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Cold Rolling Texture in Ordered CuZn Alloy*

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Abstract: The texture of 80% cold rolling CuZn ordered alloy was investigated. The development of rolling texture in 50%Cu-50%Zn(at.) alloy has been characterized by a inhomogenous {111} fiber texture with strong {111}<112> component, which is significantly different from the conventional Cu-Zn alloys. The main characters of cold rolling textures in ordered CuZn alloy are obviously similar to that in IF steel with bcc structure or ordered Fe_3Al-based alloys with imperfect B2 structure. From the rolling texture obtained by experiments and simulations, it can be estimated that main deformation mechanism are characterized by the activation of slip systems with <111> Burgers vector in CuZn ordered alloy.

Key words: cold rolling, rolling texture, ordered CuZn alloy

The rolling texture development in Cu-Zn alloys has been investigated [1,2]. With increasing Zn content, i.e. with decreasing stacking fault energy the rolling texture will be transformed from {112}<111> type to {011}<211> type, but the texture remains the characters for fcc metals. If Zn content increases further and reaches 50%(atomic fraction), an ordered B2 structure will be obtained and the texture development could be changed entirely which should be observed in details here.

1 Experimental

CuZn ingot (w_{Cu} = 51% and w_{Zn} = 49%) was obtained by vacuum melting and casting with high purity copper (99.99%Cu) and zinc(99.99%Zn). Then the ingot was forged to 4.5 mm thick at about 700 ℃. The forged sheet was cold rolled down to 1 mm thick (about 80% reduction). The {110}, {200}, {210} and {211} pole figures were determined by X-ray reflection technique, and the ODFs(Orientation Distribution Functions) were calculated by Bunge method[3]. In order to compare with the rolling texture of other ordered alloy, the {220}, {400} and {422} pole figures of 80% hot rolled Fe_3Al-based alloy sheet received from Z Sun[4] were measured and the ODF was calculated.

2 Results and Discussions

Fig. 1 shows the $\varphi_1 = 0°$ and $\varphi_2 = 90°$ ODF sections of CuZn alloy sheet before and after 80% cold rolling respectively, which give the main texture characters. It can be seen in Fig. 1(a) and (b) that the cold deformation is started from a rather random initial texture. Fig. 1(c, d) illustrate that the rolling texture component is characterized by a strong {111}<112> component ($\varphi_1 = 90°$, $\Phi=60°$, $\varphi_2=45°$) and a second strong {223}<110> component ($\varphi_1=0°$, $\Phi=45°$, $\varphi_2=45°$).

Generally, the rolling texture of the materials with B2 structure could be observed better along the so called α or γ orientation fibers[2], in which the grains are so orientated that their <110> directions are parallel to the rolling direction and the {111} planes are parallel to rolling plane respective--ly. Fig. 2 shows the α and γ fiber analysis. It can be seen that a strong γ fiber texture with a maximum at {111}<112> and a incomplete α fiber texture with a peak between {112}<110> and {111}<110> (i.e. about {223}<110>) have been generated after the cold rolling.

For the conventional Cu-Zn alloy system with fcc structure, the corresponding rolling texture was so changed that with increasing Zn content the {112}<111> type became {011}<211> type gradually [1]. Fig. 3 shows the $\varphi_2=45°$ ODF section o cold rolled Cu-Zn alloys. The main rolling texture components {112}<111>($\varphi_1=90°$, $\Phi=35°$, $\varphi_2=45°$ and {011}<211> ($\varphi_1=55°$, $\Phi=90°$, $\varphi_2=45°$) a situ-ated in the $\varphi_2=45°$ section. The rolling textures

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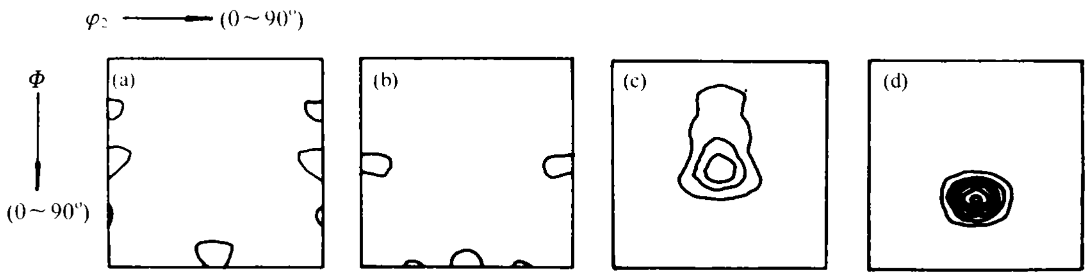

Fig.1 Textures of CuZn before(a,b) and after(c,d) 80% cold rolling (density levels:2,4,6,8,10,12,14)
(a) φ_1 = 0°(MAX = 2.9); (b) φ_1 = 90°(MAX = 2.9); (c) φ_1 = 0°(MAX = 7.7); (d) φ_1 = 90°(MAX = 13.2)

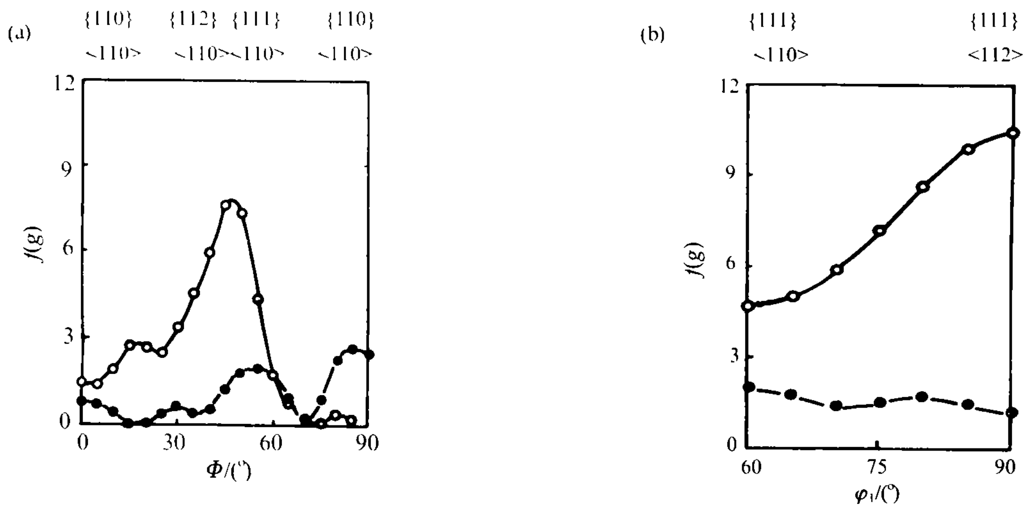

Fig.2 (a) α fiber texture and (b) γ fiber texture of cold-deformed CuZn

of pure copper, Cu-5%Zn and Cu-30%Zn alloys were characterized by different amount of texture component {112}<111> and {011}<211>(Fig. 3(a ~ c)), in which the {112}<111> was reduced with increasing Zn content, which induced the transformation of deformation mechanisms from slip to mechanical twinning and shear band formation because of the decreasing stack fault energy[1]. When the Zn content went up to 49%, however, CuZn ordered B2 structure was formed and the development of rolling texture was entirely changed. According to the φ_2=45° section in Fig. 3(d), the dominant orientation accumulation was around φ_1=90°, Φ=60°, φ_2=45° i.e. {111}<112>(which is accurately at (φ_1=90°, Φ=55°, φ_2=45°). This implies that the deformation mechanism has been changed.

The cold rolling texture in bcc metals and B2 alloy was mainly formed by the slip of dislocations with <111> Burgers vector. As an examples, Fig. 4(a) shows the φ_2=45° section of a 74% cold rolled IF steel sheet, which gives a clear γ fiber texture[5]. Fig. 4(b) illustrates the φ_2=45° section of the 80% rolled Fe_3Al-based alloy sheet with imperfect B2 structure, which also shows a strong γ fiber texture. Therefore it can be seen in Fig. 3 and Fig. 4 that some characters of cold rolling texture in ordered CuZn alloy are obviously similar to that in IF steel or ordered Fe_3Al-based alloy.

It is generally believed that during deformation at room temperature the mainly activated slip systems in bcc metals and B2 alloy should be the {110}<111>, but also the slip on {112} plane shows a strong tendency to be activated after which the γ fiber texture would be formed[6,7]. Comparing the similar texture formation it can be therefore estimated that the main operative slip systems in CuZn alloy could be {110}<111> and {112}<111> as well.

Raabe[8] has simulated the rolling texture in Fe_3 Al-based alloy with incomplete B2 structure. The results show that the simulation will have a good agreement with the texture of rolled CuZn shown in Fig. 2, especially in the area near α-fiber, in addition to the activation of {110}<111> and {112}<111> slip systems, the {001}<100> slip

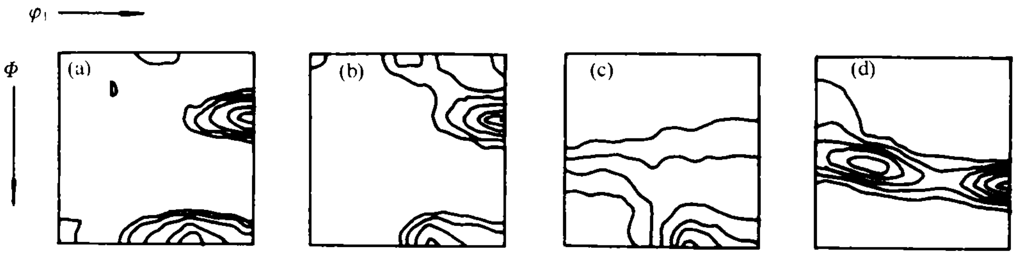

Fig.3 ODFs of cold-rolled Cu-Zn alloys with different Zn content(φ_2=45° section)
(a) Cu-75%Red. (MAX = 11)(Hirsch[1]); (b) Cu-5%Zn 75%Red. (MAX=7)(Hirsch[1]); (c) Cu-30%Zn 75%Red. (MAX=7)(Hirsch[1]); (d) Cu-49%Zn 80%Red. (MAX=13.2)

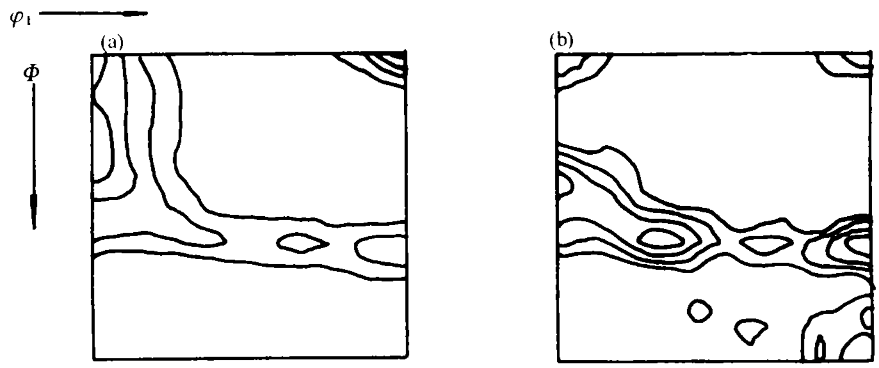

Fig.4 φ_2=45° section of ODFs of IF steel and Fe_3Al-based alloy respectively
(a) cold rolled IF with 74% Red. (MAX = 5.9, Level:2,3,4); (b) rolled Fe_3Al with 80%Red. (MAX = 5.9, Level:2,3,4)

system is also taken into account, which indicates that the deformation behavior of B2 structure should be more complicated than that in bcc metals.

However, the deviations of cold rolling texture between CuZn alloy and IF steel or Fe_3 Al-based alloy can be observed clearly in Fig. 3 and 4, which implies that the details deformation mechanism including combinations of active slip systems and the movement behaviors of dislocations etc. are different in many details among CuZn alloy, IF steel and Fe_3 Al-based alloy. Therefore further research works in this aspect should be done.

3 Summary

The ordered CuZn demonstrates a cold rolling texture which is quite different from that in conventional Cu-Zn alloys with fcc structure. The texture is characterized by a inhomogenous {111} fiber texture with strong {111}<112> component, which is similar to the cold rolling textures in conventional bcc metals and Fe_3Al-based alloy with imperfect B2 structure. The main deformation mechanism should be the activation of slip systems with <111> Burgers vector, which commonly occurred in bcc and B2 alloys. The development of cold rolling texture and the corresponding details of the deformation mechanism in CuZn ordered alloy have to be investigated further.

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