EFFECT OF Fe CONTENT ON RECRYSTALLIZATION TEXTURES OF HIGH-PURITY ALUMINUM

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ABSTRACT In order to clarify the effect of Fe content on the development of the {100}<001> recrystallization texture in Al, high purity Al containing Fe in the range between 0 to 0.20% was cold rolled 95% and either annealed isochronally up to 450℃ or rapidly annealed at 450℃. Their texture were studied by ODF analysis. It was found that at Fe concentration below 0.06%, the development of the {100}<001> orientation was remarkably enhanced by rapid annealing. The effect of the Fe content itself was rather small in this concentration range. At Fe concentration above 0.06%, the {100}<001> orientation developed remarkably with increasing Fe content independently of annealing cycles. At high Fe concentrations above 0.10%, such increases in the {100}<001> orientation was limited by the pinning effect of Al_3Fe particles.

Keyword : *solute atom, Fe content, orientation distribution function, {100}<001> orientation, recovery*

1. INTRODUCTION

In the past, the effect of Fe on the recrystallization texture of Al has been studied mostly in those specimens in which Fe is completely in solution or fully precipitated as Al_3Fe particles before cold rolling [1 to 9]. In the industrial production, however, hot rolled plates are generally temperatures, annealed at intermediate cooled in air and subjected to subsegment cold rolling. Since the effect of Fe in such cases is little known, this was studied in the present investigation.

2. EXPERIMENTAL PROCEDURE

The starting materials were 4 mm thick hot rolled plates of high purity Al-containing Fe in the range between 0 and 0.40%. They were annealed at 450℃ for 30min and cooled in air. Their oxidized surfaces were removed by mechanical grinding. These plates were cold rolled 95% reduction in thickness under good lubrication. They were further subjected to isochronal annealing of 30 min at temperatures between 200 and 450℃ or pulse annealing at 450℃. As reference, cold rolled specimens were also directly heated to 450℃ and held 30min. This annealing cycle will be referred hereafter as rapid annealing at 450℃.

These annealed specimens were chemically thinned down to 0.15 mm thickness using NaOH solution. {111}, {200} and {220} pole figures were determined on there specimens, and from there, orientation distribution function were calculated up to 22nd order. In the following figures, only $\phi=0^{\circ}$ and $\phi=25^{\circ}$ sections of these function are presented in order to save the space.

Locations of important main orientations on those constants ϕ sections are illustrated in Fig 1.

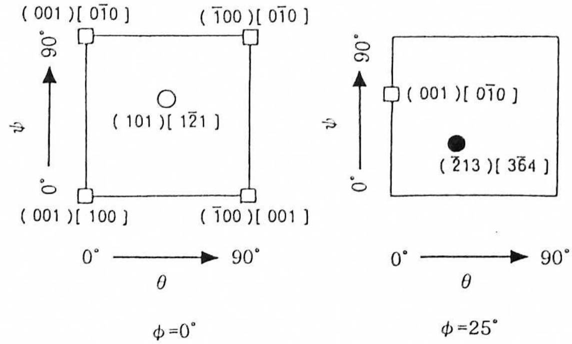


Fig.1 Positions of important ideal orientations on ϕ=0° and 25° sections

3. RESULTS

3.1 Rapid annealing at 450℃

{111} Pole figures observed in the specimens rapidly annealed at 450℃ are illustrated in Fig.2. ϕ=0° and ϕ=25° sections of orientation distribution functions (ODF) of these specimens are shown in Fig.3. Both results show that, in pure Al(0%Fe), both {100}<001> and {123}<634> orientations were very strong. Below and above 0.06%Fe, Fe had a different effect on the annealing texture. At Fe content below 0.06%, the {100}<001> orientation decreased significantly with increasing Fe content, while the {123}<634> orientation did not show any remarkably changes. At Fe content above 0.06%, the {100}<001> orientation developed remarkably, whereas the {123}<634> orientation was rather weak. In Al-0.20%Fe and Al-0.40% Fe alloys, secondary recrystallization occurred in this annealing cycle, Fig.4. so that strong isolated peaks were observed both in their {111} pole figures, Fig.2 and ϕ=0° and ϕ=25° sections, Fig.3.

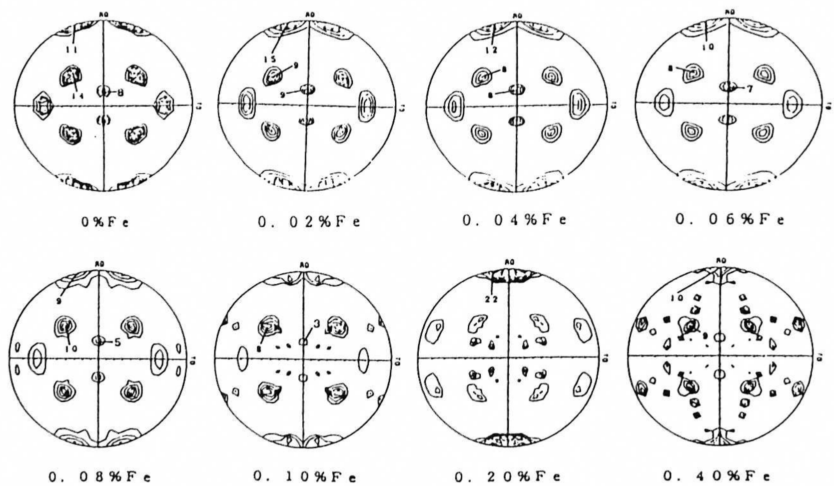


Fig.2 {111} pole figure showing textures observed after rapid annealing at 450℃

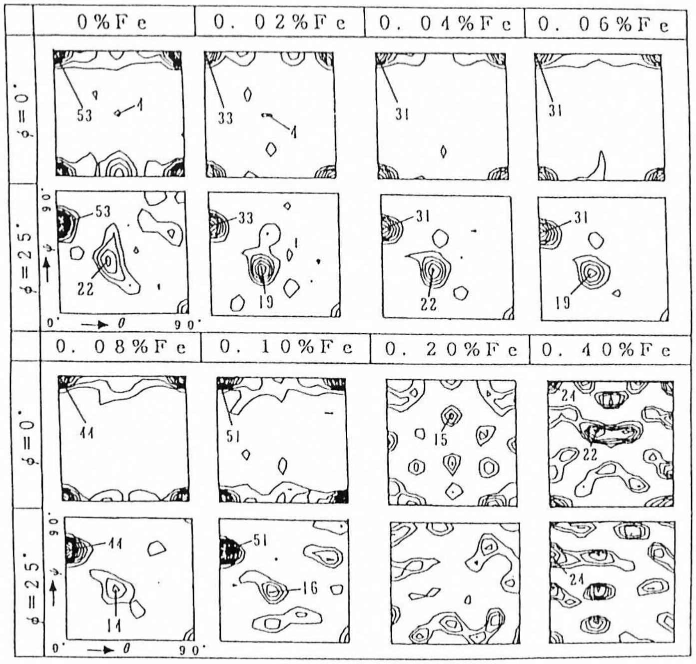


Fig.3 ϕ=0° and 25° sections of orientation distribution function representing textures of specimens rapid annealed at 450℃

3.2 Isochronal annealing up to 450℃

{111} pole figures observed in the specimens isochronally annealed up to 450℃ are given in Fig.4. ϕ=0° and ϕ=25° sections of ODF of these specimens are shown in Fig.5. In pure Al(0%Fe), both {100}<001> and {123}<634> orientation were main orientations of the texture. In this specimens, however , the {100}<001> orientation was much weaker than in the specimens rapidly annealed at 450℃. The intensity of {123}<634> orientation, on the other hand, was not markedly different between there two annealing cycles. Also in this case, the effect of Fe is different at Fe content below and above 0.06%Fe. At Fe content below 0.06%, the intensity of {100}<001> orientation was rather constant, showing the orientation densities of 20 to 29. At Fe constant above 0.06%, the {100}<001> orientation developed remarkably. Also in this concentration range, the orientation density of the {100}<001> orientation was constant, yielding values of about 55. In this case, secondary recrystallization was not observed in Al-0.20% Fe and Al-0.40%Fe alloys.

In this annealing cycle, the {123}<634> orientation decreased continuously with increasing Fe content up to 0.40%.

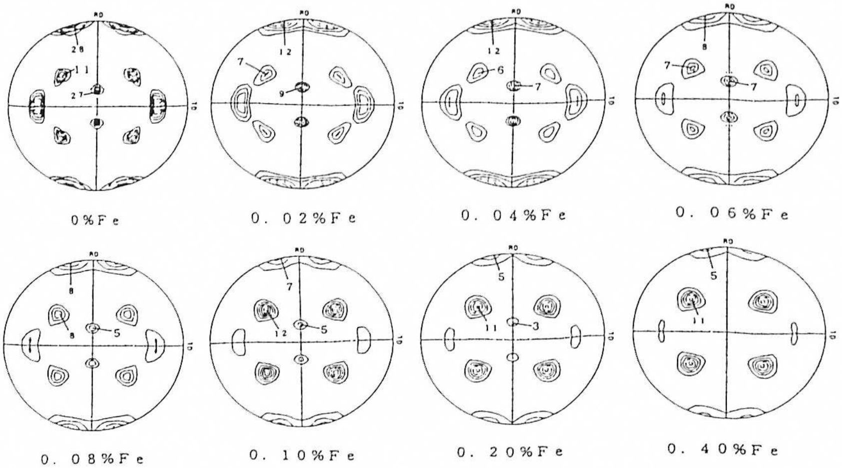


Fig.4 {111} pole figure showing textures observed after isochronally annealing up to 450℃

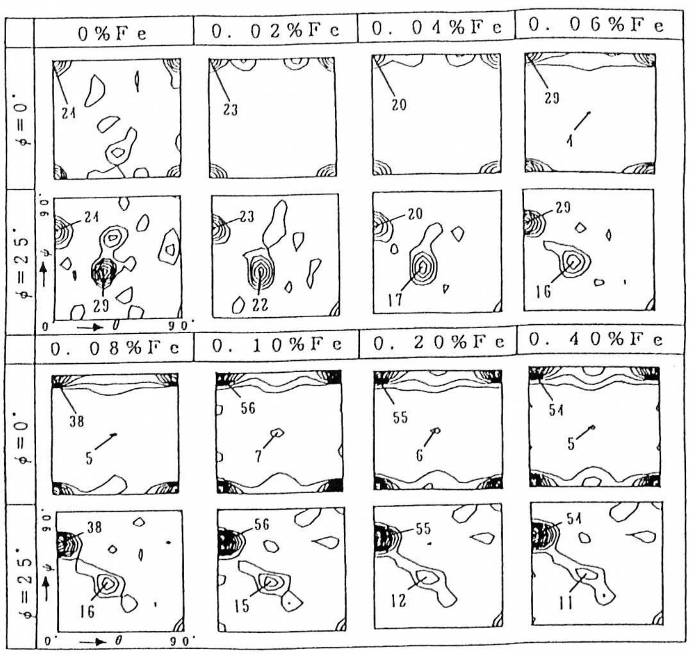


Fig.5 ϕ=0° and 25° sections of orientation distribution function representing textures of specimens isochronally annealed up to 450℃

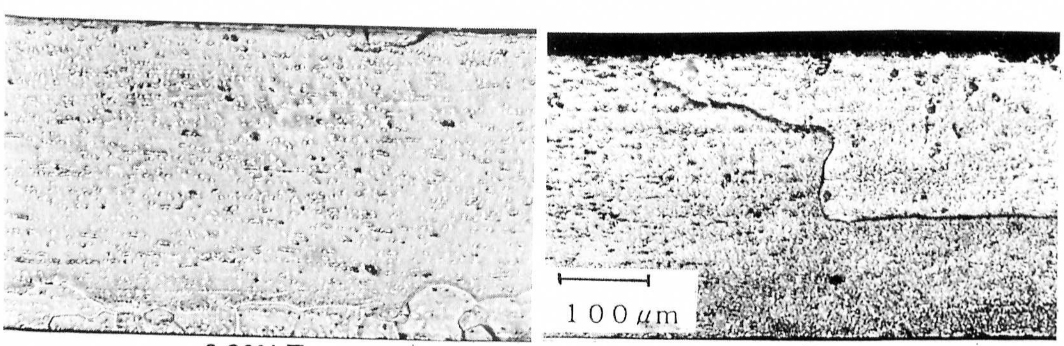
4. DISCUSSIONS

In Fig.7, The {100}<001> orientation densities of specimens subjected to two annealing cycles are plotted against the Fe content. It is evident that, depending upon the Fe content, three different effects of Fe can be observed.

(1) 0<Fe<0.06% : In this range, the development of the {100}<001> orientation depended strongly on annealing cycles. It developed strongly only in the rapidly annealing , suggesting that the recovery suppresses the nucleation and growth of the {100}<001> recrystallized grains. It is further interesting to note that, in the rapidly annealed specimens, the development of the {100}<001> orientation was suppressed with increasing Fe content. This may be ascribed to pinning effect due to Al_3Fe precipitates.

(2) 0.06%<Fe<0.10% : In this concentration range, the {100}<001> orientation increased remarkably with increasing Fe content. Metallographic observations revealed that coarse Al_3Fe particles were present in these specimens. It is suggested that, since nucleation of recrystallized grains are enhanced at there particles, groups of fine grains with random orientations are formed around these particles. These fine grains with random orientations may be readily consumed by larger {100}<001> recrystallized grains during grain growth. As a result, the {100}<001> orientation increases with increasing Fe content.

(3) 0.10%<Fe<0.20% : In this concentration range, growth of recrystallized grains was limited, since a large amount of Al_3Fe particles was presents, as was revealed by metallographic observations. The development of the {100}<001> orientation was therefore limited, giving a constant orientation density in this range. Such possibilities are supported by the very fine grain sizes of these specimens. In the rapidly annealed specimens, however, the driving force was very high, since recovery did not occur extensively. Under such high driving force and in the presence of a large amount of precipitates, secondary recrystallization can occur extensively, Fig.6.



0.20% Fe 0.40% Fe

Fig.6 Secondly recrystallization observed in Al-0.20%Fe and Al-0.40%Fe alloys observed after rapid annealing at 450℃

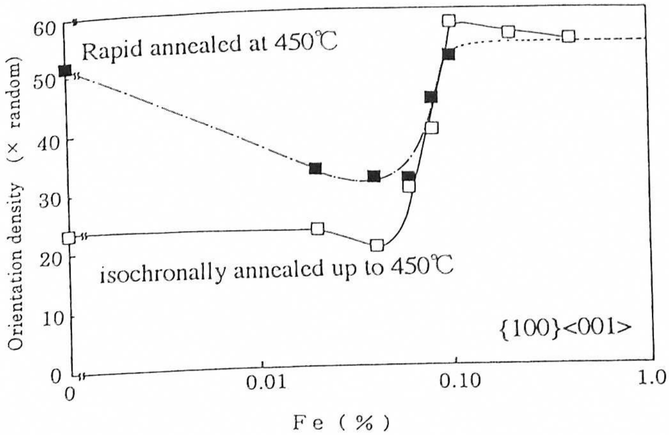


Fig.7 Orientation density of the {100}<001> orientation plotted against Fe content

5. CONCLUSION

(1) In the Fe concentration range between 0 and 0.06%, the development of the {100}<001> orientation is strongly suppressed by recovery which occurs during annealing. This effect become less distinct with increasing Fe content.

(2) In the Fe concentration range between 0.06 and 0.10% the {100}<001> orientation increases with increasing Fe content. It is suggested that this is because fine grains nucleated at Al_3Fe particles are readily consumed by large {100}<001> grains during grain growth.

(3) In the Fe concentration above 0.10%, the development of the {100}<001> orientation is limited, since growth of grains with this orientation is limited by numerous Al_3Fe particles. It has been observed that secondary recrystallization can occur, if the driving forces are sufficiently high.

6. REFERENCES

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