Application of Non-Contact Thermoacoustic Imaging for Embedded Explosive Detection

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Thermoacoustic imaging (TAI) takes advantage of the high contrast of microwave imaging and high spatial resolution of ultrasound imaging. In thermoacoustic imaging an incident microwave pulse is converted to ultrasound via localized thermoelastic expansion and creates an image proportional to the sample's absorption. TAI is a non-ionizing modality and has been studied for biomedical applications, such as breast cancer detection.

In today’s world, Improvised Explosive Devices (IEDs) are a major threat to civilians and military personnel. Traditional TAI employs a relatively narrow-band ultrasound transducer to detect TA signals, which requires acoustic coupling and physical contact between the transducer and the sample. Since safety is the primary concern, remote detection of IEDs is of paramount importance. Previous simulation studies have shown that TAI is a promising modality to detect embedded explosives in a biological or high water content medium. In this experimental study, we investigate non-contact TAI employing a laser and a millimeter-wave (W-band) vibrometer to remotely detect thermoacoustic-induced surface vibrations on Agarose™ gel embedded with an explosive simulant. The gel is composed of 1.5% Agarose™ with 30 ppt salinity. The amplitude and frequency of the surface vibrations depends on the width of the microwave pulse, thickness of the gel and depth of the sample. Although the laser vibrometer has higher sensitivity than the W-band, it requires a smooth reflective surface for optimal performance. The W-band vibrometer does not require an optically reflective surface and performs well even with a rough surface. Detection of the embedded explosive is achieved through time and frequency domain analysis of the acoustic signal.