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Texture of Rapidly Solidified Foils of Tin, Indium, Bismuth, and Their Alloys

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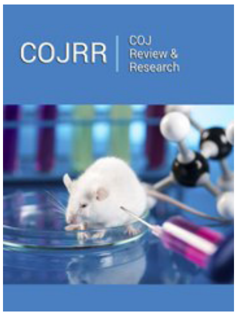

Abstract

Tin, indium, bismuth, and their alloys are produced with rapidly solidified crystallization. Cooling rate was in the order 10^5-10^6K/s. A thickness of foils was 30-80μm. Polar densities, p_{hkl}, of diffractional lines h_{kl} were calculated by Harris method. It was established, that tin, indium, and bismuth have texture (100), (101) and texture $(10\bar{1}2)$ bismuth, correspondly. These textures are conserved in solid solution and eutectic alloys. Textures of tin and indium are caused with most density packed planes. The texture of bismuth is caused with orientation covalent bonds.

Keywords: Rapidly solidified foils; Tin; Indium; Bismuth; Polar density of diffractional line; Texture, Eutectic alloys

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Introduction

Alloys of tin, indium and bismuth are considered as solders, contained lead and cadmium, are dangerous for the Enviroment and Humen Health. These metals are anisotropic, and their properties depend on texture (predominant orientation of grains) of material. Texture must be taken into account when producing solders and other production. Despite on large quantity of investigation of the alloys on base of light melt metals, forming of texture was studied not enough. Because in this article was considered forming of textures of tin, indium, bismuth, and their solid solutions, eutectic, and intermediate phases.

The foil textures were studied with roentgen methods, for example using the inverse pole figures. The polar densities, p_{hkl}, of diffraction were calculated by Harris method [1]. A mass of alloy ≈0.2g was cut off from ingot and melted into a quartz tube at 450-600K and then injected on inner polish surface of rotary copper cylinder. Thickness of rapidly solidified foil (RSF) is 30-80μm. According to calculation [2-4], cooling rate were 10^5-10^6K/s, which corresponds to the ultrarapid quenching rate range. Roentgen radiation fell on the foil surface, which was contacted with crystallizer. PSF of tin and have texture (100) and (101) correspondly, bismuth-binary texture $(10\bar{1}2)$ + (0001). Textures (100) of Sn, (101) of In and $(10\bar{1}2)$ of Bi are increased and texture (0001) of Bi is disappeared with increase of the rotation frequency of the cupper and the concentration of doping atoms.

The planes (100) of tin and (101) of indium and their solid solutions have the most densities of atoms, what define growth of grains with such orientations and forming texture [1,3-8]. Forming of texture $(10\bar{1}2)$ in bismuth and its alloys are caused crystal structure and orientation of covalent bonds, which form angles 95, 5° to each other. Two covalent bonds of every atom are located in same plane $(10\bar{1}2)$. The third bond binds two atom in adjacent planes $(10\bar{1}2)$. Broken covalent bonds on planes $(10\bar{1}2)$ contribute to the additional atom from the liquid to the crystal phase, which leads to a rapid growth of grains in which plane $(10\bar{1}2)$ is perpendicular to the direction of the heat flow [8]; (Table 1).

Table1: Polar densities of diffraction lines of tin, indium, bismuth, and its alloys.

Tin		In		Bi		Bi-2 at. % Sn	Bi-2 at. % In
Diffract. Lines	Polar Density	Diffract. Line	Polar Density	Diffract. Line	Polar Density	Polar Density	Polar Density
200	5,9	002	0,7	$(10\bar{1}\bar{2})$	4,1	8,9	7,1
101	0,1	110	0,6	1014	0,1	0,2	0,1
220	0,0	112	0,7	1120	0,2	0,1	0,4
211	0,0	200	0,4	1015	0,3	0,2	0,4
301	0,0	103	0,7	2022	0,5	0,2	0,5
112	0,0	211	0,7	1017	0,1	0,1	0,2
-	-	202	3,5	2025	0,3	0,1	0,2
-	-	213	0,6	2130	1,0	0,1	0,1
-	-	-	-	1232	1,0	0,1	0,3
-	-	-	-	0009	3,2	0,1	1,1

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Indium and tin form β-phase (In_3Bi) and γ -phase ($InSn_4$). RSF of β-phase has texture (101) and γ-phase – texture (0001). Forming textures in these phases are caused the most densities of atoms on planes, what define growth of grains with such orientations [5,6]. Texturies of RSF of the eutectic in + 47 at. % Sn are (101) of β-phase and $(10\bar{1}\bar{2})$ of γ-phase [5-7]. RSF of the eutectic alloy In-56 at. % Bi consist of solid solution bismuth (texsture $(10\bar{1}\bar{2})$ and ε-phase (InBi) with light texture (101) +(111). RSF of the eutectic alloy In-21 at. % Bi are mixture of In and In_2Bi with weak texture (001) +(110) and (1012) +(1011), correspondly [9].

Study of PSF of ternary alloy showed that texture formation occurs in their phases. For example, the foils consist of the solid solution of bismuth and tin and ε-phase (InBi), which have textures $(10\bar{1}\bar{2})$ +(0001), (100) and (102) +(101), correspondly. Thus, the formation of the texture of pure components and phases formed in binary and ternary alloys based on tin, indium and bismuth is determined by density of atoms on the crystal planes and orientation of covalent bonds.

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