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Effect of processing parameters on characteristics of an Al-Al_2Cu composite produced in situ by powder metallurgy

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***Abstract*— Al-Al_2Cu composites due to their high Young's modulus, good compressive strength, ductility, good tensile properties and high hardness have gained a lot of attention. There are different methods for fabrication of these composites. In the present investigation, an Al-Al_2Cu composite fabricated in situ by powder metallurgy. Commercially pure Al powders (38-75 µm) and commercially pure Cu powders (<45 µm) were initially chemically treated with 1% NaOH and 15% HCl respectively to ensure their surface activation before blending. Then the Al/Cu powder mixtures containing 20 wt.% of Cu powders were cold pressed in a steel die at 750 MPa using a 45 ton hydraulic press. The resultant cylindrically shaped samples were subjected to sintering at different temperatures for different times. The results of XRD and SEM studies as well as microhardneess and hardness measurements revealed that the optimum sintering time and temperature were 60 min and 600˚C respectively. Also a sample was fabricated at identical condition using the same Al powder with no Cu addition to serve as the reference sample. SEM studies revealed that sintering the Al-Al_2Cu eutectic generated by reaction between Al and Cu distributed uniformly in the Al matrix. All the composites exhibited higher hardness values as compared with their reference counterparts.**

Keywords: In situ Al-Al_2Cu composites, Powder metallurgy, Microstructure, Microhardness, Hardness.

1. INTRODUCTION

The metal matrix composites (MMCs) have gained wide spread interest in aerospace, sports equipments manufacturing and other fields where high stiffness, strength, and weight savings are essential [1-3]. MMCs are made by dispersing a reinforcing material into a metallic matrix. Unlike ex situ composites, in the in situ composites the reinforcing phase is formed directly in the matrix by chemical reaction or phase transformation during solidification of the molten matrix alloy [4, 5]. The potential advantages of in situ composites include thermodynamic stability, homogeneous dispersion of the reinforcing particles, recyclability and improved bonding between the reinforcing phase and the matrix alloy [4-8]. Generally, the processing methods of MMCs can be broadly divided into two main categories of solid state and liquid routes. Powder metallurgy (PM), as a solid processing method, offers a number of advantages over the casting techniques such as a more uniform distribution of the reinforcing particles in the matrix alloy as well as less destructive reactions at the particle-matrix interface[9-12].

According to the binary phase diagram of Al/Cu, shown in Fig. 1, various phases and intermetallics, may form depending on chemical composition and temperature. The Al rich corner of this phase diagram reveals that small quantities of Cu (0.25 at%) dissolves in Al at room temperature. At quantities less than 33 at% Cu, eutectic transformation occurs in a broad region resulting in Al_2Cu and solid solution of Cu in Al [13]. In this paper, a mixture of Al and Cu powders containing 20 wt.% of Cu was cold pressed and sintered at various times and temperatures. The Al_2Cu intermetallic compound was formed during the reactions between Al and Cu particles and served as a reinforcement phase in the matrix. In addition, Cu is one of the few elements that have relatively high solubility in Al. Thus, the sintered compact contains Al(Cu) solid solution that is mechanically tougher than pure Al and contributes in improved hardness and mechanical properties of the resultant composite. However, in order to gain these enhanced properties, the sintering parameters should be optimized which is the subject of the present investigation.