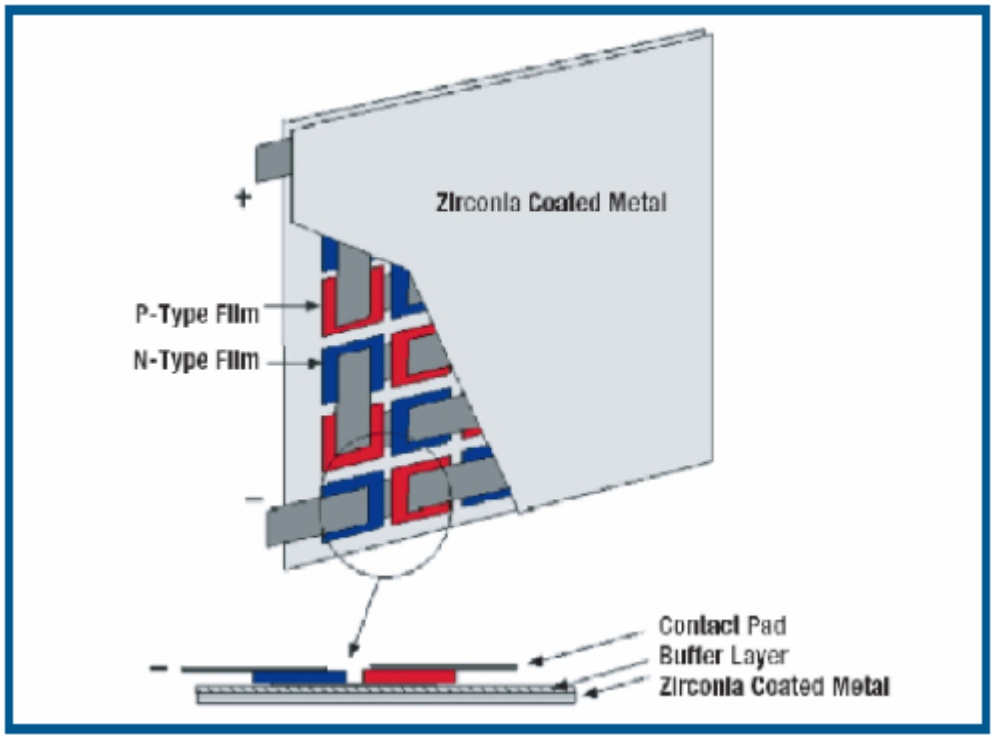
Advanced Thermoelectric Materials for Efficient Waste Heat Recovery in Process Industries

Improved Thermoelectric Materials Will Enable Cost-Effective Conversion of Waste Heat to Electrical Power

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 (TE) conversion. A conversion efficiency of only 6 to 8% has been achieved in thermoelectric generator (TEG) 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 Nation and Our Industry

- Industrial energy savings of 1.6 trillion Btu per year by 2020
- Recovery of energy from industrial waste heat stacks
- Economic benefits due to the generation of on-site electricity from waste heat
- Potential use of thermoelectric generation to cool furnaces and exhaust gases

Applications in Our Nation's Industry

Thermoelectric conversion technology can be applied in any industry with waste heat including the following:

- Aluminum
- Chemicals
- Glass
- Metal Casting
- Steel

Project Description

The goal of this project is to integrate advanced TE materials into a power generation device that can convert waste heat from an industrial process to electrical power with an efficiency of ≥20%.

Barriers

Major barriers to be overcome include:

- Scale-up and transfer of TE technology from laboratory to an industrial device
- Efficient transfer of thermal energy from the waste heat stream through the TE elements

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.

Progress and Milestones

- Design a conversion system based on properties of currently available materials (Complete)
- Complete a preliminary cost analysis (Complete)
- Develop N- and P-type advanced materials for use in TE system (Complete)
- Design and construct thermal mock-up of TE generator (TEG) for testing of heat transfer and emissions performance
- Test TEG mock-up in an industrial furnace exhaust gas line
- Characterize emissions and develop a strategy to minimize impact of emissions on heat transfer

Commercialization

The industrial partnering approach will lead to a more effective commercial implementation of this technology. The project is collaboration between a supplier of TE generators, and some of the world's largest operators of glass and aluminum melting furnaces. These partners have a vested interest in the success of this project and are potential users of this technology. The industrial partners will be able to utilize the technology being developed in this program to produce a significant fraction of their required electrical power.

Project Partners

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Pacific Northwest National Laboratory
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Owens-Illinois
Toledo, OH

Michigan Technological University
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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
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Ending FY08
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