the ENERGY lab

PROJECT FACTS

Advanced Research

Development of High-Temperature/ High-Sensitivity Novel Chemical Resistive Sensor

Background

The Historically Black Colleges and Universities and Other Minority Institutions (HBCU/OMI) Program provides a mechanism for cooperative research among these institutions, the private sector, and the U.S. Department of Energy (DOE) Office of Fossil Energy. The program provides for the exchange of technical information to raise the overall level of HBCU/OMI competitiveness with other institutions in the field of fossil energy research and development (R&D); enhances educational and research training opportunities for tomorrow's scientists by developing and supporting a broad-based research infrastructure; and positions HBCU/OMI graduates to assume leadership and technical roles in America's fossil energy commerce.

DOE's Advanced Research Sensors and Controls Program is spearheading national efforts to develop sensing and control technologies and methods to achieve seamlessly integrated, automated, optimized, and intelligent power systems. The program is led by the National Energy Technology Laboratory (NETL) and is implemented through R&D agreements with other national laboratories, industry, and academia. The program strategy is to develop robust sensing approaches, using durable materials and highly automated process controls, that will optimize the operation and performance of advanced power systems. The performance of these systems is limited by the lack of sensors and controls capable of withstanding high-temperature and high-pressure conditions. Harsh environments are inherent to new power systems that aim to achieve high efficiency with low emissions. These systems are complex, with operational constraints and system integration challenges that push the limits of traditional process controls.

Project Description

NETL will partner with the University of Texas at San Antonio to design, fabricate, and develop novel high-temperature, high-sensitivity chemical sensors for the selective detection of fossil energy gases in power and fuel systems. Project researchers will explore and utilize the advantages of mixed-ionic-conductive lanthanum barium cobaltate (LBCO) thin film–based, chemical-resistive sensors to aid in the development of the next generation of highly efficient, near-zero-emission power generation technologies.

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PROJECT DURATION

Start Date
05/15/2010

End Date
03/31/2013

COST

Total Project Value
$200,000

DOE/Non-DOE Share
$200,000 / $0

The LBCO thin films will be characterized at high temperatures (greater than 700 degrees Celsius) in various gas compositions to allow analysis and control of parameters that affect sensitivity. The poison resistance and cross sensitivity of the devices will also be subjected to detailed investigation. To understand the thin film chemical behavior in the target high-temperature range, theoretical and modeling studies will be performed on the absorption, reactivity, and stability of the LBCO thin films in various operating environments and at various temperatures.

Goals and Objectives

The project goal is to systematically investigate and understand the mechanisms of mixed -ionic-conductive LBCO thin films and establish the relationship between their electrochemical properties and surface/interface structure. Project objectives include—

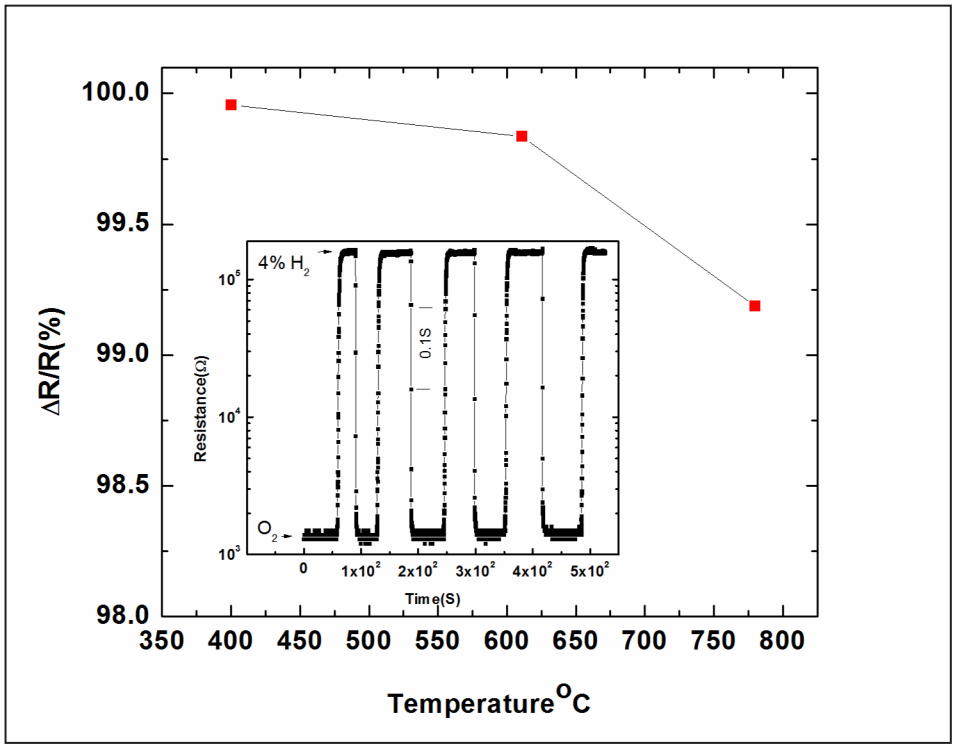
- Resolving and optimizing the fabrication issues of LBCO single crystalline thin films.
- Establishing the relationship between processing conditions with the microstructure, sensing properties, and stability of LBCO thin films.
- Understanding the kinetics and mechanisms of reduction-oxidation processes on the LBCO thin films.
- Demonstrating the high-temperature, high-sensitivity, and chemically stable devices for high-temperature applications.

Accomplishments

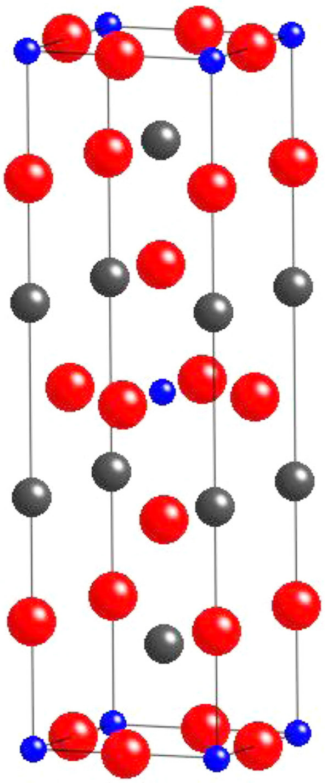
The project has identified several key properties of highly epitaxial, single crystalline LBCO thin films. These include chemical stability at high temperatures (greater than 800 degrees Celsius), electrical resistivity that is sensitive to various oxidizing/reducing environments, short response time (less than 0.1 second), and ultra-fast surface exchange kinetics (low activation energy of 0.26 electron volts). These discoveries suggest that LBCO thin films may be candidates for the fabrication of high-temperature, ultra-sensitive chemical sensors and control systems for power and fuel monitoring systems.

Benefits

The project will demonstrate the full range of applicability of LBCO thin films to a variety of practical applications and will establish a bridge between the advanced technology industries and the fundamental sciences. This will help create the next generation of highly efficient, near-zero-emission power technologies.



LBCO response at different temperature



Conceptual structure of LBCO Material