Romanian Reports in Physics, Vol. 60, No. 1, P. 105–110, 2008

ASPECTS CONCERNING LASER CONSERVATION OF ORGANIC ART WORKS*

M. SIMILEANU, J. STRIBER, R. RADVAN

National Institute of Research and Development for Optoelectronics – INOE 2000, CERTO
1 Atomistilor Street, Magurele – Ilfov, Romania, e-mail: simileanu@inoe.inoe.ro

(Received August 9, 2006)

Abstract. In this work we present successful laser cleaning strategies concerning organic materials such as: paper, textile and parchment. Tests have been carried out using the fundamental (1064 nm), second harmonic (532 nm) and third harmonic (355 nm) from a Q-switched Nd: YAG laser; the laser cleaning process was real time monitored by microscopic and thermographic techniques in order to assure a safe removal of the adherent deposits. Also, one of the main advantages that laser cleaning brings into the restoration/conservation domain, namely selectiveness, was characterized. The irradiated probes have been investigated with an optical microscope, in order to determine any deterioration that may have occurred to the paper substrates, as well as the efficiency of laser cleaning.

Key words: laser cleaning, organic substrates, selectivity.

1. INTRODUCTION

Conventional techniques do a lot against most of the factors that endanger art objects, but new approaches of advanced technology introduce more practical and reliable advanced analysis/ diagnosis/cleaning/conservation techniques [1, 2].

The laser technology has developed rapidly and laser cleaning had become a practical and reliable technique offering the conservator a high level of precision and control.

An important factor of the cleaning process concerns its selectivity, which allows us to remove only the encrustation without affecting the substrates, described in Fig. 1, where: β = absorbance coefficient, I_0 = incident flux, $T_{1,3,5}$ = encrustation temperature, $T_{2,4,6}$ = substrate temperature.

The main factor favoring selective vaporization was shown to be when the absorption coefficient (β) of the encrustation was sufficiently large to lead to a temperature rise favoring vaporization (T_1, T_3) while the absorption coefficient of the underlying material was small enough to limit temperature rises to moderate values (T_2, T_4) that did not allow the occurrence of thermal expansion, melting or vaporization.

* Paper presented at the Annual Scientific Conference, May 26, 2006, Faculty of Physics, Bucharest University, Romania.

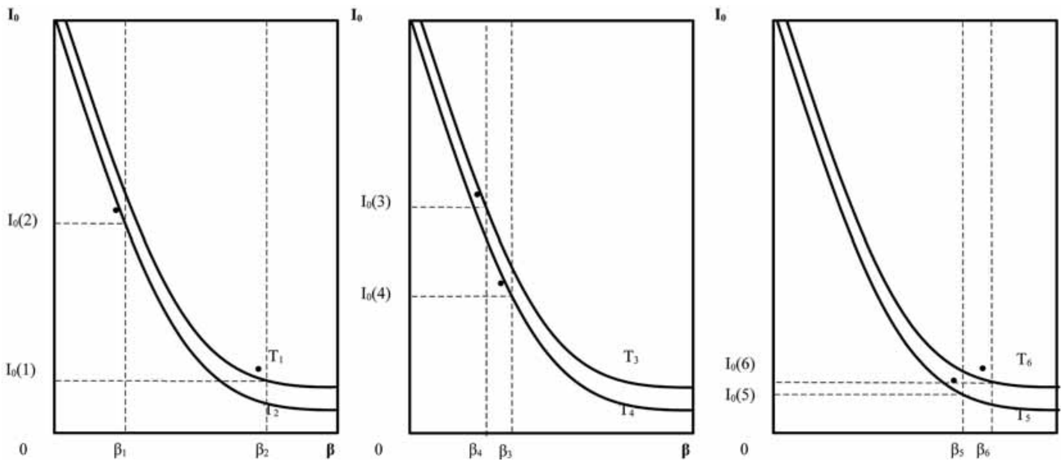

Fig. 1 – Comparative diagram of the types of situations encountered in laser cleaning, proof of the spallation process selectivity.

Laser cleaning should be regarded as a generic practice requiring specific adaptation to the precise combination of object (substrate) and encrustation (pollutant layer) requiring removal. At the same time, this inherent complexity results in a technique capable of adaptation to a wide variety of specific requirements.

2. LASER CLEANING STRATEGIES

In all the following experiments the laser cleaning was accomplished with a Q-switched Nd:YAG laser, using its 1064 nm and 532 nm wavelengths, with a frequency range from 2–20 Hz and 0.6 cm^2 spot size.

2.1. PAPER

Based on the synthesis [3] that was accomplished earlier – regarding laser cleaning of organic substrates – and on the set of initial investigations that accompanied it, a series of tests were made initially on the back side of some art works in order to find the accurate laser parameters.

The irradiated surfaces were then investigated using an x-y optical microscope in order to observe the appropriate wavelength and fluence.

Substrate melting is in all cases undesirable since morphological change in the substrate will be implied in this situation.

As shown in Fig. 3, in the cases when the maximum laser power (100%) was used – corresponding to an energy of 450 mJ for 1064 nm and 210 mJ for 532 nm –

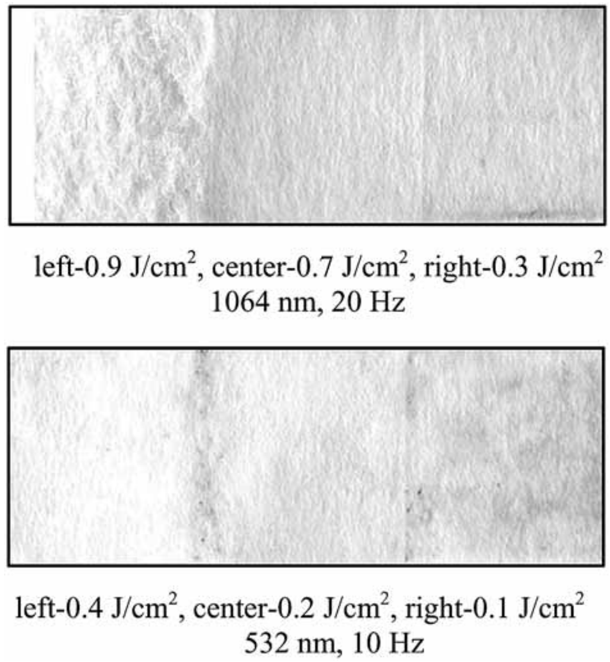

Fig. 2 – Tests made on the back of the paper art work.

the paper substrates were deteriorated, presenting various degrees of disruption (higher ones at 1064 nm, and barely visible ones where 532 nm radiation was concerned). However, when the laser power is decreased to 75% for both wavelengths, the results were more than satisfactory since the paper substrates were no more affected, and the cleaning presented a higher efficiency degree. In any case, evaluating the obtained results it was concluded that the best outcome was accomplished using the following laser parameters:

– wavelength: 1064 nm;
– frequency: 20 Hz;
– energy: 330 mJ.

According to this laser working regime, the two art works on the back of which the test were made, were successfully laser cleaned. The procedure implied constant and precise layer selectiveness based on the absorption coefficient of the adherent deposits, crayon marks, as well as ink, tempera and paper substrates.

As is shown in Fig. 4, the crayon marks and adherent deposits were efficiently removed from both art works, the paper substrates, as well as the tempera and ink ones, were not affected.

2.2. TEXTILE

A series of tests have been conducted in order to evaluate the potential for using a Q-switched Nd:YAG laser – working at 1064 nm, 532 nm and 355 nm –

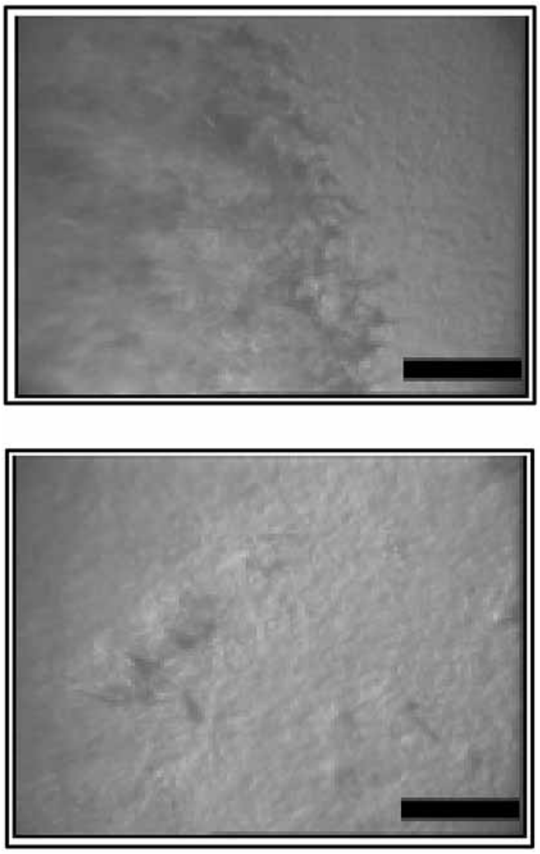

Fig. 3 – Optical microscope images: up – 1064 nm, 0.9 J cm^2, down – 532 nm, 0.4 J/ cm^2.

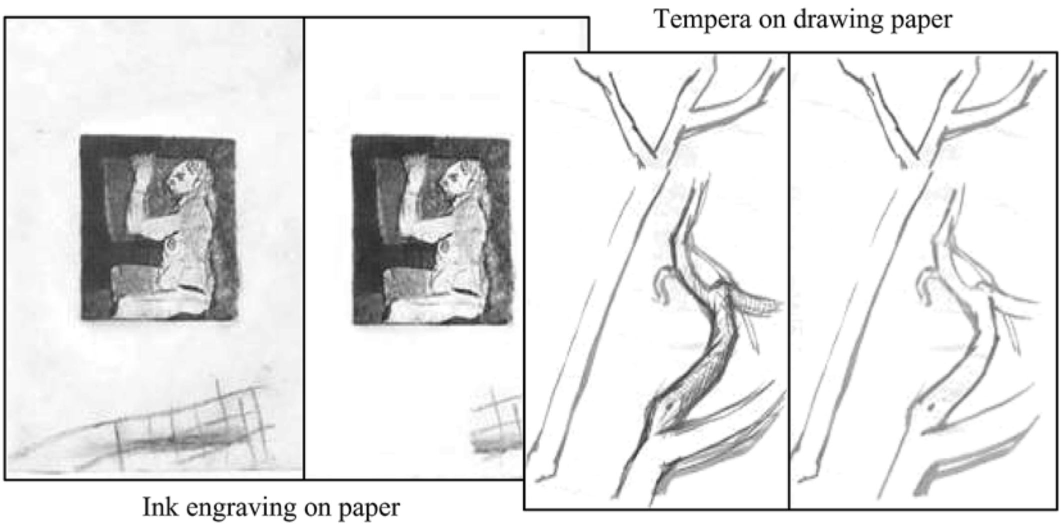

Fig. 4 – Laser cleaning of paper art works.

for cleaning textile. The tests were based on the most important studies and investigations made on textile materials that have been made so far [1, 3].

The experiments were made on two types of textiles different by their textures and their processing degree, artificially soiled with charcoal.

In both cases the adequate laser wavelength was proven to be 1064 nm one, since 532 nm produced fiber discoloration and the 355 nm one was inefficient.

Cleaned surfaces were examined with a laser microscope x-y in order to determine any disruption or deterioration that may have occurred.

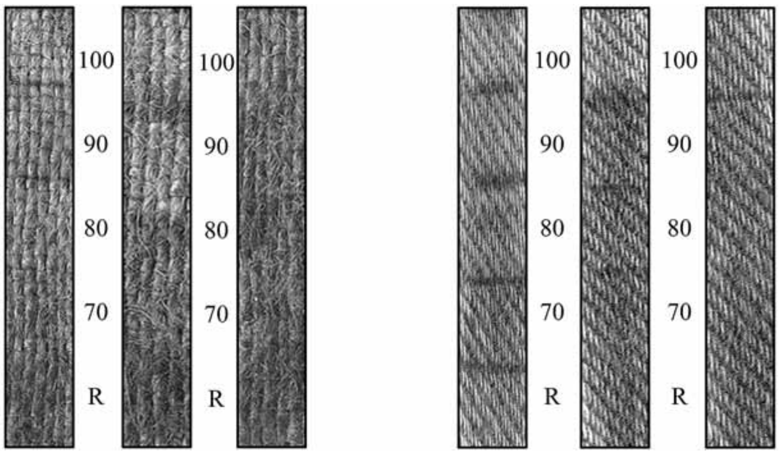

Fig. 5 – Laser cleaning tests: 1064 nm: 100–450 mJ, 90–330 mJ, 80–148.6 mJ, 70–65.21 mJ;
532 nm: 100–210 mJ, 90–118.8 mJ, 80–54.04 mJ, 70–27.8 mJ;
355 nm: 100–90 mJ, 90–41.4 mJ, 80–13.1 mJ, 70 – under 1 mJ.

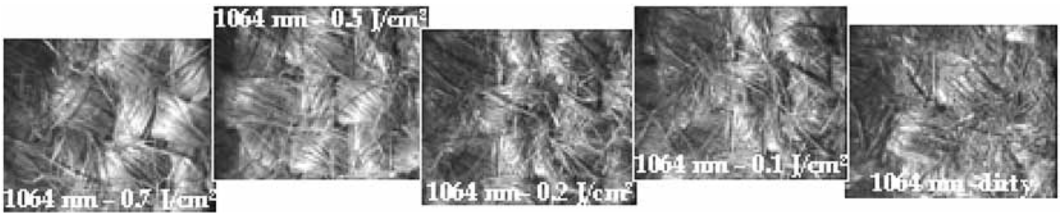

Fig. 6 – Laser cleaning efficiency *vs.* fluence.

2.3. PARCHMENT

In order to establish the proper working regime several tests were made on two sorts of parchment, in conformity with the studies and investigations published so far.

In both cases, the adequate laser cleaning parameters are:

- wavelength: 1064 nm;
- frequency: 20 Hz;
- energy: 206 mJ.

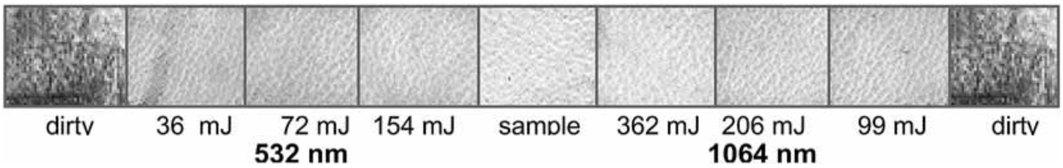

Fig. 7 – Laser cleaning tests on lamb parchment.

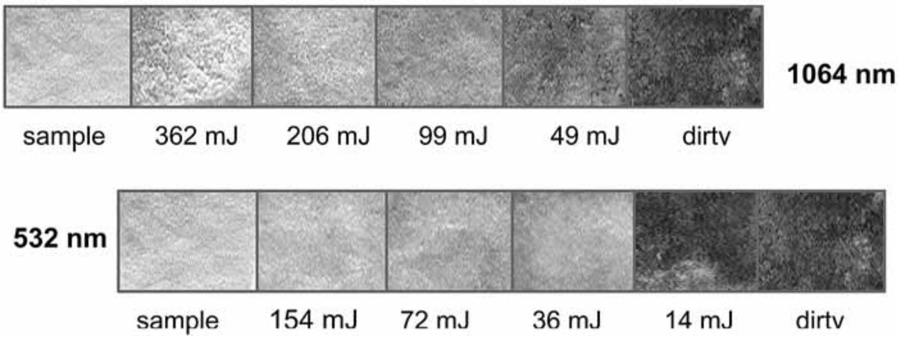

Fig. 8 – Laser cleaning tests on goat parchment.

3. CONCLUSIONS

As scientific research in the conservation field progresses, the drawbacks of the conventional cleaning methods become more and more obvious. Traditional methods of art work conservation rely on mechanical or chemical techniques chosen by a conservator. As these processes are difficult to control, extensive expertise and experience is necessary to achieve an optimal result. Nevertheless, in many cases the substrates are damaged in the process of cleaning. Mechanical methods of cleaning can destroy the texture of the art work, while the application of chemicals may affect their chemical structure and/or cause ageing due to their non-controlled penetration.

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