

Nanosecond laser induced carbon fiber reinforced plastic processing under Ar gas ambience for suppression HAZ

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1. Introduction

A carbon fiber reinforced plastic (CFRP) is expected to be applied to automobile, aerospace and several industries, because of having the characteristics of light weight, weather resistance, chemical resistance and dimensional stability [1]. Laser processing is one of useful tools for CFRP because the laser process, which is a non-contact, does not involve any mechanical cutting forces and tool wear. However, the matrix resin in CFRP was quickly decomposed by laser irradiation before cutting of the carbon fiber, which caused to form a heat affected zone (HAZ) because of differences in thermal properties and laser absorption of carbon fiber and epoxy resin, respectively. In this study, CFRP plates were cut with a nanosecond laser at the wavelength of 1064 nm, and atmosphere was changed from air to argon (Ar) gas for suppression of the HAZ. The ambient gas is an important factor for suppression of HAZ since formation of HAZ might be related to the oxidation of carbon fiber and epoxy resin.

2. Experimental setup

Figure 1 shows a schematic diagram of Experimental set-up. A multi-directional stack type of CFRP plate, which composed of a carbon fiber and an epoxy resin, was put on the X-Y stage in the processing chamber. Ar gas was filled at 0.1 MPa in the chamber after exhaust at 1Pa. In this condition, the laser was irradiated the CFRP passing the attenuator for adjusting the laser intensity, as shown in Table.1. Emission spectra of CFRP was measured and analyzed with a spectrometer.

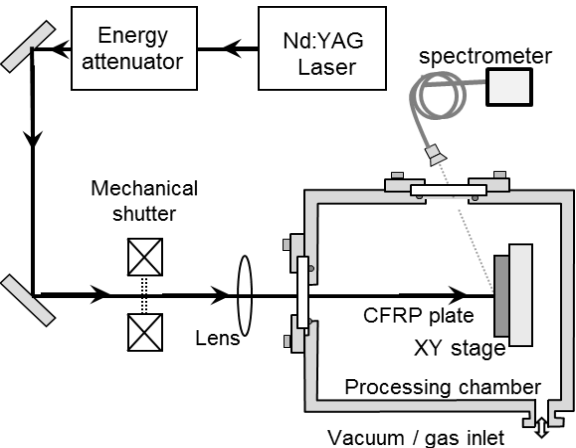


Fig.1 Experimental Procedure

3. Results and Discussion

Figure 2 shows the emission spectra of the plume ablated from CFRP. Line spectra were recorded doubly (C II Swan band) ionized carbon atomic lines at 473 nm and 512 nm and ionized oxygen atomic line of 386 nm, respectively.

Table 1 Experimental condition		
Wavelength	(nm)	1064
Pulse width	(ns)	6
Repetition rate	(Hz)	10
Spot diameter	(μm)	100
Laser Intensity	(W/cm ²)	2.8×10 ⁸ ~2.9×10 ¹⁰
Atmospheric condition①	Air (0.1Mpa)	
Atmospheric condition②	Ar gas (0.1 MPa)	

It indicates the presence of ionized carbon and oxygen in the plume. Under Ar gas ambience, the emission lines were observed the C I and Ar II lines of 563 nm and 434 nm, respectively, together with the C II Swan band. It was also worth noting that the O II line of 386 nm was decreased with increase the C II line of 563nm under Ar gas. It suggests that the ionized carbon and oxygen from CFRP are collided with Ar atom to produce the neutral carbon and ionized Ar atom. Comparing the air and Ar gas ambience experiments, it suggests that the Ar atom had not only suppression of oxidation but also a cooling effect for laser plume.

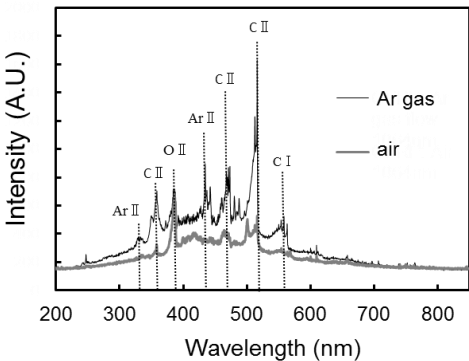


Fig.2 Ablation plume emission of CFRP with laser at 4.2x10⁹ W/cm² under air and Ar gas ambience.

4. Summery

The CFRP plates were cut with the laser under air and Ar gas ambience. The emission spectra were evaluated by spectroscopic analysis. The results revealed that the laser cutting of the CFRP under Ar gas ambience might be a useful method to reduce the HAZ because of suppression of the oxidation of the carbon fiber.