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ROLLING AND RECRYSTALLIZATION TEXTURES OF A Ni-40Co ALLOY

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Abstract

The deformation texture of a Ni-40 wt. percent Co alloy has been found to be of neither the pure metal nor the alloy type. On annealing, an almost random texture is produced in this alloy in the fully recrystallized condition. During the grain growth stage, a weak cube component develops which does not show much of a variation even after prolonged annealing.

Introduction

Rolling and recrystallization textures of a number of F.C.C. metals such as Cu and Al and their alloys have been well documented. It is now known that copper or pure metal type deformation texture is obtained in materials of medium to high stacking fault energies, whereas α- brass or alloy type deformation texture is exhibited by materials of low stacking fault energies. While the alloy type texture has practically only the brass (B_S) {110}<112> component, in the pure metal type the Cu {112}<111>, S {123} <634> and the B_S components are nearly equally strong. The recrystallization textures of pure Cu, Al and Ni consist predominantly of the cube {100}<001> component, which is found to decrease in intensity and even vanish on addition of certain solute metal atoms.

Although Ni is an industrially important F.C.C. metal, not much work has been reported in the literature on the deformation and recrystallization textures of pure Ni and its alloys. Addition of Co is known to decrease the stacking fault energy of Ni drastically(1). In a previous investigation (2) pure Ni and a series of Ni-Co alloys with nominal weight percentages of cobalt ranging from 10 to 60 were prepared in the laboratory and cold rolled upto 95% reduction. An examination of the deformation textures revealed that while pure Ni and Ni-Co alloys with upto 30 wt percent. Co showed pure metal type texture, the alloy with 60 wt. percent Co exhibited the alloy type texture (see Fig. 1a-c). The Ni-40Co alloy showed a mixed texture indicating that it was in the transitional range. The present work reports the results of an investigation into the development of the rolling and recrystallization textures in the Ni-40Co alloy.

Experimental

The alloy was melted under vacuum and given several cold rolling and annealing treatments to yield the starting material of almost random texture. Samples cut out from the starting materials were cold rolled in a laboratory rolling mill to 40%, 70%, 90% and 95% reduction in thickness. Recrystallization anneals on the 95% cold rolled materials were carried out at 800°C in an appropriate salt bath for periods of time ranging from a few minutes to 50 hrs.

Crystallographic textures from the cold rolled and the recrystallized samples were determined by measuring the $\{111\}$, $\{200\}$, $\{220\}$ and $\{311\}$ incomplete pole figures. Three dimensional orientation distribution functions (O.D.F's) were calculated from these pole figure data in the usual manner.

Results and Discussion

The $\{111\}$ pole figures of the alloy cold-deformed 40%, 70%, 90% and 95%, are given in Fig. 2 (a-d). Evidently, a strong Goss texture develops in the 40% cold-worked material which eventually changes into mainly a Brass-type texture after 95% deformation. Figure 3 shows four ϕ_2 sections (ϕ_2=0°, 45°, 60° and 65°) of the O.D.F's of each of the cold-rolled materials. The development of the deformation texture in this alloy as a function of increasing cold deformation can be clearly followed from this figure. After 40% cold-work the major texture components are found to be the Goss $\{110\}\langle 001\rangle$, Cu $\{112\}\langle 111\rangle$ and also some S $\{123\}\langle 634\rangle$. Cold-working by 70% produces a marked shift of the Goss orientation to near the B_s orientation, $\{110\}\langle 112\rangle$. The relative intensity of the B_s component increases with increasing amount of cold rolling and this becomes quite sharp after 95% deformation. The intensity of the Cu-component increases significantly after 70% cold rolling. Further deformation leads to a decrease in the sharpness of this component which ultimately becomes quite weak after 95% cold-rolling. The S component sharpens after 70% cold-work, then weakens a little bit and finally becomes sufficiently intense after 95% deformation. Thus, the deformation texture of the 95% cold-rolled alloy can be described as lying in between that of pure metal type and alloy type.

The 95% cold-rolled alloy was subjected to recrystallization anneal at 800°C for various lengths of time ranging from 8 minutes to 50 hours. The development of the annealing texture in this alloy can be followed from the figure 4 (a-d). After 8 mts annealing, essentially an α-brass type texture develops. A longer anneal for 15 mts produces almost a random texture, see Fig. 4b. Recrystallization of the alloy is found to be effectively complete at this stage. Increasing the annealing time beyond this produces grain growth and weak cube texture $\{100\}\langle 001\rangle$ and its first generation twins develop. There seems to be hardly any variation in the texture for annealing time upto 50 hours (Fig.4d).

Fig. 5 represents the O.D.F. for the 95% cold-rolled alloy which was annealed at 800°C for 15 minutes to achieve full recrystallization. The intensity level here is quite low, as was also seen from the relevant pole-figure (Fig.4b). A host of components have been identified in the overall texture, but none of them is found to have a significant volume fraction.

Thus the Ni-40Co alloy which is found to possess quite a sharp cold-rolling texture, does not produce a sharp recrystallization texture on annealing. The cube component is rather insignificant in the texture of the full recrystallized material. Though it sharpens in intensity during the grain-growth stage, it never reaches a high intensity level, even after prolonged annealing. The cube component has been found to be highly intense and is the most dominant component of the recrystallization textures of pure Ni and Ni-Co alloys containing upto 30 wt. percent cobalt (Fig. 6a). On the other hand, a Ni-60Co alloy has also been found to develop a sharp recrystallization texture,but does not show any cube component (Fig.6b). Thus the Ni-40Co alloy seems to belong to neither of these two classes, whether in the cold rolled or the recrystallized conditions, and, therefore, truly represents a transitional behaviour.

Conclusions

1. The Ni-40 wt. percent Co alloy shows a deformation texture which is neither pure metal type, nor alloy type.
2. The recrystallization texture of the alloy is rather weak and nearly random.
3. A weak cube component develops during the grain growth stage and does not practically show any variation in intensity with prolonged aging.

References

1. P.C.J. Gallagher : Met. Trans., Vol.1,P.2429,1970.
2. R.K. Ray and K. Lücke: Unpublished research.

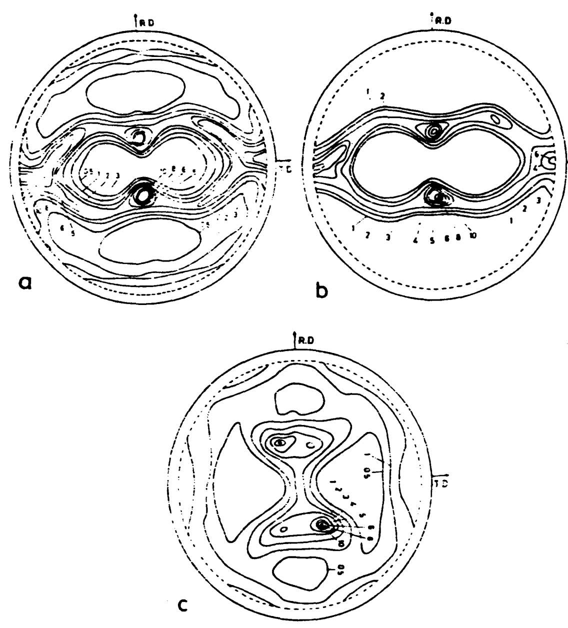

Fig. 1 {111} pole figures of 95% cold rolled a) pure Ni, b) Ni-30Co and c) Ni- 60Co.

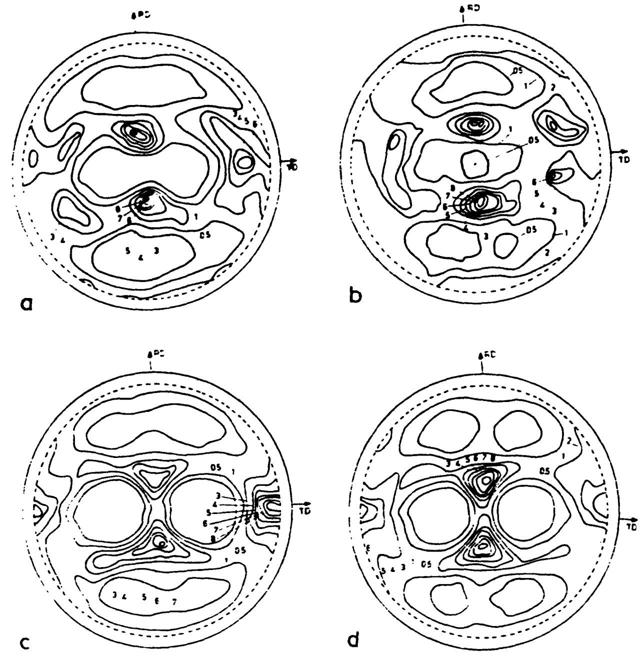

Fig. 2 {111} pole figures of Ni-40Co alloy, cold rolled a)40%, b) 70%, c) 90% and d)95%.

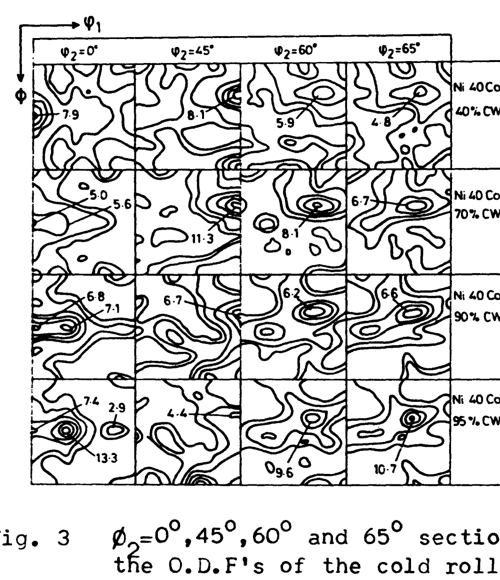

Fig. 3 $\phi_2=0^{o},45^{o},60^{o}$ and 65^{o} sections of the O.D.F's of the cold rolled materials.

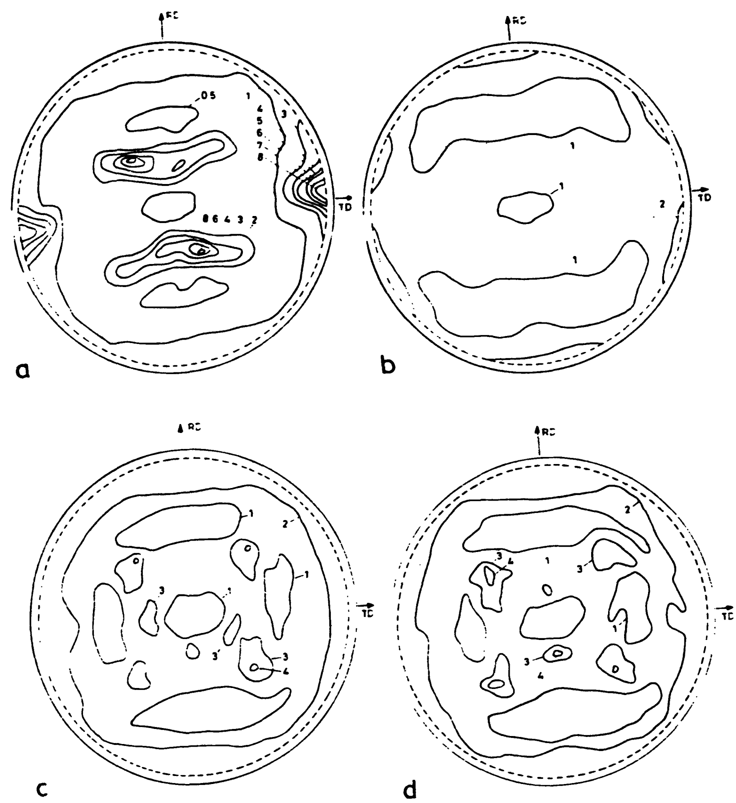

Fig. 4 {111} pole figures of the alloy, cold-rolled 95% and given a recrystallization anneal at a) 8 mts b) 15 mts c) 3hrs and d) 50 hrs.

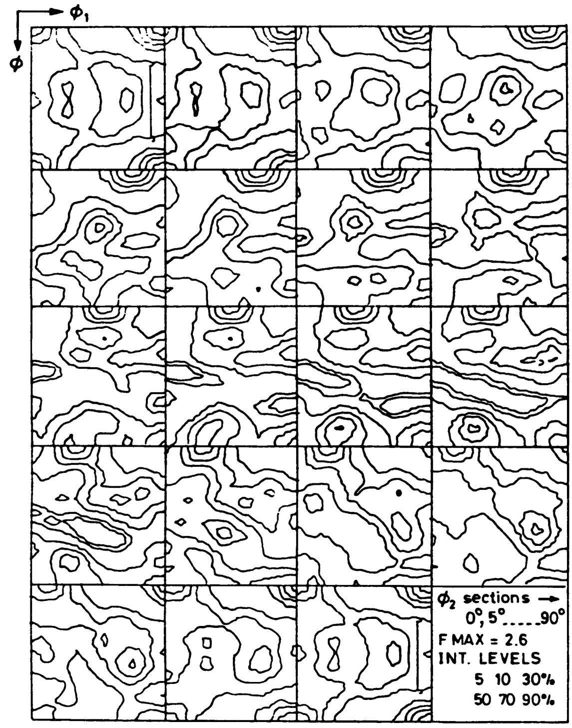

Fig. 5 O.D.F. of the 95% cold-rolled alloy, annealed at 800° for 15 minutes.

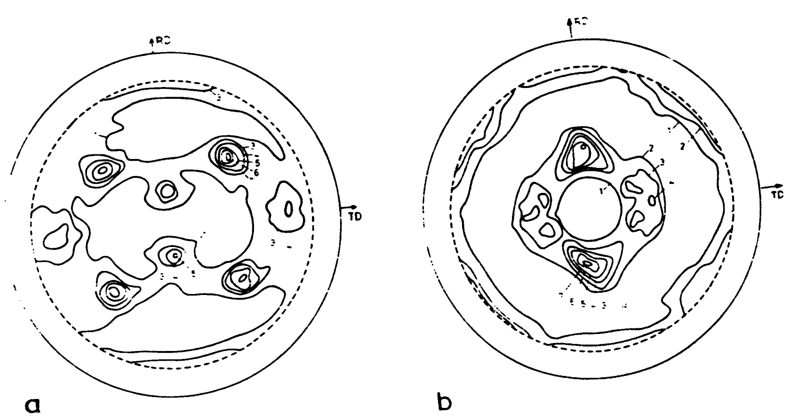

Fig. 6 {111} pole figures showing the recrystallization textures of a) Ni-30Co and b) Ni-60Co.