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TECHNOLOGY FACT SHEET

ENABLING ENERGY RECOVERY FROM HIGH TEMPERATURE SOURCES

Introduction

This invention showcases a substantial new advancement in electrical contact technology. Researchers at the Sensors and Electron Devices Directorate of the U.S. Army Research Laboratory (ARL), Adelphi, Maryland, designed, built, and successfully tested a new metallurgical connection that exhibits low electrical resistance while maintaining structural integrity at high temperatures, with a duty lifetime expected to be significantly greater than other electrical contact methodologies on the market today.

TEG module (located about muffler box in image at left) can achieve five percent fuel savings by recovering energy in exhaust heat alone (image source: DOE)

Concept

ARL researchers envision this new technology being applied in multiple fields of use in any device whose components operate for prolonged periods at temperatures exceeding 300 ^{o}C. One example would be thermoelectric power generation (TEG). TEG modules, solid-state devices that create electrical power from temperature differences, are the focus of rapidly growing research, and are finding a wide range of applications, such as waste-heat scavenging from automobile exhaust trains. The image above depicts a TEG module installed near the center of a large passenger vehicle (Source: Department of Energy). The module decreases engine load, which results in a reported 5% increase in fuel efficiency. The ARL invention could enable an improved device positioned closer to the engine to achieve greater temperature differences, stronger energy output, and even higher fuel efficiency.

Invention Overview

- *Novel electrical junction maintains structural integrity from 300 ^{o}C to more than 600 ^{o}C with very low levels of electrical resistance; 800 ^{o}C possible*
- *Method is simple to practice and adaptable for mass production*
- *Multiple fields of use, including thermoelectric power generation*
- *TRL 5 – Fully functioning TEG device and test data available*
- *Technical Report ARL-TR-4480 available on the web*
- *Recipient of 2010 Department of the Army Research and Development Award*

Doing Business with ARL

- *ARL is a leader in partnering with domestic firms*
- *Successfully developed and implemented innovative tools to ease the technology transfer process*
- *Tools include Patent License Agreements (PLAs); Cooperative Research and Development Agreements (CRADAs); Test Services Agreement (TSA); and others*
- *Visit www.arl.army.mil for more information*

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Features/Capabilities/Intellectual Property

Current electrical contact manufacturing techniques, such as soldering and brazing, have important limitations. Metallurgical brazing, the most common technique, usually involves a mixture of elemental aluminum and silicon. These elements are chemically aggressive and are known to react with thermoelectric (TE) components, causing significant degradation of the interface resulting in performance penalties, such as high electrical resistance.

The ARL invention overcomes these obstacles by taking advantage of a novel nickel-alloy metallurgy. Nickel is already known as an effective electrical contact material for thermoelectric devices, and the contact joint resulting from this new method should be stable at temperatures above 800 °C. Present lab experience with a TEG test device indicates the electric contact is also unusually strong and robust. This is due, in part, to the closely matched thermal expansion coefficients, which reduce thermal stresses from repeated heating and cooling cycles.

The measured contact resistivity was 12 microOhm-cm^2, which is orders-of-magnitude less than the resistivity of the thermoelectric material, itself. Thus, electric current is not significantly impeded at the junction between the shoe and the TE materials. Other features/capabilities/intellectual property offered by this invention include the following:

- Materials used are commonly found in the industry.
- Easily adaptable to existing solder and braze process lines.
- Thin-film deposition would enable miniaturization and direct integration with high-temperature circuits.
- Low resistivity creates opportunity for high current applications.
- IP includes novel process and composition of matter.

Potential Markets/Applications

This novel electrical contact method and material could enable new, high-temperature commercial applications, particularly in the area of waste-heat scavenging and energy harvesting. For example, it is estimated that the amount of process heat wasted in the glass, steel, aluminum and chemical industries exceeds 100 million MBTU per year. A typical plant in these industries may reject on the order of 60 MBTU per hour, or 18 MW. Exploiting the higher temperature regimes of waste heat could greatly improve conversion efficiency and create the prospect of generating electricity below the cost of power supplied by the grid. Other potential applications/industries might include:

- Combined Heat & Power – Integration with nuclear and fossil-fueled energy plants
- Energy Harvesting Circuits – DC-DC, DC-AC, AC-DC converters, RF amplifiers

Key Advantages & Benefits

- ❖ *Enables operating temperature range beyond 300 °C, the practical limit for most TEG devices today*
- ❖ *Demonstrated environmental stability and low electrical resistivity*
- ❖ *Uses commonly available materials of construction*
- ❖ *Method adaptable to existing solder and braze process lines*
- ❖ *Wide variety of potential applications*
- ❖ *Inventor team available to work with commercialization partner*

Contact Information

This technology was developed by ARL. It is now available for licensing and CRADA opportunities.

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