Homeland Security

Science and Technology

TechNote

U.S. Department of Homeland Security

SAVER

System Assessment and Validation for Emergency Responders

The U.S. Department of Homeland Security (DHS) established the System Assessment and Validation for Emergency Responders (SAVER) Program to assist emergency responders making procurement decisions.

Located within the Science and Technology Directorate (S&T) of DHS, the SAVER Program conducts objective assessments and validations on commercial equipment and systems and provides those results along with other relevant equipment information to the emergency response community in an operationally useful form. SAVER provides information on equipment that falls within the categories listed in the DHS Authorized Equipment List (AEL).

The SAVER Program is supported by a network of technical agents who perform assessment and validation activities. Further, SAVER focuses primarily on two main questions for the emergency responder community: "What equipment is available?" and "How does it perform?"

For more information on this and other technologies, contact the SAVER Program Support Office.

RKB/SAVER Telephone: 877-336-2752
E-mail: saver@dhs.gov
Website: https://www.rkb.us/saver

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NUSTL

Laser-Based Explosives Detectors

Rapid, reliable explosives detection is vital to protecting lives and property. Explosives detectors are used to screen people, luggage, and packages; investigate unknown substances; and prevent suicide attacks and damage from roadside bombs. No single technology can counter every threat and research continues into new and improved methods for explosives detection. Laser-based detection techniques hold promise for new capabilities, especially in standoff and multi-threat detection.

Background

A number of methods are currently used to detect or identify explosives, including imaging (e.g., x-rays) and chemical identification (e.g., ion mobility spectrometry). However, the wide range of threat scenarios creates a need for additional methods. Laser-based detection techniques are being investigated because they have potential for multi-threat and standoff detection capabilities that may not be possible with other approaches. In a laser, the specific wavelength of emitted light can be carefully controlled, which allows for improved chemical analysis through spectroscopy. Lasers also have the unique property of long-distance propagation of intense energy, which holds promise for standoff detection of explosives. The possibility of standoff detection, where the equipment and operator could remain at a safe distance from an explosive, has broad applications in countering threats.

Figure 1. Laser techniques for standoff explosives detection *(Photograph courtesy of Lawrence Berkeley National Laboratory)*

Laser-Based Detection Technologies

While laser-based explosives detection techniques are the subject of much research, there are currently few mature technologies or commercially available products. Technologies included here fall under U.S. Department of Homeland Security Authorized Equipment List numbers 07ED-01-LASR and 07ED-04-LASR, portable and standoff laser-based explosives detectors.

Laser Induced Breakdown Spectroscopy (LIBS) uses a high-energy pulsed laser focused through a lens to ionize particles on the sample surface. This ionized state, called a plasma, emits light with characteristic frequencies that are used to identify the sample's composition. A number of portable commercial products are available for production monitoring, environmental analyses, and research in point (close proximity) explosives detection. Extensive research is being conducted on LIBS for standoff explosives detection. A number of prototypes have been built and tested with detection to distances up to 45 meters.

Raman Spectroscopy (RS) uses a laser that is beamed at a sample, and the reflected light comprises wavelengths that uniquely correspond to the chemical composition of the sample. Commercial handheld instruments are available for point detection that can identify unknown substances, either loose or in clear or translucent sealed containers. Depending on an instrument's spectral library, it can identify explosives, toxic or industrial chemicals, and narcotics. As a standoff detection technique, RS has been demonstrated to detect explosive materials at distances up to 50 meters. Work continues on methods to reduce interferences, boost the weakness of the Raman scattering signal intensity, and reduce the size of the prototype components.

Figure 2. Point chemical/explosives detector *(Handheld Raman Spectrometers Market Survey Report, April 2012, www.rkb.us/saver)*

Terahertz (THz) Spectroscopy uses a pulsed laser in the terahertz region of the electromagnetic frequency spectrum to probe a sample. Characteristic reflections can be used for both imaging and spectroscopic analysis. Commercial prototypes of a handheld imager and an air sampler for chemical identification have been developed, and research into THz spectroscopy as a standoff explosives detection technique is ongoing. In one experiment, a technique called THz Time Domain Spectroscopy has identified the explosive RDX at 30 meters. A useful characteristic of THz lasers is that waves in this region have the ability to pass through clothing and other materials without posing a health concern, making them valuable for screening individuals for explosives.

Photofragmentation-Laser Induced Fluorescence (PF-LIF) is a two-step process in which larger molecules are fragmented and excited by a laser to produce fluorescent light, which can be detected and characterized. PF-LIF is limited to explosives containing nitro compounds. It is being studied as a standoff technique and, under laboratory conditions, has demonstrated detection of trinitrotoluene (TNT) molecules at distances up to 2.5 meters.

Coherent Anti-Stokes Raman Spectroscopy (CARS) is a variant of Raman spectroscopy often used in combustion diagnostics. Three laser beams of different frequencies interact with the sample to produce a coherent optical signal. A number of studies have used CARS for detection of solid particles of explosives and have demonstrated standoff detection over 10 meters.

Photoacoustic Spectroscopy (PAS) uses laser light that causes localized heating in a sample, generating sound waves that can be detected by sensitive microphones. Experiments using an eye-safe laser and a quartz-crystal tuning fork resonator have demonstrated trace explosives detection up to 20 meters.

Photothermal Deflection Spectroscopy (PDS) measures the bending of light at a surface due to heating of the surface. Experiments using microcantilevers as sensitive elements have demonstrated detection of explosives in close proximity and at a distance of 1 meter. Further experiments are expected to show improved standoff distances.

Cavity Ring-Down Spectroscopy (**CRDS)** measures the decay time of laser light in a mirrored cavity, which is related to the substance in the cavity. A prototype instrument using a mid-infrared tunable laser has been designed to detect trace levels of low vapor pressure explosives in ambient air in close proximity to the explosive material.

Optimal Dynamic Detection of Explosives (ODD-Ex) is a standoff detection technique that uses shaped, ultra-fast laser pulses to excite specific molecules for spectroscopic analysis. A prototype system for this technique is under development.

Considerations

Numerous challenges exist in advancing these technologies to the commercial stage. Explosives detectors need to be very sensitive in order to detect trace quantities, because of the low vapor pressures of many explosives compounds, and the possible effects of concealment. They also need to be very selective to uniquely identify the explosive in a background of environmental interferents. The high-powered open lasers that are required by some of the techniques are not eye-safe and can initiate explosion of some sensitive compounds. Practical considerations in system size, weight, and cost must also be addressed. Because of the importance of explosives detection, techniques will be improved for different applications, and complementary technologies may be combined. For example, the integration of RS and LIBS, and of imaging techniques with other laser-based spectroscopic methods, is being researched.

References

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