MICROSTRUCTURE ANALYSIS OF ZINC-BISMUTH (ZN-BI) ALLOYS

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Abstract:
The study investigates the miscibility gap phenomenon in Zinc-Bismuth (Zn-Bi) alloys, a crucial aspect influencing the microstructure and properties of these alloys. The miscibility gap refers to the region in the phase diagram where two components of an alloy system are not fully soluble in each other, leading to the formation of distinct phases. Understanding the miscibility behavior is essential for tailoring the properties of Zn-Bi alloys for various industrial applications. This paper discusses the experimental methods employed to analyse the miscibility gap and discusses surface study of samples by using proper etchant on the Zn-Bi alloys.

Keywords: Zinc-Bismuth alloys, Miscibility gap, Phase diagram, Etching

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Introduction:

The microstructure and properties of Zn-Bi alloys are influenced by the phase behavior, particularly the miscibility gap, which occurs when the two components of the alloy system exhibit limited solubility in each other. Understanding the miscibility behavior is crucial for designing alloys with tailored properties for specific applications. This study aims to investigate the microstructure of Zn-Bi alloy samples. The separation is influenced by interaction at the phase boundaries which determines, for example, the concave or convex shape of the boundary and also by viscosity and process parameters like heating and cooling rates. We have prepared the microstructures of the solidified samples to investigate the phase distribution especially in the vicinity of the phase boundary originating from the miscibility gap in the liquid state. The density of etch pits more at the separation region than at centre with average density of 10^3 /cm^2.

2 Experimental Methods:

2.1 Alloy Preparation: Zn-Bi alloys with different compositions were prepared by melting high-purity Zinc (Zn) and Bismuth (Bi) metals . The Zinc metal added into the Bismuth solution in a precise ratio of 9:1, 8:2, 7:3, 6:4, 5:5, 4:6, 3:7, 2:8 and 1:9 by S-L-S process. The polycrystalline blanks were obtain and used for microstructure testing. Polycrystalline blanks were prepared by melting with 1,2,3,4,5,6,7,8 and 9gm of Zinc with 9,8,7,6,5,4,3,2, and 1 gm of Bismuth metal in beaker, and cooling the melt slowly. The alloys were cast into cylindrical molds and allowed to solidify at room temperature. The blanks fabricated by us have optically smooth surface.

2.2. Equilibrium study of the Bi–Zn system :

The experimental effort was limited to the investigation of the discrepancies concerning the solubility limit of Zn in (Bi) between the theoretical and experimental assessments. Nine alloys were prepared, one with approximately wt% Zn into Wt% Bi . The low Zn content alloy was expected to lie in the single-phase region of the phase diagram, according to the experimental assessment. According to calculations, it was expected to lie in the two-phase area. The morphology of the sample did not allow the measurement of the composition of the Zn-rich phase. The microstructure of Bismuth samples for different weight % of Zinc into Bismuth as shown in Fig 2. (a to i)

2.3 Microstructural Analysis:

The Zn-Bi alloys was examined using optical microscopy on Samples with Carl Zeiss Jenapol Metallurgical optical Research Microscope as shown Fig.1. Dislocation influence a number of plastical properties like – plasticity, mechanical strength etc. It is well known that when grown faces are treated with a suitable solvent, they mostly reveal etch pits. (dislocation sites). Hence, chemical etching technique has been employed to developed new etchants. The dislocation content was estimates by the using dislocation etchants developed by present authors after numerous trials. The best etching action was observed at 4part of 1N dilute nitric acid + 6 part of distilled water. The mixure is capable of producing well defined triangular etch pits , etching time is 5 second to yield etch pits as shown in Fig 3. The majority raw of triangular etch pits observed in separation region of Bi-Zn samples.

Results and Discussion

A Bismuth-rich and Zinc-rich areas are visible in the microstructure. The separation line between them is a curve that represents a shape of a crystallization front. Two observed zones represent individual microstructures. In the zinc-rich area, many spheroidal particles of almost pure bismuth can be observed. These are the products of the monotectic transformation taking place at the temperature of 416 °C under the conditions of thermodynamic equilibrium. Their different sizes and inhomogeneous distribution are a consequence of a coagulation effect during slow solidification. The larger surface tension of zinc, then bismuth at the same temperature and the almost lack of mutual solubility of both elements generated the observed shapes of Bi particles. Zinc has higher melting point than bismuth, thus the embryo of (Zn) solid phase can grow as a primary precipitate. Moreover, the considerably larger size of the zinc precipitates was caused by a relatively long time of diffusion. At the border of both zones, from the side of the zone rich in zinc. The presence of a miscibility gap significantly influences the mechanical, thermal, and electrical properties of Zn-Bi alloys. The formation of distinct phases leads to changes in the alloy's strength, ductility, and thermal conductivity. These properties can be tailored by adjusting the alloy composition and processing parameters.

Conclusion

The following major conclusions can be drawn from the present experimental investigation:

Two observed zones represent individual microstructures. In the zinc-rich area, many spheroidal particles of almost pure bismuth can be observed as shown in Fig 2. These are the products of the monotectic transformation taking place at the temperature of 416 °C under the conditions of thermodynamic equilibrium. Their different sizes and inhomogeneous distribution are a consequence of a coagulation effect during slow crystallization. The larger surface tension of zinc, then bismuth at the same temperature and the almost lack of mutual solubility of both elements generated the observed shapes of Bi particles. The opposite effect took place for zinc precipitates into the (Bi) matrix. Zinc has higher melting point than bismuth, thus the embryo of (Zn) solid phase can grow as a primary precipitate. The growth orientation was limited by heat transfer directions. Moreover, the considerably larger size of the zinc precipitates was caused by a relatively long time of diffusion. At the border of both zones, from the side of the zone rich in zinc, one can observe a strip devoid of bismuth precipitates. This effect is analogous to the halo effect observed around weakly coherent precipitates of slowly crystallized alloys. The same zone also exists for an alloy crystallized in supergravity conditions. The strong gradient of the chemical composition near the separation boundary was observed; The density of etch pits more at the separation region than at centre with average density of 10^3 /cm^2.

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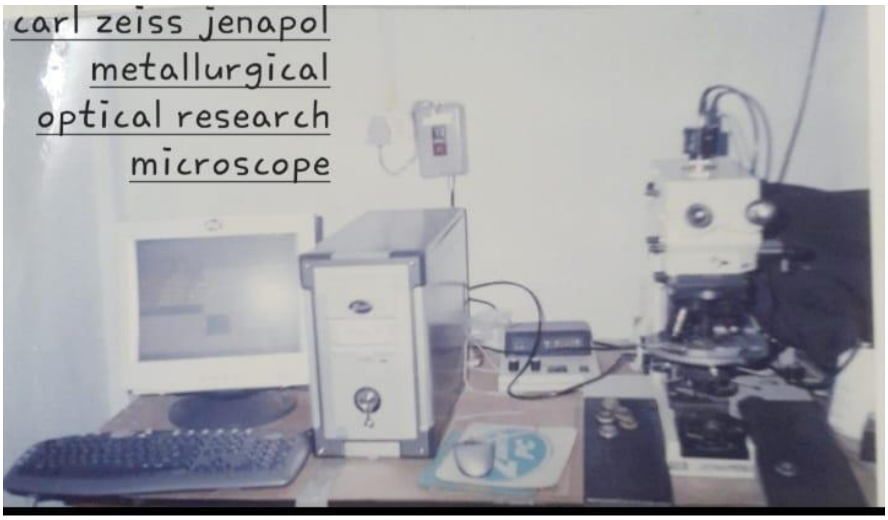

Fig 1. Carl Zeiss Jenapol Metallurgical optical Research Microscope 3.

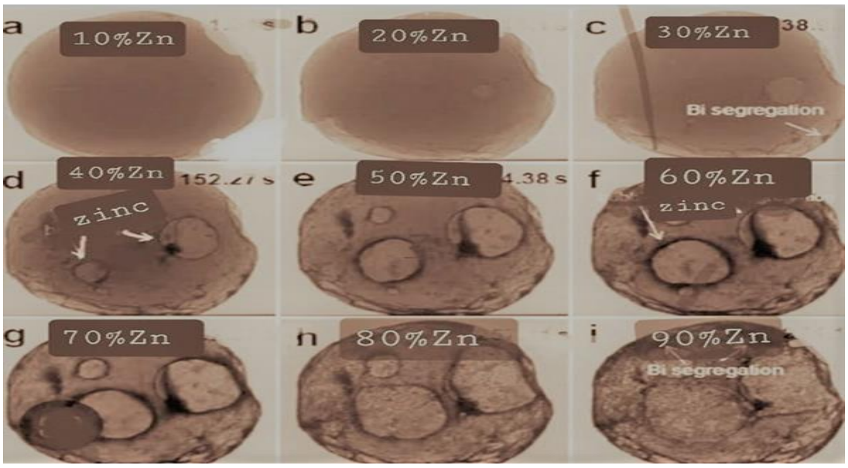

Fig 2 Bismuth Samples microstructure

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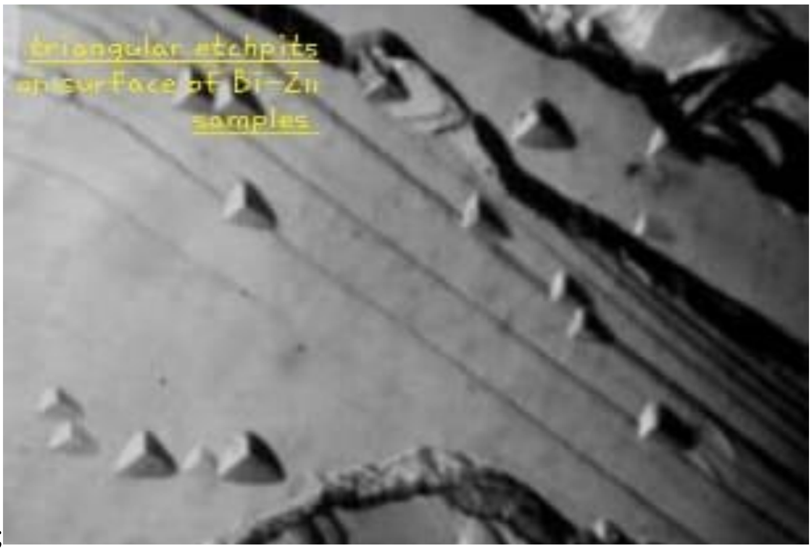

Fig 3. Etch pits on the Zn- Bi Samples