# A STUDY OF RECRYSTALLIZATION OF AN Al–Li ALLOY

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

## Abstract

The recrystallizing temperatures of an Al–Li alloy were determined and the recrystallization nucleating mechanisms were studied. The results showed that the starting recrystallizing temperature of the alloy is 250℃ and the finishing recrystallizing temperature is 400℃. There are two recrystallization nucleating mechanisms, i.e. subgrain coalescence and subgrain growth.

## Introduction

Al–Li alloys are considered as ideal structural materials in aerospace industry because of their high strength, high modulus and low density. Much work has been done in studying the new types of Al–Li alloys, heat treatment, forming, mechanical properties and fracture mechanisms of the alloys in recent years. The purpose of this paper is to determine the recrystallizing temperature of an Al–Li alloy and to study the recrystallization mechanisms.

## Experimental

The Al–Li alloy used in the present work was of composition of 2.2Li–2.2Cu–1.3Mg–0.12Zr–0.05Bi, with balanced Al. After cast at 725℃, the alloy was homogenized at 520℃ for 16 hours. Then it was hot–rolled at 500℃ with a total reduction of 88% and cold–rolled with a total reduction of 71%. The alloy was annealed at various temperatures in a muffle furnace and the hardness of the specimens was measured immediately after annealing. The microstructure study was done on EM 400T Transmission Electron Microscope.

## Results

Fig.1 shows the hardness versus annealing temperature curve. From this curve and X–ray diffraction results, it is determined the starting recrystallizing temperature $t_r^s$ is 250℃ and the finishing recrystallizing temperature $t_r^f$ is 400℃.

Fig.2(a) is the microstructure of cold-rolled material which contains dislocation tangled cell-structure. Fig.2(b) and Fig.2(c) give the microstructure of the material annealed at 250℃ and 400℃ for 60 min respectively.

Fig.3 shows the microstructure of materials annealed at 530℃ for 2s when the material is in the primary stage of recrystallization.

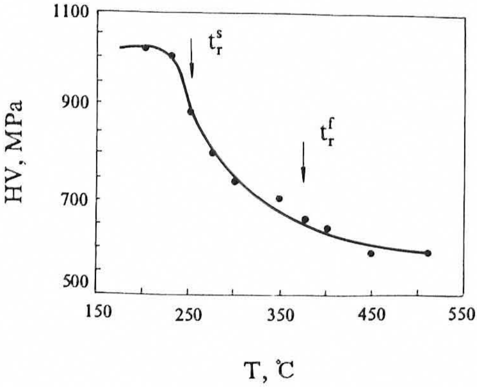
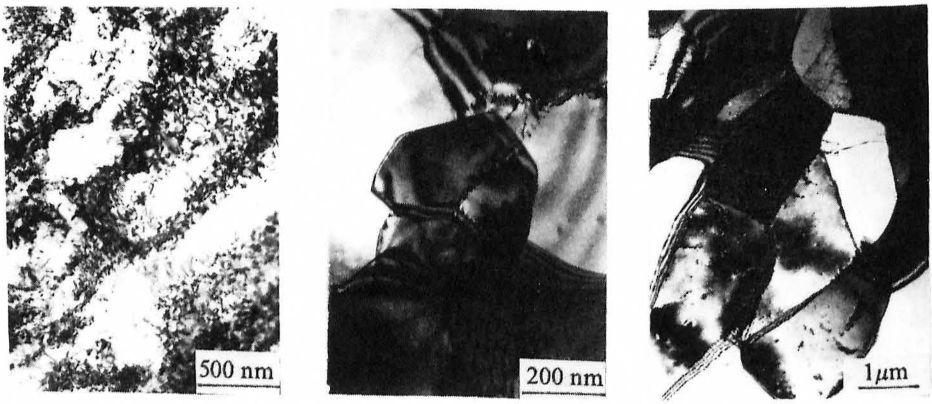
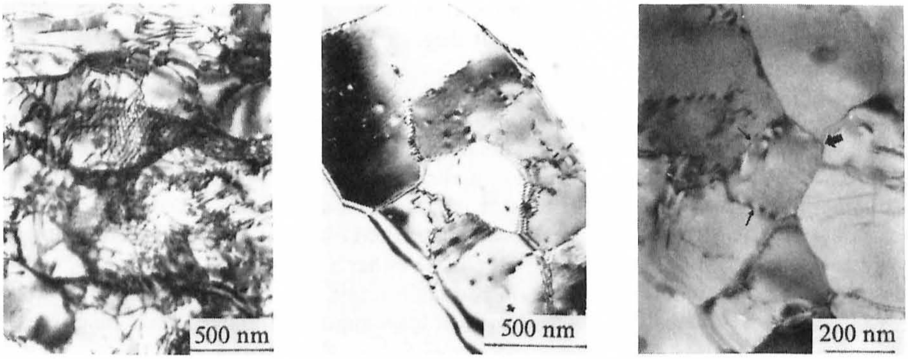



Fig.1 Hardness vs. annealing temperature curve.




(a) (b) (c)

Fig.2 TEM microstructure of Al-Li alloy.
a. as-rolled condition;
b. annealed for 60 min at 250℃;
c. annealed for 60 min at 400℃.




(a) (b) (c)

Fig.3 Initial recrystallization stage of Al–Li alloy (annealed for 2s at 530℃).
a. dislocation network;
b. subgrain in an original grain;
c. recrystallization nucleus.

## Discussion

In 1960's and 1970's, three main recrystallization mechanisms were proposed, i.e. subgrain growth[1], subgrain coalescence[2] and bulge nucleation[3]. A lot of work has been done to study the recrystallization nucleation, but this problem is still in dispute. There has not been much work dealing with the recrystallization mechanisms in Al–Li alloys.

The present work shows that the recrystallization nucleating mechanisms in the studied Al–Li alloy are subgrain coalescence and subgrain growth. As shown in Fig.2(b), some subgrain boundaries are dissociating, which may be considered as the evidence for subgrain coalescence. In completely recrystallized microstructure, there are still residual subgrain boundaries (Fig.2(c)), also indicating that these new grains come from subgrain coalescence.

From Fig.2(b), it is noticed that the individual subgrain has grown to some extent before a group of subgrains coalesces completely. This implies that subgrain coalescence and subgrain growth can take place at the same time.

Under TEM, it was observed that part of the boundary of a subgrain (in the center of Fig.3(c)) becomes a high–angle one (shown in a bigger arrow) and part of it still maintains a low-angle one (shown in smaller arrows), which means that the nucleus is in formation. The high-angle part would move at a relatively high speed and the low-angle part may either become a high angle one or dissociate. The subgrain growth does function even if the low-angle part dissociates.

From Fig.2(c), it can be seen that some grains are still divided by low-angle boundaries although recrystallization has finished. This problem was noticed by some workers[4], but not explained. When the nuclei in formation encounter, there are three cases. When two low-angle parts of the subgrains meet each other, similar and dissimilar signs of sub-boundaries can merge and the angle of the resulted boundary is the algebraic sum of the original ones, while the boundary itself can be either a high-angle or low-angle one. When two high-angle parts encounter or one high-angle part meets another low-angle part, whether single dislocation characteristic of low-angle boundaries takes place needs to be studied further.

In the formation of the nuclei, the connecting subgrain boundary may remain when two subgrains grow respectively. This may also cause the subgrain boundaries to exist in a completely recrystallized material.

From Fig.3, it is also noticed that the recrystallization in the studied alloy is inhomogeneous. After annealed at 530℃ for 2s, there are still a lot of dislocation networks in some part of the material (Fig.3(a)); In some part, regular subgrain structure has been formed. Fig.3(b) shows some subgrains in an original grain and the subgrains are divided by dislocation walls. In some favourable places, new nuclei are being formed (Fig.3(c)).

## Conclusion

1. The starting recrystallizing temperature of the studied Al-Li alloy is 250℃ ; the finishing recrystallizing temperature 400℃ respectively.

2. In the studied Al-Li alloy, there are two recrystallization nucleating mechanisms, i.e. subgrain coalescence and subgrain growth.

## References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