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Bioactive coatings on double depth laser-textured zirconia substrates: mineralization behaviour and cell adhesion

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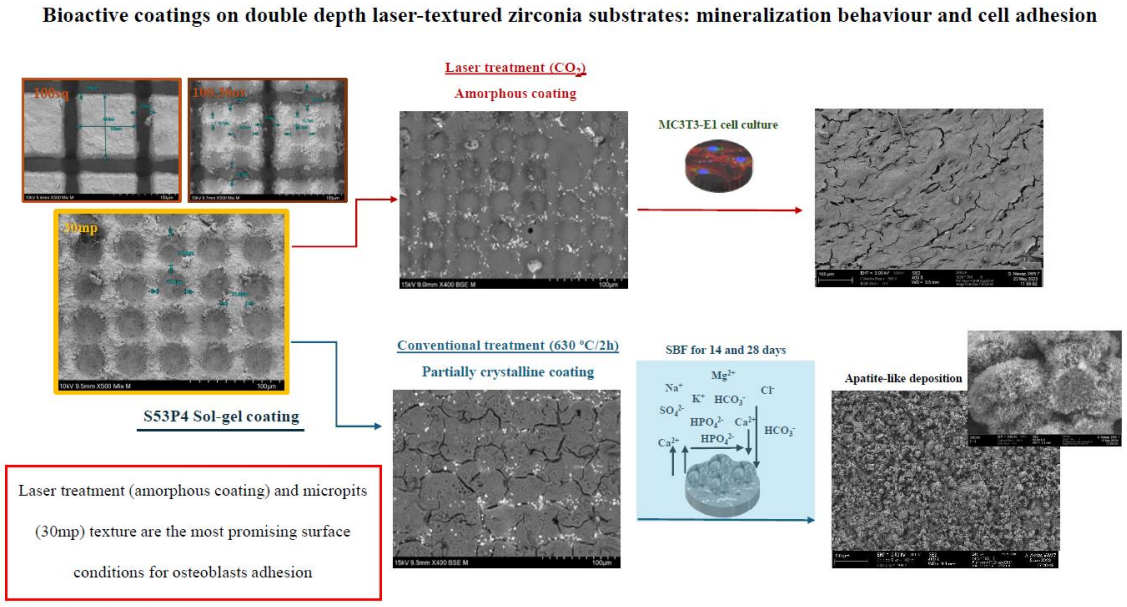

Abstract

Commercial zirconia dental implants have a well stablished surface treatment to improve osseointegration based on grit-blasting and acid-etching procedures. Recently, laser surface texturing (LST) has emerged as an eco-substitute for commercial procedures. Furthermore, LST allows the creation of designed textures, that have been proving their potential to improve

osseointegration. Different textures lead to different outcomes, and defining which texture maximizes the implant osseointegration is an emergent challenge, due to the complex balance between promoting cellular activity and mineralization behaviour.

In this study, three different textures were successfully designed and obtained via LST: i) a cross-linked groove texture with squared ridges of 100 μm, groove width of 30 μm and 100 μm of depth; ii) a micro pit texture with aligned spots with 35 μm diameter, spaced by 15 μm and 30 μm depth; Finally, the third texture consisted of the overlap of the previous textures, resulting in six micro pits per squared ridge.

Then, the samples were coated with S53P4 Bioactive Glass and submitted to two different thermal treatments: conventional treatment (CT), in a furnace at air (temperature of 630ºC and holding time of 2 hours) and laser treatment (LT). The CT resulted in a partially crystalline coating, while LT coating exhibited a more amorphous composition.

In terms of mineralization behaviour, the partially crystalline coatings, obtained by CT, achieved more apatite-like deposition after immersion for 14 and 28 days in SBF than the amorphous LT coatings, which is in accordance with Leena Hupa studies [1]–[3]. Furthermore, surface topography also proved to affect the samples mineralization behaviour, since the texture of micro pits, for both thermal treatments, presented higher apatite-like deposition.

Regarding cellular activity tests, LT samples achieved higher cell adhesion and viability results when compared to CT samples. The overlapped texture showed promising results, but the most coherent results were found for the micro pits texture, exhibiting high cellular viability and adhesion, pointing to geometric features with close dimensions of osteogenic cells as the ideal ones to promote osseointegration, which is in accordance with Staehlke et al. [4] and Anselme et al. [5] findings.

This study developed a system that brought together the physical and chemical factors of functionalized zirconia surfaces, thereby confirming the superior mineralization behaviour for partially crystalline coatings and suggesting micro pit texture as the ideal one to promote osseointegration.

References:

[1] S. Fagerlund, J. Massera, N. Moritz, L. Hupa, and M. Hupa, "Phase composition and in vitro bioactivity of porous implants made of bioactive glass S53P4," Acta Biomater., vol. 8, no. 6, pp. 2331–2339, 2012, doi: 10.1016/j.actbio.2012.03.011.

[2] L. Aalto-Setälä, P. Uppstu, P. Sinitsyna, N. C. Lindfors, and L. Hupa, "Dissolution of amorphous s53p4 glass scaffolds in dynamic in vitro conditions," Materials (Basel)., vol. 14, no. 17, pp. 1–14, 2021, doi: 10.3390/ma14174834.

[3] L. Aalto-Setälä, M. Siekkinen, N. Lindfors, and L. Hupa, "Dissolution of Glass–Ceramic Scaffolds of Bioactive Glasses 45S5 and S53P4," Biomed. Mater. Devices, no. 0123456789, 2023, doi: 10.1007/s44174-022-00059-4.

[4] S. Staehlke, P. Oster, S. Seemann, F. Kruse, J. Brief, and B. Nebe, "Laser Structured Dental Zirconium for Soft Tissue Cell Occupation—Importance of Wettability Modulation," Materials (Basel)., vol. 15, no. 3, 2022, doi: 10.3390/ma15030732.

[5] K. Anselme, L. Ploux, and A. Ponche, "Cell/Material Interfaces: Influence of Surface Chemistry and Surface Topography on Cell Adhesion," J. Adhes. Sci. Technol., vol. 24, no. 5, pp. 831–852, Jan. 2010, doi: 10.1163/016942409X12598231568186.