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Research paper

Enhanced mechanical properties and in vitro corrosion behavior of amorphous and devitrified $Ti_{40}Zr_{10}Cu_{38}Pd_{12}$ metallic glass

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ABSTRACT

The effects of annealing treatments on the microstructure, elastic/mechanical properties, wear resistance and corrosion behavior of rod-shaped $Ti_{40}Zr_{10}Cu_{38}Pd_{12}$ bulk glassy alloys, synthesized by copper mold casting, are investigated. Formation of ultrafine crystals embedded in an amorphous matrix is observed for intermediate annealing temperatures, whereas a fully crystalline microstructure develops after heating to sufficiently high temperatures. The glassy alloy exhibits large hardness, relatively low Young's modulus, good wear resistance and excellent corrosion behavior. Nanoindentation measurements reveal that the sample annealed in the supercooled liquid region exhibits a hardness value of 9.4 GPa, which is 20% larger than in the completely amorphous state and much larger than the hardness of commercial Ti–6Al–4V alloy. The Young's modulus of the as-cast alloy (around 100 GPa, as determined from acoustic measurements) increases only slightly during partial devitrification. Finally, the anticorrosion performance of the $Ti_{40}Zr_{10}Cu_{38}Pd_{12}$ alloy in Hank's solution has been shown to ameliorate as crystallization proceeds and is roughly as good as in the commercial Ti–6Al–4V alloy. The outstanding mechanical and corrosion properties of the $Ti_{40}Zr_{10}Cu_{38}Pd_{12}$ alloy, both in amorphous and crystalline states, are appealing for its use in biomedical applications.

1. Introduction

Owing to their excellent mechanical strength and resilience, metallic materials show a great potential for load-bearing orthopedic applications and are superior in many aspects to alternative biomaterials such as polymers and ceramics. To assure long life-time of the bone implant, biomaterials need to combine high strength with relatively low Young's modulus (as close as possible to the Young's modulus of bone). This avoids loosening of the implant, a biomedical incompatibility

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