the ENERGY lab

PROJECT FACTS

Advanced Research

Multifunctional Nanowire/Film Composites-Based Bimodular Sensors for In Situ, Real-Time High Temperature Gas Detection

Background

Real time monitoring of combustion gas composition is important for improving the efficiency of combustion processes and reducing the emission of pollutants. However, such measurement usually requires sensors to be operated at high temperatures in harsh environments. Currently, commercially available sensor technology capable of withstanding such harsh environments is extremely limited; therefore, there is an urgent need to develop novel high-temperature gas sensors. The materials and sensors developed under this project could also be used in other areas, such as energy harvesting and storage, petroleum refining, and industrial pollution control.

Description

Researchers at the University of Connecticut are developing a unique class of multifunctional metal oxide/perovskite-based composite nanosensors for industrial and combustion gas detection at high temperature (700 °C–1300 °C). A sensing platform will be designed and fabricated with an array of integrated electroresistive and electrochemical nanosensors to meet the challenge of gas detection in high-temperature, complex gaseous environments in various combustion conditions. The miniaturized platform will be bimodular (i.e., made up of two forms of new composite nanomaterials): three-dimensional (3D) nanowire/dendrite arrays and two-dimensional (2-D) composite nanofibrous thin film. The 3-D and 2-D composite architectures are assembled by single-crystal 3-D nanowire/nanodendrites or polycrystalline 2-D nanofibrous films made of multifunctional metal oxides. These nanocomposites will combine the functions of wire/dendrite arrays and thin film to increase the nanosensors' sensitivity to catalysts, stability at high temperatures, and ability to detect multiple gases.

CONTACTS

Robert Romanosky
Advanced Research Technology Manager
National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-4721
robert.romanosky@netl.doe.gov

Richard Dunst
Project Manager
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-6694
richard.dunst@netl.doe.gov

Pu-Xian Gao
Principal Investigator
University of Connecticut
Storrs, Connecticut
860-486-9213
puxian.gao@ims.uconn.edu

PARTICIPANT

University of Connecticut
Storrs, Connecticut

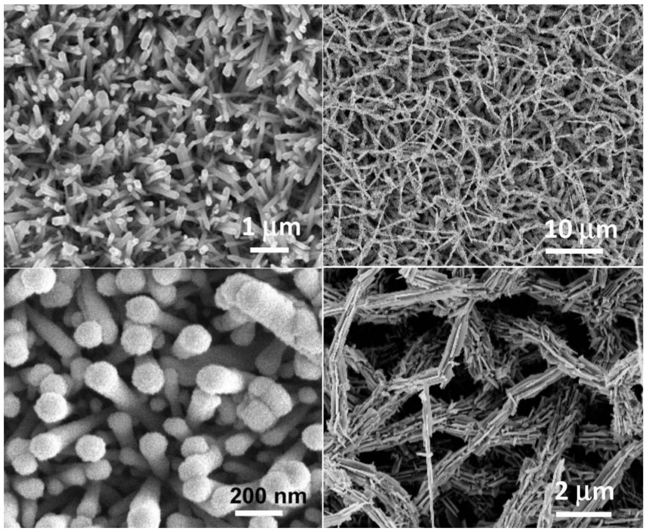
PERIOD OF PERFORMANCE

10/01/2009 to 9/30/2012

COST

Total Project Value
$1,010,772

DOE/Non-DOE Share
$795,607 / $215,165



Metal Oxide-based Nanowire/Film Assembly
(Source: Pu-Xian Gao)

Goals and Objectives

The goal of the project is to advance the gas detection field by developing high-temperature, in situ, real-time gas sensors using a unique class of multifunctional metal oxide/perovskite core-shell composite nanostructures for industrial and combustion gas detection to facilitate the production of hydrogen from coal and contribute to U.S. energy security. The project is designed upon these specific objectives:

- Synthesize metal oxide-based nanowire/film composites by vapor phase/solution phase deposition or electrospinning.
- Determine and optimize the deposition parameters for growth of nanowire/film composites with specific dimensionality, spacing, thickness, aspect ratios, and uniformity.
- Investigate nanowire/film composites in terms of structure, morphology, electronic structure, chemical properties, and high-temperature stability using a range of microscopy and spectroscopy techniques.
- Design and fabricate bimodular nanosensors using the nanowire/film composite nanostructures.
- Characterize the resistive detection module of the nanosensors in different high-temperature, gaseous environments and establish corresponding calibration curves.
- Characterize the potentiometric detection module of the nanosensors in different high-temperature, gaseous environments and establish corresponding calibration curves.

Benefits

The bimodular gas sensor developed through this project will be more robust and provide more information than sensors currently available for harsh conditions at high temperature. These nanosensors can achieve good selectivity, fast response, and enhanced sensitivity in high-temperature gas detection due to the diversity of the nanomaterials, inherent large specific surface area of nanostructures, and minimized gas diffusion resistance. Applications for this technology include combustion monitoring in industrial and power plants and high-temperature gas sensing for vehicle and aircraft engines.

NETL