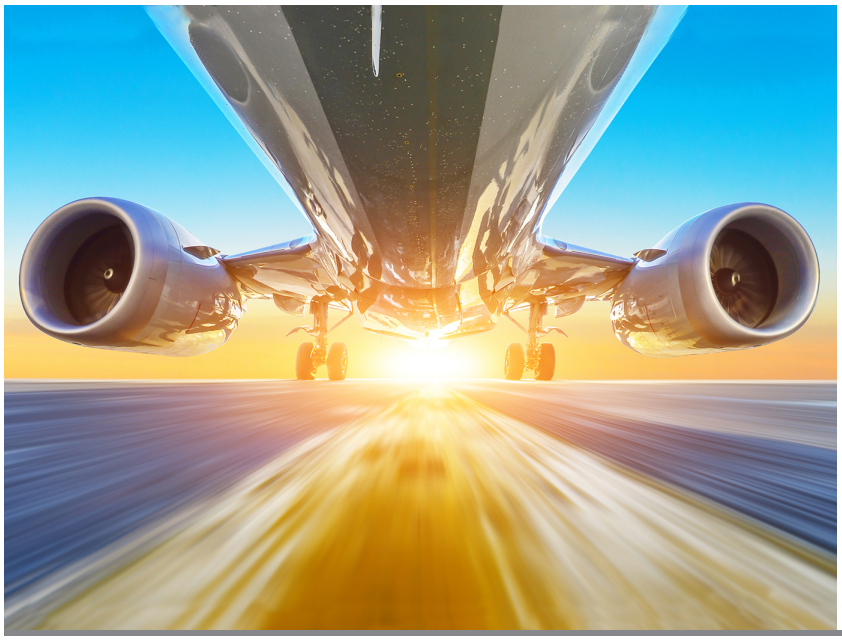


National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Materials and Coatings

Ruthenium-Doped Thermoelectric Materials

Robust material converts excess heat energy into electricity

Innovators at NASA's Glenn Research Center have developed a novel thermoelectric material that raises the bar for solid-state power conversion devices. There is growing momentum in the aerospace and automotive industries to harvest energy from heat (such as exhaust from combustion), but advances have been hampered by the lack of environmental durability and performance levels of thermoelectric materials currently in use. Glenn's breakthrough material is a ruthenium-doped gadolinium orthotantalate that excels at directly converting heat into energy. More important, this material does not break down at higher temperatures or air environments - even without special coatings or inert packaging. Glenn's pioneering material enables designers to make great strides in developing solid-state power conversion devices for application in aerospace, automotive, and power-generation industries.

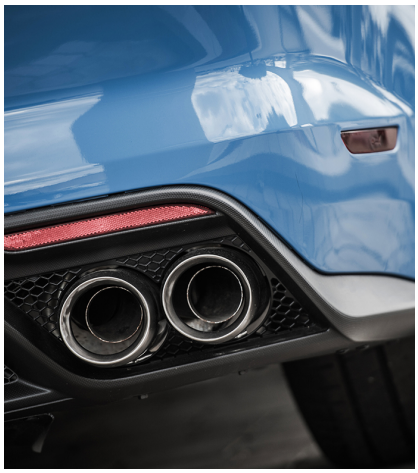
BENEFITS

- Efficient: Can convert waste enthalpy (such as exhaust) into electrical power in gas turbine engines
- Low Thermal Conductivity: Has a thermal conductivity of approximately 2W/mK, making this material an excellent thermoelectric
- Durable: Operates at temperatures above 700 degrees C, where current materials become unstable
- Oxidation-resistant: Does not oxidize in air, unlike current state-of-the-art thermoelectric materials
- Simple: Does not require special coatings or inert packaging

THE TECHNOLOGY

Solid state power conversion devices, such as thermoelectrics, depend upon temperature gradients for their operation. For example, aeronautic gas turbine engines maintain the necessary temperature gradients throughout their systems due to the enthalpic processes of combustion, which offers the possibility of generating electrical power for use in primary and secondary electrical systems in the aircraft. However, until now thermoelectric materials have not been able to withstand the combination of high temperatures and oxidative environments present in gas turbine engines. Glenn's innovation overcomes these limitations by using a doped oxide pyrochlore (crystal compound) semiconductor as the thermoelectric material. The material has a low thermal conductivity, which allows it to maintain a thermal gradient and sufficient electrical conductivity to produce an electromotive force. The pyrochlore allows the thermoelectric material to be present within a gas turbine engine, converting heat directly into electricity and functioning at high temperatures without oxidizing in air. Glenn's innovative thermoelectric material permits the benefits of solid-state power conversion devices to improve fuel efficiencies for a broader range of applications than has ever been possible. This innovation is in the early stages of development, and Glenn welcomes opportunities for co-development.

The ability of Glenn's new thermoelectric materials to harvest energy from heat without breaking down hold great promise for the power-generation industry, including CHP plants



Glenn's ruthenium-doped thermoelectrics could improve automotive fuel efficiency by converting waste heat from exhaust into energy

APPLICATIONS

The technology has several potential applications:

- Aerospace
- Automotive
- Electronics
- Power (e.g. Combined Heat and Power (CHP) systems)
- Semiconductors
- Turbines
- Unmanned vehicles

PUBLICATIONS

Patent No: 11,362,253

technology.nasa.gov

NASA's Technology Transfer Program pursues the widest possible applications of agency technology to benefit US citizens. Through partnerships and licensing agreements with industry, the program ensures that NASA's investments in pioneering research find secondary uses that benefit the economy, create jobs, and improve quality of life.

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