Impact of alloying on properties and oxidation resistance of magnetron sputtered Zr–Hf–Cu based metallic glasses

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1 Introduction

Thin-film metallic glasses are a class of metallic alloys with an amorphous disordered structure and a viscous flow in the super-cooled liquid region. Their extraordinary properties make them promising for widespread applications, e.g. microelectromechanical systems, diffusion barriers, surface modification of crystalline materials. One of the prerequisite to use them at elevated temperatures in air is their sufficient oxidation resistance.

2 Results

Recently, we have showed that a gradual substitution of Hf for Zr in ternary Zr–Hf–Cu thin-film metallic glasses prepared by magnetron co-sputtering allowed us to tune their mechanical properties and glass transition temperature (Zítek et al. (2018)). In the present study,

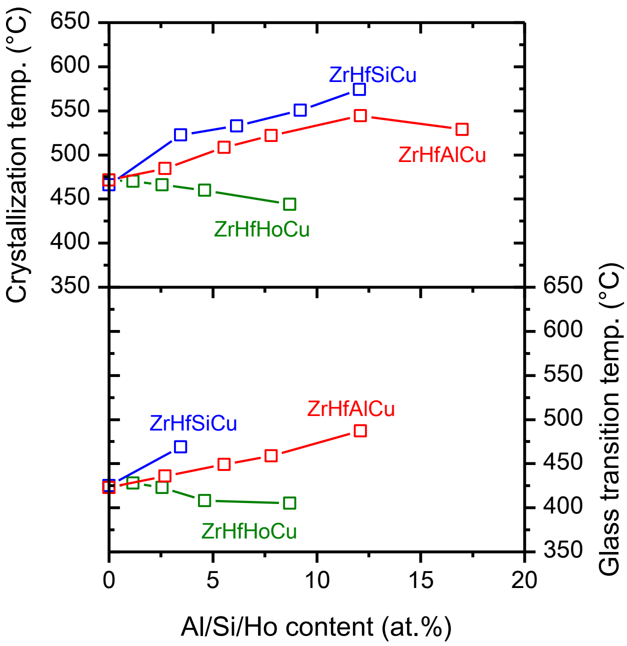

Figure 1: Crystallization temperature and glass transition temperature of the Zr–Hf–X–Cu thin films (X = Al, Ho, Si).

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we focus on alloying of the Zr–Hf–Cu thin-film glasses with additional elements (X = Al, Ho, Si) up to ~15 at.% and investigation of a possibility to further tune or enhance their mechanical and thermal properties, and oxidation resistance. The films were deposited using four unbalanced magnetrons equipped with Zr, Hf, X and Cu targets in pure Ar. The magnetrons with the Zr, Hf and X targets were operated in a dc regime while the magnetron with the Cu target in a high-power impulse regime. The Zr, Hf, X and Cu contents in the films were controlled by adjusting the dc powers and the average target power in a period, respectively. The films were deposited without substrate bias voltage and external heating onto rotating substrates.

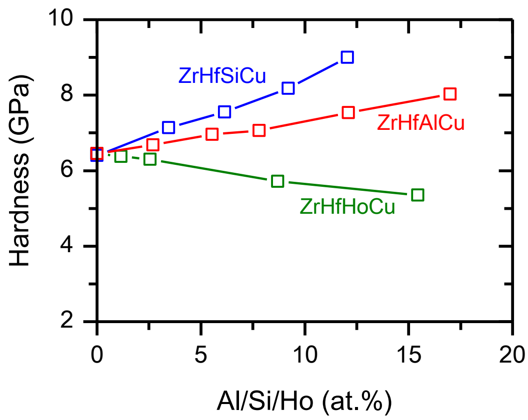

Figure 2: Hardness of the Zr–Hf–X–Cu thin films (X = Al, Ho, Si).

All Zr–Hf–X–Cu films investigated (up to ~15 at.% X) exhibit an X-ray amorphous structure. The glass transition detected by differential scanning calorimetry can be, however, recognized only to about 3.5 at.% Si, 9 at.% Ho and 12 at.% Al. The glass transition temperatures and crystallization temperatures are shown in Figure 1. An alloying with Al or Si enhances the mechanical properties of the films (see Figure 2) and the thermal stability of their amorphous state while an alloying with Ho is detrimental in this respect. In addition, Al or Si extend the width of the super-cooled liquid region of the alloys and maintain their high oxidation resistance even in the super-cooled liquid region.

References

Zítek M., Zeman P., Zuzjaková Š., Kotrlová M., Čerstvý R. (2018) Tuning properties and behavior of magnetron sputtered Zr-Hf-Cu metallic glasses, *J. Alloys Compd.*, Volume 739, pp. 848-855.