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Effect of lattice strain on the electrical conductivity of rapidly solidified copper-iron metastable alloys

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ABSTRACT

Copper–iron alloys (CFAs) with composition CFA_X; x= 10, 30 and 50 at% Fe were prepared by gas atomization process, sintered and heat treated in vacuum. Rapid solidification and the incorporation of Fe into Cu hint at strain generation in the lattice bringing changes in electrical conductivity. The origin of this strain is discussed using structural and electrical properties. The substitutional solid solution formed between Cu and Fe due to rapid solidification was decomposed during heat treatment in all the three compositions, followed by the increase in Fe particle size, decrease in lattice strain and increase in electrical conductivity.

Keywords:

Gas atomization, Electron Backscattered Diffraction, Heat Treatment, Strain, Electrical Conductivity

1. Introduction

Over the past decades, the contemporary developments of the electronic and automobile industries have increased property requirements which require the conductive material to possess better conductivity and higher strength [1]. Copper base alloys find numerous applications in many advanced technological fields owing to the good combination of high electrical and thermal conductivities [2, 3]. Cu-Fe system is of particular interest because of the relatively low cost of iron as compared to that of other possible alloying elements [4]. CFA are expected to be high strength and high electro conductive materials [5]. The application of CFA however is limited because CFAs cannot form stable phases i.e. they are described as the peritectic system with a miscibility gap [6]. The enthalpy of mixing are largely positive for the CFA [7] i.e. it shows large positive deviation from Roult's law [8]. Y. Nagakawa (1958) found the immiscibility in liquid state in super cooled copper iron alloy [9]. Much of the research has been carried out to understand thermodynamics of microstructure evolution and phase distribution in CFA system [10, 11, and 12].

CFA processed by conventional casting methods have serious segregation of individual Cu and Fe phases due to low cooling rates of about 10^2K/sec achieved whereas CFA processed through rapid solidification techniques like gas atomization can achieve cooling rates up to 10^6 K/sec [13], so