

論文 / 著書情報
Article / Book Information

題目(和文)	Cu-Ni-Si系合金における析出強化と変形双晶形成挙動
Title(English)	Deformation Twinning in Relation to Precipitation Strengthening in Cu-Ni-Si alloy
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学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

論文要旨

THESIS SUMMARY

専攻 : Department of	材料工学	専攻	申請学位 (専攻分野) : Academic Degree Requested	博士 (工学)	Doctor of (工学)
学生氏名 : Student's Name	荒木章好		指導教員 (主) : Academic Advisor(main)	里 達雄	教授
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要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words)

This thesis clarified that two kinds of precipitates form in the Cu-Ni-Si alloy using differential scanning calorimetry (DSC) and transmission electron microscopy (TEM). This thesis also clarified the work hardening behavior and Bauschinger effect on the basis of the interaction between the δ -Ni₂Si precipitates and dislocations. In addition, this thesis revealed that deformation twinning happens in the alloy and it strongly depends on the interaction between precipitates and dislocations, and showed the enhanced deformation twinning results in high elongation. This thesis suggested a guideline of precipitation microstructure for high strength and high formability. The thesis consists of 6 chapters.

In Chapter 1 “**General introduction**”, background, current problems and objectives of this thesis are presented. Especially, the importance of clarifying the precipitation process in the early stage of aging and the effect of the precipitate on the work hardening behavior is described.

In Chapter 2 “**Precipitation behavior in Cu-Ni-Si alloy**”, two different precipitates are found to form in this alloy system using DSC and TEM observation. The differences of the two precipitates are demonstrated in this chapter. X-phase is the main precipitating phase during aging treatment at 573 K, whereas the δ -Ni₂Si phase is the main precipitating phase during aging treatment at 723 K. The results suggested that the formation of X phase cause the two-stage hardening behavior during under-aged condition. In addition, the size, volume fraction and number density of δ -Ni₂Si as a function of aging time during aging treatment at 723 K is also investigated in this chapter using resistivity measurements and TEM observations.

In Chapter 3 “**Work hardening behavior in Cu-Ni-Si alloy**”, the interaction between the precipitates and dislocations was investigated from the analysis of the initial work hardening rate and the Bauschinger effect. The shearable/nonshearable transition occurs at the aging condition of 3.6 ks at 723 K in the specimen with large grain size and low dislocation density. In addition, it was estimated that the most of precipitates are non-shearable after the peak-aged condition. TEM observation confirmed that the precipitate is cut by dislocations before the transition, and the dislocation loops are left around the precipitates after the transition. The transition time becomes earlier in the specimen with high dislocation density because the precipitates can easily form and grow on the dislocations.

The formation of the thin deformation twins was found in the under-aged Cu-Ni-Si alloy deformed at room temperature. In addition, the formation of the deformation twins accelerates the work hardening, resulting in the increase of the work hardening rate.

In Chapter 4 “**Deformation twinning behavior in Cu-Ni-Si alloys**”, the work hardening behavior and microstructure change during tensile deformation of Cu-Ni-Si alloy deformed at 77 K and of Cu-Ni-Si with high content of Zn deformed at room temperature have been investigated. The results for the Cu-Ni-Si alloy deformed at 77 K indicated that the deformation twinning significantly depends on the precipitate state. Investigations for the under-aged and peak-aged specimen revealed the applied stress is a significant factor for the deformation twinning. While the deformation twinning behavior in the over-aged specimen cannot be explained from the point of the applied stress.

Microstructure observation for the Zn-added Cu-Ni-Si alloy revealed the deformation twins first nucleates at the vicinity of the grain boundaries, and then grows as strain increases. Furthermore, the enhanced deformation twinning results in the low and constant work hardening rate and high elongation. The combination of the precipitation hardening and twinning deformation is expected to achieve high strength and formability.

In Chapter 5 “**Effect of precipitates on the deformation twinning**”, the cause of the deformation twinning is explained from both micro and macro point of view using TEM observations and slip line observations. The TEM suggested the possibility that the coarse precipitates can restrict the propagation of the deformation twins, while fine precipitates have no direct effect on the deformation twinning.

The slip line observation revealed that the dislocation slip localized on a few slip planes in 3.6 ks aged condition, while the slip distribution was very homogeneous in over-aged condition. The results suggested the stress concentration is another significant factor for the deformation twinning, and the superposition of the precipitation strengthening and the stress concentration successfully explained the twinning deformation behavior in the Cu-Ni-Si alloy.

In Chapter 6, “**General conclusions**”, conclusions obtained each chapter are summarized.

備考：論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1 copy of 800 Words (English).

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