Microstructure evolution and mechanical properties of Mg/Al diffusion bonded joints

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Abstract

Mg/Al was bonded successfully via vacuum diffusion bonding in this paper. Microstructure evolution, the growth kinetic of IMCs, diffusion behaviors and mechanical properties were investigated, and their relations were discussed. The results indicate that, the multi-layer diffusion couple at the joint consisted of Al-based solid solution (α), Al_3Mg_2 layer (β), $Al_{12}Mg_{17}$ layer (γ), and Mg-based solid solution (δ). In addition, Mg/Al vacuum diffusion bonding was a diffusion-controlled process. Growth kinetic equations of the intermetallic phases were developed and the calculation results were in good agreement with the experimental data. The different interdiffusion coefficients calculated could characterize the nature of the differences in growth-rate. Microhardness was measured by the nanoindentation hardness tester. The result showed that the microhardness of the transition layer was higher than those of Al and Mg base metals due to Al-Mg intermetallic phases. Mechanical properties of the bonded joints were investigated by shear strength, the graphs of shear fracture showed a brittle fracture which occurred at the joint interface.

Keywords: Diffusion bonding; Magnesium (Mg); Aluminum (Al); Growth kinetics; Intermetallic phases; Interdiffusion.

1. Introduction

In the field of aerospace, automobile manufacturing and other energy consuming industry, lightweight construction materials have become one of the current research focuses due to the low level of energy consumption [1]. Magnesium (Mg) and aluminum (Al) have been studied in many fields due to the low density, excellent mechanical properties and other excellent characteristics [2-4]. Joining Mg and Al would meet the requirements of special properties for some applications, particularly in the field of aerospace, such as aircraft engine, which requires meeting different requirements of temperature and mechanical performance at both sides [5,6]. In order to fully utilize the superiority of Mg and Al, to achieve weight and cost reduction, a few researchers have used dissimilar bonding technique to join Mg and Al such as brazing [7,8], friction stir bonding[9] and vacuum diffusion bonding [10-12], etc. They almost involve all fields of bonding [13,14].

The difficulty when joining Mg and Al is the formation of high hardness and brittleness intermetallic compounds (IMCs). By using vacuum diffusion bonding the development of