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The Change of Electrical Resistivity According to Different Quench Techniques in Copper-Manganese Alloy

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It is known that copper has electrical and thermal conductivity. Therefore Cu-based alloys are used in technological and engineering applications. This paper is aimed at studying influence of various heat treatment on electrical resistivity properties of samples from binary Cu-Mn alloy. The chemical composition of the alloy was found to be Cu_{75.8}-Mn_{24.2} (wt.%) by using energy dispersive x-ray analysis (EDAX) technique. Electrical resistivity is a fundamental property of many materials. Hence, it is a key physical property of all materials. The electrical properties of binary Cu-Mn system performed by using a standard four-point probe D.C. method A Keithley 2400 sourcemeter. The resistivity measurements are carried out in the temperature range from 50 to 300 °C during heating. In the measurements, important properties were observed. The values of electrical resistivity of alloy was determined as a function of temperature. The specific resistivity changed linearly with the temperature. The differents showed the resistivity as a function of quenching temperature. The relative values of electrical resistivity also increased with increasing rate of quenching.

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Introduction

Most copper-based shape memory alloys are easier to produce and process and are also inexpensive compared to Ni-Ti shape memory alloys [1]. Cu and Mn are two important elements in several commercial alloys. Manganese is considered to be one of the most important alloying elements in different grades of steel, cast iron and copper-based alloys. Manganese improves the tensile strength, machinability, toughness, hardness, and abrasion resistance of steel [2]. The validation of regressions formulations was found to be in a good agreement with the experimental data which indicates the efficiency of the factorial design to predict the metallurgical properties of manganese ores under the influence of different impurities [3]. Much work has already done on Cu-Mn alloys, partly because of great technical interest in the mechanical, electrical and magnetic properties of this alloy system [4]. Therefore, it is interesting to investigate the physical properties of the Cu-Mn alloys. Copper-based shape memory alloys are very sensitive to the thermal effects before and after the transformation. These effects may cause important changes on crystallographic properties or the other transformation parameters of the alloys [5]. Due to exposed physical and mechanical effects, metal and alloys exhibit a very surprising properties. Under the various mechanical and thermodynamic conditions, microstructural changes. The previous studies showed that the resistivity of engineering materials such as metals and alloys depend on the temperature to which the material is exposed. The purpose of this study is to determine the influences of heat treatment on electrical resistivity of Cu-Mn alloy.

Experimental

The chemical compositions of alloy was determined as Cu_{75.8}-Mn_{24.2} by EDX analysis. The Cu_{75.8}-Mn_{24.2} alloy was prepared in an arc furnace under argon atmosphere using a high purity Cu and Mn

(99.9 %) powders. In this study, two heat treatments were used. First group of samples obtained from alloy was homogenized at 900 °C for 30 min. in an Ar atmosphere and cooled to 25 °C inside the furnace, and then air-cooled (sample 1). Other group of samples was austenitized at 900 °C for 30 min. followed by quenching in iced-water (sample 2). Measurements of electrical resistivity were made in the range of 50-300 °C at room temperature at the frequency of 1 Hz with typical 250 micrometer in diameter probe using a standard four-point probe D.C. method. A Keithley 2400 sourcemeter was used.

Results and discussion

Since we know importance of electrical properties in Cu-based alloys, electrical resistivity of measurements have been applied to in order to search the effect of heat treatments on the electrical resistivity at room temperature. The two most common methods of measuring the transformation temperatures are by electrical resistivity and differential scanning calorimetry (DSC) measurements. Cooling process in alloy can produce permanent changes such as internal hard, dislocation and state of equilibrium deposition. The presence of vacancies play important roles to cooling Cu-based. When cooling rate increases, also density of defects increases and lattice structure changes. Especially alloys are cooled fast at high temperature; enough time will not be for the formation of equilibrium [6-8]. This increases the concentration of vacancies and grain size influences of physical properties such as electrical resistance and electrical resistivity [9]. In our previous works, details about microstructures of alloy have been given. These studies have showed that sample consist of austenite structure with α precipitation which is copper-rich solid solution [10, 11]. The resistivity measurements are carried out in the temperature range from 50 to 300 °C during heating. The heating rate is 5 °C/min. The values of electrical resistivity with

temperature are performed as shown in Fig. 1.

(a)

(b)

Figure 1. Electrical Resistivity as a function of temperature for samples (a) sample 1 and (b) sample 2.

In the Fig 1a shows the resistivity increases with the increasing temperature. Figure 1a is observed that the increase in temperature (100-250 °C) leads to an increase in electrical resistivity. Figure 1b is revealed that the resistivity is minimum at high temperatures. That is to say, phonons will

prevail in spite of many neglecting mechanisms like electron-electron scattering, residual resistivity, and traces of magnetic impurities. The value of electrical resistivity is also affected by grain size but to a smaller extent compared to the effect of temperature and chemical composition [12, 13]. An other result the electrical resistivity of sample 1 is increasing (after 200 °C), in sample 2 decreased. But the electrical resistivity the sample 2 is higher than the sample 1. It can be explained by the combination of the uniform distribution of fine precipitation and heat treatments. The electrical resistivity strongly depends on temperature and defects. This the crystall of defects such as dislocations, vacancies, internal defects and impurity atoms. Many research reports have indicated the preferential precipitation of Cu-rich precipitates at the open volume defects in many alloy systems. These defects act as heterogeneous nucleation sites for the formation of Cu-rich precipitates [14-16]. The electrical resistivity is increased by small grain size and vacancies in sample 2 [9]. Amorphous magnetic alloys exhibit high electrical resistivities due to electron scattering from the atomic disorder. High resistivity results in reduced eddy currents [16].

4. Conclusion

In many applications, the electrical behaviour of a material is important. To select and use materials for electrical and electronic applications, we must understand how properties such as electrical conductivity are controlled. We must also realise that electrical behaviour is influenced by the structure of a material, the processing of a material, and the environment to which a material is exposed. The microstructures and electrical resistivity were investigated in the Cu-Mn (wt.%) alloy. When the temperature of a metal increases, thermal energy causes the atoms to vibrate. The atom may not be in its equilibrium position, and it therefore interacts with and scatters electrons. The main free path decreases, the mobility of

electrons is reduced, and the resistivity increases. The Cu_{75.8}-Mn_{24.2} alloy can be used in technological application where low or high electrical resistivity. This is particularly true in the development of new electronic materials for a variety of important technological application.

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