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Effect of graphite particle size on wear property of graphite and Al_2O_3 reinforced AZ91D-0.8%Ce composites

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Abstract: The graphite particles and Al_2O_3 short fibers reinforced AZ91D-0.8%Ce composites were fabricated by squeeze-infiltration technique. The researches about the effects of different graphite particle sizes on the microstructure and wear property of the composites were performed under the condition of constant contents of graphite particles and Al_2O_3 short fibers. The results reveal that the grain size of the composites changes less when the graphite particle size descends. Moreover, Ce enriches around the graphite particle and Al_2O_3 short fibers and forms Al_3Ce phase with Al element. The graphite that works as lubricant decreases the wear loss. The wear resistance of the composites increases as the graphite particle size increases. At low load the composites have similar wear loss; at high load the composite with the largest graphite particle size has the best wear resistance. The wear mechanism of all the composites at low load is abrasive wear and oxidation wear; at high load, except the composites with the particle size of 240 μm whose wear mechanism is still abrasive wear and oxidation wear, the wear mechanism of others changes to delamination wear.

Key words: magnesium matrix composite; particle size; graphite; wear property

1 Introduction

Magnesium alloy has high potential as light structure material in the development of automobile and aerospace industries. Its high specific strength and mechanical properties makes it valuable in many applications[1−2]. However, its corrosion and wear resistance limit it to be used as widely as Al alloy[3−4]. One possible solution to improve the wear property of magnesium alloy is to use particles, fibers or rare earth elements as additives to magnesium matrix[5−8]. But most of the researches focus on hard particles (like SiC and TiC particles) reinforced magnesium matrix composites[9−11]. Investigation on the graphite particle that has lubricious effect during sliding process is absent. Recently, QI et al[12−13] have studied the effect of rare earth on graphite reinforced Mg alloy and find better wear property by adding rare earth. WU et al[14] have investigated the effects of graphite on the microstructures and properties of Mg composite. In the present work, for the combining use of lubricating graphite particles and hard Al_2O_3 short fibers, the AZ91D-0.8%Ce composites were fabricated and the wear property of the composites was investigated along with the wear mechanism, especially investigating the effect of graphite particle size on the microstructure and wear property.

2 Experimental

AZ91D-0.8%Ce alloy was chosen as matrix. The short fibers with a diameter of 8−12 μm and a length of 300−700 μm contained 98.9% Al_2O_3. The contents of Al_2O_3 short fiber and graphite were kept constant with volume fractions of 8% and 15%, respectively. The average graphite particles size was 240, 125, 83 and 55 μm, respectively.

The process of fabricating the composites was carried out by two steps. First, the graphite particle and Al_2O_3 short fibers were prepared into a preform. Second, the squeeze-infiltration technique was used to add molten AZ91D-0.8%Ce alloy into the preform. The pouring temperature was 680 ℃, applied pressure was 55 MPa and maintaining time was 60 s. Dry sliding wear tests

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were operated using a pin-on-disc type wear apparatus MM2000. In this system, the specimen size was *d*6 mm×12 mm, the friction disc kept rotating at a constant speed of 0.785 m/s, and slid a distance of 376.8 m. The worn surface was analyzed by JSM−6700F scanning electron microscope(SEM) with an energy-dispersive X-ray spectrometer(EDS). The density of sample was measured using the standard Archimedes method with distilled water. Mass changes before and after wear tests were used to calculate the volume loss.

3 Results and discussion

3.1 Microstructures of composites

The optical microstructure photographs of the composites with different graphite particle sizes are shown in Fig.1. It reveals that the graphite particle and Al_2O_3 short fibers disperse uniformly in the composites and no agglomeration is observed evidently. The graphite takes the form of flake and Al_2O_3 short fibers appear in round and needle shapes as pointed in Fig.1(b). Some rod-like phases are found around the boundaries of graphite and Al_2O_3 short fibers which can be seen in the backscattering image of the composite. By comparing the electronegativity of Mg with Al, Ce prefers to form rod-like Al_3Ce phase with Al, which is confirmed by XRD analysis. As graphite particle size descends the grain size changes less. This indicates that during solidification the graphite particle size affects the process of nucleation and growth less, so the grain size of the composites has no evident changes.

3.2 Influence of graphite particle size on wear loss of composites

The variations in wear loss as a function of load of the composites with different graphite particle sizes are shown in Fig.2. It reveals that the wear loss increases with increasing the load. At 20 N, all the composites show low wear loss due to the presence of Al_2O_3 short fibers that can keep intact and efficiently bear load. The composites with 55, 83 and 125 μm particles have similar wear loss under 140 N, but the composite with the 240 μm particle shows difference that keeps a low wear loss. Although the wear loss of all the composites increases quickly from 140 to 180 N, the composite with the 240 μm particle still keeps the lowest wear loss. Compared with the composite with the 55 μm particle, the wear loss of the composite with the 240 μm particle descends by 77% and 46% at 20 N and 180 N, respectively. This implies that although the fine grains strengthen the matrix, the effect of graphite particle is primary and works effectively under high load.

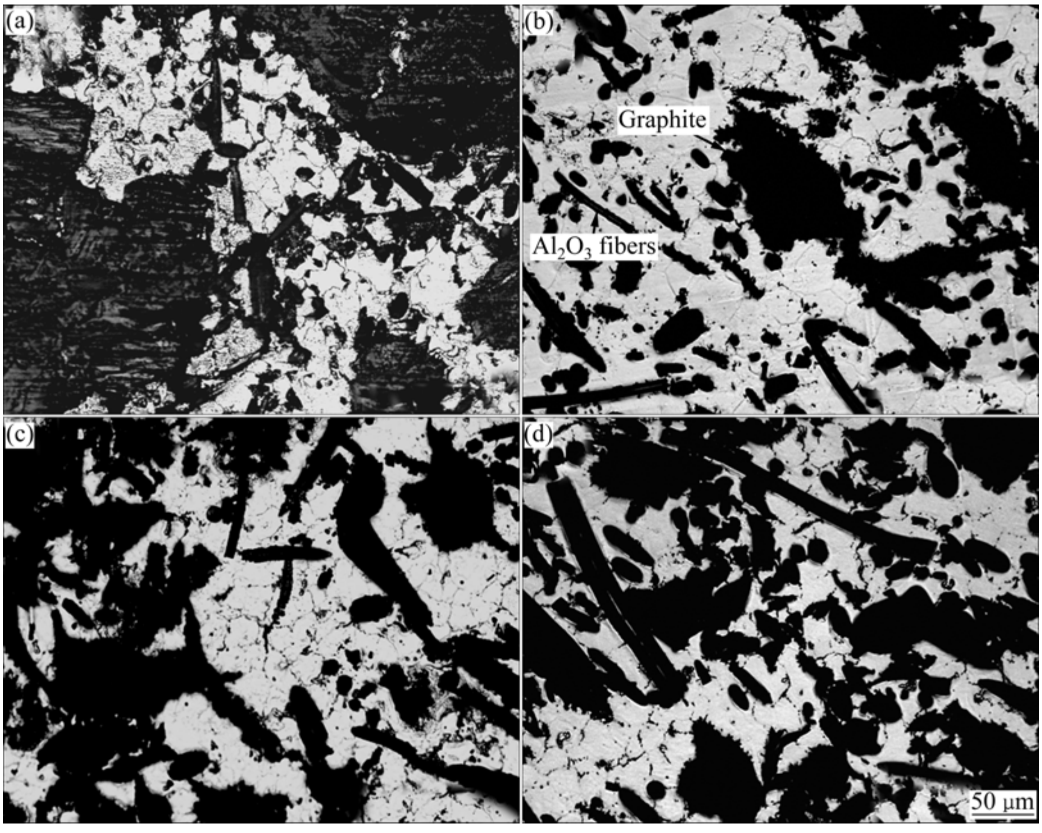

Fig.1 Optical microstructure photographs of composites with different graphite particle sizes: (a) 240 μm; (b) 125 μm; (c) 83 μm; (d) 55 μm