# Chemical and Biological Detection & Defense

## Advanced Multifunctional Biochip

### Army Issues and Technology Impact

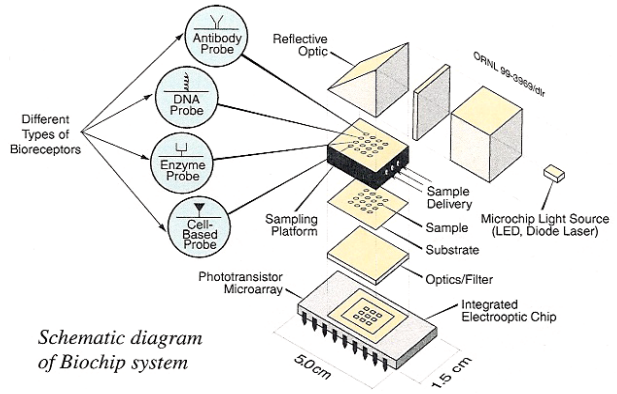
Rapid detection of biological warfare (BW) agents in the battlefield—whether bacteria, viruses, or toxins—is critical to the ability of the soldier of the future to function in a variety of peacekeeping and combat situations. It is also crucial to homeland security. Military personnel and civilian first responders need to have rapid sensing capabilities available to detect BW agents in air, in water, or on solid surfaces such as soil so that (1) appropriate protective measures (such as respirators and protective clothing) can be rapidly initiated and (2) decontamination can be performed.

An advanced detection technology developed at ORNL, the advanced multifunctional biochip, can rapidly identify multiple BW agents/species in air and water and on solid surfaces. The biochip is rugged and field-portable and can be used by personnel with minimal training. Its highly sensitive detection technology reduces the risk of both false positives and false negatives.

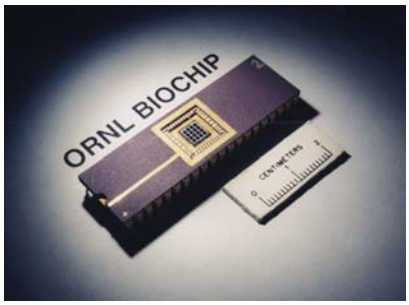
### Technical Concept

ORNL has been developing a unique sensing tool for BW agent detection, the advanced multifunctional biochip, for 3 years under the DOE Chemical-Biological Non-Proliferation Program. The heart of the technology is an electronic microchip with multiple highly sensitive phototransistors. The phototransistors can independently and simultaneously read fluorescence from bioreceptors (DNA and antibodies) associated with each element of the microchip.

Combining the microchip with a miniature diode laser, associated optics, appropriate fluidics systems for handling assay solutions, and highly sensitive bioassays produces a device that can be adapted to a variety of applications in the field. Integrating an air sampler and an agent concentrator would allow detection of airborne agents; a liquid collection system would allow testing of water. The bioassays that are used test for DNA signatures and unique protein antigenic signatures simultaneously, so that agents can be positively identified by two independent biomarkers. The use of fluorescence-based assay schemes coupled with laser excitation provides great detection sensitivity, while the use of ultra-small assay volumes reduces the total time required for assays.




*Schematic diagram of Biochip system*




*Integrated circuit detection system of the ORNL Biochip*

## Development Approach

The advanced multifunctional biochip device is being developed as a generic device for DOE applications. A device specific to DoD requirements could be developed by integrating the various components into a complete, rugged, field-portable unit that can be successfully used by minimally trained personnel. The following tasks would permit this development for DoD.

1. Develop a rugged optics system that will retain its alignment under heavy military usage.
2. Engineer and fabricate microscale fluidics and assay chambers and develop computer programs and controls to allow autonomous military operation.
3. Develop a sample collection system amenable to the multiple modes of sample collection likely to be encountered by military and first-responder personnel.
4. Engineer a straightforward control panel and output readout for military use.

Collaboration with some of the DoD facilities tasked with development of BW defense systems (e.g., Edgewood Arsenal) would be very important to the success of this project. Use of specialized reagents (i.e., antibodies) will be essential for simultaneous detection of a wide range of agents. Other analytical detection systems under development by DoD personnel may also be amenable to deployment as part of the biochip platform.

## ORNL Facilities

ORNL's Advanced Biomedical Science and Technology Group is a multidisciplinary team of physicists, engineers, chemists, and biologists with experience in optics; electrical circuit design; instrument development; and detection of explosive, chemical, and biological agents. The design of the biochip, accomplished through collaboration among biologists and engineers, is unique to ORNL. ORNL researchers developed the optics and the bioassay procedures and designed the microchip. ORNL has several proprietary technologies related to the advanced multifunctional biochip.

*Point of Contact:*
Tuan Vo-Dinh, Group Leader and Corporate Fellow
Advanced Biomedical Science and Technology Group
Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, TN 37831-6101
865-574-6249
vodinht@ornl.gov