Materials and Design 32 (2011) 900–906

Contents lists available at ScienceDirect

Materials and Design

journal homepage: www.elsevier.com/locate/matdes

Investigation of the effect of composition on microhardness and determination of thermo-physical properties in the Zn–Cu alloys

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ARTICLE INFO

Article history:
Received 13 August 2009
Accepted 27 June 2010
Available online 8 July 2010

Keywords:
E. Electrical resistivity
E. Microhardness
F. Microstructure

ABSTRACT

Zinc–copper of (99.99%) high purity alloys were directionally solidified upward with different compositions, C_o, Zn–(0.7,1.5, 2.4 and 7.37) wt.% Cu under two different solidification conditions (G = 3.85 K/mm, V = 0.0083 mm/s and G = 8.70 K/mm, V = 0.436 mm/s) using a Bridgman type directional solidification apparatus. The measurements of microhardness of directionally solidified samples were made by using a microhardness test device. The dependence of microhardness (HV) on composition was analyzed. According to these results, it has been found that the values of HV increase with the increasing Cu content (C_o). Variation of electrical resistivity (ρ) and electrical conductivity (σ) with the temperature were also measured by using a standard d.c. four-point probe technique. The enthalpy of fusion (ΔH) and specific heat (Cp) of the Zn–Cu alloys were determined from heating curve during the transformation from solid to liquid phase by using differential scanning calorimeter (DSC).

1. Introduction

Zinc-base alloys are high strength and hardness, means that it is the ideal alternative to machined, pressed, stamped and fabricated items. Complex net-shaped zinc housings with precise thin walls give excellent electrical performance and shielding properties for electronic connectors as well as shields, chassis and frames for handheld telecommunication and computing equipment. Zinc-base alloys have been used in many applications, including mobile phone antennae, portable computers, disk drives, radiofrequency circuits, transformer cores, high-quality filters, precision interlocking gears, and heat sinks, shutter mechanisms in cameras and many other consumer electrical and electronics consumer applications [1–3]. Moreover, the mechanical properties of zinc-based alloys make them attractive substitutes for cast iron and copper alloys in many structural and pressure-tight applications. Because zinc is less costly than copper, these zinc-base alloys have a distinct cost advantage over copper-base alloys [4–6].

Solidification and melting are transformations between crystallographic and non-crystallographic states of a metal or alloy. These transformations are of course basic to such technological applications as ingot casting, foundry casting, continuous casting, and single crystal growth for directionally solidified composite alloys. An understanding of the mechanism of solidification and how it is affected by such parameters as temperature distribution, solidification condition and alloying, are important in the control of mechanical and electrical properties of the cast metals and fusion welds [7,8].

Peritectic and near-peritectic alloys occupy an outstanding position among the engineering materials. Many technically important alloy systems such as steels, Cu alloys, rare earth permanent magnets and high Tc superconductors display peritectic reactions where phase and microstructures selection plays an important role for the processing and the properties of the material [9,10]. Despite the practical importance of peritectic alloys, the varieties of complex solidification microstructures that can form in these alloys have drawn the recent attention of researches to this field [11].

The aim of the present work was to experimentally investigate the dependency of the microhardness (HV) on copper composition (C_o), and also find out the influence of temperature on the electrical resistivity (ρ), electrical conductivity (σ), temperature coefficient of resistivity (α), enthalpy of fusion (ΔH) and specific heat (Cp) of the Zn–Cu casting alloys.

2. Experimental procedure

2.1. Sample preparation and solidification

Using the vacuum melting and hot filling furnaces, Zn–(0.7, 1.5, 2.4 and 7.37) wt.% Cu alloys have been prepared under vacuum atmosphere by using 99.99% purity of zinc and copper. After

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0261-3069/$ - see front matter
doi:10.1016/j.matdes.2010.06.049