Thermoelectric Generation from SNAP III to Body Heat Harvesters: Inventing Materials to Unleash Technology

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Direct conversion of heat into electricity has attracted the interest of scientists and technologists since World War II. Although thermoelectric generators still have relatively low efficiencies, the possibility of converting low-enthalpy heat into electric energy in motionless devices has provided advantages in terms of miniaturization and reliability that often defeated competitive technologies such as Rankine engines. In recent years research on thermoelectric materials and generators has further revamped based upon two facts. On one side, nanotechnology has opened disruptive innovation paths in material research, leading to an impressive enhancement of the thermoelectric efficiency. On the other side, demand for thermoelectric conversion has extended to a host of new applications. Thermoelectric generators are nowadays considered to boost energetic efficiency wherever mechanical energy is obtained through fuel combustion (e.g. in cars). Also, miniaturized TEGs are sought to improve the portability of many devices, from sensing to near-field communication. It is therefore not surprising that, along with blue-sky research on high efficiency materials, over the last five years an important research avenue have surfaced to tune material characteristics to specific scenarios of deployment.

In this presentation the current priorities of thermoelectric material research for large-scale applications will be reported. The search for low-cost, geo-abundant, non-toxic thermoelectric materials capable of heat conversion at relatively low temperatures will be presented and discussed, and the current paradigms guiding research in this field will be reviewed. It will be shown how, while efficient thermoelectric materials are already at reach, what still hinders their full deployment in real-world heat converters stands aside the thermoelectric material itself, being related to the science and technology of heat transport from thermal sources to the thermoelectric elements – and of heat dissipation away from the thermoelectric element. Also, additional issues such as contact stability in time under thermal stress will be discussed as they represent an additional critical element to build an efficient and durable thermoelectric device. As a case study, body heat harvesting to power wearable devices will be analyzed. An outlook to what innovation will sensibly achieve in the next decade – and a warning about the limits of thermoelectric technology – will close the talk.

The work reported in this presentation was supported by FP7-NMP-2013-SMALL-7, SiNERGY (Silicon Friendly Materials and Device Solutions for Microenergy Applications) Project, Contract n. 604169.