Surface hardening of Zr-Cu based bulk metallic glasses using gaseous thermochemical treatment

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Abstract

Gaseous thermochemical surface treatment is commonly applied for enhancing the metallic material performance with respect to their wear, tribological and corrosion resistance. In thermochemical processing, interstitial elements are introduced in the metallic substrate at elevated temperatures in order to deliberately change the chemical composition of the surface. Amorphous multi-component metallic systems, viz. bulk metallic glasses have been extensively researched in the past decades due to their promising structural capabilities in engineering applications. The present research investigates thermochemical treatment by gaseous oxidizing of Zr-Cu based bulk metallic glass systems with high glass forming ability. The metallic glass systems are treated below their glass transition temperatures in atmospheres imposing high oxygen partial pressures. X-ray diffraction analysis, light optical microscopy (LOM), scanning electron microscopy (SEM) coupled with energy dispersive spectroscopy (EDS) and microhardness testing were utilized for evaluating the hardened oxygen-containing case developed during the treatment. The oxide layer was found to consist of two different layers, an outer layer comprised of copper oxide islands due to the outward diffusion of Cu and an inner layer consisting of different oxide zones. For all the studied Zr-Cu based BMGs, the inner oxide layer mostly consists of tetragonal ZrO2 and minor amounts of CuO, Al2O3 and monoclinic ZrO2. In silver containing BMG, a small fraction of expelled non-oxidized silver, as a consequence of volume and thermal expansion, can be seen on the top surface which is covered by copper oxide particles. The surface hardness of thermochemical treated BMG samples reached approximately 1200 HV (except Ag containing Zr- based BMG). The results shows that a homogenous hardened case can be achieved after conducting gaseous thermochemical treatment without devitrification of the amorphous substrate.

Keywords: ZrCu bulk metallic glasses, Gaseous thermochemical treatment, Surface hardness

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