# Photoacoustic Spectroscopy for the Detection of Surface Contamination

The rapid detection and identification of hazardous materials (i.e., chemical, biological, energetic) deposited on surfaces is of great importance for military and homeland defense applications. A nondestructive depth profiling method for determining the composition of unknown materials is an attractive analysis tool. Photoacoustic spectroscopy (PAS) offers unique capabilities for investigating condensed phase samples due to its simplicity and resistance to scattering effects, which is often an issue associated with other common techniques such as infrared (IR) reflectance spectroscopy. Investigating solid samples using the photoacoustic technique is advantageous as it allows optical absorption measurements to be made for optically opaque samples. Furthermore, PAS allows for discrimination between the sample and surface or different sample layers.

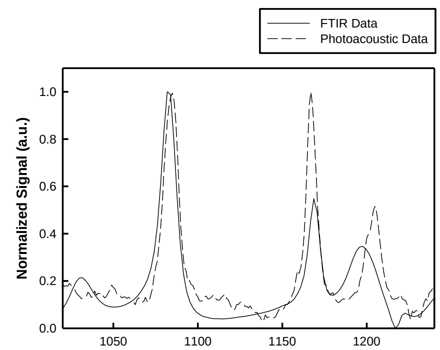


**Fig. 1 Measured laser photoacoustic spectrum of TNT compared to FTIR reference spectrum.**

The U.S. Army Research Laboratory has demonstrated a quantum cascade laser (QCL)-based PAS platform for the detection of condensed-phase materials. Our results illustrate that this method can be used to collect quality infrared spectra of energetic analytes of interest, including TNT (Fig.1). Additionally, variation of the QCL pulse repetition rate allows for identification and molecular discrimination of analytes based solely on photoacoustic spectra collected at different film depths. Initial proof-of-concept results illustrate that this method can be used for depth profiling analyses to distinguish among tetraethoxysilane (TEOS) films deposited on photoresist-coated silicon wafers based on their laser photoacoustic spectra (Fig. 2). To our knowledge, this is the first reported study detailing the development of a photoacoustic device employing a single, continuously tunable QCL for depth profiling studies, including discrimination between a material and the substrate on which it is deposited.

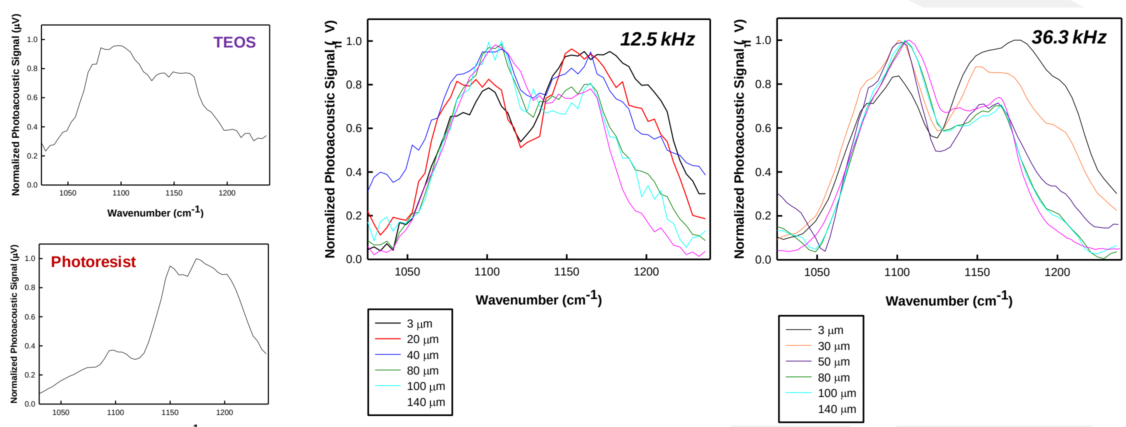


**Fig. 2 Laser photoacoustic spectral absorption features for varying thicknesses of TEOS films on a photoresist-coated silicon substrate collected at 12.5 kHz and 36.3 kHz.**

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