and lower in capillary part (~410- 570 K).

[1] F.J.Gordillo-V´azquez, M.Camero and C.G´omez-Aleixandre, Plasma Sources Sci. Technol. 15 (2006), 42-51.
[2] H. W. Drawin, F. Klan, and H. Ringler, Zeitschrift fur Naturforschung, Part A, A 26(2), 186-197
[3] Kramida, A., Ralchenko, Yu., Reader, J., and NIST ASD Team (2015). NIST Atomic Spectra Database (ver. 5.3), [Online].

Topic 3

Plasma sources and reactors at low and atmospheric pressure, dusty plasma

P3-01

RF atmospheric pressure plasma jet: a method for synthesis of metallic particles

A. Lazea-Stoyanova[1,*], V. Marascu[1,2], C. Stancu[1], G. Dinescu[1]

[1]*National Institute for Lasers, Plasma and Radiation Physics, 409 Atomistilor street, 077125 Magurele, Bucharest, Romania*
[2]*Faculty of Physics, University of Bucharest, 405 Atomistilor, 077125 Magurele, Bucharest, Romania*
[*]*andrada@infim.ro*

Depending on their specific characteristics, metallic particles are used in applications starting from catalysis, electronics, optics, medicine and up to sensor technology. In recent years, an emphasis was set on synthesis techniques that have a great industrial potential and, thus, non-toxic/non-harmful, easy to implement and cheap methods are preferred. Metallic particles made of various metals can be prepared by many synthesis methods.

In this contribution, we present the synthesis of metallic particles by a radiofrequency (RF) plasma jet operating at atmospheric pressure in an inert gas. We used copper, titanium or zinc bulk metals as source materials. [1] We obtained copper, titanium and zinc particles with sizes between 100 nm and few microns. We observed that the plasma operating parameters differ for synthesis of copper particles compared with titanium or zinc particles. Corroborating the information provided by plasma characterization (via Optical Emission Spectroscopy) with visual plasma analyses and with topographic investigations of the electrode surface we determined the RF power threshold at which synthesis starts for each metal. For instance, copper particle synthesis starts at 50 W, whereas titanium needs at least 70 W. Additionally, the particles were characterized by Scanning Electron Microscopy and we observed that the size and shape of the particles is determined by the plasma operating parameters.

Keywords: *metallic particles, atmospheric pressure, RF plasma.*

Acknowledgements: This work was supported by a grant of the Romanian National Authority for Scientific Research and Innovation, CNCS – UEFISCDI, project number PN-II-RU-TE-2014-4-2035 and projects PN16470101-04. V. Marascu acknowledges the support in the frame of EUROfusion Consortium, project 1-EU12 WPEDU-RO.

References:

[1] A. Lazea-Stoyanova et. al, Plasma Processes and Polymers, **12**, (2015), 8, 705-709.

P3-02

Light sources based on gas discharges for photodynamic therapy

P. Chiru[1], P. Dinca[1,2], B. Butoi[1,2], O.G. Pompilian[1], I. Jepu[1], C. Porosnicu[1], C.P. Lungu[1]

[1]*National Institute for Laser, Plasma and Radiation Physics, 077125, Magurele, Romania*

[2]*University of Bucharest, Faculty of Physics, 077125, Magurele, Romania*

petrica.chiru@inflpr.ro

In order to inactivate pathogen cells and tumors, the photodynamic therapy method is frequently used in our days. This means irradiation of photoactive colorants, sensible to light and a specific wavelength [1]. This therapy was successfully used to treat several diseases like abnormal cellular growth as cancer, rheumatoid arthritis, vitiligo, pathologic myopia, macular degeneration caused by age and arteriosclerosis. The greatest step forward was in cancer treatment but the photodynamic therapy showed great efficiency in treating onychomycosis, for example and the surfaces contaminated with biologic contaminants (bacteria, fungus etc.) [2, 3].

The interaction between visible light and a photo sensible agent, generating short life species of cytotoxic agents, is the principle of the photodynamic therapy. Under excitation effect, the photo sensible agent is converted in order to produce radical species and hydrogen peroxide. This mechanism results in the local elimination of the affected cell. For superficial skin affections, the light is directly applied on the affected tissue while for internal affections the light source is connected to a catheter with optical fiber, which allows reaching the targeted organ. Recently, many incoherent alternative light sources have been analyzed to replace the laser within the photodynamic treatment. Between these, we decided to study the light sources based on gas discharges produced in a 10-10^4 Pa pressure range with emission in UV-visible.

The experimental set-up consists in a quartz tube with coaxial electrodes, where the generated luminous radiation is exteriorly oriented, driven by a variable frequency pulsed discharge. The bright emission discharge produced as a result of pure and mixed gases was studied from the electrical and spectral point of view.

Emission spectra in range of 300 to 800 mm were acquired and processed using a SM 240 spectrometer. The applied voltage was of sinusoidal AC type of p-p voltage of 960 V while the p-p current was ~4.3 mA. The maximum pressure in Ar gas for which the discharge between the electrodes was stable was 8×10^3 Pa. For the Xe case, the 3.2×10^3 Pa was the maximum pressure for which the discharge between the electrodes was stable. Further on, the discharge striations were obtained with the increase of pressure. The emission lines who produce photodynamic effect were: Ar at 309 nm, 344 nm, 750,59 nm, 763.51nm, 811.53 nm and Xe at 537.5 nm, 833.16 nm and 873.9 nm. The ignited plasma in the proposed experimental device was characterized. A maximum electron temperature of 1700 K at ~18 kHz frequency was estimated using the emitted radiation of the sealed tube filled with 50%Ar: 50%Xe gas mixture.

Keywords: *Photodynamic therapy; excitation effect; luminous radiation.*

[1] N. Philip, B. Saoudi, M.-C. Crevier, M. Moisan, J. Barbeau, J. Pelletier, IEEE Transactions on Plasma Science, **30**, 1429 – 1436 (2002);

[2] Anil Kumar Bhatta, Uma Keyal, Xiu Li Wang, Photodiagnosis and Photodynamic Therapy, **15**, (2016), 228-235;

[3] M. Moisan, B. Saoudi, J. Pelletier, J. Barbeau, IEEE International Conference on Plasma Science ICOPS, (2002).

P3-03

Novel electromagnetic space propulsion with radio frequency (RF) plasma generation and heating- investigation of plasma detachment through magnetic nozzle

A.-M.T. Andreescu[1], M. Teodorescu[2], G. Dinescu[2], D. Ifrim[1], I.F. Popa[1], R. Mihalache[1]

[1]*Romanian Research &Development Institute for Gas Turbines COMOTI, Bucharest, 220D Iuliu Maniu Ave., District 6, 061126, Romania*
theodora.andreescu@comoti.ro, dan.ifrim@comoti.ro, ionut.popa@comoti.ro radu.mihalache@comoti.ro
[2]*National Institute for Laser, Plasma and Radiation Physics (NILPRP), Str. Atomistilor, 409, PO Box MG-36, 077125, Magurele, Romania*
maximilian.teodorescu@infim.ro, dinescug@infim.ro

Recent advances in efficient plasma generation using radio frequency waves have gain interest in magnetic nozzles for plasma propulsion application in space [1]. This scientific work is addressing to future development of ESA`s nanosatellites electromagnetic thrusters based on RF sources for plasma generation and double current free layer mechanism involved in supersonically acceleration.

The typical design of the RF plasma thrusters is composed of the RF plasma source, a magnetic confinement device and an exhaust nozzle. Also, a main component is the RF driven helix like antenna/electrodes, with an important role in the discharge initiation and its control, depending on the energies and flow of the initially neutral gas into the magnetised plasma with a high degree of ionization. Like in other plasma thrusters a number of two stages are distinguished: the production stage inside the RF plasma source and the acceleration stage in magnetic nozzle. [2]

One of the targets is to contour the processes which take place inside the RF source: wave plasma interaction that leads to the deposition of wave energy into the plasma column and plasma dynamics processes [3] (such as ionization, heating, confinement and flowing). The first scientific work will be directed on scaling neutral gas pressure, magnetic field, mechanical geometry, frequency and RF power. The second scientific work will be focused on choosing the optimum RF discharge configuration of the three proposed: two electrodes cylindrical DBD concept, multi electrode cylindrical DBD concept and Helicon based concept.

As an expected result of this scientific research is to transform the radio frequency sources architectures into efficient electric propulsion system with capability to shift between high specific impulse and higher thrust. A prime objective of this paper is to intercept some of critical system`s parameters and to identify the tradeoffs they derive and also to improve the understanding of proper balance between wide ranges of competing physical phenomenology that are involved in that complex system.

Keywords: *electric propulsion, plasma source, ESA`s missions, magnetic nozzle*

[1] Claudio Bruno, Series: Progress in Astronautics and Aeronautics, ISBN-13: 978-1563479298, AIAA (2008);
[2] F.F. Chen, Third Edition, Springer, (2016), ISBN 978-3-319-22308-7, 405-410;
[3] P. Chambert, N.Braithwaite, Cambridge University Press, (2011), ISBN 978-0-521-76300-4, 260-287.

P3-04

High voltage pulses circuit for generating a plasma plume at atmospheric pressure

O.S. Stoican

INFLPR-Magurele, 409 Atomistilor St. 077125, Romania
stoican@infim.ro

A peculiarity of the plasma generator considered here is that electrical supply consists of two voltage sources parallel connected, namely a circuit that produces a train of negative high voltage pulses with peak value of about -4kV, and a conventional dc voltage source whose output voltage can be varied in the range from −100 V to −1000 V, respectively (Fig.1). The plasma source consists of a nozzle-shaped cavity made in a solid cylindrical block of aluminum. Its general outlines have been described earlier in [1]. The present work was focused to the enhancement of the high voltage pulses and summing circuits in order to optimize the plasma generator operation. The high voltage pulses source is based on the flyback converter topology [2]. Excitation signal is provided by a multipurpose peripheral board (driver circuit) controlled by a computer. By using Ar as working gas, effects of high voltage pulses rate on plasma stability, for different dc voltages and gas flow rate have been investigated. The measurement chain was described in [3]. According to the experimental results, after the plasma plume is initiated, for dc voltage greater than a critical value the electrical discharge continues more than 10 s after the disabling of the high voltages pulses (applied initially with a frequency of 100Hz). Consequently, a stable plasma plume is maintained by applying high voltage pulses at a minimum rate. This approach improves the circuit supply reliability, energy efficiency and diminishes electromagnetic interferences. Possible methods to detect the interruption of the plasma jet are listed. Occurrence of the plasma low frequency oscillations and their correlation with operating conditions (discharge current, working gas flow and mechanical arrangement of the electrodes) have been observed and reported. Effects on the plasma plume control are discussed.

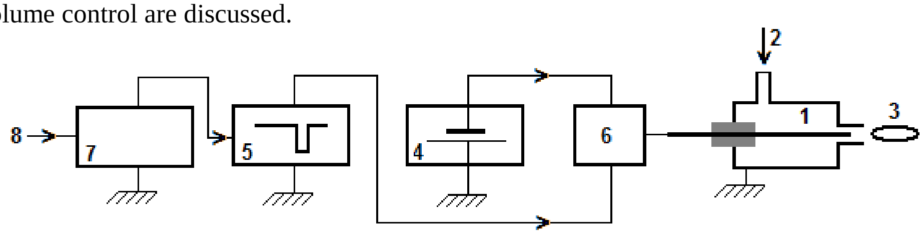


Fig.1: Experimental setup. 1-plasma source; 2-gas flow; 3-plasma plume; 4-dc voltage source; 5-high voltage pulses source; 6-voltage summing circuit; 7-driver circuit, 8-computer.

This work is supported by ANCSI project PN 16 47 -LAPLAS IV
Key words: atmospheric pressure plasma source, high voltage pulses, plasma oscillations

[1] O. S. Stoican, Eur. Phys. J. Appl. Phys., **55**, 30801 (2011);
[2] L. Wuidart, Application Note 513/0393, ST Microelectronics, (1999);
[3] O. S. Stoican, 16th IBWAP, July 7-9, (2016), Constanta, Romania, S2P24, 99.

P3-05

Experimental set-up for the interaction of electron beams with complex plasmas

D. Ticoş, C.M. Ticoş, G. Dinescu

National Institute for Lasers Plasma and Radiation Physics, 409th Atomistilor Street, 77125, Magurele, Romania
toaderdorina@yahoo.com

The paper presents an experimental setup designed and built for the study of the interaction of an electron beam of 10 to 15 keV with complex plasmas. This set-up is made of three vacuum chambers: the electron beam source, the electron beam channel and the interaction chamber where the electron beam interacts with a radiofrequency plasma crystal. Electrons from a Penning hollow anode discharge operating in air at a few mtorr are extracted and accelerated at several kV [1]. An electron beam is formed in vacuum by the action of the magnetic field produced by a pair of coils. The electron beam is further passed through an rf plasma and interacts with a cloud of electrically charged microparticles levitated in the sheath of the plasma. The rf plasma is produced between two parallel plate electrodes in argon at a few hundred mTorr. Several diagnostics methods are used for the characterization of the electron beam and rf plasma in order to understand the interaction between the plasma crystal and the electron beam. The interaction between electrons and complex plasmas [2] is important for various fields such as astrophysics [3], thermonuclear reactions in tokamaks [4] and surface plasma processing.

Keywords: *electron beam, dusty plasma, charged microparticles.*

[1] D. Toader, M. Oane, C.M. Ticoş, Rev. Sci. Instrm. **86**, (2015) p013301;
[2] D. Wang, D. Liu, J. Liu, Journ. Appl. Phys. **88** (3) (2000) p 1276-1280;
[3] L.S. Mathews, V. Land, T.W. Hyde, The Astrophys. Journ. **744**, (2012), 1146;
[4] C.M. Ticoş, Z. Wang, G.A. Wurden, J.L. Kline, D.S. Montgomery, Physics of Plasmas **15**, (2008), 103701.

P3-06

Wake-induced oscillations and rotational motion of cylindrical dust particles trapped in the sheath of low density plasma

N. Udrea[1,2], C.M. Ticoş[1]

[1]*National Institute for Laser, Plasma and Radiation Physics, Bucharest 077125, Romania*
[2]*nicoleta.udrea@inflpr.ro*

The interest for dynamics of nonspherical dust [1-5] has grown and is justified since in many cases the dust particles have different shapes (astrophysical enviroment, plasma reactor). In this paper, we present a simple experiment to introduce the nonlinear behavior of oscillating systems in the dusty plasma laboratory. The chosen approach consists of determination of particles kinetics from visual observations using a high speed camera.
An experimental analysis of nonlinear oscillations of one single dust particle, respectively small assemblies of two and three dust cylindrical particles levitated in the sheath of a capacitive rf plasma, above the driven electrode is made. The problem is analyzed starting with single rod particle effects, where levitation, confinement in plasma traps, charging [5], and oscillations are involved. Self-excited horizontal and vertical oscillations are discussed [6]. An interesting behavior is observed in the system with two particles, regarding the vertical oscillations, a periodicity of the amplitude is observed. Each large amplitude cycle in time is followed by two more small amplitude cycles (smaller than other). Particular attention is paid to the case of three particles, where a rotational motion in the absence of any external magnetic field is observed.
Dust-dust interaction and the attracting ion wakes [6, 7] are proposed as possible mechanisms for inducing the observed dust oscillations. Dust particles levitation displacement across a wide range of rf voltage is measured.

Keywords: *oscillations, cylindrical particles, wake potential, dusty plasma.*

[1] Banu, C. M. Ticoş, Phys. Plasmas **22**, 103704 (2015);
[2] V. I. Molotkov, A. P. Nefedov, M. Yu. Poustylnik et al., JETP Lett. **71**, 102 (2000);
[3] B. M. Annaratone, A. G. Khrapak, A. V. Ivlev, et al., Phys. Rev. E **63**, 036406 (2001);
[4] B.M. Annaratone, A. V. Ivlev, V. E. Fortov, et al., IEEE Transactions on plasma science, **39**, 11, (2011);
[5] A. V. Ivlev, A. G. Khrapak, S. A. Khrapak et al., Phys. Rev. E **68**, 026403 (2003);
[6] C.M. Ticoş, P.W. Smith, P.K. Shukla, Phys. Lett A **319** (2003) 504–509N;
[7] I. H. Hutchinson, Phys. Rev. Lett **107**, 095001 (2011).

Topic 4

Plasma processing, surface modification, deposition, etching

P4-01

Development of hybrids nanocomposites materials based on graphene and siloxane polymer by low pressure and DBD discharges to improve the corrosion behaviour of steel

A. Anagri[1,*], F. Arefi-Khonsari[1], C. Debiemme-Chouvy[1], M. Tran[1], J. Pulpytel[1], A. Baitukha[1]

[1]Sorbonne Universités, UPMC Univ Paris 06, CNRS, Laboratoire Interfaces et Systèmes Electrochimiques, 4 place Jussieu, F-75005, Paris, France
**abdssadek.anagri@gmail.com*

Corrosion has been a perennial issue of concern for the steel industry. One of the well-known pre-treatment coatings for steel is chromate conversion coatings but due to environmental concerns and legislations, their use has been restricted. The present study concerns an alternative eco-friendly pre-treatment coatings consisting of hybrid nanocomposite materials based on graphene embedded siloxane plasma polymers. The deposition of hybrid nanocomposites films were performed by using a low pressure (PECVD) reactor as well as a dielectric barrier discharge (DBD) at atmospheric pressure. Direct current polarization (DCP) and electrochemical impedance spectroscopic (EIS) techniques were used to measure the polarization and corrosion resistance of the coated steel substrates.

The graphene used is produced by the chemical Hummers' method. The optimal weight percentage of the graphene in the plasma polymer, and particle size of graphene were optimized to ensure good protection against corrosion but also to avoid its aggregation which will cause delamination in the hybrid layers formed respectively.
An approach using an aerosol-assisted process in which a dispersion containing preformed graphene nanoparticles and the liquid precursor of the polymeric component was atomized and injected in the form of an aerosol in the dielectric barrier discharge (DBD) at atmospheric pressure.

Keywords: *PECVD, DBD, Corrosion, Graphene, Hybrids materials, Nanocomposites, EIS and DCP.*

P4-02

Plasma activation of silica surface for self-assembled monolayer deposition of octadecyltrichlorosilane

A. Besleaga[1], F. Samoila[1], L. Sirghi[1,2]

[1]*Iasi Plasma Advanced Research Center (IPARC), Faculty of Physics, Alexandru Ioan Cuza University of Iasi, Blvd. Carol I nr. 11, Iasi 700506, Romania*
[2]*lsirghi@uaic.ro*

Covalent bonding of octadecyltrichlorosilane (OTS) molecules to silanol (Si-OH) groups on silicon oxide surface to form self-assembled monolayers (SAMs) has been studied by many groups as a technique for fabrication of super-hydrophobic surfaces terminated in methyl ($-CH_3$) nonpolar groups [1]. Previous to SAM deposition, the silica surface has to be activated by generation of Si-OH groups. Currently there are few techniques used to activate the silica surface, chemical treatment of surface by piranha solution (H_2SO_4/H_2O_2 4:1), UV/ozone irradiation and air plasma treatment [2].

In this work we used plasma of a d. c. discharge at low pressure in a mixture of air and water vapour at low pressure to activate the surface of a glass substrate by generation of Si-OH functional group on surface. For the plasma activation, the glass substrates (1.5×1.5 cm^2) were loaded on the cathode (a stainless steel disk with area 100 cm^2) and subjected to the negative glow plasma of a dc glow discharge (discharge current voltage and intensity about 460V and 5 mA, respectively) in water vapor and air mixture at pressure of 20 Pa for 10 min [3]. Then, the OTS molecules are covalently bound to the plasma activated surface by SAM deposition. The entire process of silanization is based on adsorption, self-assembly and covalent binding of OTS molecules onto glass surface. After the activation processes, the glass substrates were imbedded in a solution of OTS in toluene (concentration = 2 mM) for 24h to allow chemisorptions of OTS molecules. To complete the formation of covalent bonds, the substrates were transferred to an oven and baked for 20min at 120ºC. The OTS modified glass surface has been investigated by Atomic Force Microscopy (AFM) and water contact angle measurements. Water contact angle were measured by analysis of profiles of small sessile drops of water, while mean root square roughness of surfaces was determined by analysis of AFM images acquired in tapping mode in air. The water contact angle was 93.16±2.5º for OTS modified substrates, and less than 5° for the hydroxylated glass surface. The roughness of the OTS modified glass surface was slightly higher than that of the glass surface due to non uniform deposition of OTS.

Keywords: *plasma hydroxylation, self-assembled monolayer, silane modified silica surface.*

[1] Lessel, Matthias, et al., Surface and Interface Analysis **47**, (2015), 5, 557-564;
[2] Dan Zhanga, You Wang b,c, Yang Gana, Applied Surface Science **274**, (2013), 405–417;
[3] Sirghi, L. Rom., J. Phys **56**, (2011), 144-148.

.

P4-03

Hydrogen content of carbon nanowalls obtained by PECVD at different parameters of synthesis

M. Acosta Gentoiu[1,6], S. Vizireanu[2], I. Burducea[3], S.D Stoica[2], B. I. Bita[4], I. Mihalache[4] C. Grigorescu[5], S. Antohe[6], G. Dinescu[2,6]

[1]Departamento de Investigación en Física, Universidad de Sonora, Apdo., Postal 5-088, C.P. 83190, Hermosillo, Sonora, México
[2]National Institute for Lasers, Plasma and Radiation Physics, Atomistilor No.409, PO Box MG-36, Magurele-Bucharest, Romania.
[3]Horia Hulubei National Institute of Physics and Nuclear Engineering, Magurele, Ilfov, 077125, Romania
[4]National Institute for R&D in Microtechnologies, 023573, Bucharest, Romania
[5]National Institute R&D for Optoelectronics, 077125, Magurele, Romania
[6]Faculty of Physics, University of Bucharest, 077125, Magurele, Romania
**macostagen@gmail.com*

Carbon nanowalls (CNW) consists of a network of interconnected self-supported vertical walls made from graphene sheets, randomly oriented, with thicknesses less than a few tens of nanometers [1]. Herein, the CNW structures were synthetized by plasma enhanced chemical vapor deposition, using a low pressure expanding RF plasma jet generated in argon in presence of acetylene and hydrogen mixture [2]. The CNW samples were synthetized in similar conditions, except the deposition temperature T_D and Ar flow rate were varied. The microprobe elastic recoil detection analysis (ERDA) was used to investigate the hydrogen content and H:C ratios along depth. Scanning electron microscopy SEM and Raman spectroscopy were employed to substantiate the morphological and structural differences in the material. The ERDA results showed a hydrogen concentration quite homogeneous along CNW depth. Moreover, the values of hydrogen content increased at lower Ar flow rates. The reduction of Ar flow rates, along with higher $T_{D,}$ also produced a decrease in length and increased the number of walls and defects on unit of surface. Electrical measured were carried out in the respective samples, which were deposited onto electrodes with a gap around 2 mm. Higher T_D and lower Ar flow rates lead to an improvement in electrical conductance. No strong dependence of the conductance upon hydrogen content was observed.

Keywords: *nanowall, PECVD, ERDA, Graphene.*

[1] M. Hiramatsu, Y. Nihashi, H. Kondo, M. Hori, Japanese Journal of Applied Physics, **52**, (2013), 1;
[2] S. Vizireanu, L. Nistor, M. Haupt, V. Katzenmaier, C. Oehr, G. Dinescu, Plasma Processes and Polymers, **5**, (2008), 3, 263-268.

Acknowledgments: M. Acosta Gentoiu acknowledge the support of the National Council of Science and Technology Center (CONACYT), Mexico for her doctoral study in Romania. The work was partially financed in the frame of the projects Nucleus programme-contract 4N/2016 (INFLPR) and PN-III-P2-2.1-PED-2016-0287.

P4-04

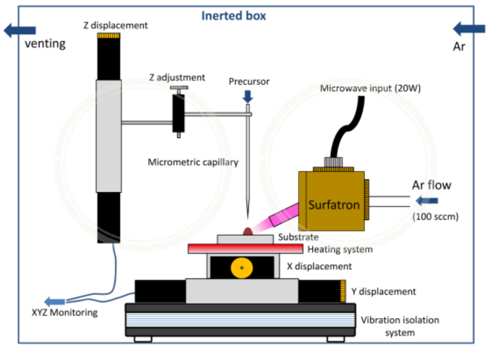
Sub-micrometric patterns deposited by localized atmospheric pressure plasma enhanced chemical vapor deposition

M. Haacké[1], A. Boileau[1], T. Gries[1], C. Noël[1], T. Belmonte[1, *]

[1] *Département CP2S, Institut Jean Lamour, Université de Lorraine, UMR CNRS 7198, Parc de Saurupt, Nancy, F-54011, France*

[*] *thierry.belmonte@univ-lorraine.fr*

Micro and nano-patterning of surfaces by the top-down approach is a challenge in the fields of microelectronics, MEMS and micromechanics, with potential applications in medicine and photonics. A previous study demonstrated the possibility of depositing sub-micrometric localized coatings − spots, lines or even more complex shapes – made of amorphous hydrogenated carbon (a-C:H) on silicon substrates, thanks to a moving XY stage and using chemical vapour deposition assisted by an argon atmospheric pressure microwave plasma. Acetylene, used as precursor, was injected into the post-discharge region, perpendicularly to the substrate, by means of a glass capillary with sub-micrometric diameter. The kinetics of the deposition reaction was investigated according to the geometric configurations of the capillary (diameter, distance to the substrate…). [1]



Schematic representation of the experimental device

Recently, we have found that inerting the deposition area with a non-reactive gas such as nitrogen thanks to a glove compartment was found to dramatically enhance the resolution of the hydrogenated carbon (a-C:H) and amorphous silicon (a-Si:H) patterns. Sub-micrometric spots, lines and 3D-shapes were successfully deposited under these controlled conditions. The patterned coatings were characterized by SEM, white-light interferometry and AFM. This new process of additive manufacturing by atmospheric plasma offers a high resolution at low cost.

Keywords: *micro and nano-patterning, atmospheric pressure plasma jets, 3D printer.*

[1] A. Boileau, T. Gries, C. Noël R.P. Cardoso and T. Belmonte, J. Phys. D Appl. Phys. **49**, (2016), 44.

P4-05

Atmospheric pressure etching of silicon surface with fluorine-containing cold plasma jets

M.D. Ionita, E.R. Ionita*, G. Dinescu

National Institute for Laser, Plasma and Radiation Physics,
409 Atomistilor Str., Magurele- Bucharest, 077125, Romania
**ionita.rosini@infim.ro*

Silicon etching is widely used and necessary process in semiconductor industry. Plasma etching is a preferred alternative to the chemical methods (wet etching), because it is environmental friendly. Nowadays, the etching is performed mostly by low pressure plasmas, which allows a good process control, and a fine design of size and shape of the nano-microstructures. However, last decades were marked by the development of cold atmospheric plasma sources. They can be operated in absence of vacuum, allows processing in open atmosphere, and the limitations concerning the size and shape of the substrates are considerably reduced.

In this contribution, we report on the atmospheric pressure etching of silicon using a cold plasma jet based on a discharge with bare electrodes (DBE), sustained at 13.56 MHz. The principle of operation of this plasma jet source was presented in detail elsewhere [1, 2]. When working in argon, at power values in the range 5-25 W, the source produces a jet with a diameter of about 2 mm and length of 10-15 mm. Stable operation was proved with small amounts of foreign gases (1-5% of oxygen, nitrogen, SF_6) admixed in the main argon gas.

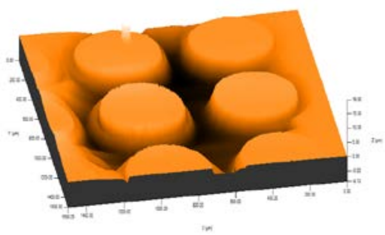


Figure 1. 3D image of pattern silicon surface etched in a mixture of Ar and SF_6 plasma for 10 minutes.

In order to check on the etching process, silicon wafers were first patterned by magnetron sputtering with spots of Au, using a metallic mask with openings of 400 microns. The as-prepared samples were exposed to the plasma jet in static mode. The experiments were carried out in open atmosphere, the plasma was generated at 20W, in 6500 sccm Ar, 1 sccm SF_6, 2 mm nozzle to substrate distance. The processing time was varied in the range 1-30 minutes. The modification of silicon surface was investigated by optical microscopy, profilometry and scanning electron microscopy. Patterning of silicon material was demonstrated, as shown in Figure 1. Depending on the process conditions the etching rates have been in the range 0.8-1 µm/min.

Acknowledgement: This work has been financed by the National Authority for Research and Innovation in the frame of Nucleus programme-contract 4N/2016.

Keywords: *silicon etching, atmospheric pressure, fluorine plasma treatment.*

[1] E.R. Ionita, M.D. Ionita, E.C. Stancu, M. Teodorescu, G. Dinescu, Appl. Surf. Sci. **255**, (2009), 5448–5452;
[2] E.R. Ionita, I. Luciu, G. Dinescu, C. Grisolia, Fusion Eng. Des. **82**, (2007), 2311–2317.

P4-06

Deposition of plasma-polymerized hexamethyldisilazane films onto polypropylene track-etched membranes

L.I. Kravets[1,*], S.N. Dmitriev[1], V. Satulu[2], B. Mitu[2], G. Dinescu[2]

[1]*Joint Institute for Nuclear Research, Flerov Laboratory of Nuclear Reactions, Joliot-Curie Str. 6, 141980 Dubna, Russia*
[2]*National Institute for Lasers, Plasma and Radiation Physics, Atomistilor Str. 409, 077125 Magurele, Bucharest, Romania*
**kravets@jinr.ru*

The synthesis and characterization of the polymer bilayer composite membranes prepared by deposition of thin films formed on one side of a porous substrate using a plasma polymerization method were studied. Polypropylene track-etched membranes (PP TM) with thickness of 10.0 μm and pore diameter of 300 nm (pore density of 10^8 cm^{-2}) were used as porous substrates. To produce the membrane, PP-foil Torayfan T2372 (Toray Co., Japan) was irradiated by xenon ions accelerated at the cyclotron and then subjected to physicochemical treatment using the method described in [1]. The deposition of the polymer films on the membrane surface was conducted by RF-discharge (100 W, 13.56 MHz) [2] generated at a working pressure of 0.7 Pa established by a mixture of argon, used as feed gas, with hexamethyldisilazane (HMDSN) vapors used as precursor. The deposition time was varied.

The membrane characterization was carried out by atomic force microscopy (AFM), the surface properties were characterized by measuring the water contact angles, and the chemical structure was investigated by X-ray photoelectron spectroscopy (XPS) and Fourier-transformed infrared spectroscopy (FTIR) in attenuated total reflectance (ATR) mode. The measurements of the current-voltage characteristics of the membranes were carried out with a direct current regime in the voltage range of –1 to +1 V using a PC-controlled potentiostat ‘Elins P-8S’ (Russia) with a scan rate of 50 mV/s. A two-chambered cell with Ag/AgCl electrodes, containing a water solution of potassium chloride of identical concentration on both sides of the membrane was used for this purpose.

It has been shown that deposition of the plasma-polymerized HMDSN layers on the surface of PP TM results in bilayer composite membranes with both layers having hydrophobic properties. The developed bilayer membranes present a diode-like effect, namely the ion transport in electrolyte solutions depends on the current direction through the pores. This effect is caused by decreasing the pore diameter in the deposited polymer layer that results in changing the pore geometry as well as existence in the pores of an interface between two layers of different nature. The membranes of this kind can be used for directional ion transport.

Keywords: *plasma polymerization, polymer composite membranes, hydrophobic layers, asymmetric conductivity.*

[1] L.I. Kravets, S.N. Dmitriev, P.Yu. Apel, Collect. Czech. Commun. **62**, (1997), 752-760.
[2] L. Kravets, S. Dmitriev, N. Lizunov, V. Satulu, B. Mitu, G. Dinescu, Nucl. Instr. Meth. B **268**, (2010), 485-492.

P4-07

Evaluation of 3D thin film profile in magnetron sputtering deposition

B. Mitu[1*], R. Coca[2], G. Dinescu[1]

[1]*National Institute for Lasers, Plasma and Radiation Physics, 409 Atomistilor Str., PO Box MG 36 Magurele Bucharest, Romania*

[2]*Self-Employed,* razvan.coca@gmail.com*, 062163, Bucharest, Romania*

**mitub@infim.ro*

Magnetron sputtering deposition is among the most used techniques for thin film synthesis for a large variety of materials, from the metallic ones to dielectrics and polymers. For the conventional balanced magnetron configuration with circular target, the sputtering process is predominant from a circle corresponding to the highest intensity of the magnetic field on the target. The ejected particles condense on surfaces that are placed in the proximity of the magnetron sputtering cathode and conduct to deposition of thin films with various 3D profiles, which depend on the substrate positioning.

The present contribution deals with the theoretical estimation of the probability for a particle ejected from a particular position on the target in a given solid angle to arrive to the substrate. It is considered that the substrate plane is oriented in respect to the target plane at an angle Θ, separated by the distance K measured along the target plane normal vector from target center to the substrate plane. Upon integrating along the circle on the target from which the particles are ejected, distribution of probability on the substrate plane can be obtained.

An example of the obtained 3D thin film profile is presented in Figure 1. It corresponds to the positioning of the target to substrate on an angle of 20°, and a distance of 3 cm, when considering that most of the deposition takes place from a thin circle of 5 cm diameter of the target. The color distribution was considered so the lightest yellow color corresponds to the highest film thickness, while the darkest one (violet) to the lowest thickness. Such modelling should fit effectively to the experimental conditions corresponding to dominant atomic sputtering, like in the case of pure chemical elements (metals).

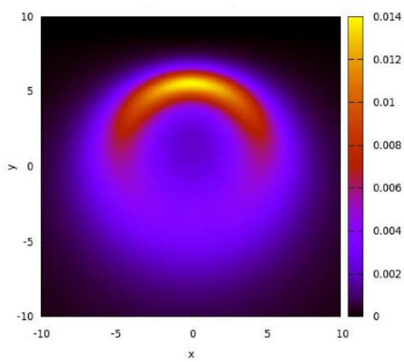


Figure 1. 3D profile of a film deposited on a substrate positioned at 20° in respect to the target (5 cm diameter) and 3 cm apart from it.

Keywords: *magnetron sputtering, thin films, probability distribution, profilometry.*

Acknowledgement: This work has been partially financed by the Ministry of Research and Innovation in the frame of Nucleus Programme - contract 4N/2016.

P4-08

Dielectric properties of PTFE-like thin films obtained by magnetron sputtering

V. Satulu*, V. Ion, B. Mitu, G. Dinescu

[1]*National Institute for Lasers, Plasma and Radiation Physics,*
409 Atomistilor, Magurele- Bucharest, 077125, Romania
**veronica.satulu@infim.ro*

Fluorinated polymers have found a broad range of applications as thin films, from hydrophobic and super-slippery surfaces to protective coatings or active layers in sensors. In the present contribution, results on magnetron sputtering of polytetrafluorethylene (PTFE) are presented aiming at their use in electronic devices.

Deposition of PTFE-like thin films was performed by RF magnetron sputtering of a PTFE (Goodfellow, FP307980) polymeric target at power level in the range 50 – 110 W. The magnetron head is mounted at 45° with respect to the substrates' holder plane and positioned at 9 cm distance. The uniformity of the deposition was obtained by rotating the substrate (100 rpm). The working pressure under continuous Ar flow of 100 sccm was $6x10^{-3}$ mbar.

Under the investigated deposition conditions, we determined an increase of the deposition rate from 1 nm/min at 50W to almost 7 nm/min at 110 W, while the obtained thin films were extremely smooth, with roughness values below 1 nm for film thickness of approximately 200 nm. The FTIR measurements showed the presence of typical PTFE absorptions bands associated to CF_3 vibrations at 978 cm^{-1} and CF_2 vibrations at 1182 and 1227 cm^{-1}. Nevertheless, the band at 1715 cm^{-1} associated to $C=CF_2$ or $CF=CF_2$ bonds point out towards the crosslinking structure obtained upon target sputtering.

The dielectric function of PTFE deposited on Pt/Si substrates was determined in two frequency regimes: in the low frequency range (1KHz - 5 MHz) by dielectric spectroscopy and in the optical range (UV-VIS-Near IR) by spectroscopic ellipsometry. The value of the dielectric permittivity was calculated in the plane capacitor approximation and was found to be ε_r~2.8, which is slightly higher than the expected values. At the same time, the electrical losses have values below $7.5*10^{-3}$, which is one order of magnitude higher than those reported for the pure material. In the optical range (300-1700 nm), the values of the refractive index were found in the range n~1.44-1.4, with extinction coefficients k below 10^{-4}.

These results are encouraging for a possible utilization of the PTFE thin films in various devices, for example as active layers in surface acoustic wave based sensors.

Keywords: *Magnetron Sputtering, Thin Films, PTFE-like, Dielectric Function.*

Acknowledgement: This work has been financed by the Ministry of Research and Innovation in the frame of Nucleus programme - contract 4N/2016.

P4-09

Design, deposition and characterization of PVD optical coatings: a systematic experimental approach

I. Pana[1,*], C. Vitelaru[1], N.C. Zoita[1], A. Kiss[1], M. Braic[1]

[1]*National Institute for Optoelectronics, 409 Atomistilor St., 077125, Magurele-Bucharest, Romania*
[2]*Faculty of Physics, University of Bucharest, 405 Atomistilor St., 077125, Magurele-Bucharest, Romania*
**iulian.pana@inoe.ro*

The optical properties of PVD oxides and nitrides coatings have been extensively studied in recent years. These multilayered coatings are widely used for different optical applications, such as colored optical filters, Bragg mirrors, high power optical, antireflective (AR) or low emissivity (low-e) coatings. The development of such applications [1] requires i) the control and reproducibility of the complex refractive index of the coatings; ii) synthesis of monolayers with amorphous and isotropic structure and no birefringence; iii) their good adhesion to the substrate, high scratch and abrasion resistance, iv) superior thickness uniformity (< 3 %) and low surface roughness of the coatings. The magnetron sputtering process is widely used on large industrial scale for production of coatings, fulfilling all the above mentioned requirements [2].

In this contribution we present the results of a systematic experimental approach, starting from the deposition by magnetron sputtering technique and optical characterization of single oxides, nitrides and metallic layers. The investigation of the optical properties of the individual monolayers (SiN_x, Ag, SiO_x and TiO_x) in terms of refractive index and extinction coefficient was carried out by spectrophotometric measurements, combined with multilayer modelling and reverse engineering. The measured monolayer characteristics were used as input parameters in the design, targeting for specific spectral characteristics of the multilayers. Three different kinds of applications were considered: AR (Vis reflectance < 2 %), low-e (Vis transmittance of 85 % combined with high IR reflectance ~ 80 %) and colored optical filters (Vis reflectance ~ 45 %, solar transmittance ~ 80 %). The optical modelling process was performed considering a compromise between the coating's cost-effectiveness and overall performance, specific to each type of application. The comparison between the designed and measured spectral photometric curves of three different multilayers, one for each of the above mentioned applications, will be presented, demonstrating the design and experiment accordance.

Keywords: *magnetron sputtering, PVD optical coatings, multilayer design*

[1] L. Martinu, D. Poitras, J. Vac. Sci. Technol. A, **18**, (2000), 06, 2619-2645;
[2] J.A. Dobrowolski, J.R. Pekelsky, R. Pelletier, M. Ranger, B.T. Sullivan, A.J. Waldorf, Appl. Opt. **31**, (1992), 19, 3784-3789.

Acknowledgements: This work was funded by the Romanian Ministry of Research and Innovation, through projects PN 16.40.01.01 and PN 16.40.01.02.

P4-10

HiPIMS and reactive magnetron sputtering techniques used for obtaining fusion related materials

C. Porosnicu[1], V. Tiron[2], P. Dinca[1.3], B. Butoi[1], I. Burducea[4], O.G. Pompilian[1], I. Jepu[1], C.P. Lungu[1]

[1]National Institute for Lasers, Plasma and Radiation Physics, 077125, Bucharest, Romania
[2]Faculty of Physics, Alexandru Ioan Cuza University, 700506, Iasi, Romania
[3]Faculty of Physics, University of Bucharest, 050107, Bucharest, Romania
[4]Horia Hulubei National Institute of Physics and Nuclear Engineering, IFIN-HH, Magurele 077125, Romania
corneliu.porosnicu@inflpr.ro

In magnetic confinement devices, the interaction between the edge plasma and the surrounding surfaces strongly influences the conditions in the core plasma. Because the plasma-facing components (PFC) are exposed to high heat and particle fluxes from plasma, they must withstand long-term operation and demonstrate a low level of dust production and fuel accumulation.

In thermonuclear fusion devices, the fuel retention by diffusion, ion implantation and trapping strongly depends on the material properties. The reactive magnetron sputtering technique was used as model system in order to study the influence of beryllium (Be) and tungsten (W) (materials that will be used as PFC in ITER) films microstructure [2] and gaseous pre-implantation on nuclear fuel retention behaviour.

Very good results were obtained using high power intensity magnetron sputtering technique (HiPIMS) for preparation of Be-W mixed layers having nitrogen (N) and/or deuterium (D) seeded during the deposition process mimicking depositions as plasma facing material. HiPIMS usage for PFC materials behavior studies ensures that the chemical composition and properties of the coatings can be fine-tuned by adjusting the pulse parameters like: applied voltage, pulse length, delay between micro-pulses and sequences, repetition frequency.

Rutherford backscattering spectrometry (RBS) measurements were performed on the Be-W with N and D gas inclusions, Be thin films with D prepared with DCMS (direct current magnetron sputtering) technique and Be-W layers obtained by HiPIMS. The morphological and structural analysis of W, Be and W-Be based films deposited by HiPIMS revealed: (i) small cone-shaped blisters with diameters of several micrometres and height of up to 300 nm are formed on W and Be-W films surface while no visible blistering occurred for the Be thin films; (ii) Be thin films are amorphous, while W thin films are highly oriented, with only (110) phase; (iii) Be-W mixed films are polycrystalline, with single or multiple phase for the two materials, depending on the content of Be in the films.

The obtained films were analysed in order to verify the gaseous thermal desorption spectroscopy (TDS) for deuterium content. The results showed N concentration around 16% for W and D concentration around 19% for Be and Be-W mixed layers, according to the layer and the release temperatures were highly dependent on the layer's structures.

Keywords: *Plasma Wall Interaction, Plasma Facing Components, Beryllium, Fuel Retention*

[1] G. Federici et al. Nucl. Fusion **41**, (2001), 1967.
[2] P. Wang, W. Jacob, and S. Elgeti, J. Nucl. Mater. **456**, (2015), 192–199.

P4-11

Cleaning of carbon layers from surfaces by low pressure radiofrequency plasma

C. Stancu, S.D. Stoica, V. Satulu, V. Ion, G. Dinescu

National Institute for Lasers, Plasma and Radiation Physics, 409 Atomistilor Str., PO Box MG-36, Magurele-Bucharest, 077125, Romania
cristian.stancu@infim.ro

In this contribution we present results regarding the cleaning of surfaces coated with carbon containing layers by low pressure radiofrequency plasma. The basic ideas for the plasma cleaning experiments were the following: i) designing of discharge configurations suitable for plasma generation in front of the surfaces to be cleaned; ii) avoid the plasma contact with metallic surfaces (electrodes or chamber walls) to avoid radicals recombination and contamination by sputtering processes; iii) operation of the plasma sources in low ionic bombardment regime, in order to avoid the risk of damage of in case of the optical surfaces.

The experimental system consists in a glass cylindrical vacuum chamber on which a plasma source is mounted facing at 3 cm the sample to be cleaned. Vacuum is realized by two pumps: a rotary pump which ensure a pressure of 10^{-2} mbar and a turbo molecular pump which ensures a pressure of 10^{-5} mbar. Two type of plasma sources were used for cleaning: a plasma source with outer annular electrodes, and a plasma source having a central powered electrode. Plasma is generated in RF (13.56 MHz). Plasma was investigated by optical emission spectroscopy, mass spectrometry and Langmuir probes in order to identify species and determine the plasma parameters.

Silicon surfaces covered by thin a-C:H films were used as contaminated surface models. The a-C:H films (thickness about 600 nm) were deposited by PECVD using Ar mixed with CH_4 [1], in a separate setup. The contaminated surfaced were exposed to the low-pressure radiofrequency plasma generated in Ar and N_2 at different RF powers, different times and different mass flow rates. Profilometry and ellipsometry investigations were performed, that proved on erosion of the film by gradual roughening, and its removal.

Keywords: *plasma cleaning, carbon removal, radiofrequency plasma*

[1] L.I. Kravets; S.N. Dmitriev, V. Satulu, B. Mitu, G. Dinescu, Journal of Physics Conference Series, **516**, (2014), 012006.

Acknowledgments: This work was performed in the frame of Nucleus programme-contract 4N/2016 - INFLPR financed by the Romanian National Authority for Research and Innovation.

P4-12

Cleaning of oleic acid contaminant from glass surface by low-pressure discharge plasma

F. Samoilă[1], L. Sirghi[1, *]

[1]*Iasi Plasma Advanced Research Center (IPARC), Faculty of Physics, Alexandru Ioan Cuza University of Iasi, Blvd. Carol I nr. 11, Iasi 700506, Romania*
[*]*lsirghi@uaic.ro*

There are various methods for surface cleaning, which roughly can be divided in wet chemical processes and dry processes [1]. Plasma cleaning is a simple, fast and environmentally friendly dry method. Unlike the wet chemical cleaning, plasma cleaning is easily controllable and the waste products are generally in gaseous form and can be liberated directly to the atmosphere (most of the resulted gases have no toxicity). The contaminant removal rate during the plasma treatment depends on physical and chemical properties of the contaminant, on the substrate and also on plasma properties.

In a previous study [2] we have noticed that exposure of clean glass surface to overheated oleic acid vapour resulted in coverage of the surface with oleic acid nanodroplets. In this work we investigate the efficiency of low-pressure plasma in air and water vapour mixture for removing oleic acid nanodroplets from glass surface. Contaminated glass surfaces were scanned by an atomic force microscope working in true noncontact mode. The topography images of oleic acid nanodroplets on glass were analyzed to determine average values of droplet height and contact line radius. Before plasma treatment we noticed a uniform coverage of 50% of the glass surface area with oleic acid nanodroplets having spherical cap shape with average values of contact line radius and height of 170 nm and 6 nm, respectively. Exposure of the glass surfaces contaminated with oleic acid nanodroplets to the negative glow plasma of a d. c. glow discharge in air and water vapour at low pressure (20 Pa) resulted in a noticeable decrease of oleic acid nanodroplet sizes. After 1 minute of plasma treatment, the average height of oleic acid nanodroplets decreases to 2.75 nm, while the average contact line radius decreases to 115 nm. Plasma treatment of glass contaminated with oleic acid nanodroplets for more than 5 minutes resulted in complete removal of oleic acid nanodroplets from the glass surface.

Keywords: *plasma surface cleaning, oleic acid contaminant, glass substrate*

[1] Dan Zhanga, You Wang b,c, Yang Gana, Applied Surface Science **274**, (2013), 405–417;

[2] F. Samoila, A. Besleaga, L. Sirghi, Atomic Force Microscopy of Contamination of glass surface exposed to oleic acid vapors, Proceedings of the 15th International Conference on Global Reseaech and Education, Advances in Intelligent Systems and Computing 519 (2016) p71.

Topic 5

Biological and medical applications of plasmas, plasmas in liquids

P5-01

Degradation of 2,4-D in water by pulsed corona discharge

M. Magureanu[1], C. Bradu[2], D. Dobrin[1], V.I. Parvulescu[3]

[1]National Institute for Laser, Plasma and Radiation Physics, Atomistilor Street 409, PO Box MG-36, 077125, Magurele, Romania, e-mail: monimag@gmail.com
[2]University of Bucharest, Faculty of Biology, Department of Systems Ecology and Sustainability, Splaiul Independentei 91-95, 050095, Bucharest, Romania
[3]University of Bucharest, Faculty of Chemistry, Department of Organic Chemistry, Biochemistry and Catalysis, Regina Elisabeta Blvd. 4-12, 030016 Bucharest, Romania

Pesticides are commonly detected in various water bodies and often exceed ecotoxicological thresholds [1,2]. These chemicals threaten various aquatic organisms and thus pesticide pollution raises considerable concern [3]. In this work, a pulsed corona discharge above liquid combined with ozonation, with O_3 produced in the discharge [4] was used to degrade 2,4-dichlorophenoxyacetic acid (2,4-D), a widely used herbicide, often detected in surface and ground water and sometimes in trace amounts even in drinking water [5].

Fig. 1a shows the removal of 2,4-D as a function of treatment time (c/c_0), as well as the mineralization (TOC/TOC_0, reflecting the complete degradation to CO_2, H_2O and other inorganics) and the concentration of chloride ions in the treated solutions. Fig. 1b shows the removal as a function of input energy. These data correspond to discharge powers in the range 2-31 W, obtained by varying the duration of the voltage pulses (55-470 ns).

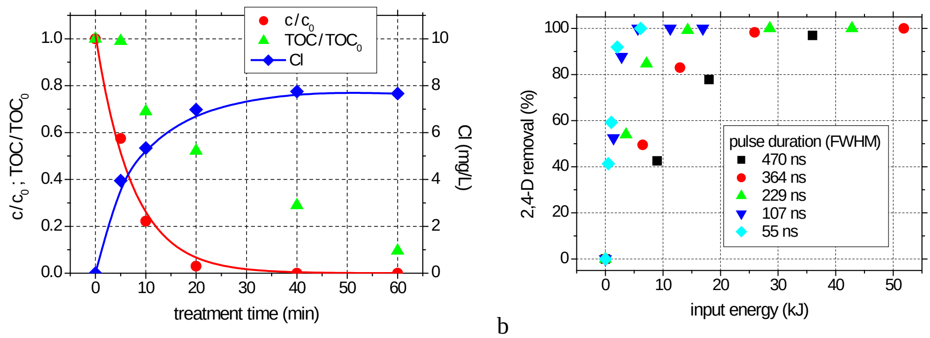


Fig. 1. a – Removal, mineralization and dechlorination of 2,4-D by corona discharge as a function of treatment time (input power 31 W); b – Removal as a function of input energy.

As shown in Fig. 1a, the target compound is completely removed within 30 min treatment, with a reaction rate constant of 0.195 min^{-1}. An important finding is the very good mineralization degree, exceeding 90% after 60 min treatment. The chlorine balance suggests the removal of chlorinated by-products within 30-40 min. The results were not affected by reducing discharge power obtained by shortening pulse duration down to 107 ns, while for shorter pulses slightly lower removal is obtained. Thus, enhanced energy efficiency of the degradation process can be achieved by tuning the pulse width.

[1] K. Knauer, Environ. Sci. Europe, **28** (2016), 13;
[2] W.W. Stone et al., Environ. Sci. Technol., **48** (2014), 11025−11030;
[3] L.H. Nowell et al., Sci. Total Environ. 476–477, (2014), 144–157;
[4] M. Magureanu et al., Chemosphere 165, (2016), 507-514;
[5] D.B. Donald et al., Environ. Health Perspect. 115, (2007), 1183-1191.

P5-02

Stimulation of seed germination by non-thermal plasma

M. Magureanu[1], D. Dobrin[1], M. Gidea[2]

[1]*National Institute for Laser, Plasma and Radiation Physics, Atomistilor Street 409, PO Box MG-36, 077125, Magurele, Romania,*

[2]*University of Agronomic Sciences and Veterinary Medicine, Marasti Blvd. 59, 011464 Bucharest, Romania*

monimag@gmail.com

Enhancing productivity in agriculture requires planting of high vigor seeds, and hence treatment of seeds is widely used in order to stimulate seed germination and fertilization, as well as for protection against pathogens and pests [1]. Although chemical treatment is largely applied, environmental pollution and possible crop contamination are causes of concern, therefore physical treatment started to be regarded as an alternative [1].

Investigations on the effect of non-thermal plasma on seeds started almost 20 years ago [2]. Most of the early studies were performed in low-pressure RF and microwave discharges [3,4], while in more recent work atmospheric pressure plasmas were used [5,6]. We have investigated the influence of several types of discharges (surface discharge, dielectric barrier discharges in planar geometry or in coaxial fluidized-bed configuration) on cereals (wheat, barley) and various legume seeds (radish, tomato, lentils, cucumber). Fig. 1 shows the comparison between untreated and plasma-treated wheat seeds.

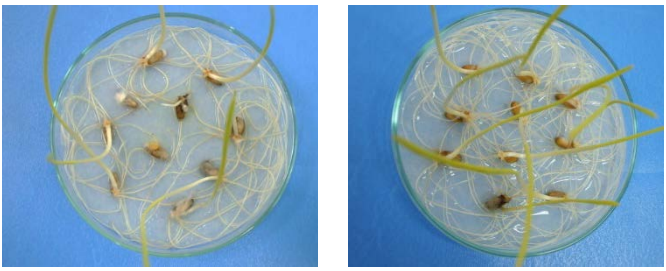


Fig. 1. Wheat seeds: left – untreated (control) right – treated by plasma generated in a surface discharge (sinusoidal voltage with 15 kV amplitude and 50 Hz frequency)

Generally, it was found that the germination rate increases as a result of plasma exposure and that germination is faster for plasma-treated seeds. The growth parameters, namely the length and weight of roots and sprouts, were considerably enhanced by plasma treatment. Modifications of seed surface and wettability were also observed, resulting in increased water uptake for the seeds exposed to plasma.

Keywords: *non-thermal plasma, seed germination, plant growth stimulation.*

Acknowledgment: Financial support from the project PN-III-P2-2.1-PED-2016-1577 and from PN-16 47 01 04 is acknowledged.

[1] S. de Sousa Araújo et al., Frontiers in Plant Science **7**, (2016), 646;
[2] A. Dubinov et al., IEEE Transactions on Plasma Science **20**, (2000), 180;
[3] N. Puac et al., Plasma Processing and Polymers, Wiley-VCH, (2005), 193;
[4] B. Sera et al., Plasma Science and Technology **10**, (2008), 506;
[5] D. Dobrin et al., Innovative Food Science and Emerging Technologies **29**, (2015), 255;
[6] A. Zahoranova et al., Plasma Chemistry and Plasma Processing **36**, (2016) 397.

P5-03

Plasma spraying on polymers: a study on bioactive and antibacterial coatings

L. Barillas[1], J.M. Cubero-Sesin[2] and I. Vargas[1]

[1]Plasma Laboratory for Fusion Energy and Applications, Instituto Tecnológico de Costa Rica, P.O. Box 159-7050, Cartago, Costa Rica
[2]School of Materials Science and Engineering, Instituto Tecnológico de Costa Rica, P.O. Box 159-7050, Cartago, Costa Rica
**laura.plasma.tec@gmail.com, lbarillas@tec.ac.cr*

New frontiers in the field of orthopedics and tissue engineering are arising thanks to the use of polymers. Characteristics like their low specific weight, cost, and performance [1], and additionally, new manufacturing and processing technologies –mainly additive manufacturing or 3D printing–, have extended their application and customization for a wide range of medical devices, such as implants. Usually, it is desired for some implants to support bone in-growth and to enhance osseointegration with the remaining bone or tissue structure, as well as to avoid post-surgical complications like bacterial infections.

To accomplish these purposes, implants can be coated with different materials through technologies like thermal spray. Among different thermal spray techniques, Atmospheric Plasma Spray (APS) is the most widely used technology for surfacing implants [2]. Nevertheless, plasma sprayed coatings have been primarily applied to metallic substrates, and unfortunately, only a few studies are available on polymers and composite materials [2].

Therefore, the aim of this study was to coat polymers commonly used in orthopedics and tissue engineering applications, with bioactive and antibacterial materials. Due to the physics and experimental nature of Atmospheric Plasma Spray, and the few references about plasma sprayed coatings over polymers, the experimentation was conducted first based on trial and error until reaching the adequate parameters to obtained appropriate coatings. The main goal of the study was to obtain depositions over polymers that are equivalent to depositions over metals, focusing on the analysis of macro and micro structure. In this case, coatings were evaluated mostly in terms of substrate shape (non-deformation of the polymer probes), coating stability and morphology of the coating. Some characterization techniques include simple visual inspection (20 cm from sight), scanning electron microscopy (SEM) imaging and X-ray Diffraction (XRD).

Results show succesful and equivalent depositions for PEEK substrates when compared to depositions on metals, indicating good potential for plasma sprayed coatings on polymers.

Keywords: *plasma spray, bioactive, antibacterial, coatings, polymers.*

[1] L. W. McKeen, Handbook of Polymer Applications in Medicine and Medical Devices, ser. Plastics Design Library. Oxford: William Andrew Publishing, (2014), **3**, 21 – 53;
[2] S. Beauvais and O. Decaux Therm. Spray 2007 Glob. Coat. Solut., (2007), 371–377.

P5-04

The effect of a cold atmospheric filamentary plasma jet on stored products pest and wheat germination

L.G. Carpen[1,2], C. Chireceanu[3], M. Teodorescu[1], A. Chiriloaie[3], A. Teodoru[3], G. Dinescu[1,2]

[1]National Institute for Laser, Plasma and Radiation Physics, Atomistilor 409, Magurele-Bucharest,077125, Romania
[2]Faculty of Physics- University of Bucharest, Atomiştilor 405, Magurele, Bucharest, 077125, Romania
[3]Research & Development Institute for Plant Protection, Ion Ionescu de la Brad 8, Bucharest, 013813, Romania
**lavinia.carpen@infim.ro*

The control of insect pests of stored products by implementation of alternative methods to chemicals has recently drawn considerable attention from the food research and agricultural production community

The beetles of the species *Tribolium confusum* and *Tribolium castaneum* (Coleoptera: Tenebrionidae) are two major pests of stored products worldwide that feed on various stored products and these pests drastically reduce the quality and quantity of the infested products [1]. These are the two species onto which our experiments were performed.

Figure 1. *Image of the plasma jet and treatment chamber during operation*

The objective of the study was to investigate the effect of an atmospheric filamentary plasma discharge (power 90 W) operating in argon and argon/oxygen mixture (flow rates 3000 sccm Ar, 1-8 sccm O_2) for pests control and wheat germination, in a closed environment (Figure 1). We have measured the mortality of adult insects at different days after treatment, at various plasma to sample distances. Each sample consisted in 30 grams of wheat and 25 insects.

It was observed that, contrary to the control sample, the mortality rate increases in time, after treatment. For example, in just one day after the treatment, the mortality was (96±0)% for *T. castaneum*. The mortality rate increased when the distance between plasma and the wheat sample was decreased from 10 cm to 6 cm. Based on this study, a positive correlation between exposure time and insect mortality was observed.

The contribution complements these results with data on plasma effect on wheat germination.

Keywords: *plasma treatment of seeds, atmospheric plasma jet, pest control.*

[1] S. Mohammadi, SohrabImani, D. Dorranian, S. Tirgari, Mahmoud Shojaee, J. Biodivers Environ. Sci. **7**, (2015);
[2] K. V. Donohue, B. L. Bures, M. A. Bourham, R.M. Roe, J. Econ. Entomol. **101** (2), (2008).

Acknowledgments: This work has been financed by the National Authority for Research and Innovation in the frame of Nucleus programme-contract 4N/2016 and contract PN-III-P2-2.1-PED-2016-0287

P5-05

TVA obtained Cu/Ag layers having antimicrobial properties used in smart ventilation systems

B. Butoi[1,2], C. Porosnicu[1], P. Dinca[1,2], I. Jepu[1], O.G. Pompilian[1], C.P. Lungu[1], M Diaconu[3], G. Soreanu[3], I. Cretescu[3]

[1]National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor Street, Magurele, Romania
[2]Faculty of Physics, University of Bucharest, 405 Atomistilor Street, Magurele, Romania
[3]"Gheorghe Asachi" Technical University of Iasi, Department of Environmental Engineering and Management, 700050, Iasi, Romania
**bogdan.butoi@g.unibuc.ro*

While air conditioning systems have become an ordinary item found in almost all homes and work spaces, more health problems have found their sources in the air filtration systems of these devices. Having a steady flow of air and moisture, these filters are an ideal place where bacteria like Staphylococcus aureus (S. aureus) can prosper. These bacteria are the most common source of infection that causes skin and soft tissue infections such as abscesses (boils), furuncles, and cellulitis. In some extreme cases, S. aureus can cause serious infections like bloodstream infections, pneumonia, bone and joint infections.

This work is focused on designing a smart, eco-friendly ventilation system that ensures clean, decontaminated air, while lowering the energy consumptions of buildings. Small, solar powered tubes, filled with electronics, placed in key points on glass facades ensure air circulation by convection. Issues have risen in how to trap incoming bacteria from outside and passively clean the air and kill the bacteria trapped in the tubes.

Thermionic vacuum arc (TVA) method was used to coat 1x1mm and 0.5x0.5mm grids with Cu, Ag and Cu/Ag layers in order to determine the best way to approach the problem.

SEM and AFM measurements were performed on the deposited thin films to determine the morphological proprieties while XRD measurements show the crystalline growth of them. Different deposition parameters can influence the topology of the film as well as the grain size that can have a major impact on the antibacterial proprieties.

We tested the deposited grids in a controlled system that ensured a steady flow of S. aureus contaminated air passing throw them in order to determine the efficiency in retaining and killing the bacteria. More tests have been done in order to determine the improvement of air quality, with very promising results.

Keywords: *antibacterial thin films, Staphylococcus aureus, Cu/Ag thin films.*

P5-06

Laser processing of hybrid biomimetic coatings

M. Icriverzi[1,2,3], V. Dinca[3], L. Rusen[3], S. Brajnicov[3,4], V. Marascu[3,5], A. Bonciu[3,5], A. Cimpean[2], M. Dinescu[3], A. Roseanu[1]

[1]Institute of Biochemistry of the Romanian Academy, 296 Splaiul Independentei, 060031, Bucharest, Romania
[2]University of Bucharest, Faculty of Biology, Bucharest Romania
[3]National Institute for Lasers, Plasma, and Radiation Physics, Magurele RO-077125, Romania
[4]Craiova University, Faculty of Science, Craiova, Romania
[5]University of Bucharest, faculty of Physics, Bucharest, Romania

Multifunctional biointerfaces aiming enhanced characteristics towards in vitro and in vivo response are relying on the ability to control the surface chemical and physical characteristics of materials. In this work, biomimetic nano- hybrid coatings of copolymer (Co), lactoferrin (Lf) and hydroxyapatite (HA) were obtained by Matrix Assisted Pulsed Laser Evaporation (MAPLE) method. The morphology and chemical characteristics of the coating were evaluated by Scanning Electron Microscopy, Atomic Force Microscopy and FTIR measurements.

The potential of biomimetic coatings to induce an inflammatory response was evaluated in vitro using as a model of inflammation THP-1 cells differentiated to macrophages and stimulated with bacterial endotoxins (LPS). Fluorescent microscopy experiments revealed that THP-1 cells adhered preferentially to the hybrid Lactoferrin - hydroxyapatite coated surfaces when compared to films embedded with HA or Lf alone. In the presence of LPS, a decrease in the total number of cells was observed irrespective of surface covering. The lowest total and relative amount of the pro-inflammatory TNF-α cytokine release was detected in the case of Co-Lf-HA biomaterials.

Surface functionalization with hybrid biomimetic Lf-HA proved to modulate the cellular response thus being an efficient method to improve the biological performances of bone implants.

Keywords: *Laser, biomimetic, macrophages.*

Acknowledgments: The research leading to these results has received funding from the Romanian Ministry of National Education, CNCS – UEFISCDI, under the project PN-II-PT-PCCA 239/2014, TE24/2015, and Romanian Academy Project 1/2016-2017 of the Institute of Biochemistry and University of Bucharest-Biology Doctoral School.

Topic 6

Application of plasmas in nanoscience and nanotechnology

P6-01

Nanomaterials processing by plasma in liquids

S. Vizireanu[1], M.D. Ionita[1], E.R. Ionita[1], S.D. Stoica[1], L. Carpen[1], M. Teodorescu[1], I. Ion[2], D. Panaitescu[3], G. Dinescu[1]

[1] *National Institute for Lasers, Plasma and Radiation Physics, Atomistilor Str. 409, Magurele, Bucharest, 077125, Romania*
[2] *National Institute for R&D in Electrical Engineering ICPE-CA, Carbon Materials Laboratory, Splaiul Unirii Nr.313 Bucharest Romania*
[3] *National Institute for R&D in Chemistry and Petrochemistry, 060021, Bucharest, Romania.*
s_vizi@infim.ro

Plasma submerged [1] or in contact with liquids represents a new and promising method for synthesis of new materials, degradation of organic compounds, decontamination, bacterial inactivation, and biomedicine. It offers an attractive opportunity for processing liquid dispersions of nanomaterials in an eco-friendly manner, without surfactants or strong acids. In particular, the functionalization of nanoparticles, powders, carbon nanostructures by submerged plasma in their dispersion in order to change surface properties, control the dispersability, and sedimentation speed is of wide interest.

In the present study, we used an RF plasma jet source operated at atmospheric pressure [2] in argon and argon/nitrogen/oxygen mixtures. It was submerged in dispersions (see Figure 1) of graphene oxide, reduced graphene oxide, and nanocellulose. We intended to introduce nitrogen and oxygen containing functional groups, similar to the case of Carbon Nanowalls functionalization [3].

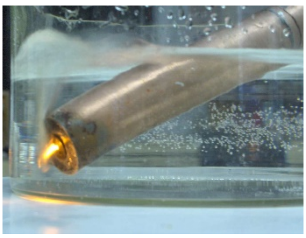


Figure 1. Image of plasma jet source sub-merged into liquid

We tested various parameters (composition, gas flow rate, RF power, and treatment time) to identify the most effective conditions for adding specific functional group onto the studied materials. We report results regarding the characteristics of the treated materials, as obtained after evaporation, following the SEM, UV-Vis, FTIR, Raman and XPS investigations.

Keywords: *plasma in liquids, nanomaterials, graphene, nanocellulose.*

Acknowledgments:

This work has been financed by the National Authority for Research and Innovation in the frame of Nucleus programme-contract 4N/2016 and contract PN-III-P2-2.1-PED-2016-0287.

Reference:

[1] G. Dinescu, E.R. Ionita, Pure Appl. Chem., **80**, (2008), 9, 1919;
[2] M. Teodorescu, M. Bazavan, E. R. Ionita, G. Dinescu, Plasma Sources Sci. Technol., **21,** (2012), 5, 055010;
[3] M.D. Ionita, S. Vizireanu, S.D. Stoica, M. Ionita, A. M. Pandele, A. Cucu, I. Stamatin, L. C. Nistor, G. Dinescu, Eur. Phys. J. D **70**, (2016), 2, 31

P6-02

Interface characteristics of W/Si multilayers prepared by TVA

A. Anghel[1], M. Badulescu[1], M. Vlaicu[1,2], C. Logofatu[2], C. Surdu-Bob[1]

[1]*National Institute for Laser, Plasma and Radiation Physics, Atomistilor 409, 077125, Magurele, Romania*

[2]*National Institute of Materials Physics, Atomistilor 405A, 077125, Magurele, Romania*

alexandru.anghel@inflpr.ro

In X-ray optical systems based on multilayer structures, the quality of interfaces plays a critical role and depends on both individual layer roughness and diffusion at interfaces [1-4]. Although high quality W/Si multilayer x-ray mirrors were already obtained by different deposition techniques, there is still a great interest in improving their performance and developing new synthesis methods. Here we report on the characteristics of W/Si multilayers synthesized by Thermionic Vacuum Arc (TVA) plasma [5]. Interfacial structures were investigated by comparing and correlating film analysis by X-ray reflectometry (XRR), X-ray diffraction (XRD) and X-ray photoelectron spectroscopy (XPS) of W and Si films in both single- and multi- layer configurations. The major finding is that even though individual layer roughness was reduced from 0.9 to 0.5 for W and from 0.9 to 0.4 for Si by adjusting the TVA plasma parameters (discharge voltage and discharge current), an asymmetrical diffusion at interfaces still remains and influences the reflection performance of the structure, as can be observed in Figure 1. Our explanation is based on a multilayer period variation induced by this asymmetrical diffusion defined by a thicker interlayer formation at the Si on W interface than at the W on Si one.

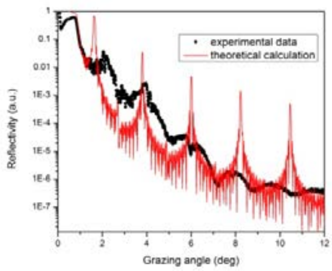


Figure 1. XRR spectra of a $(W_{2nm}/Si_{2nm})_{18}$ stack: experimental data (black line) and theoretical calculation with no interlayer formation at the interfaces (red line)

References:

[1] D. Spiga, *Development of multilayer-coated mirrors for future X-ray telescopes-PhD Thesis,* (2006)

[2] E. Spiller, D., M. Krumrey, Journal of Applied Physics, **74**, (1), (1993);

[3] N. Kaiser, *Some Fundamentals of Optical Thin Film Growth in Optical Interference Coatings*, Springer, (2003);

[4] I. Nedelcu et al, Thin Solid Films 515 (2006) 434;

[5] C. Surdu-Bob, I. Mustata, C. Iacob, J. of Optoel. and Adv. Mat., **9**, 9, (2007), 2932 – 2934.

Acknowledgments: This work was supported by a grant of the Romanian National Authority for Scientific Research and Innovation, CNCS-UEFISCDI, project No. PN-II-RU-TE-269/2015.

P6-03

Tailoring sp^2/sp^3 ratio in Diamond -Like Carbon films via deposition parameters in a high voltage anodic vacuum plasma

M. Badulescu[1], A. Anghel[1], C.C. Surdu-Bob[1], C. Logofatu[2], C. Luculescu[1]

[1]*National Institute for Lasers, Plasma and Radiation Physics, P. O. Box MG 36, Bucharest, 77125 Romania*
[2]*National Institute for Materials Physics, P. O. Box MG. 7, Bucharest, 77125 Romania*
alexandru.anghel@inflp.ro

In recent years, DLC films have attracted special interest among the exciting research topics in materials science and structural engineering, due to their unique properties. DLC films posses a unique combination of properties such as high optical transparency in the visible and infrared (IR) region, high electrical resistance, low friction coefficient, chemical inertness, high thermal conductivity and low electron affinity [1]; [2]; [3]. They could be tailored by varying and controlling their microstructure and sp^2/sp^3 carbon bonding ratio [4].

The goal of the conducted experiments was to find what are the deposition process parameters responsible for the change in sp^3 content of DLC films using high voltage anodic plasma in vacuum.

X-ray photoelectron spectroscopy and Raman spectroscopy were employed. Correlation between visible Raman and XPS data of our DLC films with the deposition parameters shows a preferential sp^3 bond fraction increase with lowering discharge voltage and increasing anode sample distance.

It was found that this process offers a great opportunity for tailoring DLC films over a wide range of properties, making it useful for different applications such as sensors, biomedical, vacuum nanoelectronics.

Keywords: *DLC films, sp^2/sp^3-tailored, XPS and Raman analysis.*

Acknowledgments: This work was supported by a grant of the Romanian National Authority for Scientific Research and Innovation, CNCS-UEFISCDI, project No. PN-16.47.01.03

[1] K. Bewilogua, D. Hofmann, Surf. Coat. Technol., **242**, (2014), 214–225;
[2] J. Robertson, Phys. Status Solidi (a), (2008), 2233–2244;
[3] Q. Wei, J. Narayan, Int. Mater. Rev., **45**, (2000), 133–164;
[4] C.A. Charitidis, Int. J. Refract. Met. Hard Mater., **28**, (2010), 51–70.

P6-04

Titanium 2D nanopatterns obtained by magnetron sputtering deposition with colloidal masks

A. Demeter[1], L. Sirghi[1, 2]

[1]*Iasi Plasma Advanced Research Center (IPARC), Faculty of Physics, "Alexandru Ioan Cuza" University of Iasi, Iasi-700506, Romania*
[2]*lsirghi@uaic.ro*

Nanomaterials exhibit unique physico-chemical properties, which make them suitable for a wide range of applications. The advancement and development of many such 'nano' applications relies strongly on the design and fabrication of nanoparticle arrays and patterned films. Among these, the plasmonic films are intensely investigated for their potential in fabrication of high sensitivity biosensors based on surface plasmon resonance absorption of light [1]. Recent advances in nanofabrication methodology used for fabrication of nanopatterned films with enhanced plasmonic behaviour include electron beam lithography, focused ion beam lithography and colloidal lithography (CL).

In this work, we used CL consisting of plasma sputtering depositions with colloidal masks for fabricating of two-dimensional titanium nanostructures on quartz substrates. The whole fabrication process comprises the following steps: 1) substrate cleaning and hydroxylation in low-pressure glow discharge plasma in air and water vapour mixture; 2) spin-coating deposition of colloidal masks (CMs) formed by a monolayer of polystyrene beads (500 nm in diameter) on quartz substrates; 3) reactive ion etching (RIE) in rf discharge plasma in oxygen of the closed packed CMs; 4) magnetron sputtering deposition of the titanium thin films on the substrates with either close-packed or etched CMs; 5) removal of the colloidal mask (lift-off) by sonication in deionized water, which leaved the 2D titanium nanopatterns on the quart substrate.

The fabricated nano-patterns of Ti were investigated by AFM and SEM to characterize their morphology and quality. The deposition method, etching of the CMs and the pressure of the working gas used in sputtering depositions had a great impact on the morphology of the deposited 2D titanium nanopatterns. We used anisotropic sputtering depositions at relatively low pressure of the sputtering gas (3 mTorr), fact that determines formation of well defined higher 2D patterns. For depositions with closed-packed CMs, the patterns consisted in triangular patches with maximum height of 20 nm. For the depositions with etched CMs, the patterns consisted in a hexagonal lattice of holes in a relatively uniform film with thickness around 50 nm. The plasmonic light absorption of the fabricated titanium nanopatterns was investigated by analysing their UV-Visible extinction spectra. The extinction spectra of the titanium patterns obtained with etched CMs showed a plasmonic absorption peaks at 670 nm and 657 nm, depending on the sputtering technique used (direct current magnetron or high power impulse magnetron).

[1] Hicks, Erin M., Olga Lyandres, W. Paige Hall, Shengli Zou, Matthew R. Glucksberg, and Richard P. Van Duyne, *Journal of Physical Chemistry C* 111 (2007) 4116-4124.

Keywords: *nanosphere lithography, titanium nanopatterned surface, plasmonic light absorption, magnetron sputtering deposition.*

P6-05

TiO_2 thin films deposited by rf-magnetron sputtering for optoelectronic applications

D. Dogaru[1,2,*], C. Besleaga[2], A.C. Galca[2], M. Nistor[3], L. Ion[1]

[1]*Faculty of Physics, University of Bucharest, Atomistilor 405, 077125, Magurele, Romania*
[2] *National Institute of Materials Physics, Atomistilor 405A, 077125, Magurele, Romania*
[3] *National Institute for Plasma, Lasers and Radiation Physics, Atomiştilor 409, 077125 Magurele, Romania*
[*]*daniela.dogaru@infim.ro*

Magnetron sputtering techniques provide simpler implementation than chemical vapor deposition methods for preparation of high-quality oxide semiconductors. This fabrication process gives the possibility of controlling the quality and quantity of thin films deposition.

Titanium dioxide (TiO_2) is a wide-band gap material that is important for applications such as transparent electronics, photovoltaics or photochemical catalysis. A major step toward the development of electronic devices is to enhance the conductivity of the thin films. However, controlling the conductivity of TiO_2 thin films poses great challenges due to the strong electron-phonon coupling present in this material.

The current study aims at analyzing the most important experimental conditions to fulfill the requirements of good conductivity and transparency. TiO_2 thin films were grown on glass substrates at room temperature and at 500°C in a mixed Ar/O_2 gas. The deposition technique used in this current experiment is radio frequency (rf) magnetron sputtering using a metallic Ti target. The O_2 concentration and the cathode power were varied for tuning the film properties and a better understanding of the growth mechanism. The structural, surface morphology, optical and electrical properties of thin films were analyzed in correlation with the deposition parameters used in the present study. The physical characterizations are based on X-ray diffraction, atomic force and scanning electronic microscopy, ellipsometry and electrical resistivity measurements. Based on these investigations, a detailed description of the process of synthesis is presented, as well as a discussion about the role of the microstructure and composition on the physical properties of TiO_2 films.

Keywords: *TiO_2 thin films, rf-sputtering, growth mechanism.*

P6-06

The influence of nitrogen doping upon the phase change characteristics of GeSb2Te4

M. Osiac

[1]*Department of Physics, University of Craiova, A.I. Cuza 13, 200585, Craiova, Romania*
[*]m_osiac@yahoo.com

The phase change memory (PCM) is a rather new and promising procedure, which proposed the chalcogenide compound to be used as active material because it satisfies various criteria needed for non-volatile memory devices. The $Ge_1Sb_2Te_4$ (GST-124) compounds represent good candidate for PCM devices because they have a rapid switching speed and are suitable in semiconductor fabrications. Intensive efforts have been made to improve phase change characteristics and device performances. Doping is an effective means of tuning the alloy's phase-change properties. The amorphous GST-124 doped with nitrogen thin films were deposited on silicon substrates for average power 30 W, while the Ar gas pressure was kept constant at 0.66 Pa and the N_2 gas pressure was variable to get the various amount of nitrogen in the deposited film. The target-sample distance was 8 cm. The target peak power of 10-15 kW was attained during the high power impulse magnetron sputtering (HiPIMS) operation (for – 950 V applied voltage, pulse width of 20 µs and pulse frequency ranged between 100 and 200 Hz). I-V measurements were performed in the voltage sweep mode to verify the switching properties of the nitrogen incorporated GST films. I-V curves of active layer of the nitrogen incorporated GST-124 indicate that the threshold voltage Vth varies as a function of nitrogen content. The thermal properties were performed by heating the films to 400ºC. The surface of the annealed films was investigated by Atomic force microscopy. The chemical composition was analyzed by electron excited energy-dispersive x-ray spectroscopy (EDX) attached to the SEM. The Raman spectra of as-grown and post annealed GST-124 film with nitrogen show the vibration modes.

Keywords: *chalcogenide, HiPIMS, thin film.*

P6-07

InGaZnO thin films grown by pulsed electron beam deposition for electronic applications

F. Gherendi, N.B. Mandache, M. Nistor

National Institute for Lasers, Plasma and Radiation Physics (NILPRP),
Plasma Physics and Nuclear Fusion Laboratory,
P.O.Box MG-32,077125, Bucharest-Magurele, Romania
mnistor@infim.ro

Indium gallium zinc oxide (InGaZnO) is an emerging amorphous semiconductor oxide for electronic industry as a candidate to replace the amorphous hydrogenated silicon. Since the electrical and optical properties of InGaZnO thin films depend on the deposition method, the optimization of the performance of such channel layers in thin film transistors is challenging for next generation of optoelectronic applications.

Pulsed electron beam deposition method (PED) has been used to grow InGaZnO thin films on various substrates between room temperature and 500°C under 10^{-2} mbar gas pressure. PED has features in common with pulsed laser deposition: the pulsed nature of the process, the very anisotropic character of the ablation plume and a high energy of species, while using a pulsed electron beam instead of a laser beam for ablation of a target [1, 2].

The composition, surface morphology and structure of InGaZnO thin films were correlated to their electrical (resistivity, mobility and carrier density) and optical (UV-VIS-NIR absorption) properties. These studies showed that a simple way to tune the physical properties of InGaZnO thin films is given by the control of the PED growth conditions. In fact, changing the working gas (argon or oxygen) and substrate temperature leads to strong effects on the optical and electrical film properties. These strong effects were correlated with the composition of these films, evidencing the role played by the In and Ga cations and/or oxygen composition. Films deposited in oxygen are very resistive and have a transparency of 80 - 90 % at 550 nm. The films grown in argon as working gas exhibit an oxygen deficiency, resulting in a decrease of the resistivity by 6 orders of magnitude, from 7×10^{3} Ωcm at room temperature to 4×10^{-3} Ωcm at 500 °C, together with a drastic reduction of the film transmittance at 550 nm (from 47 % to 17 %). The amorphous structure of InGaZnO thin films is stable up to 500°C, indicating that electrical properties are not associated with crystallization. These results are discussed in correlation with energy of ablation plasma species impinging on the substrate.

[1] M. Nistor, N.B. Mandache, J. Perrière, J. Phys. D: Appl. Phys. **41** (2008) 165205 ;
[2] M. Nistor, L. Mihut, E. Millon, C. Cachoncinlle, C. Hebert, J. Perrière, RSC Adv. **6** (2016) 41465.

Keywords: *Thin films; pulsed electron beam ablation; deposition.*

Deposition of fluorinated polymer films onto track-etched membrane surface by plasma chemical methods

L.I. Kravets[1], A.B. Gilman[2], M.Yu. Yablokov[2], V. Satulu[3], B. Mitu[3], G. Dinescu[3]

[1]*Joint Institute for Nuclear Research, Flerov Laboratory of Nuclear Reactions, Joliot-Curie Str. 6, 141980 Dubna, Russia*
[2]*Enikolopov Institute of Synthetic Polymer Materials RAS, Profsoyuznaya Str. 70, 117393 Moscow, Russia*
[3]*National Institute for Laser, Plasma and Radiation Physics, Atomistilor Str. 409, 077125 Magurele, Bucharest, Romania*
e-mail: kravets@jinr.ru

The synthesis and properties of polymer composite membranes with hydrophilic porous substrate and hydrophobic top layer were studied. To prepare the composite membranes the fluorinated polymer films have been applied on one side of the poly(ethylene terephthalate) and polypropylene track-etched membranes used as the porous substrates. The plasma polymerization of 1,1,1,2-tetrafluoroethane [1], RF magnetron [2] and electron-beam sputter deposition of polytetrafluoroethylene [3] techniques were used for applying of polymer films onto membrane surface. The influence of the deposition time on the surface properties, chemical composition and wettability on both sides of the composite membranes is reported.

It was found that the application of such layers results in bilayer composite membranes with hydrophilic and hydrophobic sides. The surface roughness of the initial membrane changes in these processes. Besides, the deposition of a polymer film causes an essential narrowing the pores. The research of the electrochemical properties of the composite membranes has shown that the deposition of the hydrophobic polymer layer results in the creation of membranes featuring asymmetry of conductivity in solutions of electrolytes, which manifests itself at various orientations of membranes in an electric field. The principal cause of appearing the asymmetric conductivity is the changing the pore geometry due to the essential reduction of their diameter in the layer of the deposited polymer.

This work has been financed by the bilateral project with JINR, FLNR, and NILPRP (No 04-5-1131-2017/2021) and by the grant (No 17-08-00812) from Russian Foundation for Basic Research.

[1] L. Kravets, S. Dmitriev, N. Lizunov, V. Satulu, B. Mitu, G. Dinescu, Nucl. Instr. Meth. B **268**, (2010), 485-492.
[2] V. Satulu, B. Mitu, V. Altynov, N. Lizunov, L. Kravets, G. Dinescu, Thin Solid Films (2017), in press.
[3] L.I. Kravets, A.B. Gilman, M.Yu. Yablokov, A.N. Shchegolikhin, B. Mitu, G. Dinescu, High Temp. Mater. Proc. **19,** (2015), 121-139.

Keywords: plasma chemical methods, bilayer composite membranes, hydrophobic layers, asymmetric conductivity

Topic 7

Fusion plasma physics and technology

P7-01

ITG driven turbulence: test modes approach

V. Baran[1,2], M. Vlad[1], F. Spineanu[1]

[1]*National Institute of Laser, Plasma and Radiation Physics, 409 Atomistilor, 077125 Magurele, Romania*
[2]*Faculty of Physics, University of Bucharest, 405 Atomistilor, 077125, Magurele, Romania*
virgil.baran@inflpr.ro

The problem of turbulence is still unsolved and its better understanding is crucial for a variety of major fields like fluid mechanics, plasma physics and astrophysics. In the last decades, the majority of results have been obtained by direct numerical simulations, while analytical approaches based on first principles, due to the strong nonlinear character of the stochastic advection process, have been rather scarce.

In particular, the confinement of fusion plasma is strongly influenced by the low frequency drift type turbulence; in this case, the usual analytical treatments fail to take into account the particle trapping, essential in order to correctly reproduce the transport properties of the turbulence.

In this work, we extend the test modes approach, used previously to successfully describe the influence of trajectory trapping on the dynamics of drift turbulence [1], to the case of Ion Temperature Gradient (ITG) driven turbulence evolution. The basic principle consists of extracting the evolution tendencies from the growth rates and frequencies of the test modes, which, in turn, depend on the statistical properties of the background turbulence on which they develop.

We comment on the mechanism of generation and growth of zonal flows in the case of ITG turbulence, which turns out to be fundamentally different with respect to the drift turbulence case.

Keywords: *turbulence evolution, ITG, test modes.*

[1] M. Vlad, Phys. Rev. E **87**, 053105 (2013)

P7-02

The helical stable structures occuring at q=1 surface in tokamak

F. Spineanu[1], M. Vlad[1], V. Baran[1]

[1]*National Institute of Laser, Plasma and Radiation Physics, 409 Atomistilor, 077125 Magurele, Romania*
**f.spineanu@ifa-mg.ro*

1. The origin of the problem and the proposed model

The central part of the tokamak has high temperature and correspondingly is a channel of high conductivity which allows a symmetrical profile for the current density. This actually produces the periodic decrease of the safety factor q(r) under the magnitude unity, with the result of strong MHD instbilities called "saw-teeth". They expell up to 10% of the thermal energy stored within q=1 surface. However, reccurent experimental observations have revealed the possibility of formation of helical structures around q=1, consisting of density accumulation, or impurity accumulation or even current density. This phenomenon, called "snakes" due to the high regularity of signals, is robust, with almost invariance to a long series of saw-teeth. It is not explained yet.

We propose an explanation which appears to result from distinct physical directions. First, numerical experiments (D.C. Montgomery) have shown that a stable helical MHD structure is always present in the tokamak equilibria. Second, the largely dominant two-dimensional nature of the strong (tokamak) confinement permits consideration that are typical for asymptotic coherent organization as an ideal Euler 2D fluid. But it has been shown that the highly coherent structure in this case is shifted relative to the center, (Ralph A. Smith) justified by higher entropy at negative statistical temperature; third, the "natural current distribution" in tokamak supports helical structures (J.B. Taylor); fourth, there is a mathematical model that explains the helical invariance of the equilibrium of the vorticity (H. Chen). We find that the possible unified model of these properties should rely on the existence of the MHD invariant connecting vorticity, current density and particle density.

2. Quantitative model

We use the special set of MHD (Bogoyavlenskij) transformations acting on the Elsasser variables (velocity, magnetic field) and find the surface that corresponds to the singular transition between zones of distinct density. It is close to a helical envelope of a higher density concentration and seems to provide the required stability which is observed in experiments.

Keywords: *tokamak, helical structures, snakes of density, stable Kulikovskii surfaces.*

[1] F. Spineanu, M. Vlad and V. Baran, in preparation, 2017.

P7-03

High power laser interaction with fusion technology materials

C.P. Lungu[1], C. Porosnicu[1], P. Dinca[1,2], B. Butoi[1,2], O.G. Pompilian[1], I. Jepu[1], L. Avotina[3], A. Marcu[1]

[1]National Institute for Laser, Plasma and Radiation Physics, 077125,Magurele, Romania
[2]Faculty of Physics, University of Bucharest, 050107, Bucharest, Romania
[3]Uniersity of Latvia, Institute of Chemical Phyics, LV-1004 Riga, Latvia
cristian.lungu@inflpr.ro

Beryllium, carbon and tungsten are presently the materials used in fusion technology, as for example in Joint Experimental Torus (JET) experiment at Culham, UK. Special requirements of these materials have to be simultaneously satisfied, as for example high temperature resistance, low influence on the fusion plasma and low fuel retention rate.

In order to produce clean energy by fusion technology, the composition of plasma facing tiles is one of the problems to be solved. These tiles must be capable to withstand bombardment with high energy radiations, neutrons and steady state ion fluxes from the plasma and also to large heat loads (>10 MW/m^2). These conditions will lead to chemical and physical sputtering at the interaction of plasma with plasma facing tiles.

Beryllium (Be), tungsten (W) and carbon fiber composites (C) will be used in next-generation fusion devices like ITER. Be-C-W mixed layers were deposited using thermionic vacuum arc (TVA) technology [1-2]. The experimental set-up used for sample fabrication is composed of three individual anode-cathode systems. Deposition rates and thickness were in-situ monitored for beryllium and tungsten using a quartz micro-balance system. This allowed us to obtain the variable Be-C-W atomic ratio and a total thickness of about 400 nm, similar with the re-deposited layers encountered in fusion machines.

The Be-C-W composite films were further exposed to laser radiation from a terawatt Ti: Sapphire laser system, ~100 fs pulse duration in single pulse and multi-pulse mode in deuterium (~20 Torr). Laser repetition rate was 10 Hz, pulse duration about 100 fs and the pulse power was estimated to about 40 GW. The laser beam is focused over the substrate surface, but the substrate is not perpendicularly oriented. The normal focal spot size was about 0.5 micrometers and was approximatively positioned on the target surface. However, the incident angle here was a small one estimated at few to several degrees (~ 5^0), so the resulting energy density on the irradiated zones was estimated as being only up to 5-10 TW/cm^2.

Higher carbon content in deposited films increased the ablation process while the tungsten rich films decreased it. Enhanced ablation due to deuterium presence was noted for all samples. Analyzing the non-irradiated surfaces the increase of the graphite peak was suggesting an amorphous carbon removal by deuterium, possible by deuterated methane formation, while the change of the ripples size formed in low power density irradiated zones was suggesting differences in the plasmon formation according to the ambient gas composition and pressure. These are the two proposed mechanisms of the Be-C-W (and particularly carbon based) materials degradation and ablation enhancement in the presence of deuterium gas.

[1] I. Jepu, et al., Romanian Reports in Physics, **63** (2011), 804–816;
[2] A. Marcu, et al., Thin Solid Films, **519** (2011), 4074-4077.

P7-04

Characteristics of tungsten particles obtained at atmospheric pressure by a plasma jet

V. Mărăscu[1, 2*], A. Lazea-Stoyanova[1], C. Stancu[1], S.D. Stoica[1], B. Mitu[1], G. Dinescu[1, 2]

[1]National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor Street, 077125, Magurele, Romania

[2]Faculty of Physics, University of Bucharest, 405 Atomistilor Street, 077125, Magurele, Romania

**valentina.marascu@infim.ro*

Tungsten particles generation in ITER tokamak, during plasma-wall interaction, represents an important quest for controlled fusion research experiments. Tungsten particles have the potential capacity to incorporate tritium during ITER operation, presenting danger of human and environmental contamination [1]. Therefore, studying in advance the properties of W particles is of high interest.

In this work, we produced tungsten particles using a radiofrequency (13.56 MHz) atmospheric pressure plasma jet [2]. The experimental setup consists of an atmospheric pressure plasma source which operates in Argon atmosphere [2, 3] having a tungsten bar as powered electrode. Due to plasma-tungsten bar interaction the surface of the tungsten bar starts to be eroded, leading to metallic particles formation.

By using Optical Emission Spectroscopy, we could establish the presence of tungsten atoms in plasma discharge and we observed the starting point of the erosion process. The particles morphology was analysed by Scanning Electron Microscope and their composition and structure was investigated by Energy-dispersive X-ray spectroscopy and X-ray diffraction. The obtained tungsten particles have various shapes, from spherical up to cubic, and their size vary from nanometric to 1-2 μm.

Finally, we have established an optimal set of plasma parameters (regarding the radiofrequency power, gas flow rate and deposition time) for producing tungsten particles at atmospheric pressure in a reproducible process.

Acknowledgments

V. Mărăscu acknowledges the support in the frame of the project 1-EU12 WPEDU-RO, "EUROfusion Consortium contribution to education in fusion research at the predoctoral and PhD level", Joint Research Unit - Institute for Atomic Physics, Romania. Partially, this work has been financed in the frame of Nucleus programme- contract 4N/2016 (INFLPR), and of projects PN-II-RU-TE-2014-4-2412 and PN-II-RU-TE-2014-4-2035.

Keywords: *tungsten particles, nano- and micrometric particles, atmospheric pressure plasma.*

References

[1] C. Grisolia et al, Journal of Nuclear Materials **463** (2015), 885–888;

[2] A. Lazea-Stoyanova, A. Vlad, A.M. Vlaicu, V.S. Teodorescu, G. Dinescu, Plasma Processes and Polymers, **12**, (2015), 705-709;

[3] A. Lazea-Stoyanova, M. Enculescu, S. Vizireanu, V. Marascu, G. Dinescu, Digest Journal of Nanomaterials and Biostructures **9**, 3 (2014), 1241 – 1247.

P7-05

Tungsten as a plasma-facing materials in fusion devices: impact of helium high-temperature irradiation on hydrogen retention

E. Bernard[1,*], R. Sakamoto[2], A. Kreter[3], N. Yoshida[4], F. Ghiorghiu[5], R. Bisson[5], T. Angot[5], M.F. Barthe[6], M. Thompson[7], C. Corr[7] and C. Grisolia[1]

[1]*IRFM, CEA Cadarache, France.*
[2]*National Institute for Fusion Science, Toki, Japan.*
[3]*Forschungszentrum Jülich GmbH, Jülich, Germany.*
[4]*Kyushu University, Fukuoka, Japan.*
[5]*PIIM, Aix Marseille University, Marseille, France.*
[6]*CEMHTI, CNRS, Orléans, France.*
[7]*Australian National Laboratory, Canberra, Australia*
**elodie.bernard@cea.fr*

Plasma-facing materials for next generation fusion devices, like ITER and DEMO, are loaded with intense fluxes of light elements (notably He and H isotopes). For tungsten (W), one of the most promising candidates, incident He particles can drastically affect the surface, with the formation of dislocation loops, bubbles or W-fuzz [1]. Temperature is a key parameter to examine, as it affects vacancy and interstitial mobility in the material.
The WHIrr (W under Helium Irradiation) project focuses on the study of He impact on W and its consequences for the material properties [2], using various irradiation techniques and controlled irradiation temperature (300 to 800ºC). Transmission Electron Microscopy (TEM) was used to evaluate the evolution of W microstructure, coupled with complementary analysis (Positron Annealing Spectroscopy (PAS) and Grazing Incidence Small Angle X-ray Scattering (GISAXS)). We will present the most recent results of the WHIrr project, notably on W samples exposed to He in the linear plasma device PSI-2 (with 10^{20}-10^{22} $s^{-1}.m^{-2}$ flux and 10^{23}-10^{26} m^{-2} fluence ranges).
W fuzz was not observed, nevertheless He irradiation leads to major changes in the material morphology, rising concerns about properties such as H retention. Tritium (T) and deuterium (D) inventories were evaluated through two complementary techniques: T gas loading and desorption at Saclay Tritium Lab, and D ion beam implantation followed by Temperature Programmed Desorption at Aix Marseille University. Impact of He irradiation temperature, flux and fluence on the subsequent H trapping and release were investigated. First, we observe that the material preparation prior to He irradiation was crucial, with a major reduction of the D/T trapping when W had been annealed at 1500ºC for 2h. The T loading study highlights that increasing the He fluence leads to higher T inventory. Also, for a given fluence, increasing the He flux reduces the T trapping: for the same 800ºC and $3x10^{23}$ m^{-2} He exposure, retention is almost twice higher for the $3x10^{20}$ $s^{-1}.m^{-2}$ case compared to the $2x10^{22}$ $s^{-1}.m^{-2}$ one, suggesting a diffusion-like process. Both surface and bulk have appeared to influence the D/T trapping and inventory, confirming the need to pursue the study with a more complete set of surface and irradiation conditions.

Keywords: *tungsten, ITER, irradiation.*

[1] Y. Ueda et al., Fusion Engineering and Design 89, 7-8, 901-906 (2014);
[2] E. Bernard et al., J. Nucl. Mater 484, 24-29 (2017).

P7-06

Modification of tungsten surfaces by He and He/H_2 hollow cathode discharges

C. Stancu[1], E.R. Ionita[1], M. Teodorescu[1], S.D. Stoica[1], V. Marascu[1], G. Dinescu[1], S. Peillon[2], F. Gensdarmes[2], C. Grisolia[3]

[1]National Institute for Lasers, Plasma and Radiation Physics, 409 Atomistilor Str., PO Box MG-36, Magurele-Bucharest, 077125, Romania
[2] Institut de Radioprotection et de Sûreté Nucléaire (IRSN), Gif-sur-Yvette, 91192, France
[3]CEA, IRFM, F-13108 Saint-Paul-lez-Durance, France
cristian.stancu@infim.ro

Stability of W surfaces when exposed to He and He/H_2 discharges is important for ITER operation. In this contribution, we present results regarding the modification of W surface at high temperature, under He and He/H_2 plasma exposure. In order to have simultaneous heating and plasma exposure we used a hollow cathode discharge.

The experimental setup consists in a vacuum chamber pumped by two pumps: a rotary pump and a turbomolecular pump. The pumps ensure an initial vacuum of $4*10^{-4}$ mbar. Plasma is generated in RF (13.56 MHz) using a parallel-plate hollow cathode configuration. The active RF electrode consists in two tungsten planar pieces positioned face to face at 3 mm distance. The other electrode is represented by the grounded chamber walls which has much larger area than that of the parallel plate electrode. The area asymmetry leads to negative self-bias of the active electrode, sustaining the hollow cathode effect.

The samples under study were mounted as part of the parallel-plate electrode. The tungsten samples were heated by the He or He/H_2 discharge at temperatures in the range 950-1230ºC when power values in the range 200-300W were applied. The exposure time was varied in the range 30-90 minutes. Optical microscopy, SEM, AFM, weighing, and profilometry investigations were realized on the exposed surfaces.

From optical microscopy investigations, we observed that the aspect of sample surfaces changes after exposure to the hollow electrode discharge. From SEM images, we observed that the treated tungsten surfaces become porous, and in case of tungsten surfaces He plasma exposure they appear as covered with bubbles (blistering). The surfaces roughness increased with the temperature and with exposure time (AFM and SEM images). The tungsten samples were weighted prior and after processing: relative mass losses of 0.23%, and 0.57% were noted.

As plasma investigations, optical emission spectroscopy, V-I characteristics, Langmuir probes and mass spectrometry investigations were realized and electron densities, electron temperatures, and species content were determined.

Acknowledgment: This work was financed in the frame of Romania-France cooperation project IFA-CEA code C5-07/2016, and by the Enabling Technology Euratom Project STANDS.

Keywords: *hollow discharge, tungsten modification by plasma.*

P7-07

Ion energy distribution function measurements during high power impulse magnetron sputtering of W and Al targets in Ar-He and Ar-D_2 gas mixtures

V. Tiron[1], C. 0[1, *], I. Mihaila[2], G. Popa[1]

[1] *Iasi Plasma Advanced Research Center (IPARC), Faculty of Physics, Alexandru Ioan Cuza University of Iasi, Iasi-700506, Romania*

[2] *Integrated Center of Environmental Science Studies in the North-Eastern Development Region (CERNESIM), Alexandru Ioan Cuza University of Iasi, Iasi-700506, Romania*

[*]*claudiu.costin@uaic.ro*

High power impulse magnetron sputtering (HiPIMS) is a suitable technique to simulate particular aspects of plasma-wall interaction and nuclear fuel retention in fusion devices because the instantaneous power density applied on the magnetron cathode is comparable with the power density expected to be delivered to the ITER divertor (10 MW/m^2).

The present work reports on the ion energy distribution function (IEDF) of the sputtered material as well as of the sputtering gas measured at substrate position in a HiPIMS discharge. W and Al targets (2 inch in diameter) were sputtered in Ar-He and Ar-D_2 gas mixtures, for different mass flow ratio. The magnetron was driven by a pulsed-dc power supply working in the frequency range of 3÷7 kHz, with the pulse duration of 3 µs and a maximum voltage of 1 kV, obtaining a peak power density of 3 kW/cm^2. The substrate was placed at 10 cm from the target.

The IEDFs were measured using an energy resolving mass spectrometer (EQP 1000, Hiden Analytical). The contribution of the ion species to the total ion flux arriving to the substrate was calculated by integrating over each IEDF. The target material and the sputtering gas mixture (*via* its pressure and composition) have a strong influence on the results. The total ion flux to the substrate is dominated by gas mixture ions (Ar^+, He^+, D_2^+, D^+) when sputtering W, while metal ions (Al^+) are dominant when sputtering Al. Higher energies (80-120 eV) were measured for W^+ ions with respect to Al^+ ions (40-80 eV). Both W^+ and Al^+ ion fluxes diminish when the lighter gas (He or D_2) fraction increases in the gas mixture. The IEDF of the lighter gas is narrower when sputtering Al. The IEDF of He^+ ions is low sensitive to the gas mixture composition. Other working parameters like average power, pulse duration, repetition frequency, target voltage, magnetic field configuration etc. influence the IEDFs and the ion flux composition during HiPIMS operation.

Keywords: *high power impulse magnetron sputtering, ion energy distribution function, mass spectrometry.*

P7-08

The influence of nitrogen gas inclusions on deuterium retention and release properties of Be-W mixed layers

P. Dinca[1,2], C. Porosnicu[1], V. Tiron[3], B. Butoi[1,2], I. Jepu[1], O.G. Pompilian[1]
I. Burducea[4], C.P. Lungu[1]

[1]National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor Street, Magurele, Romania
[2]Faculty of Physics, University of Bucharest, 405 Atomistilor Street, Magurele, Romania
[3]Faculty of physics, "Al. I. Cuza" University,700506 Iasi, Romania
[4]Horia Hulubei National Institute of Physics and Nuclear Engineering, IFIN-HH, Magurele 077125, Romania
**dincapaulpavel@yahoo.com*

In designing next generation fusion devices one would have to take into consideration the nuclear fuel retention in plasma facing components (PFC) and also how the material impurities would influence the deuterium (D) and tritium (T) plasma. Taken into consideration these two facts mentioned above, the choice materials for ITER will be beryllium (Be) and tungsten (W). These materials will act complementary to fulfill the needed requirements in order to withstand the extreme conditions of PFC. Furthermore, the imposed T limit in the PFC components and due to its radioactivity, shortens the lifespan of a thermonuclear reactor unless efficient solutions will be provided to recycle nuclear fuel trapped in materials. Due to high thermal load induced by particles bombardment, the divertor area will be composed entirely of W tiles actively cooled by nitrogen (N) puffed in this area with the main purpose to attenuate the heat loads preventing divertor melting during plasma instabilities. Energetic particles from plasma can escape despite magnetic confinement and interact with the PFC. This interaction can lead to PFC materials sputtering and redeposition of mixed layers composed of Be and W with nuclear fuel and also N.

Our aim is to study the impact of N gas inclusion on D retention and release mechanisms for Be-W mixed layers.

Beryllium-tungsten 2 µm layers were deposited on molybdenum, graphite and silicon substrates in a reactive argon-deuterium gas mixture respectively argon-deuterium-nitrogen by means of combination of multipulse - high power impulse magnetron and direct current magnetron sputtering techniques. The elemental composition and thickness of the layers was well controlled during the deposition process. Structural examinations were undertaken by means of X-ray diffraction and Rutherford backscattering method (RBS). The results showed a change in the samples structure with the adding of nitrogen into the gas mixture evidenced by the appearance of W_2N peaks in the diffraction chart. The RBS showed a in depth uniformity of concentrations for beryllium and tungsten for the measured samples. In order to investigate the deuterium retention mechanisms and to make an assessment of the deuterium inventory thermal desorption spectrometry was performed. The deuterium desorption spectra for the batch of samples obtained with nitrogen showed an obvious behavior to shift to higher temperatures. This behavior was directly linked with nitrogen desorption.

Keywords: *Codeposited Mixed Layers, Beryllium-Tungsten, Deuterium retention, release mechanism.*

P7-09

Nano-porous coatings for gas retention studies

C. Ruset[1], E. Grigore[1], M. Rasinski[2], E. Fortuna[3], J. Grzonka[3], M. Gherendi[1], C. Luculescu[1], N.P. Barradas[4], E.J. da Costa Alves[4], A. Hakola[5]

[1]*National Institute for Laser, Plasma and Radiation Physics, Atomistilor St., 077125, Magurele-Bucharest, Romania*
[2]*Warsaw University of Technology, Materials Science and Engineering Faculty, Poland*
[3]*Wydzial Inzynierii Materialowej Politechnika Warszawska, ul. Woloska 141, 02-507 Warszawa, POLAND*
[4]*IPFN, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais,1049-001 Lisboa, PT*
[5]*VTT Technical Research Centre of Finland, P. O. Box 1000, FI-02044, Finland*
**ruset@infim.ro*

The plasma-wall interaction during the operation of a nuclear fusion device leads to a migration of materials associated with erosion and re-deposition phenomena [1]. Together with the re-deposited material certain amounts of gases from the discharge chamber are captured into the surface layer. Ex-situ investigation of the fusion materials such as W and Be containing D, T, He, N, O, Ar is very important for fusion.

Another requirement for gas containing materials is manufacturing of reference samples for calibration of LIBS and GDOES equipment with D and He lines. At the moment there are no such samples available on the market.

One way to produce coatings with high gas retaining capability is to manipulate their structure towards a nano-porous one. In this respect the processing parameters of the Combined Magnetron Sputtering and Ion Implantation (CMSII) technique have been modified aiming the production of nano-porous coatings. This technique was initially developed for compact W coatings applied on more than 4000 CFC and fine grain graphite tiles for JET, ASDEX Upgrade and WEST tokamaks [2].

In the present paper the results concerning production and characterization of Ar containing W nano-porous (np-W) coatings are mainly presented. SEM, TEM, EDX, RBS, GDOES and TDS techniques were used for analyses of these layers. The layer thickness was about 1 μm and the pores size in the range of 10-20 nm. By heating of the layer to 950 °C (during the TDS analysis) the pores size increased up to 200 nm and the total thickness reached 1.4 μm. The total amount of Ar retained in np-W was $8.6 \cdot 10^{20}$ atoms/m^2 while in compact W coating of the same thickness only $5.7 \cdot 10^{19}$ atoms/m^2 it was found.

The same technique, optimized for each specific application, was used to produce D containing W, Ti and Zr coatings.

Keywords: *tungsten nano-porous coatings, argon, deuterium, combined magnetron sputtering and ion implantation*

[1] M Mayer, et al., Phys. Scr. T**167**, (2016), 014051 (9pp);
[2] C. Ruset, et al., Fusion Engineering and Design **84**, (2009), 1662–1665.

Acknowledgements: *This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission*

P7-10

Investigation of the He content within W coatings by using GDOES

E. Grigore[1], C. Ruset[1], M. Gherendi[1], M. Firdaouss[2], A. Weckmann[2]

[1]*National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor, 077125, Magurele, Romania*
[2]*Institut de Recherche sur la Fusion par confinement Magnétique IRFM, Cadarache, France*
[3]*KTH Royal Institute of Technology, Stockholm, Sweden*
**dedigrig@infim.ro*

He is one of the D-T fusion reaction products and that is why the assessment of He content within *PFC* (Plasma Facing Components) and its influence on *PFC* is a high priority issue for *ITER* from material view point. Formation of bubbles and fuzz structure at the W surface under bombardment with He ions are known phenomena that might affect the structure of the components at the interface with fusion plasma.

Depth profile analysis represents a key element in understand fuel retention or erosion/deposition pattern of *PFC* in a fusion device. The selection of a reliable measurement technique for chemical composition is not an easy task. When gases such as deuterium or helium have to be measured this task becomes more difficult and, that is why the assessment of erosion/deposition pattern and fuel retention phenomena involves a series of complementary investigation instruments.

GDOES (Glow Discharge Optical Emission Spectrometry) technique is able to perform depth profile analysis by measuring the intensities of the emission of the excited atomic species removed from the surface of the investigated samples. W coated samples with He content have been deposited by *CMSII* (Combined Magnetron Sputtering and Ion Implantation) and were used as calibration samples for *GDOES*. The He content within the layer has been evidenced by *TDS (*Thermal Desorption Spectroscopy*)* measurements while *TOF-ERDA (*Time-of-Flight Elastic Recoil Detection Analysis*)* has been used for quantitative analysis. The *GDOES* equipment has been calibrated for depth profile analysis of He by using the *TOF-ERDA* results. Compared with *TOF-ERDA* method the *GDOES* is a faster investigation technique that allows the He depth profile investigation across larger thickness (tens of microns) with good depth resolution.

Keywords: *Helium retention, W coatings, GDOES.*

P7-11

Thermophysical properties of W based plasma facing materials for fusion reactors

M. Galatanu[1,2], M. Enculescu[1], G. Ruiu[1], A. Galatanu[1]

[1)] *National Institute of Materials Physics, Atomistilor Street 405 A, Magurele, Ilfov 077125, Romania*
[2)] *Doctoral School in Physics, University of Bucharest, Atomistilor Street 405, Magurele, Ilfov 077125, Romania*
gala@infim.ro

Tungsten is considered as the most suited material for plasma facing components (PFC) in the DEMO fusion reactor. In the divertor W will be exposed to high heat fluxes (10-20 MW/m^2) and intense neutron irradiation (~5-10 dpa), while in the blanket smaller heat fluxes are expected (2-5 MW/m^2) with an irradiation which might top at around 100 dpa. While W good thermal conductivity, high melting point and sputtering threshold combined with a low tritium retention are desired properties for a PFC material, its high ductile to brittle transition temperature and high oxidation rate are problems which must be solved to increase the operating time for PFC and decrease the maintenance or replacement costs. W reinforcement with fibbers or oxide dispersed strengthened W are considered as option to enhance its mechanical properties, while the so-called self passivation W-alloys are investigated in order to decrease its oxidation in case of an accidental exposure to air. Thermal shocks are another point of concern, since cracks and delamination might not only affect the plasma and PFC but also other diagnostic components inside the vessel. The solution for this problem has not been found yet.

In this work we consider a different approach to PFC materials processing, namely to create W based composites with different dispersions, both metallic and ceramic. Such materials should preserve the refractory nature of W, its good thermal conductivity and improve features like high heat flux, mechanical and oxidation behaviour. Composite consolidation by spark plasma sintering offers some advantages over classic methods like pressure less sintering or hot isostatic pressing, since it allows for good grain joints even when very dissimilar materials are connected. We have used this method to produce W-based composites with up to 30% volume concentrations of dispersed Fe, Ir, Re, Cr and SiC and have investigated the morphology of these new materials and their thermophysical properties. Based on these results we analyse possible strategies to design composites with suited properties for improved W based PFCs.

Keywords: *W plasma facing materials, spark plasma sintering, thermophysical properties.*

P7-12

Cracks and nanodroplets produced on tungsten surface by dense plasma jets

A. Scurtu[1], N. Udrea[1], C. Luculescu[1], M. Gălăţanu[2], A. Gălăţanu[2], D. Ticoş[1], C.M. Ticoş[1]

[1]National Institute for Laser, Plasma and Radiation Physics, 077125 Bucharest, Romania
[2]National Institute of Material Physics, 077125 Bucharest, Romania

The coaxial plasma guns which has been successfully used to accelerate dust particles at hipervelocities [1] are a great tools that can connect dusty plasma physics and fusion physics. Strong interactions between high energy plasma and the material walls of tokamaks will lead to the appearance of the dust particles of 10 nm to 100 μm. The mainly mechanism that produce dust in tokamaks are blistering, material erosion and migration, surface flaking, arching [2]. It can lead to instability and the danger of radioactive contamination due to the activation of the dust particles which can contain nuclei of tritium. Also, dust can play a positive role, being used as a local plasma diagnostic tool [3]. Our goal in these experiments is a better understanding of the interaction of strong plasma jets with tungsten particles. In our experimental set up we are using a miniature coaxial gun to produce a plasma jet consisting of electrons and argon ions. The coaxial gun had two electrodes made of stainless steel, a long centered rod and a coaxial outer cylindrical shell. It is powered by two capacitors banks which are charged by a HV dc supply up to a value of 2 kV.

Small samples of 10 mm in diameter made from pure tungsten were exposed to a dense plasma jet produced by a coaxial plasma gun operated at a maximum energy of 2 kJ. The surface of the samples was analyzed using scanning electron microscope (SEM) before and after applying consecutive plasma shots. Cracks were produced in the surface due to plasma heating. Nanoparticles of a few tens of nanometers in size could be observed in certain circumstances due to local melting of the surface. Four types of samples were prepared by spark plasma sintering from powders with the average particle size ranging from 70 nanometers up to 80 microns. The plasma power load to the sample surface was estimated to be 59 kW per shot. The plasma temperature and density were measured with a triple Langmuir probe.

Keywords: *plasma jet, fusion materials, tungsten.*

[1] C. M. Ticoş, Z. Wang, L. A. Dorf, G. A. Wurden, A Plasmadynamic Hypervelocity Dust Injector for the National Spherical Torus Experiment, Review of Scientific Instruments 77, 10E304 (2006);
[2] Merlino, R Plasma Physics Applied, 2006: 73-110 ISBN: 81-7895-230-0;
[3] Wang, Z.; Ticoş, C.M.; Dorf, L.A. & Wurden G.A. (2006). Micro-particle Probes for Laboratory Plasmas, IEEE Transactions on Plasma Science 34, 242 (2006), ISSN 0093-3813.

P7-13

Lost alpha particle monitor for JET. A conceptual design

S. Soare[1], V.L. Zoita[1], V. Braic[1], T. Craciunescu[1], D. Falie[1], V. Golonorod'ko[2], V. Kiptily[3], I. Lengar[4], R.C. Pereira[5], V. Yavorskij[2], I. Zychor[6], N. Balshaw[3], D. Croft[3], A. Cufar[4], M. Curuia[1], A. Fernandes[5], J. Figueiredo[5, 7], Y. Krivchenkov[3], N. Lam[3], C. Marren[3], S. Mianowski[6], V. Riccardo[3], K. Schoepf[2], Z. Stancar[4], L. Swiderski[6], V. Thompson[3], and JET contributors (EUROfusion Consortium, JET, Culham Science Centre, Abingdon, OX14 3DB, UK)

[1]Institute of Atomic Physics, Magurele, Ilfov, Romania
[2]University of Innsbruck, Fusion@Österreichische Akademie der Wissenschaften (OEAW), Austria
[3]Culham Centre for Fusion Energy (CCFE), Culham Science Centre, Abingdon, UK
[4]Slovenian Fusion Association (SFA), Jozef Stefan Institute, Reactor Physics Department, Ljubljana, Slovenia
[5]Instituto de Plasmas e Fusao Nuclear, Instituto Superior Tecnico, Universidade de Lisboa, Lisboa, Portugal
[6]Institute of Plasma Physics and Laser Microfusion, Narodowe Centrum Badan Jadrowych, 05-400 Otwock-Swierk, Poland
[7]EUROfusion Programme Management Unit, JET, Culham Science Centre, Abingdon, UK

A new diagnostics technique, the Lost Alpha Monitor (LAM), for the investigation of escaping alpha particles in JET has been proposed [1]. The method is based on the detection of the gamma radiation induced by the escaping particles on a target external to the plasma. For a beryllium target this reaction is $^{9}Be(\alpha, n\gamma)^{12}C$. The implementation on JET of the LAM technique would make possible correlated measurements of lost and confined alphas using the same nuclear reaction.

The paper presents the conceptual design of the LAM diagnostics for JET.
The main components of the proposed LAM diagnostics include a radiation collimator and shield which houses two gamma-ray detectors located behind lithium hydride neutron attenuators. The radiation shield is made up of a core stainless-steel collimator surrounded by the neutron and gamma-ray shield constructed from thick plates of high density polyethylene and lead. The collimator-shield assembly is placed behind the existing KJ5 soft X-ray camera in octant 4. The KJ5 soft X-ray camera shield is used as a pre-collimator for the LAM diagnostics. The fields-of-view of the LAM gamma-ray detectors are actually defined by the KJ5 collimator. Two solutions have been considered for the LAM beryllium target. The first proposal is to extend one of the TAE antenna protection tiles, while the other considers a separate dedicated target.

The LAM gamma-ray detectors are based on the CeBr3 scintillators [2] coupled to metal channel dynode photomultipliers. The solution for the data acquisition is based on the ATCA data acquisition platform which includes fast digitizers [3].

[1] V.G. Kiptily et al., Fusion Alpha-Particle Diagnostics for DT Experiments on the Joint European Torus, International Conference on Fusion Reactor Diagnostics, Varenna, 2013;
[2] I. Zychor et al., Physica Scripta (2015);
[3] R.C. Pereira, et al., Fusion Engineering and Design, **88**, (2013) 1409.

*See the author list of "Overview of the JET results in support to ITER" by X. Litaudon et al. to be published in Nuclear Fusion Special issue: overview and summary reports from the 26th Fusion Energy Conference (Kyoto, Japan, 17-22 October 2016)

P7-14

JET plasma influence on the beryllium/nickel marker tiles

O.G. Pompilian, I. Jepu, P. Dinca, B. Butoi, C. Porosnicu, A. Niculescu, C.P. Lungu

National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor Street, Magurele, Romania
oana.pompilian@inflpr.ro

In fusion technology, Be, C and W and tungsten are presently the materials used in fusion technology, as for example in Joint Experimental Torus (JET) experiment at Culham, UK. Special requirements of these materials have to be simultaneously satisfied, as for example high temperature resistance, low influence on the fusion plasma and low fuel retention rate.

Beryllium/nickel marker tiles, consisting on Be bulk tiles and 2 superposed layers of 2 µm Ni and 10 µm Be were prepared at NILPRP using thermionic vacuum arc (TVA) technology and were installed into the first wall of the Joint European Torus (JET) reactor. After 2 years of operation, the marker tiles were removed from JET by remote handling during the 2015 shutdown and were disassembled in the BeHF (beryllium handling facility) at JET and were sent in Romania for sectioning in small samples. The operation was performed in the Beryllium Coating Laboratory in dry conditions. In the same way, W lamellae from Tile 5 retrieved from JET divertor were sectioned with a milling machine using special cutting discs containing more than 21% diamond powder embedded in a copper alloy.

The obtained samples were characterized in order to highlight the influence of the fusion plasma on beryllium marker tiles and W lamellae

The TDS analyses were performed at a heating rate of 10 K/min with a maximum temperature of 1323 K. The samples (5x5 mm) were placed in nickel holders in order to reduce the beryllium contamination of the measurement chamber due to material evaporation at high temperatures. The main desorption of deuterium occurred between 600K-1000 K reaching its maximum in most cases around the temperature of 800 K. These high temperatures of release for deuterium indicate that all samples have traps with high binding energy. These defects were produced most likely due to irradiation damage. In some cases, a release of D was observed after 1200 K. This might be associated with defects into the bulk structure. The lack of low temperature peaks (below 625K) proves that the deuterium removal procedure (heating the chamber walls) is quite efficient preventing deuterium trapping and accumulation in low energy binding states. By integrating the desorption spectra, the total amount of deuterium retained in Be samples was obtained. These values are in the range of $(4.6\text{-}15.9)\cdot 10^{17}$ D/cm^2.

A number of twentyone Be samples were analyzed by XRD. The spectra emphasized the formation of beryllide compounds such as BeNi and Be_2Cr. In addition, formation of oxides such as BeO, CrO and Fe_3O_4 was also detected on particular samples.

[1] C. P. Lungu, I. Mustata, V. Zaroschi, A. M. Lungu, A. Anghel, P. Chiru, M. Rubel, P. Coad G. F. Matthews and JET-EFDA contributors, Phys. Scr. T128 (2007) 157–161

Topic 8

Laser plasmas and their applications

P8-01

Plasma Diagnostics Interferometry for 10 PW Laser driven electron acceleration

S. Balascuta[1,*], G. Acbas[1]

[1]*National Institute for R&D in Physics and Nuclear Engineering, Department of ELI-NP, 30 Reactorului, 077125, Magurele, Romania*

[*]*septimiu.balascuta@eli-np.ro*

1. General

The acceleration of high quality electron beams with less than 1% energy bandwidth and less than 0.005 radians divergence, in the high gradient electric fields of the plasma wake driven by a laser beam with intensity above 10^{18} W/cm^2 focused in a gas, is the goal of the first experiment planned at E6 Interaction Area, located at the Extreme Light Infrastructure Nuclear Physics (ELI-NP) facility [1]. The plasma will be generated by a 10 PW laser pulse (800 nm, 200 J/pulse, 20 fs/pulse) focused in a gas jet by a 30m focal-distance parabolical mirror. To determine the optimum plasma parameters that assure the conditions for electron acceleration, it will be used plasma diagnostics methods based on emission spectroscopy to study the intensity and width of the spectral lines emitted by ions and of the Thomson scattered light at the 800 nm. To visualize the conditions of electron beam acceleration, two experimental methods (transversal Normarski interferometry [2] and Shadowgraphy [3]) are planned to be implemented with a 400-nm probe pulse with 0.5mJ, generated from the main laser pulse.

2. Methods and Results

To evaluate the energy and pulse duration of the probe beam, for a stable and efficient electron acceleration under conditions of the Laser pulse matching, the simulation, of the probe beam was done in OpticsStudio® from Zemax. The construction of a three-dimensional model of probe-beam transport system was done in Autodesk to understand the space constrains and to compute the required resolution of the time delay between the probe and main laser pulses that must be synchronized in the gas target. For the feasibility study of Normarski transversal interferometry, Virtual Lab Fusion® from LightTrans was used to calculate the contrast of the interference image on the window of the CCD camera, using the two-dimensional maps of the plasma index of refraction, computed using the code EPOCH [4] with the plasma density and laser parameters expected for the first-day experiments. Numerical calculations were performed to design a compact Normarski interferometer with a polarizing cube. The results provided the range of the optimum plasma density and length, for the acceleration of electron beams with the optimum parameters required for future applications.

Keywords: *Laser driven electron acceleration, Shadowgraphy, Normarski interferometry, Thomson scattering, Emission spectroscopy, Plasma physics, Particle in cell simulation.*

References:

[1] I.C.E. Turcu et al, Romanian Reports in Physics, **68**, P, (2016), S145-S231.
[2] Milan Kalal et al, Journal of the Korean Physical Society, **56**, (2010).
[3] E. Simions et al., Plasma Phys. Control. Fusion, 58, 065004 , 2016.
[4] Arber, T. D. et al., Plasma Physics and Controlled Fusion **57,** (2015), 11,113001.

P8-02

Polylactide-co-caprolactone based coatings deposited by Matrix Assisted Pulsed Laser Evaporation: an optimization study

S. Brajnicov[1,2], P. Neacsu[3], V. Dinca[1], V. Marascu[1,4], A. Bonciu[1,4], A. Cimpean[3] and M. Dinescu[1]

1National Institute for Lasers, Plasma and Radiation Physics, Magurele, Bucharest, Romania
2University of Craiova, Faculty of Mathematics and Natural Sciences, Craiova, Romania
3University of Bucharest, Faculty of Biology, Bucharest, Romania
4University of Bucharest, Faculty of Physics, Magurele, Romania

For many applications in the field of medical implants, particularly in the development of metallic orthopedic implants with high level of osseointegration, one of the main challenges is the creation of complex hybrid coatings with specific properties allowing acceptance into the organism/bone without the risk of infections. A key factor to achieve these goals is the ability to obtain functional biointerfaces with controlled morphological and chemical characteristics. Matrix-assisted pulsed laser evaporation (MAPLE) was demonstrated to be a highly versatile deposition method for organic materials deposition, including natural and synthetic polymers.

In the present study, the MAPLE technique was successfully used for the deposition of a new synthetized copolymer (i.e. Poly(lactide-co-caprolactone)-block-poly(ethyleneglycol)-block-poly(lactide-co-caprolactone) (PLCL-PEG-PLCL)). The structure and morphology of the deposited layers were investigated by Fourier Transform Infrared Spectroscopy (FTIR), Atomic Force Microscopy (AFM) and Scanning Electron Microscopy (SEM). FTIR studies show that, for a well defined range of process parameters (incident laser fluence, numbers of pulses and spot size) the deposition process does not alter the main functional groups of the deposited material.

In vitro preliminary study of osteoblast response to these coatings showed a high degree of cytocompatibility for most of the tested parameters for the MAPLE coatings.

Acknowledgments: This work was supported by Romanian National Authority for Scientific Research (CNCS–UEFISCDI), under the projects PNII- PT-PCCA-2013-4-199, PN-II-RU-TE-2014-4-2434 and Nucleus programme- contract 4N/2017.

P8-03

Combinatorial deposition by PLD and investigation of W, Mg, C composites for plasma-facing materials (PFM)

L.N. Dumitrescu[1,2], V. Ion[1], A. Moldovan[1], D. Colceag[1], A Bonciu[1,3], M. Dinescu[1]

[1]*National Institute for Laser, Plasma and Radiation Physics, Magurele, Romania*
[2]*University of Craiova, Faculty of Sciences, Craiova, Romania*
[3]*University of Bucharest, Faculty of Physics, Bucharest, Romania*

In different parts of the tokamak machine plasma-wall interactions leads to mixed materials formation on the walls and contamination of the plasma. The materials used for coatings in thermonuclear fusion machine are high Z elements: tungsten (W) and low Z: carbon and beryllium (C, Be). The main problems are the erosion and redeposition during tokamak operation combined with retention of the seeding impurities (hydrogen and nitrogen). Because this is likely to have several consequences resulting in material property changes due the detachment and material mixing, these studies become a paramount importance. In our work, we studied the hydrogen and nitrogen influence on the topography, on the ratios between elements and compositional properties. Because Be is a toxic element in experiments it can be substituted by magnesium (Mg), which has similar properties. Different compositions of the gas mixture (Ar, H, N), number of pulses and substrate temperatures ranging from 200° to 600° C were used.

We report preliminary results on different (W/Mg/C) layers properties with different compositions deposited by combinatorial PLD. The resulted thin films were analyzed in terms of morphology, topographical, optical, structural, and compositional properties by atomic force microscopy (AFM), scanning electron microscopy (SEM), spectro-ellipsometry (SE), X-ray diffraction (XRD), energy dispersive X-ray spectroscopy (EDX) and secondary ion mass spectrometry (SIMS).

Keywords: *tungsten, composite, PFM, PLD, tokamak.*

Acknowledgement: EURATOM, Consortium EUROFUSION 1EU-12/01.01.2016 (WPEDU-RO)

P8-04

Plasma treatment of layered double hydroxides thin films deposited by laser techniques

A. Matei[1], R. Birjega[1], D.D. Baciu[1], A. Vlad[1], A. Marinescu[1], M.D. Ionita[1], R. Zavoianu[2], M. Dinescu[1]

[1]National Institute for Lasers, Plasma and Radiation Physics, 409 Atomistilor Str., 76900 Bucharest-Magurele, Romania
[2]University of Bucharest, Faculty of Chemistry, Department of Chemical Technology and Catalysis, 4-12 Regina Elisabeta Bd., Bucharest
**andreea.matei@inflpr.ro*

Lamellar materials layered double hydroxides (LDH) have been deposited as thin films by laser -based techniques (pulsed laser deposition - PLD and matrix assisted pulsed laser evaporation - MAPLE). LDHs based on Ni and Al hydroxides (with atomic ratio Ni/Al=3) have been investigated. Frozen targets containing 10% LDH powders in water were used for MAPLE, while for PLD the targets consisted in dry-pressed pellets. The surface of the as deposited thin films has been modified by atmospheric pressure plasma treatment at room temperature, knowing that such treatment induces in most of the cases significant changes with regards to the wettability properties and the morphology of the films. The structure and the surface morphology of the deposited films were investigated by X-Ray Diffraction, Atomic Force Microscopy and Scanning Electron Microscopy. The possible applications of the as deposited films, especially in electrochemical sensors, are presented and discussed. Cyclic voltammetry on LDH modified electrodes, before and after plasma treatment, has been performed in the presence the flavor enhancer monosodium glutamate (E 621) as test analyte, in order to establish the detection range and sensitivity.

Keywords: *laser processing, plasma treatment, thin films, layered double hydroxides.*

Acknowledgements: This work was supported by the Ministry of Research and Innovation by Nucleus Program 4N/2016, and grant, CNCS – UEFISCDI, project number PN-II-RU-TE-2014-4-0976 (contract TE 270/2015) – “DESYRE”.

P8-05

Polymeric guiding system obtained by direct laser writing

A. Matei[1], F. Jipa[1], B. Calin[1], M. Zamfirescu[1], M. Dinescu[1], B. Mitu[1], V. Marascu[1], J. Heitz[2], C. Plamadeala[2]

[1]*National Institute for Lasers, Plasma and Radiation Physics, 409 Atomistilor Str., 77125 Bucharest-Magurele, Romania*
[2]*Institute of Applied Physics, Johannes Kepler University Linz, 4040 Linz, Austria*
andreea.matei@inflpr.ro

Microfluidic systems are in the current trend of miniaturization of biosensors. In this work, we produced polymeric structures with controlled geometry by direct laser writing technique. Irradiating the commercial photoresist IPL780 with a ps laser (λ = 355 nm) we produced structures consisting of a reservoir and a channel with various dimensions. The laser power varied in the range 2-75 mW and the scanning speed was fixed, 0.5 mm/s.

For a second set of experiments, a beam of a Ti-sapphire femtosecond-laser incorporated in a two-photon polymerization setup was used to produce similar channels in a home-made photoresist. The micro-structures were written on a glass substrate at a speed of 50 µm/s, with a laser excitation power of 24 mW.

The as processed structures have been further exposed to atmospheric pressure plasma treatment at room temperature in order to optimize the liquid flow process.

The structures properties and the preliminary studies on liquid flow through inscribed channels are reported.

Keywords: *direct laser writing, plasma treatment, microfluidics.*

Acknowledgements: This work was supported by the Ministry of Research and Innovation by Nucleus Programme 4N/2016.

P8-06

Conceptual design of electron spectrometer for laser-plasma experiments

M.L. Mitu[1,2], N. Iacob[1], C.M. Ticoş[1]

[1] National Institute for Laser, Plasma and Radiation Physics, 409 Atomistilor St., 077125, Magurele, Romania
[2] Electron Accelerators Laboratory, 077125, Bucharest, Romania
maria.mitu@inflpr.ro

The paper presents the design considerations of a magnetic spectrometer for the analysis of the electrons produced by laser plasma acceleration technique.

The main characteristics of the high-energy electrons generated from ultra-intense laser-plasma interaction can be determined by using a magnetic spectrometer [1]. An electron spectrometer has been designed to measure the energy distribution, the angular distribution of the magnetic field deflection depending on the spatial distribution and the initial beam energy of the high-energy electrons. The spectrometer design has been optimized in order to observe a broad range of energies from 1 to 200 MeV in a single pulse, with the possibility of simultaneous measurement of the spectral distribution of the electron beam on two detectors located in different planes. The spatial magnetic field distribution is simulated and used into charged particles tracking code to reconstruct the extracted spectrum (energy and angle distribution) of the electron beam deflected through the magnet system. Using an input electron beam profile from a typical laser-plasma experiments we were able to predict the features of the electron beam using the images constructed on detectors. The magnetic system introduces an energy dependent dispersion such that the electron energy is translated to position on each detector plane. An analytical model where the dispersion equation is obtained and numerical simulations of electron trajectories with different energies entering the spectrometer are used to identify the calibration scale for detection of real electron bunches.

Keywords*: laser-plasma interaction; electron magnetic spectrometer; magnetic field deflection*

[1] Y. Glinec, J. Faure, A. Guemnie-Tafo, V. Malka, H. Monard, J.P. Larbre, V. De Waele, J.L. Marignier, and M. Mostafavi, Rev. Sci. Instrum. **77**, 103301 (2006).

P8-07

Mobilization of tungsten particles by ns laser pulses and imaging of plasma dynamics

A. Bercea[1], A. Palla-Papavlu[1], F. Stokker-Cheregi[1, *], M. Dinescu[1], T. Acsente[1], C. Grisolia[2], P. Delaporte[3], G. Dinescu[1]

[1]*National Institute for Lasers, Plasma and Radiation Physics, 409 Atomistilor St., 077125, Magurele, Romania*
[2]*IRFM, CEA/Cadarache - bât. 513, F-13108, Saint Paul lez Durance, France*
[3]*Aix-Marseille Université/CNRS, LP3 laboratory (UMR CNRS 7341), F-13288 Marseille, France*
**stokker@gmail.com*

In this work we examine the efficiency of laser ablation and subsequent mobilization of tungsten particles under various experimental conditions using ns laser pulsed sources. Our research is meant to address some of the peculiar issues posed by the functioning of next-generation fusion reactors, such as ITER. More specifically, we address the expected accumulation of W dust within the reactor, and we explore the potential of laser ablation techniques towards the removal and/or mobilization of such by-product particles. Although the motivation of our work stems from a particular applicative purpose, we also go into an in-depth fundamental analysis of the dynamics of laser plasmas made of mobilized tungsten particles.

The obtaining of surfaces contaminated with W particles was achieved using a gas aggregation cluster source based on a magnetron sputtering discharge (MS-GAS), which is described in detail in Ref. [1]. The contaminated surfaces were placed within a removal experimental setup employing a KrF excimer laser working at a wavelength of 248 nm and 1 Hz pulse repetition rate. The experiments were carried out at fluences ranging from 0.5 to 2 J/cm^2. The efficiency of the particles removal was checked for different numbers of pulses delivered in the same area. Scanning electron microscopy (SEM) investigations were used to reveal both the ablation and collection of particles on substrates placed parallel to the contaminated surfaces. Moreover, plasma imaging experiments were conducted in air and vacuum in order to evidence the dynamics of the tungsten particles and fragments mobilized by laser pulses.

[1] T. Acsente, R.F. Negrea, L.C. Nistor, C. Logofatu, E. Matei, R. Birjega, C. Grisolia, G. Dinescu, EUROPEAN PHYSICAL JOURNAL D **69**, 161 (2015).

Keywords: *laser ablation, plasma imaging, tungsten particles*

P8-08

Effects of excimer laser parameters on carbon laser ablation plasma dynamics

C. Ursu[1], P.-E. Nica[2]

[1]Polymer Materials Physics Laboratory, "Petru Poni" Institute of Macromolecular Chemistry, 41 A Gr. Ghica Voda Alley, 700487 Iasi, Romania
[2]"Gheorghe Asachi" Technical University of Iasi, Blvd. Mangeron no.64, 700029 Iasi, Romania
**cristian.ursu@icmpp.ro*

In the last two decades, excimer lasers have been found very attractive due to their applications in industry (micromachining, cutting and drilling), or in the medical field (eye surgery, dermatological treatment). They are also used in research, as ablation source in pulsed laser deposition, for the development of new materials or the improvement of their properties. Additional optics for beam shaping and/or homogenizing is usually used, the quality and properties of the deposited layers being dependent on the energy distribution in the focalization spot.

In this work, we present a particular case of carbon excimer laser ablation plasma, having carbon dimers created in an extended region of the plume, which implies a high potential for the fabrication of nanostructured carbon materials (graphene, fullerenes, carbon nanotubes, etc.). A KrF laser is used at large working distance for the ablation of graphite in vacuum [1] or in an inert gas, without supplementary optics to reshape or to affect the energy distribution of the laser spot. The resulted transitory plasma has a peculiar dynamics due to an arrow like geometrical shape, with carbon dimers observed during the evolution in an extended region, up to a distance of 12.5 mm from the target, even in the case of the expansion into vacuum. Various complementary techniques are used to investigate the properties of the expanding plasma. Electrical measurements performed using a Faraday cup detector placed in various angular positions with respect to the short and the long axis of the laser beam are correlated with the results obtained by ICCD fast imaging and time- and space- resolved optical emission spectroscopy. Then, plasma parameters as expansion velocities, its ion species, and temperature are calculated as function of the delay after the laser pulse and laser fluence.

Keywords: *arrow like plasma, carbon dimers, plasmas interaction.*

[1] P.-E. Nica, G.B. Rusu, O.-G. Dragos, C. Ursu, IEEE Transactions on Plasma Science, **42**, (2014), 10, 2694-2695.

P8-09

Modification of Layered Double Hydroxides (LDHs) thin films properties with organic anion chromophore by laser techniques

I. Tirca[1,2], A. Vlad[1], M. Secu[3], R. Birjega[1], R. Zavoianu[4], V. Marascu[1], A. Marinescu[1], M. Dinescu[1]

1 National Institute for Lasers, Plasma and Radiation Physics, Atomistilor 409, Bucharest, Romania,
2University of Craiova, Faculty of Sciences, RO-200585, Craiova, Romania
3National Institute for Materials Physics, P.O. Box MG-7, 77125 Bucharest-Magurele, Romania
4 University of Bucharest, Faculty of Chemistry, Department of Chemical Technology and Catalysis, 4-12 Regina Elisabeta Bd., Bucharest, 030018, Romania
**angela.vlad@gmail.com*

Mg-Al layered double hydroxide (LDH) thin films having Mg/Al of 2.5 with/without organic chromophores (coumarin-343) guest intercalated in layered double hydroxide host were deposited via pulsed laser deposition (PLD)[1, 2]. Powders of intercalated coumarins and of pristine LDH were obtained by coprecipitation and reconstruction, respectivelly. The thin films were deposited at 266, 532 and 1064 nm wavelength of a Nd:YAG laser working at a repetition rate of 10 Hz and pulse duration of 5 ns in order to find the best deposition parameters (Fig. 1). Optical and structural properties of the obtained thin films were investigated and the obtained results shown the ability of our films to have a luminiscence response (Fig. 2). We observed that 532 nm and 1064 nm favored the formation of a thicker film with prospective applications in photoluminiscence materials.

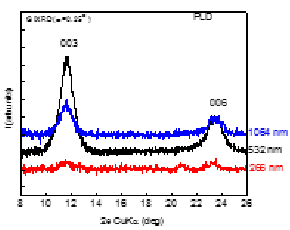


Fig. 1

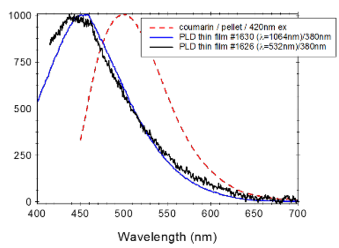


Fig. 2.

Fig. 1. XRD on Mg2.5Al LDH thin film at all wavelengths
Fig. 2. Photoluminiscence spectra of coumarin-Mg2.5Al thin films at 532 and 1064 nm

Keywords: *Layered double hydroxides, laser techniques, thin films deposition.*

[1]. A. Vlad, R. Birjega, A. Matei, C. Luculescu, B. Mitu, M. Dinescu, R. Zavoianu, O. D. Pavel, Appl. Surf. Sci. **302**, (2014), 99-104;
[2]. Birjega R, Vlad A, Matei A, Dumitru M, Stokker-Cheregi F, Dinescu M, Zavoianu R, Raditoiu V, Corobea MC, Appl Surf Sci **374**, (2016), 326-330.

Acknowledgments:
Financial support from Romanian National NUCLEU Program LAPLAS4-code 16 47 and TE271/2015 is gratefully acknowledged

Exhibition and companies

E-01

Litron Lasers Ltd

A. Muntean[1,2]

[1]8 Consul Road, Rugby, CV21 1PB, England
[2]amuntean@litron.co.uk

Lasers designed for research, engineered for industry

Litron Lasers is a specialist in the design and manufacture of pulsed Nd:YAG lasers, PIV Nd:YAG lasers, DPSS Nd:YAG, CW Nd:YAG lasers and true TEM_{00} lasers. Wavelengths available are 1064 nm, 532 nm, 355 nm, 266 nm and 213 nm. Applications include PIV and Visualisation, Spectroscopy and LIBS, Surface Processing and Ablation, Scientific Research, LCD and Semiconductor Processing, Laser Pump Sources, Photoacoustic Imaging and Remote Sensing. Designed to be rugged and offer true 24 hour operation our range of pulsed YAG lasers is extremely extensive ranging from small compact Q-switched systems to ultra high energy lasers including injection seeding options, high repetition rate lasers, true TEM00 lasers and fully integrated type II BBO OPO tunable lasers. Our range of DPSS CW lasers also includes pulsed Nd:YLF lasers offering industry leading outputs of up to 30 mJ per pulse at 1 kHz, 527 nm.

Litron's philosophy is to keep all design and a significant proportion of manufacturing in-house. As a result all electronics, both digital and analogue, mechanics, software and all optics for the lasers are designed at Litron. This structure results in not having to rely on third-party support when supporting our own products, a significant customer benefit.

Custom High Energy Pulsed Nd:YAG Laser System Including Type II BBO OPO with Hands-Free Tuning and Beam Switching

E-02

HISTERESIS - your R&D partner

Lasers, Vacuum, Spectroscopy, Optics, Nanotechnology

IASI, EVO Business Center, Sos. Pacurari 127

office@histeresis.ro

1. Who is HISTERESIS and how we can help you?

We are specialized in the distribution of high-technology equipment both for scientific and industrial activities on the Romanian market and in the Republic of Moldova. We have managed to extend our activity to cover various fields of activity from laser, optics and spectroscopy to vacuum activity, material characterization and cryogenics.

We offer the necessary expertise for spotting the best solutions within the research projects developed within important fields of activity such as physics, chemistry, analytical and environmental sciences but also for university and high-school didactic purposes. We collaborate with and provide support to a wide range of universities, research centers, and industries.

2. Our producers and supplyers.

- **Quantel** - world leader in pulsed solid state lasers;
- **Agilent Technologies - Vacuum Products Division**, world leader in vacuum;
- **Avantes -** miniature spectrometer systems for online measurements and analysis;
- **Nanovea** - professional solutions in the fields of nano to macro profilometry;
- **Princeton Instruments -** CCD, ICCD, EMCCD cameras and spectrometers;
- **SUSS Microtec** - process equipment for semiconductor R&D area;
- **Allectra -** leader in high and ultra-high vacuum components**;**
- **Nor-Cal** – complete line of vacuum components;
- **Altechna** - laser technology company group specialized in laser components;
- **STANDA –** opto-mechanical components;
- **Gooch & Housego –** high performance optics;
- **SPECS -** surface spectroscopy: XPS, UPS, AES, ISS, STM, LEEM/PEEM, LEED;
- **Neocera** - PLD & PED systems for thin film deposition;
- **Laservision** - Germany -laser protection equipment;

The success of our company on the Romanian market has been and will always be based on our well - established relationship with our customers.

We have managed to keep our clients close by always keeping in touch with them, offering appropriate solutions according to their needs in a rapid and efficient manner based on our great range of projects and also due to our tenacity to be on their side right from the beginning stage of their projects. These are the main aspects that have ensured us exclusivity in terms of client preferences and long term collaborations.

Our company is among the most recognized ones on the Romanian market due to the high quality of our range of products. Our name is always correlated with the name of the manufacturers that are represented by us. We have always put all our effort in promoting the image and the products of our partners through quality, reactivity, professionalism & constant and close contact with the customers.

E-03

Centexbel

Technologiepark-Zwijnaarde 7, 9052 Gent, Belgium
http://www.centexbel.be/

General

Centexbel is the Belgian scientific and technical centre for the textile and plastics industry. As a collective research centre, this non-profit organization helps the companies to reinforce their market position by promoting and supporting innovation. Centexbel closely involves the industry, the authorities and its staff in its operation. To fulfil its mission, Centexbel offers an extensive range of activities and services to the textile and plastics industry, including **Testing, Certification, Consultancy and Research & Development** while guaranteeing independent and objective advice, the expertise of 160 highly educated collaborators, trans-sectorial and international networking, focus on sustainable development, practice-oriented support, partnership and an open approach.

Testing

Centexbel has several ISO 17025 accredited Testing Laboratories.

- Chemical Testing: fastnesses, gutter test, gas and liquid chromatography, metal and element analyses …
- Microbiological Assessments: cleanroom garments, protective clothing, cytotoxicity, Agar diffusion, shake flask …
- Physical & Mechanical Testing: tensile test, conductivity, ageing and weathering, abrasion, microscopy (including SEM), thermal and transpiring mannequin …
- Burning Behaviour: flammability, smoke density & composition, heat insulation …

Research & Development

Research is very important within Centexbel. The research areas exploited are:

- Functional Thermoplastic Textiles (FTT): polymer formulation, extrusion processes and thermoplastic composites
- Textile Functionalisation & Surface Modification (TF&SM) covering environmental friendly finishing and coating formulations, energy saving processes, new applications like smart textiles and thermoset composites
- Health, Safety and Security (HSS) including medical textiles and smart textiles
- Plastic Characterization, Processing & Recycling (PCPR): polymer formulation, plastic processing and property evaluation and recycling of polymer

E-04

S.C. DAVO STAR IMPEX S.R.L.

D. Anton[1], R. Anton[2]

[1]77-79 Valea Oltului Street, 06197, Bucharest, Romania
[2]daniela@davo.ro, radu@davo.ro

Clothing industry experts

DAVO STAR is a successful family-run enterprise whose main activity is offering integrated services for the clothing industry to world-wide spread companies activating in this specific field.

Since the foundation, in 1994, the company has constantly grown and diversified its activity. Originally the activity was centered on the production of ready-made clothes, such as jackets, coats, trousers, skirts, blouses, etc. In 1998, we built our own factory, with 3 levels and 1800 square meters unfold surface. The business grew constantly and we reached in 2002 a total production capacity of approximately 60.000 pieces/month.

Starting with 2007, as a consequence of the massive industry move of our main customers into China and other Asian countries, we adopted new business methods and competitive strategies in order to keep up with the pace of change. Thus the emphasis moved from simply offering production capacity to providing a full package of clothing-related services.

As a proof of its constant interest in everything that is innovative in textile and clothing area, from the state of the art technologies to the multi-disciplinary approach, DAVO obtained in 2010 the certification from the National Authority for Scientific Research and dedicated an important part of its resources to this particular domain.

Because Romania became a member state of the European Union, our company was given the opportunity to participate, along with prestigious universities and research institutes, in collaborative projects funded by the European Commission.

As part of SONO project DAVO has had a sono-chemical pilot machine installed in its facility. The aim of this project is to create antibacterial fabrics treated with nanoparticles to be used in the healthcare industry. The antibacterial fabrics were used to make bedsheets, pajamas and medical personnel gowns.

Fig. 1 Sono-chemical pilot machine

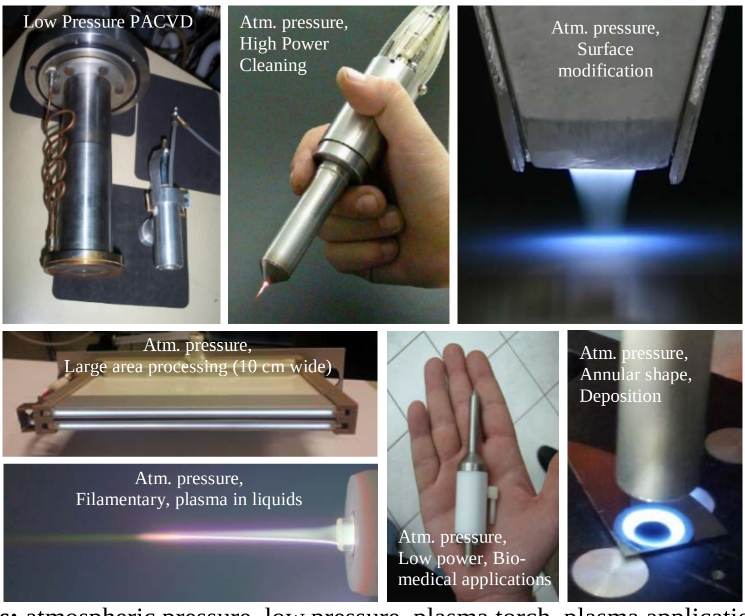
E-05

Low and atmospheric pressure cold plasma jet sources

Plasma Processes, Materials and Surfaces Group[1]

National Institute for Laser, Plasma and Radiation Physics, Atomistilor 409, 077125, Magurele- Bucharest, Romania
[1]dinescug@infim.ro

At the National Institute for Lasers, Plasma and Radiation Physics we have developed various pressure plasma jet sources using DBD (Dielectric Barrier Discharges) and DBE type (Discharges with Bare Electrodes) principles [1, 2, 3]. As shape, the sources are axial or planar, and special designs for specific processing purposes are possible. They are using radiofrequency power generators and can be operated, depending on design, in the cold regime with a few tens of watts. The main gas is Argon, used at mass flow rates in the range 1000-5000 sccm. They can be provided with systems for injection of reactive gases or aerosols. The applicative potential of these plasmas was proved by polymer surface modification in order to control the wettability, cleaning and etching, patterning the cells growth on surface, promoting the adhesion of dental prostheses, operation in liquid phase for chemical decomposition, growth and functionalization of vertical graphene layers, and synthesis of metallic nanoparticles.



Keywords: atmospheric pressure, low pressure, plasma torch, plasma applications.
Acknowledgement: This work has been financed by the National Authority for Research and Innovation in the frame of Nucleus Programme-contract 4N/2016 and contract PN-III-P2-2.1-PED-2016-0287.

References:

[1] E.R. Ionita, M.D. Ionita, E.C. Stancu, M. Teodorescu, G. Dinescu, Appl. Surf. Sci., 255 (10), (2009) 5448-5452
[2] G. Dinescu, E.R. Ionita, Pure Appl. Chem., 80(9) (2008)1919-1930
[3] M. Teodorescu, M. Bazavan, E.R. Ionita, G. Dinescu, Plasma Sources Sci. Technol. 24. (2015) 025033

Author Index

D

E

F

G

H