Spallation behavior of bulk metallic glasses

L.H.Dai*, X.Huang, Z.ling

*State Key Laboratory of Nonlinear Mechanics, Institute of Mechanics, Chinese Academy of Sciences, Beijing 100190, China

Keywords: Plate-impact experiments, Spallation, Metallic glasses, Free volume.

Abstract

Spallation experiments have been conducted on a typical Zr-based bulk metallic glass (BMG) using a single-stage light gas gun. With a multi-stress pulse technique [1] and specially designed double flyers, samples are subjected to dynamic tensile loadings of identical amplitude (~3.2 GPa) but with different durations (~102 ns) to uncover the damage evolution process. Equiaxed cellular patterns and ductile damage zones are observed on the spalled surfaces and the cross-sections of recovered samples. It is revealed that the spallation in BMGs originates from nucleation, growth and coalescence of micro-voids. Based on the free-volume theory, we propose a micro-void nucleation model of bulk amorphous alloys [2], which indicates that the nucleation of microvoids at the early stage of spallation in BMGs results from diffusion and coalescence of free volume. And an explicit expression for the void nucleation rate is presented. Furthermore, to reveal the mechanism of void growth during the spallation process in BMGs, a theoretical description of void growth undergoing remote hydrostatic tension is presented [3]. The critical pressure for cavitation instabilities and a dimensionless number characterizing the competition of inertial effects, loading rate effects and viscous effects are derived. Numerical simulations indicate that inertial effects can induce vibration of the void growth rate at the rise stage of loading history and impede the growth at the steady stage. And the viscous effects will induce higher growth rate and disappearance of vibrating growth.

[1] Y.L.Bai, Z.Ling, L. Luo, F.J.Ke, micro damage under impact loading, ASME Journal of Applied Mechanics, 59 (1992) 622-627.

[2] X. Huang, Z. Ling, H.S. Zhang, J. Ma, L.H. Dai, How does spallation microdamage nucleate in bulk amorphous alloys under shock loading, Journal of Applied Physics, 110 (2011) 103519.

[3] X. Huang, Z. Ling, L.H. Dai, Cavitation instabilities in bulk metallic glasses, *International Journal of Solids and Structures*, in press (2013)