Topic: N151-068

eM-TECH, Inc.

Ultra-High Temperature Thermoelectrics

Hypersonic vehicles require reliable, maintenance free, compact, high temperature capable power sources – requirements that are difficult to attain using battery-based systems. eM-TECH's Thermoelectric Generator (TEG) system technology meets those requirements. In addition, it also increases the temperature limits of legacy TEG systems from approximately 600 C to 1250 C while achieving a figure of merit (ZT) above 1 through the innovative use of silicon carbide and stable aerogels. eM-TECH, Inc. specializes in providing advanced technology solutions to problems of critical importance within the fields of materials chemistry, thermal management, adhesives, composites, and ultra-high heat to electricity conversion. We seek partnerships with government test facilities to demonstrate/validate the prototype system capabilities and with prime contractors to license the manufacturing and incorporation of the technology.

Technology Category Alignment:

Aircraft Propulsion, Power and Thermal
High-Speed/Hypersonics
Power Generation/Energy Conversion
Manufacturing Technology for Affordability
Radio Frequency Weapons (RFW)

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SYSCOM: ONR
Contract: N68335-17-C-0060
Corporate Brochure: https://navystp.com/vtm/open_file?type=brochure&id=N68335-17-C-0060

Department of the Navy SBIR/STTR Transition Program

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Ultra-High Temperature Thermoelectrics

eM-TECH, Inc.

WHO

SYSCOM: ONR

Sponsoring Program: NAVY

Transition Target: High Speed/Hypervelocity Demonstrator(s) (NAVY; Air Force; DARPA; Army, and NASA)

TPOC:
Mr. Rick Burnes
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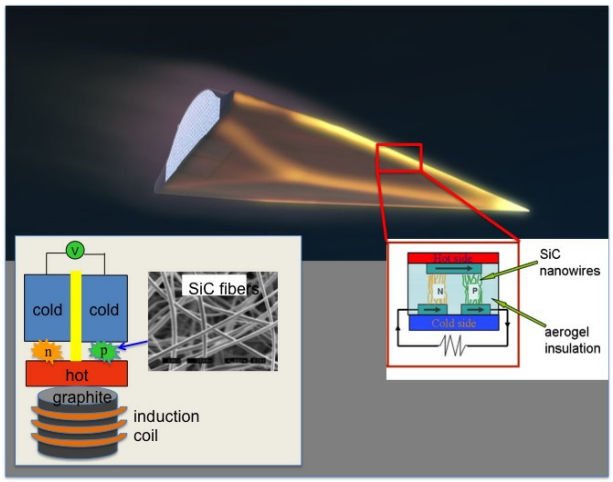
Other transition opportunities: Air Force hypersonic program
Railgun program

Notes: This solution is within Key Performance Parameter (KPP) – Energy.



eM-TECH depiction of the Seebeck coefficient measurement apparatus with nanofibers and schematic of the TEG device on leading edge of the hypersonic vehicle. Copyright eM-TECH, 2018

WHAT

Operational Need and Improvement: Batteries in hypersonic vehicles are cumbersome, require thermal insulation and maintenance. Leading edge thermoelectric generators (TEGs) save space and convert heat generated during hypersonic flight into electricity. Use of TEGs can reduce or eliminate need for batteries required to power on-board electronics. TEGs can be implemented in hypersonic missiles, projectiles, and other applications generating heat.

Specifications Required: Compact, reliable, maintenance free, high temperature capable TEGs capable of meeting expected missile form factors and combined mechanical and thermal environments with a minimum figure of merit (ZT) above 1 and high side temperatures of 1,250 degrees centigrade (degrees C) to supplement power generation.

Technology Developed: Through the innovative use of silicon carbide (SiC), high temperature stable aerogels and a proprietary metallization/attachment process for SiC fibers, eM-TECH has developed a reliable, compact, ultra-high temperature thermoelectric generator system that can survive exposure to temperatures up to 1200 degrees C and is ideally suited for supplementing power systems in hypersonic vehicles and projectiles. In short, it is a semiconductor device that converts heat into electricity without moving parts.

In addition, eM-TECH has developed a unique apparatus for measuring Seebeck coefficient and electrical impedance (collectively, power factor) at 1250 degrees C. This apparatus is capable measuring data with delta T of >900 degrees C and can simulate heat generated upon re-entry at hypersonic speeds.

Warfighter Value: The incorporation of thermoelectric generation enables a reduction in the size of thermal battery packs and other power generation approaches associated with air-breathing propulsion systems. Our TEG technology greatly reduces or eliminates the need for on-board battery power. Our robust thermoelectric generators become active and generate electricity needed for accurate navigation throughout hypersonic flight – to include vehicle reentry into the atmosphere where aerodynamic heating (at Mach 20 or higher) generates temperatures in excess of 1200 degrees C.

WHEN

Contract Number: N68335-17-C-0060 **Ending on:** July 2, 2019

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Develop TE power factor testing unit working at 1200C or above	N/A	met the requirement, measures Seebeck coefficient and electrical impedance at >1200C	TRL 7	2nd QTR FY18
Preparation of robust SiC nano-fibers in aerogel matrix	N/A	the fiber/aerogel composite is stable at >1000C	TRL 6	3rd QTR FY18
p or n-type doping of SiC nano-fibers	N/A	numerous docents have been explored where some boost Seebeck coefficient to > 200uV/K	TRL 6	3rd QTR FY18
Metallization of SiC nano-fibers	N/A	anticipated adhesion to tungsten metal cupons	TRL 5	4th QTR FY18
Preparation of a TEG module (prototype)	High	TRL 4	TRL 7	3rd QTR FY19

HOW

Projected Business Model: We are currently looking for partnerships with government test facilities to demonstrate/validate the prototype system capabilities and with prime contractors to license the manufacturing and incorporation of the technology. In addition to sale of the IP we would provide key development aid to the project until the final product is fully ready for launch.

Company Objectives: For direct implementation of our technology specific primes that we are interested in getting connected with are Lockheed Martin, Boeing, and Raytheon. We also would like to further expand and develop this technology for possible guidance of railgun projectiles and even power co-generation for nuclear and space systems.

Potential Commercial Applications: Commercial and dual applications of this technology include electrical power generators from satellites, fuel cells and combustion driven engines such as for aircraft and ground transportation. By harvesting combustion engine waste heat, the overall efficiency of these engines is improved. A further use is to provide back up to solar photovoltaic cells. Additional commercial applications of current technology will be in power co-generation from existing nuclear power plant, power generation from waste heat generated from steel mills or glass foundries. In addition to co-generation current technology can be applied to solar farms where solar thermal energy is converted in to electricity. In some cases temperatures from 800 -1000 degrees C can be achieved.

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