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Control Al/Mg intermetallic compound formation during ultrasonic-assisted soldering Mg to Al

Zhiwu Xu[1], Zhengwei Li[1], Jiaqi Li[1], Zhipeng Ma[2], Jiuchun Yan[1]

1. State Key Laboratory of Advanced Welding and Joining, Harbin Institute of Technology, Harbin 150001, PR China

2. Department of Materials Science and Engineering, Northeast Petroleum University, Daqing 163318, China

Corresponding authors. xuzw@hit.edu.cn (Zhiwu Xu) qingdaolzw@163.com (Zhengwei Li)

Abstract To prevent the formation of Al/Mg intermetallic compounds (IMCs) of Al_3Mg_2 and $Al_{12}Mg_{17}$, dissimilar Al/Mg were ultrasonic-assisted soldered using Sn-based filler metals. A new IMC of Mg_2Sn formed in the soldered joints during this process and it was prone to crack at large thickness. The thickness of Mg_2Sn was reduced to 22 μm at 285 °C when using Sn-3Cu as the filler metal. Cracks were still observed inside the blocky Mg_2Sn. The thickness of Mg_2Sn was significantly reduced when using Sn-9Zn as the filler metal. A 17 μm Mg_2Sn layer without crack was obtained at a temperature of 200 °C, ultrasonic power of Mode I, and ultrasonic time of 2 s. The shear strengths of the joints using Sn-9Zn was much higher than those using Sn-3Cu because of the thinner Mg_2Sn layer in the former joints. Sn whiskers were prevented by using Sn-9Zn. A cavitation model during ultrasonic assisted soldering was proposed.

Keywords ultrasonic-assisted soldering, intermetallic compound, Mg_2Sn, shear strength, cavitation

1. Introduction

Intermetallic compounds (IMCs) are binary, ternary or polymetallic ordered phases owning different crystal structures and properties compared with those of elemental metals [1]. When joining dissimilar alloys, IMCs easily form in joints because the dissimilar alloys always have different atom diameters, crystal structures, and electro-negativities [2]. IMC always has low ductility and high brittleness [3]. When a joint bears external forces, crack easily initiates and propagates inside IMC [4], deteriorating the mechanical properties of the joint. Therefore, the formation of IMCs must be prevented when joining dissimilar alloys.

As two of the lightest metals, Al and Mg alloys can effectively reduce the weight of structures and therefore are extensively used [5]. However, joining Al/Mg alloys is a problematic process from beginning to end. Many methods have been applied for this purpose, including fusion welding [6], diffusion welding [7], liner friction welding [8], and explosive