A novel hyperspectral camera for the imaging of artworks

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Different artworks were investigated through a novel hyperspectral camera adopting time-gated photoluminescence imaging, allowing to identify and characterize the luminescent materials used in a rapid, non-invasive and reliable way.

Keywords: Hyperspectral Imaging, Time-gated Photoluminescence Imaging

1. Introduction

Hyperspectral imaging (HSI) is a technique that allows to record the continuous light spectrum of each point of an image scene, resulting in a three dimensional data-cube function of the point coordinates and the frequency. This technique finds a large number of applications in different fields. In Art Conservation, HSI has been proposed since the early 1990s as a non-invasive method for inspecting the spectral content of the light reflected, transmitted or emitted by an artwork surface, allowing the identification of areas of different material composition, past restoration treatments, preparatory sketches as well as for achieving high-precision colour rendering [1-2].

HSI has been implemented in different manners, that differ according to how the data-cube is recorded and constructed. Recently, a novel HSI method based on the Fourier-transform approach exploiting a common-path birefringent interferometer - the Translating-Wedge-Based Identical Pulses eNcoding System (TWINS) [3-4] - has been effectively applied to conservation science [5]. The capabilities of the system were tested on different artistic surfaces, as the Renaissance oil painting ascribed to Michelangelo Buonarroti, La crocifissione (Viterbo, Italy), the glass stained windows at Santo Spirito Church (Milan, Italy) and an ancient Egyptian cartonnage in steady state reflectance, transmittance and fluorescence steady state mode respectively.

2. Experimental

The novel hyperspectral camera is constituted by a TWINS interferometric system coupled to an intensified CCD detector (C9546-03 Hamamatsu Photonics image intensifier and R6 Retiga CCD camera). The camera is optically combined to a macro-imaging or micro-imaging photoluminescence system employing a pulsed laser (3^{rd} harmonic of a Q-switched Nd:YAG laser, λ=355nm, 70 µJ pulse energy, 1 ns pulse duration, 100 Hz repetition rate) as excitation source.
The measurements protocol consists in recording hyperspectral data-cube of the PL emission at different delays with respect to the pulsed excitation, allowing to reconstruct the RGB map of the emission at different timescales as well as the PL emission spectra is selected Region of Interest (ROI), from both fast- and long-living emitters [6].
The approach has been employed for remote imaging of 19^{th} and 20^{th} century paintings and for microscopy examinations of paint stratigraphies (Fig.1), demonstrating the high flexibility and versatility of the system.

3. Results

An example of the reconstructed RGB map of the emission at different timescales of a stratigraphic cross-section from Russian modern paintings is shown in Fig. 1.

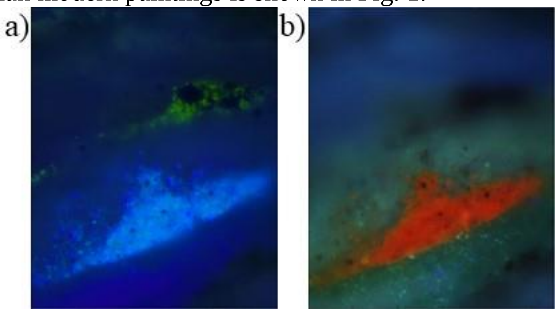

Fig. 1 Reconstructed RGB map of the emission at (a) nanosecond and (b) microsecond timescale.

On the basis of PL emission at different timescales, we have determined the presence of cadmium sulphide and zinc oxide based paints.

4. Conclusion

PL spectral and lifetime features, achieved through hyperspectral imaging, allows to map, identify and characterize different luminescent pictorial materials at macro- and micro-scale, showing how the protocol represents a rapid, non-invasive and reliable way for studying luminescent artistic materials.

References

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