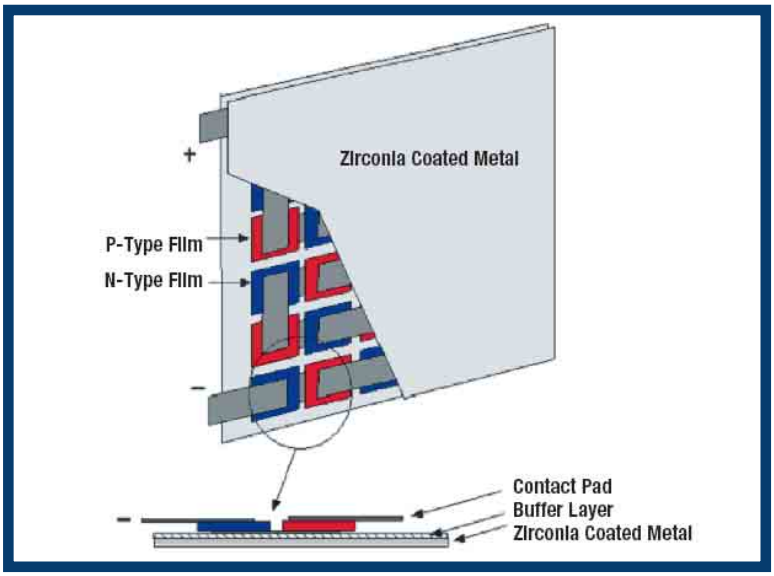
Advanced Thermoelectric Materials for Efficient Waste Heat Recovery in Process Industries

New Materials and Better Designs Will Enable Cost-Effective Thermoelectric Devices

A large amount of thermal energy is available from waste energy streams associated with many industrial processes, including melting, refining, annealing, and forming. Waste heat recovery from exhaust gases provides an opportunity to significantly improve the overall energy efficiency of energy-intensive process industries. One approach for recovering energy from the systems is to generate electrical power through thermoelectric conversion. A conversion efficiency of only 6 to 8% has been achieved in thermoelectric systems in the past. With recent advances in materials technologies, it may be possible to achieve an efficiency of 20%, thus making the technology economically viable.

This project will develop high efficiency thermoelectric energy conversion technology to recover energy from exhaust gases. New technology in thermoelectric materials will be combined with advanced capabilities in modeling to design and develop new thermoelectric generators. The project will also assess the influence of emissions, including particulates, on overall system efficiency.



Design and fabrication of a thermoelectric array device

Benefits for Our Industry and Our Nation

Economic benefits will be realized due to the generation of electricity from waste heat and the elimination of electricity transmission losses. Electrical energy recovered from waste heat can also be used for preheating purposes. Thermoelectric generation can be used as a means to cool furnaces and exhaust gases.

Applications in Our Nation's Industry

The thermoelectric conversion technology can be applied in the aluminum, chemicals, glass, metal casting, and steel industries.

Project Description

The goal of this project is to develop thermoelectric energy conversion technology that will enable conversion of waste heat from exhaust gases to useful electrical power with efficiencies greater than 20%.

Barriers

Major barriers to be overcome include the following:

- Existing materials may not be adequate to achieve required thermoelectric efficiencies;
- Particulate buildup on walls due to emissions from unoptimized processes may reduce heat transfer to thermoelectric systems, thus reducing efficiency; and
- The cost-effectiveness of the thermoelectric systems is not known.

Pathways

The objectives of the project will be achieved through (1) developing thin-film thermoelectric materials; (2) fabricating prototype generators; (3) bench-testing generators in configurations similar to those encountered in the glass industry; (4) understanding the effect of, and minimizing, the buildup of materials on furnace walls due to particulate emissions that may degrade thermoelectric efficiency; (6) designing prototype thermoelectric generators for implementation in waste heat stacks; (7) testing thermoelectric systems in industrial settings; and (8) conducting economic analysis for implementation of technology.

Milestones

- Design a conversion system based on properties of currently available materials
- Complete a preliminary cost analysis
- Fabricate a prototype system
- Bench-test the prototype system and demonstrate 10% conversion efficiency in bench tests
- Develop advanced thermoelectric materials
- Scale up deposition processes for advanced thermoelectric materials
- Fabricate a prototype system with advanced materials
- Achieve 40% conversion efficiency in bench tests
- Characterize emissions and develop a strategy to minimize buildup of particles on inner walls
- Test a thermoelectric system at an industrial partner's site
- Achieve at least 20% conversion efficiency with a thermoelectric system

Commercialization

This project is a collaboration between a supplier of melting furnaces to the glass industry, a supplier of thermoelectric materials, and some of the world's largest suppliers of glass, who will also be potential users of this technology. The partnering approach will lead to a more effective implementation of the technology.

Project Partners

PPG Industries Inc.
Pittsburgh, PA
(John Connors: 412-820-8787)

Leadbetter & Sons Inc.
Carlisle, PA

Michigan Tech
Houghton, MI

Owens-Illinois
Toledo, OH

Pacific Northwest National Laboratory
Richland, WA

Visteon Automotive Systems
Allen Park, MI

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.

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1-877-EERE-INF (1-877-337-3463)
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