Plasma-Assisted Nanomaterials Engineering

International Conference on
Plasma Surface Engineering (PSE)
Partner Country Workshop

February 10 - 11, 2022

Book of Abstracts

Introduction

The workshop on Plasma-Assisted Nanomaterials Engineering focuses on low and atmospheric pressure plasmas as tools for the preparation of 0-, 1-, 2- and 3-D nanomaterials including, but not limited to, nanorods, nanoparticles, nanocomposite films, and others.

The event continues the program of Partner Country Workshops organized in relation to and preceding the International Conference on Plasma Surface Engineering (PSE) held formerly biennially in Garmisch-Partenkirchen and now in Erfurt, Germany. The PSE conference hosts about 600 people from Europe, the Americas, and Asia and involves a large industrial exhibition of companies producing plasma equipment and those using plasma processes. Following Belgium as a Partner Country of the 16th PSE, the Czech Republic was selected for this role at the 17th PSE in 2020, and Prof. Jaroslav Vlček from the University of West Bohemia in Plzen was elected to chair the event. As that event was affected by COVID-19 lockdowns, it has been decided that the Czech Republic would remain a Partner Country for the upcoming 18th PSE in 2022, and Prof. Vlček will serve again as a PSE chairman.

The Workshop aims to promote the PSE and increase the interest of Czech companies to employ plasma techniques in their applications. Due to the recent development of COVID-19 related issues the workshop will is held online on February 10 - 11, 2022.

All colleagues from academia and industry as well as students are warmly welcomed.

Organizing Committee

- Hynek Biederman [1] , *Chairman*
- Jaroslav Kousal [1], *Secretary*
- Jaroslav Vlček [2], *Chairman of the PSE 2022*
- Karel Mašek [1], *Chairman of the Czech Vacuum Society*
- Andrei Choukourov [1]
- Ondřej Kylián [1]
- Pavel Pleskunov [1]
- Daniil Nikitin [1]

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Website

- https://www.mff.cuni.cz/cs/kmf/pse-satellite-2022

PANE 2022

Plasma-Assisted Nanomaterials Engineering
Workshop Programme Overview

Thursday, February 10, 2022			Friday, February 11, 2022		
8:45-9:00	Opening		8:55-9:00	Opening	
9:00-12:05	**Session 1**		**9:00-12:05**	**Session 3**	
	Chair	Biederman		Chair	Haviar
9:00-9:40	Inv 1	Haberland	9:00-9:40	Inv 3	Houška
9:55-10:15	Or 1	Carstens	9:55-10:15	Or 9	Popok
10:20-10:40	Or 2	Honorat	10:20-10:40	Or 10	Sergievskaya
10:50-11:10	Or 3	Gonzáles-Elipe	10:50-11:10	Or 11	Thomann
11:15-11:35	Or 4	Mashchenko	11:15-11:35	Or 12	Del Sole
11:10-12.05	Dis 1	Virtual coffee	11:10-12.05	Dis 3	Virtual coffee
13:15-16:25	**Session 2**		**13:15-16:35**	**Session 4**	
	Chair	Pleskunov		Chair	Mareš
13:15-13:55	Inv 2	Mareš	13:15-13:55	Inv 4	Hanuš
14:10-14:30	Or 5	Trimukhe	14:10-14:30	Or 13	Vahl
14:35-14:55	Or 6	Adejube	14:35-14:55	Or 14	Haviar
15:05-15:25	Or 6	Zajíčková	15:05-15:25	Or 15	Mitu
15:30-15:50	Or 7	Al-Muhkhrabi	15:30-15:50	Or 16	Kumar
15:55-16:20	Dis 2	Virtual coffee	15:55-16:20	Dis 4	Virtual coffee
16:20-1625	Closing		16:20-16:35	Closing	

List of abstracts

Invited talks

Oral contributions

INVITED TALKS

Clusters and Nanoparticles, properties, generation, and some applications

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The surprising properties of gold - from the dimer on - will be mentioned in a first introduction; than some size dependent properties will be touched upon. Especially two unusual properties of clusters will be briefly discussed: a surface induced phase-transition, and a negative heat capacity. The magnetron sputter source will be discussed with the emphasis on how little we do understand it, and several experimental results will be presented. Finally, a recent simulation will be discussed and ways on how it could be extended, to better understand the magnetron source.

Research and development of novel pulsed plasma technologies for deposition of advanced thin-film materials

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High Power Impulse Magnetron Sputtering (HiPIMS) is a method that enables to prepare dense and defect-free thin films. HiPIMS benefits can be found in high ionization fraction of sputtered particles allowing better tuning of the coating properties by substrate bias voltage. On the other hand, lower deposition rates due to the back-attraction of the sputtered ions to the target can be found as the main drawback of HiPIMS technology which limits its use in industry. At HVM PLASMA, HiPIMS is intensively studied. To increase the application potential, a grant project was started in 2018. The achieved results can be divided into three categories:

First, fast reactive HiPIMS deposition of oxide barrier coatings was studied. It was proved that the deposition rate of oxide coatings prepared by HiPIMS can achieve higher deposition rate compared to MF pulsed dc magnetron sputtering. Our results were supported by Monte-Carlo simulations of sputtering rates.

Second, positive pulse after the main negative HiPIMS pulse (bipolar HiPIMS) was studied. The plasma parameters were analysed by energy resolved mass spectroscopy and by Langmuir probe. The coatings on dielectric substrates were prepared and their mechanical properties were examined. Application potential was found in deposition into the deep grooves or holes.

Third, the hybrid power supply combining pulsed dc magnetron sputtering with arc evaporation was developed. The modified pulsed power supply allows initiation of pulsed arc discharge during HiPIMS pulse at a defined time. The plasma created by this power supply was analysed by mass spectroscopy and the prepared carbon coatings were examined.

All these innovative technologies significantly advance the plasma deposition and contribute to production of entirely new nanotechnology-based products.

Pathways for the preparation of functional coatings by simulations at various scales

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The presentation will cover different ways how to support the experimental research in the field of functional coatings by computer simulations. Various levels of theory (ranging from solid-state physics through atomic-scale ab-initio simulations to atomic-scale simulations based on empirical interaction potentials) and various simulation algorithms (ranging from static calculations of properties through searching for a local energy minimum to reproducing the time evolution of growing films) will be considered. The first part [1,2] will deal with a design of multilayered high-performance VO_2-based thermochromic coatings. Luminous transmittance, modulation of solar energy transmittance and coating color will be optimized. The results will be compared with our experiments using controlled high-power impulse magnetron sputtering. The second part [3,4] will deal with the identification of maximum achievable N content, [N], in amorphous (Si)-(B)-C-N networks, assuming that it is limited by the formation, presence and loss of N_2 molecules. For example, the difficulties with the preparation of superhard C_3N_4 will be explained by a maximum [N] in CN_x of 42%. Again, the results will be compared with our experiments. The third part [5,6] will deal with reproducing the atom-by-atom growth of crystalline ZrO_2 of various orientations in a wide range of conditions. Effects of energy distribution function (no only average energy delivered into the films), mass of arriving particles (momentum delivered into the films), growth temperature and surface energy will be explained. Deposition protocol which allowed us to prepare ZrO_2 of desired orientation, despite a high surface energy, will be shown.

References

[1] J. Houska et al., Sol. Energy Mater. Sol. Cells 191, 365-371 (2019)
[2] J. Houska, Sol. Energy Mater. Sol. Cells 230, 111210 (2021)
[3] J. Houska, Acta Mater. 174, 189-194 (2019)
[4] J. Houska, ACS Appl. Mater. Inter. 12, 41666-41673 (2020)
[5] J. Houska, Surf. Coat Technol. 304, 23-30 (2016)
[6] J. Houska et al., Appl. Surf. Sci. 572, 151422 (2022)

Nanomaterials produced using gas aggregation source of nanoparticles

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The gas aggregation source of nanoparticles (GAS) is nowadays a well-established tool for synthesizing different nanomaterials on a lab-scale for more than two decades. The main research interest moved in the time from a synthesis of single metal, size-selected nanoparticles towards development of complex nanostructures like nanocomposite films or composite multi-component nanoparticles (NPs).

In the presented study, possibilities of fabrication of nanocomposite films with NPs inclusions made by means of GAS will be discussed. Special attention will be devoted to the limitation of different deposition techniques for hard polymer/metal nanocomposite coatings.[1,2]

The use of the GAS is also extensively studied for the production of heterogeneous nanoparticles with different structures. The most common approach is a synthesis of such NPs in one aggregation chamber either by sputtering from a composite target or in a so-called multi-magnetron arrangement. Another option, an in-flight coating of the nanoparticles will be discussed in this work. Different experimental arrangements and their effect on the final structure of the nanocomposite NPs will be reviewed. [3,4]

References

[1] J. Hanuš, T. Steinhartová, et al. *Plasma Process. Polym*. 13 (2016) 879–887.
[2] M. Vaidulych, J. Hanuš, et al. *Plasma Process. Polym*. 14 (2017) e1600256.
[3] J. Hanus, M. Vaidulych, et al. *J. Phys. D Appl. Phys*. 50 (2017) 475307.
[4] T. Košutová, J. Hanuš, et al. *J. Phys. D. Appl. Phys.* 54 (2021) 015302.

ORAL CONTRIBUTIONS

Long-term memristive dynamics of Ag-based nanostructures

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Neuromorphic systems are considered to have the potential to outperform our current hardware architectures in solving a broad range of problems like e.g. pattern-recognition through shaping of adaptive and self-organized systems inspired by biological neuronal networks. Especially, the memristive dynamics of Ag-nanostructures, which allows the engineering of nanogaps with a reconfigurable resistivity, offer promising pathways for the design of such systems. Here, we report on the long-term memristive dynamics of two different Ag-based nanostructures (nanoscale filaments evolved from a continuous electrode, as well as assemblies of AgPt-nanoparticles) acquired by an unconventional cAFM approach. Here, the memristive system is directly integrated at the apex of the cantilever tip. Compared to conventional cAFM probing of memristive systems on a planar substrate, our approach offers the potential to avoid experimental uncertainties related to the thermal drift of the cantilever. Similarities between the memristive dynamics of Ag-based nanostructures and biological computational principles, such as short-term memory, temporal correlations and inhibitory dynamics, are highlighted. These insights can promote the design of neuromorphic systems with computational dynamics closely oriented towards biological neuronal networks.

Polypropylene nanoparticles generation using 355 nm laser ablation

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A massive contamination of the environment by micro- and nano-plastics has been observed in all compartments of the biosphere [1]. This pollution has raised growing public concern and increased the demand for insights on the toxicity and biological consequences of such particles.

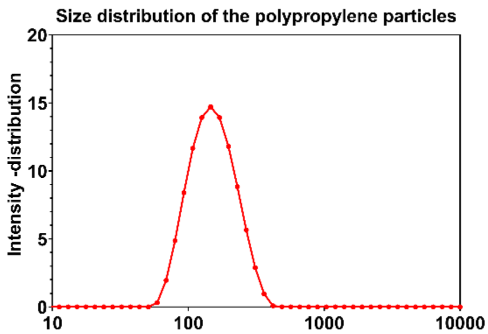

Figure 1: Size distribution of the polypropylene nanoparticles generated by 40 mJ, 355 nm laser pulse (Dynamic light scattering measurement)

However, the research on micro and nano-plastics toxicology is hampered by the availability of the appropriate material. Indeed, most of the toxicological studies has been performed with polystyrene particles designed for applications in diagnostics and molecular biology. For such applications, the polymer is high-purity and designed to interfere with cells and bioassays only minimally.

On the other hand, the extraction and purification of particles from the environment is a tedious process involving harsh treatment conditions. With the aim of providing nano-plastics of relevant sizes, we have investigated the use of underwater laser ablation and photofragmentation with a 355 nm Q-switched laser. We focus our efforts on producing polypropylene particles, starting from commercial plastic sheets. Laser ablation appears to generate particles of appropriate sizes (Figure 1). The size distribution was measured using dynamic light scattering and scanning electron microscopy. The parameters influencing nanoparticles size and the stability of the resulting solution were also investigated.

Acknowledgments: The work was funded by the German Federal Ministry of Education and Research (BMBF, funding no. 03Z22D511 to K.W.).

References

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Patterning and nanostructuration of plasma thin films grown under acoustic wave activation

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In this work we have assisted the plasma deposition of TiO_2 thin films with acoustic waves (AWs) generated in a piezoelectric substrate and shown the occurrence of outstanding submillimeter patterning phenomena characterized by substantial lateral changes in nanostructure, density, crystal structure and properties. The reported experiment entails the merging of two physical processes: plasma interaction during thin film deposition and MHz acoustic wave activation. As an example, Figure 1 shows some characterization images of a TiO_2 thin film prepared by magnetron sputtering (MS) under AW activation.

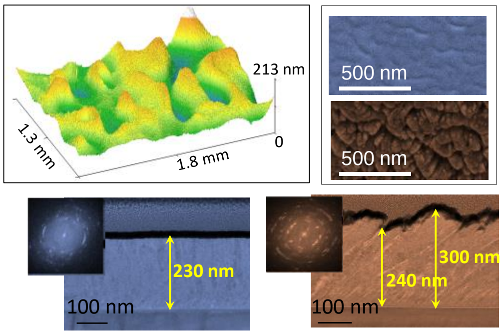

Figure 1.- Confocal microscopy and SEM and TEM images of a patterned TiO_2 thin film prepared by AW activated MS.

We envisage that this combination of phenomena and excitation processes will provide new tools for the patterning and surface activation of thin films during growth [1].

Acknowledgments

We thank the FEDER program through AEI-MICINN (PID2020-112620GB-I00) and the H2020-EU.1.2.1-FET OPEN program (grant 899352, project SOUNDofICE) for financial support.

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Plasmonic MALDI MS: Ag nanoparticles as a booster for organic matrix

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Matrix-assisted laser desorption-ionization mass spectrometry (MALDI MS) is a widespread Nobel prize Awarded method that has already found utilization in medicine and biology, e.g., in proteomics [1]. Therefore, any improvement in this methodology, e.g., enhancement of detection limit, possibility to measure new types of molecules, spectra reproducibility, and quality, significantly impacts those fields. Classical MALDI is based on mixing the sample with the matrix, usually absorbing in UV region; when such matrix is irradiated by laser in this wavelength region, the matrix can transfer the hydrogen ion to the analyte. After such soft ionization, charged molecules are then measurable by TOF – MS. The laser power increase is leading at first signal enhancement especially at low concentration, however too much laser power leads to background rise, which burdens the detection of analyte.

Our approach utilizes plasmonic properties of Ag nanoparticles (NPs) prepared by gas aggregation source of nanoparticles absorbing at wavelength of MALDI laser (320nm). Concretely the enhancement of electric field around them is utilized, to increase the probability of soft ionization at lower laser power; 80 W is nowadays recommendation for sinapic acid (SA), and 40 W is required for α-Cyano-4- hydroxycinnamic acid matrices (CHCA). This approach of plasmonic nanoparticles/matrix mix is not only significantly enhances the MALDI spectra of bovine serum albumin (BSA) and Riboflavin analytes using SA and CHCA, but also leads to better detection limit and demonstrates positive effect of utilization of Ag nanoparticles for molecules detection.

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Pulsed plasma surface functionalized nanosilver for gene delivery

Ajinkya M. Trimukhe[1], Prasad A. Pofali[2], Amogh A. Vaidya[3], Uday B. Koli[4], Prajakta Dandekar[4], Rajendra R. Deshmukh[1], Ratnesh D. Jain[2*]

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Lack of suitable surface properties in biomaterials is an acute challenge for their utilization in nucleic acid delivery, since surface modification of materials, in an effective, environment friendly and economical way. In this investigation we have modified the surface of silver nanoparticles (AgNPs) with chitosan biopolymer, using plasma treatment, to extend their application scope in intracellular DNA delivery. The plasma functionalized; chitosan modified AgNPs (Metalo Polymeric Nanocarriers; MPNCs) possessed superior biocompatibility compared to unmodified AgNPs. Carboxylic groups were incorporated on the surface of nanosilver using 360° rotating pulsed plasma reactor and acrylic acid vapors were used as precursor gas. Pulsed plasma polymerization process was optimized with respect to working pressure of the system, duty cycle for pulsing, time of treatment and flow rate. Biocompatibility of the plasma functionalized nanosilver was enhanced by coupling it with Chitosan Oligosaccharide (COS), using EDC (1-Ethyl-3-(3-dimethylaminopropyl) carbodiimide) to form amide linkages. The resulting MPNCs showed high cell viability and bio-stability, which was attributed to plasma processing of nanosilver and its association with COS. In vitro cellular studies illustrated significant uptake of nanoplexes. The study suggested the potential of plasma functionalization for manipulating surfaces of metallic nanoparticles to enhance their application in intracellular gene delivery [1].

[1] Pulsed Plasma Surface Functionalized Nanosilver for Gene Delivery. A. M. Trimukhe, P. A. Pofali, A. A. Vaidya, U. Koli, P. Dandekar, R. R. Deshmukh, Ratnesh D. Jain; *Frontiers in Bioscience, Landmark*, 25, (2020) 1851-1871.

Dynamic Resistive Switching in Nanoparticle Networks with and without dielectric matrix

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Resistive switching with brain-like dynamics is an integral property of percolating nanoparticle networks (PNN). These complex dynamics are considered to have a high potential for reservoir computing thus integration of PNN into functional devices is of significant interest. Here we discuss and compare the dynamic switching observed in PNN with and without a dielectric matrix. By a stepwise fabrication process, the nanoparticle networks deposited at the percolation threshold are subsequently covered with a dielectric matrix. The resistive switching, interevent interval, avalanche sizes and avalanche duration of the networks are analysed, revealing a power law dependency. Our results show that the power law and critical dynamics of the networks are similar to the observed dynamics in neural biological system. The dynamic resistive switching of the network is retained after the incorporation of a dielectric matrix. This retention of the dynamics shows the possibility of embedding the networks into functional devices. The results also open up more possibilities for manipulation of brain-like dynamics in artificial neural networks.

Acknowledgements

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Cu-coated polymer nanofibers for antibacterial effects

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The advantage of polymer nanofibers forming nonwoven mats is their large surface area, high porosity, and good pore interconnectivity. It makes them highly suitable as base materials for delivery of active substances, filtration, or as breathable dressings. Copper-coated nanofibrous materials are desirable for catalysis, electrochemistry, sensing, and biomedical use. The preparation of copper or copper-coated nanofibers can be pretty challenging, requiring many chemical steps that we eliminated in our robust approach, in which for the first time, Cu was deposited by magnetron sputtering onto temperature-sensitive polymer nanofibrous mats [1]. The polymer mats were prepared by electrospinning of polycaprolactone (PCL). The Cu-coated PCL nanofibers were characterized by SEM and XPS, tested as antibacterial agents for various Gram-positive and Gram-negative bacteria, and their toxicity to cells was studied too. Fast release of Cu^{2+} ions (concentration up to 3.4 μg/mL) led to significant suppression of E. coli and S. aureus colonies but was insufficient against S. typhimurium and Ps. aeruginosa. The effect of Cu layer oxidation upon contact with liquid media was investigated by X-ray photoelectron spectroscopy revealing that, after two hours, 55% of Cu atoms are in the form of CuO or $Cu(OH)_2$.

[1] A. Manakhov, N. Sitnikova, A. Tsygankova, A. Alekseev, L. Adamenko, E. Permyakova, V. Baidyshev, Z. Popov, L. Blahová, M. Eliáš, L. Zajíčková, A. Solovieva, Membranes 11 (2021) 965

Impregnation of C:H:N:O films by dyes with different functional groups in way to enhance sorption of antibiotics

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The formation of a biofilm on an implant is still the number one problem in arthroplasties. When a biofilm develops on the implant surface, an inflammatory reaction develops, which often leads to infection that occurs in up to 2% of cases [1]. Protocol treatment involves intravenous injection of broad-spectrum antibiotics; but unlike the planktonic bacteria, the antibiotics have minor effect on the colonies in the biofilm form which develops in 65% [1]. Revision surgery and implant replacement is required in this case and average price is $60,000 for each episode [1]. New alternative approach is needed to reduce the likelihood of biofilm development. A good compliment to general antibiotic therapy can be a local solution of the problem - biocide films covering the surface of the implant.

In previous works the C:H:N:O plasma polymer films impregnated by antibiotics appeared as promising way how to produce effective antibacterial coating, however the films are releasing antibiotics in amounts corresponding to 40 % [2] of film volume and the antibiotics interaction with plasma polymer network was until now question. We targeted this question by impregnation of C:H:N:O films by dyes with different functional groups. Such experiments gave us by spectrophotometric measurements the information not only about kinetics of the release of substance, but also about the amount which left in the thin film, for films tailored in crosslinking as well as in chemical composition. The results of dyes impregnation allowed us to find deposition conditions of C:H:N:O films which are most suitable after antibiotics impregnation and allowed us to create very effective antibacterial surface.

References

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[2] J. Kratochvíl et al. Plasma Processes and Polymers, Mar. vol. 15, no. 3 (2018)

AlN Nanostructures Formed by Reactive Magnetron Sputtering

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AlN is a wide band gap semiconductor with a number of distinguished properties such as high thermal conductivity and resistivity, high chemical and thermal stability, good mechanical strength and piezoelectric characteristics making it attractive for power electronics, nanoelectromechanical and energy harvesting devices [1, 2]. One of the widely used methods for AlN production is a reactive magnetron sputtering. While some level of maturity is reached for the thin film synthesis, the methodology for AlN nanostructure growth is currently at the beginning of its development.

In the current work, commercial sputtering system Flextura 200 (Polyteknik AS) is utilized for the AlN growth. Pure Al target is sputtered by argon plasma, the supplied nitrogen (as molecular gas cracked in this plasma) reacts with atomic aluminium forming an aluminium nitride at the Si substrate. Growth of AlN is governed by several parameters among which the working pressure, gas (both Ar and N_2) flows and substrate temperature are the most important. Varying these parameters allows to control the columnar structure and surface morphology of the synthesised films. To get the nanostructures separated from each other, the growth needs to be catalyst-assisted. In the current work, Au and Al nanoislands were tested as catalysts as well as the growth was performed at different deposition angles allowing to obtain the nanostructures with different geometry and morphology. The challenges to optimize the sputtering conditions and produce the structures with required parameters will be discussed in the presentation.

Acknowledgments

The authors acknowledge financial support of the Novo Nordisk Foundation under the project “Nanoscale Energy Generators” (grant No. NNF20OC0064735).

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In operando analysis during sputtering onto liquids for nanoparticle synthesis.

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Although the synthesis of nanoparticles (NPs) by low-pressure plasma-based sputtering onto liquids offers many advantages as compared to wet-chemistry-based approaches (see [1] and references therein), not much is known about the NP formation mechanism in these conditions. Ideally, in operando analysis of the produced colloidal suspensions during the process is requested.

Here, we present the first report about temperature evolution of the host liquid during the sputtering of copper onto castor oil. Two thermocouples, placed under the liquid surface and in the bulk solution, monitor the temperature in situ, during the sputtering process. The effect of the working gas pressure and sputter power was studied. It was shown that the liquid temperature increased at a rate of up to 1°C/min depending on the process conditions. These experimental data are compared with COMSOL simulations.

In the second part of the talk, we present our recent time– and space- resolved absorption spectrophotometry measurements during the plasma treatment but also afterward, while keeping the sample in the vacuum chamber. In this case, we recorded the absorbance of the solutions made by depositing silver atoms onto either a silicone oil or an ionic liquid (BMIM-TFSI). Our data highlight that these two systems show different dynamics despite the sputtering conditions were identical.

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Nanostructured and composite films using helium behavior in materials

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Interaction of He ions or helium plasmas with materials has been widely studied, especially in the frame of nuclear fusion. It has been proved that due to its low solubility and high mobility in metals, He is able to diffuse on a long pathway, inducing the formation of vacancies where it can accumulate. This finally may lead to the formation of He filled high pressure nanosized bubbles, which presence inside the material drastically modify the properties. When helium is incorporated at the very near surface, it has been shown that rupture of the metal lattice can occur which induce processes like flaking or the development of a so-called porous fuzz structure.
The objective of our work is to carry out deposition of thin films by DC magnetron sputtering in Ar/He mixtures in order to benefit from this particular behavior of helium. We investigated Si, Al and Zr and we evidenced that, depending on the He proportion in the gas phase and on the element, films of different nature can be elaborated, which exhibit completely different properties than that of Ar gas deposited ones. For instance, gas/solid nanocomposite films where He is trapped in pores dispersed over the entire thickness [1] or highly porous nanostructured films [2] were obtained. Thus, playing with the plasma gas, may be a way to broaden the film properties accessible by the magnetron sputtering technique.

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Oxygen plasma surface modification of fullerene C_{60} for stable aqueous dispersion

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Fullerenes, and in particular C_{60}, are promising nanomaterials, due to their biological, physical, photochemical, and electrical properties. However, their low solubility in water (less than 0.04 ng/mL for C_{60}) represents a limit to their extensive use. The physicochemical properties of water dispersions (namely, nano-C_{60}) were widely described in literature. Wet chemistry methods and mechanical ones (extensive stirring/sonication) have already been developed to ease the dispersion of C_{60} in water by introducing polar functional groups on the fullerene cage. Still, these methods are time consuming and scarcely adhere to green chemistry principles due to the use of organic solvents. In this work, we will introduce a timesaving, dry chemistry approach based on O_2 Low-Pressure (LP) Plasma treatment to enhance the dispersion of C_{60} in water. A similar surface modification was already performed on multi-walled carbon nanotubes to increase their hydrophilicity. [1] To the best of our knowledge, it is the first time that such treatment is used to modify C_{60} powder surface with polar oxygenated moieties. Different conditions of power and treatment time were tested; subsequently, treated powders were dispersed in distilled deionized water. The non-destructivity of plasma treatment was proved via MALDI-TOF analysis on both powders and suspensions. The enhancement in C_{60} concentration in water was supported by UV-Vis spectroscopy and TOC measurements. Particles' size (~200-250nm), polydispersity index (~0.15) and ζ potential (~ -40mV) of the suspensions were assessed via DLS and ELS. Furthermore, XPS analysis both on powders and aqueous dispersions, drop-casted on Si wafers, highlighted the massive presence of carboxylic groups especially on the surface of the fraction of powder dispersed in water after treatment.

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Memristive Switching and Photon Sensing in Nanoparticle-based Devices

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The rise of Big Data and artificial intelligence imposes a significant growth in the demand on information processing capabilities. In contrast to conventional transistor-based electronics, the field of neuromorphic engineering draws inspiration from information processing in highly interconnected neuron assemblies and offers great potential to create novel, more efficient electronics. A crucial aspect of bio-inspired electronics is to mitigate bottlenecks in the communication between dedicated memory and processing. For bio-inspired electronics, memristive devices with reconfigurable resistance states are considered as highly promising. Here, nanocomposite devices with metal nanoparticles embedded in a dielectric matrix are discussed in terms of their resistive switching properties. In particular, SiO_xN_y/Ag/SiO_xN_y cross point devices are compared regarding their electrical properties to Ag alloy nanoparticle-based devices. Tailored Ag alloy nanoparticles (NPs) embedded in a SiO_2 or SiO_xN_y dielectric matrix are used in a multi-stack setup fabricated by means of a Gas Aggregation Source (GAS) to realize a broad range of filamentary type of switching (diffusive and bipolar) characteristics. Furthermore, memsensors, unifying reconfigurable resistance states and sensor functionalities, are discussed as a promising pathway to bridge the gap between signal detection and signal processing.

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Nanostructured Thin-Film-Based Hydrogen Gas Sensors Prepared by Advanced Sputtering Techniques

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Metal oxide semiconductors (MOSs) are well established as active materials in gas sensor assemblies. Especially nanostructured MOSs attract the attention because of the unique electronic properties of nanomaterials and a high reactive area. Here, we present the study of various multilayer structures produced by conventional sputtering depositions and high-power impulse magnetron sputtering (HiPIMS).

By tuning the deposition parameters of reactive high-power impulse magnetron sputtering, specifically the pulse length, we were able to prepare substoichiometric WO_{3-x} films with various stoichiometry and structure [1]. Subsequently, the films were annealed in air at moderate temperature (350°C). We demonstrate that the stoichiometry of the as-deposited films influences considerably the type of crystalline phase formed in the annealed films. To characterize the sensing response to hydrogen, we decorated the tungsten oxide films with Pd nanoparticles prepared by conventional sputtering.

In the second part [2], we deposited the cupric oxide films by reactive DC sputtering. These films were then supplemented with an additional layer, which was sputter deposited from the metallic tungsten target in a reactive mode. Surprisingly, the newly added layer consists of copper tungstates rather than copper oxides. The final structures are described in detail, as well as their sensing performance in dry and humid air.

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Nanocomposites based on chitosan and Ag nanoparticles for wound fast healing

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This work presents a method for obtaining antimicrobial and biocompatible Ag NPs/chitosan nanocomposites by using an atmospheric pressure plasma source based on a dielectric barrier discharge. Non-woven polyester textiles were used as supports for development of medical patches. They were exposed to a DBD plasma generated in radiofrequency (13.56 MHz) at 30 W in a continuous argon flow of 3000 sccm for ensuring superhydrophilic behavior of the substrate. Same parameters were afterwards employed for plasma induced graft polymerization (PIGP) of chitosan, with various concentration of Ag nanoparticles (30 nm diameter) in the range 0 – 5 %, either in single step or in multiple steps, in order to allow different loading of the patches with active substances.

The antimicrobial effect of the dressings depending on the Ag NPs concentration and degree of loading was proved against a wide range of strains, including *S. Aureus, E. Faecalis, P. Aeruginosa, E. Coli,* and *C. Albicans* yeast. The study of the compatibility and cell proliferation of the dressings was tested for fibroblast and keratinocyte cell lines. The results evidenced that under moderate Ag NPs loading and low number of PIGP procedures one can obtain both antimicrobial and biocompatibility effect of the dressings.

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Water stable Ag/C:H:N:O nanocomposites for LSPR sensing applications

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Nanoparticles, made of plasmonic material, can exite after light irradiation a Localised Surface Plasmon Resonance (LSPR). The LSPR, often observed as a absorbance peak, is determined, among others, by the nanoparticle size, shape and the medium in the closest vicinity of the nanoparticle. The change of the medium properties results in the sfift of the LSPR peak , observable by UV-VIS spectroscopy. This effect is often used for sensing applications. Our work is motivated by the develompent of nanostructures, based on Ag/C:H:N:O composite, able to detect pathogens of Lyme Borreliozis desease.

We report here, the development a sensoric structure by immobilized Ag nanoparticles, produced by gas aggregation source, in the C:H:N:O plasma polymer, prepared by sputtering of nylon 6,6 target in reactive N_2/Ar atmosphere. We prove that the elevated temperature of plasma polymer during Ag nanoparticles deposition is the effective way of stabilization of the final surface as the nanoparticles are not detached from the surface even using an ultrasound bath. The sensitivity of detection is dependent on the distance from the nanoparticles. The sensing range of the prepared transducer layer was tested by overcoating of the nanocomposite by C:H:N:O film with different thicknesses. It was proved, that the sensing layer can detect changes in the distance of more than 32 nm from the surface, which somewhat correspond with the size mark proteins. Finally the prepared Ag nanoparticles/C:H:N:O nanocomposite was successfully tested for detection of different liquids.

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