Removal of Paints from Metal Surfaces by Fiber Laser

Kanokwan Chongcharoen, Phumipat Kittiboonanan and Amarin Ratanavis

Department of Industrial Physics and Medical Instrumentation, Faculty of Applied Science, Lasers and Optics Research Center (LANDOS), Science and Technology Research Institute, King Mongkut's University of Technology North Bangkok, Thailand

Abstract

In this study, experiments have been carried out to investigate paint removal using a Q-switch fiber laser emitting the wavelength of 1064 nm. The results have shown that the pulsed fiber laser radiation is efficient in removing paint from metal surfaces. This study suggests that the removal of paint is occurred by the rapid thermal expansion of heated region. The mechanisms contributing to the removal process at low and high laser fluencies are discussed.

Keywords: Laser cleaning, Fiber laser, Paint removal

Introduction

Intense and short pulse infrared (IR) lasers are generally used for cleaning applications [1-5]. This relies on the photothermal ablation process that can often be successful in removing undesirable layers of materials without causing damage [6-9].

IR lasers using for cleaning applications are currently dominated by Nd:YAG and Diode lasers [1-11]. The advances in laser technology offer fiber lasers as a potential candidate for laser cleaning in applications [12]. However, the use of fiber laser for cleaning method must be determined for each individual case.

In recent years, paint removal has been interested to be applicable in automobile industry, aerospace, graffiti removal, and corrosion maintenance. In addition, the development of mobile handheld fiber lasers could establish the desirability of the removal in the sense of compactness, robustness and beam quality.

This research work devotes to study the feasibility and the effects of the use of a Q-switch fiber laser removing paints from metal surfaces. This work serves as an attempt to examine advantages of the fiber laser as the future tool for cleaning and to understand characteristics involved removal processes.

Methodology

The use of a Q-switch fiber laser was performed for cleaning procedures. The fiber laser provides the wavelengths at 1064 nm with the pulse length of 100 ns. Maximum pulse energy is 0.5 mJ. The maximum repetition rate of 50 kHz was carried out. Figure 1 shows the experimental setup to remove paints from metal surfaces. The laser beam was focused and scanned to the painted surface. The beam size was 100 microns. The average laser fluencies (F) were calculated by dividing the pulse energy (E) by the beam size. The energy values of the laser were measured and the F values were calculated.

The painted samples were prepared with the averaged thicknesses of 10 microns and 30 microns. The colors of the samples are black, red, blue and green. By controlling the laser fluencies on the surface, the depth of the paint removal can be controlled.

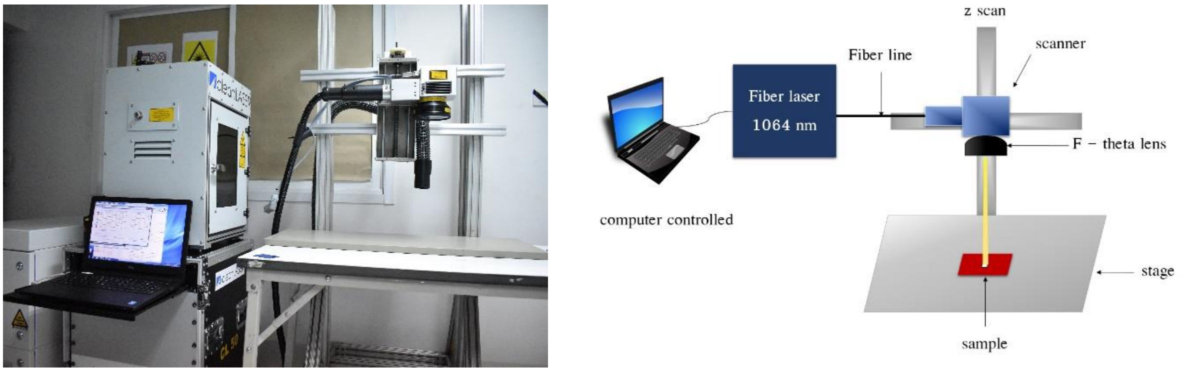

Figure 1: Experimental setup for paint removal using the fiber laser.

Results and Discussions

Figure 2 shows the microscope images of the paint removal at the averaged paint thicknesses of 10 microns. The cleaning was achieved at 0.15 J/cm^2 to 1.50 J/cm^2. The cleaning results can be used to determine the feasibility of the fiber laser as a cleaning tool. With the advancements in the fiber laser system, the selective process to obtain different cleaning levels is achievable.

Figure 2 also serves as a detailed survey involving trial cleaning that has been carried out to establish the cleaning condition. Due to the colors, the painted samples having strongly different absorption reveal different cleaning thresholds. However, it is apparent that the pulse energy of 0.60 mJ/cm^2 is sufficient to removal the paint layer from the metal surface. As the fluence is increased above a certain value, the ablation efficiency become to increase dramatically. However, it should be mentioned that the black paint is easily removed with a very low energy at 0.15 J/cm^2 due its nature of very high absorption.

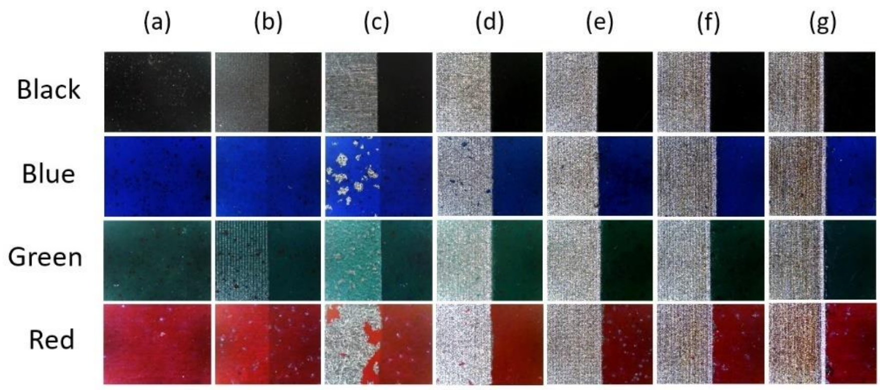

Figure 2: Microscope image of the removal of the averaged paint thicknesses of 10 microns using the fiber laser at the fluences (b) 0.15 J/cm^2, (c) 0.30 J/cm^2, (d) 0.60 J/cm^2, (e) 0.90 J/cm^2, (f) 1.20 J/cm^2 and (g) 1.50 J/cm^2. The column (a) shows the examples of painted surfaces before the treat of laser radiation.

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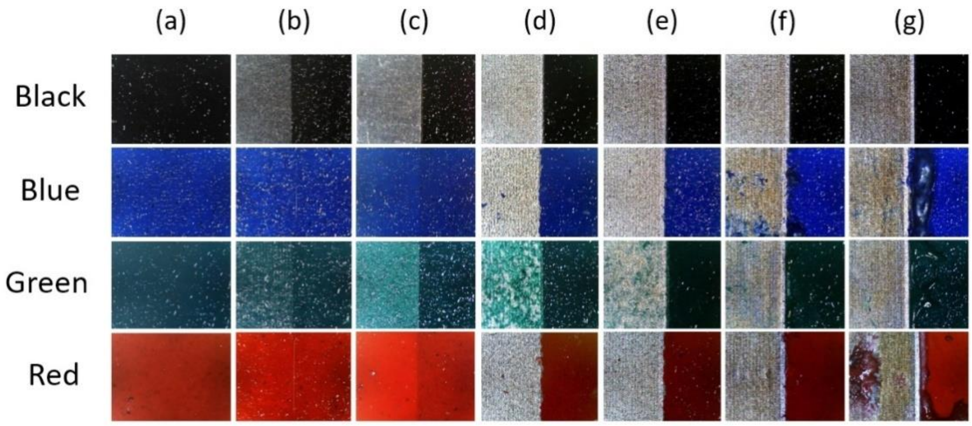

Figure 3: Microscope image of the removal of the averaged paint thicknesses of 30 microns using the fiber laser at the fluencies (b) 0.15 J/cm^2, (c) 0.30 J/cm^2, (d) 0.60 J/cm^2, (e) 0.90 J/cm^2, (f) 1.20 J/cm^2 and (g) 1.50 J/cm^2. The column (a) shows the examples of painted surfaces before the removal by laser radiation.

Figure 3 shows the representative cleaning results for the averaged paint thickness of 30 microns. In comparison with Figure 2, it is clear that as the laser fluence required for the removal is directly proportional to the paint thickness.

Due to the short pulse event in nanosecond, the laser ablation is simultaneously occurred by the photothermal and photochemical process. However in this case, the photothermal process dominates the removal caused by the IR radiation of the fiber laser.

Conclusion

A Q-switched fiber laser was investigated to serve as a cleaning tool. The paint removal was demonstrated. To test the capability of the fiber laser, the pulsed laser beam was focused and scanned onto the painted surface. Initially, a low laser fluence was used. The laser fluence was increased in steps to observe the level of removal. The cleaning examined by a microscope (40X) was evident. The fluences at 0.60 J/cm^2 and 0.90 J/cm^2 were sufficient to remove paint thicknesses of 10 microns and 30 microns, respectively.

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