Mg - based Bulk Metallic Glass Composite

Lalu G. Robin, Kevin J. Laws & Michael Ferry
School of Materials Science & Engineering, UNSW
UNSW THE UNIVERSITY OF NEW SOUTH WALES

Mg Al Ti
ARC Centre of Excellence
Design in Light Metals

Overview:

The preparation of Mg-based bulk metallic glass (BMG) matrix composites by using in situ crystallisation methods has been proven to be an effective method to overcome the brittle nature of BMG alloys. The reinforcing phases in BMG matrix composite are expected to hinder the propagation of shear bands and promote the formation of multiple shear bands, hence retarding the onset of catastrophic failure in the BMG matrix.[1]

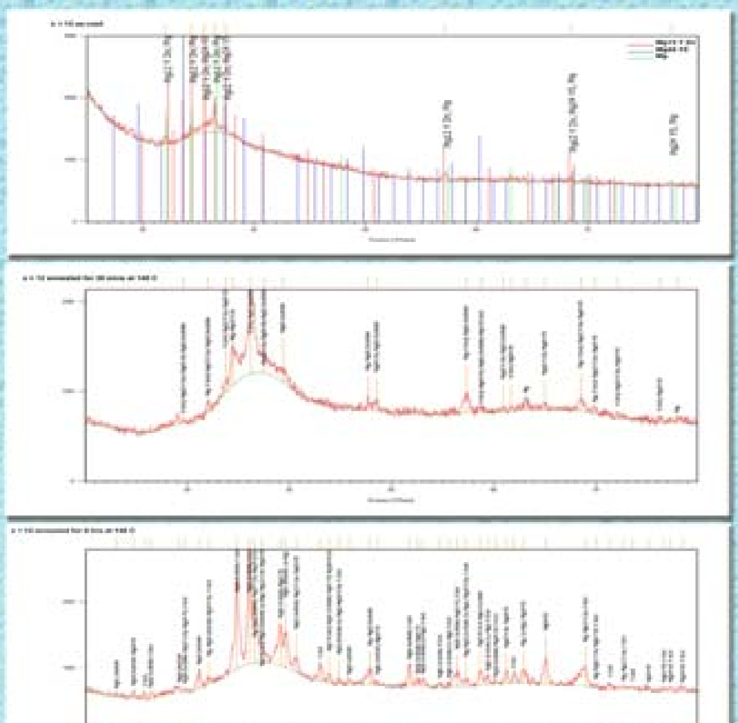
The control of crystal nucleation, growth and stability may be achieved via specific alloying criterion concerning solute atom selection and concentration under the consideration of the competitive growth kinetics of both equilibrium and metastable crystalline phases.[2]

This work examines the effects of both alloy composition and cooling rate in the Mg-Cu-Y-Zn glass-forming system on the as-cast microstructure and the coarsening or evolution of competing crystalline phases on heat treated samples. According to Hui. X et al the compositions of the alloys were designed using the formula Mg65+x (Cu0.667Y0.333)30-x Zn5 [x = 6, 12, 14 and 16]. A low-pressure injection die casting method was employed to produce bulk metallic glass composite Mg-Cu-Y-Zn alloy-strips. [3]

The ability to generate three-dimensional (3D) microstructures in solids is of great importance in understanding their true nature, as it eliminates speculation about the spatial distribution of features associated with conventional 2D techniques.

SEM & 3D microstructures of as-cast alloy x = 12:

XRD patterns using Microcapiliary attachment:



Evolution of competing crystalline phases at different cooling rates:

The critical cooling rate is defined as the minimum cooling rate required to supercool a liquid metal (amorphous structure) to a temperature at which atoms cannot rearrange themselves to form a crystalline structure.

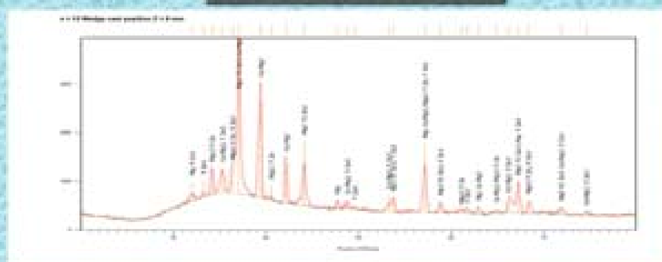
Wedge casting is a widely-used method for investigating the effect of cooling rate on the development of as-cast microstructure (Perepezko and Hildal, 2006). In this work, a wedge-shaped copper mould with a half angle of 2.86° was used. The wedge geometry provides a wide range of cooling rates for a given alloy composition with the large copper block found to be an adequate heat sink for the alloy during solidification.

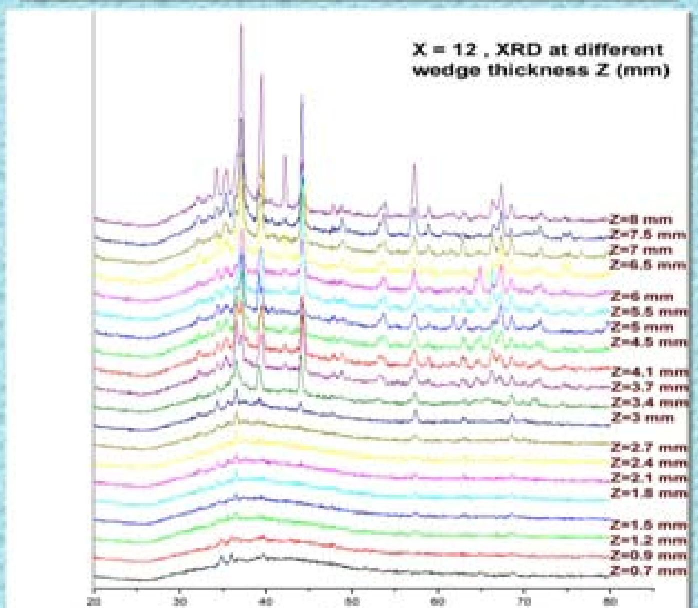
For the alloy x = 12, the narrow edge of the wedge casting was fully amorphous and further travelling to the broad edge through the centre line, sectioned along the middle of the wedge casting, it was observed that the crystalline peaks are getting stronger at different wedge thickness(Z). These XRD results provides us to choose different critical thickness of the designed alloy.

The wedge-shaped casting was sectioned along its centre line. One half was polished for optical metallography and scanning electron microscopy with the other half for hardness measurements and X-ray diffraction (XRD).

The cooling rate of the Mg - based Bulk Metallic Glass Composite during cooling from the liquidus temperature (470 °C) to the glass transition temperature (125 °C) can be approximately given by:

$$\frac{dT}{dt} \approx \frac{184(^{\circ}Cs^{-1}mm^{-1})}{Z(mm)}$$





References:

[1] Hui, X., Dong, W., Chen, G. L., & Yao, K. F. (2007). *Acta Materialia*, 55(3), 907-920.
[2] Xu, W., Ferry, M., Cairney, J. M., & Humphreys, F. J. (2007). *Acta Materialia*, 55, 5157-5167.
[3] Laws, K. J., Gun, B., & Ferry, M. (2008a). *Materials Science and Eng. A*, 475, 348-354.

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