DEPARTMENT OF SURFACE ENGINEERING AND OPTOELECTRONICS F-4

The research program is associated with vacuum science, technology and applications. The main activities are focused on plasma science, the modification of advanced biomedical materials and products for improved biocompatibility, the characterization of inorganic, polymer and composite materials with different thin films on the surface, the modification and characterization of fusion-relevant materials, the thermodynamics of trapped gases and methods for sustaining ultra-high-vacuum environment, vacuum optoelectronics, and basic research in the field of surface and thin-film characterization by electron and ion spectroscopy techniques.

Head:
Prof. Miran Mozetič

Non-equilibrium gaseous plasma created in molecular gases is a rich source of neutral reactive gaseous species. An electron temperature of several 10,000 K ensures the frequent dissociation of gaseous molecules upon inelastic collisions with fast electrons. The neutral atoms are often stable in the gas phase since the association with parent molecules requires three-body collisions, which are unlikely to appear at pressures below 100 Pa. The major loss mechanism for neutral reactive particles in low-pressure plasma is therefore heterogeneous surface recombination. The recombination coefficient depends on the ability of the surface facing the gaseous media rich in neutral atoms to bond to them chemically. Depending on the type of atoms it can be very low for many glasses, some polymers and several types of ceramics, but much larger for materials that chemisorb atoms. Systematic research on the interaction between neutral oxygen atoms and selected nanostructured materials enabled the discovery of a material with the highest coefficient ever reported in the scientific literature. The recombination coefficient was determined experimentally in the early afterglow of oxygen plasma created by an electrodeless radiofrequency discharge. Extremely high values of the atomic oxygen loss coefficient on a carbon nanowall (CNW) surface were observed. CNW layers consisting of interconnected individual nanostructures with an average length of 1.1 μm, average thickness of 66 nm and surface density of 3 CNW/μm^2 were prepared by plasma-jet-enhanced chemical vapour deposition using C_2H_2/H_2/Ar gas mixtures at the National Institute for Laser, Plasma and Radiation Physics in Bucharest, Romania. An image obtained with our atomic force microscope is shown in Figure 1. The surface-loss coefficient for oxygen atoms was determined at various densities of oxygen atoms in the experimental chamber up to $1.3 \times 10^{21} m^{-3}$. CNWs and several different samples of known coefficients for the heterogeneous surface recombination of neutral oxygen atoms have been placed separately in the afterglow chamber and the oxygen-atom density in their vicinity was measured with calibrated catalytic probes. A comparison of the measured results allowed us to determine the loss coefficient for CNWs and the obtained value of 0.59 ± 0.03 makes this material an extremely effective sink for oxygen atoms [1].

The group of Prof. Janez Kovač invented an analytical solution for the convolutional integral describing depth profile analyses of thin films.

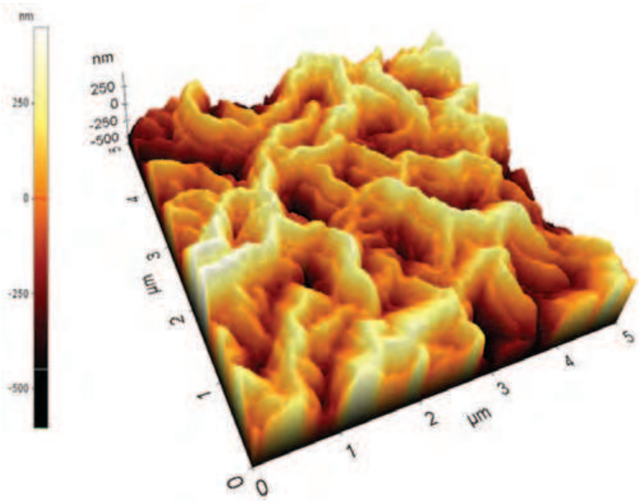

Figure 1: An AFM image of plasma-assisted synthesized carbon nanowalls of highest recombination coefficient for neutral oxygen atoms [1].

In many cases the oxygen atoms should be preserved since they are useful for both functionalization with polar functional groups and the controlled etching of polymers. Surface saturation with polar oxygen-rich groups is achieved in a fraction of a second, providing the plasma is sustained in a chamber made from inert materials, typically quartz or borosilicate glasses [2]. Further exposure of polymer materials to an oxygen plasma leads to etching. The etching is often non-uniform and results in nano-structuring of the surface morphology. A combination of a rich morphology and saturation with polar functional groups allows for the super-hydrophilic character of originally hydrophobic materials. Polymer composites are etched selectively so that the polymer component is removed from the sample surface, leading to modified surface properties. Furthermore, such a treatment makes it possible to distinguish the distribution and orientation of fillers inside the polymer matrix. A systematic treatment of advanced thermochromic prints used in the food industry was performed. The prints contain a polymer matrix and a-few-μm-large capsules containing thermochromic ink. The quality of the prints depends on the distribution of the capsules inside the polymer matrix. The prints were

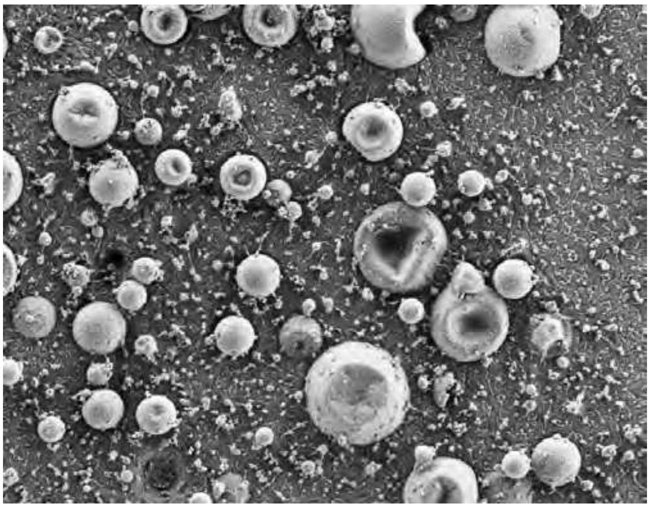

Figure 2: A SEM image of oxygen-plasma treated sample reveals distribution of capsules inside the thermochromic print [2].

treated using oxygen plasma for different periods in order to remove the surface polymer of a certain thickness. After several seconds of plasma treatment the uppermost capsules became visible by imaging the print surface with a scanning electron microscope. As the treatment proceeded more capsules were revealed, thus enabling a determination of the capsule's lateral distribution. After a prolonged treatment some capsules themselves were etched, as revealed in Figure 2. Knowing the etching rate for the specific polymer it was possible to estimate even the distribution of the capsules versus the depth of the print.

Textiles need to be treated prior to dyeing with natural dyes, which is usually done with the use of mordants (metal salts), with many of them being ecologically unsafe. The plasma treatment of cotton was used for improving the adsorption of the extracted dye of curcuma. Dyeing was performed on 100 % cotton fabric, both raw and bleached. The raw cotton was pre-treated using a classic wet-chemical scouring process and treated with an oxygen and ammonia low-pressure radiofrequency plasma. The chemical changes on the substrate surface were analysed using X-ray photoelectron spectroscopy and the morphological changes of samples, with a scanning electron microscope. Raw untreated, raw soured, raw plasma treated and bleached cotton were all dyed in the extracted dye of curcuma. CIEL*a*b* colour values and K/S values were measured using a reflectance spectrophotometer Spectraflash 600 Plus. The UV permeability was measured using spectrophotometer Cary 1E UV/VIS. The samples were also tested after a repetitive wash to examine the wash fastness. The results showed that the selection of gas for creating plasma is crucial for increasing the adsorption of natural dye of curcuma onto the cotton. The classic wet-chemical modifications of scouring and bleaching, and the use of oxygen plasma, were unsuitable methods for increasing the adsorption of curcuma onto cotton. The K/S values of those samples were lower than of those of the untreated sample. Treating raw cotton with ammonia plasma not only increased the adsorption of curcuma, it also increased the washing fastness of the dyed cotton. The effect was explained by the formation of nitrogen functional groups that were introduced onto the cotton's surface. In addition, these samples also had the highest ultraviolet protection factor, which was not significantly reduced after washing. This study was the subject of diploma work by Miha Kavčič, who received the Prešeren award for his thesis "The influence of oxygen and ammonia plasma treatment of cotton on adsorption of natural curcumin dyestuff".

Miha Kavčič received the Prešeren award for his diploma "The influence of oxygen and ammonia plasma treatment of cotton on adsorption of natural curcumin dyestuff".

The application of TiO_2 nanoparticles in textile finishes is attracting interest due to its relatively straightforward immobilization onto cotton fabrics, enabling the fabrication of cotton fabrics with excellent protection against UV radiation and its photocatalytic bacteriostatic effects. In collaboration with the National Institute of Chemistry in Ljubljana and the University of Ljubljana, we proposed a new route for the functionalization of cotton fibres with organic–inorganic hybrid materials using titanium tetraisopropoxide (TiP) and aminopropyltriethoxysilane (APTES) for the preparation of sol-gel TiP/APTES coatings. The presence of TiP and TiP/APTES hybrids on cotton fibres was established using X-ray photoelectron spectroscopy (XPS), scanning electron microscopy (SEM) and infrared attenuated total reflectance (ATR) analyses. Our XPS and ATR investigations showed the chemical interaction of the TiP and TiP/APTES hybrids with the cellulose fibres. From XPS spectra of O 1s, Si 2p and C 1s we identified the formation of the Si-O-C covalent bonds on treated samples indicating a reaction between the cellulose and APTES molecules [3].

The production of innovative materials from renewable and abundant bio-resources, such as nano-celluloses obtained from cellulosic sources, is becoming an important area of research, since it offers a unique combination of good physical properties producing a variety of high-value products with a low impact on the environment. Nano-cellulose can be classified into two types: cellulose nanofibrils (CNFs) and cellulose nanocrystals (CNCs), which are different in terms of morphology. These novel forms of cellulose come from abundant and renewable natural sources, thus having low-cost, being economically beneficial in replacing synthetic fibres like carbon

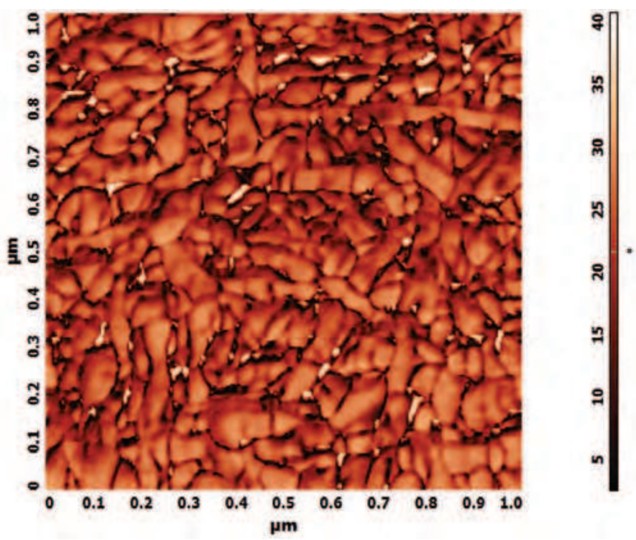

Figure 3:. AFM image of rod-shaped cellulose nanofibrils obtained from sisal [4].

and glass. CNFs exhibit attractive properties such as the large specific surface area, a very high elastic modulus, a high aspect ratio, a low thermal expansion, a non-abrasive nature, a non-toxic character and their ability to act as a significant reinforcement at low filler-loading levels stimulates their use as reinforcing agents in the polymer-nanocomposites sector. CNFs have great potential application in various fields, such as regenerative medicine, tissue engineering scaffolds, catalysis, textiles, surface coatings, drug delivery, food packaging and green nanocomposite materials. Nano-cellulose was successfully extracted from different lignocellulosic biomass sources using a combination of chemical treatments such as alkaline treatment, bleaching and acid hydrolysis. The shape, size and surface properties of the nano-cellulose generally depend on the source and hydrolysis conditions. A comparative study of the fundamental properties of raw material, bleached and nanocellulose was carried out by means of Fourier-transform infrared spectroscopy, scanning electron microscopy, atomic force microscopy, transmission electron microscopy, birefringence, X-ray diffraction, inverse gas chromatography and thermogravimetric analyses. Through the characterization of the nano-cellulose obtained from different sources, the isolated nano-cellulose showed an average diameter of less than 50 nm, high crystallinity, high thermal stability and a great potential to be used with acid coupling agents due to a predominantly basic surface [4].

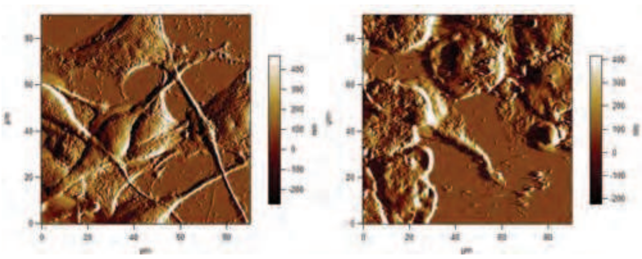

Figure 4: Deflection signal images of fixed human-brain glioblastoma (U87) cells before (left) and after (right) plasma treatment [5].

Plasma medicine is a rapidly growing field of interdisciplinary science. In this case plasma is often created at atmospheric pressure because the biological materials are usually destroyed upon exposure to a vacuum environment. Because the probability of a three-body collision at atmospheric pressure is very high the life-time of neutral reactive species is very short. This effect limits the application of atmospheric pressure plasma to small volumes of high electric field where the dissociation of gaseous molecules occurs. The reactive gaseous species interact with biological matter as well as the medium. The reactive species, such as OH, H_2O_2, NO and O_2^-, are the main components of the cold plasma jet that provides for therapeutic effects, not only with cancer, but also with biological disinfection, viral destruction and wound healing. It is well known that NO is an omnipresent intercellular messenger in all vertebrates, modulating blood flow, thrombosis, neuronal activity, immune response, inflammation, and plays a critical role in tumorigenesis by modulating the apoptotic machinery. Both NO radical and superoxide can form peroxynitrite once they collide or even locate within a few cell diameters of each other. Peroxynitrite is a powerful oxidant and nitrating agent that is known to be much more damaging to the cells than NO or superoxide, because cells readily remove superoxide and NO to reduce their harmful effects, while they fail to neutralize peroxynitrite. The morphological characteristics and differences of the cell membrane between normal human astrocytes and glial tumour cells are not well explored. Following a treatment with cold atmospheric plasma, evaluation of the selective effect of plasma on cell viability of tumour cells is poorly understood and requires further evaluation. Using atomic force microscopy we imaged the morphology of glial cells before and after cold atmospheric plasma treatment. To look more closely at the effect of plasma on cell membranes, high-resolution imaging was used. We report on the differences between normal human astrocytes and human glioblastoma cells by considering the membrane surface details. Our data, obtained for the first time on these cells using atomic force microscopy, argue for an architectural feature on the cell membrane, i.e., brush layers, different in normal human astrocytes to glioblastoma cells. The brush layer disappears from the cell-membrane surface of normal E6/E7 cells and is maintained in the glioblastoma U87 cells after plasma treatment. This work was performed in collaboration with George Washington University, USA [5].

Our group is also involved in the European project IP4Plasma: Industrial innovations based on EU intellectual property assets in the field of atmospheric pressure plasma technology, funded by European Union under the 7^{th} Framework Programme for Research and Innovation. In the IP4Plasma project, plasma equipment manufacturers and end-users work with leading experts in research to demonstrate the suitability of the atmospheric pressure plasma technology for existing and new industrial applications in the advanced medical diagnostics sector and healthcare products. In the project nine European partners from research and industry areas are involved: Spinverse Ltd (Finland), Fraunhofer Institute for Surface Engineering and Thin Films IST (Germany), IMA (Belgium), Jozef Stefan Institute (Slovenia), LIONEX GmbH (Germany), 2B (Italy), SOFTAL Corona & Plasma GmbH (Germany), Tosama (Slovenia), VITO - Flemish

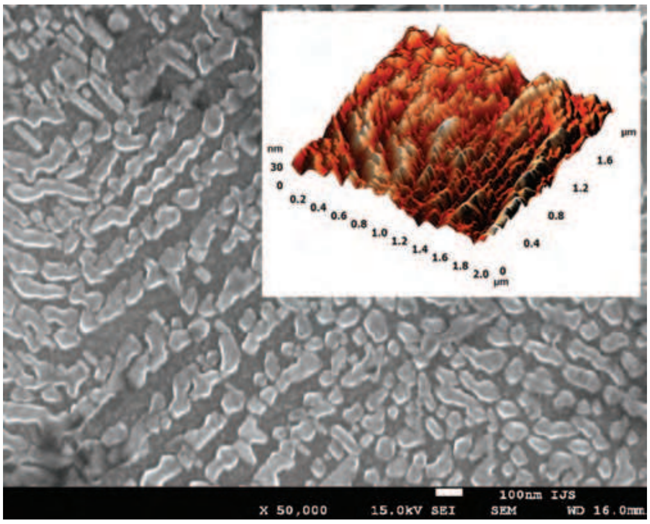

Figure 5: SEM and AFM images of stainless-steel sample treated subsequently by oxygen and hydrogen plasmas [6]

Institute for Technological Research (Belgium). In the project a new type of plasma equipment has been developed, capable of the cost- and resource-efficient deposition of coatings. The IP4Plasma project aims to improve the properties of wound dressings produced by Tosama by improving the wound draining behaviour and add anti-bacterial properties to the surface of materials by plasma deposition of non-silver-containing chemistries. Our group performs detailed analyses of the surface composition and the chemical structure of treated materials by XPS and time-of-flight secondary-ion mass spectrometry (ToF-SIMS) methods supporting the optimization of an atmospheric-pressure plasma treatment process.

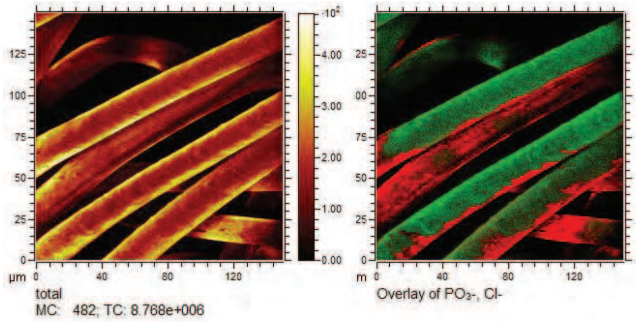

Figure 6: ToF-SIMS images of wound dressing treated in Tosama by a new atmospheric pressure plasma technology. Left - morphology of polymer fibres, right - distribution of the Cl-ions on the fibres.

Gaseous plasma is also useful for tailoring the surface properties of inorganic materials. Metal oxides are formed upon the exposure of metals to oxygen plasma, while hydrogen plasma causes a reduction of the oxides. The metal oxides often do not grow as thin films, which is typically for thermal oxidation, but rather in the form of one- or two-dimensional nanostructures. The method for the rapid synthesis of large quantities of metal oxide nanowires was invented by our group a decade ago and the technique is nowadays used in many laboratories worldwide. Both oxygen and hydrogen plasma were used in order to reveal the oxidation and reduction kinetics during the treatment of stainless steel. The experiments were performed in collaboration with the Solar Centre Font Romeu, France, where samples are heated upon exposure to plasma independently of the plasma parameters using concentrated solar radiation. Approximately 500-nm-thick oxide films of rich morphology formed on the surface of AISI 316L stainless steel samples upon brief exposure to oxygen plasma, which was created by microwave discharge. During the plasma treatment, the samples were simultaneously heated by concentrated solar radiation such that the temperature increased almost linearly to approximately 1100 K, after which the heating was abruptly turned off. After oxidation, the samples were exposed to hydrogen plasma in the same experimental chamber using the same heating regime to reduce the oxide films. The sample temperature was monitored using an infrared pyrometer. The results showed several knees in the signal versus treatment time due to chemical reactions between the oxidised stainless steel and the hydrogen plasma. Scanning electron microscopy, atomic force microscopy and Auger electron spectroscopy (AES) depth profiling were used to determine the surface and thin-film modifications. The oxidation by oxygen plasma caused the formation of densely packed oxide crystallites rich in Fe and Mn on the surface, followed by a rather thick chromium oxide subsurface film. The removal of the oxygen from the surface film was indicated by a sudden decrease in the material's emissivity that occurred in a few seconds at approximately 1300 K. Subsequent oxidation and reduction cycles caused nanostructuring of the surface morphology because evenly distributed islets of uniform lateral dimensions (approximately 100 nm) were observed on the surface after the treatments [6].

Solar energy is the cleanest renewable natural resource available since it does not produce air pollutants or CO_2. The world's energy demands are growing rapidly and the development of coatings with a high absorption of solar radiation and low thermal emittance is thus a driving force for the development of absorber coatings with spectral selectivity. Thickness Sensitive Spectrally Selective (TSSS) paint coatings made by the deposition of black paints with controlled thickness on metallic substrates are a cheap alternative to vacuum-based coatings. In collaboration with the National Institute of Chemistry in Ljubljana, we prepared and characterized a new type of TSSS paint coating using a paint made of black manganese spinel pigment dispersed in polysiloxane resin binder with the help of (3-aminopropyl)triethoxy silane (APTMS), which served as a dispersant. Absorber coatings gave a solar absorbance of 0.91 and a thermal emittance of 0.12, excellent homogeneity and good stability up to 400 °C. The coatings were investigated by infrared spectroscopy and XPS, AES and AFM surface analyses. The thermal stability and the improvement of th espectral selectivity of the TSSS coatings were explained by changes in the surface chemical composition and by the oxidation states of the elements observed in XPS spectra of Mn 2p, Fe 2p, O 1s and Si 2p and by the depth distribution of elements measured by AES depth profiling [7].

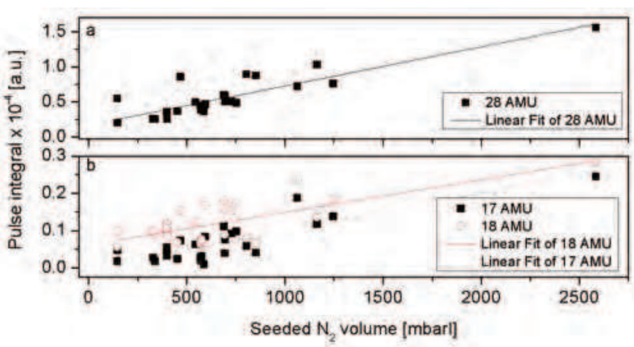

Figure 7: Response of pulse-integrated intensities of MS signals to nitrogen seeding at a) 28 AMU (nitrogen) and b) 17 and 18 AMU (ammonia) [9].

The miniaturization of modern sealed vacuum devices and greater demands for their stable operation require an accurate determination of the gas composition in the early stage of their operation or after a long operational period. Among a few highly gas-sensitive methods, quadrupole mass spectrometry (QMS) and ion-trap mass spectrometry (ITMS) seem to be the most appropriate ones for this task as the gas amounts are well below 1x10^{-4} mbar L. We continue with the QMS experiments and have started with evaluations of the ITMS, which is a relatively new instrument. A new approach, how to prepare any type of mass spectrometer for routine quantitative analysis of small gas amounts, was elaborated. In the first stage, it was calibrated by an innovative *in-situ* procedure using four different gases: nitrogen, hydrogen, argon and neon. Each gas was admitted into a chamber with a precisely determined volume, equipped by a capacitance manometer. By opening the variable leak valve and setting it to a small and constant conductance to the mass spectrometer, an exponential decay of the gas flow rate was generated. Simultaneously, ion currents versus flow rate were determined over three orders of magnitude. A non-linear response at very low flow rates was detected. In the second stage, gas quantities from 3x10^{-5} mbar L to 6x10^{-7} mbar L of pure gas were admitted, which proved that, after the numerical correction, the achieved accuracy was still rather high. Finally, small amounts of mixtures with two gases were prepared and analysed. Various unexpected mutual effects within both instruments, the QMS and ITMS, greatly modified the instrument's response, which resulted in a substantially lower accuracy [8]. The observed anomalies need to be considered carefully in the evaluations of very small amounts of gas mixtures with unknown gas ratios.

Figure 8: Miha Kavčič received the Prešeren award. From left to right: M. Mozetič (co-supervisor), M. Kavčič and M. Gorjanc (supervisor).

In the development of commercially viable fusion-energy exploitation, the upcoming experimental ITER will no doubt be a crucial milestone. ITER will be a tokamak-type reactor, in which the burning fusion fuel is contained by magnetic fields. However, the operation of the reactor is also in a great many sway determined by plasma-wall interaction (PWI), which takes place in a specially designated part of the reactor, called the divertor. Impurities from the wall which enter the plasma core limit the performance of the reactor, while the impurities in the plasma edge promote sputtering and thereby determine the life time of the plasma-facing components (PFCs). The PFCs were traditionally made out of carbon-based materials, however due to the problems of the in-vessel accumulation of hydro-carbon deposits, larger tokamaks have recently been fitted with all-metallic divertors. Similarly, ITER will operate with a tungsten divertor, while the remaining plasma-facing surfaces will be covered with beryllium. Because of the limited power-handling capabilities of the metallic PFCs, a significant fraction of the energy in the plasma edge will have to be dissipated by radiation. To promote this radiation, impurities are seeded into the plasma edge. Among the impurities tested so far, nitrogen has shown to have the most beneficial effect on the plasma performance; however, before nitrogen seeding is implemented in ITER, mechanisms of in-vessel nitrogen retention must be studied thoroughly. This is especially true for ammonia formation, which acts as an unpredictable source of fuel retention and can have serious safety and operational consequences for ITER. The research was performed at the JET fusion reactor, which, besides being the largest currently operating tokamak, is the only reactor with the same composition of the plasma walls as ITER. Besides the intrinsic impurities, N_2, Ne and Ar are routinely injected into the vessel during impurity seeding. Moreover, Ar is also injected as part of the disruption-mitigation gas to quell oncoming disruptions. The impurities were analysed with a mass spectrometer (MS), located below the divertor cryopumps. The MS is magnetically shielded, which allows for data acquisition in all phases of the reactor's operation. As the plasma pulses at JET are characteristically 20 s long, the MS is set up to record the spectral intensities at discrete masses during the discharges, which results in a sampling time between 1 and 1.5 s. Between discharges, the MS acquires full spectra, typically in the 0–60 AMU range. The results outline as deuterated methane and nitrogen as the most prominent impurities in non-seeded pulses, while their dependency on discharge parameters indicate PWI as their most likely source. Nitrogen seeding gives rise to a significant increase in nitrogen; however, also to ammonia production, which is confirmed by the response in intensities at ammonia-related masses to the amount of seeded nitrogen, as shown in Figure 8. This publication is the first report of such analysis in any tokamak with an ITER-like inner wall. Moreover it is also the first instance of participation at the JET experimental campaigns for our department, as well as the Slovenian Fusion Association.

Pia Škodlar, a student of Medical College from Ljubljana, supervised by Dr. Ita Junkar, received an award granted by the pharmaceutical company Krka for the research work: "Methods for improving hemocompatibility of vascular implants".

Figure 9: Pia Škodlar (left) supervised by Dr. Ita Junkar (right) received the Krka award.

Some outstanding publications in the past year

1. Mozetič, Miran, Vesel, Alenka, Stoica, Silviu-Daniel, Ionut Vizireanu, Sorin, Dinescu, Gheorghe, Zaplotnik, Rok. Oxygen atom loss coefficient of carbon nanowalls. Applied Surface Science, ISSN 0169-4332, 2015, vol. 333, p. 107-213.
2. Mozetič, Miran, Primc, Gregor, Vesel, Alenka, Zaplotnik, Rok, Modic, Martina, Junkar, Ita, Recek, Nina, Klanjšek Gunde, Marta, Guhy, Lukus, Sunkara, Mahendra K., Gorjanc, Marija, Stana-Kleinschek, Karin. Application of extremely non-equilibrium plasmas in the processing of nano and biomedical materials. Plasma sources science & technology, ISSN 0963-0252, 2015, vol. 24, no. 1, p. 015026-1-015026-12.
3. Tomšič, Brigita, Jovanovski, Vasko, Orel, Boris, Mihelčič, Mohor, Kovač, Janez, Francetič, Vojmir, Simončič, Barbara. Bacteriostatic photocatalytic properties of cotton modified with TiO2 and TiO2/aminopropyltriethoxysilane. Cellulose, ISSN 0969-0239, 2015, vol. 22, no. 5, p. 3441-3463.
4. Deepa, B., Abraham, Eldho, Cordeiro, Nereida, Mozetič, Miran, Mathew, Aji P., Oksman Niska, Kristina, Faria, Marisa, Thomas, Sabu, Pothan, L. A. Utilization of various lignocellulosic biomass for the production of nanocellulose: a comparative study. Cellulose, ISSN 0969-0239, 2015, vol. 22, no. 2, p. 1075-1090.
5. Recek, Nina, Cheng, Xiaoqian, Keidar, Michael, Cvelbar, Uroš, Vesel, Alenka, Mozetič, Miran, Sherman, Jonathan H. Effect of cold plasma on glial cell morphology studied by atomic force microscopy. PloS one, ISSN 1932-6203, 2015, vol. 10, issue 3, p. 1-14.
6. Mozetič, Miran, Vesel, Alenka, Kovač, Janez, Zaplotnik, Rok, Modic, Martina, Balat-Pichelin, Marianne. Formation and reduction of thin oxide films on a stainless steel surface upon subsequent treatments with oxygen and hydrogen plasma. Thin Solid Films, ISSN 0040-6090, 2015, vol. 591, part B, p. 186-193.
7. Mihelčič, Mohor, Francetič, Vojmir, Kovač, Janez, Šurca Vuk, Angela, Orel, Boris, Kunič, Roman, Peros, Dimitrios. Novel sol-gel based selective coatings: from coil absorber coating to high power coating. Solar energy materials and solar cells, ISSN 0927-0248, 2015, vol. 140, p. 232-248.
8. Nemanič, Vincenc, Žumer, Marko, Lakner, Mitja. Ultimate limits in the gas composition determination within small sealed volumes by quadrupole mass spectrometry. Vacuum, ISSN 0042-207X, 2015, vol. 119, p. 112-118 Vacuum.
9. Jet Efda Contributors, Drenik, Aleksander, Mozetič, Miran, et al. Mass spectrometry analysis of the impurity content in N[sub]2 seeded discharges in JET-ILW. Journal of nuclear materials, ISSN 0022-3115, 2015, vol. 463, p. 684-687.

Awards and appointments

1. Dr Gregor Primc: Award for outstanding achievements in the year 2014, awarded by the Jožef Stefan Institute International Postgraduate School for developing an innovative sensor with highest commercial potential and for the establishment of a spin-out company Plasmadis Ltd.
2. Miha Kavčič: The Prešeren award for academic degree with title: *The influence of oxygen and ammonia plasma treatment of cotton on adsorption of natural curcumin dyestuff* (doc. dr. Marija Gorjanc and prof. dr. Miran Mozetič). The award was given in Faculty of Natural Sciences and Engineering.
3. Pia Škodlar: The Krka award for students' research work with title: *Methods for improving hemocompatibility of vascular implants* (dr. Ita Junkar). The award was given in Pharmaceutical Corporation Krka.

Patents granted

1. Miran Mozetič, Nikolas Panagiotopoulos, Giorgos A. Evangelakis, Method for tetragonal zirconia oxide thin films growth suitable for catalytic devices, SI24659 (A), Slovenian Intellectual Property Office, 30. 09. 2015.
2. Gregor Primc, Miran Mozetič, Uroš Cvelbar, Alenka Vesel, Method and device for detection and measuring the density of neutral atoms of hydrogen, oxygen or nitrogen, SI24727 (A), Slovenian Intellectual Property Office, 30. 11. 2015.

INTERNATIONAL PROJECTS

1. Services
   Asst. Prof. Janez Kovač
2. 7FP - IP4Plasma; Industrial Innovations Based on EU Intellectual Property Assets in the Field of Atmospheric Plasma Technology
   Asst. Prof. Janez Kovač
   European Commission
3. EFDA-JET 2013 Experimental Campaigns
   Dr. Aleksander Drenik
   Ministry of Education, Science and Sport, Ljubljana
4. COST TD1208; Electrical Discharges with Liquids for Future Applications; COST Training School on Liquid Discharges
   Prof. Uroš Cvelbar
   Cost Office
5. NATO Grant; SPS 984555; Atmospheric Pressure Plasma Jet for Neutralisation of CBW
   Prof. Uroš Cvelbar
   Nato - North Atlantic Treaty Organisation
6. COST MP1101; Biomedical Applications of Atmospheric Pressure Plasma Technology
   prof. dr. Uroš Cvelbar
   Cost Office
7. Plasma Facing Components-1-IPH-FU, EUROFUSION
   Dr. Aleksander Drenik
   European Commission
8. JET Campaigns-JET1-FU, EUROFUSION
   Dr. Aleksander Drenik
   European Commission
9. Medium Size Tokamak Campaigns-MST1-FU, EUROFUSION
   Dr. Aleksander Drenik
   European Commission
10. Characterization of Gaseous Plasma for Nanoparticle Synthesis
    Asst. Prof. Alenka Vesel
    Slovenian Research Agency
11. Deposition of Coatings on Plasma prepared Medical Stents
    Prof. Uroš Cvelbar
    Slovenian Research Agency
12. Molecular Imaging of Biological Samples Using MeV Ions and keV Clusters for TOF-SIMS Spectrometry
    Asst. Prof. Janez Kovač
    Slovenian Research Agency
13. Advanced Physical Techniques for Modification of Polymer and Composite Functionalities for Biomedical Applications
    Prof. Miran Mozetič
    Slovenian Research Agency
14. Guided Nanoherding of Quantum Dots
    Prof. Uroš Cvelbar
    Slovenian Research Agency
15. Synthesis and Characterization of Pt Nanocatalysts at Metal Oxide based Supports for Fuel Cells Application
    Asst. Prof. Alenka Vesel
    Slovenian Research Agency
16. Ion and Laser Beam induced Formation of Biocompatibile Alloys in Multilayered Thin Film Structures
    Asst. Prof. Janez Kovač
    Slovenian Research Agency
17. Measurements of Plasma Parameters in Capacitive and Inductive RF Discharges
    Prof. Uroš Cvelbar
    Slovenian Research Agency
18. Sniffing for Carcinogenic Substances - Research for Toxic Gas Molecule Sensing with Networks of Carbon Nanowalls
    Prof. Uroš Cvelbar
    Slovenian Research Agency
19. Advanced Photo-electrochemical Cells with Nanostructured Iron Oxide Electrodes
    Prof. Miran Mozetič
    Slovenian Research Agency
20. Irradiation of Metal Oxide Nanowires
    Prof. Uroš Cvelbar
    Slovenian Research Agency
21. ECS Electrochemical Society
    Prof. Uroš Cvelbar
    Slovenian Research Agency

RESEARCH PROGRAMS

22. Vacuum technique and materials for electronics
    Dr. Vincenc Nemanič
23. Thin film structures and plasma surface engineering
    Prof. Miran Mozetič

R & D GRANTS AND CONTRACTS

1. Development of the functional textiles used fot the treatment of diabetic foot (malum perforans)
   Prof. Miran Mozetič
2. New materials for printed sensors and indicators and their integration in smart printed matter
   Asst. Prof. Alenka Vesel
3. Self-lubricating and wear resistant PVD hard coatings based on (V,Cr,Al,Ti)N for hot-working processes
   Asst. Prof. Janez Kovač
4. Interaction between fully dissociated moderately ionized ammonia plasma and glass-fiber reinforced polymers
   Prof. Miran Mozetič
5. Nanostructures and related composites for detection of hazardous gaseous molecules
   Prof. Uroš Cvelbar
6. Functionalization of polymer cardiovascular implants for optimal hemocompatibility
   Asst. Prof. Alenka Vesel

NEW CONTRACT

1. Characteristics of gaseous plasma in gaps
   Prof. Uroš Cvelbar
   Kolektor Sikom d. o. o.

VISITORS FROM ABROAD

1. Dr Mahendra Sunkara, University of Louisville, Louisville, USA, 17–20 January 2015
2. Prof. Marian Lehocky, Tomas Bata University, Zlin, Czech Republic, 3–5 February 2015
3. Dr Petr Stloukal, Tomas Bata University, Zlin, Czech Republic, 3–5 February 2015
4. Prof. Slobodan Milošević, Institute of Physics, Zagreb, Croatia, 2 April 2015
5. Dr Nevena Puač, Institute of Physics, Belgrade, Serbia, 7–12 May 2015
6. Kosta Spasić, Institute of Physics, Belgrade, Serbia, 7–20 May 2015
7. Dr Davor Peruško, Vinča Institute of Nuclear Sciences, Belgrade, Serbia, 24–29 May 2015
8. Dr Maja Obradović, University of Belgrade, Belgrade, Serbia, 5–8 July 2015
9. Dr Marian Lehocky, Tomas Bata University, Zlin, Czech Republic, 14–20 July 2015
10. Prof. Michael J. Gordon, University of California, Santa Barbara, USA, 17–20 September 2015
11. Dr Robert Olejnik, Tomas Bata University, Zlin, Czech Republic, 23–30 September 2015
12. Jiri Matyas, Tomas Bata University, Zlin, Czech Republic, 23–30 September 2015
13. Prof. Petr Slobodian, Tomas Bata University, Zlin, Czech Republic, 23–30 September 2015
14. Prof. Masaru Hori, Nagoya University, Nagoya, Japan, 27–30 September 2015
15. Prof. Makoto Sekine, Nagoya University, Nagoya, Japan, 27–30 September 2015
16. Prof. Hiroki Kondo, Nagoya University, Nagoya, Japan, 27–30 September 2015
17. Shun Imai, Nagoya University, Nagoya, Japan, 27–30 September 2015
18. Hyungjun Cho, Nagoya University, Nagoya, Japan, 27–30 September 2015
19. Dr Marko Karlušić, Ruđer Bošković Institute, Zagreb, Croatia, 5–6 October 2015
20. Dr Zdravko Siketić, Ruđer Bošković Institute, Zagreb, Croatia, 5–7 October 2015
21. Dr Nevena Puać, , Institute of Physics, Belgrade, Serbia, 15–20 October 2015
22. Nikola Škoro, Institute of Physics, Belgrade, Serbia, 15–20 October 2015
23. Dr Danijela Vujošević, Institute for Public Health of Montenegro, Podgorica, Montenegro, 21–25 October 2015
24. Dr Davor Peruško, Vinča Institute of Nuclear Sciences, Belgrade, Serbia, 15–20 November 2015
25. Dr Suzana Petrović, Vinča Institute of Nuclear Sciences, Belgrade, Serbia, 15–20 November 2015
26. Dejan Pjević, Vinča Institute of Nuclear Sciences, Belgrade, Serbia, 30 November–3 December 2015

STAFF

Researchers
1. Prof. Uroš Cvelbar
2. Dr. Aleksander Drenik
3. Dr. Ita Junkar
4. Asst. Prof. Janez Kovač
5. **Prof. Miran Mozetič, Head**
6. Dr. Vincenc Nemanič
7. Asst. Prof. Alenka Vesel

Postdoctoral associates
8. Dr. Gregor Filipič
9. Dr. Gregor Jakša
10. Dr. Martina Modic
11. Dr. Gregor Primc
12. Dr. Nina Recek
13. Dr. Rok Zaplotnik

Postgraduates
14. Nataša Hojnik, B. Sc.
15. Matej Holc, B. Sc.
16. Matic Resnik, B. Sc.
17. Marko Žumer, B. Sc.

Technical officers
18. Tatjana Filipič, B. Sc.

Technical and administrative staff
19. Tinkara Bezovšek, B. Sc.
20. Urška Kisovec, B. Sc.
21. Janez Trtnik

BIBLIOGRAPHY

Original Article

1. A. G. Carrasco *et al.* (14 authors), "Nitrogen removal from plasma-facing components by ion cyclotron wall conditioning in TEXTOR", *J. nucl. mater.*, vol. 463, pp. 688-692, 2015.
2. Xinqun Cheng, K. Rajjoub, Jonathan H. Sherman, Jerome Canady, Nina Recek, Dayun Yan, Ka Bian, Ferid Murad, Michael Keidar, "Cold plasma accelerates the uptake of gold nanoparticles into glioblastoma cells", *Plasma processes polym.*, vol. 12, iss. 12, pp. 1364-1369, 2015.
3. B. Deepa, Eldho Abraham, Nereida Cordeiro, Miran Mozetič, Aji P. Mathew, Kristiina Oksman Niska, Marisa Faria, Sabu Thomas, L. A. Pothan, "Utilization of various lignocellulosic biomass for the production of nanocellulose: a comparative study", *Cellulose (Lond.)*, vol. 22, no. 2, pp. 1075-1090, 2015.
4. Xiaolong Deng, Anton Nikiforov, Danijela Vujošević, Vineta Vuksanović, Boban Mugoša, Uroš Cvelbar, Nathalie De Geyter, Rino Morent, Christophe Leys, "Antibacterial activity of nano-silver non-woven fabric prepared by atmospheric pressure plasma deposition", *Mater. lett.*, vol. 149, pp. 95-99, 2015.
5. Nevenka Elezović, Peter Ercius, Janez Kovač, Velimir Radmilović, Biljana Babić, Nedeljko Krstajić, "Synthesis and characterization of Pt nanocatalyst on $Ru_{0.7}Ti_{0.3}NO_2$ support as a cathode for fuel cells application", *Journal of electroanalytical chemistry*, vol. 739, pp. 164-171, 2015.
6. Nevenka Elezović, Velimir Radmilović, Janez Kovač, Biljana Babić, Lj. Gajić-Krstajić, Nedeljko Krstajić, "Pt nanoparticles on tin oxide based support as a beneficial catalyst for oxygen reduction in alkaline solutions", *RSC advances*, issue 21, pp. 15923-15929, 2015.
7. Jinghua Fang, Igor Levchenko, Anne Mai-Prochnow, Michael Keidar, Uroš Cvelbar, Gregor Filipič, Zhao Jun Han, Kostya Ostrikov, "Protein retention on plasma-treated hierarchical nanoscale gold-silver platform", *Scientific reports*, vol. 5, pp. 13379 -1-13379 -11, 2015.
8. Gregor Filipič, Oleg Baranov, Miran Mozetič, Uroš Cvelbar, "Growth dynamics of copper oxide nanowires in plasma at low pressures", *J. appl. phys.*, vol. 117, no. 4, pp. 043304-1-043304-9, 2015.
9. Selestina Gorgieva, Martina Modic, Barbara Dovgan, Maja Kaisersberger Vincek, Vanja Kokol, "Plasma-activated polypropylene mesh-gelatin scaffold composite as potential implant for bioactive hernia treatment", *Plasma processes polym.*, vol. 12, issue 3, pp. 237-251, 2015.
10. Annika Hermann, Kristina Lachmann, Lisa Fischer, Janez Kovač, Michael Thomas, "Area-selective epoxy coatings by DBD-PECVD in 3D cavities for protein coupling", *Surf. innov.*, vol. 3, no. 4, pp. 206-214, 2015.
11. Petr Humpolíček, Zdenka Kucekovà, Věra Kašpárková, Jana Pelková, Martina Modic, Ita Junkar, Miroslava Trchová, Patrycja Bober, Jaroslav Stejska, Marián Lehocký, "Blood coagulation and platelet adhesion on polyaniline films", *Colloids surf., B Biointerfaces*, vol. 133, pp. 278-285, 2015.
12. Roghayeh Imani, Barbara Drašler, Veno Kononenko, Tea Romih, Kristina Eleršič, Janez Jelenc, Ita Junkar, Maja Remškar, Damjana Drobne, Veronika Kralj-Iglič, Aleš Iglič, "Growth of a novel nanostructured ZnO urchin: control of cytotoxicity and dissolution of the ZnO urchin", *Nanoscale research letters*, vol. 10, pp. 1-10, 2015.
13. Darja Jaušovec, Mojca Božič, Janez Kovač, Janez Štrancar, Vanja Kokol, "Synergies of phenolic-acids' surface-modified titanate nanotubes (TiNT) for enhanced photo-catalytic activities", *J. colloid interface sci.*, vol. 438, pp. 277-290, 2015.
14. Katja Jazbec, Martin Šala, Miran Mozetič, Alenka Vesel, Marija Gorjanc, "Functionalization of cellulose fibres with oxygen plasma and ZnO nanoparticles for achieving UV protective properties", *J. nanomater.*, vol. 2015, article ID 346739, 9 pp., 2015.
15. Ita Junkar, Martina Modic, Miran Mozetič, "Modification of PET surface properties using extremely non-equilibrium oxygen plasma", *Open chemistry*, vol. 13, no. 1, pp. 490-496, 2015.
16. Ita Junkar, Gregor Primc, Tanja Mivšek, Matic Resnik, Janez Kovač, Andrijana Sever Škapin, Aleš Podgornik, Miran Mozetič, "Plasma treatment-promising tool for preparation of disposable monolithic columns", *Journal of analytical & bioanalytical techniques*, vol. 6, iss. 4, pp. 1-7, 2015.
17. Metod Kolar, Miran Mozetič, Karin Stana-Kleinschek, Mirjam Fröhlich, Boris Turk, Alenka Vesel, "Covalent binding of heparin to functionalized PET materials for improved haemocompatibility", *Materials (Basel)*, vol. 8, no. 4, pp. 1526-1544, 2015.
18. V. B. Korovin, D. I. Baron, M. M. Kozulya, V. Ya. Chernichenko, E. D. Kramskoy, V. K. Pashnev, Miran Mozetič, "RF wall conditioning at the Uragan-2M with use of high vacuum cryogenic trap", *Vopr. at. nauki teh., Ser. âd.-fiz. issled.*, vol. 95, issue 1, pp. 53-55, 2015.
19. Ana D. Kramar, Bratislav M. Obradović, Alenka Vesel, Milorad M. Kurajica, Mirjana M. Kostić, "Preparation of hydrophobic viscose fabric using nitrogen DBD and copper ions sorption", *Plasma processes polym.*, vol. 12, no. 10, pp. 1095-1103, 2015.
20. Nikša Krstulović, K. Salamon, Martina Modic, Marijan Bišćan, Ognjen Milat, Slobodan Milošević, "Dynamics of double-pulse laser produced Titanium plasma inferred from thin film morphology and OES", *Spectrochim. acta, Part B: At. spectrosc.*, vol. 107, pp. 67-74, 2015.
21. Mukta Vishwanath Kulkarni, Yogita Patil-Sen, Ita Junkar, Chandrashekhar Kulkarni, Martina Lorenzetti, Aleš Iglič, "Wettability studies of topologically distinct titanium surfaces", *Colloids surf., B Biointerfaces*, vol. 129, pp. 47-53, May 2015.
22. Cédric Labay, José M. Canal, Martina Modic, Uroš Cvelbar, M. Quiles, M. Armengol, M. A. Arbos, F. J. Gil, Cristina Canal, "Antibiotic-loaded polypropylene surgical meshes with suitable biological behaviour by plasma functionalization and polymerization", *Biomaterials*, vol. 71, pp. 132-144, 2015.
23. Igor Levchenko, Michael Keidar, Anne Mai-Prochnow, Martina Modic, Uroš Cvelbar, Jinghua Fang, Kostya Ostrikov, "Plasma treatment for next-generation nanobiointerfaces", *Biointerphases*, vol. 10, no. 2, pp. 029405-1-029405-13, 2015.
24. Igor Levchenko, Anne Mai-Prochnow, S. Yick, M. M. M. Bilek, A. Kondyurin, Z.-J. Han, Jinghua Fang, Uroš Cvelbar, Davide Mariotti, Kostya Ostrikov, "Hybrid carbon-based nanostructured platforms for the advanced bioreactors", *J. nanosci. nanotechnol.*, vol. 15, no. 12, pp. 10074-10090, 2015.
25. Jorge López Garciá, Gregor Primc, Ita Junkar, Marián Lehocký, Miran Mozetič, "On the hydrophilicity and water resistance effect of styrene-acrylonitrile copolymer treated by CF_4 and O_2 plasmas", *Plasma processes polym.*, vol. 12, iss. 10, pp. 1075-1084, 2015.
26. Marija T. Mihajlović, Slavica S. lazarević, Ivona Janković - Častvan, Janez Kovač, Bojan Jokić, Đorđe Janaćković, Rada Petrović, "Kinetics, thermodynamics, and structural investigations on the removal of Pb^{2+},

Cd^{2+}, and Zn^{2+} from multicomponent solutions onto natural and Fe(III)-modified zeolites", *Clean technol. environ. policy*, vol. 17, no. 2, pp. 407-419, 2015.
27. Mohor Mihelčič, Vojmir Francetič, Janez Kovač, Angela Šurca Vuk, Boris Orel, Roman Kunič, Dimitrios Peros, "Novel sol-gel based selective coatings: from coil absorber coating to high power coating", *Sol. energy mater. sol. cells*, vol. 140, pp. 232-248, Sep. 2015.
28. Ingrid Milošev, Nataša Kovačević, Janez Kovač, Anton Kokalj, "The roles of mercapto, benzene and methyl groups in the corrosion inhibition of imidazoles on copper. I., Experimental characterization", *Corros. sci.*, vol. 98, pp. 107-118, 2015.
29. Miran Mozetič *et al.* (17 authors), "Application of extremely non-equilibrium plasmas in the processing of nano and biomedical materials", *Plasma sources sci. technol.*, vol. 24, no. 1, pp. 015026-1-015026-12, 2015.
30. Miran Mozetič, Alenka Vesel, Janez Kovač, Rok Zaplotnik, Martina Modic, Marianne Balat-Pichelin, "Formation and reduction of thin oxide films on a stainless steel surface upon subsequent treatments with oxygen and hydrogen plasma", *Thin solid films*, vol. 591, part B, pp. 186-193, 2015.
31. Miran Mozetič, Alenka Vesel, Silviu-Daniel Stoica, Sorin Ionut Vizireanu, Gheorghe Dinescu, Rok Zaplotnik, "Oxygen atom loss coefficient of carbon nanowalls", *Appl. surf. sci.*, vol. 333, pp. 107-213, 2015.
32. Krunal Narendrakumar, Mukta Vishwanath Kulkarni, Owen Addison, Anca Mazare, Ita Junkar, Patrik Schmuki, Rachel Sammons, Aleš Iglič, "Adherence of oral streptococci to nanostructured titanium surfaces", *Dent Mater*, vol. 31, no. 12, pp. 1460-1468, Dec. 2015.
33. Vincenc Nemanič, Marko Žumer, "New organic fiber-based core material for vacuum thermal insulation", *Energy build.*, vol. 90, pp. 137-141, 2015.
34. Vincenc Nemanič, Marko Žumer, Mitja Lakner, "Ultimate limits in the gas composition determination within small sealed volumes by quadrupole mass spectrometry", *Vacuum*, vol. 119, pp. 112-118, 2015.
35. Peter Panjan, Aljaž Drnovšek, Janez Kovač, Peter Gselman, Tonica Bončina, Srečko Paskvale, Miha Čekada, Darja Kek-Merl, Matjaž Panjan, "Oxidation resistance of CrN/(Cr,V)N hard coatings deposited by DC magnetron sputtering", *Thin solid films*, vol. 591, part B, pp. 323-329, 2015.
36. Davor Peruško, Janez Kovač, Suzana Petrović, Goran Dražić, Miodrag Mitrić, Momir Milosavljević, J. Ciganović, "Intermixing and phase transformations in Al/Ti multilayer system induced by picosecond laser beam", *Thin solid films*, vol. 591, part B, pp. 357-362, 2015.
37. Suzana Petrović, D. Milovanović, Branislav Salatić, Davor Peruško, Janez Kovač, Goran Dražić, Miodrag Mitrić, Milan Trtica, Branislav Jelenković, "Composition and structure of NiAu nanoparticles formed by laser ablation of Ni target in Au colloidal solution", *Mater. chem. phys.*, vol. 166, 2015, pp. 223-232.
38. Deepalekshm Ponnamma, Josephine George, Martin George Thomas, Chin Han Chan, Srećko Valić, Miran Mozetič, Uroš Cvelbar, Sabu Thomas, "Investigation on the thermal and crystallization behavior of high density polyethylene/acrylonitrile butadiene rubber blends and their composites", *Polym. eng. sci.*, vol. 55, issue 5, pp. 1203-1210, 2015.
39. Anton Popelka, Igor Novák, Marián Lehocký, František Bilek, Angela Kleinová, Miran Mozetič, M. Špírková, Ivan Chodák, "Antibacterial treatment of LDPE with halogen derivatives via cold plasma", *Express polym. lett.*, vol. 9, no. 5, pp. 402-411, 2015.
40. Nevena Puač, Saša Lazović, Rok Zaplotnik, Miran Mozetič, Zoran Lj. Petrović, Uroš Cvelbar, "Effect of dissipated power due to antenna resistive heating on E- to H-mode transition in inductively coupled oxygen plasma", *Indian J. Phys. (2004)*, vol. 89, issue 6, pp. 635-640, 2015.
41. Harinarayanan Puliyalil, Uroš Cvelbar, Gregor Filipič, A. Petrič, Rok Zaplotnik, Nina Recek, Miran Mozetič, Sabu Thomas, "Plasma as a tool for enhancing insulation properties of polymer composites", *RSC advances*, vol. 5, no. 47, pp. 37853-37858, 2015.
42. Zoran M. Raspopović, Vladimir Stojanović, Uroš Cvelbar, Željka Nikitović, Jasmina V. Jovanović, "Role of pressure in transport of F^- ions in BF_3 gas for technological applications", *FME Trans.*, vol. 43, no. 2, pp. 168-172, 2015.
43. Nina Recek *et al.* (16 authors), "Effect of cold plasma on glial cell morphology studied by atomic force microscopy", *PloS one*, vol. 10, issue 3, pp. 1-14, 2015.
44. Petr Slobodian, Uroš Cvelbar, Pavel Riha, Robert Olejnik, J. Matyas, Gregor Filipič, H. Watanabe, S. Tajima, H. Kondo, M. Sekine, Masaru Hori, "High sensitivity of a carbon nanowall-based sensor for detection of organic vapours", *RSC advances*, vol. 5, no. 110, pp. 90515-90520, 2015.
45. Maja Sopotnik, Adrijana Leonardi, Igor Križaj, Peter Dušak, Darko Makovec, Tina Mesarič, Nataša Poklar Ulrih, Ita Junkar, Kristina Sepčić, Damjana Drobne, "Comparative study of serum protein binding to three different carbon-based nanomaterials", *Carbon (N. Y.)*, vol. 95, pp. 560-572, 2015.
46. Vedran Šantak, Rok Zaplotnik, Zrinka Tarle, Slobodan Milošević, "Optical emission spectroscopy of an atmospheric pressure plasma jet during tooth bleaching gel treatment", *Appl. spectrosc.*, vol. 69, no. 11, pp. 1327-1333, 2015.
47. Nina Špička, Živa Zupin, Janez Kovač, Petra Forte-Tavčer, "Enzymatic scouring and low-temperature bleaching of fabrics constructed from cotton, regenerated bamboo, poly(lactic acid), and soy protein fibers", *Fiber Polym.*, vol. 16, no. 8, pp. 1723-1733, 2015.
48. Brigita Tomšič, Vasko Jovanovski, Boris Orel, Mohor Mihelčič, Janez Kovač, Vojmir Francetič, Barbara Simončič, "Bacteriostatic photocatalytic properties of cotton modified with TiO2 and TiO2/aminopropyltriethoxysilane", *Cellulose (Lond.)*, vol. 22, no. 5, pp. 3441-3463, 2015.
49. Jelena Vasiljević, Ivan Jerman, Gregor Jakša, Jenny Alongi, Giulio Malucelli, Milena Zorko, Brigita Tomšič, Barbara Simončič, "Functionalization of cellulose fibres with DOPO-polysilsesquioxane flame retardant nanocoating", *Cellulose (Lond.)*, vol. 22, no. 3, pp. 1893-1910, 2015.
50. Nena Velkova, Aleš Doliška, Lidija Fras Zemljič, Alenka Vesel, Bodo Saake, Simona Strnad, "Influence of carboxymethylation on the surface physical-chemical properties of glucuronoxylan and arabinoxylan films", *Polym. eng. sci.*, vol. 55, iss. 12, pp. 2706-2713, December 2015.
51. Alenka Vesel, Janez Kovač, Rok Zaplotnik, Martina Modic, Miran Mozetič, "Modification of polytetrafluoroethylene surfaces using H_2S plasma treatment", *Appl. surf. sci.*, vol. 357, part B, pp. 1325-1332, 2015.
52. Alenka Vesel, Miran Mozetič, Marianne Balat-Pichelin, "Sequential oxidation and reduction of tungsten/tungsten oxide", *Thin solid films*, vol. 591, part B, pp. 174-181, 2015.
53. T. Wauters *et al.* (22 authors) and JET EFDA Contributors, "Isotope exchange by ion cyclotron wall conditioning on JET", *J. nucl. mater.*, vol. 463, pp. 1104-1108, 2015.
54. Rok Zaplotnik, Marijan Bišćan, Zlatko Kregar, Uroš Cvelbar, Miran Mozetič, Slobodan Milošević, "Influence of a sample surface on single electrode atmospheric plasma jet parameters", *Spectrochim. acta, Part B: At. spectrosc.*, vol. 103/104, pp. 124-130, 2015.
55. Rok Zaplotnik, Marijan Bišćan, Nikša Krstulović, Dean Popović, Slobodan Milošević, "Cavity ring-down spectroscopy for atmospheric pressure plasma jet analysis", *Plasma sources sci. technol.*, vol. 24, no. 5, pp. 054004-1-054004-14, 2015.

Review Article

1. Mukta Vishwanath Kulkarni, Anca Mazare, Ekaterina Gongadze, Šárka Perutková, Veronika Kralj-Iglič, Ingrid Milošev, Patrik Schmuki, Aleš Iglič, Miran Mozetič, "Titanium nanostructures for biomedical applications", *Nanotechnology (Bristol)*, vol. 26, no. 6, pp. 062002-1-062002-19, 2015.

Published Conference Contribution

1. Akhil M. K. Chandran, Vladimir V. Srdić, Goran M. Stojanović, Harinarayanan Puliyalil, Gregor Filipič, Uroš Cvelbar, "Investigation on band gap energy and effect of various surface plasma treatments on nano structured SnO_2 semiconductor", In: *IEEE NANO 2015*, 15th International Conference on Nanotechnology, July 27-30, 2015, Rome, Danvers, IEEE = Institute of Electrical and Electronics Engineers, 2015, pp. 315-318.
2. Xinqun Cheng, K. Rajjoub, Jonathan H. Sherman, Jerome Canady, Nina Recek, Michael Keidar, "Cold plasma accelerates the uptake of gold nanoparticles into glioblastoma cells", In: *Programme*, ISCP 2015, 22nd International Symposium on Plasma Chemistry, Sunday 5 July - Friday 10 July, 2015, Antwerp, Belgium, Antwerp, Universitet Antwerpen, 2015, 4 pp.
3. Ana Drmota, Emil Vončina, Janez Kovač, Uroš Cvelbar, "Tesnjenje hibridnih komponent: Ana Drmota Petrič ... [et al.]", In: *Vir znanja in izkušenj za stroko: zbornik foruma*, Industrijski forum IRT, Portorož, 8. in 9. junij 2015, Darko Švetak, ed., Škofljica, Profidtp, 2015, pp. 177-180.
4. B. Lazić, Svjetlana Janjić, Miran Mozetič, Gregor Primc, Marija Gorjanc, "Adsorption of lead (PB) on flax fibres treated using classical wet-chemical and dry plasma treatment", In: *Proceedings*, 15th Autex Conference, June 10-12, 2015, Bucharest, Romania, Mirela Blaga, ed., Iasi, "Gheorghe Asachi" Technical University, Faculty of Textiles, Leather and Industrial Management, 2015, 5 f.

5. Miran Mozetič, Alenka Vesel, Rok Zaplotnik, Silviu-Daniel Stoica, Sorin Ionut Vizireanu, Gheorghe Dinescu, "Surface recombination of oxygen atoms on carbon nanowalls", In: *Programme*, ISCP 2015, 22nd International Symposium on Plasma Chemistry, Sunday 5 July - Friday 10 July, 2015, Antwerp, Belgium, Antwerp, Universitet Antwerpen, 2015, 2 pp.
6. Matic Resnik, Joško Valentinčič, Izidor Sabotin, Andrej Lebar, Marko Jerman, Nejc Matjaž, Mihael Junkar, "Heat exchanger tube sampling in nuclear power plants", In: *Engineering - development and innovations for new employments 2014: proceedings of the 4th AMES International Conference, Ljubljana, Slovenia, October 23th, 2014*, Iztok Golobič, ed., Franc Cimerman, ed., 1st ed., Ljubljana, Association of Mechanical Engineers of Slovenia - AMES, 2015, pp. 112-116.
7. Alenka Vesel, Martina Modic, Miran Mozetič, "Biocompatibility of polymer surface treated in SO_2 or H_2S plasma", In: *Programme*, ISCP 2015, 22nd International Symposium on Plasma Chemistry, Sunday 5 July - Friday 10 July, 2015, Antwerp, Belgium, Antwerp, Universitet Antwerpen, 2015, 2 pp.

Independent Component Part or a Chapter in a Monograph

1. Harinarayanan Puliyalil, Gregor Filipič, Uroš Cvelbar, "Recent advances in the methods for designing superhydrophobic surfaces", In: *Surface energy*, Mohammed Salih Salih, ed., Rijeka, InTech, cop. 2015, pp. 311-335.

Patent Application

1. Marián Lehocký, Petr Stloukal, Vladimír Sedlarik, Petr Humpolíček, Alenka Vesel, Miran Mozetič, Rok Zaplotnik, Gregor Primc, Dana Kreizlová, *Zařízení pro generování UV záření a způsob generování tohoto záření*, PV 2015-815, Úřad Průmyslového Vlastnictví, 26. 11. 2015.
2. Miran Mozetič, Nikolas Panagiotopoulos, Giorgos A. Evangelakis, *Method for tetragonal zirconia oxide thin films growth suitable for catalytic devices*, WO2015142295 (A1), World Intellectual Property Organization, 24. 09. 2015.
3. Gregor Primc, Miran Mozetič, Uroš Cvelbar, Alenka Vesel, *Method and device for detection and measuring the density of neutral atoms of hydrogen, oxygen or nitrogen*, WO2015176733 (A1), World Intellectual Property Organization, 26. 11. 2015.

Patent

1. Miran Mozetič, Nikolas Panagiotopoulos, Giorgos A. Evangelakis, *Method for tetragonal zirconia oxide thin films growth suitable for catalytic devices*, SI24659 (A), Urad RS za intelektualno lastnino, 30. 09. 2015.
2. Gregor Primc, Miran Mozetič, Uroš Cvelbar, Alenka Vesel, *Method and device for detection and measuring the density of neutral atoms of hydrogen, oxygen or nitrogen*, SI24727 (A), Urad RS za intelektualno lastnino, 30. 11. 2015.

Mentoring

1. Gregor Jakša, *Modification, characterisation and application of SiO_2 surfaces with aminoalkyl(aryl)silanes:* doctoral dissertation, Ljubljana, 2015 (mentor Bogdan Štefane; co-mentor Janez Kovač).
2. Metod Kolar, *Improving biocompatibility of poly(ethylene terephthalate) surfaces by immobilization of heparin:* doctoral dissertation, Ljubljana, 2015 (mentor Miran Mozetič; co-mentors Alenka Vesel, Karin Stana-Kleinschek).
3. Nina Recek, *Modification of biomaterials for selective adhesion of cells:* doctoral dissertation, Ljubljana, 2015 (mentor Alenka Vesel; co-mentor Miran Mozetič).