HIGH POWER DIODE LASER WELDING OF HIGHLY REINFORCED SIC / AL COMPOSITES

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KEYWORDS: laser, welding, metal matrix, SiC

INTRODUCTION

The application of metal matrix composites with high contents of ceramic reinforcement in electronics packaging is being investigated since late 80s. The most important candidates within this family are the Al matrix composites reinforced with a high proportion of SiC particles (AlSiC). AlSiC combine the most fitted CTEs, with high thermal conductivity, reduced density and outstanding values of specific strength and stiffness [1, 2]. Current technologies allow to fabricate flat samples made of AlSiC, but to obtain more complex shapes different processing technologies are needed. Among them, welding or brazing are cost effective technologies to obtain complex and even hermetic structures made of AlSiC. In particular, among many feasible technologies, laser welding is getting interest because of its precision and flexibility. In particular, High Power Diode Lasers (HPDL) are promising candidates to become a standard in the processing of materials in few years time if applications are developed to them. This laser technology is much cheaper than others and emits in the near infrared where the reflectivity of many metals is lower.

In this work we use HPDL to make bead on plate tests as well as brazing on AlSiC samples to obtain continuous seams in the materials. The effect that laser power, laser speed and atmospheres have on the quality of welds is studied.

EXPERIMENTAL

AlSiC substrates used were constituted by 75 vol.% SiC particles with a bimodal particle size distribution (average sizes of 46.7 and 5.9 μm) restrained in an aluminium alloy matrix (A356) that was infiltrated by a high pressure system by Electrovac.

The laser used was DL13S from Rofin-Dilas with 1300 W maximum power at 940 nm. Laser power, power density and speed were modified in different test.

Two different types of tests were carried out. Bead on plate tests were used to determine the weldability of the samples under different conditions of laser power, laser speed and atmospheres. Brazing was carried out with a 5356 alloy and the effect of coatings on substrates was analyzed.

RESULTS

During bead on plate tests, aluminium from the matrix flowed and appeared in the top face of the composites where the laser beam irradiated the sample (figure 1a). This phenomenon is caused by the low wettability of SiC. During laser irradiation, aluminium melts and, by capillarity, it tries to flow from SiC particles as there is no external pressure that enforces it to stay in the composite. To avoid this problem, we have added an external pressure to reduce
the speed at which aluminium flows. Applying a pressure of 2 atm. of argon, reduces the amount of aluminium that is removed from the composite to a negligible quantity (fig. 2b).

![Fig. 1: Effect of modifying laser power and gas pressure during bed on plate tests.](image1)

To get good joining of the samples there is the need of adding a filling material. We have made several tests using AA5356 in bead on plate tests (figure 2a) and on several geometries to join two different AlSiC pieces (figure 2b). Using appropriate parameters it is possible to get a good wetting of the samples and to get a homogeneous seam without degrading the composites.

![Fig. 2: Results obtained using a 5356 wire: (a) bed on plate tests and (b) joining two different pieces.](image2)

**CONCLUSION**

Laser irradiation causes the aluminium to come to the surface of AlSiC samples, leaving pores and gaps in the material. These defects are reduced when applying a 2 atm. external argon pressure. This method, jointly with using an AA5356 filler material during laser welding, allows obtaining continuous seams without degrading the joined AlSiC were obtained.

**REFERENCES**