


Editorial

Metallic Biomaterials Surface Engineering

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Metals are widely used as biomaterials due to their good thermal conductivity and mechanical and surface properties. They can be used to repair bone tissues through the osseointegration process, a fundamental and necessary functional mechanism of connection between the bone tissue and the metallic prosthesis, without which the surgery would fail. At the same time, metallic biomaterials can be applied to repair soft tissues or relieve drugs. In any case, the device surface plays a paramount role in the surgery success. Nowadays, the research into new metallic alloys, new functional surface modifications and coatings, new texturing and shaping technologies have gained great interest in both the academic and industrial fields.

This book aims to report the state-of-the-art in the field by highlighting the most recent applications and technologies adopted. For this reason, the papers focused on several and different aspects such as the designing of new metallic materials with a lower Young modulus highlighting the correlation between structure and surface properties, as well as the surface modifications to obtain device antibacterial activity, improved cellular adhesion properties and drug delivery ability.

The stress-shielding phenomenon is the main limit of the metallic biomaterials, often characterised by a higher Young modulus than the bone tissue. To reduce the Young modulus, the alternatives are basically to change the device shape or its chemical composition. From this perspective, Trueba et al. [1] produced and characterised porous Ti cylinders using a simple and economical freeze-casting technique, achieving the biomechanical and biofunctional balance required for improved and successful osseointegration. Imai et al. [2] presented the great potentials of two kinds of bulk metallic glasses (BMGs), Zr-based and Ti-based BMGs, metallic materials with metastable glassy states. These so-called amorphous alloys are characterised by higher strength, higher elasticity, higher failure resistance, and lower Young's modulus than crystalline alloys. In addition, the amorphous alloys showed excellent mechanical properties and corrosion resistance. Tuminoh et al. [3] studied new absorbable materials for biomedical applications made of CNF-reinforced Mg–Zn composites, finding the optimum process parameters to obtain a high elastic modulus, hardness, and degradation resistance. The interest to reduce the elastic modulus has encouraged the research also on the development of β -type titanium alloys, adding specific amounts of β stabilisers, characterised by a higher corrosion resistance and mechanical properties than α -type and $\alpha + \beta$ -type Ti alloys.

On the other hand, Shimabukuro et al. [4] investigated the biological responses, the surface compositions, and metal ion release behaviours of alloying elements β -type Ti alloys, Nb, Ta, and Zr, compared with Ag, evaluating the bacteria and osteogenic cells adhesion. The Ag specimen inhibited both cellular viability and bacterial adhesion due to Ag ion release. In comparison, Nb and Ta specimens inhibited only bacterial adhesion and exhibited no harmful effects on cellular viability. Therefore, Nb and Ta are useful as non-cytotoxic antibacterial elements.

The additive manufacturing technologies could allow designing new β -type titanium alloys, as Chen et al. [5] reported. He focused on developing biomedical β -type Ti alloys. The author underlined the two methods often used to predict the β -phase stability of new



Citation: Monetta, T.; Acquesta, A. Metallic Biomaterials Surface Engineering. *Metals* **2021**, *11*, 1366. <https://doi.org/10.3390/met11091366>

Received: 26 July 2021

Accepted: 12 August 2021

Published: 30 August 2021

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β -type Ti alloys, the molybdenum equivalency (Moeq) and the DV-X molecular orbital have emerged. On the other hand, the as-built parts produced by additive manufacturing technologies have to be submitted to surface treatments due to their poor quality, as discussed by Acquesta et al. [6]. The author investigated the effects of surface characteristics on morphological and corrosion resistance of the titanium alloy Ti-6Al-4V parts fabricated by the new additive manufacturing technologies and highlighted the need to allow their safe use in biomedical applications.

The surface treatments were the topic also discussed by Javier Gil et al. [7], who designed a potential new bactericide treatment for NiTi orthodontic archwires through silver nanoparticles electrodeposition to prevent the accumulation of dental plaque and the development of dental caries during orthodontic treatment and Pan et al. [8], who studied the effects of low-temperature plasma (LTP) treatments on Ti surfaces, evaluating the surface properties, the porphyromona gingivalis adhesion, as well as colony formation on surfaces. The results demonstrated that the LTP is beneficial due to the low microbial adhesion levels and a reduced incidence of inflammatory conditions.

The magnesium alloys should be ideal candidates for biodegradable metallic devices, but the high corrosion rate limits their applications. Thus, surface treatments are needed to reduce the corrosion rate. Monetta et al. [9] reviewed the latest state-of-the-art on the control of the degradation rate of magnesium alloys anodised through plasma electrolytic oxidation (PEO) treatment. From the review emerged the new way to perform the PEO treatment applying an alternate current in pulsating conditions, resulting in the optimisation of the oxide anodic thickness and the corrosion rate.

The metallic biomaterial can be used as a drug reservoir. Golgovici et al. [10] presented several experimental results regarding the electrodeposition of polypyrrole and polypyrrole-indomethacin coatings on nickel-chromium NiCr alloy substrates widely used in dentistry involving deep eutectic solvent-based electrolytes. The synthesised polypyrrole coating layers acted as an active reservoir for indomethacin, belonging to the non-steroidal anti-inflammatory class of drugs.

We hope that this book will contribute to deepening the topics still open to the academic and industrial world by showing new ways and technologies for the properties' optimisation of metallic biomaterials.

Conflicts of Interest: The authors declare no conflict of interest.

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