UNIVERSITY OF MINNESOTA
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Heat to Electricity Using Phase Transformations in Ferroelectric Oxides

Technology No. 20170206

Electrical Energy from Heat in Small Temperature Difference Regime

A device with a ferroelectric oxide crystal layer in a capacitive arrangement and a switch converts heat to electric energy in a small temperature difference regime. The method uses oxide crystals that undergo highly reversible phase transformations from a strongly ferroelectric phase to a paraelectric phase upon heating. As the crystal is cooled through the phase transformation it releases (latent) heat, transforms to the ferroelectric phase, and develops a strong polarization. If this crystal is the dielectric of a capacitor that is connected in parallel to a reference capacitor, it will draw charge from the reference capacitor. Sloshing of this charge back and forth between the active and reference capacitor through a load resistance constitutes the direct conversion of heat to electricity. This technology has many applications, such as waste heat recovery in data centers and handheld devices, solar-thermal sources, household waste heat, waste heat from power plants, waste heat from heavy industry and air conditioning systems, powering of satellites, geothermal sources.

Waste Heat Recovery

Heat loss costs billions of dollars each year, and no good method for energy conversion in the small temperature difference regime currently exists. Several mechanical, solid state or hybrid technologies can realize the opportunity of lower-grade waste heat recovery, but they suffer from drawbacks. Mechanical systems are often limited by their complexity, large footprint and parasitic power requirements, and solid-state devices suffer from low efficiency and high cost. This technology offers a new source of electricity for the small temperature difference regime (10-250 degrees C) by using an oxide crystal-based device to convert waste heat to electricity through phase transformation. Upon heating, the crystal absorbs heat while transforming to the non-ferroelectric phase at a higher temperature and simultaneously releases charge to the reference capacitor. This novel approach could increase efficiency, reduce costs and increase the effective battery life of electronic devices.

BENEFITS AND FEATURES:

- Higher efficiency
- Reduced cost (target $1/W)
- Increased effective battery life of electronic devices
- Separation of charge rather than the creation of dipoles (larger power densities and larger thermodynamic efficiency)
- Much better adapted to miniaturization
- Heat transfer problem strongly favors a thin film-based geometry
- Novel materials and processing methods satisfy non-generic conditions of compatibility
- Does not require a separate electrical generator

APPLICATIONS:

- Heat-to-electricity generators in the industrial sector
- Internal combustion engines
- Waste heat recovery in data centers and handheld devices
- Solar-thermal sources
- Household waste heat
- Waste heat from power plants, heavy industry and air conditioning systems
- Powering of satellites
- Geothermal sources

Phase of Development - Concept with design

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