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# Dynamic behavior of ZrCuAl Bulk Metallic Glasses under high pressure and high strain rate induced by laser shock

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## Abstract

High Velocity debris shielding is of concern since the amount of orbiting space objects is continuously increasing. Thus, the space industry is always searching for innovative and effective materials combining high mechanical properties and lightweight. The Bulk Metallic Glasses family appears to be suitable for such applications. Therefore, the suitability of a ternary  $Zr_xCu(90-x)Al_{10}$  Bulk Metallic Glass (with  $x=45, 50, 55, 60$ ) is investigated by characterizing its dynamic behavior at high pressure and high strain rate ( $10^7$ - $10^8$  1/s). Laser irradiation of various pulse durations (350 fs, 600 ps and 5 ns) were used to generate different shock waves profiles to study the strain rate dependency on the spalling process. Ejecta velocities were measured for several sample thicknesses and pulse durations by Photonic Doppler Velocimetry and transverse shadowgraphy. Spall velocity diagram for 350 fs shots emphasize two distinct velocity domains that may be attributed to a rheological/material behavior change. Scanning Electron Microscopy observations performed on the recovered fracture surfaces highlight the presence of a peculiar feature known as "Cup and Cone". The presence of cups and cones and their morphologies are revealed to be strongly strain rate and compositional dependent. This last dependency can be correlated to specimens Poisson's ratios that are known to have a role on the fracture behavior of Bulk Metallic Glasses. Furthermore, cups are found on sample while cones are observed on spall. By investigating the cups and cones morphologies, two distinct regions are observed: a smooth viscous-like in the center and a flat peripheral one with a large vein-pattern. Energy Dispersive Spectroscopy measurements conducted on these features bring an atomic segregation out taking place during spallation. A mechanism for the initiation and the growth of these cups and cones but also a process for atomic segregation during spallation will be presented.

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**Keywords:** Bulk Metallic Glasses, Dynamic Behavior, Laser Shock, Spallation