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# Contribution of Reflection Terahertz Time Domain-Imaging (THz-TDI) to Imaging Analysis of Artworks

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**Abstract**—Different kinds of artefacts (easel painting, panel paintings and Asian lacquerwares) have been scanned by THz-TDI and results have been compared with those obtained by others standard imaging techniques (x-ray radiography, cross sectional imaging, technical photography).

## I. INTRODUCTION

IN THE recent years, a growing number of investigations have defined the position of THz-TDI among investigation protocols currently used for cultural heritage investigation [1,2,3].

Our study, comparing THz images with those obtained by other imaging techniques, contributes to place the system among the other complementary imaging techniques used for artifacts and museum collections inspection.

## II. RESULTS

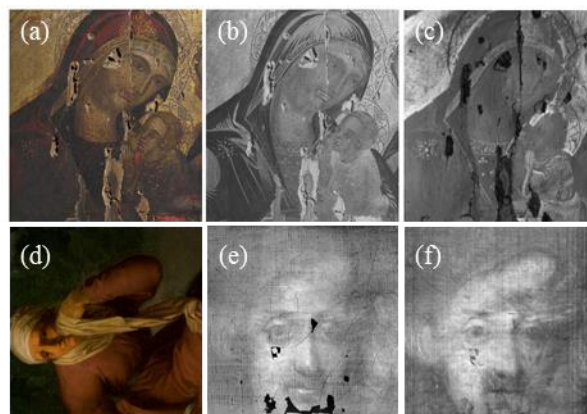
Different kinds of artefacts (easel painting, panel paintings and Asian lacquerwares) have been scanned by THz-TDI (Picometrix T-Ray 4000).

The painting *The dying Messalina and her mother* (by Nicolai Abildgaard, 1797, oil on canvas, Statens Museum for Kunst collection, Fig. 1a-c) offered the occasion to compare results obtained by THz-TDI with those obtained by the more mature digital X-ray radiography and cross-section imaging. Both X-ray radiography and THz-TDI were able to image the painting below the present one and the hidden portrait has been imaged by THz-TDI with a surprising richness of details. The information provided by the two techniques allowed to speculate on the painting technique used by the unknown painter of the hidden portrait and to expand the knowledge about the response of different pigments in widely different electromagnetic ranges. The ability of THz to image the actual stratigraphy of the painting has been assessed, finding it suitable for long term monitoring of lining intervention.

We also performed THz-TDI on *A Garden in front of a Country Seat* (by David II Teniers, 17<sup>th</sup> century, oil on panel, Statens Museum for Kunst collection). Even in this case, both X-ray radiography and THz-TDI were able to image the painting below the present one. While the wooden structure remained mostly hidden by the more opaque ground and paint layers in the X-radiograph, it has been better visualized by THz-TDI. A feature, barely notable in X-radiograph and attributed either to the unknown artist hand or to the presence of a material (including restoration ones) between the actual and the hidden painting, has been detected in THz images.

The investigation of modern and contemporary Asian lacquerwares by means of THz-TDI and X-ray radiography demonstrated the strength of THz-TDI in imaging organic supporting structures of lacquerwares, overpassing the limit of standard X-ray radiography in imaging materials with low atomic number and organic materials.

Finally, THz-TDI has been applied during the pre- and post-conservation imaging investigation of a gilded 14<sup>th</sup> century icon (*Virgin with the Child and a Saint*, unknown author, Library of Taormina, Sicily, Fig. 1 d-f). The original gilding technique (gold leaves) has been identified by THz-TDI scanning. Furthermore THz-TDI facilitated the localization of the gilding used for tracing decorative motives on the figures' dresses, allowing the conservator to protect them properly from aggressive agents during cleaning operations. The comprehensive non-invasive imaging diagnostics highlighted the importance of combining different methods to reach convincing conclusions about painting composition and condition.



**Fig. 1.** (a) gilded 14th century icon, Vis image; (b) gilded 14th century icon, reflected IR image; (c) gilded 14th century icon, THz image; (d) The dying Messalina and her mother, Vis image (detail); (e) The dying Messalina and her mother, x-ray radiograph; (f) The dying Messalina and her mother, THz image

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