the ENERGY lab

PROJECT FACTS

Carbon Sequestration

Passive Wireless Acoustic Wave Sensors for Monitoring CO_2 Emissions for Geological Sequestration Sites

Background

Increased attention is being placed on research into technologies that capture and store carbon dioxide (CO_2). Carbon capture and storage (CCS) technologies offer great potential for reducing CO_2 emissions and, in turn, mitigating global climate change without adversely influencing energy use or hindering economic growth.

Deploying these technologies in commercial-scale applications requires a significantly expanded workforce trained in various CCS specialties that are currently under-represented in the United States. Education and training activities are needed to develop a future generation of geologists, scientists, and engineers who possess the skills required for implementing and deploying CCS technologies.

The U.S. Department of Energy's (DOE) National Energy Technology Laboratory (NETL) has selected 43 projects to receive more than $12.7 million in funding, the majority of which is provided by the American Recovery and Reinvestment Act (ARRA) of 2009, to conduct geologic sequestration training and support fundamental research projects for graduate and undergraduate students throughout the United States. These projects will include such critical topics as simulation and risk assessment; monitoring, verification, and accounting (MVA); geological related analytical tools; methods to interpret geophysical models; well completion and integrity for long-term CO_2 storage; and CO_2 capture

Project Description

NETL is partnering with the University of Pittsburgh to develop a knowledge base leading to the successful development of novel sensors and sensor systems for CO_2 emission monitoring. The University of Pittsburgh plans to address several technical objectives through comprehensive research, including (1) developing passive and wireless acoustic wave sensor platforms; (2) developing and characterizing carbon nanotubes (CNTs)/polymer nanocomposites (composite materials in which one of the composites has at least one dimension of less than 100 nanometers) that are highly selective to low concentrations of CO_2; (3) testing acoustic wave CO_2 gas sensors; (4) implementing and demonstrating the acoustic wave CO_2 gas sensors at the sequestration sites; and (5) providing graduate student training on the advanced sensor technology and nanomaterials for applications in the area of CCS.

Potential impacts of the project include:

- Significantly advanced sensor technology for detecting very low levels of CO_2 emissions for applications at CO_2 sequestration projects.

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PARTNERS

None

PROJECT DURATION

Start Date
12/01/2009

End Date
11/30/2012

COST

Total Project Value
$366,900

DOE/Non-DOE Share
$300,000/$66,900

Government funding for this project is provided in whole or in part through the American Recovery and Reinvestment Act.

- Novel application of nanomaterials and devices, specifically for in situ and real-time monitoring of CO_2 emissions from geological sequestration sites.
- An in-depth understanding of material properties and microfabrication technology, as well as device development based on acoustic wave sensors and polymer nanocomposite thin films.
- Acquisition of key data to assess physical and geochemical subsurface processes associated with CO_2 emplacement.

Goals/Objectives

This project aims to develop an acoustic wave CO_2 gas sensor technology that can be used for measuring and monitoring very low levels of CO_2 emissions for geological sequestration sites in real-time and continuous mode. There are four overall project objectives:

1. Fabricate two types of acoustic wave sensors: langasite-based bulk acoustic wave (BAW) sensors with frequencies of 5 MHz and 10 MHz; and lithium niobate ($LiNbO_3$)-based passive wireless acoustic wave sensors with frequencies of 210 MHz and 2.45 GHz.
2. Use single-wall and multi-wall CNTs and CO_2 permeable polyimide to form nanocomposite thin film. Plasma treatment will be performed on the CNTs to achieve complete mixing of CNTs with the polymer matrix for desirable electrical properties and CO_2 permeability.
3. Fabricate, characterize, and test acoustic wave sensors with surface coated nanocomposite thin films, including repeatable fabrication of multiple acoustic wave sensors, and testing the sensors in the test module for performance evaluation, as well as in field tests at pilot sites.
4. Train two PhD students in the field of advanced wireless acoustic wave sensors for application in CCS technologies.

Benefits

The overall project will make a vital contribution to the scientific, technical, and institutional knowledge base necessary to establish frameworks for the development of commercial-scale CCS. This research will lay down a solid foundation for the development of commercially viable advanced sensor technology to detect very low levels of CO_2 emissions for in situ real-time monitoring of CO_2 emissions at the geological sequestration sites. This, in turn, will provide sufficient and precise data for further evaluation of the coupled subsurface processes—including hydrological, mechanical, and geochemical—to ensure that CO_2 will be stored permanently. Additionally, the project will offer graduate student research opportunities that will help cultivate a workforce trained in the skills and competencies required to implement CCS technologies on a commercial-scale.

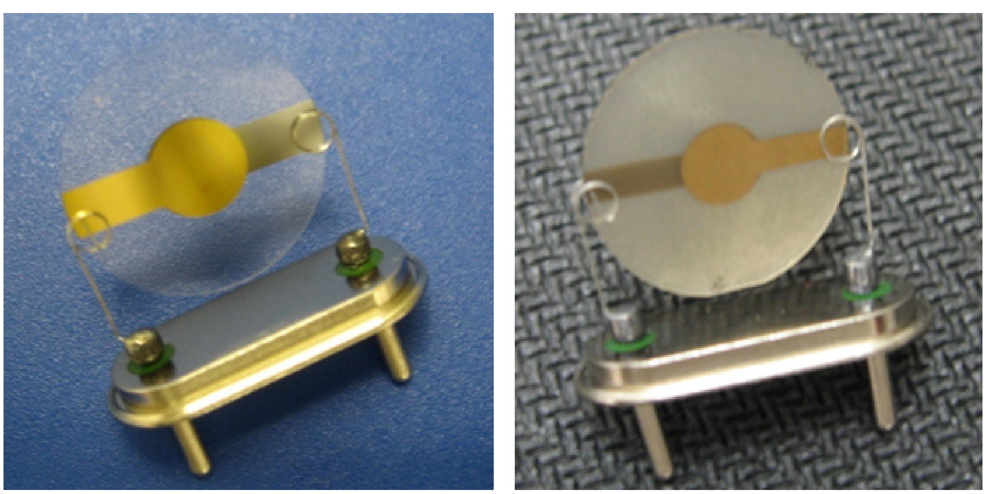

Figure 1. Quartz (left) and langasite (right) BAW resonators. The langasite resonators being developed under this project are capable of achieving a high electro-mechanical coupling and possess a high phase transformation temperature up to 1,470 °C.