Supplementary Materials

Integrated Imaging and Spectroscopic Analysis of Painted Fresco Surfaces using Terahertz Time-Domain Technique

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S.1 Sample Cross-Section

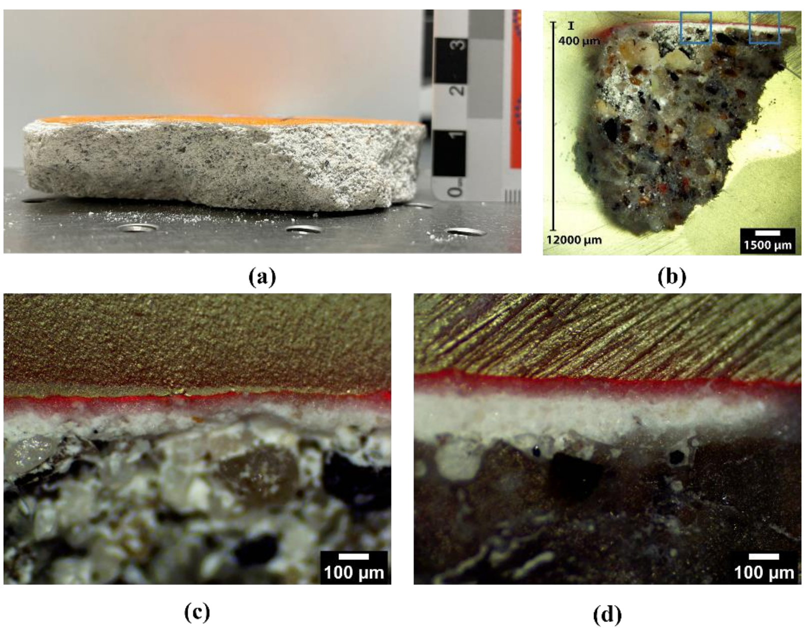

Figure S1 – (a) Lateral view of the mock-up sample. Stereomicroscopy images of a cross-section of the sample at 0.67x magnification (b), and of two different areas with 5x magnification (c and d). The pictorial layer has thickness of about 30-50 µm, while the first lime plaster layer is about 100 µm.

S.2 Amplitude Axial Intensity Variation

The changes induced on the beam intensity and amplitude were evaluated measuring the signal back reflected from a metallic mirror at various axial positions. We considered as reference signal the one taken at the focus (determined by maximum intensity signal) and moved the stage along the axial direction with step size of about 400 µm (3 ps), to retrieve the signal at different axial misalignment. Figure S1 depicts the THz signals at increasing defocusing positions. Clearly, the defocusing causes the shift in the temporal position of the peak and the decreases of the signal intensity. This decrease can be approximated by a Gaussian function, linked to the Gaussian profile of the THz beam. We interpolated the peak position and intensity with a Gaussian curve, obtaining the parameters reported in the figure. The maximum temporal shift considered here corresponds to 15 ps that in axial length are about 2 mm.

The temporal drift induces on the amplitude of the electric field a frequency-dependent modulation. Between the 70 and 90 cm^{-1}, the amplitude has the higher reduction of the intensity (FigureS2(a)) when the axial misalignment is 15 ps. The signal half its intensity at 80 cm^{-1} at the higher axial misalignment tested in this work. The variations are better appreciable when the ratio between the defocused and focused signal is calculated (FigureS2(b)). Apart from intensity reduction, the small absorption peaks associated to water vapor presents in the chamber does not change in frequency position, demonstrating that the temporal shift does not affect the spectroscopic signature of the material.

When the signal misalignments are corrected in the temporal domain, the amplitude of the electric field does not change in intensity, but only small noise fluctuations are removed (FigureS2(b)). As before, comparing the ratio between focused and defocused positions evidenced a high concordance with the uncorrected signal (FigureS2(d)). Similarly, the small absorptions peaks detected on the raw data were not affected by the correction of the axial misalignment. Overall, small shift of the back-reflected THz signal from its optimal focus position does not heavily corrupt the amplitude of the electric field. It reduces the intensity less than 5% if the misalignment is about 3 ps, and less than 10% is the misalignment is about 6 ps. This validates the use of the amplitude in the evaluation of the absorption coefficient, after curvature correction, for small temporal delays (value depends on the instrument optics and beam source).

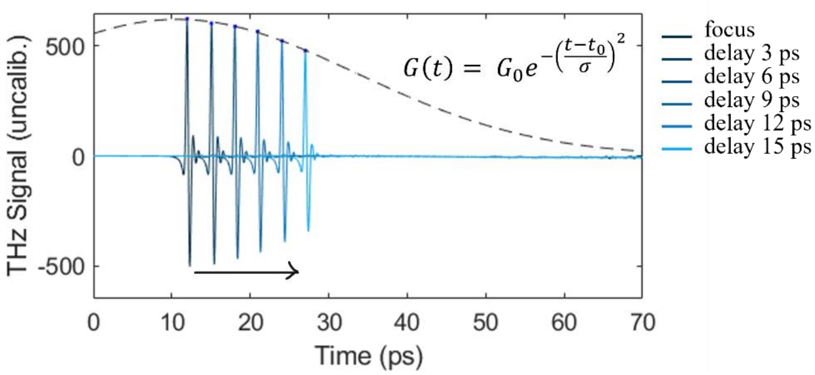

Figure S2 – THz-TD signal detected from a highly reflecting surface at different axial position. The most intense signal corresponds to the focus position, while the others are detected by defocusing the reflecting surface by 400 µm each step. The intensity of the signal decreases following a Gaussian function (Adj. R^2 = 0.9907).

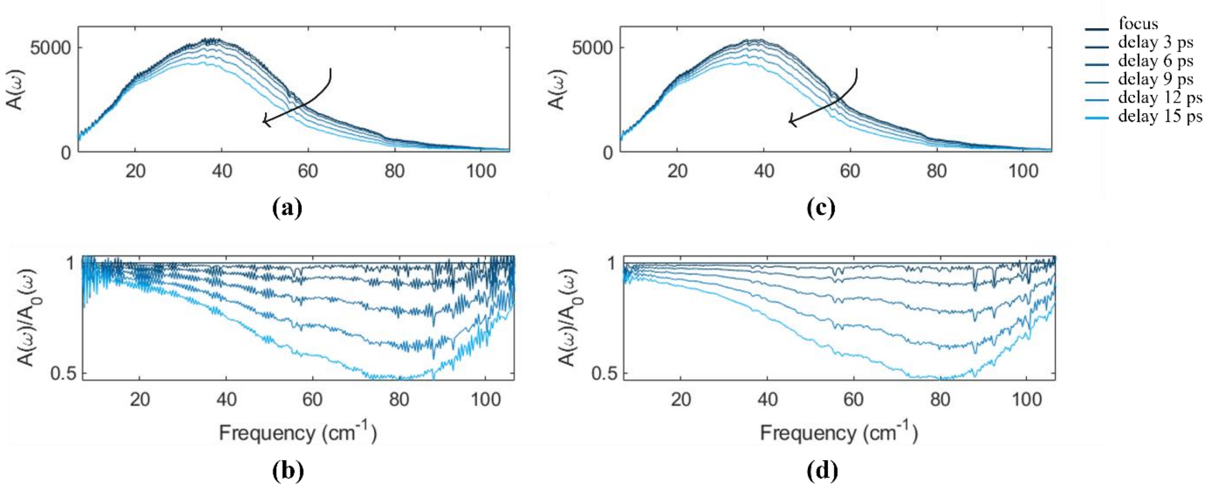

Figure S3 – (a) Amplitude of the signal in frequency domain at different axial position. The signal intensity decreases with greater axial misalignment and depends on from the frequency. (b) Ratio between the amplitude at increasing misalignment and the amplitude at focusing position. (c) Amplitude of the signal in frequency domain at different axial positions, after correction of the THz signal in time domain. (d) Ratio between the amplitude at increasing misalignment and the amplitude at focusing position, after correction of the THz signal in time domain.