Surface functionalization of Zr-based bulk metallic glasses

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Abstract: Metallic glasses are recent materials. First developed in the 60s, they are well-known for their high mechanical resistance and their ability to become viscous at relatively low temperatures. Functionnalization of their surfaces is a promising way to further increase their functional properties such as controlled wettability, improved optical properties or controlled interaction with the body. However, their amorphous structure is in a metastable state and maintaining them at too high temperatures will irreparably leads to their crystallization, and thus the loss of their unique properties. Many surface treatments used for crystalline alloys such as surface melting and cladding, coating deposition by thermal spraying or heat treatment, induce a temperature rises at the surface and heat diffusion in the volume. Thus, they are not adapted to these materials. Thereby, two innovative techniques that are thermoforming and ultra-short pulse duration laser treatment have been used and may allow to texture material's surface by avoiding their crystallization. Thermoforming processing technique uses the thermomechanical properties of bulk metallic glasses to deform them in the viscous state, corresponding to its super-cooled liquid region ($T > Tg$). Good knowledge of the rheological properties of the glass, combined with controlled experimental conditions, allows the replication of micro or nanometric patterns with great precision while preserving the amorphous structure. Ultrashort pulse duration lasers allow the deposition of a large quantity of energy on highly localized areas in a very short time, thus limiting the heat transfer to the bulk of the irradiated material. This thesis is focused on the effect of these two surface processing techniques on physical and chemical properties of Zr-based bulk metallic glasses and thus on the modification of their surface properties such as wettability and corrosion resistance. We will see that both techniques present their advantages and can be particularly adapted for biomedical applications.