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 together with preliminary results on test samples.

I. INTRODUCTION

The advantages in utilizing the peculiar features of the THz radiation for the nondestructive diagnostics of artworks has been recently demonstrated [1]. Due to the capability of the THz radiation of penetrating dielectric materials, a typical application is related to the search for hidden paintings or drawings covered by a superimposed layer. [2, 3, 4]

At the ENEA center of Frascati a THz imaging system and a THz Free Electron Laser have been utilized to demonstrate the possibility of detecting features of paintings hidden under a layer of gesso. Moreover the phase capabilities of the device make it possible to distinguish the different pigments of the painting, thus realizing a real THz image of the sample [5].

THz-ARTE, a bilateral joint research project aimed at the realization of a portable hyperspectral imaging system for the analysis wall paintings, has recently started in the frame of the scientific collaboration between Italy and Japan.

II. RESULTS

In order to design the device and to test its capabilities different fresco samples were realized and their properties were measured with different techniques. In the meanwhile a low cost prototype of the device was developed at the ENEA research center of Frascati.

Fresco model samples were prepared 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 100 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.

In order to reduce the cost of the imaging prototype, the mechanical structure, including motion devices and control electronics, was directly derived by a commercial 3D printing system, performing some modifications to mount the probe head (Fig. 1). A new control software was designed taking into account the new requirements of the device, and the device capabilities, in terms of precision and resolution, were tested. Results were satisfactory, except for the z-axis precision, that requires a better gear to achieve the required accuracy and reproducibility. This is essential to utilize a laser triangulation device mounted on the z-axis, which is used to perform phase measurements at “constant distance” on irregular surfaces.

Two radiation sources are available to be mounted on the 3D system, the first operating at 97 GHz, the second in the range between 20 and 40 GHz.

The performance of the first source, an IMPATT diode, was tested and the output power was measured to be about 70 mW CW. It is possible to modulate the source in order to increase the S/N ratio of the detection. The 97 GHz source was then mounted on the 3D imaging system in a layout that includes a WR10 directional coupler, to separate the radiation launched toward the sample through a pyramidal tip from the signal reflected by the sample (fig. 2).
The reflected signal is detected by means of a Shottky diode with a 200 V/W responsivity.

The use of a second directional coupler, in a configuration similar to the one adopted for the compact FEL imaging system described in [2], was not necessary, due to the high amplitude stability of the IMPATT source.

With such a layout it is possible to measure the phase change occurring when the radiation is reflected from the sample and thus to obtain both spectroscopic and topologic information about the sample. In order to separate the two contributions to the phase it is possible to use the laser triangulation system, that provides the topologic information.

A new source holder is being built, with z-axis micrometric adjustment, which also hosts the laser triangulation system. The layout of the holder can be seen in fig. 3.

With this device it is possible to adjust both the height of the probe and of the laser triangulation system independently, in order to better adapt the system to the specific configuration of the sample.

![Fig. 3. 3D model of the THz source/laser holder](image)

A new software for THz scanning has been developed and preliminary scans were performed. Results were satisfactory (fig. 4), despite some artifacts are present in the images, due to the high diffraction from the sample borders, being the launching tip non sufficiently close to the sample due to some mechanical constraint. The new holder (fig.3) allows a fine tuning of the distance between the probe and the sample in order to reduce the diffraction effects observed in the preliminary tests.

![Fig. 4. Image of a coin obtained with the IMPATT source mounted on the 3D scanning system.](image)

III. CONCLUSIONS

A series of samples mimicking the structure of both wood and mural paintings are being prepared and a systematic series of measurements will be performed shortly. Comparative measurements in the near and medium infrared spectral range will also be performed.

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REFERENCES


