



Featured Letter

Application of a new ultrasonic-assisted semi-solid brazing on dissimilar Al/Mg alloys

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ARTICLE INFO

Article history:

Received 8 May 2018

Received in revised form 29 May 2018

Accepted 30 May 2018

Available online 30 May 2018

Keywords:

Ultrasonic

Semi-solid brazing

Intermetallic compound

Microstructure

Diffusion

Cavitation

ABSTRACT

In this work, an ultrasonic-assisted semi-solid brazing method was proposed to join Al/Mg. Oxide films on substrate surfaces can be successfully removed even when filler metal was at semi-solid state. A large quantity of intermetallic compounds (IMCs) formed at 460 °C because of large amount of Al and Mg dissolved into joint caused by strong cavitation. Decreasing the temperature to 430 °C could significantly reduce IMC. However, weak cavitation happened inside low liquid phase fraction at 420 °C, making it difficult to break IMCs and solid phases.

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1. Introduction

Light-weight alloys of Al/Mg have been increasingly used in aviation and aerospace industries. Various technologies for Al/Mg alloys have attracted considerable attention [1,2]. However, intermetallic compounds (IMCs), such as $\text{Al}_{12}\text{Mg}_{17}$ and Al_3Mg_2 , easily formed in joints [3]. Even for solid-state joining technologies, such as friction stir welding, IMCs still form in joint because peak temperature easily exceeds the Al/Mg eutectic temperatures [4].

Given the low operating temperature and designable option of filler metals, brazing showed considerable potential in joining dissimilar Al/Mg [5]. Liu et al. [6] reported that Mg/Al IMCs were avoided and a few Mg_2Zn phases formed when using a zinc-based alloy as filler metal. Wang et al. [7] successfully conducted low temperature brazing of Al/Mg alloys using Sn-xZn fillers. Xu et al. [8] developed stirring brazing of Al/Mg using semi-solid Sn-Zn-Al filler and indicated that instead of Al-Mg IMC, Mg-Sn IMC, appeared.

To reduce IMCs, we propose an ultrasonic-assisted semi-solid brazing (UASSB) method. The feasibility of UASSB to join Al/Mg alloys and the microstructure characteristics of UASSB joints were discussed.

2. Principle of UASSB

During ultrasonic-assisted brazing, cavitation occurs inside liquid filler metals, which is responsible for the removal of the oxide film on substrates. Cavitation can also occur in semi-solid materials, showing potential in grain refinement [9]. In UASSB, the heating device is first heated to a pre-determined temperature, allowing filler metal to reach semi-solid state. Then Al/Mg samples are fixed (Fig. 1a) on the heating device. The problem of high melting point of Zn-Al filler metal and the reaction between Al/Mg can be solved by decreasing temperature and breaking IMCs through cavitation.

3. Experimental

Pure Al and AZ31B Mg sheets, provided by Northeast Light Alloy Co. Ltd., were used as substrates. The substrates were cut into $10 \times 40 \times 3 \text{ mm}^3$. Zn-20.95Al (Fig. 1b) was used as filler metal. Substrates and filler metal were ground using 500# emery papers and ultrasonically cleaned with acetone for 10 min. The sonotrode was operated at a frequency of 20 kHz and ultrasonic power of 666.7 W on lower sheet at 0.2 MPa. Ultrasonic vibration time was 5 s, and heating temperature ranged from 420 to 460 °C. Metallographic specimens were polished and observed via scanning electron microscopy (SEM, FEI-Quanta 200F) equipped with energy dispersive X-ray spectrometer (EDS). The hardness was tested on HVS-1000 machine with load of 10 g for 10 s. The phases of

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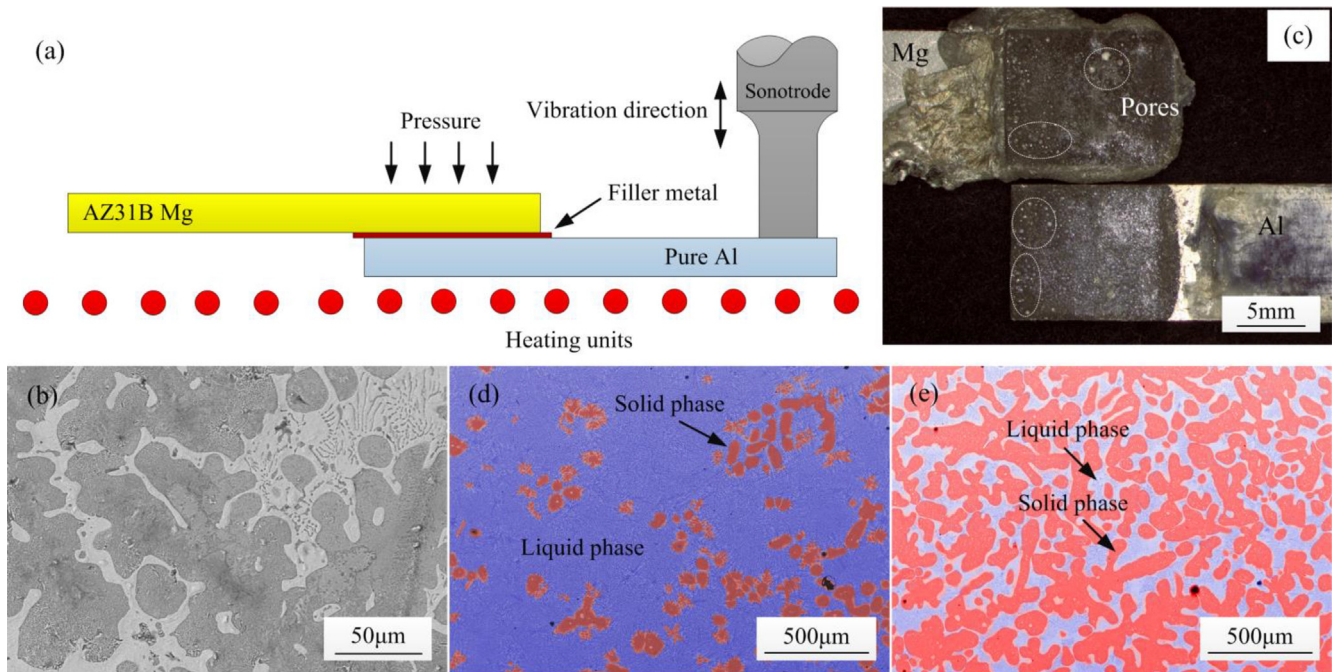


Fig. 1. (a) Schematic of UASSB, (b) Zn-20.95Al, (c) semi-solid brazing Al/Mg without ultrasonic, Zn-20.95Al at 453 °C (d) and 418 °C (e).

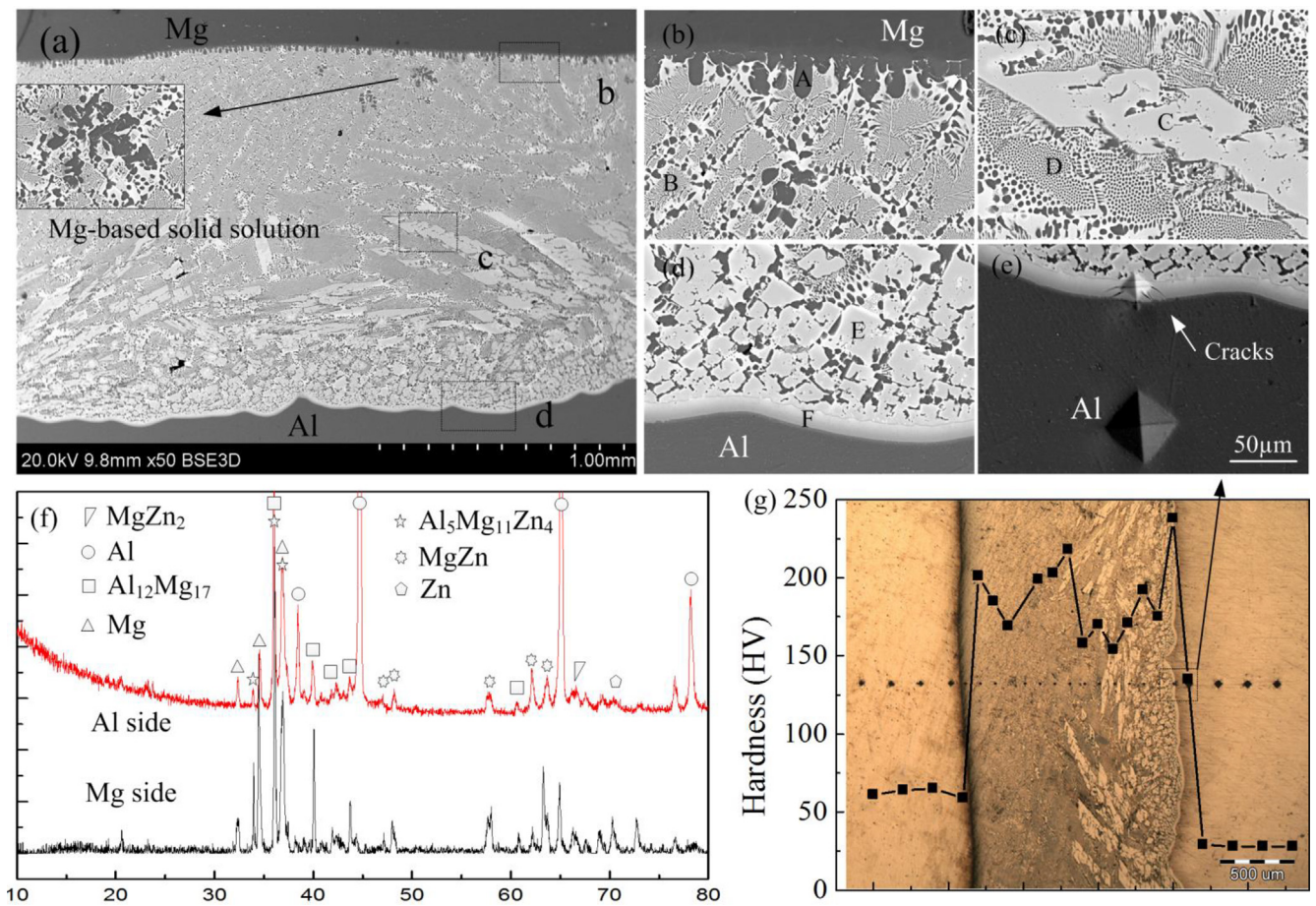


Fig. 2. Microstructure of UASSB joint (460 °C, 5 s): (a) cross section, (b)–(d) regions b–d marked in (a), (e) hardness indentations near Al, (f) XRD pattern and (g) hardness.

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