Microcasting of Mg-Ti alloys and their Wettability in Phosphate Bonded Investment Shell Molds

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Abstract: In this paper, microcasting has been applied to cast Mg-Ti alloy. The investigation carried on characterization of 70Mg-30Ti alloy was cast by vacuum pressure casting process in phosphate bonded investment moulds. Improved wettability was observed between Ti and Mg with microcasting under vacuum.

Keywords: Mg-Ti alloy, Phosphate bonded investment moulds, microcasting.

1. INTRODUCTION

Magnesium has been identified as a promising biodegradable implant material because it does not cause systemic toxicity and can reduce stress shielding. However, it corrodes too quickly in the body. Alloying magnesium with titanium is expected to improve the corrosion resistance of magnesium [1]. Mg-Ti alloys with a titanium content ranging from 5 to 35 at.-% were successfully synthesized by mechanical alloying. In a binary Mg-Ti alloy there are 5 different sites: Mg_4, Mg_3Ti, Mg_2Ti_2, $MgTi_3$ and Ti_4. The wetting behavior of molten pure Mg droplets on pure Ti substrate, a crucial phenomenon in the design of Mg matrix composites reinforced with Ti particles, was investigated by the sessile drop method. The effects of two important parameters on the contact angle were evaluated: Mg evaporation during the wetting test; and surface oxide film of the substrate. When the molten Mg contacts an area of pure Ti after reduction, the contact angle suddenly decreased. The equilibrium value at the stable state strongly depended on the surface roughness of the Ti plate [2].

Traditional process of preparing investment shell mould uses colloidal silica binder. The working temperature of the investment powder and liquid are critical factors in determining the setting time, expansion, surface roughness and consequently the final fit of the castings [3-20]. The compressive strength of gypsum bonded investment I was between 4–5 MN/m^2 which had been found adequate to withstand casting pressure [21]. This strength may not be sufficient the casting pressure Ti alloys. Micro-sized investment shell moulds with complex configurations cavity can be prepared with phosphate bonded investments [22]. The purpose of this investigation was characterization of Mg-Ti alloy cast by vacuum pressure casting process in phosphate bonded investment shell moulds.

2. MATERIALS METHODS

Phosphate bonded investments consist of magnesium oxide and ammonium hydrogen-phosphate as binder and the two different SiO_2 modifications quartz and cristobalite as filler. The powdery binder and filler components were mixed with a liquid which consists of aqueous silica sol (Table 1). In contrast to the wax patterns used in investment casting process, microcasting process mostly works with injection molded plastic patterns which have much higher mechanical strength. In the present work, microelectro discharge machining was employed to get microcavities. The microcasting process requires a lost plastic pattern to be mounted on a gate and feeding system made of wax. For cost-effective microcasting, the assembly of single patterns is built up into tree-from as shown in figure 1. The pattern assembly was completely embedded in ceramic slurry. The liquid metal was poured into investment mould under vacuum pressure. The investment mold was evacuated, and then the melt was poured into the mold, filling the cavity only due to gravitational forces. After that, pressure is applied to the melt (figure 2).

Table 1: Investment slurry preparation.

Temperature powder and liquid	25^{o}C
Mixing ratio	100g: 22 ml
Stirring time under vacuum	60 sec
Steering speed	360 rpm
Processing time	6 min.

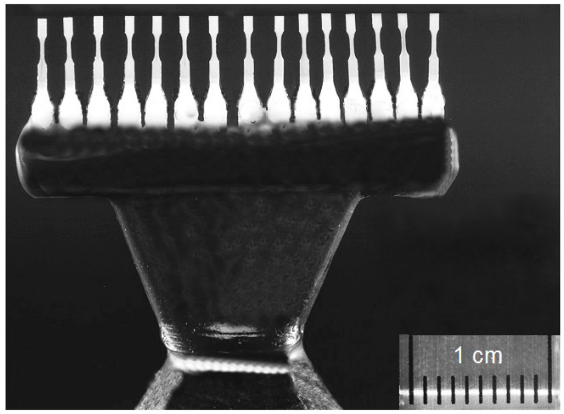

Figure 1: Pattern assembly.

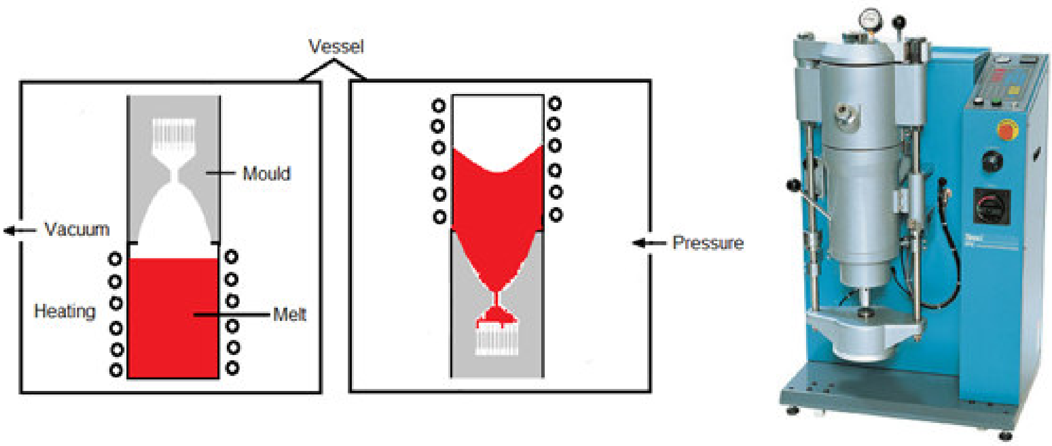

Figure 2: Vacuum pressure casting process.

3. RESULTS AND DISCUSSION

The 70%Mg-30%Ti alloy was cast microcasting process. The microstructure investigations reveals that after casting in the as-cast the alloy microstructure is uniform with areas of very small grains and some big grains inside. There is a small amount of the Mg_3Ti, Mg_2Ti_2, $MgTi_3$ phases.

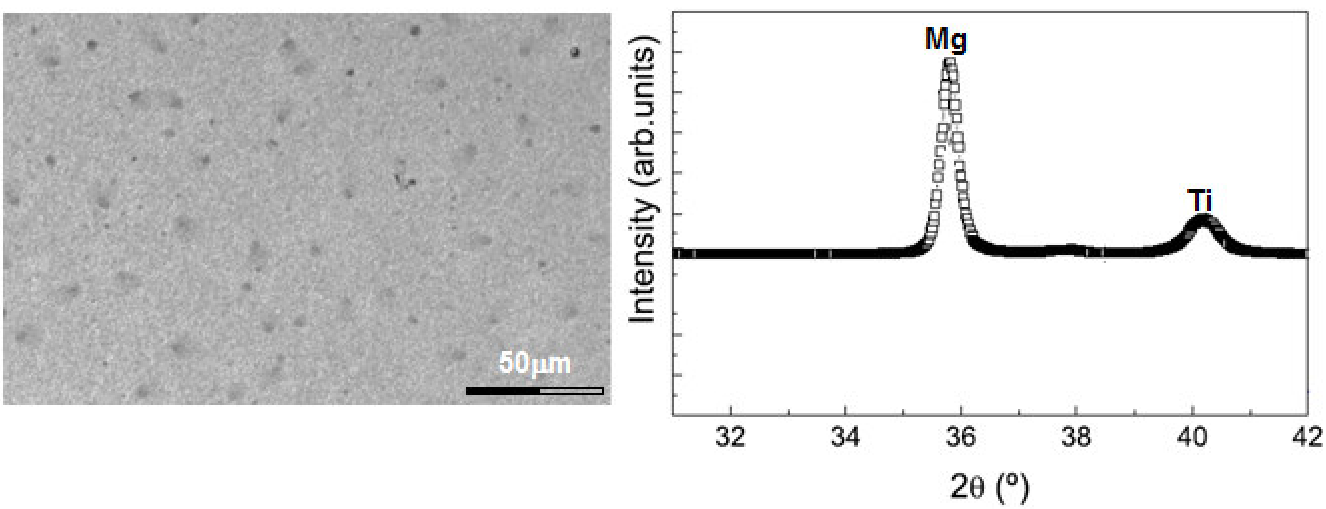

Figure 3: Microstructure and XRD of 70Mg-30Ti alloy.

Good interfacial bonding was observed between Mg and Ti as shown in figure 4. The result in the present study have clarified that Ti has a good wettability by molten Mg droplets [2]. The microhardness of this alloy was found to be 156HV.

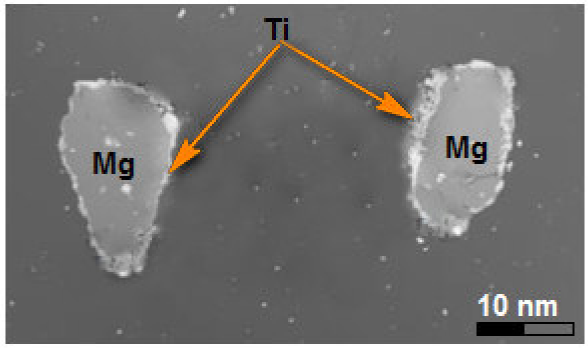

Figure 4: Wettability of Ti to Mg.

4. CONCLUSIONS

This paper proves that the microcasting is an ideal fabrication method for metal parts in microdimensions. Small amount of the Mg_3Ti, Mg_2Ti_2, $MgTi_3$ phases were found in the as-cast structure. Improved wettability was observed between Ti and Mg with microcasting under vacuum.

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