# Real-Time Identification and Characterization of Asbestos and Concrete Materials with Radioactive Contamination

Project ID: 65004

Dr. George Xu, Rensselaer Polytechnic Institute

Dr. Xi-Cheng Zhang, Rensselaer Polytechnic Institute

## Research Objectives

Concrete and asbestos-containing materials were widely used in U.S. Department of Energy (DOE) building construction in the 1940s and 1950s. Over the years, many of these porous building materials have been contaminated with radioactive sources, on and below the surface. This intractable radioactive-and-hazardous-asbestos mixed-waste-stream has created a tremendous challenge to DOE decontamination and decommissioning (D&D) project managers. The current practice to identify asbestos and to characterize radioactive contamination depth profiles involve bore sampling, and is inefficient, costly, and unsafe. A three-year research project was started on 10/1/98 at Rensselaer with the following ultimate goals: (1) development of novel non-destructive methods for identifying the hazardous asbestos in real-time and in-situ, and (2) development of new algorithms and apparatus for characterizing the radioactive contamination depth profile in real-time and in-situ.

## Research Progress and Implications

### a) Asbestos Identification

Asbestos cannot be identified by its chemical properties only. Existing methods, such as PLM and TEM, utilize mainly its optical properties, but have not been able to meet the requirements of real-time and *in-situ* applications in D&D. Novel methods will have to be developed to complement and to replace the existing methods.

Electro-optic Terahertz Time-domain Spectroscopy (EO THz-TDS) is a new technology being developed at Rensselaer's Ultrafast Optoelectronics Laboratory and elsewhere. The development of THz-TDS has opened this scientifically and technologically important, but long inaccessible spectroscopic region. The ultrawide bandwidth, coherence and sensitivity of this technique have been used to characterize the electronic, vibronic, and compositional properties of solid, liquid and gas phase materials, flames and flows. Many believe that research in this area could lead to a breakthrough that may eventually become as significant as ultrasound and X-ray technologies. Our expertise in optoelectronic and environmental engineering research allows us to propose innovative approaches to test that: each asbestos-containing sample has unique signatures which can be identified and characterized with the new THz time-domain spectroscopy method, and a unique electro-optic, far-infrared (FIR), electromagnetic (EM) field sampling and imaging system can be developed for real-time and in-situ applications.

As of 6/15/1999, the THz Imaging Laboratory has concentrated on the development of a unique THz imaging system. The short-term goal was to develop an adequate system with an ultrahigh sensitive and broad bandwidth for initial asbestos testing. A computer was purchased to control the system and to analyze the data. Necessary optical elements (in addition to the equipment that already exists at Rensselaer) were also purchased for the near-field THz sampling of asbestos at different optical wavelength. Testing of the system on limited asbestos samples has been done. Reference asbestos samples have been purchased to establish a library for benchmarking and testing. Preliminary results show that the signatures locate in a very broad range, especially when the concentration of asbestos in the building materials vary significantly. This creates challenges in system design and sample classification. Issues have been identified for further investigation in the coming years. The prototype THz system and preliminary measurements have been presented at the Conference of Laser and Electro-Optics'99 at Baltimore, and Laser'99 at Munich.

**b) Radiological Contamination Depth Profiling**

This task is accomplished with relatively mature technology-gamma spectroscopy and Monte Carlo simulations. As of 6/15/1999, a non-destructive method based on *in-situ* gamma spectroscopy has been developed to determine the depth of radiological contamination in media. This method is based on our earlier work, Gamma Penetration Depth Unfolding Algorithm (GPDUA), which uses point kernel techniques to predict the depth of contamination from uncollided peak information. The GPDUA is designed and verified through extensive Monte Carlo simulations and validated through laboratory experiments. The method requires the a priori knowledge of the contaminant source distribution, which may be obtained from limited number of traditional bore sampling. The non-invasive method then will be extremely useful for quick scanning of large areas with deep contamination. It is estimated that this will reduce the time from weeks to one-day for a small building. The workers are much safer, because no air-radioactivity will be involved. The applicable radiological contaminants of interest are any isotopes that emit two or more gamma rays per disintegration or isotopes that emit a single gamma ray but have gamma-emitting progeny in secular equilibrium with its parent (e.g., $^{60}Co$, $^{235}U$, and $^{137}Cs$ to name a few). The predicted depths from the GPDUA algorithm using Monte Carlo N-Particle Transport Code (MCNP) simulations and laboratory experiments using $^{60}Co$ have consistently produced predicted depths within 5 % of the actual or known depth for a point-shaped contaminant. Several DOE users have expressed great interests in the technology, already no field testing has been arranged so far. A peer-reviewed paper for this research has been accepted for publication.

## Planned Activities

From 6/15/1999 to 6/14/2000, we will systematically test asbestos materials with the THz system developed. We will study different types of asbestos such as chrysotile, amosite, crocidolite, and tremolite. We will consider concentration of asbestos in ACM ranging from 10% to 100%. Other environmental factors, such as moisture and impurity, will also be considered in the quality of sampling and identification. The roles of these sample conditions on the temporal and spectral distributions, as well as the sensitivity of the proposed method will be studied in detail. Realistic asbestos samples (e.g., transite panels) from DOE facilities will be investigated. Experiments involving both transmitted and reflected THz spectroscopy will be performed to establish a library of more definitive "finder prints" for the ACM most common in DOE. The optimal THz frequencies will be determined. Conventional analytical methods, such as PLM and ETM recommended by the EPA, will be utilized to provide benchmarking and quality assurance. Intercomparison with other credited research groups of similar systems will be performed as well. The THz detector system needs to be further improved so a portable system can be eventually developed for field application. It is realized that there is a large number of asbestos types to be investigated. The establishment of a complete reference asbestos sample set will continue to be one of the important tasks for the 2nd year of research. The details about the development plan presented in our original proposal will be followed. The final goal is a portable system for field demonstration.

Research will continue to extend the GPDUA to include more realistic in-depth radiological contamination distributions. These will include disk and distributed disks, which are observed shapes after diffusion of contaminants from surface into the porous building materials. Monte Carlo simulations will be used to develop GPDUA, followed by laboratory validations. A commercially available HPGe gamma detector system will be modified with specially designed collimator to accommodate the required counting condition. Dissemination at technical journals/meetings and contacts for preliminary field testing will be pursued aggressively. Again, the detailed research plan presented in the original proposal will be followed. The final goal is also a portable system for field demonstration.

## Information Access


1. Naessens, E. P. and Xu, X.G. A Non-Destructive Method To Determine The Depth Of Radionuclides In Materials In-Situ. Health Physics. 77(1):76-88;1999.
2. Chen, Q; Jiang, Z; Sun, F. G.; Zhang, X.-C. Two-Fold Improvement of THz Optoelectronic Generation and Detection. CLEO'99, Baltimore, May, 1999.
3. Jiang, Z.; Sun, F. G.; Chen, Q.; Zhang, X.-C. Electro-Optic Sampling near Zero Optical Transmission Point. CLEO'99, Baltimore, May, 1999.