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MICROSTRUCTURAL EVOLUTION OF Al-Si BASED COMPOSITES REINFORCED WITH *IN-SITU* TiB_2 PARTICLES

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ABSTRACT

The present paper investigates the size distribution of Si needles as a function of weight fraction of the TiB_2 reinforcement in Al-7Si and Al-12Si based composites. It was observed that with the increase in the amount of the TiB_2 particles, the size of the Si needles as well as α-Al cell decreases. It was also observed that the range of particle size distribution of Si is narrowed down towards the higher weight fractions of the TiB_2 particles. The decrease in size of the Si needles in both alloys was attributed to the growth restriction of by higher amount of reinforcement.

Keywords: Al-Si alloy; TiB_2 particles; *in- situ* composites; particle size distribution

1. INTRODUCTION

Amongst the aluminum-based alloys, Al-Si alloy constitutes the bulk of the foundry alloy owing to its easier castability, lightweight and other desirable properties. While most the work has been concentrated on age hardenable Al-Si alloy [1,2], several attempts have been made to improve the strength of these Al-Si alloys by the modification of Si needles [3,4], refinement of α-Al, combination of both modification and grain refinement [5,6] and the melt thermal treatment [7]. The property enhancement by the addition of reinforcements is another prospect. In this direction, although some work has been carried out in both hypoeutectic and eutectic Al-Si alloys reinforced with *in-situ* TiB_2 particles [4,8,9], but the reports on the effect of these *in-situ* particles on the morphology of Si particles donot exist.

The present work focuses on the synthesis of hypoeutectic and eutectic Al-Si based composites with TiB_2 particles reinforced *in-situ*. The resulting microstructures of the composites were investigated for the size distribution of the Si needles as a function of the weight fraction of the TiB_2 particles.

2. EXPERIMENTAL DETAILS

In the present study, hypoeutectic (Al-7Si) and eutectic (Al-12Si) Al-Si alloys were reinforced with 2.5, 5, 7.5 and 10wt.% *in-situ* TiB_2 particles. The composites were prepared by melting together appropriate amounts of commercial purity Al and Al-20Si master alloy and allowing the melt to react with K_2TiF_6 and KBF_4 salt in a stoichiometric ratio corresponding to fixed weight fraction of TiB_2 at 800°C for 60 minutes. The composites have been characterised by X-Ray diffraction (XRD), scanning electron microscopy (SEM) and optical microscopy. The Leica Image Analyser was used to measure the size of the Si particles in the composites. A large number of Si particles (approximately 400) from different regions of a casting (here composite) were analysed to get a representative size distribution of the Si particles.

3. RESULTS AND DISCUSSION

Al-7Si alloy was reinforced with different weight fractions (2.5, 5, 7.5 and 10) of *in-situ* TiB_2 particles. The presence of these *in-situ* particles becomes more prominent above 5wt.% of the particles, as can be seen from the XRD pattern of the composites in Fig. 1. The complete absence of Al_3Ti particles can be inferred from the XRD pattern.

There is a progressive decrease in the size of the α-Al cell (white region) as well as the Si particle size as we gradually move towards the higher weight fractions of TiB_2 particles. This can be clearly inferred from the optical photomicrographs in Fig. 2. The decrease in the size of the Si needles can be attributed to its growth restriction. As the amount of the TiB_2 particles in the melt increases, the space available for the growth of the Si needles decreases sharply, thereby restricting their growth. This phenomena is more prominent from the SEM photomicrographs in Fig 3, where the Si particles decreases from a mean size of 3.6μm in a composite with 2.5wt.% TiB_2 to 1.8μm with that of 10wt.% TiB_2.

A gradual change in the size distribution of the Si is observed as we move towards the higher weight fraction of the TiB_2 particles (Fig. 4). It can be clearly seen that the percentage of the particles in the size range of 1-3μm increases from a mere 4.5% in the base alloy (Al-7Si) to as high as 96% when the alloy is reinforced with 10wt.% TiB_2 particles.

The eutectic Al-12Si alloy was also reinforced with similar weight fractions of TiB_2 particles as in case of the hypoeutectic alloy. The SEM photomicrographs of the composites are shown in Fig. 5. A distinct decrease in the size of the Si needles with increase in weight fraction of TiB_2 is observed due to the similar reasons as explained in case of the hypoeutectic alloy.
A shift in the particle size distribution of the Si towards the lower size is evident from the histograms in Fig. 6.

A comparison between the mean size of the Si needles as a function of the weight fraction of TiB_2 in Fig. 7 shows that for at any particular wt.% of TiB_2 reinforced in the two alloys, the size of the Si needles in hypoeutectic alloy is much lesser than that of the eutectic alloy.

4. CONCLUSIONS

1. There is complete absence of Al_3Ti particles in the composites synthesised.
2. There is a progressive decrease in the size of the Si particles with increase in the TiB_2 content in both the alloys.
3. The size distribution of Si particles is narrowed down at higher weight fraction of reinforcements.

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FIGURES

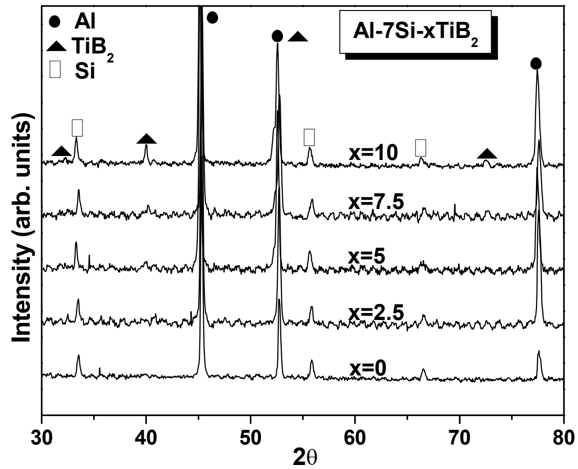

Fig. 1 XRD patterns of Al-7Si-TiB_2 composites

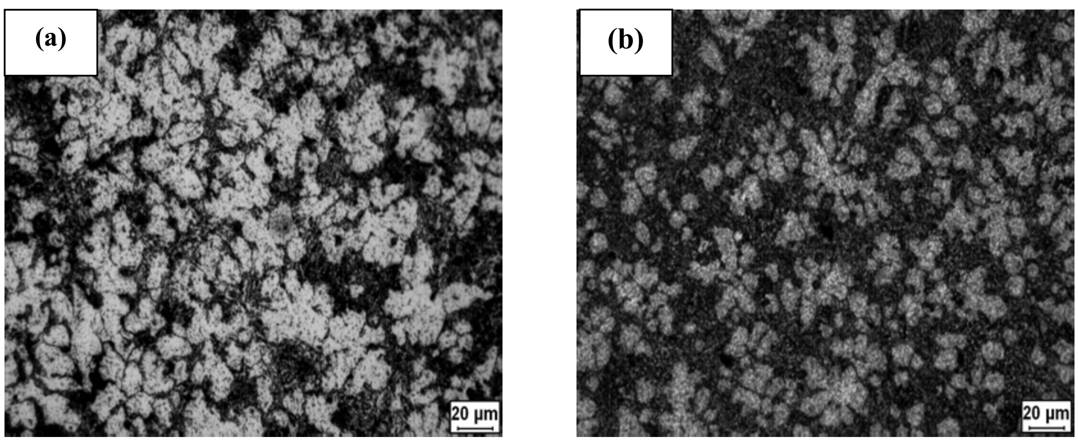

Fig. 2 Optical micrographs of Al-7Si based composites reinforced with (a) 2.5 wt.% and (b) 10 wt.% TiB_2 particles.

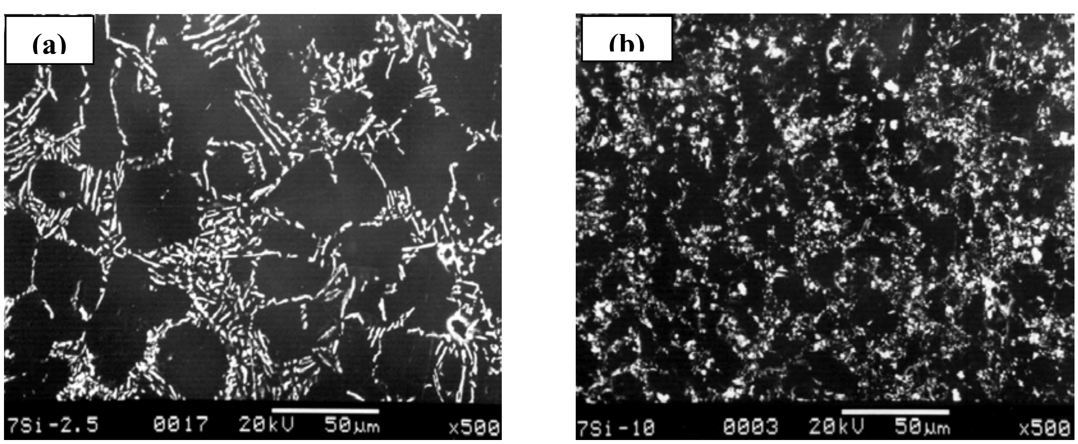

Fig. 3 SEM photomicrographs of Al-7Si based composites reinforced with (a) 2.5 wt.% and (b) 10 wt.% TiB_2 particles.

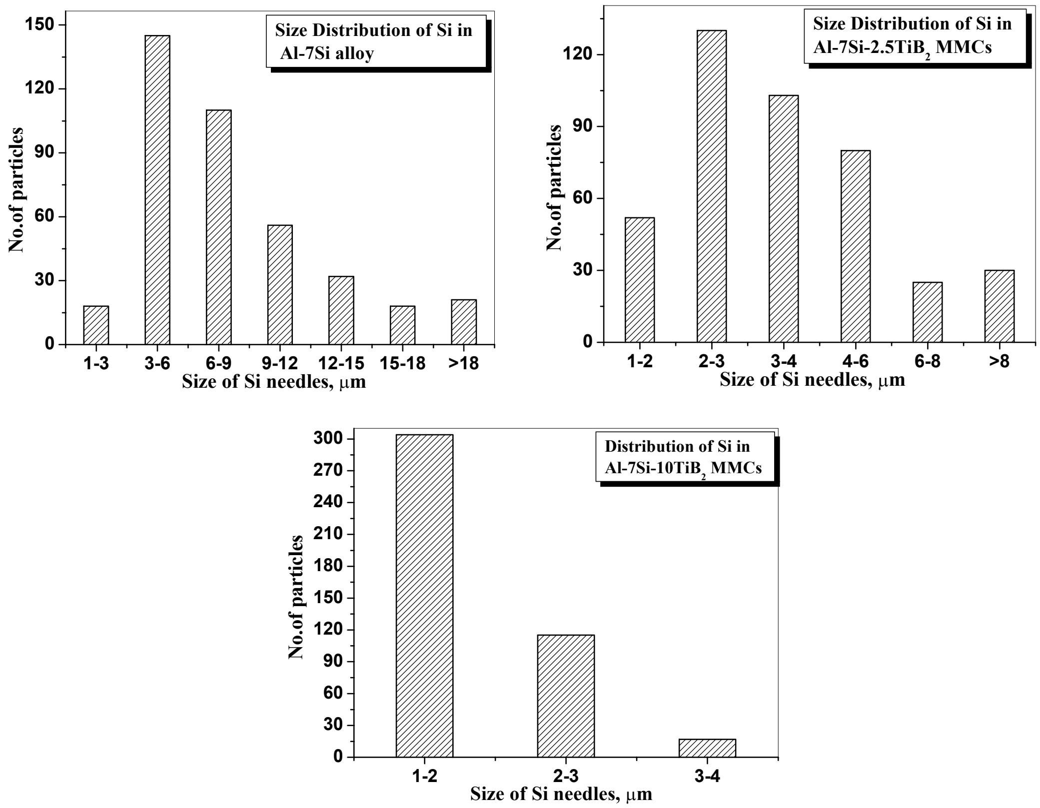

Fig. 4 Particle size distribution of the Si particles in (a) Al-7Si alloy (b) 2.5wt.% TiB_2 and (c) 10wt.% TiB_2

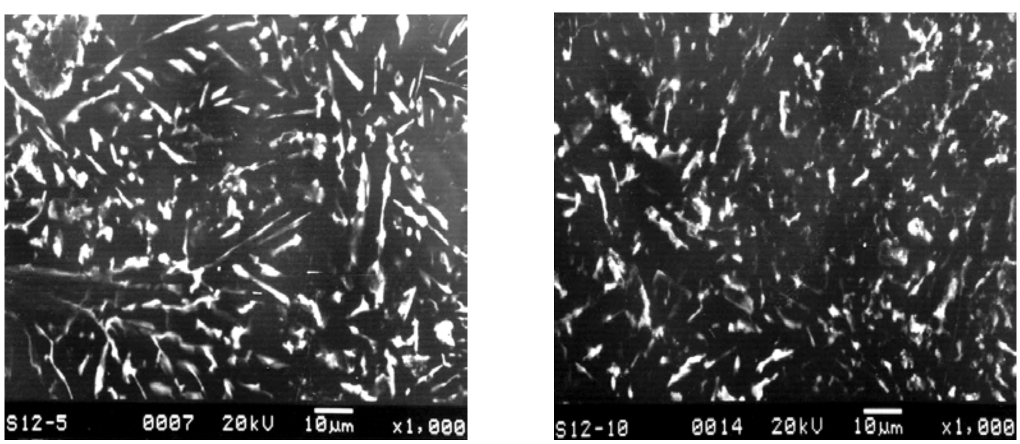

Fig. 5 SEM photomicrographs of Al-12Si based composites reinforced with (a) 5 wt.% and (d) 10 wt.% TiB_2 particles.

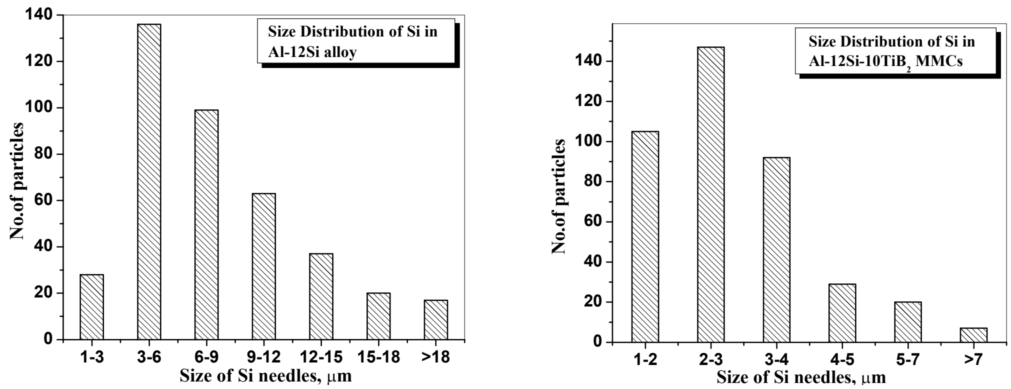

Fig. 6 Particle size distribution of the Si particles in (a) Al-12Si alloy and (b) 10wt.% TiB_2

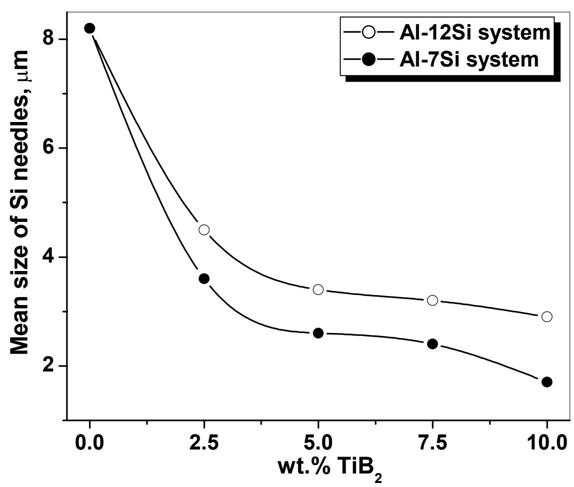

Fig. 7 Mean particle size of the Si particles in Al-7Si and Al-12Si alloy as a function of wt.% TiB_2 particles