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EFFECT OF PLASTIC DEFORMATION ON THE STRUCTURE AND TEXTURE OF CUSN6 ALLOY

WPŁYW INTENSYWNEGO ODKSZTAŁCENIA PLASTYCZNEGO NA STRUKTURĘ I TEKSTURĘ STOPU CUSN6

Abstract

This paper presents the results of study in the structure and texture CuSn6 alloy deformed in the RCS (repetitive corrugation and straightening) process. Investigated the influence of process parameters on the above property. The obtained results were correlated with the results of the alloy subjected to cold rolling.

Keywords: *Copper alloys*, *Plastic deformation*, *structure and texture*, *X-ray analysis*, *EBSD analysis*

Streszczenie

W artykule przedstawiono wyniki badań struktury oraz tekstury stopu CuSn6 odkształconego w procesie RCS (cykliczne gięcie i prostowanie). Określono wpływ parametrów procesu na wyżej wymienione własności. Uzyskane rezultaty skorelowano z wynikami badań stopu poddanego walcowaniu na zimno.

Słowa kluczowe: *stopy miedzi*, *odkształcenie plastyczne*, *struktura i tekstury*, *analiza rentgenowska*, *badania EBSD.*

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1. Introduction

In response to still increasing requirements of modern engineering materials, more research is moving towards the development of the materials with finest microstructure, known as ultra-fine-grained materials that will have improved properties compared to currently known materials. In the group of methods used to modify the properties of the materials, in order to obtain a microstructure of the smallest particle size (10 to 1,000 nm) can be featured SPD method (Severe Plastic Deformation). SPD method belongs to a group of plastic treatment method consists in intensive plastic deformation, which is not intended to change shape, but the development of requested mechanical properties of the metal by the ultrafine of microstructure. One of the recently developed techniques of SPD is a cyclic process of repetitive corrugation and straightening plates, called RCS [2, 4, 5].

2. The course of study

2.1. Material to studied

The studied material consisted non annealed tape of CuSn6 alloy, initial strengthening state (z4), cold-rolled in 8 cycles and the tape subjected to intensive plastic deformation using the RCS method (repetitive corrugation and straightening) in 8 and 13 cycles [4, 5]. The chemical composition of the test material are presented in Table 1.

Table 1

CuSn6 chemical composition (PN-92/H-87050) (%wag.)

Material	Tin	Zinc	Phosphorus	Nickel	Lead	Iron	Other	Copper
CuSn6	5.5–7	0.3	0.01–0.35	0.3	0.05	0.1	0.2	reszta

2.2. Studied methodology

X-ray diffraction studies samples were analyzed on the PANalytical X'Pert PRO diffraction system, using filtered radiation from the lamp with copper anode. X-ray phase analysis was conducted in the Bragg-Brentano geometry using *X'* celerator strip detector. Stress measurements were made of samples analyzed with sin2ψ technique using Stress X'Pert Plus software. Crystallite size was determined by using Sherrera method. In order to determine the texture is made of four pole figures for each of the studied samples. Then set the orientation distribution function (FRO) [1]. In the FRO analysis was applied ADC method using iterative operator. Calculations was made using the Tex Labo 3.0 [3]. EBSD analysis was conducted in Zeiss supra 35 scanning electron microscopy equipped with acamera and software for acquisition and analysis of backscattered electrons.

3. The results

The results of *X*-ray phase analysis showed, regardless of the deformation process, CuSn phase in the studied materials (Fig. 1). Stress Measurement in the two directions shown that after classic rolling the material were compressive stresses. Material after deformation in the RCS process were a compressive stress in the direction of the rolling direction and the tensile stress in the cross direction to the rolling direction independent of the number of cycles (Fig. 2). Table 2 shows the obtained measurement values and the results of stress measurement and crystallite size analyzed strip. Figure 3 shows the change in position of the reflex (311) CuSn phase as a function of ψ (deformed material in the RCS in 13 cycles).

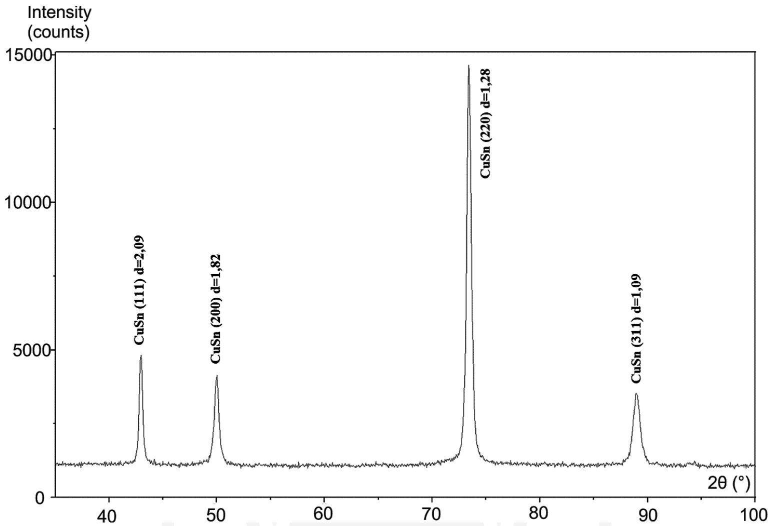


Fig. 1. Diffraction pattern of CuSn6 alloy strip rolled in 8 cycles

Rys. 1. Dyfraktogram taśmy stopu CuSn6 walcowanej w 8 przepustach

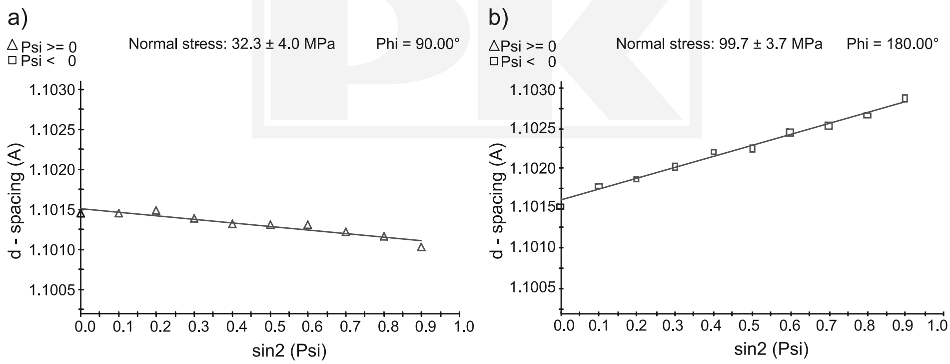


Fig. 2. Stress measurement results in the direction of: a) the rolling direction and b) the cross direction to the rolling direction (CuSn6 alloy strip after deformation in RCS process in 13 cycles, the dependence of d spacings sin2ψ function , peak (311))

Rys. 2. Wyniki pomiaru naprężeń w kierunku: a) równoległym do kierunku walcowania oraz b) w kierunku prostopadłym do kierunku walcowania (taśma stopu CuSn6 po odkształceniu metodą RCS w 13 przepustach, zależność wartości odległości międzypłaszczyznowej d w funkcji sin2 ψ, refleks (311))

Table 2

Summary results of the stress and the crystallite size measurements

Type of the treatment process	Stress results in the direction of the rolling direction [MPa]	Stress results in the cross direction to the rolling direction [MPa]	Crystallite size [nm]
CuSn6 alloy strip classic rolled in 8 cycles	–138.9 ± 6.1	–161,2 ± 7,9	35,1
CuSn6 alloy strip deformation in the RCS process in 8 cycles	–9.2 ± 10.4	115,2 ± 9,3	19,5
CuSn6 alloy strip deformation in the RCS process in 13 cycles	–32.3 ± 4.0	99,7 ± 3,7	20,9

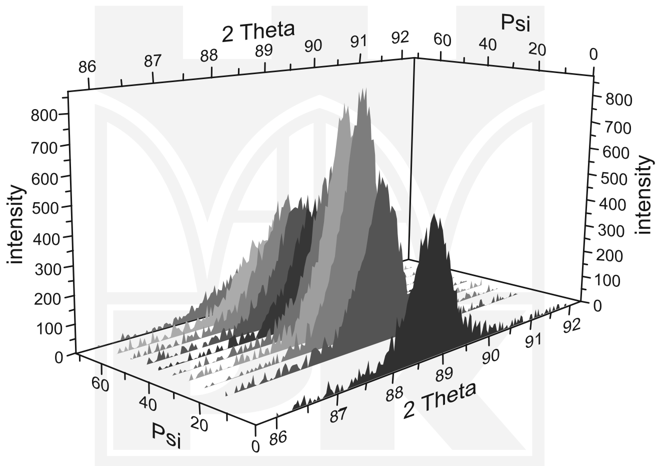


Fig. 3. Changes in the peak position (311) phase CuSn w sin2 ψ function (CuSn$_6$ alloy strip deformation in the RCS process in 13 cycles)

Rys. 3. Zmiany położenia refleksu (311) fazy CuSn w funkcji ψ (taśma CuSn6 odkształcona metodą RCS w 13 przepustach)

In order to determine the texture of studied materials were determinated experimental pole figures by the reflectance method (Fig. 4a). Figure 5 presented FRO and figure 4b – calculated complete pole figures. FRO analysis revealed the presence of several components of texture. Classic rolled conducive to formation of Brass texture component – {011} <211> faded in the direction of Goss texture component – {011} <100>. Deformation of the material by RCS process causes changes in the shares of the above texture components. Table 3 presented the results of texture analysis of studied samples.

EBSD analysis made it possible to obtain the orientation distribution maps, distribution of grains map and qualitative map with plotted boundaries of grain (Fig. 6).

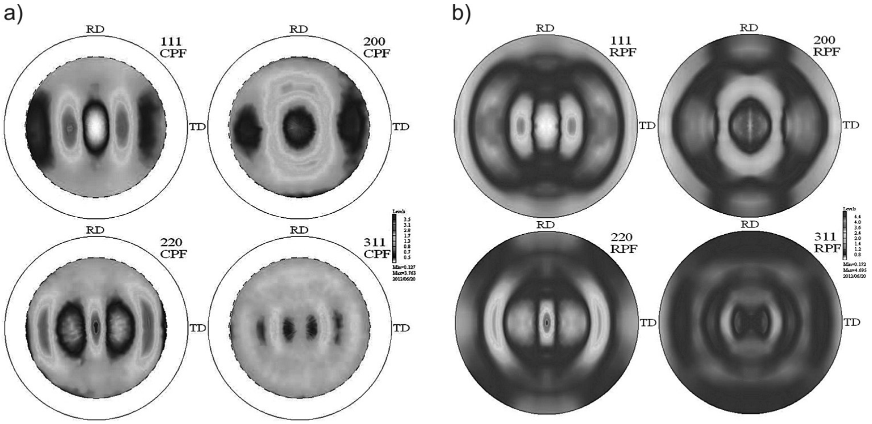


Fig. 4. a) Experimentally determined pole figures $CuSn_6$ alloy strip classic rolled in 8 cycles. b) calculated complete pole figures $CuSn_6$ alloy strip classic rolled in 8 cycles

Rys. 4. a) Wyznaczone eksperymentalnie figury biegunowe taśmy stopu CuSn6 walcowanej klasycznie w 8 przepustach, b) obliczone pełne figury biegunowe taśmy stopu CuSn6 walcowanej klasycznie w 8 przepustach

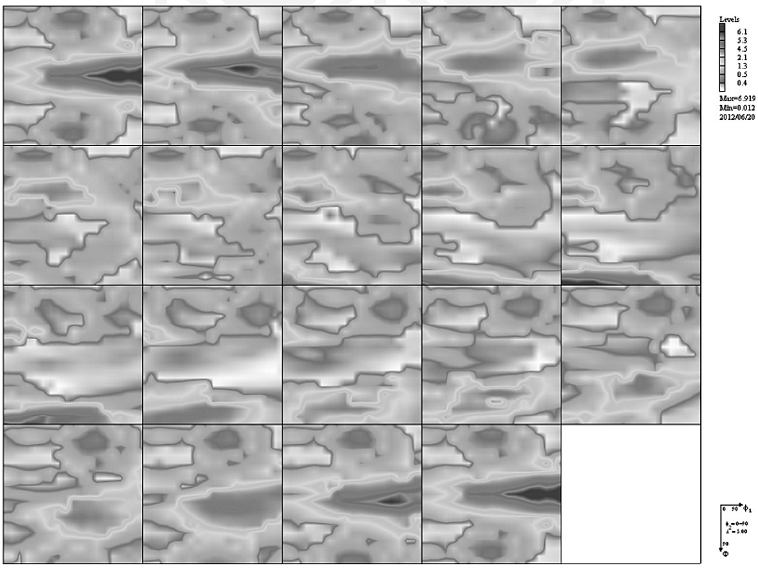


Fig. 5. Orientation distribution function $CuSn_6$ alloy strip classic rolled in 8 cycles

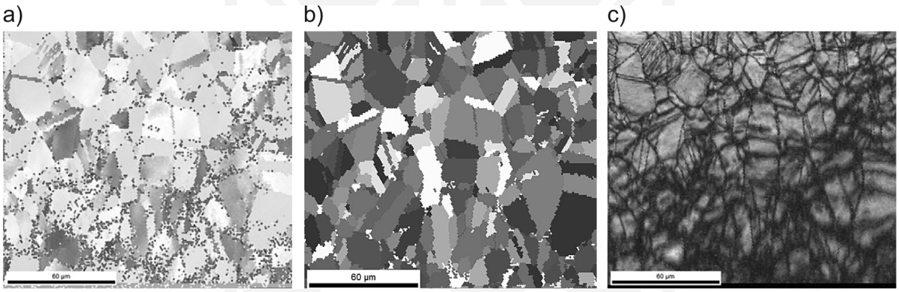
Rys. 5. Funkcja rozkładu orientacji taśmy stopu CuSn6 walcowanej klasycznie w 8 przepustach

From the study it can be concluded, that the RCS process did not affect significantly to average grain size, but changed the nature of the grain boundaries turning their proportions relative to classic rolled material. That means the deformations of this type form the low-angle edge boundaries in the workpiece material. In the structure of RCS deformed material number of twins and some grains elongated along was observed.

Table 3

Summary results of texture measurements

Type of the treatment process	Share of texture brass component [%]	Share of texture Goss component [%]	Share of texture random component [%]
CuSn6 alloy strip classic rolled in 8 cycles	33	17	50
CuSn6 alloy strip deformation in the RCS process in 8 cycles	40	4	56
CuSn6 alloy strip deformation in the RCS process in 13 cycles	44	2	54



Rys. 6. EBSD analysis results of $CuSn_6$ alloy strip classic rolled in 8 cycles: a) orientation distribution maps, b) distribution of grains map, c) boundaries of grain map – kolor niebieski – kąt > 15°, kolor czerwony – kąt > 2°

Rys. 6. Wyniki badań EBSD taśmy CuSn6 walcowanej klasycznie w 8 przepustach: a) mapa rozkładu orientacji, b) mapa rozkładu ziaren, c) mapa rozkładu granic ziaren – kolor niebieski – kąt >15º, kolor czerwony – kąt > 2º

4. Conclusions

Based on the experimental results were the following conclusions:

1. Texture analysis showd, that CuSn6 alloy deformation in RCS process increase the share of Brass component, and reduces the share of Goss component compared to classic rolled.
2. EBSD analysis showd, that RCS proces has impact to microstructure modification through visible grain elongation in the direction of the deformation proces, that resulting twins are formed and affect to low-angle edge boundaries compared to classic rolled material.

3. Crystallite size measurement by sherrer method confirm the presence of nano-scale structures in the studied materials after deformation by RCS process.
4. Stress measurment was occured compressive stress after classic rolled process, while in stips after deformation in the RCS process were a compressive stress in the direction of the rolling direction and the tensile stress in the cross direction to the rolling direction.

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