Dynamic measurements at THz frequencies with a fast rotary delay line

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***Abstract*— A fast rotary delay line is fabricated and characterized for terahertz (THz) frequencies. With this new device, we present dynamic measurements of spray painting process and fast moving objects detection along with thickness determination.**

I. INTRODUCTION

For several decades now, THz spectroscopy and imaging have been applied to many different fields. However, some burdens still remain in its commercial generalization, particularly for the industry sector. One of these difficulties lies in the acquisition time. In a typical THz time-domain spectroscopy system (THz-TDS), the THz pulse is sampled in time by the means of a micrometer linear delay line. While this method permits high precision of the pulse reconstruction, it is time-consuming, often on the minute scale. One solution to this problem can be found in the design of curvilinear mirrors directly connected to a rotating mirror. Recently, we presented several classes of analytical and semi-analytical solutions for the design of a fast rotary linear optical delay line (FRLODL) [1]. We require the generated optical delay to be linear with the rotation angle and long enough for THz applications (at least 100 ps). Also, the optical input and output must be separate and stable to avoid the use of other moving optical componenets. In this work [2], we present an experimental implementation of such FRLODL along with new practical applications

II. FABRICATION AND CHARACTERIZATION OF THE FRLODL

The FRLODL surface is made with a computer numerical control (CNC) machining with a 5 µm precision of linear translation. Details about the calculated surface can be found in [1]. The incoming and outgoing optical beams are parallel and have a constant 2 cm separation in space. We fabricated four blades on the same disk allowing in principle to increase by four the total scan rate. We tested the FRLODL with speeds up to 48 Hz (192 Hz maximum, Fig 1). The motor and the electronics were limiting this speed. The total delay was experimentally evaluated to 100 ps.

III. PRACTICAL APPLICATIONS OF THE FRLODL

As a first application, we present monitoring of spray painting process. A paper substrate is placed in the path of the THz beam and we start recording THz signal while the FRLODL rotates at 10 Hz. Then, we spray red enamel paint during 7-8 seconds and leave it to dry for several minutes. Careful analysis of the variation in amplitude and time of the main peak reveal the phases of spraying and evaporation (Fig.1(a)-(b)).

As a second application, we present the simultaneous detection and thickness characterization of fast moving objects. While recording THz pulses at 24 Hz, we drop cylindrical samples of low density polyethylene (LDPE) of different thicknesses in the path of the THz beam. The rate of fall at the position of the THz beam is 1 m/s. By looking at the induced time delay and by knowing the refractive index of LDPE (1.513), it is possible to find the thickness of the samples. The found thicknesses correlate with manually measured ones.

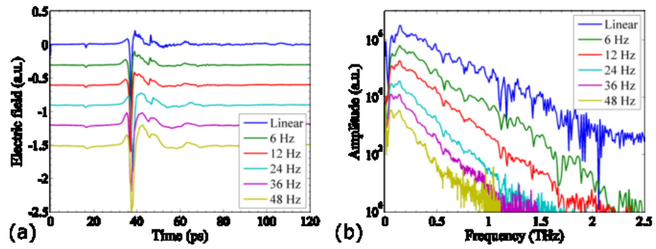

Fig. 1. (a) Recorded THz pulses for different rotation speeds and (b) corresponding power spectra.

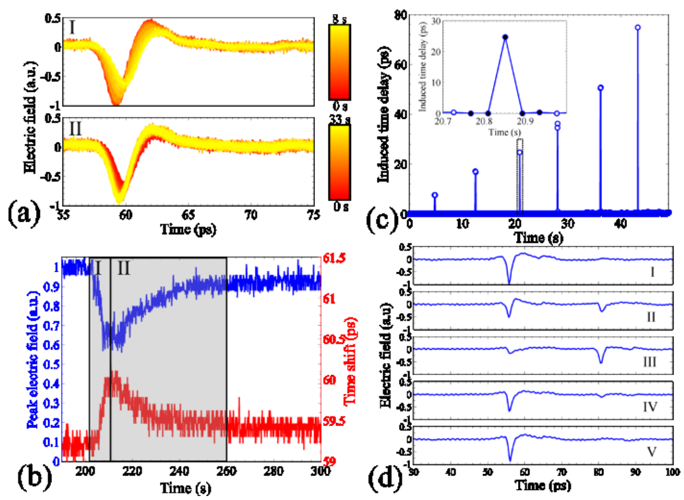

Fig. 2. (a)-(b) Monitoring of painting process; (c)-(d) Detection of fast moving LDPE samples. (a) Time traces at the stage of spraying and drying and (b) normalized amplitude and time shift. (c) Induced time delay by the passing of the LDPE samples and (d) corresponding time traces for the 14.72 mm sample.

REFERENCES

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