Combined LIBS/OCT technique for examination of paintings

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In this contribution results on simultaneous use of Laser Induced Breakdown Spectroscopy (LIBS) and Optical Coherence Tomography (OCT) for depth-resolved elemental analysis of stratigraphy of multilayer paintings will be presented. The LIBS is a technique based on atomic emission from the cooling plasma plume generated by a laser pulse focused on the material under investigation. The spectral analysis of the fluorescence emission from the plasma permits for identification of chemical elements of the target. In the modality of this technique called the LIBS stratigraphy, consecutive laser pulses with energy adjusted at low level to ensure ablation of a thin layer of material in one shot are applied to the same place. As a result the elemental concentration profiles as a function of a number of laser pulses are obtained. The disadvantage of this technique lays in lack of information on the depth from which certain spectrum is collected and thus the absolute determination of layer thicknesses is not possible. Moreover, since the ablation rate is not constant for different strata within the structure of a painting, the obtained profile, if presented as a function of the laser pulse number, is distorted nonlinearly. This drawback may be overcome by means of OCT, used here mostly as a technique for profile imaging with micrometric resolution. Combining a high spatial resolution OCT instrument with a high spectral resolution LIBS system enhances significantly the quality and accuracy of stratigraphic analysis. The experiment was conducted essentially as follows: firstly the surface profile of the target was obtained with OCT 3D scanning, then the laser pulse was applied and fluorescence spectrum of generated plasma was collected. After that the OCT scan of the crater was performed followed by the next laser pulse. The procedure was completed when the final OCT scan was collected after the last laser pulse.

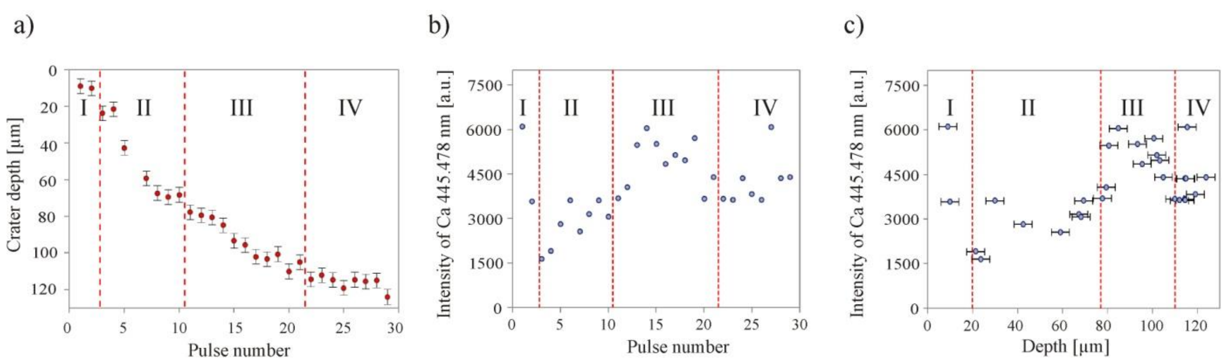

Figure 1. OCT and LIBS data obtained from historic painting on canvas; a) Ablation crater depth versus pulse number as determined by OCT. Notice ablation rate change between layers (dashed lines); b) Intensity of a calcium spectral line determined from the plasma emission signal shown as a function of LIBS laser pulse number; c) Intensity of the same calcium spectral line shown as a function of depth of origin as determined with OCT.

This novel approach enables the precise in-depth scaling of elemental concentration profiles and the recognition of layer boundaries by estimating the corresponding differences in material ablation rate. Additionally, the latter is supported, within the transparency of the object, by analysis of the OCT cross-sectional views. The potential of the method will be illustrated by presenting results on the detailed analysis of the structure of a historic painting on canvas performed to aid its planned restoration.

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