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Abstract. The work presented here in describes the synthesis of aluminum based titanium-hydride particulate composite by casting method and its foaming behavior of magnesium alloy. Results obtained indicate that the Al-10TiH_2 composite can be synthesized successfully by casting method. Further, results also reveal that closed-cell magnesium alloy foam can be synthesized by using Al-10TiH_2 composite as a foaming agent.

1. Introduction

Cellular metallic materials are of scientific and commercial interest in recent decades, owing to their fascinating mechanical properties for light weight structural applications [1-3]. It has been reported that there are basically two popular methods in the liquid state synthesis of foams/ porous metallic materials [2]. One of the methods is by treating the molten melts with foaming agents like TiH_2, which eventually decompose to liberate hydrogen gas or by direct blowing gases in to liquid metals [4]. The other method of liquid state processing is by infiltration of the melt into the interstitial voids of the place-holders [5]. Although, extensive work has been done on aluminum based cellular materials, the foaming technology is rather limited; in the case of magnesium foams [6-10]. Interestingly, stir casting has also been reported to be an efficient method of synthesizing Mg alloy foam [10]. This method is similar to infiltration technique, where the fly-ash micro-balloons play the role of place holders, while the molten magnesium occupies the interstitial regions up on solidification [10].This paper discusses the role of the ceramic particles (grain refiners) on the temperature distribution in the solidifying liquid and hence affecting the nucleation behavior, and more viable theory is proposed herein. The primary considerations of this theory are (i) no chemical interaction takes place across the liquid/ceramic-particle interface; (ii) temperature of the ceramic particle and the liquid is same, initially; and (iii) Heat is continuously lost by the system to the surroundings.

In the present study, an aluminum based composite has been developed with TiH_2 particles entrapped in the matrix. This composite has been used as an inoculant for the synthesis of a porous magnesium alloy with uniform pore-distribution. The following sections discuss the method in detail.

2 Experimental

Initially, commercially pure aluminum of about 2kg was taken in a graphite crucible and melted in an induction furnace. When the temperature of the melt reached 700ºC, TiH_2 powder (particle size ~40µm) was wrapped in aluminum foil and plunged in to the melt followed by quick stirring and casting into a copper mold. The Al-10TiH_2 composite ingot synthesized above was plunged in to molten AZ31 alloy (SF_6+CO_2 gas atmosphere) in the form of machined chips followed by stirring for about 30sec. This melt was held for about 10 min and cast into a copper mold. The castings obtained were cut and the microstructure was characterized using SEM-EDS technique. And the results obtained are discussed in the following section.

3 Results and Discussion

Figure 1(a-b) depict the SEM photomicrographs which represent the microstructure of Al-TiH_2 composite synthesized. The microstructure reveals uniformly distributed TiH_2 particles uniformly distributed in Al- matrix. The EDS- line-scan (Fig. 2(a-b)) across the particle indicates that the TiH_2 particles are nearly un-decomposed despite their contact with the liquid aluminum. This could be due to the fact that TiH_2 particles need certain contact time in aluminum melt to decompose [5], which is quite less in the present case.

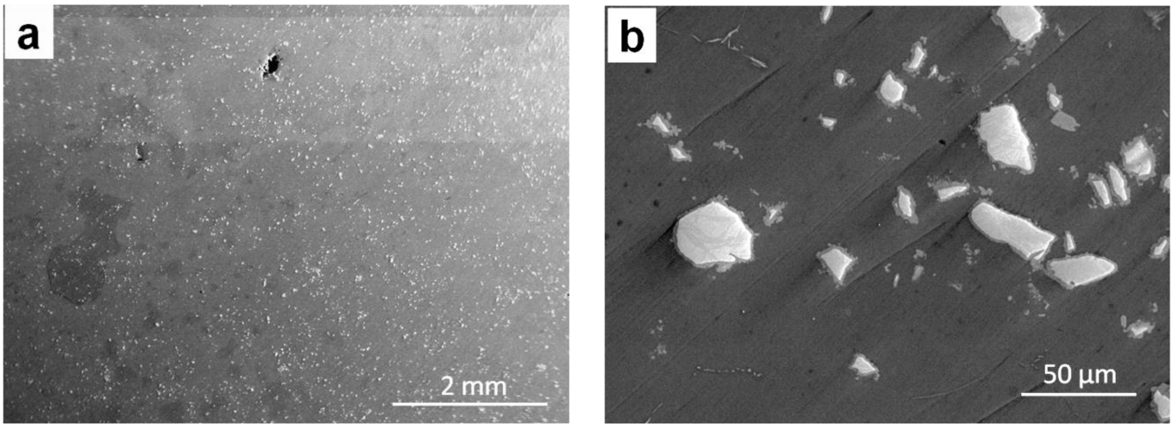

Fig.1 (a-b) SEM micrographs of as-cast Al-TiH_2 particulate composite

Microstructure seen in Fig.1 (a-b) and Fig.2 (a-b) reveals that the un-decomposed for TiH_2 particles are entrapped in the aluminum matrix resulting in a composite. Such composite was added to molten AZ31 magnesium alloy below 700ºC followed by stirring (30sec) and casting in to a copper mold after 10min of holding time. During this process, the TiH_2 particles are uniformly distributed in the AZ31 alloy melt and decompose to evolve hydrogen eventually resulting in porous magnesium alloy up on solidification. It is evident from the Fig. 3(a) that the entrapped hydrogen gas results in fine pores uniformly distributed in the AZ31 alloy casting.

Ellingham diagram of metal hydrides [11] suggests that magnesium hydride possesses nearly positive free energy of formation. Hence it is less stable at elevated temperatures, therefore the decomposition of the TiH_2 particles in quite possible in molten magnesium alloy. Thus, adequate amount of hydrogen gas is available for pore formation as it is obvious from the SEM micrograph shown in Fig. 3(a). Further, the SEM-EDS elemental distribution (Fig.3 (b-e)) along the pore wall shows traces of Al and Ti uniformly distributed in Mg matrix. This observation also confirms above mentioned inference that TiH_2 particles decompose in molten Mg alloy forming hydrogen gas pores leaving behind Al and Ti in the matrix.

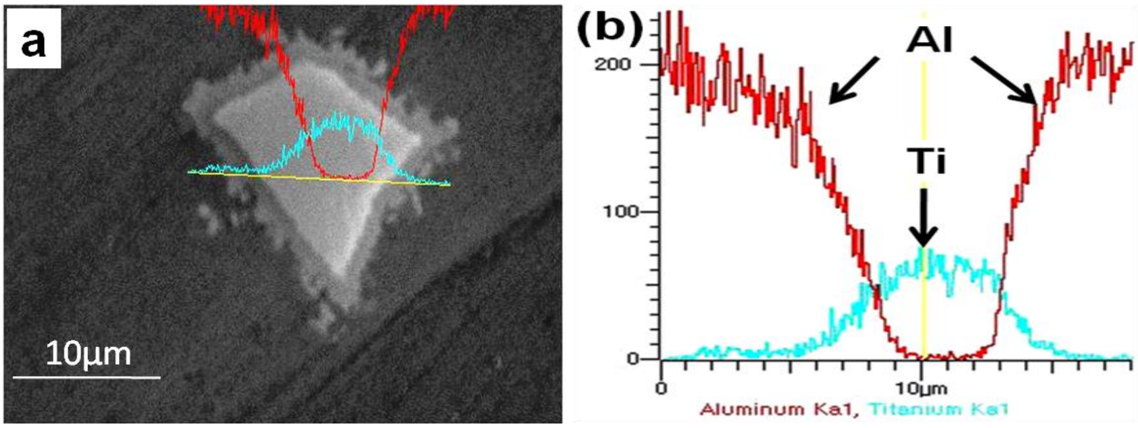

Fig.2 (a-b) SEM-EDS micrograph indicating the line-scan across the TiH_2 particle in aluminum matrix composite

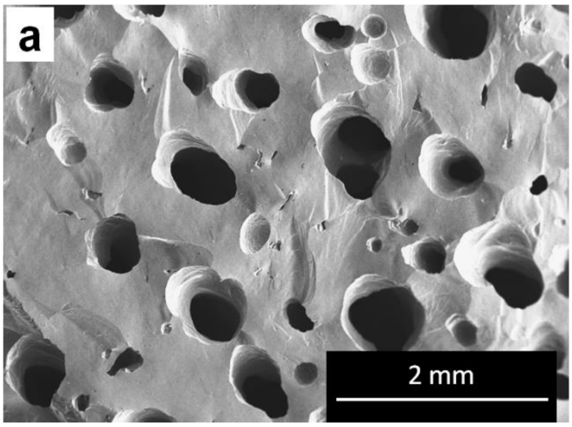

Fig.3(a) SEM micrograph of porous AZ31 alloy synthesized

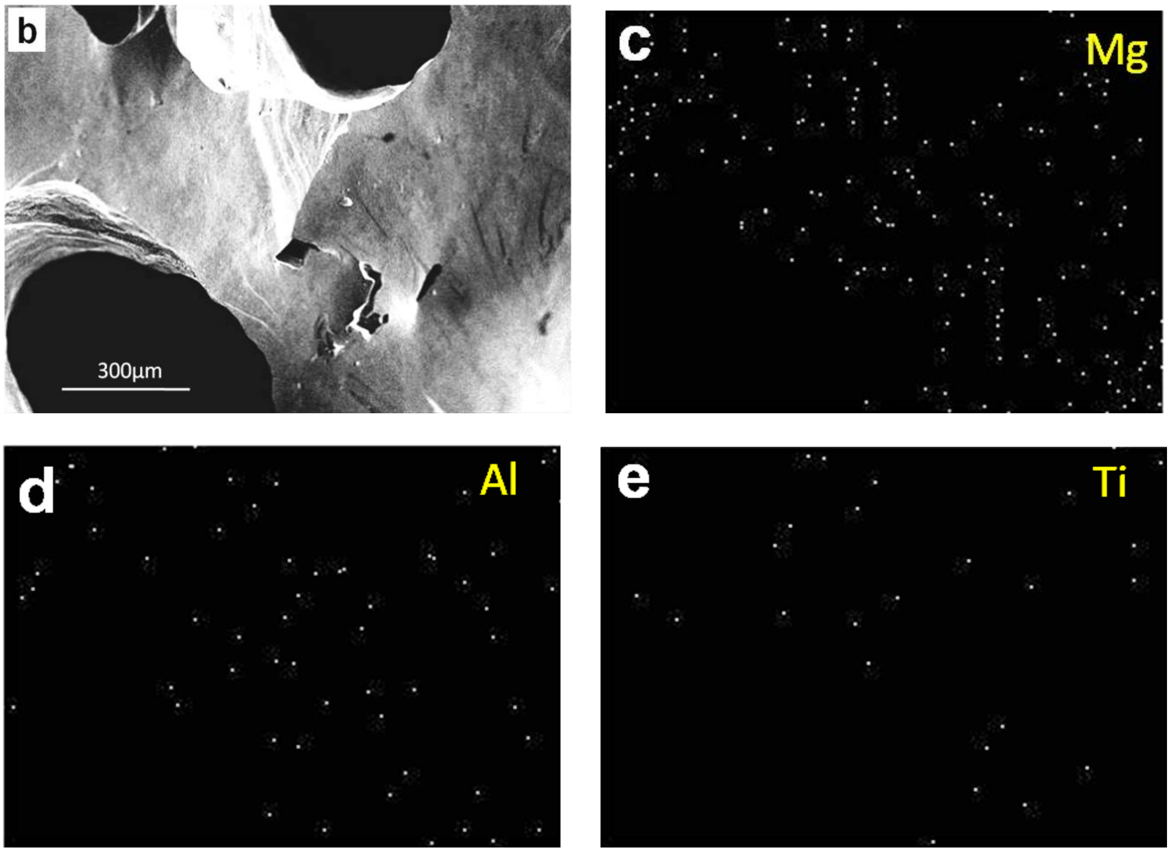

Fig.3 (b-e) SEM-EDS micrograph indicating the elemental mapping along the cell wall of porous AZ31 alloy

4 Conclusion

The results obtained from the present work reveal that Al-TiH_2 composite can successfully be synthesized by casting technique, by retaining un-decomposed TiH_2 particles. It has been found that, a closed-cell porous magnesium alloy can successfully be synthesized by inoculating the Al-TiH_2 composite in to the Mg alloy melt.

Further development of this technique of synthesizing Mg alloy foam needs a quantitative approach.

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