Grant AFC719-29: PoroSense: An Intrinsically Safe, Distributed Fiber-optic Gas Sensing Platform for Underground Mines

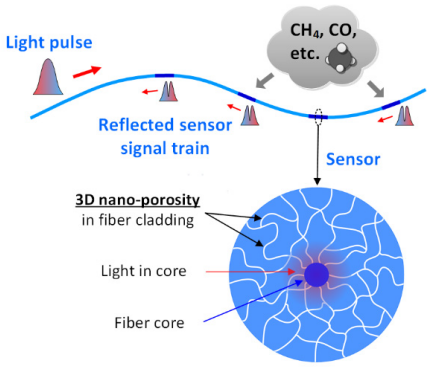
Organization and Principal Investigator: Virginia Tech (Yizheng Zhu)

Focus Area: Health and Safety Interventions

Priority Area: Proof of concept development of the explosion permissible sensory or robotic equipment

Problem Statement and Research Approach: The proposed project seeks to develop a proof-of-concept distributed fiber gas sensing platform that will potentially enable a new class of permissible optical sensors for underground mines. This new system is built upon the success of a previous MSHA-proved, mine-demonstrated experimental methane fiber sensor developed at the Center for Photonics Technology at Virginia Tech. The proposed system is aimed at greatly expanding the intrinsic permissibility and functionality of underground sensing, all enabled by a novel porous-clad optical fiber, thus the name PoroSense.

The concept of the PoroSense distributed sensing platform is illustrated in the adjacent figure. It utilizes a single, long optical fiber with 3D nano-porosity in its cladding. A large number of gas sensors, e.g. methane and carbon monoxide, are densely fabricated along the fiber. The 3D nano-porosity allows gases to penetrate and interact with the light inside the fiber core, thus enabling gas sensing. At the same time, it prevents flammable dust particles from entering the fiber. This special feature, in addition to the well-known electrical passivity of fiber-optic sensors, represents a fundamentally safer approach for sensing in underground mines with markedly enhanced safety, coverage, flexibility and functionality.



The PoroSense platform will have significant monitoring applications in underground mines, such as monitoring longwall face, bleeder ventilation systems, and belt entries. It not only will benefit mining monitoring, but also may be used to study underground gas profile and provide assistance and communication capacities for mine rescue and escape.

Specific Aims: The objectives of this project are to:

- Demonstrate the concept of using porous-clad optical fibers, pulsed laser absorption spectroscopy and spectral self-calibration as a valid means of rapid gas sensing.
- Determine the feasibility of porous-clad fibers as a low-loss medium for long-span distributed Sensing.
- Determine the sensor's performance and permissibility potential.

At the conclusion of the project, we expect to have successfully demonstrated and lab tested a prototype distributed gas sensing system with a 20m long PCOF and 6 or more sensors, have assessed its capabilities and potential for safe gas monitoring in coal mines, and have acquired in-depth knowledge for future advancements and commercialization efforts. Such outcome will significantly advance the technical state-of-the-art in the area of gas detection and quantification, and offer a potentially safer alternative for underground monitoring.