Bio-compatibility enhancement of a Zr-based bulk metallic glass using nanosecond laser surface texturing

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The consideration of bulk metallic glasses (BMGs) for biomedical applications, ranging from orthopaedic, cardiovascular and dental implants to surgical devices, has gained momentum in recent years [1]. This is due to the remarkable mechanical and chemical properties of BMGs. These include low elastic modulus [2], high wear resistance [3], good corrosion resistance [4], and favourable processing capabilities for producing micro and nanoscale features [5]. However, when exploring the possibility of using any alloy composition as implant material, ensuring bio-compatibility is a key consideration since the reaction of implants with the host tissue determines their long-term performance. Surface treatments, such as coating [6], ion implantation [7] and laser surface texturing (LST) [8], have been successfully applied on traditional biomedical alloys, especially titanium alloys, to enhance their bio-compatibility. Among these methods, LST has been reported as a promising technique for the modification of the surface properties of biomaterials due to its unique characteristics of flexibility, simplicity, controllability and reproducibility [9]. In addition, LST has also been shown to avoid the introduction of toxic substances on processed surfaces [10]. In the research presented here, LST was employed to fabricate two types of textures, dimple and groove, on a Zr-based BMG, commonly known as Vitreloy 105. The surface topography, chemical composition and wettability of processed surfaces were evaluated via non-contact three-dimensional confocal microscopy, scanning electron microscopy, X-ray photoelectron spectroscopy and contact angle measurements. The cellular response of MG63 pre-osteoblasts cell lines to laser textured surfaces was investigated via cell viability tests, cell attachment and cell morphology observations using specific instruments and test formats. The underlying mechanism induced by LST on the bio-compatibility enhancement of the Zr-based BMG substrate was also investigated from different perspectives, which include surface chemistry, wettability and surface roughness modifications.

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