WALL THICKNESS MEASUREMENT OF PLASTIC BOTTLES

In this paper, we present use of TeTechS' terahertz sensor system for wall thickness measurement of an opaque plastic bottle. TeTechS Inc. provides sensor technology solutions that use safe Terahertz Waves to find previously undetectable objects and defects in industrial manufacturing processes, improving productivity and profitability.
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INTRODUCTION
This document describes proposed reflection-mode, time-domain Terahertz pulse measurement setup to measure the thickness of the walls of plastic bottles or the thickness of individual layers in multi-layer structures. The Terahertz pulses reflected from the walls of the plastic bottles have a specific time delay that allows users to calculate the thickness of each wall of an opaque plastic bottle.

PROBLEM
The problem addressed here is the measurement of the wall thickness of plastic bottles, using a non-contact, non-invasive, and non-destructive measurement technique. Currently, to measure the wall thickness of opaque plastic bottles, two methods are being used. One is to cut the bottles and measure the wall thickness using a caliper; this method is destructive and time consuming. The other method is to use Hall Effect (Magna-mike) measurement probes wherein measurements are made when a magnetic probe is held or scanned on one side of the test material and a small target ball (or disk or wire) is placed on the opposite side or dropped inside a container. The probe’s Hall Effect sensor measures the distance between the probe tip and the target ball. This technique is time consuming and incapable of integrating to manufacturing lines. Thus, there is a need for a fast, non-contact, non-destructive, and high precision measurement (~10µm) technique for thickness measurement of opaque plastic bottles, which has the capability of integrating to manufacturing lines for advanced manufacturing.

EXPLORED METHOD
Figure 1 below shows the schematic configuration of a reflection measurement setup for conducting thickness measurement using TeTechS’ terahertz sensor system. Terahertz (THz) pulses are reflected from the walls of the bottle under test, penetrating into plastics and reflecting at each plastic/air boundaries. The THz pulses from the transmitter goes to the multi-layer structure or sample under test and the reflected pulses from the sample is coupled into the THz detector. The reflected THz pulses from the multi-layer sample have their time delay measured that corresponds to the thickness of the walls of the plastic bottle. The peak amplitudes of the reflected pulses also decrease as they experience reflections consistent with Fresnel reflections.
Figure 2 shows the terahertz reflection-mode measurement for an opaque plastic bottle that shows the reflection from the first interface between air and plastic (outside interface) and then reflection from the second interface between air and plastic (inside surface). From the difference between the time delays of these two reflected pulses one can calculate the thickness of the plastic wall. This method is independent of the second wall of the bottle and basically can be used for any multilayer structure. For the second wall of the bottle, the bottle can be rotated by 180 degrees and the measurement can be conducted to find the thickness of the second wall. The Terahertz beam can be focused on the sample with a spot size of 1 mm to enhance the spatial resolution.
CONCLUSION

We present the basics for the use of TeTechS' terahertz sensor system in a reflection-mode measurement configuration for wall thickness measurement of multilayer samples such as plastic bottles. The technique uses terahertz pulses that is incident on a multi-layer plastic bottle and determines the thickness of each wall based on the time delay of the reflected pulses with a very high precision.