COMBINED PHOTOACOUSTIC IMAGING TO DELINEATE THE INTERNAL STRUCTURE OF PAINTINGS

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Photoacoustic methods are tested for the 3D survey of painting artworks to achieve both the micrometric cross-sectional measurement of pictorial layers and the visualization of hidden underdrawings in a non-invasive way.
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1. Introduction

In the field of cultural heritage diagnostics, the cross-sectional analysis of paintings represents a challenge in terms of the non-invasive approach. In fact, the presence of opaque or strongly scattering materials, such as pigments, often hinders the penetration of the incident near-infrared radiation commonly used with the non-invasive pure optical techniques [1]. Such limit may be overcome by photoacoustic (PA) methods, which instead exploit the presence of opaque media inside the examined object [2]. In this work, combined photoacoustic imaging was tested for the study of paintings, to obtain stratigraphic information on paint layers and to visualize details not visible to the naked eye (i.e. underdrawings) [3,4].

2. Methods and samples

The proposed method is based on the detection and analysis of acoustic waves generated inside a material, following consecutive irradiation with either the fundamental or the second-harmonic wavelength of a pulsed Nd:YAG laser (IESL-FORTH). The technique was evaluated on acrylic paint laid on glass coverslips and an ad-hoc prepared samples simulating a real paintings on canvas. A geometric pattern was drawn with graphite on the preparation layer covering the canvas support. The reliability of the results was evaluated by comparison with optical coherence tomography (OCT), using a spectral-domain OCT and a time-domain confocal-OCT prototype (INO-CNR).

3. Results

The visualization of the underdrawing (Fig. 1, left) was achieved by raster scanning a 10 mm × 10 mm area with the 1064 nm excitation wavelength, which is highly absorbed by graphite, thus generating PA waves. No signal was detected in correspondence of the paint, since the latter is transparent in this spectral range. The cross sectional analysis was then performed by scanning the same area with the 532 nm wavelength. Thickness measurements were based on the frequency analysis of the transmitted PA waves, undergoing an exponential attenuation effect as they propagate through the material. The photoacoustic signal attenuation image (PAcSAI, Fig. 1, right), computed on the measured average transmitted frequency (ATF), allowed to measure the paint thickness, resulting ~ 78 μm, in good agreement with OCT thickness (~82 μm).

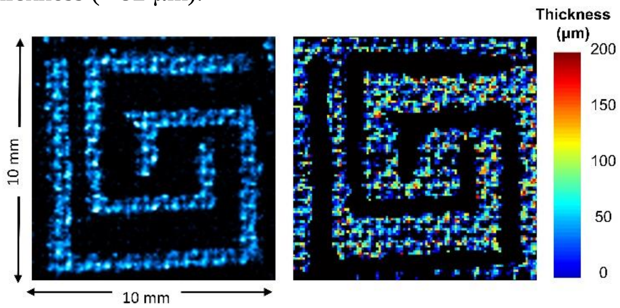

Fig. 1 Combined photoacoustic imaging applied on the painted mock-up: (left) PA image showing the geometrical pattern of the graphite underdrawing (right) PAcSAI image providing the measurement of the paint thickness (axial values represented in colour scale).

4. Conclusions

Combined photoacoustic imaging proved effective for the non-invasive 3D survey of paintings, providing a useful diagnostic tool in case of conservation studies and restoring operations.

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