DEPARTMENT OF SURFACE ENGINEERING AND OPTOELECTRONICS F-4

The Department of Surface Engineering conducts interdisciplinary research on designing the surface properties of various materials. We use advanced techniques for surface and thin-film characterization, in particular with our XPS, AES, SIMS and AFM instruments. The scientific activities are focused on surfaces and coatings, gaseous discharges, thermodynamically non-equilibrium plasma and the interaction of reactive plasma species with organic and inorganic materials. Patent applications protect innovative solutions for industry, medicine, biotechnology and agriculture.

Head:
Prof. Miran Mozetič

The research team has been deeply involved in the preparation of the Slovenian Strategy of Smart Specialization (S4). The document represents the roadmap for the transition to a modern society according to European Smart Specialisation Strategy (S3). Strategic Research and Innovation Partnerships (SRIPs) have been established. Among them, the most relevant for our department's activities are the SRIPs "Factories of Future" and "Food". Plasma technologies have been recognized as a key enabling technology by both SRIPs. Most currently used plasma technologies do not meet the standards of Industry 4.0, neither in conventional industries such as automotive and electrical, nor in agriculture. The research team of the Department of Surface Engineering prepared action plans for crossing the gap between current praxis and the demands of Industry 4.0. The team members are among the leading researchers in current large R&D projects, both in agriculture and the food industry.

The research team organized several topical workshops on plasma technologies that attracted attendance from both the commercial and academic spheres. The workshops represent unique opportunities for networking and the exchange of ideas. The organization of scientific meetings is recognized as a vital activity also by the Slovenian government. The high-profile events were awarded at a ceremony organized by Slovenian Convention Bureau. A member of our team, prof. Janez Kovač, was announced a Congress Ambassador of Slovenia for the organization of the European vacuum conference in Portorož. The conference gathered about 200 participants with good attendance by users as well as producers of vacuum equipment and large industrial vacuum systems. The photograph, Figure 1, was taken at the ceremony organized at Ljubljana Castle.

Figure 1: Prof. dr. Janez Kovač was announced as a Congress Ambassador of Slovenia for the organization of the Joint Vacuum Conference JVC-16 and European Vacuum Congress EVC-14.

Team members often serve as invited speakers at various scientific and professional meetings. Since we are renowned for activities related to Industry 4.0, the team members are frequently invited to lecture on the state of the art and demands in adopting plasma technologies to meet the criteria of Industry 4.0. The team leader, Prof. Miran Mozetič, served as a plenary speaker at the large conference of Asia-Pacific Physicists which was organized in Malaysia in autumn 2019. He explained the shortcomings of current plasma technologies and presented the roadmap, stressing the challenges for the plasma scientist, in particular for the adoption of plasma technologies to enable integration to smart production lines. The photograph, Figure 2, was taken at this conference, which was attended by about 500 participants.

Figure 2: The team leader was a plenary speaker at the 14th Asia-Pacific Physics Conference in Malaysia.

Current plasma reactors useful for the processing of materials suffer from a lack of reliable sensors for the real-time and spatially resolved monitoring of plasma parameters in industrial-size reactors. Many current reactors operate at a rather low power density, so the major reactants are neutral plasma radicals rather than charged particles. While the density of charged particles is often fairly homogeneous in industrial-size reactors, large gradients of neutral reactive species are often observed. The gradients, both spatial and temporal, are due to the variations in

The research team is deeply involved in industrial research within the Slovenian Strategy of Smart Specialization (S4).

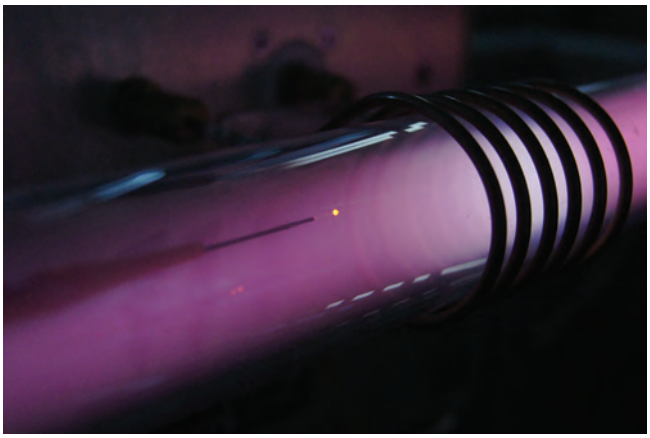

Figure 3: The tip of the patented catalytic probe is heated to about 1000 K by a laser connected to the other side of an optical fibre.

Figure 4: Dr Nina Recek is testing the decontamination and germination of plasma-treated seeds.

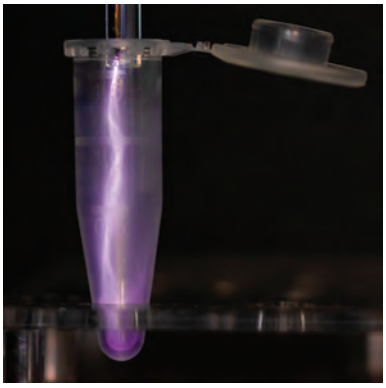

Figure 5: Treatment of Eppendorf tubes with gaseous plasma is useful for suppressing the adhesion of microvesicles and exosomes.

the probability of the heterogeneous surface recombination of radicals on the materials facing the plasma. There is a lack of reliable techniques for the determination of the radicals' density in low-pressure gaseous plasma. Different research groups have invented innovative techniques for measuring the densities with good space and time resolutions, and some are promising for applications in smart production lines. One solution employs a very reliable method – calorimetry. The research team has developed several solutions and the most sophisticated is the laser-driven catalytic probe. The original patent application was filed in 2014, and the EU patent was granted in 2019 [1]. The catalytic tip is kept continuously at high temperature, and the laser power needed to sustain such a constant temperature is inversely proportional to the flux of radicals onto the catalytic tip. A photograph of the tip immersed into an experimental plasma reactor is shown in Figure 3.

A large project "Innovative eco-friendly plasma technology for decontamination of seeds" was initiated in January 2019. The research team has ambitious plans to develop a technology for a plasma treatment to disinfect different seeds and suppress the concentration of toxins below the level prescribed by international standards. The technology will be developed up to Technological Readiness Level (TRL) 6: technology demonstrated in a relevant environment. Six partners are involved in the applied research and development of a prototype of a plasma reactor useful for seed treatment in the continuous mode. The consortium leader is the largest Slovenian producer of the seeds, while the scientific leadership was accepted by dr. Nina Recek (Figure 4). Researchers with different skills from several departments of the Jozef Stefan Institute are involved in this ambitious project.

The research team was also involved in another large project entitled "Food4Future". A novel technology was introduced for improving the properties of polyethylene (PE) and polypropylene (PP) foils suitable for applications in food packaging. The key innovative step was the optimization of plasma parameters for the treatment of these foils to achieve excellent adhesion of a chitosan-colloidal coating of superior antibacterial and antioxidant properties and low permeability for oxygen. First, a layer of chitosan macromolecular solution was deposited onto the plasma-treated surface, which enabled excellent antibacterial properties. Then, the second coating was deposited, containing a network of polyphenol resveratrol with embedded chitosan nanoparticles, which enabled antioxidant and antimicrobial properties simultaneously. X-ray photoelectron spectroscopy (XPS) and infrared spectroscopy (FTIR) showed successful binding of both coatings onto the foils. In addition, both layers enabled a reduced oxygen permeability and wetting contact angle of the foils; the latter indicates excellent anti-fog properties as well. Foils treated according to the methods of the invention exhibited over 90% reduction of bacteria as compared to the untreated foils and increased antioxidant activity by over a factor of 10. The technique is useful in different packagings, such as food (meat, vegetables, dairy and bakery products) and pharmaceutical packaging. An appropriate patent application was filed [2].

The bio-medical application of plasma technologies remains a hot topic of interdisciplinary research worldwide. The research team is among the most innovative in this scientific niche. A European patent disclosing a method for the modification of tools used for the isolation of microvesicles, nanovesicles or exosomes was granted in autumn 2019 [3]. A fruitful collaboration with researchers from the University of Ljubljana enabled the development of the method for the modification of the inner surface of Eppendorf tubes. The research on membrane nanostructures as a relevant factor influencing the cell-environment interactions was selected by the University of Ljubljana as one of the outstanding research achievements in 2019. The university announces such achievements annually to highlight outstanding researchers who have achieved particularly visible results in terms of international reputation as well as reverberation with the professional and general public. A photograph of plasma in an Eppendorf tube is shown in Figure 5.

Another interesting plasma application is the treatment of vascular stents. A couple of students were involved in these activities with the mentorship of Prof. Ita Junkar. The students Nika Špajzer and Nina Naprudnik prepared a report entitled "New generation of vascular stents" and their supervisor received the Silver Award at the 53rd Slovenian Young Researcher meeting for mentorship of this interdisciplinary research work. Furthermore, the report was granted a "Krka award" at the 49th

Competition of young researchers organized by the largest Slovenian pharmaceutical company Krka. The Silver Award is shown in Figure 6.

Nitinol (a nickel-titanium alloy) is used as the appropriate material in many medical applications; however, the possible release of toxic nickel from its surface and absorption in human tissue remains a significant concern. We developed a new route for suppressing the Ni release and thus improving the biocompatibility of this material. Our innovative procedure enables the formation of a thin titania film on the surface of this alloy. The oxide film represents a diffusion barrier for Ni ions from bulk material and thus prevents any release of Ni. The AES depth profile in Figure 7 reveals an immeasurably low concentration of nickel within the oxide film. The biocompatibility investigations, performed according to the ISO standard protocol using L929 human cells, showed the absence of any cytotoxic effects that might be due to the nickel's release. The investigation of nickel release of samples exposed to Hank's solution, measured by ICP-OES, also showed negligible Ni concentrations. The results were reported in a renowned journal [4]. This paper is the first report worldwide on a nickel-free titanium oxide film on the surface of any alloy containing Ni and Ti.

Multilayers play an important role in many scientific and technological fields and are most common in the fabrication and applications of semiconductor quantum-well structures. Therefore, there is a global demand for the reliable and quantitative characterization of the fabricated structures. Among the various methods, sputter depth profiling by ion bombardment in combination with secondary-ion mass spectrometry (SIMS) or electron spectroscopies (XPS, AES) has proved to be versatile and ubiquitously applicable. All three methods are available in our laboratories. The depth profiles of thin multilayer structures are, however, frequently distorted, mainly by sputtering-induced artefacts. A convenient means for the quantification of depth profiles with appropriate analysis and reconstruction of a measured depth profile is the Mixing-Roughness-Information (MRI) depth model, which takes into account three effects: atomic mixing, roughness and information depth. Recently, we improved the MRI model to take into account an additional artefact, i.e., the influence of preferential sputtering of different elements on depth resolution and profile shape in the sputter-depth profiling of multilayers. In our experimental and theoretical study of the preferential sputtering of very thin layers (thickness between 5 and 20 nm), we found how the interface width, interface location and layer thickness are affected by preferential sputtering in XPS, AES and SIMS depth profiling. The successful application of the MRI model expanded for the effect of preferential sputtering was used for fitting the as-measured AES depth profiles of Ag/Ni multilayers. These results were published in a leading journal for surface and thin-film characterization [5]. Figure 8 reveals applicability in the case of Ag/Ni structures.

The research team often participates in fusion-related projects either accomplished in our labs or at large tokamaks. The second-largest fusion experiment in Germany is tokamak ASDEX-U, located in Garching, Germany. In our experimental shifts, we evaluated the nitrogen concentration and ammonia production in N_2-seeded H-mode gaseous discharges [6]. We monitored the ammonia production using divertor spectroscopy and analysis of the exhaust gas (Figure 9). The amount of the detected ammonia increased continuously for five discharges with the same nitrogen seeding rate. The results show that the rate of ammonia formation exhibited the same trend as the nitrogen density in plasma. This density, in turn, was strongly influenced by the nitrogen wall inventory. The spatial distribution of the detected ammonia suggests that a significant contribution to the net ammonia formation occurs in plasma-shaded areas, through the surface reactions of neutral species. The results are important for designing the peculiarities of future fusion reactors, where it is supposed that nitrogen-seeding will be necessary for cooling the divertor plasma and thus prolonging the service time of the first-wall material.

Figure 6: Prof. dr. Ita Junkar was awarded for mentoring two students who prepared research on developing the new generation of vascular stents.

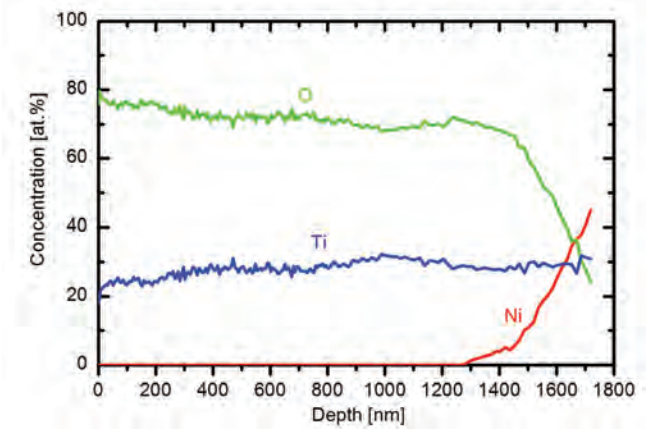

Figure 7: AES depth profile of the Nitinol sample oxidized according to our methods of invention based on treatment with hydrogen and oxygen plasma.

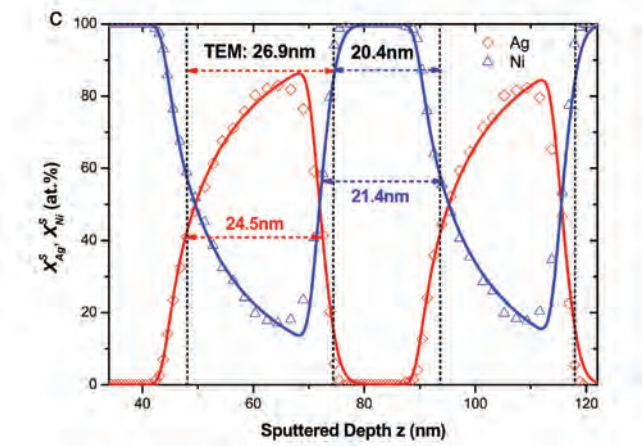

Figure 8: A region from the measured AES depth profile of multilayer structure Ag/Ni and modelling curves for Ag and Ni distribution obtained by the improved MRI model taking into account preferential ion sputtering rate.

Some outstanding publications in the past three years

[1] Gregor Primc, Miran Mozetič, Uroš Cvelbar, Alenka Vesel, Method and device for detecting and measuring the density of neutral atoms of hydrogen, oxygen or nitrogen, European patent EP 3146327B1, granted on 6th November 2019.

[2] Alenka Vesel, Miran Mozetič, Nives Ogrinc, Lidija Fras Zemljič, Tjaša Kraševec Glaser, Method for synthesizing impermeable foils for food packaging of superior antimicrobial and antioxidant properties with minimized oxygen permeability, patent application GB 1907793.2, filled on 31st May 2019.

[3] Ita Junkar, Veronika Kralj-Iglič, Roman Štukelj, Rok Zaplotnik, Miran Mozetič, Method for treatment of tools and tools used for isolation of microvesicles, nanovesicles or exosomes, European Patent EP 3185921B1, granted on 4th September 2019.

[4] Monika Jenko, Matjaž Godec, Aleksandra Kocijan, Rebeka Rudolf, Drago Dolinar, Maja Ovsenik, Matevž Gorenšek, Rok Zaplotnik, Miran Mozetič. A new route to biocompatible Nitinol-based on a rapid treatment with H2/O2 gaseous plasma. Applied Surface Science (2019), vol. 473, p. 976-984.

[5] Siegfried Hoffman, Gang Zhou, Janez Kovač, Sandra Drev, SongYou Lian, Bin Lin, Yi Liu, Jiang Yong Wang, Preferential sputtering effects in depth-profiling of multilayers with SIMS, XPS and AES, Applied Surface Science (2019), vol. 483, p. 140-155.

[6] Aleksander Drenik, Jernej Kovačič, Natan Osterman, Matjaž Panjan, PRIMC, Gregor Primc, Matic Resnik, Rok Zaplotnik, The ASDEX-Upgrade team and the EUROfusion MST1 team, Evolution of nitrogen concentration and ammonia production in N2-seeded H-mode discharges at ASDEX Upgrade. Nuclear fusion (2019), vol. 59, p. 046010-1-18.

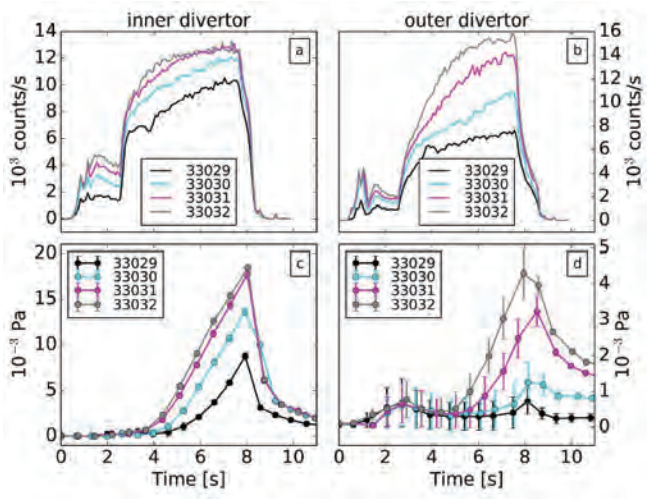

Figure 9: Time traces of the ND emission (a) and (b), and partial pressures of ammonia in the neutral gas (c) and (d), in the inner (a) and (c) and outer (b) and (d) divertor.

Awards and Appointments

1. Prof. Janez Kovač received the recognition Congress Ambassador from the Slovenian Convention Bureau for organising the Joint Vacuum Conference JVC-16 and European Vacuum Conference EVC-14
2. Asst. Prof. Ita Junkar received the silver recognition of the Association for Technical Culture of Slovenia for the result achieved at the 53rd Meeting of young Researchers of Slovenia 2019 for supervising the research paper authored by Nika Špajzer and Nina Naprudnik
3. Prof. Miran Mozetič, Asst. Prof. Gregor Primc and Prof. Alenka Vesel received the bronze medal ARCA 2019 at the 17th International Innovation Exhibition
4. Prof. Miran Mozetič, Asst. Prof. Gregor Primc, Prof. Alenka Vesel and Asst. Prof. Rok Zaplotnik were among the recipients of the bronze medal ARCA 2019 at the 17th International Innovation Exhibition

Patents granted

1. Rok Zaplotnik, Miran Mozetič, Gregor Primc, Alenka Vesel, Masaru Hori
   Carbon nanostructured materials and methods for forming of these materials
   SI25662 (A), Urad RS za intelektualno lastnino, 31. 12. 2019.
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
   EP3146327 (B1), European Patent Office, 06. 11. 2019.
3. Ita Junkar, Veronika Kralj-Iglič, Roman Štukelj, Rok Zaplotnik, Miran Mozetič
   Method for treatment of tools and tools used for isolation of microvesicles, nanovescicles or exsomes
   EP3185921 (B1), European Patent Office, 04. 09. 2019.

INTERNATIONAL PROJECTS

1. COST CA15114; Anti-Microbal Coating Innovations to prevent Infectious Diseases (AMICI)
   Prof. Uroš Cvelbar
   Cost Office
2. COST CA18113; Understanding and Exploiting the Impact of Low pH on Microorganisms
   Dr. Martina Modic
   Cost Association Aisbl
3. H2020 - PEGASUS; Plasma Enabled and Graphene Allowed Synthesis of Unique nano Structures
   Prof. Uroš Cvelbar
   European Commission
4. H2020-EUROfusion-Plasma Facing Components-1-IPH-FU, EUROFUSION
   Asst. Prof. Rok Zaplotnik
   European Commission
5. H2020 EUROfusion - Education-ED-FU
   Prof. Miran Mozetič
   European Commission
6. H2020 EUROfusion - Medium Size Tokamak Campaigns-MST1-FU
   Asst. Prof. Rok Zaplotnik
   European Commission
7. H2020-EUROFUSION-WPPFC-PEX-FU, WPPFC-PEX-FU, EUROFUSION
   Asst. Prof. Rok Zaplotnik
   European Commission
8. Plasma-Assisted Design of Multifunctional Carbon Nanowalls Bio-Sensor
   Prof. Uroš Cvelbar
   Slovenian Research Agency
9. Innovative Coatings for Bare Metallic Vascular Stents for Reduction of Restenosis and Acceleration of Natural Endothelization
   Prof. Miran Mozetič
   Slovenian Research Agency
10. Transport and Field Emission Properties of Low-Dimensional Molybdenum and Tungsten Based Nanomaterials
    Dr. Vincenc Nemanič
    Slovenian Research Agency
11. Catalytic Probes for Characterization of Hydrogen Plasma
    Asst. Prof. Gregor Primc
    Slovenian Research Agency
12. Control of Chemical Composition of Thin Films by High Resolution Mass Spectrometry of Secondary Ions
    Prof. Janez Kovač
    Slovenian Research Agency
13. Advanced Catalysts based on Multilayered Vertically Oriented Graphene Nanostructures
    Prof. Alenka Vesel
    Slovenian Research Agency
14. Investigation of Helium Retention in Plasma Facing Materials Using Advanced Analytical Methods
    Dr. Gregor Filipič
    Slovenian Research Agency
15. Characterization of Oxygen Plasma Sustained with Powerful Gaseous Discharges
    Prof. Miran Mozetič
    Slovenian Research Agency
16. Consequences of electron emission from hot plasma-facing components in nuclear fusion reactors
    Prof. Miran Mozetič
    Slovenian Research Agency

RESEARCH PROGRAMMES

1. Vacuum technique and materials for electronics
   Dr. Vincenc Nemanič
2. Thin film structures and plasma surface engineering
   Prof. Miran Mozetič
3. Fusion technologies
   Asst. Prof. Rok Zaplotnik

R & D GRANTS AND CONTRACTS

1. Ecologically friendly in-situ synthesis of ZnO nanoparticles for the development of protective textiles
   Asst. Prof. Gregor Primc
2. Initial stages in surface functionalization of polymers by plasma radicals
   Prof. Janez Kovač
3. Plasma-assisted wound treatment and topical introduction of molecules
   Prof. Uroš Cvelbar
4. Novel higly sensitive and fast water qulity monitoring sensors
   Prof. Uroš Cvelbar
5. Advanced surface finishing technologies for antibacterial properties of patient specific 3D printed implantable materials
   Asst. Prof. Ita Junkar
6. Hybrid and Reengineered Nanocatalysts for New Purification Routes
   Prof. Uroš Cvelbar
7. New generation of superior creep resistant steels with nanoparticles modified microstructure
   Prof. Uroš Cvelbar
8. Development of new, environment-friendly approaches for plant and human virus inactivation in waters
   Asst. Prof. Gregor Primc
9. Innovative sensors for real-time monitoring of deposition rates in plasma-enhnced chemical vapour deposition (PECVD) systems
   Asst. Prof. Rok Zaplotnik
10. Advanced hydrodesulphurisation with catalyst nanomaterials
    Prof. Uroš Cvelbar
11. Advanced hemocompatible surfaces of vascular stents
    Asst. Prof. Ita Junkar
12. Evaluation of the range of plasma parameters suitable for nanostructuring of polymers on industrial scale
    Prof. Miran Mozetič
13. Selective plasma oxidation of FeCrAl alloys for extended-lifetime of glow plugs for diesel engines
    Prof. Janez Kovač
14. Innovative configuration of inductively coupled gaseous plasma sources for up-scaling to industrial-size reactors
    Prof. Miran Mozetič
15. Carbon nanowalls for future supercapacitors
    Prof. Alenka Vesel
16. Food for future - F4F
    Prof. Alenka Vesel
    Ministry of Education, Science and Sport
17. Potential of biomass for development of advanced materials and bio-based products
    Asst. Prof. Ita Junkar
    Ministry of Education, Science and Sport
18. Innovative ECO plasma seed treatment (for sowing and for human and animal diet/ nutrition
    Dr. Nina Recek
    Ministry of Education, Science and Sport
19. Building blocks, tools and systems for the Factories of the Future – GOSTOP
    Prof. Miran Mozetič
    Ministry of Education, Science and Sport
20. Development of nanostructured biosensors for diagnosis/treatment of cancer and surfaces with antibacterial
    Dr. Metka Benčina
    Ministry of Education, Science and Sport
21. Strategic Research & Innovation Partnership Factories of the Future (SRIP FoF)
    Prof. Miran Mozetič
    Ministry of Economic Development and Technology
22. Method for preparation of bacteriostatic surfaces on 3D printed medical implants
    Dr. Matic Resnik
    Ministry of Education, Science and Sport
23. Novel type of antibacterial coatings on textile materials and plastics with controllable release of antibacterial agent
    Prof. Uroš Cvelbar
    Ministry of Education, Science and Sport
24. Income from Coowners of Invention for Reimbursement of Costs for IP Protection in the Case of EVT140_Mozetič_Carbon Nanowall
    Prof. Miran Mozetič
    Nagoya University
25. EVT770_Mozetič_CNW2_Reimbursement of the Costs for Patent; Income from Coowners of Invention for Reimbursement of Costs for IP Protection in the Case of EVT770_Mozetič_CNW2
    Prof. Miran Mozetič
    Nagoya University

NEW CONTRACTS

1. Co-finanicing of L-project L2-1834 Carbon nanowalls for future supercapacitors
   Prof. Alenka Vesel
   Iskra, d. o. o.
2. Innovative sensors for real-time monitoring of deposition rates in plasma-enhanced chemical vapour deposition (PECVD) systems
   Asst. Prof. Rok Zaplotnik
   Iskra, d. o. o.

VISITORS FROM ABROAD

1. Dr. Francesco Mauro Ghezzi, Instituto di Fisica del Plasma – CNR, Milan, Italy, 14 January–4 February 2019
2. Hana Šourkova, Technical University of Liberec, Liberec, Czech Republic, 29–31 January 2019
3. B. Eng. Jaroslav Vozlab, Technical University of Liberec, Liberec, Czech Republic, 29–31 January 2019
4. Prof. Won Ho Choe, Korean Advanced Institute of Science and Technology, Daejeon, South Korea, 11–15 February 2019
5. Dr. Davor Peruško, Vinča Institute of Nuclear Science, Belgrade, Serbia, 5–10 May 2019
6. Dr. Suzana Petrović, Vinča Institute of Nuclear Science, Belgrade, Serbia, 5–10 May 2019
7. Dr. Maja Popović, Vinča Institute of Nuclear Science, Belgrade, Serbia, 5–10 May 2019
8. Dr. Lenka Zajičkova, Central European Institute of Technology (CEITEC), Brno, Czech Republic, 23–25 May 2019
9. Prof. Dr. Masaru Hori, Nagoya University, Nagoya, Japan, 25–26 May 2019
10. Prof. Dr. Radjeep Singh Rawat, Nanyang Technological University, Singapore, Singapore, 25–26 May 2019
11. Prof. Dr. David Neil Ruzic, University of Illinois, Illinois, USA, 25–26 May 2019
12. Prof. Dr. Jean-Paul Booth, Ecole Polytechnique, Palaiseau, France, 30 May–2 June 2019
13. Dr. Nuno Pinhao, Instituto Superior Technico, Lisbon, Portugal, 30 May–2 June 2019
14. Berke Karaman, Istanbul Technical University, Istanbul, Turkey, 23–28 June 2019
15. Prof. Dr. Mustafa Kamil Ürgen, Istanbul Technical University, Istanbul, Turkey, 23–28 June 2019
16. Cagatay Yelkarasi, Istanbul Technical University, Istanbul, Turkey, 23–28 June 2019
17. Prof. Dr. Petr Humpoliček, Tomas Bata University, Zlin, Czech Republic, 1–4 July 2019
18. Dr. Miomir Milosavljević, Vinča Institute of Nuclear Science, Belgrade, Serbia, 23–27 September 2019
19. Ana Grce, Vinča Institute of Nuclear Science, Belgrade, Serbia, 23–27 September 2019
20. Barbora Ptoskova, Tomas Bata University, Zlin, Czech Republic, 30 September–31 October 2019
21. Prof. Aleš Mraček, Tomas Bata University, Zlin, Czech Republic, 1 October 2019
22. Petr Smolka, Tomas Bata University, Zlin, Czech Republic, 1 October 2019
23. Prof. Slobodan Milošević, Institute of Physics, Zagreb, Croatia, 1 October 2019
24. Dr. Nikša Krstulović, Institute of Physics, Zagreb, Croatia,1 October 2019
25. Dr. Dejan Maletić, Institute of Physics, Belgrade, Serbia, 1 October 2019
26. Prof. Dr. Masaru Hori, Nagoya University, Nagoya, Japan, 3–5 December 2019
27. Atsushi Ozaki, Nagoya University, Nagoya, Japan, 1–8 December 2019

STAFF

Researchers

1. *Prof. Uroš Cvelbar, 01.05.19, transferred to Department F6*
2. *Dr. Aleksander Drenik, on leave 01.03.16*
3. Asst. Prof. Ita Junkar
4. Prof. Janez Kovač
5. **Prof. Miran Mozetič, Head**
6. *Dr. Vincenc Nemanič, 01.05.19, transferred to Department F6*
7. Prof. Alenka Vesel
8. Asst. Prof. Rok Zaplotnik
9. **Postdoctoral associates**
10. Dr. Metka Benčina
11. *Dr. Gregor Filipič, 01.05.19, transferred to Department F6*
12. Dr. Matej Holc
13. Dr. Petr Humpolíček
14. Dr. Kinga Kutasi
15. Dr. Marián Lehocký
16. *Dr. Martina Modic, 01.05.19, transferred to Department F6*
17. Asst. Prof. Gregor Primc
18. Dr. Nina Recek
19. Dr. Matic Resnik
20. **Postgraduates**
21. Jernej Ekar, B. Sc.
22. *Dr. Nataša Hojnik, 01.05.19, transferred to Department F6*
23. *Martin Košiček, B. Sc., 01.05.19, transferred to Department F6*
24. Dane Lojen, B. Sc.
25. Domen Paul, B. Sc.
26. Pia Starič, B. Sc.
27. *Petra Stražar, B. Sc., 01.05.19, transferred to Department F6*
28. *Marko Žumer, B. Sc., 01.05.19, transferred to Department F6*
29. **Technical officers**
30. Tatjana Filipič, B. Sc.
31. Eva Levičnik, B. Sc.
32. **Technical and administrative staff**
33. *Ula Groznik, B. Sc., 01.05.19, transferred to Department F6*
34. *Urška Kisovec, B. Sc., 01.05.19, transferred to Department F6*
35. Maja Šukarov, B. Sc.
36. Janez Trtnik

BIBLIOGRAPHY

Original Article

1. Aleksander Matavž, Andreja Benčan, Janez Kovač, Ching-Chang Chung, Jacob L. Jones, Susan Trolier-McKinstry, Barbara Malič, Vid Bobnar, "Additive manufacturing of ferroelectric-oxide thin-film multilayer devices", *ACS applied materials & interfaces*, 2019, **11**, 49, 45155-45160.
2. Tamilselvan Mohan, Alja Čas, Matej Bračič, Olivija Plohl, Alenka Vesel, Maja Rupnik, Lidija Fras Zemljič, Janez Rebol, "Highly protein repellent and antiadhesive polysaccharide biomaterial coating for urinary catheter applications", *ACS biomaterials science & engineering*, 2019, **5**, 11, 5825-5832.
3. Monika Jenko, Matjaž Godec, Aleksandra Kocijan, Rebeka Rudolf, Drago Dolinar, Maja Ovsenik, Matevž Gorenšek, Rok Zaplotnik, Miran Mozetič, "A new route to biocompatible Nitinol based on a rapid treatment with H_2/O_2 gaseous plasma", *Applied Surface Science*, 2019, **473**, 976-984.
4. Siegfried Hofmann, G. Zhou, Janez Kovač, Sandra Drev, S. Y. Lian, B. Lin, Y. Liu, Jiang Yong Wang, "Preferential sputtering effects in depth profiling of multilayers with SIMS, XPS and AES", *Applied Surface Science*, 2019, **483**, 140-155.
5. Martina Modic, Janez Kovač, John R. Nichols, Špela Kos, Gregor Serša, Uroš Cvelbar, James L. Walsh, "Targeted plasma functionalization of titanium inhibits polymicrobial biofilm recolonization and stimulates cell function", *Applied Surface Science*, 2019, **487**, 1176-1188.
6. Darja Božič, Simona Sitar, Ita Junkar, Roman Štukelj, Manca Pajnič, Ema Žagar, Veronika Kralj-Iglič, Ksenija Kogej, "Viscosity of plasma as a key factor in assessment of extracellular vesicles by light scattering", *Cells*, 2019, **8**, 9, 1046.
7. Danjela Kuščer, Andraž Kocjan, Maja Majcen, Anton Meden, Kristian Radan, Janez Kovač, Barbara Malič, "Evolution of phase composition and microstructure of sodium potassium niobate -based ceramic during pressure-less spark plasma sintering and post-annealing", *Ceramics international*, 2019, **45**, 8, 10429-10437.
8. Martin Minarik *et al.* (11 authors), "Preparation of hierarchically structured polystyrene surfaces with superhydrophobic properties by plasma-assisted fluorination", *Coatings*, 2019, **9**, 3, 201.
9. Tadeja Kosec, Andraž Legat, Janez Kovač, Damjan Klobčar, "Influence of laser colour marking on the corrosion properties of low alloyed Ti", *Coatings*, 2019, **9**, 6, 375.
10. Suzana Petrović, Davor Peruško, Evangelos Skoulas, Janez Kovač, Miodrag Mitrić, Jelena Potočnik, Zlatko Rakočević, Emmanuel Stratakis, "Laser-assisted surface texturing of Ti/Zr multilayers for mesenchymal stem cell response", *Coatings*, 2019, **9**, 12, 854.
11. Klemen Avsec, Monika Jenko, Marjetka Conradi, Aleksandra Kocijan, Alenka Vesel, Janez Kovač, Matjaž Godec, Igor Belič, Barbara Šetina, Črtomir Donik, Matevž Gorenšek, Boštjan Kocjančič, Drago Dolinar, "Surface properties of retrieved cementless femoral hip

endoprostheses produced from a Ti6Al7Nb alloy", *Coatings*, 2019, **9**, 12, 868.
12. Žiga Gosar, Janez Kovač, Miran Mozetič, Gregor Primc, Alenka Vesel, Rok Zaplotnik, "Deposition of $SiO_xC_yH_z$ protective coatings on polymer substrates in an industrial-scale PECVD reactor", *Coatings*, 2019, **9**, 4, 234.
13. Ladislav Vrsalović, Ivana Ivanić, Stjepan Kožuh, Borut Kosec, Milan Bizjak, Janez Kovač, Urška Gabor, Mirko Gojić, "Influence of heat treatment on the corrosion properties of CuAlMn shape memory alloys", *Corrosion reviews*, 2019, **37**, 6, 579-589.
14. Arijana Filipić, Gregor Primc, Rok Zaplotnik, Nataša Mehle, Ion Gutiérrez-Aguirre, Maja Ravnikar, Miran Mozetič, Jana Žel, David Dobnik, "Cold atmospheric plasma as a novel method for inactivation of potato virus Y in water samples", *Food and environmental virology*, 2019, **11**, 3, 220-228.
15. Rupert Kargl, Matej Bračič, Matic Resnik, Miran Mozetič, Wolfgang Bauer, Karin Stana-Kleinschek, Tamilselvan Mohan, "Affinity of serum albumin and fibrinogen to cellulose, its hydrophobic derivatives and blends", *Frontiers in chemistry*, 2019, **7**, 581.
16. Aleksander Drenik, Sebastijan Brezinšek, P. Carvalho, V. Huber, Natan Osterman, G. F. Matthews, Mitja Nemec, "Analysis of the outer divertor hot spot activity in the protection video camera recordings at JET", *Fusion engineering and design*, 2019, **139**, 115-123.
17. Igor Lengar, Andrej Žohar, P. Batistoni, Sergei Popovichev, S. Conroy, JET Contributors, "Characterization of JET neutron field in irradiation locations for DD, DT and TT plasmas", *Fusion engineering and design*, 2019, **146**B, 1967-1970.
18. Bor Kos, Scott W. Mosher, Ivan Aleksander Kodeli, Robert. E. Grove, Jonathan Naish, Barabara Obryk, Rosaria Villari, Paola Batistoni, JET Contributors, "Application of ADVANTG to the JET3 - NEXP streaming benchmark experiment", *Fusion engineering and design*, 2019, **147**, 111252.
19. Thomas Reichbauer, Aleksander Drenik, Rachael McDermott, Wolker Rohde, the ASDEX Upgrade Team, "Assessment of nitrogen fluence from the divertor plasma in nitrogen seeded discharges", *Fusion engineering and design*, 2019, **149**, 111325.
20. Anže Prašnikar, Andraž Pavlišič, Francisco Ruiz-Zepeda, Janez Kovač, Blaž Likozar, "Mechanisms of copper-based catalyst deactivation during CO_2 reduction to methanol", *Industrial & engineering chemistry research*, 2019, **58**, 29, 13021-13029.
21. Andrea Jurov, Dean Popović, Iva Šrut Rakić, Ida Delač Marion, Gregor Filipič, Janez Kovač, Uroš Cvelbar, Nikša Krstulović, "Atmospheric pressure plasma jet-assisted impregnation of gold nanoparticles into PVC polymer for various applications", *International journal of advanced manufacturing technology*, 2019, **101**, 3/4, 927-938.
22. Nikola Mikušová, Kateřina Nechvilová, Andréa Kalendová, Tereza Hájková, Zdenka Capáková, Ita Junkar, Marián Lehocký, Miran Mozetič, Petr Humpolíček, "The effect of composition of a polymeric coating on the biofilm formation of bacteria and filamentous fungi", *International journal of polymeric materials*, 2019, **68**, 4, 152-159.
23. Sandhya Gopalakrishnan, Indu Raj, T. Aby Mathews, Jiji Abraham, Hanna J. Maria, Miran Mozetič, Sabu Thomas, Nandakumar Kalarikkal, "Development of oral-fluid-impervious and fracture-resistant silver-poly(methyl methacrylate) nanoformulations for intra-oral/extra-oral rehabilitation", *Journal of applied polymer science*, 2019, **2019**, 47669.
24. Olivija Plohl, Urban Ajdnik, Sašo Gyergyek, Irena Ban, Alenka Vesel, Tjaša Kraševac Glaser, Lidija Fras Zemljič, "Superior stability and high biosorbent efficiency of carboxymethylchitosan covalently linked to silica-coated core-shell magnetic nanoparticles for application in copper removal", *Journal of environmental chemical engineering*, 2019, **7**, 1, 102913.
25. Stojana Veskovič Bukudur, Janez Kovač, Blaž Karpe, Polona Umek, Aleš Nagode, Romana Cerc Korošec, Milan Bizjak, "High temperature corrosion of commercial FeCrAl alloys (Kanthal AF) in nitrogen gas", *Journal of mining and metallurgy. Section B, Metallurgy*, 2019, **55**, 1, 55-63.
26. Vincenc Nemanič, Marko Žumer, Janez Kovač, "Hydrogen permeability of AISI 316 ITER grade stainless steel", *Journal of nuclear materials*, 2019, **521**, 38-44.
27. Lidija Androš-Dubraja, Damir Pajić, Martina Vrankić, Jure Dragović, Matjaž Valant, Metka Benčina, Marijana Jurić, "Single-step preparation of rutile-type $CrNbO_4$ and $CrTaO_4$ oxides from oxalate precursors-characterization and properties", *Journal of the American Ceramic Society*, 2019, **102**, 11, 6697-6704.
28. Roman Štukelj, Metka Benčina, Mattia Fanetti, Matjaž Valant, Mitja Drab, Aleš Iglič, Veronika Kralj-Iglič, "Synthesis of stable cannabidiol (CBD) nanoparticles in suspension", *Materiali in tehnologije*, 2019, **53**, 4, 543-549.
29. Metka Benčina, Ita Junkar, Tina Mavrič, Veronika Kralj-Iglič, Matjaž Valant, Aleš Iglič, "Performance of annealed TiO_2 nanotubes in interactions with blood platelets", *Materiali in tehnologije*, 2019, **53**, 6, 791-795.
30. A. Achour, S. Solaymani, Sorin Ionut Vizireanu, A. Baraket, Alenka Vesel, N. Zine, A. Errachid, Gheorghe Dinescu, Jean-Jacques Pireaux, "Effect of nitrogen configuration on carbon nanowall surface: towards the improvement of electrochemical transduction properties and the stabilization of gold nanoparticles", *Materials chemistry and physics*, 2019, **228**, 110-117.
31. Metka Benčina, Ita Junkar, Rok Zaplotnik, Matjaž Valant, Aleš Iglič, Miran Mozetič, "Plasma-Induced crystallization of TiO_2 nanotubes", *Materials*, 2019, **12**, 4, 626.
32. Tjaša Kraševac Glaser, Olivija Plohl, Alenka Vesel, Urban Ajdnik, Nataša Poklar Ulrih, Maša Knez Hrnčič, Urban Bren, Lidija Fras Zemljič, "Functionalization of polyethylene (PE) and polypropylene (PP) material using chitosan nanoparticles with incorporated resveratrol as potential active packaging", *Materials*, 2019, **12**, 13, 2118.
33. Žiga Gosar, Denis Đonlagić, Simon Pevec, Janez Kovač, Miran Mozetič, Gregor Primc, Alenka Vesel, Rok Zaplotnik, "Deposition kinetics of thin silica-like coatings in a large plasma reactor", *Materials*, 2019, **12**, 19, 3238.
34. Jelena Pavlović, Margarita Popova, Magdolna R. Mihályi, Matjaž Mazaj, Gregor Mali, Janez Kovač, Hristina Lazarova, Nevenka Rajić, "Catalytic activity of SnO_2- and SO_4/SnO_2-containing clinoptilolite in the esterification of levulinic acid", *Microporous and mesoporous materials: zeolites, clays, carbons and related materials*, 2019, **279**, 10-18.
35. The ASDEX-Upgrade team and the EUROfusion MST1 team, Aleksander Drenik *et al.* (15 authors), "Evolution of nitrogen concentration and ammonia production in N_2-seeded H-mode discharges at ASDEX Upgrade", *Nuclear fusion*, 2019, **59**, 4, 046010.
36. The ASDEX Upgrade Team and the EUROfusion MST1 team, L. Guimarais *et al.* (16 authors), "Link between divertor conditions and high-field-side/low-field-side midplane density profiles in H-mode plasmas at ASDEX upgrade", *Nuclear fusion*, 2019, **59**, 19, 126041.
37. B. Labit *et al.* (466 authors), "Dependence on plasma shape and plasma fueling for small edge-localized mode regimes in TCV and ASDEX Upgrade", *Nuclear fusion*, 2019, **59**, 8, 086020.
38. Matej Holc, Gregor Primc, Jernej Iskra, Primož Titan, Janez Kovač, Miran Mozetič, Ita Junkar, "Effect of oxygen plasma on sprout and root growth, surface morphology and yield of garlic", *Plants*, 2019, **8**, 11, 462.
39. Ilkay Karakurt, Kadir Ozaltin, Daniela Vesela, Marián Lehocký, Petr Humpolíček, Miran Mozetič, "Antibacterial activity and cytotoxicity of immobilized glucosamine/chondroitin sulfate on polylactic acid films", *Polymers*, 2019, **11**, 7, 1186.
40. Kateřina Skopalová, Zdenka Capáková, Patrycja Bober, Jana Pelková, Jaroslav Stejskal, Věra Kašpárková, Marián Lehocký, Ita Junkar, Miran Mozetič, Petr Humpolíček, "In-vitro hemocompatibility of polyaniline functionalized by bioactive molecules", *Polymers*, 2019, **11**, 1861.
41. Miroslav Mrlik, Marketa Ilcikova, Josef Osicka, Erika Kutalkova, Antonín Minařík, Alenka Vesel, Jaroslav Mosnacek, "Electrorheology of SI-ATRP-modified graphene oxide particles with poly(butyl methacrylate): effect of reduction and compatibility with silicone oil", *RSC advances*, 2019, **9**, 3, 1187-1198.
42. Tanja Zidarič, Nana Ivana Hrastnik, Ervin Šest, Janez Kovač, Vasko Jovanovski, Samo B. Hočevar, "A novel bismuth imidazolate-based sensor for detection of trace lead(II)", *Sensors and actuators. B, Chemical*, 2019, **291**, 354-361.
43. Raghuraj S. Chouhan, Gregor Žitko, Vesna Fajon, Igor Živković, Majda Pavlin, Sabina Berisha, Ivan Jerman, Alenka Vesel, Milena Horvat, "A unique interactive nanostructure knitting based passive sampler adsorbent for monitoring of Hg^{2+} in water", *Sensors*, 2019, **19**, 15, 3432.
44. Karthika Prasad, Nina Recek, Renwu Zhou, Rusen Zhou, Morteza Aramesh, Annalena Wolff, Robert E. Speight, Miran Mozetič, Kateryna Bazaka, Kostya Ostrikov, "Effect of multi-modal environmental stress on dose-dependent cytotoxicity of nanodiamonds in Saccharomyces cerevisiae cells", *Sustainable materials and technologies*, 2019, **22**, e00123.

Review Article

1. Miran Mozetič, "Surface modification to improve properties of materials", *Materials*, 2019, **12**, 4, 441.

2. Alenka Vesel, Rok Zaplotnik, Gregor Primc, Miran Mozetič, "Synthesis of vertically oriented graphene sheets or carbon nanowalls: review and challenges", *Materials*, 2019, **12**, 18, 2968.

Published Conference Contribution

1. Jelena Pavlović, Margarita Popova, Magdolna R. Mihályi, Matjaž Mazaj, Gregor Mali, Janez Kovač, Hristina Lazarova, Nevenka Rajić, "Catalytic activity of clinoptilolite-based catalysts in the esterification of levulinic acid", In: *Proceedings of the 8th Serbian-Croatian-Slovenian Symposium on Zeolites, Proceedings of the 8th Croatian-Slovenian-Serbian Symposium on Zeolites, Proceedings of the 8th Slovenian-Serbian-Croatian Symposium on Zeolites: [3 - 5 October 2019, Belgrade, Serbia]*, Serbian Zeolite Association, 2019, 89-92.
2. Jure Žigon, Marko Petrič, Sebastian Dahle, Ayata Ümit, Rok Zaplotnik, "The influence of artificial weathering and treatment with FE-DBD plasma in atmospheric conditions on wettability of wood surfaces", In: *Tagungsband: 3. Niedersächsisches Symposium Materialtechnik, 14 bis und 15. Februar 2019*, (Fortschrittsberichte der Materialforschung und Werkstofftechnik, **7)**, 2019.

Independent Component Part or a Chapter in a Monograph

1. Mitja Drab, Luka Mesarec, Roghayeh Imani, Marko Jeran, Ita Junkar, Veronika Kralj-Iglič, Samo Kralj, Aleš Iglič, "The role of membrane vesiculation and encapsulation in cancer diagnosis and therapy", In: *Advances in biomembranes and lipid self-assembly*, (Advances in biomembranes and lipid self-assembly, **29)**, Elsevier, 2019, 159-199.
2. Miran Mozetič, Alenka Vesel, Gregor Primc, Rok Zaplotnik, "Introduction to plasma and plasma diagnostics", In: *Non-thermal plasma technology for polymeric materials: applications in composites nanostructured materials, and biomedical fields*, Elsevier, 2019, 23-65.

Patent

1. Rok Zaplotnik, Miran Mozetič, Gregor Primc, Alenka Vesel, Masaru Hori, *Carbon nanostructured materials and methods for forming of these materials,* SI25662 (A), Urad RS za intelektualno lastnino, 31. 12. 2019.
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,* EP3146327 (B1), European Patent Office, 06. 11. 2019.
3. Ita Junkar, Veronika Kralj-Iglič, Roman Štukelj, Rok Zaplotnik, Miran Mozetič, *Method for treatment of tools and tools used for isolation of microvesicles, nanovescicles or exsomes,* EP3185921 (B1), European Patent Office, 04. 09. 2019.

Theses and Mentoring

1. Matej Holc, *Effects of highly reactive gaseous plasma treatment on the germination and growth of garlic:* doctoral dissertation, Ljubljana, 2019 (mentor Miran Mozetič; co-mentor Ita Junkar).