Terahertz Time-domain Imaging of a 17th Century Lacquered Cabinet: a Contribution to European Lacquerwares Characterization

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***Abstract*—A late 17th century white European lacquered cabinet, attributed to the Gérard Dagly workshop and belonging to the Barbara Piert-Borgers private collection of Far-East and European lacquerware, has been investigated by means of terahertz time domain imaging (THz-TDI), giving new insights into its composition.**

I. Introduction

LACQUERWARES are objects decorated by multiple, composite layers of lacquer. Far-Eastern lacquer production dates back to 5000 B.C. and, starting from the 15th century, they have been imported towards Europe. Due to their increasing popularity, they were imitated in Europe from the 17th century onwards. In context of an interdisciplinary research project on European lacquers, called 'European Lacquer in Context', THz-TDI [1-4] was considered as a useful tool to investigate the internal structure, stratigraphy and condition of surface or subsurface layers of these complex multi-layered objects [5].

II. Results

The examined cabinet was realized by applying a European lacquer layer on the top of paint layers and decorative techniques which were applied on a ground layer and the respective wooden support.

Fig. 1. Visible image of the examined cabinet. The red square indicates the scanned area

An area of the cabinet's right door has been scanned using a Picometrix T-ray 4000 system.

The visible image of the scanned area of the cabinet's door is shown in Fig. 2a, while the corresponding peak-to-peak THz image is shown in Fig. 2b. The peak-to-peak THz image highlights certain heterogeneity within the area (dark greyish areas), not connected to the decoration apparatus of the art-piece.

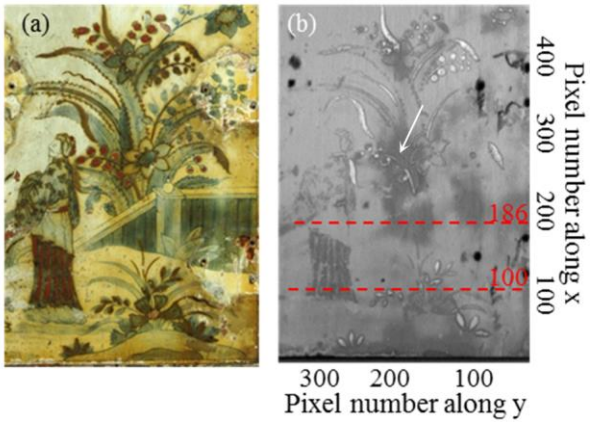

Fig. 2. (a) Visible image of the scanned area of the lacquered cabinet. (b) Terahertz peak-to-peak image of the scanned area; the scanlines used to plot the B-scans of Fig. 4 are indicated by dashed red lines. The white arrow points at one of the stain-like heterogeneities.

A frequency analysis of the THz image confirms that these stains have a different behavior compared to the adjacent areas (Fig.3).

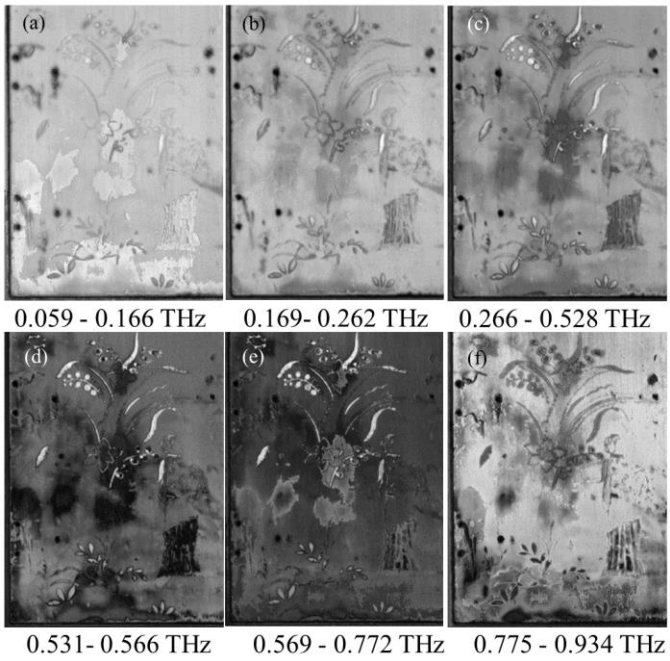

Fig. 3. a-f Terahertz frequency images of the scanned area

To gain a better understanding of the true nature of these stains, and to relate and to localize them within the lacquer's stratigraphy, B-scans have been realized after signal deconvolution (Figs. 4a and 4b).

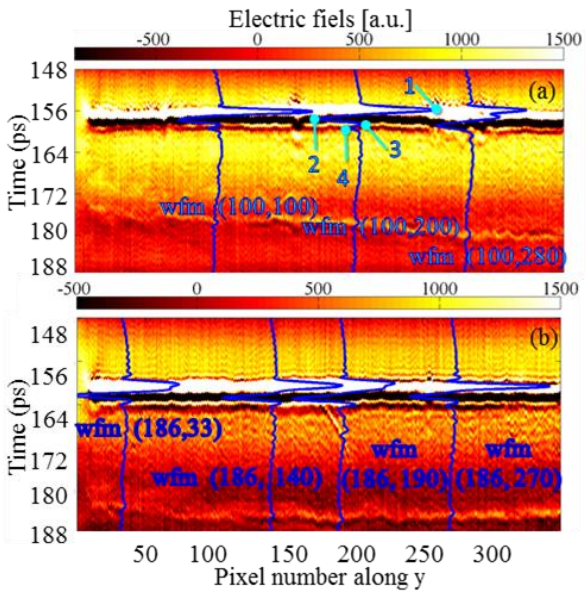

Fig. 4. (a) B-scan corresponding to the electric field value recorded along the scanline 100 of Fig. 2a; three representative waveforms are plotted within it. (b) B-scan corresponding to the electric field value recorded along the scanline 186 of Fig. 2a; three representative waveforms are plotted within it.

The recorded THz waveforms are composed of four main peaks, which indicate the presence of at least four different layers with dielectric contrast. An additional peak is detected where further decorations were applied on the top of the background (waveform 100, 280 in Fig. 4a).

The raw B-scan along scanline 186 as a function of the arrival time shows no significant changes in the cabinet's stratigraphy where the stains are located, compared to that of the adjacent stainless areas. The THz signals arising from the reflection at the air/cabinet interface are often observed to split at the locations of the stains (waveform 186, 22 and 186,190 of Fig. 4b). This suggests the presence of additional surface material in those areas. Furthermore, changes in the moisture content within the wooden panel cannot be excluded.

Finally, the THz image of the wooden support located underneath the lead-white ground layer has been clearly imaged (Fig. 5).

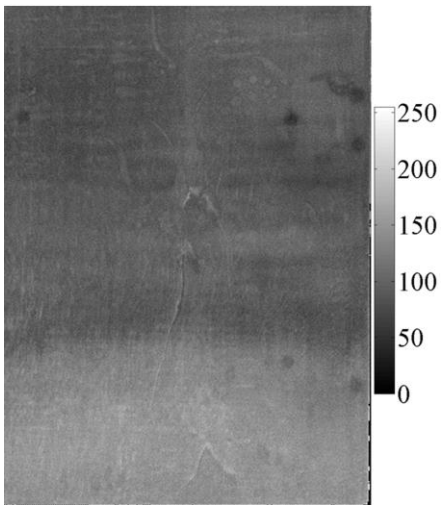

Fig. 5. THz frequency image of the wooden panel

This confirms the capability of THz-TDI in imaging subsurface features behind dense lead-white layers with a high refractive index, differently than the traditional X-radiography, where the lead-white efficiently shields X-rays because of high Pb stopping power.

To conclude, while giving a non-invasive picture of the lacquerware stratigraphy and preservation condition of hidden layers and support, the stain-like heterogeneities highlighted by THz-TDI on the lacquerware surface have encouraged the conservators to take a set of diagnostic measurements to further understand their nature and cause.

REFERENCES

[1] Mittleman, D. (2003). Terahertz imaging. In Sensing with terahertz radiation (pp. 117-153). Berlin Heidelberg: Springer .

[2] Picollo, M., Fukunaga, K., & Labaune, J. (2015). Obtaining noninvasive stratigraphic details of panel paintings using terahertz time domain spectroscopy imaging system. Journal of Cultural Heritage, 16(1), 73-80. [3] Wai Lam, C., Deibel, J., & Mittleman, D. M. (2007). Chan, Wai Lam, Jason Deibel, and Daniel M. Mittleman. "Imaging with terahertz radiatio. *Reports on progress in physics*, *70*(8), 1325–1379.

[4] Koch-Dandolo, C. L., Filtenborg, T., Fukunaga, K., J., S.-H., & Jepsen, P. U. (2015). Reflection terahertz time-domain imaging for analysis of an 18th century neoclassical easel painting. Applied Optics 54, 54, 5123-5129.

[5]. C.L. Koch Dandolo, M.C. Christensen, P. Uhd Jepsen, Characterization of European Lacquers by Terahertz (THz) Reflectometric Imaging, IEEE Proceedings of the 1st Digital Heritage Conference. IEEE, 2013. p. 89-94.