A MODIFICATION TO THE SUBGRAIN COALESCENCE MODEL

Ding Hua and Cui Jianzhong
Northeastern University, P.O.Box 317
Shenyang, China

Abstract

The recrystallizing temperatures of an Al–Mg alloy were determined with the recrystallization nucleating mechanisms studied. The results showed that the starting recrystallizing temperature of the studied alloy is 300℃ and the finishing recrystallizing temperature 400℃ respectively. It was found that there are two nucleating mechanisms in recrystallization process, i.e. subgrain growth and subgrain coalescence. These two mechanisms can function simultaneously in a small region. In this way, the original subgrain coalescence model was modified according to the results obtained from observation and analysis.

Introduction

The recrystallization of metals and alloys has been studied widely over the past half of the century, but there are still some problems which remain unsolved. The recrystallization nucleating mechanisms in the field of physical metallurgy is one of the problems which have been in dispute for a long time[1]. The aim of the present work is to determine the recrystallizing temperatures of an Al–Mg alloy and to go further into recrystallization nucleating mechanisms through this study.

Experimental

The Al–Mg alloy used was of composition of 7.2Mg–0.85Mn–0.085Zr–0.11Cr–0.16Fe–0.10Si, with balanced Al. The homogenizing regulation was 460℃ /24 hr +470℃ /24 hr. The cold rolling reduction was 14%.

The specimens were annealed at different temperatures for 60 min in a muffle furnace and the hardness of the specimens was measured. TEM observation was done on EM 400T Transmission Electron Microscope.

Results

The recrystallizing temperatures can be determined by temperature versus hardness curve (Fig.1). The starting recrystallizing temperature is 300℃ and the finishing recrystallizing temperature is 400℃ respectively.

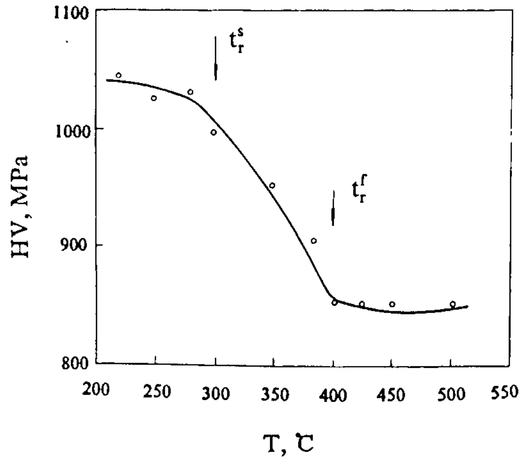

Fig.1 Hardness vs annealing temperature curve
holding time 60 min

Fig.2 show the microstructure of the specimens annealed at 300℃ for 60 min. It was found that the microstructure was quite inhomogeneous. In some part of the specimen, dislocation networks remained while the subgrain structure was formed (Fig.2(a)). Fig.2(b) shows that the subgrain boundaries were dissociating, suggesting that subgrain coalescence was acting as the nucleating mechanism. Fig.2(c) shows a group of subgrains

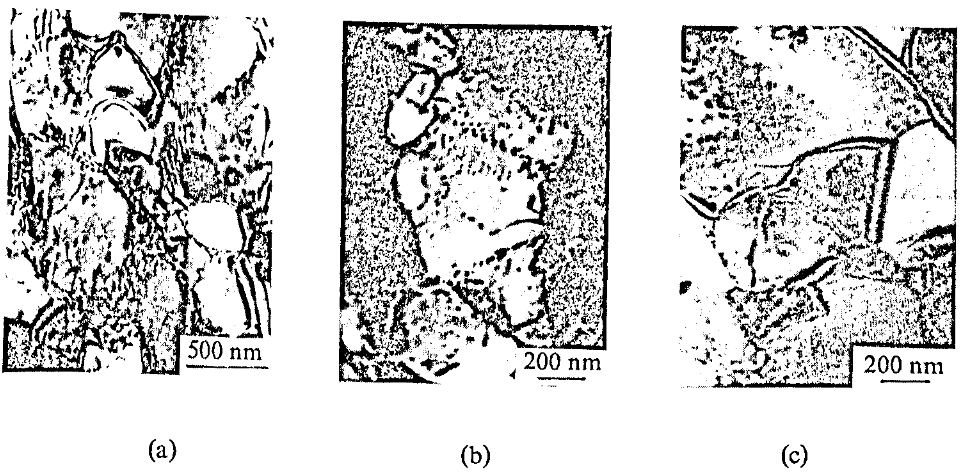

Fig.2 TEM microphotograph of Al-Mg alloy
T=300℃ , holding time 60 min

in the nucleating process. It can be seen that one subgrain boundary was interacting with an array of dislocations and was bulging. This means that this subgrain was growing and its boundary might acquire more and more dislocations through this absorbing process and turn to be a high angle one.

Discussion

The three main models for recrystallization nucleation proposed by previous research workers were subgrain growth[2], subgrain coalescence[3] and bulge nucleation[4]. A lot of experimental work has been done to support these models. Most of the studies about the recrystallization nucleation considered only one isolate mechanism, but in fact, two mechanisms may act simultaneously in a very small region. Fig.2(c) indicates that the subgrains have grown to some extent before a group of subgrains coalesces completely. The similar case was also observed in the recrystallization of Al–Li alloy[5]. This implies that subgrain coalescence and subgrain growth can function at the same time. Subgrain coalescence accompanied by subgrain growth is shown in Fig.3.

(a) (b) (c)

Fig.3 Subgrain coalescence accompanied by subgrain growth

When recrystallization is about to start, the microstructure is generally inhomogeneous. In some part of material, the substructure is still not formed; while in other parts, regular subgrains have already taken shape. In Fig.3, part of the outer border of a group of subgrains has a higher angle of misfit. When recrystallization begins, this part of subgrain boundary would move by absorbing the dislocations in the adjacent substructure in which the regular subgrains have not been formed. And it would become more and more misoriented with respect to its neighbours by this absorbing process. At the same time, the subgrain boundaries within this group are dissociating. The dislocations in these subgrain boundaries would join the dislocations in the connecting boundaries and therefore the angles of misfit of the connecting boundaries become higher. When the outer border of this group of subgrains become a high–angle boundary, a new nucleus is formed.

In the nucleation at the original boundary, bulge and subgrain coalescence may function simultaneously, too. It was considered that the process of subgrain coalescence at boundaries may be a necessary precursor of bulge nucleation[6].

Conclusion

1. The starting recrystallizing temperature and finishing recrystallizing temperature of the studied Al–Mg alloy are 300℃ and 400℃ respectively.

2. In the recrystallization process of the Al–Mg alloy, there are two nucleation mechanisms, i.e. subgrain coalescence and subgrain growth. In a small region, these two mechanisms can function simultaneously.

Acknowledgment

The authors wish to thank Ms. Zhang Caibei for her assistance in preparation of specimens for TEM.

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The publication of this paper is supported by the Wang Zhaofan Commemoration Fund.