A Continuum of Science to Systems

A unique strength of PNNL is the ability to leverage an in-depth understanding of the relevant science while at the same time involving the appropriate engineering disciplines to develop field-ready systems that provide practical solutions to product quality problems. Our talented and versatile engineers and scientists, using technical capabilities and drawing upon knowledge gained through more than 40 years of government and industry-sponsored research activities, can provide a continuum of expertise from basic science theory through hardware development.

Innovative technologies developed by our Optics and Infrared Sensing staff have resulted in several patents and numerous awards, including various R&D Magazine R&D 100 awards and Federal Laboratory Consortium awards for successful transfer of technologies to the industrial sector.

Markets

Our diverse technical group leverages years of experience, state-of-the art facilities and technology developed for government clients. These capabilities can be customized and applied to industrial and commercial needs.

Key Industrial Markets

- Agriculture and food
- Aviation/aerospace
- Automotive
- Chemicals
- Energy
- Petroleum
- Pharmaceuticals and medical products

Current Government Markets

- Department of Energy
- Department of Defense
- Environmental Protection Agency
- Department of Homeland Security

Potential Markets

- Nuclear
- Health
- National Security
- Space

Unlike many firms that offer only a narrow set of expertise and products, PNNL leverages multidisciplinary teams to address your unique needs. Our ability to form teams of experts from across PNNL and team with other national laboratories, universities and industrial partners enables us to develop new and innovative tools that expand your ability to improve product quality.

Primary Collaborators

- Eigenvector Research
- Joint Institute for Laboratory Astrophysics
- Lucent Technologies/Bell Laboratories
- Maxion Technologies
- University of Arizona
- University of Washington
- Princeton University
- Rice University
- Stevens Institute of Technology
- University of California San Fransisco

Teaming moves research forward

To advance the development of quantum cascade (QC) lasers, PNNL's Optics and Infrared Sensing team collaborates with Maxion Technologies and Princeton University. Maxion, which manufactures and sells QC lasers licensed by Lucent Technologies, supplies the QC lasers that we use in our sensor and infrared optics development work. Maxion also performs a wide variety of laser research and development for PNNL through small business innovative research contracts and other sources of funding.

About Pacific Northwest National Laboratory

Pacific Northwest National Laboratory is a Department of Energy Office of Science research facility that delivers breakthroughs in the areas of environment, energy, health, fundamental sciences and national security. Battelle, based in Columbus, Ohio, has operated PNNL since 1965. A unique agreement with the Department of Energy enables us to work with industrial clients and leverage DOE's vast resources. We have a strong history of working with industry over the past 40 years. PNNL is located in Richland, Wash., and has an annual business volume of more than $700 million and more than 4,000 employees.

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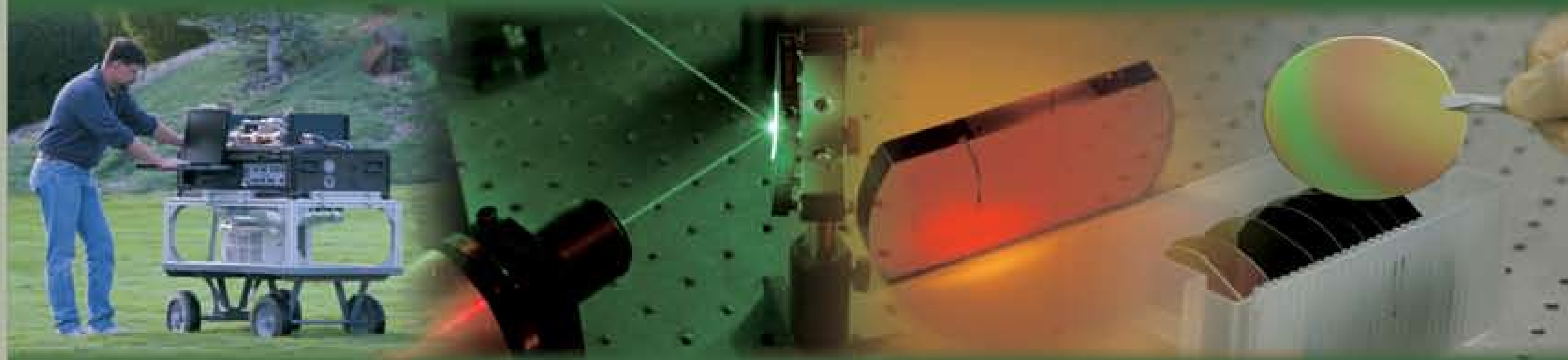


Pacific Northwest National Laboratory
Operated by Battelle for the U.S. Department of Energy

Optics and Infrared Sensing

SCIENCE-BASED SOLUTIONS *for National Security*

Stepping up to the challenge

The ability to detect minute concentrations of certain chemicals and biological materials in environmental samples is critical to our nation's ability to identify potential threats to our national security.

The Optics and Infrared Sensing team at Pacific Northwest National Laboratory offers a wide range of capabilities to help government clients develop sensor systems for detecting chemical and biological compounds—substances that could be used to make chemical, biological and nuclear weapons. The same capabilities can be applied to industry for monitoring pollution, monitoring food and water supplies, and improving medical imaging and diagnostics.

Science-based solutions

The chemical emissions from materials involved in chemical and nuclear weapons production are often difficult to identify because they are low in concentration and similar to pollutants and chemicals in the air, water and soil. However, many of these chemicals have an infrared spectrum that is easily identifiable. Our Optics and Infrared Sensing Program is developing point- and remote-sensing instruments to positively identify these emissions for a broad range of homeland security and civilian applications.

In support of our point- and remote-sensing work, we are developing mid- and long-wave infrared lasers. Additionally, our team of renowned scientists is constructing integrated optics that will allow these sensors to be miniaturized, providing a solution for lightweight airborne and space missions.

PNNL also continues to develop the Northwest Infrared (NWIR) spectral library of quantitative infrared absorption spectra. This unique library is the "gold standard" of vapor-phase infrared reference spectra and is uniquely adapted to both remote and point sensing. The library is a unique asset to PNNL's development of infrared sensors and methods, including sensors for detecting weapons of mass destruction.

In addition, we are using our established expertise in optics to develop biodetection systems for the rapid detection of biothreats in complex samples. Our work ranges from fluorescence analysis for bio-aerosol warning systems to benchtop and handheld detection systems using fluorescent nanoparticles to enable selective and sensitive detection in liquid samples. Our detection methods employ ultraviolet and visible light sources to identify specific fluorescent detection tags or biological compounds based on their unique fluorescent emission signatures.

From fundamental research to field deployable systems, PNNL's Optics and Infrared Sensing team is recognized for its innovation. For more than 40 years, PNNL has provided solutions to clients in the following areas:

- Optical system development, including integrated optics, fiber optics and electro-optics
- Laser physics and engineering
- Laser-based sensing and inspection
- Field portable instrumentation
- Advanced chemical, biological and nuclear sensing systems

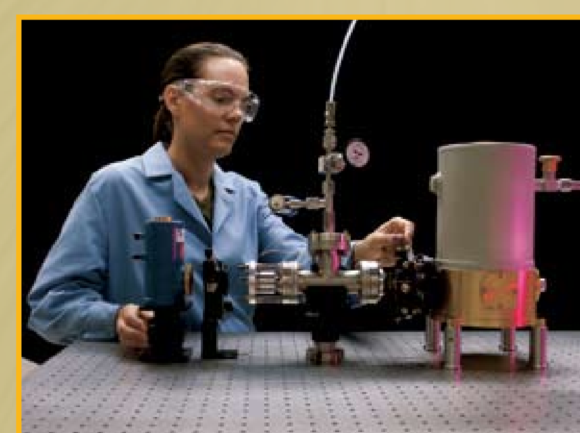
Core Capabilities

Remote Sensing

Our expert scientists and engineers are developing remote sensing systems designed to detect trace gases in the atmosphere from distances ranging from a few hundred yards to more than six miles. Remote sensors can detect chemical emissions associated with the production of chemical, biological and nuclear weapons.

Frequency Modulated Differential Absorption Lidars (FM-DIAL) are a type of sensing system designed by our researchers to detect chemicals with narrow band absorption features, such as water, oxygen and carbon dioxide. This detection capability is currently being expanded to include broader absorption features to enhance trace chemical detection in atmosphere. The FM-DIAL has been successfully field deployed in a variety of harsh environmental and meteorological conditions to detect several chemicals associated with weapons of mass destruction.

Quantum Cascade Laser Development



Experienced scientists in the Optics and Infrared Sensing group are building custom quantum cascade laser systems that can be used with both point- and remote- sensing systems for a wide range of applications, including trace chemical detection, food and water supply monitoring and explosives detection. Quantum cascade lasers are compact and extremely stable light sources, making them ideal for use with highly sensitive and selective chemical sensors. Quantum cascade lasers also are being used for the alignment and calibration of other infrared instruments for ground, airborne and space applications.

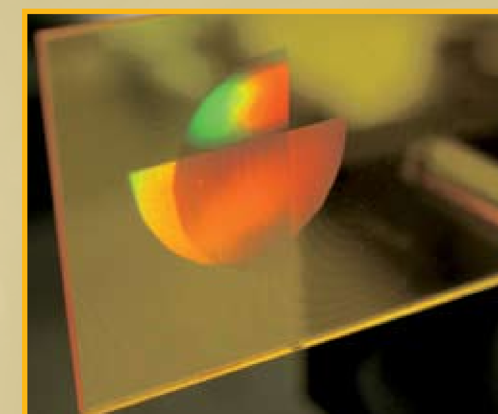
Point Sensing

We are providing the next generation of point sensors for environmental monitoring of air, water, soil, food and other complex samples. Point sensors can be used for screening luggage, shipping containers and people for explosives, firearms, narcotics, chemical weapons, pathogens and toxins.

One point sensor under development monitors the air for traces of chemicals associated with weapons production. High sensitivity—as low as parts-per-billion—is achieved by using optical cavities, consisting of precisely aligned, highly reflective mirrors.

In addition, we are developing point sensors for the trace detection of biothreats in complex environmental samples. These sensors use automated fluidics to concentrate the biological materials on microbeads and utilize fluorescent probes for detection. Applications include detecting pathogens, such as *E. coli*, and toxins that occur naturally in the environment as well as detecting toxins or disease-causing bacteria, viruses and spores in food, water, air and soil samples.

Photonic Materials and Devices



Current point- and remote-sensing systems are usually large and cumbersome and require time and skill to operate. We've developed integrated optical systems that will be used to miniaturize both point and remote systems, making them easier to deploy. Our team of optics professionals are developing mid- and long-wave infrared optical materials and component technology to provide fully integrated and miniaturized sensor solutions on an integrated platform. Ultimate uses for these miniaturized lightweight sensors include air sampling units in unmanned air vehicles and on space missions.

As part of this work, we are researching the fundamental properties of chalcogenide glasses to create photonic devices and have developed a suite of metrology tools to characterize the glasses. Chalcogenide glasses hold the key to the development of miniature components needed to guide and modify light in the long-range infrared region used by many of our chemical and biological sensors.

Laser Photo-acoustic Spectroscopy

Photo-acoustic spectroscopy was discovered by Alexander Graham Bell in 1880. With the development of lasers, it has evolved into a highly sensitive chemical detection technique known as laser photo-acoustic spectroscopy (LPAS). PNNL, in collaboration with Rice University, is developing the use of small, quartz tuning forks as highly selective, compact acoustic sensors in place of microphones. These tuning forks are being used to develop prototype battlefield sensors for chemical weapon agents. The tuning forks, operated in conjunction with room-temperature quantum cascade lasers, offer the potential for miniaturized LPAS-based sensors that operate in a region of the infrared that is highly sensitive to molecules of interest for chemical and biological sensing.