A Millimeter Wave/Terahertz 3D Scanner for Wall Painting Investigation

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Abstract—A portable THz imaging system for the study of wall paintings is currently under construction in the framework of the THz-ARTE project. The device design and operating principle will be presented.

I. INTRODUCTION

ENEA has a long experience in THz source and applications, and recently the possibility of using the peculiar features of the THz radiation for the nondestructive diagnostics of artworks has been investigated. The capability of the THz radiation of penetrating dielectric materials can be utilized to build a tool to search for hidden paintings or drawings covered by a superimposed layer or to detect subsuperficial defects in wall paintings. [1, 2, 3, 4]

The feasibility of such a device was demonstrated, at the ENEA center of Frascati, making use of a THz Imaging system with a Free Electron Laser as a source and with a mechanical 3D positioning system to scan the sample. Such a setup was used to detect the features of paintings hidden under a layer of gesso. The system demonstrated the capability of measuring the phase of the reflected signal, thus obtaining simultaneous information about the topology of the surface and about the spectroscopic features of the sample. It was then possible to obtain a real THz image of the sample [5].

After such a demonstration, the next goal is the realization of a portable iPER-spectral imaging system for the analysis wall paintings. This is the main objective of THz-ARTE, a bilateral joint research project recently started in the frame of the scientific collaboration between Italy and Japan.

II. RESULTS

The mechanical structure of the scanning device is derived by a commercial 3D printing system, modified to mount the probe head. A new control software was designed to take into account the new requirements of the device.

Different fresco samples were realized at NICT in Japan, and at CNR-IFAC. Samples prepared at NICT were analysed utilizing a Picometrix T-Ray 400 pulse-echo imaging system. The effects of different particle size of fillers and of internal layer structures were studied. Transmission properties of the samples from NICT and CNR-IFAC were measured at the ENEA 120 GHz FEL imaging device. Results were used in order to tailor the characteristics of the imaging device prototype, in terms of power of the radiation source and sensitivity of the detectors.

A 97 GHz IMPATT source, with an output of about 70 mW CW was used in the prototype, in a configuration that includes a probe head with a directional coupler to detect the radiation reflected from the sample. The reflected signal is detected by means of a Shottky diode with a 200 V/W responsivity.

Another source, operating in the range 20-40 GHz is available for next measurements.

A laser triangulation device, mounted on the z-axis, is used to perform phase measurements at “constant distance” on irregular surfaces. Such a feature requires a better resolution and reproducibility for the z-axis motion system. System will be modified shortly to fulfil this requirements.

Fig. 1. Prototype of the 3D THz imaging scanner with the 97 GHz IMPATT source.

A series of samples mimicking the structure of both wood and mural paintings with hidden defects (holes, cracks) have been prepared at CNR-IFAC and a systematic series of measurements will be performed shortly. Comparative measurements in the near and medium infrared spectral range will also be performed. Detection of water damage in wall painting will also be the next goal of the project.

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REFERENCES