

REVOLUTIONARY DIAGNOSTICS – NONTRADITIONAL APPROACHES FOR DEVELOPING BREAKTHROUGH CAPABILITIES AGAINST EMERGING THREATS

Threat Agnostic Ultrafast Femtosecond Laser Photonic Molecular Sensing Platform: Label-free Diagnostics Based On Miniaturized Coherent Anti- stokes Raman Spectroscopy (ft-cars)

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The need to efficiently collect and identify chemical biological threats and delivering state of the art of diagnostic capabilities in real-time remains imperative to biological chemical defense and security, among others. Warfighters require an integrated layered defense against emerging biological and chemical threats to include monitoring and diagnosis of ever-changing threat agents, with the goal to provide results at the earliest indication of exposure. There are a variety compelling reasons to develop methods for the rapid on-site, remote detection of chemical biological species at low levels with high sensitivity and specificity. Performing chemical biological analysis in situ without the necessity to rely on fixed, pre-known labeled assays/immunodiagnostic detection techniques. Warfighters are in the need of systems able to perform rapid, sensitive, and definitive identification of traditional and newly developed chemical biological threat agents The platform must be disease agnostic and has an open-architecture that can respond quickly to an emerging threat.

A label-free (no antibody/no tag needed) photonics based molecular sensing platform is future-proof, it enables field-detection without surprise, and can detect threat agent agnostically, since it does not rely on creating labels/antibodies, is an ideal platform which allows the Warfighter to easily collect minimally invasive samples types from individuals in remote environments and obtain a quick answer to allow a response to the diagnosis of an emerging threat, without relying on the traditional select agent list.

This paper will present an instrument that is a revolutionary molecular spectroscopy technique, which can be miniaturized and relatively straightforward to implement, compare to that of complicated label based immunoassay, or mass spectrometry based techniques such as GC-MS or Time of Flight (TOF), et,al.. We present a nonlinear optical system based on ultrafast mode-locked laser enabled Fourier Transformed Coherent Anti-Stokes Raman Spectroscopy (FT-CARS), which offers unprecedented sensitivity and speed, it is label free for threat molecules.

The instrument construction is portable and integrated, e.g. the entire instrument with optical system and control electronics of the FT-CARS can be packed into a box of the size of $\sim 0.020\text{m}^3=20\text{L}$, which including control electronics, miniature vacuum pumps for fluidic controls(for sample collection), power supply, and battery, et. al. The integrated instrument is estimated weight of 25-30 lbs (12-14 kg). It is feasible to build a portable coherent spectroscopic device with threat agents detection sensitivity estimated concentration of 50-100 ng/mL, on all types of the chemical biological species of interest, as well as the instrument's multiplexing feature allows detecting multiple species simultaneously. The response time will be less than 1 millisecond per molecule under detection. It is an integrated solutions combining detection, collection, and identification of threat agents label free and future agnostic.