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Micromachining of CFRP with Short Pulse Lasers

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1. Introduction

We have been investigating material processing of CFRP (Carbon Fiber Reinforced Plastic) with short pulse lasers in order to control mechanical and thermal damages [1]. While short pulse lasers enable us to process the CFRP with less thermal damages compared to CW lasers, machining speed tends to be slow due to the limited average power of the laser system. Hence, we focus our attention on micromachining of sub-mm thick CFRP. The short pulse lasers are advantageous to the micromachining of the thin composite material because of the precise cutting quality with minimal HAZ. Considering the excellent mechanical and thermal properties of carbon fibers, the CFRP has potentials to replace metals and would be useful for innovative devices in various industries. It has to be noticed that there are two types of Carbon fibers (CF), PAN-type and Pitch-type [2]. In order to clarify the effects of types of CF in short pulse laser processing, we performed the simple cutting experiments using UV-ps (266nm/35ps) laser pulses. Varying laser power, and scanning speed, we observed SEM images of samples. We also measured times to cut through the samples.

2. Experimental Results

Figure 1 shows SEM images of PAN-based ((a)-(c)) and Pitch-based ((d)-(f)) 250μm-thick CFRP cut by the UV-ps laser pulses with repetition rate of 50kHz. Laser power and scanning speed are 0.5W and 1500mm/s for (a) and (d), 2W and 1500mm/s for (b) and (e), 2W and 40mm/s for (c) and (f), respectively. All SEM images were taken at the positions where the cutting direction was perpendicular to the fiber orientation. Comparing (a) and (b), (d) and (e) in Fig.1, all of the images showed high quality cutting without HAZ in spite of that the pulse energies for (b) and (e) were 4-times higher than that for (a) and (d). In case of the scanning speed of 1500mm/s, PAN-based and Pitch-based CFRPs did not show significant differences. On the contrary, comparing (b) and (c) in Fig.1, PAN-based CFRP suffered thermal damages, where a part of polymer was evaporated and CFs were exposed, in spite of that the laser irradiation conditions were the same. Comparing (d) and (f), however, Pitch-based CFRP seemed to be intact even in the slow scanning speed of 40mm/s. This is due to the higher thermal conductivity of Pitch-type CFs.

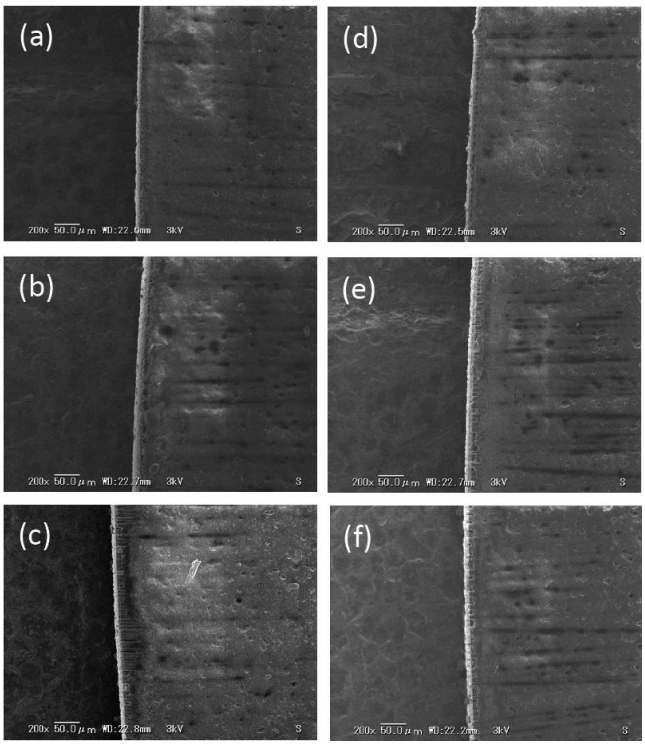

Fig.1 SEM images of PAN-based ((a)-(c)) and Pitch-based ((d)-(f)) CFRP cut by the UV-ps laser with
(a) and (d) 0.5W in 1500mm/s,
(b) and (e) 2W in 1500mm/s,
(c) and (f) 2W in 40mm/s

3. Conclusions

We performed CFRP cutting experiments with an UV-ps (266nm/35ps) laser system. Varying laser power and scanning speed, 250μm-thick CFRP was cut in the shape of a disk of 20mm in diameter. From observations of SEM images, it was confirmed that the scanning speed of laser beams should be faster to avoid significant HAZ. Also PAN-based CFRPs were more vulnerable to thermal damages than Pitch-based CFRPs.

References

[1] M. Fujita, T. Somekawa, and N. Miyanaga, Physics Procedia, **41**, (2013) 629.
[2] The Japan Carbon Fiber Manufacturers Association: http://www.carbonfiber.gr.jp/english/material/what.html.