Processing and properties of Zr-Co-Al bulk metallic glass for biomedical applications

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Amphithéâtre Rassat (Faculté biologie)

Jury:
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Monsieur Stéphane Gorsse, Maître de conférence à l'ICMCB Université de Bordeaux, examinateur
Monsieur Damien Fabregue, Prof. à MATEIS INSA Lyon, invité
Monsieur Nicolas Courtois, Directeur recherche et affaires cliniques chez Anthogyr, invité
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Abstract: The medical sector is currently facing a challenge regarding the miniaturization of biomedical devices. To allow for less invasive surgeries and safer procedures, there is a need to produce and characterize new materials such as metallic glasses with controlled properties. In this context, a ternary Zr-Co-Al metallic glass is synthesized and structurally characterised. In as-cast conditions, both corrosion and mechanical properties are studied. Thanks to polarisation tests or long-term immersion, it is shown that the studied glass satisfies the medical standards and that cobalt plays a key role in the corrosion mechanism. Thanks to specific fatigue tests, it is demonstrated that the Zr-Co-Al metallic glass meets also the requirements of the medical standard. Compression tests are analysed thanks to a serrated flow analysis considering shear band dynamic in two regimes: a steady propagation regime followed by a catastrophic one. This modified approach to the serrated flow analysis brings interesting information, complementary to the more spread self-ordered criticality approach. Contrasting with the literature, the unusual stability of the glass transition temperature with heating rate, leading to high activation energy toward structural reorganisation, is also reported. Attempts to modify the energy state of the glass are carried out by performing relaxation and rejuvenation treatments. The sensitivity of the studied Zr-Co-Al is compared to the one of Zr-Cu-Al BMGs and the observed differences support the idea of differences in structural heterogeneities between these glasses. Additionally, we demonstrate that rejuvenation by cyclic loading under the yield stress can enhance the plasticity of the Zr-Cu-Al-based BMG. Finally, the effect of minor alloying (substitution of Zr by Nb) on mechanical and corrosion properties is also investigated, underlining the importance of the alloying route.