Surface Engineering of Biomaterials, Devices and Regenerative Materials: Health, Food, and Agriculture Applications

Room Town & Country B - Session MD2-2-ThM

Coatings and Sensors for Health, Food and Agriculture: Antibacterial, Bioactive, and Flexible Interfaces II

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8:00am **MD2-2-ThM-1 Surface Modification of AZ31B by Oxygen-Plasma Immersion Ion Implantation to Promote Schwann Cell Interaction for Peripheral Nerve Regeneration***, **Luciana Malvestiti [luciana.malvestiti.1@ulaval.ca]**, Carlo Paternoster, Francesco Copes,* LBB, CHU de Quebec research center, Laval University, Canada*; Paolo Mengucci, Giani Barucca,* Department SIMAU, Università Politecnica delle Marche, Ancona, Italy*; Silvia Ceré,* INTEMA-CONICET, Mar del Plata National University, Argentina*; Andranik Sarkissian,* Plasmionique Inc., Varennes, QC, Canada*; Diego Mantovani,* LBB, CHU de Quebec research center, Laval University, Canada

Their biocompatibility, electrical conductivity and biodegradability properties, make Mg-based alloys a potential biomaterial for peripheral neuropathy. Even if these alloys release Mg^{2+} cations, fundamental in neurological functions, their high corrosion rate triggers implant failure and tissue damage. To control the degradation pattern, and improve the biological response, a plasma-based technique (oxygen-plasma immersion ion implantation, O-PIII) was used on a Mg-based substrate (AZ31B) to generate a thin MgO layer. In addition, other modified surface properties such as roughness and surface energy, improved the general biological response of the material

O-PIII was performed in a PBII-300 system (Plasmionique) on the surface of chemically polished (CP) AZ31B (Al 3 wt.%, Zn 1 wt.%, Mg bal.) specimens. Pressure (5 to 10 mTorr), and pulse repetition rate (200 to 1000 Hz) were working parameters. The morphological, chemical and electrochemical characterization was performed with scanning electron microscopy (SEM), X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), static drop contact angle, and polarization curves in Hanks' solution. The cytotoxicity of the corrosion products toward Schwann cells (SC), and the interaction between the modified alloy and SC were studied through an indirect test and adhesion test, respectively.

Plasma treatment introduced different surface features depending on the used parameter values, which affected the morphology, roughness, chemical composition, and corrosion resistance. After O-PIII, XPS revealed an increase in MgO content, accounting for the ~70% total detected oxygen. The hydrophilicity of the treated surfaces decreased, from ~40° for CP to ~75°-100° after O-PIII, being within the range that promotes protein adsorption[2]. Applying O-PIII, the corrosion rate was reduced, improving also the corrosion pattern of the material. SC exposure to 10% and 1% extracts did not show a relevant cell viability reduction. After 6 h of incubation, SC were adhered on the modified surfaces exhibiting an elongated morphology, which could be compatible with a regenerative phenotype.

O-PIII modified the AZ31B surface topography, chemical composition (Mg oxide/hydroxide related species), and wettability, enhancing its corrosion resistance. Low concentration of corrosion products did not affect SC viability, moreover, the modified surface allowed SC attachment. These results support the use of O-PIII technique as a potential surface modification for AZ31B, constituting a valid approach for peripheral nerves regeneration.

8:20am **MD2-2-ThM-2 Multifunctional PEO–PPy/Zn Coatings Combined with Electrical Stimulation for Enhanced Antimicrobial and Osteogenic Titanium Surfaces***, **Valentim A. R. Barão [vbarao@unicamp.br]**, Maria Helena R. Borges, Samuel Santana Malheiros, Julia M. Teodoro,* University of Campinas (UNICAMP), Brazil*; João Gabriel S. Souza,* Guarulhos University (UNG), Brazil*; Elidiane C. Rangel,* Sao Paulo State University (UNESP), Brazil*; Ana Paula Souza, Bruna Egumi Nagay,* University of Campinas (UNICAMP), Brazil

Dental implant failure often results from polymicrobial biofilm infections and poor osseointegration, underscoring the need for multifunctional surface modifications of titanium (Ti). Here, we developed a plasma electrolytic oxidation (PEO) coating followed by the electrodeposition of the conductive polymer polypyrrole (PPy) and the antimicrobial agent zinc (Zn), combined with osteogenic stimulation through electrical therapy (ES). We systematically investigated the surface, mechanical, physicochemical, tribological, electrochemical, antimicrobial (mono- and polymicrobial biofilms), and biological properties, as well as osteogenic activity using MC3T3-E1 cells. Ti discs were prepared as four groups: (1) machined, (2) PEO, (3) PEO+PPy, and (4) PEO+PPy/Zn, each evaluated with or without ES. The PEO+PPy and PEO+PPy/Zn surfaces exhibited enhanced mechanical strength, tribocorrosion resistance, reduced wear, and increased hardness ($p<0.05$). Zn incorporation imparted pronounced antimicrobial effects, significantly decreasing biofilm viability and metabolic activity ($p<0.05$), while promoting protein adsorption ($p<0.05$). Moreover, ES further improved cell proliferation, osteogenic differentiation, and mineralized nodule formation ($p<0.05$). Collectively, the multifunctional PEO+PPy/Zn coating, particularly when combined with ES, shows strong potential to enhance implant longevity by strengthening substrate resistance, preventing microbial colonization, and stimulating osteogenesis.

8:40am **MD2-2-ThM-3 Effect of Zirconium Addition on Zn- and Mg-Based Thin Film Properties Deposited by Magnetron Sputtering for Intravascular Biodegradable Materials***, **Fatiha Challali [fatiha.challali@univ-paris13.fr]**, Cristiano Poltronieri,* Laboratoire des Sciences des Procédés et des Matériaux (LSPM) – CNRS, France*; Vinicius De Oliveira F. Sales, Carlos Henrique Michelin Beraldo, Carlo Paternoster,* Université Laval, Canada*; Frédéric Chaubet,* Université Sorbonne Paris Nord, France*; Philippe Djemia,* Laboratoire des Sciences des Procédés et des Matériaux (LSPM) – CNRS, France*; Diego Mantovani,* Université Laval, Canada

Intravascular medical devices allow the treatment of internal vessel-related diseases circumventing open-surgery, in daily-hospital treatment, and with great benefits for patients. The thickness of the devices is inversely proportional to how far in vascular bed diseased sites can accessed, especially for cerebrovascular applications. Unhappily, the fabrication of thin and ultrathin (hundreds to tens of microns) metallic implants remains a key challenge for these applications. Moreover, biodegradable metals are now a reality for adding the degradability components to these devices. For thin intravascular applications, zinc-based alloys are promising candidates due to their moderate degradation rates compared to magnesium-based materials, despite mechanical properties and corrosion rate still need to be investigated. The uniformity of the expected degradation also constitutes a main bottleneck, and metallic glasses, being exempted by surface defects like grain joints, provide a new insight, as recently shown on amorphous Zn–Mg–Ca. Thin film metallic glasses (TFMGs), characterized by a disordered atomic structure, exhibit exceptional mechanical properties, including a large elastic limit (>2%), high hardness, and yield strength (>2 GPa). Their homogeneous atomic arrangement promotes uniform corrosion with tunable rates depending on alloy composition.

This work aimed to enhance the glass-forming ability (GFA) and achieve tunable corrosion rates in Zn- and Mg-based thin films through the addition of Zr. Incorporating Zr as a glass-forming element is an effective strategy to extend the compositional ranges of amorphous or nanocrystalline alloys. The addition of Zr enables precise control over the microstructure and crystallinity, facilitating the design of biodegradable materials with improved performance. Thin films of Zn–Zr and Mg–Zr binary alloys were synthesized by magnetron co-sputtering onto silicon substrates using pure metallic targets, with thicknesses ranging from 300 to 900 nm, covering a wide composition range. The film microstructure and chemical composition were analyzed by XRD and SEM/EDS, respectively. Corrosion behavior was evaluated through electrochemical measurements performed at room temperature, while biodegradability was assessed by immersion tests in simulated body fluid at 37 °C for up to eight weeks. XRD results showed that Mg–Zr films exhibited a nanocrystalline structure, while amorphous Zn–Zr films were obtained for Zn contents between 26 and 88 at.%. Immersion tests revealed premature cracking and delamination in Zn- and Mg-rich films after one week, whereas Zr-rich films remained adherent even after eight weeks of immersion.

9:00am **MD2-2-ThM-4 Influence of Microstructure and Processing Voltage on the Formation and Properties of Coatings Obtained by Micro-Arc Oxidation (MAO) in Ti-25Ta-xNb Alloys**, ***Fernanda de Freitas Quadros [ff.quadros@unesp.br]***, Sao Paulo State University (UNESP), Brazil; *Katia Barbaro,* Istituto Zooprofilattico Sperimentale del Lazio e della Toscana, Italy; *Diego Rafael Nespeque Corrêa,* Sao Paulo State University (UNESP), Brazil; *Julietta V. Rau,* Istituto di Struttura della Materia, Consiglio Nazionale delle Ricerche, Italy; *Carlos Roberto Grandini,* Sao Paulo State University (UNESP), Brazil

The Micro-Arc Oxidation (MAO) technique has emerged as one of the most effective methods for improving the surface properties of metallic materials, particularly in titanium (Ti) alloys used for biomedical applications[1]. Although Ti exhibits good mechanical performance, high corrosion resistance, and excellent biocompatibility, issues such as corrosion, infection, and implant rejection may still occur[2]. Ti is an allotropic element, displaying a hexagonal close-packed (α) structure below 882 °C and a body-centered cubic (β) structure above this temperature[2]. The addition of β-stabilizing elements, such as tantalum (Ta) and niobium (Nb), lowers the β-transus temperature and can enhance the material's corrosion resistance and biocompatibility due to the intrinsic properties of Ta and Nb [3]. This study aimed to investigate the influence of microstructure, particularly through variations in Nb content, on coatings obtained by MAO in Ti-25Ta-xNb alloys (x = 10, 20, and 30 wt.% Nb) under different applied voltages (200, 250, and 300 V). X-ray diffraction (XRD) analyses revealed the predominance of Ti oxides in the anatase and rutile phases, with rutile being more pronounced in samples processed at higher voltages [3]. Scanning electron micrographs showed that both the alloy microstructure and the applied voltage significantly influenced coating formation and morphology, with variations in pore size, shape, and interconnectivity [3]. Rockwell C microhardness tests demonstrated good film adhesion to the substrate under all conditions analyzed [3]. In biological assays, Ti-25Ta-xNb substrates (200–300 V) exhibited non-cytotoxic behavior toward stem cells and effective antibacterial activity against Escherichia coli, Staphylococcus aureus, Pseudomonas aeruginosa, and Enterococcus faecalis, with the Ti-25Ta-30Nb alloy treated at 300 V showing the most promising performance. These findings indicate that surface modification via MAO, combined with controlled Nb addition, produces coatings with excellent adhesion, biocompatibility, and antimicrobial properties. The authors acknowledge the financial support from the funding agencies FAPESP, CAPES, and CNPq.

1. *Review of micro-arc oxidation of titanium alloys: Mechanism, properties and applications.* Journal of Alloys and Compounds, 2023. **948**: p. 169773.
2. *A review—metastable β titanium alloy for biomedical applications.* Journal of Engineering and Applied Science, 2023. **70**(1): p. 1-36.
3. *Surface Characteristics of TiO2 Coatings Formed by Micro-Arc Oxidation in Ti-25Ta-x Nb Alloys: The Influence of Microstructure and Applied Voltage.* Coatings, 2025. **15**(6): p. 730.

9:20am **MD2-2-ThM-5 Pulsed Laser Deposited Electron-Rich Max Phases as Antibacterial, Anticorrosive Agents and Toxic Gas Detectors**, ***Sangeeta Kale [sangeetakale2004@gmail.com]***, *Revathi B.S., Piyush Shah,* Defence Institute of Advanced Technology (DIAT), India **INVITED**

MAX phases are layered ternary carbides and nitrides which exhibit both metallic and ceramic properties, demonstrating their promise for biomedical applications. Salient properties include high electrical conductivity, mechanically rigid, thermal and chemical stability, corrosion resistive, drug delivery agents and antibacterial nature. MAX, along with its derivative MXenes, show a plethora of applications which are under rapid investigations.

Considering the complex structure, achieving high-quality thin films of MAX phases is quite challenging. Of many techniques used, pulsed laser deposition (PLD) technique is one of the best routes for generating stoichiometric thin films, provided the substrates are carefully chosen. Through this work, we explore PLD of Titanium Aluminium Carbide (Ti_3AlC_2) MAX phase thin films on Silicon (100) substrate, focusing on film properties and possible applications. A KrF Excimer Laser (248 nm, 20 ns) was used to grow the film from MAX target. At 700°C, energy density ~2.5 J/cm^2, pulse repetition rate of 5 Hz, at chamber pressure of 1×Torr, 2000 Å films were grown.Uniform, pin-hole-free smooth films showed no indications of fragmented growth. Microscopic morphological studies hinted presence of free electrons on the film surface, which confirmed the metallic behaviour of the film on a semiconductor substrate. These stoichiometry-maintained micro-crystallites show large number of free electrons with intrinsic strain which could be explored for non-conventional device applications.

Through this talk, these films as anti-corrosive and anti-bacterial agents would be explored. Simple Salt-spray technique and both gram-positive and gram-negative bacterial agents would be used for these confirmations. Toxic chemical, Hydrazine, is evaluated against this MAX phase for its detection using simple potentiometric approach. These results would be elaborated using structure-property relationships.

References:

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4. Comparative evaluation of MAX, MXene, NanoMAX, and NanoMAX-derived-MXene for microwave absorption and Li ion battery anode applications, Arundhati Sengupta et.al., Nanoscale, 12, 8466, **2020**

10:20am **MD2-2-ThM-8 Dislocation-Mediated Plasticity and Strain Localization in Transition Metal Nitrides: Insights from Micropillar Compression**, ***Rainer Hahn [rainer.hahn@tuwien.ac.at]***, CDL-SEC, TU Wien, Austria; *Peter Polcik, Szilard Kolozsvari,* Plansee Composite Materials GmbH, Germany; *Klaus Boebel,* Oerlikon Surface Solutions AG, Liechtenstein; *Helmut Riedl,* CDL-SEC, TU Wien, Austria **INVITED**

Transition metal nitrides are key materials in advanced protective and functional coatings, yet their mechanical response is often constrained by intrinsic brittleness. Recent studies show that defect engineering and electronic structure control can fundamentally alter this behavior, enabling metallic-like plasticity in selected compounds. In this work, we employ in-situ micropillar compression to investigate the deformation mechanisms of epitaxial TiN, CrN, and WN thin films. Despite their structural similarity, these nitrides exhibit strikingly different responses under load. TiN and CrN deform through slip-band formation and early strain localization, indicating limited dislocation mobility and a strong tendency toward brittle failure. In contrast, WN displays pronounced metal-like plasticity, sustaining large plastic strains through dislocation glide and interaction processes more typical of metallic systems. These findings demonstrate how compositional tuning and bonding character influence the transition from brittle to ductile behavior in refractory nitrides. The results establish in-situ micropillar compression as a powerful tool to uncover intrinsic deformation pathways and identify WN as a key model system bridging metallic and ceramic mechanical responses.

11:00am **MD2-2-ThM-10 Biofunctional Zinc Phosphate-Loaded Membranes as a Potential Anti-Biofilm and Remineralizing Approach for Caries Management**, ***Gina Prado-Prone [gpradoprone@comunidad.unam.mx]***, *Lorena Reyes-Carmona, Lizeth A. González-Vargas,* Laboratorio de Biointerfases, DEPeI, Facultad de Odontología, Universidad Nacional Autónoma de México; *Phaedra S. Silva-Bermudez,* Unidad de Ingeniería de Tejidos, Terapia Celular y Medicina Regenerativa; Instituto Nacional de Rehabilitación Luis Guillermo Ibarra Ibarra, Mexico; *Sandra E. Rodil,* Instituto de Investigaciones en Materiales, Universidad Nacional Autónoma de México; *Nicola Cioffi,* Dipartimento di Chimica, Università degli Studi di Bari Aldo Moro, Italy; *Camila A. Zamperini Zamperini,* Department of Restorative Dentistry, College of Dentistry, University of Illinois Chicago, USA; *Argelia Almaguer-Flores,* Laboratorio de Biointerfases, DEPeI, Facultad de Odontología, Universidad Nacional Autónoma de México

Introduction: Dental caries is the most common oral disease, mainly caused by persistent cariogenic biofilm on dental surfaces. The acidic environment created by acid-producing and acid-tolerant bacteria leads to dental demineralization and, ultimately, caries formation. The most important strategies in cariology currently focus on preventing caries and treating early-stage lesions by inhibiting biofilm formation and optimizing tooth health remineralization. Therefore, developing novel antibiofilm and remineralizing anti-caries biomaterials has great potential to enhance caries prevention and treatment.

Objectives: To develop zinc phosphate (ZnP)-loaded membranes and evaluate their capacity to prevent dental caries-related biofilms and promote dental remineralization.

Methods: ZnP microparticles were synthesized via chemical precipitation. Membranes were synthesized via electrospinning a polycaprolactone-gelatin blend (1:1) incorporating ZnP microparticles at 1%, 2%, and 5% (w/w) concentrations. The micro-morphology, chemical composition, wettability, and thermal properties were analyzed using SEM, EDS, FTIR, WCA, TGA, and DSC. The *in vitro* anti-biofilm effect was evaluated by turbidity and Alamar Blue assays using four bacteria associated with caries: *Streptococcus mutans* (25175™ATCC®), *Streptococcus sanguinis* (110556™ATCC®), *Lactobacillus acidophilus* (4356™ATCC®), and *Veillonella parvula* (17745™ATCC®). To assess the remineralization potential of the experimental membranes in *in vitro* root caries lesions, human root dentin specimens were slightly demineralized and exposed to the membranes under remineralization cycling. The mineral density, depth, and porosity of the final root caries lesions were assessed by computer microtomography and confocal scanning laser microscopy after rhodamine infiltration.

Results: Membranes exhibited a microfibrillar structure with interconnected porosity and desirable physico-chemical properties for clinical applications. Antibacterial testing showed 44-80% inhibition of biofilm formation of the four bacterial strains on the ZnP-membrane surfaces; the antibiofilm effect appears to depend on the ZnP concentration. The 5% ZnP-loaded membranes exhibited a more favorable pattern of remineralization for *in vitro* root caries treatment, but there were no statistically significant differences in caries depth and porosity among groups ($p \geq 0.05$).

Conclusions: ZnP-loaded membranes can potentially be used as an anti-biofilm and remineralizing approach for dental caries management.

Acknowledgements: This work was funded by the UI System/UNAM Joint Research Partnership Program, and the UNAM-PAPIIT #TA100424 and #IN207824 projects.

11:20am **MD2-2-ThM-11 Growth Mechanism and Cellular Response to Film Thickness Variations of Nanoporous Alkaline Titanate-Converted, Magnetron Sputtered Ti Thin Films***, **Matthew Wadge [m.wadge@mmu.ac.uk]**,* Manchester Metropolitan University, UK*; Kozim Midkhatov,* University of Manchester, UK*; Jonathan Wilson, Louise Briggs, Timothy Cooper, Zakhar Kudrynskyi,* University of Nottingham, UK*; Reda Felfel,* University of Strathclyde, UK*; Ifty Ahmed, Colin Scotchford, David Grant,* University of Nottingham, UK*; Justyna Kulczyk-Malecka,* Manchester Metropolitan University, UK*; Mahetab Amer,* University of Manchester, UK*; Peter Kelly,* Manchester Metropolitan University, UK

The standard process for improving bioactivity of implant surfaces for natural fixation is reliant on high temperature (>1500 K) plasma spraying of hydroxyapatite (HA) [1]. However, these surfaces have been shown to spall due to their brittle nature, high internal stresses, and weak mechanical adhesion [1]. Bioactive titanate surfaces have been developed as a low-temperature, more simplistic alternative, however, their applicability is limited to titanium (Ti) and its alloys only via chemical conversion routes [1]. The present authors previously demonstrated the applicability of titanate surfaces generated from PVD Ti coatings [2], however, assessment of thickness variation on cellular performance is still required, due to potential unwanted effects such as poor cellular proliferation. This paper highlights for the first time the cellular performance of titanate films generated on various thicknesses of Ti coating. By varying the thickness of the PVD deposited Ti coating, one can influence the formation mechanism of the wet-chemically derived titanate surface produced, since the mechanism is diffusion dependant and material limited.

Magnetron sputtering was employed to generate the Ti coatings (ca. 50, 100, 200, 500 nm) owing to its excellent step coverage, relatively quick deposition rate, ability to coat onto, and from, a wide variety of materials. In the conversion process, Ti coatings are treated in NaOH (5 M; 60 ºC; 24 h) to generate sodium titanate structures [1]. The resultant materials were characterised using SEM, EDX, XPS, XRD, as well as cellular assessments, in order to understand the formation mechanism, the resultant morphological (Fig.1&2), structural (Fig.3) and chemical (Fig.4) properties, as well as influence on cellular response. It was clear that the Ti coatings exhibited good step coverage. Following titanate formation, only the 200 and 500 nm coatings produced the characteristic nanoporous 'webbed' titanate structures, due to the lack of free Ti in the coating, as opposed to the conventional diffusion limitation (Na and O) of the titanate mechanism. Both XPS and XRD analyses confirmed the formation of titanate on all of the coatings tested, despite the morphological differences and irrespective of thickness. Through utilising sputtering, the applicability of these titanate materials in a biomedical context can be significantly improved due to its ability to coat most materials and matching the subsequent wet-chemical temperature conditions.

References

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[2] M. Wadge, et al., Journal of Colloid and Interface Science, 566, 271-283, 2020

11:40am **MD2-2-ThM-12 Antibacterial Performance of Electrodeposited Copper Coatings on Titanium Alloy Surfaces for Biomedical Applications***, **Bryan Angel Zárate Verduzco [1629251c@umich.mx]**,* Universidad Michoacana de San Nicolás de Hidalgo, Mexico*; Victor Manuel Solorio García, Miguel Ivan Dávila Perez,* Tecnologico Nacional de México/ Instituto Tecnológico de Morelia, Mexico*; Roberto Guerra González, Sandra Edith Lopez Castañeda, Alfonso Lemus Solorio, Maria Guadalupe Carreon Garcidueñas,* Universidad Michoacana de San Nicolás de Hidalgo, Mexico

The increasing incidence of implant-associated infections underscores the urgent need for effective antibacterial surface modifications that prevent biofilm formation without compromising the mechanical integrity of metallic implants. In this study, copper (Cu) coatings were electrodeposited onto Ti6Al4V alloys fabricated by powder metallurgy to impart bacteriostatic functionality and inhibit microbial colonization. Controlled deposition was performed at varying durations (1 min, 5 min, 15 min, 1 h, and two h). Surface morphology and composition were characterized by scanning electron microscopy (SEM) and energy-dispersive spectroscopy (EDS), revealing dense, adherent Cu layers whose thickness increased proportionally with deposition time. Microbiological assays against Staphylococcus aureus (MRSA) and Escherichia coli demonstrated over 99% reductions in bacterial viability after 24 h, along with marked suppression of biofilm development and maturation on the coated surfaces. The antibacterial mechanism was attributed to the controlled release of Cu^{2+} ions, which induces an oligodynamic effect on bacterial membranes and interferes with early-stage adhesion and extracellular matrix formation. These results confirm that electrodeposited Cu films on Ti6Al4V represent a cost-effective, scalable, and environmentally responsible route toward infection-resistant implants. This approach provides a promising alternative to conventional antibiotic prophylaxis, supporting the development of next-generation biomaterials designed to reduce post-surgical infections and improve the long-term safety and performance of metallic implants.

12:00pm **MD2-2-ThM-13 Low-Pressure Plasma Processes for the Deposition of Adherent Diamond-Like Carbon Coatings on Titanium Alloys for Biomedical Applications***, Chloé Audet, **Pascale Chevallier [pascale.chevallier@crchudequebec.ulaval.ca]**,* Laboratory for Biomaterials and Bioengineering, (CRC-Tier I), Dept Min-Met-Materials Eng., & Regenerative Medicine, CHU de Quebec, Laval University, Canada*; Sandra Rubio,* Laboratoire Interdisciplinaire de Spectroscopie Electronique, Namur Institute of Structured Matter, University of Namur, Belgium*; Andranik Sarkissian,* Plasmionique Inc, Canada*; Laurent Houssiau,* Laboratoire Interdisciplinaire de Spectroscopie Electronique, Namur Institute of Structured Matter, University of Namur, Belgium*; Diego Mantovani,* Laboratory for Biomaterials and Bioengineering, (CRC-Tier I), Dept Min-Met-Materials Eng., & Regenerative Medicine, CHU de Quebec, Laval University, Canada

Titanium and its alloys are widely recognized as the gold standard for bone contact implants due to their suitable mechanical properties and biological performances. However, their long-term clinical performance remains impaired, mainly due to insufficient integration with surrounding tissues and the risk of infection. In order to enhance their performance, surface modification through coatings are explored. Among these coatings, diamond-like carbon (DLC) has emerged as a promising material due to its superior mechanical properties, chemical inertness, and stability, as well as its ability to integrate antibacterial agents such as Ag, ZnO, etc., resulting in a multifunctional coating. However, due to the high intrinsic stresses of DLC compared to the native oxide layer, the adhesion of DLC to metallic surfaces remains rather low. Therefore, this work focuses on improving DLC adhesion to the Ti alloy surface using plasma-assisted chemical vapor deposition (PECVD), by optimizing different surface pretreatments prior to coating. The results showed that the nature and duration of the pretreatment significantly influenced the chemical composition and topography of the substrate prior to deposition, which in turn had an impact on the thickness, structure and morphology of the DLC. Short methane carburizing, particularly for 10 min, appeared to be the most effective pretreatment, as it removed the native oxide layer, enhanced carbon implantation, led to thick, adherent DLC coatings with a diamond-like structure, and stable even after 7 days of aging in pseudo-physiological conditions. In contrast, argon etching alone was ineffective, and combining both treatments yielded thinner films.

Controlled plasma carburization prior to DLC deposition significantly improves coating adhesion and stability on Ti alloys, paving the way for improved implant performance. The addition of antibacterial agents within the DLC matrix could further improve clinical outcomes of implants and reduce implant-associated infections.

Keywords: Surface modification, plasma-enhanced chemical vapor deposition, diamond-like carbon, Ti-alloy medical implant.

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