High-Power Fiber Laser-Induced Damage on the Surface of a Quadcopter Drone

Reem Al Ameri, Antaryami Mohanta, Taif Alhmoudi, Guillaume Matras and Chaouki Kasmi
Directed Energy Research Center, Technology Innovation Institute,
Abu Dhabi, United Arab Emirates
Reem.AlAmeri@tii.ae

Abstract— Unmanned Aerial vehicles (UAVs), also known as drones, have been misused by unauthorized groups such as drug dealers. Therefore, many methods including the use of high-power lasers have been proposed to neutralize or damage the drones. In this study, several experiments were performed on the surface of a quadcopter drone using a high-power fiber laser. The laser power was fixed at 900 W, the laser irradiation time was 5 s and the distance between the laser head and the quadcopter drone was 4.4 m. Three different laser beam diameters such as 0.60, 0.74, and 1.02 cm were used in the experiment. The results have shown that the smallest beam diameter can lead to faster penetration through the surface of the drone in 0.375 s.

Keywords- Laser-material interaction, High-speed imaging, UAV, Drone

I. INTRODUCTION

Directed energy systems comprised of high-power lasers, microwave sources, or particle beams have been considered as potential weapon systems to neutralize or damage commercial UAVs/drones involved in malicious activities [1]. In such directed energy systems, focused electromagnetic energy or atomic or subatomic particles beam has been employed for degradation, damage, or complete destruction of the targets [2]. In this research, the effect of the interaction of a high-power fiber laser with the surface of a quadcopter drone is studied. An appropriate selection of laser parameters could result in efficient damage to drones, which requires a deep insight into the laser-material interaction process. An in-depth understanding of the thermal damage process caused by a high-power laser on the mechanical structure of a drone, which holds and protects the electronics, could help in identifying the laser parameters needed to disrupt the desired performance of the drone. Three experiments have been conducted to understand the high-power laser effect on the surface of a static quadcopter drone.

II. EXPERIMENT

A. Experiment Setup

A Continuous Wave (CW) fiber laser having a maximum power of 6 kW, and wavelength of 1080 nm was used to investigate its interaction with the surface of a quadcopter drone. The laser head was placed at 4.4 m from the body surface of the drone, which has an average thickness of 2 mm. The laser power and irradiation time were fixed at 900 W and 5 s, respectively. Three laser beam diameters were used, which are 0.60, 0.74, and 1.02 cm. A high-speed camera with an 850 nm band pass filter was used to capture the images from the laser-material interaction zone.

B. Experimental Results

Fig.1 shows the laser-irradiated surface of the drone at different laser beam diameters for a fixed laser power of 900 W. The decrease in laser beam diameter increases the power density, which results in increasing damage to the drone. High-speed camera images were used to determine the damage time, which is found to be the shortest, i.e., 0.375 s for the smallest beam diameter of 0.60 cm.

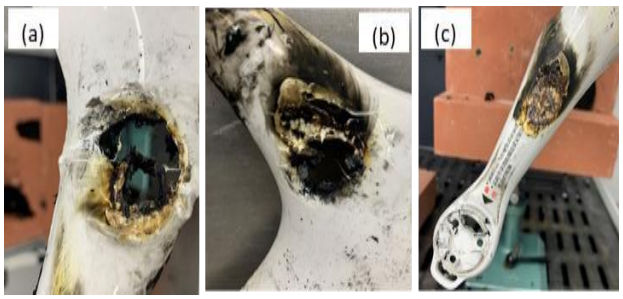

Figure 1. The drone surface after laser irradiation for a beam diameter and power density of (a) 0.60 cm and 3.18×10^3 W/cm^2 (b) 0.74 cm and 2.10×10^3 W/cm^2 (c) 1.02 cm and 1.10×10^3 W/cm^2, respectively.

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