PROJECT facts

Advanced Research

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U.S. Department of Energy
Office of Fossil Energy
National Energy Technology Laboratory

Distributed Fiber Optic Gas Sensing for Harsh Environments

Description

Gasification is a key technology platform for advanced fossil-fueled power systems. An important factor limiting the performance of gasifiers is a lack of reliable sensors for real-time monitoring and control. A critical limitation of existing sensors is their inability to withstand the high temperatures and pressures, as well as the corrosive and erosive environments, found within gasifiers and downstream equipment. When distributed at key locations within the gasifier, improved sensors should enable operators to monitor, control, and thereby improve the reliability and efficiency of the process.

The National Energy Technology Laboratory (NETL) and GE Global Research are collaborating on a three-year project to develop a fiber optic micro-sensor that is robust enough to detect common fossil fuel gases in harsh environments under high temperature (500 ºC) and pressure (200 psi). This type of sensor creates the opportunity to simultaneously detect a variety of gases along with temperature by placing/distributing sensor elements along the length of the fiber. Sensor development is targeting the *in-situ* detection and quantification of multiple gas species found during production and treatment of coal-derived synthesis gas (syngas). Gases common to this environment include hydrogen (H_2), carbon monoxide and dioxide (CO and CO_2), sulfur species (HCS, H_2S, COS), and other trace contaminants.

Technical Approach and Accomplishments

The project scope includes the selection and characterization of fiber cladding materials, and development of sensor fabrication processes that will enable the detection of H_2 and CO in harsh gasification environments. Qualification of gas samples, cladding materials, and sensor characterization will occur through designed experimental evaluations. As the project progresses, the test conditions will increase in complexity to refine the design and lead to demonstration of the feasibility of sensor fabrication, with acceptable performance ranges of selectivity, sensitivity, and overall accuracy.

The scope of work also encompasses development of a sensor interrogation system resulting in the development of one or more fully characterized, distributed fiber-based gas sensor prototypes that represent an optimized set of materials as well as fabrication processes. Anticipated primary technology products include:

- High-quality sapphire long period grating (LPG) or fiber Bragg grating (FBG) sensors — both single and multiple grating devices,
- Cladding materials and a fabrication process to produce multiple high-temperature chemical sensing fiber optic devices, and
- A multiple gas sensing device that operates at temperatures of 500 ºC and pressures of 200 psi.

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PROJECT DURATION

Start Date

07/21/05

End Date

01/25/08

COST

Total Project Value

$788,759

DOE/Non-DOE Share

$631,007 / $157,752

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In Year 1 of the project, GE Global defined the sensor specifications and pursued the identification and characterization of cladding materials to facilitate selective gas sensing of two or more gases. Sol gel colloidal processes were developed for applying the cladding materials to silica fiber. A sensor interrogation system also was developed, including a data acquisition process to resolve gas detection and quantification under dynamic temperature and pressure conditions; and appropriate sensor packaging to facilitate testing in a simulated fossil-fuel environment. Equipment required for this testing was initiated, and extended to Year 2 for a multi-gas testing setup.

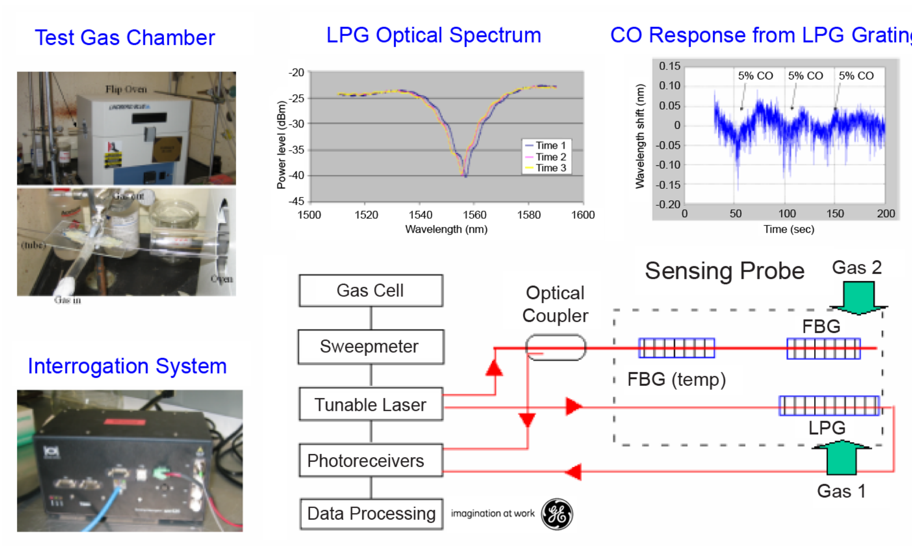

Diagram of micro-sensor prototype, interrogation system, and test setup

During Year 1, GE also has collaborated with Pennsylvania State University to refine the processes for fabricating sapphire fibers with various types of gratings. GE is conducting further developmental work to apply cladding materials to the resulting sapphire fiber, using techniques and materials that are similar to those developed for silica fibers. The purpose is to compare the performance of the silica fiber against that of sapphire, which potentially offers greater material stability and resistance to corrosion.

In Year 2, the scope of work includes optimization of the material compositions and processes for the fabrication of distributed silica and sapphire fiber gas sensors, to achieve the desired sensitivity and selectivity with regard to the target samples. Testing will evolve from characterization testing into sensor response testing under various pressures, temperatures, and mixed-gas environments. This testing will assist NETL to refine the sensor interrogation system as well as develop a model of the distributed fiber-based gas sensor. A complete prototype sensor system will be fabricated and tested.

In Year 3, the scope of work will include extensive testing of the complete sensor prototype in a simulated fossil-fuel mixed-gas stream, as well as optimization of any aspect of the sensor that is found to fall short of the desired specifications. During this testing, the performance limitations of the sensor will be explored, including maximum operational temperature and pressure, and approximate sensor lifetime, along with selectivity, sensitivity, and accuracy in a complex mixed-gas environment.

Benefits

The development of a fiber optic micro-sensor that can accurately sense gas composition under the harsh conditions characteristic of fossil-fueled gasifiers will contribute to the increase in reliability and efficiency of gasification systems. This work will also provide sensing options for other power and industrial systems where harsh environment monitoring is needed.