Extending terahertz technology to obtain highly accurate thickness of automotive paint

July 12 2016

Now automotive body paint jobs get a major boost from the rapidly emerging field of terahertz (THz) technology used to improve the precision and quality control of layered paint coatings.

In a novel approach to industrial applications of THz technology, a team of German researchers began from the principle that thicknesses of multi-layered paint coatings can be measured using time-of-flight measurements of ultrashort THz pulses. The model they developed obtained a new level of precision in measuring individual coating layers. Their report appears in the current issue of *Applied Physics Letters*.

Developed by a team of investigators from the University of Kaiserslautern and Fraunhofer Institute for Physical Measurement Techniques in Kaiserslautern, the algorithm-informed computer model resolves individual paint layer thicknesses within multilayered paint samples well below ten microns—seven microns is typical—and down to four microns under certain constraints. A micron—also called a micrometer—is one thousand times smaller than a millimeter, many times smaller than the diameter of a human hair.

"By introducing an advanced regression procedure with a self-calibration model, our approach presents a framework that takes into consideration real industrial challenges such as the effect of wet-on-wet spray in the painting process. This is important because the multi-layer car coating process is complex, and a new approach is needed to improve vehicle paint quality control," explained René Beigang, the study's lead researcher.

THz technology uses non-ionizing radiation that occurs on the electromagnetic spectrum between microwave energy and infrared light waves, with frequency ranges from 0.3 THz to 10 THz. Invisible to the unaided eye, THz energy is considered non-destructive and non-invasive, and has many desirable analytical and industrial properties. It penetrates a variety of non-conducting materials and passes through common materials such as clothing, plastic, wood and paper. Excitement over its potential in a range of disciplines is rapidly building as teams race to harness it for uses as diverse as medical imaging to airport security checks.

The gist of their work is this: The time trace of a typical reflected pulse shows that there is a reflection from the front surface and substrate, as well as from each interface between different paint layers. From the time delay between consecutive reflected pulses the thickness of the layer can be deduced.

"By scanning the THz beam across the sample a 2-D image of the layer thicknesses of each individual layer can be obtained," Beigang explained.

He added that conventional approaches for automotive paint thickness measurements are limited due to the complexity of the multi-step painting process. Typically, five layers of thin coatings, including zinc phosphate, e-coat, primer or filler, basecoat and clearcoat, are deposited on the vehicle surface.

"New possibilities to overcome these restrictions have been shown by terahertz radiation," he said.

Results show this new approach is suitable to measure individual paint coatings on a variety of materials. These include metallic substrates, carbon-fiber-reinforced polymers, and on dielectric substrates—all with high accuracy.

"We believe our results with terahertz waves show we have successfully managed them to develop an extremely precise approach to help improve an industrial process involving multi-layered automotive paints," said Beigang.

More information: Highly accurate thickness measurement of multi-layered automotive paints using terahertz technology, *Applied Physics Letters*, DOI: 10.1063/1.4955407

Provided by American Institute of Physics