High Aspect Ratio Laser Cutting of CFRP using Nanosecond UV Laser Pulses

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Carbon Fiber Reinforced Plastics (CFRPs) are expanding their applications in various fields including the aviation and automobile industries because CFRPs are lightweight, strong, and durable. Machining and water jets are used for CFRP cutting, but there are problems with machining accuracy and running costs. Recently, laser processing has been researched as an alternative technology to CFRP cutting [1-3], but the heat-affected zone (HAZ) deteriorated by the irradiation of laser light is an unavoidable problem, and is a major obstacle to using laser-cutting as a standard process.

In this study, we aim to develop high quality laser processing technology applicable to CFRPs designed for aircraft using a pulsed laser at a wavelength of 258 nm.

The samples are unidirectional CFRPs for Aircraft (supplied by Toray Industries, Inc.), with a thickness of 1.6 mm. Laser pulses have a duration of 7 ns and a repetition rate of 10 kHz. Laser light with average power of 1 W was focused on the CFRP with a diameter of 20 μm, and the stage on which the CFRP was placed was moved once (single scan) at a speed of 0.05-1 mm/s orthogonal to the orientation of the carbon fibers. Fig. 1 is a microscope photograph of the cross-section of a laser-cut groove when the stage was moved at a speed of 0.1mm/s and 0.2 mm/s. The moving speed of 0.05 mm/s realizes separation of the 1.6 mm CFRP with a cutting width of 20 μm which corresponds to the left edge of the CFRP in Fig. 1. This gives an aspect ratio of more than 80.

EDX analysis was performed on the surface and cross-section of the laser-cut groove. In Fig. 2(a), it is clearly observed that the vertical position of each laser-cut carbon fiber is almost aligned but they are covered with a thin layer. Fig.2 (b) and (c) show the results of carbon and sulfur analysis for the same area as Fig. 2(a). Sulfur is just one of the components included in the resin, and the carbon concentration of the layer is around the middle of the resin and CFs. This implies that the layer formed after the CFRP was laser-cut, and that the layer is a mixture of resin and particles of carbon fiber.

We believe this to be the first report of high aspect ratio laser cutting of more than 80 on CFRPs, and it is expected to meet the requirements of industries.

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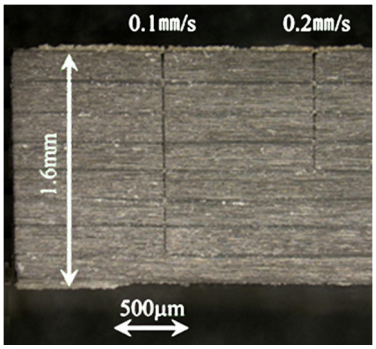

Fig. 1. Microscope photograph of the cross-section of a laser-cut groove of 1.6 mm thick CFRP.

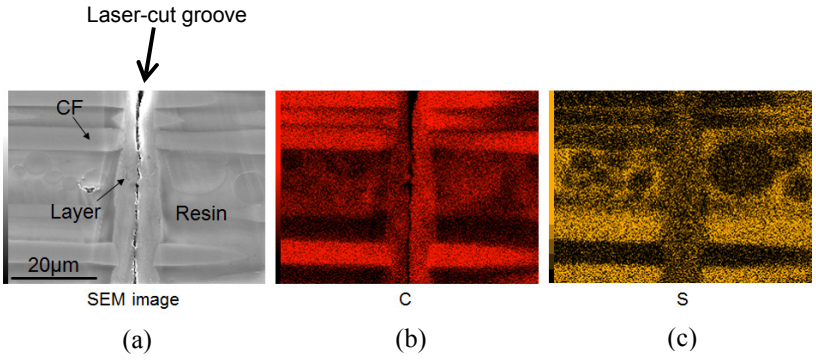

Fig. 2 (a) SEM photograph of the cross-section of the laser-cut groove by 258nm laser pulses. EDX on carbon and sulfur are shown in (b) and (c). Brightness is proportional to the concentration of carbon and sulfur, respectively.