Investigation on Tensile Strength and Interface of Fiber-Metal Laminates Based on Carbon Fiber Reinforced Zn-Al Alloy

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Abstract: Fiber metal laminates (FMLs) which consist of AZ31 magnesium layers and continuous carbon fiber reinforced Zn-8%Al alloy (mass fraction) composite layer was fabricated by hot-pressing technology. The reaction between magnesium and Zn-Al alloy leaded to a well-bonded interface. Tensile test was carried out and the result indicated an improvement of tensile strength by 102% compared with original AZ31 magnesium sheets. Both the interface of Cf-Zn-Al and the interface of Mg-Zn-Al were characterized by SEM equipped with EDS. This research proves the feasibility of joining metal sheets with carbon fiber reinforced low-melting-point alloy composites sheets to fabricate metallurgically bonded FMLs.

Keywords: Fiber Metal Laminates; Carbon fiber reinforced Metal Matrix Composites; Tensile strength; Interface; Zn-Al alloy.

1 Introduction

Fiber metal laminates (FMLs) are hybrid composites which bond alternative metal sheets and fiber reinforced composites sheets [1, 2]. FMLs have excellent performance because of the combination of advantages of both metal alloys and composites. Due to their excellent properties, FMLs are being applied to many structural parts in aerospace and aeronautical industry, such as fuselage skin structures of the next generation commercial aircrafts [3, 4].

This work is stimulated by the lack of researches in the MMCs-based FMLs. The aim is to investigate the feasibility of producing metallurgically bonded FMLs.

（缺关键词）

2 Experimental procedure

Zn-8Al matrix composite reinforced with continuous carbon fiber was made using pressure infiltration method. At this point, a hydraulic machine was used to press the semi-solid slurry to infiltrate into the carbon fiber at 1 MPa.

AZ31 Mg alloy sheets with a thickness of 0.8mm were used to fabricate FMLs. Covered by Mg alloy sheets on both sides, the composites sheet was put back into the mould and heated to 340℃. The pressure was 0.5MPa and maintaining time was 3 minutes.

3 Result and discussion

Fig. 1 shows SEM images of sections of FMLs which is perpendicular to fiber orientation. As shown in Fig. 1, the pressure during casting process does not change the original configuration. The Zn-8Al alloy sheets between fiber layers function as barriers and no agglomeration of fibers occurs. Fig. 2 (a) shows magnified images of composites. It can be seen that all the interstices among fibers were filled with Zn-8Al alloy semi-solid slurries, which manifests a good infiltration during the fabrication process of Cf/Zn-8Al composites. Besides, no serious casting defects, such as porosity could be found. The alternate configuration and semi-solid processing technology make the pressure for slurries to infiltrate carbon fiber much less than that used in common pressure infiltration process. The magnified image of interface is shown in Fig. 2 (b). An obvious and uniform interface area (the dark area) without any micro-cracks or debonding is observed between carbon fiber and Zn-8Al alloy. The thickness of the interface is about 100nm.

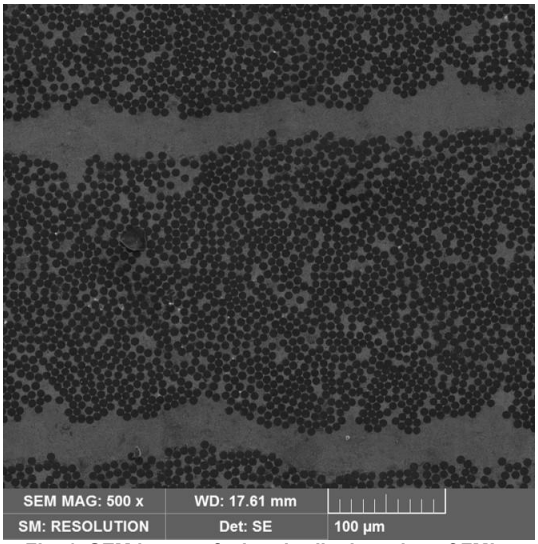

Fig. 1. SEM image of a longitudinal section of FMLs

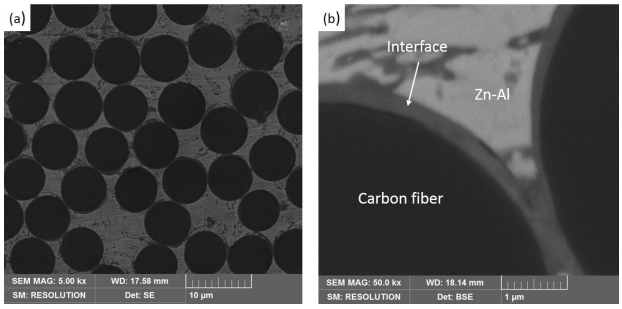

Fig. 2. SEM image and magnified Back-scatter electron (BSE) image at Cf/Zn-Al interface. (a) SEM image at 5kx magnified times, (b) BSE image at 50kx magnified times.

The mechanical properties of FMLs and AZ31 Mg alloys sheets used in this research are shown in Fig. 3. The ultimate tensile strength of FMLs reached 495MPa, which increased by 102% compared with that of AZ31 Mg alloy. However, the elastic modulus decreased from 45GPa to 37GPa. This may be the result of overreaction between Mg and a certain amount of carbon fibers, as shown in Fig. 4. The extremely low modulus of damaged carbon fibers decreased the modulus of FMLs at macro level to a great extent. The tensile curve shows no obvious yield point or plastic deformation stage, which represents typical deformation mechanism of fiber metal laminates.

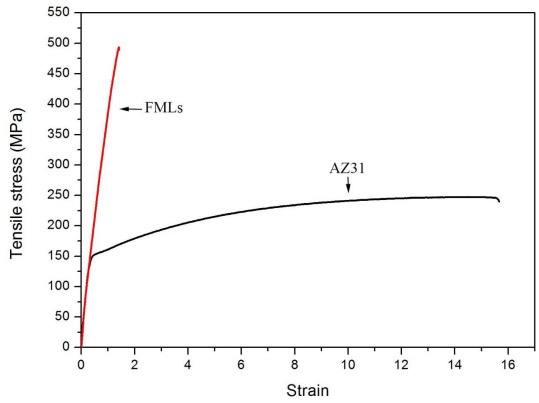

Fig. 3. Tensile curve of AZ31 Mg/Cf-Zn-Al FMLs and AZ31 Mg alloy sheet

4 Conclusion

In this work, the mechanical properties and interfacial characteristics of a new kind of metallurgically bonded FMLs were investigated. The results are as follows:

1)The Zn-Al alloy reacted with carbon fiber and formed a chemical bonding interface. The formation of brittle interfacial phases was prevented.

2) The tensile strength of AZ31 Mg/Cf-Zn-Al FMLs reached 495MPa, which increased by 102% compared with that of AZ31 Mg alloy.

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