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Microstructure stability of as-extruded bimodal size SiCp/AZ91 composite

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ABSTRACT

The microstructure stability and micro-hardness of as-extruded bimodal size (micron+submicron) SiCp/AZ91 composites were investigated. Results show that the significant grain refinement appears around micron SiCp at the temperature range of 643–693 K. Compared with monolithic AZ91 alloy and micron SiCp/AZ91 composite, the obvious submicron particle dense zones (SPDZs) are formed in the vicinity of micron SiCp in bimodal size SiCp/AZ91 composite during thermal stability test, which results in the small average grain size and improved microstructure stability. The micro-hardness of bimodal size SiCp/AZ91 composite is higher than that of monolithic AZ91 alloy and micron SiCp/AZ91 composite. The micro-hardness of bimodal size SiCp/AZ91 composite depends strongly on grain size and the lowest micro-hardness appears at 643 K.

1. Introduction

Magnesium alloys have received extensive attentions for their low density, high specific strength and stiffness in recent years [1–4]. But the low modulus, strength and abrasion resistance have limited their industrial applications. Previous studies have revealed that particle reinforced magnesium matrix composites (PMMCs) can overcome the demerits of the monolithic Mg alloys and expand their industrial application for their simple preparation process and low cost [5,6]. However, casting defects such as pore and particle agglomerates etc. that existed in the as-cast composite reduce their mechanical properties. Besides, the poor bonding strength between particles and Mg matrix will also reduce PMMCs' mechanical properties [7,8]. Previous researches have revealed that the improvement of interface strength was an effective way to enhance mechanical properties [9,10]. The application of second process e.g. forging, rolling and extrusion, has a significant effect on refining grain size, improving particle distribution and enhancing bonding strength [11–16]. Deng et al. [17,18] found that the forging process has a significant effect on refining grain size, improving particle distribution and interfacial bonding between SiCp and Mg, which results in the enhancement of tensile properties. On Wang et al.'s investigation of SiCp/Mg–Zn–Ca composite [19], the interface between SiCp and the matrix was also modified by hot extrusion, which was thought to be one reason for the improved mechanical properties. Shang et al. [20] found that tensile properties of SiCp/Mg–Al–Zn composite can be affected by extrusion temperature through influencing grain size, texture, the amount and size of $Mg_{17}Al_{12}$ phase. Two-step deformation (forge+extrusion) has been applied by Wu et al. [16] on the 5 μm SiCp/AZ91 composite; the further improved tensile properties are obtained. Recently, Deng et al. [21] found that microstructure and mechanical properties of SiCp/AZ91 composites processed by two-step deformation can be affected significantly by particle size. In order to give full play to the merits of different particle sizes, the fine grained bimodal size (submicron+micron) SiCp/AZ91 composite has been obtained by author's previous research [22]; the results showed that the mixture of a little amount fine particles and micron particles had significant influence on enhancing the tensile properties of Mg matrix.

However, less noted, but no less important, the microstructure stability which means the extent of grain growth during thermal treatment of fine grains will directly influence the application of magnesium matrix composite under high temperature conditions. Radi et al. [23] have reported that the introduction of 2 wt% Al_2O_3 nano-particles into the base AZ31 alloy could restrict grain boundary migration during the annealing treatment and increase the activation energy of grain growth, thus resulting in enhanced microstructure stability. Ferry et al. [24] have reported that the existence of ~5 nm diameter Al_3Sc particles in fine-grained Al–Sc

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alloys could improve the microstructure stability significantly at temperatures up to 773 K. Compared with nanoparticles, micron particles have different influences on microstructure stability. Robson et al. [25] have reported that the addition of micron particles (>1 μm) could stimulate DRX during deformation. While during the subsequent annealing, fine static recrystallized

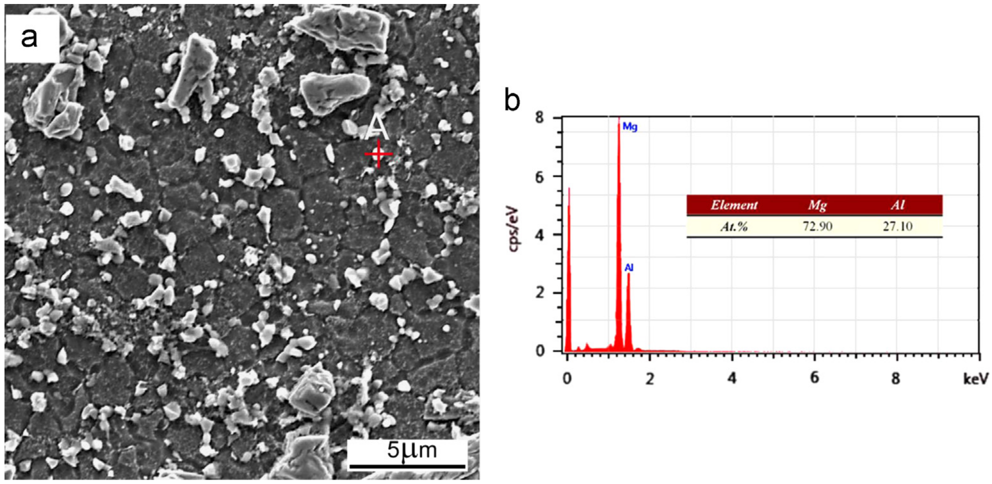

Fig. 1. (a) SEM micrographs of as-extruded bimodal size SiCp/AZ91 composite before thermal stability test and (b) the EDS results of point "A" marked in (a).

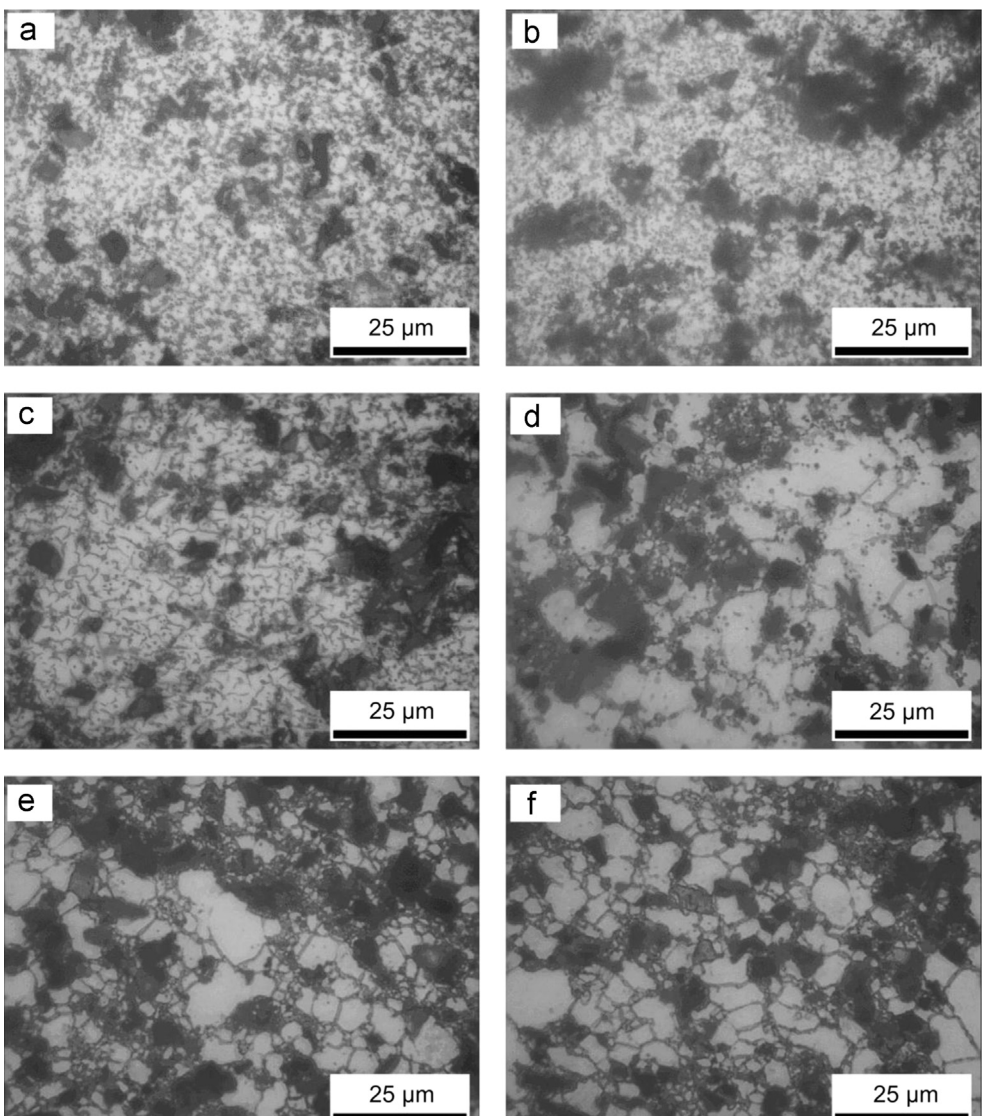

Fig. 2. OM micrographs of as-extruded bimodal size SiCp/AZ91 composite before (a) and after thermal stability test (30 min) at (b) 543 K, (c) 593 K, (d) 643 K, (e) 693 K and (f) 743 K.