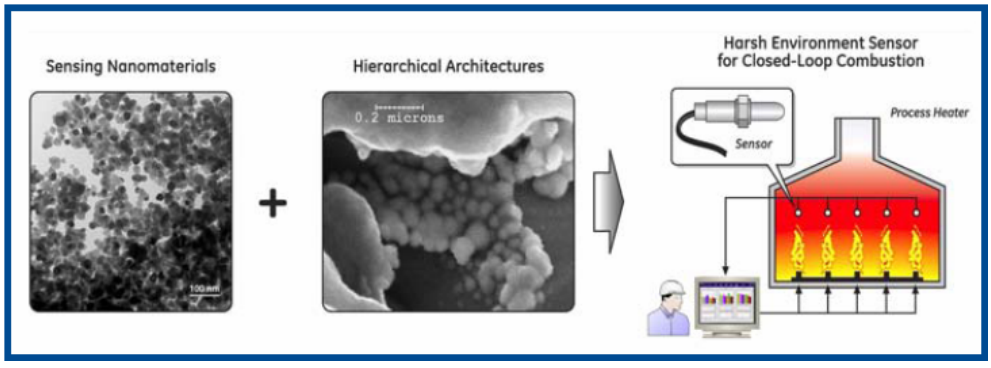
Hierarchical Nanoceramics for Industrial Process Sensors

Nanoengineered Sensors will Monitor Combustion with Enhanced Sensitivity and Flexibility

Remarkable progress in nanotechnology has led to the development of new classes of materials with unprecedented control of material structure, composition, defects, and resulting properties. A range of multifunctional ceramics potentially applicable to high-temperature sensors have been produced using templated synthesis and self or directed assembly. This bottom-up approach has also enabled production of hierarchical architectures not possible with traditional ceramic processing methods.

In this project, partners will develop a robust, tunable materials platform for high-temperature gas-sensing applications. These materials will enable a new generation of sensors for industrial process environments, including furnaces and process heaters. The nanoengineered materials can enable greater sensitivity due to a vastly increased sensor surface area, enhanced selectivity due to nanoscale control of sensing activity, and superior stability based on a unique multi-scale architecture.

Burners in industrial process heaters are typically controlled by adjusting the air-fuel ratio without real-time, online diagnostics. The new sensors will provide the input needed for real-time tuning and balancing of combustion burners. The performance of these sensor materials will be validated in a simulated service environment typical of industrial process heaters.



Benefits for Our Nation and Our Industry

Process heating is the largest fuel end-use in U.S. industry. Improved efficiency in combustion systems for industrial heat and power will increase economic competitiveness by reducing both national energy consumption and costs for materials widely used in consumer goods. An array of nano-ceramic gas sensors for real-time burner balancing will increase combustion efficiency by at least 0.5%, which, across U.S. industrial process heating will by 2030:

- Save 24 trillion Btu per year;
- Decrease CO_2 emissions by 0.5 million tons per year;
- Decrease NO_X emissions by 3,000 tons per year; and
- Decrease CO emissions by 1,600 tons per year.

Applications in Our Nation's Industry

Development of new nanoengineered ceramics for use in industrial process sensors will provide real-time feedback control over air-fuel mixtures in all industrial combustion heating applications.

Project Description

The goal of this program is to develop a robust, tunable gas-sensing materials platform for high-temperature applications.

Barriers

Major barriers to be overcome include:

- Lack of reliable gas sensors with the required sensitivity and selectivity for measuring CO, NOX, and other combustion products in harsh furnace environments; and
- Insufficient stability of electrode microstructure in other ceramic and metal sensor materials under development.

Pathways

The objectives of this project will be achieved through (1) synthesizing and optimizing hierarchical nanostructures; (2) synthesizing and optimizing sensing nanomaterials; (3) integrating sensing functionality into hierarchical nanostructures; (4) demonstrating material performance in a sensing element; and (5) validating material performance in a simulated service environment.

Progress and Milestones

- Synthesize hierarchical porous nanostructures with 10 times the surface area of existing materials (Complete)
- Develop a preliminary process for synthesizing sensing nanomaterials with crystallite sizes less than 100 nm (Complete)
- Demonstrate sensing activity of nanoparticles for NOX and CO (Complete)
- Develop a process for functionalizing hierarchical structures that retains the nanoscale features while demonstrating sensing activity
- Characterize and validate material and sensing performance in a simulated service environment

Commercialization

Industry participants in this project are well-placed to leverage the new technology in a variety of markets. GE's sensor businesses already supply advanced sensors to an international market and are prepared to provide an integrated path to servicing many processes in the power industry. US Steel will play an important part in technology evaluation.

Project Partners

GE Global Research
Niskayuna, NY
(Dr. Mohan Manoharan: manoharan@research.ge.com)

U.S. Steel
Pittsburgh, PA

University of Florida
Gainesville, FL

Brookhaven National Laboratory
Upton, NY

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Ending FY09
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