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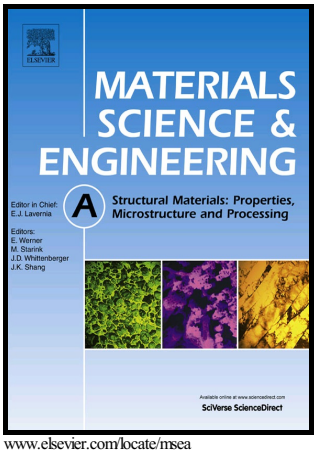

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Effect of Zirconium Purity on the Glass-Forming-Ability and Notch Toughness of $Cu_{43}Zr_{43}Al_7Be_7$

Laura M. Andersen^, Douglas C. Hofmann[∇], and Kenneth S. Vecchio^*

^Department of NanoEngineering, University of California, San Diego, 9500 Gilman Drive, La Jolla, CA
[∇]Materials Development and Manufacturing Technology Group, NASA Jet Propulsion Laboratory/California Institute of Technology, MS 18-105, 4800 Oak Grove Dr. Pasadena, CA, 91109

*Corresponding author.
E-mail address: kvecchio@ucsd.edu (K.S. Vecchio).

Abstract

The effect of substituting standard grade zirconium lump (99.8% excluding up to 4% hafnium) for high purity zirconium crystal bar (99.5%) in a $Cu_{43}Zr_{43}Al_7Be_7$ bulk metallic glass (BMG) is examined. The final hafnium content in the BMG specimens was found to range from 0-0.44 at.%. Introducing low purity zirconium significantly decreased the glass-forming-ability and reduced the notch toughness of the BMG. In contrast, when adding high purity hafnium to $Cu_{43}Zr_{43}Al_7Be_7$ made with high purity zirconium, no significant change in the glass-forming-ability or toughness was observed. This suggests that the introduction of low purity zirconium in BMGs creates a more complex response than a simple addition of hafnium. It is likely that other impurities in the material, such as oxygen, play a role in the complex crystallization kinetics and change in mechanical properties. The notch toughness was measured through four-point-bend tests, which showed a decrease in notch toughness from an average of ~53 MPa-$m^{1/2}$ for the high purity samples to an average of ~29 MPa-$m^{1/2}$ with full substitution of low purity zirconium. A similar decrease in glass-forming-ability and toughness is observed in commercially synthesized high purity $Cu_{43}Zr_{43}Al_7Be_7$. The large scale commercial process is expected to introduced some unintentional impurities, which decrease the properties of the BMG in the same way as the lower purity elements. Lastly, Weibull statistics are used to provide an analysis of variability in toughness for both ingots synthesized in a small laboratory arc-melter and those synthesized commercially.

Keywords: bulk amorphous alloys, crystallization, toughness, zirconium, hafnium, Weibull statistics