Determination of automobile paint thickness using non-contact THz-TDS technique

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***Abstract*—We use pulsed THz-TDS as a non-contact method for the measurement of thickness in automobile paint on a non-metallic substrate. We use a least square algorithm in order to fit the reflected pulses of each layer. Extracting the delay of each from the theoretical function allows us to know the thickness of each layer present in the system.**

I. Introduction

The automotive is a highly profitable global industry where quality control is a key step of the production process. One of the variables that determine the appearance and durability of a car, is its paint coating. This protects the car from UV rays, chemical corrosion, scratches [1] as well as giving it a shiny and colorful presentation. Recently the rapid progress of THz-TDS systems have made possible the development of non-contact tools for measuring thickness [2] outside "laboratory" environments, moreover, the metal-free paints used in the automotive industry are mostly transparent in this band. In this paper several automotive paint thickness are obtained from TDS measurements by a least square fitting of the reflected waveform.

II. Theoretical background

The multi-layer systems studied in this work consists of four layers, clearcoat, basecoat, primer 2 and primer 1. A single-cycle THz radiation was sent to the sample, then we recorded the radiation reflected by the different layers that make up the system.

Then a reference pulse is recorded by changing the sample under study by a mirror in the same position. Using a least squares algorithm to adjust the reflected pulses of multilayer system with n + 1 reference pulses, where n is the number of layers of the multilayer system, and with different time delay and amplitude each, it is possible to obtain the thickness of the layers present in the system. The thickness is given by

$$d_i = \frac{c\Delta t_{ij}}{2n_i}, \tag{1}$$

where c is the speed of light, d_i is the thickness of the i-th layer, Δt_{ij} is the temporal delay between the i-th and the j-th pulse and n_i is the refractive index of the i-th layer.

III. Results

We measured a total of eighteen different samples supplied by a manufacturer of car parts. For clarity only the results corresponding to two of them will be discussed in this abstract, but all of them have similar characteristics. The pulses reflected from each sample are shown in Fig.1. Along with the measured pulses (continuous line) the resulting fitted superposition of 5 pulses is presented (dashed line).

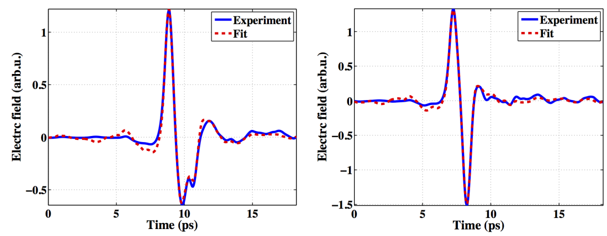

Fig. 1. Experimental (cotinuous) and fitted (dashed) pulse of a) sample A and b) sample B.

The numerical values extracted from the fitting process are shown for various samples on Table I.

TABLE I
LAYER THICKNESS (μm)

	Sample A	Sample B
Layer 1	40.5	35.1
Layer 2	82.1	57.0
Layer 3	65.3	60.4
Layer 4	58.3	57.5

IV. Conclusion

In this work we use a least square algorithm to estimate the thickness of paint films in a multi-layer system. This tool has enormous potential for non-destructive quality control in several industries, particularly in the automotive one.

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