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DEFORMATION TEXTURES IN A COPPER NICKEL ALLOY

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ABSTRACT

Non-random distribution of orientations between the neigbouring grains of polycrystalline aggregates leads to preferred orientations or textures. Texture analysis of a Cu-10 % Ni alloy carried out on three types of cast materials after varying amounts of deformation led to clearly defined copper type texture due to the dominance of high stacking fault energy SFE regions in the structure. (123) $[41\bar{2}]$ is the strongest orientation observed with (123) as the plane lying paralel to the rolling plane and $[41\bar{2}]$ as the direction paralel to the rolling direction.

Key Words : Texture, Stacking fault energy

BAKIR NİKEL ALAŞIMLARINDA DEFORMASYON ÖRGÜSÜ

ÖZET

Polikristalin malzemelerde komşu taneler arasındaki yerleşim ilişkileri tercihli yerleşim veya örgüyü ortaya çıkarır. Üç farklı tip döküm prosesi ve farklı deformasyon seviyeleri sonrası Cu-% 10 Ni alaşımlarından alınan numuneler üzerinde yapılan analiz, yapıda hakim durumda olan yüksek istif hatası enerjisinden dolayı bakır tipi örgüyü açık bir şekilde ortaya çıkarmıştır. Gözlenen en kuvvetli yerleşim, haddeleme düzlemine paralel (123) düzlemi ve haddeleme yönüne paralel $[41\bar{2}]$ yönünden oluşan (123) $[41\bar{2}]$ olmuştur.

Anahtar Kelimeler : Örgü, İstif hatası enerjisi

1. INTRODUCTION

Non-random distribution of orientations between the neigbouring grains of polycrystalline aggregates leads to preferred orientations or textures. Deformation textures originate from the crystallographic nature of slip and twinning processes. At large strains slip is the dominant factor but twinning can also lead to texture development due to massive re-orientation involved (Hatherly and Hutchinson, 1979).

In single crystals the slip direction rotates until it comes to the plane of compression. Similar rotations occur in the individual grains of polycrystals (Honeycombe, 1968; Smallman, 1970). The restricted number of operative slip systems available produces crystal lattice rotations toward a limited number of end points, and gives rise to a deformation texture. The resultant texture is dependent on the nature of the imposed stress or strain system, the extent of deformation and operative deformation modes, which are functions of crystal structure and atomic bonding (Hatherly and Hutchinson, 1979).

The degree of texture produced by rolling is described in terms of an ideal orientation which consists of an (hkl) plane lying paralel to the rolling plane and an <uvw> direction paralel to the rolling direction. The scatter about an ideal orientation decreases with increasing amounts of deformation.

More than one texture can co-exist in some rolled metals (Smallman, 1970).

Preferred orientations are best described using pole figures, which are simple stereographic projections showing the scatter of particular crystallographic directions in the grain structure. Pole figures contain some reference directions corresponding to easily defined directions in the specimen (Hatherly and Hutchinson, 1979). Deformation of face centred cubic materials and alloys results in one or other of two types of texture, classified for convenience as copper type and brass type (Dündar, 1983).

With the exception of silver, the texture of the common face centred cubic metals can be described as (123) $[41\bar{2}]$ or better as (123) $[41\bar{2}]$ + (146) [211] which are the ideal orientations of copper type texture. The (110) $[1\bar{1}2]$ ideal orientation of brass type textures, which was once believed to represent all cold-rolled face centred cubic metals, is produced only by the deformation of silver and alloys of most of the common fcc metals. The (146) [211] orientation is an intermediate between (123) $[41\bar{2}]$ and (110) $[1\bar{1}2]$, with the (111) pole near the rolling direction as the rotational axis (Dündar, 1983).

The fundamental factor governing the texture transition is stacking fault energy rather than the misfit between the solvent and solute atoms. The decrease in stacking fault energy of a material which is produced mainly by addition of solute atoms leads to texture transition from copper type to brass type (Smallman and Green, 1964).

High stacking fault energy materials produce copper type textures. Any material with a stacking fault energy less than 35 mJ/m² produces a brass type texture when rolled at a temperature not higher than 0.25 of the absolute melting point Tm. The rolling texture transition is a function of deformation temperature as well. A metal which possesses a stacking fault energy higher than 35 mJ/m^2 may show a (110) $[1\bar{1}2]$ brass texture if it is rolled at a temperature below 0.25 Tm. Conversely, raising the temperture may favour the copper texture in an alloy which usually produces a brass type texture.

Deformation of copper gives rise to (123) $[41\bar{2}]$ + (146) [211] textures. Addition of different amounts of solutes to copper lead to a transition from copper type to brass type texture. 10 at.% zinc is enough to produce a change in texture, whereas much smaller amounts of aluminium or tin would initiate the transition. With further amounts of solutes a complete transition takes place. However a complete transition never occurs in the copper-nickel system, in which only a small transition can be achieved with an addition of 50 at % nickel (Dündar, 1983).

2. EXPERIMENTAL PROCEDURE

The research was carried out on the copper-10% nickel alloy (Dündar, 1983; 1989). Sand-cast, chill-cast and semi continuously cast ingots of the same composition were cold rolled to various degrees of deformation.

A Philips model texture goniometer was used to determine the textures of the deformed materials. Strips of metal cut paralel to the longitudinal planes of the 50, 80 and 90 % deformed materials were stuck together to make an area of 3 cm x 3 cm and mounted in bakelite. After polishing on grade 400 emery paper a light etch of ferric chloride solution in HCl was applied to remove the deformed layer due to polishing. Specimens were mounted in the goniometer at such a height that the needle at the top could just touch them in the centre. The 2θ angle for the {111} poles was calculated as 43.47º. Thus the 2θ setting for the counter was adjusted to 43.47º and the θ setting for the goniometer to 21.73º. The goniometer was set to give a 10º spiral in 16 minutes. Only reflections up to 70º out from the centre could be measured. The chart was set to 10^3 counts/second and a speed of 600 mm/hr. Pole figures obtained from chart recordings were drawn on a 10º spiral Wulff net. Since the counter sensitivity was kept constant throughout the experiments the pole figures obtained from different rolling reductions could be compared with each other. Standard projections were used to assign textures to the experimental pole figures.

3. RESULTS

No distinct texture could be observed at low deformation levels (Figure 1) The scatter about the ideal orientation due to insufficient deformation is observed in the sand-cast alloy, even after 80 % deformation (Figure 2) Clearly defined copper-type texture was obtained from the analysis of all three types of materials after 90 % deformation (Figure 3).

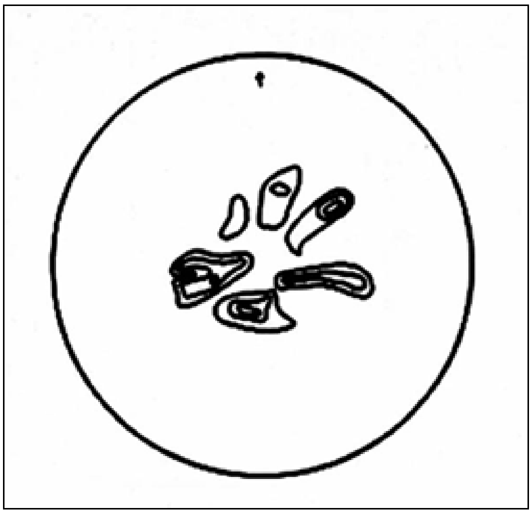


Figure 1. Low deformation texture

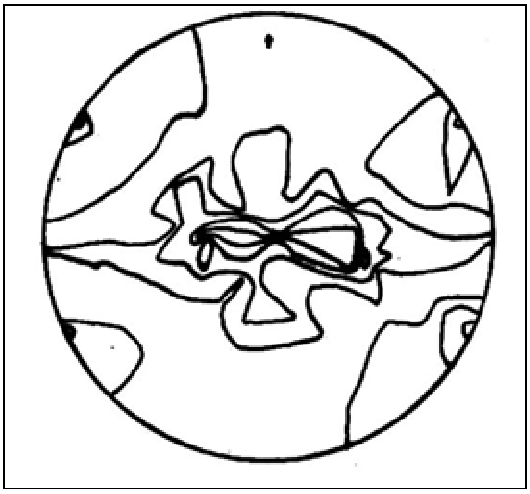
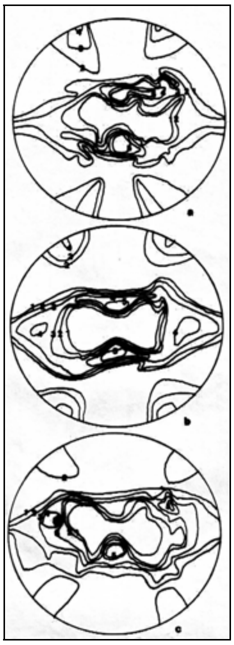


Figure 2. Texture of 80 % deformed sand cast material



a) Sand cast, b) Chill cast, c) Semi-continuously cast

Figure 3. Texture of 90 % deformed materials

4. DISCUSSION

It is shown in previous publications (Dündar, 1983; 1989) that the degree of microsegregation in Cu-Ni alloys is significantly influenced by the rate of solidification. Slow rates of solidification produces initial dendrite arms rich in nickel content leading to decreases in the SFE. Diffusion and convection mechanisms maintain uniform composition by carrying the rejected copper away from the dendrite arms. The liquid to solidify last produces high SFE copper enriched material in the interdendritic regions.

The number of grains in the scanned area affect the uniformity of the texture. Chill cast material showing small grain size produced the most regular texture as a result of reflections from a large number of grains. Sand–cast material produced some scatters due to a large grain reflecting more strongly than the other grains. Dendrites oriented in arrays in large grains of semi-continuously cast material give rise to similar scatter although more symmetric.

(123) [41$\bar{2}$] is the strongest orientation pointing to the copper type texture from the interdendritic regions. The (146) [211] orientation claimed to be an intermediate between (123) [41$\bar{2}$] and (110) [1$\bar{1}$2] could not be detected at all .The reflections from (112) [$\bar{1}\bar{1}$1] revealed the second strongest orientation. (110) [1$\bar{1}$2] detected in sand cast material as a brass type texture of low SFE pointed the degree of microsegregation of Ni on the dendrite arms. (110) [011] is the other weaker reflection.

5. CONCLUSIONS

1. Cu-10 % nickel alloy is characterised with the copper type texture (123) [41$\bar{2}$].
2. The amount of Ni is not enough for a complete transition to brass type texture.
3. High Ni content on dendrite arms gives rise to a weak (110) [1$\bar{1}$2] orientation.

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