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Study The Miscibility Gap Of Zinc-Bismuth (Zn-Bi) Alloys And Surface Analysis Of The Zn-Bi Alloy.

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Abstract:

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 simple experimental method which was used to fabricate the Zn-Bi samples , examine the miscibility gap and also discusses the surface study of samples by using proper etchant on the Zn-Bi alloys. The density of etch pits more at the separation region than at centre with average density of 10^3 /cm^2.

Keywords: Zinc-Bismuth alloys, Miscibility gap, Etching

Introduction :

Zinc-Bismuth (Zn-Bi) alloys are of significant interest due to their potential applications in various fields such as soldering, nuclear reactors, and thermoelectric devices. 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 appropriate properties for specific applications. This study aims to investigate the miscibility gap in Zn-Bi alloys . For present study Zn and Bi used in the experiments are commercial ingot with the purities of 99.99%. The experimental results at 245◦ confirmed the low solubility of Zn in (Bi), as the sample with low Zn content clearly exhibits a two-phase structure as shown in Fig.1.The results of solubility of both the elements . Chemical etching study suggest that the density of etch pits more at the separation region than at centre and number of etch pts increase as increase the weight percentage of Zinc in Bismuth.

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 .

Zn and Bi used in the experiments for present study are commercial ingot with the purities of 99.99%. 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 at room temperature. The polycrystalline blanks were obtained and used as samples for surface study . 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 as shown in Fig 2 for different wt% of Zinc into Bismuth.

2.2 Surface Analysis:

The surface of Zn-Bi alloys was examined using optical microscopy Carl Zeiss Jenapol Metallurgical optical Research Microscope 3. on Samples were prepared by standard metallographic techniques, followed by etching with appropriate reagents to reveal the microstructure. Dislocation influences 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. The majority raw of triangular etch pits observed in separation region of Bi-Zn samples with Carl Zeiss Jenapol Metallurgical optical Research Microscope 3. As shown in Fig 3.

3.Results and Discussion

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 another. 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 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 as shown in Fig 1. 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.

4.Conclusion

- 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.
- The zinc-rich zone contained minor precipitates of parent bismuth, resulting from the mutual Bi–Zn solubility in a non-equilibrium state.

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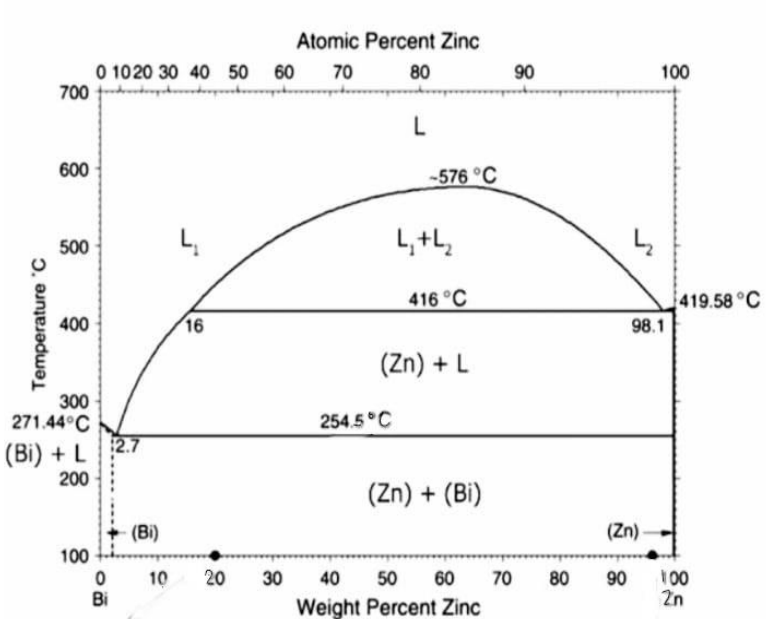

Fig.1 Phase Diagram of Zn-Bi alloy

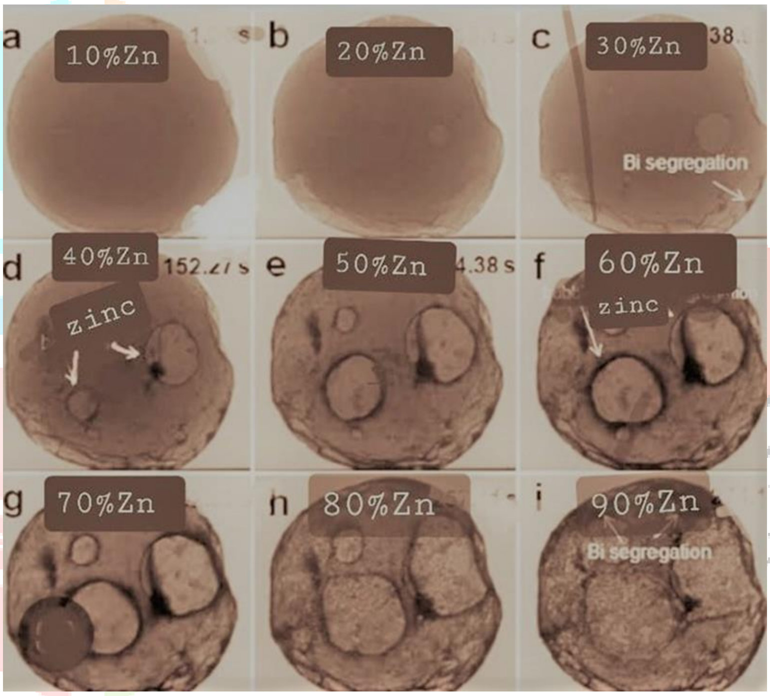

Fig.2 Zn-Bi samples with different wt%

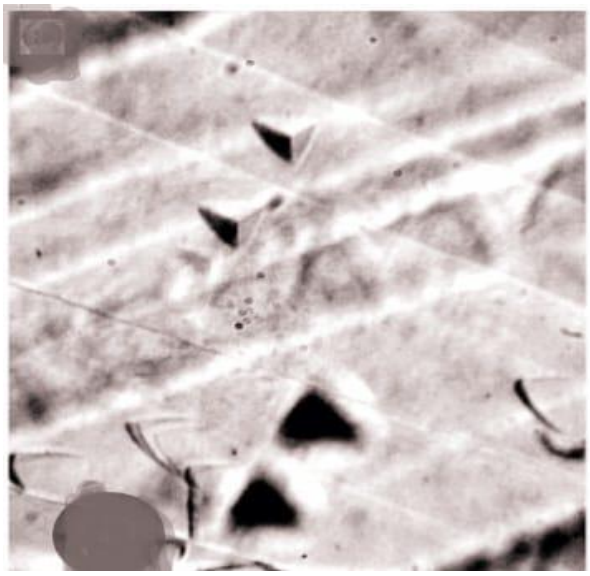

Fig 3. Etch pits on the Zn-Bi samples