IOP Conference Series: Materials Science and Engineering

PAPER • OPEN ACCESS

Cladding of Mg alloy with Zr based BMG Alloy

To cite this article: A.K. Prasada Rao *et al* 2016 *IOP Conf. Ser.: Mater. Sci. Eng.* **114** 012129

IOP Conf. Series: Materials Science and Engineering **114** (2016) 012129 doi:10.1088/1757-899X/114/1/012129

Cladding of Mg alloy with Zr based BMG Alloy

A.K. Prasada Rao[12*], Y.S. Oh[3], M.K. Faisal[1], N.J. Kim[2]

[1]Faculty of Manufacturing Engineering, Universiti Malaysia Pahang, Malaysia
[2] GIFT, POSTECH, Republic of Korea
[3] RIST, POSTECH, Republic of Korea

*Corresponding author: akprasada@yahoo.com

Abstract. In the present work, an attempt has been made to clad AZ31 magnesium alloy with Zr-based bulk metallic glassy alloy (Vit-1), by casting method. The interface studies conducted using SEM-EDS line scan indicate that a good bond is formed at the clad interface of Zr and Mg. And the mechanism involved is discussed herein.

1. Introduction
Magnesium alloy sheet applications have been growing in transportation systems in recent years. Recent development of twin-roll casting technology has shown that it can efficiently produce low cost, high performance wrought Mg alloy sheet products having equivalent mechanical properties to conventional ingot cast Mg alloys. On the other hand, unfortunately, Mg alloys exhibit poor resistance to corrosion which is a serious problem which limits their applications in wider domains. Several research attempts had been done till now in protecting Mg from corrosion. Most of them were through alloying additions and coatings. As a part of these efforts, present authors have recently developed a new technology of cladding Al on the surface of the Mg alloy strips through twin-roll casting process [1-2]. Another such cladding was done on Mg alloys using a bulk-metallic glassy Zr alloy, in the present work using injection casting in inert atmosphere. It is known that cladding of Zr on Mg alloys improves the corrosion resistance of the later [3]. On the other hand, bulk metallic glasses also have superior corrosion resistance. Most of the research work done till date deals with laser-cladding process [3-5], which has its economic limitations for large scale set-up. However, the present work deals with a casting process which can result in a Zr alloy clad Mg alloy. The detailed experimental work and the results obtained are discussed in the following sections.

2. Experimental Details
A well-known bulk metallic glass, the Vit-1 alloy (in ribbon form ~50µm thick) has been chosen for cladding Mg alloy (AZ31) in the present investigation. As mentioned above the clad specimens were obtained by injection casting of molten magnesium alloy in to a water-cooled copper mould cavity containing Zr alloy ribbons. In fig.1 (a-c) below, a detailed procedure of cladding is explained. Fig.1 (a) shows a schematic diagram of the copper mould with BMG ribbon affixed to its mould walls using a double-sided copper adhesive tape. In the next stage, molten magnesium alloy at 700ºC is injected into the mould cavity shown in fig. 1(b) under inert atmosphere and allowed it to cool to room temperature. Once the casting is done, the mould was opened and the Mg alloy casting obtained was

found to have the BMG ribbon clad on its surface, as shown in fig. 1(c). The as-cast specimen was then sectioned along its transverse axis and prepared using metallographic procedure. The clad interface of this specimen was studied under the SEM-EDS and the results obtained are discussed in the following section.

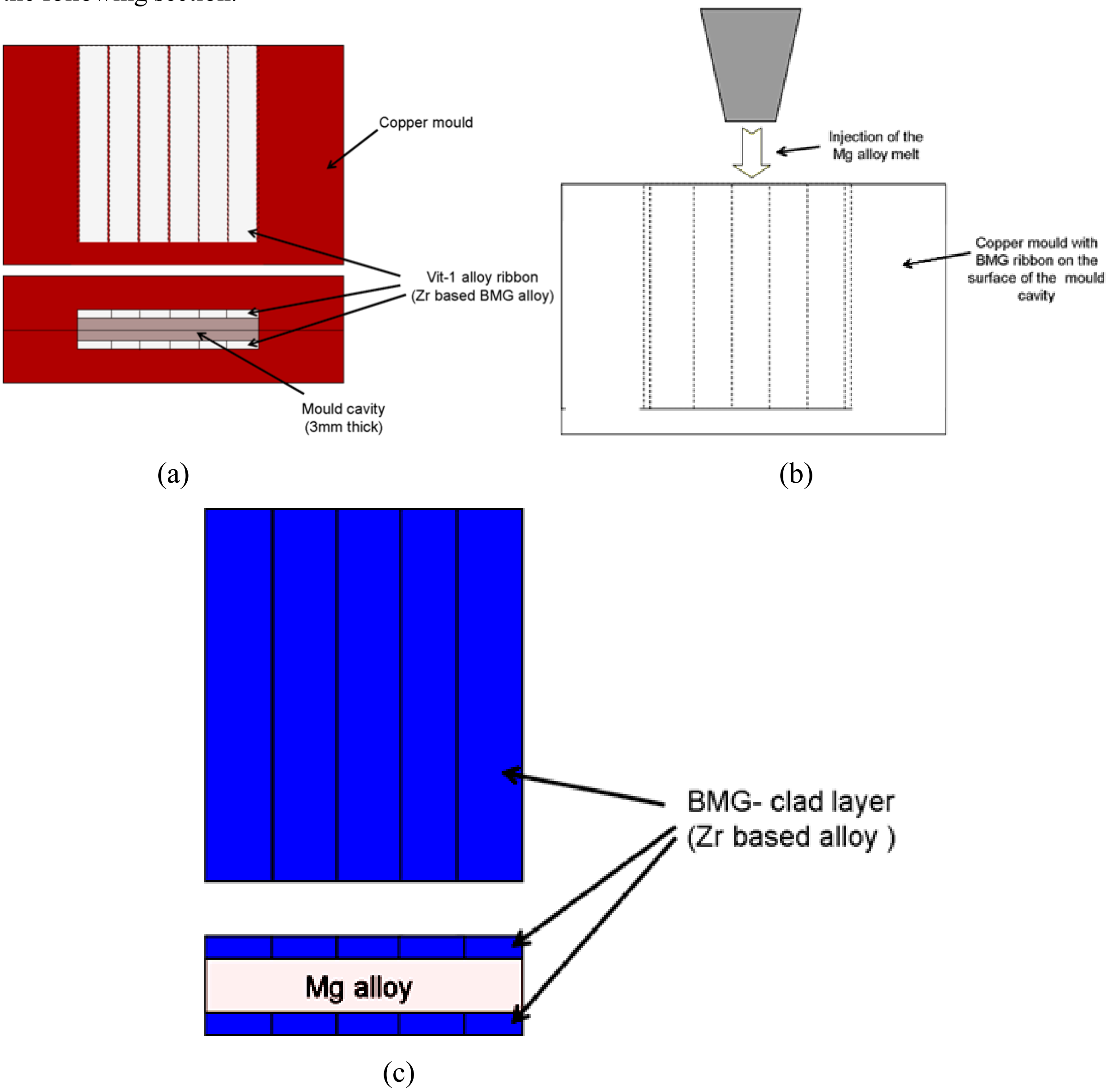


Fig. 1(a-c) Schematic illustration of cladding magnesium with BMG ribbons through melt-injection technique

3. Results & Discussion

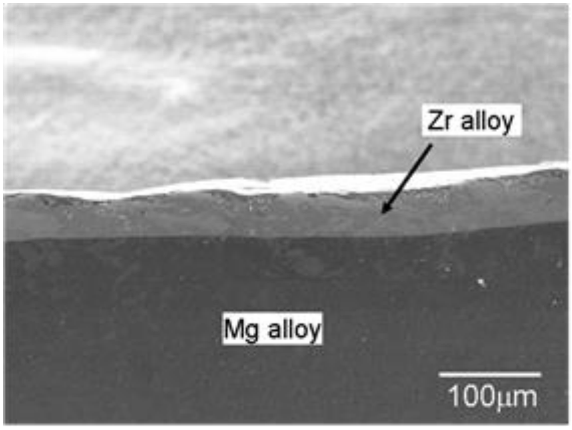
Figure 2(a) shows the SEM photo-micrograph of the Zr – Mg clad interface, a clad specimen of Zr alloy appears on the Mg alloy substrate, with a thickness of about 50µm. A detailed observation at the clad – interface reveals good bonding between layers of Zr and Mg alloys, which can be seen from EDS results shown in Fig. 2(b-c). In the fig. 2(c), the line-scan shows little diffusion across the clad interface. The results obtained are discussed below:

The glass-transition temperature (T_g) of Vit-1 alloy is about 450°C, and initial Mg alloy melt temperature is about 700°C. When the melt is injected in to the mould cavity with BMG ribbon on

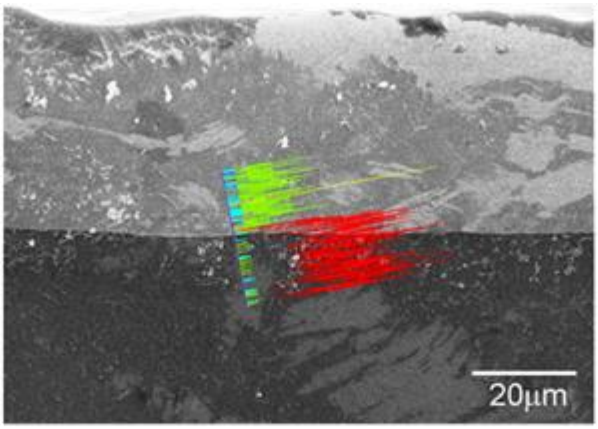
IOP Conf. Series: Materials Science and Engineering **114** (2016) 012129 doi:10.1088/1757-899X/114/1/012129

its mould walls, the solidification of the melt will start from the surface of the ribbon following heterogeneous nucleation mechanism. Here, the BMG ribbon acts as a potential substrate for nucleation of Mg alloy. Referring to the Mg-Zr binary phase diagram [6], it is understood that there is a considerable amount of solid solubility of Zr in Mg below 650ºC. This could cause the diffusion across the clad interface, which is reflected in the EDS line-scan shown in the fig. 2(c). Never-the-less, this diffusion helps in better bonding at the interface. Interestingly, it can also be seen from fig. 2(c) that the diffusion does not extend further, to reach the outer surface of the clad layer, owing to the high cooling rate provided by the water-cooled copper mould.

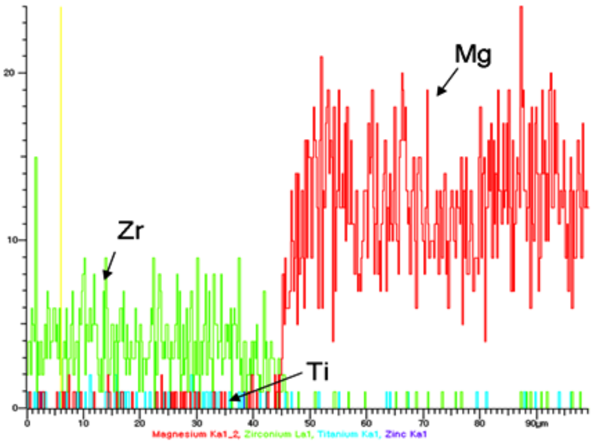
Unlike in the case of laser cladding, this process does not form thick reaction zone at the clad-interface, which enables further rolling of the Zr clad Mg alloy sheet. Since the BMG clad layer is thin (~50µm), it is expected that the shear band formation is less intensive, hence enables the clad sheet for further processes like bending. Present method can be conveniently extended to twin-roll strip casting, which further improves the bonding at the clad interface.



(a)



(b)



(c)

Fig. 2 Scanning electron photomicrographs revealing the (a) clad-interface, (b-c) SEM-EDS line elemental line-scan across the clad interface of the as-cast Mg alloy with BMG clad layer

4. Conclusion

From the results obtained it has been proved that Mg alloy can successfully be clad with Zr alloy or Zr-based BMG alloy using casting method. There is an ample scope for extending present findings to twin-roll strip casting in order to produce Mg alloy strips with Zr-based alloy or its BMG alloy. Eventually corrosion-proof Mg sheets can be produced on large scale.

References

[1] A.K. Prasada Rao, K.H. Kim, J. H. Bae, G.T. Bae, D. H. Shin and Nack J. Kim, , Materials Science Forum, Vols. 618-619, (2009), 467-470
[2] J. H. Bae, A.K. Prasada Rao, K.H. Kim and Nack J. Kim, Scripta Materialia, Vol.64(9), (2011) 836-839
[3] R. Subramanian, S. Sircar, and J. Majumder, Journal of Materials Science, Vo.26, (1991) 951-956
[4] T.M. Yue, Y.P. Su and H.O.Yang, Materials Letters, Vol.61 (1) (2007) 209-212
[5] T.M. Yue and Y.P. Su, Applied Surface Science, Vol.255(5), Part.1 (2008) 1692-1698
[6] R. Arroyave, D. Shin, and Z.K. Liu, Calphad, Vol. 29(3) (2005) p 230-238