Femtosecond pulse laser cleaning of Makrana marble and semi-precious stones for the preservation of the Holy Samadh

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Abstract

This study examines the use of heat-free femtosecond pulse laser technology for the cleaning of Makrana marble and semi-precious stones from the Soami Bagh Samadh temple in Agra, India. We determined the ablation thresholds of the semi-precious stones used in the inlay stonework with femtosecond laser pulses and demonstrated that laser ablation can effectively remove dust layers and environmental staining from the marble surfaces without damaging the original material. We demonstrated, by using optical microscopy, colorimetry, scanning electron microscopy and Raman spectroscopy, that femtosecond laser processing of surfaces reduced the risk of thermal damage due to minimal heat generation and allowed the preservation of the original surface structure. This research suggests that femtosecond pulse laser technology can be a sustainable and effective cleaning method for heritage places such as the Holy Samadh temple.

Keywords: femtosecond pulse laser cleaning, heritage conservation, marble, built heritage, sustainability

1 Introduction

Lasers have become a popular tool for the restoration of cultural heritage places around the world [1, 2]. Lasers present various benefits compared to more conventional cleaning methods. Compared to sandblasting, one of the most common methods, lasers offer more control over the depth of removal, and precision for small-scale conservation work. Grit blasting produces fine dust particles that may cause respiratory problems to the operator. Moreover, dust and debris can have negative impacts on the surrounding environment, especially if the site is located near waterways or vegetation. Chemicals are highly effective cleaning method but can be hazardous for the operators and requires special handling and disposal measures. Chemicals also pose environmental concerns due to their toxicity to the ecosystems and can be very expensive.

Lasers offer a more sustainable option for conservators. By means of touch-free delivery of electromagnetic laser energy to the surface, laser processing does not rely on any additional specific substance like chemicals, grits, or water to clean surfaces. Consequently, the reliance on potentially toxic, non-degradable, or non-reusable resources is avoided. Requiring electrical power to operate, laser cleaning is more respectful of the environment and waste collection and management is easier. Therefore, laser cleaning mitigates the consumption of energy, resource use, and production of waste.

The most common lasers in conservation today rely on pulses of light in the time range of

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