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Increasing fracture strength in bulk metallic glasses using ultrasonic nanocrystal surface modification

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ABSTRACT
Microstructure inhomogeneity is imparted into the surface of a Vit1b Zr-based bulk metallic glass (BMG) using ultrasonic nanocrystal surface modification (UNSM). As a result, compressive residual stresses with a maximum magnitude of 1130 MPa were induced in the near-surface region. Substantial improvements in both fracture strain and strength were observed for the treated specimen in three-point bending tests. The microstructure inhomogeneity and free volume generated by severe plastic deformation resulted in increased shear band density during three-point bend tests, which is evidenced by the vein-like pattern observed on the fracture surface of the treated specimen. Moreover, the enrichment of shear bands can cause the interaction between shear bands and can thus obstruct their propagation, leading to work-hardening behavior. High magnitude compressive residual stresses are also believed to impede and slow down the propagation of the shear bands. The synergistic effect of induced inhomogeneity, increased free volume and compressive residual stresses improves the fracture stress and strain of the UNSM-treated BMG.

KEYWORDS: Ultrasonic nanocrystal surface modification (UNSM); Bulk metallic glasses; Fracture strength; Compressive residual stress; Shear bands propagation; Molecular dynamics simulation

1. INTRODUCTION

The amorphous atomic structure of bulk metallic glasses (BMGs) gives rise to unique mechanical properties including, high elasticity, high hardness, superior wear resistance and corrosion resistance [1–5]. Due to these exceptional properties, BMGs are envisaged favorably for many functional and structural applications [4–6]. The amorphous structure of BMGs, however, also leads to extremely low ductility due to the lack of work-hardening during plastic deformation. The uncontrolled propagation of shear bands during deformation often leads to