International Journal of Adhesion & Adhesives 52 (2014) 77–81

Contents lists available at ScienceDirect

International Journal of Adhesion & Adhesives

journal homepage: www.elsevier.com/locate/ijadhadh

Analysis of the influence of adhesives in laser weld bonded joints

H.Y. Wang*, L.M. Liu

School of Material Science and Engineering, Dalian University of Technology, Key Laboratory of Liaoning Advanced Welding and Joining Technology, PR China

ARTICLE INFO

Article history:
Accepted 16 April 2014
Available online 25 April 2014

Keywords:
Mg alloys
Al alloys
Adhesive
Decomposition

ABSTRACT

Laser weld bonding (LWB) is a hybrid welding technology that combines laser welding and adhesive bonding. In the hybrid welding process, the adhesive significantly affects the welding process and the property of the LWB joint. Results show that the adhesive partially decomposes in the heat-affected zone, the impaired size of which is mainly attributed to laser beam power. The property of the LWB joint is influenced by the thermal impaired area and adhesive thickness. To control the adhesive thickness and reduce the weld porosities in the fusion zone, a metallic interlayer is added in the welding process of LWB.

1. Introduction

The rapid development of new adhesives has led to an increasing use of adhesive bonding in the manufacturing sector to join assemblies [1]. Obtaining high bonding properties for metals is possible by using structural adhesives [2,3]. Compared to the common welding methods, adhesive bonding has many advantages such as simplified process, favorable fatigue properties, and the ability to join dissimilar metals [4–6]. However, some adhesive joints become brittle at low temperatures and have a low strength at high temperatures, thus limiting the use of adhesive bonding in many applications [7–9].

To increase the application of adhesive bonding, many researchers have developed special hybrid welding technologies to improve bonding properties [10]. Weld bonding as a hybrid welding method combines welding and adhesive bonding to join many metals. Weld bonding is widely used in automotive welding and clearly improves the fatigue property of the joint, compared to the simplified adhesive joints and weld joints [11–14]. Chen et al. [15] investigated Mg alloy weld bonding, which combines the advantages of adhesive bonding and spot welding. Laser spot welding and adhesive bonding can be used to join light metals such as Al alloys [16,17], which are used in the production of planes by the Edison Welding Institute (EWI). Laser weld bonding (LWB) has been proposed as an alternative to laser welding and adhesive bonding [18] to join Mg and Al alloys effectively. Friction stir spot-welding technology has recently been used with adhesives to join Mg and Al successfully [19]. The effects of adhesives on the microstructures of joints have been extensively investigated in the above mentioned studies. In contrast, studies on the effect of the heat source on the adhesive bonding process are limited.

In the hybrid joining process of fusion welding adhesive bonding or friction stir spot-welding adhesive bonding, the welding process and adhesive bonding property both affect each other. The thermal influence of LWB decomposes the adhesive in the fusion zone, thus affecting the microstructure of joints. Moreover, the laser beam clearly affects the adhesive. To understand the characteristics of adhesive bonding, the adhesive decomposition has been investigated in this paper. Furthermore, a reliability evaluation method for LWB joints is discussed. The results of this study will be beneficial to the research on hybrid welding and adhesive bonding.

2. Experimental

Samples of extruded AZ31Mg alloy ($100 \times 20 \times 1.5\ mm^3$) and 6061Al alloy ($60 \times 30 \times 1.7\ mm^3$) are used in the following experiments. The chemical compositions of these two alloys are shown in Table 1. The experiments are carried out using a pulsed Nd-YAG laser with a maximum average output power as 500 W. The laser powers used in the experiments are in the range of 280– 450 W. The welding speed is $300\ mm\ min^{-1}$. The defocusing amount is -3.5 mm. The configuration of the LWB specimens is shown in Fig. 1. The adhesive used in experiment is an epoxy adhesive made by Henkel Co. Oxide film on the specimen surface is removed by 800 grids emery paper before welding, then degreased by acetone and trichloroethylene.

The resultant welds are sliced using an electron discharge machine and then grounded with SiC paper, and finally micro-polished using 0.5 mm Al_2O_3 powder. Microstructures of the LWB fusion zones are observed by scanning electron microscopy (SEM). Elements and phases in the weld zone are analyzed using energy dispersive spectroscopy (EDS). According to the characteristics of the dissimilar metals, the samples of the Mg alloys and Al alloys

* Corresponding author.

http://dx.doi.org/10.1016/j.ijadhadh.2014.04.005
0143-7496/

Table 1
Tensile shear loads of adhesive bonding joints (F/kN).

Prepared adhesive thickness	Measured thickness	Tensile shear load
0.05	0.048	5.5
0.10	0.09	6.8
0.15	0.16	7.8
0.20	0.19	7.8
0.3	0.28	7.4

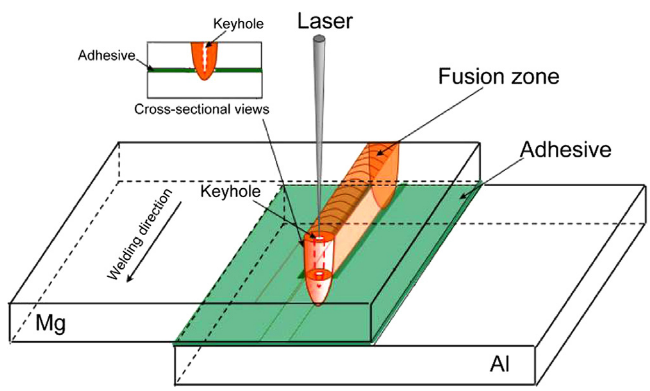

Fig. 1. The configuration of the LWB specimens.

for SEM are etched in an acid mixture. Tensile shear testing of LWB samples is performed at room temperature using an Instron type testing machine with 5 mm min^{-1} cross-head speed. The fracture of the LWB joint is examined by SEM. The laser welding sample and adhesion sample are done under same conditions.

3. Results and discussion

3.1. Adhesive decomposition in the welding process

The adhesive in the LWB decomposes because of the thermal effect of the laser beam power. The adhesive in the laser-welding fusion zone decomposes into several types of gases. For example, bisphenol-A diglycidylether is the main content of the adhesive used in this experiment. Bisphenol-A diglycidylether decomposes as follows:

$$(C_{11}H_{12}O_3)_n \rightarrow C_xH_y + nCO + nCO_2$$

The adhesive in the fusion zone decomposes and is released from the welding pool, reducing the intermetallic content of the fusion zone. The adhesive next to the laser-welding joint is still thermally affected by laser welding. The temperature at the fusion zone edge is clearly lower than the temperature of the laser-welding pool, but still exceeds the maximum temperature for the adhesive. Therefore, the thermal effect of laser welding locally decomposes the adhesive.

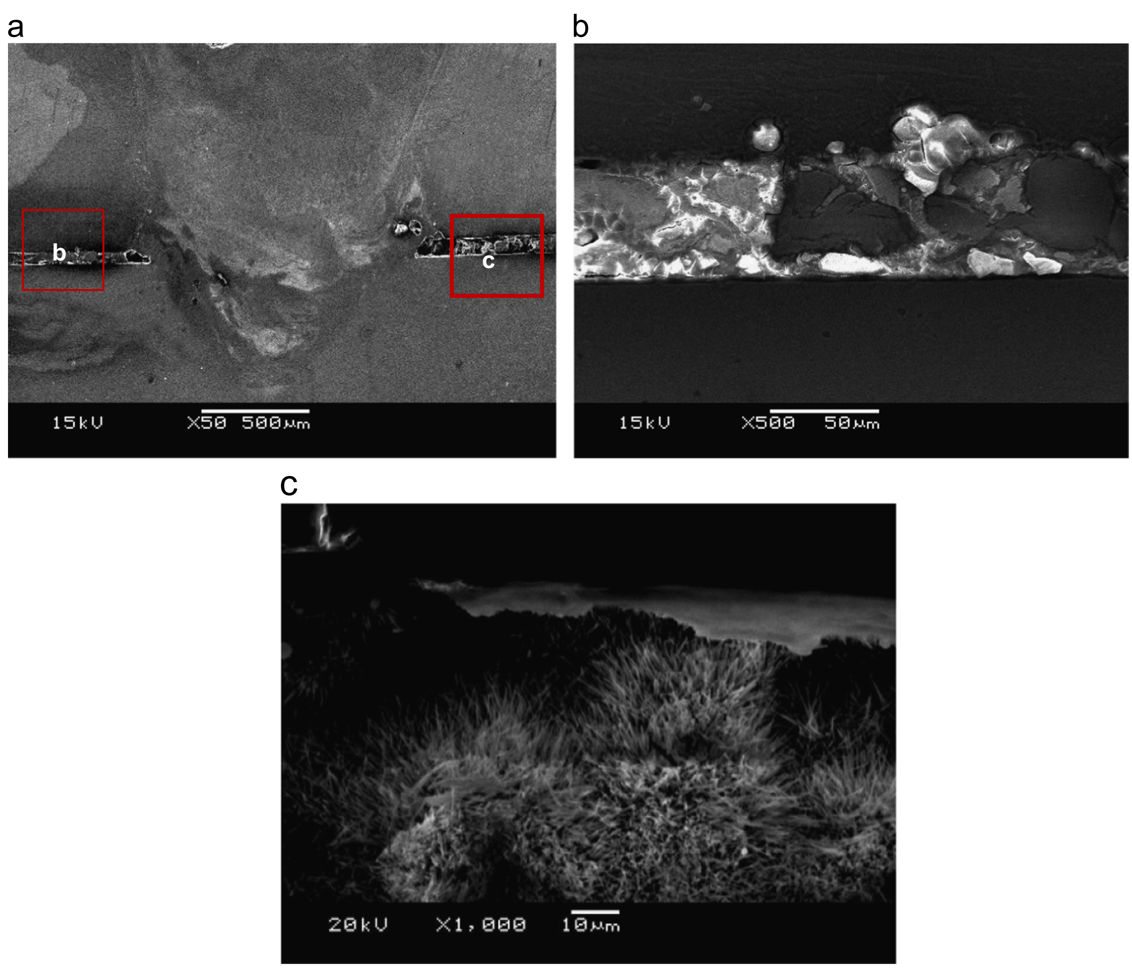

Fig. 2. Adhesive microstructures at the edge of the joint, a) macrostructure of the LWB joint, b) microstructures of the adhesive layer, c) microstructures of the decomposed adhesive.